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BITUMINOUS-COAL MINING

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MECHANIZATION, EMPLOYMENT, AND OUTPUT PER MAN IN BITUMINOUS-COAL MINING

by

Willard E. Hotchkiss,
F. G. Tryon, Charlotte K. Warner, L. N. Plein, Walter M. Dake,
R. L. Anderson, J. J. Gallagher, and Margaret H. Schoenfeld

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CHAPTER VII

BASES FOR ANALYZING PERFORMANCE OF MECHANICAL- AND HAND-LOADING MINES*

The importance of loading from the point of view of employment and the rapidity of the transition from hand to machine methods make mechanization of loading by far the most important current item of mining technology. Loading coal into mine cars employs more men than any other deep-mine occupation. Studies of the Bituminous Coal Division of the National Recovery Administration in 1933, when all but 12 percent of deep-mine tonnage was loaded by hand, revealed that from 50 to 60 percent of all the persons employed in underground bituminous mines were occupied with loading coal. Today, with approximately 25 percent of the tonnage loaded by machines, the ratio of loaders to other employees is somewhat smaller, but loading still offers far greater potential employment than any other deep-mine process. The remainder of this report, therefore, will deal with output per man in the several coal regions and the relationships between mechanical loading and productivity. It is first necessary, however, to list and describe briefly a few of the important nontechnological causes of change in the statistical measures of average output and to appraise the statistical data which form the basis for the analysis.

NONTECHNICAL CAUSES OF INCREASED AVERAGE LABOR OUTPUT

Concentration of Production in More Efficient Mines

Among the causes of increasing output of mine labor, use of mechanical power has undoubtedly been outstanding. Power has long been used in auxiliary operations such as pumping and ventilating and since 1890 has been applied in underground mines to cutting, hauling, drilling, and finally to loading coal. Strip mining embodies an exceptionally intensive application

*By Frederick G. Tryon, formerly Chief of the Coal Economics Division of the U. S. Bureau of Mines, now Director of the Division of Research, National Bituminous Coal Commission; Willard E. Hotchkiss; Charlotte K. Warner; and Joseph J. Gallagher.

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of mechanical power for removing the earth and rock covering the coal and, as in underground mining, loading, hauling, and other processes are highly mechanized.

Notwithstanding the technical progress in all divisions of mining activity during the past generation, the adaptation of mine processes to these changes required the exercise of managerial functions which are indispensable to a well-rounded operation of any mine and especially of a mechanized mine. Such functions involve mine lay-out, personnel, and above all the synchronizing of the several operations.

There is, however, still another important factor which affected the recorded average labor output. The demand for coal during the World War brought thousands of new mines into production and resulted in the expansion of what later proved to be an already overdeveloped industry. Although capacity continued to increase for a time after the war, it soon became obvious that the top-heavy structure must collapse; between 1923 and 1929, 3,274 commercial mines[1] went out of business, with a corresponding shrinkage in the number of jobs.

Even after this drastic liquidation capacity was still in excess of demand, and in the depression years 1929-32, 630 more commercial mines went out of business. It is true that some of these 3,904 mines that closed were worked out, but the great majority of them were marginal, high-cost mines that could operate only in periods of attractive prices. For the most part they labored under competitive disadvantages, unfavorable resource conditions, and managerial difficulties. The closing of such mines tended to raise the average level of labor productivity.

The brunt of the liquidation in the years 1922-29 fell upon the mines that produced from 10,000 to 50,000 tons a year. In figure 37 it may be seen that the curve showing the number of mines in this group (known as Class 4) dropped from 3,139 in 1922 to 2,047 in 1924, and the downward course continued through 1935 (see also table B-18). Class 3 and Class 2 mines, those producing from 50,000 to 100,000 and those producing 100,000 to 200,000 tons a year, declined in number less sharply

[1] "Commercial mines" is here used to designate all mines with an annual production of more than 1,000 tons as distinct from small-scale operations, known as "wagon mines" and "country banks", producing less than 1,000 tons annually.

than Class 4 mines in the years prior to 1930. At the same time, Class 1 mines, those producing over 200,000 tons a year, actually increased in number between 1923 and 1929. It is interesting to note that Class 5 mines, those producing less than 10,000 tons a year, showed a rather surprising vitality between 1923 and 1929. The total significance of this group, however, is slight.[2]

It may also be seen in figure 37 that Class 1 mines, those producing over 200,000 tons a year, have consistently produced a much larger share of the total output than have any other class. It is notable that the proportion of total output produced by the various size groups declines with the size of mines. This means that, in spite of the large number of small mines, the bituminous industry is essentially a mass-production industry in which the average unit labor requirements are determined chiefly by the concerns having the larger output.

Liquidation of smaller mines of course added to the concentration of tonnage in mines of large capacity. In 1923 about 47 percent of the bituminous tonnage of the country was produced in mines with an output of over 200,000 tons a year, a figure comparable to war and pre-war averages. This group lost its relative advantage in the immediate post-war years, but between 1923 and 1929 it increased its percentage of total output from 47.2 to 65.2. During the depth of the depression Class 1 mines again lost ground to other groups, but in 1935, 62.2 percent of the total output came from this group, and in 1936, 69.0 percent.

The accompanying tabulation, prepared from studies of the United States Coal Commission and the United States Bureau of

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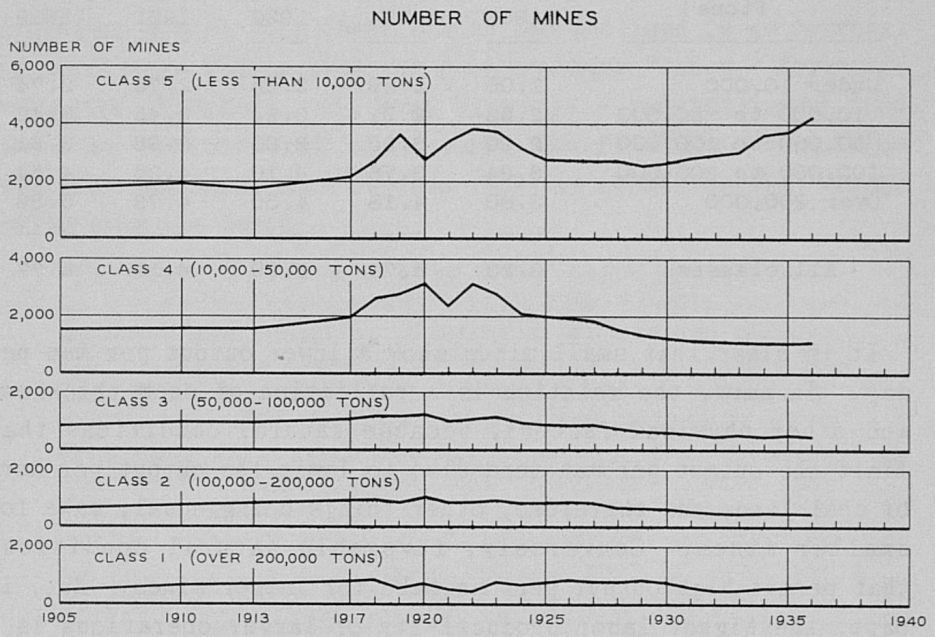
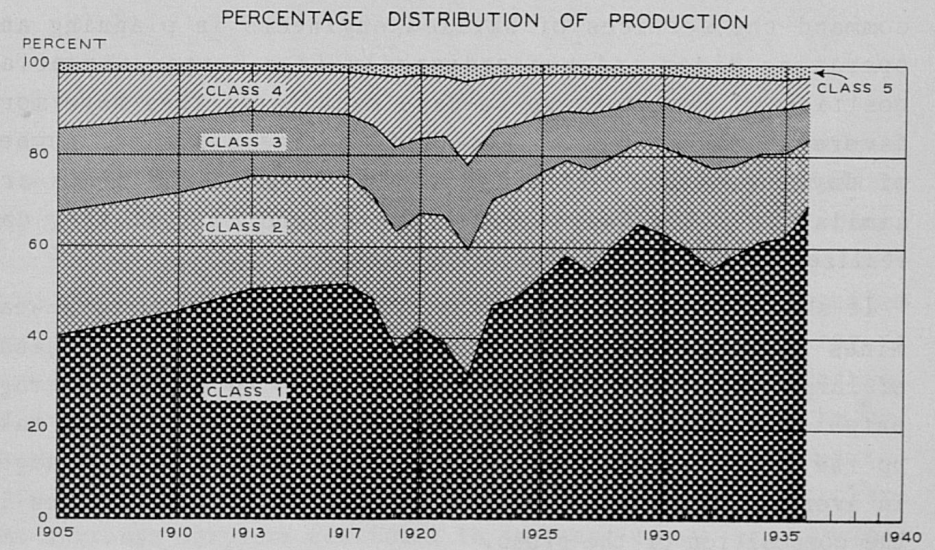
[2]This showing was due in part to more complete lists of small operators available in later years and in part to the fact that mines that had once been in a higher group dropped into the smallest group during the period. Many of the mines in this lowest group are known as "local commercials", a designation coming from the fact that they serve a local market, often using a truck for delivery. Such mines are not subject to competitive pressure to as great an extent as are larger mines which ordinarily must depend on commercial industrial markets. The same line of reasoning largely explains the increase in the number of mines in this group after 1929, when mines in other size groups were decreasing. The actual vitality of truck and wagon mines with their local domestic markets was undoubtedly greater under adverse conditions than that of the somewhat larger mines. The truck mines were likewise favored by the increasing mileage of hard roads.

Figures for 1934 and 1935 are not fully comparable with those for preceding years since the coverage of small trucking operations was much more complete after 1933 than it had been before. This improved coverage was made possible by the cooperation of the NRA Divisional Code Authorities.

Figure 87.- NUMBER OF COMMERCIAL BITUMINOUS-COAL MINES AND PERCENTAGE DISTRIBUTION OF PRODUCTION, BY SIZE OF MINES, 1905-36





BASED ON TABLE B-18

MINERAL TECHNOLOGY AND OUTPUT PER MAN STUDIES
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Mines, shows clearly the relationship between size of mines or companies and output per man-day:[3]

Production (tons)	Output per man per day				
	1905	1914	1920	1921	1929
Under 10,000	1.96	2.29	2.36	2.70	2.74
10,000 to 50,000	2.52	2.91	3.24	3.45	3.42
50,000 to 100,000	2.90	3.35	3.80	3.98	3.91
100,000 to 200,000	3.34	3.78	4.10	4.26	4.54
Over 200,000	3.80	4.18	4.50	4.73	5.32
All classes	3.23	3.71	3.99	4.19	4.77

It is clear that small mines show a lower output per man per day. In part, the relation is a reflection of seam thickness and other physical factors, because natural conditions that limit the output per man tend also to limit the output per acre of coal land, and therefore, other things being equal, make for smaller mines. Conversely, favorable natural conditions that permit high output per man make for larger mines. But, in part, the higher labor productivity of larger operations is a matter of superior management and equipment. Large enterprises command the services of skilled engineers in planning and operating mines and are ordinarily in a better financial position to invest in up-to-date machinery; they have more favorable market connections and operate a greater number of days per year. In other words, large-scale mines are similar to other large-scale enterprises in that they can realize the savings of mass production.

It should be clear, then, that the elimination of many weak mines and a growing concentration of tonnage in the hands of large-scale producers have contributed to raising average output per man-day. Because the component units that make up the totals of all mines change from year to year, changes in average performance reflect to some extent the changes in the composition of the group.

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[3] Data for 1904-21 from *Report of the United States Coal Commission* (S. Doc. 195, 68th Cong., 2d sess., 1925), pt. III, p. 1886. The figures represent mines of commercial size exclusive of so-called "local commercial" mines employing less than 10 men.

Data for 1929 from F. G. Tryon and L. Mann, "Coal," *Mineral Resources of the United States: 1929* (U. S. Dept. Com., Bur. Mines, 1932), Part II, "Nonmetals," p. 720. Only independent companies are included; captive or consumer-owned mines have been excluded.

Shifts From Old to New Mining Areas

In 1890, 65 percent of the bituminous output of the country was produced in four northern States - Pennsylvania, Ohio, Indiana, and Illinois. Twenty-four years later, in 1914, production coming from these States had declined to 57 percent. The percentage coming from the four southern States - Kentucky, Tennessee, Virginia, and West Virginia - had increased from 12 to 25 between 1890 and 1914. The following quotation indicates the importance of this relative growth in the tonnage coming from the South.

> Whereas . . . . southern Ohio declined notably in relative importance among the fields of the Appalachians competing in western markets and whereas the Pittsburgh district also lost in relative standing, shipments from northern West Virginia increased, the non-union regions of eastern Kentucky were developed with extraordinary rapidity, and an entire new field - Logan County, West Virginia, coming into first production in 1905 - had taken rank as one of the most productive districts of the country by 1914. . . . . In 1898, 86 per cent of the coal shipped up the Lakes originated in the union districts of Pittsburgh and Ohio. In 1913 their share had dropped to 67 per cent. In 1898 southern West Virginia shipped to the Lakes only 40,000 tons, or less than 1 per cent of the total. In 1913 its contribution ran over 6,000,000 tons, or 23 per cent of the total.[4]

In general the coal fields in the northern States mentioned were close to the great consuming markets and were naturally the first to be opened. With the development of railroads, which gave southern fields access to markets under low per-mile freight rates, the stimulus of highly flexible wage scales incident to the nonunion labor policies then prevailing in those areas resulted in a rapid growth of southern tonnage. At times, also, large-scale suspension of mining in the organized fields of the North threw business to the South. Until 1923 the growth of the southern fields was relative, but northern shippers continued to increase or at least to hold their total annual tonnage. After 1923 an actual displacement of tonnage occurred, caused primarily by widening differentials in wage rates, and during the remainder of the 1920's, as

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[4]F. G. Tryon, "The Effect of Competitive Conditions on Labor Relations in Coal Mining," *The Annals of the American Academy of Political and Social Science*, Vol. CXI (1924), p. 87.

the South increased its tonnage, that of the North sharply declined, not only relatively but absolutely.

Table 17 shows the proportion of the national bituminous output produced from 1920 to 1938 in each of the four important northern and the four southern States mentioned. It may be noted that the northern States dropped from 59 percent of the Nation's tonnage in 1920 to 41 percent in 1927 and the southern fields advanced from 26 to 45 percent. In other words, nonunion States with no fixed standards of wages and working conditions absorbed more and more of the business. The low point for the northern area was reached in 1927, when a prolonged strike occurred. Between 1927 and 1929 the previous trend was reversed; in the latter year the four northern States produced 46 percent of the total output and the four southern States produced 41 percent. These percentages have remained relatively constant through 1938.

Table 17.- PERCENTAGE OF TOTAL BITUMINOUS-COAL PRODUCTION PRODUCED IN THE IMPORTANT NORTHERN AND SOUTHERN STATES, 1920-37[a]

Year	Northern					Southern				
	Total	Illinois	Indiana	Pennsylvania	Ohio	Total	Kentucky	Tennessee	Virginia	West Virginia
1920	58.8	15.6	5.1	30.0	8.1	25.5	6.3	1.2	2.0	16.0
1921	57.2	16.7	4.9	27.9	7.7	28.0	7.6	1.1	1.8	17.5
1922	51.6	13.9	4.5	26.8	6.4	32.7	10.0	1.1	2.5	19.1
1923	56.3	14.1	4.6	30.4	7.2	30.2	7.9	1.1	2.1	19.1
1924	51.9	14.1	4.5	27.0	6.3	33.5	9.3	1.0	2.2	21.0
1925	48.7	12.9	4.1	26.3	5.4	37.6	10.6	1.0	2.5	23.5
1926	47.7	12.1	4.0	26.7	4.9	39.5	11.0	1.0	2.5	25.0
1927	41.2	9.0	3.5	25.7	3.0	45.0	13.4	1.1	2.5	28.0
1928	43.8	11.2	3.3	26.2	3.1	42.4	12.4	1.1	2.4	26.5
1929	46.0	11.4	3.4	26.8	4.4	40.6	11.3	1.0	2.4	25.9
1930	46.5	11.5	3.6	26.6	4.8	40.4	11.0	1.1	2.3	26.0
1931	46.2	11.6	3.7	25.6	5.3	40.8	10.5	1.2	2.5	26.6
1932	43.7	10.8	4.3	24.1	4.5	42.7	11.4	1.2	2.5	27.6
1933	45.0	11.2	4.1	23.8	5.9	42.7	10.8	1.1	2.5	28.3
1934	46.4	11.5	4.1	25.0	5.8	41.8	10.7	1.2	2.6	27.3
1935	46.4	12.0	4.2	24.5	5.7	41.3	11.0	1.1	2.6	26.6
1936	46.2	11.6	4.1	25.0	5.5	41.5	10.8	1.2	2.6	26.9
1937[b]	45.9	11.6	3.9	24.9	5.5	41.6	10.6	1.2	3.1	26.7

[a] Computed from data in *Mineral Resources of the United States* (U. S. Dept. Int., Geological Survey, 1920-23; U. S. Dept. Com., Bur. Mines, 1924-31); *Statistical Appendix to Minerals Yearbook* (U. S. Dept. Int., Bur. Mines, 1932-33 to 1935); *Minerals Yearbook, 1937* (U. S. Dept. Int., Bur. Mines, 1937), pp. 787-867; and *Bituminous Coal Tables, 1936-1937* (U. S. Dept. Int., Nat. Bituminous Coal Com., 1938).

[b] Estimated.

The data presently available do not show how much the shift in relative percentage from North to South may have contributed to an increase in the national average of output per man-day. Average seam thickness in Pennsylvania in 1920 was 62 inches; in West Virginia, 64 inches; and in Virginia, 62 inches. Average seam thickness in Ohio was 62 inches, and in the adjoining southern area of eastern Kentucky it was 52 inches. On the score of the most important single physical factor in productivity, therefore, the shift conferred little advantage. A greater advantage probably resulted from the factor of age of mines. In 1926, for example, approximately 90 percent of the output of eastern Kentucky came from mines opened after 1910. In contrast, only about 50 percent of the coal mined in Ohio during the same year came from mines operated since 1910, and about 15 percent came from mines opened before 1900. Obviously the operator of a new mine can employ modern principles of mine lay-out and modern technology so as to realize significant advantages in labor requirements. Certain limited areas of the northern districts had the additional resource handicap of an advanced state of depletion in particular seams. Such districts as Clearfield, Pennsylvania; Hocking Valley, Ohio; and Georges Creek, Maryland, had little thick coal left.

Whatever the causes, it is a fact that man-day output in Ohio and Pennsylvania increased at a slower pace than it did in the newer fields to the south. In Ohio output per man-day was actually about 1.5 percent less in 1930 than in 1920, whereas in eastern Kentucky man-day output in the same period increased about 23 percent. Pennsylvania showed an increase of 22 percent between 1920 and 1930; West Virginia 27 percent. These figures suggest that shift of tonnage from north to south has been one factor in increasing the national man-day output, but it is probably a minor one.

It will be noted that the comparisons just made apply exclusively to Appalachian areas; they do not apply to Illinois and Indiana. Development of a large stripping industry and the widespread use of deep-mine mechanical loading in the late twenties resulted in substantial increases in output per man-day in the Illinois-Indiana area. In spite of this, Illinois and Indiana lost tonnage heavily during the period of the twenties. In 1890 about 17 percent of the national production came from these two States; in 1914 and in 1920

the percentages were 18 and 21, respectively. Compared with this, only 13 percent of the Nation's output came from Illinois and Indiana in the strike year 1927. Since then the area has advanced to slightly over 16 percent of the total output of the country, about the same position that it held prior to 1900.

There can be no doubt that the handicap under which the Illinois-Indiana area operated during the twenties was largely incident to adverse wage differentials and unsettled labor conditions. It is equally obvious that the gain in relative position after 1927 was due in large measure to exceptionally favorable costs realized in strip mines and in highly mechanized deep mines which were producing progressively larger percentages of the total tonnage from the area.

Shifts of tonnage have not been confined to major areas; notable shifts have occurred within States. For example, almost 20 percent of Illinois output 40 years ago came from the thin-vein longwall district[5] in the northern part of the State close to the Chicago market. This district has declined as thicker veins in southern areas have been developed. The accompanying tabulation shows the percentage of Illinois deep-mine output that came from longwall mines between 1900 and 1936:[6]

Year	Percent	Year	Percent	Year	Percent
1900	18.4	1923	2.8	1930	0.7
1909	12.1	1924	2.6	1931	0.8
1912	9.2	1925	1.9	1932	1.1
1915	6.9	1926	1.6	1933	1.6
1918	5.0	1927	1.2	1934	2.2
1920	4.3	1928	0.8	1935	1.5
1921	2.9	1929	1.1	1936	1.4
1922	2.7				

In contrast to 18.4 percent of the tonnage produced in these mines in 1900, the percentage since 1925 has been less than 2.5. All these longwall mines were working thin seams less than 4 feet in thickness; tonnage per miner was correspondingly

[5]The more common method of mining in America is the room-and-pillar system in which pillars of coal are left to support the roof. In longwall mining the only pillars left are so-called shaft pillars and sometimes pillars along the mainline haulageways.

[6]Computed from data in annual *Coal Report of Illinois* for the years 1900-36 (Illinois Dept. Mines and Minerals).

low and the piece rate agreed upon to compensate for the difficult conditions was correspondingly high. The greater output per man that could be realized in the thick seams in the southern part of the State was, of course, the chief reason for the shift of Illinois tonnage from the north to the south. Although longwall methods were suitable to the veins in which they were operated, the resource handicap of the thin seams could not be overcome. The shift of tonnage from thinner to thicker seams in Illinois occurred between the years 1900 and 1918; as a factor contributing to increased labor output, it of course applies only to that period.

Data have not been compiled from which it would be possible to measure the extent to which shifts of tonnage from older to newer mining areas have increased labor output, but it appears that the over-all influence of these shifts has on the whole been favorable. It is not believed, however, that the joint influence of more favorable resource conditions and concentration of production in more efficient mines over the period covered by this review has increased average man-day output as much as have technical and managerial improvements.

Changes in Composition of the Working Force

It is probable that the long-time trend of output per man has also been influenced slightly by changes in the composition of the working force. While historical statistics of the age composition of coal miners are meager, the working force in the past 20 years has contained a larger proportion of adult men than at the time of the 1880 census. In that year 5 percent of the employees above ground and $6\frac{1}{2}$ percent of the underground force were boys under 16 years of age. As early as the 1889 census fewer boys were reported as being attached to the industry - $3\frac{1}{2}$ percent on the surface and 3 percent underground. By 1902 the proportion of boys under 16 had declined to 2 percent for both surface and underground employees, and 7 years later (in the 1909 census) less than 1 percent were reported in this age group.[7]

[7] In the anthracite industry the employment of boys was a much greater problem. In the 1880 census 43 percent of the surface workers and 9 percent of the underground workers were reported as boys (age not given). They were engaged mainly in the breakers as slate pickers. By 1909 the number of boys under 16 had declined to about 7 percent of the outside force and less than 0.05 percent of the underground force, and by 1919 boys had practically disappeared as surface workers.

The introduction of labor legislation, compulsory education, and the gradual advance in living standards have combined to reduce greatly, and in most States virtually to eliminate, the employment of boys underground; this has, in a minor way, contributed to the indicated gain in productivity.

In the meantime, technology itself was doubtless affecting the character of the working force underground. The period from 1890 to 1936 was one of continuous and rapid change in mining methods. The technical developments are outlined in some detail in chapter II. Although data are lacking from which to measure quantitatively their effect on the amount and kind of labor employed in mining, it is obvious that such important technical changes could not occur without having an effect on the composition of the working force of mines that became mechanized.

Coal-mining literature has not dealt with occupational phases of mechanization to the extent that it has with the machinery phase, but a few comparisons of the basic occupations will indicate the nature of the change that occurred. Probably the most striking contrast is the one between the amount of labor involved in undercutting coal with a pick and the operation of a modern cutting machine. Likewise, transition from man to animal and then to machine power in haulage is almost equally significant in its effect not only on the amount but on the type of human labor required. The available data in reference to mechanical loading since 1923 make it possible to measure the effect on unit labor requirements of this most recent item in mine mechanization somewhat more closely than earlier technical advances can be measured. Even here, however, the measurements recorded have to do with the amount rather than the kind of labor employed.

For knowledge of effects of mechanization on the character of the working force, reliance must be placed largely on personal observations, but it is obvious that the type as well as the amount of labor required to produce a given output differs in highly mechanized mines and in mines in which many of the processes continue to be performed by hand. Changes in the character of the working force are especially pronounced in the case of a basic change like the substitution of mechanical loading for hand loading; the use of a highly developed machine such as the mobile loader obviously intensifies the

change. An employee may have all the qualities required to do the heavy work involved in shoveling coal and yet not be able to adapt himself to the machine operations incident to mobile loading.

In considering such adaptations, two important facts must be recognized. In the first place, development of highly mechanized operations in the bituminous industry is not a unique occurrence; the problem of adaptation is one with which modern industry is constantly confronted. In the second place, the activities of so-called hand-loading miners are by no means confined to shoveling coal into mine cars. Hand loaders must have skill in laying tracks in the rooms, in setting timbers, in watching roof, and in drilling and blasting. Machine operation involves a higher specialization of tasks than hand loading and necessitates an ability on the part of miners to operate the machine and to adjust themselves to its speed. It has not been possible to make detailed studies concerning the extent to which miners have been able to do this. Testimony of both operators and miners on the subject varies considerably, but the point is usually emphasized that coal mining has traditionally required a high level of intelligence with alertness and adaptability to new conditions.

One operator in whose mines mechanical loading now approaches 100 percent has observed that high-school graduates have shown an inclination to enter his mines - something that rarely happened in the past. Other operators who have carried mechanization a long way have expressed the view that nearly all able-bodied miners under 50 years of age readily adapt themselves to the requirements of machine operation. However, all competent observers admit that there are some miners who cannot make the shift from old to new processes, and the alternative to throwing such employees out of work is to provide work that does not require the learning of new skills. Although the exact nature and extent of changes in the working force as the result of mechanization cannot be precisely measured, it seems probable that over the period of almost half a century covered by this analysis of long-time trends they have had a tendency to increase labor output.[8]

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[8] See F. G. Tryon and Others, *Technology and the Mineral Industries* (WPA National Research Project in cooperation with U. S. Dept. Int., Bur. Mines, Report No. E-1, Apr. 1937), p. 20.

SOURCE AND CHARACTER OF DATA

Since 1890 every operator of a bituminous-coal mine producing over 1,000 tons per year has been asked to report once a year to the U. S. Bureau of Mines (before 1925 to the U. S. Geological Survey) certain simple facts about his business. These include (1) the number of tons produced; (2) the average number of men employed; (3) the number of days the mine operated; and (4) since 1903, the number of hours in the established working day. Similar data were reported in the census year 1880.

Building upon the fact that the typical coal mine works with a customary crew of men and adjusts itself to the fluctuation of demand by intermittent operation, the early statisticians computed the number of man-days worked at the mine by multiplying its reported average number of men employed by its reported days of operation. The result, divided into the number of tons produced, yielded output per man per day. Averages for States and regions were carefully weighted by the number employed. This system of measurement, refined and interpreted by later workers, provides the chief reservoir of information on the productivity of labor in coal mining and is the one drawn upon in the present study.

Few other industries offer the economist so large a store of material for inductive studies of the relations of technology and employment. The record covers not only the machines installed and the output per worker, but permits analysis of the interactions of technical change with interfield competition, wage rates, labor relations, costs, and plant capacity. The fluctuations in these items may be traced from year to year through cycles of prosperity and depression. Quantitative measures of the resource factors which control productivity are more complete than for any other of the extractive industries. The record covers all establishments of commercial size, that is, mines producing over 1,000 tons annually, and it is reasonably comparable from mine to mine and from year to year over a period of almost half a century.

On the other hand, the very comprehensiveness of such a record is necessarily purchased at the cost of precision in observation. The system of statistical reporting has been based upon voluntary cooperation, for the collecting agencies

had no power to compel the submission of reports. It had to be adapted to the limitations of producers' records and simple enough to be applicable to thousands of reporting units. In 1936 the mines of commercial size numbered 6,875, of which 4,218 produced less than 10,000 tons a year. A production of 10,000 tons represents an annual turn-over of perhaps $20,000. Hence, a great number of the reports represent small-scale business.

The results, therefore, are statistical aggregates, or averages, and not engineering observations. They are in no sense a substitute for the time studies of the production engineer or for detailed cost-accounting analysis. They do show trends and broad relationships in a way that studies based on isolated cases, no matter how accurately reported, cannot approach.

Subject to these limitations, the long-time trends of labor productivity in coal mining are clearly revealed:

(1) In the half-century covered by the record, output per man per day has increased twofold to threefold.

(2) The increase has been gradual. It is the result of a continuing process of technical evolution rather than of sudden revolutionary change. Aside from short-time irregularities, to which reference will later be made, the upward course of the output per man-day, when shown on a ratio scale, follows a straight line from 1880 to 1932. (See figure 1.)

(3) The chief cause of the short-time irregularities in daily output is found, upon analysis, to be changes in the length of the working day. Most important of these is the universal adoption in 1933 of the 8-hour (and later 7-hour) day under the bituminous-coal code of NRA.

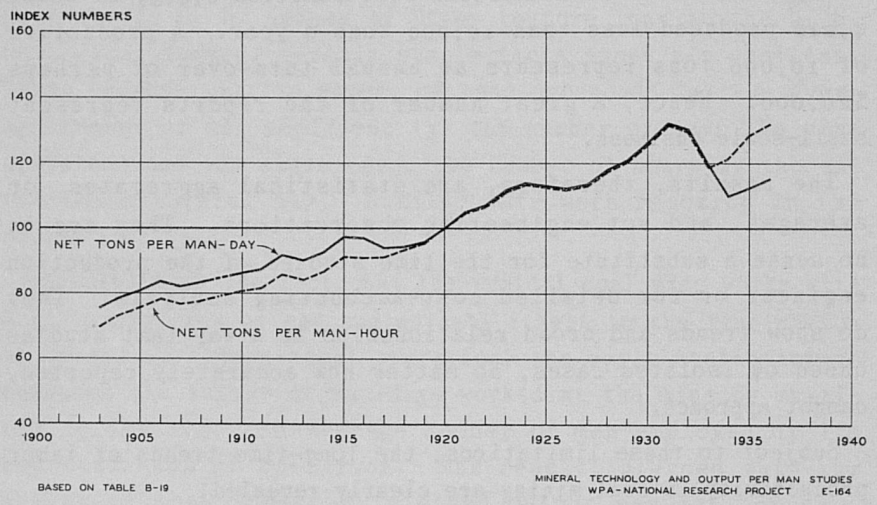
A clearer picture is given by the record of output per man-hour. This can be calculated beginning with 1903.[9] Figure 38 shows the trend of output per worker since that year, reckoned both per day and per hour. Reduced to the hourly basis the trend approaches still closer to a straight line.

Even on the hourly basis, however, the line of productivity shows certain irregularities that suggest the existence of

[9]Prior to 1903 systematic records of the length of the working shift at each mine are lacking.

Figure 88.- INDEXES OF OUTPUT PER MAN-DAY AND PER MAN-HOUR IN THE BITUMINOUS-COAL INDUSTRY, 1908-86

(1920=100)



BASED ON TABLE B-19

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statistical refraction in the underlying data. Most of the causes of distortion have been pointed out in earlier reports of the Bureau of Mines and the U. S. Geological Survey. To show their bearing upon the subject of this study it will be in order to describe briefly the factors involved in the computation of output per worker and the errors of observation to which, at times, they become subject.

We will consider the items of (1) tonnage produced, (2) average men employed, (3) share-the-work agreements, (4) days operated, (5) man-days (the product of men employed times days), and (6) hours per day and total man-hours.

Tonnage Produced

The volume of the product in coal mining is readily ascertainable. It is all reducible to the standard net ton of 2,000 pounds. Ninety percent of the output is shipped to market in railroad cars or river barges, and the number of tons reported as shipped by the mine operator may be checked against the number reported as loaded by the originating carrier. An additional 6 percent consists of colliery fuel, coal made into beehive coke, local sales, or truck shipments from mines with rail or river connections, the measurement of which offers

no serious difficulty. The remaining 4 percent, derived from "truck" or "wagon mines", is harder to ascertain, and, since 1923, no attempt has been made to canvass mines producing less than 1,000 tons per year.[10] The total output of the mines producing over the minimum limit and included in the statistical record may be accepted as reaching a high standard of accuracy.

Number of Men Employed

The second element in measuring the output per worker is the average number of men employed. This presents greater difficulties.

Until recently the questionnaires used contained no instructions as to how the average was to be determined, the method being left to the judgment of the reporting producer. The methods used have varied.

The Bureau of Mines, however, in making a careful study of the returns over a period of years, found that the average had been most frequently derived by adding together the number of names on the pay roll in each of the 2-week periods during which the men worked and dividing the sum by the number of active pay-roll periods.[11] This process gives the normal working force when the mine is operating, excluding periods

[10] Based on *Minerals Yearbook, 1938* (U. S. Dept. Int., Bur. Mines, 1938), p. 694.

[11] It is particularly important that this method be followed in certain districts where the demand is highly seasonal and where the number of men on the rolls declines sharply in summer and increases in winter. Critical review of the data indicates that in such districts operators have generally allowed for these seasonal fluctuations and reported a figure representative of the mean for the year. This is shown by the following comparison of the numbers reported in 1933 and 1934, when the annual average only was called for, with the computed monthly average in 1935 when data for each month was called for. It is clear that the averages reported in 1933 and 1934 are comparable with the mean of 1935 rather than with the maximum, as reported in the month of peak employment.

State	Years when annual average only was reported		1935 when monthly pay rolls were reported	
	1933	1934	Monthly mean	Maximum month
Arkansas	3,671	3,415	3,705	4,053 (Oct.)
Colorado	7,908	8,094	8,127	9,578 (Dec.)
Kansas	3,809	3,744	3,850	4,191 (Nov.)
Michigan	1,186	1,556	1,451	1,648 (Dec.)
Montana	1,324	1,571	1,551	1,850 (Nov.)
Utah	2,906	2,807	2,730	3,589 (Dec.)
Wyoming	3,753	3,760	3,987	4,441 (Dec.)

(Data for the first two columns are from annual reports of the Bureau of Mines; data for the last two are from F. G. Tryon and Others, *Employment and Related Statistics of Mines and Quarries, 1935*, Part I, "Bituminous Coal" (WPA National Research Project in cooperation with U. S. Dept. Int., Bur. Mines and U. S. Dept. Com., Bur. Census, Report No. E-4, July 1937), p. 11. Periods of shut-down are excluded from the third column.

of shut-down when only maintenance men are employed. It is slightly in excess of the number actually working, because of the inclusion of absentees and because of labor turn-over.[12]

Many operators, however, did not take the trouble to average their pay-roll periods but reported instead the number of men employed in a "typical" period. When this occurs there is a strong tendency to report the most recent pay-roll period at the time the return is made, usually in January of the following year.[13] If the recent pay roll approximates the average for the year preceding, this method yields a fair picture of the normal working force of the mine. When a coal mine uses its whole crew as long as it has orders for coal and then shuts down completely except for a few maintenance men, the typical pay-roll period and the average pay-roll period will be substantially the same. In ordinary years, therefore, when employment is neither increasing nor decreasing, no great error is involved. The chance of error is least in averaging a group of mines; it increases when one mine only is considered because of the special conditions that may always affect individual experience.[14]

In a year of sharp changes in demand and employment, however, the practice of reporting typical pay rolls would tend to introduce an element of bias into the employment record. During a prolonged period of depression the operator tends to reduce his working force. He may adjust to the decline of demand by eliminating needless jobs, by shutting down high-cost portions of the mine, or by ceasing to hire new

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[12]The inflation due to labor turn-over can hardly be great since it is confined to the turn-over occurring within a pay-roll period. Studies by Delos Walker for the U. S. Coal Commission indicate that the turn-over in bituminous-coal mines is much the same as in manufacturing industry, averaging 100 percent per year in 1921. At this rate, the turn-over in a 2-week pay period would be 5 percent. Assuming that the average man quits at the midpoint of the pay period, the actual inflation would therefore be 2½ percent. (For data see *Report of the United States Coal Commission* [1925], pt. III, p. 1263.)

The effects of absenteeism are discussed in the section dealing with time worked.

[13]In a study of 129 shipping mines reporting to the Illinois Department of Mines and Minerals in 1929 such a tendency was obvious. The department sent out its 1929 questionnaire between Christmas and the first of the year and, as would be expected, reports were actually made out some time in January 1930. It was found that there was a definite tendency to report the number of men at work during a period in January 1930. Admittedly, this is a small sample of mines on which to base conclusions as to bias in reporting on a large scale; however, the U. S. Bureau of Mines frequently sent out its questionnaire around the first of the year and found it to be true that returns to the State Department of Mines and Minerals were usually the same as those made to the Bureau. (From an unpublished manuscript by J. E. Ely, Labor Productivity in Illinois Coal Mining, prepared for National Research Project, "Mineral Technology and Output Per Man Studies.")

[14]Tests applied to census of mines and quarries data for Indiana mines in 1929 showed that 60 percent of the tonnage in the State came from mines in which there was a variation of 10 percent or more in employment between the maximum and minimum months. (See appendix A for a detailed discussion of these data.)

men as others leave. Under these conditions the number of men employed in the pay-roll period at the end of the year would be smaller than the average for the year as a whole. With the recorded number of men lower than the average for the year, the recorded labor output would be higher than the actual labor output. This happened extensively during the early years of the great depression, and it is probably the chief cause of an apparent sudden rise in the output per man for 1930, 1931, and 1932, all years of sharply contracting pay rolls.

Conversely, when employment is increasing sharply, the practice of reporting a recent typical pay roll would overstate the average number employed and understate the output per worker. This condition prevailed during the recovery years after 1932. Its effects were intensified by the shortening of the working week under the NRA code to 40 hours in 1933 and to 35 hours in 1934. This reduction in working time, coming on the heels of the revival in demand, operated to increase the numbers on the pay rolls. Under these conditions the employer making out his annual return and setting down, under the query on average number of men employed, the number on his latest pay roll would overshoot the mark. Such errors of overstatement in the numbers employed are among the chief causes for the apparent decrease in the output per worker for 1933 and 1934, which appears in figure 38 even when the ratio is calculated on an hourly basis.

It is clear that the chance of bias from this cause is greatest during periods of depression and recovery. To guard against it, arrangements were made in 1935 and 1936 to ascertain the number of men on the pay rolls at the fifteenth of each month, from which the average for each mine was then computed directly by the Bureau of Mines. Beginning with 1935, therefore, the chance of error from this particular cause was eliminated, and the returns for that year reached higher standards of accuracy than were previously attained.[15]

[15] The additional details secured by the Bureau of Mines at the 1935 canvass were made possible by the cooperation of the Works Progress Administration. The results are published in the monograph, Tryon and Others, *Employment and Related Statistics of Mines and Quarries, 1935*, Part I, "Bituminous Coal." It should be noted that, in computing the average number employed, pay periods in which the mine was inactive and maintenance men only were employed were excluded from the computation, the object being to ascertain the numbers employed when the mines were in operation. The element of intermittent employment so characteristic of coal mining was taken care of by a supplementary inquiry recording the number of days worked by the mine.

Share-the-Work Agreements

The depression has raised another special problem in recording employment by the practice of dividing the available work among two or more groups of men who labor on alternate days. Such arrangements for staggering or alternating work are not to be confused with the practice of operating both a day and a night shift but relate rather to division of the available jobs between two groups of men on the same shift, usually the day shift.

The practice first attracted attention in Illinois, where, as early as 1932, in an effort to take care of men displaced through mechanization, the wage agreement with the United Mine Workers provided that:

> In any mechanized mine where men belonging to the local affected have been thrown out of work due to such mechanization, the men so affected shall be entitled to share the work equally up to the point where the further sharing of work would impair the efficiency of operation or the quality of the product.

The provision cited appears to be mandatory. Another clause of the Illinois agreement is permissive. It provides that men on the rolls of mines in a given locality may at their option share work with employees of other mines thrown idle.

Adoption of a share-the-work agreement in a mine creates the possibility that either of two sets of employment figures might be returned: (1) the figure which the operator has been accustomed to report, namely the total number on the pay roll, or (2) the actual number of men working. Obviously, the number working is the only valid figure to use in computing labor productivity. In Illinois the Department of Mines and Minerals promptly recognized the difficulty and beginning with 1932 asked the owners of mines affected by such agreements to report both the number of men on the pay roll and the number of men working. In 1934, for example, it was found that 35 mines in Illinois were operating under such agreements. The total number of men on the pay rolls of these mines was reported as 14,139 and the average number working as 11,240, the difference between the two amounting to 2,899. A sufficient number of the operators of these mines reported the higher figure to introduce a definite bias into the Bureau of Mines record

of output per man for Illinois. Fortunately the State figures permit correction of this bias in the "mechanized" mines of the State, at least as far back as 1932. Beginning with 1935 the Federal Bureau made arrangements to ascertain the actual number of men working. The bias is therefore eliminated as far as the mechanized mines are concerned. How far it continues to affect the hand-loading mines of the State through the operation of permissive work-sharing has not been determined.

Similar agreements to share the work at mechanized mines were made in Indiana, though on a much smaller scale. These were adequately treated in the statistics for 1935-36 by the collection of special data covering both numbers working and numbers on the roll. No basis for correcting errors arising from this practice prior to 1935 is available.

Outside of Illinois and Indiana the number of staggered-work agreements appears to be small, at least during the period covered by this study. The practice is authorized by the wage contracts for Iowa and Washington, but the authors have found no instances of definite agreements for dividing the work in either State which affected the years 1935-36.[16] No systematic search has been made for purely local agreements which may not be covered by the district contracts, although it is reported by officials of the United Mine Workers of America that there are some agreements of this type.

There remains the further possibility that work was divided among the men during the depression years without formal agreement of any kind. Such arrangements have undoubtedly existed, particularly when a company sought to provide some employment for all the men living in the houses of its camp. If the company continues to report total names on the pay roll, the computed man-days would be inflated and the average output per man correspondingly depressed. Specific data on this point are lacking. Inquiries made thus far suggest that the employer has commonly stated the number working rather than the total on the rolls, and that outside of Illinois and

[16] Various district wage contracts during this period provided that preference might be given to men at idle mines in the filling of vacancies at active mines (U. M. W. of A. District No. 6, Ohio, Oct. 1, 1935, to Apr. 1, 1937, Section 44; U. M. W. of A. District No. 62, Northern Panhandle of West Virginia, Apr. 1, 1934, to Mar. 31, 1935). Various agreements likewise provided that daymen on idle days should have an equal division of the available work which they usually perform when the mine hoists. Such provisions, however, do not involve a problem of double counting between two crews of men who work on alternate schedules.

Indiana the factor of divided working time has had no great effect upon the output per worker. Where the operator reports actual man-days or man-hours, for example, the chance of error from divided working time disappears. Where the error persists, it has generally been overshadowed by other factors working in the opposite direction. It remains, however, one of the undeniable hazards in measuring employment under the conditions of the depression.

The subject deserves further study, partly because there is reason to believe that staggered employment may increase. It is associated, for example, with the practice of employing a swing shift in order to permit operating 6 days a week rather than being restricted to the 5-day week written into the present wage agreements.

Time Worked

In the American coal industry few mines keep an accurate record of the time worked by the men. The time of employees paid by the day can usually be ascertained from the pay rolls, but for the tonnage or piece workers, who constitute on the average about 60 percent of the working crew, no record of the time spent is ordinarily kept.

An approximate answer to the question of time worked is given by the record of tipple time. Ordinarily, "the tipple runs when the mine runs." Hence, in the effort to record working time, the U. S. Geological Survey and U. S. Bureau of Mines phrased their inquiry:

> Total number of full days mine (tipple) was in operation during the year. Parts of days should be reduced to equivalent in full days.

The figure reported by the operator, in answer to this question was then multiplied by the average number of men employed to ascertain the total number of man-days worked at the mine.

The result tends to understate somewhat the time of surface employees engaged in the shops or power plant, or in operating the hoist, fans, and pumps, since they work on days when the mines are idle. On the other hand, it tends to overstate the time of the tonnage workers by the amount of absenteeism.[17]

[17] At any one time some of the men on the rolls will be absent because of illness or other factors. The percentage of absenteeism among the tonnage men was found by studies of H. B. Drury for the U. S. Coal Commission to average 10 percent. *Report of the United States Coal Commission* (1925), pt. III, p. 1128.

Generally, however, the tipple time gives a reasonably consistent measure of the average time worked by the crew in those districts following the standard custom of operating mine and tipple on the same schedule.

A bias arose, however, in certain districts where the custom developed locally of sending men underground to do preparatory work and even to load coal on days when the tipple was not in operation. In Utah and in Routt County, Colorado, this practice had a serious distorting effect upon the calculated output per man. To obviate this the operator was requested, beginning in 1932, to report mine time separately from tipple time. The mine time was then multiplied by the number of men inside to obtain man-days worked below ground; the tipple time was multiplied by the number of men outside to obtain man-days above ground.[18] This permitted correction of the bias in the districts in question, though the record after 1932 is not strictly comparable with that before.[19] The influence of this change in method is noted in the following chapters wherever it has a significant effect upon the area under discussion. For the United States as a whole the effect is obviously too small to impair the comparability of the record.

A wholly different type of bias in the record of working time arose during the period of car shortage in 1920 and the years immediately following. Increase of traffic and the disturbed conditions of the war had brought on a congestion of railway transport, and from 1917 to mid-1923, whenever the demand was active, the typical mine found that its ability to market coal was limited by the supply of railroad cars. The cars available were allocated among the mines on the line on the basis of ratings determined by the originating railroad. The standard system of rating which ultimately developed (known as CS-31) was based upon the mine's daily capacity. The rating was determined by dividing the tons shipped by the number of tipple

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[18]The method still fails to allow for the fact that certain classes of outside men working in the shops and power plant, or operating fans and hoists, work more days than the tipple. Inability to make accurate allowance for the time worked by these men results in understatement of the number of man-days of surface labor.

[19]The use of tipple days as a measure of average working time has also at times given unduly high ratios of output per man in strip mining. As is developed at greater length in chapter IV, the men who operate the stripping shovel may work more days than either the tipple employees or those loading coal in the pit, with the result that man-days computed from tipple time only are too low and output per man-day too high. Adequate correction for this bias was not possible until 1935, when data simultaneously collected on dollar wages paid, studied in connection with the prevailing wage rates, furnished a check on the computed number of man-days of labor.

hours and multiplying the quotient by the number of hours in the recognized working day. The lower the number of tipple hours, therefore, the higher became the rating. As a result the producer had a strong incentive to arrange his operations so as to reduce his tipple time, or even to understate it, thereby inflating hourly capacity and daily rating. It is believed that some of these understatements of tipple time were carried over into the annual reports made by operators to the U. S. Geological Survey. The effects upon the annual record of working time are first apparent in 1920, and from that year through 1924 the "car shortage" bias operated to overstate slightly the average output per man.[20] The effect was greatest in the newly opened fields of West Virginia and eastern Kentucky where the congestion of railway traffic was most acute. Despite the element of inflation there is no doubt that throughout this period the actual man-day output continued to increase.

Number of Man-days

Prior to 1932 the number of man-days was calculated for each mine by multiplying the average number of men employed by the total days of tipple (or mine) operation. The product is obviously no better than the two factors from which it is derived, and the defects in either automatically carry over into the result.

Beginning in 1932, in an effort to improve the accuracy of these data, the Bureau of Mines asked all operators who

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[20]The record indicates a lag in time between the advent of the car shortage and its effects upon the annual record of time worked. Car shortage first appeared in late 1916, and mine ratings early became a subject of controversy. However, the method of rating mines on the basis of production per tipple hour was not formally adopted as the national standard until September 12, 1918. From the armistice to September 1919 car supply was plentiful, and from November 1 to December 12, 1919 most of the mines were idle on account of a strike. Throughout 1920, however, car shortage was the factor limiting production in virtually all districts (except for brief periods of the so-called "daymen's strikes") and mine ratings were the subject of much attention, and the indications of an effect upon the reported annual working time are clear. The great suspension of 1922 and the railroad shopmen's strike brought another acute car shortage at all mines remaining in operation; this continued into the early part of 1923. In March 1923, CS-31 (which had been revised in December 1919) was revoked and new mine-rating rules were issued by the individual carriers. Existing ratings were reviewed and in many cases sharply reduced. Shortly thereafter the congestion of traffic cleared up and throughout 1924 there was a car surplus, but remembering past shortages and anticipating possible future restrictions, operators were still keenly interested in their ratings. In the judgment of the authors the effects upon recorded working time continued to have some influence upon the annual reports for 1924. By 1925, however, all concerned had come to realize that car shortages were over. The railroad rating had become a routine record, seldom consulted and devoid of immediate interest, and the effects of this particular bias upon time worked and therefore upon output per man had disappeared.

kept actual records of either man-days or man-hours to use them in rendering the annual reports.[21] Wherever such actual man-days have been available the Bureau has used them in place of the former calculated man-days.

Only a small proportion of the operators - chiefly large companies - have thus far been able to supply such data based upon actual records. The number is increasing, however, and fortunately for the purpose of this study, it includes a great many of the mines that have installed loading machinery. In 1936 approximately 35 percent of the total number of man-days worked in the industry as a whole consisted of reports based upon systematic records, the remaining 65 percent being computed as before.

In some instances the change from computed to actual man-days has obviously affected the historical comparability of the series. In general, the recorded numbers of man-days tend to run somewhat higher than the old calculated numbers, thus serving to lower output per man. At individual mines the change may have a material effect. Nationally the effect is probably small.

Hours per Day and Total Man-hours

As already pointed out, in order to follow the course of output per worker it is necessary to allow for changes in the length of the work shift. This is done by converting man-days into man-hours by multiplying the former by the number of hours in the working day. Any defects in the determination of man-days, therefore, carry over into the record of man-hours. In addition, the operation introduces a further possibility of error through difficulties in determining the number of hours actually worked by the miner.

The published statistics of the Bureau of Mines cover the length of the established working day and are given in table B-1. Each mine reports its standard day, whether 10, 9, 8, or 7 hours. The average for all mines, weighted by the number of men employed, stood at 8.7 hours in 1903, the year of earliest record, and at 8.6 hours in 1916. It declined to 8.3 in 1917 and to 8.1 in 1918 as the 8-hour standard spread

[21] Most of the returns received in response to this request have been in terms of man-days rather than man-hours.

to West Virginia and Kentucky in the tightening of the labor market and the growth of collective bargaining which accompanied the war. This change in working hours is reflected in a downward dip of the curve of output per man-day in figure 38. Calculated per man-hour, the curve of labor output shows no break at this point.

It is clear, however, that the official statistics do not reveal the full extent of the changes that have occurred at times in hours actually worked. The established working day does not of itself measure the length of time spent at work.

Men may leave before the mine as a whole stops work. Time workers may lose fractional days through illness or accident. In particular, the tonnage men or piece workers who constitute 50 to 70 percent of the working force in a hand-loading mine may quit work early, for the custom of the industry allows them that freedom. It has never been customary for these men to punch time clocks, and generally no record is kept of the hours they spend in the mine.[22] Sometimes a man leaves because he has finished his allotted work for the day, sometimes because he feels ill or has other interests to attend to, or sometimes because he has earned enough for 1 day. In prosperous times, therefore, the normal working day may overstate slightly the actual number of hours worked.

On the other hand, the decline in labor standards during the early years of the great depression, from 1930 to 1932, led to practices of working longer than the normal operating day. The published statistics make no allowance for overtime. Some mines follow the clean-up system by which the miners are expected each day to load out all coal shot down and the daymen are expected to bring it to the surface. During the depression overtime was not always paid for, and it became more common. Running time was poor and wages extremely low. Miners were anxious to piece out their meager earnings by working longer hours. Individual men stayed on after the mine as a whole stopped loading, or entered the mine on days when the tipple

[22] This conclusion is confirmed by the response of producers to the request that actual man-days or man-hours be reported wherever a record was kept, which has been carried in the annual questionnaire since 1932. Most of the producers indicating that a record is kept have reported in terms of man-days rather than man-hours. This is because it is much easier to record a man's presence in the mine during the day than to record the hours at which he entered and left. Whereas the proportion of total man-days based upon actual records was 35 percent in 1936, the corresponding proportion for total man-hours was much less. Conversion of reported man-days into calculated man-hours necessarily involves the uncertainties of the actual number of hours worked by tonnage men above referred to. Operators reporting actual man-hours usually also report actual man-days.

was idle to prepare their rooms and load an extra car or two of coal. None of these practices is reflected in the official statistics. The nominal working day - doubtless reported in good faith - increased but little during this period, the average standing at 8.09 hours in 1930, 8.08 in 1931, and 8.10 in 1932. Were time-clock records available, these hours would doubtless be increased, especially in the South. The bias in this instance tends to understate slightly the number of man-hours between 1930 and 1932; conversely, the tendency is to overstate output per worker.

Upon adoption of the NRA code working hours were everywhere fixed by agreement and, with the approval of both employers and the men, were vigorously enforced. The changes in practice help to explain the apparent differences in hourly output before and after the code, which at first sight seem to be greater than a reduction from 8.10 to 7.02 hours alone would justify (see table B-1). The 8-hour day became effective at all mines on October 2, 1933, and the 7-hour day at all but a few small local mines on April 1, 1934.

As in the case of man-days, the mechanized mines have been among the first to develop actual records. On the whole, therefore, the chances of error in converting man-days to man-hours are less for the mechanized mines than for the hand-loading mines.

Summary

The authors are well aware of the limitations of mass data regarding labor productivity. On the whole there are few industries for which the available records of man-days and output per worker are as good as for bituminous-coal mining. The defects which the statistician discovers are probably due more to the vigor with which the field of coal has been explored than to inherent inferiority of its records in comparison with those of other kinds of business. Perhaps the chief lesson to be drawn is the importance to both managers and mine workers of extending to all mines the practice of maintaining actual records of man-days or man-hours worked which the more progressive mines have already developed.

The net effects of the several causes of statistical bias upon the recorded output per worker may be summarized briefly by reference to figure 38.

The apparent drop in the daily per-man output in 1917-18 is due to shortening of the working day in the southern coal fields. Computed on a per-man-hour basis, no break in the long-time trend is shown.

The slight upward bend in per-man output from 1920 to 1924 is due, in part at least, to what has been termed the "car shortage" bias, that is, to an understatement of the factor of time worked, carried over, from the system of mine ratings for distribution of railroad cars, into the annual reports of number of days operated.

The somewhat sharper upward bend from 1930 to 1932 is due to a combination of factors associated with the difficulties of statistical measurement during the great depression. First and probably most important is the tendency to understate the average number of men employed in a period of falling pay rolls by reporting as typical a recent pay roll, representing the end of the year rather than the mean. Second is unreported overtime or time worked on days when the tipple was not loading coal. Both factors work to overstate output per worker. Over the industry as a whole they clearly outweigh any share-the-work arrangements in effect during the same period.

The downward bend in the curve of output per man-hour in 1933 and 1934 is due chiefly to overstatement of the average number of men employed in a period of rising pay rolls and partly to the extension of share-the-work arrangements.

These various elements of bias were largely disposed of in 1935 and 1936 by improvements in the methods of statistical reporting, chief of which is the collection of monthly pay-roll figures and of corrective data on the effects of share-the-work agreements in Illinois and Indiana. These improvements make the 1935 and 1936 measurements the most accurate yet available.

The explanations cited are given in terms of industry averages. The factors mentioned have been present in some districts and absent in others. For individual districts still other influences affect the record; these require special analysis.

In the case of particular mines the effects of one or more of these factors may be augmented by simple errors of reporting.

For the mass of mines covered by the analysis the percentage of error introduced by these factors is small.

Conclusions must, of course, be qualified in the light of the data upon which they rest. An effort is made to include in the analysis, at all significant points where explanation appears necessary, a statement of possible error or of any lack of conclusiveness in the recorded findings. The findings relate primarily to trends rather than to short-time fluctuations. Nevertheless, it cannot be seriously doubted that the data are a useful guide for studying unit labor requirements in relation to employment.

CLASSIFICATION OF MINES

Basis of Classification

Data on mechanical loading in the records of the U. S. Geological Survey start with the year 1923, but in comparing performance of mines that turned to mechanical loading with performance of those that remained on a hand-loading basis, analysis was extended back to 1918 and continued through the year 1935. This was done to include a 5-year period of complete hand loading for both groups of mines. For some items, 1936 and 1937 figures became available while the study was in progress but too late to be analyzed in detail without undue expense and delay. Quantitative measures of performance, therefore, pertain chiefly to the period 1918-35. The continued advance of mechanical loading since 1935 is indicated by the fact that the percentage of the total underground tonnage of the country loaded by machine in 1936 was 16.3, and in 1937 about 20.0, compared with 13.5 in 1935.

The group of over 900 mines that had installed and used mechanical loading devices at one time or another during the years 1923-35 were classified for the purpose of the study in two major groups: (1) those whose experience with mechanical loading was substantial and successful, and (2) those whose experience was limited and apparently experimental. The following criteria as to loading were used in classifying mines:

(1) *Successfully mechanized mines (designated as Group "A").*- All mines that produced 30 percent or more of their tonnage by mechanical loading in 1935; all mines idle, or worked out, or abandoned in 1935 but consistently producing 30 percent or more of their tonnage by me-

chanical loading in 3 years of significant activity immediately prior to shutting down.[23]

(2) *Experimentally mechanized mines (designated as Group "B").*— All mines that produced less than 30 percent of their tonnage by mechanical loading in 1935; mines that were idle or abandoned in 1935 but produced less than 30 percent of their tonnage by mechanical loading in 3 years immediately prior to shutting down; mines that tried out mechanical loading and reverted to hand loading.

A series of identical mines in Group "A" that had continued as producing mines during the whole period of the study was designated as Group "A-1." The purpose of this segregation was to show comparability of results with the more inclusive Group "A" mines, some of which came in as new mines during the period or were inactive in some years, although they were important from the standpoint of mechanical loading.

When the data for Group "B" mines were subjected to analysis it was found that many of these mines had reverted to hand loading and that the machine tonnage of mines in which there was 30 percent or less of mechanical loading had slight effect on average productivity. For that reason it was not deemed necessary in considering the performance of hand-loading and machine-loading mines to treat this group separately since, taking the period as a whole, they were from a practical standpoint hand-loading mines. Analyses of performance, therefore, differentiate Group "A" and Group "A-1" mines from "all other" mines. The "all other" group includes those mines that never installed mechanical loading together with Group "B" mines that utilized it on an experimental or temporary basis.

Performance data in respect to the following items were tabulated and charted: (1) tons mechanically loaded, (2) tons cut by machine - percent of total underground production, (3) number of mines, (4) production, (5) hourly capacity, (6) men employed, (7) days operated per year, (8) tons per man-hour, and (9) number of men required to maintain 1,000 tons of hourly capacity. In addition, tables are presented showing (1) number, production, and tonnage mechanically loaded of

[23] Thirty percent was used as a dividing point because it was found that mines running over 30 percent usually soon approached full mechanization of the loading process, whereas those running under 30 percent were clearly still essentially on a hand-loading basis.

Group "A" mines, 1918-35; (2) a comparison of number, production, and tonnage mechanically loaded of Group "A" and Group "B" mines, 1918-35; and (3) growth of mechanical loading by types of equipment, 1918-36. These tables will be found in appendix B, tables 20-63. The facsimile of the office form 501-A used in tabulating data by mines and for summarizing data for the several areas will be found in appendix C. The form is marked to show sources of data and methods used in computing averages. Tables and charts are presented for the United States; for Illinois and Indiana in the Middle West; for central and western Pennsylvania (which includes No. 8 field in Ohio) and for Alabama in the Appalachian field; and for Wyoming, Montana, Utah, and Washington in the far West. Data for other areas in which there was mechanical loading in 1935 were not of sufficient significance to warrant presentation in this form.

To recapitulate:

Group "A" includes mines that successfully mechanized their loading process;

Group "A-1" (a subdivision of Group "A") includes mines that successfully mechanized their loading process and were in operation each of the years 1918 to 1935;

Group "all other" includes mines that never installed mechanical loading, together with Group "B" mines, which did a limited amount of mechanical loading without becoming essentially machine-loading mines.

A check on the comparative record of performance for Group "A" mines in relation to the group "all other" mines was found in the fact that performance curves for Group "A" and the identical series Group "A-1" were in most instances the same. Fluctuations in Group "A" from year to year were not so much the result of changes in the composition of the group as the result of occurrences within the mines making up the group, since like performance was registered in the "A-1" group which was composed of the same mines throughout the period. As the deviations between Group "A" and Group "A-1" mines were relatively few, the charts of performance in the two groups for the most part speak for themselves. In interpreting the results, reference is made to the "A-1" group only when there is particular occasion to emphasize likeness or to point out unlikeness of performance between the two groups.

The crux of the study of performance lies in the record of labor output or its reciprocal, unit labor requirements. From the foregoing discussion of statistical procedures it will be recalled that the labor-output measure was based on computed rather than actual working time. In analyzing comparative performance for machine-loading and hand-loading mines, the data for man-days were translated into man-hours. As previously noted, defects in the data may affect some of the short-time fluctuations; they are not believed to distort seriously the trends for the period as a whole.

Changes in the Composition of Groups

Changes from year to year in the composition of the groups to which analysis pertains must also be noted in interpreting results. Within areas where mechanically loaded production assumed significant proportions, physical, technical, and managerial conditions in Group "A" mines were in general superior to those in mines that continued to load by hand. The hand-loading group of mines, on the other hand, is made up indiscriminately of the mines that were left after selecting the Group "A" mines. Group "A" is therefore much more homogeneous in its composition than the group "all other" mines. Moreover, by comparing the performance of the more inclusive Group "A" with that of the identical series Group "A-1", it is possible to draw fairly accurate conclusions concerning changes in the performance of the individual mines making up the "A" group.

For "all other" mines there is no way of determining to what extent fluctuations in average performance are due to occurrences in individual mines and to what extent to changes in the composition of the group. As analysis proceeds it will be noted that performance of the hand-loading group of mines was greatly influenced by the elimination of mines that were unable to survive.

In considering differences in performance, both of mechanical-loading and hand-loading mines, in the years to which this study pertains, account must be taken of the disastrous decline which nearly every bituminous area of the country suffered at one time or another between 1923 and 1933. Fluctuations in the several factors that reveal performance in the various mines and areas have quite a different significance when

related from year to year to a base of total output which is rapidly declining than they would have if related to a relatively constant base. The impact of the decline fell with varying degrees of intensity on different areas and mines with the result not only that the significance of individual mines in the total picture was constantly changing but that a vast number of mines disappeared entirely from the scene. In general, the hand-loading mines were the ones that suffered this fate.

Changes in the composition of the group of mines remaining on a hand-loading basis were so great that records of performance for the group throw practically no light on the performance of individual mines. As will be noted, general conclusions concerning the performance of different sections of this group can frequently be inferred from known facts concerning occurrences in particular areas, as, for instance, the development of truck mining in Illinois, but such conclusions do not constitute measures of performance. Although quantitative figures for the "all other" group of mines have been analyzed for the purpose of showing general trends as between hand-loading mines and those that turned to machine loading, extreme care is needed to avoid applying general averages for the group to specific mines or to subdivisions of the areas analyzed.

COMPETITION AND REGIONAL DISTRIBUTION

It cannot be assumed that decreases in unit labor requirements resulting from machine loading represent a net loss of employment. Hope of lowering costs through reduction in labor requirements was the dominant motive that led operators to install mechanical loading. Areas in which such loading became particularly significant in the late twenties were areas that were making desperate efforts to overcome a handicap of competition not only with strip mines but with deep mines that had low standards of wages and working conditions. Under these circumstances pressure was intense to reduce operating costs in the hope of gaining business or at least of forestalling even greater losses.

Shifts of production between areas reflect in considerable measure an influx of coal from southern Appalachian and other low-wage areas into markets formerly supplied largely by

Illinois and Indiana, where wages were relatively high. Bearing in mind that the total tonnage of the country was much smaller in 1937 than it was in 1918, it is significant that in 1918 the percentage of the Nation's output that came from Illinois and Indiana was the same as that which came from West Virginia and Kentucky, 21 percent, whereas in 1929 only 14.8 percent of the total came from Illinois and Indiana, but 37.2 percent came from West Virginia and Kentucky. Deep-mine operators in Illinois and Indiana not only suffered from the general decline of the bituminous industry and from loss of tonnage to other areas but also encountered increasingly stiff competition from strip operators in their own area. Accentuating these factors was the close proximity of large consuming centers to be served if competitive conditions could only be met. The promise of immediate return from machine loading, in the forms of reduced cost and more business, was great, and accordingly pressure to mechanize was well-nigh irresistible.

Not only did mechanization of loading appear as a means of survival for operators but it gave hope of stabilizing employment. The fact that loss of business was the outstanding cause of meager employment created a motive for union cooperation which was only less strong than the motive which operators themselves had for mechanizing. Inasmuch as the extent to which operators in these strongly unionized areas could benefit from mechanical loading depended in large measure on the cooperation of labor, a favorable attitude on the part of the union was of crucial importance. The day rate for inside skilled labor was reduced in Illinois and Indiana in 1928 from $7.50 to $6.10, with corresponding adjustments in tonnage rates, but more important than this was the cooperation of the union in fixing rates for mechanical loading. This joint effort was highly successful, and in the period from 1928 to 1936 the major portion of the mechanized tonnage of the country came from the Illinois-Indiana area. In the year 1937 the rapid advances of mechanical loading in other areas brought the Illinois-Indiana proportion of the total machine-loaded output of the country down to 43 percent, but these two States have continued to load mechanically an increasing percentage of their own deep-mine tonnage.[24]

[24] Unless specifically attributed to another source, figures for 1937 and 1938 are preliminary and may differ somewhat from figures to be published in *Minerals Yearbook*.

Concentration of machine loading in the Illinois-Indiana area and the fact that the balance of the machine-loaded tonnage came from scattered areas made these two States the focal point of mechanical loading during the years following 1927. When the situation in the area is analyzed it becomes apparent that the growth of machine loading from 1927 to 1937 was not a phenomenon that stood by itself. It was a sequel to a whole succession of technical advances. From the standpoint of natural resources, of corporate strength, of management, of labor, and of markets, conditions were highly favorable; the movement was one that seemed to have promise for both operators and miners.

Although mechanical loading in the United States was highly concentrated in the Illinois-Indiana area, the movement was developed to an even higher degree in Wyoming and Montana. About 90 percent of Wyoming tonnage and 80 percent of Montana tonnage was loaded by machine in the years 1935-37; hand loading in these States had practically disappeared. The thick coal seams of the Rocky Mountain areas offer conditions highly favorable to mechanization of loading. Corporate and marketing conditions are also favorable, because much of the tonnage is from captive mines that dispose of their output to their parent interests, the railroads of the area. It is notable, however, that with wages on an even higher level than in Illinois and Indiana, the labor factor is fully as significant in Wyoming and Montana as it is in the two Midwestern States. In 1928, when the day rate for skilled labor (trackmen) in Illinois and Indiana was reduced from $7.50 to $6.10, the Wyoming rate was reduced from $7.92 to $6.72 and the Montana rate, which is the highest in the country, from $8.39 to $7.19.

During the years following 1927, when Illinois and Indiana were making rapid strides with mechanical loading, they were the only States east of the Mississippi River in which there were regional union agreements; labor standards in most southern and eastern areas were extremely low. It is notable that mechanical loading did not make any significant advances in the high-tonnage eastern areas until the National Recovery Administration and collective bargaining entered the picture in October 1933 and greatly reduced the wage differentials between these areas and the union areas to the west. With the advance of labor standards Appalachian operators showed

Table 18.- DISTRIBUTION OF BITUMINOUS COAL LOADED MECHANICALLY, BY STATE, AND PROPORTION OF STATE UNDERGROUND TONNAGE LOADED MECHANICALLY, 1935[a]

State	Underground tonnage loaded mechanically		Percent of total State production loaded mechanically
	Net tons	Percent	
United States	47,177,224	100.0	13.5
Illinois and Indiana	26,280,778	55.7	56.7
Illinois	20,513,082	43.5	55.3
Indiana	5,767,696	12.2	62.5
Wyoming	4,530,032	9.6	89.8
Western Pennsylvania and Ohio No. 8 field	4,322,865	9.2	6.5
Central Pennsylvania	3,624,405	7.7	10.4
West Virginia	2,059,322	4.4	2.1
Alabama	1,303,653	2.8	15.4
Montana	1,291,373	2.7	80.3
Utah	898,118	1.9	30.5
Virginia	651,807	1.4	6.7
Western Kentucky	430,930	0.9	5.3
Washington	429,617	0.9	27.6
Arkansas	292,064	0.6	26.6
Tennessee	238,579	0.5	5.6
Colorado	197,319	0.4	3.3
Eastern Kentucky	102,320	0.2	0.3
Maryland, Missouri, New Mexico, North Dakota, Oklahoma, and remainder of Ohio	529,042	1.1	3.6

[a] F. G. Tryon, L. Mann, and W. H. Young, "Bituminous Coal," *Minerals Yearbook, 1937* (U. S. Dept. Int., Bur. Mines, 1937), pp. 831, 833. Data for central and western Pennsylvania, Ohio No. 8 field, and eastern and western Kentucky compiled from unpublished records of the Bureau of Mines.

increasing interest in mechanical loading. This was strikingly true in West Virginia, where machine output advanced from about 2 million tons in 1935 to over 15 million tons in 1937, and to 20 million tons in 1938.

Table 18 shows the distribution by State of tonnage loaded mechanically in 1935, the last year for which detailed analyses of performance in hand-loading and mechanical-loading mines

were made. Illinois, Indiana, and Wyoming produced 65.3 percent of the total machine-loaded output of the country. Wyoming, Montana, Indiana, and Illinois, in the order named, headed the list of States in regard to the percentage of their own underground production loaded mechanically.

Tonnages, loaded by machine in such areas as western Pennsylvania, central Pennsylvania, and West Virginia were substantial, even compared with Wyoming, and they far exceeded those of other far western areas where machine loading was important, but the percentage of their own output mechanically loaded in these important eastern States was small.

Such States as Washington and Utah in the far West and Alabama and Arkansas in the South, where the percentages of output loaded mechanically gave the movement local significance, produced total tonnages that were too small to influence the national picture. Local factors and general business conditions have caused numerous ups and downs in the areal development of mechanical loading; but, with the exception of West Virginia where the most significant advances have occurred more recently, tonnages loaded by machine in 1935 indicate, in general, the progress of mechanization in the areas concerned.

Experience with machine loading in areas other than those discussed above was rather sporadic during the period ending in 1935. Discussion is more logically associated with developments in these areas since 1935 and is therefore deferred to chapter XI, in which more recent advances in mechanization are considered.

Among the four States that loaded a major portion of their tonnage mechanically in 1935, Wyoming was the first State to advance the movement significantly. In 1923, 1 percent of the State's tonnage was machine loaded, and this had increased to 20 percent as early as 1926. Each year of the period under review has shown an increasing percentage of coal mechanically loaded. Montana was the latest of the four States to start machine loading, and the rise here was much more spectacular. From the first record in 1928, when 17 percent of output was so loaded, it had increased to 57 percent in 1930 and to approximately 80 percent in 1932, at which level it has since remained. In Indiana it was not until 1928 that machine

loading advanced to 20 percent of underground output, and its increase was gradual but steady through 1933 when it had reached approximately 50 percent. Between 1933 and 1934 machine loading forged ahead at a rapid pace, in the latter year reaching 63 percent of underground production. Illinois mines showed a gradual increase in machine tonnage from 1923 to 1926 and a spectacular increase from 13 percent in 1928 to almost 50 percent in 1930 and 60 percent in 1931. During 1932, 1933, and 1934 there was a decline in the percentage mechanically loaded, but by 1936, 62 percent was being machine loaded.

COMPARATIVE SIGNIFICANCE OF AREA DATA

The significance of mechanization data for different areas depends, as previously indicated, on several factors. In any over-all statistical analysis, coverage of a fairly large number of items and reasonably extended time series are essential since erratic performance in individual items and inevitable errors of reporting in mass data are accentuated when coverage is limited. The unit of analysis for the present study is in most cases a particular State. Performance records for mechanized- and hand-loading mines were analyzed for significant States wherever the number of Group "A" mines was large enough to avoid revealing operations of an individual concern.[25] There were only a few States in which the number and tonnages of Group "A" mines were large enough to have national significance; in some cases, to which appropriate reference is made, indications of inaccurate reporting throw considerable doubt on recorded data.

It has already been noted that the high percentages of total tonnage loaded by machine in Wyoming and Montana give greater significance to these States in connection with machine loading than would otherwise result from their tonnages relative to national output. In addition, Wyoming has done important pioneering in mechanical loading. All told, the importance of these areas is primarily in showing results of mechanization when carried to an advanced stage under rather favorable resource conditions. However, relatively small total tonnage

[25] The bituminous areas in central and western Pennsylvania are distinct and are usually considered separately in a geographical analysis of the industry. In western Pennsylvania the most important seam is the Pittsburgh, which extends across the West Virginia Panhandle into eastern Ohio. Accordingly, in order to avoid disclosures in Ohio, data for western Pennsylvania include mines in the Pittsburgh No. 8 field in Ohio.

and special marketing conditions limit the application of this far Western experience to eastern areas, which produce the major portion of the Nation's coal. Tonnage in both Wyoming and Montana is largely from captive mines and is disposed of to the parent interests of the mining companies.

Turning to the important Appalachian region, records for mechanical loading prior to 1935 were, for the most part, too meager to justify drawing conclusions. West Virginia, which leads all the States in total output of bituminous coal, loaded only about 2 percent of its tonnage mechanically in 1935, and coverage of mines for the period 1918-35 was too small to justify tabulation of results. About 6 percent of western Pennsylvania tonnage was loaded by machine in 1935; records of machine loading in that area before 1935 give no adequate basis for general conclusions. Central Pennsylvania, where 10 percent of output was loaded mechanically in 1935, is the only Appalachian area in which experience during the period covered is extensive or typical enough to have general significance.

In spite of relatively meager experience with mechanical loading prior to 1935, the heavy total tonnages of West Virginia and Pennsylvania give a significance even to their limited use of mechanical loading which would not apply to the experience of less important areas. For example, central Pennsylvania, prior to 1935, had demonstrated the advantages of conveyors in that area, and valuable experience with mobile loaders had been acquired in western Pennsylvania. An indication of the possible future of machine loading in the East is found in its phenomenal expansion in West Virginia during 1936, 1937, and 1938.

Considering the small amount of the country's tonnage produced in far Western mines and the limited experience in most of the Appalachian fields prior to 1935, Illinois and Indiana remain the two States in which analysis of mechanical-loading statistics for the period 1918-1935 is significant. In 1935 these two States produced 55.7 percent of the machine-loaded tonnage of the country, and 56.7 percent of their joint output was machine loaded. Performance records of machine loading in the area span more than a decade of time and cover a substantial number of mines.

Data for the period ending in 1935 are more nearly adequate for the Illinois-Indiana area than for any other in the country, and mechanization in the area continues to advance. Notwithstanding the spectacular increase of machine loading in West Virginia since 1935 and substantial advances elsewhere, Illinois and Indiana together still produced one-half of the machine-loaded tonnage of the country in 1936. Although advance of mechanization in areas that produce the major portion of the Nation's coal was more rapid in 1937 than it was in 1936, Illinois and Indiana were still producing 43 percent of the machine-loaded tonnage of the country in 1937, far larger concentration than is shown in any other heavy-tonnage area.

In an earlier chapter attention was called to the importance of a suitable balance between physical conditions, corporate strength, management, marketing outlets, and labor in the development of mechanization. In respect to labor it is true that before and during the introduction of mechanical loading serious strikes had occurred throughout the Illinois-Indiana area, and local difficulties were by no means unknown in the periods intervening between the major stoppages. Nevertheless, relations with labor in this area had for many years been firmly established on a permanent basis of collective bargaining, and, as already noted, the introduction of machine loading itself was brought about with the cooperation of labor.

Balancing all the factors, discussed in chapter III, that determine both progress of mechanization and changes in labor productivity, it is obvious that these general conditions go far toward explaining the successful development of mechanization in the Illinois-Indiana area. In addition to these general factors, extremely difficult competitive conditions created a strong motive, which resulted in translating potential into actual mechanization within a short period of time. Taking all the general and special factors together, conditions for installing machine loading in Illinois and Indiana in the late twenties should be characterized as excellent rather than average.

CHAPTER VIII

PERFORMANCE OF MECHANICAL- AND HAND-LOADING MINES IN THE ILLINOIS-INDIANA AREA*

In 1935, out of a total machine-loaded output of about 47 million tons, over 26 million came from Illinois and Indiana. In 1936 the Illinois-Indiana machine-loaded tonnage stood at one-half of the total for the country and, in spite of spectacular advances in West Virginia, it was still 43 percent of the total in 1937.

The growing importance of machine loading in this area is indicated by the following percentages, for selected years, that mechanically loaded tonnages are of total deep-mine output in the same State:[1]

State	1923	1926	1928	1930	1931	1932	1935	1936	1937
Illinois	0.2	3.8	13.5	48.0	59.4	57.0	55.3	62.4	70.7
Indiana	0.3	11.3	21.0	32.3	39.1	42.8	62.5	70.5	80.6

Related to competitive and other factors that helped to stimulate the introduction of machine loading in this area are, of course, favorable resource conditions and the advances made in the better-situated mines with regard to mechanization of other mine processes. Comparison of hand-loading and machine-loading mines reflects the influence of other phases of mine technology. Although data are lacking which would permit segregation of each technical item, it cannot be doubted that results under machine loading are attributable to a considerable degree to excellence and balance in the general equipment of leading Illinois and Indiana mines.[2]

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*By Willard E. Hotchkiss and Charlotte K. Warner.

[1]Based on tables B-23 and B-28. The 1937 figures are estimates of the National Bituminous Coal Commission.

[2]A recent unpublished study by J. Edward Ely of 129 Illinois shipping mines operating in 1929 and 114 operating in 1935, based on data reported to the Illinois Department of Mines and Minerals for those years, attempted to determine by use of statistics the relative importance of several technical, physical, and management factors in explaining the different productivities of mines.

Whatever the scientific merit or the methods used for allocating value to the several factors considered, an analysis of particular mines in one area for only

[Continued]

Beginning with early experiments, the movement toward machine loading covers practically the whole period of the present study, but the most notable advances have been made during the past decade. Competitive, managerial, resource, marketing, and labor factors which stimulated the introduction of machine loading in Illinois and Indiana were outlined in chapter VII. It is not necessary to review all these influences, but in considering the growth of machine loading, note should always be taken of the system of collective bargaining which for many years has been firmly established in the area. In spite of periodic general suspensions and frequent local stoppages, there has been no likelihood in recent years that the policy of operating under union agreements would be discontinued.

At the expiration of the Jacksonville Agreement in 1927, the Illinois-Indiana area was surrounded east, south, and southwest by nonunion areas in which operators were relatively free to

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2 [*Continued*]
two years would not furnish a basis for generalization concerning the importance of these factors for the industry as a whole. However, a rough statement of the conclusions reached will give a general idea of the complex factors by which labor output is influenced.

The study concluded that the factors listed below explained the major portion of the difference in labor output per man-day among mines by the number of tons indicated:

Machine loading	100-percent mobile loading over hand loading	3.00
	100-percent pit-car loading over hand loading	1.10
Machine haulage	Mainline locomotive haulage over mule haulage	1.05
	Gathering-locomotive haulage over mule haulage	0.28
Seam thickness	Increase of 1 foot in thickness (up to 7 feet - beyond 7 feet, no further increases)	0.40
Size of mine	Large over very small mines	0.95

It will be noted that the productivity factors listed above have to do mainly with mining technology or thickness of seams. Recalling that Illinois, the mining area to which these estimates apply, has relatively thick seams and that this area is one in which mechanical loading has been highly developed, it is interesting to note that the study allocates an importance more than twice as great to the factor of mobile loading over hand loading as it does to any of the other factors enumerated. In the same connection, the indication of relative effectiveness of the higher-capacity form of mobile loader and of the lower-capacity pit-car loader checks with comparisons made later in this chapter.

The experience of the 129 mines did not afford an adequate basis for computing the savings effected by machine undercutting as compared with the old-time practice of undercutting by hand. Machine cutting had become the general practice in Illinois, and the mines which did not use machines were probably shooting off the solid, rather than undercutting by hand.

J. Edward Ely, author of Labor Productivity in Illinois Underground Coal Mining, a study made for the National Research Project, in which these calculations occur, was associated with the present study in its earlier stages and had access to all the basic data. His method of allocating influence to different items in mine operation is known to statisticians as multiple correlation. The effort represents a promising approach to the statistical measurement of significant items which cannot be entirely segregated.

reduce wages, increase hours, and determine working conditions. Not only were southern Appalachian operators utilizing their flexible labor standards to encroach upon the previous markets for Illinois-Indiana coal, but competition from low-cost strip operators in the immediate area intensified the pressure upon underground mines. Miners and operators alike were eager to remedy these conditions. Factors that helped to facilitate mechanization in Illinois and Indiana have been previously enumerated, but the jeopardy from potentially fatal competition furnished the major impetus given the machine-loading movement after 1926.

The forces that were stimulating mechanization brought extraordinary results. The foregoing tabulation shows that in 1926 less than 4 percent of Illinois output was loaded by machine, but 4 years later 48 percent was so loaded. This represented an eleven-fold increase of mechanically loaded coal. In Indiana the movement had developed somewhat further in 1926 than it had in Illinois; from 11 percent of total deep tonnage machine loaded in that year, the percentage increased to 32 percent in 1930.

Although proximity and relative similarity of conditions justify consideration of Illinois and Indiana as one major area, development of mechanical loading in the two States has not been identical. Because of differences in significant items of data and in recorded results, separate analysis is made for the two States. Comparative performance of machine-loading and hand-loading mines in Illinois and Indiana, successively, is followed by a composite summary of employment factors for the area as a whole.

ILLINOIS

Tons Mechanically Loaded

It may be seen from figure 39 that in 1923, when the record of mechanical loading started, the machine tonnage was insignificant. Development of the movement during the next 4 years was gradual in Group "A" mines; only 4,446,000 tons were loaded by machine in 1928. From 1928 to 1931, however, a phenomenal advance brought machine output to a peak of 21,124,000 tons. A severe drop occurred in the depression

Figure 89.- COMPARATIVE PERFORMANCE IN ILLINOIS OF UNDERGROUND MINES WHICH HAVE ADOPTED MECHANICAL LOADING AND OF ALL OTHER UNDERGROUND MINES, 1918-85

(Strip mines are excluded)

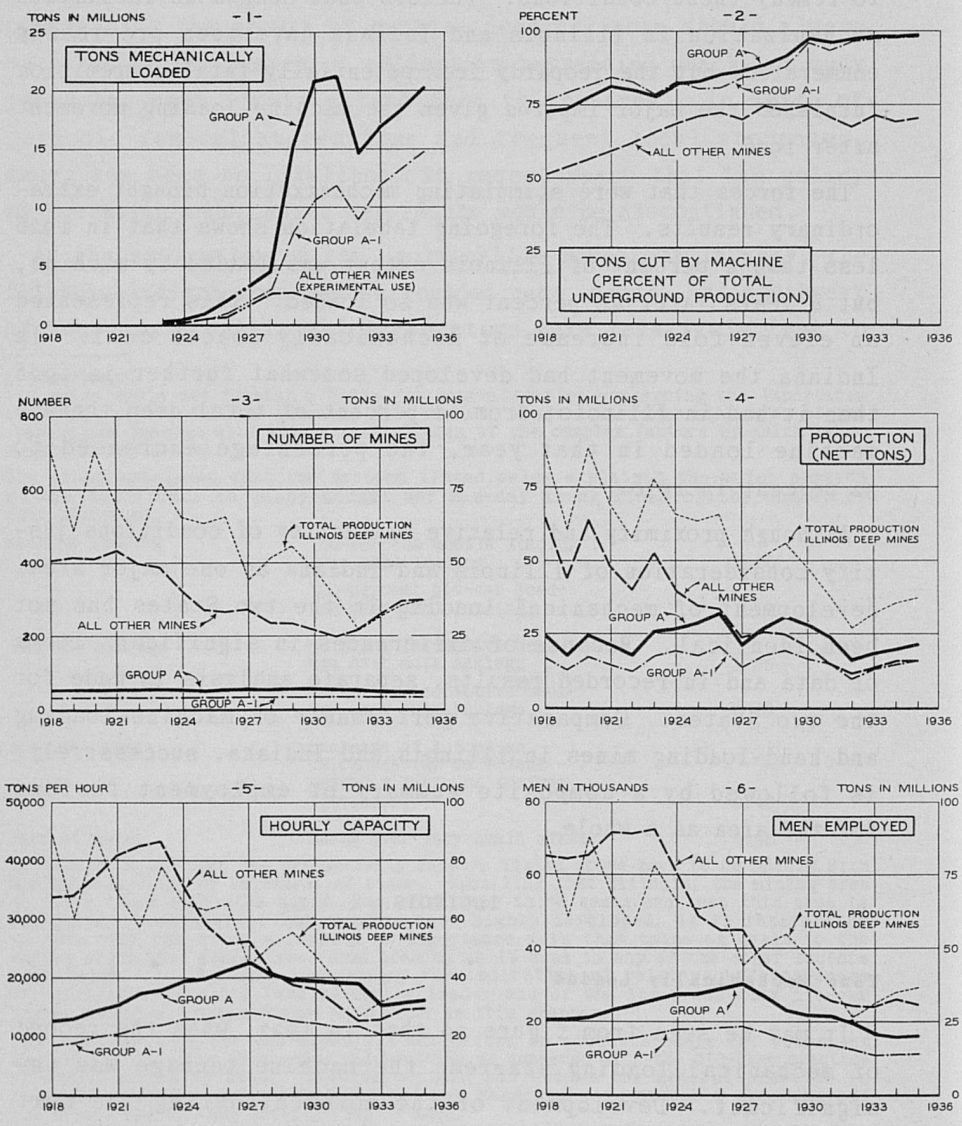
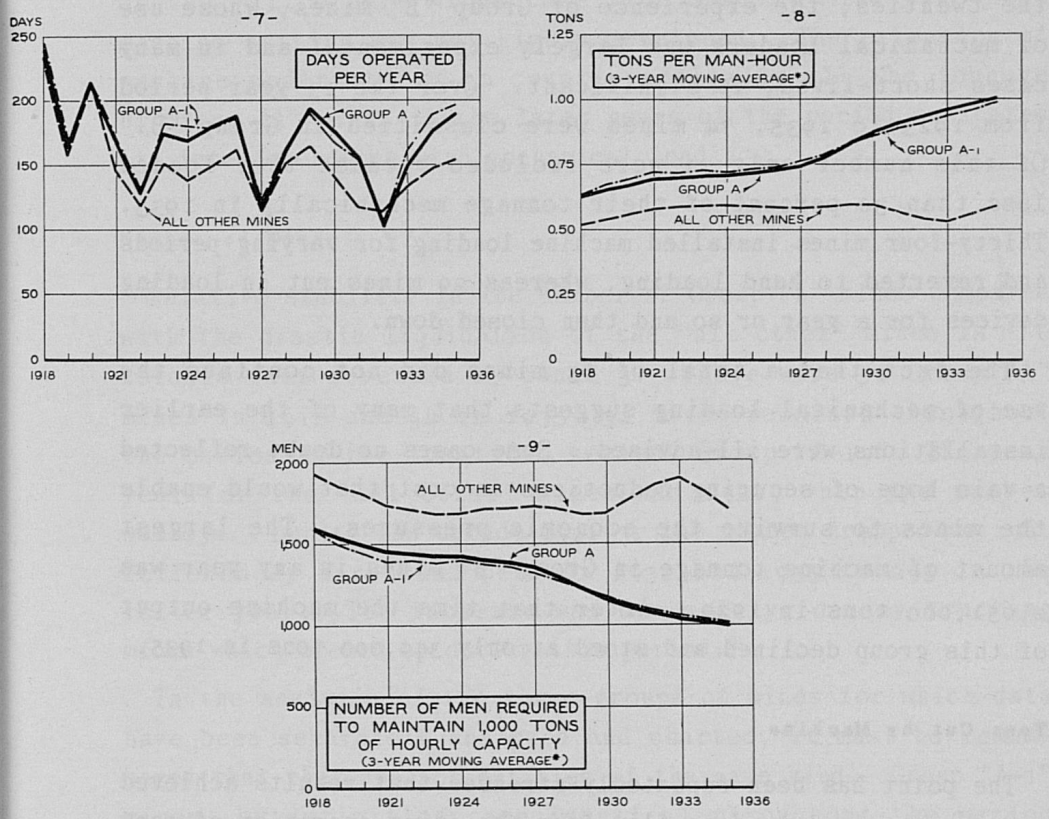


Figure 89.- COMPARATIVE PERFORMANCE IN ILLINOIS OF UNDERGROUND MINES WHICH HAVE ADOPTED MECHANICAL LOADING AND OF ALL OTHER UNDERGROUND MINES, 1918-85 - *Continued*

(Strip mines are excluded)



* ACTUAL FIGURES FOR 1918 AND 1935

FOR DESCRIPTION OF GROUPS OF MINES SEE PP. 295-8.

BASED ON TABLE B-20

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year 1932, but by 1935 the total machine-loaded tonnage of the State stood at 20,164,000 tons.

The mechanically loaded tonnage shown in panel 1 as coming from "all other" mines reflects, of course, the mechanical loading of the Group "B" mines. Since Illinois served in a measure as a proving ground for mechanical loading during the twenties, the experience of Group "B" mines, whose use of mechanical loaders was largely experimental and in many cases short-lived, is significant. Over the 13-year period from 1923 to 1935, 74 mines were classified in Group "B." Of this number only 11 were included because they loaded less than 30 percent of their tonnage mechanically in 1935. Thirty-four mines installed machine loading for varying periods and reverted to hand loading, whereas 29 mines put in loading devices for a year or so and then closed down.

The fact that a total of 63 mines did not continue the use of mechanical loading suggests that many of the earlier installations were ill-advised. Some cases no doubt reflected a vain hope of securing reductions in cost that would enable the mines to survive the economic pressures. The largest amount of machine tonnage in Group "B" mines in any year was 2,651,000 tons in 1929. After that time the machine output of this group declined and stood at only 349,000 tons in 1935.

Tons Cut by Machine

The point has been repeatedly stressed that results achieved under mechanical loading flow from the joint operation of many factors, among which mechanization and balanced operation of other mine processes are outstanding. The only machine process other than mechanical loading which could be measured from Bureau of Mines data is undercutting by machine. Considering that in the later years of the period covered by the study most of the tonnage that was not undercut was shot from the solid,[3] it would not appear that machine undercutting has exerted a major influence on the comparative performance of machine-loading and hand-loading mines.

Group "A" mines and the identical series "A-1" had a high degree of machine undercutting as far back as 1918. Group "A" mines increased their percentage of undercutting from 72.6 in

[3]This is the technical phrase for blasting without previous undercutting. See machine-cutting section of chapter II for more detailed discussion.

1918 to 98.6 in 1935. The "all other" group likewise increased its percentage of machine undercutting substantially during the early years of the period - from 51.2 percent in 1918 to 72.4 percent in 1926. The leveling off and subsequent decline were mainly the result of the changing composition of the group. After 1928 an increasing percentage of the tonnage of the "all other" mines came from smaller mines in which machine cutting was not highly developed. The extension of machine undercutting to cover practically all the tonnage of Group "A" mines in the later years of the period indicates its interdependence with mechanical loading.

Number of Mines

Relative stability in the number of Group "A" mines compared with the drastic liquidation of the "all other" mines is the notable fact revealed by panel 3. There were 52 Group "A" mines in 1918 and 44 in 1935; 32 mines remained throughout the period in the identical series, Group "A-1." The peak year for the "all other" mines was 1921, when the number was 434. During the decade 1921-31 the number dropped to 196, followed by a rebound between 1931 and 1935 to 295 in the latter year. The increase was due mainly to many trucking mines which opened up during this period.[4]

In the analysis of the three groups of mines for which data have been separately analyzed and charted, it must be remembered that they are not entities of the same kind. Group "A-1" mines, by definition, are identical throughout the period and have greater homogeneity than the "all other" mines. As the phrase "all other" suggests, this group contained mines of diverse types, and its composition changed from year to year. Change resulted not only from the great liquidation of mines in the group but also from the fact that mines which would fall in this group are more readily opened than are those which could qualify as Group "A."

Production

Panel 4 shows the steep downward trend in total deep-mine production from 1920 to 1932 which was the end-result of sharp

[4]Local commercial mines (mines employing less than 10 men), wagon or truck mines with an annual production of less than 1,000 tons, and so-called "country banks" are excluded from the count of number of mines in all years.

fluctuations from year to year. The essential meaning of this decline becomes clear from analysis of the curve for particular years in the light of known conditions.

Disregarding the depression year 1921 and the strike years 1919 and 1922, low production years for almost all areas, it is notable that the year 1923, during which output would normally register a big advance to make up for low production in 1922, showed an output of 10 million tons less than in 1918 and 1920. The year 1923 was regarded as a fairly prosperous year; in the later discussion of employment and hourly capacity it appears that, although tonnage was substantially below the 1918 peak in 1923, liquidation of capacity had not yet started. Production declined from 78 million tons in 1923 to 66 million tons in 1926. In other words, from 1920 to 1926 a drop of about 22 million tons occurred.[5]

Between 1923 and March 31, 1927, the basic wage of $7.50 per day remained in force under the Jacksonville Agreement. The languishing of the Illinois coal industry during this period and the crisis of the 1927 strike were doubtless responsible for some change in the relationships between the union and operators. The reduction of the $7.50 rate to $6.10 in 1928 with corresponding reductions in tonnage rates was accompanied by a program of cooperation under which the spectacular advance in machine loading occurred. The years from 1923 to 1929 represented a period when, with minor recessions, the business cycle was swinging upward. Coal production in Illinois in 1928 and 1929 was in harmony with this swing, but from 1923 to 1927 output ran strikingly counter to the general trend of business. In 1929, after 2 years of substantial advance in tonnage, output was still 11 million tons less than it was in 1926.

Production registered a further precipitous decline during the depression from 55 million tons in 1929 to 27 million tons in 1932. Partial recovery occurred between 1932 and 1935 and output stood at 37 million tons in the latter year. Although analysis of performance terminates with the year 1935, there

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[5] At least a part of the decline from 1918 to 1923 may be regarded in the light of a readjustment from abnormal war and post-war demands, but it should be noted that this short period includes not only a depression but two major strikes. It is reasonable to suppose that any tendency that consumers may have had to substitute other energy producers for coal during this period was accentuated by the seriously unsettled condition of the coal industry.

was a further advance to 42 million tons in 1936, and a decrease to 41 million tons in 1937.

The causes for such drastic readjustments as those in the Illinois coal industry during this period are seldom simple or apparent. Among forces that can be appraised, competition of other fuels and improvements in combustion which tended to reduce the demand for coal must be included with those already cited. These forces were operative throughout the industry, but in Illinois they were greatly enhanced by the intensity of competition with other coals. Coal from low-wage areas in the East and South was making heavy inroads upon Illinois markets; urgency of producing lower-cost coal to meet competition was acute. The accompanying tabulation, showing average daily earnings of all wage earners, gives an indication of the influence of the wage factor in the Illinois situation:[6]

Year	Date of sample pay period	Ill.	Ind.	Ohio	Pa.	Ky.	W. Va.
1921-22	Oct. 1-Feb. 15	$8.47	$7.92	$7.49	$6.10	$5.72	$6.39
1924	Oct.-Dec.	8.32	8.11	7.04	6.41	5.42	5.53
1926-27	Nov. 26-Mar. 22	8.58	7.98	6.81	6.16	4.99	5.45
1929	First quarter	6.84	6.65	4.91	5.37	4.95	5.10
1931	First quarter	6.81	6.55	4.08	4.71	4.56	4.66
1933	February	5.10	5.21	2.83	3.03	3.01	3.12

Comparative rigidity of costs in Illinois deep mines under the Jacksonville Agreement undoubtedly accelerated the rise of the stripping industry. Deep-mine operators were beset on all sides by competition of other fuels, competition of other areas, and competition of strip mining nearby.

Despite the serious situation with which Illinois deep mining was confronted, those mines that later turned to mechanical

[6] Based on the following Bulletins published by the U. S. Department of Labor, Bureau of Labor Statistics: *Hours and Earnings in Anthracite and Bituminous Coal Mining: Anthracite - January, 1922; Bituminous - Winter of 1921-22* (Bull. No. 316, 1922); *Hours and Earnings in Anthracite and Bituminous Coal Mining, 1922 and 1924* (Bull. No. 416, Sept. 1926); *Hours and Earnings in Bituminous Coal Mining, 1922, 1924, and 1926* (Bull. No. 454, Nov. 1927); *Hours and Earnings in Bituminous Coal Mining, 1929* (Bull. No. 516, May 1930); *Wages and Hours of Labor in Bituminous-Coal Mining: 1933* (Bull. No. 601, Aug. 1934).

loading fared much better than the mines that did not. In the years 1918-26 Group "A" mines increased their output from 24 million to 32 million tons, but the Group "all other" mines declined from 65 million to 34 million tons. Reverting to panel 1, it will be seen that mechanical loading figured but slightly in the Group "A" tonnage during this period. It is also notable that the same upward trend in tonnage characterizes the Group "A-1" mines, indicating that the increase was not brought about simply by the entry of new mines.

In considering the drastic decline in output of the Group "all other" mines it must always be recognized that this group was heterogeneous and included the poorer mines of the area; in many of them unfavorable resource conditions and other disadvantages made high costs inevitable. Many of them could only operate when the price of coal was high, and they were out of the race when competition forced prices down. Decline in output of the Group "all other" mines reflected largely a closing down of mines as the curve for this group in panel 3 indicates.

Loss of tonnage as a result of the 1927 strike was about the same for both groups of mines; after the strike mechanical loading advanced materially. From 1928 on, it is a substantial factor in the performance of mines in the "A" group. In 1928 Group "A" mines loaded 17 percent of their tonnage by machine; in 1929, 50 percent. At the same time, their output rose to 30 million tons, a figure but slightly under that of the 1926 peak. In view of the contrast, not only between the two groups but in the output of Group "A" mines before and after the expansion of machine loading, there is every reason to believe that demoralization of the coal industry in Illinois would have been much greater than it was if machine loading had not enabled the mines of the "A" group to lower costs and thus recover some of the lost tonnage. Mines in this group were able to increase both their total output and their share of the business.

In 1928 and 1929 expansion of general business reached its height, a fact which should be related to the output of both groups of mines. Moreover, the average efficiency of the "all other" mines had unquestionably been raised by the liquidation of weak mines during the years 1923-27. In these circumstances it is not surprising that decline of tonnage in the "all other"

group was arrested. Output was about the same in 1929 as it had been in 1927. Although Group "A" mines lost tonnage, they were still able to increase their share of total tonnage moderately in the years 1930 and 1931; however, the coming of the depression following the financial crash late in 1929 brought new forces into play.

Decline of industrial demand during a depression tends to give relatively greater importance to the domestic market than it possesses in periods of business prosperity. Low transportation costs frequently enable small mines with inferior mechanical equipment to compete in a local domestic market. This fact, and the further fact that by 1927 the weaker mines in the "all other" group had been eliminated, enabled this group to weather the depression about as well as the more highly mechanized Group "A" mines.

An important factor in the ability of the "all other" group to carry on during the depression and the years of advancing business following 1932 was the development of a vigorous trucking industry in Illinois. Improvements in motor transport and the phenomenal rapidity with which good roads had spread to most sections of Illinois and to adjoining States in the early thirties, added to the proximity of large consuming markets, made conditions almost ideal for the development of trucking. Meantime, the general unemployment acted to induce truck operators to seek business at exceedingly low charges, often sufficient to yield them only the barest levels of subsistence. The radius for truck shipment is of course less than for rail shipment, but within that radius trucking mines often enjoy an advantage in transportation costs and in elimination of retail charges, factors which are highly important in the domestic market. Trucking mines have the further advantage of lower fixed charges, which means that a higher percentage of their total expense can be adjusted to the volume of business.

Besides all this, small enterprises that operate with limited capital do not need to be successful in order to offer severe competition to their more efficient rivals. No doubt, in the absence of proper accounting, many trucking concerns have sold coal below cost, but as long as original equipment holds up such concerns can continue in business, and the disaster that ultimately results from selling below cost may be long

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deferred. Even then, the places of concerns that fail are frequently filled through reorganizations and the starting of new ventures. Trucking mines, both the profitable and the unprofitable ones, are likely to have a permanent place in the Illinois picture.

To summarize, two circumstances chiefly explain the ability of the "all other" mines to hold their share of the total business during the depression: average efficiency had been raised by the previous liquidation of weak mines, and trucking mines that had opened had exceptional ability to meet demands in the domestic market, the relative importance of which the depression had enhanced.

Reviewing the market position of hand-loading mines from the standpoint of output, it is notable that their share of total tonnage declined from 73 percent in 1918 to 37 percent in 1931, but in the years 1932-35 they averaged about 43 percent of total Illinois deep tonnage.

In view of the superior ability with which Group "A" mines escaped liquidation and came to produce a rapidly increasing share of the total Illinois deep tonnage before machine loading came into the picture, it is obvious that the classification of mines that was adopted for the purposes of this study was in essence a classification into "good" mines and "poor" mines. Group "A" was made up of mines which throughout the period were in a relatively advantageous position in respect to resources, management, corporate strength, trade outlets, and technology. The "all other" mines, especially at the beginning of the period, included a disproportionate share of mines whose relative weakness was reflected in heavy liquidation when expanding markets gave way to declining markets.

Although the record begins in 1923, panel 1 and table B-21 reveal that mechanical loading was not of sufficient importance prior to 1926 to influence greatly average efficiency of Group "A" mines. In analyzing performance of the two groups of mines it is essential to divide the period from 1918 to 1935 into two parts: (1) 1918 to 1926, and (2) 1928 to 1935. The strike year 1927 divides the two periods and, because of its abnormal conditions, has been omitted.

During the period 1918-26 Group "A" mines increased their share of the area's production of deep-mined coal from 27.2 to

48.5 percent. Even more significant, the group increased its total tonnage from 24 million to 32 million tons. In other words, during this period, which preceded any substantial development of machine loading, all the impact of the decline in Illinois tonnage fell on mines of the "all other" group. Output from this group was 65 million tons in 1918 and 34 million tons in 1926.

From 1928 to 1931 Group "A" mines absorbed from 50.6 to 62.6 percent of the total business of the State. From 1932 to 1935 hand-loading mines managed to maintain their relative position in the market.

Summing up the experience of the two groups of mines for the whole period from 1918 to 1935, Group "A" mines substantially held their own during a prolonged period of adversity in the industry while the "all other" group lost about 75 percent of its tonnage.

Hourly Capacity

The curve for hourly capacity as shown in panel 5 represents potential hourly output by mines operating with current equipment, management, organization, and labor force. It has been commonly assumed that mechanization of loading would cause undue expansion of mine capacity. In order to throw light on this question, a comparative analysis of the hourly capacity of Group "A" mines and "all other" mines was made.

Note has already been made of the discrepancy between the trends of capacity and production in the "all other" group of mines from 1918 to 1923. It will be recalled that there were two major strikes and a depression during this period. Conditions were assumed to be highly abnormal in those years, and capacity did not become adjusted to the lowered output. The subsequent loss of capacity in the group after 1923 was due to the shutting down of a great number of mines.

Hourly capacity in Group "A" mines increased steadily from 13,000 tons in 1918 to 23,000 tons in 1927. Since this increase occurred before mechanical loading had reached significant proportions, it could not have resulted from that movement. The decline in hourly capacity that occurred both in the inclusive Group "A" and the identical series of "A-1" mines after 1927, at a time when mechanical loading was increasing,

seems to show that the result of large-scale machine loading has not hitherto been to increase mine capacity. Looking toward the future, proof is not at hand to show that increase in capacity will be a major result of the expansion of machine loading.

Men Employed

Peak employment was reached in the year 1923 when the total number of men for all deep mines in Illinois was 98,903. In 1935 the number employed had declined to 41,093. The causes of this decline are essentially the same as those which brought about the general decline in the bituminous industry, already discussed at some length. As will be noted later in discussing labor output, many more men would have been required to produce the 1935 output of coal if unit labor requirements had remained as they were in 1918, but it is highly improbable, other conditions being what they were, that the actual output of Illinois in 1935 and intervening years could have been produced and sold under 1918 unit labor requirements. Shrinking markets must be set down as the major cause of the decline in the number of men employed.

Contrasted with this over-all decline, the number of men employed in Group "A" and in Group "A-1" mines actually increased during the period 1918 to 1927. In Group "A" 20,265 men were employed in 1918, and this number rose to 30,689 by 1927, an increase of 51.4 percent. Because of the inclusion of more mines in this group in the latter year, the percentage increase in employment in Group "A-1" mines was less - or 39.5 percent. This increase means, of course, that the entire loss fell on the "all other" group. From a peak of 72,667 men on the pay rolls of the mines of the "all other" group in 1923, the number shrank to only 45,199 men in 1927, a decline of 38 percent. This is the comparative record of the two groups of mines during a period prior to extensive introduction of machine loading.

After 1927 Group "A" mines in Illinois turned to mechanical loading on a large scale. Beginning in 1928 the number of men employed in both Group "A" and "A-1" mines started to decline. Whereas 30,689 men were employed in Group "A" mines in 1927, only 23,446 were employed there in 1929. Inasmuch as

production was increasing during 1928 and 1929, there can be little doubt that in those years, unlike the earlier period, much of the decline in the number of men employed resulted directly from the widespread installation of mechanical loading. After 1929 the explanation for a decline in the number of men employed is again complicated by the factor of a declining market. Between 1932 and 1935, when output was increasing from the low point reached in the depression, there was no increase in the number of men employed. Taking the period 1927-35 as a whole, the number of men employed in Group "A" mines dropped from 30,689 to 16,118, a decrease of 47 percent.

Turning to the record of "all other" mines during these same years, the number of men employed dropped from 45,199 in 1927 to 24,975 in 1935, a decline of 45 percent. In other words, job mortality was nearly the same for the hand-loading and the machine-loading mines during the period from 1927 to 1935 when machine loading was an important item in the operation of Group "A" mines. The conditions previously noted which enabled the hand-loading mines to maintain their relative share of the tonnage during the years 1932 to 1935 were of course in considerable measure responsible for their ability to make the comparative showing they did in respect to men employed.

As previously indicated, the authors of this report consider it unwarranted to infer that the number of men employed in Group "A" mines could have remained at the 1926-27 level if these mines had not resorted to machine loading. It is extremely doubtful whether these mines could have met the competitive conditions with which they were confronted on the basis of unit labor requirements and unit costs in the year 1926.

Operators with any chance of retaining business had little choice about trying to cut costs and, with labor the largest cost item, this meant cutting labor costs. Union representatives, aware of this fact, presumably entered into cooperative arrangements for the installation of loading machines, believing that employment would decline less if costs were lowered. Among the States east of the Mississippi River, Illinois and Indiana were the only ones with a wage structure fixed by collective bargaining. Loss of business to other areas and consequent decline in the number of men employed would undoubtedly have been much more serious if the industry in

Illinois had not reduced labor costs. It is highly probable that more jobs would have been lost if Group "A" mines had continued to load coal by hand.

To summarize, for every 1,000 men employed in Group "A" mines in Illinois in 1923, 1,170 men were employed in 1927, an increase of 170 men per thousand. In the "all other" group, on the other hand, only 620 men were employed in 1927 for every 1,000 men employed in 1923. This was a period when mechanical loading was insignificant. During the period 1927-35, when mechanical loading was increasing rapidly in Group "A" mines, there was little choice between the two groups of mines from the standpoint of job security. Of every 1,000 men employed in Group "A" mines in 1927, 525 men were employed in 1935; of every 1,000 men employed in the "all other" group of mines in 1927, 550 were employed in 1935. Looking at the period 1918-35 as a whole, job security was much greater in Group "A" mines than in those of the "all other" group. Of every 1,000 men employed in Group "A" mines in 1918, approximately 800 were employed in 1935; of every 1,000 men employed in the "all other" group of mines in 1918, less than 400 were employed in 1935. In other words, job mortality was three times as great, for the period as a whole, in the mines of the "all other" group as it was in Group "A" mines. This, of course, is merely restating that Group "A" mines were on most counts greatly superior to the "all other" mines.

Share-the-Work Agreements and Numbers Employed.- Before closing this analysis of the trend of employment, recognition should be accorded to the local share-the-work agreements adopted by the Illinois operators and the miners' union in an effort to mitigate the impact of mechanization upon the employees of the industry. Reference has already been made (chapter VII) to the provision of the State wage contracts, adopted as early as 1932, authorizing the staggering of work among the employees of the mines affected by mechanization. It is known that in 1935 local agreements for dividing work were in effect at 27 Illinois shipping mines, excluding strip pits. At these mines the difference between the average number of men actually working and the total number on the pay rolls was reported to the State mining department as 2,617. It is apparent, therefore, that the share-the-work agreements of Illinois exercised an appreciable influence in reducing

the number of men displaced. In effect, the share-the-work contracts had preserved 2,617 jobs, although thereby reducing by approximately 20 percent the average number of days of working time available to each man on the rolls.

Most of the jobs preserved by the share-the-work agreements were at the highly mechanized mines. Twenty of the mines enumerated belonged to Group "A." Seven were in the "all other" group, four being incompletely mechanized mines classified in this study as Group "B" mines and three being hand-loading mines. For all of the 27 mines the figures for men employed in 1935 represent the average number of men actually working rather than the total number on the rolls. If allowance is made for the practice of dividing work, the total number of men on the pay rolls of the Group "A" mines in 1935 is increased by 1,722 and becomes 17,840. Similarly, the total number of men on the pay rolls of the "all other" mines is increased by 895 and becomes 25,870. On this basis, the decline in number of jobs between 1927 (before share-the-work agreements were developed) and 1935 is reduced to 42 percent for the highly mechanized mines of Group "A" and to 43 percent for the mines of the "all other" group.

Days Operated per Year

Employment opportunity in an industry is reflected not only in job security but in the availability of work as indicated by the number of days each year a person is actually at work. In this, Group "A" mines make a much better showing than the group "all other" mines. Panel 7 reveals the superior position of this group of mines both before and after the installation of machine loading.

For the years 1923 to 1926 Group "A" mines averaged 27 more days of operation per year than did the "all other" group. The low points of operation in 1927 and 1928 were the result of suspensions that were in progress from April to October of 1927 and from April to midsummer of 1928. Leaving these strike years out of the count, Group "A" mines again averaged more days of employment than did the Group "all other" mines during the years 1929-31. In 1932, another strike year, Group "A" mines dropped below the "all other" group, but they regained their advantage immediately thereafter and held it to the

end of the period. During 1933, 1934, and 1935 Group "A" mines averaged 24 more days per year than did mines of the "all other" group. Considering the joint effect on employment of the number of men employed and the number of days worked, it is clear that opportunity for higher annual earnings from 1923 to 1935 was greater in Group "A" mines than in "all other" mines.

Tons per Man-hour and Number of Men Required to Maintain 1,000 Tons of Hourly Capacity

Panels 8 and 9 reveal the fact, which has been emphasized repeatedly, that mines included in Group "A" required fewer men per unit of output than mines of the "all other" group. Panel 8 records increases in labor productivity expressed in tons of output per man-hour of labor; panel 9 expresses the same result in reciprocal form - the number of men required to maintain 1,000 tons of hourly capacity. In relating changes in labor productivity to advancing technology, whenever improved output results from increased expenditures for equipment the resulting higher productivity is a gross gain rather than a net saving. Carrying charges on the new equipment must be deducted from the decrease in labor cost to establish the net savings reflected in profits.

As an approach to the question of how mechanical loading affected labor output, the years 1918-35 are divided into three periods: 1918-22, 1923-27, and 1928-35.

During 1918-22 both groups of mines were hand-loading, and it will be noted that from 1918 to 1921 both groups registered substantial decreases in unit labor requirements. Moreover, the recorded decreases are greater for Group "all other" than for Group "A" mines. The latter required 150 fewer men to maintain 1,000 tons of hourly capacity in 1921 than they required in 1918, whereas the "all other" group of mines required about 200 fewer men.

The authors believe that these figures contain more than normal inaccuracies and that they somewhat overstate the decrease in unit labor requirements for both groups of mines. As explained in chapter VII in discussing known biases in the figures, the period from 1918 to 1922 was one of acute railroad-car shortage. The system of car allotments caused

a bias in the direction of overstating mine capacity, and these inaccuracies in reporting tended to carry over to some extent into operators' returns to the United States Geological Survey, with the result that increases in labor output or, conversely, decreases in unit labor requirements were accentuated.[7] There is no doubt, however, that unit labor requirements in both groups of mines decreased substantially during this period.

A somewhat different picture is shown for the period 1923-27. Group "A" mines loaded 0.5 percent of their tonnage by machine in 1923, 0.9 percent in 1924, 2.9 percent in 1925, and 6.1 percent in 1926. The Bureau of Mines compiled no data on machine loading in 1927. It is apparent that the direction of productivity curves for Group "A" mines could not have been influenced in any material way by machine loading at this time. Decrease in unit labor requirements for Group "A" mines was very gradual during this period, as indeed it had been from 1921. This, together with the fact that so large a percentage of their tonnage was cut by machine, indicates not only that these mines had already taken advantage of most of the improved technology then current but also that their mechanized processes were well advanced, which is known to be true. Unit labor requirements in the "all other" group of mines showed practically no change between 1923 and 1927.

For the period 1928-35 the picture again changes. Group "A" mines loaded 17 percent of their output by machine in 1928, 76 percent in 1930, 93 percent in 1932, and 95 percent in 1935. In 1928 unit labor requirements in the group started a downward sweep which continued through 1935. It required 350 fewer men to maintain 1,000 tons of hourly capacity in 1935 than it did in 1927, an over-all decline of 26 percent.

Although the correlation between increase in machine loading and decrease in unit labor requirements is obvious, it must again be recognized that many factors that have influenced productivity of Group "A" mines cannot be brought within the scope of quantitative measurement. It must also be recognized that introduction of mechanical loading did not stand by itself as a segregated policy of management; to be successful it had to be incorporated in a synchronized program which included all the technical and management processes of a mine.

[7] For further discussion of the car-shortage bias, see chapter VII, ftn. 20.

Nevertheless, extension of mechanical loading was a focal point in managerial policy during this period, and without it unit labor requirements could scarcely have decreased to the extent reflected in panel 9. The slight change in unit labor requirements during the years 1921 to 1927 indicates that the forces that brought about the downward trend of labor requirements in earlier years were about spent by 1921. The new forces that accentuated the decrease in labor requirements after 1927 were closely associated with the introduction of loading machines.

The curve for unit labor requirements in the "all other" group of mines remained almost constant between 1927 and 1930 as it had between 1921 and 1927. After 1930 the record is obscured by errors in reporting. The authors believe that unit labor requirements in this group of mines did not change greatly between 1930 and 1935, and this belief is strengthened by two checks made on the labor-output data for these years.

In the first place, unit labor requirements remained almost constant between 1921 and 1930 although the composition of the "all other" group changed greatly during this period. After 1930 it is true that this group included an increasingly large number of trucking mines, but the virtual equality of requirements in 1930 and 1935 indicates that trucking mines were not preeminently responsible for the intervening rise. In the second place, as originally reported to the Bureau of Mines, unit labor requirements in Group "A" mines tended to rise in the years from 1930 to 1933 as did those in mines of the "all other" group. It was possible in the case of Group "A" mines to make a correction for divided working time, and when this correction was made, the downward trend of unit labor requirements remained substantially the same during these years.

Comparative Labor Requirements With Mobile Loaders and Pit-Car Loaders

Mobile loaders and pit-car loaders are the types used almost exclusively in Illinois. The pit car is one of the simplest loading devices, being merely a mechanical aid to hand loading: the mobile loader, on the other hand, represents almost complete mechanization. In order to show the comparative effect of different types of equipment upon productivity, a study

of unit output was made for selected mines during a period of hand loading and for the same mines during a period in which loading equipment of the type being studied was in use.[8] Included in this study were 17 Illinois mines using mobile loaders and 21 Illinois mines using pit-car loaders. In the mines using mobile loaders 33 percent fewer men were required to maintain 1,000 tons of hourly capacity than had been required in the same mines during a representative period under hand loading. In the 21 pit-car mines 17 percent fewer men per 1,000 tons of hourly capacity were required than during the period of hand loading.

In discussing different types of loading equipment emphasis is directed to the fact that they apply mechanical power in varying degrees of intensity and have correspondingly different influences on unit labor requirements. The comparisons just noted illustrate this point. Figure 40 embodies a more comprehensive proof of the same point (see also table B-24). In the upper panel is shown the mechanically loaded tonnage of Group "A" mines broken down by type of mechanical equipment used, and in the lower panel is shown the composition of Group "A" average unit labor requirements by type of loading equipment.[9] Since the average effect of mechanical loading on labor output was not great prior to 1928, the following analysis by types of loaders is confined to the period from 1928 to 1935.

For mines using mobile loaders the average number of men required to maintain 1,000 tons of hourly capacity in 1928 was 1,232; this number declined to 836 in 1935, a drop of 32.1 percent. On the other hand, unit labor requirements for mines in which pit-car loaders predominated declined from 1,305 men per 1,000 tons of hourly capacity in 1928 to 1,182 in 1935, a drop of only 9.4 percent. Performance of mines that shifted from pit-car to mobile loaders followed

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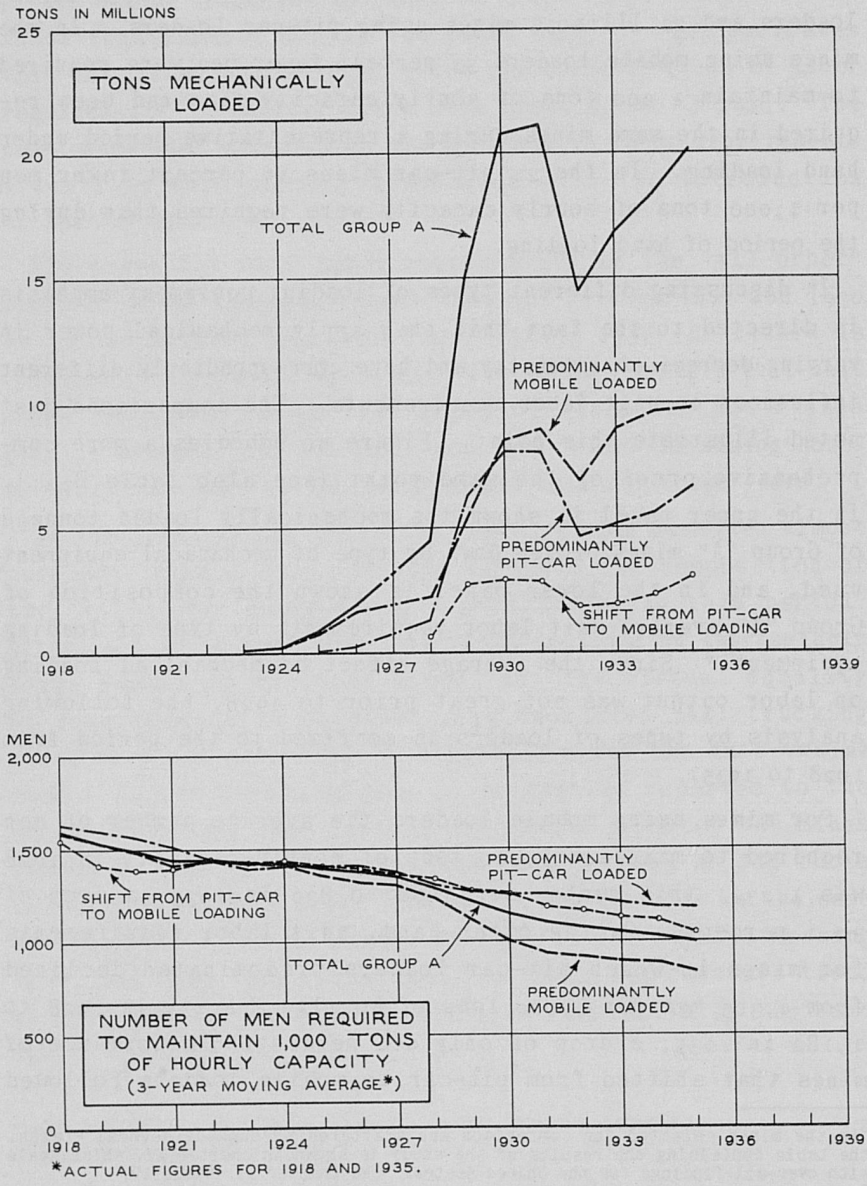
[8] As the mines selected for comparison are scattered throughout several States, the table containing the results of the study is shown in chapter XI, which deals with over-all findings for the United States. See chapter XI, table 19.

[9] The division of Group "A" mines fell logically into three groups: (1) mines that used only mobile loaders or in which they were used for at least two-thirds of the mechanically loaded tonnage for at least 3 years, (2) mines that used only pit-car loaders or in which they were used for at least two-thirds of the mechanically loaded tonnage for at least 3 years, and (3) mines that started their mechanical-loading program with pit cars and changed to mobile loaders at the end of the period. A few mines that could not be classified under any of the above groupings had to be omitted.

Figure 40.- TONNAGE MECHANICALLY LOADED AND UNIT LABOR REQUIREMENTS AT GROUP "A" MINES IN ILLINOIS, BY TYPE OF LOADING EQUIPMENT USED, 1918-85

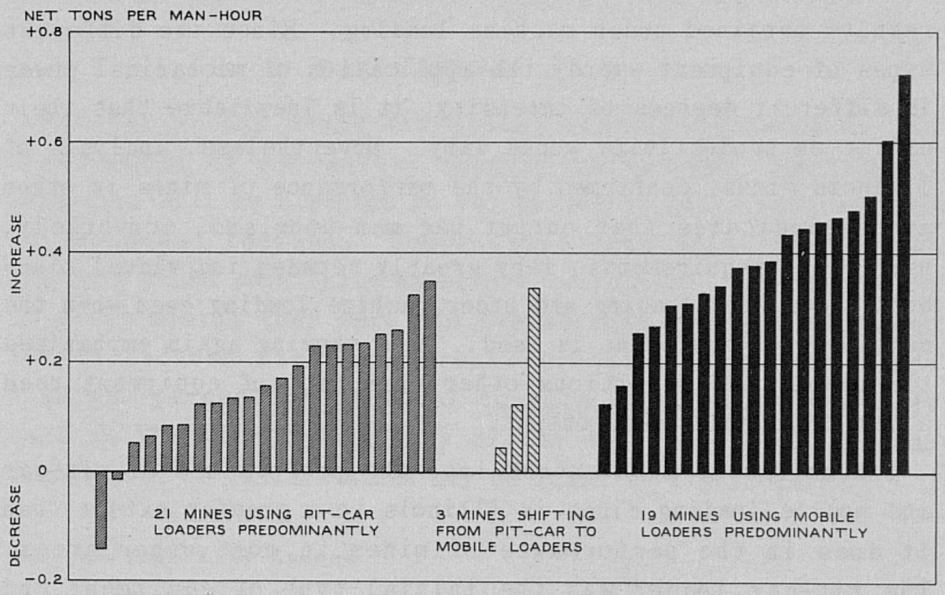


*ACTUAL FIGURES FOR 1918 AND 1935.

BASED ON TABLE B-24

MINERAL TECHNOLOGY AND OUTPUT PER MAN STUDIES
WPA-NATIONAL RESEARCH PROJECT E-166

Figure 41.- AVERAGE INCREASE (OR DECREASE) IN TONS PER MAN-HOUR IN A MECHANICAL-LOADING PERIOD, 1931-35, OVER A HAND-LOADING PERIOD, 1918-22, FOR 43 ILLINOIS GROUP "A" MINES, BY TYPE OF LOADING EQUIPMENT USED



BASED ON DATA OF THE U.S. BUREAU OF MINES

MINERAL TECHNOLOGY AND OUTPUT PER MAN STUDIES
WPA-NATIONAL RESEARCH PROJECT E-167

The figures represent the combined result of all factors influencing output per man-hour in the course of the 18 years from 1918 to 1935. The hand-loading period represents in each case the average for the 5 years 1918-22 (centering therefore on 1920). The mechanical-loading period represents in each case the average for the 5 years 1931-35 (centering therefore on 1933), except that in a few instances the mines were not loading mechanically in 1931 or 1932, in which event a shorter period was used. It is obvious that the savings reflect many other factors besides mechanical loading, such as changes in cutting, haulage, preparation, labor efficiency, and management, and also whatever alteration in seam conditions may have occurred.

roughly the course of pit-car mines until 1930 and thereafter showed a greater reduction in labor requirements. In other words, this third group consisted of mines using pit-car loaders at the beginning of the period and mobile loaders at the end of the period, and their performance reflected this fact.

The previous measures of savings have dealt with averages, but it is also valuable to show performance records in individual mines in Group "A." Figure 41 presents the average increase (or decrease) in tons per man-hour in a highly mechanized period over a hand-loading period for a selected group of 43 Illinois mines. Forty of these mines used either mobile

or pit-car loading equipment, whereas in 3 mines equipment was mixed.[10]

From the performance record of mines it becomes clear that the type of equipment used has an important influence on the results obtained under machine loading. Since the different types of equipment embody the application of mechanical power in different degrees of intensity, it is inevitable that their effect on productivity would vary. Nevertheless, analysis of Illinois mines, confirmed by the performance of mines in other areas, indicates that output per man-hour and, conversely, unit labor requirements, vary greatly between individual mines both under hand loading and under machine loading even when the same type of equipment is used. This showing again emphasized the point that conditions other than type of equipment used always influence labor output.

A time factor also enters into the performance of pit-car and mobile-loading mines in Illinois to a greater extent than it does in the performance of mines in most other areas. The pit-car loader was the initial type of equipment and represented mechanical loading in an early stage. For that reason pit-car loaders were used in the earlier years in mines that were later found to be well adapted to the use of mobile loaders. The history of mechanical loading in Illinois and Indiana has followed similar lines.

The mobile loader has undergone substantial changes in recent years with the idea of making it adaptable for use in thin seams from which it was formerly excluded because of its bulk. These changes are not expected to overcome all the effects of thin seams on productivity, but replacement of less-effective by more-effective equipment will unquestionably tend to make labor more productive under machine loading in the future than it has been in the past. The Illinois-Indiana area has been an important proving ground for mechanical loading. It follows that replacement of pit-car loaders with mobile

[10] The highly mechanized period for the majority of mines covered the years 1931 to 1935, and the hand-loading period the years 1918 to 1922. Seventy-five percent or more of the total tonnage was loaded mechanically for at least three of the five years 1931-35. The separation of mines into groups using either pit-car loaders predominantly or mobile loaders predominantly was on the basis of the mines using one type of equipment for at least two-thirds of their mechanically loaded tonnage for 3 or more years. Several mines shifted from pit-car loaders at the beginning of the period to mobile loaders at the end, and these were classified separately. This somewhat arbitrary classification was set up so that there would be a degree of comparability between the various mines shown. Thirteen mines which did not meet the above tests were not included in this selected group.

loaders in this area will have considerable significance for the industry as a whole, especially in view of current changes in design which enlarge the field of operation for mobile loaders.

INDIANA

Without in any sense minimizing the significance of the development of mechanical loading in Indiana, particular attention will be directed to the points of difference between Illinois and Indiana. Competitive conditions that faced Illinois mines were fully as severe in Indiana, and in respect to strip mining they were and are locally perhaps even more severe because strip mines have produced in recent years a larger percentage of total tonnage in Indiana than they have in Illinois. A summary of the data used in analyzing performance of Indiana mines may be found in figure 42.

Tons Mechanically Loaded

Considering the period from 1923 to 1935 as a whole, the advance of mechanical loading has been somewhat more steady in Indiana than in Illinois, and the percentage of Indiana deep-mine output loaded by machine in 1935 was 62.5 percent in comparison with 55.3 percent for Illinois. Indiana produced 12.2 percent of the total machine-loaded tonnage of the country in that year; Illinois produced 43.5 percent. The phenomenal rise in mechanically loaded tonnage that took place in Illinois between 1928 and 1930 is lacking in Indiana, but from 1932 to 1935 the increase in mechanical loading was more pronounced in Indiana.

Another significant difference between the two States concerns changes in the composition of Group "A" mines. These changes were much greater in Indiana, where a substantial number of mines were added to the group during the period and a number dropped out. Because of this the curve for loading-machine tonnage for Group "A" mines deviated more widely from the curve for Group "A-1" in Indiana than in Illinois.

The only year from 1923 to 1935 in which Group "A" mines showed a decline in mechanically loaded tonnage was 1932, when the amount was only 247,000 tons less than it had been in 1931. Group "A" mines made a striking advance between

Figure 42.- COMPARATIVE PERFORMANCE IN INDIANA OF UNDERGROUND MINES WHICH HAVE ADOPTED MECHANICAL LOADING AND OF ALL OTHER UNDERGROUND MINES, 1918-35

(Strip mines are excluded)

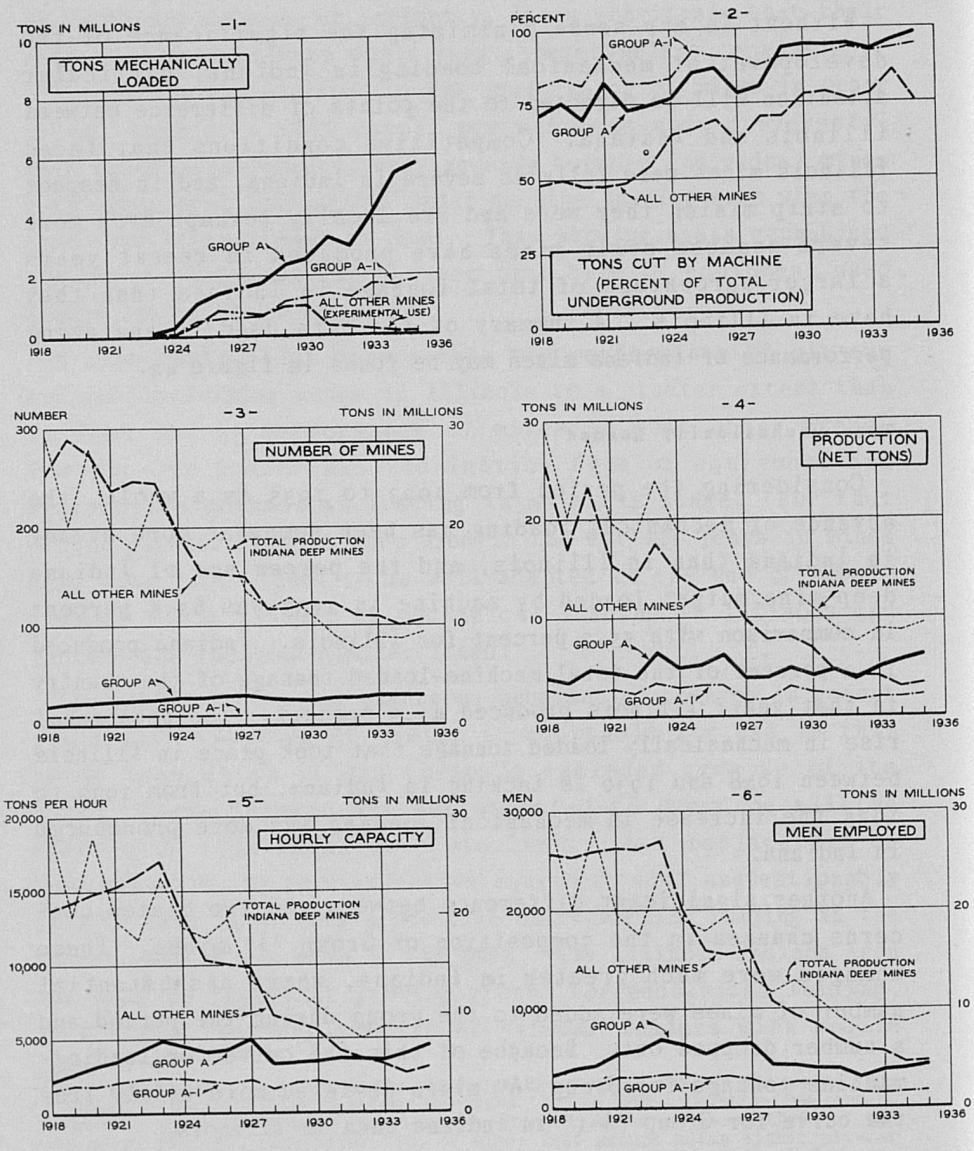
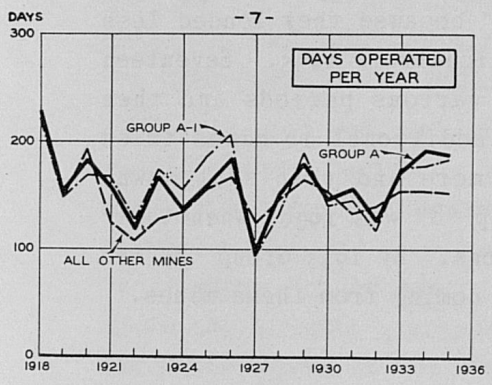
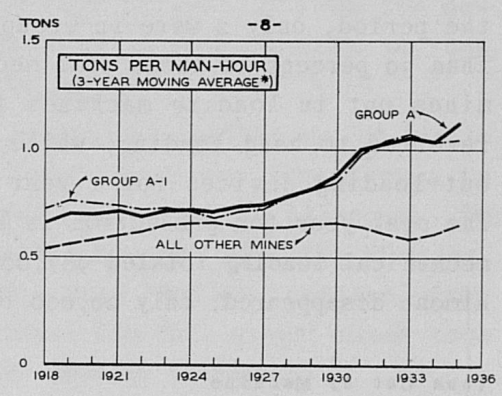
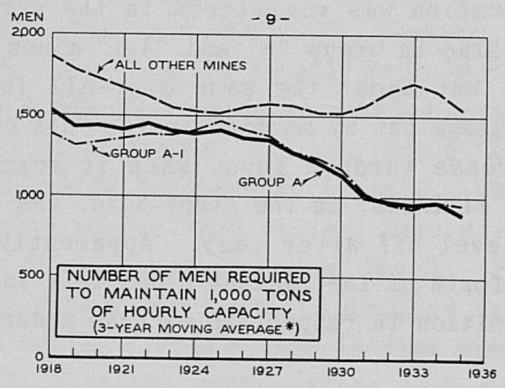


Figure 42.- COMPARATIVE PERFORMANCE IN INDIANA OF UNDERGROUND MINES WHICH HAVE ADOPTED MECHANICAL LOADING AND OF ALL OTHER UNDERGROUND MINES, 1918-85 - *Continued*

(Strip mines are excluded)







* ACTUAL FIGURES FOR 1918 AND 1935.

FOR DESCRIPTION OF GROUPS OF MINES SEE PP 295-8.
BASED ON TABLE B-25

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1932 and 1935 as more mines in the group turned to mechanical loading. Group "A-1" mines advanced only moderately during these years.

Many of the earlier installations in Indiana were short-lived, sometimes on a trial basis, and frequently discarded after a short period. Of 29 mines classified in Group "B" over the period, only 2 were in Group "B" because they loaded less than 30 percent of their coal mechanically in 1935. Seventeen mines put in loading machines for various periods and then reverted to hand loading, while an additional 10 mines tried out loading devices for 1 year or more and then shut down. The peak year for production in Group "B" was 1930, when their mechanical loading totaled 987,000 tons. By 1935 Group "B" had almost disappeared, only 20,000 tons coming from these mines.

Tons Cut by Machine

A greater fluctuation was registered in the percentage of tonnage cut by machine in Group "A" and "A-1" mines in Indiana than in Illinois, but about the same over-all increase occurred. The percentage cut by machine in the "all other" group continued to increase through 1934, when it reached a peak of 86 percent. In Illinois, on the other hand, the "all other" group tended to level off after 1927. Apparently no let-up occurred in the efforts of the Indiana mines left in this group to better their position in respect to machine undercutting.

Number of Mines

In Illinois the total number of mines in Group "A" decreased over the years; in Indiana the end of the period saw 9 to 10 new mines in the picture. There were only 10 mines in the identical series Group "A-1" in Indiana, a smaller percentage of the total "A" group than in Illinois.

The "all other" group in Indiana decreased in number from 291 in 1919 to a low of 100 in 1934 with a small increase indicated in 1935. In Illinois the drastic liquidation in number of mines was stopped in 1931, after which the number increased through 1935. The apparent difference between the two States is partly a matter of statistical coverage, the returns for small mines in Indiana being less complete.

Production

The deep-mine industry in Indiana suffered more severe tonnage loss than in Illinois. In 1918 underground production was 29 million tons; in 1929 it had declined to 13 million, a loss of 55 percent. During the depression years a further decline to $7\frac{1}{2}$ million tons in 1932 occurred. From the depression low, tonnage increased to 10 million tons in 1936 and then dropped to 9 million in 1937.

Between 1918 and 1926, when mechanical loading was of little significance, output in the Group "A" mines rose from 4 to 6 million tons, the trend paralleling that of Illinois. It should be noted in this connection, however, that the identical "A-1" mines in Indiana showed a much smaller increase, from 2,800,000 to only 3,253,000 tons. The "all other" mines took the whole impact of the over-all loss in tonnage.

In the period 1927-32, when Group "A" mines were intensifying their efforts to mechanize loading, production showed little variation - ranging roughly from $3\frac{1}{2}$ to $4\frac{1}{2}$ million tons. Indiana "A" mines registered an advance between 1932 and 1935 from $3\frac{1}{2}$ to 6 million tons. In 1935 Group "A" mines were doing the same volume of business as in 1926. The "A-1" mines did not fare quite so well and in 1935 were still over a million tons short of reaching the 1926 level. Production in the "all other" group continued to decline from 1927 to 1934. The ability of the Illinois hand-loading mines to retain their relative place in the market after 1929 was not paralleled in Indiana.

Summarizing the period as a whole, Group "A" and "A-1" mines were able to hold their own in the face of a disastrous decline in the total business of the area. Because of the tremendous tonnage losses taken in the group of hand-loading mines, the "A" mines were able to increase their share of the tonnage from 13 percent in 1918 to 65 percent in 1935.

Hourly Capacity

Hourly capacity in both "A" and "all other" mines increased sharply up to 1923. Since then the capacity of the "A" group has remained much the same, indicating that increased mechanization of loading has not caused further expansion of capacity. Failure of capacity in the "all other" group to

adjust itself to declining production levels in the immediate post-war years was remedied after 1923, and the tremendous drop in capacity reflects the drastic liquidation of this period.

Men Employed

Employment has suffered serious declines in Indiana. In 1923, 33,780 men were employed in underground mines; by 1934 this number had fallen to 8,487 and in 1935 it increased to 8,765.

Most of this shrinkage occurred in the hand-loading mines. Although the number of jobs in Group "A" mines decreased by 40 percent in 1935 from the peak employment year 1923, the group so increased its share of the total business that reduction in jobs was much less than it was for the "all other" group. The over-all loss in employment in the hand-loading mines was from 27,000 in 1923 to 4,652 in 1935, a decline of 83 percent.

A miner's chance of holding his job in Indiana was much better, taking the 17-year period as a whole, in a Group "A" mine than in a hand-loading mine. Of every 1,000 jobs in Group "A" in 1923, 600 jobs remained in 1935. In the hand-loading mines, on the other hand, only 170 jobs were left in 1935 for every 1,000 available in 1923.

It should be noted that the figures for men employed in 1935 represent, in the case of certain mines known to have operated under staggered-work agreements, the average number working rather than the total number on the rolls. If allowance were made for the practice of dividing work, the total number of men on the pay rolls would be increased by several hundred workers, most of whom were employed at the mechanized mines.

Days Operated per Year

Superiority in annual working time in Group "A", compared with "all other" mines, was not so pronounced in Indiana as in Illinois. In recent years, however, Group "A" mines have shown a considerable advantage over the hand-loading group, amounting to 17 days in 1933, 39 days in 1934, and 36 days in 1935.

When the question of employment opportunity is viewed from the joint angle of men employed and of days operated, it

becomes clear that the group "all other" mines has been largely forced out of the employment picture.

Tons per Man-hour and Number of Men Required to Maintain 1,000 Tons of Hourly Capacity

The curves of unit labor requirements for mechanical-loading mines have the same general trends in Indiana as in Illinois. In the period prior to 1927, when the influence of mechanical loading was unimportant, Group "A" mines showed a gradual decline in man-hour requirements. Between 1928 and 1935, when mechanical loading in "A" mines increased from 46 to 95 percent of Group "A" output, labor requirements were sharply reduced. Although no single item can be cited as the sole cause of this sharp decline, the fact remains that the downward trend appeared simultaneously with the rapid increase in mechanical loading.

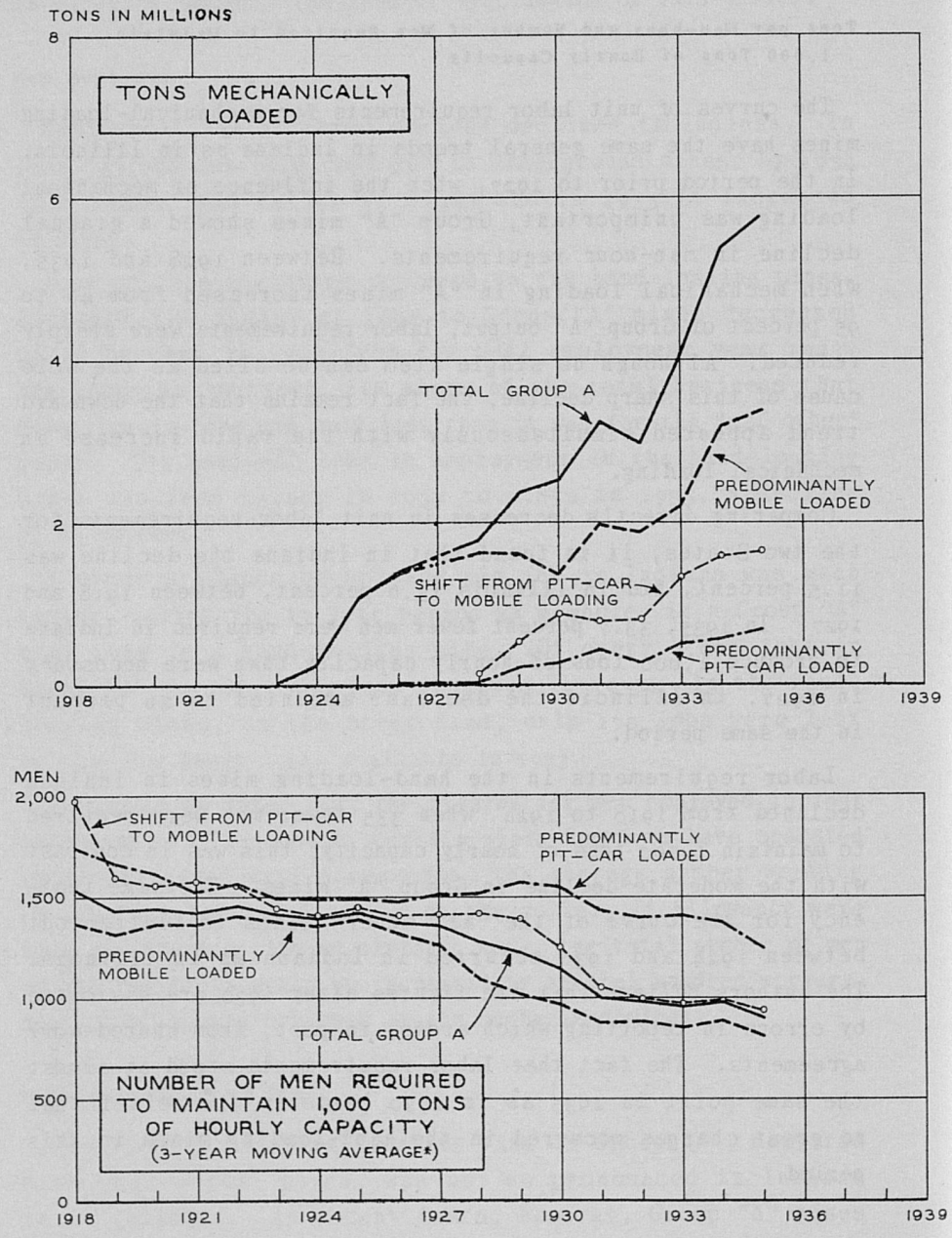
Comparing directly decreases in unit labor requirements for the two States, it is found that in Indiana the decline was 11.5 percent, and in Illinois 15.6 percent, between 1918 and 1927. In 1935, 33.7 percent fewer men were required in Indiana to produce 1,000 tons of hourly capacity than were necessary in 1927; in Illinois the decrease amounted to 26 percent in the same period.

Labor requirements in the hand-loading mines in Indiana declined from 1918 to 1924, when 335 fewer men were required to maintain 1,000 tons of hourly capacity; this was in contrast with the moderate decline in Group "A" mines. The same tendency for the curve of the "all other" mines to flatten out between 1924 and 1930 occurred in Indiana as in Illinois. The authors believe that the figures after 1930 are distorted by errors in reporting which arose, in part, from shared-work agreements. The fact that labor requirements stood at almost the same point in 1935 as in 1930 leads to the belief that no great changes occurred in the hand-loading mines in this period.

Comparative Labor Requirements With Mobile Loaders and Pit-Car Loaders

In Indiana the pit-car and the mobile loader were used almost exclusively although in recent years a few mines have installed conveyors. The upper panel of figure 43 shows the composition

Figure 48.- TONNAGE MECHANICALLY LOADED AND UNIT LABOR REQUIREMENTS AT GROUP "A" MINES IN INDIANA, BY TYPE OF LOADING EQUIPMENT USED, 1918-35



*ACTUAL FIGURES FOR 1918 AND 1935.

BASED ON TABLE B-29

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of Group "A" tons mechanically loaded by type of equipment which predominated, and the lower panel shows unit labor requirements by type of equipment (see also table B-29). The important fact brought out in the chart is the considerably greater reductions in man-hour requirements made in mines that used mobile loaders. The mines that used pit-car loaders showed the smallest decreases, and mines that shifted from pit-car to mobile loaders followed roughly the course of pit-car mines up to 1929, after which reduction in labor requirements was accelerated. Inasmuch as these mines loaded predominantly with pit-car loaders before 1929 and switched to mobile loaders during the following years, the showing of this group in reference to the relative efficiency of the two types of loaders tends to confirm conclusions indicated for the other two groups.

COMPOSITE EMPLOYMENT FACTORS IN THE ILLINOIS-INDIANA AREA

In the case of Group "A" mines in Illinois, which utilized different types of loading equipment, many significant differences in performance are concealed in group averages. This is true within individual States in respect to nearly all the items analyzed, and it is of course even more true when data for different States are combined. Nevertheless, Illinois and Indiana together constitute in many respects a major area in the bituminous industry, an area that possesses sufficient identity to differentiate it from other important coal-producing areas of the country.

The authors believe that the foregoing analysis makes it clear that mechanical loading, taken together with all the other items of mine operation essential to its success, has substantially decreased unit labor requirements; however, it must also be recognized that a decrease in unit labor requirements is no new phenomenon. It has become especially significant during the past two decades because of the sharp decline in the amount of bituminous coal that the market has been able to absorb. Considering all the mines in the Illinois-Indiana area for the period from 1918 to 1935, declining business has been the major cause of declining employment.

Although more employment would have been provided in 1935 if mechanical-loading mines had continued under the 1927 labor

requirements, it is clear that business would have been lost unless costs were materially reduced. A striking fact which emerges from analysis of performance for Group "A" mines from 1928 to 1935 is the rapid decline of unit labor requirements. Since no data are available for measuring the volume of employment that came from the business salvaged through loading by machine, that item in the employment situation must remain a matter of speculation although it is believed that the amount of business and employment salvaged was quite substantial.

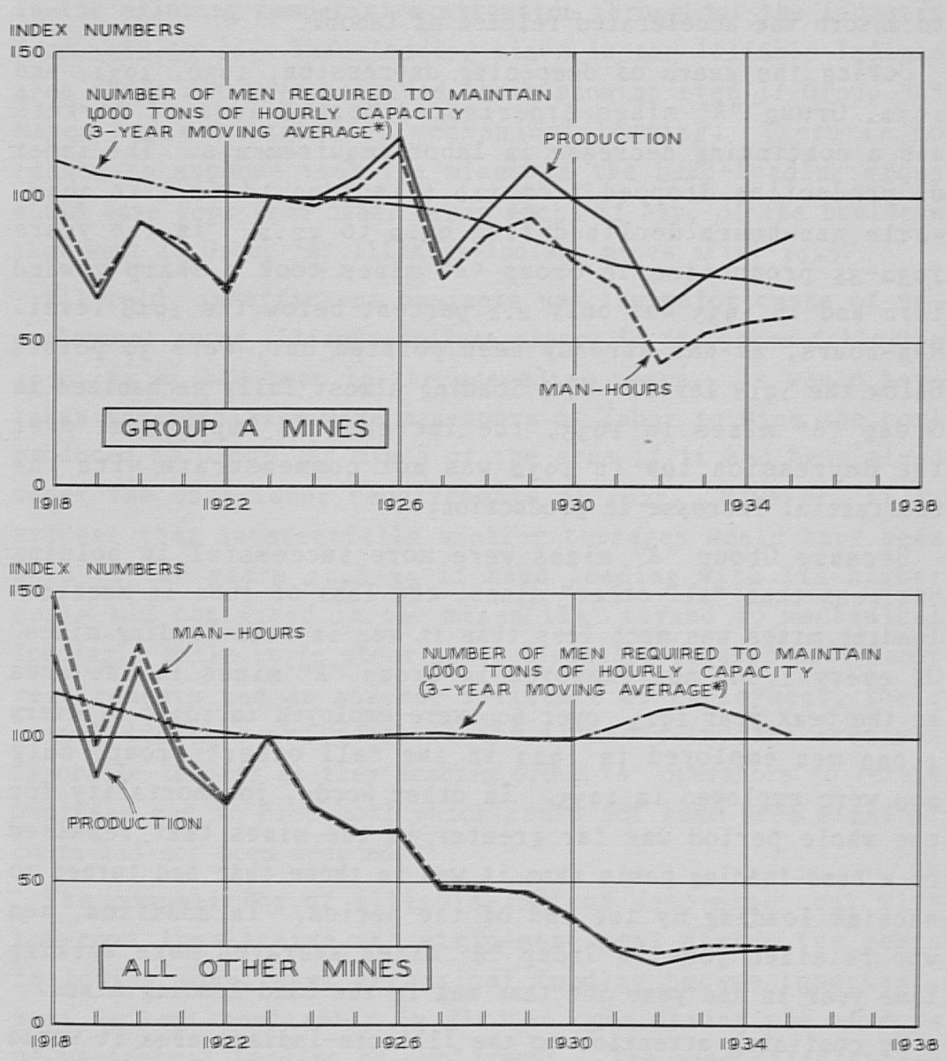
Figure 44 shows, for the period 1918-35, indexes of total man-hours, underground production, and number of men required to maintain 1,000 tons of hourly capacity for Group "A" and for "all other" mines. The base year used was 1923. It will be seen that the index of the number of men required to maintain 1,000 tons of hourly capacity in Group "A" mines declined steadily throughout the period. In the "all other" mines man-hour requirements remained almost constant after 1923. The recorded advance between 1931 and 1934 is believed to have resulted from faulty reporting under the conditions of the depression years. The trend is better shown by the more accurate observation of 1935 which indicates little change from the predepression level. In this group of mines which did not turn to mechanical loading the greatest single cause of lost employment was the closing of mines that could not survive. Employment opportunity for the period as a whole was conditioned almost entirely by the demand for coal. Indexes of both production and man-hours dropped over the period, production declining from 128.1 in 1918 to 27.1 in 1935 and man-hours from 148.6 to 27.4 in the same period.

Group "A" mines, able to survive the decline in the industry, became predominantly mechanical-loading mines after 1928. Mechanical loading unquestionably exerted a large influence in enabling these mines to combat adverse conditions, but the fact remains that throughout the period they were superior to the "all other" mines in resource conditions, financial stability, management, equipment, and market connections. Changes in unit labor requirements had a greater influence on employment opportunity in this group than they did in the "all other" group.

In 1935 the index of Group "A" tonnage, 86.4, was almost the same as it was in 1918, but the index of man-hours in 1935

Figure 44.- INDEXES OF PRODUCTION, MAN-HOURS, AND UNIT LABOR REQUIREMENTS AT GROUP "A" AND "ALL OTHER" MINES IN THE ILLINOIS-INDIANA AREA, 1918-35

(1928=100)



*ACTUAL FIGURES FOR 1918 AND 1935.

FOR DESCRIPTION OF GROUPS OF MINES SEE PP. 203-5.

BASED ON TABLE B-30

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had dropped 39 points below the 1918 level. Between 1918 and 1926 unit labor requirements declined from an index of 112.1 to 97.0. On the other hand, the trend of production and man-hours was upward, and this partly counteracted the effect of declining labor requirements on employment.

Tonnage mechanically loaded in Group "A" mines was increasing in 1928 and 1929. Even though production rose in those years from the low point reached after the 1927 strike, employment opportunity lagged; the market did not increase sufficiently to absorb the accelerated release of labor.

During the years of deepening depression, 1930, 1931, and 1932, Group "A" mines experienced both a loss of markets and a continuing decrease in labor requirements. The index of production dropped from 110.6 in 1929 to 60.1 in 1932, while man-hours declined from 92.2 to 42.2. In the years 1932-35 production in Group "A" mines took a sharp upward turn and in 1935 was only 2.1 percent below the 1918 level. Man-hours, as has already been pointed out, were 39 points below the 1918 level. With loading almost fully mechanized in Group "A" mines in 1935, the increase in employment over the depression low in 1932 was not commensurate with the substantial increase in production.

Because Group "A" mines were more successful in holding business than "all other" mines, the loss of jobs in machine-loading mines was much less than it was in hand-loading mines. Of every 1,000 men employed in Group "A" mines in the area in the peak year 1923, over 600 were employed in 1935; of every 1,000 men employed in 1923 in the "all other" group, only 300 were employed in 1935. In other words, job mortality for the whole period was far greater in the mines that remained on a hand-loading basis than it was in those that had turned to machine loading by the end of the period. In addition, men who retained jobs in Group "A" mines averaged more working time year in and year out than men in the hand-loading mines.

By confining attention to the Illinois-Indiana area it would be possible to conclude that when Group "A" mines took business that they could not have secured under hand loading they thereby diminished the business and the employment available for hand-loading mines. Such a conclusion, however, would ignore the fact that Group "A" mines were much more successful than the other group in combating adversity long before mechanical loading became important.

The most disastrous losses of tonnage and liquidation of mines in the "all other" group occurred between 1923 and 1928 when machine loading was not a major factor in Group "A" mines.

In Indiana this decline continued through to 1935, but in Illinois, because of the increase in trucking mines, the hand-loading group was strengthened and able to hold its relative share of business after 1931. It seems fair to infer that in the existing competitive situation throughout the industry from 1928 to 1935 hand-loading mines in the Illinois-Indiana area could not have bettered their showing even if Group "A" mines had not turned to mechanical loading. There is no reason to suppose that the mines in the hand-loading group could have kept from other areas much, if any, of the business that went to Group "A" Illinois-Indiana mines after 1928.

All told, insufficient business was the major cause of unemployment among Illinois-Indiana miners in the years following 1928, as it had been in the preceding years. It would have taken substantially more man-hours of labor to mine the coal produced by Group "A" mines of the area if it had been mined under the unit labor requirements of 1927. However, it is evident that substantially smaller tonnages would have been sold in the years 1928-35 if hand loading with its higher costs had continued in the mines that turned to mechanical loading. While it is clear that, directly, reduced unit labor requirements had an adverse influence on employment, their actual indirect influence in the Illinois-Indiana area was favorable insofar as they enabled Group "A" operators to retain business and to mine coal which could not have been mined if costs had not been reduced.[11]

The competition of Illinois-Indiana deep-mine coal with low-cost Appalachian and strip-mine coal during the years following 1927, when mechanical loading became important, must be kept constantly in mind in considering the effects of mechanical loading on employment. The wage differential

[11]Differences in costs under different degrees of mechanization are shown in the following producing, administrative, and selling costs of the National Bituminous Coal Commission for the period April to December 1937. (Refer to Docket No. 15, Exhibit Nos. 190, 186, 189, 187, and 188, respectively, for Illinois, and Exhibit Nos. 213, 209, 212, 210, and 211 for Indiana. These are available to the public in printed form at the offices of the National Bituminous Coal Commission in Washington, D. C.) Interest charges are not included.

State	All mines	Strip mines	Deep mines		
			All	Mechanical-loading	Hand-loading
Illinois	$1.76	$1.43	$1.87	$1.75	$2.18
Indiana	1.64	1.46	1.80	1.76	1.96

Mines classified as "mechanical-loading" loaded over half their tonnage mechanically. Other deep mines were classified as "hand-loading."

which Illinois-Indiana mines suffered prior to 1933 was greatly modified when substantially the whole bituminous industry was brought under collective bargaining and National Recovery Administration codes. Strip-mining competition, however, has been growing in intensity since 1933 and is an important factor in the Illinois-Indiana marketing situation. A new factor is the sudden advance of mechanical loading in West Virginia since 1935.

CHAPTER IX

PERFORMANCE OF MECHANICAL- AND HAND-LOADING MINES IN THE FAR WEST*

The influence which even the limited bituminous output of the far West might exert nationally is diminished by the remoteness of those mines from the great consuming centers of the East and the Middle West. Under these circumstances possible markets for coal are confined largely to local domestic consumption, to consumption in local industries, particularly metallurgical industries, and to supplying railway fuel.

In the practical working out of production and distribution the domestic market has furnished the main outlet for commercial producers, since both metallurgical and railway fuel have been produced largely in captive mines and disposed of to the affiliated railways or industrial corporations. In some cases the difficulties of commercial producers have been intensified by the fact that captive mines have disposed of surpluses in the commercial market. Sparsity of population is, of course, another limitation upon the possible development of commercial markets, and this inherent difficulty has been aggravated by the competition of oil and gas in several far Western areas.

The prevalence of captive mines has resulted in the tonnage of the far West being produced in large part by concerns that have had relatively large holdings and that, from the standpoint of corporate strength and management, have been in a favorable position to install technical improvements whenever it appeared profitable to do so. Relieved of the market fluctuations incident to highly competitive commercial production, captive mines have been able to plan their production on an annual basis with a prospect that schedules could be successfully maintained, subject only to changes which the business cycle made in the requirements of parent concerns. In these circumstances mechanization programs were relatively immune from some of the most serious hazards that confront commercial mines.

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*By Willard E. Hotchkiss, Frederick G. Tryon, and Charlotte K. Warner.

Figure 45.- COMPARATIVE PERFORMANCE IN WYOMING OF UNDERGROUND MINES WHICH HAVE ADOPTED MECHANICAL LOADING AND OF ALL OTHER UNDERGROUND MINES, 1918-35

(Strip mines are excluded)

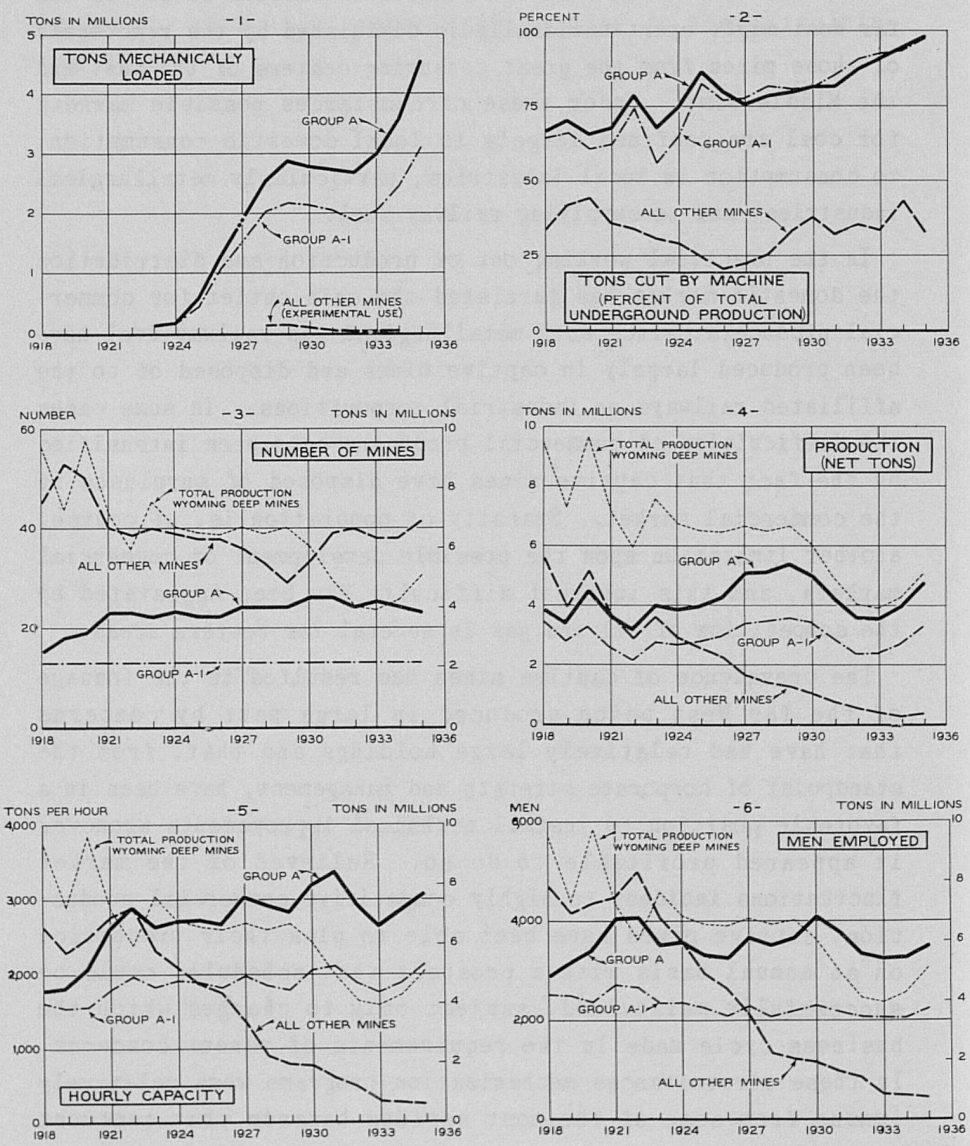
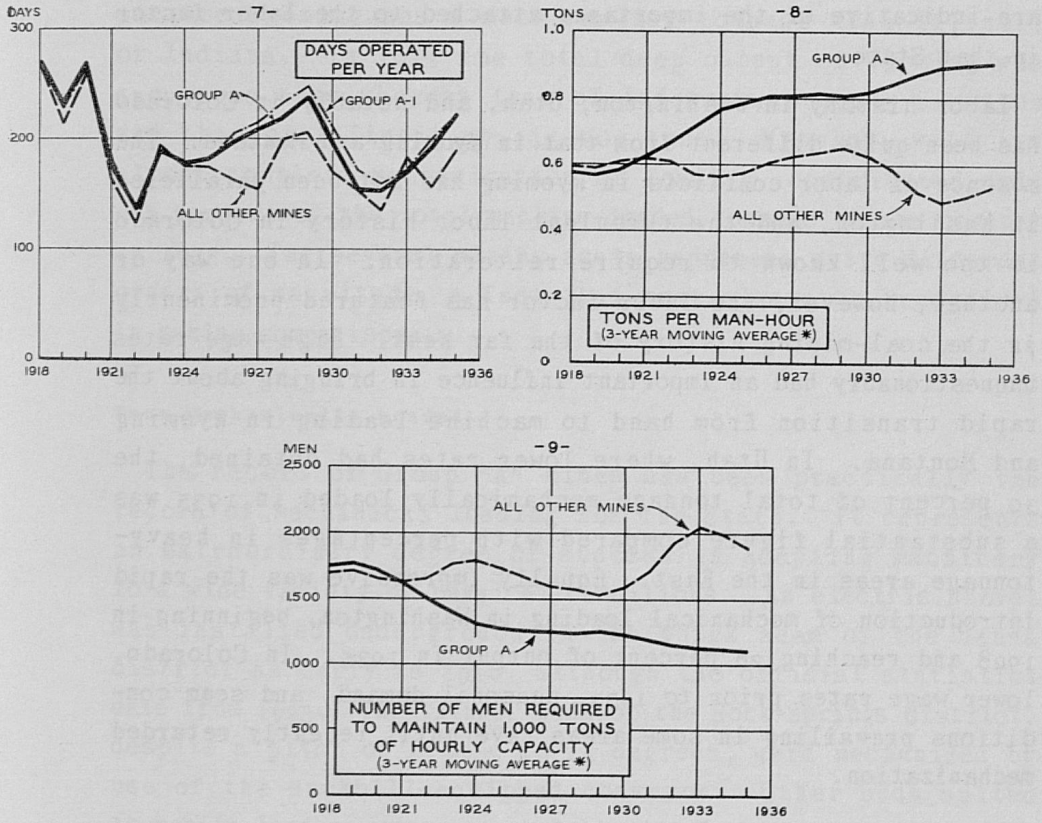


Figure 45.- COMPARATIVE PERFORMANCE IN WYOMING OF UNDERGROUND MINES WHICH HAVE ADOPTED MECHANICAL LOADING AND OF ALL OTHER UNDERGROUND MINES, 1918-85 - *Continued*

(Strip mines are excluded)



* ACTUAL FIGURES FOR 1918 AND 935. GROUP "A" INCLUDES THE HAND-LOADING OPERATIONS OF THE UNION PACIFIC COAL COMPANY AT HANNA, RELIANCE ROCK SPRINGS, SUPERIOR, AND WINTON WHICH COULD NOT BE ACCURATELY SEPARATED FROM THE MECHANICAL-LOADING OPERATIONS IN THE RECORDS OF TONS PER MAN-HOUR AND NUMBER OF MEN REQUIRED TO MAINTAIN 1,000 TONS OF HOURLY CAPACITY. FIGURES FOR GROUP "A-I" MINES WERE NOT COMPUTED FOR THESE PANELS.

FOR DESCRIPTION OF GROUPS OF MINES SEE PP. 203-5.

BASED ON TABLE B-31

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Added to all these items is the fact that the northern portion of the far West has always been high-wage territory. The highest wage rate for the whole industry is found in Montana and the next highest in Wyoming. The long history of union agreements and peaceable relations in Wyoming, as well as the safeguards given to labor in connection with mechanization, are indicative of the importance attached to the labor factor in that State.

Labor history in Washington, Utah, and notably in Colorado has been quite different from that in Wyoming and Montana. The absence of labor conflicts in Wyoming has not been paralleled in Washington, and the turbulent labor history in Colorado is too well known to require reiteration. In one way or another, however, the labor factor has featured prominently in the coal-mining history of the far West. High wage rates unquestionably had an important influence in bringing about the rapid transition from hand to machine loading in Wyoming and Montana. In Utah, where lower rates had obtained, the 30 percent of total tonnage mechanically loaded in 1935 was a substantial figure compared with percentages in heavy-tonnage areas in the East. Equally impressive was the rapid introduction of mechanical loading in Washington, beginning in 1928 and reaching 28 percent of output in 1935. In Colorado, lower wage rates prior to 1933, seasonal demand, and seam conditions prevailing in some areas have until recently retarded mechanization.

WYOMING

Wyoming is the most important center of mechanical loading in the far West. As in Indiana and Illinois, mining was carried on during the period of this study under relatively high wage rates. Physical conditions, though different from those in the Illinois-Indiana area, were nevertheless conducive to a mechanical-loading program. The largest company in Wyoming, The Union Pacific Coal Company, not only pioneered in installing loaders but developed the special duckbill self-loading head for shaking conveyors. Performance of Wyoming mines has been charted in figure 45.

In 1923, 1.4 percent of deep-mine output was loaded mechanically, and this increased to 89.8 percent in 1935. In 1936

there was a further increase, to 92.2 percent, and the National Bituminous Coal Commission estimated the same percentage in 1937. Wyoming leads all States in regard to percentage of total output loaded by machine and, for practical purposes, the industry in the State has become completely mechanized. It must be kept in mind, however, that in terms of the national picture Wyoming has a much smaller tonnage than Illinois or Indiana. In 1935 the total deep output of Wyoming was 5,043,000 tons whereas that of Indiana was 9,233,000 tons and that of Illinois 37,115,000 tons. Wyoming, with its almost complete mechanization of loading, contributed only 9.6 percent of the total machine-loaded tonnage of the country in 1935. The several mining areas represent quite different orders of magnitude, a fact that must always be recognized in making comparisons.

Tons Mechanically Loaded

The record of Group "A" mines has been practically the record of mechanical loading for the State. It represents an extraordinary degree of success in adapting machinery to a wide variety of physical conditions. An electric shovel was installed underground in the thick seam of the Hanna district as early as 1916, although the official statistics date from 1923. The thinner beds of the Rock Springs district, despite a pitch of from 5 to 15 degrees, were mechanized by use of the duckbill-equipped conveyor. Other beds suited to mobile loaders were successfully developed.

Tons Cut by Machine

Machine cutting in Group "A" mines rose from 66.8 percent in 1918 to 98.2 percent in 1935. In the case of "all other" mines the tonnage cut by machine has remained small. Many of the mines in this group, especially at the end of the period, represented small operations where cutting machines have not been used in the past.

Number of Mines

The number of mines in Group "A" rose from 15 in 1918 to 23 in 1921 and remained fairly stable throughout the rest of the period. There were 13 mines in Group "A-1."

The group of "all other" mines declined from 53 in 1919 to 29 in 1929 and then increased to 41 in 1935. The increase in number at the end of the period was almost entirely in the group of smallest mines with an annual production of less than 10,000 tons and represented mainly small trucking operations. Although the number of these concerns increased, it will be noted in panel 4 that there was no corresponding increase in production. Mines falling in the group producing less than 10,000 tons annually have for many years contributed less than 2 percent of the total output of the State.

Production

The coal industry in Wyoming suffered severe inroads after the World War; however, when adjustments to a new level were made in 1924, production was sustained for a period of years. Between 1924 and 1930 total production remained almost constant, fluctuating between 6,000,000 and 6,750,000 tons. The decline during the depression years was severe and output reached a low of 3,919,000 tons in 1933.

At the beginning of the period, in 1918, Group "A" mines contributed 41.1 percent of the total underground tonnage of the State; by 1935 this group was producing 93.5 percent of the tonnage. At the end of the period the only survivors in the "all other" group were the trucking mines and a few rail mines whose seam conditions were a barrier to mechanization.

In Illinois and Indiana the ability of Group "A" mines to continue in the face of declining markets was believed to be the direct result of their success in mechanical loading; because of lower labor costs per ton they were able to hold business that would probably have gone to other areas or States.

In Wyoming the situation is complicated by the fact that from 40 to 60 percent of the Group "A" tonnage was captive coal, produced for the use of an affiliated railroad. How much, if any, of this captive outlet would have been lost had the mines in question failed to mechanize is obviously a matter of speculation. However, even a consumer operating its own mines cannot ignore the comparative cost of its own product and that of commercial coal or of fuel oil. The railroad system concerned already supplies a fourth of its requirements

with fuel oil and has ceased to operate its captive mine in Washington. Under the circumstances it is evident that a reduction in mining costs at captive as well as commercial operations helps to hold the market for coal.

The commercial mines of the State were affected by the competition of natural gas, and it is noteworthy that nearly all of those able to survive through 1935 had turned to mechanical loading.

Hourly Capacity

Capacity of both hand-loading and mechanical-loading mines increased up to 1922, when it was practically the same for both groups of mines. Thereafter Group "A" capacity continued to rise to a high of 3,386 tons per hour in 1931, followed by a sharp decline during the depression. The group of hand-loading mines absorbed about all the capacity liquidation, dropping from 2,896 tons per hour in 1922 to 231 tons in 1935.

Men Employed

The average number of men employed at Group "A" mines increased over the period as a whole, standing at 2,866 in 1918 and 3,481 in 1935 (panel 6). The fluctuations prior to 1930 were largely the result of new mines entering the group. The "A-1" identical mines have shown little change over the period in total number employed.

On the other hand, the "all other" mines, which employed 5,001 men in the peak year 1922, gave work to only 434 men in 1935.

It is clear that job opportunity was much greater in the large captive or commercial mines that adopted mechanical loading than in those mines remaining on a hand-loading basis. A man working in the "all other" mines in 1922 had only 1 chance of 10 of being employed in 1935, unless he could transfer to a mechanized mine.

Fortunately for the men in the hand-loading mines, many such transfers to the mechanized operations did take place. The largest producer in the area, operating a number of mines, followed the policy of installing loading machines no faster than the men displaced could be absorbed at other jobs in its properties under normal rates of labor turn-over and super-

annuation.[1] This policy, while perhaps foregoing immediate savings in cost, won the cooperation of labor and aided the work of management in adapting mechanization to the limitations of local seam conditions.

Days Operated per Year

Prior to 1924 the numbers of days worked in the mechanical-loading and hand-loading mines were almost identical. In the period 1925-30 the greater working time of the "A" and "A-1" mines must be considered in relation to the superior position of captive mines in affording greater opportunity for work as well as to the fact that those mines installed mechanical loading. During the depression years, however, the heavy loss in tonnage in the "A" group is reflected in the drop in the number of days of operation to such an extent that working time for mechanical-loading and hand-loading mines was again approximately the same.

Tons per Man-hour and Number of Men Required to Maintain 1,000 Tons of Hourly Capacity

In Wyoming it was not possible to show performance records of output per man-hour and unit labor requirements on the same basis as in other States. The change in the method of reporting man-hours adopted by the U. S. Bureau of Mines in 1932 caused a substantial difference in the returns of the largest producer in this area. The problem was discussed with the company during the course of this study, and a new statement of man-hours was obtained for the period 1926-35 which was more accurate than the old one and was comparable throughout the period. As the new series is clearly more informative, it has been substituted for the old one. A complication arose, however, because of the fact that the new series was compiled by camps or districts rather than by mines, the company being unable to separate the record for each mine within a given camp. To use the new series, therefore, it has been necessary to include the hand-loading mines located within the camps where mechanization occurred and, in order to keep

[1] Eugene McAuliffe, of The Union Pacific Coal Company, wrote in the *Mining Congress Journal* in February 1930 (Vol. 16, p. 94): "Early in the mechanical loading program, the policy of refusing to release men to put machines in their places was put into effect and made public. Machines were introduced only at such times and in such numbers as the natural reduction in forces made possible."

the record comparable, to include them also back to 1918, the beginning of the period studied. Specifically, therefore, the "A" series in panels 8 and 9 of figure 45 includes the hand-loading operations of the company in the Hanna, Reliance, Rock Springs, Superior, and Winton districts.[2] In all, eight hand-loading mines were included in this way.

This difference in the composition of Group "A" mines, which results from the inclusion of the eight hand-loading mines referred to, must be kept in mind in examining the curves of panels 8 and 9. At the beginning of the period nearly all of the eight were operating. They began to shut down immediately after 1923. By 1928 all but two had closed, and by 1935 all of them were idle or abandoned. On the whole, these eight mines naturally represented the higher-cost operations of the company, with lower tonnages per man-hour, and they affect the Group "A" average accordingly. Their inclusion, for example, tends to lower the Group "A" curve in panel 8 during the early part of the period; there was no corresponding effect in 1935, when all of them had ceased production. For this reason, the indicated increase in the tons per man-hour from 1918 to 1935 is slightly greater than it would be if mechanized mines only were considered. The general trend of the curve, however, would remain unchanged, the increase in output per man-hour extending over the entire period from 1918-19 to 1935.

If the record is examined year by year it is evident that the output per man-hour in the Group "A" mines advanced rapidly from 1921 to 1926, slowed down for a time, and then advanced again at a somewhat less rapid pace from 1930 to the end of the period.

The increase shown from 1921 to 1926 is of interest because it occurred while hand loading was still the dominant method of production. As already noted, mechanical loading had begun in the Wyoming field even before 1923, but its contribution to the gains in productivity during this period was slight.

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[2] The company's mines in the Cumberland field, which remained on a hand-loading basis prior to their abandonment in 1930, were not included in Group "A" but were shown in the "all other" group.

It should be noted that the new series is used only in panels 8 and 9, since they are the only ones affected by the record of man-hours. In panels 1 to 7 the classification of mines into Groups "A" and "all other" is the same as the standard adopted for use in other States.

In part, the increase from 1921 to 1926 was due to the diminishing influence, as they were progressively closed down, of the eight hand-loading mines referred to. The larger part of the increase, apparently, was due to improvements effected in other ways. Just how these improvements were obtained the statistics do not disclose. It is known that machine cutting was extended during these years (panel 2), that certain properties were consolidated, and that important changes occurred in company management. The over-all result emphasizes the fact noted elsewhere that mechanical loading is only one of many influences affecting productivity, and that improvement in other types of equipment or better coordination of operations underground may result in marked savings independent of the mechanization of loading.

In the latter part of the period, from 1930 on, the increase in productivity is clearly associated with the growth of mechanical loading.

For the Group "A" mines as a whole the over-all increase in output per man-hour between 1918 and 1923 was 24.6 percent. Between 1923 and 1935 it was 26.2 percent.

The increase in productivity in Wyoming after 1923 was thus less than it was in Illinois or Indiana. Among the causes that differentiate the Rocky Mountain States from the Mississippi Valley States is the presence of pitching seams which limited the form of mechanization in many Wyoming mines to the less powerful types of machines, particularly the duckbill. In Wyoming the spread of mechanization to virtually all of the larger mines has carried it into more and more difficult seam conditions. Again, the average for Group "A" is affected by the inclusion of one large high-cost producer, whose two mines were exhausting the thicker portions of their coal. At the end of the period these two mines were facing progressively more difficult seam conditions, as evidenced by the fact that in February 1938 the mines were permanently abandoned. If this company is eliminated from Group "A", the remaining mines show a greater increase in productivity. For all these reasons, the weighted average savings in Group "A", as shown by panels 8 and 9, are probably less than the savings effected by individual operators under favorable circumstances.

Specific data for The Union Pacific Coal Company are given in a paper published by its president, Mr. Eugene McAuliffe.[3] For all mines of the company, including both hand-loading and mechanical-loading operations, the indicated output per man-hour increased as follows:

Year	Tons per man-hour	Percent loaded mechanically	Year	Tons per man-hour	Percent loaded mechanically
1923	0.581	3.32	1935	0.877	99.03
1924	.650	5.72	1936	.878	99.95
1925	.722	9.55	1937	.894	99.50
3-year weighted average	.642	6.04	3-year weighted average	.883	99.51

The increase in average output per man-hour for 1935-37 over 1923-25 in this company's experience amounts to 37.5 percent. The increase is the result of all factors operative, of which mechanical loading is but one.

Panel 9 in figure 45 is the converse of panel 8 and shows that in 1923 the Group "A" mines required 1,399 men to maintain 1,000 tons of hourly capacity; in 1926, 1,247 men; and in 1935, 1,109 men.

The fluctuations in labor requirements in the "all other" mines as shown in panel 9 reflect the changing composition of this residual group with the steady reduction in its capacity after 1922. By 1930 the tonnage of the hand-loading mines was becoming insignificant. Today it consists of truck mines and a few rail mines so located that adverse physical conditions have prevented mechanization. Under such conditions an increase in average unit labor requirements was to be expected.

MONTANA

Conditions were exceedingly favorable for the introduction of mechanical loading in Montana which was a strong union area over the whole period of the study and had the highest wage

[3] "Fifteen Years of Safety Work in Bituminous Coal Mines," *Transactions, Coal Division, American Institute of Mining and Metallurgical Engineers*, Vol. 130 (1938), pp. 468-76.

The figures for tons per man-hour have been computed from detailed data for production and man-hours. While the classes of employees covered in this paper are not the same as those called for in the reports of the U. S. Bureau of Mines, the trends indicated are similar.

Figure 46.- COMPARATIVE PERFORMANCE IN MONTANA OF UNDERGROUND MINES WHICH HAVE ADOPTED MECHANICAL LOADING AND OF ALL OTHER UNDERGROUND MINES, 1918-35

(Strip mines are excluded)

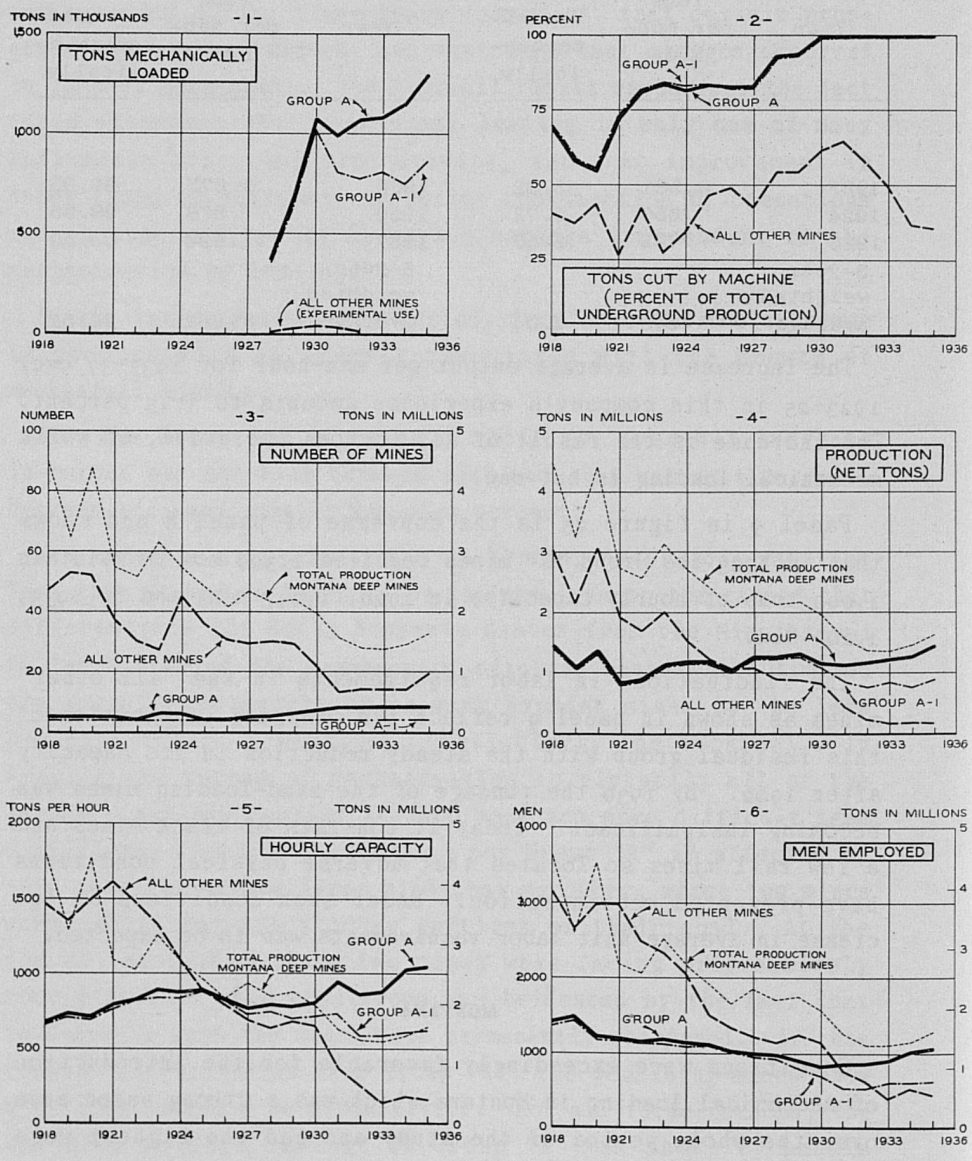
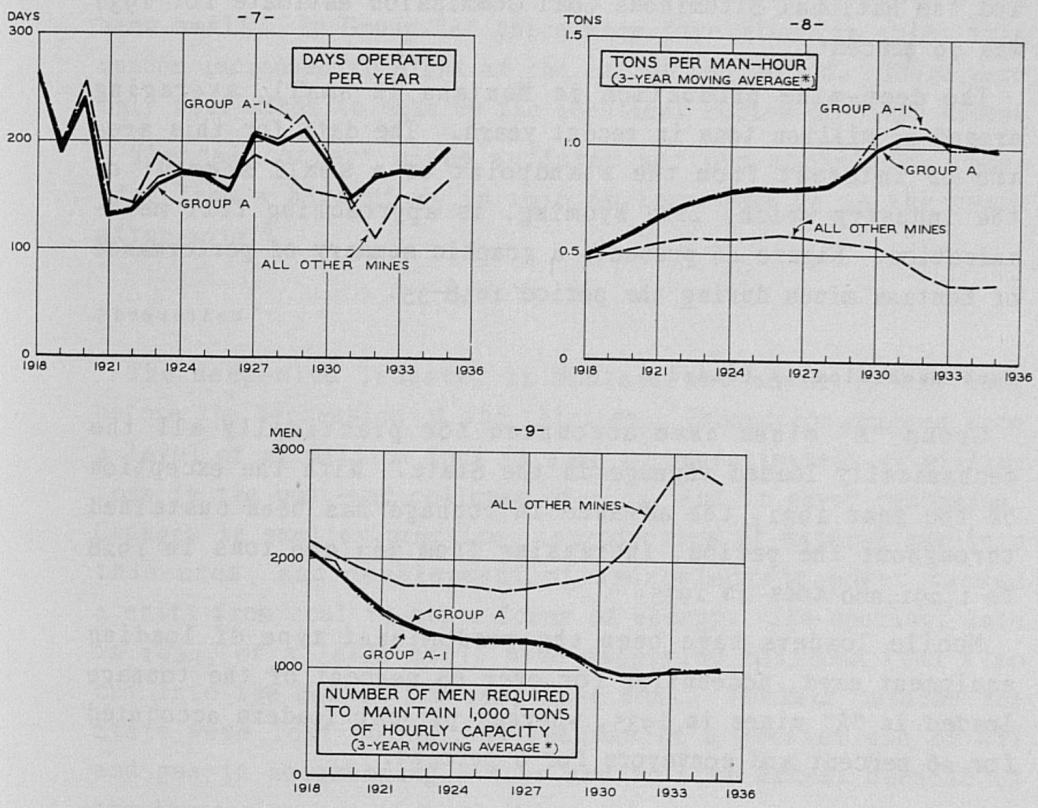


Figure 46.- COMPARATIVE PERFORMANCE IN MONTANA OF UNDERGROUND MINES WHICH HAVE ADOPTED MECHANICAL LOADING AND OF ALL OTHER UNDERGROUND MINES, 1918-35 - *Continued*

(Strip mines are excluded)



* ACTUAL FIGURES FOR 1918 AND 1935.

FOR DESCRIPTION OF GROUPS OF MINES SEE PP. 203-5

BASED ON TABLE B-35

scale in the country. Physical conditions were exceptionally well adapted for the introduction of loading machines and the corporate and managerial set-up was advantageous to a program of mechanization. As a result the percentage of the deep-mined coal mechanically loaded rose from 17.1 in 1928 to 80.3 in 1935. In 1936 the percentage increased to 83.2, and the National Bituminous Coal Commission estimate for 1937 was 79 percent.

The deep-mine production in Montana is small, averaging around $1\frac{1}{2}$ million tons in recent years. The data for this area are of interest from the standpoint of a small segment of the industry which, like Wyoming, is approaching full mechanization. Figure 46 presents a graphic summary of performance of Montana mines during the period 1918-35.

Tons Mechanically Loaded

Group "A" mines have accounted for practically all the mechanically loaded tonnage in the State. With the exception of the year 1931, the advance in tonnage has been sustained throughout the period, increasing from 363,000 tons in 1928 to 1,291,000 tons in 1935.

Mobile loaders have been the predominant type of loading equipment used, accounting for over 68 percent of the tonnage loaded in "A" mines in 1935, whereas pit-car loaders accounted for 26 percent and conveyors for 6 percent.

Tons Cut by Machine

A wide differential exists in Montana as in Wyoming between percentage of tonnage cut by machine in Group "A" and in "all other" mines. Group "A" mines increased machine cutting from 55 percent of total production in 1920 to 83 percent in 1923. No increase in cutting occurred during the next 3 or 4 years, but upon the advent of the mechanical-loading program the tonnage undercut again increased, and the 100-percent mark was reached in 1930.

Although machine cutting was increasing up to 1931 in the "all other" mines, the decline thereafter is of little significance in view of the small total tonnage produced by this group. The decline does not represent abandonment of machine cutting so much as it does the fact that the tonnage in this

group after 1931 came from small mines which had never used machines. The average yearly tonnage per mine in this group in 1935 was less than 10,000 tons.

Number of Mines

The number of mines using mechanical loading in Montana has been small. In Group "A" there were five mines in 1918; this number increased to eight at the end of the period. There were only four mines to make up the identical series of "A-1" mines.

The "all other" mines suffered serious mortality, dropping from a high of 53 in 1919 to less than 20 in the years after 1930.[4]

Production

The deep-mine industry in Montana was severely hit long before the depression of the thirties. Production dropped from a level of $4\frac{1}{2}$ million tons in 1920 to approximately $2\frac{1}{2}$ million tons in the post-war collapse of 1921, and it never recovered. Changes in smelter practice, introduction of natural gas into this area, and development of hydroelectric power caused a shift from coal to other forms of energy. The opening, late in 1924, of a large strip mine supplying railroad fuel also cut into the market for deep-mine coal. Markets outside the State were lost to Montana because of a greater use of oil and gas in neighboring States and to some extent because of the increasing use of North Dakota lignite.

Production of the "A" mines remained relatively stable over the whole period: 1,457,000 tons were mined in 1918 and 1,429,000 tons in 1935. However, the Group "A" output of about $1\frac{1}{2}$ million tons in 1918 was but 32 percent of deep production, whereas roughly the same Group "A" tonnage in 1935 was 89 percent. The operating situation in Montana, as in Wyoming, is not comparable with Illinois-Indiana conditions in that between 50 and 60 percent of the "A" tonnage came from captive mines whose output went to the parent company. In an area highly weighted with captive tonnage a permanent

[4] Attention is called to the fact that local commercial mines (mines employing less than 10 men) have been omitted from the count of the number of "all other" mines.

The number of such local commercial mines is impressive, 58 in 1935, but the tonnage contributed by them is insignificant.

trade outlet may be a much more potent influence in sustaining output than the degree of mechanization.

To summarize, Group "A" mines, to a considerable degree, were able to hold their relative position because of their corporate relationship - not primarily because they installed mechanical loading; the "all other" mines lost their markets almost entirely - not primarily from failure to install mechanization devices but because the markets of this area were being supplied by strip coal or by forms of energy other than coal. Although it may be argued that a lower selling cost made possible by a high degree of mechanization might have enabled deep-mined coal to compete more effectively with oil and gas, it seems unlikely that even complete mechanization could have reduced costs sufficiently to stem the tide.

The identical series of "A-1" mines shows a sharp divergence from Group "A" after 1930. This represents a declining tonnage in one large mine in Montana in Group "A-1", which had practically gone out of production by the end of 1935, and the inclusion of a large new mine in Group "A."

Hourly Capacity

The hourly capacity curve for Group "A" mines has shown a moderate increase over the 17-year period. Here, again, the increasing spread between the "A" and "A-1" curves after 1930 has been mainly due to the opening of a large new mine in the "A" group, which has shown an enormous increase in output per mine-hour.

Hourly capacity of the "all other" mines dropped from 1,615 tons in 1921 to a low of 135 tons in 1933 - the natural result of the tremendous drop in tonnage of this group.

Men Employed

The Group "A" curve of employment showed a consistent decline from 1,457 men in 1919 to 815 in 1930, although production in these mines during this period was slightly upward. The increase in employment after 1930 is due to the inclusion of a large new mine in the "A" series. The "A-1" mines remained at about the same level after 1930.

Loss of jobs fell almost entirely on the "all other" mines; in the peak year 1918, 3,143 men were employed, and by 1935

this group employed only 426. Otherwise stated, in the hand-loading group 9 out of 10 of the 1918 jobs were lost by 1935. In the mechanical-loading mines 3 out of every 10 men who were employed in the peak year 1919 had lost their jobs by 1935.

Days Operated per Year

Prior to 1927 the difference in working time between the two groups of mines was small, a slight advantage going to the "all other" group. The advantage in working time of the "A" group after 1927 must be considered in relation to the superior market connections of its captive mines.

Tons per Man-hour and Number of Men Required to Maintain 1,000 Tons of Hourly Capacity

Curves of productivity and unit labor requirements in Montana show much the same general trends that they do in Wyoming. The "A" mines show marked savings in unit labor requirements during the period of hand loading prior to the installation of loading machines. In 1918, 2,062 men were required to produce 1,000 tons of hourly capacity in Group "A" mines; in 1924 only 1,289 were necessary. That this decline was associated with changes in mining practice is indicated by the contemporary increase in the tonnage cut by machine shown in panel 2. Between 1924 and 1928 unit labor requirements remained about the same, an indication, perhaps, that the forces making for large savings under hand loading had been about exhausted. At the outset of the machine-loading program in 1927-28 labor requirements again started to decline. The reduction between 1926, the last year of hand loading, and 1930, when 93 percent of the output was mechanically loaded (with mobile loaders, pit-car loaders, and duckbills), was 20 percent. In a 5-year period these Montana mines changed from hand loading to almost complete mechanical loading, with the result that labor requirements showed comparatively little change after 1930.[5]

Labor requirements per unit of capacity in "all other" mines in 1918 were about equal to those in Group "A" mines.

[5]The change in method of reporting man-days and man-hours had little effect on Group "A" mines. If the same basis of "calculated" man-hours ("number of men" times "number of days mines operated" times "hours in official workday") had been used throughout the period 1932-35, labor requirements would have shown a reduction of 5 percent.

Although there was the same tendency in the hand-loading group to show a marked decline in the following years, the decrease was much less sharp than in the "A" mines, and labor requirements remained almost constant between 1922 and 1930. The increases in labor requirements after 1930 were probably due in the main to the changed composition of the group, which at the end of the period was made up largely of very small mines.

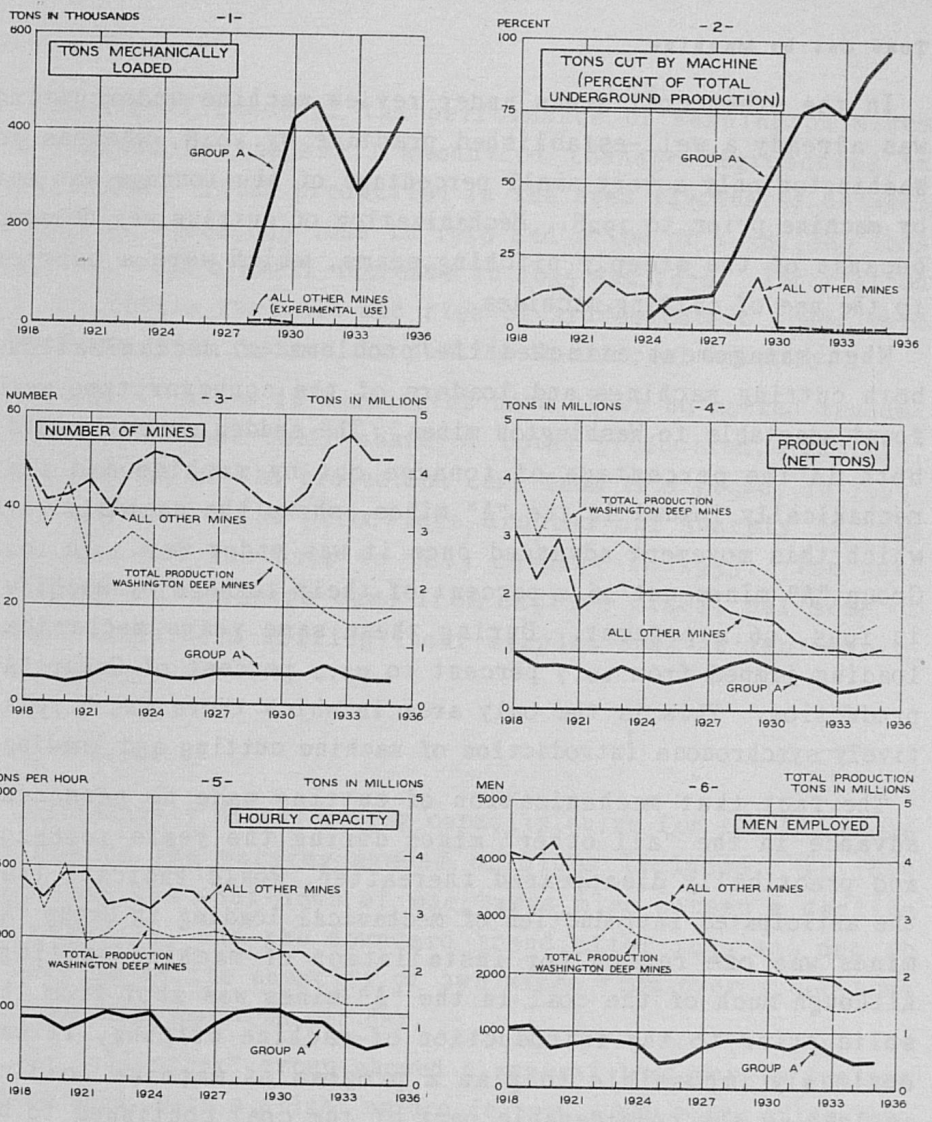
WASHINGTON

Wage scales in Washington were relatively high throughout the period of this study, but physical handicaps and labor resistance delayed mechanical loading. The coal deposits of the State range from sub-bituminous to high-rank bituminous or even to anthracite and are characterized by a great variety of physical conditions. In general, however, mining conditions are exceptionally difficult. Steeply pitching seams and bad roof necessitating close timbering occur in many mines of the State and are factors that were almost prohibitive to the introduction of mechanical loading in the earlier years. In view of such obstacles mechanical loading was not undertaken until the problem had been thoroughly studied and until experience from other areas, especially Wyoming, became available. It was surprising that mechanical loading in 1935 had advanced to cover 27.6 percent of the output. In 1936, 33.6 percent was loaded by machine, and the National Bituminous Coal Commission estimated an increase to 42 percent for 1937.

In analyzing Washington performance under hand and machine loading, the significance of these data must be considered in relation to small production, limited number of men employed, and the substantial amount of captive tonnage, as well as the physical handicaps under which coal is extracted. The great variation in physical conditions sometimes makes averages misleading. The record for Washington is interesting as a side light on mechanization from an outlying area of the industry; it is not typical of bituminous mining generally but is significant for its success in overcoming handicaps. See figure 47 for a graphic summary.

Figure 47.- COMPARATIVE PERFORMANCE IN WASHINGTON OF UNDERGROUND MINES WHICH HAVE ADOPTED MECHANICAL LOADING AND OF ALL OTHER UNDERGROUND MINES, 1918-36

(Strip mines are excluded)



FOR DESCRIPTION OF GROUPS OF MINES SEE PP. 203-5.
BASED ON TABLE B-39

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Tons Mechanically Loaded

The series of mechanized mines charted has been confined to Group "A" inasmuch as the identical series of "A-1" mines was too small to show separately. The mechanical loading of Group "B" mines was entirely negligible. Group "A" tonnage

mechanically loaded rose from 86,000 tons in 1928 to almost ½ million tons in 1931, and though there was a decline in 1932 and 1933, by 1935 tonnage loaded was almost back to the 1931 level.

Tons Cut by Machine

In the other coal areas under review machine undercutting was already a well-established practice by 1918, whereas in Washington only a very small percentage of the tonnage was cut by machine prior to 1928. Mechanization of cutting was delayed because of the steeply pitching seams, which were a barrier to the use of cutting machines.

When management attacked the problems of mechanization, both cutting machines and loaders of the conveyor type were found adaptable to Washington mines. The sudden spurt forward, both in the percentage of tonnage cut by machine and that mechanically loaded in the "A" mines, shows the rapidity with which this movement advanced once it was under way. In 1928 Group "A" mines cut 26.4 percent of their tonnage by machine; in 1935, 96.4 percent. During these same years mechanical loading jumped from 10.7 percent to 91.1 percent of Group "A" production. This is the only area in which there was a relatively synchronous introduction of machine cutting and loading.

The fact that mechanization of cutting made no permanent advance in the "all other" mines during the years 1918-29, and practically disappeared thereafter, would indicate that the anticipated introduction of mechanical loading in Group "A" mines was one reason for installation of machine cutting. Although much of the coal in the "A" mines was shot from the solid prior to the introduction of machine cutting, it was obviously impossible to plan a program of machine loading as long as any considerable part of the coal continued to be undercut by hand.

Number of Mines

The number of mines in the "A" group has been small. There were five in 1918, an increase to eight in 1932, and a drop back to five in 1934 and 1935. Disclosure of individual operations prevented the inclusion of the "A-1" series of identical mines.

There has been no persistent downward trend in number of "all other" mines as has been noted in other areas. The sharp upward swing after 1930 was due to the increase in the number of trucking operations.

Production

The significance of the performance of Washington mines is limited by the small amount of tonnage represented in this State. Total production in the area fluctuated between a high of 4,082,000 tons in 1918 and a low of 1,383,000 tons in 1934, with a small increase in 1935 and 1936. Importation of California fuel oil and rise of hydroelectric power were among the chief reasons for decline in the coal industry.

Group "A" mines in Washington have shown no marked tendencies to increase their share of total production. In 1918, 24.4 percent of the production came from this group; in 1929, 35.8 percent. The percentage dropped off sharply in 1933 and 1934 but was back to 30.3 percent in 1935. The bulk of Group "A" tonnage came from captive mines, but some of these mines were selling their surplus coal in the commercial market.

Hourly Capacity

Irregularity of the hourly capacity curve for the "A" mines is due to the varying number of mines included. In 1925 and 1926 the shut-down of one large mine caused a decline in capacity, and the downward trend after 1930 was due to a decline in the capacity of two mines from over 1,000 tons to less than 400 tons per day.

The "all other" group showed a general tendency to decline after 1926, with a slight upturn in 1935. New mines after 1930 were so small that they did not cause any increase in capacity.

Men Employed

The size of the coal industry in Washington has meant that it was always a small source of employment. In the peak year 1918, 5,109 men were employed in the mines; in the low year 1934, the number had dropped to 2,161.

In the "A" mines, which varied in number throughout the period, there was an over-all loss in employment of 53.6 percent between the 1919 peak and 1935. For the "all other" mines the loss was only slightly more, a drop of 59.0 percent occurring between 1920 and 1935.

Trend of Output per Man

It is not feasible to measure the net changes in productivity resulting from mechanization in this State. The tonnage and the number of mines covered is small, and their experience is affected by variable factors which obscure the underlying trends.

Of the eight mines in Group "A", only two were in operation during each year, and it is therefore impossible to show any data for Group "A-1" on a strictly comparable basis from year to year without danger of disclosing data for individual operations. One mine in Group "A" was new in 1932, and its record for the next few years is affected by development work, which tends to increase the number of man-hours per ton. Three large mines in the group are affected by a change in reporting man-hours in 1932: their "actual man-hours" based on a systematic record after 1932 run somewhat higher than the number obtained by the method of calculating man-hours which was used before 1932.[6] The effect of this, of course, is to increase unit labor requirements. Still another mine in Group "A" formerly produced a large tonnage of railway fuel for the use of an affiliated railroad, but in 1932 it was leased to an independent operator and thereafter produced only a small tonnage which was sold on the commercial market. This mine, therefore, had a large effect upon the average before 1932 and a small effect thereafter, and as the mine operates a very thick seam, and has low unit labor requirements, its inclusion lowers the group average before 1932 and increases it thereafter. The case of this mine illustrates the difficulty of computing changes in average output per man-hour in a field where physical conditions vary as greatly as in Washington.

[6]Prior to 1932 man-hours were calculated by multiplying the number of men, the number of days of tipple operation, and the number of hours in the established working day. After 1932 the Bureau of Mines asked for actual man-hours from the companies keeping such records. The experience of the companies in question indicated that actual man-hours run above calculated man-hours, a fact which tends to increase unit labor requirements in the period since 1932 in comparison with that before 1932.

The combined effect of these influences is to depress group "A" average unit labor requirements in the early part of the period under review and to raise it in the latter part. The averages are given in panels 8 and 9 of table B-33, but as they are clearly not comparable, the usual charts have been omitted from figure 47.

Prospects for the Future

For the foregoing reasons statistical analysis of available data on mechanization up to 1935 in Washington cannot be expected to give an accurate index of effects that mechanization may have had on employment opportunity. Even if data concerning the trend of past performance were entirely comparable they probably would be less valuable as an indication of what the future may hold than would an analysis of the current situation. The reasons for this lie largely in the recency of the movement, the smaller number of mines covered, and the fact that prior to 1935 effort was in large measure focused on overcoming great initial difficulties.

In some cases obstacles to mechanization which were formerly considered insurmountable have recently been overcome. Developments during the past few years at the Roslyn mines are pertinent as an example of progress in meeting difficulties. These mines were formerly operated almost entirely to supply coal to the Northern Pacific Railroad, but during the past decade the larger sizes have been sold commercially.

Mining in the Roslyn seam is carried on under adverse conditions. Pitches are steep, the roof requires close timbering, and other natural obstacles have to be overcome. For these and other reasons there was, until recently, very little mechanical loading or machine cutting. By 1935 almost all the coal was undercut by machines and loaded mechanically in Group "A" mines.

Mr. George Watkins Evans, author of a paper in which the Roslyn operations were described,[7] has expressed the opinion that there are few fields in Washington that could not be

[7] "Mechanization in the Roslyn Coal Field," *Transactions of the American Institute of Mining and Metallurgical Engineers*, Vol. 130 (1938), pp. 307-11. For reference to the modification of the duckbill principle developed in Washington, see ch. V, ftn. 9.

successfully mechanized if there were sufficient volume to justify the capital investment required.

Mechanization in Washington, as in Montana, appears to have gained its impetus largely from successful development in Wyoming, although the loading devices principally used in Wyoming mines were not directly adapted to Washington conditions. Reports to the Bureau of Mines show the hand-loaded conveyor as the type of machine by which, chiefly, mechanization advanced in Washington during the period covered by this study. In order to meet local conditions, however, considerable adaptations are taking place in the character of equipment, with increasing elimination of the work of hand shoveling. Devices that can operate on a 7- or 8-percent downgrade are reported in use. In view of the heavy pitches in most Washington mines, such a development would have considerable significance.

In the consideration of the possible future of mechanization in Washington it is interesting to note that the Royal Commission on Fuel of the Province of British Columbia, in which mining conditions are somewhat similar to those in Washington, is giving consideration to the problem of mechanization, particularly in the light of Washington experience.

UTAH

Conditions in Utah are somewhat different from those in the far West areas previously considered. Prior to NRA, Utah mines were not organized, wage rates were below those in Wyoming and Montana, and the pressure to install mechanical loading in an effort to reduce labor costs was not so intense. A large part of Wyoming and Montana tonnage is produced by captive mines; in Utah most of the tonnage must be sold in the commercial market. In view of these conditions, mechanization in respect to both mechanical loading and machine cutting has been considerable. Utah mines loaded 18.1 percent of their coal mechanically in 1928 and, though growth has been slow, 30.5 percent of the total output was mechanically loaded in 1935. In 1936 the percentage had increased to 41.8 percent and, according to an estimate of the National Bituminous Coal Commission, to 49 percent in 1937.

Distortion of Utah Figures Due to Practice of Men Working When Tipple Is Idle

Before analyzing the standard charts it is necessary to call attention to exceptional conditions of employment in Utah mines which have affected the data in respect to hourly capacity, days operated per year, tons per man-hour, and number of men required to maintain 1,000 tons of hourly capacity.

It was a common practice in Utah for men to go into the mines and work at the face on days when the tipple was idle.[8] During the years 1918-31 the Bureau of Mines labor-output figures were based on man-day data computed from tipple days operated rather than actual days worked by the men. Under the conditions prevailing in Utah this resulted, of course, in a man-day figure which was considerably lower than actual number of man-days worked. Beginning in 1932 the Bureau of Mines asked operators to report their actual man-days and man-hours of employment when known. It was found that many Utah operators, recognizing the need for more accurate employment data, kept a record of the man-shifts or man-hours worked. For the years after that it was therefore possible to correct the error which the reports for earlier years had carried. Since the divergent figures were not comparable, table B-43 has been arranged to include, for the "A" and "A-1" mines, both corrected and uncorrected data. Figure 48 presents graphically the data in this table.

Tons Mechanically Loaded

The record of mechanical loading in Utah starts in 1926. Group "A" mines showed a sharp increase in mechanical loading between 1926 and 1929, tonnage jumping from 104,000 to 867,000 tons. With the decline in total production during the depression mechanical loading also dropped, but by 1935 machine-loaded tonnage in Group "A" mines had increased to slightly over the 1929 level.

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[8] This practice was not confined solely to Utah mines; wherever drift mines are prevalent it is easy for men to enter the mines and perform work in preparation for the next shift. In areas where shaft mines are the rule it is not easy for a miner to make other than a scheduled trip into the mine. Although it is true that this practice occurred elsewhere, especially in the western States, up to the present time these distortions have not been reflected in the reporting to the extent that they were in Utah, where management permitted regular work underground on days when no coal was dumped by the tipple.

Figure 48.- COMPARATIVE PERFORMANCE IN UTAH OF UNDERGROUND MINES WHICH HAVE ADOPTED MECHANICAL LOADING AND OF ALL OTHER UNDERGROUND MINES, 1918-35

(Strip mines are excluded)

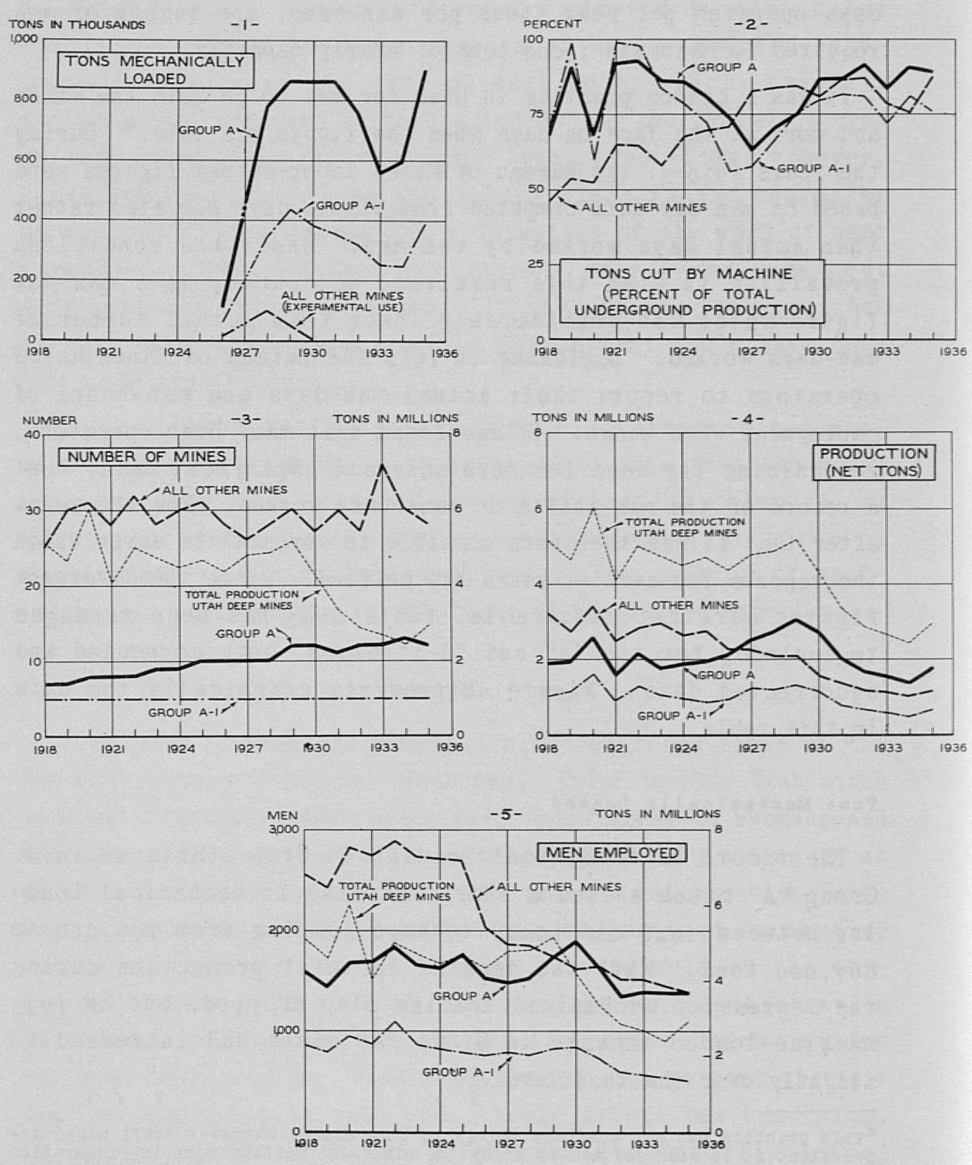
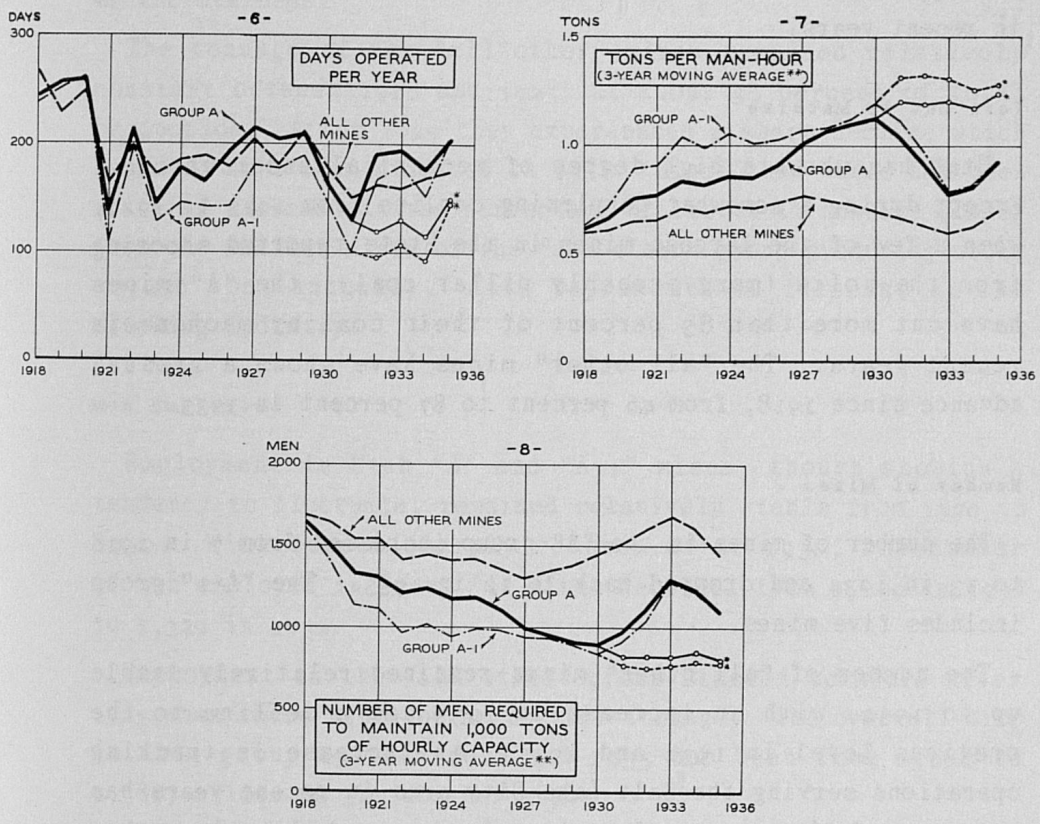


Figure 48.- COMPARATIVE PERFORMANCE IN UTAH OF UNDERGROUND MINES WHICH HAVE ADOPTED MECHANICAL LOADING AND OF ALL OTHER UNDERGROUND MINES, 1918-35 - *Continued*

(Strip mines are excluded)



* REPRESENTS DATA ON A "CALCULATED" BASIS FOR 1932-35 AND IS COMPARABLE WITH DATA FOR EARLIER YEARS. FOR EXPLANATION SEE P. 277.

** ACTUAL FIGURES FOR 1918 AND 1935.

FOR DESCRIPTION OF GROUPS OF MINES SEE PP. 203-5.

BASED ON TABLE B-43

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Mechanical loading in Group "B" mines was unimportant. Utah's experience was similar to that of Wyoming and Montana in that mines that adopted the new technique were successful in adapting it to their uses. Throughout the period of mechanical loading mobile loaders have been used almost exclusively. although there has been an increased use of conveyor loading in recent years.

Tons Cut by Machine

Utah has shown a high degree of mechanical undercutting.[9] Except during a somewhat perplexing decline from 1925 to 1929, when a few of the largest mines in the State reported shooting from the solid (more probably pillar coal), the "A" mines have cut more than 85 percent of their coal by machine in recent years. The "all other" mines have shown a gradual advance since 1918, from 46 percent to 87 percent in 1935.

Number of Mines

The number of mines in the "A" group increased from 7 in 1918 to 13 in 1934 and dropped back to 12 in 1935. The "A-1" group includes five mines.

The number of "all other" mines remained relatively stable up to 1932, with an increase in 1933 and a decline to the previous level in 1934 and 1935. An increase in trucking operations serving the Salt Lake City area in recent years has been one of the reasons for the relative stability in number of mines in the face of a declining production after 1929.

Production

Utah did not experience the sharp decline in total tonnage during the years 1918-29 that occurred in Montana, Wyoming, and, to a lesser extent, in Washington. In 1929 a production of 5,161,000 tons was at about the same level as in 1918. The drop during the depression years was severe, however, a low of 2,406,000 tons being reached in 1934.

The tonnage of Group "A" mines has constituted an increasing percentage of the total for the State, advancing from

[9]Part of this has been stimulated by a law passed in 1924 which made shooting from the solid illegal, Utah having an explosive-dust problem as well as gaseous mines.

36.8 percent in 1918 to 63.6 percent in 1930. Since 1930 the "A" mines have not bettered their position, remaining at about the 60-percent level. The increase in mechanical loading, it will be noted, occurred between 1926 and 1929, the years in which the "A" mines were greatly increasing their share of the business.

The tonnage of the "all other" mines remained relatively constant between 1918 and 1925, at about 58 percent of total production. After 1925 they experienced a sharp decline which seems to have been arrested in 1931. Since then there has been quite an increase in the percentage of the total tonnage coming from the smaller mines of the "all other" group producing under 50,000 tons annually. This represents an increase in the trucking industry.

Men Employed

Employment in Utah "A" and "A-1" mines, though showing a tendency to fluctuate, remained relatively stable from 1920 to 1930. With output sharply reduced after 1930, the number of men employed in Group "A" mines declined from 1,899 in 1930 to 1,329 in 1932.

Employment in the "all other" group started downward after 1925 when these mines began to lose tonnage. The over-all drop in this group between 1922 and 1935 has been from 2,888 to 1,381, a loss of 52 jobs per 100.

Days Operated per Year

The curves marked by an asterisk for "A" and "A-1" mines after 1932 represent the average number of days worked by the tipple and are comparable with the data as reported prior to 1932. The continuation of the "A" and "A-1" curves after 1932 is representative of average days worked by the men.[10]

Tons per Man-hour and Number of Men Required to Maintain 1,000 Tons of Hourly Capacity

If the asterisked lines after 1930 for "A" and "A-1" mines are accepted as the best guide of unit labor requirements, man-hour requirements have been declining since 1918. It will

[10] See table B-43.

be noted that for Group "A" mines a large part of the reduction was made between 1918 and 1926, before mechanical loading became important. Some part of the steep decline between 1918 and 1921, however, resulted because of several new mines that opened in 1918 and were on development work in that and in the following year. A new mine will frequently show unusually high per-ton labor requirements until development work is advanced. After 1926 mechanical loading came with a rush, several mines operating with power shovels during 1927. In that year unit labor requirements again declined and have continued to decline since, but at a more moderate rate. It must be kept in mind, however, that mechanical loading had not advanced in Utah, even in the "A" mines, to the extent that it had in Wyoming and Montana. In 1928, 28 percent of the production in "A" mines was mechanically loaded; in 1932, 46 percent; in 1935, 51 percent. The fact that the mobile loader was the predominant type of equipment used in these mines during this period in Utah made for larger savings.

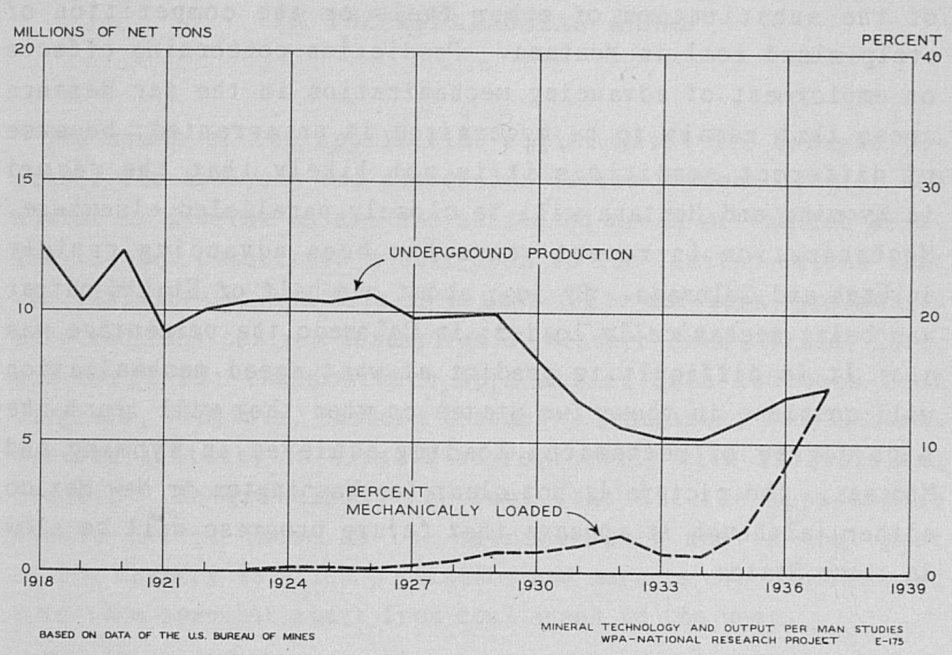
In the "all other" mines no correction could be made to show the figures over the whole period on a comparable basis, and it may be assumed that the increase in labor requirements between 1930 and 1933 is the result of changes in method of reporting man-hours.

COLORADO

Colorado is the largest coal-producing State west of the Mississippi River. Figure 49 shows the course of underground production in this State and the percentage of coal mechanically loaded.

Prior to 1935 Colorado had experimented with mechanical loading, but its experience was limited. Only four mines in the State could be classified as Group "A" mines in 1935, and only 3.3 percent of the tonnage was loaded by machine in that year. This was an advance from less than 1 percent mechanically loaded prior to 1928. Apparently all types of loading equipment were tried, none of them achieving outstanding success. Mines that installed loading devices during the late twenties and early thirties frequently reverted to hand loading after a short period of trial. Significant

Figure 49.- TOTAL UNDERGROUND PRODUCTION IN COLORADO AND PERCENTAGE OF OUTPUT MECHANICALLY LOADED, 1918-37



progress with mechanical loading in Colorado is too recent to figure in the analysis of performance to 1935.[11]

SIGNIFICANCE OF FAR WESTERN EXPERIENCE

The history of mechanical loading in Wyoming and Montana is significant in revealing results when, with favorable resource conditions, mechanization becomes practically complete. Recent progress in Washington offers a striking example of success in overcoming serious resource obstacles. Developments since 1935, especially in Colorado, supplementing Washington experience, seem to indicate that resource handicaps are not likely to have the effect in retarding mechanization in the far West in the future that they have had in the past.

Mechanization of loading in Wyoming, by far the most important far Western area from the standpoint of this study, has not had as significant reactions on employment in the mechanized mines as it would have had if less considerate labor policies had obtained. On the other hand, the employment opportunity formerly available in mines which remained on

[11] New Mexico is the only other coal-producing State in the far West. The State produced nearly 1,400,000 tons in 1935, of which about 100,000 tons were machine loaded.

a hand-loading basis has practically disappeared in both Wyoming and Montana. Upon these mines fell the chief impact of the substitution of other fuels or the competition of strip-mined coal in Montana. Prediction concerning effects on employment of advancing mechanization in the far Western areas that remain to be mechanized is unwarranted; because of different conditions it is not likely that the record in Wyoming and Montana will be closely paralleled elsewhere. Mechanization in recent years has been advancing rapidly in Utah and Colorado. By 1937 about one-half of Utah's output was being mechanically loaded; in Colorado the percentage was 14. It is difficult to predict at what speed mechanization will continue in these two States or when they will reach the high degree of mechanical loading achieved in Wyoming and Montana. The picture is not clear for Washington or New Mexico either, although it appears that future progress will be slow in these States.

CHAPTER X

PERFORMANCE OF MECHANICAL- AND HAND-LOADING MINES IN THE APPALACHIAN AREAS*

The areas of the Appalachian region which are brought together for analysis and discussion in the present chapter are almost as diverse as are the scattered areas of the far West. They do not constitute a unit even to the limited extent that the Illinois-Indiana area is a unit. The northern Appalachian area includes central Pennsylvania, western Pennsylvania, Ohio, and Maryland; the southern Appalachian area includes West Virginia, Virginia, eastern Kentucky, Tennessee, and Alabama. Western Kentucky is classified regionally with Illinois and Indiana. Nevertheless, the fact that all the Appalachian fields except those at the extreme south are in that part of the country in which population and markets are concentrated sets them somewhat apart from coal areas to the west.

The accessibility and richness of the coal resources in the Appalachian fields has enabled them, during the decade ending in 1936, to supply over 70 percent of the Nation's bituminous coal and to provide about the same proportion of the jobs in the bituminous industry.

From the standpoint of the present study the chief significance of the region is as an example of mechanical loading in its earlier stages. At the time the analysis of Bureau of Mines data, on performance of mechanized and unmechanized mines from 1918 to 1935, was completed, the record for 1936 was but partially compiled, and only estimates were available for 1937. Analysis of comparative performance of mechanical-loading and hand-loading mines had to be confined to those areas that had gone far enough with mechanical loading in 1935 to make a significant showing. The only Appalachian areas that qualify under this criterion are central and western Pennsylvania and Alabama.

Outside of Pennsylvania significant machine tonnage in the northern Appalachian area came exclusively from the Pittsburgh

*By Willard E. Hotchkiss and Charlotte K. Warner.

No. 8 field in Ohio, which was classified with western Pennsylvania.[1] Mechanically loaded tonnage in the rest of Ohio prior to 1935 was negligible, as was that of Maryland.

In the southern Appalachian area West Virginia and Virginia contributed, respectively, 4.4 percent and 1.4 percent of the total machine tonnage of the country in 1935. However, the West Virginia machine tonnage of slightly over 2 million tons in 1935 was only about 2 percent of total West Virginia output, the largest percentage for any year up to that time. Virginia's mechanically loaded output in 1935 was about 650,000 tons, or 6.7 percent of output. In eastern Kentucky and Tennessee mechanical loading up to 1935 was so limited as to have no significance even locally.

In considering performance data for central and western Pennsylvania it should be noted that differences in resource conditions have resulted in different types of loading equipment. Western Pennsylvania, where mechanical loading centered mainly in the thick Pittsburgh seam, has followed the example of Illinois and Indiana in installing chiefly mobile and pit-car loaders. In central Pennsylvania, on the other hand, thin seams and moderately dipping beds have led to the adoption of hand-loaded conveyors.

CENTRAL PENNSYLVANIA[2]

Tons Mechanically Loaded

Mechanical loading in this area has been on a considerably smaller scale than in the Midwestern and far Western States. Total machine-loaded output in 1935 was 3,624,000 tons, which represents but 10.4 percent of underground production. The percentage remained the same in 1936 and in 1937 increased to an estimated 11 percent.

Examination of the Group "A" curve shows machine-loaded tonnage increasing throughout the period 1924-34, even including the depression years, but with a slight drop in 1935.

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[1] Resource conditions in western and central Pennsylvania are basically different, and in discussion of bituminous mining they are usually regarded as separate areas. For the purpose of the present study two Ohio Group "A" mines in the Pittsburgh No. 8 field, whose identity would have been disclosed if they had been analyzed separately, were combined with the Group "A" mines of western Pennsylvania.

[2] Includes the following counties: Armstrong, Bedford, Blair, Bradford, Cambria, Cameron, Center, Clarion, Clearfield, Clinton, Elk, Forest, Fulton, Huntingdon, Indiana, Jefferson, Lycoming, McKean, Potter, Somerset, Tioga, and Warren.

Group "B" in central Pennsylvania, which appears in panel 1 of figure 50 as "all other" mines, reached a maximum output of slightly over 1 million tons in 1931 and dropped to 324,000 tons in 1935.

Experience of Group "B" mines in central Pennsylvania is worthy of study. The degree of experimentation in this area is apparent from the installation and later abandonment of mechanical-loading devices in 68 mines during the period of this study. Some experiments lasted only 1 or 2 years, others as long as 5 or 6 years, before the mines reverted to hand loading. An additional 30 mines put in loading machines for less than the 30 percent of their tonnage that would have qualified them for Group "A", and later went out of business, in some cases permanently. Most of the installations were made only 1 or 2 years before the mines closed down, which may indicate that resort to mechanization reflected a desperate effort to survive. Only 21 mines were included in Group "B" because they loaded less than 30 percent of their output by machine in 1935.

The hand-loaded conveyor was the chief type of equipment used in this area. The fact that 68 mines found it inadvisable to continue mechanical loading and reverted to hand loading suggests that the equipment may not have been adapted to conditions in these mines or that management did not use it effectively. Efficient use of conveyors, like that of mobile loaders, may require some adjustment in mining practice. Another pertinent consideration was the relatively low wage scale in central Pennsylvania prior to 1934 which, in many cases, may well have minimized the saving from conveyor loading below a point that would justify the carrying charges on the equipment. All in all, Group "B" experience, both in the mines that survived and in those that perished, seems to reflect a quest for savings that were not realized.

Tons Cut by Machine

The percentage of the tonnage cut by machine in Group "A" mines increased considerably after 1928, the period in which mechanical loading started to assume significant proportions of the Group "A" tonnage. Although the "all other" mines also showed a considerable increase in machine cutting, advancing

Figure 50.- COMPARATIVE PERFORMANCE IN CENTRAL PENNSYLVANIA OF UNDERGROUND MINES WHICH HAVE ADOPTED MECHANICAL LOADING AND OF ALL OTHER UNDERGROUND MINES, 1918-85

(Strip mines are excluded)

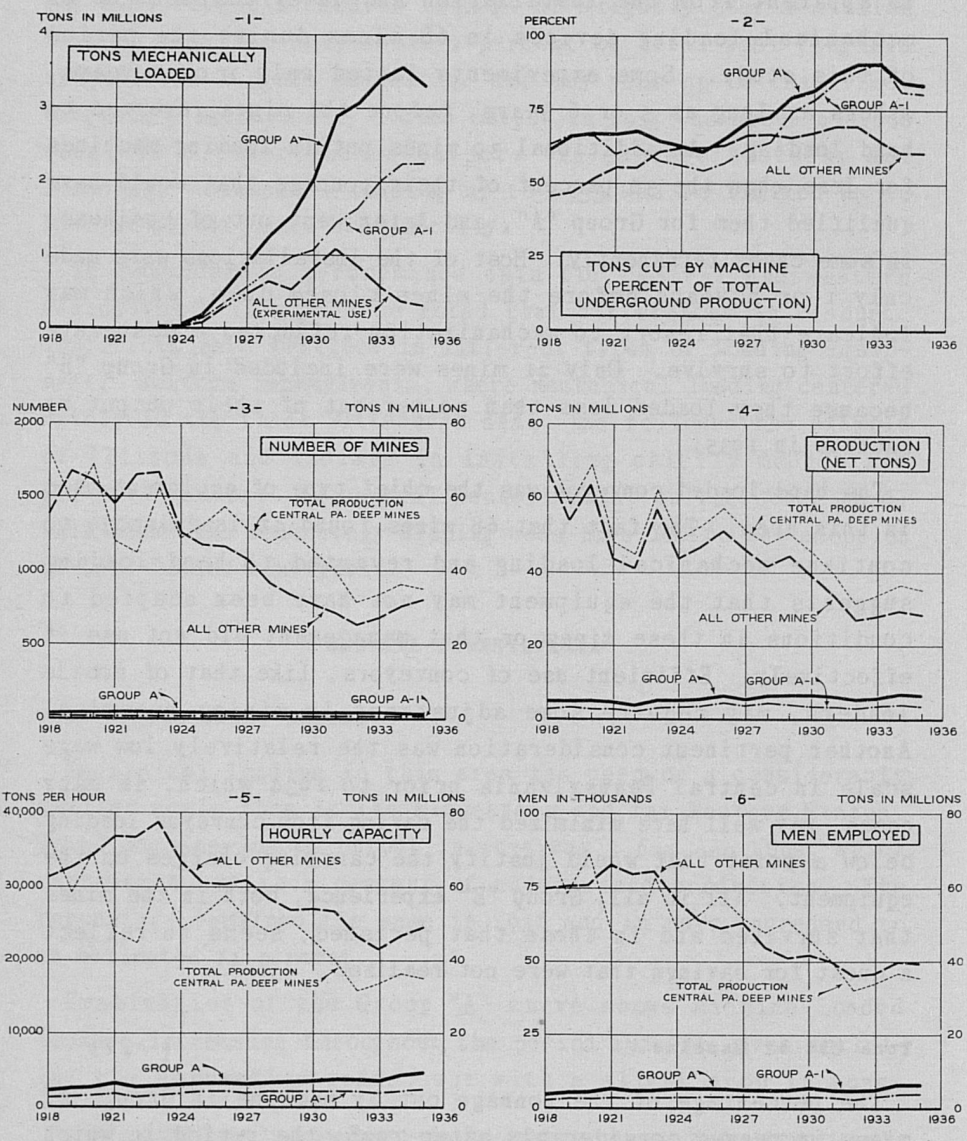
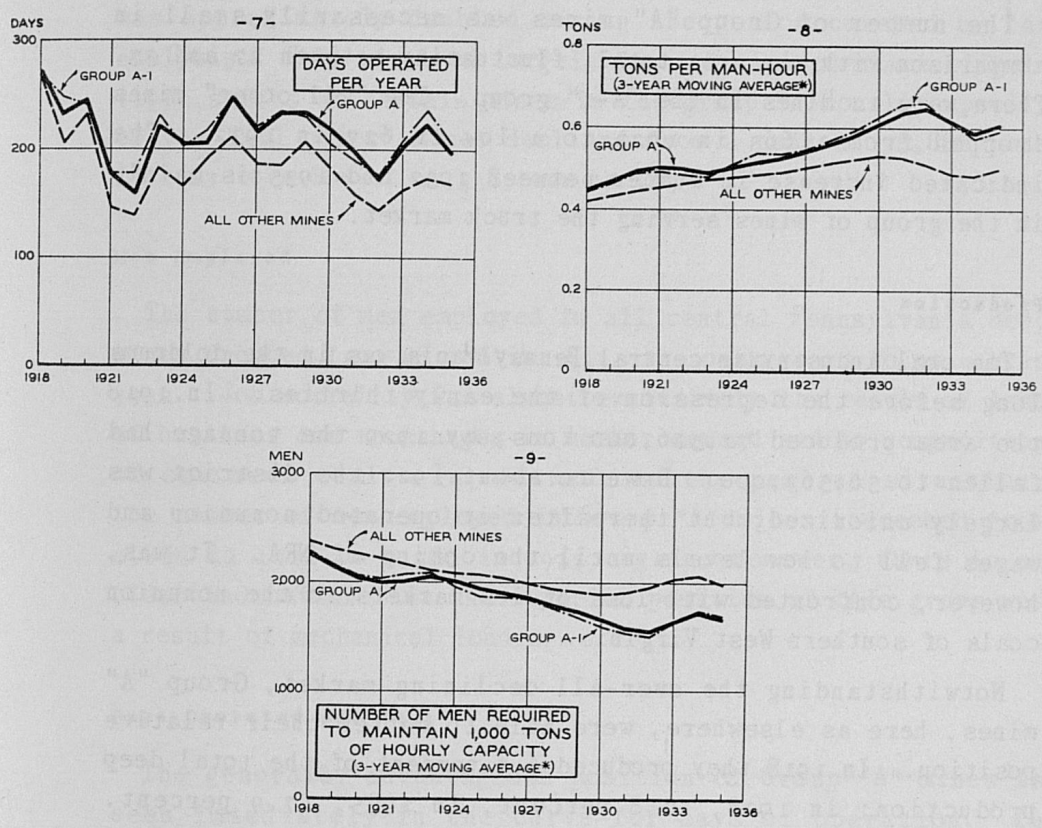


Figure 50.- COMPARATIVE PERFORMANCE IN CENTRAL PENNSYLVANIA OF UNDERGROUND MINES WHICH HAVE ADOPTED MECHANICAL LOADING AND OF ALL OTHER UNDERGROUND MINES, 1918-35 - *Continued*

(Strip mines are excluded)



*ACTUAL FIGURES FOR 1918 AND 1935.

FOR DESCRIPTION OF GROUPS OF MINES SEE PP 203-5.

BASED ON TABLE B-47

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from 45.9 percent in 1918 to 69.8 percent in 1931, most of the gain was made during the first 10 years of the period. For this district the figures of machine cutting include tonnage mined with pneumatic picks.

Number of Mines

The number of Group "A" mines was necessarily small in comparison with the area total, fluctuating between 27 and 33. There were 12 mines in the "A-1" group. The "all other" mines dropped from 1,663 in 1923 to a low of 627 in 1932. The indicated increase in number between 1932 and 1935 is mainly in the group of mines serving the truck market.

Production

The coal industry in central Pennsylvania was in the doldrums long before the depression of the early thirties. In 1918 the area produced 72,526,000 tons; by 1929 the tonnage had fallen to 50,563,000. Down to about 1927 the district was largely unionized, but thereafter it operated nonunion and wages fell to low levels until the coming of NRA. It was, however, confronted with loss of its markets to the nonunion coals of southern West Virginia.

Notwithstanding the over-all declining market, Group "A" mines, here as elsewhere, were able to better their relative position. In 1918 they produced 6.5 percent of the total deep production; in 1928, 12.8 percent; in 1935, 17.9 percent. The fact that these mines, in the face of a disastrous decline in tonnage for the area, continued to increase their share of total business after 1928 was not necessarily the result of mechanical loading. Group "A" mines in this, as in other areas, included a number of particularly strong mines from the standpoint of corporate relations, management, and market connections. About 35 percent of the tonnage was produced by captive operations, and much of the remainder came from mines that had relatively permanent trade outlets for their product These factors were probably as much responsible for the retention of business as was mechanical loading. It is notable that the percentage of mechanical loading in Group "A" mines in central Pennsylvania had been considerably less than in Group "A" mines in Midwestern and far Western areas. The

maximum mechanically loaded tonnage for Group "A" during the period of study was 60.6 percent in 1933. The percentage declined to 52.7 by 1935.

Hourly Capacity

In this area capacity of the Group "A" and "A-1" mines was approximately doubled during the period covered by the analysis. This resulted largely from the inauguration of multiple shifts at certain mines in the group.[3] Hourly capacity of the "all other" mines declined from a peak of 38,886 tons in 1923 to a low of 21,538 tons in 1933.

Men Employed

The number of men employed in all central Pennsylvania deep mines dropped from 88,786 in 1921, the peak year, to 50,417 in 1932. Job mortality was almost exclusively the result of loss of business due to changes in market demand and to competition of southern coal. In contrast to the general situation, the number of men employed in Group "A" mines increased from 4,884 in 1918 to 7,582 in 1935; again, however, there is no clear indication that the superior position of this group was a result of mechanical loading.

Days Operated per Year

The generally advantageous position of Group "A" mines is seen immediately in the curve for days of operation. In every year of the period they offered their employees more opportunity for work than did the "all other" mines.

Tons per Man-hour and Number of Men Required to Maintain 1,000 Tons of Hourly Capacity

From 1918 to 1927, when mechanical loading had no significance in the performance records of the "A" group, the trend of unit labor requirements in both groups of mines was downward, with about the same differential between the groups existing in

[3] Multiple shifts have the effect of increasing the average daily tonnage. The increase carries over into the statistical device adopted for analyzing the trend of capacity, namely, dividing daily production by the number of hours in the established working day, which yields the ratio of hourly capacity shown in the curves. The increase in terms of the daily tonnage which can be produced at these mines is real but appears to result more from the increase in the number of shifts per day than from simple expansion of facilities.

Figure 51.- COMPARATIVE PERFORMANCE IN WESTERN PENNSYLVANIA AND IN THE OHIO NO. 8 FIELD OF UNDERGROUND MINES WHICH HAVE ADOPTED MECHANICAL LOADING AND OF ALL OTHER UNDERGROUND MINES, 1918-85

(Strip mines are excluded)

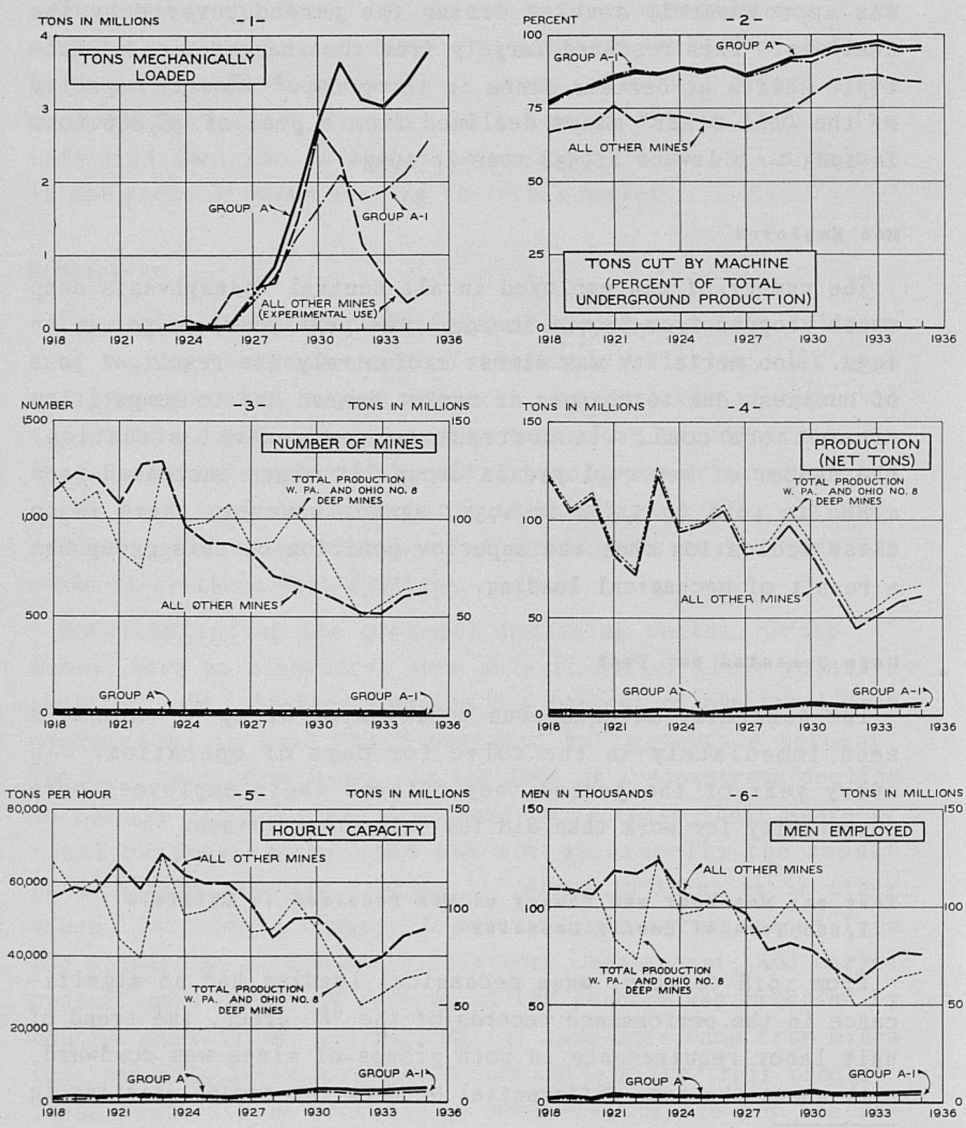
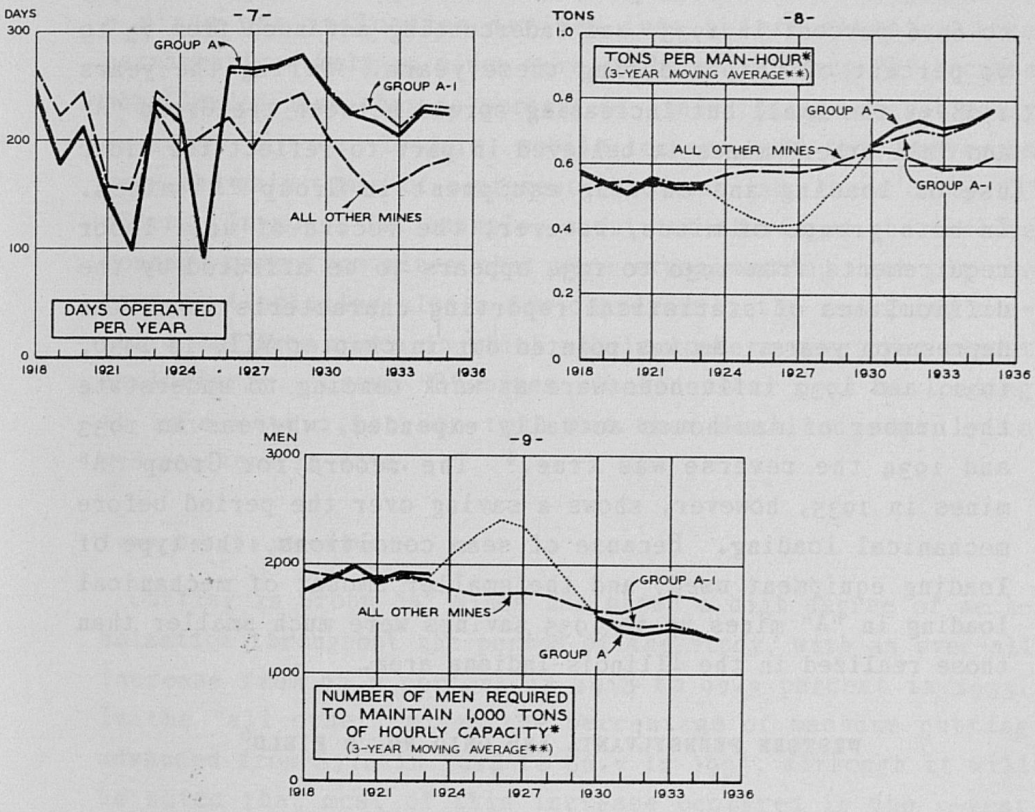


Figure 51.- COMPARATIVE PERFORMANCE IN WESTERN PENNSYLVANIA AND IN THE OHIO NO. 8 FIELD OF UNDERGROUND MINES WHICH HAVE ADOPTED MECHANICAL LOADING AND OF ALL OTHER UNDERGROUND MINES, 1918-35 - *Continued*

(Strip mines are excluded)



* THE COURSE OF THE GROUP "A" AND "A-1" CURVES BETWEEN 1924-25 TO 1928-29 IS SHOWN BY A DOTTED LINE TO INDICATE THAT THE ACTUAL POSITION DURING THIS PERIOD IS NOT KNOWN. SEE P. 298.

** ACTUAL FIGURES FOR 1918 AND 1935.

FOR DESCRIPTION OF GROUPS OF MINES SEE PP. 203-5.

BASED ON TABLE B-51

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1927 as in 1918. In the "all other" group the over-all decline amounted to 16 percent; in the "A" mines, to 18 percent. During this period the forces that made for decreased requirements were operating about equally in both groups.

In 1928 and thereafter an advance in both mechanical loading and machine cutting occurred in the "A" mines. Mechanical loading rose from 20.2 percent of Group "A" output in 1928 to 60.6 percent in 1933, and undercutting advanced from 73 to 90 percent of output during these years. During the years 1928-31 the small but increasing spread between the Group "A" and "all other" mines is believed in part to reflect the wider use of loading and cutting equipment in Group "A" mines. In both groups of mines, however, the record of unit labor requirements from 1930 to 1934 appears to be affected by the difficulties of statistical reporting characteristic of the depression years. As was pointed out in chapter VII, in 1930, 1931, and 1932 influences were at work tending to understate the number of man-hours actually expended, whereas in 1933 and 1934 the reverse was true.[4] The record for Group "A" mines in 1935, however, shows a saving over the period before mechanical loading. Because of seam conditions, the type of loading equipment used, and the smaller amount of mechanical loading in "A" mines up to 1935 savings were much smaller than those realized in the Illinois-Indiana area.

WESTERN PENNSYLVANIA AND OHIO NO. 8 FIELD[5]

Tons Mechanically Loaded

The total tonnage mechanically loaded in western Pennsylvania and in the Ohio No. 8 field was impressive - 4,323,000 tons in 1935, 6,855,000 tons in 1936, and 9,867,000 tons in 1937 - but in percentage the area stands far down the list. Only 6.5 percent of deep output was loaded mechanically in 1935 and 8.3 percent in 1936; there was an estimated increase to 11.7 percent in 1937.

Prior to 1928 the tonnage loaded in Group "A" mines was negligible, but between 1928 and 1931 it increased from less than

[4] See also appendix A.

[5] Western Pennsylvania includes Allegheny, Beaver, Butler, Fayette, Greene, Lawrence, Mercer, Venango, Washington, and Westmoreland Counties. Ohio No. 8 field includes Belmont, Harrison, and Jefferson Counties.

1 million to over $3\frac{1}{2}$ million tons. After the depression drop to about 3 million, tonnage in 1935 had risen to 3,772,000.

Between 40 and 50 percent of the tonnage loaded in this area in the years 1928-31 came from Group "B" mines. The experimental nature of many of these early installations is revealed by the fact that 51 mines put in machine loading for a year or more and then reverted to hand loading, and 7 mines put in loading devices just before shutting down permanently. Only 12 mines were included in Group "B" because they loaded less than 30 percent of their tonnage mechanically in 1935. Pit-car loaders, mobile loaders, and face conveyors were the main types of equipment that went into these Group "B" mines. In 1931, for example, about two-thirds of the machine tonnage came from mines that were experimenting with pit-car loaders (including also a few conveyors); the remaining one-third was from mines in which mobile loaders were used almost exclusively. Group "B" mines reached their peak of loading in 1930 with 2,729,000 tons and then declined rapidly to 378,000 tons in 1934.

Tons Cut by Machine

Cutting in Group "A" mines has shown a high degree of mechanization throughout the period of the study, with an over-all increase from 77.3 percent in 1918 to 97.3 percent in 1933. In the "all other" mines the percentage of machine cutting advanced from 67.0 in 1918 to 86.7 in 1933, although it will be noted that most of this increase occurred in the 5-year period 1927-31.

Number of Mines

The number of mines that successfully adopted mechanical loading in this area remained small. In 1918 Group "A" included 7 mines; the number rose to 11 at the end of the period. The two mines in the Ohio No. 8 field were in the group of six mines making up the "A-1" series. The number of mines in the "all other" group reached a maximum of 1,299 in 1923, but the exceedingly high mortality rate reduced the number to 516 in 1933. The increase to 627 in 1935 was mainly in the group of smaller mines serving local markets.

Production

The total deep-mine output of the area amounted to 122,299,000 tons in 1918. The low point of 73,169,000 tons reached in 1922 was the result of the great strike that shut down about 95 percent of the capacity in the Pittsburgh district and 100 percent of the capacity in Ohio. After the poststrike increase in 1923 tonnage started to decline, the over-all loss between 1918 and 1929 amounting to 19 million tons. Between 1929 and 1932 production dropped from 103 million to 50 million, a more severe loss than that which occurred in central Pennsylvania.

Figures for Group "A" mines have little significance in this area other than as performance records of two or three large companies. In 1918 these mines produced 1.5 percent of the deep output; they produced 10.3 percent in 1932. The percentage dropped to 9.1 in 1935. Part of the increase prior to 1932 was due to the addition of new mines to the group, although Group "A-1" shows that there was a slight tendency for mechanical-loading mines to increase their share of the business. As in central Pennsylvania, the increasing use of mechanical loading was doubtless only one of the factors enabling these mines to hold their position.

Hourly Capacity

In this area there was a marked increase in the capacity of the Group "A" and "A-1" mines during the period covered by the analysis. It results largely from the inauguration of multiple shifts at certain mines in the group.[6] Capacity in the "all other" mines was almost cut in half between 1923 and the low point of 1932, although since then it has tended to pick up rapidly.

Men Employed

There were 110,549 men employed in deep mines in western Pennsylvania and the Ohio No. 8 field in 1918, and by 1923 this number had increased to 126,774 men. After 1923 the coal industry in this area was attacked on two fronts - increased competition from southern areas and a general decline in markets. Liquidation of capacity set in almost immediately

[6] See ftn. 3.

and the number of men employed dropped precipitously, reaching a low of 64,321 in 1932, a decline of about 50 percent. Mechanization was a small contributing factor in the great loss of jobs that occurred in this area. The great majority of men were forced out of employment because mines were closed down by the hundreds. Conditions improved in 1933 and 1934, and by 1935 the number of men employed had risen to 79,986.

The number of men employed in Group "A" mines is too small to have significance in the over-all employment picture. Group "A" mines employed 1,649 men in 1918 and 5,360 in the peak year 1930. This figure had dropped to 5,013 in 1935. The identical series of "A-1" mines employed 1,271 men in 1918, 4,214 in 1930, and 3,542 in 1935. As in other areas, Group "A" mines revealed superior ability to withstand adversity.

Days Operated per Year

The curve of days operated for the "all other" mines conforms in general to the production curve. Group "A" mines worked 45 days less than the "all other" mines in the strike year 1919 because of the fact that the "A" mines are located in the Pittsburgh area of Pennsylvania and in eastern Ohio, both union strongholds at that time. The same explanation holds for the strike of 1922, when the "A" mines worked 58 days less than the "all other" group. In 1923 and 1924 working time was higher for the "A" group, but in 1925 the "A" mines dropped to 90 days compared with 203 for the "all other" mines.

In 1924 operators in the Pittsburgh district signed the Jacksonville Agreement to continue the $7.50-per-day scale until 1927. By 1925 the forces of competition between union and nonunion areas were already under way with nonunion operators reducing wage scales to the 1917 level and lower. Operators in the Pittsburgh area felt they could no longer pay the Jacksonville scale and stay in business, and they started to shut down their mines early in 1925. One large company in the area closed all its 50 mines in that year and reopened later on a nonunion basis. In the following year, 1926, the average number of days worked in Group "A" mines rose from the low of 90 to 267. The advantage in working time was maintained by the "A" group until the end of the period.

Tons per Man-hour and Number of Men Required to Maintain 1,000 Tons of Hourly Capacity

Man-hour requirements for both Group "A" and "all other" mines were almost identical between 1918 and 1923. Starting in 1924-25 and continuing through 1928-29, the curves of unit labor requirements in the "A" and "A-1" mines run considerably higher than those of the "all other" mines. The difference is probably more apparent than real, the explanation lying in unusual circumstances during much of this period. Several mines of the "A" group were working under disturbed labor conditions from 1925 to 1929, which doubtless had some effect on productivity. It is also true, however, that the method of computing man-days by multiplying mine working time by the reported number of men employed, which at best gives only an approximation, is not adapted to measuring performance during an industrial dispute.[7] By 1930 the abnormal conditions had disappeared, and the mines of this group had regained any lost ground and forged ahead of the "all other" group. Mechanical loading was advancing rapidly: 29 percent of Group "A" output was machine loaded in 1929 and 61 percent was so loaded in 1931, although from 1931 to 1935 the percentage of machine loading in the group remained relatively constant.

Without doubt the increasing spread between Group "A" and "all other" mines after 1930 was largely the result of mechanical loading. The irregularities in the curve of labor requirements of the "all other" mines from 1930 to 1934 are almost surely attributable, as in other areas, to faulty reporting under the conditions of the depression years.[8]

OHIO

Except for the Ohio mines classified with western Pennsylvania, performance data for machine-loading and hand-loading mines were not analyzed as were those for central and western Pennsylvania. Nevertheless, Ohio experience with mechanical loading is worthy of mention.

Figure 52 shows the course of deep-mine production and the percentage of coal mechanically loaded in all Ohio mines.

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[7]The data reported by the mines in question to the Bureau of Mines have been checked against those reported to the Pennsylvania Department of Mines and found to be the same.

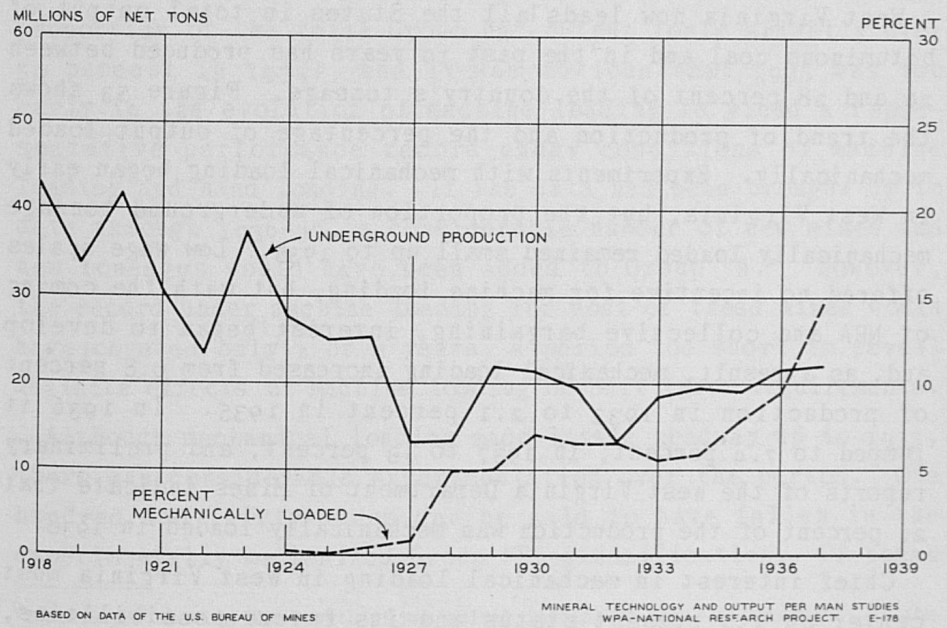
[8]See appendix A.

Ohio lost many of its markets to nonunion areas after the World War in the period following the Jacksonville Agreement. In 1927 and 1928 Ohio mines were shut down by serious strikes as a result of nonagreement over wage rates at the expiration of this agreement, and by 1929 the area was virtually all nonunion. Ohio markets had shrunk so much during the twenties that the depression could do little more damage and, except in 1932, tonnage varied but slightly from 1929 to 1937.

Although experimentation with mechanical loading began in Ohio in the midtwenties, the percentage loaded remained a minor part of total underground production. In 1936, however, 10 percent of the production of all Ohio mines was mechanically loaded, and this was raised to 14 percent in 1937 according to the preliminary figures of the National Bituminous Coal Commission.

The incentives for increasing markets were just as strong in Ohio as in the Illinois-Indiana area, but a combination of factors retarded a general movement toward mechanical loading. Low wage rates in Ohio after 1927 were, of course, an important deterrent to a mechanical-loading program, but part of the severe tonnage loss was due to competition of

Figure 52.- TOTAL UNDERGROUND PRODUCTION IN OHIO AND PERCENTAGE OF OUTPUT MECHANICALLY LOADED, 1918-37



BASED ON DATA OF THE U.S. BUREAU OF MINES

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southern areas where wages were also low. Equally important in this area was a lack of recognition on the part of management of the advantages of mechanical loading. Part of this was no doubt caused by the fact that a considerable portion of Ohio tonnage came from old mines in which depletion was so far advanced that the life of the properties did not seem to justify heavy investment in new equipment. Physical conditions are, on the whole, not unfavorable, although difficult roof conditions in some areas would have prevented early installations of machine loaders.

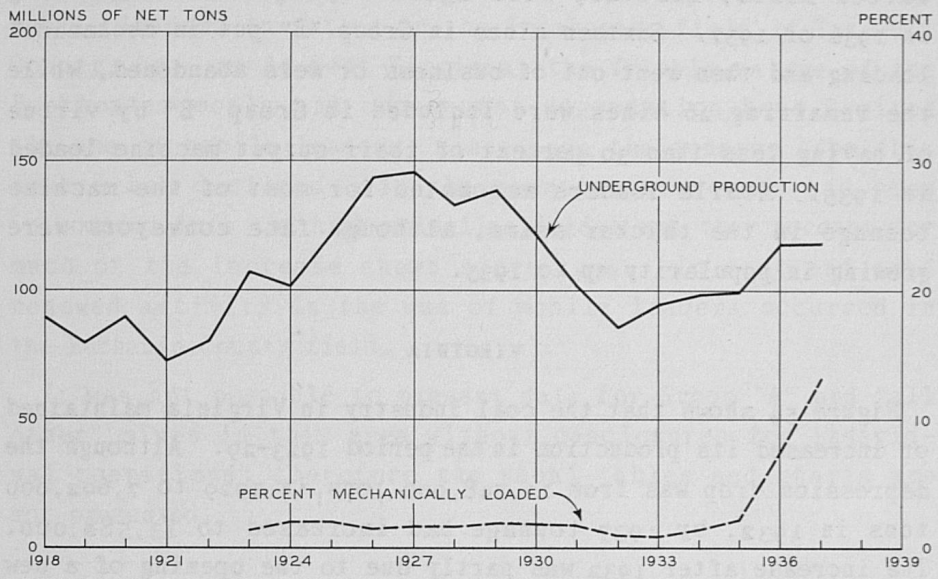
Only two Ohio mines located in the Pittsburgh No. 8 seam could be classified in Group "A", and to avoid disclosure of data for these mines they were included with Group "A" mines in western Pennsylvania. Over 90 percent of the total tonnage mechanically loaded in Ohio in the years 1933-35 came from these two mines. Seven Group "B" mines were also classified in the Ohio No. 8 field. Of these, four reverted to hand loading after short periods of experimentation; the other three were below the 30-percent mark for mechanical loading in 1935. Outside of the No. 8 field experimentation with mechanical loading was confined to 16 Group "B" mines which contributed a negligible part of the total machine-loaded tonnage of Ohio.

WEST VIRGINIA

West Virginia now leads all the States in total output of bituminous coal and in the past 10 years has produced between 26 and 28 percent of the country's tonnage. Figure 53 shows the trend of production and the percentage of output loaded mechanically. Experiments with mechanical loading began early in West Virginia, but the proportion of underground tonnage mechanically loaded remained small up to 1935. Low wage scales offered no incentive for machine loading, but with the coming of NRA and collective bargaining, interest began to develop and, as a result, mechanical loading increased from 0.8 percent of production in 1933 to 2.1 percent in 1935. In 1936 it jumped to 7.4 percent, in 1937 to 13 percent, and preliminary reports of the West Virginia Department of Mines indicate that 21 percent of the production was mechanically loaded in 1938.

Chief interest in mechanical loading in West Virginia must center on its present status and its future possibilities, aspects which are covered in detail in chapter VI.

Figure 58.- TOTAL UNDERGROUND PRODUCTION IN WEST VIRGINIA AND PERCENTAGE OF OUTPUT MECHANICALLY LOADED, 1918-37



BASED ON TABLE B-55

MINERAL TECHNOLOGY AND OUTPUT PER MAN STUDIES
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Past performance records were too limited to have any value for analysis, and the standard charts and tables as presented for other areas have been omitted.[9] Only 16 mines in 1935 could have been classified in Group "A", and their combined tonnages amounted to less than 2 percent of the State's output. Mechanical loading in these Group "A" mines was not a dominant proportion of the total Group "A" output (only slightly over 50 percent in 1934), and it was obvious that 1935 was too early in the evolution of machine loading to yield a representative performance record under conditions of machine loading and hand loading. If the data had been brought up to date through 1936-37, a considerable number of new mines and new tonnages would have been added to Group "A." However, the record under machine loading for most of these mines would have covered only 1 or 2 years, a period too short to reveal definite effects of machine loading on unit labor requirements.

Although mechanical loading made little headway up to 1935, there was considerable experimentation over the period. One hundred and thirty mines can be said to have fallen in the experimentally mechanized Group "B" classification. Of these

[9] Table B-55, showing the growth of mechanical loading by types of equipment, is the only one of the standard series presented.

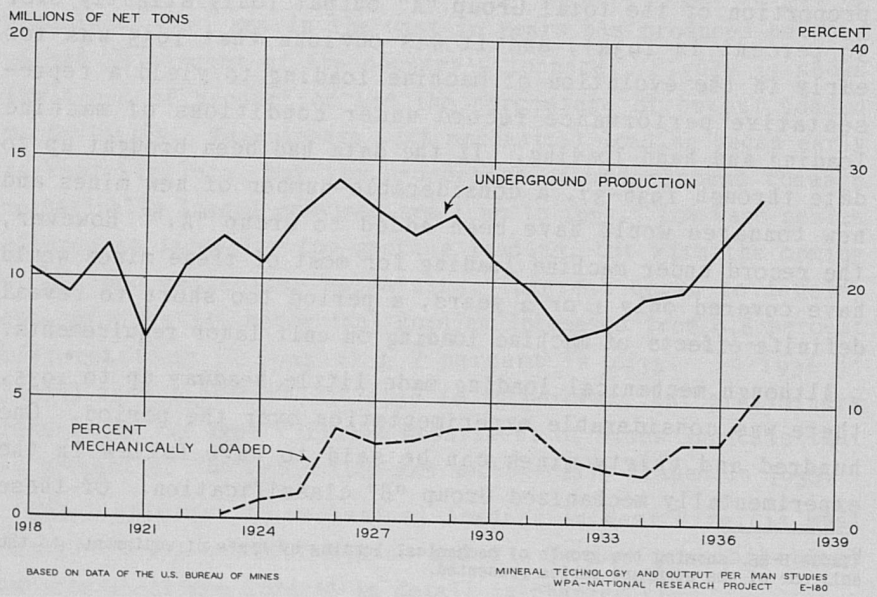
130 mines, 88 experimented with loading machines for short periods and then reverted to hand loading. Eleven of the latter mines, however, were again trying machine loading in 1936 or 1937. Sixteen mines in Group "B" put in mechanical loading and then went out of business or were abandoned, while the remaining 26 mines were included in Group "B" by virtue of having less than 30 percent of their output machine loaded in 1935. Mobile loaders accounted for most of the machine tonnage in the thicker seams, although face conveyors were growing in popularity up to 1935.

VIRGINIA

Figure 54 shows that the coal industry in Virginia maintained or increased its production in the period 1923-29. Although the depression drop was from 12,748,000 tons in 1929 to 7,692,000 tons in 1932, by 1937 tonnage had increased to 13,588,000. The increase after 1932 was partly due to the opening of a new field in Buchanan County made possible by an extension of the Norfolk and Western Railway.

As in West Virginia, low wage rates were a principal factor in retarding machine loading. The 1937 estimate of underground production mechanically loaded in Virginia is 11 percent.

Figure 54.- TOTAL UNDERGROUND PRODUCTION IN VIRGINIA AND PERCENTAGE OF OUTPUT MECHANICALLY LOADED, 1918-37



BASED ON DATA OF THE U.S. BUREAU OF MINES

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The trend of mechanical loading is shown in figure 54. Machines of various types have been used. From 1926 to 1931 the bulk of the mechanically loaded tonnage was loaded by mobile loaders installed in the Pocahontas field in Tazewell County, but, as in West Virginia, the friable nature of the Pocahontas coals and consequent degradation have limited the use of mobile loaders; since 1932 the tonnage from this source has declined. In the meantime conveyors had been introduced into the high-volatile fields, and they account for much of the increase shown since 1934. In 1935 and 1936 renewed activity in the use of mobile loaders occurred in the Buchanan County field.

It was not possible to present data for Group "A" and "all other" mines in this area without disclosures for individual operations; therefore the usual tables and charts are not presented.

ALABAMA

Alabama coal fields lie at the southern extremity of the Appalachian region, but mining conditions in the area are basically different from those that obtain in heavy-tonnage Appalachian areas to the north. Resource conditions in Alabama are adverse. Many of the seams are thin and pitch heavily. In general the beds contain a high percentage of impurity and 81 percent of the 1936 output had to be mechanically cleaned. As a result of the difficulties with which mining is surrounded, costs per ton in Alabama are high. For the period from April to December 1937 the National Bituminous Coal Commission found total producing, administrative, and selling costs to be $2.53 per ton in Alabama, Georgia, and parts of Tennessee, compared with $2.19 for parts of West Virginia and Virginia, known as Southern No. 1, and $2.04 for parts of West Virginia, Virginia, Tennessee, and eastern Kentucky areas, known as Southern No. 2. Unlike other low-wage areas to the north, the necessity of reducing costs brought about more interest in mechanical loading in Alabama prior to the reduction of wage differentials under the Bituminous Coal Code of the National Recovery Administration in 1933 than it did in West Virginia, Virginia, and Kentucky. Performance of Alabama mines has been charted in figure 55.

Figure 55.- COMPARATIVE PERFORMANCE IN ALABAMA OF UNDERGROUND MINES WHICH HAVE ADOPTED MECHANICAL LOADING AND OF ALL OTHER UNDERGROUND MINES, 1918-35

(Strip mines are excluded)

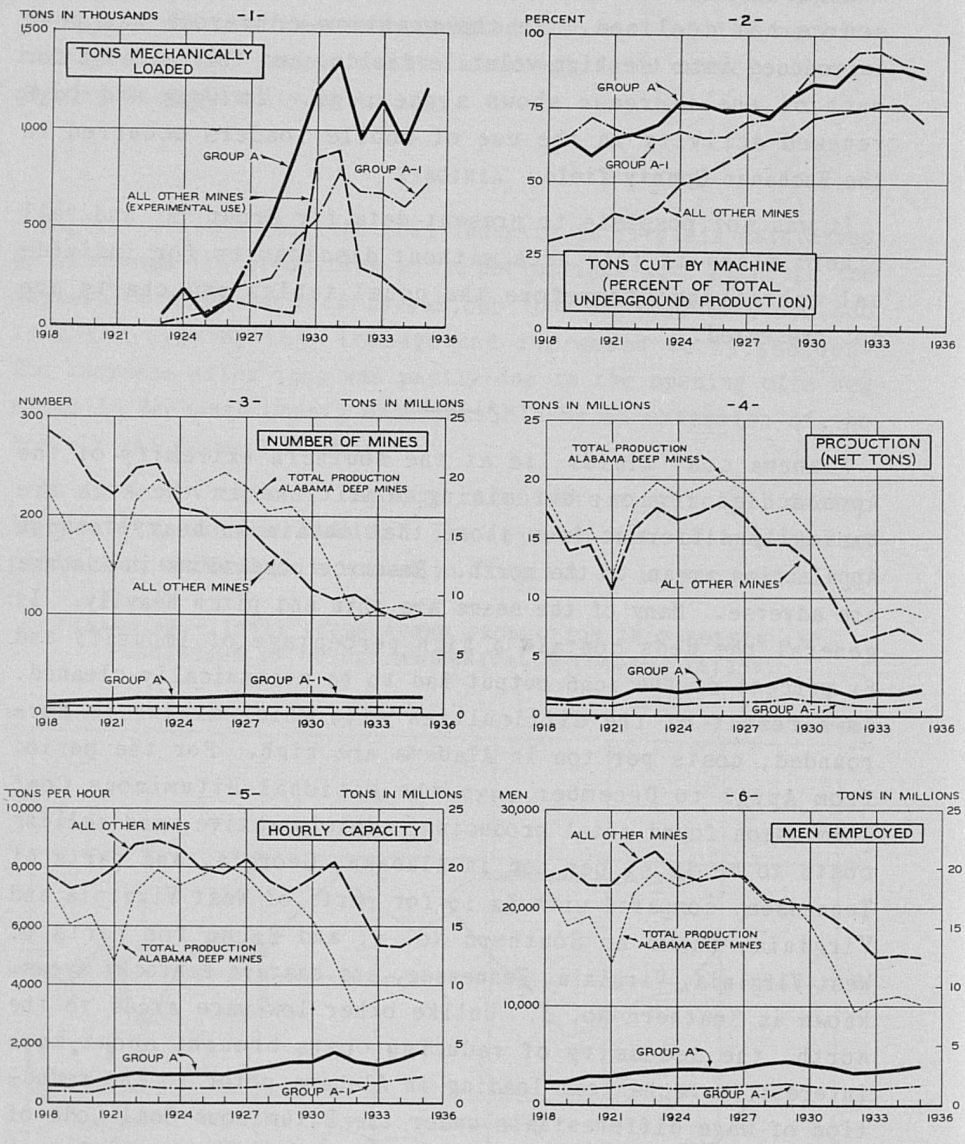
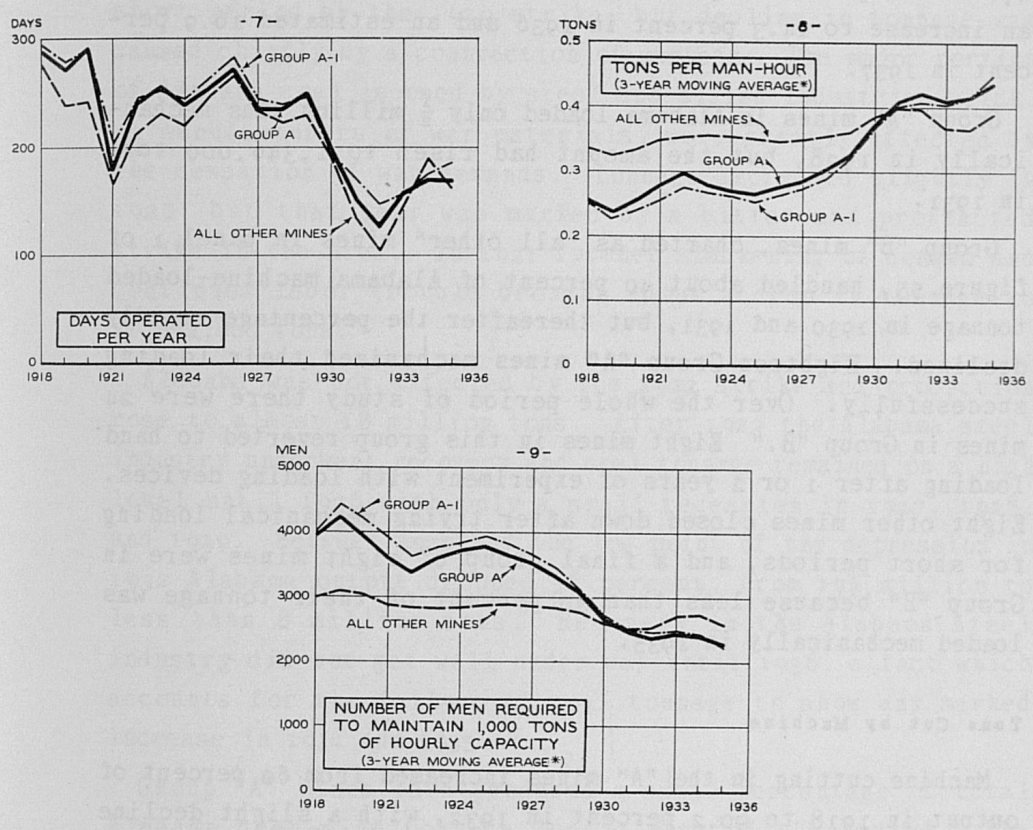


Figure 55.- COMPARATIVE PERFORMANCE IN ALABAMA OF UNDERGROUND MINES WHICH HAVE ADOPTED MECHANICAL LOADING AND OF ALL OTHER UNDERGROUND MINES, 1918-35 - *Continued*

(Strip mines are excluded)



*ACTUAL FIGURES FOR 1918 AND 1935.

FOR DESCRIPTION OF GROUPS OF MINES SEE PP 203-5.

BASED ON TABLE B-56

MINERAL TECHNOLOGY AND OUTPUT PER MAN STUDIES
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Tons Mechanically Loaded

The mechanical-loading movement, though under way as early as 1923, did not make much progress until 1930, when 13.4 percent of Alabama deep-mine coal was loaded mechanically. This increased to 18.8 percent in 1931. The depression brought about a drop to 11.8 percent in 1934, and this was followed by an increase to 14.3 percent in 1936 and an estimated 16.9 percent in 1937.

Group "A" mines in Alabama loaded only ½ million tons mechanically in 1928, but the amount had risen to 1,346,000 tons in 1931.

Group "B" mines, charted as "all other" mines in panel 1 of figure 55, handled about 40 percent of Alabama machine-loaded tonnage in 1930 and 1931, but thereafter the percentage rapidly declined. Eighteen Group "A" mines mechanized their loading successfully. Over the whole period of study there were 24 mines in Group "B." Eight mines in this group reverted to hand loading after 1 or 2 years of experiment with loading devices. Eight other mines closed down after trying mechanical loading for short periods, and a final group of eight mines were in Group "B" because less than 30 percent of their tonnage was loaded mechanically in 1935.

Tons Cut by Machine

Machine cutting in the "A" mines increased from 60 percent of output in 1918 to 90.2 percent in 1932, with a slight decline in 1935. In the "all other" group machine-cut output increased from 30 percent in 1918 to 77 percent in 1934.

Number of Mines

The number of Group "A" mines in Alabama increased from 11 in 1918 to 17 in 1926 and varied by only 1 during the remainder of the period. Seven mines were included in the identical Group "A-1" series. The number of "all other" mines was at a peak of 286 in 1918. Except during 1922 and 1923 the trend was sharply downward over the remainder of the period. Decline in the number of "all other" mines between 1918 and 1927 centered in small mines having an annual output of less than 50,000 tons, with the result that the total tonnage for the group

remained at about the 1918 level between 1923 and 1927 despite the sharp decline in number of mines.

Production

Alabama deep-mine output, which was 18,563,000 tons in 1918, dropped to 15,029,000 tons in 1919. The area was tied up for a short period by the 1919 strike, but decline in tonnage was caused chiefly by a contraction of markets. The major portion of Alabama coal is used by steel and allied industries which, as manufacturers of war materials, were greatly affected by the cessation of war demands. Tonnage increased slightly in 1920, but that year was marked by a bitter and protracted strike in the area. In 1921 further slackening of demand and continued labor trouble brought about a drop in tonnage to 11,922,000 tons.

Alabama was not affected by the 1922 strike and production rose to almost 18 million tons. After 1922 the Alabama steel industry underwent recovery and coal tonnage remained on a high level until 1926 with only a small recession in 1927, 1928, and 1929. Between 1929 and the low point of the depression in 1932 Alabama output dropped 56 percent, from 17½ million to less than 8 million tons. Recovery in the Alabama steel industry did not get well under way until 1936, a fact which accounts for the failure of coal tonnage to show any marked increase in 1934 and 1935.[10]

Group "A" mines have produced a small percentage of total Alabama deep-mine tonnage during most of the period. The production curve for "all other" mines follows closely the curve for the State. Group "A" mines, however, have bettered their position over the 18-year period. In 1918 they produced only 7.3 percent of Alabama deep-mine tonnage, whereas in 1935 they produced 24 percent. The identical Group "A-1" mines increased their share of the total from 5.1 percent in 1918 to 13.5 percent in 1935. As in other areas, Group "A" mines had better market outlets than the "all other" mines. About 40 percent of the tonnage of the group came from captive mines

[10] Recalling that 1930, 1931, and 1932 were years of active experimentation with mechanical loading in Alabama, it is interesting to note that this movement occurred during a period of extreme decline in tonnage.

and a major portion of the remaining tonnage was produced for known trade outlets.

Hourly Capacity

The hourly capacity of both Group "A" and Group "A-1" mines has increased, the Group "A" mines at a more substantial rate because new mines came into the group. In part, the increase was caused by the introduction of multiple shifts at certain mines (see page 291, footnote 3). The capacity of the "all other" group apparently was not influenced by the sharp decline in business until after 1931.

Men Employed

The coal industry in Alabama enjoyed a period of relatively steady demand in the years 1922-27 and employment remained at a correspondingly high level. Declining demand, first apparent in 1928, started a downward trend in the number of men employed which was not arrested until 1933. From a peak of 29,000 men employed in deep mines in 1923 the number dropped to a low of 18,000 in 1933, a decline of 38 percent. Very little advance occurred in 1934 and 1935.

Group "A" mines in Alabama, as in other areas, were able to withstand adverse conditions much better than other mines. The number of men employed in the mines of this group rose from 2,229 in 1918 to a peak of 4,227 in 1929. In 1935, 3,898 men, only 7.8 percent less than in 1929, were still on the rolls of Alabama Group "A" mines. The identical group of "A-1" mines employed 1,544 men in 1918, 2,084 men in 1929, and 1,962 in 1935, a drop of 5.9 percent from the 1929 peak.

Decline in number employed by the "all other" group of mines was not serious until after 1927. The heavy post-war reduction in output had been temporary and was reflected in fewer annual working days rather than in the loss of jobs. Between 1927 and 1929, however, declining output was also reflected in fewer men employed, and the number dropped sharply with the spectacular loss of tonnage after 1929.

Days Operated per Year

Working time in Alabama coal mines depends largely on the prosperity of the steel industry. Between 1918 and 1929 this

State averaged more days of employment per year than any other large bituminous area in the country. In 1929, when the average number of working days for all deep mines in the United States was 220, Alabama mines worked 233 days. After 1929 meagerness of working time was the typical employment condition of the Alabama coal industry.

For the greater part of the period from 1918 to 1935 the record of Group "A" mines for days operated per year has been somewhat better than that of the "all other" group, but the difference is not striking.

Tons per Man-hour and Number of Men Required to Maintain 1,000 Tons of Hourly Capacity

In areas previously studied the bases upon which Group "A" mines are divided from "all other" mines brought together in Group "A" the mines in which resource, management, and engineering conditions were generally more favorable to high productivity than they were in the other mines of their respective areas. This fact was revealed by superior performance of Group "A" mines before, as well as after, the introduction of mechanical loading. In Alabama, on the other hand, Group "A" mines had higher unit labor requirements or lower productivity than the group of "all other" mines throughout most of the period of study, and their average did not overtake the average for the "all other" group until 1931.

A study of the individual companies in Group "A" indicates that they were not inferior from the standpoint of management. The very fact that they undertook mechanical loading suggests that their management was progressive. Their action in mechanizing cutting more rapidly than the "all other" mines and their success with mechanical loading would seem to put them ahead of other Alabama mines from the standpoint of technology. Group "A" mines in Alabama also had the advantage of high-quality coal and proximity to the Birmingham market. Against these advantages the mines suffered from the handicap of difficult physical conditions; in an area noted for geological handicaps these mines were distinctly below the average. It is impossible to measure exact physical conditions or their effects on productivity, but the following tabulation suggests

the relative influence of the two factors, seam thickness and dip, on the two groups:

Seam thickness (inches)[11]			Degree of dip (1920)[12]	
Year	All mines	Group "A"	Mine	Degrees
1917	56.3	-	All mines[13]	$3\frac{1}{2}$
1918	-	46.5	Group "A"	
			Mine 1	$12\frac{1}{2}$
1935	-	49.4	Mine 2	14
1937	57.6	-	Mine 3	16

Over the 18-year period covered by the study Group "A" mines showed considerable savings in unit labor requirements, chiefly in the years after 1927 when mechanical loading was being rapidly introduced. The percentage of Group "A" output mechanically loaded jumped from 22 percent in 1928 to 48 percent in 1930 and 63 percent in 1933; it dropped to 52 percent in 1934 but was back to 60 percent in 1935.

Even with these large increases in mechanical loading within the group, the registered declines in unit labor requirements appear too large to be attributable entirely or even chiefly to mechanical loading. The suggestion that improvement in other factors such as haulage and cutting are responsible for the decline in unit labor requirements is fortified by the fact that mechanical loading in Alabama "A" mines was performed mainly by hand-loaded conveyors and pit-car loaders, the types of equipment having the smallest influence on productivity. Conveyors were used to load roughly 50 percent of the machine output of Group "A" mines from 1930 to 1935. Pit-car loading was used for about 35 or 40 percent, and a modified longwall system in use in certain mines in this area permitted the use of scrapers for the balance. In one or two instances the scraper installations resulted in a rather large increase in output per man-hour.

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[11]Weighted averages of seam thickness, computed from data for 1917 from *Annual Report of Coal Mines, State of Alabama, 1917* (Birmingham, Ala.: Dispatch Printing Co., 1917); for 1918 from same for 1918 (1918); for 1935 from *Forty-fourth Annual Report of State Mining Department of Alabama, Coal Mines, 1935* (Wetumpka, Ala.: Wetumpka Printing Co., 1936); and for 1937 from same for 1937 (1938).

[12]Degree of dip taken from unpublished records of the study of physical conditions, made by Margaret H. Schoenfeld (see chapter III, ftn. 7).

[13]Weighted average.

A study of geological factors connected with bituminous mining in Alabama seems to indicate that in areas with exceptionally poor geological conditions the physical factors encountered tend to show more fluctuations from better to worse than they do in areas where seam conditions - thickness, pitch, and purity of coal - are more favorable.[14] In the absence of opportunity for quantitative measurement there is reason to believe that changes in physical conditions of actual workings in Alabama Group "A" mines may have contributed substantially to change in productivity.

Unit labor requirements in the "all other" mines showed but moderate decline over the period as a whole. In 1918, 2,985 men were needed to maintain an hourly capacity of 1,000 tons; in 1935, 2,571 men. The movement of the curve between 1930 and 1934 is affected, as it was in other areas, by certain inaccuracies in statistical reporting during the depression years. From 1930 to 1932 there was a definite tendency to understate the number of man-hours actually worked, and in 1933-34 a tendency to overstate the number. The more accurate observations for 1935 leave no doubt that substantial savings in labor requirements have been attained.

Considering the direction taken by the curves of productivity and unit labor requirements during the period of the present study, emphasis should constantly be placed upon the fact that the significance of these curves is almost entirely in the relation they bear to the resource conditions with which bituminous operators in Alabama had to contend. From this standpoint it is a fair assumption that any positive results of mechanical loading in Alabama were chiefly by way of overcoming obstacles which would have been impossible or extremely difficult to overcome without these aids.

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[14] This is the case for some other States, notably Washington.

CHAPTER XI

SUMMARY AND CONCLUSIONS*

The fact of employment opportunity or lack of opportunity has a significance which is primarily local in the sense that a job is attached to a given mine in a given locality rather than to the coal industry. Miners are affected by an increase or a decrease in the number of jobs or in working time to the extent that these changes apply to nearby mines in which they may hope to find employment. From this point of view an analysis of data by areas is of greater interest than an over-all picture of the industry. Yet, increasingly, employers, labor, and the Government are finding themselves forced to regard the problems of the bituminous-coal industry in terms of their national as well as their local aspects.

In discussing performance data for the particular areas the danger of drawing conclusions from short-time fluctuations has been emphasized. It is even more necessary to limit conclusions to general trends in the case of the composite records for the United States.

It must also be kept in mind that averages can be misleading when applied to groups of changing composition. Conclusions to be drawn from performance of hand-loading mines are, therefore, necessarily tentative, in view of the heavy mortality suffered within this group. In view of these limitations, composite showings for hand-loading and machine-loading mines throughout the industry have value chiefly as a vehicle for reviewing trends already noted in connection with particular areas.

PERFORMANCE OF MECHANICAL- AND HAND-LOADING MINES IN THE UNITED STATES, 1918-35

Aggregate performance data on mechanical loading to the end of 1935 were compiled and charted for the whole United States on the same basis used for the individual areas. Because the important areas heretofore analyzed account for the bulk of the total machine tonnage, their performance necessarily

*By Willard E. Hotchkiss.

influences the composite showings for the country as a whole.[1] The standard performance charts for the United States are presented in figure 56.

Tons Mechanically Loaded

Tonnages mechanically loaded in Groups "A" and "A-1" conform closely to the corresponding curves for Illinois because of the large percentage of the machine-loaded tonnage coming from the mines of that State. In Group "B" mines over 11 million tons were machine loaded in 1930, and in 1934 this had declined to 1,779,000 tons. The slight increase in 1935 was mainly the result of mines that put in loading equipment for the first time but which were still under the 30-percent mark. In 1935 Group "B" mines were responsible for only 5.5 percent of the total tonnage mechanically loaded.

Tons Cut by Machine

Since successful machine loading is dependent on other mine processes operating at a high level of mechanization, it is natural to find Groups "A" and "A-1" with a greater percentage of their tonnage cut by machine than have the hand-loading mines. By 1932 Groups "A" and "A-1" were cutting about 95 percent of their tonnage by machine. The large increases in percentage of tonnage cut in hand-loading mines seem to have halted about 1931, the group showing a tendency to level off at about 85 percent.

Number of Mines

Mines included in Group "A" numbered 170 in 1918 and 226 in 1935. The identical "A-1" group included 104 mines.[2] The

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[1] About 43 million, or 90 percent, of the 47 million tons of coal mechanically loaded in the United States in 1935 came from areas for which performance data have been analyzed. Some areas have been discussed without detailed analysis of performance, such as Colorado in chapter IX and Ohio, West Virginia, and Virginia in chapter X. Discussion of the few remaining areas (Kentucky, Arkansas, Tennessee, Maryland, Missouri, New Mexico, North Dakota, Oklahoma, and that part of Ohio outside the No. 8 field), which together loaded only 1,587,935 tons mechanically in 1935, centers in the current situation and possibilities for the future, covered in chapter VI. In one of these minor areas, Arkansas, mechanical loading was of local importance with 28.6 percent of the State's output so loaded in 1935. Although Arkansas experience with mechanical loading has considerable value for other areas from the standpoint of what can be done to overcome adverse physical conditions, its discussion pertains more logically to the analysis of the current situation and future possibilities as covered in chapter VI.

[2] The individual areas for which performance data are shown separately will not, of course, add to the totals as shown for the United States in table B-80. There were "A" mines in Arkansas, Colorado, eastern and western Kentucky, Maryland, Missouri, North Dakota, Oklahoma, Tennessee, Virginia, and West Virginia which were not shown separately.

Figure 56.- COMPARATIVE PERFORMANCE IN THE UNITED STATES OF UNDERGROUND MINES WHICH HAVE ADOPTED MECHANICAL LOADING AND OF ALL OTHER UNDERGROUND MINES, 1918-85

(Strip mines are excluded)

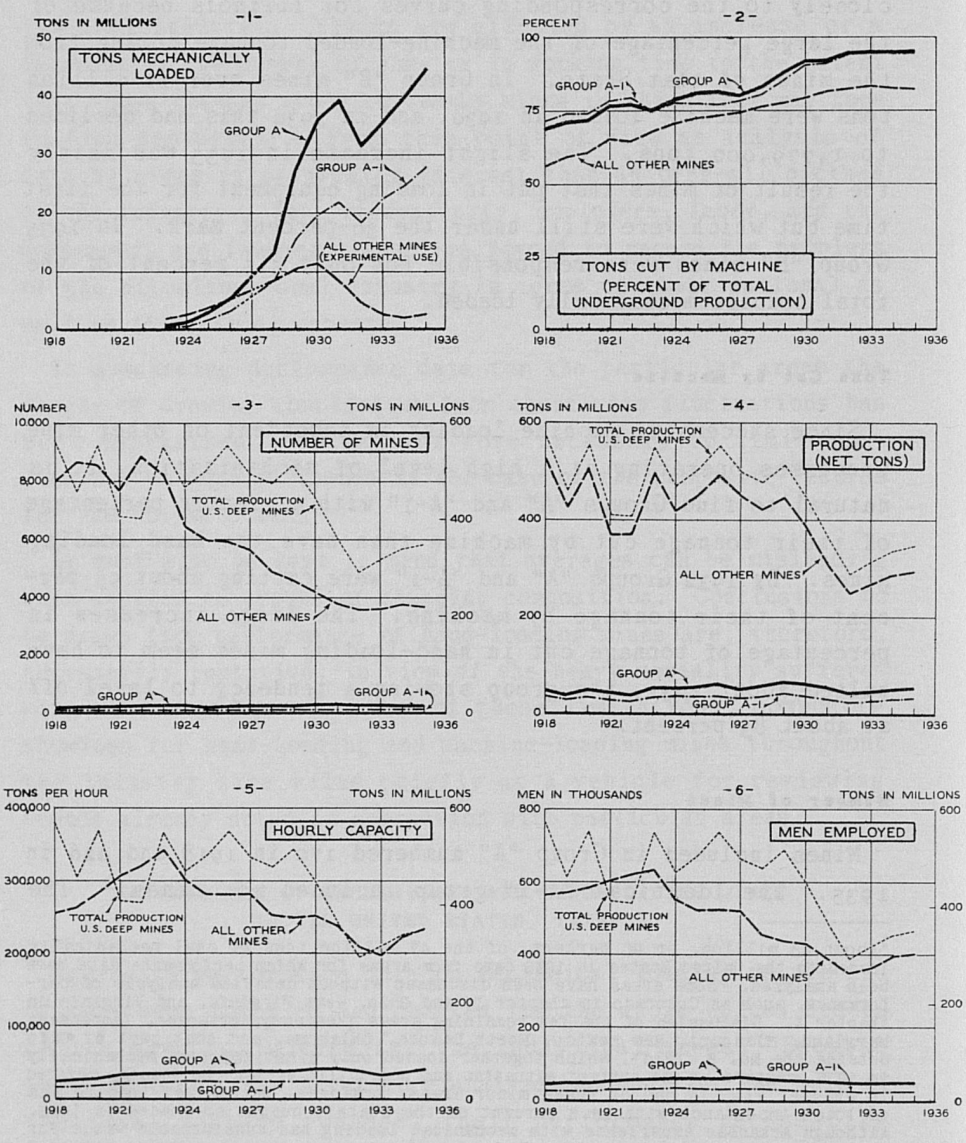

Figure 56.- COMPARATIVE PERFORMANCE IN THE UNITED STATES OF UNDERGROUND MINES WHICH HAVE ADOPTED MECHANICAL LOADING AND OF ALL OTHER UNDERGROUND MINES, 1918-35 - *Continued*

(Strip mines are excluded)

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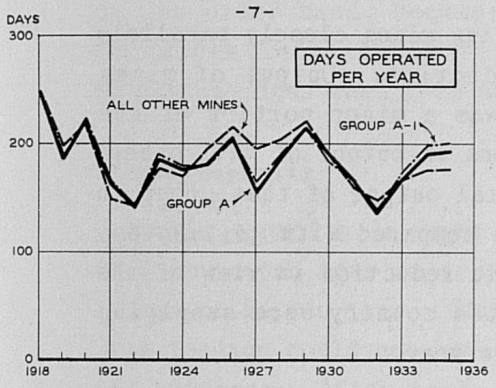

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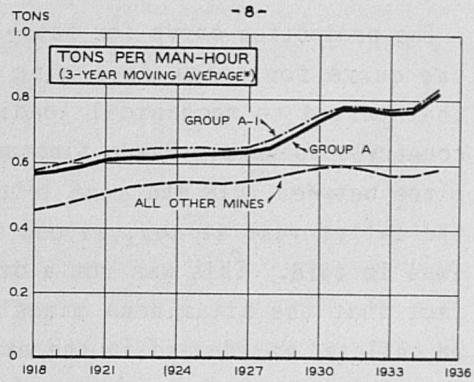

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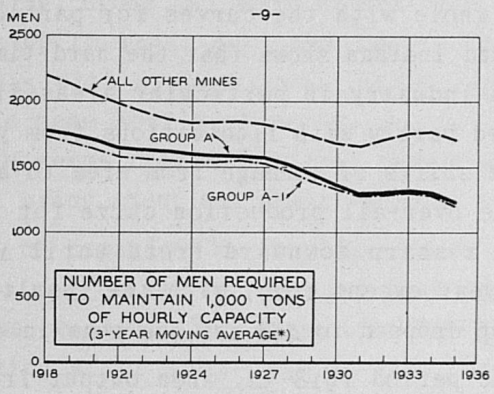

*ACTUAL FIGURES FOR 1918 AND 1935.

FOR DESCRIPTION OF GROUPS OF MINES SEE PP. 203-5.

BASED ON TABLE B-60

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maximum for the country in the "all other" group was reached in 1922 when it contained 8,824 mines. After 1923 the group suffered high mortality and by 1932 had declined to only 3,544 mines - two-fifths of the number that were in operation in 1922.[3] This had increased slightly, to 3,698, by 1935.

Production

The production curve for hand-loading mines closely parallels the curve for total deep-mine production. Output of mines that turned to mechanical loading was a minor portion of the country's tonnage. Sharp fluctuations in output of "all other" mines between 1918 and 1926 left total output of that group in the latter year at 492,741,000 tons compared with 521,789,000 tons in 1918. This was not a drastic reduction in view of the fact that the bituminous mines of the country were supplying an inflated war demand in the earlier year.

Comparison of the production curve for "all other" mines in the country as a whole with the curves for particular areas such as Illinois and Indiana shows that the hard times suffered by the bituminous industry in particular areas from 1918 to 1926 was associated partly with fluctuations from year to year but even more with shifts of tonnage from area to area. After 1926, however, the over-all production curve for "all other" mines maintained a sharp downward trend until 1932. This applied in every year except 1929, with the result that total output of the group dropped to 248,101,000 tons in 1932.

During the whole period 1918-32, when output from the "all other" group underwent sharp fluctuations and drastic decline, Group "A" mines exhibited comparative stability. The trend of production in Group "A" mines was upward from 1918 to 1929, rising from 46,479,000 to 66,608,000 tons, an increase of 43 percent. This increase in output was only partly the result of an increase in the number of mines in the group in the latter year, for in the "A-1" identical series of mines production rose from 33,068,000 to 41,371,000 tons, an increase of

[3]The count of number of mines in the "all other" group is not strictly comparable over the entire period. "Wagon mines" and "country banks" have been excluded throughout the period, but local commercial mines (mines employing less than 10 men) could only be excluded from 1923 to 1935. Between 1922 and 1924 the recorded decline is therefore greater than that which actually occurred. In making a comparison between these and published figures of the Bureau of Mines for Class 4 and 5 mines, it must be remembered that the Bureau of Mines tables include local commercial mines.

25 percent. In the period of general business depression from 1929 to 1932 the downward trend of output in this group was not so severe as was that of the mines that continued to load by hand. To sum up the period as a whole, Group "A" mines produced 19 percent more coal in 1935 than they did in 1918, whereas Group "A-1" mines were able to sell about the same amount of coal at the end of the period as at the beginning. On the other hand, because of vast liquidation of capacity, the mines left in the "all other" group in 1935 produced 44 percent less than they produced in 1918.

Hourly Capacity

Hourly capacity in Group "A" mines rose from 23,000 tons in 1918 to 39,000 tons in 1927; in Group "A-1" mines it rose from 17,000 to 24,000 tons. This occurred in the years when mechanical loading could not have been an important factor in causing the increase. After 1928, in the period of intense mechanization of loading, Group "A" mines showed only a slight expansion of capacity up to 1931, declined during the depression, and ended in 1935 with 41,000 tons. Group "A-1" mines in 1935 reported the same hourly capacity, 24,000 tons, as in 1927. The evidence seems conclusive that mechanical loading up to 1935 did not bring about any great increase in mine capacity.

Expansion of capacity in the "all other" mines was marked from 1918 to 1923 when the all-time peak of 344,000 tons per mine-hour was reached. The large liquidations that took place in coal mining after 1923 reduced mine capacity to 250,000 tons in 1929, and a further 50,000 tons were lost by 1933. Better markets caused the hourly capacity curve to turn upward slightly from 1933 to 1935.

Men Employed

The number of men employed in Group "A" mines increased from 42,000 in 1918 to 63,000 in 1927 and then declined to 50,000 in 1935. The identical series of Group "A-1" mines was able to offer in 1935 practically the same employment as in 1918.[4]

For the country as a whole employment centered in the hand-loading mines. Employment was at its peak in 1923 when 636,000

[4] It must be kept in mind that the performance curves of Group "A" and Group "A-1" mines for the United States are highly weighted by Illinois and thus tend to reflect Illinois experience.

men were employed. In 1929 the number had fallen to 439,000. Within a period of 6 years 197,000 jobs were lost. The great depression of the early thirties caused further retrenchments and by 1932 employment had dropped to 351,000. Recovery in the coal industry, apparent since the middle of 1933, assisted in some measure by the 7-hour day and the 5-day week, resulted in a slight increase in employment; in 1935, 402,000 men were employed in hand-loading mines.

From the national standpoint the ability of Group "A" mines to offer job security to their personnel was of minor significance in the over-all employment picture. In 1935 approximately 90 percent of the jobs were still concentrated in hand-loading mines.

Days Operated per Year

A comparison of working time in Group "A" and "all other" mines shows that for the country as a whole the hand-loading group held the advantage in many of the years up to 1929. The strike in Illinois and Indiana was, of course, the explanation for the low points reached in 1927 and 1928 in Group "A" mines. In 1934 and 1935 Group "A" mines worked 13 and 16 more days, respectively, than the hand-loading group.

Tons per Man-hour and Number of Men Required to Maintain 1,000 Tons of Hourly Capacity

Superiority of Group "A" mines is shown by their consistent ability to mine coal with less labor per unit of output than was needed by mines of the "all other" group. This fact, striking for areas in which mechanical loading was concentrated prior to 1935, is shown with equal clearness in panels 8 and 9 for the United States as a whole. Comparison on a national basis of the mechanized and nonmechanized groups is greatly affected by the fact that the mechanized mines reflect chiefly Illinois-Indiana experience and the nonmechanized or "all other" mines reflect chiefly Appalachian experience, including that of West Virginia and Kentucky.

If attention is directed to panel 9 for the United States it may be seen that the "all other" mines showed greater improvement for part of the period of study than did Group "A" mines. During the period 1918-28, a time when mechanical loading was

unimportant, unit labor requirements for the "all other" group declined 18.6 percent whereas the decline for Group "A" mines was 14.4 percent.

The trend of unit labor requirements in both groups of mines was plainly downward during the entire period 1918-31. How much of the decline for the "all other" group can be attributed to managerial or technical changes other than mechanical loading and how much to inaccuracies in reporting and to the changing composition of the group cannot be determined. Whatever the major causes, labor requirements decreased from 2,198 men per 1,000 tons of hourly capacity in 1918 to 1,739 men in 1929, a decline of 21 percent. Between 1930 and 1934 the trend of the curve is affected by inaccuracies of reporting associated with the depression years to which references have already been made. The general trend, however, seems to have been slightly downward, for the net change from 1929 to the more careful observations of 1935 was a decline of 2 percent. During the period after 1923 average performance of the "all other" group of mines was greatly improved by the closing of many marginal mines, but it is also probable that mines which were able to survive did so in part by improving their productivity.

In regard to Group "A" mines it appears that prior to 1928, even though they were probably ahead of the "all other" mines as a class in utilizing the then-current technology, they were unable to make as great an improvement in labor productivity during this period as was made in the mines of the other group. In the years following 1928, when performance of Group "A" mines came to reflect increasingly the results of mechanical loading, spread in productivity between the two groups again increased, and it is believed that this represented mainly the effects of mechanical loading. Unit labor requirements in Group "A" mines were 20 percent less in 1935 than they were in 1928. In the "all other" group of mines they were only 5 percent less, the average decrease for all deep mines being 7.5 percent.

Changes in unit labor requirements cannot be translated into terms of employment without making assumptions regarding other factors that enter into the employment ratio. One such factor is length of the working day. In 1934 the official working day was reduced from 8 hours to 7, but there is no way

of forecasting future changes. Another factor destined to have a major effect on employment opportunity is the amount of coal that will be produced by mines operating at different levels of productivity. In the past, as mechanization of loading progressed, Group "A" mines produced an increasing percentage of the total output; this percentage has continued to increase during the 2 years following 1935.

Reductions in cost resulting from mechanical loading naturally increased the amount of coal produced in certain areas, but there is no way of determining to what extent this increase was at the expense of other areas or of mines that did not mechanize. Increased tonnage which reflected sales that could not have been made on higher cost levels represented a contribution to employment, but sales that resulted from taking business away from another area or another mine meant merely a shift of employment from one place to another.

In analyzing effects of mechanical loading in the Illinois-Indiana area it became fairly clear that the employment situation would have been worse than it was if operators had not utilized the lower costs incident to mechanical loading in order to arrest loss of tonnage to other areas. For the industry as a whole it seems clear that the only way in which decline in unit labor requirements can be prevented from resulting in loss of man-hours of employment is by increasing the market for coal sufficiently to counteract the adverse effect of increased output per man.

Comparative Labor Requirements With Different Loading Devices

Man-hour output in any area, and for the industry as a whole, is a resultant of many factors in which the complementary items of resource conditions and mining technology are preeminent. To whatever extent types of equipment may vary in their effect on labor output, the results achieved with them depend in large part upon conditions and management in the mines in which they operate.

In recognition of the fact that the effects of mechanical loading depend greatly upon the coordination and types of equipment used, comparisons were made of labor requirements in the various areas when different types of loading were in use

Table 19.– LABOR OUTPUT AND LABOR REQUIREMENTS IN SELECTED BITUMINOUS-COAL MINES IN PERIODS OF HAND AND MECHANICAL LOADING, BY TYPE OF LOADER[a]

Type of loader	Number of mines	Tons produced per man-hour			Number of men required to maintain 1,000 tons of hourly capacity		
		Hand-loading period	Mechanical-loading period	Percentage increase	Hand-loading period	Mechanical-loading period	Percentage decrease
Scraper loaders[b]	5	0.396	0.695	75.5	2,525	1,439	43.0
Mobile loaders, total	39	.736	1.116	51.6	1,359	896	34.1
Illinois and Indiana	33	.728	1.111	52.6	1,374	900	34.5
Illinois	17	.748	1.120	49.7	1,337	893	33.2
Indiana	16	.670	1.087	62.2	1,493	920	38.4
Montana	3	.745	1.114	49.5	1,342	898	33.1
Wyoming	3	.885	1.209	36.6	1,130	827	26.8
Duckbills[c]	5	.777	0.954	22.8	1,287	1,048	18.6
Pit-car loaders, total	34	.698	0.833	19.3	1,433	1,200	16.3
Illinois	21	.701	0.842	20.1	1,427	1,188	16.7
Indiana	13	.685	0.787	14.9	1,460	1,271	12.9
Hand-loaded face conveyors[d]	21	.435	0.503	15.6	2,299	1,988	13.5

[a] Computed from data of the U. S. Bureau of Mines. In general, mines were selected which showed that in 2 years or more 75 percent or more of total production had been loaded by one type of equipment. Figures for the mechanical-loading period represent average performance of from 2 to 4 years under mechanical loading ranging from 75 to 100 percent of total mine output. The hand-loading period covered was an average of 3 or 4 years under representative hand-loading conditions. Mines could not, of course, be included if there was no hand-loading period, i. e., mines that opened up completely mechanized or for which it was difficult to get a representative hand-loading period were omitted. Mines were also omitted that showed indications of inaccurate reporting. In order to retain the same relative weights of individual mines under both mechanical- and hand-loading conditions so as to reflect the composite change in productivity unaffected by changes in the relative magnitude of production between the two periods, the average for each mine was weighted on the basis of its relative significance (as measured by man-hours worked) during the period of mechanical loading covered.

[b] Arkansas, Oklahoma, central Pennsylvania, and Wyoming.

[c] Wyoming.

[d] Alabama, Arkansas, central Pennsylvania, Washington, and Wyoming.

and of labor requirements in the same mines during a hand-loading period. Selection of mines was made on a basis that is believed to reveal representative performance. Table 19 shows the results of this comparison.

Scraper loaders in the scattered mines in which they were used were the most effective of the several devices. Because of mining methods, discussed at length in chapter V, the use of scrapers is limited. Only five scattered mines located in central Pennsylvania, Wyoming, Arkansas, and Oklahoma could be studied for comparative performance of a scraper-loading period with a hand-loading period for the same mines. The comparison showed that 2,525 men were required to maintain an hourly capacity of 1,000 tons under hand loading but only 1,439 men were required with scrapers, a saving of 43 percent.

Because of the exceptionally favorable conditions under which scrapers have been installed, their effect on man-hour output

compared with hand loading has been greater than that of mobile loaders. The selected mines in which the performance of mobile loaders was studied, however, showed a decrease in man-hour requirements of 34.1 percent in the mechanical-loading compared with the hand-loading period.

Thirty-four mines using pit-car loaders reduced the number of men required per 1,000 tons of hourly capacity by 16.3 percent.

Five mines using duckbill loaders reduced man-hour requirements by 18.6 percent.

Twenty-one mines scattered in Alabama, Arkansas, central Pennsylvania, Washington, and Wyoming made an over-all saving of 13.5 percent with conveyors.

In considering the national significance of types of loading equipment used in particular areas, it should be recognized that during the past few years mobile loaders have undergone substantial changes in design which have greatly increased their flexibility for use under varying conditions. Changes in machine design will not entirely overcome the drag of poor resource conditions on man-hour output, but the use of increasingly effective equipment and improvements in management will unquestionably tend to reduce unit labor requirements under machine loading.

The smallest unit labor requirements or the largest labor outputs under hand loading were in States where natural conditions were most favorable, as in Illinois, Indiana, Wyoming, and Montana. In general, the best combination of resource factors was found in those States having thick coal, level seams or seams with manageable pitches, and good floor and roof. Such conditions favored the mobile loader when operators in those areas turned to machine loading. The result was that areas with excellent physical conditions were in a position to realize greater savings than areas with poorer conditions which used lower-powered equipment.

In Wyoming, where man-hour requirements under hand loading were comparable with Illinois and Indiana, the duckbill loader became the dominant type of loading equipment, but here again there was a definite fitness of this equipment to the physical conditions. Southern Wyoming mines with steep pitches, to which duckbill loaders were adapted, realized savings, but less than did mines that were able to use mobile loaders.

The relation between physical conditions and pit-car loaders is much less marked than that between physical conditions and mobile and duckbill loaders. Pit-car loaders were favored during the early stages of mechanization in Illinois and Indiana because they were cheap and applicable to existing mining practice. As organization for more complete mechanization progressed, pit-car loaders declined in favor of mobile loaders from which greater saving could be realized. Man-hour output records of Illinois and Indiana mines under pit-car loading and mobile loading reflect in large measure the relative degrees of mechanization embodied in the two types of equipment, pit-car loaders being installed as a mechanical aid to hand miners, whereas mobile loaders necessitated reorganization of many mine processes.

The hand-loaded conveyor is the only loader that can be installed in almost any mining situation. This means that in earlier years many mines with unfavorable resource factors had no alternatives to conveyors when they turned to mechanical loading. Although the hand-loaded conveyor is potentially a slower-speed and lower-capacity form of mechanical loading, the smaller savings shown by mines using it were also the result of resource handicaps. For example, in Alabama and Arkansas seams are thin and pitching, and, in Alabama, the seams contain many impurities. Conditions are not so adverse in central Pennsylvania as they are in Alabama and Arkansas, but thin seams and moderately pitching beds, plus the necessity of mining clean coal, forced central Pennsylvania mines to use conveyors rather than more powerful types of equipment. It is believed that under favorable conditions and with close supervision larger savings could be made with hand-loaded conveyors than the experience of the 21 mines in table 19 would indicate.

Analysis of comparative performance under hand loading and machine loading with different types of equipment in different areas shows clearly that the effect of mechanical loading on productivity depends in large measure on the type of loader used. Nevertheless, the fact that output per man varies greatly between mines, both under hand loading and machine loading, even with the same type of equipment, indicates that conditions other than type of equipment have a large influence on man-hour output. Physical conditions that indicate utilization of one type of loader rather than another

help to determine output per man even when equipment best adapted to the particular seam is used. Management exerts a very important influence in combining the best technology to attain the highest degree of productivity possible under existing resource conditions.

NATION-WIDE VIEW OF MECHANIZATION TO 1938

Advance of mechanical loading since 1935 has been outstanding. Equally significant has been the growth of strip mining. These two phases of mechanized mining appear destined to play an important part in the bituminous industry in the years immediately ahead. Although both of them will be influenced by numerous, unpredictable forces, careful study of current situations in the light of past experience will indicate some of the probable trends for the future. Economic and resource factors, which will in part determine the future of strip mining, were discussed at some length in chapter IV. The place of strip mining in this chapter is merely to serve as a phase of mechanization in comparison with machine loading in deep mines and to give a balanced picture of mechanization as a whole.

Effort to appraise the current situation in mechanical loading must necessarily be broken down into areas and types of mining conditions. While the study for the period ending in 1935 was in progress, figures for 1936 and estimates for 1937 revealed rapid development of new centers of mechanization. In order to connect the current situation with the history of the movement to the end of 1935, State and regional comparisons of tonnage and percentage distributions of mechanically loaded deep-mine tonnage were made for the years 1930, 1935, 1936, and 1937. The year 1930 was shown because the total output of bituminous coal in the country was nearly the same in that year as it was in 1936 and 1937, and the bases upon which percentages of mechanical loading are figured therefore remain fairly constant.

Table 20 shows that the Middle West (chiefly Illinois and Indiana) is still the most important center of mechanical loading although its proportion of the total tonnage mechanically loaded dropped from 57.5 percent in 1930 to 43.7 percent in 1937. The southern Appalachian area, represented mainly by

Table 20.- PERCENTAGE DISTRIBUTION OF BITUMINOUS COAL MECHANICALLY LOADED, BY REGION, 1930 AND 1935-37[a]

Region	1930	1935	1936	1937
United States	100.0	100.0	100.0	100.0
Middle West and Southwest	58.2	57.4	51.0	44.4
Middle West (Ill., Ind., west Ky., Mo., and Iowa)	57.5	56.7	50.2	43.7
Southwest (Ark. and Okla.)	0.7	0.7	0.8	0.7
Appalachian	25.9	23.6	31.9	40.0
Nothern (Pa., Ohio, and Md.)	18.3	17.2	16.8	18.4
Southern (W. Va., Va., east Ky., and Tenn.)	7.6	6.4	15.1	21.6
Alabama	4.4	2.8	2.6	2.5
Rocky Mountain (Wyo., Mont., Wash., N. Dak., Colo., Utah, and N. Mex.)	11.5	16.2	14.5	13.1

[a]Data computed for 1930 from F. G. Tryon, L. Mann, and H. O. Rogers, "Coal," *Mineral Resources of the United States: 1930* (U. S. Dept. Com., Bur. Mines, 1932), Part II, "Nonmetals," p. 673; for 1935 from F. G. Tryon, L. Mann, and W. H. Young, "Bituminous Coal," *Minerals Yearbook, 1937* (U. S. Dept. Int., Bur. Mines, 1937), p. 833; and for 1936 from *Bituminous Coal Tables, 1936-1937* (U. S. Dept. Int., Nat. Bituminous Coal Com., 1938). In some cases special break-downs were required to obtain sufficiently detailed figures. The data for 1937 represent preliminary estimates of the National Bituminous Coal Commission based on reports of State Departments of Mines, operators, and sales of new equipment.

West Virginia, showed the greatest increase in the same period - from 7.6 to 21.6 percent of the total. The percentages contributed by the northern Appalachian Region and the Rocky Mountain Region were about the same in 1937 as in 1930.

Turning to the showing for individual States in table 21, by far the most phenomenal advance in mechanical loading since 1935 has been in West Virginia where the tonnage loaded by machine in 1937 was $7\frac{1}{2}$ times that for 1935; in contrast to the 2 percent of its total output loaded by machine in 1935, 13 percent was so loaded in 1937. Preliminary figures of the West Virginia Department of Mines indicate that 21 percent was mechanically loaded in 1938.

Other States making notable advances are Colorado, with machine-loaded tonnage in 1937 five times that of 1935, and Ohio, Arkansas, Utah, and Washington, with 1937 machine tonnage approximately double that of 1935. Advances in these States involved comparatively small tonnages, but Pennsylvania, which

Table 21.- BITUMINOUS COAL MECHANICALLY LOADED AND PERCENTAGE OF UNDERGROUND PRODUCTION, BY STATE, 1930 AND 1935-37[a]

State	Number of tons				Percent of underground production			
	1930	1935	1936	1937	1930	1935	1936	1937
United States	46,993,848[b]	47,177,224	66,976,872	83,500,000	10.5	13.5	16.3	20.3
Alabama	2,056,052	1,303,653	1,741,452	2,100,000	13.4	15.4	14.3	16.9
Arkansas	244,816	292,064	522,411	550,000	16.6	26.6	33.3	34.2
Colorado	122,660	197,319	557,548	1,018,039	1.5	3.3	8.2	14.3
Illinois	22,846,555	20,513,082	26,110,068	28,344,362	48.0	55.3	62.4	70.7
Indiana	3,503,183	5,767,696	7,146,090	7,426,306	32.3	62.5	70.5	80.6
Iowa	(c)	0	(c)	(c)	(c)	0	(c)	(c)
Kentucky	989,156	533,250	658,747	1,300,000	1.9	1.3	1.4	2.8
Eastern	417,631	102,320	318,164	n.a.	1.0	0.3	0.8	-
Western	571,525	430,930	340,583	n.a.	5.4	5.3	4.3	-
Maryland	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)
Missouri	109,088	(c)	0	0	6.1	(c)	0	0
Montana	1,114,705	1,291,373	1,464,121	1,431,000	57.0	80.3	83.2	79.2
New Mexico	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)
North Carolina	12,000	0	0	0	42.1	0	0	0
North Dakota	0	(c)	(c)	(c)	0	(c)	(c)	(c)
Ohio	1,497,000	1,488,303	2,049,075	3,204,102	7.0	7.8	9.5	14.4
Oklahoma	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)
Pennsylvania	7,034,906	6,469,485	9,033,855	11,951,639	5.7	7.2	8.3	10.9
Central	2,847,763	3,624,405	3,930,181	4,275,470	6.3	10.4	10.3	11.0
Western	4,187,143	2,845,080	5,103,674	7,676,169	5.4	5.1	7.2	10.8
Tennessee	53,255	233,579	290,220	450,000	1.0	5.6	5.7	8.5
Utah	861,692	898,118	1,358,543	1,835,000	20.2	30.5	41.8	48.9
Virginia	864,391	651,807	779,232	1,500,000	7.9	6.7	6.7	11.1
Washington	424,206	429,617	608,488	838,000	18.4	27.6	33.6	41.7
West Virginia	2,228,401	2,059,322	8,712,935	15,490,863	1.8	2.1	7.4	13.1
Northern	580,321	356,198	2,613,046	5,906,414	1.8	1.5	9.3	20.4
Southern	1,648,080	1,703,124	6,099,889	9,584,449	1.8	2.3	6.8	10.6
Wyoming	2,864,698	4,530,032	5,189,263	5,300,000	47.7	89.8	92.2	92.1
Undistributed	167,084[b]	518,524	754,824	760,689	1.6	8.5	8.4	9.0

[a]For sources see table 20, ftn. a.

[b]This figure differs slightly from that shown in *Mineral Resources of the United States: 1930* (U. S. Dept. Com., Bur. Mines, 1932) because of revisions made during the present study.

[c]Included in "Undistributed."

n.a. Data not available.

ranks second among the States in total bituminous output, almost doubled its 1935 machine tonnage in 1937.

In spite of significant advances in new areas, the States in which machine loading was concentrated prior to 1935 continued in 1936 and 1937 to increase their ratio of machine-loaded to hand-loaded tonnage. In Illinois the percentage of underground tonnage mechanically loaded increased from 55.3 in 1935 to 70.7 in 1937; in Indiana the increase was from 62.5 to 80.6. Wyoming increased from 89.8 percent of deep production to 92.1 percent in the same period, but a small percentage decline occurred in Montana.

Figure 57 shows the distribution of hand-loaded, machine-loaded, and strip-mined tonnages by State for 1930, 1935, 1936, and 1937. If it is kept in mind that the output for the country varied but little in 1930, 1936, and 1937, tonnage

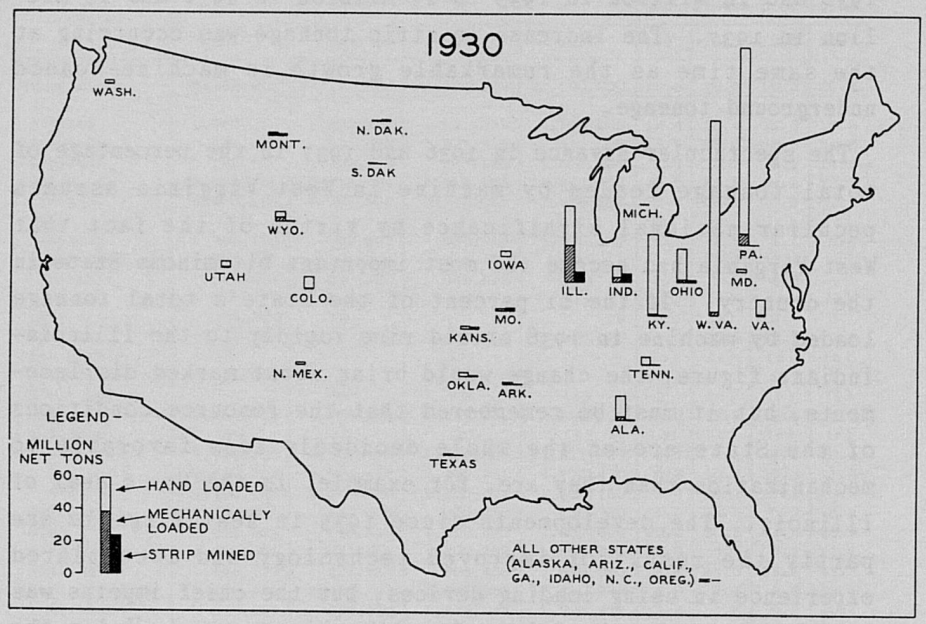
figures in the different areas are highly significant. Strip mining, which represents the highest degree of mechanization, increased in the Illinois-Indiana area from 12 million tons in 1930 and 14 million in 1935 to 17 million in 1936 and 19 million in 1937. The increase in strip tonnage was occurring at the same time as the remarkable growth in machine-loaded underground tonnage.

The spectacular advance in 1936 and 1937 in the percentage of total tonnage loaded by machine in West Virginia assumes peculiar national significance by virtue of the fact that West Virginia has become the most important bituminous State in the country. If the 21 percent of the State's total tonnage loaded by machine in 1938 should rise rapidly to the Illinois-Indiana figure, the change would bring about marked displacements, but it must be remembered that the resource conditions of the State are on the whole decidedly less favorable to mechanization than they are, for example, in the No. 6 seam of Illinois. The developments since 1935 in West Virginia are partly the result of improved technology and accumulated experience in using loading devices, but the chief impetus was basic changes in the labor situation since 1933. Under the higher wage rates now prevailing, certain favorable areas in the Sewickley, Pittsburgh, and Island Creek seams are being mechanized with exceptional rapidity. How fast mechanization can be extended to inherently more difficult areas remains to be seen.

Strip mining under favorable conditions has an advantage in man-hour output and in cost over deep mining, even in areas with low wage standards. This no doubt would have resulted in its growth even if the standards of the low-wage areas had not been raised. Nevertheless, the over-all competitive advantage of strip mining over deep mining has been intensified by higher wage levels in areas which supply the major portion of the Nation's bituminous coal.

The influence on deep-mine mechanization of raising the wage level in low-wage areas is, of course, much more direct than in the case of strip mines. The recent rise of mechanical loading in West Virginia and substantial advances in other areas whose wage standards were raised are in large measure direct reflections of these changes. Through its effect on competition,

Figure 57.- DISTRIBUTION OF HAND-LOADED, MECHANICALLY LOADED, AND STRIP-MINED BITUMINOUS COAL, BY STATE, 1930 AND 1935-37



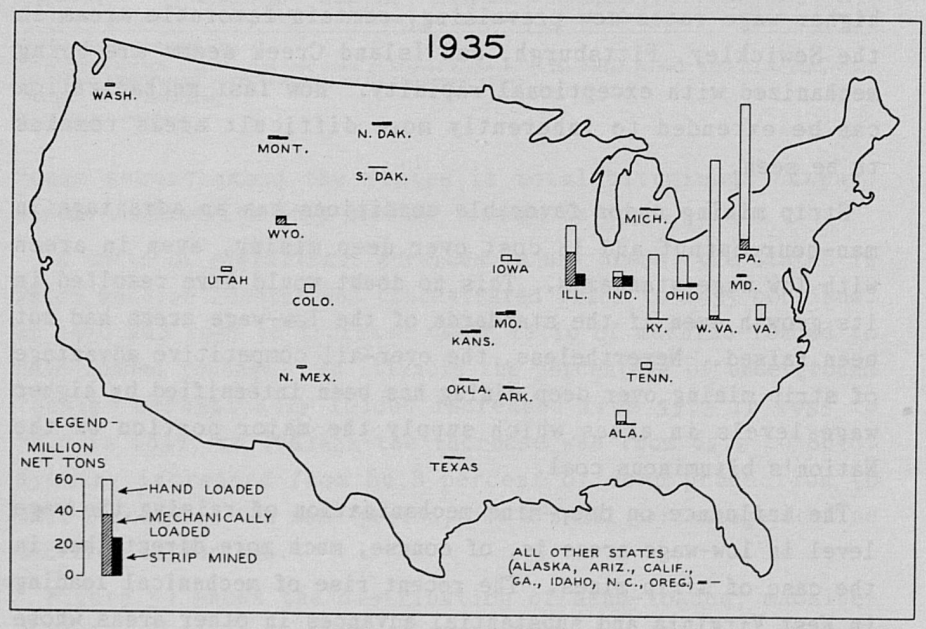
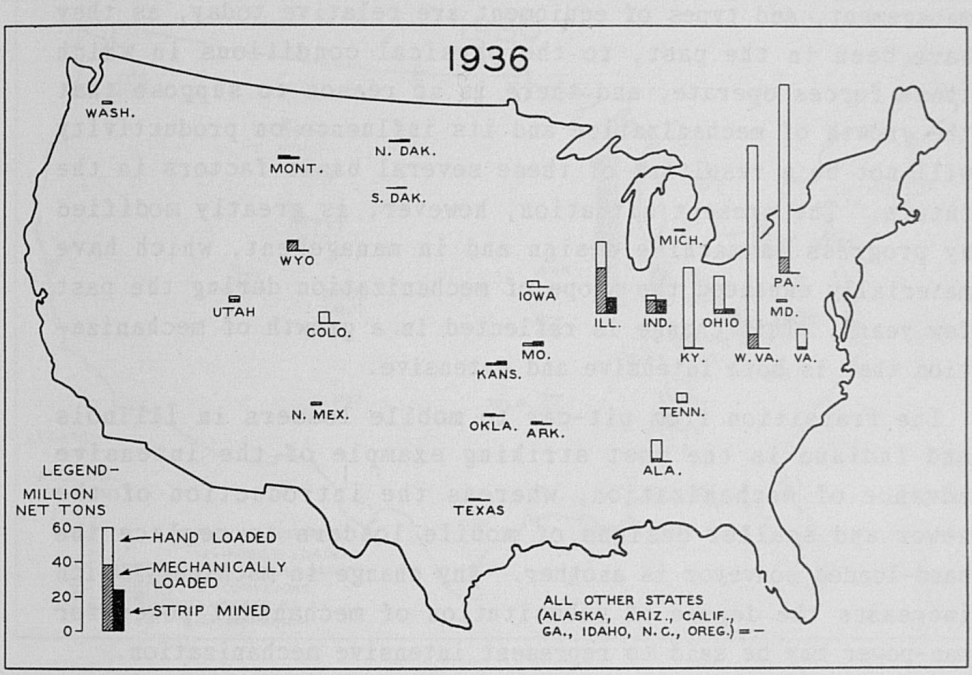
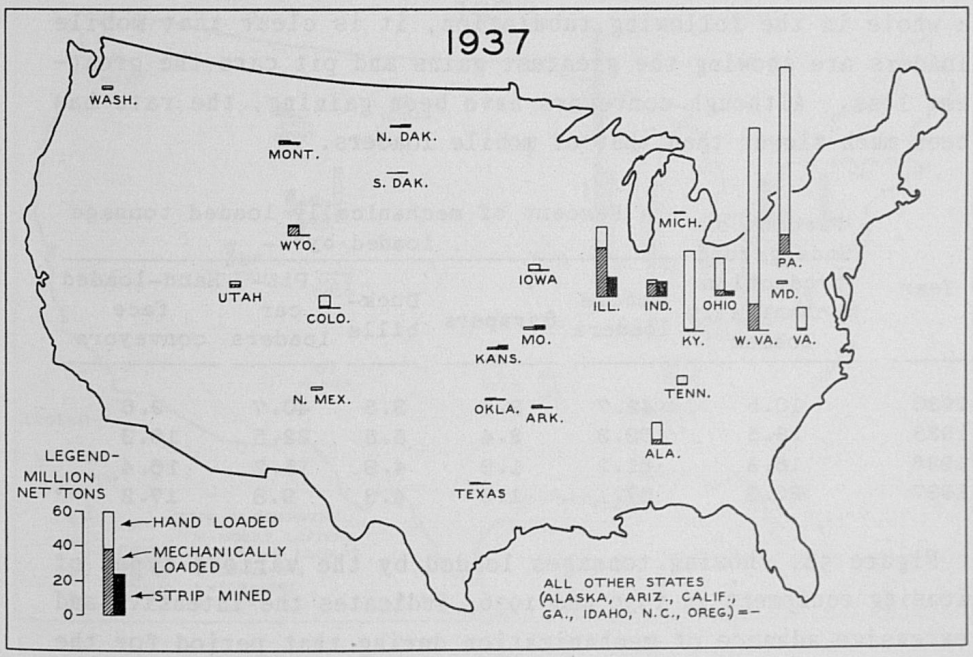


Figure 57.- DISTRIBUTION OF HAND-LOADED, MECHANICALLY LOADED, AND STRIP-MINED BITUMINOUS COAL, BY STATE, 1930 AND 1935-37 - *Continued*





BASED ON DATA OF THE U.S. BUREAU OF MINES AND THE NATIONAL BITUMINOUS COAL COMMISSION

MINERAL TECHNOLOGY AND OUTPUT PER MAN STUDIES
WPA-NATIONAL RESEARCH PROJECT E-183

increase in mechanical loading in heavy-tonnage eastern areas tends to stimulate further advances in other areas.

The influences exerted by labor standards, flexibility of management, and types of equipment are relative today, as they have been in the past, to the physical conditions in which these forces operate, and there is no reason to suppose that the growth of mechanization and its influence on productivity will not be a resultant of these several basic factors in the future. The present situation, however, is greatly modified by progress in machine design and in management, which have materially enhanced the scope of mechanization during the past few years. This change is reflected in a growth of mechanization that is both intensive and extensive.

The transition from pit-car to mobile loaders in Illinois and Indiana is the most striking example of the intensive advance of mechanization, whereas the introduction of the newer and smaller designs of mobile loaders to replace the hand-loaded conveyor is another. Any change in machinery which increases the degree of substitution of mechanical power for man-power may be said to represent intensive mechanization.

In looking at the percentage figures for the country as a whole in the following tabulation, it is clear that mobile loaders are showing the greatest gains and pit cars the greatest loss. Although conveyors have been gaining, the rate has been much slower than that of mobile loaders.

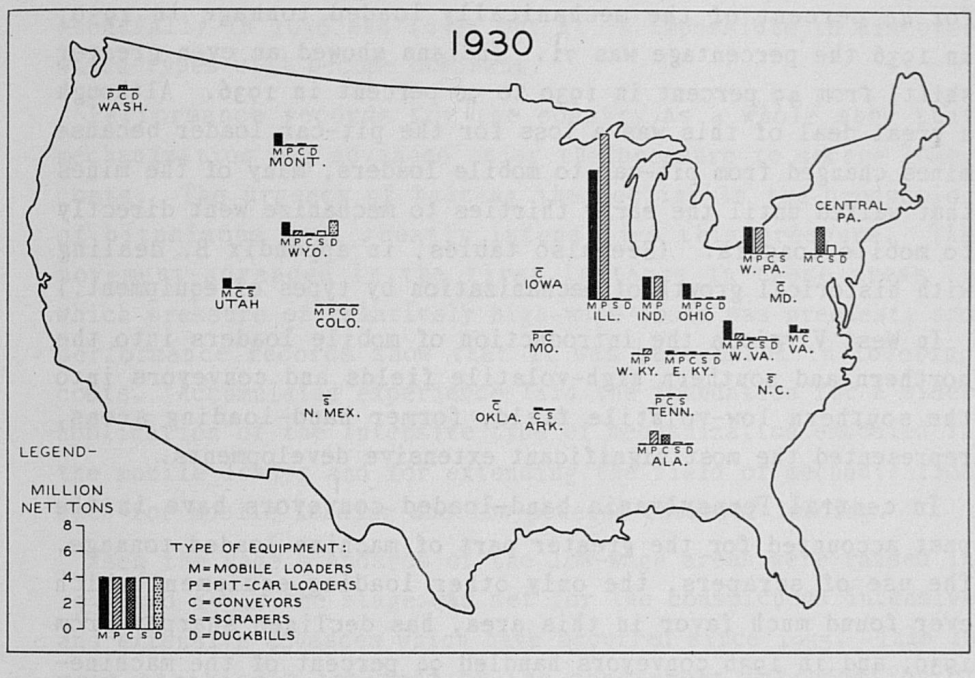
Year	Percent of underground production mechanically loaded	Percent of mechanically loaded tonnage loaded by[5] –				
		Mobile loaders	Scrapers	Duck-bills	Pit-car loaders	Hand-loaded face conveyors
1930	10.5	42.7	3.5	3.5	40.7	9.6
1935	13.5	52.3	2.4	5.5	23.5	16.3
1936	16.3	61.2	1.9	4.8	15.7	16.4
1937	20.3	67.1	1.6	4.3	9.8	17.2

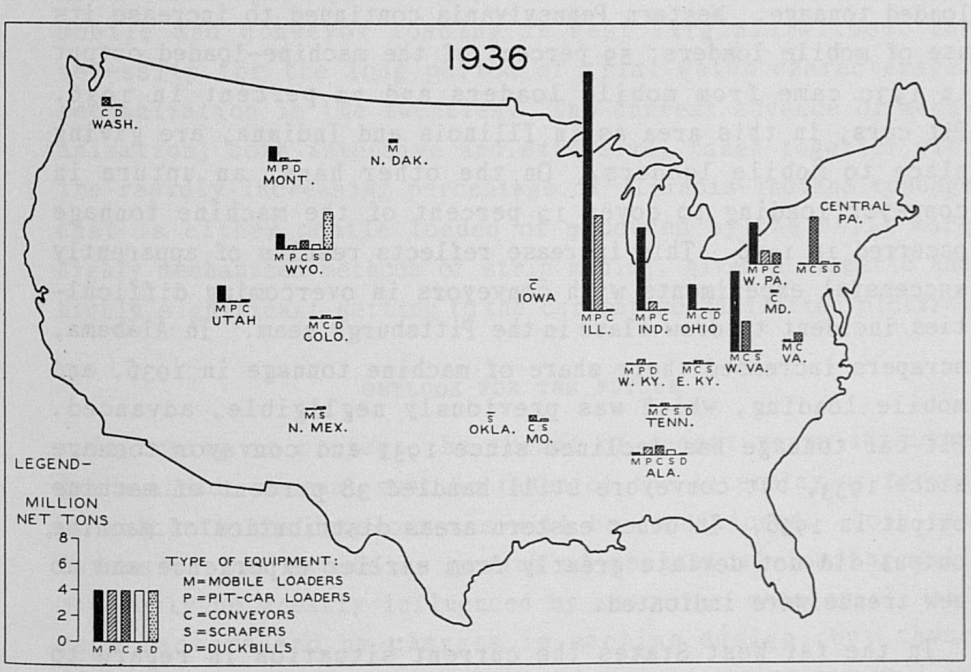
Figure 58, showing tonnages loaded by the various types of loading equipment in 1930 and 1936, indicates the intensive and extensive advance of mechanization during that period for the individual areas.[6]

[5] Based on table B-63.

[6] Figures were not available when this study was completed to show the distribution for 1937 for every State.

Figure 58.- DISTRIBUTION OF MECHANICALLY LOADED BITUMINOUS COAL, BY TYPE OF LOADER AND STATE, 1930 AND 1936





BASED ON DATA OF THE U.S. BUREAU OF MINES

MINERAL TECHNOLOGY AND OUTPUT PER MAN STUDIES
WPA-NATIONAL RESEARCH PROJECT E-184

In Illinois and Indiana substitution of the higher-powered mobile loader for the pit-car loader was the significant intensive development. In Illinois mobile loaders accounted for 44 percent of the mechanically loaded tonnage in 1930; in 1936 the percentage was 71. Indiana showed an even greater shift, from 49 percent in 1930 to 90 percent in 1936. Although a great deal of this was a loss for the pit-car loader because mines changed from pit-car to mobile loaders, many of the mines that waited until the early thirties to mechanize went directly to mobile loaders. (See also tables, in appendix B, dealing with historical growth of mechanization by types of equipment.)

In West Virginia the introduction of mobile loaders into the northern and southern high-volatile fields and conveyors into the southern low-volatile field, former hand-loading areas, represented the most significant extensive developments.

In central Pennsylvania hand-loaded conveyors have in the past accounted for the greater part of machine-loaded tonnage. The use of scrapers, the only other loading equipment which ever found much favor in this area, has declined sharply from 1930, and in 1936 conveyors handled 94 percent of the machine-loaded tonnage. Western Pennsylvania continued to increase its use of mobile loaders; 59 percent of the machine-loaded output in 1930 came from mobile loaders and 72 percent in 1936. Pit cars, in this area as in Illinois and Indiana, are giving place to mobile loaders. On the other hand, an upturn in conveyor loading to cover 12 percent of the machine tonnage occurred in 1936. This increase reflects results of apparently successful experiments with conveyors in overcoming difficulties incident to draw slate in the Pittsburgh seam. In Alabama, scrapers increased their share of machine tonnage in 1936, and mobile loading, which was previously negligible, advanced. Pit-car tonnage has declined since 1931 and conveyor tonnage since 1933, but conveyors still handled 38 percent of machine output in 1936. In other eastern areas distribution of machine output did not deviate greatly from earlier experience and no new trends were indicated.

In the far West States the current situation in regard to types of loading equipment has much less significance than in the East. The duckbill loader has proved a satisfactory device in Wyoming and its use there has spread to cover increasing amounts of machine-loaded tonnage. In Montana and Utah mobile

loaders remain dominant, but in Washington physical conditions limit equipment to face conveyors and modified duckbills. In Colorado all types of loading equipment have been tried, especially in 1936 and 1937, but it is impossible to discover which types will become dominant.

Performance records for the country as a whole show that mechanization has advanced under the pressure to secure lower costs. The urgency of halting the decline in the production of bituminous coal greatly intensifies this pressure. The movement advanced in the first instance in those areas in which pressure of relatively high-wage costs was greatest, and performance records show that it was successful in lowering costs. Accumulated experience laid the foundation for a wider application of the intensive type of mechanization embodied in the mobile loader and for extending the field of mechanization both for mobile loading and low-powered conveyor loading.

When the wage standards of the low-wage areas were raised in 1933 and 1934, the stage was set for the conspicuous intensive and extensive advances which have occurred since 1935. This is most strikingly typified by the concurrent introduction of mobile and conveyor loading in West Virginia without the necessity for the long period of trial which characterized mechanization in the twenties. The current advance of mechanization, both intensive and extensive, taken together with the rapidly increasing percentage of Illinois-Indiana tonnage that is either mobile loaded or produced by the still more highly mechanized methods of strip mining, gives a dramatic and highly significant setting to the current mechanization picture.

OUTLOOK FOR THE FUTURE

In trying to project the trends of recent years into the years ahead, account must be taken of the interplay of forces by which future developments will be conditioned. Both the intensive and extensive growth of mechanical loading will obviously be greatly influenced by resource, managerial, and wage factors and by changes in machine design, but these factors and the effects of mechanization on employment will be closely interrelated to the development of markets. In turn, all of the operating and market factors and their effects on employment will be subject to the policies of operators,

workers, and Government. In concluding the discussion of these topics, different phases of unemployment will be sketched and the factors that influence the relation of technology to employment will be summarized.

It will aid in viewing the problem in perspective to recall that despite the admitted fact of unemployment, the decline in number of jobs since 1929 is less in bituminous-coal mining than in many other branches of industry. In 1937 the average number of men employed, according to preliminary data of the National Bituminous Coal Commission, was 484,000; it was 503,000 in 1929. The decrease amounted to 3.8 percent.

Prospective Advances in Mechanical Loading

Mechanical loading and strip mining in 1937 were most important in the Mississippi Valley States, which included Illinois and Indiana. In this area, which offers one-fifth of the employment in the bituminous-coal industry, 41 percent of the total production was loaded mechanically and 27 percent came from strip mines. The far West, where only one-twentieth of the employment centers, produced 42 percent of its output by mechanical loading and 11 percent by stripping. Approximately three-fourths of the total production and employment in the bituminous-coal industry is in the great Appalachian coal fields, where in 1938 only 11 percent of the total output was loaded by machine and where strip mining was insignificant. The future of mechanical loading must necessarily lie chiefly in the latter area.

The advances made during the past 2 or 3 years indicate substantial increase in the years immediately ahead; the mechanical-loading movement will extend into fields in which little or no coal was mechanically loaded in 1936 and 1937. It is to be expected, moreover, that the shift from low-powered to high-powered equipment by reason of more flexible designs and better management will continue. Many mines from which mobile loaders would have been excluded in the twenties will begin their mechanization programs with these machines.

Looking at mechanization from the standpoint of types of equipment, it is clear that though the use of pit-car loaders will continue for a number of years in areas where they are already installed (a progressive decline in their use is

plainly indicated), there will be little reason for new installations. Extension of scraper loading must depend upon highly problematical developments in roof control, which would make possible concentrated mining on long faces. Duckbill loaders are operated with marked success in the pitches of Wyoming, and some of them appear to be successful in other scattered areas. Experimentation in new areas, together with possible improvements in design and use, may sharpen considerably the moderately upward trend of duckbill loading. The future of mechanical loading in general appears to center largely with the mobile loader and the conveyor.

Shifts that have already occurred from pit-car loaders to mobile loaders and the number of recent installations of conveyors and mobile loaders are fairly good indications of trends for the immediate future. For the next few years mobile loaders are likely to predominate in thick to medium seams and conveyors in seams ranging from medium to thin, the choice often hinging on physical conditions other than thickness, particularly on character of the roof. A trend toward use of loaders in combination with conveyors is also evident.

Installation of mobile loading in new centers during the past 3 years has greatly enlarged the experience base for future mechanization. Those Illinois and Indiana mines from which the major portion of mechanically loaded tonnage came prior to 1936 were in a position to secure the advantages of machine loading as it was practiced during the twenties. Recent experience in areas which are now extensively adopting mechanical loading indicates that knowledge gained from earlier efforts, together with the improvements in design and in mining practice, has stimulated and intensified mechanization programs in heavy-tonnage eastern areas.

Although the initial impetus to mechanize was the result of relatively high wage rates in Illinois, Indiana, and Wyoming, since 1933 wage contracts covering the major part of the industry have tended to narrow differentials. The present prospect is that future changes in wage levels will be spread over practically the whole industry. However, profit margins are precarious in all areas, and effort to support them by reducing unit labor requirements will continue to stimulate mechanization.

During the 6-year period 1932-37 the percentage of total underground production that was loaded mechanically increased from 12 to about 20 percent. *Coal Age* has estimated that one-fourth of the underground output was mechanically loaded in 1938. It is possible that this percentage may more than double within the next decade. However, the areas less favored from the standpoint of resources and other conditions, even if they should come to load mechanically as large a percentage of total output as the better areas, can hardly hope to achieve as high man-hour output records. The average man-hour output in the mechanized mines of the country, therefore, can never reach the levels of areas where conditions are most propitious.

Market Factors

The major purpose of mechanization in bituminous mining is to reduce cost, and this in turn is directed toward increasing profit or forestalling loss either by selling more goods or by realizing better margins on sales made. Efforts to safeguard reasonable margins may be expected to be an essential element in any program of market stabilization, but in the long run the forces of competition will without doubt tend to translate savings in the cost of mining into increased sales. Although mechanization in most forms tends to diminish the amount of labor required to produce a given unit of product, its effect on employment in a particular mine, in an area, or in the industry will ultimately depend upon the success that operators have in translating reduced costs into increased sales.

Individual operators or groups of operators can stimulate demand somewhat through sales campaigns, but results of such efforts are limited by potential markets. Markets for coal arise out of demand for energy. The cost at which a unit of energy can be produced by coal helps in part to determine both the amount of energy used and the portion of the total which will be provided by coal in competition with gas, oil, and hydroelectric power.

The cost of coal-generated energy depends upon the cost of mining, the cost of delivering coal to the point of use, the energy content of the coal delivered, and the efficiency with which heat units of the coal are transformed into energy in the form of steam or electricity. Although the labor cost

of mining coal is only one of the items in total cost, it is a highly important item. Labor cost for underground mines according to the latest cost figures of the National Bituminous Coal Commission ranges from 52 to 68 percent of total production, administration, and selling cost. As noted earlier, labor requires a smaller percentage of total cost in strip mines than it does in underground mines - roughly 32 to 42 percent. In underground mines the average percentage of labor cost is highest in hand-loading mines and lowest in mines that have the most efficient installations of machine loading. In a representative group of hand-loading mines located in Michigan, Illinois, Indiana, Kansas, Missouri, Texas, parts of Oklahoma, and New Mexico, the National Bituminous Coal Commission found labor costs to be between 61 and 81 percent of total costs, whereas in a group of mechanical-loading mines in Illinois and Indiana labor costs ran from 50 to 52 percent. In any case the number of man-days required to produce a given quantity of coal has a direct effect on labor cost and therefore on the price at which coal can be profitably sold.

Granting the influence which increasing mechanization will have in reducing cost and stimulating sales, the sales efforts of individual operators will need to be supplemented by some organized program of sales promotion. For a number of years at least, low-cost strip coal will be an important market factor in certain areas. Strip mines can afford to sell coal more cheaply than deep mines can, and those mechanized deep mines whose costs are relatively low can afford to sell at a lower price than the most-efficient hand-loading mines. The inroads which oil, gas, and hydroelectric power make upon the energy market and continuing improvements in noncoal fuel combustion will enhance competitive pressure. Under these conditions it is unlikely that any upswing of the business cycle will automatically create enough demand to bring prosperity to the entire bituminous industry.

Bituminous mining suffered substantial decline in the twenties during years of rapid industrial expansion. The falling off of total production and employment in the industry clearly reflects something more basic than the cyclical fluctuations to which industries in general are subject. Experience and competent authority concede to gas, oil, and hydroelectric power some advantage in uses for which, respectively, they are

best adapted, but competent engineers have expressed the view that in the conditions which are met in the major portion of the energy market a given expenditure for coal will bring greater returns in kilowatt hours of energy than the same expenditure for competing energy producers. The coal industry, beginning with obvious advantages to which have been added in recent years the further advantages of improved technology in both mining and combustion, has nevertheless permitted alternative energy producers to crowd it out of a part of its market.

In few countries does power enter into the life of the ordinary citizen to the extent that it does in the United States; in few countries has per-capita consumption of energy reached anything like the level it has already attained here. And yet, although an extraordinary expansion in the use of energy has been in progress, the American coal industry, which produces the major portion of that energy, has lingered on the brink of disaster. Barring such changes as might materially increase per-capita power consumption, there appears to be little prospect that even the most effective efforts to stimulate business can result in sufficient bituminous consumption to provide full-time employment for the present labor force of the industry.

Varying conditions and frequently conflicting viewpoints make it difficult to speak of marketing policy as applied to the whole bituminous industry, but man-hours of employment for miners cannot be greatly enhanced in the years ahead except through some concerted program for stimulating a steady and fairly rapid increase in the market for coal-generated energy. About the only feasible way to prevent mechanization from diminishing employment opportunity is to make it an instrument, through volume of sales, by which employment opportunity may by increased.

The immediate needs involve further unification and expansion of efforts along two lines - research into the now-timely problem of increasing coal's share of the energy market and research into the possibilities of developing new uses for coal, thereby creating additional markets. The crusade for wider use of energy is at present directed largely through the hydroelectric industry under the leadership of the Government.

This movement is regarded with some misgiving by the coal industry just as it is by the utilities. No doubt the Government hydroelectric program may force both the utilities and the coal industry to alter some of their policies, but in the long run both industries stand to benefit by a wider use of energy. If, as its proponents predict, Government expansion of hydroelectric power serves to extend considerably the use of electrical energy, a period of prosperity would probably bring about the development of a market for energy which would be served only in part by hydroelectric power. Should increased mass demand for electrical appliances attain significant proportions (as did that for automobiles in the twenties), the coal industry, whose product stands high as an energy producer, would probably be the chief beneficiary.

Mechanization and Public Policy

Unemployment in the bituminous industry must be approached from the standpoint of the existing situation rather than on the basis of ideal conditions. The industry has a productive capacity far in excess of any prospective demand for coal. Moreover, access to a flexible labor force provides a ready means for increasing capacity in response to immediate demand for coal.

The economic forces which have brought about both mass production and increasing concentration of business in highly mechanized mines continue to operate. It is probable, therefore, that any substantial increase in coal consumption would result more largely in increased business for the stronger mines than it would in relief for the weaker ones. General expansion of the bituminous industry cannot eradicate the problem of meager employment in mines whose operations seem likely to remain unstable.

Effort to reduce cost by lowering unit labor requirements through improved technology pervades modern industry; it is part of an evolutionary process. If immediate human interests associated with technical change are safeguarded and an increased supply of goods equably distributed, benefits are unmistakable. However, the human effects of increased mechanization vary between industries, between periods in the development of particular industries, with methods and speed of

installation, and with the conditions which surround particular mechanization projects.

History of industry indicates that the urge to secure the advantages of advancing technology is irresistible. Mechanization in coal mining is not new, and its recent advances conform to a pattern that is typical of American industry. Changes in recent years seem moderate, however, when compared with those of other industries.[7] The present mechanization trend is a culminating phase of the movement rather than the movement in its entirety. Devices which one after another have become standard equipment in coal mining have nearly always advanced slowly in their early stages, registering only slight changes from year to year; but as designs were improved and results demonstrated, the pace accelerated. The culminating phases of a movement which has spread over many years frequently assume a revolutionary appearance which a complete history of the transition tends to dissipate.

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[7] Following are examples selected from data assembled by the National Research Project illustrating the rate of transition from hand work to machine work in other industries. These examples include the linotype machine, the dial telephone, three types of glass products, and cigars:

It took the linotype machine about 20 years to supplant straight-matter typesetting by hand.

In 1920, 98 percent of telephones in use by the Bell System were of the manual type; by 1935, 48 percent were dial 'phones.

Prior to 1917 large, long-filler cigars were manufactured entirely by hand; by 1933 the proportion of these cigars made by the automatic long-filler cigar machine had risen to 65 percent.

In 1903 the so-called Lubbers semiautomatic cylinder machine was introduced in window-glass manufacture, followed in 1917 by the Colburn automatic machine and in 1924 by the Fourcault sheet automatic machine; by 1927 only 2 percent of window-glass manufacture, which prior to 1903 had required five different crafts of skilled workers, was produced by hand.

The Owens automatic machine was introduced into the manufacture of bottles, jars, and containers in 1905 and of "feed and flow" devices in 1917; by 1925 it is estimated that 90 percent of this branch of the glass industry was using automatic machinery.

Prior to 1917 electric-light bulbs were manufactured exclusively by hand methods; by 1926, 83 percent of the output of one of the largest producers and 98 percent of the output of another important manufacturer were produced by automatic machine.

The effect of improved technology in combination with other factors on output in five other industries is indicated in the accompanying tabulation. It compares indexes of output per wage earner and per man-hour for the five industries in 1919 and 1936 with similar indexes for bituminous coal. All indexes are on a 1929=100 base.

Industry	Number of wage earners in 1929	Output per wage earner		Output per man-hour	
		1919	1936	1919	1936
Boots and shoes	206,000	85.8	114.3	82.8	138.7
Cotton goods	425,000	84.0	103.9	85.0	132.6
Iron and steel	420,000	61.7	87.5	51.0	112.8
Motor vehicles	447,000	41.8	95.2	42.7	115.7
Paper and pulp	128,000	67.3	103.9	60.4	120.5
Bituminous coal	503,000	70.4	86.5	79.5	109.7

The data for the industries other than bituminous coal are from H. Magdoff, I. H. Siegel, and M. B. Davis, *Production, Employment, and Productivity in 59 Manufacturing Industries, 1919-36* (WPA National Research Project, Report No. S-1, May 1939), part two. The bituminous-coal figures were computed from table B-1.

Mechanical loading, considered in its setting of general industrial technology, cannot be regarded merely as a forced response to local or general pressures since the World War. These pressures, without doubt, have accelerated the movement and have resulted in some unwise installations, especially in the early years. In recent years, however, hasty installations have been less frequent. Mechanization of loading has covered roughly the past 2 decades and is now finding its culmination in a rapidly widening coverage of the industry in both area and tonnage. Progress in the design and production of flexible, high-powered machines and in the skill with which management uses them is rapidly carrying the movement forward.

The increasing rate of mechanization is stimulated by the fact that strip mining, a more intensive technology than any found in deep mines, has grown to significant dimensions in certain areas. Moreover, mechanical loading takes on particular significance from the fact that the hand operation it replaces has hitherto employed more than half of all wage earners in the industry. Although this has been a matter of common knowledge, the crumbling of such an important stronghold of hand labor comes as a shock to those who must adjust themselves to new conditions. This shock is accentuated by the absence of prospect that consumption of coal will increase enough to absorb fully the labor released by mechanized operation.

With the mechanization of loading rapidly extending its coverage of the industry, its effects upon employment are no longer localized to the extent that they were when mechanical loading in Illinois and Indiana was a partial offset to low wage standards in Appalachian areas. As previously emphasized, the Illinois and Indiana mines which mechanized loading during the twenties probably secured thereby enough business to more than balance, from the employment angle, the adverse effects of decreased unit labor requirements.

In the current situation, the more rapidly mechanization advances and the greater its influence becomes in lowering unit labor requirements, the more inevitable it is that either production must expand or the volume of employment as measured in total man-hours must decline. Whether a decline in man-hours registers itself chiefly in reducing the number of jobs or in reducing the hours of employment opportunity for

the average miner depends upon other unpredictable factors, including the number of mines operating, governmental policies regarding unemployment, and the attitude of the mine owners and employees toward the problem. Much depends upon the relative emphasis placed, on the one hand, upon dividing employment through staggered-work agreements or reduction of hours or, on the other hand, upon maintaining the annual earnings of the men who remain at work. Between 1923 and 1929 the shrinkage in man-hours of employment was absorbed almost wholly through a reduction in the number of men employed. Between 1929 and 1937 the shrinkage in man-hours was absorbed chiefly through a reduction in the average number of days worked per year and in the average number of hours per day, so that the number of men on the rolls in 1937 came within 3.8 percent of that in 1929. Whatever the method of adjustment, it is clear that any decline in unit labor requirements must be balanced by an increase in tonnage sold if the total number of man-hours of employment opportunity is to hold its own. This is now true whether the problem is viewed nationally or regionally.

The complex conditions which limit employment opportunity in bituminous mining reduce to a few factors, of which unit labor requirements and market demand are controlling. Considered locally, employment in the bituminous industry depends upon the ability of the mines in an area or region to sell coal in competition with other energy producers. Their ability to do this not only depends upon the relative cost at the point of consumption of energy from different areas and different plants, but it depends likewise upon the total market for energy.

The energy market is divided among coal, oil, gas, and hydroelectric power. The market for bituminous coal is affected by the amount of energy used and by the relative success of different purveyors of energy in persuading consumers to buy it in one form rather than another. Future limits to the total energy market will be determined by growth of population, expansions in industry, and changes in standards of living which directly or indirectly affect per-capita use of energy. In regard to competition of coal with other energy producers, it is fairly obvious not only that the oil, gas, and hydroelectric industries are highly developed today, but that they are all susceptible to substantial expansion, although in the case of oil and gas, expansion would bring a depletion factor

into the picture at an earlier time than would be the case with coal. It is notable, however, that a recently published study of the petroleum and natural-gas industry concludes that over the next decade production will increase.[8]

The hydroelectric industry is so intimately bound up with public policy that, sooner or later, the mutual relationships between hydroelectric policy and coal policy will require consideration. The probable influence on demand of the relative advantages of these sources of energy was considered in connection with market factors.

Concerted attempts to push coal sales either by stimulating increased use of energy or by inducing consumers to use bituminous coal instead of alternative energy producers will almost surely stimulate opposing pressures which in some measure will neutralize the efforts put forth. If, on the other hand, the groups which have a stake in the bituminous industry can, through continuing study, enable the industry to make full use of its advantages, it seems probable that policies could be developed and maintained that would considerably advance the interests of the industry and of the people who find their means of support in it.

Decision in reference to mechanization rests in the first instance with the individual operator, subject to such restraints as resource conditions, financial requirements, collective bargaining, and general policy may impose. Results of procedures adopted by other operators, both successful and unsuccessful, supplemented by a thorough study of his individual problem, are the guides upon which an operator must depend in planning new installations. Plunging suddenly into new processes without careful study of all factors involved frequently means, as it has meant in many coal mines, that expensive equipment is installed without necessary preparation and with great prejudice to possible savings.

Human adjustments must always be made as technology advances. Policies which operators follow in adjusting labor forces to mechanized operation have important bearing on employment. This phase of mechanization could not be studied comprehensively in the course of the present inquiry, but there

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[8] O. E. Kiessling and Others, *Technology, Employment, and Output per Man in Petroleum and Natural-Gas Production* (WPA National Research Project in cooperation with U. S. Department of the Interior, Bureau of Mines, Report No. E-10, July 1939).

is evidence that operators who have installed mechanical loading in cooperation with workers have found that policy advantageous, although evidence is lacking that avoidance of displacements was a general policy in mechanized mines. Most of the operators who adopted mechanical loading in the twenties did so under great competitive pressure, and many of them were not in a position to give much attention to the effect of mechanization on employment. Naturally the least disturbance occurred in those mines in which mechanization proceeded at a pace which obviated necessity for displacing individual workers. In southern Wyoming, where mechanization of loading is now practically complete, normal turn-over and adjustments in hiring new help were in general depended upon to take up the slack in the labor force occasioned by mechanization.

Bituminous mines that are not highly mechanized call for greater versatility on the part of workers than is found in industries in which skills are more specialized, and the character of work enables the miners to adapt themselves to new processes with a minimum of difficulty. Machine loading nevertheless involves higher specialization than hand loading, and the miner must be able to work with the machine and to adjust himself to its tempo. Operators in southern Illinois whose mines have become highly mechanized testify that able-bodied miners, except those advanced in years, readily meet the requirements of machine operation. It is conceded, however, that installation of new machines usually necessitates providing alternate working places for employees who cannot acquire the new skills.

Adjustments in individual mines necessitated by mechanization can, in general, be met without undue hardship if moderate and cooperative policies are wisely administered, but this is the smallest part of the employment problem in bituminous mining. The greatest loss of jobs comes to employees working in high-cost mines which are either forced out of business entirely or have sales curtailed by competitive disadvantage. This problem is beyond the scope of an individual operator. The low-cost operator has no urge to protect employees of his high-cost competitor, and the latter is powerless in the face of conditions beyond his control. Unemployment in marginal mines and that which results from the liquidation of high-cost mines obviously cannot be met by policies employed exclusively by individual operators.

Furthermore, operators are but one of several interests involved in the employment problem. Initiative for dealing with employment problems in marginal mines may have to come from the employees. For many years organized labor has had a seat at the council table for part of the bituminous industry, and in recent years for nearly all of it. For the most part, labor has focused attention on wages, hours, and general working conditions, interpreting wages in terms of daily and tonnage rates rather than annual earnings.[9] Its influence on policies outside of wages and hours has been largely indirect.

One important item in mechanization history in which the union had both a direct and an indirect part was the advance of mechanical loading in Illinois and Indiana during the late twenties. Pressure for mechanization in this area arose to a large extent out of the wage differentials which were unfavorable in comparison with those of eastern areas operating nonunion in the years following the Jacksonville Agreement. After prolonged strikes in 1927 and 1928 the day rate in Illinois and Indiana was reduced from $7.50 to $6.10, and tonnage rates accordingly, and the union contract carried rates for mechanical-loading machines. Mechanical loading served as a partial compensation for the handicap of unfavorable wage differentials, but a more ample restoration of the balance between Illinois and Indiana on the one hand and Appalachian areas on the other awaited the narrowing of wage differentials under the joint influence of NRA codes and the extension of union control into eastern areas. Growth of mechanical loading in Illinois and Indiana after 1928 and in West Virginia during the past 3 years is, without doubt, closely related to wage levels and labor costs.

The official attitude of the United Mine Workers toward mechanization has been somewhat in contrast with that taken by many other unions. Because new techniques are assumed to displace labor, workers in the past have frequently offered vigorous resistance to them. Although such resistance seldom prevents mechanization, it may delay the movement and it

[9] In the 1937 wage negotiations one of the official proposals of the United Mine Workers of America was for an annual wage. The proposal was as follows: "A minimum of two hundred (200) days employment each year shall be guaranteed to all mine workers employed in and around the mines. Day men shall be paid the regular rates of pay provided in district wage agreements for each day less than the guaranteed two hundred (200), and tonnage men shall be paid a basic $6.00 day rate for each day less than the guaranteed two hundred (200)." *United Mine Workers Journal*, Vol. XLVIII, No. 5 (Mar. 1, 1937).

frequently shifts the angle from which employers undertake it. Union opposition to mechanization in bituminous mining has come largely from local groups and has not been a reflection of general policy.

The union has shown increasing interest during recent years in general problems of the industry including, naturally, employment opportunity, which is the most urgent need of its members. The rapid strides by which mechanization of loading advanced in the late twenties, aggravation of unemployment during the depression, and the current transition from hand to mechanical loading in West Virginia and other areas have all served to center attention on the progress of mechanization in its relation to employment. Union labor has been conspicuously successful in maintaining labor standards in the areas which it controlled, and finally in extending them over the whole industry; because of meager working time, however, these achievements have not been translated into satisfactory annual earnings for the average man.

Whatever the results of labor policy may have been at a time when the major tonnage of the country came from nonunion areas, it is not to be expected that union labor, having extended its control over practically the whole industry, will willingly retreat from the position which it has won in respect to wage levels. During the past few years wage levels in many basic industries have substantially advanced, and a policy of high wages has become an item in our national economy to which many employers now subscribe. As mechanization in coal mining advances and as the proportion of total mining costs comprised by labor costs decreases in magnitude, struggles over the level of wage rates may become less crucial in future conferences between operators and miners than they have been in the past. It is notable that in the case of strip mining, in which labor costs represent a smaller percentage of total costs than they do in any other part of the industry, wage negotiations do not seem to have been particularly difficult, and operations have not been interrupted to the extent that they have in underground mines. Whatever may be the significance of future negotiations concerning the level of wage rates, there are strong indications that the now more urgent problem of employment will receive greater attention than has been given to it in the past.

Unemployment in the industry is a long-time phenomenon and has been aggravated by a variety of conditions, only part of which are directly amenable to human control. Effort to modify the mechanization movement in order to forestall drastic displacement of labor cannot solve the problem of unemployment for mines that languish or go out of business.

By and large, the shift of tonnage to those mines classified by the present study in Group "A" (mines that successfully employed mechanical loading) meant absorption of an increasing percentage of the total business by the mechanized mines. Unless mines that mechanize succeed in adding substantially to their volume of business, mechanization must result in decreased employment opportunity in those mines. However, the most serious effect of mechanization probably comes through the difficulties it creates for mines which do not or cannot mechanize.

Employment opportunity, whether measured in terms of job security, favorable working time, or both, is greatest in those mines which, from the standpoint of equipment, management, market outlets, and corporate strength, occupy a strategic position. At the other end of the scale are mines which, although able to survive, lack market outlets sufficient to utilize their productive capacity. In Illinois and Indiana, for example, job mortality between 1923 and 1935 was vastly greater in the hand-loading mines than it was in the mechanized ones.

Acute hardships result whether jobs are lost through declining markets, reduction of capacity, or decreased unit labor requirements due to mechanization. Those miners who lose their jobs through the closing of a mine or for other causes are faced by an immediate problem; when many men are suddenly thrown out of employment the impact on displaced workers who cannot be reabsorbed mounts to tragic proportions. Large numbers of miners who have lost their jobs through the closing down of mines in years past still consider themselves attached to the industry. There are no fixed criteria for differentiating the cumulative effects of loss of jobs in past years from the current problem of unemployment and meager employment. A long step toward job security would be accomplished if the bituminous industry as now constituted could remove the threat of displacement from the presently active workers in the

industry and give assurance of more adequate employment to the large number of miners who suffer from reduced running time.

The public also has a stake in bituminous mining. For many years State and Federal Governments have supplied the industry with scientific and statistical service, and fact-finding commissions have made studies from time to time looking toward possible legislation. In cooperation with operators and miners the National Recovery Administration undertook an extensive policy of stabilization. After the National Industrial Recovery Act was set aside by the Supreme Court, Congress, by acts passed in 1935 and in 1937, created the National Bituminous Coal Commission.

The law under which the National Bituminous Coal Commission is trying to stabilize and in some measure to regulate the bituminous industry is broad enough to include programs for promoting business if the Commission should decide to adopt such programs and should it secure appropriations for carrying them out. There is ample precedent in the Department of Agriculture, the Department of Commerce, and other Government agencies for Federal effort to aid an industry in meeting its problems. Enlarging the market for coal is of crucial importance to coal operators and their employees and, indirectly, of material consequence to the general public.

The Commission apparently is not attempting to influence directly the mechanization movement, but mechanization is among the most obtrusive facts which its stabilization efforts must ultimately confront. It is not likely that shifts of business to mines that have low mining costs, favorable trade outlets, or other advantages over competitors can be prevented, but it appears certain that hardships attending such shifts can be better mitigated under constructive policies developed around the fundamental idea of collective bargaining than they can if left to the lawless course of chance. Collective bargaining, supplemented when necessary by controls required in the public interest, should be able to work out a middle course.

The National Bituminous Coal Commission[10] serves as a medium through which may be directed efforts of operators, workers, consumers, and Government for advancing the welfare of the

[10] Since this was written the functions of the Commission have been transferred to the office of the Secretary of the Interior.

bituminous-coal industry and its employees. All these elements are needed in meeting the difficult employment problems. It is not to be expected that measures which can be adopted will either eradicate unemployment or point the way to any early enlargement of employment opportunity in the bituminous industry. Until such time as equilibrium is reached between the labor force of the industry as a whole and of particular areas on the one hand and labor requirements under advanced technology on the other, unemployment and meager employment in bituminous mining will continue. The problem which these present challenges the best statesmanship which can be commanded.

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APPENDIX A

DETAILED EXPLANATION OF BASIC EMPLOYMENT DATA

AVERAGE NUMBER OF MEN EMPLOYED

Employees Excluded

The following employees are excluded from the Bureau of Mines totals:

(1) Mine employees not producing coal, such as maintenance men and watchmen. Other occasional groups engaged in development work at certain mines not yet producing or ordinarily not producing are not, in general, included in the Bureau of Mines figures.
(2) Employees of small irregular mines producing less than 1,000 tons a year. These mines are known as "wagon mines" and "country banks."
(3) Coke-works employees.
(4) Office workers.

Absenteeism

In counting names on the pay roll as the average number employed, it is impossible to exclude those men who are absent for a short period between two pay-roll periods. This applies to both voluntary and involuntary absence.

The only large-scale study of absenteeism was one made by the United States Coal Commission for the years 1920 and 1921.[1] The amount of absenteeism was based on the ratio between time worked by the men and time worked by the mine. Daymen, who constituted approximately 40 percent of mine personnel, were found to have worked about 20 percent more days than the mine tipple, whereas tonnage men worked about 10 percent less than the tipple. In other words, for 40 percent of the men absence was not a problem; the remaining 60 percent of the men had an absence rate of about 10 percent. Inferences as to the precise amount of inflation attributable to absentees in the man-day and labor-output figures are unwarranted. However, this is not believed to be a major source of error.

[1] See *Report of the United States Coal Commission* (S. Doc. 195, 68th Cong., 2d sess., 1925), pt. III, pp. 1124-33.

An interesting side light on this subject is the considerable reduction in absenteeism that takes place when a mine installs mechanical-loading machinery, especially of the mobile-loading type. Whereas a loading-machine operator whose work is timed to coincide with the operation of an expensive machine is necessary to complete the mining cycle, the absence of a hand loader does not disrupt the mining process.

Monthly Fluctuations in Employment

Unpublished records of the 1929 census of mines and quarries make it evident that there is some variation from month to month in the volume of employment in bituminous mines. The number of men employed on the fifteenth or nearest representative day of each month in 1929 were listed for individual mines in Indiana. Each mine was then classified according to the percentage that the maximum number employed in a single month was of the minimum number. Months in which the only men employed were a small number occupied with maintenance work were excluded in considering minimum monthly employment. The data are summarized in the following tabulation:[2]

Percent that maximum monthly employment is of minimum	Number of Mines		Tonnage	
	Number	Percent of total	Tons (thousands)	Percent of total
No variation	33	37.9	5,072	28.9
100.1 to 104.9	4	4.6	1,129	6.4
105 to 109.9	3	3.5	1,001	5.7
110 to 114.9	3	3.4	704	4.0
115 to 119.9	7	8.1	1,433	8.1
120 to 129.9	2	2.3	679	3.9
130 to 139.9	4	4.6	1,399	8.0
140 to 149.9	7	8.1	857	4.9
150 to 199.9	7	8.1	2,288	13.0
200 to 249.9	5	5.7	2,041	11.6
250 to 299.9	1	1.1	162	0.9
300 to 349.9	0	0	0	0
350 or over	11	12.6	815	4.6
Total	87	100.0	17,580	100.0

[2]Based on unpublished data of the U. S. Bureau of the Census.

The tabulation shows that 33 mines in Indiana, which produced nearly 30 percent of the State's tonnage, reported the same number of men at work on the fifteenth day of each month. Seven mines that produced about 12 percent of the tonnage reported a variation of less than 10 percent. These two groups, covering slightly more than 40 percent of the tonnage, showed negligible fluctuation in employment. On the other hand, almost 60 percent of the production came from mines that had a variation of 10 percent or more, and 17 percent of the tonnage was from a group that had more than a 200-percent variation.

Share-the-Work Agreements

Reference has been made to the fact that the wage contracts between the Illinois Coal Operators Association and the United Mine Workers of America, which became effective in August 1932, carried a share-the-work provision, as follows:

> In any mechanized mine where men belonging to the local affected have been thrown out of work due to such mechanization, the men so affected shall be entitled to share the work equally up to the point where the further sharing of work would impair the efficiency of operation or the quality of product. . . . .
>
> After a mine has been idle, except through strike, for a period of thirty days, the miners employed at mines in the same locality may at their option share work with those thrown idle, either by doubling up in working places or some other manner mutually agreeable; except there will be no change in men in working places oftener than every five days of operation. When a part of the miners at any mine or mines are thrown idle, as above, for a period of five days of operation they shall be entitled to share with the balance in the work in manner provided, unless provided otherwise.

Adoption of this practice raised an obvious possibility of misunderstanding in the reporting of employment. The Department of Mines and Minerals of Illinois recognized the difficulty and, starting in 1932, asked operators to report both the number of men on the pay roll and the number of men working. The following tabulation gives the figures in these two groups for the number of shipping mines indicated for the years 1932-37:[3]

[3]Based on *Annual Coal Reports* of the Illinois Department of Mines and Minerals. Numbers of employees include a few men in strip mines.

Year	Number of mines	Number of employees		
		Working	On pay roll	Percent that number on pay roll is of number at work
1932	45	13,835	19,050	137.7
1933	28	8,129	11,287	138.8
1934	35	11,240	14,139	125.8
1935	28	9,880	12,519	126.7
1936	44	12,072	14,955	123.9
1937	53	13,403	16,477	122.9

Obviously it cannot be assumed that all these mines reported incorrectly to the U. S. Bureau of Mines the number of men on the pay roll rather than the number working. In the year 1934, for example, it was found that of a possible overstatement of 2,899 men, 1,600 were in excess of the average number actually working. In 1935 and 1936 the Bureau of Mines corrected the reported number of men to take account of divided working time.

For purposes of this study the authors have also reviewed the reports previously received from mechanized mines in Illinois and have corrected them for divided working time in 1932, 1933, and 1934, using the data in the State reports cited above. Although the Illinois State Department did not report on share-the-work agreements in 1931, the practice may have been followed at least partially in that year.

It has not been feasible to ascertain how far work-sharing was followed at hand-loading mines in the State during this period. It is known, however, that the number of such mines covered by formal agreements was small.

AVERAGE NUMBER OF DAYS WORKED

It has been noted in chapter VII that mine employees do not always put in a full working day; similarly, all employees do not work the same number of days that the tipple operates. In the United States Coal Commission study on absenteeism in 1921[4] it was found that the daymen worked about 20 percent more days than the number of days on which the tipple was in operation, whereas tonnage men worked about 10 percent less. In this sample study daymen constituted about 40 percent and

[4] *Report of the United States Coal Commission (1925)*, pt. III, pp. 1124-33.

tonnage men 60 percent of the total number covered. All these employees together, it was found, worked about 3 percent more days than their mines. The National Recovery Administration made a somewhat similar study for the pay-roll period December 1-15, 1933, summarized in the following tabulation:[5]

Division	Number of mines	Weighted average of number of tipple starts	Daymen		Tonnage men	
			Number earning pay	Average days worked	Number earning pay	Average days worked
I[6]	860	8.3	64,133	8.4	122,989	7.3
II[7]	164	8.6	15,842	8.8	15,861	7.8

It will be noted that in the sample mines the daymen, in 1933, still worked more time than the mine and the tonnage men worked slightly less.

[5]Based on *Bituminous Coal Code Statistics, Nov. and Dec., 1933* (NRA Division of Research and Planning).

[6]Includes Pennsylvania, Ohio, Michigan, West Virginia, Maryland, Kentucky, and northern Tennessee.

[7]Includes Illinois, Indiana, and Iowa.

APPENDIX B

TABLES

Most of the tables in this appendix refer to mechanical loading. Separate performance statistics are presented for groups of mines according to the degree of mechanical loading they have achieved. Mines falling in Group "A" had successfully mechanized their loading process by 1935. A subgroup, designated as Group "A-1", is comprised of mines in Group "A" which operated each year in the period 1918-35. Mines in Group "B" are those which have installed mechanical loading devices but were still essentially on a hand-loading basis in 1935, or which tried out mechanical loading and then reverted to hand loading. The latter mines, together with mines which never tried mechanical loading, comprise the "all other" group. For a more detailed description of the several groups see chapter VII, section entitled "Classification of Mines", pages 203-7.

Wherever United States production figures are presented, the figures for Alaska have been included. This is the practice which has been followed by the U. S. Bureau of Mines. Alaskan production, however, is negligible, amounting to 119,425 tons in 1935, or about 0.03 percent of the total tonnage.

Table B-1.- PRODUCTION, EMPLOYMENT, AND LABOR OUTPUT IN THE BITUMINOUS-COAL INDUSTRY, 1880-1938[a]

Year	Net tons produced[b]	Average number of men employed	Employment				Labor output	
			Average number of days worked	Total man-days worked[c]	Weighted average length of established work-day	Total man-hours worked[d]	Net tons per man-day	Net tons per man-hour[d]
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1880[e]	40,301,758	93,415	227	21,205,205	(f)	(f)	1.90	(f)
1890	111,302,322	192,204	226	43,438,104	(f)	(f)	2.56	(f)
1891	117,901,238	205,803	223	45,894,069	(f)	(f)	2.57	(f)
1892	126,856,567	212,693	219	46,623,567	(f)	(f)	2.72	(f)
1893	128,385,231	230,365	204	46,994,460	(f)	(f)	2.73	(f)
1894	118,820,405	244,603	171	41,827,113	(f)	(f)	2.84	(f)
1895	135,118,193	239,962	194	46,552,628	(f)	(f)	2.90	(f)
1896	137,640,276	244,171	192	46,880,832	(f)	(f)	2.94	(f)
1897	147,617,519	247,817	196	48,572,132	(f)	(f)	3.04	(f)
1898	166,593,623	255,717	211	53,956,287	(f)	(f)	3.09	(f)
1899	193,323,187	271,027	234	63,420,318	(f)	(f)	3.05	(f)
1900	212,316,112[j]	304,375	234	71,223,750	(f)	(f)	2.98	(f)
1901	225,828,149	340,235	225	76,552,875	(f)	(f)	2.95	(f)
1902	260,216,844	370,056	230	85,112,880	(f)	(f)	3.06	(f)
1903	282,749,348	415,777	225	93,549,825	8.7	813,883,478	3.02	.347
1904	278,659,689	437,832	202	88,442,064	8.6	760,601,750	3.15	.366
1905	315,062,785	460,629	211	97,192,719	8.6	835,857,383	3.24	.377
1906	342,874,867	478,425	213	101,904,525	8.6	876,378,915	3.36	.391
1907	394,759,112	513,258	234	120,102,372	8.6	1,032,880,399	3.29	.382
1908	332,573,944	516,264	193	99,638,952	8.6	856,894,987	3.34	.388
1909	379,744,257	(f,g)	209	(f)	(f)	(f)	(f)	(f)
1910	417,111,142	555,533	217	120,550,661	8.6	1,036,735,685	3.46	.402
1911	405,907,059	549,775	211	116,002,525	8.6	997,621,715	3.50	.407
1912	450,104,982	548,632	223	122,344,936	8.6	1,052,166,450	3.68	.428
1913	478,435,297	571,882	232	132,676,624	8.6	1,141,018,966	3.61	.419
1914	422,703,970	583,506	195	113,783,670	8.6	978,539,562	3.71	.432
1915	442,624,426	557,456	203	113,163,568	8.6	973,206,685	3.91	.455
1916	502,519,682	561,102	230	129,053,460	8.6	1,109,859,756	3.89	.453
1917	551,790,563	603,143	243	146,563,749	8.3	1,216,479,117	3.76	.454
1918	579,385,820	615,305	249	153,210,945	8.12	1,244,072,873	3.78[h]	.466
1919	465,860,058	621,998	195	121,289,610	8.06	977,594,257	3.84[h]	.477
1920	568,666,683	639,547	220	140,700,340	8.04	1,131,230,734	4.01[i]	.499[i]
1921	415,921,950	663,754	149	98,899,345	8.04	795,150,742	4.21	.523
1922	422,268,099	687,958	142	97,590,036	8.06	787,381,690	4.29[i]	.532[i]
1923	564,564,662	704,793	179	126,157,947	8.06	1,016,833,053	4.48[h]	.555
1924	483,686,538	619,604	171	105,952,284	8.08	856,094,455	4.57	.565
1925	520,052,741	588,493	195	114,756,135	8.08	927,229,571	4.53	.561
1926	573,366,985	593,647	215	127,515,506	8.07	1,029,050,133	4.50	.557
1927	517,763,352	593,918	191	113,705,411	8.08	918,739,721	4.55	.564
1928	500,744,970	522,150	203	105,813,960	8.08	854,976,797	4.73	.586
1929	534,988,593	502,993	219	110,367,239	8.08	891,767,291	4.85	.600
1930	467,526,299	493,202	187	92,330,327	8.09	746,952,345	5.06	.626
1931	382,089,396	450,213	160	72,077,019	8.08	582,382,314	5.30	.656
1932	309,709,872	406,380	146	59,385,730	8.10	481,024,413	5.22	.644
1933	333,630,533	418,703	167	69,860,117	8.07	563,771,144	4.78	.592
1934	359,368,022	458,011	178	81,724,000	7.27	594,133,480	4.40	.605
1935	372,373,122	462,403	179	82,803,000	7.02	581,277,060	4.50	.641
1936	439,087,903	477,204	199	95,078,532	7.02	667,451,295	4.62	.658
1937	442,455,000	484,000[j]	(f)	(f)	(f)	(f)	(f)	(f)
1938	342,000,000[j]	(f)	(f)	(f)	(f)	(f)	(f)	(f)

a Source: Mineral Resources of the United States (U. S. Dept. Int., Geological Survey, 1890-1923; U. S. Dept. Com., Bur. Mines, 1924-31); Statistical Appendix to Minerals Yearbook (U. S. Dept. Int., Bur. Mines, 1932-33 - 1935); Minerals Yearbook (U. S. Dept. Int., Bur. Mines, 1937); Bituminous Coal Tables (U. S. Dept. Int., Nat. Bit. Coal Com., 1936-37).

b These production data include virtually all coal mined in the United States except Pennsylvania anthracite. In 1921 and for the years 1924-38 no canvass was made of wagon-mine production. Wagon mines are small workings that produce less than 1,000 tons a year and operate spasmodically. The exclusion of their production in these years is not considered serious, probably not more than about a million tons.

c These are calculated figures, men times days, for 1890 through 1925; figures for 1926-34 are from unpublished records; that for 1935 is from Annual Coal Report, U. S. Bur. Mines; and that for 1936 is from Bituminous Coal Tables, Nat. Bit. Coal Com.

d Data on man-hours worked and output per man-hour are based on established length of work-day and therefore subject to error insofar as the established length of work-day varied from the actual hours worked per day by the employees. See text discussion on this point, pp. 199-201.

e Data for 1880 are derived from Tenth Census of the United States (U. S. Dept. Com.), Vol. XV, "Report on the Mining Industries of the United States (Exclusive of the Precious Metals)," pp. 681-684. They relate to the States east of the 100th meridian and are exclusive of "irregular product" from small operations or "farmers' diggings." In estimating the output per man per day, the statisticians of the Census Office considered two boys to be the equivalent in producing capacity of one man. Hence the figure cited for "average number of men employed" represents the 90,354 reported as men plus one-half of the 6,121 reported as boys under 16 years of age. The figures cover the census year ending May 31, 1880.

f Data not available.

g The census figure for average number employed in 1909 is 488,000.

h These figures differ slightly from those shown in table B-9. In table B-9 net tons per man per day have been based on production figures which exclude wagon-mine production.

i 1920 and 1922 were peak years for wagon-mine production, the quantities for these years being, respectively, 4,934,711 and 3,459,392 net tons. For no other year does wagon-mine production rise as high as two million tons. Since there are no employment data for wagon mines, the labor output figures for these years have been based only on production by commercial mines.

j Preliminary estimate by Nat. Bit. Coal Com.

Table B-2.- INDEXES OF PRODUCTION, MAN-DAYS, AND NUMBER OF MEN REQUIRED TO MAINTAIN 1,000 TONS OF DAILY CAPACITY IN THE BITUMINOUS-COAL INDUSTRY, 1890-1938[a]

(1910=100)

Year	Production	Man-days	Number of men required to maintain 1,000 tons of daily capacity	Year	Production	Man-days	Number of men required to maintain 1,000 tons of daily capacity
	(1)	(2)	(3)		(1)	(2)	(3)
1890	26.7	36.0	135.3	1914	101.3	94.4	93.4
1891	28.3	38.1	134.6	1915	106.1	93.9	88.6
1892	30.4	38.7	127.3	1916	120.5	107.1	88.9
1893	30.8	39.0	126.6	1917	132.3	121.6	92.0
1894	28.5	34.7	121.8	1918	138.9	127.1	91.7
1895	32.4	38.6	119.4	1919	111.7	100.6	90.0
1896	33.0	38.9	117.6	1920	136.3	116.7	86.2
1897	35.4	40.3	113.8	1921	99.7	82.0	82.4
1898	39.9	44.8	112.1	1922	101.2	81.0	80.6
1899	46.3	52.6	113.5	1923	135.4	104.7	77.2
1900	50.9	59.1	116.3	1924	116.0	87.9	75.8
1901	54.1	63.5	117.3	1925	124.7	95.2	76.5
1902	62.4	70.6	113.1	1926	137.5	105.8	76.8
1903	67.8	77.6	114.5	1927	124.1	94.3	76.1
1904	66.8	73.4	109.7	1928	120.1	87.8	73.0
1905	75.5	80.6	106.9	1929	128.3	91.6	71.3
1906	82.2	84.5	103.1	1930	112.1	76.6	68.5
1907	94.6	99.6	105.2	1931	91.6	59.8	65.4
1908	79.7	82.7	103.5	1932	74.3	49.3	66.4
1909	91.0	(b)	(b)	1933	80.0	58.0	72.3
1910	100.0	100.0	100.0	1934	86.2	67.8	78.5
1911	97.3	96.2	99.0	1935	89.3	68.7	76.8
1912	107.9	101.5	94.1	1936	105.3	78.9	74.7
1913	114.7	110.1	95.8	1937	106.1	(b)	(b)
				1938	82.0	(b)	(b)

a Source: Table B-1, cols. 1, 4, and 7 (col. 3 above is the reciprocal of table B-1, col. 7).

b Data not available.

Table B-3.- SALIENT STATISTICS ON MACHINE CUTTING OF BITUMINOUS COAL, 1891 TO 1936[a]

Year	Total underground production[b]	Cut by Machines: Tons	Cut by Machines: Percent of underground production	Number of cutting machines	Average number of days worked	Average tons of coal produced: Per year per machine[c]	Average tons of coal produced: Per day per machine[d]	Average tons of coal produced: Per day per machine operator[e]
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1891	117,901,238	6,211,732	5.3	545	223	11,398	51.11	25.56
1892	126,856,567				219			
1893	128,385,231				204			
1894	118,820,405				171			
1895	135,118,193				194			
1896	137,640,276	16,424,932	11.9	1,446	192	11,359	59.16	29.58
1897	147,617,519	22,649,220	15.3	1,956	196	11,579	59.08	29.54
1898	166,593,623	32,413,144	19.5	2,622	211	12,362	58.59	29.30
1899	193,323,187	43,963,933	22.7	3,125	234	14,068	60.12	30.06
1900	212,316,112	52,784,523	24.9	3,907	234	13,510	57.74	28.87
1901	225,828,149	57,843,335	25.6	4,341	225	13,325	59.22	29.61
1902	260,216,844	69,611,582	26.8	5,418	230	12,848	55.86	27.93
1903	282,749,348	77,974,894	27.6	6,658	225	11,711	52.05	26.03
1904	278,659,689	78,606,997	28.2	7,663	202	10,258	50.78	25.39
1905	315,062,785	103,396,452	32.8	9,184	211	11,258	53.36	26.68
1906	342,874,867	118,847,527	34.7	10,212	213	11,638	54.64	27.32
1907	394,759,112	138,547,823	35.1	11,144	234	12,433	53.13	26.57
1908	332,573,944	123,183,334	37.0	11,569	193	10,648	55.17	27.59
1909	379,744,257	142,496,878	37.5	13,049	209	10,920	52.25	26.13
1910	417,111,142	174,012,293	41.7	13,254	217	13,129	60.50	30.25
1911	405,907,059	178,158,236	43.9	13,829	211	12,883	61.06	30.53
1912	450,104,982	210,538,822	46.8	15,298	223	13,763	61.72	30.86
1913	478,435,297	242,421,713	50.7	16,379	232	14,801	63.80	31.90
1914	421,423,024	218,399,287	51.8	16,507	195	13,231	67.85	33.93
1915	439,792,807	243,237,551	55.3	15,692	203	15,501	76.36	38.18
1916	498,587,287	283,691,475	56.9	16,198	230	17,514	76.15	38.08
1917	546,000,586	306,396,127	56.1	17,235	243	17,778	73.16	36.58
1918	571,097,575	323,931,133	56.7	18,463	249	17,545	70.46	35.23
1919	460,225,107	276,019,799	60.0	18,959	195	14,559	74.66	37.33
1920	559,807,130	339,813,476	60.7	19,103	220	17,788	80.85	40.43
1921	410,864,467	272,702,389	66.4	19,618	149	13,901	93.30	46.65
1922	412,059,215	267,032,931	64.8	20,436	142	13,067	92.02	46.01
1923	552,624,528	377,435,543	68.3	21,229	179	17,779	99.32	49.66
1924	470,079,584	336,271,335	71.5	18,660	171	18,021	105.39	52.70
1925	503,181,834	366,725,758	72.9	17,551	195	20,895	107.15	53.58
1926	556,444,290	410,912,680	73.8	17,466	215	23,526	109.42	54.71
1927	499,385,186	374,040,637	74.9	17,388	191	21,511	112.62	56.31
1928	480,956,393	369,687,007	76.9	15,261	203	24,224	119.33	59.67
1929	514,720,494	403,606,717	78.4	14,731	219	27,398	125.11	62.56
1930	447,683,940	362,425,163	81.0	14,237	187	25,457	136.13	68.07
1931	363,157,015	302,262,746	83.2	13,216	160	22,871	142.94	71.47
1932	290,068,744	243,954,770	84.1	12,017	146	20,301	139.05	69.53
1933	315,360,352	266,999,985	84.7	11,845	167	22,541	134.98	67.49
1934	338,578,381	284,676,715	84.1	11,905	178	23,912	134.34	67.17
1935	348,725,830	293,664,208	84.2	11,881	179	24,717	138.08	69.04
1936	410,962,046	348,332,330	84.8	11,974	199	29,091	146.19	73.10

a Source: Mineral Resources of the United States (U. S. Dept. Int., Geological Survey, 1891-1923; U. S. Dept. Com., Bur. Mines, 1924-31); Statistical Appendix to Minerals Yearbook (U. S. Dept. Int., Bur. Mines, 1932-33-35); Minerals Yearbook (U. S. Dept. Int., Bur. Mines, 1937); Bituminous Coal Tables (U. S. Dept. Int., Nat. Bit. Coal Com., 1936-37).

b For the years 1891 through 1913 the small amount of strip coal produced has been included. In 1914 and thereafter the strip tonnage excluded has been the "total tons mined at strip pits" and will not agree with other tables which exclude "total at same mines," a figure that included an insignificant production underground in operations which are both strip pits and deep mines.

c Col. (2) divided by col. (4).

d Col. (6) divided by col. (5).

e Col. (7) divided by 2. Two men constitute a cutting-machine crew.

Table B-4.- PERCENT OF DEEP-MINED BITUMINOUS COAL PRODUCED BY THE THREE MAJOR METHODS OF HAULAGE EMPLOYED, 1924[a]

States	Animals only[b]	Locomotives only[b]	Locomotives and animals[b]
United States	12.0	34.1	53.9
Alabama	30.3	34.3	35.4
Alaska	100.0	-	-
Arkansas	75.0	3.3	21.7
California	100.0	-	-
Colorado	37.1	5.9	57.0
Georgia	100.0	-	-
Illinois	4.8	23.9	71.3
Indiana	14.6	26.9	58.5
Iowa	49.7	1.9	48.4
Kansas	49.2	17.2	33.6
Kentucky	7.2	53.4	39.4
Maryland	28.9	13.9	57.2
Michigan	0.4	32.5	67.1
Missouri	77.1	9.0	13.9
Montana	11.0	24.1	64.9
New Mexico	16.0	-	84.0
North Dakota	62.7	3.1	34.2
Ohio	14.9	19.6	65.5
Oklahoma	77.0	3.0	20.0
Oregon	100.0	-	-
Pennsylvania	10.7	33.9	55.4
Tennessee	14.9	19.6	65.5
Texas	70.8	4.9	24.3
Utah	7.5	11.8	80.7
Virginia	3.3	62.8	33.9
Washington	22.6	32.0	45.4
West Virginia	4.6	47.5	47.9
Wyoming	31.1	2.5	66.4
Other States	100.0	-	-

a Source: H. O. Rogers, "Exit the Mule," Coal Age, Vol. 32, No. 2 (Aug. 1927), pp. 84-88.

b Includes a few mines also using ropes.

Table B-5.- NUMBER OF ANIMALS AND LOCOMOTIVES IN SERVICE AT WEST VIRGINIA BITUMINOUS-COAL MINES, 1898-1937[a]

Year	Total production	Number of animals	Number of mines using locomotives	Number of locomotives in use				
				Electric	Steam[b]	Compressed air	Gasoline[b]	Total
1898	16,700,999	2,162	(c)	(c)	(c)	(c)	-	(c)
1899	19,252,995	2,333	63	24	64	3	-	91
1900	22,647,207	2,614	72	43	69	4	-	116
1901	24,068,402	3,325	96	78	60	3	-	141
1902	24,570,826	3,132	109	107	64	2	-	173
1903	29,337,241	4,047	145	154	74	3	-	231
1904	32,406,752	4,760	168	206	77	6	-	289
1905	37,791,580	5,272	243	253	90	3	-	346
1906	43,290,350	5,477	281	335	83	3	-	421
1907	48,091,583	5,915	333	439	76	4	-	519
1908	41,897,843	6,073	404	590	81	5	-	676
1909	51,849,220	5,901	402	723	78	10	-	811
1910	61,671,019	6,572	483	888	72	7	-	967
1911	59,831,580	6,551	447	921	54	33	-	1,008
1912	66,786,687	6,486	480	1,194	62	38	17	1,311
1913	71,254,136	6,473	502	1,365	46	40	28	1,479
1914	71,707,626	6,390	662	1,571	59	43	29	1,702
1915	77,184,069	6,208	658	1,693	40	43	32	1,808
1916	86,460,127	6,406	774	1,957	37	41	29	2,064
1917	86,441,667	7,080	924	2,438	34	12	47	2,531
1918	89,935,839	7,418	946	2,687	36	24	49	2,796
1919	79,036,553	6,958	1,008	3,032	31	26	39	3,128
1920	89,970,707	7,341	1,036	3,361	38	32	43	3,474
1921	72,786,996	7,902	1,142	3,921	37	31	44	4,033
1922	80,488,192	6,886	991	3,918	27	40	37	4,022
1923	107,899,941	7,954	1,178	4,470	25	28	43	4,566
1924	101,662,897	6,668	1,074	4,427	18	37	35	4,517
1925	122,380,959	5,579	952	4,421	20	29	35	4,505
1926	143,509,340	5,976	1,027	4,713	23	17	44	4,797
1927	145,122,447	5,602	933	4,743	20	17	24	4,804
1928	132,952,159	4,769	803	4,478	25	17	12	4,532
1929	138,518,855	3,901	748	4,245	21	17	8	4,291
1930	121,472,638	3,373	729	4,253	27	17	4	4,301
1931	101,473,172	2,772	658	4,113	36	17	2	4,168
1932	85,608,735	2,015	566	3,479	15	7	3	3,504
1933	94,343,535	2,319	578	3,720	12	17	5	3,754
1934	98,134,393	2,103	515	3,863	32[d]	(d)	4	3,899
1935	99,179,061	2,167	520	3,958	33[d]	(d)	1	3,992
1936	117,925,706	1,871	493	3,964	24[d]	(d)	5	3,993
1937	118,050,000[e]	1,985	475	4,041	13[d]	(d)	3	4,057

a Source: Production from Mineral Resources of the United States (U. S. Dept. Int., Geological Survey, 1898-1923; U. S. Dept. Com., Bur. Mines, 1924-31); Statistical Appendix to Minerals Yearbook (U. S. Dept. Int., Bur. Mines, 1932-33-35); Minerals Yearbook (U. S. Dept. Int., Bur. Mines, 1937); Bituminous Coal Tables (U. S. Dept. Int., Nat. Bit. Coal Com., 1936-37). Haulage data from Annual Reports (Dept. of Mines, West Virginia); data from 1898 to 1925 are on a fiscal year, 1925 to date on calendar year.

b Includes a large number used exclusively on the surface.

c Data not available.

d Compressed-air locomotives included with steam.

e Preliminary figure.

Table B-6.- NUMBER OF ANIMALS AND LOCOMOTIVES IN SERVICE AT PENNSYLVANIA BITUMINOUS-COAL MINES, 1897-1937[a]

Year	Total production	Number of animals	Number of locomotives in use				
			Electric	Steam[b]	Compressed air	Gasoline[b]	Total
1897	54,417,974	6,769	(c)	(c)	(c)	-	(c)
1898	65,165,133	6,310	(c)	(c)	(c)	-	131
1899	74,150,175	8,013	122	110	13	-	245
1900	79,842,326	9,633	174	119	17	-	310
1901	82,305,946	10,108	231	134	23	-	388
1902	98,574,367	11,833	323	130	16	-	469
1903	103,117,178	12,899	435	162	23	-	620
1904	97,938,287	12,849	560	169	27	-	756
1905	118,413,637	13,710	660	161	31	-	852
1906	129,293,206	14,707	833	162	43	-	1,038
1907	150,143,177	15,323	1,014	174	50	-	1,238
1908	117,179,527	14,486	966	170	67	-	1,203
1909	137,966,791	14,722	1,169	163	109	-	1,441
1910	150,521,526	13,741	1,358	166	149	-	1,673
1911	144,561,257	13,774	1,438	145	165	-	1,748
1912	161,865,488	13,908	1,617	168	164	-	1,949
1913	173,781,217	13,868	1,933	148	168	-	2,249
1914	147,983,294	12,693	2,152	154	162	40	2,508
1915	157,955,137	12,135	2,308	154	156	46	2,664
1916	170,295,424	12,381	2,603	142	137	50	2,932
1917	172,448,142	13,730	2,965	135	125	64	3,289
1918	178,550,741	14,173	3,261	175	106	70	3,612
1919	150,758,154	13,670	3,567	181	103	79	3,930
1920	170,607,847	14,334	3,832	190	91	85	4,198
1921	116,013,942	12,939	4,036	146	76	83	4,341
1922	113,148,308	13,347	4,105	178	61	115	4,459
1923	171,879,913	13,244	4,461	151	48	100	4,760
1924	130,633,773	10,648	4,179	153	45	70	4,447
1925	136,928,019	9,856	4,038	139	17	80	4,274
1926	153,041,638	9,637	4,142	132	16	98	4,388
			Battery / Trolley				
1927	132,964,639	8,607	342 / 3,826	105	14	85	4,372
1928	131,202,163	7,260	299 / 3,535	66	11	67	3,978
1929	143,516,241	6,714	285 / 3,576	58	11	61	3,992
1930	124,462,787	5,826	272 / 3,577	39	4	53	3,945
1931	97,658,698	4,699	239 / 3,405	37	2	55	3,738
1932	74,775,862	3,994	229 / 3,252	32	5	42	3,560
1933	79,295,944	4,192	235 / 3,228	31	(c)	49	3,543
1934	89,825,875	(c)	(c) / (c)	(c)	(c)	(c)	(c)
1935	91,404,670	4,411	210 / 3,116	31	(c)	54	3,411
1936	109,887,470	4,505	205 / 3,307	25	(c)	45	3,582
1937	110,160,000[d]	4,320	197 / 3,367	22	(c)	31	3,617

a Source: Production from Mineral Resources of the United States (U. S. Dept. Int., Geological Survey, 1897-1923; U. S. Dept. Com., Bur. Mines, 1924-31); Statistical Appendix to Minerals Yearbook (U. S. Dept. Int., Bur. Mines, 1932-33-35); Minerals Yearbook (U. S. Dept. Int., Bur. Mines, 1937); Bituminous Coal Tables (U. S. Dept. Int., Nat. Bit. Coal Com., 1936-37). Haulage data from Annual Reports (Dept. of Mines, Pennsylvania).

b Includes a large number used exclusively on the surface.

c Data not available.

d Preliminary figure.

Table B-7.- GROWTH OF TOTAL TONNAGE OF BITUMINOUS COAL MECHANICALLY CLEANED, 1906-36[a]

(Figures represent net tons of clean coal. Data for central washeries operated by consumers are not available before 1927. No canvass was made in 1922, 1924, 1925, or 1926.)

Year	Bituminous coal cleaned by wet and pneumatic methods at mines				Washed at central plants operated by consumers	Grand total mechanically cleaned
	Wet methods	Pneumatic methods	Total	Percent of national production		
1906	9,251,946	-	9,251,946	2.7	(b)	(b)
1907	11,269,518	-	11,269,518	2.9	(b)	(b)
1908	11,870,438	-	11,870,438	3.6	(b)	(b)
1909	14,443,147	-	14,443,147	3.8	(b)	(b)
1910	16,035,387	-	16,035,387	3.8	(b)	(b)
1911	(c)	-	(c)	(c)	(b)	(b)
1912	17,538,572	-	17,538,572	3.9	(b)	(b)
1913	22,069,691	-	22,069,691	4.6	(b)	(b)
1914	20,264,141	-	20,264,141	4.8	(b)	(b)
1915	20,873,727	-	20,873,727	4.7	(b)	(b)
1916	22,922,218	-	22,922,218	4.6	(b)	(b)
1917	25,483,696	-	25,483,696	4.6	(b)	(b)
1918	22,017,293	-	22,017,293	3.8	(b)	(b)
1919	16,884,062	(d)	(d)	3.6[d]	(b)	(b)
1920	17,984,289	(d)	(d)	3.3[d]	(b)	(b)
1921	13,628,724	(d)	(d)	3.4[d]	(b)	(b)
1923	20,140,385	(d)	(d)	3.8[d]	(b)	(b)
1927	21,119,441	3,650,584	24,770,025	4.8	2,922,022	27,692,047
1928	21,188,911	3,786,185	24,975,096	5.0	3,807,943	28,783,039
1929	26,427,971	5,843,979	32,271,950	6.1	4,527,170	36,799,120
1930	27,794,648	7,895,109	35,689,757	7.6	3,109,862	38,799,619
1931	25,063,165	8,514,638	33,577,803	8.8	2,594,570	36,172,373
1932	20,818,509	6,539,090	27,357,599	8.8	2,920,770	30,278,369
1933	22,992,590	7,573,839	30,566,429	9.2	3,991,782	34,558,211
1934	27,555,730	8,297,984	35,853,714	10.0	3,972,845	39,826,559
1935	31,006,643	8,504,533	39,511,176	10.6	5,849,845	45,361,021
1936	42,795,529	10,590,948	53,386,477	12.2	7,708,499	61,094,976

a Source: For 1906-34, L. N. Plein, "Statistical Analysis of the Progress in Mechanical Cleaning of Bituminous Coal From 1927-34," Economic Paper No. 18 (U. S. Dept. Int., Bur. Mines, 1936); for 1935, Minerals Yearbook (U. S. Dept. Int., Bur. Mines, 1937); for 1936, Bituminous Coal Tables (U. S. Dept. Int., Nat. Bit. Coal Com., 1936-37).

b Data not available.

c The returns for 1911 apparently were incomplete, but the error cannot now be corrected. As published, they showed 10,830,823 tons of clean coal, equivalent to 2.7 percent of the total output.

d Pneumatic cleaning began in 1919, but no statistics are available for 1919 to 1923. The tonnages in those years, however, were small, but estimates are included in the percentages of national production.

Table B-8.- MECHANICALLY CLEANED BITUMINOUS COAL, BY STATE, AND PERCENTAGE OF TOTAL STATE OUTPUT MECHANICALLY CLEANED, 1927-36[a]

(Net tons of clean coal)

State	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936
	Mechanically cleaned tonnage									
United States	27,692,047	28,783,039	36,799,120	38,799,619	36,172,373	30,278,369	34,556,211	39,826,559	45,361,021	61,094,976
Alabama	13,153,643	13,064,095	13,565,632	11,760,020	9,303,386	5,842,039	6,729,913	7,150,888	6,841,269	9,922,514
Arkansas	9,250	6,893	9,839	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Colorado	1,362,998	1,276,764	1,270,985	888,005	542,265	284,749	361,870	417,295	492,874	713,678
Illinois	560,642	442,054	526,551	1,152,817[c]	1,546,459[c]	1,640,221[c]	1,756,812[c]	2,323,242[c]	3,154,128	5,613,522
Indiana	250,282	245,522	498,415	(c)	(c)	(c)	(c)	(c)	1,283,555	2,198,067
Kansas	-	-	-	-	-	(b)	(d)	(d)	(d)	(d)
Kentucky	309,262	541,975	457,655	290,780	341,954	331,416	233,238	308,735	351,568	514,647
Maryland	-	-	-	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Michigan	155,190	111,469	157,369	(e)	(e)	(e)	(e)	(e)	(e)	(e)
Missouri	-	-	-	(b)	(b)	(b)	454,911[d]	813,488[d]	1,169,351[d]	1,771,870[d]
Montana	142,802	101,586	73,293	(b)	-	-	-	(b)	(b)	(b)
New Mexico	-	-	-	-	-	-	(b)	(b)	(b)	(b)
Ohio	7,278	-	204,543	719,646[e]	816,906[e]	854,123[e]	1,123,115[e]	1,260,654[e]	1,151,546[e]	1,331,545[e]
Oklahoma	5,646	-	-	-	(b)	(b)	(b)	(b)	-	-
Pennsylvania	5,625,092	6,905,546	11,100,193	13,496,934	12,657,958	10,799,082	12,722,812	15,652,268	17,844,642	21,584,403
Tennessee	344,562	326,903	308,449	297,768	249,453	247,650	308,778	341,530	341,117	257,987
Virginia	1,289,496	269,271	(f)	(f)	(f)	(f)	(f)	(f)	389,548	473,992
Washington	820,481	892,498	967,098	819,662	603,497	485,610	519,417	400,336	614,771	1,203,783
West Virginia	3,655,423	4,298,463	7,639,098[f]	9,227,968[f]	9,715,433[f]	9,323,094[f]	10,267,905[f]	11,008,766[f]	11,613,813	15,360,671
Other States	-	-	-	146,019	395,062	470,385	79,440	155,357	112,839	148,297
	Percent of State output mechanically cleaned									
United States	5.3	5.7	6.9	8.3	9.5	9.8	10.4	11.1	12.2	13.9
Alabama	66.5	74.1	75.7	75.5	77.5	74.4	76.8	78.2	80.4	81.1
Arkansas	0.6	0.4	0.6	*	*	*	*	*	*	*
Colorado	14.0	13.0	12.8	10.8	8.2	5.1	6.9	8.0	8.3	10.5
Illinois	1.2	0.8	0.9	1.6[c]	2.6[c]	3.5[c]	3.4[c]	4.1[c]	7.1	11.0
Indiana	1.4	1.5	2.7	(c)	(c)	(c)	(c)	(c)	8.2	12.3
Kansas	-	-	-	-	-	*	(d)	(d)	(d)	(d)
Kentucky	0.4	0.9	0.8	0.6	0.9	0.9	0.6	0.8	0.9	1.1
Maryland	-	-	-	*	*	*	*	*	*	*
Michigan	20.5	18.1	19.6	(e)	(e)	(e)	(e)	(e)	(e)	(e)
Missouri	-	-	-	*	*	*	8.1[d]	13.9[d]	18.5[d]	25.5[d]
Montana	4.5	3.1	2.2	*	-	-	-	*	*	*
New Mexico	-	-	-	-	-	-	*	*	*	*
Ohio	*	-	0.9	3.1[e]	3.9[e]	5.9[e]	5.6[e]	5.9[e]	5.3[e]	5.4[e]
Oklahoma	*	-	-	-	*	*	*	*	-	-
Pennsylvania	4.2	5.3	7.7	10.8	13.0	14.4	16.0	17.4	19.5	19.6
Tennessee	6.0	5.8	5.7	5.8	5.3	7.0	8.2	8.3	8.3	5.1
Virginia	10.0	2.3	(f)	(f)	(f)	(f)	(f)	(f)	4.0	4.1
Washington	31.1	35.4	38.4	35.6	32.7	30.5	37.3	28.9	39.4	66.4
West Virginia	2.5	3.5	5.5[f]	7.0[f]	8.7[f]	10.0[f]	10.0[f]	10.2[f]	11.7	13.0
Other States	-	-	-	*	*	*	*	*	*	*

a Source: L. N. Plein, "Statistical Analysis of the Progress in Mechanical Cleaning of Bituminous Coal From 1927-34," Economic Paper 18 (U. S. Dept. Int., Bur. Mines, 1936); 1935, Minerals Yearbook (U. S. Dept. Int., Bur. Mines, 1937); 1936, Bituminous Coal Tables (U. S. Dept. Int., Nat. Bit. Coal Com., 1936-37). Central washeries operated by consumers in Colorado and Pennsylvania are included.

b Included with "Other States."

c Data for Indiana included with those for Illinois.

d Data for Kansas included with those for Missouri.

e Data for Michigan included with those for Ohio.

f Data for Virginia included with those for West Virginia.

* Less than 0.05 percent.

Table B-9.- NET TONS PRODUCED PER MAN PER DAY AT ALL BITUMINOUS-COAL MINES, UNDERGROUND MINES, AND STRIP MINES IN SELECTED STATES, 1910-36

Year	United States			Alabama			Arkansas			Illinois			Indiana		
	All Mines[a]	Strip Mines[b]	Deep Mines[c]	All Mines[a]	Strip Mines[b]	Deep Mines[c]	All Mines[a]	Strip Mines[b]	Deep Mines[c]	All Mines[a]	Strip Mines[b]	Deep Mines[c]	All Mines[a]	Strip Mines[b]	Deep Mines[c]
1910	3.46	-	3.46	2.91	-	2.91	2.67	-	2.67	3.95	-	3.95	3.67	-	3.67
1911	3.50	-	3.50	2.91	-	2.91	2.80	-	2.80	3.73	-	3.73	3.68	-	3.68
1912	3.68	-	3.68	2.91	-	2.91	2.95	-	2.95	3.95	-	3.95	3.88	-	3.88
1913	3.61	-	3.61	2.82	-	2.82	2.76	-	2.76	4.10	-	4.10	4.06	-	4.06
1914	3.71	5.06	3.71	2.87	-	2.87	2.96	-	2.96	4.19	8.46	4.18	4.27	5.38[d]	4.27
1915	3.91	5.93	3.90	2.96	-	2.96	2.96	-	2.96	4.35	7.77	4.33	4.17	8.34	4.09
1916	3.89	6.21	3.88	2.73	2.35	2.73	2.87	-	2.87	4.43	7.59	4.41	4.48	7.70	4.40
1917	3.76	5.49	3.75	2.59	5.14	2.57	2.87	-	2.87	4.22	7.42	4.21	4.53	8.35	4.42
1918	3.77	5.46	3.75	2.63	2.32	2.64	2.74	2.52	2.74	4.36	9.33	4.35	4.45	6.72	4.38
1919	3.83	5.53	3.82	2.42	3.72	2.39	2.74	2.09	2.74	4.47	7.74	4.46	4.71	7.36	4.64
1920	4.01	6.02	3.98	2.58	3.52	2.57	2.94	-	2.94	4.78	9.98	4.77	4.91	8.58	4.81
1921	4.21	7.31	4.18	2.93	5.81	2.86	3.03	2.69	3.03	4.80	9.21	4.78	4.86	7.92	4.78
1922	4.29	6.83	4.23	3.03	4.93	3.00	3.32	2.97	3.34	5.06	9.84	5.03	5.24	7.35	5.12
1923	4.47	7.50	4.42	2.94	3.90	2.91	3.39	5.16	3.23	5.03	10.00	4.99	5.45	9.94	5.22
1924	4.57	8.79	4.50	3.11	3.55	3.10	3.23	4.55	3.07	5.17	12.97	5.06	5.73	10.30	5.41
1925	4.53	10.64	4.44	3.00	4.07	2.97	2.99	5.41	2.75	5.34	15.10	5.16	5.87	11.73	5.38
1926	4.50	9.45	4.42	2.89	4.06	2.86	3.00	6.40	2.77	5.31	14.22	5.14	5.72	11.66	5.23
1927	4.55	9.97	4.46	3.10	3.87	3.07	3.05	6.70	2.88	5.36	16.52	5.14	6.13	11.71	5.30
1928	4.73	11.27	4.61	3.09	4.65	3.05	2.79	5.40	2.69	5.57	15.16	5.29	6.51	14.17	5.31
1929	4.85	13.01	4.72	3.08	4.78	3.05	2.70	4.44	2.65	6.06	18.91	5.68	7.00	14.88	5.68
1930	5.06	13.92	4.92	3.38	5.55	3.36	2.87	6.57	2.81	6.42	19.45	5.91	7.56	16.17	5.93
1931	5.30	15.78	5.12	3.84	4.38	3.84	2.58	11.93	2.53	6.54	20.19	5.88	7.95	17.42	6.02
1932	5.22	15.67	4.99	3.60	5.28	3.59	2.61	9.42	2.54	6.30	18.12	5.44	8.65	16.86	6.29
1933	4.78	12.77	4.61	3.26	4.17	3.25	2.57	6.37	2.51	6.00	15.14	5.42	7.52	14.62	5.87
1934	4.40	12.11	4.23	2.62	3.70	2.61	2.46	6.33	2.42	5.62	14.08	5.08	7.75	13.69	5.87
1935	4.50	11.21	4.32	2.79	2.75	2.79	2.47	5.95	2.42	5.97	12.65	5.40	7.91	12.74	6.24
1936	4.62	12.60	4.42	2.90	3.75	2.90	2.58	8.43	2.52	6.55	15.63	5.81	8.48	13.51	6.61

See footnotes at end of table.

Table B-9.- NET TONS PRODUCED PER MAN PER DAY AT ALL BITUMINOUS-COAL MINES, UNDERGROUND MINES, AND STRIP MINES IN SELECTED STATES, 1910-36 - Continued

Year	Kansas			Kentucky			Missouri			Montana			No. Dakota (Lignite)		
	All Mines[a]	Strip Mines[b]	Deep Mines[c]	All Mines[a]	Strip Mines[b]	Deep Mines[c]	All Mines[a]	Strip Mines[b]	Deep Mines[c]	All Mines[a]	Strip Mines[b]	Deep Mines[c]	All Mines[a]	Strip Mines[b]	Deep Mines[c]
1910	2.58	-	2.58	3.26	-	3.26	2.00	-	2.00	3.19	-	3.19	3.61	-	3.61
1911	2.86	-	2.86	3.19	-	3.19	2.05	-	2.05	3.50	-	3.50	3.43	-	3.43
1912	2.97	-	2.97	3.38	-	3.38	2.17	-	2.17	4.03	-	4.03	3.46	-	3.46
1913	2.93	-	2.93	3.51	-	3.51	2.22	-	2.22	3.92	-	3.92	3.50	-	3.50
1914	2.87	3.77	2.83	3.79	-	3.79	2.30	4.51	2.23	4.01	-	4.01	4.20	-	4.20
1915	2.80	5.34	2.63	4.11	-	4.11	2.23	4.35	2.02	4.40	-	4.40	4.09	-	4.09
1916	2.78	5.84	2.59	3.91	-	3.91	2.37	5.31	2.06	3.94	-	3.94	3.64	-	3.64
1917	3.11	5.46	2.95	3.72	1.34	3.73	2.44	5.01	2.16	3.80	-	3.80	3.78	3.83	3.78
1918	3.02	6.93	2.80	3.48	1.57	3.49	2.48	5.99	2.14	3.75	-	3.75	3.58	2.77	3.59
1919	2.89	5.40	2.74	3.47	1.95	3.47	2.40	5.40	2.03	4.02	-	4.02	3.45	5.45	3.43
1920	3.19	7.10	2.96	3.95	1.56	3.95	2.56	6.66	2.19	4.19	-	4.19	3.75	8.73	3.55
1921	3.08	7.73	2.87	4.11	5.89	4.11	2.50	7.89	2.10	4.58	-	4.58	4.19	10.48	3.93
1922	3.02	7.95	2.73	4.89	9.49	4.86	2.88	8.77	2.26	5.03	-	5.03	4.40	6.34	4.05
1923	3.19	10.85	2.83	4.83	12.09	4.78	3.08	9.15	2.51	5.00	-	5.00	4.60	6.72	4.07
1924	3.29	11.11	2.83	4.65	10.32	4.58	3.07	9.09	2.15	5.25	19.96	4.99	5.61	10.34	4.41
1925	3.43	11.15	2.79	4.69	9.33	4.63	3.17	9.15	2.08	6.64	36.76	5.45	6.62	12.53	5.12
1926	3.43	11.60	2.66	4.52	8.37	4.48	3.27	9.08	2.26	7.14	47.64	5.49	6.56	12.18	5.16
1927	3.57	11.63	2.56	4.50	10.64	4.45	3.26	8.57	2.06	6.99	58.31	5.33	6.78	14.08	4.86
1928	3.68	12.84	2.39	4.69	8.59	4.66	3.47	10.21	2.17	7.93	48.45	5.43	7.00	13.42	4.93
1929	3.63	11.64	2.67	4.64	14.41	4.61	3.87	12.92	2.30	7.90	25.86	5.69	6.84	15.15	4.65
1930	3.96	11.54	2.64	4.83	12.17	4.81	4.07	16.32	2.18	8.45	28.50	6.11	7.50	13.13	4.60
1931	4.24	15.83	2.11	5.26	12.40	5.25	4.75	13.90	2.20	9.27	40.85	6.59	7.04	16.05	3.86
1932	4.19	14.89	1.99	5.41	18.89	5.41	4.45	15.12	2.01	9.64	70.57	6.56	7.12	15.98	3.99
1933	4.15	13.15	1.83	4.87	-	4.87	4.02	11.10	1.95	9.80	75.47	6.53	7.93	13.06	4.90
1934	4.45	12.44	1.80	4.33	-	4.33	4.29	13.84	1.87	9.73	62.24	5.91	6.65	10.31	4.25
1935	4.00	8.85	1.99	4.28	1.23	4.28	4.02	11.05	1.87	9.30	58.05	5.81	7.61	11.29	5.24
1936	4.80	11.75	2.08	4.34	5.06	4.34	4.13	13.63	1.94	10.53	65.63[e]	6.35	8.20	12.25	5.34

See footnotes at end of table.

Table B-9.- NET TONS PRODUCED PER MAN PER DAY AT ALL BITUMINOUS-COAL MINES, UNDERGROUND MINES, AND STRIP MINES IN SELECTED STATES, 1910-36 - Continued

Year	Ohio			Oklahoma			Pennsylvania			Texas (Lignite)			Wyoming		
	All Mines[a]	Strip Mines[b]	Deep Mines[c]	All Mines[a]	Strip Mines[b]	Deep Mines[c]	All Mines[a]	Strip Mines[b]	Deep Mines[c]	All Mines[a]	Strip Mines[b]	Deep Mines[c]	All Mines[a]	Strip Mines[b]	Deep Mines[c]
1910	3.61	-	3.61	2.12	-	2.12	3.61	-	3.61	3.71	-	3.71	3.91	-	3.91
1911	3.73	-	3.73	2.24	-	2.24	3.69	-	3.69	3.19	-	3.19	3.70	-	3.70
1912	3.77	-	3.77	2.40	-	2.40	3.89	-	3.89	3.22	-	3.22	3.85	-	3.85
1913	3.84	-	3.84	2.34	-	2.34	3.78	-	3.78	3.22	-	3.22	3.83	-	3.83
1914	3.84	-	3.84	2.41	(d)	2.41	3.75	-	3.75	3.13	-	3.13	4.15	-	4.15
1915	3.94	6.91	3.92	2.62	4.28	2.61	4.00	-	4.00	3.02	-	3.02	4.50	-	4.50
1916	4.26	8.58	4.22	2.60	6.14	2.56	3.91	-	3.90	2.81	-	2.81	4.40	-	4.40
1917	4.26	7.25	4.21	2.45	6.73	2.39	3.80	3.39	3.80	2.84	-	2.84	4.74	5.56	4.74
1918	4.22	7.61	4.10	2.49	4.42	2.46	3.80	4.64	3.79	3.07	-	3.07	4.66	-	4.66
1919	4.39	7.39	4.29	2.44	2.81	2.42	3.96	4.99	3.94	2.94	-	2.94	4.48	-	4.48
1920	4.74	6.17	4.60	2.70	4.83	2.65	3.96	5.16	3.94	3.48	-	3.48	4.69	-	4.69
1921	4.60	9.77	4.50	2.69	5.69	2.58	4.03	6.69	4.01	3.65	-	3.65	5.08	-	5.08
1922	4.92	9.07	4.62	3.12	4.41	3.00	3.84	5.82	3.78	3.29	-	3.29	5.16	-	5.16
1923	4.94	10.72	4.73	3.00	4.15	2.88	4.13	5.71	4.11	3.20	-	3.20	5.24	-	5.24
1924	4.82	10.62	4.55	3.06	4.28	2.92	4.29	6.12	4.27	3.86	48.23	3.46	5.40	-	5.40
1925	4.68	11.89	4.35	2.70	3.98	2.51	4.37	6.81	4.35	3.97	25.94	3.43	5.90	7.20	5.90
1926	4.56	10.27	4.31	2.88	3.87	2.75	4.37	6.56	4.35	4.22	13.04	3.06	6.15	33.04	6.11
1927	4.52	10.09	4.06	3.35	5.44	3.08	4.26	6.36	4.24	6.03	28.37	4.29	6.18	18.79	6.14
1928	4.28	11.99	3.84	3.34	5.51	3.12	4.52	7.18	4.49	5.96	29.61	4.39	6.34	10.76	6.31
1929	4.64	12.58	4.41	3.36	6.46	3.12	4.73	6.89	4.71	6.19	23.44	4.63	6.02	20.35	5.98
1930	4.67	11.48	4.53	3.49	6.98	3.25	4.82	6.10	4.81	5.03	26.92	4.33	6.20	26.41	6.14
1931	4.69	14.08	4.54	3.59	6.87	3.24	4.96	5.87	4.96	6.70	33.20	5.78	6.81	24.93	6.72
1932	4.71	11.83	4.54	3.40	7.40	2.93	4.66	5.48	4.65	7.25	34.40	6.53	6.65	12.09	6.58
1933	4.55	10.16	4.42	3.26	8.52	2.81	4.24	5.15	4.24	7.55	41.75	6.89	6.29	18.45	6.20
1934	4.23	8.12	4.11	3.02	6.57	2.56	3.98	5.06	3.97	7.26	33.18	6.48	6.17	12.88	6.08
1935	4.44	9.70	4.19	3.19	7.73	2.68	4.10	4.95	4.09	7.22	20.51	6.60	6.00	11.89	5.93
1936	4.42	10.21	4.15	3.15	11.88	2.61	4.22	5.89	4.21	7.57	(e)	-	6.00	9.68	5.94

a Source: Man-day data computed (number of men employed multiplied by average days worked) for 1910-23 from Mineral Resources of the United States (U. S. Dept. Int., Geological Survey, 1910-23); for 1924-36, net tons per man-day published in Mineral Resources of the United States (U. S. Dept. Com., Bur. Mines, 1924-31); Statistical Appendix to Minerals Yearbook (U. S. Dept. Int., Bur. Mines, 1932-33-35); Minerals Yearbook (U. S. Dept. Int., Bur. Mines, 1937); Bituminous Coal Tables (U. S. Dept. Int., Nat. Bit. Coal Com., 1936-37).

Net tons per man-day calculated on basis of production figures exclusive of wagon-mine production (mines producing less than 1,000 tons annually) in the years 1918, 1919, 1920, 1922, and 1923 for the U. S. and following States: Ark., Kans., Ky., Mo., Mont., N. Dak., Ohio, Okla., and Pa. In this period wagon-mine production assumed larger proportions than in any other years and since there are no employment data for wagon mines, labor output was based only on production from commercial mines. Between 1910 and 1917 wagon-mine production was small and has been included. In 1921 and from 1924 to 1936 no canvass was made of wagon-mine production.

Due to revisions made during the present study, figures may not in all cases agree with those shown in publications of the Bur. Mines.

b Source: Man-day data taken from unpublished records of Bur. Mines, 1914-25; for 1926-36, net tons per man-day published in Mineral Resources of the United States (U. S. Dept. Com., Bur. Mines, 1926-31); Statistical Appendix to Minerals Yearbook (U. S. Dept. Int., Bur. Mines, 1932-33-35); Minerals Yearbook (U. S. Dept. Int., Bur. Mines, 1937); Bituminous Coal Tables (U. S. Dept. Int., Nat. Bit. Coal Com., 1936-37).

Net tons per man-day for strip mines based on returns which included data for underground mines in operations which were both strip pits and deep mines. This was necessary because of the impossibility of separating men engaged in stripping from those engaged in other work. Horse-stripping operations were excluded from 1914 to 1921 and included thereafter.

Due to revisions made during the present study, figures may not in all cases agree with those shown in publications of the Bur. Mines.

c Computed. Data for strip mines were subtracted from those for all mines.

d Data for Oklahoma included with those for Indiana.

e Data for Texas lignite included with those for Montana.

Table B-10.- PERCENT OF BITUMINOUS-COAL PRODUCTION MINED BY STRIPPING IN SELECTED STATES, 1914-38[a]

Year	Tonnage stripped in United States[b]	Percent of total State production mined by stripping									
		United States	Alabama	Illinois	Indiana	Kansas	Missouri	Montana	North Dakota	Oklahoma	Ohio	Pennsylvania
1914	1,280,946	0.3	-	0.6	1.7[c]	5.3	6.4	-	-	(c)	-	-
1915	2,831,619	0.6	-	0.8	3.8	11.4	17.2	-	-	0.8	1.2	-
1916	3,933,395	0.8	0.4	0.7	4.2	12.5	21.6	-	-	2.9	1.6	-
1917	5,789,977	1.0	1.2	0.6	4.8	11.2	20.1	-	0.9	3.6	3.1	0.2
1918	8,288,245	1.4	1.2	0.6	4.5	12.1	21.2	-	0.5	3.3	5.9	0.6
1919	5,634,951	1.2	1.8	0.7	4.0	10.3	24.1	-	1.3	4.2	4.9	0.4
1920	8,859,553	1.6	1.2	0.7	4.6	11.9	21.0	-	8.5	3.7	7.2	0.7
1921	5,057,483	1.2	2.7	0.8	3.9	10.5	22.0	-	10.0	6.8	2.6	0.4
1922	10,208,884	2.4	2.0	1.2	7.1	13.2	28.5	-	15.0	11.4	11.3	1.7
1923	11,940,134	2.1	2.6	1.6	8.7	14.6	24.8	-	25.3	10.9	7.3	0.8
1924	13,606,954	2.8	1.9	3.4	11.7	18.7	39.5	6.7	36.2	13.4	9.4	0.7
1925	16,870,907	3.2	2.0	5.1	15.4	24.8	44.6	21.1	38.2	17.0	10.9	0.6
1926	16,922,695	3.0	1.6	5.0	15.6	29.0	41.3	26.1	37.2	16.0	9.1	0.7
1927	18,378,166	3.5	1.9	6.0	24.8	36.3	48.5	26.2	41.9	16.8	17.1	0.9
1928	19,768,577	4.0	1.9	7.8	29.4	42.9	47.7	35.5	45.8	14.8	15.2	0.8
1929	20,268,099	3.8	1.8	8.9	30.6	34.3	49.3	35.8	46.2	13.1	7.5	0.5
1930	19,842,359	4.2	1.1	11.4	34.2	43.1	53.7	35.3	54.2	13.0	5.0	0.6
1931	18,932,381	5.0	0.6	14.3	37.1	58.0	63.8	34.5	59.4	16.6	4.6	0.5
1932	19,641,128	6.3	0.9	19.6	43.5	60.6	63.3	35.2	58.6	21.6	5.8	0.3
1933	18,270,181	5.5	0.6	15.0	36.8	64.9	62.6	36.5	61.2	20.8	5.1	0.3
1934	20,789,641	5.8	0.6	14.9	40.6	69.7	65.3	43.4	61.4	25.2	5.8	0.4
1935	23,647,292	6.4	0.4	16.6	41.4	64.8	64.5	41.6	58.1	24.4	9.7	0.5
1936	28,125,857	6.4	0.4	17.9	43.1	68.8	61.8	43.9	61.7	22.3	10.2	0.7
1937	31,750,853	7.1	*	21.8	46.6	73.4	57.8	41.2	64.2	29.1	10.2	0.7
1938	(c)	(d)	(d)	26.0	52.0	(d)	(d)	(d)	(d)	(d)	(d)	(d)

a Source: For 1914-18, O. E. Kiessling, F. G. Tryon, and L. Mann, The Economics of Strip Coal Mining (U. S. Dept. Com., Bur. Mines, Econ. Paper 11, 1931); for 1919-31, Mineral Resources of the United States (U. S. Dept. Int., Geological Survey, 1919-23; U. S. Dept. Com., Bur. Mines, 1924-31); for 1932-34, Statistical Appendix to Minerals Yearbook (U. S. Dept. Int., Bur. Mines); for 1935, Minerals Yearbook (U. S. Dept. Int., Bur. Mines); for 1936, Bituminous Coal Tables, 1936-37 (U. S. Dept. Int., Nat. Bit. Coal Com.); for 1937-38 the strip production figures have been estimated on basis of data published in State reports and other information available to the Nat. Bit. Coal Com.

Production figures for strip mines exclude all coal mined in operations which are both strip pits and deep mines. They exclude tonnage in horse stripping mines from 1914-21 and include it thereafter.

b Source: For 1914-31, Mineral Resources of the United States (U. S. Dept. Com., Bur. Mines, 1930-31); for 1932-34, Statistical Appendix to Minerals Yearbook (U. S. Dept. Int., Bur. Mines, 1932-1933 - 1935); for 1935-36, Minerals Yearbook (U. S. Dept. Int., Bur. Mines, 1937-38); for 1937 estimated on basis of data published in State reports and other information available to the Nat. Bit. Coal Com.

c Data for Oklahoma included with those for Indiana.

d Data not available.

* Less than 0.05 percent.

Table B-11.- DISTRIBUTION OF BITUMINOUS COAL MINED BY STRIPPING, BY STATE, AND PERCENTAGE OF TOTAL STATE OUTPUT MINED BY STRIPPING, 1936[a]

State	Stripped tonnage		Percent stripped tonnage is of total State tonnage
	Tons	Percent of U. S. total	
United States	28,125,857	100.0	6.4
Illinois	9,112,669	32.4	17.9
Indiana	7,679,801	27.3	43.1
Missouri	2,460,749	8.7	61.8
Ohio	2,458,116	8.7	10.2
Kansas	2,025,714	7.2	68.8
North Dakota (lignite)	1,366,921	4.9	61.7
Montana and Texas	1,312,695	4.7	34.3
Pennsylvania	753,784	2.7	0.7
Oklahoma	343,598	1.2	22.3
Iowa	272,534	1.0	6.9
Wyoming	142,694	0.5	2.5
Arkansas	55,115	0.2	3.4
Alabama	52,154	0.2	0.4
South Dakota (lignite)	33,517	0.1	81.1
Kentucky	31,897	0.1	0.1
Colorado	22,376	0.1	0.3
West Virginia	1,523	*	*

a Source: Bituminous Coal Tables, 1936-1937 (U. S. Dept. Int., Nat. Bit. Coal Com.), p. 16.

* Less than 0.05 percent.

Table B-12.- BITUMINOUS-COAL PRODUCTION IN ILLINOIS, BY COUNTY AND SEAM FOR SHIPPING MINES AND BY COUNTY FOR LOCAL MINES, 1937[a]

County	Seam (shipping mines)							Total production		
	1	2	3	4	5	6	7	Shipping mines	Local mines	Total
Adams								-	909	909
Bond						51,757		51,757	-	51,757
Brown								-	20,231	20,231
Bureau		57,207[b]						57,207	13,320	70,527
Cass								-	915	915
Christian						4,743,598		4,743,598	15,700	4,759,298
Clinton						264,413		264,413	-	264,413
Crawford								-	1,436	1,436
Edgar						27,087[c]		27,087	36,488	63,575
Franklin						10,108,267		10,108,267	-	10,108,267
Fulton					2,206,218[d]	769,950[e]		2,976,168	356,152	3,334,320
Callatin								-	34,003	34,003
Greene								-	8,912	8,912
Crundy		9,770[c]						9,770	159,758	169,528
Hancock								-	2,516	2,516
Henry	85,691	536,564[c]						622,255	106,683	728,938
Jackson						1,599,078[e]		1,599,078	121,016	1,720,094
Jasper								-	555	555
Jefferson								-	380	380
Jersey								-	1,001	1,001
Johnson								-	135	135
Knox	234,732					487,529[c]		722,261	140,914	863,175
LaSalle		399,532[f]						399,532	77,197	476,729
Livingston								-	16,153	16,153
Logan								-	2,969	2,969
McDonough								-	6,482	6,482
Macon					145,289[b]			145,289	-	145,289
Macoupin						3,515,265		3,515,265	5,621	3,520,886
Madison						1,295,392		1,295,392	363,240	1,658,632
Marion						317,542		317,542	-	317,542
Marshall								-	11,200	11,200
Menard								-	143,649	143,649
Mercer								-	27,925	27,925
Monroe								-	300	300
Montgomery						928,598		928,598	-	928,598
Morgan								-	1,092	1,092
Peoria					1,112,036			1,112,036	373,681	1,485,717
Perry					21,013	3,826,450[g]		3,847,463	25,892	3,873,355
Pope								-	47	47
Putnam			45,879[b]					45,879	-	45,879
Randolph						1,337,086[h]		1,337,086	53,027	1,390,113
Rock Island								-	45,261	45,261
St. Clair						2,009,768[i]		2,009,768	687,858	2,697,626
Saline					2,808,224[j]	651,906[c]		3,460,130	37,427	3,497,557
Sangamon					1,922,882	415,814		2,338,696	255,408	2,594,104
Schuyler								-	73,673	73,673
Scott								-	2,119	2,119
Shelby								-	12,205	12,205
Stark								-	20,783	20,783
Tazewell					126,007			126,007	156,614	282,621
Vermilion						1,681,771[k]	201,701[l]	1,883,472	390,931	2,274,403
Wabash								-	9,419	9,419
Warren								-	10,418	10,418
Washington						311,004		311,004	24,713	335,717
White						33,857		33,857	-	33,857
Will		1,318,001[c]						1,318,001	75,076	1,393,077
Williamson					398,351[c]	1,983,863[m]		2,382,214	436,775	2,818,989
Woodford		72,984[b]						72,984	-	72,984
Total	320,423	2,394,058	45,879	-	8,740,020	36,359,995	201,701	48,062,076	4,370,179	52,432,255
Stripped	-	2,058,378	-	-	2,435,034	6,541,984	140,678	11,176,074	549,796	11,725,870
Deep mined	320,423	335,680	45,879	-	6,304,986	29,818,011	61,023	36,886,002	3,820,383	40,706,385
Local mines[n]	349,514	285,397	21,434	7,370	1,924,627	1,337,492	444,345		4,370,179	
GRAND TOTAL	669,937	2,679,455	67,313	7,370	10,664,647	37,697,487	646,046			52,432,255

a Source: Computed from Coal Report of Illinois, 1937 (Dept. of Mines and Minerals.) Unless otherwise noted, all coal is deep mined by room-and-pillar method.

b All by longwall.

c All mined by stripping.

d 1,901,389 tons by stripping.

e 565,222 tons by stripping.

f 194,043 tons by stripping, balance of 205,489 tons by longwall.

g 2,835,722 tons by stripping.

h 758,234 tons by stripping.

i 235,715 tons by stripping.

j 138,294 tons by stripping.

k 13,942 tons by stripping.

l 140,678 tons by stripping.

m 196,677 tons by stripping.

n Method of mining by seam, not known for local mines.

Table B-13.- BITUMINOUS COAL MECHANICALLY LOADED IN SHIPPING MINES IN ILLINOIS, BY SEAM, TYPE OF EQUIPMENT, AND COUNTY, 1937[a]

County	Seam No. 5					Seam No. 6					Total				
	Mobile loaders		Pit-car loaders		Total tons	Mobile loaders		Pit-car loaders		Total tons	Mobile loaders		Pit-car loaders		Total tons
	No.	Tons	No.	Tons		No.	Tons	No.	Tons		No.	Tons	No.	Tons	
Bond						1	5,113			5,113	1	5,113			5,113
Christian						57	4,545,320	6	40,363	4,585,683	57	4,545,320	6	40,363	4,585,683
Franklin						170	8,704,107	176	1,250,896	9,955,003	170	8,704,107	176	1,250,896	9,955,003
Jackson						20	1,033,856			1,033,856	20	1,033,856			1,033,856
Macon			3	71,075[b]	71,075[b]								3	71,075[b]	71,075[b]
Macoupin						41	1,674,287	342	1,606,440	3,280,727	41	1,674,287	342	1,606,440	3,280,727
Madison						16	687,058	57	348,365	1,035,423	18	687,058	57	348,365	1,035,423
Marion						7	252,950			252,950	7	252,950			252,950
Montgomery						15	781,494	54	147,104	928,598	15	781,494	54	147,104	928,598
Peoria	3	126,811			126,811						3	126,811			126,811
Perry						12	434,691	4	16,641	451,332	12	434,691	4	16,641	451,332
Randolph						11	405,763	9	44,747	450,510	11	405,763	9	44,747	450,510
St. Clair						37	1,154,344	14	37,006	1,191,350	37	1,154,344	14	37,006	1,191,350
Saline	51	1,231,852	8	93,193	1,325,045						51	1,231,852	8	93,193	1,325,045
Sangamon	5	41,978	127	744,834	786,812	2	19,276	71	396,538	415,814	7	61,254	198	1,141,372	1,202,626
Vermilion						18	619,140	38	173,485	792,625	18	619,140	38	173,485	792,625
Washington						7	219,670	2	13,491	233,161	7	219,670	2	13,491	233,161
Williamson						23	1,169,154	49	283,320	1,452,474	23	1,169,154	49	283,320	1,452,474
Total	59	1,400,641	138	909,102	2,309,743	437	21,706,223	822	4,358,396	26,064,619	496	23,106,864	960	5,267,498	28,374,362

a Source: Computed from Coal Report of Illinois, 1937 (Dept. of Mines and Minerals).

b Tonnage loaded by hand-loaded face conveyors.

Table B-14.- GROWTH OF MECHANICAL LOADING IN WESTERN KENTUCKY, BY TYPES OF EQUIPMENT, 1923-36[a]

Year	Production (net tons)	Mechanical loading		MECHANICAL LOADING BY TYPES OF EQUIPMENT													
				Mobile loaders			Scrapers			Duckbills and self-loading conveyors			Pit-car loaders			Hand-loaded face conveyors		
	Underground mines [b]	Total tons	Per cent of underground production	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of installations
1923	10,064,276	29,515	0.3	27,015	91.5	5	2,500	8.5	1	--	--	--	--	--	--	--	--	--
1924	7,700,095	54,852	0.7	54,852	100.0	8	--	--	--	--	--	--	--	--	--	--	--	--
1925	10,791,813	62,687	0.6	42,850	68.4	3	19,837	31.6	2	--	--	--	--	--	--	--	--	--
1926	14,358,535	30,746	0.2	13,446	43.7	3	17,300	56.3	2	--	--	--	--	--	--	--	--	--
1927[c]	19,857,582																	
1928	15,342,595	81,158	0.5	67,305	82.9	7	5,750	7.1	2	8,103	10.0	2	--	--	--	--	--	--
1929	14,041,479	249,589	1.8	21,912	8.8	1	21,000	8.4	1	--	--	--	206,617	82.8	34	--	--	--
1930	10,622,807	571,585	5.4	139,272	24.4	9	--	--	--	--	--	--	432,253	75.6	76	--	--	--
1931	8,501,229	820,506	9.7	132,135	16.1	7	--	--	--	--	--	--	688,371	83.9	115	--	--	--
1932	9,537,781	1,011,403	10.6	78,847	7.8	7	--	--	--	--	--	--	932,556	92.2	113	--	--	--
1933	7,834,397	742,304	9.5	54,567	7.4	7	--	--	--	--	--	--	687,737	92.6	90	--	--	--
1934	8,214,779	704,166	8.6	--	--	--	--	--	--	--	--	--	704,166	100.0	90	--	--	--
1935	8,132,613	430,930	5.3	--	--	--	--	--	--	--	--	--	430,930	100.0	91	--	--	--
1936	7,974,444	340,583	4.3	230	0.1	1	--	--	--	5,200	1.5	4	335,153	98.4	72	--	--	--

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitution of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period. The counties included in western Kentucky are Butler, Caldwell, Christian, Crittenden, Daviess, Hancock, Henderson, Hopkins, McLean, Muhlenberg, Ohio, Union, Warren, and Webster.

b The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

c Data on mechanical loading not available.

Table B-15.- GROWTH OF MECHANICAL LOADING IN ARKANSAS, BY TYPES OF EQUIPMENT, 1923-1936[a]

Year	Production (net tons)	Mechanical loading		MECHANICAL LOADING BY TYPES OF EQUIPMENT													
				Mobile loaders			Scrapers			Duckbills and self-loading conveyors			Pit-car loaders			Hand-loaded face conveyors		
	Underground mines[b,c]	Total tons	Per cent of underground production	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of installations[d]
1923	1,078,511	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1924	1,228,196	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1925	1,020,947	10,000	1.0	--	--	--	--	--	--	--	--	--	--	--	--	10,000[e]	100.0	(1)
1926	1,260,922	71,527	5.7	--	--	--	--	--	--	--	--	--	--	--	--	71,527[e]	100.0	(3)
1927[f]	1,398,515																	
1928	1,542,832	108,513	7.0	--	--	--	40,000	36.9	2	--	--	--	--	--	--	68,513	63.1	(10)
1929	1,615,405	187,377	11.6	--	--	--	44,986	24.0	6	--	--	--	--	--	--	142,391	76.0	(10)
1930	1,474,294	244,816	16.6	--	--	--	48,600	19.9	10	--	--	--	--	--	--	196,216	80.1	(10)
1931	1,124,340	207,520	18.5	--	--	--	42,140	20.3	5	--	--	--	--	--	--	165,380	79.7	(11)
1932	998,145	153,265	15.4	--	--	--	20,812	13.6	5	--	--	--	--	--	--	132,453	86.4	(10)
1933	852,365	144,736	17.0	--	--	--	34,150	23.6	6	--	--	--	--	--	--	110,586	76.4	(5)
1934	831,106	208,826	25.1	--	--	--	67,800	32.5	9	--	--	--	--	--	--	141,026	67.5	(5)
1935	1,098,805	292,064	26.6	--	--	--	65,924	22.6	8	--	--	--	--	--	--	226,140	77.4	(10)
1936	1,567,672	522,411	33.3	--	--	--	120,840	23.1	9	--	--	--	--	--	--	401,571	76.9	(15)

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

c Excludes tonnage of wagon mines and country banks.

d Number of mines in which hand-loaded conveyors, other than pit-car loaders, were used.

e The figures for hand-loaded face conveyors for the years 1923 to 1926 are incomplete as no specific inquiry regarding this type of equipment was made prior to 1928. However, when a mine reported conveyors without being asked, the incomplete replies are shown here to prove the fact that this equipment was early used.

f Data on mechanical loading not available.

Table B-16.- BITUMINOUS-COAL PRODUCTION AND TONNAGE MECHANICALLY LOADED IN PENNSYLVANIA, BY COUNTY, 1937[a]

County	Part of State	Total production[b]	Tons mechanically loaded	Percent mechanically loaded
Total	-	110,417,947	11,492,971	10.4
Allegheny	Western	15,213,350	2,382,920	15.7
Armstrong	Central	2,945,132	71,824	2.4
Beaver	Western	89,777	3,000	3.3
Bedford	Central	471,506	2,800	0.6
Blair	Central	227,667	-	-
Bradford	Central	8,092	-	-
Butler	Western	700,448	-	-
Cambria	Central	14,807,485	1,593,784	10.8
Centre	Central	473,490	111,001	23.4
Clarion	Central	1,254,862	187,459	14.9
Clearfield	Central	3,168,807	84,551	2.7
Clinton	Central	40,912	-	-
Elk	Central	606,955	16,271	2.7
Fayette	Western	20,715,179	1,222,768	5.9
Fulton	Central	139,525	-	-
Greene	Western	4,157,344	106,110	2.6
Huntingdon	Central	482,907	-	-
Indiana	Central	6,710,349	1,017,297	15.2
Jefferson	Central	2,131,721	84,631	4.0
Lawrence	Western	264,255	-	-
Lycoming	Central	60,009	-	-
McKean	Central	7,277	-	-
Mercer	Western	314,812	-	-
Somerset	Central	5,218,592	1,060,237	20.3
Tioga	Central	162,059	45,615	28.1
Venango	Western	17,116	-	-
Washington	Western	19,399,990	2,949,632	15.2
Westmoreland	Western	10,628,329	553,071	5.2

a Source: Computed from Annual Bituminous Report (Dept. of Mines, Pa.), mimeographed release.

b Includes a small proportion of strip-mined coal.

Table B-17.- BITUMINOUS-COAL PRODUCTION AND TONNAGE MECHANICALLY LOADED IN WEST VIRGINIA, BY TYPES OF LOADING EQUIPMENT AND COUNTY, 1937[a]

County	Total production	Mechanical loading					
		Net tons			Percent of total production		
		Mechanically loaded[b]	Hand-loaded into Conveyors	Total	Mechanically loaded[b]	Hand-loaded into Conveyors	Total
Total	118,965,066	11,497,410	3,993,453	15,490,863	9.6	3.4	13.0
Barbour	1,624,794	190,887	-	190,887	11.7	-	11.7
Berkeley	246	-	-	-	-	-	-
Boone	3,745,147	400,307	449,196	849,503	10.7	12.0	22.7
Braxton	37,425	-	-	-	-	-	-
Brooke	1,390,743	87,073	4,956	92,029	6.2	0.4	6.6
Clay	954,489	-	-	-	-	-	-
Doddridge	400	-	-	-	-	-	-
Fayette	12,851,148	46,247	391,595	437,842	0.4	3.0	3.4
Gilmer	21,233	-	-	-	-	-	-
Grant	18,297	-	-	-	-	-	-
Greenbrier	1,792,487	53,087	41,760	94,847	3.0	2.3	5.3
Hancock	54,375	-	-	-	-	-	-
Harrison	4,011,618	493,787	-	493,787	12.3	-	12.3
Kanawha	7,057,445	471,834	668,814	1,140,648	6.7	9.5	16.2
Lewis	16,565	-	-	-	-	-	-
Lincoln	3,205	-	-	-	-	-	-
Logan	15,432,927	4,067,169	910,581	4,977,750	26.4	5.9	32.3
McDowell	22,852,772	41,958	154,749	196,707	0.2	0.7	0.9
Marion	8,719,856	388,655	-	388,655	4.5	-	4.5
Marshall	617,287	-	-	-	-	-	-
Mason	85,762	-	-	-	-	-	-
Mercer	3,536,419	-	-	-	-	-	-
Mineral	281,255	-	-	-	-	-	-
Mingo	4,004,060	487,427	-	487,427	12.2	-	12.2
Monongalia	6,321,230	4,126,192	-	4,126,192	65.3	-	65.3
Nicholas	34,087	-	9,639	9,639	-	28.3	28.3
Ohio	2,038,252	49,898	251,200	301,098	2.4	12.2	14.8
Preston	596,005	-	-	-	-	-	-
Putnam	507,954	3,252	2,735	5,987	0.6	0.6	1.2
Raleigh	14,567,337	380,770	826,737	1,207,507	2.6	5.7	8.3
Randolph	948,375	196,388	7,806	204,194	20.7	0.8	21.5
Summers	755	-	-	-	-	-	-
Taylor	634,787	-	-	-	-	-	-
Tucker	512,494	-	29,806	29,806	-	5.8	5.8
Upshur	183,785	-	-	-	-	-	-
Wayne	28,130	-	-	-	-	-	-
Webster	842,502	-	70,127	70,127	-	8.3	8.3
Wyoming	2,639,418	12,479	173,752	186,231	0.5	6.6	7.1

a Source: Computed from Annual Report of the Department of Mines, West Virginia.

b Almost entirely by mobile loaders.

Table B-18.- NUMBER OF COMMERCIAL BITUMINOUS-COAL MINES AND PERCENTAGE OF TOTAL PRODUCTION, BY SIZE OF MINE, 1905-36[a]

Year	Number of commercial bituminous coal mines						Percent of total production					
	Class 1 (more than 200,000 tons)	Class 2 (100,000 to 200,000 tons)	Class 3 (50,000 to 100,000 tons)	Class 4 (10,000 to 50,000 tons)	Class 5 (less than 10,000 tons)	Total	Class 1 (more than 200,000 tons)	Class 2 (100,000 to 200,000 tons)	Class 3 (50,000 to 100,000 tons)	Class 4 (10,000 to 50,000 tons)	Class 5 (less than 10,000 tons)	Total
1905	411	612	808	1,514	1,715	5,060	40.2	27.3	18.2	12.4	1.9	100.0
1910	618	763	960	1,568	1,909	5,818	46.0	25.7	16.5	10.2	1.6	100.0
1913	694	837	959	1,558	1,728	5,776	50.6	24.8	14.4	8.9	1.3	100.0
1917	792	914	1,044	1,996	2,193	6,939	51.9	23.5	13.6	9.4	1.6	100.0
1918	821	929	1,198	2,636	2,735	8,319	48.6	22.7	15.1	11.6	2.0	100.0
1919	550	854	1,181	2,784	3,625	8,994	37.6	26.0	18.2	15.4	2.8	100.0
1920	701	1,031	1,279	3,160	2,750	8,921	42.1	25.3	16.1	14.6	1.9	100.0
1921	482	807	1,003	2,346	3,400	8,038	39.1	27.8	17.1	13.5	2.5	100.0
1922	416	848	1,084	3,139	3,812	9,299	31.5	28.0	18.5	18.4	3.6	100.0
1923	748	935	1,176	2,742	3,730	9,331	47.2	23.2	15.0	12.2	2.4	100.0
1924	646	819	943	2,047	3,131	7,586	49.0	23.8	14.1	10.9	2.2	100.0
1925	714	833	891	1,969	2,737	7,144	53.7	22.7	12.4	9.4	1.8	100.0
1926	823	845	867	1,912	2,730	7,177	58.1	21.0	10.9	8.3	1.7	100.0
1927	779	818	879	1,831	2,704	7,011	54.8	22.3	12.3	8.9	1.7	100.0
1928	773	687	725	1,513	2,752	6,450	60.7	19.4	10.4	7.7	1.8	100.0
1929	827	660	668	1,361	2,541	6,057	65.2	17.9	9.1	6.3	1.5	100.0
1930	716	608	644	1,239	2,684	5,891	63.1	18.6	9.9	6.7	1.7	100.0
1931	578	536	551	1,144	2,833	5,642	59.9	20.0	10.3	7.7	2.1	100.0
1932	465	477	469	1,111	2,905	5,427	55.7	21.8	11.0	8.8	2.7	100.0
1933	498	455	502	1,075	3,025	5,555	58.9	19.5	11.0	8.0	2.6	100.0
1934	551	485	479	1,072	3,671[b]	6,258[b]	61.3	19.2	9.6	7.2	2.7	100.0
1935	561	479	503	1,056	3,716[b]	6,315[b]	62.2	18.5	9.7	6.8	2.8	100.0
1936	660	452	460	1,085	4,218[b]	6,875[b]	69.0	14.8	7.6	5.9	2.7	100.0

a Source: Mineral Resources of the United States - Part II (U. S. Dept. Com., Bur. Mines) 1929, p. 712; 1930, p. 640; 1931, p. 437; Statistical Appendix to Minerals Yearbook (U. S. Dept. Int., Bur. Mines) 1932-33, p. 388; 1934, p. 294; 1935, p. 256; 1936, p. 819; Bituminous Coal Tables (Nat. Bit. Coal Com.) 1936-37, p. 15. The term commercial mines as used here refers to all bituminous coal mines with the exception of wagon mines producing less than 1,000 tons annually.

b Not strictly comparable with figures for 1933 and prior years because of more complete coverage by several States in 1934-36 of small trucking mines (producing more than 1,000 tons per year).

Table B-19.- INDEXES OF OUTPUT PER MAN-DAY AND PER MAN-HOUR IN THE BITUMINOUS-COAL INDUSTRY, 1903-36[a]

(1920=100)

Year	Output per man per day (1)	Output per man per hour (2)	Year	Output per man per day (1)	Output per man per hour (2)
1903	75.3	69.5	1920	100.0	100.0
1904	78.6	73.3	1921	105.0	104.8
1905	80.8	75.6	1922	107.0	106.6
1906	83.8	78.4	1923	111.7	111.2
1907	82.0	76.6	1924	114.0	113.2
1908	83.3	77.8	1925	113.0	112.4
1909	(b)	(b)	1926	112.2	111.6
1910	86.3	80.6	1927	113.5	113.0
1911	87.3	81.6	1928	118.0	117.4
1912	91.8	85.8	1929	120.9	120.2
1913	90.0	84.0	1930	126.2	125.5
1914	92.5	86.6	1931	132.2	131.5
1915	97.5	91.2	1932	130.2	129.1
1916	97.0	90.8	1933	119.2	118.6
1917	93.8	91.0	1934	109.7	121.2
1918	94.3	93.4	1935	112.2	128.5
1919	95.8	95.6	1936	115.2	131.9

a Source: Table B-1, cols. 7 and 8.

b Data not available.

Table B-20.- SALIENT STATISTICS SHOWING PERFORMANCE OF GROUP A-1, GROUP A, AND ALL OTHER BITUMINOUS-COAL MINES IN ILLINOIS, 1918-35[a]

Year	Production underground mines[b]	Panel 1			Panel 2			Panel 3			Panel 4		
		Tons mechanically loaded			Tons cut by machine - Per cent of total production			Number of mines			Production (net tons)		
		Group A-1	Group A	All other mines (Group B - "Experimentally mechanized")	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines[c]	Group A-1	Group A	All other mines
1918	88,735,172				76.1	72.6	51.2	32	52	406	16,724,879	24,113,924	64,621,248
1919	60,461,968				79.2	73.4	53.9	32	53	416	12,265,201	17,093,456	43,368,512
1920	88,135,353				81.9	77.6	56.4	32	52	413	17,185,825	24,464,059	63,671,294
1921	69,036,719				84.5	81.2	59.4	32	53	434	14,434,006	21,135,304	47,901,415
1922	57,686,375				82.9	80.0	62.0	32	54	399	12,221,897	17,714,456	39,971,919
1923	77,941,966	-	136,997	8,304	78.8	77.8	65.5	32	55	390	17,492,663	25,216,568	52,725,398
1924	65,946,957	-	250,028	9,556	83.0	82.3	68.7	32	54	322	19,002,026	26,549,933	39,397,024
1925	63,440,092	378,897	818,282	475,647	80.5	83.3	71.0	32	50	271	18,558,227	28,602,983	34,837,109
1926	65,842,531	978,216	1,933,181	572,117	80.8	85.1	72.4	32	53	267	20,683,005	31,952,475	33,890,056
1927	44,018,154	(e)	(e)	(e)	84.2	86.4	70.1	32	55	272	13,894,397	20,445,449	23,572,705
1928	51,608,757	2,912,155	4,445,887	2,524,846	85.1	88.6	74.9	32	53	235	17,740,617	26,117,444	25,491,313
1929	55,270,828	7,868,791	15,101,514	2,650,519	88.0	91.7	73.5	32	55	235	19,276,075	30,280,805	24,990,023
1930	47,580,700	10,563,836	20,748,185	2,098,370	96.5	97.9	74.8	32	56	216	16,610,283	27,414,798	20,165,902
1931	37,977,698	11,832,697	21,123,541	1,453,353	93.9	96.3	71.0	32	54	196	14,384,982	23,772,184	14,205,514
1932	26,923,252	8,892,317	14,434,892	924,625	96.6	97.8	67.7	32	53	214	9,945,803	15,488,225	11,435,027
1933	31,788,513	11,926,519	16,837,836	283,790	97.7	98.3	71.6	32	47	257	13,048,524	18,159,929	13,628,584
1934	35,112,301	13,252,294	18,382,025	100,322	98.0	98.5	69.3	32	45	294	14,586,400	19,770,200	15,342,101
1935	37,115,382	14,694,428	20,164,010	349,072	98.2	98.6	70.6	32	44	295	15,835,950	21,329,203	15,786,179

See footnotes at end of table.

Table B-20.- SALIENT STATISTICS SHOWING PERFORMANCE OF GROUP A-1, GROUP A, AND ALL OTHER BITUMINOUS-COAL MINES IN ILLINOIS, 1918-35[a] - Continued

Year	Production underground mines[b]	Panel 5			Panel 6			Panel 7			Panel 8			Panel 9		
		Hourly capacity			Men employed			Days operated per year			Tons per man-hour*			Number of men required to maintain 1,000 tons of hourly capacity*		
		Group A-1[d]	Group A[d]	All other mines	Group A-1[d]	Group A[d]	All other mines	Group A-1[d]	Group A[d]	All other mines	Group A-1[d]	Group A[d]	All other mines	Group A-1[d]	Group A[d]	All other mines
1918	88,735,172	8,603	12,665	33,940	13,566	20,265	65,361	243	238	238	.634	.626	.518	1,577	1,597	1,931
1919	60,461,968	9,181	13,109	34,095	13,949	20,338	64,377	167	163	159	.670	.650	.539	1,493	1,538	1,855
1920	88,135,353	10,039	14,357	37,366	13,960	21,103	65,646	214	213	213	.694	.667	.555	1,441	1,499	1,802
1921	69,036,719	10,676	15,633	41,012	15,131	23,062	71,914	169	169	146	.722	.691	.577	1,385	1,447	1,733
1922	57,686,375	11,752	17,436	42,705	15,810	24,293	71,435	130	127	117	.719	.693	.587	1,391	1,443	1,704
1923	77,941,966	12,014	18,012	43,360	16,928	26,236	72,667	182	175	152	.727	.704	.594	1,376	1,420	1,684
1924	65,946,957	13,196	19,638	35,686	18,098	27,682	60,678	180	169	138	.718	.704	.594	1,393	1,420	1,684
1925	63,440,092	13,033	19,974	29,226	18,270	27,888	48,825	178	179	149	.731	.719	.587	1,368	1,391	1,704
1926	65,842,531	13,826	21,359	25,989	18,494	29,164	45,110	187	187	163	.737	.728	.584	1,357	1,374	1,712
1927	44,018,154	14,120	22,617	26,076	18,918	30,689	45,199	123	113	113	.760	.742	.580	1,316	1,348	1,724
1928	51,608,757	13,522	20,533	20,963	17,274	27,210	35,719	164	159	152	.787	.776	.588	1,271	1,289	1,701
1929	55,270,828	12,550	19,612	18,932	15,093	23,446	31,580	192	193	165	.828	.826	.597	1,208	1,211	1,675
1930	47,580,700	12,359	19,607	18,005	14,212	22,202	29,801	168	175	140	.857	.870	.595	1,167	1,149	1,681
1931	37,977,698	12,068	19,470	15,177	13,884	21,817	26,097	149	153	117	.891	.909	.564	1,122	1,100	1,773
1932	26,923,252	11,954	18,981	12,538	12,796	19,893	24,618	104	102	114	.913	.930	.539	1,095	1,075	1,855
1933	31,788,513	10,258	15,548	12,809	10,921	16,384	24,248	159	146	133	.943	.960	.527	1,060	1,042	1,898
1934	35,112,301	10,759	15,741	14,416	11,220	16,098	26,412	187	173	147	.962	.976	.554	1,040	1,025	1,805
1935	37,115,382	11,484	16,122	14,644	11,670	16,118	24,975	197	189	154	.986	1.002	.588	1,014	998	1,701

a Source: U. S. Bureau of Mines. Certain of the figures in this table (under columns "Tons mechanically loaded") differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

c Excludes wagon mines, country banks, and local commercial mines.

d Corrected for divided working time (share-the-work) 1932 to 1935.

e Data not available.

* Three-year moving average except for terminal years.

Table B-21.- NUMBER, PRODUCTION, AND TONNAGE MECHANICALLY LOADED OF GROUP A BITUMINOUS-COAL MINES ("MECHANIZED GROUP") IN ILLINOIS, 1918-35[a]

Year	ALL UNDERGROUND MINES			GROUP A MINES ("MECHANIZED GROUP") (All mines of "Mechanized Group" including those newly opened or closed during period)							SUB-GROUP A-1 MINES ("IDENTICAL MECHANIZED") (Includes only such Group A as operated each year of period)					
					Production of these mines			Mechanical loading of these mines				Production of these mines			Mechanical loading of these mines	
	Number[b]	Production[c] (net tons)	Total tons mechanically loaded[d]	Number of mines in Group A	Net tons	Per cent of total underground	Number of these mines loading mechanically during the year	Net tons	Per cent of total Group A output	Per cent of total tonnage mechanically loaded by all mines	Number of mines in Sub-Group A-1	Net tons	Per cent of total underground	Number of these mines loading mechanically during the year	Net tons	Per cent of total Sub-Group A-1 output	Per cent of total tonnage mechanically loaded by all mines
	(1)	(2)	(3)	(4)	(5)	(6) (5) ÷ (2)	(7)	(8)	(9) (8) ÷ (5)	(10) (8) ÷ (3)	(11)	(12)	(13) (12) ÷ (2)	(14)	(15)	(16) (15) ÷ (12)	(17) (15) ÷ (3)
1918	458	88,735,172		52	24,113,924	27.2					32	16,724,879	18.8				
1919	469	60,461,968		53	17,093,456	28.3					32	12,265,201	20.3				
1920	465	88,135,353		52	24,244,059	27.8					32	17,165,825	19.5				
1921	487	69,056,719		53	21,135,304	30.6					32	14,434,006	20.9				
1922	453	57,686,375		54	17,714,456	30.7					32	12,221,897	21.2				
1923	445	77,941,966	145,301	55	25,216,568	32.4	1	136,997	0.5	94.3	32	17,492,663	22.4				
1924	376	65,946,957	259,584	54	26,549,933	40.3	1	250,028	0.9	96.3	32	19,002,026	28.8				
1925	321	63,440,092	1,293,929	50	28,602,983	45.1	5	818,282	2.9	63.2	32	18,558,227	29.3	3	378,897	2.0	29.3
1926	320	65,842,531	2,505,298	53	31,958,475	48.5	7	1,933,161	6.1	77.2	32	20,683,005	31.4	4	978,216	4.7	39.0
1927	327	44,018,154	(e)	55	20,445,449	46.4	(e)	(e)			32	13,894,397	31.6	(e)	(e)		
1928	288	51,608,757	6,970,733	53	26,117,444	50.6	29	4,445,887	17.0	63.8	32	17,740,617	34.4	17	2,912,155	16.4	41.8
1929	290	55,270,828	17,758,035	55	30,280,805	54.8	43	15,101,514	49.9	85.1	32	19,276,075	34.9	24	7,868,791	40.8	44.3
1930	272	47,580,700	22,846,555	56	27,414,798	57.6	49	20,748,185	75.7	90.8	32	16,610,283	34.9	26	10,563,836	63.6	46.2
1931	250	37,977,698	22,576,694	54	23,772,184	62.6	49	21,123,541	88.9	93.6	32	14,384,982	37.9	28	11,832,697	82.3	52.4
1932	267	26,923,252	15,359,517	53	15,488,225	57.5	48	14,434,892	93.2	94.0	32	9,945,803	36.9	28	8,892,317	89.4	57.9
1933	304	31,788,513	17,121,626	47	18,159,929	57.1	44	16,837,836	92.7	98.3	32	13,048,524	41.0	29	11,926,519	91.4	69.7
1934	339	35,112,301	18,482,347	45	19,770,200	56.3	43	18,382,025	93.0	99.5	32	14,586,400	41.5	31	13,252,294	90.9	71.7
1935	339	37,115,382	20,513,682	44	21,329,203	57.5	44	20,164,010	94.5	98.3	32	15,835,950	42.7	32	14,694,428	92.8	71.6

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitution of final returns for preliminary estimates, or in the adoption of uniform classifications over the entire period.

b Excludes wagon mines, country banks, and local commercial mines.

c The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

d Includes the tonnage mechanically loaded by the Group B mines ("experimentally mechanized").

e Data not available.

Table B-22.- COMPARISON OF NUMBER, PRODUCTION, AND TONNAGE MECHANICALLY LOADED OF GROUP A AND GROUP B BITUMINOUS-COAL MINES IN ILLINOIS, 1923-35[a]

Year	ALL UNDERGROUND MINES					GROUP A MINES - ("MECHANIZED GROUP") (All mines of "Mechanized Group" including those newly opened or closed during period)				GROUP B MINES ("Experimentally mechanized")			
			Mines with mechanical loading					Mechanical loading of these mines				Mechanical loading of these mines	
	Number[b]	Production[c] (net tons)	Number	Production	Total tons mechanically loaded[d]	Number of these mines loading mechanically during the year	Production of these mines loading mechanically during the year	Net tons	Per cent of total tonnage mechanically loaded by all mines	Number of these mines loading mechanically during the year	Production of these mines loading mechanically during the year	Net tons	Per cent of total tonnage mechanically loaded by all mines
1923	445	77,941,966	2	281,369	145,301	1	203,537	136,997	94.3	1	77,832	8,304	5.7
1924	376	65,946,957	4	1,159,878	259,584	1	506,470	250,028	96.3	3	653,408	9,556	3.7
1925	321	63,440,092	16	4,912,083	1,293,929	5	3,384,774	818,282	63.2	11	1,527,309	475,647	36.8
1926	320	65,842,531	21	8,445,308	2,505,298	7	5,790,539	1,933,181	77.2	14	2,654,769	572,117	22.8
1927	327	44,018,154	(e)	(e)	(e)	(e)	(e)	(e)		(e)	(e)	(e)	
1928	288	51,608,757	61	20,233,581	6,970,733	29	14,318,633	4,445,887	63.8	32	5,914,948	2,524,846	36.2
1929	290	55,270,828	73	28,910,320	17,752,033	43	23,951,039	15,101,514	85.1	30	4,959,281	2,650,519	14.9
1930	272	47,580,700	69	28,052,576	22,846,555	49	24,395,958	20,748,185	90.8	20	3,656,618	2,098,370	9.2
1931	250	37,977,698	76	25,498,132	22,576,854	49	21,848,530	21,123,541	93.6	27	3,649,902	1,453,353	6.4
1932	267	26,923,252	71	16,917,409	15,359,517	48	14,540,164	14,434,892	94.0	23	2,377,245	924,625	6.0
1933	304	31,788,513	52	18,971,319	17,121,626	44	17,512,086	16,837,836	98.3	8	1,459,233	283,790	1.7
1934	339	35,112,301	48	21,635,890	16,482,347	43	19,559,570	18,382,025	99.5	5	2,076,320	100,322	0.5
1935	339	37,115,382	55	24,858,462	20,513,082	44	21,329,203	20,164,010	98.3	11	3,529,259	349,072	1.7

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b Excludes wagon mines, country banks, and local commercial mines.

c The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

d Includes the tonnage mechanically loaded by the Group B mines ("experimentally mechanized").

e Data not available.

Table B-23.- GROWTH OF MECHANICAL LOADING IN ILLINOIS, BY TYPES OF EQUIPMENT, 1923-36[a]

Year	Production (net tons)	Mechanical Loading		MECHANICAL LOADING BY TYPES OF EQUIPMENT													
				Mobile loaders			Scrapers			Duckbills and self-loading conveyors			Pit-car loaders			Hand-loaded face conveyors		
	Underground mines[b]	Total tons	Per cent of underground production	Tons	Per cent of total tons loaded	Number of Machines	Tons	Per cent of total tons loaded	Number of Machines	Tons	Per cent of total tons loaded	Number of Machines	Tons	Per cent of total tons loaded	Number of Machines	Tons	Per cent of total tons loaded	Number of Installations[c]
1923	77,941,966	145,301	0.2	145,301	100.0	19	--	--	--	--	--	--	--	--	--	--	--	--
1924	65,946,957	259,584	0.4	251,884	97.0	27	--	--	--	--	--	--	--	--	--	7,700	3.0	(1)
1925	63,440,092	1,293,929	2.0	675,359	52.2	49	230,114	17.8	17	--	--	--	388,456	30.0	36	--	--	--
1926	65,842,531	2,505,898	3.8	1,848,309	73.8	89	187,212	7.5	17	--	--	--	469,777	18.7	38	--	--	--
1927[d]	44,018,154																	
1928	51,608,757	6,970,733	13.5	3,207,917	46.0	128	--	--	--	1,719	*	2	3,761,097	54.0	964	--	--	--
1929	59,270,828	17,752,033	32.1	6,325,149	35.6	215	19,320	0.1	2	--	--	--	11,407,564	64.3	1,885	--	--	--
1930	47,580,700	22,846,555	48.0	9,965,814	43.6	255	38,610	0.2	1	658	*	1	12,841,473	56.2	1,971	--	--	--
1931	37,977,698	22,576,994	59.4	10,055,746	44.5	254	28,448	0.1	2	--	--	--	12,325,149	54.6	2,162	187,551	0.8	(8)
1932	26,923,252	15,359,517	57.0	7,744,854	50.4	289	2,298	*	2	--	--	--	7,528,871	49.0	2,042	83,494	0.6	(6)
1933	31,788,513	17,121,686	53.9	10,351,882	60.5	281	--	--	--	--	--	--	6,755,929	39.4	1,444	14,415	0.1	(1)
1934	35,112,301	18,482,347	52.6	11,643,841	63.0	281	--	--	--	--	--	--	6,816,416	36.9	1,336	22,090	0.1	(1)
1935	37,115,382	20,513,082	55.3	12,809,739	62.4	319	--	--	--	--	--	--	7,664,306	37.4	1,319	39,037	0.2	(2)
1936	41,813,930	26,110,068	62.4	18,607,302	71.3	431	--	--	--	--	--	--	7,465,608	28.6	1,151	37,158	0.1	(1)

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitution of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

c Number of mines in which hand-loaded conveyors, other than pit-car loaders, were used.

d Data on mechanical loading not available.

* Less than 0.05 percent.

Table B-24.- TONS MECHANICALLY LOADED AND NUMBER OF MEN REQUIRED TO MAINTAIN 1,000 TONS OF HOURLY CAPACITY AT GROUP A MINES IN ILLINOIS, BY TYPES OF LOADING EQUIPMENT, 1918-35[a]

Year	Tons mechanically loaded				Number of men required to maintain 1,000 tons of hourly capacity			
	All Group A mines	Mines in which the following equipment was the predominant type used:[b]			All Group A mines	Mines in which the following equipment was the predominant type used:[b]		
		Mobile loaders	Pit-car loaders	Mines shifting from pit-car to mobile loaders		Mobile loaders	Pit-car loaders	Mines shifting from pit-car to mobile loaders
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1918					1,597	1,590	1,631	1,541
1919					1,538	1,538	1,600	1,414
1920					1,499	1,495	1,567	1,387
1921					1,447	1,410	1,513	1,395
1922					1,443	1,441	1,443	1,445
1923	136,997	136,997			1,420	1,433	1,393	1,433
1924	250,028	250,028			1,420	1,414	1,401	1,439
1925	818,282	737,584	80,698		1,391	1,351	1,408	1,408
1926	1,933,181	1,660,826	238,023		1,374	1,314	1,414	1,391
1927	(c)	(c)	(c)	(c)	1,348	1,302	1,376	1,353
1928	4,445,887	2,279,602	1,308,899	633,960	1,289	1,232	1,305	1,333
1929	15,101,514	5,354,931	6,205,361	2,723,597	1,211	1,111	1,267	1,271
1930	20,748,185	8,567,315	8,015,653	2,908,560	1,149	1,000	1,250	1,256
1931	21,123,541	8,978,876	8,006,818	2,813,594	1,100	935	1,253	1,182
1932	14,434,892	6,884,490	4,637,307	1,855,126	1,075	919	1,238	1,167
1933	16,837,836	8,956,660	5,148,876	1,907,209	1,042	893	1,203	1,130
1934	18,382,025	9,673,868	5,606,953	2,334,298	1,025	881	1,188	1,114
1935	20,164,010	9,789,830	6,668,438	3,053,032	998	836	1,182	1,050

a Source: Computed from U. S. Bureau of Mines data.

b The division of Group A mines fell logically into three groups: (1) mines which used only mobile loaders or in which they were used for at least two-thirds of the mechanically loaded tonnage for at least 3 years, (2) mines which used only pit-car loaders or in which they were used for at least two-thirds of the mechanically loaded tonnage for at least 3 years, and (3) mines which started their mechanical-loading program with pit-car loaders and changed to mobile loaders at the end of the period. It will be noted that the tonnages in columns (2), (3), and (4) above do not equal the total tonnage in column (1). A few mines using both pit-car loaders and mobile loaders on about an equal basis had to be omitted. Man-hour requirements for these mines were also omitted.

c Data not available.

Table B-25.- SALIENT STATISTICS SHOWING PERFORMANCE OF GROUP A-1, GROUP A, AND ALL OTHER BITUMINOUS-COAL MINES IN INDIANA, 1918-35[a]

Year	Production underground mines[b]	Panel 1			Panel 2			Panel 3			Panel 4		
		Tons mechanically loaded			Tons cut by machine - Per cent of total production			Number of mines			Production (net tons)		
		Group A-1	Group A	All other mines (Group B - "Experimentally mechanized")	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines[c]	Group A-1	Group A	All other mines
1918	29,247,196				81.5	71.4	48.2	10	19	253	2,763,309	3,923,122	25,324,074
1919	20,078,373				83.9	75.5	49.6	10	21	291	2,168,298	3,317,757	16,760,616
1920	27,985,152				81.1	69.7	47.4	10	21	274	2,375,572	4,625,057	23,360,095
1921	19,498,666				92.5	82.0	47.3	10	23	237	2,700,409	4,363,191	15,135,475
1922	17,758,174				81.9	72.4	48.3	10	24	247	2,242,882	3,984,288	13,773,886
1923	23,923,212	-	7,684	69,858	82.1	74.1	54.1	10	25	245	3,346,076	6,460,787	17,462,425
1924	18,969,024	26,978	262,186	62,931	83.4	76.4	64.8	10	27	194	2,828,326	4,813,380	14,152,644
1925	17,955,580	497,145	1,054,993	376,449	92.5	85.2	66.6	10	26	155	3,097,845	5,170,429	12,735,151
1926	19,568,770	591,242	1,393,367	810,502	91.2	86.7	69.1	10	28	152	3,253,384	6,181,884	13,386,886
1927	13,478,614	(d)	(d)	(d)	90.3	78.1	61.3	10	29	149	1,617,699	3,786,529	9,692,085
1928	11,554,468	606,879	1,772,517	653,661	87.5	80.2	70.1	10	26	117	1,667,225	3,895,079	7,559,389
1929	12,729,550	1,112,146	2,353,716	920,279	90.5	93.4	70.1	10	24	118	3,021,139	4,765,852	7,963,698
1930	10,850,750	1,242,373	2,515,728	987,455	90.1	94.3	77.6	10	23	123	2,324,890	3,939,288	6,861,462
1931	8,990,271	1,393,353	3,234,963	276,301	91.8	94.0	78.6	10	26	121	2,173,412	4,542,552	4,447,719
1932	7,532,716	1,236,586	2,988,080	237,265	93.5	94.6	75.8	10	26	110	1,585,099	3,564,248	3,968,468
1933	8,695,976	1,709,898	4,065,498	156,857	92.1	92.5	73.0	10	29	108	1,993,298	4,706,818	3,989,158
1934	8,518,231	1,685,389	5,386,761	15,925	93.8	95.9	86.1	10	28	100	1,927,826	5,562,093	2,956,138
1935	9,232,800	1,852,777	5,747,553	20,143	94.6	98.1	75.0	10	28	106	2,063,875	6,030,460	3,202,340

See footnotes at end of table.

Table B-25.- SALIENT STATISTICS SHOWING PERFORMANCE OF GROUP A-1, GROUP A, AND ALL OTHER BITUMINOUS-COAL MINES IN INDIANA, 1918-35[a] - Continued

Year	Production underground mines[b]	Panel 5			Panel 6			Panel 7			Panel 8			Panel 9		
		Hourly capacity			Men employed			Days operated per year			Tons per man-hour*			Number of men required to maintain 1,000 tons of hourly capacity*		
		Group A-1	Group A	All other mines	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines
1918	29,247,196	1,563	2,189	13,763	2,177	3,355	25,736	221	224	230	.718	.653	.534	1,393	1,531	1,873
1919	20,078,373	1,844	2,676	14,252	2,549	3,896	25,511	147	155	147	.760	.699	.558	1,316	1,431	1,792
1920	27,985,152	1,768	3,177	14,974	2,281	4,177	25,940	168	182	195	.746	.692	.576	1,340	1,445	1,736
1921	19,498,666	2,034	3,496	15,382	3,005	5,645	26,216	166	156	123	.735	.703	.595	1,361	1,422	1,681
1922	17,758,174	2,243	4,185	16,091	2,987	5,837	26,041	125	119	107	.719	.686	.614	1,391	1,458	1,629
1923	23,923,212	2,390	4,836	17,053	3,283	6,861	26,919	175	167	128	.721	.709	.641	1,387	1,410	1,560
1924	18,969,024	2,266	4,627	15,202	3,302	6,293	19,728	156	136	134	.709	.719	.650	1,410	1,391	1,538
1925	17,955,580	2,082	4,039	10,245	2,904	5,376	15,816	186	160	156	.677	.705	.655	1,477	1,418	1,627
1926	19,568,770	1,965	4,223	10,020	3,116	6,376	15,453	207	183	167	.704	.731	.640	1,420	1,368	1,563
1927	13,478,614	2,174	4,976	9,850	2,825	6,402	15,781	93	96	123	.720	.758	.631	1,389	1,355	1,585
1928	11,554,468	1,579	3,246	6,558	2,064	4,193	10,569	132	150	146	.777	.783	.637	1,287	1,277	1,570
1929	12,729,550	1,988	3,328	6,070	2,487	4,162	9,141	190	179	164	.803	.819	.654	1,245	1,221	1,529
1930	10,850,750	2,076	3,416	5,606	2,459	3,849	8,310	140	146	153	.845	.877	.654	1,183	1,140	1,529
1931	8,990,271	1,861	3,540	4,180	2,090	3,846	6,751	146	156	133	.974	1.001	.635	1,027	999	1,575
1932	7,532,716	1,694	3,536	3,543	1,428	3,008	5,841	117	126	140	1.038	1.024	.601	963	977	1,664
1933	8,695,976	1,408	3,461	3,259	1,358	3,620	5,641	177	170	153	1.072	1.050	.588	933	952	1,701
1934	8,618,231	1,494	3,986	2,665	1,503	3,891	4,596	178	192	153	1.027	1.030	.602	974	971	1,661
1935	9,232,800	1,611	4,582	3,010	1,538	4,113	4,652	183	188	152	1.049	1.112	.648	953	899	1,543

a Source: U. S. Bureau of Mines. Certain of the figures in this table (under columns "Tons mechanically loaded") differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitution of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b The strip production used in subtraction is the "total at same mines" and includes an insignificant production underground in operations which are both strip pits and deep mines.

c Excludes wagon mines and country banks.

d Data not available.

* Three-year moving average except for terminal years.

Table B-26.- NUMBER, PRODUCTION, AND TONNAGE MECHANICALLY LOADED OF GROUP A BITUMINOUS-COAL MINES ("MECHANIZED GROUP") IN INDIANA, 1918-35[a]

Year	ALL UNDERGROUND MINES			GROUP A MINES ("MECHANIZED GROUP") (All mines of "Mechanized Group" including those newly opened or closed during period)						SUB-GROUP A-1 MINES ("IDENTICAL MECHANIZED") (Includes only such Group A as operated each year of period)						
					Production of these mines		Number of these mines loading mechanically during the year	Mechanical loading of these mines				Production of these mines		Number of these mines loading mechanically during the year	Mechanical loading of these mines		
	Number[b]	Production[c] (net tons)	Total tons mechanically loaded[d]	Number of mines in Group A	Net tons	Per cent of total underground		Net tons	Per cent of total Group A output	Per cent of total tonnage mechanically loaded by all mines	Number of mines in Sub-Group A-1	Net tons	Per cent of total underground		Net tons	Per cent of total Sub-Group A-1 output	Per cent of total tonnage mechanically loaded by all mines
	(1)	(2)	(3)	(4)	(5)	(6) (5)÷(2)	(7)	(8)	(9) (8)÷(5)	(10) (8)÷(3)	(11)	(12)	(13) (12)÷(2)	(14)	(15)	(16) (15)÷(12)	(17) (15)÷(3)
1918	272	29,247,196		19	3,923,122	13.4					10	2,763,309	9.4				
1919	312	20,078,373		21	3,317,757	16.5					10	2,168,298	10.8				
1920	295	27,985,152		21	4,685,057	16.5					10	2,375,572	8.5				
1921	260	19,498,666		23	4,363,191	22.4					10	2,700,409	13.8				
1922	271	17,758,174		24	3,984,208	22.4					10	2,242,682	12.6				
1923	270	23,923,212	77,542	25	6,460,787	27.0	1	7,684	0.1	9.9	10	3,346,076	14.0	-	-	-	-
1924	221	18,969,024	325,117	27	4,816,380	25.4	6	262,136	5.4	80.6	10	2,828,326	14.9	3	26,978	1.0	8.3
1925	181	17,955,580	1,431,442	26	5,170,489	28.8	7	1,054,993	20.4	73.7	10	3,027,845	17.3	3	497,145	16.0	34.7
1926	180	19,568,770	2,203,859	28	6,131,864	31.6	9	1,395,357	22.5	63.2	10	3,253,334	16.6	3	591,242	18.2	26.8
1927	178	13,478,614	(e)	29	3,786,529	28.1	(e)	(e)			10	1,617,699	12.0	(e)	(e)		
1928	143	11,554,468	2,426,178	26	3,895,079	33.7	11	1,772,517	45.5	73.1	10	1,667,225	14.4	4	606,879	36.4	25.0
1929	142	12,729,550	3,273,995	24	4,765,852	37.4	14	2,353,716	49.4	71.9	10	3,021,139	23.7	5	1,112,146	36.8	34.0
1930	146	10,850,750	3,503,183	23	3,989,288	36.8	17	2,515,728	63.1	71.8	10	2,324,890	21.4	6	1,242,373	53.4	35.5
1931	147	8,990,271	3,511,264	26	4,542,552	50.5	19	3,234,963	71.2	92.1	10	2,173,112	24.2	7	1,393,393	64.1	39.7
1932	136	7,552,716	3,225,345	26	3,504,248	47.3	22	2,988,080	85.8	92.6	10	1,585,099	21.0	8	1,236,586	78.0	38.3
1933	137	8,695,976	4,222,355	29	4,706,818	54.1	25	4,069,498	86.4	96.3	10	1,993,898	22.9	8	1,709,898	85.8	40.5
1934	128	8,518,231	5,402,686	28	5,562,993	65.3	27	5,336,761	96.8	99.7	10	1,927,826	22.6	9	1,685,389	87.4	31.2
1935	133	9,232,800	5,767,656	28	6,030,460	65.3	28	5,747,553	95.3	99.7	10	2,063,875	22.4	10	1,852,777	89.8	32.1

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitution of final returns for preliminary estimates, or in the adoption of uniform classifications over the entire period.

b Excludes wagon mines and country banks.

c The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

d Includes the tonnage mechanically loaded by the Group B mines ("experimentally mechanized").

e Data not available.

Table B-27.- COMPARISON OF NUMBER, PRODUCTION, AND TONNAGE MECHANICALLY LOADED OF GROUP A AND GROUP B BITUMINOUS-COAL MINES IN INDIANA, 1923-35[a]

Year	ALL UNDERGROUND MINES					GROUP A MINES ("MECHANIZED GROUP") (All mines of "Mechanized Group" including those newly opened or closed during period)				GROUP B MINES ("Experimentally mechanized")			
			Mines with mechanical loading					Mechanical loading of these mines				Mechanical loading of these mines	
	Number[b]	Production[c] (net tons)	Number	Production	Total tons mechanically loaded[d]	Number of these mines loading mechanically during the year	Production of these mines loading mechanically during the year	Net tons	Per cent of total tonnage mechanically loaded by all mines	Number of these mines loading mechanically during the year	Production of these mines loading mechanically during the year	Net tons	Per cent of total tonnage mechanically loaded by all mines
1923	270	23,923,212	4	369,555	77,542	1	45,588	7,684	9.9	3	223,967	69,858	90.1
1924	221	18,969,024	8	803,917	325,117	6	740,986	262,186	80.6	2	62,931	62,931	19.4
1925	181	17,955,530	14	1,659,223	1,431,142	7	1,087,955	1,054,993	73.7	7	571,268	376,149	26.3
1926	180	19,568,770	16	2,887,774	2,203,859	8	1,400,070	1,393,357	63.2	8	1,487,704	810,502	36.8
1927	178	13,478,614	(e)	(e)	(e)	(e)	(e)	(e)		(e)	(e)	(e)	
1928	143	11,554,168	17	3,069,030	2,426,178	11	1,937,843	1,772,517	73.1	6	1,131,187	653,661	26.9
1929	142	12,729,550	26	4,015,527	3,273,995	14	2,801,099	2,353,716	71.9	12	1,214,428	920,279	28.1
1930	146	10,850,750	27	4,266,901	3,503,185	17	2,833,643	2,515,728	71.8	10	1,433,258	987,455	28.2
1931	147	8,990,271	25	4,537,700	3,511,264	19	3,568,121	3,234,963	92.1	6	969,579	276,301	7.9
1932	136	7,532,716	25	4,007,083	3,225,345	22	3,316,296	2,988,080	92.6	3	690,787	237,265	7.4
1933	137	8,695,976	25	4,889,242	4,222,355	23	4,231,822	4,065,498	96.3	2	657,420	156,857	3.7
1934	128	8,518,231	28	5,880,998	5,402,686	27	5,411,932	5,385,761	99.7	1	439,066	15,925	0.3
1935	133	9,232,800	30	6,325,544	5,767,696	28	6,030,460	5,747,553	99.7	2	295,084	20,143	0.3

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitution of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b Excludes wagon mines and country banks.

c The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

d Includes the tonnage mechanically loaded by the Group B mines ("experimentally mechanized").

e Data not available.

Table B-28.- GROWTH OF MECHANICAL LOADING IN INDIANA, BY TYPES OF EQUIPMENT, 1923-36[a]

Year	Production (net tons)	Mechanical loading		MECHANICAL LOADING BY TYPES OF EQUIPMENT													
				Mobile loaders			Scrapers			Duckbills and self-loading conveyors			Pit-car loaders			Hand-loaded face conveyors		
	Underground mines[b]	Total tons	Per cent of underground production	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of installations[c]
1923	23,923,212	77,542	0.3	70,476	90.9	15	--	--	--	--	--	--	7,066	9.1	3	--	--	--
1924	18,969,024	325,117	1.7	325,117	100.0	37	--	--	--	--	--	--	--	--	--	--	--	--
1925	17,955,580	1,431,142	8.0	1,379,169	96.4	73	51,973	3.6	8	--	--	--	--	--	--	--	--	--
1926	19,568,770	2,203,859	11.3	1,822,754	82.7	76	343,983	15.6	11	--	--	--	37,122	1.7	7	--	--	--
1927[d]	13,478,614																	
1928	11,554,168	2,426,178	21.0	2,192,193	90.4	72	--	--	--	--	--	--	233,985	9.6	44	--	--	--
1929	12,729,550	3,273,995	25.7	1,999,686	61.1	64	--	--	--	--	--	--	1,267,042	38.7	163	7,267	0.2	(1)
1930	10,850,750	3,503,183	32.3	1,713,390	48.9	66	--	--	--	--	--	--	1,789,793	51.1	233	--	--	--
1931	8,990,271	3,511,264	39.1	2,026,568	57.7	67	--	--	--	--	--	--	1,475,096	42.0	186	9,600	0.3	(1)
1932	7,532,716	3,225,345	42.8	2,364,354	73.3	84	--	--	--	--	--	--	818,514	25.4	168	42,477	1.3	(2)
1933	8,695,976	4,222,355	48.6	3,146,318	74.5	91	--	--	--	--	--	--	1,041,146	24.7	167	34,591	0.8	(1)
1934	8,518,231	5,402,686	63.4	4,199,727	77.7	96	--	--	--	--	--	--	1,037,434	19.2	165	165,525	3.1	(2)
1935	9,232,800	5,767,696	62.5	4,986,408	86.5	123	--	--	--	--	--	--	703,697	12.2	99	77,591	1.3	(2)
1936	10,142,735	7,146,090	70.5	6,402,957	89.6	146	--	--	--	--	--	--	667,637	9.3	74	75,496	1.1	(2)

a Source: U. S. Bureau of Mines. Certain of these figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitution of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

c Number of mines in which hand-loaded conveyors, other than pit-car loaders, were used.

d Data on mechanical loading not available.

Table B-29.- TONS MECHANICALLY LOADED AND NUMBER OF MEN REQUIRED TO MAINTAIN 1,000 TONS OF HOURLY CAPACITY AT GROUP A MINES IN INDIANA, BY TYPES OF LOADING EQUIPMENT, 1918-35[a]

Year	Tons mechanically loaded				Number of men required to maintain 1,000 tons of hourly capacity			
	All Group A mines	Mines in which the following equipment was the predominant type used:[b]			All Group A mines	Mines in which the following equipment was the predominant type used:[b]		
		Mobile loaders	Pit-car loaders	Mines shifting from pit-car to mobile loaders		Mobile loaders	Pit-car loaders	Mines shifting from pit-car to mobile loaders
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1918					1,531	1,370	1,745	1,976
1919					1,431	1,314	1,664	1,597
1920					1,445	1,364	1,618	1,558
1921					1,422	1,361	1,524	1,575
1922					1,458	1,408	1,563	1,560
1923	7,684	7,684			1,410	1,377	1,497	1,443
1924	262,186	262,186			1,391	1,353	1,486	1,403
1925	1,054,993	1,054,993			1,418	1,389	1,488	1,445
1926	1,393,357	1,385,507	7,850		1,368	1,318	1,477	1,406
1927	(c)	(c)	(c)	(c)	1,355	1,261	1,508	1,410
1928	1,772,517	1,621,186	8,000	143,331	1,277	1,096	1,513	1,416
1929	2,353,716	1,609,871	202,899	540,946	1,221	1,018	1,570	1,387
1930	2,515,728	1,350,725	280,194	884,809	1,140	961	1,543	1,248
1931	3,234,963	1,992,911	446,210	795,842	999	872	1,429	1,056
1932	2,988,080	1,897,811	288,997	801,272	977	878	1,391	989
1933	4,065,498	2,199,855	542,563	1,323,080	952	853	1,404	969
1934	5,386,761	3,193,986	601,796	1,590,979	971	883	1,374	977
1935	5,747,553	3,380,852	718,825	1,647,876	899	807	1,244	934

a Source: Computed from U. S. Bureau of Mines data.

b The division of Group A mines fell logically into three groups: (1) mines which used only mobile loaders or in which they were used for at least two-thirds of the mechanically loaded tonnage for at least 3 years, (2) mines which used only pit-car loaders or in which they were used for at least two-thirds of the mechanically loaded tonnage for at least 3 years, and (3) mines which started their mechanical-loading program with pit-car loaders and changed to mobile loaders at the end of the period. Only one mine in the total for Group A was using face conveyors and could not be classified as falling under one of the three headings. To prevent disclosure of data for individual operations, the tonnage was included under pit-car loaders; the man-hour requirements of this mine, however, were omitted.

c Data not available.

Table B-30.- INDEXES OF PRODUCTION, MAN-HOURS, AND UNIT LABOR REQUIREMENTS AT GROUP A AND ALL OTHER MINES IN THE ILLINOIS-INDIANA AREA, 1918-35[a]

(1923=100)

Year	Group "A" mines			"All other" mines		
	Production	Man-hours	Number of men required to maintain 1,000 tons of hourly capacity[b]	Production	Man-hours	Number of men required to maintain 1,000 tons of hourly capacity[b]
1918	88.5	97.3	112.1	128.1	148.6	115.7
1919	64.4	68.6	107.3	85.7	96.3	111.2
1920	91.8	91.7	105.3	124.0	131.7	107.9
1921	80.5	83.4	101.9	89.8	95.0	103.9
1922	68.5	66.2	101.9	76.6	77.1	101.9
1923	100.0	100.0	100.0	100.0	100.0	100.0
1924	99.0	96.9	99.9	76.3	76.0	99.5
1925	106.6	102.5	98.5	67.8	67.5	100.2
1926	120.4	115.7	97.0	67.4	68.6	101.1
1927	76.5	71.3	95.3	47.4	48.6	102.0
1928	94.7	86.4	90.8	47.2	48.2	100.8
1929	110.6	92.2	85.5	47.0	46.2	99.3
1930	99.1	77.5	81.0	38.5	37.6	99.3
1931	89.4	68.8	76.3	26.6	27.3	104.3
1932	60.1	42.2	74.6	21.9	25.1	109.4
1933	72.2	52.7	72.4	25.1	28.3	112.0
1934	80.0	56.0	71.4	26.1	28.6	107.4
1935	86.4	58.3	68.8	27.1	27.4	101.1

a Source: Computed from U. S. Bureau of Mines data.

b Three-year moving average except for terminal years.

Table B-31.- SALIENT STATISTICS SHOWING PERFORMANCE OF GROUP A-1, GROUP A, AND ALL OTHER BITUMINOUS-COAL MINES IN WYOMING, 1918-35[a]

Year	Production underground mines[b]	Panel 1			Panel 2			Panel 3			Panel 4		
		Tons mechanically loaded			Tons cut by machine - Per cent of total production			Number of mines			Production (net tons)		
		Group A-1	Group A	All other mines (Group B - "Experimentally mechanized")	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines[c]	Group A-1	Group A	All other mines
1918	9,438,688				64.4	66.8	33.7	13	15	45	3,467,684	3,875,545	5,563,143
1919	7,219,738				66.0	70.1	42.2	13	18	53	2,788,866	3,340,972	3,878,766
1920	9,630,271				60.3	65.6	44.8	13	19	50	3,296,340	4,455,320	5,174,951
1921	7,200,666				62.2	67.9	35.7	13	23	40	2,569,764	3,606,044	3,594,622
1922	5,971,724				74.6	78.7	34.2	13	23	39	2,134,561	3,168,355	2,803,369
1923	7,575,031	107,698	107,698	105	55.5	67.9	30.5	13	22	40	2,716,643	3,965,808	3,609,223
1924	6,757,468	161,523	161,523	-	65.3	74.6	29.2	13	23	39	2,679,463	3,847,413	2,910,050
1925	6,519,653	444,189	579,272	-	82.8	86.7	24.5	13	22	38	2,705,664	3,934,590	2,585,063
1926	6,459,429	1,076,901	1,278,460	-	76.9	79.4	20.2	13	22	38	2,940,890	4,213,844	2,245,585
1927	6,687,428	(e)	(e)	(c)	77.6	75.2	22.4	13	24	36	3,395,837	5,055,316	1,632,112
1928	6,499,914	2,029,086	2,530,351	102,097	81.4	78.6	25.4	13	24	33	3,404,485	5,091,762	1,408,152
1929	6,632,041	2,195,999	2,889,376	112,593	80.7	79.7	33.5	13	24	29	3,563,841	5,347,486	1,284,555
1930	6,005,522	2,153,415	2,781,535	83,163	81.3	81.6	38.2	13	26	33	3,404,755	4,965,389	1,040,133
1931	4,901,429	2,063,917	2,733,861	42,137	85.3	81.5	32.7	13	26	39	2,864,667	4,171,571	729,858
1932	4,072,912	1,887,774	2,691,082	6,781	90.4	87.9	35.1	13	24	40	2,378,634	3,555,789	517,123
1933	3,918,965	2,068,976	2,969,920	-	92.8	91.0	33.5	13	25	38	2,392,371	3,528,652	390,313
1934	4,248,647	2,498,866	3,560,180	11,424	93.3	94.2	43.3	15	24	38	2,699,003	3,961,780	286,867
1935	5,042,837	3,120,286	4,530,032	-	97.9	98.2	33.0	15	23	41	3,262,136	4,714,955	327,882

See footnotes at end of table.

Table B-31.- SALIENT STATISTICS SHOWING PERFORMANCE OF GROUP A-1, GROUP A, AND ALL OTHER BITUMINOUS-COAL MINES IN WYOMING, 1918-35[a] - Continued

Year	Production underground mines[b]	Panel 5			Panel 6			Panel 7			Panel 8			Panel 9		
		Hourly capacity			Men employed			Days operated per year			Tons per man-hour*			Number of men required to maintain 1,000 tons of hourly capacity*		
		Group A-1	Group A	All other mines	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines	Group A-1[d]	Group A[d]	All other mines	Group A-1[d]	Group A[d]	All other mines
1918	9,438,688	1,605	1,788	2,614	2,516	2,866	4,668	270	271	266	-	.574	.593	-	1,742	1,686
1919	7,219,738	1,536	1,800	2,276	2,495	3,162	4,124	227	232	213	-	.568	.587	-	1,761	1,704
1920	9,630,271	1,549	2,070	2,488	2,354	3,415	4,364	266	269	260	-	.584	.608	-	1,712	1,645
1921	7,200,666	1,788	2,606	2,791	2,688	4,019	4,465	179	173	161	-	.624	.619	-	1,603	1,616
1922	5,971,724	1,962	2,891	2,896	2,639	4,044	5,001	136	137	121	-	.669	.608	-	1,495	1,645
1923	7,575,031	1,808	2,637	2,314	2,279	3,486	4,043	188	188	195	-	.715	.568	-	1,399	1,761
1924	6,757,468	1,903	2,702	2,091	2,311	3,540	3,573	176	178	174	-	.764	.561	-	1,309	1,783
1925	6,519,653	1,869	2,717	1,857	2,231	3,295	2,928	181	181	174	-	.787	.537	-	1,271	1,862
1926	6,459,429	1,802	2,674	1,744	2,037	3,237	2,609	204	197	161	-	.802	.545	-	1,247	1,835
1927	6,687,428	1,965	3,009	1,333	2,241	3,685	2,077	216	210	163	-	.804	.555	-	1,244	1,802
1928	6,499,914	1,826	2,906	880	2,028	3,510	1,310	233	219	200	-	.812	.593	-	1,232	1,686
1929	6,632,041	1,789	2,809	780	2,179	3,643	1,171	249	238	206	-	.806	.611	-	1,241	1,637
1930	6,005,522	2,027	3,199	774	2,278	4,065	1,123	210	194	168	-	.816	.588	-	1,225	1,701
1931	4,901,429	2,094	3,386	596	2,154	3,791	943	171	154	153	-	.843	.538	-	1,186	1,859
1932	4,072,912	1,870	2,905	479	2,047	3,308	839	159	153	135	-	.870	.473	-	1,149	2,114
1933	3,916,965	1,739	2,626	267	2,023	3,221	495	172	168	143	-	.893	.453	-	1,120	2,208
1934	4,248,647	1,864	2,850	253	2,023	3,251	476	200	192	155	-	.898	.479	-	1,114	2,088
1935	5,042,837	2,109	3,048	231	2,216	3,481	434	221	221	190	-	.902	.532	-	1,109	1,880

a Source: U. S. Bureau of Mines. Certain of the figures in this table (under columns "Tons mechanically loaded") differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitution of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

c Excludes wagon mines and country banks.

d Figures for Group "A" mines are not strictly comparable with those shown in other panels. Due to the impossibility of separating accurately the productivity data of the Union Pacific Coal Company by mines it was necessary to include in the "A" series the hand-loading mines of this company. Specifically, Group "A" includes the hand-loading operations of the Union Pacific Coal Company at Hanna, Reliance, Rock Springs, Superior, and Winton. Group "A-1" mines could not be shown.

e Data not available.

* Three-year moving average except for terminal years.

Table B-32.- NUMBER, PRODUCTION, AND TONNAGE MECHANICALLY LOADED OF GROUP A BITUMINOUS-COAL MINES ("MECHANIZED GROUP") IN WYOMING, 1918-35[a]

Year	ALL UNDERGROUND MINES			GROUP A MINES ("MECHANIZED GROUP") (All mines of "Mechanized Group" including those newly opened or closed during period)						SUB-GROUP A-1 MINES ("IDENTICAL MECHANIZED") (Includes only such Group A as operated each year of period)						
					Production of these mines			Mechanical loading of these mines				Production of these mines			Mechanical loading of these mines		
	Number[b]	Production[c] (net tons)	Total tons mechanically loaded[d]	Number of mines in Group A	Net tons	Per cent of total underground	Number of these mines loading mechanically during the year	Net tons	Per cent of total Group A output	Per cent of total tonnage mechanically loaded by all mines	Number of mines in Sub-Group A-1	Net tons	Per cent of totl underground	Number of these mines loading mechanically during the year	Net tons	Per cent of total Sub-Group A-1 output	Per cent of total tonnage mechanically loaded by all mines
	(1)	(2)	(3)	(4)	(5)	(6) (5)÷(2)	(7)	(8)	(9) (8)÷(5)	(10) (8)÷(3)	(11)	(12)	(13) (12)÷(2)	(14)	(15)	(16) (15)÷(12)	(17) (15)÷(3)
1918	60	9,438,688		15	3,875,545	41.1					13	3,467,684	36.7				
1919	71	7,219,738		18	3,340,972	46.3					13	2,788,866	38.6				
1920	69	9,630,271		19	4,455,320	46.3					13	3,296,340	34.2				
1921	63	7,200,666		23	3,606,944	50.1					13	2,559,764	35.6				
1922	62	5,971,724		23	3,168,355	53.1					13	2,134,561	35.7				
1923	62	7,575,031	107,803	22	3,965,808	52.4	1	107,698	2.7	99.9	13	2,718,643	35.9	1	107,698	4.0	99.9
1924	62	6,757,468	161,523	23	3,847,418	56.9	2	161,523	4.2	100.0	13	2,679,463	39.7	2	161,523	6.0	100.0
1925	60	6,519,655	579,272	22	3,934,590	60.3	5	579,272	14.7	100.0	13	2,705,664	41.5	3	444,189	16.4	76.7
1926	60	6,499,429	1,278,460	22	4,213,841	65.2	8	1,278,460	30.3	100.0	13	2,940,890	45.5	6	1,076,901	36.6	84.2
1927	60	6,687,428	(e)	21	5,055,316	75.6	(e)	(e)			13	3,395,837	50.8	(e)	(e)		
1928	57	6,499,914	2,632,448	24	5,091,762	78.3	19	2,530,351	49.7	96.1	13	3,404,485	52.4	10	2,029,086	59.6	77.1
1929	53	6,632,041	3,001,969	24	5,347,486	80.6	20	2,889,376	54.0	96.2	13	3,563,841	53.7	12	2,195,999	61.6	73.2
1930	59	6,005,522	2,864,698	26	4,965,389	82.7	21	2,781,535	56.0	97.1	13	3,404,755	56.7	12	2,153,435	63.2	75.2
1931	69	4,901,482	2,775,998	26	4,171,571	85.1	23	2,733,861	65.5	98.5	13	2,864,627	58.4	12	2,063,917	72.0	74.3
1932	64	4,072,912	2,697,863	24	3,555,789	87.3	21	2,691,082	75.7	99.7	13	2,378,634	58.4	12	1,887,774	79.4	70.0
1933	63	3,918,965	2,969,920	25	3,528,652	90.0	23	2,969,920	84.2	100.0	13	2,392,371	61.0	12	2,068,976	86.5	69.7
1934	62	4,248,647	3,571,604	24	3,961,780	93.2	23	3,560,180	89.9	99.7	13	2,699,003	63.5	13	2,498,866	92.6	70.0
1935	64	5,042,837	4,530,032	23	4,714,955	93.5	23	4,530,032	96.1	100.0	13	3,262,136	64.7	13	3,120,285	95.7	68.9

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitution of final returns for preliminary estimates, or in the adoption of uniform classifications over the entire period.

b Excludes wagon mines and country banks.

c The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

d Includes the tonnage mechanically loaded by the Group B mines ("experimentally mechanized").

e Data not available.

Table B-33.- COMPARISON OF NUMBER, PRODUCTION, AND TONNAGE MECHANICALLY LOADED OF GROUP A AND GROUP B BITUMINOUS-COAL MINES IN WYOMING, 1923-35[a]

Year	ALL UNDERGROUND MINES					GROUP A MINES ("MECHANIZED GROUP") (All mines of "Mechanized Group" including those newly opened or closed during period)				GROUP B MINES ("Experimentally mechanized")			
			Mines with mechanical loading					Mechanical loading of these mines				Mechanical loading of these mines	
	Number[b]	Production[c] (net tons)	Number	Production	Total tons mechanically loaded[d]	Number of these mines loading mechanically during the year	Production of these mines loading mechanically during the year	Net tons	Per cent of total tonnage mechanically loaded by all mines	Number of these mines loading mechanically during the year	Production of these mines loading mechanically during the year	Net tons	Per cent of total tonnage mechanically loaded by all mines
1923	62	7,575,031	2	446,173	107,803	1	321,280	107,698	99.9	1	121,893	105	0.1
1924	62	6,757,468	2	487,883	161,523	2	487,883	161,523	100.0	-	-	-	-
1925	60	6,519,653	5	1,186,682	579,272	5	1,186,682	579,272	100.0	-	-	-	-
1926	60	6,459,429	8	1,987,780	1,278,460	8	1,987,780	1,278,460	100.0	-	-	-	-
1927	60	6,687,428	(e)	(e)	(e)	(e)	(e)	(e)		(e)	(e)	(e)	
1928	57	6,499,914	22	4,589,723	2,632,448	19	4,241,495	2,530,351	96.1	3	348,228	102,097	3.9
1929	53	6,632,041	24	5,195,692	3,001,969	20	4,764,674	2,889,376	96.2	4	431,018	112,593	3.8
1930	59	6,005,522	24	4,906,799	2,864,698	21	4,599,630	2,781,535	97.1	3	307,169	83,163	2.9
1931	65	4,901,429	27	4,136,736	2,775,998	23	3,953,666	2,733,861	98.5	4	183,070	42,137	1.5
1932	64	4,072,912	23	3,391,783	2,697,863	21	3,348,219	2,691,082	99.7	2	43,564	6,781	0.3
1933	63	3,918,965	23	3,390,212	2,969,920	23	3,390,212	2,969,920	100.0	-	-	-	-
1934	62	4,248,647	24	3,997,022	3,571,604	23	3,952,114	3,560,180	99.7	1	44,908	11,424	0.3
1935	64	5,042,837	23	4,714,955	4,530,032	23	4,714,955	4,530,032	100.0	-	-	-	-

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b Excludes wagon mines and country banks.

c The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

d Includes the tonnage mechanically loaded by the Group B mines ("experimentally mechanized")

e Data not available.

Table B-34.- GROWTH OF MECHANICAL LOADING IN WYOMING, BY TYPES OF EQUIPMENT, 1923-36[a]

Year	Production (net tons)	Mechanical loading		MECHANICAL LOADING BY TYPES OF EQUIPMENT													
				Mobile loaders			Scrapers			Duckbills and self-loading conveyors			Pit-car loaders			Hand-loaded face conveyors		
	Underground mines[b]	Total tons	Per cent of underground production	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of installations[c]
1923	7,575,031	107,803	1.4	107,698	99.9	6	--	--	--	105	0.1	1	--	--	--	--	--	--
1924	6,757,468	161,523	2.4	161,523	100.0	6	--	--	--	--	--	--	--	--	--	--	--	--
1925	6,519,663	579,872	8.9	449,914	77.7	26	20,758	3.6	1	--	--	--	--	--	--	108,600[d]	18.7	(1)
1926	6,459,489	1,278,460	19.8	855,815	66.9	30	183,868	14.3	7	103,221	8.1	7	--	--	--	136,156[d]	10.7	(1)
1927[e]	6,687,428																	
1928	6,499,914	2,632,448	40.5	1,051,784	40.0	34	259,957	9.9	6	995,938	37.8	56	36,944	1.4	10	287,825	10.9	(6)
1929	6,632,041	3,001,969	45.3	1,119,525	37.3	32	389,890	13.0	10	1,137,974	37.9	74	223,191	7.4	60	131,389	4.4	(3)
1930	6,005,522	2,864,698	47.7	999,775	34.9	33	340,513	11.9	10	1,107,724	38.7	77	302,877	10.6	65	113,809	3.9	(3)
1931	4,901,429	2,775,998	56.6	855,622	30.8	32	358,279	12.9	11	1,169,306	42.1	95	235,724	8.5	99	157,027	5.7	(3)
1932	4,072,912	2,697,863	66.2	714,325	26.5	29	290,382	10.7	10	1,122,079	41.6	104	242,268	9.0	87	328,809	12.2	(3)
1933	3,918,965	2,969,920	75.8	625,206	21.0	22	358,609	12.1	10	1,380,293	46.5	104	315,315	10.6	88	290,417	9.8	(6)
1934	4,248,647	3,571,604	84.1	724,397	20.3	21	401,603	11.2	10	1,830,624	51.3	128	326,106	9.2	76	286,498	8.0	(4)
1935	5,042,837	4,530,032	89.8	899,477	19.8	22	444,514	9.8	9	2,430,969	53.7	150	254,313	5.6	70	500,759	11.1	(6)
1936	5,627,652	5,189,263	92.2	1,103,545	21.3	24	316,507	6.1	10	2,893,833	55.7	175	243,627	4.7	66	631,751	12.2	(6)

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitution of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

c Number of mines in which hand-loaded conveyors, other than pit-car loaders, were used.

d The figures for hand-loaded face conveyors for the years 1923 to 1926 are incomplete as no specific inquiry regarding this type of equipment was made prior to 1928. However, where a mine reported conveyors without being asked, the incomplete replies are shown here to prove the fact that this equipment was early used.

e Data on mechanical loading not available.

Table B-35.- SALIENT STATISTICS SHOWING PERFORMANCE OF GROUP A-1, GROUP A, AND ALL OTHER BITUMINOUS-COAL MINES IN MONTANA, 1918-35[a]

Year	Production underground mines[b]	Panel 1			Panel 2			Panel 3			Panel 4		
		Tons mechanically loaded			Tons cut by machine - Per cent of total production			Number of mines			Production (net tons)		
		Group A-1	Group A	All other mines (Group B "Experimentally mechanized")	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines[c]	Group A-1	Group A	All other mines
1918	4,532,505				69.7	69.3	40.9	4	5	47	1,428,216	1,456,992	3,075,513
1919	3,236,369				57.7	57.2	37.5	4	5	53	1,071,061	1,097,108	2,139,261
1920	4,413,866				55.2	54.8	44.2	4	5	52	1,326,786	1,356,954	3,056,912
1921	2,733,958				72.6	72.4	26.8	4	5	37	815,969	821,859	1,912,099
1922	2,572,221				81.0	81.0	42.3	4	4	30	894,244	894,244	1,677,977
1923	3,147,678				83.6	83.4	27.1	4	6	27	1,131,432	1,141,133	2,006,545
1924	2,711,993				82.7	81.4	34.7	4	6	45	1,172,733	1,195,640	1,516,353
1925	2,401,956				83.1	83.1	46.9	4	4	35	1,183,720	1,183,720	1,218,236
1926	2,067,083				82.7	82.7	49.1	4	4	30	1,005,670	1,005,670	1,061,413
1927	2,321,524	(d)	(d)	(d)	82.5	82.9	42.6	4	5	29	1,230,784	1,256,252	1,065,272
1928	2,143,191	362,963	362,963	3,632	92.7	92.9	54.6	4	5	30	1,216,307	1,251,007	892,184
1929	2,188,699	659,155	677,591	30,047	93.1	93.4	54.4	4	6	29	1,243,738	1,304,475	884,224
1930	1,956,638	1,025,495	1,073,384	41,321	99.9	99.9	61.9	4	7	22	1,064,738	1,151,775	804,863
1931	1,557,341	812,247	992,176	34,407	100.0	100.0	64.7	4	8	13	812,247	1,122,024	435,317
1932	1,376,938	776,444	1,065,192	9,019	100.0	100.0	57.4	4	8	14	774,850	1,159,976	216,962
1933	1,367,414	813,432	1,087,328	—	100.0	100.0	49.4	4	8	14	813,432	1,205,194	162,220
1934	1,451,611	755,208	1,148,428	—	100.0	100.0	36.4	4	8	14	757,198	1,270,360	181,251
1935	1,607,553	865,185	1,291,373	—	100.0	100.0	35.4	4	8	19	865,810	1,428,552	179,001

See footnotes at end of table.

Table B-35.- SALIENT STATISTICS SHOWING PERFORMANCE OF GROUP A-1, GROUP A, AND ALL OTHER BITUMINOUS-COAL MINES IN MONTANA, 1918-35[a] - Continued

Year	Production underground mines[b]	Panel 5			Panel 6			Panel 7			Panel 8			Panel 9		
		Hourly capacity			Men employed			Days operated per year			Tons per man-hour*			Number of men required to maintain 1,000 tons of hourly capacity*		
		Group A-1	Group A	All other mines	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines
1918	4,532,505	669	687	1,462	1,360	1,416	3,143	267	265	263	.491	.485	.464	2,037	2,062	2,155
1919	3,236,369	708	733	1,351	1,415	1,457	2,666	189	187	198	.527	.524	.491	1,898	1,908	2,037
1920	4,413,866	691	710	1,499	1,375	1,215	2,989	240	239	255	.586	.583	.516	1,706	1,715	1,938
1921	2,733,958	761	790	1,615	1,143	1,189	2,989	134	130	148	.659	.656	.545	1,517	1,524	1,835
1922	2,572,221	822	822	1,477	1,141	1,141	2,494	136	136	142	.716	.713	.568	1,397	1,403	1,761
1923	3,147,678	847	892	1,334	1,117	1,179	2,332	167	160	188	.750	.749	.568	1,333	1,335	1,761
1924	2,711,993	843	874	1,092	1,098	1,136	2,022	174	171	173	.776	.776	.587	1,289	1,289	1,764
1925	2,401,956	886	886	881	1,108	1,108	1,503	167	167	171	.793	.793	.574	1,261	1,261	1,742
1926	2,067,083	822	822	789	1,016	1,016	1,332	153	153	166	.791	.790	.584	1,264	1,266	1,712
1927	2,321,524	729	762	699	956	999	1,222	211	206	188	.792	.792	.573	1,263	1,263	1,745
1928	2,143,191	749	794	630	929	981	1,135	203	197	177	.811	.808	.559	1,233	1,238	1,789
1929	2,188,699	691	773	685	799	903	1,244	225	211	156	.899	.882	.555	1,112	1,134	1,802
1930	1,956,638	712	800	641	695	815	1,142	187	180	152	1.062	.985	.532	942	1,015	1,880
1931	1,557,341	736	941	364	569	843	752	138	149	147	1.106	1.041	.478	904	961	2,092
1932	1,376,938	570	868	242	570	846	619	170	167	110	1.089	1.046	.407	918	956	2,457
1933	1,367,414	588	880	135	604	883	389	173	171	150	.993	1.015	.358	1,007	985	2,793
1934	1,451,611	607	1,028	176	601	1,004	524	171	170	143	.994	1.002	.351	1,006	998	2,849
1935	1,607,553	628	1,044	157	625	1,061	426	197	195	164	1.002	.984	.369	998	1,016	2,710

a Source: U. S. Bureau of Mines. Certain of the figures in this table (under columns "Tons mechanically loaded") differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

c Excludes wagon mines, country banks, and local commercial mines.

d Data not available.

* Three-year moving average except for terminal years.

Table B-36.- NUMBER, PRODUCTION, AND TONNAGE MECHANICALLY LOADED OF GROUP A BITUMINOUS-COAL MINES ("MECHANIZED GROUP") IN MONTANA, 1918-35[a]

Year	ALL UNDERGROUND MINES			GROUP A MINES ("MECHANIZED GROUP") (All mines of "Mechanized Group" including those newly opened or closed during period)						SUB-GROUP A-1 MINES ("IDENTICAL MECHANIZED") (Includes only such Group A as operated each year of period)					
					Production of these mines			Mechanical loading of these mines				Production of these mines			Mechanical loading of these mines		
	Number[b]	Production[c] (net tons)	Total tons mechanically loaded[d]	Number of mines in Group A	Net tons	Per cent of total underground	Number of these mines loading mechanically during the year	Net tons	Per cent of total Group A output	Per cent of total tonnage mechanically loaded by all mines	Number of mines in Sub-Group A-1	Net tons	Per cent of total underground	Number of these mines loading mechanically during the year	Net tons	Per cent of total Sub-Group A-1 out-put	Per cent of total tonnage mechanically loaded by all mines
	(1)	(2)	(3)	(4)	(5)	(6) (5) ÷ (2)	(7)	(8)	(9) (8) ÷ (5)	(10) (8) ÷ (3)	(11)	(12)	(13) (12)÷(2)	(14)	(15)	(16) (15) ÷ (12)	(17) (15) ÷ (3)
1918	52	4,532,506		5	1,466,992	32.1					4	1,428,216	31.5				
1919	56	3,256,369		5	1,097,108	33.9					4	1,071,061	33.1				
1920	57	4,413,966		5	1,356,964	30.7					4	1,326,786	30.1				
1921	42	2,733,966		5	821,859	30.1					4	815,969	29.8				
1922	34	2,672,221		4	894,244	34.8					4	894,244	34.8				
1923	33	3,147,678	---	6	1,141,133	36.3	--	--	--	--	4	1,131,432	35.9	--	--	--	--
1924	51	2,711,993	---	6	1,195,640	44.1	--	--	--	--	4	1,172,733	43.2	--	--	--	--
1925	39	2,401,966	---	4	1,183,720	49.3	--	--	--	--	4	1,183,720	49.3	--	--	--	--
1926	34	2,067,083	---	4	1,006,670	48.7	--	--	--	--	4	1,006,670	48.7	--	--	--	--
1927	34	2,321,624	(e)	5	1,256,252	54.1	(e)	(e)			4	1,230,704	53.0	(e	(e)		
1928	35	2,143,191	366,595	5	1,251,007	58.4	4	362,963	29.0	99.0	4	1,216,307	56.8	4	362,963	29.8	99.0
1929	35	2,188,699	707,638	6	1,304,475	59.6	5	677,691	51.9	95.8	4	1,242,738	56.8	4	669,155	53.0	93.1
1930	29	1,956,638	1,114,705	7	1,151,775	58.9	7	1,073,394	93.2	96.3	4	1,064,738	54.4	4	1,025,496	96.3	92.0
1931	21	1,557,541	1,026,583	8	1,122,024	72.0	7	992,176	88.4	96.6	4	812,247	52.2	4	812,247	100.0	79.1
1932	22	1,376,938	1,074,211	8	1,159,976	84.2	7	1,065,192	91.8	99.2	4	774,850	56.3	4	776,444	100.2 f	72.3
1933	22	1,367,414	1,087,328	8	1,206,194	88.1	7	1,087,328	90.2	100.0	4	813,432	59.5	4	813,432	100.0	74.8
1934	22	1,451,611	1,148,428	8	1,270,360	87.5	8	1,148,428	90.4	100.0	4	757,198	52.2	4	755,208	99.7	65.8
1935	27	1,607,553	1,291,373	8	1,428,562	88.9	8	1,291,373	90.4	100.0	4	865,210	53.9	4	865,125	99.9	67.0

a Source: U.S.Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitution of final returns for preliminary estimates, or in the adoption of uniform classifications over the entire period.

b Excludes wagon mines, country banks, and local commercial mines.

c The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

d Includes the tonnage mechanically loaded by the Group B mines ("experimentally mechanized").

e Data not available.

f One company reported slightly more tons loaded than total production.

Table B-37.- COMPARISON OF NUMBER, PRODUCTION, AND TONNAGE MECHANICALLY LOADED OF GROUP A AND GROUP B BITUMINOUS-COAL MINES IN MONTANA, 1923-35[a]

Year	ALL UNDERGROUND MINES					GROUP A MINES ("MECHANIZED GROUP") (All mines of "Mechanized Group" including those newly opened or closed during period)				GROUP B MINES ("Experimentally mechanized")			
			Mines with mechanical loading					Mechanical loading of these mines				Mechanical loading of these mines	
	Number[b]	Production[c] (net tons)	Number	Production	Total tons mechanically loaded[d]	Number of these mines loading mechanically during the year	Production of these mines loading mechanically during the year	Net tons	Per cent of total tonnage mechanically loaded by all mines	Number of these mines loading mechanically during the year	Production of these mines loading mechanically during the year	Net tons	Per cent of total tonnage mechanically loaded by all mines
1923	33	3,147,678	--	--	--	--	--	--	--	--	--	--	--
1924	51	2,711,993	--	--	--	--	--	--	--	--	--	--	--
1925	39	2,401,956	--	--	--	--	--	--	--	--	--	--	--
1926	34	2,067,083	--	--	--	--	--	--	--	--	--	--	--
1927	34	2,321,524	(e)	(e)	(e)	(e)	(e)	(e)		(e)	(e)	(e)	
1928	35	2,143,191	6	1,631,696	366,595	4	1,216,307	362,963	99.0	2	415,389	3,632	1.0
1929	35	2,188,699	8	1,605,896	707,638	5	1,281,086	677,591	95.8	3	324,810	30,047	4.2
1930	29	1,956,638	10	1,453,876	1,114,705	7	1,151,775	1,073,384	96.3	3	302,101	41,321	3.7
1931	21	1,557,341	11	1,254,487	1,026,583	7	1,096,517	992,176	96.6	4	157,970	34,407	3.4
1932	22	1,376,938	9	1,183,787	1,074,211	7	1,127,345	1,065,192	99.2	2	56,442	9,019	0.8
1933	22	1,367,414	7	1,190,194	1,087,328	7	1,190,194	1,087,328	100.0	--	--	--	--
1934	22	1,451,611	8	1,270,360	1,148,428	8	1,270,360	1,148,428	100.0	--	--	--	--
1935	27	1,607,553	8	1,428,552	1,291,373	8	1,428,552	1,291,373	100.0	--	--	--	--

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b Excludes wagon mines, country banks, and local commercial mines.

c The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

d Includes the tonnage mechanically loaded by the Group B mines ("experimentally mechanized").

e Data not available.

Table B-38.- GROWTH OF MECHANICAL LOADING IN MONTANA, BY TYPES OF EQUIPMENT, 1923-36[a]

Year	Production (net tons)	Mechanical loading		MECHANICAL LOADING BY TYPES OF EQUIPMENT													
				Mobile loaders			Scrapers			Duckbills and self-loading conveyors			Pit-car loaders			Hand-loaded face conveyors		
	Underground mines[b]	Total tons	Per cent of underground production	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of installations[c]
1923	3,147,678	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1924	2,711,993	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1925	2,401,956	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1926	2,267,083	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1927	2,321,524																	
1928	2,143,191	366,595	17.1	300,802	82.1	13	--	--	--	15,804	4.3	2	49,989	13.6	11	--	--	--
1929	2,186,699	707,638	32.3	547,350	77.4	17	--	--	--	7,942	1.1	1	150,046	21.2	23	2,300	0.3	(1)
1930	1,956,638	1,114,705	57.0	901,908	80.9	27	--	--	--	23,861	2.1	3	72,930	6.6	21	116,006	10.4	(3)
1931	1,557,341	1,026,583	65.9	806,925	78.6	27	--	--	--	155,887	15.2	9	38,863	3.8	16	24,908	2.4	(3)
1932	1,376,938	1,074,211	78.0	770,064	71.7	25	--	--	--	162,586	15.1	12	129,371	12.1	39	12,190	1.1	(2)
1933	1,367,144	1,087,328	79.5	799,499	73.5	26	--	--	--	114,366	10.5	5	170,501	15.7	35	2,942	0.3	(1)
1934	1,451,611	1,148,128	79.1	766,534	66.8	29	--	--	--	110,303	9.6	4	269,570	23.5	44	2,021	0.1	(1)
1935	1,607,553	1,291,373	80.3	885,935	68.6	28	--	--	--	73,661	5.7	4	331,777	25.7	38	--	--	--
1936	1,759,456	1,464,121	83.2	1,140,892	77.9	31	--	--	--	98,177	6.7	5	225,052	15.4	32	--	--	--

a Source: U. S. Bureau of Mines. Certain of these figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitution of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

c Number of mines in which hand-loaded conveyors, other than pit-car loaders, were used.

d Data on mechanical loading not available.

Table B-39.- SALIENT STATISTICS SHOWING PERFORMANCE OF GROUP A AND ALL OTHER BITUMINOUS-COAL MINES IN WASHINGTON, 1918-35[a]

Year	Production underground mines	Panel 1		Panel 2		Panel 3		Panel 4		Panel 5		Panel 6		Panel 7		Panel 8[b]		Panel 9[b]	
		Tons mechanically loaded		Tons cut by machine - Per cent of total production		Number of mines		Production (net tons)		Hourly capacity		Men employed		Days operated per year		Tons per man-hour*		Number of men required to maintain 1,000 tons of hourly capacity*	
		Group A	All other mines (Group B - "Experimentally mechanized")	Group A	All other mines	Group A	All other mines[c]	Group A	All other mines	Group A	All other mines	Group A	All other mines	Group A	All other mines	Group A	All other mines	Group A	All other mines
1918	4,082,212			0.0	8.1	5	50	996,888	3,085,324	437	1,418	1,012	4,097	286	272	.432	.345	2,315	2,899
1919	2,990,447			0.0	12.2	5	42	757,589	2,232,858	434	1,286	1,072	3,964	218	217	.447	.338	2,237	2,985
1920	3,757,093			0.0	13.5	4	43	781,073	2,976,020	353	1,448	695	4,299	277	257	.485	.356	2,002	2,809
1921	2,428,722			0.0	7.7	5	46	720,338	1,708,384	419	1,453	769	3,565	215	147	.543	.361	1,842	2,770
1922	2,581,165			0.0	16.3	7	40	557,180	2,023,985	487	1,228	846	3,635	143	206	.564	.371	1,806	2,695
1923	2,926,392	--	--	0.0	11.6	7	49	739,394	2,186,998	451	1,272	834	3,472	205	215	.576	.365	1,736	2,740
1924	2,655,667	--	--	3.5	12.4	6	52	590,213	2,063,454	473	1,205	775	3,083	156	214	.603	.390	1,658	2,564
1925	2,537,990	--	--	10.5	4.4	5	51	460,876	2,077,014	300	1,345	456	3,270	192	193	.621	.410	1,610	2,439
1926	2,586,568	--	--	10.9	7.9	5	46	529,315	2,057,253	298	1,326	500	3,109	222	194	.602	.425	1,661	2,353
1927	2,635,062	(d)	(d)	11.9	7.0	6	48	656,409	1,978,653	400	1,167	727	2,880	205	212	.577	.428	1,733	2,336
1928	2,619,901	86,225	3,880	26.4	5.6	6	46	808,365	1,711,536	493	951	846	2,253	205	225	.577	.426	1,733	2,347
1929	2,521,327	268,776	4,250	44.5	15.4	6	42	903,396	1,617,931	511	879	853	2,093	221	230	.614	.431	1,629	2,320
1930	2,301,928	423,506	700	59.8	0.2	6	40	746,747	1,555,181	507	913	770	2,031	184	213	.631	.446	1,585	2,242
1931	1,846,461	459,446	--	75.2	0.9	6	44	604,181	1,242,280	444	914	703	1,959	170	170	.604	.442	1,656	2,262
1932	1,590,465	362,950	--	78.6	0.2	8	53	521,559	1,068,906	438	805	844	1,966	149	166	.549	.420	1,821	2,381
1933	1,384,068	270,858	--	73.6	0.0	6	56	333,054	1,061,014	315	737	635	1,920	132	180	.510	.410	1,961	2,439
1934	1,382,991	340,885	--	87.8	0.0	5	51	390,796	992,195	245	738	474	1,687	218	186	.528	.438	1,894	2,283
1935	1,559,206	429,617	--	96.4	0.3	5	51	471,738	1,087,468	284	869	497	1,761	236	179	.572	.493	1,748	2,028

a Source: U. S. Bureau of Mines. Certain of the figures in this table (under columns "Tons mechanically loaded") differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitution of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b Because of statistical deficiencies, the figures shown in panels 8 and 9 are not comparable from year to year. See pp. 274-5.

c Excludes wagon mines and country banks.

d Data not available.

* Three-year moving average except in terminal years.

Table B-40.- NUMBER, PRODUCTION, AND TONNAGE MECHANICALLY LOADED OF GROUP A BITUMINOUS-COAL MINES ("MECHANIZED GROUP") IN WASHINGTON, 1918-35[a]

Year	ALL UNDERGROUND MINES			GROUP A MINES ("MECHANIZED GROUP") (All mines of "Mechanized Group" including those newly opened or closed during period)						
					Production of these mines			Mechanical loading of these mines		
	Number[b]	Production (net tons)	Total tons mechanically loaded[c]	Number of mines in Group A	Net tons	Per cent of total underground	Number of these mines loading mechanically during the year	Net tons	Per cent of total Group A output	Per cent of total tonnage mechanically loaded by all mines
	(1)	(2)	(3)	(4)	(5)	(6) (5)÷(2)	(7)	(8)	(9) (8)÷(5)	(10) (8)÷(3)
1918	55	4,082,212		5	996,888	24.4				
1919	47	2,990,447		5	757,589	25.3				
1920	47	3,757,093		4	781,073	20.8				
1921	51	2,428,722		5	720,338	29.7				
1922	47	2,581,165		7	557,180	21.6				
1923	56	2,926,392	--	7	739,394	25.3	--	--	--	--
1924	58	2,653,667	--	6	590,213	22.2	--	--	--	--
1925	56	2,537,890	--	5	460,876	18.2	--	--	--	--
1926	51	2,586,568	--	5	529,315	20.5	--	--	--	--
1927	54	2,635,062	(d)	6	656,409	24.9	(d)	(d)		
1928	52	2,519,901	90,085	6	808,365	32.1	2	86,225	10.7	95.7
1929	48	2,521,327	273,026	6	903,396	35.8	4	268,776	29.8	98.4
1930	46	2,301,928	424,206	6	746,747	32.4	5	423,506	56.7	99.8
1931	50	1,846,461	459,446	6	604,181	32.7	5	459,446	76.0	100.0
1932	61	1,590,465	362,950	8	521,559	32.8	5	362,950	69.6	100.0
1933	62	1,394,068	270,858	6	333,054	23.9	5	270,858	81.3	100.0
1934	56	1,382,991	340,685	5	390,796	28.3	5	340,685	87.2	100.0
1935	56	1,559,206	429,617	5	471,738	30.3	5	429,617	91.1	100.0

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitution of final returns for preliminary estimates, or in the adoption of uniform classifications over the entire period.

b Excludes wagon mines and country banks.

c Includes the tonnage mechanically loaded by the Group B mines ("experimentally mechanized").

d Data not available.

Table B-41.- COMPARISON OF NUMBER, PRODUCTION, AND TONNAGE MECHANICALLY LOADED OF GROUP A AND GROUP B BITUMINOUS-COAL MINES IN WASHINGTON, 1923-35[a]

Year	ALL UNDERGROUND MINES					GROUP A MINES ("MECHANIZED GROUP") (All mines of "Mechanized Group" including those newly opened or closed during period)				GROUP B MINES ("Experimentally mechanized")			
			Mines with mechanical loading					Mechanical loading of these mines				Mechanical loading of these mines	
	Number[b]	Production (net tons)	Number	Production	Total tons mechanically loaded[c]	Number of these mines loading mechanically during the year	Production of these mines loading mechanically during the year	Net tons	Per cent of total tonnage mechanically loaded by all mines	Number of these mines loading mechanically during the year	Production of these mines loading mechanically during the year	Net tons	Per cent of total tonnage mechanically loaded by all mines
1923	56	2,926,392	--	--	--	--	--	--	--	--	--	--	--
1924	58	2,653,667	--	--	--	--	--	--	--	--	--	--	--
1925	56	2,537,890	--	--	--	--	--	--	--	--	--	--	--
1926	51	2,586,568	--	--	--	--	--	--	--	--	--	--	--
1927	54	2,635,062	(d)	(d)	(d)	(d)	(d)	(d)	--	--	--	--	--
										(d)	(d)	(d)	
1928	52	2,519,901	3	361,029	90,085	2	241,937	86,225	95.7	1	119,092	3,860	4.3
1929	48	2,321,327	5	818,492	273,026	4	774,838	268,776	98.4	1	43,654	4,250	1.6
1930	46	2,301,928	6	967,973	424,206	5	647,641	423,506	99.8	1	320,332	700	0.2
1931	50	1,846,461	5	505,710	459,446	5	505,710	459,446	100.0	--	--	--	--
1932	61	1,590,465	5	421,738	362,950	5	421,738	362,950	100.0	--	--	--	--
1933	62	1,394,068	5	321,946	270,858	5	321,946	270,858	100.0	--	--	--	--
1934	56	1,382,991	5	390,796	340,685	5	390,796	340,685	100.0	--	--	--	--
1935	56	1,559,206	5	471,738	429,617	5	471,738	429,617	100.0	--	--	--	--

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b Excludes wagon mines and country banks.

c Includes the tonnage mechanically loaded by the Group B mines ("experimentally mechanized").

d Data not available.

Table B-42.- GROWTH OF MECHANICAL LOADING IN WASHINGTON, BY TYPES OF EQUIPMENT, 1923-36[a]

Year	Production (net tons)	Mechanical loading		MECHANICAL LOADING BY TYPES OF EQUIPMENT													
				Mobile loaders			Scrapers			Duckbills and self-loading conveyors			Pit-car loaders			Hand loaded face conveyors		
	Underground mines	Total tons	Per cent of underground production	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of installations[b]
1923	2,986,392	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1924	2,653,667	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1925	2,537,890	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1926	2,506,568	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1927[c]	2,635,062																	
1928	2,519,901	90,085	3.6	--	--	--	--	--	--	--	--	--	--	--	--	90,085	100.0	(3)
1929	2,521,327	273,026	10.8	--	--	--	--	--	--	2,923	1.1	2	--	--	--	270,103	98.9	(4)
1930	2,301,928	424,206	18.4	--	--	--	--	--	--	48,523	11.4	2	1,760	0.4	2	373,923	88.2	(4)
1931	1,846,161	459,446	24.9	--	--	--	--	--	--	45,943	10.0	2	14,044	3.1	1	399,459	86.9	(4)
1932	1,590,465	362,950	22.8	--	--	--	--	--	--	37,968	10.5	2	8,000	2.2	1	316,982	87.3	(4)
1933	1,394,068	270,858	19.4	--	--	--	--	--	--	21,799	8.1	2	--	--	--	249,059	91.9	(4)
1934	1,388,991	340,685	24.6	--	--	--	--	--	--	27,700	8.1	2	--	--	--	312,985	91.9	(4)
1935	1,559,206	429,617	27.6	--	--	--	--	--	--	25,000	5.8	2	--	--	--	404,617	94.2	(4)
1936	1,812,104	608,488	33.6	---	---	---	---	---	---	1,000	0.2	1	---	---	---	607,488	99.8	(4)

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b Number of mines in which hand-loaded conveyors, other than pit-car loaders, were used.

c Data on mechanical loading not available.

Table B-43.- SALIENT STATISTICS SHOWING PERFORMANCE OF GROUP A-1, GROUP A, AND ALL OTHER BITUMINOUS-COAL MINES IN UTAH, 1918-35[a]

Year	Production underground mines	Panel 1			Panel 2			Panel 3			Panel 4			Panel 5					
		Tons mechanically loaded			Tons cut by machine - per cent of total production			Number of mines			Production (net tons)			Hourly capacity					
														Group A-1		Group A		All other mines	
		Group A-1	Group A	All other mines (Group B- "Experimentally mechanized")	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines[b]	Group A-1	Group A	All other mines	On comparable basis over period	On reported basis 1932-1935	On comparable basis over period	On reported basis 1932-1935	On comparable basis over period	On reported basis 1932-1935
1918	5,137,000				70.0	67.8	45.7	5	7	25	1,009,062	1,891,352	3,245,648	530		973		1,520	
1919	4,631,000				98.6	90.5	53.6	5	7	30	1,143,061	1,908,761	2,722,239	567		928		1,493	
1920	6,005,000				59.6	67.5	52.0	5	8	31	1,609,074	2,591,328	3,413,672	768		1,251		1,721	
1921	4,079,000				99.0	91.5	65.0	5	8	28	877,995	1,586,645	2,492,355	1,007		1,469		1,935	
1922	4,992,000				97.9	92.3	64.4	5	8	32	1,297,137	2,152,425	2,839,575	815		1,263		1,784	
1923	4,720,000	-	-	-	83.2	85.8	57.7	5	9	28	1,041,003	1,772,604	2,947,396	1,017		1,550		2,167	
1924	4,488,000	-	-	-	78.2	85.5	67.2	5	9	30	967,362	1,869,982	2,618,018	828		1,313		1,779	
1925	4,590,000	-	-	-	71.7	80.5	69.7	5	10	31	846,582	1,923,172	2,766,828	751		1,457		1,840	
1926	4,373,793	55,083	103,619	11,000	55.4	73.9	70.5	5	10	28	910,182	2,100,091	2,273,702	796		1,353		1,588	
1927	4,781,480	(c)	(c)	(c)	57.3	62.8	82.4	5	10	26	1,213,117	2,534,645	2,246,835	843		1,467		1,377	
1928	4,842,544	348,794	777,756	100,000	66.1	70.4	83.6	5	10	28	1,186,679	2,757,146	2,085,398	833		1,689		1,448	
1929	5,160,521	430,977	867,273	53,000	75.6	75.0	84.1	5	12	30	1,319,004	3,082,366	2,078,155	872		1,844		1,225	
1930	4,257,541	381,514	860,592	1,100	79.3	86.1	80.6	5	12	27	1,127,663	2,709,630	1,547,911	972		2,104		1,099	
1931	3,350,044	351,182	861,062	-	81.8	86.2	86.6	5	11	30	786,473	1,999,663	1,350,381	983		1,938		1,125	
1932	2,852,127	318,379	754,354	-	80.9	91.4	87.0	5	12	27	649,947	1,652,354	1,199,773	846	484	1,736	1,071	(d)	929
1933	2,674,986	250,057	551,172	-	71.7	83.9	78.3	5	12	36	592,241	1,539,898	1,135,088	692	411	1,523	1,014	(d)	872
1934	2,406,183	247,138	594,804	4,689	80.9	90.3	75.6	5	13	30	453,845	1,379,482	1,026,701	680	419	1,654	1,072	(d)	856
1935	2,946,912	388,817	898,118	-	75.6	89.2	87.1	5	12	28	659,263	1,773,604	1,173,314	650	462	1,712	1,254	(d)	963

See footnotes at end of table.

Table B-43.- SALIENT STATISTICS SHOWING PERFORMANCE OF GROUP A-1, GROUP A, AND ALL OTHER BITUMINOUS-COAL MINES IN UTAH, 1918-35[a] - Continued

Year	Production underground mines	Panel 6			Panel 7						Panel 8						Panel 9					
		Men employed			Days operated per year						Tons per man-hour*						Number of men required to maintain 1,000 tons of hourly capacity*					
					Group A-1		Group A		All other mines		Group A-1		Group A		All other mines		Group A-1		Group A		All other mines	
		Group A-1	Group A	All other mines	On comparable basis over period	On reported basis 1932-1935	On comparable basis over period	On reported basis 1932-1935	On comparable basis over period	On reported basis 1932-1935	On comparable basis over period	On reported basis 1932-1935	On comparable basis over period	On reported basis 1932-1935	On comparable basis over period	On reported basis 1932-1935	On comparable basis over period	On reported basis 1932-1935	On comparable basis over period	On reported basis 1932-1935	On comparable basis over period	On reported basis 1932-1935
1918	5,137,000	852	1,596	2,564	238		243		267		.623		.609		.592		1,605		1,642		1,689	
1919	4,631,000	798	1,438	2,419	252		257		228		.713		.665		.607		1,403		1,504		1,647	
1920	6,005,000	956	1,687	2,817	262		259		248		.887		.751		.646		1,127		1,332		1,548	
1921	4,079,000	876	1,692	2,730	109		135		161		.900		.767		.647		1,111		1,304		1,546	
1922	4,992,000	1,085	1,833	2,888	199		213		199		1.030		.829		.709		971		1,206		1,410	
1923	4,720,000	852	1,666	2,715	128		143		170		.986		.809		.691		1,014		1,236		1,447	
1924	4,488,000	814	1,626	2,704	146		178		184		1.034		.855		.713		949		1,170		1,403	
1925	4,690,000	788	1,756	2,685	141		165		188		1.006		.843		.707		994		1,186		1,414	
1926	4,373,793	758	1,515	2,030	143		194		179		1.021		.905		.735		979		1,105		1,361	
1927	4,781,480	793	1,479	1,860	180		216		204		1.066		1.001		.769		938		999		1,300	
1928	4,842,544	764	1,512	1,840	178		204		180		1.075		1.062		.743		930		942		1,346	
1929	5,160,521	812	1,719	1,739	189		209		212		1.113		1.099		.725		898		910		1,379	
1930	4,257,541	830	1,899	1,605	145		161		176		1.195		1.123		.691		837		890		1,447	
1931	3,350,044	734	1,625	1,643	100		129		150		1.310	1.108	1.201	1.034	.602	.661	763	903	833	967	1,661	1,513
1932	2,852,127	596	1,329	1,513	96	168	119	191	(d)	163	1.326	.959	1.196	.907	(d)	.625	754	1,043	836	1,103	(d)	1,600
1933	2,674,986	566	1,396	1,510	107	180	129	194	(d)	159	1.306	.775	1.202	.770	(d)	.596	766	1,290	832	1,299	(d)	1,678
1934	2,406,183	530	1,373	1,434	92	151	115	176	(d)	167	1.262	.809	1.181	.807	(d)	.624	792	1,236	847	1,299	(d)	1,603
1935	2,946,918	507	1,371	1,381	145	204	148	202	(d)	174	1.284	.912	1.245	.916	(d)	.697	779	1,096	803	1,092	(d)	1,435

a Source: U. S. Bureau of Mines. Certain of the figures in this table (under columns "Tons mechanically loaded") differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b Excludes wagon mines and country banks.

c Data not available.

d Strictly comparable figures were not available for computation.

* Three-year moving average except in terminal years.

Table B-44.- NUMBER, PRODUCTION, AND TONNAGE MECHANICALLY LOADED OF GROUP A BITUMINOUS-COAL MINES ("MECHANIZED GROUP") IN UTAH, 1918-35[a]

Year	ALL UNDERGROUND MINES			GROUP A MINES ("MECHANIZED GROUP") (All mines of "Mechanized Group" including those newly opened or closed during period)							SUB-GROUP A-1 MINES ("IDENTICAL MECHANIZED") (Includes only such Group A as operated each year of period)						
					Production of these mines			Mechanical loading of these mines				Production of these mines			Mechanical loading of these mines		
	Number[b]	Production (net tons)	Total tons mechanically loaded[c]	Number of mines in Group A	Net tons	Per cent of total underground	Number of these mines loading mechanically during the year	Net tons	Per cent of total Group A output	Per cent of total tonnage mechanically loaded by all mines	Number of mines in Sub-Group A-1	Net tons	Per cent of total underground	Number of these mines loading mechanically during the year	Net tons	Per cent of total Sub-Group A-1 output	Per cent of total tonnage mechanically loaded by all mines
	(1)	(2)	(3)	(4)	(5)	(6) (5)÷(2)	(7)	(8)	(9) (8)÷(5)	(10) (8)÷(3)	(11)	(12)	(13) (12)÷(2)	(14)	(15)	(16) (15)÷(12)	(17) (15)÷(3)
1918	32	5,137,000		7	1,891,352	36.8					5	1,009,062	19.6				
1919	37	4,651,000		7	1,908,761	41.2					5	1,143,061	24.7				
1920	39	6,005,000		8	2,591,328	43.2					5	1,609,074	26.8				
1921	36	4,079,000		8	1,586,645	38.9					5	877,995	21.5				
1922	40	4,992,000		8	2,152,425	43.1					5	1,297,137	26.0				
1923	37	4,720,000	--	9	1,772,604	37.6	--	--			5	1,041,003	22.1	--	--		
1924	39	4,488,000	--	9	1,869,982	41.7	--	--			5	967,362	21.6	--	--		
1925	41	4,690,000	--	10	1,923,172	41.0	--	--			5	846,582	18.1	--	--		
1926	38	4,373,793	114,619	10	2,100,091	48.0	5	103,619	4.9	90.4	5	910,182	20.8	3	55,083	6.1	48.1
1927	36	4,781,480	(d)	10	2,534,645	53.0	(d)	(d)			5	1,213,117	25.4	(d)	(d)		
1928	38	4,842,544	877,756	10	2,757,146	56.9	10	777,756	28.2	88.6	5	1,166,679	24.5	3	348,734	29.4	39.7
1929	42	5,160,521	920,273	12	3,082,366	59.7	10	867,273	28.1	94.2	5	1,319,004	25.6	3	430,977	32.7	46.8
1930	39	4,257,541	861,692	12	2,709,630	63.6	10	860,592	31.8	99.9	5	1,127,663	26.5	5	381,514	33.8	44.3
1931	41	3,350,064	861,062	11	1,999,663	59.7	10	861,062	43.1	100.0	5	786,473	23.5	5	351,182	44.7	40.8
1932	39	2,852,127	754,354	12	1,652,354	57.9	11	754,354	45.7	100.0	5	649,947	22.8	4	318,379	49.0	42.2
1933	48	2,674,986	551,172	12	1,539,938	57.6	9	551,172	35.8	100.0	5	592,841	22.1	4	250,057	42.2	45.4
1934	43	2,406,183	599,493	13	1,379,482	57.3	12	594,804	43.1	99.2	5	453,845	18.9	5	247,138	54.5	41.2
1935	40	2,946,918	698,118	12	1,775,604	60.2	12	698,118	50.6	100.0	5	699,265	22.4	5	388,817	59.0	43.3

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitution of final returns for preliminary estimates, or in the adoption of uniform classifications over the entire period.

b Excludes wagon mines and country banks.

c Includes tonnage mechanically loaded by the Group B mines ("experimentally mechanized").

d Data not available.

Table B-45.- COMPARISON OF NUMBER, PRODUCTION, AND TONNAGE MECHANICALLY LOADED OF GROUP A AND GROUP B BITUMINOUS-COAL MINES IN UTAH, 1923-35[a]

Year	ALL UNDERGROUND MINES					GROUP A MINES ("MECHANIZED GROUP") (All mines of "Mechanized Group" including those newly opened or closed during period)				GROUP B MINES ("Experimentally mechanized")			
			Mines with mechanical loading					Mechanical loading of these mines				Mechanical loading of these mines	
	Number[b]	Production (net tons)	Number	Production	Total tons mechanically loaded[c]	Number of these mines loading mechanically during the year	Production of these mines loading mechanically during the year	Net tons	Per cent of total tonnage mechanically loaded by all mines	Number of these mines loading mechanically during the year	Production of these mines loading mechanically during the year	Net tons	Per cent of total tonnage mechanically loaded by all mines
1923	37	4,720,000	--	--	--	--	--	--	--	--	--	--	--
1924	39	4,488,000	--	--	--	--	--	--	--	--	--	--	--
1925	41	4,690,000	--	--	--	--	--	--	--	--	--	--	--
1926	38	4,373,793	6	1,214,530	114,619	5	1,083,673	103,619	90.4	1	130,857	11,000	9.6
1927	36	4,781,480	(d)	(d)	(d)	(d)	(d)	(d)		(d)	(d)	(d)	
1928	38	4,842,541	13	3,053,729	877,756	10	2,563,364	777,756	88.6	3	490,365	100,000	11.4
1929	42	5,160,521	11	3,249,286	920,273	10	2,865,646	867,873	94.2	1	383,580	53,000	5.8
1930	39	4,257,541	11	2,911,477	861,692	10	2,641,750	860,592	99.9	1	269,747	1,100	0.1
1931	41	3,350,041	10	1,957,145	861,062	10	1,957,145	861,062	100.0	--	--	--	
1932	39	2,852,127	11	1,612,779	754,354	11	1,612,779	754,354	100.0	--	--	--	
1933	48	2,674,986	9	1,369,461	551,172	9	1,369,461	551,172	100.0	--	--	--	
1934	43	2,406,183	13	1,519,376	599,493	12	1,366,541	594,804	99.2	1	152,835	4,689	0.8
1935	40	2,946,918	12	1,773,604	898,118	12	1,773,604	898,118	100.0	--	--	--	

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b Excludes wagon mines and country banks.

c Includes the tonnage mechanically loaded by the Group B mines ("experimentally mechanized").

d Data not available.

Table B-46.- GROWTH OF MECHANICAL LOADING IN UTAH, BY TYPES OF EQUIPMENT, 1923-36[a]

Year	Production (net tons)	Mechanical loading		MECHANICAL LOADING BY TYPES OF EQUIPMENT													
				Mobile loaders			Scrapers			Duckbills and self-loading conveyors			Pit-car loaders			Hand loaded face conveyors		
	Underground mines	Total tons	Per cent of underground production	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of installations[b]
1923	4,720,000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1924	4,488,000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1925	4,690,000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1926	4,373,793	114,619	2.6	114,619	100.0	8	--	--	--	--	--	--	--	--	--	--	--	--
1927[c]	4,781,480																	
1928	4,842,544	877,756	18.1	750,716	85.5	17	57,010	6.5	2	60,000	6.9	4	--	--	--	10,000	1.1	(1)
1929	5,160,521	920,273	17.8	808,935	87.9	25	111,338	12.1	3	--	--	--	--	--	--	--	--	--
1930	4,257,541	861,698	20.2	789,376	91.6	31	52,316	6.1	3	--	--	--	--	--	--	20,000	2.3	(2)
1931	3,350,044	861,062	25.7	744,515	86.5	29	36,094	4.2	2	73,425	8.5	6	3,028	0.3	1	4,000	0.5	(2)
1932	2,852,127	754,351	26.4	645,163	85.5	29	27,247	3.6	1	78,944	10.5	6	3,000	0.4	1	--	--	--
1933	2,674,986	551,172	20.6	533,286	96.7	21	2,052	0.4	1	--	--	--	5,319	1.0	2	10,515	1.9	(1)
1934	2,406,183	599,493	24.9	565,395	94.3	36	--	--	--	--	--	--	6,124	1.0	1	27,984	4.7	(2)
1935	2,946,918	898,118	30.5	836,574	93.1	37	--	--	--	--	--	--	6,355	0.7	1	55,189	6.2	(2)
1936	3,246,565	1,358,543	41.8	1,248,283	91.9	43	--	--	--	--	--	--	5,165	0.4	1	104,895	7.7	(4)

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b Number of mines in which hand-loaded conveyors, other than pit-car loaders, were used.

c Data on mechanical loading not available.

Table B-47.- SALIENT STATISTICS SHOWING PERFORMANCE OF GROUP A-1, GROUP A, AND ALL OTHER BITUMINOUS-COAL MINES IN CENTRAL PENNSYLVANIA, 1918-35[a]

Year	Production underground mines[b,c]	Panel 1			Panel 2			Panel 3			Panel 4		
		Tons mechanically loaded			Tons cut by machine - Per cent of total production			Number of mines			Production (net tons)		
		Group A-1	Group A	All other mines (Group B "Experimentally mechanized")	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines[b]	Group A-1	Group A	All other mines
1918	72,526,367				63.1	61.5	45.9	12	27	1,385	2,783,424	4,692,107	67,834,260
1919	58,169,921				66.3	66.0	47.0	12	28	1,684	3,031,512	4,645,150	53,524,771
1920	68,786,878				66.1	66.6	51.8	12	29	1,610	2,970,066	4,927,699	63,859,179
1921	47,931,941				60.0	66.5	55.5	12	30	1,444	2,736,275	4,460,249	43,471,692
1922	44,365,335				62.1	67.6	55.1	12	30	1,654	2,048,819	3,407,731	40,957,604
1923	62,148,284	---	---	12,600	57.6	64.0	60.8	12	28	1,863	3,168,702	5,005,899	57,142,385
1924	48,843,478	12,077	23,867	9,614	56.2	62.8	62.4	12	28	1,264	3,149,206	4,926,206	43,917,272
1925	52,059,894	141,400	161,049	89,463	54.4	60.7	62.2	12	28	1,178	3,616,809	5,185,455	46,874,439
1926	57,291,669	338,128	492,215	313,249	57.1	65.5	63.2	12	31	1,154	4,051,496	6,291,670	50,999,999
1927	51,188,129	(d)	(d)	(d)	61.9	70.9	66.2	12	31	1,073	3,406,287	5,241,391	45,946,738
1928	47,712,275	798,489	1,230,738	631,246	64.0	72.5	66.5	12	30	909	4,040,442	6,104,204	41,608,071
1929	50,563,488	974,810	1,522,277	534,496	74.6	79.0	65.9	12	32	834	3,894,173	6,412,732	44,150,756
1930	45,496,710	1,069,200	2,026,157	821,626	78.2	81.7	67.5	12	33	771	3,317,309	6,266,062	39,230,648
1931	39,623,150	1,449,833	2,866,070	1,094,478	84.9	87.1	69.8	12	33	719	3,187,966	6,009,202	33,618,948
1932	31,764,311	1,643,950	3,055,348	862,280	88.5	90.5	69.5	12	32	627	2,778,445	5,079,174	26,685,137
1933	33,633,585	2,010,230	3,402,225	589,030	91.2	90.4	64.2	12	31	684	3,197,695	5,616,213	28,017,372
1934	36,215,240	2,250,892	3,589,650	397,403	81.1	84.5	61.0	12	29	775	3,714,142	6,654,720	29,560,520
1935	34,918,042	2,250,758	3,300,314	324,091	80.4	83.5	60.5	12	27	800	3,461,439	6,264,100	28,653,942

See footnotes at end of table.

Table B-47.- SALIENT STATISTICS SHOWING PERFORMANCE OF GROUP A-1, GROUP A, AND ALL OTHER BITUMINOUS-COAL MINES IN CENTRAL PENNSYLVANIA, 1918-35[a] - Continued

Year	Production underground mines[b,c]	Panel 5			Panel 6			Panel 7			Panel 8			Panel 9		
		Hourly capacity			Men employed			Days operated per year			Tons per man-hour*			Number of men required to maintain 1,000 tons of hourly capacity*		
		Group A-1	Group A	All other mines	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines
1918	72,526,367	1,293	2,164	31,327	2,930	4,884	74,692	269	271	267	.440	.443	.420	2,273	2,257	2,381
1919	58,169,921	1,534	2,510	32,553	3,390	5,427	75,227	247	231	204	.468	.466	.434	2,160	2,146	2,304
1920	68,786,878	1,541	2,521	34,089	3,107	5,126	75,881	241	244	233	.487	.491	.443	2,053	2,037	2,257
1921	47,931,941	1,922	3,164	36,988	3,736	6,135	82,651	178	176	146	.491	.500	.452	2,037	2,000	2,212
1922	44,365,336	1,439	2,679	36,695	3,110	5,450	79,763	178	159	139	.483	.498	.464	2,070	2,008	2,155
1923	62,148,284	1,700	2,819	38,886	3,598	5,821	80,134	233	222	183	.480	.487	.474	2,083	2,053	2,110
1924	48,843,478	1,939	3,019	33,348	3,843	6,210	69,946	203	204	164	.510	.499	.480	1,961	2,004	2,083
1925	52,059,894	2,074	3,162	30,246	3,745	6,015	63,192	218	205	193	.535	.513	.483	1,869	1,949	2,070
1926	57,291,669	2,050	3,171	30,138	3,758	6,038	60,823	247	248	211	.535	.522	.489	1,869	1,916	2,045
1927	51,188,129	1,935	3,047	30,801	3,846	5,929	62,536	220	215	186	.543	.538	.502	1,842	1,859	1,992
1928	47,712,275	2,149	3,289	28,043	3,709	5,705	54,067	235	232	185	.568	.558	.514	1,761	1,792	1,946
1929	50,563,488	2,116	3,440	26,724	3,407	5,869	50,338	230	233	206	.593	.578	.522	1,686	1,730	1,916
1930	45,496,710	2,023	3,593	26,877	3,493	6,277	51,699	205	218	182	.627	.605	.529	1,595	1,655	1,890
1931	39,623,150	2,092	3,808	26,527	3,080	5,806	49,264	190	197	158	.657	.636	.524	1,522	1,572	1,908
1932	31,764,311	2,062	3,789	23,181	2,894	5,544	44,873	175	171	143	.663	.648	.510	1,508	1,543	1,961
1933	33,633,585	1,946	3,519	21,538	3,254	5,795	45,295	208	201	162	.612	.611	.489	1,634	1,637	2,045
1934	36,215,240	2,161	4,122	23,433	4,114	7,581	49,281	237	223	174	.572	.584	.485	1,748	1,712	2,062
1935	34,918,042	2,400	4,566	24,476	4,049	7,582	48,504	206	196	167	.593	.602	.505	1,686	1,661	1,980

a Source: U. S. Bureau of Mines. Certain of the figures in this table (in columns under "Tons mechanically loaded") differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period. The counties included in central Pennsylvania are Armstrong, Bedford, Blair, Bradford, Cambria, Cameron, Center, Clarion, Clearfield, Clinton, Elk, Forest, Fulton, Huntingdon, Indiana, Jefferson, Lycoming, McKean, Potter, Somerset, Sullivan, Tioga, and Warren.

b Excludes wagon mines and country banks.

c The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

d Data not available.

* Three-year moving average except in terminal years.

Table B-48.- NUMBER, PRODUCTION, AND TONNAGE MECHANICALLY LOADED OF GROUP A BITUMINOUS-COAL MINES ("MECHANIZED GROUP") IN CENTRAL PENNSYLVANIA. 1918-35[a]

Year	ALL UNDERGROUND MINES			GROUP A MINES ("MECHANIZED GROUP") (all mines of "Mechanized Group" including those newly opened or closed during period)							SUB-GROUP A-1 MINES ("IDENTICAL MECHANIZED") (Includes only such Group A as operated each year of period)						
					Production of these mines			Mechanical loading of these mines				Production of these mines			Mechanical loading of these mines		
	Number[b]	Production[b,c] (net tons)	Total tons mechanically loaded[d]	Number of mines in Group A	Net tons	Per cent of total underground	Number of these mines loading mechanically during the year	Net tons	Per cent of total Group A output	Per cent of total tonnage mechanically loaded by all mines	Number of mines in Sub-Group A-1	Net tons	Per cent of total underground	Number of these mines loading mechanically during the year	Net tons	Per cent of total Sub-Group A-1 output	Per cent of total tonnage mechanically loaded by all mines
	(1)	(2)	(3)	(4)	(5)	(6) (5)÷(2)	(7)	(8)	(9) (8)÷(5)	(10) (8)÷(3)	(11)	(12)	(13) (12)÷(2)	(14)	(15)	(16) (15)÷(12)	(17) (15)÷(3)
1918	1,412	72,526,367		27	4,692,107	6.5					12	2,783,424	3.8				
1919	1,712	58,169,921		28	4,645,150	8.0					12	3,031,512	5.2				
1920	1,699	68,786,878		29	4,927,699	7.2					12	2,970,066	4.3				
1921	1,474	47,931,941		30	4,460,249	9.3					12	2,739,273	5.7				
1922	1,684	44,365,335		30	3,407,731	7.7					12	2,048,819	4.6				
1923	1,691	62,148,284	12,600	26	5,005,999	8.1	--	--	--	--	12	3,168,702	5.1	--	--	--	--
1924	1,282	48,845,478	33,481	26	4,926,206	10.1	3	23,867	0.5	71.3	12	3,149,206	6.5	1	12,077	0.4	36.1
1925	1,206	52,059,894	230,512	28	5,189,455	10.0	6	161,049	3.1	69.9	12	3,616,809	7.0	2	141,400	3.9	61.3
1926	1,185	57,291,669	805,464	31	6,291,670	11.0	15	492,215	7.8	61.1	12	4,051,496	7.1	7	338,128	8.3	42.0
1927	1,104	51,188,129	(e)	31	5,241,391	10.2	(e)	(e)			12	3,466,287	6.7	(e)	(e)		
1928	939	47,712,275	1,861,984	30	6,104,204	12.8	23	1,230,738	20.2	66.1	12	4,040,442	8.5	8	798,489	19.8	42.9
1929	866	50,563,488	2,056,773	32	6,412,732	12.7	26	1,522,277	23.7	74.0	12	3,894,173	7.7	9	974,810	25.0	47.4
1930	804	45,496,710	2,847,763	33	6,266,062	13.8	31	2,026,137	32.3	71.1	12	3,317,309	7.3	11	1,069,200	32.2	37.5
1931	752	39,623,150	3,960,546	33	6,009,202	15.2	32	2,866,070	47.7	72.4	12	3,187,956	8.1	12	1,449,833	45.5	36.6
1932	659	31,764,311	3,917,628	32	5,079,174	16.0	31	3,055,348	60.2	78.0	12	2,778,445	8.8	12	1,643,950	59.2	42.0
1933	715	33,633,585	3,991,255	31	5,616,213	16.7	30	3,402,225	60.6	85.2	12	3,197,695	9.5	12	2,010,230	62.9	50.4
1934	804	36,215,240	3,967,053	29	6,651,720	18.4	29	3,569,650	53.6	90.0	12	3,711,142	10.3	12	2,250,892	60.6	56.7
1935	827	34,918,042	3,621,405	27	6,284,100	17.9	27	3,300,314	52.7	91.1	12	3,461,439	9.9	12	2,250,758	65.0	62.1

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period. For counties included in central Pennsylvania see table B-47, ftn. a.

b Excludes number and tonnage of wagon mines and country banks.

c The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

d Includes the tonnage mechanically loaded by the Group B mines ("experimentally mechanized").

e Data not available.

Table B-49.- COMPARISON OF NUMBER, PRODUCTION, AND TONNAGE MECHANICALLY LOADED OF GROUP A AND GROUP B BITUMINOUS-COAL MINES IN CENTRAL PENNSYLVANIA, 1923-35[a]

Year	ALL UNDERGROUND MINES					GROUP A MINES ("MECHANIZED GROUP") (All mines of "Mechanized Group" including those newly opened or closed during period)				GROUP B MINES ("Experimentally mechanized")			
			Mines with mechanical loading			Number of these mines loading mechanically during the year	Production of these mines loading mechanically during the year	Mechanical loading of these mines		Number of these mines loading mechanically during the year	Production of these mines loading mechanically during the year	Mechanical loading of these mines	
	Number[b]	Production[b,c] (net tons)	Number	Production	Total tons mechanically loaded[d]			Net tons	Per cent of total tonnage mechanically loaded by all mines			Net tons	Per cent of total tonnage mechanically loaded by all mines
1923	1,691	62,148,284	2	49,332	12,600	--	--	--	--	2	49,332	12,600	100.0
1924	1,282	48,843,478	8	528,260	33,481	3	431,256	23,867	71.3	5	97,004	9,614	28.7
1925	1,206	52,059,994	13	1,684,905	230,512	6	750,377	161,049	69.9	7	934,528	69,463	30.1
1926	1,185	57,291,669	35	8,800,703	805,404	15	3,853,922	492,215	61.1	20	4,946,781	313,189	38.9
1927	1,104	51,188,129	(e)	(e)	(e)	(e)	(e)	(e)		(e)	(e)	(e)	
1928	939	47,712,275	66	9,988,525	1,861,984	23	4,480,457	1,230,738	66.1	43	5,508,068	631,246	33.9
1929	866	50,563,488	78	11,097,795	2,056,773	26	4,818,017	1,522,277	74.0	52	6,279,778	534,496	26.0
1930	804	45,496,710	79	13,922,468	2,847,769	31	5,921,728	2,025,137	71.1	48	7,990,740	821,626	28.9
1931	752	39,623,150	80	13,747,535	3,960,546	32	5,997,929	2,866,070	72.4	48	7,749,606	1,094,476	27.6
1932	659	31,764,311	63	9,761,493	3,917,628	31	5,068,915	3,055,348	78.0	32	4,692,578	862,280	22.0
1933	715	33,633,585	53	10,048,259	3,991,255	30	5,599,168	3,402,225	85.2	23	4,449,091	589,030	14.8
1934	804	36,215,240	47	10,285,525	3,967,053	29	6,654,720	3,569,650	90.0	18	3,630,805	397,403	10.0
1935	827	34,918,042	47	10,129,421	3,824,405	27	6,264,100	3,300,314	91.1	20	3,865,321	324,091	8.9

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period. For counties included in central Pennsylvania see table B-47, ftn. a.

b Excludes number and production of wagon mines and country banks.

c The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

d Includes the tonnage mechanically loaded by the Group B mines ("experimentally mechanized").

e Data not available.

Table B-50.- GROWTH OF MECHANICAL LOADING IN CENTRAL PENNSYLVANIA, BY TYPES OF EQUIPMENT, 1923-36[a]

Year	Production (net tons)	Mechanical loading		MECHANICAL LOADING BY TYPES OF EQUIPMENT													
				Mobile loaders			Scrapers			Duckbills and self-loading conveyors			Pit-car loaders			Hand-loaded face conveyors		
	Underground mines[b,c]	Total tons	Per cent of underground production	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of installations[d]
1923	62,148,284	12,600	*	12,600	100.0	5	--	--	--	--	--	--	--	--	--	--	--	--
1924	48,843,478	33,481	0.1	8,654	25.8	3	24,572	73.4	8	--	--	--	--	--	--	255[e]	0.8	(1)
1925	52,059,894	230,512	0.4	20,555	8.9	2	180,255	78.2	21	--	--	--	--	--	--	29,702[e]	12.9	(4)
1926	57,891,669	805,424	1.4	30,647	3.8	2	399,577	49.6	28	--	--	--	--	--	--	375,240[e]	46.6	(21)
1927[f]	51,188,129																	
1928	47,712,275	1,861,984	3.9	37,999	2.0	3	733,340	39.4	71	21,381	1.2	3	--	--	--	1,069,264	57.4	(39)
1929	50,563,188	2,056,773	4.1	123,335	6.0	11	571,201	27.8	71	20,563	1.0	2	12,294	0.6	2	1,329,380	64.6	(51)
1930	45,496,710	2,847,763	6.3	17,566	0.6	3	686,615	24.1	75	135,675	4.8	18	--	--	--	2,007,907	70.5	(60)
1931	39,623,150	3,960,946	10.0	17,322	0.4	3	653,349	16.5	70	174,614	4.4	19	58,230	1.5	1	3,056,831	77.2	(67)
1932	31,764,311	3,917,628	12.3	14,248	0.4	2	498,336	12.5	63	116,540	3.0	16	68,329	1.7	3	3,220,175	82.4	(50)
1933	33,633,585	3,991,255	11.9	8,363	0.2	3	362,542	9.1	52	112,173	2.8	17	--	--	--	3,508,177	87.9	(44)
1934	36,215,840	3,967,053	11.0	--	--	--	215,839	6.2	53	81,634	2.1	15	--	--	--	3,639,580	91.7	(39)
1935	34,918,042	3,624,405	10.4	--	--	--	115,193	3.2	19	26,486	0.7	17	--	--	--	3,482,726	96.1	(36)
1936	38,159,053	3,930,181	10.3	19,222	0.5	2	187,473	4.8	31	33,218	0.8	12	--	--	--	3,690,268	93.9	(38)

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period. For counties included in central Pennsylvania see table B-47, ftn. a.

b Excludes tonnage of wagon mines and country banks.

c The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

d Number of mines in which hand-loaded conveyors, other than pit-car loaders were used.

e The figures for hand-loaded face conveyors for the years 1923 to 1926 are incomplete as no specific inquiry regarding this type of equipment was made prior to 1928. However, a number of mines reported conveyors without being named, and the incomplete replies are shown here to prove the fact that this equipment was early used.

f Data on mechanical loading not available.

* Less than 0.05 percent.

Table B-51.- SALIENT STATISTICS SHOWING PERFORMANCE OF GROUP A-1, GROUP A, AND ALL OTHER BITUMINOUS-COAL MINES IN WESTERN PENNSYLVANIA AND "NUMBER 8" FIELD IN OHIO, 1918-35[a]

Year	Production underground mines[b,c]	Panel 1 — Tons mechanically loaded			Panel 2 — Tons cut by machine - Per cent of total production			Panel 3 — Number of mines			Panel 4 — Production (net tons)		
		Group A-1	Group A	All other mines (Group B "Experimentally mechanized")	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines[b]	Group A-1	Group A	All other mines
1918	122,298,786				76.5	77.3	67.0	6	7	1,131	1,419,634	1,796,088	120,503,698
1919	106,017,354				80.3	80.4	68.8	6	8	1,234	1,419,488	1,693,667	104,323,687
1920	113,387,034				83.4	82.5	69.9	6	8	1,209	1,505,247	1,773,155	111,613,879
1921	83,549,202				86.6	85.5	75.7	6	8	1,073	1,538,528	1,738,380	81,810,822
1922	73,168,918				88.1	87.0	70.1	6	8	1,289	1,104,112	1,241,645	71,927,273
1923	126,150,724	--	--	39,414	87.1	86.2	73.0	6	8	1,299	2,451,720	2,779,717	123,371,007
1924	95,875,557	500	500	119,806	88.9	88.0	72.1	6	7	961	2,335,482	2,457,830	93,417,827
1925	98,213,412	18,282	18,282	2,617	87.4	87.8	70.2	6	7	878	906,551	950,320	97,263,092
1926	107,738,153	25,639	25,639	506,534	89.0	88.7	69.4	6	8	872	1,800,585	2,382,055	105,356,098
1927	86,238,716	(e)	(e)	(e)	85.6	86.2	68.1	6	9	827	2,508,601	3,344,181	82,894,535
1928	88,128,576	689,564	821,564	616,921	87.7	88.4	71.4	6	9	706	3,481,744	4,323,296	83,805,280
1929	103,365,115	1,249,798	1,740,186	1,496,632	91.0	91.9	74.5	6	10	678	4,678,743	5,938,602	97,426,513
1930	88,992,848	1,673,662	2,794,102	2,729,438	90.8	92.5	79.5	6	10	631	5,117,955	6,741,442	82,261,406
1931	68,497,957	2,120,871	3,626,203	2,349,214	94.1	95.2	84.9	6	10	584	4,255,442	5,973,037	62,524,920
1932	49,875,555	1,783,142	3,148,567	1,131,253	95.5	96.3	86.3	6	11	520	3,598,385	5,150,250	44,726,305
1933	56,029,339	1,899,448	3,047,661	671,171	96.5	97.3	88.7	6	11	516	3,505,625	4,934,453	51,094,986
1934	63,355,160	2,139,268	3,321,444	378,486	94.3	95.3	84.7	6	11	608	4,045,238	5,632,227	58,222,933
1935	66,155,209	2,680,139	3,772,141	550,724	95.0	95.8	84.3	6	11	627	4,363,270	6,042,796	60,112,413

See footnotes at end of table.

Table B-51.- SALIENT STATISTICS SHOWING PERFORMANCE OF GROUP A-1, GROUP A, AND ALL OTHER BITUMINOUS-COAL MINES IN WESTERN PENNSYLVANIA AND "NUMBER 8" FIELD IN OHIO, 1918-35[a] - Continued

Year	Production underground mines[b,c]	Panel 5			Panel 6			Panel 7			Panel 8			Panel 9		
		Hourly capacity			Men employed			Days operated per year			Tons per man-hour*			Number of men required to maintain 1,000 tons of hourly capacity*		
		Group A-1	Group A	All other mines	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines
1918	122,298,786	724	931	55,928	1,271	1,649	108,900	245	241	266	.570	.565	.514	1,754	1,770	1,946
1919	106,017,354	991	1,203	58,567	2,035	2,429	108,139	179	176	221	.534	.536	.531	1,873	1,866	1,883
1920	113,387,034	883	1,061	57,129	1,824	1,930	106,211	213	209	243	.504	.504	.543	1,984	1,984	1,842
1921	83,549,202	1,299	1,499	64,731	2,706	3,201	118,113	146	145	157	.551	.544	.528	1,815	1,838	1,894
1922	73,168,918	1,380	1,600	57,789	2,198	2,610	116,312	100	97	155	.538	.522	.531	1,859	1,916	1,883
1923	126,150,724	1,256	1,472	67,682	2,477	3,041	123,733	244	236	227	.537	.525	.540	1,862	1,905	1,852
1924	95,875,657	1,303	1,422	61,563	2,733	2,965	107,303	224	216	189	.481[d]	.471[d]	.569	2,079[d]	2,123[d]	1,757
1925	98,213,412	1,219	1,320	59,667	2,638	2,941	102,147	93	90	203	.438[d]	.437[d]	.580	2,285[d]	2,288[d]	1,724
1926	107,738,153	859	1,115	59,712	2,274	2,918	102,639	262	267	220	.411[d]	.412[d]	.576	2,433[d]	2,427[d]	1,736
1927	86,238,716	1,201	1,572	54,400	3,049	3,886	96,728	261	266	190	.418[d]	.424[d]	.575	2,392[d]	2,358[d]	1,739
1928	88,128,576	1,630	2,009	44,848	3,379	4,135	77,138	267	269	233	.495[d]	.489[d]	.588	2,020[d]	2,045[d]	1,701
1929	103,365,115	2,109	2,670	50,198	3,465	4,637	81,063	277	278	242	.566[d]	.567[d]	.618	1,767[d]	1,764[d]	1,618
1930	88,992,848	2,569	3,431	50,521	4,214	5,380	77,576	249	245	203	.657	.664	.642	1,522	1,506	1,558
1931	68,497,957	2,375	3,315	44,861	3,156	4,269	68,609	224	223	174	.684	.716	.638	1,462	1,397	1,567
1932	49,875,555	1,947	2,949	36,689	2,826	4,016	60,305	231	218	152	.707	.738	.607	1,414	1,355	1,647
1933	56,029,339	2,077	3,054	39,769	3,047	4,326	70,913	211	204	160	.692	.716	.588	1,446	1,397	1,701
1934	63,855,160	2,415	3,432	45,629	3,419	4,846	78,652	232	227	176	.719	.727	.594	1,391	1,376	1,684
1935	66,155,209	2,722	3,848	47,117	3,542	5,013	74,973	229	224	182	.768	.766	.628	1,302	1,305	1,592

a Source: U. S. Bureau of Mines. Certain of the figures in this table (under columns "Tons mechanically loaded") differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period. The counties included in western Pennsylvania are Allegheny, Beaver, Butler, Fayette, Greene, Lawrence, Mercer, Venango, Washington, and Westmoreland; those in the "Number 8" field in Ohio are Belmont, Harrison, and Jefferson.

b Excludes wagon mines and country banks.

c The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

d The actual course of the series for Group "A-1" and Group "A" mines in panels 8 and 9 is not known during the period 1924-25 to 1928-29 because the method of computing man-days (and man-hours), by multiplying days operated per year by the reported number of men employed (at best an approximation), is not adapted to measuring performance during an industrial dispute such as occurred at several Group "A" mines during this period. The disturbed labor conditions doubtlessly had some effect on productivity, but the extreme fluctuations are probably more apparent than real. The distorting factors were chiefly operative from 1925 to 1928, but are here carried back into 1924 and forward into 1929 by the operation of the 3-year moving average.

e Data not available.

* Three-year moving average except in terminal years.

Table B-52.- NUMBER, PRODUCTION, AND TONNAGE MECHANICALLY LOADED OF GROUP A BITUMINOUS-COAL MINES ("MECHANIZED GROUP") IN WESTERN PENNSYLVANIA AND "NUMBER 8" FIELD IN OHIO, 1918-35[a]

Year	ALL UNDERGROUND MINES			GROUP A MINES ("MECHANIZED GROUP") (All mines of "Mechanized Group" including those newly opened or closed during period)						SUB-GROUP A-1 MINES ("IDENTICAL MECHANIZED") (Includes only such Group A as operated each year of period)						
					Production of these mines			Mechanical loading of these mines				Production of these mines			Mechanical loading of these mines		
	Number[b]	Production[bc] (net tons)	Total tons mechanically loaded[d]	Number of mines in Group A	Net tons	Per cent of total underground	Number of these mines loading mechanically during the year	Net tons	Per cent of total Group A output	Per cent of total tonnage mechanically loaded by all mines	Number of mines in Sub-Group A-1	Net tons	Per cent of total underground	Number of these mines loading mechanically during the year	Net tons	Per cent of total Sub-Group A-1 output	Per cent of total tonnage mechanically loaded by all mines
	(1)	(2)	(3)	(4)	(5)	(6) (5)÷(2)	(7)	(8)	(9) (8)÷(5)	(10) (8)÷(3)	(11)	(12)	(13) (12)÷(2)	(14)	(15)	(16) (15)÷(12)	(17) (15)÷(3)
1918	1,138	122,298,786		7	1,795,088	1.5					6	1,119,634	1.2				
1919	1,242	106,017,354		8	1,693,667	1.6					6	1,119,488	1.3				
1920	1,217	113,387,034		8	1,773,155	1.6					6	1,505,247	1.3				
1921	1,061	83,549,202		8	1,738,330	2.1					6	1,538,528	1.8				
1922	1,297	73,168,918		8	1,241,645	1.7					6	1,104,112	1.5				
1923	1,307	126,150,724	39,414	8	2,779,717	2.2	--	--	--	--	6	2,451,720	1.9	--	--	--	--
1924	968	95,875,657	120,306	7	2,457,830	2.6	1	500	*	0.4	6	2,335,482	2.4	1	500	*	0.4
1925	805	98,213,412	20,799	7	950,320	1.0	1	18,282	1.9	87.9	6	906,651	0.9	1	18,282	2.0	87.9
1926	880	107,738,153	532,173	8	2,382,055	2.2	1	25,639	1.1	4.8	6	1,800,585	1.7	1	25,639	1.4	4.8
1927	836	86,238,716	(e)	9	3,344,181	3.9	(e)	(e)			6	2,508,601	2.9	(e)	(e)		
1928	715	88,128,576	1,438,485	9	4,323,296	4.9	6	821,564	19.0	57.1	6	3,481,744	4.0	5	689,564	19.8	47.9
1929	688	103,369,115	3,236,818	10	5,938,602	5.7	10	1,740,186	29.3	53.8	6	4,678,743	4.5	6	1,249,798	26.7	38.6
1930	641	88,992,848	5,523,540	10	6,741,142	7.6	10	2,794,102	41.4	50.6	6	5,117,955	5.8	6	1,673,662	32.7	30.3
1931	594	68,497,957	5,975,417	10	5,973,037	8.7	10	3,626,203	60.7	60.7	6	4,295,142	6.2	6	2,120,871	49.8	35.5
1932	531	49,875,555	4,279,820	11	5,150,250	10.3	11	3,148,567	61.1	73.6	6	3,598,385	7.2	5	1,785,142	49.6	41.7
1933	527	56,029,339	3,718,832	11	4,934,453	8.8	11	3,047,661	61.8	82.0	6	3,505,605	6.3	6	1,899,148	54.2	51.1
1934	619	63,855,160	5,699,930	11	5,632,227	8.8	11	3,321,144	59.0	89.8	6	4,045,238	6.3	6	2,139,268	52.9	57.8
1935	638	66,155,209	4,322,865	11	6,042,796	9.1	11	3,772,141	62.4	87.3	6	4,363,270	6.6	6	2,580,139	59.1	59.7

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates, or in the adoption of uniform classifications over the entire period. For counties included in western Pennsylvania and in "Number 8" field in Ohio see table B-51, ftn. a.

b Excludes number and tonnage of wagon mines and country banks.

c The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

d Includes the tonnage mechanically loaded by the Group B mines ("experimentally mechanized").

e Data not available.

* Less than 0.05 percent.

Table B-53.- COMPARISON OF NUMBER, PRODUCTION, AND TONNAGE MECHANICALLY LOADED OF GROUP A AND GROUP B BITUMINOUS-COAL MINES IN WESTERN PENNSYLVANIA AND "NUMBER 8" FIELD IN OHIO, 1923-35[a]

Year	ALL UNDERGROUND MINES					GROUP A MINES ("MECHANIZED GROUP") (All mines of "Mechanized Group" including those newly opened or closed during period)				GROUP B MINES ("Experimentally mechanized")			
			Mines with mechanical loading					Mechanical loading of these mines				Mechanical loading of these mines	
	Number[b]	Production[bc] (net tons)	Number	Production	Total tons mechanically loaded[d]	Number of these mines loading mechanically during the year	Production of these mines loading mechanically during the year	Net tons	Per cent of total tonnage mechanically loaded by all mines	Number of these mines loading mechanically during the year	Production of these mines loading mechanically during the year	Net tons	Per cent of total tonnage mechanically loaded by all mines
1923	1,307	126,150,784	3	1,021,684	39,414	--	--	--	--	3	1,021,684	39,414	100.0
1924	968	95,875,657	4	848,153	120,306	1	285,254	500	0.4	3	562,899	119,806	99.6
1925	885	98,213,412	3	933,105	20,799	1	187,298	18,282	87.9	2	745,807	2,517	12.1
1926	880	107,738,153	8	2,976,616	532,173	1	308,166	25,639	4.8	7	2,668,450	506,534	95.2
1927	836	86,238,716	(e)	(e)	(e)	(e)	(e)	(e)		(e)	(e)	(e)	
1928	715	88,128,576	28	8,658,844	1,438,485	6	3,113,351	821,564	57.1	22	5,545,493	616,921	42.9
1929	688	103,365,115	46	20,040,550	3,236,818	10	5,938,602	1,740,186	53.8	36	14,101,948	1,496,632	46.2
1930	641	88,992,848	44	20,211,635	5,523,540	10	6,741,442	2,794,102	50.6	34	13,470,193	2,729,438	49.4
1931	594	68,497,957	37	16,696,614	5,975,417	10	5,973,037	3,626,203	60.7	27	10,723,577	2,349,214	39.3
1932	531	49,875,555	28	11,456,928	4,279,820	11	5,145,698	3,148,567	73.6	17	6,311,230	1,131,253	26.4
1933	527	56,029,339	25	10,529,041	3,718,832	11	4,934,453	3,047,661	82.0	14	5,594,588	671,171	18.0
1934	619	63,855,160	21	10,876,527	3,699,930	11	5,632,227	3,321,444	89.8	10	5,244,300	378,486	10.2
1935	638	66,155,209	23	12,250,689	4,322,865	11	6,042,796	3,772,141	87.3	12	6,207,893	550,724	12.8

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period. For counties included in western Pennsylvania and in "Number 8" field in Ohio see table B-51, ftn. a.

b Excludes number and tonnage of wagon mines and country banks.

c The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

d Includes the tonnage mechanically loaded by the Group B mines ("experimentally mechanized").

e Data not available.

Table B-54.- GROWTH OF MECHANICAL LOADING IN WESTERN PENNSYLVANIA AND "NUMBER 8" FIELD IN OHIO, BY TYPES OF EQUIPMENT, 1923-36[a]

Year	Production (net tons)	Mechanical loading		MECHANICAL LOADING BY TYPES OF EQUIPMENT													
				Mobile loaders			Scrapers			Duckbills and self-loading conveyors			Pit-car loaders			Hand-loaded face conveyors		
	Underground mines[b c]	Total tons	Per cent of underground production	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of installations[d]
1923	126,150,724	39,411	*	39,411	100.0	3	--	--	--	--	--	--	--	--	--	--	--	--
1924	95,875,457	120,306	0.1	120,306	100.0	7	--	--	--	--	--	--	--	--	--	--	--	--
1925	98,213,112	20,799	*	20,799	100.0	3	--	--	--	--	--	--	--	--	--	--	--	--
1926	107,738,153	532,173	0.5	146,591	27.5	12	--	--	--	374,037	70.3	12	--	--	--	11,545[e]	2.2	(1)
1927[f]	86,238,716																	
1928	88,128,576	1,438,185	1.6	1,280,573	89.0	50	15,754	1.1	3	31,192	2.2	7	14,042	1.0	5	96,624	6.7	(8)
1929	103,365,115	3,236,818	3.1	2,176,349	67.2	54	15,000	0.5	2	25,654	0.8	8	981,537	30.3	247	38,278	1.2	(4)
1930	88,992,848	5,523,540	6.2	3,239,407	58.6	71	47,287	0.9	4	132,930	2.4	8	2,043,042	37.0	280	60,874	1.1	(3)
1931	68,407,957	5,975,147	8.7	3,050,168	51.7	76	19,805	0.3	2	14,375	0.8	5	2,730,807	45.7	564	89,948	1.5	(3)
1932	49,875,555	4,279,820	8.6	1,948,903	45.5	45	--	--	--	6,178	0.2	1	2,201,539	51.4	457	123,200	2.9	(4)
1933	56,029,339	3,718,832	6.6	1,915,910	51.5	44	--	--	--	--	--	--	1,695,983	45.6	458	106,939	2.9	(4)
1934	63,855,160	3,699,930	5.8	2,174,323	58.8	49	--	--	--	--	--	--	1,335,720	36.1	421	189,887	5.1	(4)
1935	66,155,209	4,322,865	6.5	2,723,347	63.0	65	--	--	--	--	--	--	1,228,290	28.4	386	371,228	8.6	(5)
1936	82,666,999	6,855,247	8.3	4,951,684	72.2	128	--	--	--	--	--	--	1,051,277	15.4	362	852,286	12.4	(7)

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period. For counties included in western Pennsylvania and in "Number 8" field in Ohio see table B-51, ftn. a.

b Excludes tonnage of wagon mines and country banks.

c The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

d Number of mines in which hand-loaded conveyors, other than pit-car loaders were used.

e The figures for hand-loaded face conveyors for the years 1923 to 1926 are incomplete as no specific inquiry regarding this type of equipment was made prior to 1928. However, where a mine reported conveyors without being asked, the incomplete replies are shown here to prove the fact that this equipment was early used.

f Data on mechanical loading not available.

* Less than 0.05 percent.

Table B-56.- GROWTH OF MECHANICAL LOADING IN WEST VIRGINIA, BY TYPES OF EQUIPMENT, 1923-36[a]

Year	Production (net tons)	Mechanical loading		MECHANICAL LOADING BY TYPES OF EQUIPMENT													
				Mobile loaders			Scrapers			Duckbills and self-loading conveyors			Pit-car loaders			Hand-loaded face conveyors		
	Underground mines[b]	Total tons	Per cent of underground production	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of installations[c]
1923	106,936,284	1,367,688	1.3	1,208,153	88.3	46	88,864	6.5	3	--	--	--	500	0.1	1	70,171	5.1	(1)
1924	101,118,149	2,012,790 [d]	2.0	1,828,995	90.9	54	178,795	8.9	11	--	--	--	5,000	0.2	1	--	--	--
1925	122,107,584	2,480,768 [d]	2.0	2,331,989	94.0	46	148,779	6.0	8	--	--	--	--	--	--	--	--	--
1926	143,353,458	2,000,696	1.4	1,966,167	98.3	47	16,745	0.8	5	17,424	0.9	1	--	--	--	--	--	--
1927[e]	115,113,202																	
1928	132,903,350	2,190,153	1.6	1,849,572	84.5	44	149,696	6.8	13	7,333	0.3	4	15,000	0.7	4	168,502	7.7	(13)
1929	138,505,793	2,697,615	1.9	1,857,379	68.9	40	130,017	4.8	10	61,972	2.3	2	364,953	13.5	66	283,294	10.5	(15)
1930	121,478,638	2,229,401	1.8	1,447,952	65.0	32	162,156	7.3	15	37,223	1.6	8	447,375	20.1	80	133,695	6.0	(13)
1931	101,471,281	1,686,804	1.7	1,160,334	68.8	28	87,373	5.2	10	70,620	4.2	13	231,856	13.7	48	136,621	8.1	(10)
1932	85,608,735	765,206	0.9	386,467	50.5	20	55,210	7.2	3	67,893	8.9	11	93,831	12.3	21	161,805	21.1	(13)
1933	94,223,315	794,280	0.8	364,602	45.9	8	9,023	1.1	4	27,164	3.4	4	180,168	22.7	16	213,323	26.9	(15)
1934	98,056,128	1,364,936	1.4	640,571	46.9	14	25,600	1.9	3	24,900	1.8	3	154,581	11.3	11	519,284	38.1	(25)
1935	99,178,665	2,059,322	2.1	1,120,065	54.4	38	57,054	2.7	3	20,000	1.0	1	--	--	--	862,203	41.9	(31)
1936	117,924,183	8,712,935	7.4	6,262,177	71.9	126	72,043	0.8	4	--	--	--	--	--	--	2,378,715	27.3	(37)

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

c Number of mines in which hand-loaded conveyors, other than pit-car loaders, were used.

d Includes the tonnage loaded mechanically in Tazewell County, Virginia.

e Data on mechanical loading not available.

Table B-56.- SALIENT STATISTICS SHOWING PERFORMANCE OF GROUP A-1, GROUP A, AND ALL OTHER BITUMINOUS-COAL MINES IN ALABAMA, 1918-35[a]

Year	Production underground mines[b]	Panel 1			Panel 2			Panel 3			Panel 4		
		Tons mechanically loaded			Tons cut by machine - Per cent of total production			Number of mines			Production (net tons)		
		Group A-1	Group A	All other mines (Group B- "Experimentally mechanized")	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines[c]	Group A-1	Group A	All other mines
1918	18,562,916				62.6	60.0	29.9	7	11	286	953,523	1,353,792	17,209,124
1919	15,026,928				65.4	63.6	31.7	7	12	270	807,348	1,146,225	13,882,703
1920	15,914,895				72.0	58.9	33.1	7	13	236	888,164	1,496,191	14,418,704
1921	11,921,786				68.0	64.6	39.2	7	13	220	870,868	1,319,369	10,602,417
1922	17,937,986				65.4	66.1	37.2	7	16	248	1,181,414	2,036,218	15,901,758
1923	19,700,597	--	46,200	4,614	64.3	69.8	41.2	7	16	253	1,112,796	2,117,709	17,582,888
1924	18,486,744	128,803	189,177	--	67.1	77.6	49.5	7	16	208	970,818	1,986,264	16,500,480
1925	19,271,713	--	39,879	63,758	65.0	76.5	52.2	7	16	203	1,072,155	2,197,198	17,074,515
1926	20,349,366	--	116,473	124,396	65.4	73.8	56.6	7	17	188	1,179,274	2,254,694	18,094,672
1927	19,070,957	(d)	(d)	(d)	70.7	74.9	61.2	7	18	189	1,154,224	2,264,731	16,806,226
1928	17,057,205	240,920	543,564	70,036	71.7	72.7	64.7	7	17	166	1,226,257	2,519,813	14,537,392
1929	17,507,175	427,610	871,263	62,401	79.6	78.8	65.7	7	18	149	1,489,686	3,090,832	14,416,343
1930	15,380,423	548,707	1,205,953	850,099	88.8	83.4	72.0	7	18	124	1,163,122	2,516,751	12,863,672
1931	11,905,714	781,284	1,346,153	891,741	87.3	82.9	73.5	7	18	116	1,148,303	2,205,584	9,700,130
1932	7,784,201	682,696	946,324	290,217	94.2	90.2	74.6	7	17	120	901,452	1,529,253	6,254,948
1933	8,708,025	672,713	1,144,266	245,042	94.7	88.7	76.5	7	17	105	894,536	1,816,576	6,891,449
1934	9,084,853	605,975	920,217	151,069	90.8	88.4	76.9	7	17	98	926,872	1,784,313	7,300,540
1935	8,467,212	728,186	1,209,646	94,007	89.5	85.9	70.4	7	17	100	1,146,325	2,031,388	6,435,824

See footnotes at end of table.

Table B-56.- SALIENT STATISTICS SHOWING PERFORMANCE OF GROUP A-1, GROUP A, AND ALL OTHER BITUMINOUS-COAL MINES IN ALABAMA, 1918-35[a] - Continued

Year	Production underground mines[b]	Panel 5			Panel 6			Panel 7			Panel 8			Panel 9		
		Hourly capacity			Men employed			Days operated per year			Tons per man-hour*			Number of men required to maintain 1,000 tons of hourly capacity*		
		Group A-1	Group A	All other mines	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines
1918	18,562,916	385	568	7,718	1,544	2,229	23,070	295	288	277	.250	.250	.335	4,000	3,922	2,985
1919	15,028,928	347	514	7,264	1,668	2,240	23,874	279	270	238	.208	.226	.324	4,425	4,237	3,086
1920	15,914,895	360	627	7,448	1,630	2,828	22,257	291	288	242	.221	.238	.332	4,202	3,922	3,012
1921	11,921,786	501	882	7,972	1,767	2,803	22,288	203	178	165	.284	.256	.349	3,906	3,597	2,865
1922	17,937,986	531	954	8,752	2,005	3,209	24,526	244	240	212	.264	.276	.353	3,623	3,356	2,833
1923	19,700,597	489	942	8,858	1,748	3,333	25,771	253	256	230	.280	.286	.356	3,759	3,584	2,809
1924	18,486,744	414	906	8,611	1,627	3,505	23,464	243	239	219	.254	.261	.353	3,831	3,704	2,833
1925	19,271,713	422	943	7,896	1,693	3,527	22,732	263	254	246	.249	.254	.350	3,937	3,774	2,857
1926	20,349,366	452	922	7,728	1,742	3,426	23,187	282	272	267	.260	.261	.346	3,831	3,636	2,890
1927	19,070,957	496	1,059	8,258	1,818	3,687	23,107	245	235	231	.273	.272	.349	3,676	3,521	2,885
1928	17,057,205	552	1,184	7,501	1,950	4,034	20,993	240	235	221	.283	.290	.355	3,448	3,322	2,817
1929	17,507,175	654	1,363	7,170	2,084	4,227	20,465	247	249	229	.314	.321	.361	3,115	3,077	2,770
1930	15,380,423	648	1,397	7,611	1,766	3,893	20,220	194	198	188	.366	.368	.385	2,717	2,667	2,597
1931	11,905,714	740	1,656	8,186	1,747	3,743	18,986	171	152	133	.423	.400	.400	2,500	2,457	2,500
1932	7,784,201	657	1,329	6,748	1,605	3,160	17,130	147	127	103	.410	.408	.395	2,451	2,375	2,532
1933	8,708,025	621	1,292	5,340	1,594	3,238	14,830	157	158	146	.390	.402	.368	2,488	2,433	2,717
1934	9,084,853	730	1,442	5,307	1,799	3,489	15,192	175	170	190	.405	.414	.366	2,415	2,404	2,732
1935	8,467,212	879	1,703	5,763	1,962	3,898	14,837	186	169	160	.448	.448	.389	2,232	2,294	2,571

a Source: U. S. Bureau of Mines. Certain of the figures in this table (under columns "Tons mechanically loaded") differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b The strip production used in subtraction is the "total at same mines" and includes an insignificant production underground in operations which are both strip pits and deep mines.

c Excludes wagon mines, country banks, and local commercial mines.

d Data not available.

* Three-year moving average except in terminal years.

Table B-57.- NUMBER, PRODUCTION, AND TONNAGE MECHANICALLY LOADED OF GROUP A BITUMINOUS-COAL MINES ("MECHANIZED GROUP") IN ALABAMA, 1918-35[a]

Year	ALL UNDERGROUND MINES			GROUP A MINES ("MECHANIZED GROUP") (All mines of "Mechanized Group" including those newly opened or closed during period)							SUB-GROUP A-1 MINES ("TECHNICAL MECHANIZED") (Includes only such Group A as operated each year of period)						
					Production of these mines			Mechanical loading of these mines				Production of these mines			Mechanical loading of these mines		
	Number[b]	Production[c] (net tons)	Total tons mechanically loaded[d]	Number of mines in Group A	Net tons	Per cent of total underground	Number of these mines loading mechanically during the year	Net tons	Per cent of total Group A output	Per cent of total tonnage mechanically loaded by all mines	Number of mines in Sub-Group A-1	Net tons	Per cent of total underground	Number of these mines loading mechanically during the year	Net tons	Per cent of total Sub-Group A-1 output	Per cent of total tonnage mechanically loaded by all mines
	(1)	(2)	(3)	(4)	(5)	(6) (5)÷(2)	(7)	(8)	(9) (8)÷(5)	(10) (8)÷(3)	(11)	(12)	(13) (12)÷(2)	(14)	(15)	(16) (15)÷(12)	(17) (15)÷(3)
1918	297	18,562,916		11	1,353,792	7.3					7	953,523	5.1				
1919	282	15,028,928		12	1,146,225	7.6					7	807,348	5.4				
1920	249	15,914,895		13	1,496,191	9.4					7	888,164	5.6				
1921	233	11,921,786		13	1,319,369	11.1					7	870,868	7.3				
1922	264	17,937,986		16	2,036,218	11.4					7	1,181,414	6.6				
1923	269	19,700,597	50,814	16	2,117,709	10.7	3	46,290	2.2	90.9	7	1,112,796	5.6	--	--	--	--
1924	224	18,186,714	189,177	16	1,986,264	10.7	4	189,177	9.5	100.0	7	970,818	5.3	1	128,803	13.3	68.1
1925	219	19,271,713	103,657	16	2,197,198	11.4	1	39,879	1.8	38.5	7	1,072,155	5.6	--	--	--	--
1926	205	20,349,366	240,869	17	2,254,694	11.1	3	116,473	5.2	48.4	7	1,179,274	5.8	--	--	--	--
1927	207	19,070,957	(e)	18	2,284,751	11.9	(e)	(e)			7	1,154,224	6.1	(e)	(e)		
1928	183	17,057,205	613,600	17	2,519,813	14.8	7	543,564	21.6	88.6	7	1,226,257	7.2	3	240,920	19.6	39.3
1929	167	17,507,175	933,664	18	3,090,832	17.7	8	871,263	28.2	93.3	7	1,199,685	8.6	3	427,610	28.5	45.8
1930	142	15,380,423	2,056,052	18	2,516,751	16.4	13	1,205,993	47.9	58.7	7	1,163,122	7.6	4	548,707	47.2	26.7
1931	134	11,905,714	2,237,894	18	2,205,581	18.5	15	1,346,153	61.0	60.2	7	1,149,303	9.7	5	781,284	68.0	34.9
1932	137	7,784,201	1,236,541	17	1,529,253	19.6	15	946,321	61.9	76.5	7	901,452	11.6	5	682,696	75.7	55.2
1933	122	8,708,025	1,389,308	17	1,816,576	20.9	15	1,144,266	63.0	82.4	7	894,536	10.3	5	672,713	75.2	48.4
1934	113	9,084,893	1,071,286	17	1,784,313	19.6	15	920,217	51.6	85.9	7	926,872	10.2	5	605,975	65.4	56.6
1935	117	8,147,212	1,303,653	17	2,031,388	24.0	17	1,209,646	59.5	92.8	7	1,146,325	13.5	5	728,186	63.5	55.9

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates, or in the adoption of uniform classifications over the entire period.

b Excludes wagon mines, country banks, and local commercial mines.

c The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

d Includes the tonnage mechanically loaded by the Group B mines ("experimentally mechanized").

Table B-58.- COMPARISON OF NUMBER, PRODUCTION, AND TONNAGE MECHANICALLY LOADED OF GROUP A AND GROUP B BITUMINOUS-COAL MINES IN ALABAMA, 1923-35[a]

Year	ALL UNDERGROUND MINES					GROUP A MINES ("MECHANIZED GROUP") (All mines of "Mechanized Group" including those newly opened or closed during period)				GROUP B MINES ("Experimentally mechanized")			
			Mines with mechanical loading					Mechanical loading of these mines				Mechanical loading of these mines	
	Number[b]	Production[c] (net tons)	Number	Production	Total tons mechanically loaded[d]	Number of these mines loading mechanically during the year	Production of these mines loading mechanically during the year	Net tons	Per cent of total tonnage mechanically loaded by all mines	Number of these mines loading mechanically during the year	Production of these mines loading mechanically during the year	Net tons	Per cent of total tonnage mechanically loaded by all mines
1923	269	19,700,597	4	186,944	50,814	3	123,271	46,200	90.9	1	63,673	4,614	9.1
1924	224	18,486,744	4	257,464	189,177	4	257,464	189,177	100.0	--	--	--	--
1925	219	19,271,713	2	171,378	103,637	1	55,342	39,879	38.5	1	416,036	63,758	61.5
1926	205	20,349,566	7	693,169	240,869	3	222,121	116,473	48.4	4	471,948	124,396	51.6
1927	207	19,070,957	(e)	(e)	(e)	(e)	(e)	(e)		(e)	(e)	(e)	
1928	183	17,057,205	11	1,527,936	613,600	7	1,132,920	543,564	88.6	4	395,016	70,036	11.4
1929	167	17,507,175	12	3,350,240	933,664	8	1,527,942	871,263	93.3	4	1,822,298	62,401	6.7
1930	142	15,380,423	24	5,641,235	2,056,052	13	2,086,996	1,205,953	58.7	11	3,554,239	850,099	41.3
1931	134	11,905,714	28	4,634,276	2,237,891	15	1,976,869	1,346,153	60.2	13	2,697,407	891,741	39.8
1932	137	7,784,201	27	2,977,956	1,236,541	15	1,367,461	946,324	76.5	12	1,610,495	290,217	23.5
1933	122	8,708,025	26	3,131,601	1,389,308	15	1,622,208	1,144,266	82.4	11	1,809,393	245,042	17.6
1934	113	9,084,853	21	3,232,446	1,071,286	15	1,585,623	920,217	85.9	6	1,646,823	151,069	14.1
1935	117	8,467,212	21	3,084,540	1,303,653	17	2,031,388	1,209,646	92.8	4	1,053,152	94,007	7.2

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b Excludes wagon mines, country banks, and local commercial mines.

c The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

d Includes the tonnage mechanically loaded by the Group B mines ("experimentally mechanized").

e Data not available.

Table B-52.- GROWTH OF MECHANICAL LOADING IN ALABAMA, BY TYPES OF EQUIPMENT, 1923-36[a]

Year	Production (net tons)	Mechanical Loading		MECHANICAL LOADING BY TYPES OF EQUIPMENT													
				Mobile loaders			Scrapers			Duckbills and self-loading conveyors			Pit-car loaders			Hand-loaded face conveyors		
	Underground mines[b]	Total tons	Per cent of underground production	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of installations[c]
1923	19,700,597	50,814	0.3	--	--	--	4,614	9.1	1	--	--	--	--	--	--	46,200[d]	90.9	(3)
1924	18,486,714	189,177	1.0	--	--	--	--	--	--	--	--	--	--	--	--	189,177[d]	100.0	(4)
1925	19,271,713	103,637	0.5	--	--	--	63,758	61.5	12	--	--	--	--	--	--	39,879[d]	38.5	(1)
1926	20,349,366	240,869	1.2	--	--	--	111,803	46.4	30	--	--	--	--	--	--	129,066[d]	53.6	(4)
1927[e]	19,070,957																	
1928	17,057,205	613,600	3.6	--	--	--	94,958	15.5	7	--	--	--	--	--	--	518,642	84.5	(8)
1929	17,507,175	933,664	5.3	9,451	1.0	2	97,200	10.4	4	--	--	--	44,764	4.8	1	782,249	83.8	(9)
1930	15,380,423	2,056,052	13.4	12,266	0.6	2	183,657	8.9	18	75,479	3.7	12	1,060,824	51.6	109	723,826	35.2	(14)
1931	11,905,714	2,237,894	18.8	24,691	1.1	2	194,296	8.7	34	1,236	*	1	1,226,693	54.8	167	790,978	35.4	(14)
1932	7,784,201	1,236,541	15.9	20,259	1.7	2	136,416	11.0	31	--	--	--	539,719	43.6	170	540,147	43.7	(15)
1933	8,708,025	1,389,308	16.0	27,116	2.0	2	149,431	10.7	9	--	--	--	516,778	39.4	144	665,983	47.9	(14)
1934	9,084,853	1,071,286	11.8	--	--	--	140,760	13.1	23	1,745	0.2	2	426,200	39.8	143	502,581	46.9	(11)
1935	8,167,212	1,303,653	15.4	17,678	1.4	4	261,857	20.1	20	6,948	0.5	2	478,798	36.7	94	538,372	41.3	(12)
1936	12,175,186	1,721,452	14.3	155,349	8.9	10	367,083	21.1	27	18,973	1.2	5	544,812	31.3	93	655,635	37.6	(15)

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitution of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

c Number of mines in which hand-loaded conveyors, other than pit-car loaders were used.

d The figures for hand-loaded face conveyors for the years 1923 to 1926 are incomplete as no specific inquiry regarding this type of equipment was made prior to 1928. However, where a mine reported conveyors without being asked, the incomplete replies are shown here to prove the fact that this equipment was early used.

e Data on mechanical loading not available.

* Less than 0.05 percent.

Table B-60.- SALIENT STATISTICS SHOWING PERFORMANCE OF GROUP A-1, GROUP A, AND ALL OTHER BITUMINOUS-COAL MINES IN THE UNITED STATES, 1918-35[a]

Year	Production underground mines[b,c]	Panel 1			Panel 2			Panel 3			Panel 4		
		Tons mechanically loaded			Tons cut by machine - Per cent of total production			Number of mines			Production (net tons)		
		Group A-1	Group A	All other mines (Group B - "Experimentally mechanized")	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines[d]	Group A-1	Group A	All other mines
1918	568,267,196				71.6	68.5	56.0	104	170	7,985	33,067,859	46,478,667	521,788,529
1919	457,950,316				74.0	70.3	59.4	104	183	8,643	26,711,306	37,200,513	420,749,803
1920	551,963,212				74.0	71.1	60.6	104	187	8,561	33,434,002	49,137,657	502,825,555
1921	408,104,619				78.1	76.0	65.6	104	196	7,689	28,241,314	41,751,701	367,352,918
1922	404,911,653				79.4	75.7	64.9	104	204	8,824	24,872,152	37,137,450	367,774,203
1923	548,075,163	125,422	350,696	1,529,030	74.9	74.6	68.3	104	205	8,216	34,421,758	52,001,111	496,074,052
1924	468,992,310	340,370	1,015,449	2,434,788	77.5	78.2	70.9	104	207	6,413	34,757,606	51,069,984	417,922,326
1925	502,259,415	1,572,032	2,970,384	3,673,678	77.5	80.5	72.1	104	198	5,987	34,406,232	53,567,437	448,691,978
1926	554,314,173	3,173,473	5,726,598	5,526,030	77.2	80.9	73.3	104	208	5,938	38,564,793	61,573,528	492,740,645
1927	498,365,554	(e)	(e)	(e)	78.4	79.8	74.5	104	220	5,641	31,608,145	49,810,743	448,544,811
1928	479,225,661	8,227,221	13,041,392	8,386,354	80.8	82.8	76.4	104	218	4,846	36,856,038	57,833,754	421,391,907
1929	513,649,859	15,458,295	27,223,197	10,138,299	85.1	87.1	77.3	104	225	4,560	41,370,915	66,608,486	447,041,373
1930	446,514,080	19,333,460	35,697,590	11,296,258	90.3	91.6	79.5	104	233	4,193	36,335,912	61,565,032	384,949,028
1931	362,778,891	21,838,411	39,223,549	8,338,559	91.0	91.9	81.8	104	236	3,776	31,656,310	55,185,158	307,593,733
1932	289,850,757	18,442,580	31,371,672	4,445,237	94.0	94.2	82.5	104	234	3,544	24,753,984	41,750,239	248,100,518
1933	315,013,552	22,344,119	35,378,824	2,441,637	95.1	94.3	83.1	104	229	3,591	28,410,237	46,042,348	268,971,204
1934	337,947,485	24,537,365	39,653,552	1,779,183	94.2	94.3	82.4	104	223	3,750	31,197,361	51,090,454	286,857,011
1935	348,184,677	27,588,040	44,572,816	2,604,408	94.7	95.0	82.3	104	226	3,698	33,575,990	55,095,468	293,089,209

See footnotes at end of table.

Table B-60.- SALIENT STATISTICS SHOWING PERFORMANCE OF GROUP A-1, GROUP A, AND ALL OTHER BITUMINOUS-COAL MINES IN THE UNITED STATES, 1918-35[a] - Continued

Year	Production underground mines[b, c]	Panel 5			Panel 6			Panel 7			Panel 8			Panel 9		
		Hourly capacity			Men employed			Days operated per year			Tons per man-hour*			Number of men required to maintain 1,000 tons of hourly capacity*		
		Group A-1	Group A	All other mines	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines	Group A-1	Group A	All other mines
1918	568,267,196	16,538	23,463	256,723	28,628	41,678	565,170	249	247	250	.577	.563	.455	1,733	1,776	2,198
1919	457,950,316	17,508	24,673	263,074	30,685	44,666	569,632	190	188	196	.593	.572	.469	1,686	1,748	2,132
1920	551,963,212	18,648	27,318	284,275	29,607	45,414	584,645	223	224	220	.612	.588	.488	1,634	1,701	2,049
1921	409,104,619	21,288	31,704	308,721	33,711	51,886	604,123	165	164	148	.634	.610	.505	1,577	1,639	1,980
1922	404,911,653	21,571	32,985	321,335	33,658	55,125	621,826	142	139	142	.639	.616	.523	1,565	1,623	1,912
1923	548,075,163	22,332	34,831	343,842	34,631	56,490	635,649	191	185	179	.645	.619	.536	1,550	1,616	1,866
1924	468,992,310	23,839	36,028	302,474	36,543	58,077	551,075	180	175	171	.649	.626	.544	1,541	1,597	1,838
1925	502,289,415	23,611	36,292	281,884	36,103	56,863	521,889	180	182	197	.650	.631	.543	1,538	1,585	1,842
1926	554,314,173	23,339	37,309	281,375	36,120	59,109	523,393	204	204	217	.645	.631	.541	1,550	1,585	1,848
1927	498,355,554	23,736	39,420	283,229	37,477	63,044	520,057	164	156	196	.653	.637	.548	1,531	1,570	1,825
1928	479,225,661	23,823	38,182	254,402	36,140	58,019	453,998	191	187	205	.677	.658	.559	1,477	1,520	1,789
1929	513,649,859	23,867	38,201	250,348	33,144	55,213	438,544	214	215	221	.715	.694	.575	1,399	1,441	1,739
1930	446,514,060	24,543	40,479	254,456	32,706	55,181	429,907	183	188	187	.757	.740	.592	1,321	1,351	1,689
1931	362,778,891	24,006	41,444	239,425	29,968	52,060	390,846	163	165	159	.785	.776	.599	1,274	1,289	1,669
1932	289,860,767	21,910	37,763	208,365	27,231	47,268	350,534	140	137	147	.798	.785	.585	1,253	1,274	1,709
1933	315,015,552	20,400	34,291	199,086	25,832	45,090	363,334	173	167	167	.793	.778	.568	1,261	1,285	1,761
1934	337,947,465	21,873	37,089	223,539	27,723	48,017	398,429	197	190	177	.802	.784	.566	1,247	1,276	1,767
1935	348,184,677	23,864	40,723	235,879	28,645	49,681	401,679	201	193	177	.833	.820	.587	1,200	1,220	1,704

a Source: U. S. Bureau of Mines. Certain of the figures in this table (under columns "Tons mechanically loaded") differ slightly from those given in previous publications publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b Excludes tonnage of wagon mines and country banks and includes local commercial tonnage.

c The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

d Excludes wagon mines and country banks in every year and local commercial mines starting in 1923.

e Data not available.

* Three-year moving average except in terminal years.

Table B-61.- NUMBER, PRODUCTION, AND TONNAGE MECHANICALLY LOADED OF GROUP A BITUMINOUS-COAL MINES ("MECHANIZED GROUP") IN THE UNITED STATES, 1918-35[a]

Year	ALL UNDERGROUND MINES			GROUP A MINES ("MECHANIZED GROUP") (All mines of "Mechanized Group" including those newly opened or closed during period)							SUB-GROUP A-1 MINES ("IDENTICAL MECHANIZED") (Includes only such Group A as operated each year of period)						
					Production of these mines		Number of these mines loading mechanically during the year	Mechanical loading of these mines				Production of these mines		Number of these mines loading mechanically during the year	Mechanical loading of these mines		
	Number[b]	Production[b,c] (net tons)	Total tons mechanically loaded[d]	Number of mines in Group A	Net tons	Per cent of total underground		Net tons	Per cent of total Group A output	Per cent of total tonnage mechanically loaded by all mines	Number of mines in Sub-Group A-1	Net tons	Per cent of total underground		Net tons	Per cent of total Sub-Group A-1 output	Per cent of total tonnage mechanically loaded by all mines
	(1)	(2)	(3)	(4)	(5)	(6) (5)÷(2)	(7)	(8)	(9) (8)÷(5)	(10) (8)÷(3)	(11)	(12)	(13) (12)÷(2)	(14)	(15)	(16) (15)÷(12)	(17) (15)÷(3)
1918	8,155	568,267,196	-	170	46,478,667	8.2					104	33,067,859	5.8				
1919	8,826	457,950,316	-	183	37,200,513	8.1					104	26,711,306	5.8				
1920	8,784	551,963,212	-	187	49,137,667	8.9					104	33,434,002	6.1				
1921	7,884	409,104,619	-	196	44,754,701	10.2					104	28,284,314	6.9				
1922	9,028	404,911,655	-	204	37,137,450	9.2					104	24,872,152	6.1				
1923	8,421	548,075,163	1,879,786	205	52,001,111	9.5	8	350,696	0.7	18.7	104	34,421,758	6.3	2	125,422	0.4	6.7
1924	6,620	468,992,310	3,450,237	*207	51,069,984	10.9	19	1,015,449	2.0	29.4	104	34,757,606	7.4	9	340,370	1.0	9.9
1925	6,185	508,259,115	6,644,062	198	53,567,437	10.7	30	2,970,384	5.5	44.7	104	34,406,232	6.9	14	1,572,032	4.6	23.7
1926	6,146	554,314,173	11,252,628	208	61,573,528	11.1	55	5,726,598	9.3	50.9	104	38,564,793	7.0	27	3,173,473	8.2	28.2
1927	5,861	498,355,554	(e)	220	49,810,745	10.0	(e)	(e)			104	31,608,145	6.3	(e)	(e)		
1928	5,064	479,225,661	21,427,746	218	57,833,754	12.1	129	13,041,392	22.5	60.9	104	36,856,038	7.7	61	8,227,221	22.3	38.4
1929	4,785	513,649,899	37,361,496	225	66,608,486	13.0	164	27,223,197	40.9	72.9	104	41,370,915	8.1	77	15,458,295	37.4	41.4
1930	4,426	446,511,060	46,993,848	233	61,565,032	13.8	193	35,697,590	58.0	76.0	104	36,335,912	8.1	85	19,333,160	53.2	41.1
1931	4,012	362,778,891	47,562,108	236	55,185,158	15.2	203	39,223,549	71.1	82.5	104	31,656,310	8.7	90	21,858,411	69.0	45.9
1932	3,778	289,850,757	35,816,909	234	41,750,239	14.4	201	31,371,672	75.1	87.6	104	21,753,984	8.5	89	18,442,560	74.5	51.5
1933	3,820	315,013,552	37,820,161	229	46,042,348	14.6	199	35,378,824	76.8	93.5	104	28,410,237	9.0	92	22,344,119	78.6	59.1
1934	3,973	337,947,165	41,432,735	223	51,090,454	15.1	206	39,653,552	77.6	95.7	104	31,197,361	9.2	98	24,537,365	78.7	59.2
1935	3,924	348,184,677	47,177,224	226	55,095,468	15.8	226	44,572,816	80.9	94.5	104	33,575,990	9.6	104	27,588,040	82.2	58.5

a Source: U. S. Bureau of mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitution of final returns for preliminary estimates, or in the adoption of uniform classifications over the entire period.

b Excludes wagon mines and country banks in every year and local commercial mines starting with 1923. The tonnage of local commercial mines is included in production figures.

c The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

d Includes the tonnage mechanically loaded by the Group B mines ("experimentally mechanized").

e Data not available.

Table B-62.- COMPARISON OF NUMBER, PRODUCTION, AND TONNAGE MECHANICALLY LOADED OF GROUP A AND GROUP B BITUMINOUS-COAL MINES IN THE UNITED STATES, 1923-35[a]

Year	ALL UNDERGROUND MINES					GROUP A MINES ("MECHANIZED GROUP") (All mines of "Mechanized Group" including those newly opened or closed during period)				GROUP B MINES ("Experimentally Mechanized")			
	Number[b]	Production[b,c] (net tons)	Mines with mechanical loading			Number of these mines loading mechanically during the year	Production of these mines loading mechanically during the year	Mechanical loading of these mines		Number of these mines loading mechanically during the year	Production of these mines loading mechanically during the year	Mechanical loading of these mines	
			Number	Production	Total tons mechanically loaded[d]			Net tons	Per cent of total tonnage mechanically loaded by all mines			Net tons	Per cent of total tonnage mechanically loaded by all mines
1923	8,421	548,075,163	61	13,510,817	1,879,726	8	1,158,115	350,696	18.7	53	12,352,732	1,529,030	81.3
1924	6,620	468,992,310	84	16,721,172	3,450,237	19	3,308,503	1,015,449	29.4	65	13,412,669	2,434,788	70.6
1925	6,185	502,259,415	100	22,532,321	6,644,062	30	7,921,636	2,970,384	44.7	70	14,610,685	3,673,678	55.3
1926	6,146	554,314,173	166	46,687,305	11,252,628	55	16,376,657	5,726,598	50.9	111	30,310,648	5,526,030	49.1
1927	5,861	498,355,554	(e)	(e)	(e)	(e)	(e)	(e)		(e)	(e)	(e)	
1928	5,064	479,225,661	344	75,575,359	21,427,746	129	35,969,362	13,041,392	60.9	215	39,605,997	8,386,354	39.1
1929	4,785	513,649,859	406	108,814,447	37,361,496	164	53,014,498	27,223,197	72.9	242	55,799,953	10,138,299	27.1
1930	4,426	446,511,060	417	106,530,176	46,993,648	193	54,269,822	35,697,590	76.0	224	52,260,354	11,296,258	24.0
1931	4,012	362,778,891	402	89,733,172	47,562,108	203	50,086,744	39,223,549	82.5	199	39,646,431	8,338,559	17.5
1932	3,778	289,850,757	354	65,498,580	35,816,909	201	38,706,317	31,371,672	87.6	153	26,792,263	4,445,237	12.4
1933	3,820	315,013,552	282	63,774,420	37,820,461	199	43,265,961	35,378,824	93.5	83	20,508,459	2,441,637	6.5
1934	3,973	337,947,465	283	71,317,446	41,432,735	206	49,803,720	39,653,552	95.7	77	21,513,426	1,779,183	4.3
1935	3,924	348,184,677	323	86,667,904	47,177,224	226	55,095,468	44,572,816	94.5	97	31,572,436	2,604,408	5.5

a Source: U. S. Bureau of Mines. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitutions of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b Excludes wagon mines, country banks, and local commercial mines. The tonnage of local commercial mines is included in production figures.

c The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

d Includes the tonnage mechanically loaded by the Group B mines ("experimentally mechanized").

e Data not available.

Table B-63.- GROWTH OF MECHANICAL LOADING IN THE UNITED STATES, BY TYPES OF EQUIPMENT, 1923-37[a]

Year	Production (net tons)	Mechanical loading		MECHANICAL LOADING BY TYPES OF EQUIPMENT													
				Mobile loaders			Scrapers			Duckbills and self-loading conveyors			Pit-car loaders			Hand-loaded face conveyors		
	Underground mines[b, c]	Total tons	Per cent of underground production	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of machines	Tons	Per cent of total tons loaded	Number of installations[d]
1923	548,075,163	1,880,000	0.3	1,652,000	87.9	106	105,000	5.5	9	*	*	1	8,000	0.4	4	117,000[e]	6.2	(5)
1924	468,992,310	3,450,000	0.7	2,998,000	86.9	166	247,000	7.2	29	--	--	--	389,000	5.9	37	188,000[e]	2.8	(7)
1925	502,259,115	6,644,000	1.3	5,239,000	78.8	219	828,000	12.5	86	--	--	--	507,000	4.5	45	724,000[e]	6.4	(30)
1926	554,311,173	11,253,000	2.0	8,055,000	71.4	295	1,492,000	13.3	133	495,000	4.4	27						
1927[f]	498,355,554																	
1928	479,225,661	21,428,000	4.5	11,761,000	54.9	397	1,548,000	7.2	130	1,200,000	5.6	82	4,117,000	19.2	1,040	2,802,000	13.1	(119)
1929	513,649,899	37,362,000	7.3	16,232,000	43.5	488	1,550,000	4.1	126	1,309,000	3.5	99	11,679,000	39.3	2,521	3,592,000	9.6	(142)
1930	416,514,060	46,994,000	10.5	20,073,000	42.7	545	1,637,000	3.5	150	1,689,000	3.5	140	19,116,000	40.7	2,876	4,540,000	9.6	(142)
1931	362,778,891	47,562,000	13.1	19,407,000	40.8	583	1,471,000	3.1	146	1,811,000	3.8	165	19,172,000	40.3	3,428	5,701,000	12.0	(152)
1932	289,850,757	35,817,000	12.4	14,825,000	41.4	548	1,132,000	3.2	128	1,630,000	4.5	159	12,590,000	35.2	3,112	5,240,000	15.7	(136)
1933	315,013,552	37,820,000	12.0	17,865,000	47.2	523	990,000	2.6	93	1,656,000	4.4	132	11,413,000	30.2	2,453	5,896,000	15.6	(114)
1934	337,947,465	41,433,000	12.3	20,750,000	50.1	534	1,004,000	2.4	119	2,082,000	5.0	157	11,099,000	26.8	2,288	6,508,000	15.7	(114)
1935	348,184,677	47,477,000	13.5	24,675,000	52.3	657	1,118,000	2.4	78	2,595,000	5.5	180	11,098,000	23.5	2,098	7,591,000	16.3	(135)
1936	409,863,169	66,977,000	16.3	40,970,000	61.2	980	1,273,000	1.9	106	3,240,000	4.8	234	8,200,000	9.8	1,650	14,400,000	17.2	(235)
1937	411,193,062	83,500,000	20.3	56,000,000	67.1	1,272	1,350,000	1.6	115	3,600,000	4.3	250						

a Source: U. S. Bureau of Mines. The data for 1937 represent preliminary estimates of the National Bituminous Coal Commission based on reports of State Department of Mines, operators, and sales of new equipment. Certain of the figures in this table differ slightly from those given in previous publications of the U. S. Bureau of Mines because of revisions made during the present study. These revisions consist in substitution of final returns for preliminary estimates or in the adoption of uniform classifications over the entire period.

b Excludes tonnage of wagon mines and country banks.

c The strip production used in subtraction is the "total at same mines" which includes an insignificant production underground in operations which are both strip pits and deep mines.

d Number of mines in which hand-loaded conveyors, other than pit-car loaders, were used.

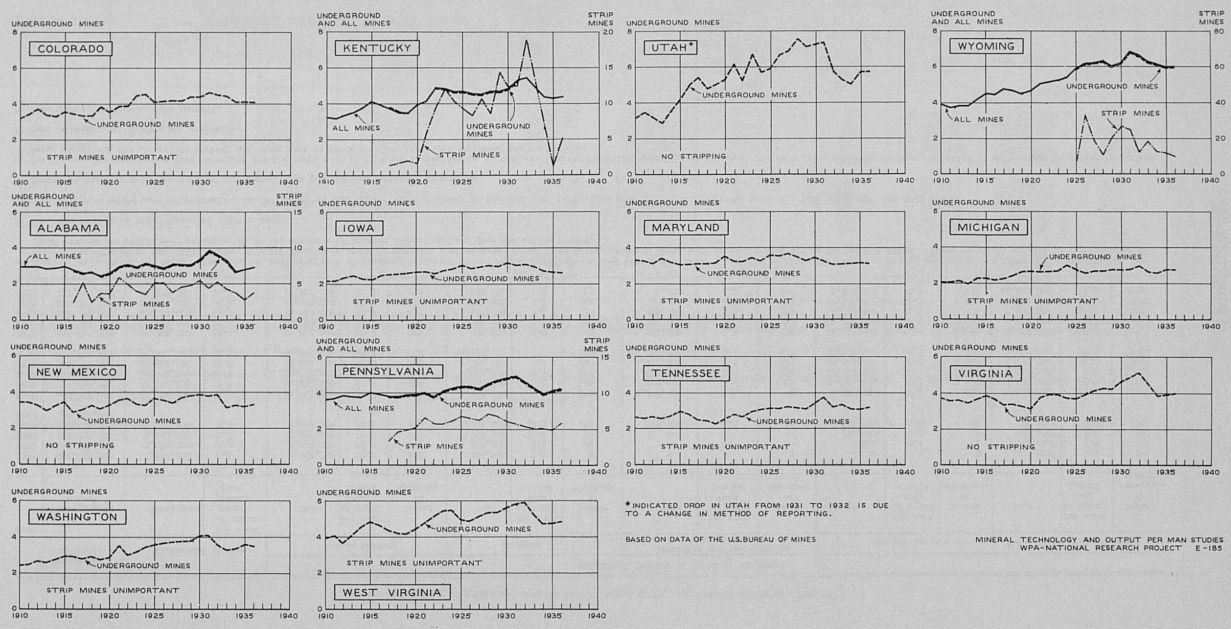
e The figures for hand-loaded face conveyors for the years 1923 to 1926 are incomplete as no specific inquiry regarding this type of equipment was made prior to 1928. However, a number of mines reported conveyors without being asked, and the incomplete replies are shown here to prove the fact that this equipment was early used.

f Data on mechanical loading not available.

* Less than 1,000 tons or 0.05 percent.

Figure B-1.- OUTPUT PER MAN PER DAY IN SELECTED STATES, BY KIND OF MINE, 1910-36

(Net tons; figures for strip mines are shown on a separate scale)



*INDICATED DROP IN UTAH FROM 1931 TO 1932 IS DUE TO A CHANGE IN METHOD OF REPORTING.

BASED ON DATA OF THE U.S. BUREAU OF MINES

MINERAL TECHNOLOGY AND OUTPUT PER MAN STUDIES
WPA-NATIONAL RESEARCH PROJECT E-185

WPA NATIONAL RESEARCH PROJECT
BITUMINOUS COAL

CODE NO. _____

TRANSCRIPTION SHEET FOR U. S. BUREAU OF MINES DATA

WPA NATIONAL RESEARCH PROJECT

BITUMINOUS COAL

TRANSCRIPTION SHEET FOR U. S. BUREAU OF MINES DATA

CONFIDENTIAL OFFICE RECORD
TO REMAIN IN CUSTODY OF
U. S. BUREAU OF MINES

CODE NO. _____

TRANSCRIBED BY _____
DATE TRANSCRIBED _____

NRP 501-A
BUREAU OF MINES MINE NO. _____

A. DATE | NAMES OF COMPANY (RECORD CHANGES) | B. MINE NAMES

Marked to show sources of data

C.
STATE _____ COUNTY _____
FIELD OR TRADE DISTRICT _____
SEAM (1920) _____ (1935)* _____
COMMERCIAL _____ CAPTIVE _____
AGE OF MINE { PRODUCTION RECORD _____ / MINE REPORTS (1926) _____

D. SEAM THICKNESS
1920 TOTAL THICKNESS _____ INCHES
NET THICKNESS _____ INCHES
1923 MAXIMUM _____ INCHES
MINIMUM _____ INCHES
AVERAGE _____ INCHES
1934* AVERAGE _____ INCHES

E. SYSTEM OF MINING

	1920	1931*
LONGWALL		
ROOM AND PILLAR, ORDINARY METHOD		
ROOM AND PILLAR, WITH PANELS		
IF ROOM AND PILLAR IS USED: ARE ROOM PILLARS EXTRACTED?		
ARE ENTRY PILLARS EXTRACTED?		

F. 1934* % PRODUCTION OBTAINED FROM PILLARS _____ %

G. 1920 WHAT % OF COAL IN NET THICKNESS MINED:
IS EXTRACTED? _____ %
IS LOST ? _____ %

H. 1920 DIP OF COAL BED _____ DEGREES

I. 1924 HAULAGE SYSTEM

	NUMBER UNDERGROUND 1924	1935
HORSES AND MULES		
ROPE HAULAGE UNITS		
STORAGE BATTERY LOCOMOTIVES: WITH TROLLEY		
WITHOUT TROLLEY		
ELECTRIC TROLLEY LOCOMOTIVES		
COMPRESSED AIR LOCOMOTIVES		
GASOLINE LOCOMOTIVES		
STEAM LOCOMOTIVES		

J. TYPE OF MINE

	SHAFT	SLOPE	DRIFT
1920			
1926			
1934			

1926 DEPTH OF SHAFT _____ FT.
1926 LENGTH OF DRIFT OR SLOPE _____ FT.
1926 AVE. DISTANCE OF TRAVEL FROM END OF SLOPE OR BOTTOM OF SHAFT TO FACE _____ FT.

K. LAMPS

	1924	1934*
OPEN FLAME		
FLAME SAFETY		
ELECTRIC BATTERY		

L. IS MINE GASEOUS { 1926 YES ____ NO ____ / 1934* YES ____ NO ____

M. 1926 THICKNESS OF OVERBURDEN
SHALLOWEST PART MINE _____ FT.
DEEPEST PART MINE _____ FT.
APPROX. AVE. DEPTH _____ FT.

N. MINE PUMPS
1926 ARE UNDERGR'D WORKINGS ABOVE DRAINAGE? _____
ARE UNDERGR'D WORKINGS WET OR DRY? _____
NO. PUMPS DELV'G WATER TO SURFACE _____
GAL. PER MIN. DELIVERED TO SURFACE _____

O. PARTINGS
1930 IS FACE BROKEN BY PARTINGS OR BANDS OF IMPURITIES? _____ IF YES, ARE PARTINGS REMOVED UNDERGR'D BEFORE LOADING COAL IN MINE CARS? _____

NAME OF PARTING	CHARACTER (ROCK, DIRT, ETC.)	AVE. THICKNESS IN PRESENT WORKINGS
		INCHES
		INCHES

NET THICKNESS OF CLEANED COAL AS MINED _____ INCHES

P. ROOF
1931 DOES ROOF IMMEDIATELY OVER COAL CONSIST OF:
DRAWSLATE _____ LIMESTONE _____
SHALE OR SLATE _____ BONE OR RASH _____
SANDSTONE _____ OTHER MAT. _____
IS TOP COAL LEFT IN PLACE TO SUPPORT ROOF? _____
IS DRAWSLATE OR ROOF ROCK TAKEN DOWN ? _____
HOW MANY INCHES TAKEN DOWN IN ROOMS? _____
IN ENTRIES? _____
IS WASTE GOBBED UNDERGROUND OR BROUGHT TO SURFACE ? _____
FOR EACH CAR ROCK BROUGHT TO SURFACE,
HOW MANY CARS OF COAL? _____
HOW MANY PROPS SET PER 1,000 TONS MINED? _____
IS ROOF SERIOUSLY AFFECTED WITH: "KETTLE BOTTOM" ? _____
"SLIPS" ? _____
DO YOU CONSIDER ROOF: GOOD ____ POOR ____ MEDIUM ____ BAD ____

Q. 1934 WAS MINE ROCK DUSTED? (1930) _____ (1934) _____

R. * SCREENING AND PREPARATION

TONS	1927	1926
R.O.M. (INCL. MODIFIED OR SPECIAL R.O.M.)		
PREPARED SIZES		
SLACK OR SCREENINGS		
HAND PICKING (ON PICKING TABLES, LOADING BOOMS, OR IN R.R. CARS) YES OR NO		

1928 SCREENING EQUIPMENT:
BAR SCREENS _____ GRAVITY _____
SHAKER _____ OTHER SCREENS _____
PICKING TABLES _____ LOADING BOOMS _____

* DATA REPORTED ON ACCIDENT QUESTIONNAIRE

PRODUCTIVITY AND VALUE OF PRODUCT

YEAR	BUR. OF MINES MINE NO.	NO. OF MINES REPORTING	TOTAL PRODUCTION (NET TONS)	AVERAGE NUMBER OF MEN					AVE. DAYS WORKED	TOTAL MAN-DAYS		OUTPUT PER MAN PER DAY		OUTPUT PER MINE PER DAY	HOURS WORKED PER DAY	TOTAL MAN-HOURS		OUTPUT PER MAN PER HOUR		OUTPUT PER MINE PER HOUR	TOTAL VALUE AT MINE OF COAL PRODUCED (DOLLARS)	AVE. VALUE PER TON
				UNDERGROUND			SURFACE	TOTAL		REPORTED	CALCULATED	REPORTED	CALCULATED			REPORTED	CALCULATED	REPORTED	CALCULATED			
				TONNAGE	HAULAGE AND TRACK	OTHERS																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1918																						
1919																						
1920																						
1921																						
1922																						
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1931																						
1932																						
1933																						
1934																						
1935																						
1936																						
1937																						
1938																						
1939																						
1940																						

Code number on Bureau of Mines list

As reported by operator

As reported by operator. Question first asked in 1931

Col. (8) X col. (9)

Col. (3) ÷ col. (10)

Col. (3) ÷ col. (11)

Col. (3) ÷ col. (9)

As reported by operator (When working time changed during the year, as in 1934, a weighted average was used)

Col. (11) X col. (15) (or as reported by operator)

Col. (11) X col. (15)

Col. (3) ÷ col. (16)

Col. (20) ÷ col. (18) [or col. (3) ÷ col. (17)]

Col. (14) ÷ col. (15)

As reported by operator

Col. (21) ÷ col. (3)

MECHANICAL EQUIPMENT

MECHANICAL EQUIPMENT

YEAR	TOTAL PRODUCTION (NET TONS)	CUT BY MACHINE		MOBILE LOADING MACHINES			SCRAPER LOADERS			DUCK BILLS AND SELF-LOADING CONVEYORS			PIT CAR LOADERS			HAND LOADED FACE CONVEYORS			TOTAL OF MECHANICAL LOADING		
		TOTAL TONS	PER CENT TOTAL PROD.	MAKE	NO.	TONS	MAKE	NO.	TONS	MAKE	NO.	TONS	MAKE	NO.	TONS	MAKE	NO.	TONS	TOTAL NO.	TOTAL TONS	PER CENT OF PROD.
	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
1918																					
1919																					
1920																					
1921																					
1922																					
1923																					
1924																					
1925																					
1926																					
1927																					
1928																					
1929																					
1930																					
1931																					
1932	As reported by operator	As reported by operator	Col. (24) ÷ col. (23)																		
1933																					
1934																					
1935																					
1936																					Col. (42) ÷ col. (23)
1937																					
1938																					
1939																					
1940																					

As reported by operator

YEAR	TOTAL PRODUCTION (NET TONS)	MECHANICAL CLEANING					TOTAL WAGE BILL (DOLLARS)	WAGE COST PER TON	MINED BY HAND		SHOT OFF SOLID		NO. OF CUTTING MACHINES	
		KIND OF EQUIPMENT	WET OR PNEU.	TONS CLEANED					TOTAL TONS	PER CENT TOTAL PROD.	TOTAL TONS	PER CENT TOTAL PROD.		
				RAW	CLEANED PRODUCT	REFUSE								
	44	45	46	47	48	49	50	51	52	53	54	55	56	
1918														
1919														
1920														
1921														
1922														
1923														
1924														
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1932														
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1934														
1935														
1936														
1937														
1938														
1939														
1940														

As reported by operator

To be obtained by correspondence if operator can conveniently furnish

Col. (51) = col. (47) ÷ col. (44)

As reported by operator

Col. (52) ÷ col. (44)

As reported by operator

Col. (54) ÷ col. (44)

As reported by operator

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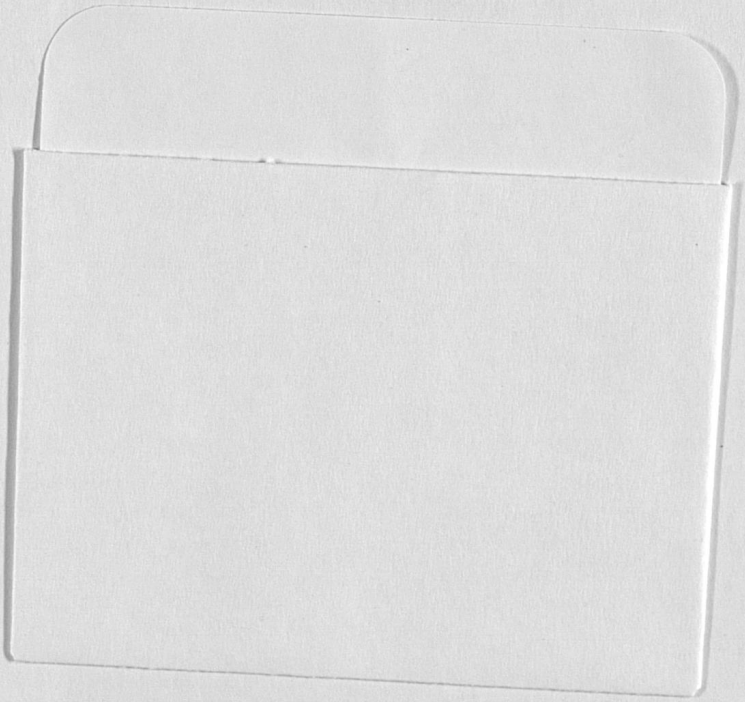

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