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CHAPTER 7

Workers and Their Performance

JOBS WERE STEADIER THAN TRAFFIC

When traffic increases substantially, the railroad companies take on more workers, as might be expected; when it declines, some of the jobs in the industry disappear. More men found places in it during every expansion of traffic for which we have any record of employment; the number of workers decreased in every contraction except, perhaps, 1918–19 (Tables 52 and 53; Chart 75). The average for the full year 1919 is higher than for the full year 1918 largely because the normal day was reduced to eight hours. To be sure, train and engine employees had nominally obtained an eight-hour day in 1917, and most other groups in 1918. But workers were hard to find in those years, since many were in the armed forces and others were attracted into war industries. Consequently, the railroads kept the men they did have on the job beyond the nominal limit and paid overtime.[1] When war industries and the armed forces released manpower, it was possible to put the shorter day into practice as something more than a system of wage-payment. With each man working fewer hours, more workers were needed to handle even the somewhat reduced volume of business.

Although, in all other cases, growing traffic resulted in more, and dwindling traffic in fewer jobs, the changes in the number of workers were always less than proportionate to those in volume, at least from 1908 onward (Tables 52, 53, and 54). For example, although traffic rose 8 percent from its low point at the end of 1927 to its high point around August 1929, employment rose only 0.3 percent. The decline in traffic during 1937–38, 28 percent, was accompanied by a fall of only 21 percent in the number of jobs.

But turning points in employment usually came later than those in traffic, at least in the cycles after 1920, in which monthly data enable us to locate them (Chart 75). Consequently, the comparison just made somewhat understates the scope of the fluctuations in the number of railway workers. In 1923–24, for example, employ-

[1] Hines, *War History* . . . , pp. 164–6.

ment did not reach a peak until four months after April 1923 (the high point of traffic), nor a trough until the month after June 1924 (the low point for traffic). The number of men fell from a higher level than in April to a lower level than in June. From the workers' point of view, it is the violence of the swings in employment that is important, whether or not they coincide precisely with those in traffic. Although some of these specific rises and falls were large, even they were smaller than the specific rises and falls in traffic units (Table 54). Employment was more stable than the volume of railway business. Opportunities to work did not multiply as fast as ton-miles and travel; but jobs were not lost as fast, either.

Table 52
Traffic Units and Number of Workers, 1908–1914

Date	1908	1909	1910	1911	1912	1913	1914
Traffic units							
Av. for 3 months ended June 30 (billions)	22.54	25.05	28.46	27.51	28.77	31.95	29.50
Level	Trough	...	Peak	Trough	...	Peak	Trough
Number of employees, June 30[a] (thousands)	1,436	1,503	1,699	1,670	1,716	1,831[b]	1,710
Traffic units per employee per month	15,696	16,667	16,751	16,473	16,766	17,449	17,251
% change from preceding trough or peak							
Traffic units	...	...	26.3	−3.3	...	16.1	−7.7
Employees	...	...	18.3	−1.7	...	9.6	−6.6

[a] All line-haul railways reporting to ICC.
[b] Estimated. Ratio in 1912 of Class I plus II plus III to Class I plus II, 1.009, applied to 1913 figure for Class I plus II roads.

We cannot be certain whether this was true before 1908. Since we have no monthly or quarterly data on passenger-miles, we cannot estimate total traffic (freight plus passenger) on as fine a basis. The fluctuations in employment were materially smaller than those in ton-miles (Table 55). However, passenger is more stable than freight traffic (Ch. 2); fluctuations in total traffic were therefore probably also smaller than those in ton-miles. It is therefore possible that changes in employment were greater than those in composite traffic. The margin between the percentage changes in the number of workers and those in freight traffic is so wide, how-

Table 53

Traffic Units, Number of Workers, and Man-hours, 1915–1921

Date	1915[a]	1916[a]	1916	1917	1918	1919	1920	1921
Level of traffic units	Trough				Peak	Trough	Peak	Trough
Traffic units (billions)	351.2	421.6	446.5	490.4	509.1	476.9	524.1	397.5
Av. number of employees (thousands)	1492[b]	1599	1647	1733	1842	1913	2023	1660
Man-hours worked (billions)[c]	4.60[b]	4.96	5.19	5.44	5.70	5.03	5.45	4.15
% change from preceding trough or peak								
Traffic units	...	...	...	...	45.0	−6.3	9.9	−24.2
Number employed	...	...	...	...	23.5	3.9	5.8	−17.9
Man-hours	...	...	...	...	23.9	−11.8	8.3	−23.9
Traffic units per								
Employee (thousands)	235	264	271	283	276	249	259	239
Man-hour	76.3	85.0	86.0	90.1	89.3	94.8	96.2	95.8

Class I line-haul railroads.

[a] Year ended June 30.

[b] Estimated in part by the ICC because of incomplete returns.

[c] Includes hours of workers reported on daily basis, estimated by the ICC on the assumption of a 10-hour day, 1915–18, an 8-hour day, 1919–21.

Table 54

Traffic Units and Number of Workers at Peaks and Troughs, 1921–1938

At Turning Points in Traffic Units									
Date of turn	July 1921	April 1923	June 1924	July 1926	Dec. 1927	Aug. 1929	Aug. 1932	Mar. 1937	May 1938
Level of traffic	Trough	Peak	Trough	Peak	Trough	Peak	Trough	Peak	Trough
Traffic units (billions)	31.85	44.67	37.94	45.03	40.67	44.05	21.00	37.85	27.27
Number employed[a] (thousands)	1,609[b]	1,871	1,744	1,800	1,701	1,706	983	1,137	903
% change from preceding turn									
Traffic units	...	40.3	−15.1	18.7	−9.7	8.3	−52.3	80.2	−28.0
Number employed	...	16.3	−6.8	3.2	−5.5	0.3	−42.4	15.7	−20.6
At Turning Points in Number of Employees									
Date of turn	[c]	Aug. 1923	July 1924	Dec. 1926	Jan. 1929	Sept. 1929	May 1933	June 1937	June 1938
Number employed[a]	[c]	1,908	1,731	1,812	1,669	1,707	932	1,144	889
% change from preceding turn, number employed	...	[c]	−9.3	4.7	−7.9	2.3	−45.4	22.7	−21.4

Class I line haul railways.

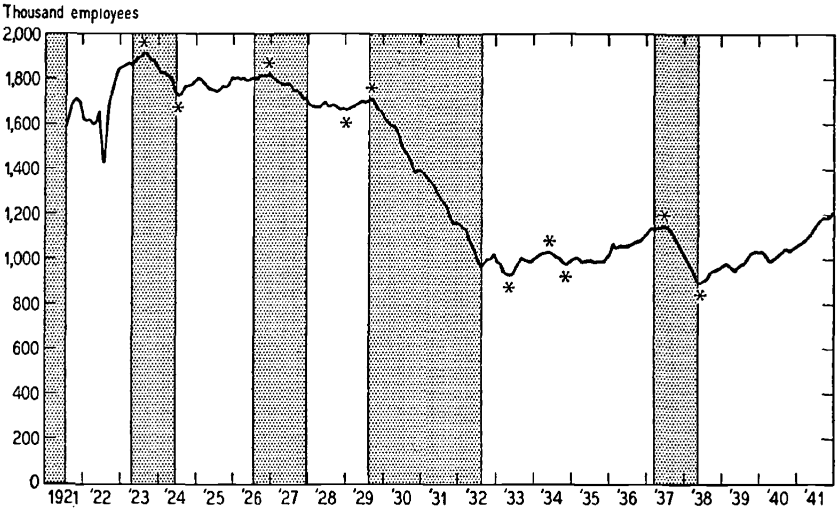
[a] Three-month average; date of turn is middle month.

[b] Average for July and August only; no data for June.

[c] Not determinable because of lack of data before July 1921.

CHART 75

Railway Employees at Middle of Month, July 1921—December 1941



Shaded periods are contractions in traffic units.

Table 55

Ton-miles and Number of Employees, 1890–1908

	Ton-miles, quarter ended June 30[a]		Employees June 30[b] (thousands)	% change from preceding peak (or trough)	
	Billions	Level		Ton-miles	No. employed
1890	20.19		749		
1891	21.74		784		
1892	23.20		821		
1893	25.24	Peak	874	...	...
1894	21.06	Trough	780	−16.6	−10.8
1895	22.51		785		
1896	23.40		827		
1897	24.60		823		
1898	29.16		875		
1899	31.89		929		
1900	35.52		1,018		
1901	38.83		1,071		
1902	40.83		1,189		
1903	46.06	Peak	1,313	118.7	68.3
1904	44.49	Trough	1,296	−3.4	−1.3
1905	49.61		1,382		
1906	54.29		1,521		
1907	63.28	Peak	1,672	42.2	29.0
1908	51.23	Trough	1,436	−19.0	−14.1

[a] Babson estimates.

[b] All line-haul railways reporting to ICC.

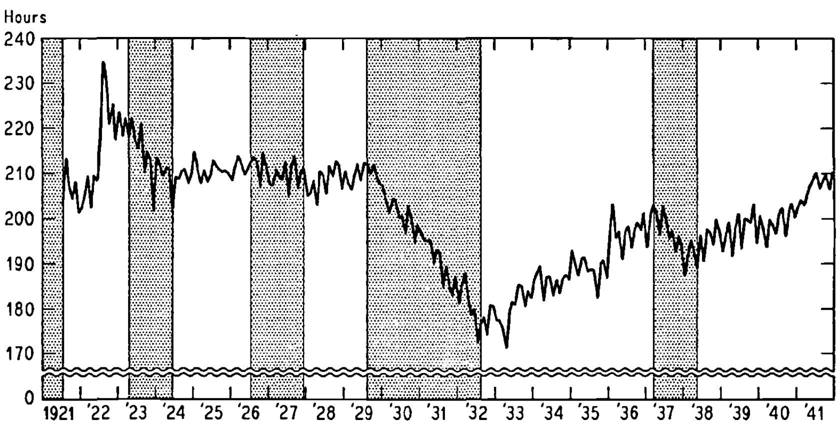
ever, that this seems unlikely. At least, the data from 1893 to 1908 do not contradict the rule we derive from later information.

LONGER WORKING MONTH IN PROSPERITY

The railroad companies make fuller use of the potential services of the workers on their payrolls in prosperity than in depression. On the average a man puts in more and more time per month as traffic grows, less and less as it diminishes. We cannot show this for all employees, because hours worked are reported for only about 90 percent. For this great group, however, man-hours worked per employee per month rose during every expansion of traffic, fell during every contraction (Chart 76).

CHART 76

Hours Worked per Month per Employee, Occupations for which Hours are Reported, July 1921—December 1941



Shaded periods are contractions in traffic units.

During the 1921–23 expansion the change was very irregular. Hours per worker increased very sharply from June to August 1922, then declined almost as quickly. A strike of railway shopmen reduced the number at work repairing equipment in July and, to a lesser extent, in August. Apparently the companies endeavored to offset the loss of some workers at least in part by having others work overtime. As the effects of the strike wore off, the average working day was shortened; hours per man were substantially fewer at the peak of traffic than at the height of the labor troubles. Nevertheless, the average at the traffic peak was well above the average at the 1921 trough.[2]

Since the average working month lengthened in expansions and shortened in contractions, the number of man-hours worked rose and fell more rapidly than the number of workers. Consequently, output of traffic units per man-hour did not increase or diminish as rapidly as output per worker.

MAN-HOURS AND TRAFFIC

More traffic per man-hour when total volume was large

Although cyclical variations in aggregate man-hours were greater than those in the number employed, they were nevertheless smaller than those in traffic. From 1921 onward, the productivity of labor, defined as traffic units per man-hour, rose in every expansion, fell in every contraction (Chart 77). Perhaps we should qualify this generalization in view of the oscillations during 1929–32. Beginning in February 1929, six months before the traffic peak in August, the curve of output per man-hour falls until November 1929, then rises until July 1931 (with a mild sag in 1930–31). In the remainder of the phase, about a year, it declines more vigorously than before. Productivity in the three trough months of the traffic contraction averaged slightly higher than in its three peak months; but the net change was slight in comparison with the rises during the neighboring expansions.

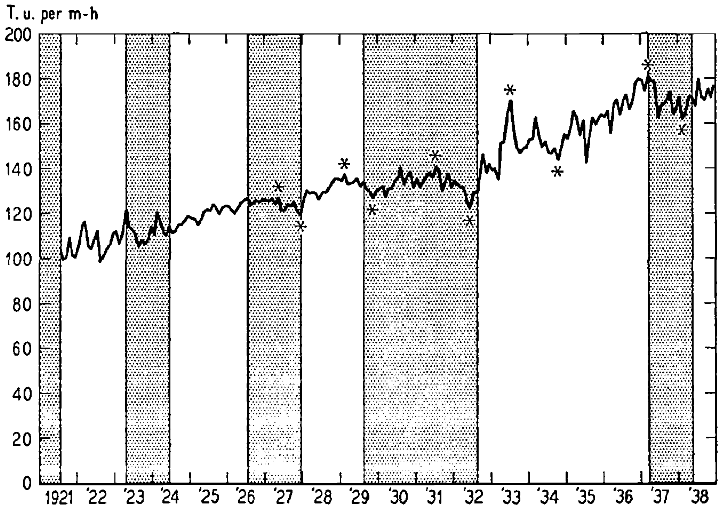
Some of the better defined minor fluctuations in traffic, within its phases, are reflected in the output-input ratio. In the 1923–24 contraction, productivity, like traffic, made a partial recovery, then declined again. Unlike traffic, it did not fall to a lower level on the second decline than on the first, but halted at a somewhat higher point. The three sub-cycles in traffic during the early years of its 1932–37 expansion have analogues in the curve of output per man-hour.

[2] There was another sharp temporary rise in February 1936. Meeting blizzard conditions called for much overtime work. The unusual weather and its consequences are described in *Railway Age*, 1936, Feb. 15, p. 287, Feb. 22, p. 320, March 7, p. 405. The statistical technique of seasonal adjustment is designed to prevent the effects of ordinary winter weather from appearing in the adjusted figures, but permits those of extraordinary weather to appear.

The cyclical rise and fall in productivity would be more pronounced if we could exclude from the divisor (total man-hours) the hours devoted not to current operations but to making improvements in railroad property. Annual figures show that the percentage of wages charged to capital account became larger in every expansion, smaller in every contraction from 1921 to 1938 (Table 56). From this fact we can fairly presume that time spent in construction and similar activity grew more rapidly in each expansion and diminished more rapidly in each contraction than total man-hours. Consequently, the labor chargeable to operation must have risen and declined less rapidly than total time worked, and traffic handled per man-hour of operating labor must have increased and decreased by somewhat larger percentages than the data plotted on Chart 77 would indicate.

CHART 77

Traffic Units per Man-hour Worked, Occupations for which Hours are Reported, July 1921—December 1938



Shaded periods are contractions in aggregate traffic units.

Annual estimates of traffic units per man-hour are feasible for two cycles before 1921–24 (Table 53); there are no data on hours worked before 1915. Productivity rose in the 1915–18 and 1919–20 expansions, fell in the 1920–21 contraction. In 1918–19, however, it increased; indeed it improved more rapidly than in either expansion. Apparently, therefore, this contraction was an exception to the general rule of positive conformity to traffic.

Table 56
Percentage of Employee Compensation Charged to Additions and Betterments, 1921–1940

Year	Level of traffic units	%	Year	Level of traffic units	%	Year	Level of traffic units	%
1921	Trough	6.35	1928	Trough	6.96	1935		5.46
1922		6.52	1929	Peak	7.68	1936		5.98
1923	Peak	7.29	1930		7.22	1937	Peak	6.04
1924	Trough	7.12	1931		6.19	1938	Trough	4.92
1925		7.51	1932	Trough	5.02	1939		4.43
1926	Peak	7.76	1933		4.82	1940		5.52
1927		7.55	1934		5.10			

Data pertain to Class I line-haul railways. Switching and terminal companies excluded in 1921 and 1922 with the aid of data in *Statistics of Railways of Class I, United States, 1916–1925,* (Bureau of Railway Economics), p. 9.

Are workers less productive when jobs are plentiful?

Some writers on business cycles have expressed the opinion that the efficiency of labor tends to decline with the progress of expansion. Inexperienced hands, they argue, are taken on. Workers become less careful in the discharge of their tasks because they know that jobs are plentiful elsewhere; who's afraid of being fired? Supervisors, busy with multiplied duties, have less time to devote to minor matters, and their management of personnel becomes less economical. Conversely, so the argument runs, when depression deepens, only the more experienced and skillful workers are retained, those who stay are more anxious to keep their jobs and discipline improves, management has more time to devote to the careful use of labor and materials.

If this were true in the railroad industry, we might expect the traffic handled per man-hour to fall in expansion and rise in contraction. But as we have just noted, what happens is precisely the opposite, taking each phase as a whole. It does not follow, however, that the improvement continues up to the very end of an expansion, or that the deterioration goes on throughout a contraction. The writers who discuss the role of changes in the productivity of labor and in other factors affecting costs per unit of product contend that rising costs help to bring business expansion to its end, and falling costs help to bring about revival. From this one might infer that these factors are supposed to be most noticeable in the later stages of expansion and of contraction. Productivity and the volume of business may move in the same direction most of the time, but the former may nevertheless begin to decline and to recover before the latter.

In that case we should expect to find a specific contraction in productivity beginning somewhat before each peak in traffic, and a specific expansion in productivity beginning somewhat earlier than each trough in traffic. But actually we cannot see any clear-cut phases in output per man-hour during the first three traffic phases (Chart 77). What we do see later fails to support the expectation consistently. Productivity was falling at the 1929 peak in traffic but not at the 1937 peak; it was rising at the 1932 and 1938 but not at the 1927 traffic trough.

The evidence afforded by the location of specific-cycle turning points, however, is often dubious. Frequently the peak does not cap a continuous rise or introduce a continuous fall. The trough does not end a smooth downward or initiate a smooth upward movement. Instead the curve fluctuates irregularly as it approaches or leaves the point we designate as a turn. If we depend on a single month to indicate the direction of change before and after it, we may obtain a false impression of the course of events. The curve of productivity provides illustrations. After the peak of traffic in July 1926 it is fairly flat for almost a year. We locate the high point of output per man-hour in May 1927 and therefore find that it lagged 10 months behind traffic. But there were only 127.3 traffic units per man-hour in May 1927; there were almost as many—126.9—in July 1926. If May 1927 (also March, for which the ratio is 127.2) had been a trifle lower, we might have placed the peak in productivity at the peak in traffic; then we would have found no lag.

To avoid the oversimplification that may arise from a consideration of turns alone, we may divide each phase of traffic into groups of months, strike an average for each group, and see whether the averages seem to change in a consistent manner. Months could be grouped according to various plans. In other business cycle studies at the National Bureau, it is customary to assign the months in each phase, except the peak and trough months, to three successive groups, as nearly equal in length as possible,[3] and compute averages for each. These averages, together with those for the three-month peak and trough groups, provide a 'pattern' of each cycle which has greater regularity than the data for individual months. This procedure is followed here. We call the several groups of months 'stages', of which there are 9 for each cycle, numbered progressively. I is the initial trough; II, III, and IV are successive stages of expansion; V is the peak; VI, VII, and VIII are successive stages of contraction; IX is the final trough. In effect the stages divide each phase into 4 successive segments. In expansion the first runs from stage I to II, the second from II to III, and so forth. In contraction the first runs from V to VI, the second from VI to VII, etc.

Table 57
Traffic Units per Man-hour Worked: Illustrative Calculations, 1927–32 Traffic Cycle

Stage of cycle in aggregate traffic units	Months included		Traffic units per man-hour		Midpoint of stage	Months since prec. mid-point	Change per month (5)÷(7)
	Dates	No.	Av. for months incl.	Change from prec. stage			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
I	Nov. 1927–Jan. 1928	3	122.6	...	Dec. 15, 1927	...	...
II	Jan. 1928–June 1928	6	128.6	6.0	Mar. 31, 1928	3.5	1.71
III	July 1928–Jan. 1929	7	132.8	4.2	Oct. 15, 1928	6.5	0.65
IV	Feb. 1929–July 1929	6	134.3	1.5	May 1, 1929	6.5	0.23
V	July 1929–Sept. 1929	3	132.1	−2.2	Aug. 15, 1929	3.5	−0.63
VI	Sept. 1929–Aug. 1930	12	131.7	−0.4	Feb. 28, 1930	6.5	−0.06
VII	Sept. 1930–July 1931	11	135.7	4.0	Feb. 15, 1931	11.5	0.35
VIII	Aug. 1931–July 1932	12	131.6	−4.1	Jan. 31, 1932	11.5	−0.36
IX	July 1932–Sept. 1932	3	132.7	1.1	Aug. 15, 1932	6.5	0.17

We have divided each cycle in traffic units into stages on this plan, and have struck an average of output per man-hour for each stage of traffic. The computations are illustrated in Table 57, columns 1–4. If the theory that productivity begins to deteriorate at some point during expansion and to improve at some point during contraction is correct, average productivity should decline at least from stage IV to V, i.e., in the fourth segment of expan-

[3] Frequently one group must be one month longer or shorter than the others. We make this the middle group.

sion, perhaps in earlier segments as well; and it should rise from VIII to IX—in the fourth segment of contraction—or perhaps earlier.

Table 58
Traffic Units per Man-hour Worked
Averages for Successive Stages of Cycles in Traffic Units

Cycle	I	II	III	IV	V	VI	VII	VIII	IX
1921–24	101.2	104.4	107.7	107.8	115.5	110.5	109.5	114.4	111.8
1924–27	111.8	115.6	120.3	122.9	125.5	125.2	125.3	123.1	122.6
1927–32	122.6	128.6	132.8	134.3	132.1	131.7	135.7	131.6	132.7
1932–38	132.7	148.8	153.6	168.4	178.4	172.1	169.2	167.7	170.5

The method of dividing a cycle into stages is illustrated in Table 57.

This was not generally true. In every segment of expansion, output per man-hour worked most commonly rose (Table 58). It improved in the first, second, and third segments of all 4 expansions, in the fourth segment of 3. In contractions it fell in all 4 of the first segments, in half of the second segments, in 3 of the third and 2 of the fourth segments. In no segment of expansion were declines more numerous than rises; in no segment of contraction were rises more numerous than declines. Furthermore, productivity was at its very highest in the final stage of expansion in 3 of 4 cycles.

It should be conceded that falling productivity was slightly less uncommon toward the end of expansion, and improving productivity toward the end of contraction. The one instance of decline in expansion occurred in the fourth segment (1927–29). In contractions there was no improvement in any first segment, but there were two instances of rise in the second; one in the third, two in the fourth. A less than unanimous preponderance of facts contrary to the theory, however, is not the same thing as a preponderance in support of it.

Whether we look at turning points or at stages, then, we are led to the conclusion that productivity did not consistently decline toward the end of an expansion in the volume of business nor did it consistently rise toward the end of a contraction. If the morale of labor and management are inversely related to traffic, other factors that are positively related to it must usually be more important.

Early changes in productivity more rapid

In general, however, output per man-hour improved more rapidly in the first segment of expansion, and deteriorated faster in the first of contraction, than in later segments (Table 59). Since our data cover four cycles, we can make twelve comparisons between the rate of change in a first segment and the rate of change in a later segment, both in the same cycle and phase. Productivity rose more rapidly in only one of the twelve later segments—the fourth of 1921–23. The fourth stage of that phase runs from September 1922 to February 1923, and output per man-hour was probably adversely affected by the shopmen's strike and its aftermath, so that the rapid rise in the fourth segment may be explained in part by the abnormally low initial level. Similarly, we can make twelve comparisons between a first segment of a contraction and later segments of the same contraction. In 9 of the 12, the later segment shows either a more gradual fall in output per man-hour or an actual rise.

Table 59
Traffic Units per Man-hour Worked
Change per Month during Segments of Phases in Aggregate Traffic Units

Phase of traffic units	Change per month in traffic units per man-hour			
	First segment	Second segment	Third segment	Fourth segment
Expansions				
1921–23	0.80	0.51	0.02	1.92
1924–26	0.84	0.59	0.32	.58
1927–29	1.71	0.65	0.23	−0.63
1932–37	1.69	0.27	0.82	1.05
Contractions				
1923–24	−2.00	−0.22	1.09	−1.04
1926–27	−0.10	0.02	−0.40	−0.17
1929–32	−0.06	0.35	−0.36	0.17
1937–38	−2.52	−0.64	−0.33	1.12

The method of computation is illustrated in detail by Table 57.

After the transition from the first segment, however, deceleration or reversal of change was less common. Comparisons between a second and a third or fourth segment, or between a third and a fourth, do not consistently disclose them (Table 60).

Table 60
Traffic Units per Man-hour Worked: Change per Month
Number of Phases in which Specified Sequences Occurred

Expansions		Contractions	
Rise in first segment, and		*Fall in first segment, and*	
Fall, or less rapid rise, in second	4	Rise, or less rapid fall, in second	4
Fall, or less rapid rise, in third	4	Rise, or less rapid fall, in third	2
Fall, or less rapid rise, in fourth	3	Rise, or less rapid fall, in fourth	3
Rise in second segment, and		*Fall in second segment, and*	
Fall, or less rapid rise, in third	3	Rise, or less rapid fall, in third	2
Fall, or less rapid rise, in fourth	1	Rise, or less rapid fall, in fourth	1
Rise in third segment, and		*Fall in third segment, and*	
Fall, or less rapid rise, in fourth	1	Rise, or less rapid fall, in fourth	3

Derived from Table 59.

Early changes larger in proportion to those in traffic

The differences in the rate of change per month may suggest that an increase in traffic during the first segment of an expansion is likely to be accompanied by a larger rise in productivity than that which would accompany an equal increase in traffic during a later segment, and that a similar alteration occurs during contraction in the relation between traffic losses and declines in productivity. But such an inference would not necessarily be correct if the growth (or decline) of traffic itself was progressively retarded during a typical phase. In Chapter 6, to be sure, we found that its growth had no general tendency to decelerate. Broadly speaking, therefore, we must expect to find the inference proper in expansions. We had no occasion in that chapter, however, to investigate the successive rates of decline during contractions. Even in expansions there were some decelerations; allowance for them might alter in detail the foundation for the impression suggested. To examine the relation between changes in traffic and in productivity we need a new kind of computation, which may be illustrated as follows. In stage I of the 1921–24 cycle, average monthly traffic was 31.85 billion units. In stage II traffic averaged 33.16 billion. The increase during the first segment was 1.31 billion (33.16 – 31.85). Output per man-hour rose from 101.2 to 104.4 units (Table 58), a difference of 3.2. The improvement in productivity per billion-unit increment of traffic was 3.2 ÷ 1.31 or 2.4 traffic units per man-hour. By the same procedure we compute that the gain in productivity per billion-unit increment of traffic during the second segment was 6.5 units per man-hour.

Table 61
Traffic Units per Man-hour Worked
Change per Billion-unit Change in Aggregate Traffic Units

Phase of traffic units	First segment	Second segment	Third segment	Fourth segment
Expansions				
1921–23	2.4	6.5	0.0	1.8
1924–26	1.9	3.1	1.5	1.4
1927–29	6.7	2.4	2.3	−18.3
1932–37	5.2	2.1	2.6	1.7
Contractions				
1923–24	−3.5	−0.3	†	−1.0
1926–27	−0.8	0.9	−1.2	−0.5
1929–32	−1.0	0.6	−0.5	0.3
1937–38	−5.5	−0.7	−0.3	2.9

† Traffic increased. Hence this segment does not present an instance of what happens to productivity in the face of successive declines in traffic.

Table 62
Traffic Units per Man-hour Worked: Change per Billion Units of Traffic
Number of Phases in which Specified Sequences Occurred

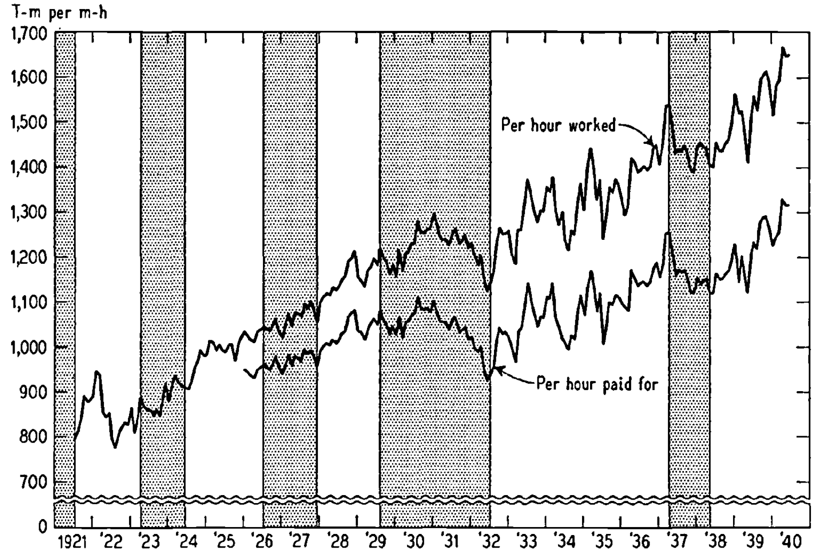
Expansions		Contractions	
Rise in first segment, and		*Fall in first segment, and*	
Fall, or smaller rise, in second	2	Rise, or smaller fall, in second	4
Fall, or smaller rise, in third	4	Rise, or smaller fall, in third	2†
Fall, or smaller rise, in fourth	4	Rise, or smaller fall, in fourth	4
Rise in second segment, and		*Fall in second segment, and*	
Fall, or smaller rise, in third	3	Rise, or smaller fall, in third	1†
Fall, or smaller rise, in fourth	4	Rise, or smaller fall, in fourth	1
Rise in third segment, and		*Fall in third segment, and*	
Fall, or smaller rise, in fourth	3	Rise, or smaller fall, in fourth	3†

Derived from Table 61.
† Out of 3, not 4, possible cases.

In this particular instance comparative results for the two segments differ from those previously obtained. The increase *per month* in productivity was greater in the first than in the second (Table 59). But the increase per *billion* in the second exceeded that in the first. Generally speaking, however, the improvement per billion, like that per month, was usually larger in the first segment of expansion than in later stretches, and the deterioration per billion was larger in the first segment of contraction (Tables 61 and 62). Most comparisons between later segments yield similar results in expansions, but not in contractions.

CHART 78

Revenue Ton-miles per Man-hour Worked, July 1921—June 1940, and per Man-hour Paid For, January 1926—June 1940: Freight Train and Engine Service



Shaded periods are contractions in revenue ton-miles.

Productivity in train and engine service

The work of most railroad employees contributes to the production of both passenger-miles and ton-miles. A track gang replacing rails, ties, or ballast on a section of line over which both freight and passenger trains operate is not engaged in serving either kind of traffic exclusively. Consequently, we are obliged to compare the collective labor of all 'hourly' groups with the composite volume of traffic. The hours of the men who run trains, however, can realistically be divided between the two services.[4] We can therefore appropriately compare man-hours worked on freight trains with

[4] Mileage of 'mixed' trains, containing both freight and passenger cars, is a minute percentage of total mileage.

revenue ton-miles, and those worked on passenger trains with passenger-miles.[5]

Table 63
Revenue Ton-miles per Man-hour Worked in Freight Train and Engine Service
Change per Month between Peaks and Troughs in Revenue Ton-miles, 1921–1929

Date of turn	July 1921	Apr. 1923	June 1924	July 1926	Dec. 1927	Aug. 1929
Level of ton-miles	Trough	Peak	Trough	Peak	Trough	Peak
Months from preceding date	...	21	14	25	17	20
Ton-miles per man-hour worked[a]	805[b]	865	909	1,041	1,078	1,199
Change from preceding date						
Total	...	60	44	132	37	121
Per month						
To peak from trough	...	2.9	...	5.3	...	6.0
To trough from peak	...	...	3.1	...	2.2	...

[a] Three-month average; date of turn is middle month.
[b] Average for July and August only; no data for June.

The ratio of ton-miles to man-hours of freight train crews has increased remarkably since 1921 (Chart 78). One hour of labor was required for about 850 ton-miles in 1921–23, about 1,450 in 1937–38. Productivity rose perceptibly in all expansions except 1921–23, and in two contractions, 1923–24 and 1926–27. It increased irregularly during the first half of the great 1929–32 contraction also; but toward the end it began to decline; the net result for the phase as a whole was a loss. In 1937–38 ton-miles per man-hour decreased. The rise in 1926–27 was noticeably slower than in the adjacent expansions. There was no very obvious difference be-

[5] For freight service the man-hour data are totals for the following 'road freight' occupations, both 'through' and 'local and way': conductors, brakemen and flagmen, engineers and motormen, firemen and helpers. For passenger service they include the work of conductors, assistant conductors and ticket collectors, baggagemen, brakemen and flagmen, engineers and motormen, firemen and helpers.

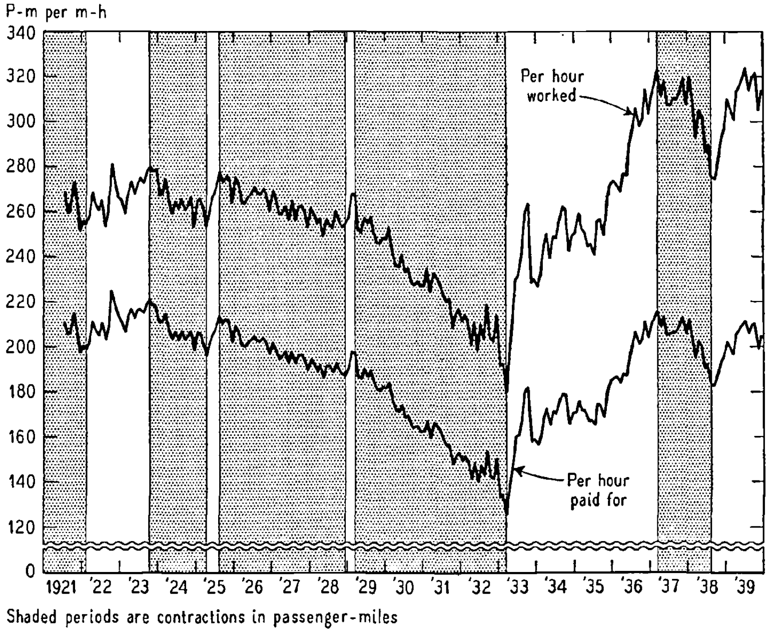
'Straight time worked', 'overtime paid for' and 'constructive allowances' are included. The third item represents equivalents in train and engine time of miscellaneous services, such as 'deadheading' back from outside to home terminal when no homebound assignment is available, attending court, etc.

Variations in labor productivity in the two services were analyzed by Gerald J. Fischer in *A Case Study of the Cyclical Behavior of Productivity and Unit Costs* (ms., April 1941). His conclusions are similar to those presented here, although his method of approach was somewhat different. He has kindly lent us his compilations of total hours worked.

tween 1923–24 and 1924–26; our usual method of computation, however, yields a slower average rise in the contraction (Table 63). Six of 7 comparisons of a phase with its following phase, therefore, indicate that productivity conformed positively to traffic. The exception arises from a comparison of 1921–23 with 1923–24: although the net effect of the highly irregular changes in the expansion was a slight rise, it was smaller in proportion to time elapsed than the increase in the contraction.

CHART 79

Passenger-miles per Man-hour Worked, and per Man-hour Paid For: Passenger Train and Engine Service, July 1921—December 1939



In passenger service, unlike freight, there was no persistent upward trend in productivity (Chart 79). In 1937, however, a new high level was reached even though the volume of traffic was much lower than at previous peaks.[6] Cycles in passenger-miles were even

[6] The trend in freight service is largely explained by the effect on hourly train performance of the technological changes described in Chapter 4. Similar influences affected passenger service, but were opposed by a downward trend in the traffic itself.

more clearly reflected in productivity than cycles in ton-miles. There was an increase in every expansion, a decrease in every contraction of travel. Even in the brief and small expansions of 1925 and 1928–29, the downward slope of output per man-hour was interrupted by short rises.

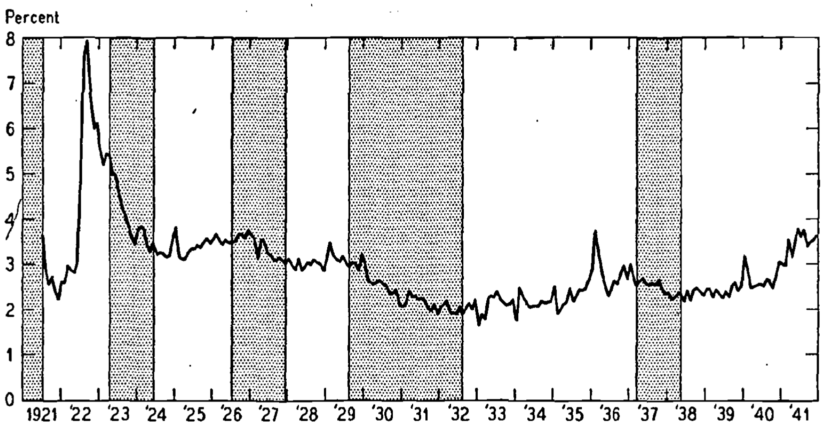
OVERTIME AND IDLE TIME

Relatively more overtime when traffic is heavy

Even though the man-hours required per unit of product do not regularly increase as expansion proceeds, or decrease in contraction, perhaps the railroad companies must pay for a greater proportion of expensive labor as traffic grows, and a smaller proportion as it diminishes. It has often been observed of business at large that overtime work increases and declines more rapidly than other work. Taken by itself this relation would tend to raise costs per unit of product in expansion. Some analysts have seen in it one of several factors which, they suppose, limit profitability and tend to bring prosperity to an end.

CHART 80

Overtime Paid for at Punitive Rates: Percentage of Total Man-hours Worked, All 'Hourly' Workers, July 1921—December 1941



Shaded periods are contractions in traffic units.

In the railway industry, some of the most striking fluctuations in the ratio of overtime to total hours were not related to the cyclical ebb and flow of traffic (Chart 80). From June to September 1922, that ratio shot up very suddenly to a point never subsequently attained (within the period covered by our data), then tumbled almost as abruptly, although not to its former low level. The shopmen's strike accounts for this wild variation. As many of their maintenance people were absent, the railroad companies were forced to keep some of the remaining workers on duty longer, at overtime rates. Even after the strike an accumulation of locomotives in need of repair provided an occasion for considerable overtime (Chart 73). The blizzard conditions in early 1936 delayed many trains and made it necessary to clear unusual quantities of snow and ice from lines and yards. One result was another sharp rise in the overtime ratio, culminating in February.

Nevertheless there was a clear general relation between the overtime ratio and the cycles in traffic. Although the intervening disturbances were great, the ratio was higher at the end of the 1921–23 expansion than at the beginning. What the high points of 1936 lie above is a general upward movement for 1932–37. The ratio rose in the 1924–26 expansion also. In 1927–29, to be sure, the curve is irregular and on the whole rather flat; in the final three months, indeed, it averaged slightly lower than in the initial three—2.99 instead of 3.08 percent. Yet there is a definite contrast between its course during this phase and the sharp declines in the neighboring phases. It fell in all the contractions, and conformed positively to cycles in traffic without exception.[7]

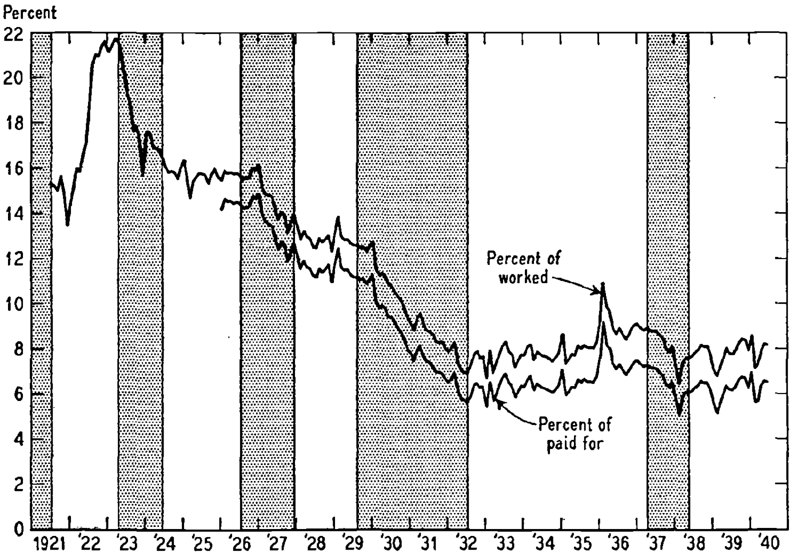
We can compare overtime in each branch of road service with fluctuations in the corresponding kind of traffic. The ratio of overtime hours to total hours on freight trains (Chart 81) rose sharply in the middle of 1922, presumably because of the shopmen's strike. Although that dispute did not involve train and engine workers, it probably often delayed the departure of crews from their starting points beyond the time when pay began, because engines were not ready. Mechanical failures probably caused additional delays on the road. The average speed of trains declined sharply in those months, especially in August (Chart 40). The unusual weather in

[7] The curve for the ratio of overtime to total hours *paid for*, all 'hourly' occupations, available only from January 1926, looks almost exactly like that for the ratio to total hours worked, except that the former is slightly lower, of course, in all months.

1936, by slowing trains, produced an erratic rise in the overtime ratio.

CHART 81

Overtime Paid For: Percentage of Total Man-hours worked, July 1921—June 1940, and of Total Paid For, January 1926—June 1940, Freight Train and Engine Service



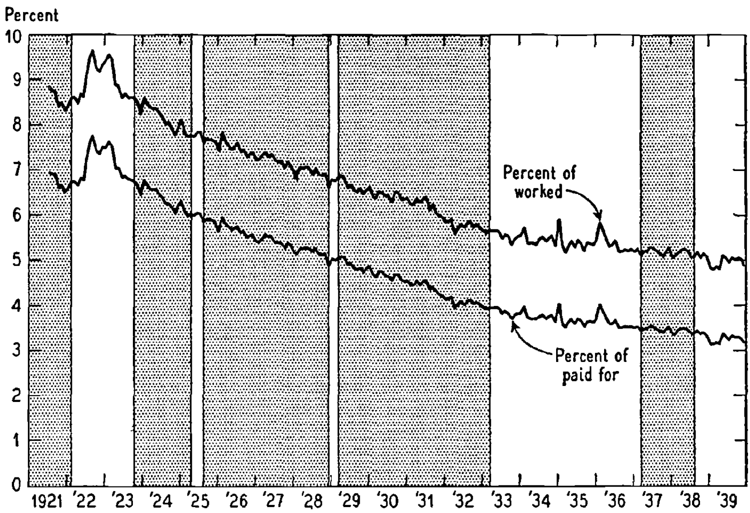
Shaded periods are contractions in revenue ton-miles.

The long decline from 1923 to 1932 must be a result of those changes in plant, equipment, and methods which tended in all phases to speed up trains. A more or less constantly increasing percentage of the crews could complete their runs within 8 hours. Still others could finish up in 9 rather than 10, in 10 rather than 11. Speeding up trains on runs long in terms of miles could eliminate overtime even if, as quickened, the run took more than 8 hours. The rules define overtime as the excess of actual hours over the time required to complete a run at a standard speed of 20 miles per hour for passenger and 12.5 miles for freight trains. For example, if a freight engineer made a trip of 125 miles at an average speed of 12.5 miles an hour or more, i.e., in 10 hours or less (including time off the locomotive at terminals), he would not earn any pay at overtime rates. If such a trip previously required

11 hours and the time were brought down to 10, overtime pay formerly accrued would disappear.[8]

CHART 82

Overtime Paid For: Percentage of Total Man-hours Worked, and of Total Paid For, Passenger Train and Engine Service, July 1921—December 1939



Shaded periods are contractions in passenger-miles.

In spite of these other influences, however, cyclical variations in ton-miles were clearly reflected in the percentage of overtime. It fell in all contractions; in 2 expansions it rose, in the other 2 it declined less rapidly than in adjacent phases. (The higher level at the end of 1921–23 can hardly be attributed to the strike, the effects of which must have disappeared by that time).

Overtime is a smaller percentage of total hours in passenger than in freight service, and its ratio to the total has been influenced more obviously by technological changes. After rising during the 1922 strike it declined almost continuously throughout our period (Chart 82). Apparently the average speed of passenger trains improved gradually but persistently, bringing more and more runs within standard working hours for such runs.

[8] For a description of the rules governing overtime and time not worked see *A Survey of the Rules Governing Wage Payments in Railroad Train and Engine Service* (Federal Coordinator of Transportation, Washington, D. C., 1936), I, 1–14.

Table 64

Ratio of Overtime and of Time not Worked to all Hours Paid for, Passenger Train and Engine Service

Change per Month between Peaks and Troughs in Passenger-miles, 1922–1938

Date of turn	Feb. 1922	Oct. 1923	Apr. 1925	Aug. 1925	Dec. 1928	Mar. 1929	Mar. 1933	Mar. 1937	Aug. 1938
Level of passenger-miles	Trough	Peak	Trough	Peak	Trough	Peak	Trough	Peak	Trough
Months from preceding date	...	20	18	4	40	3	48	48	17
Overtime hours									
Ratio (% of all hours)†	6.69	6.75	5.99	5.94	5.02	5.03	3.93	3.48	3.40
Change in ratio									
Total	...	0.06	−0.76	−0.05	−0.92	0.01	−1.10	−0.45	−0.08
Per month									
To peak from trough	...	0.003	...	−0.012	...	0.003	...	−0.009	...
To trough from peak	...	...	−0.042	...	−0.023	...	−0.023	...	−0.005
Hours not worked									
Ratio (% of all hours)†	21.6	21.2	22.6	23.0	26.1	26.1	30.2	33.0	33.5
Change in Ratio									
Total	...	−0.4	1.4	0.4	3.1	0.0	4.1	2.8	0.5
Per month									
To peak from trough	...	−0.020	...	0.100	...	0.000	...	0.058	...
To trough from peak	...	...	−0.078	...	0.078	...	0.085	...	0.029

† Three-month average; date of turn is middle month.

Little if any relation between cycles in passenger-miles and the percentage of overtime is readily observable on the chart. But computation by our usual method indicates positive conformity in 6 of 7 comparisons (Table 64). The deceleration or interruption of downward trend in expansions and the acceleration in contractions, however, were very slight. Even in the absence of noncyclical factors making for a falling ratio, fluctuations in the latter would not be important. As noted in Chapter 5, considerations of service to the public make schedules rather inflexible; consequently there is little occasion for cyclical variations in the hours consumed by the average run or in the percentage of overtime.

Relatively more unused hours paid for when traffic is light

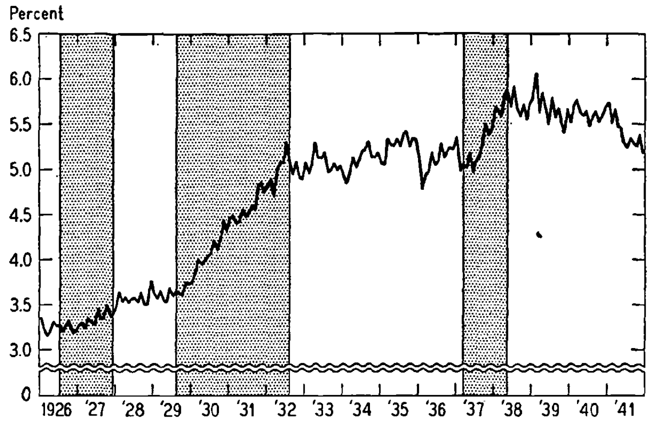
The changes in the relative importance of overtime tend to be counteracted, in their effect on costs per unit of business, by those in the relative importance of time paid for but not worked. Railroad employees draw pay for many hours they do not spend on railway premises. In part this is vacation time, although formal vacations have been relatively uncommon in the industry. But much of it arises from the inflexible nature of working assignments on trains. Before 1926 hours paid for but not worked in freight train and engine service were not reported. Without them the data for other occupations are of little value for our present purpose. Consequently we examine the ratio of time not worked to the total paid for in only five phases.

Over that period as a whole it increased (Chart 83). But it rose very slowly in 1926–27, and fluctuated irregularly without any noticeable upward trend in 1936–37. On the other hand, it rose vigorously in the contractions, and therefore conformed inversely to cycles in traffic.

The conformity is explained principally by conditions governing that part of the unused hours which is paid for in connection with train service. A railroad cannot so arrange its line, terminals, and schedules that the run of a train will usually require exactly a full working day. In many cases the run must be shorter. But if a trip takes 6 hours and the engineer spends half an hour in reporting for duty or signing off, there is not much he can do with the remaining $1\frac{1}{2}$ hours of the theoretical eight-hour day. Wage contracts provide that a man must be paid for a full day, and sometimes, in addition, require that he must receive specified minimum aggregate earnings per month. When the wages for working time only are insufficient to meet the contract requirements, train and engine employees in road service must be paid for enough extra hours, not worked, to meet the minimum.[9]

CHART 83

Man-hours Paid For but Not Worked: Percentage of Total Paid For, All 'Hourly' Workers, January 1926—December 1941



Shaded periods are contractions in traffic units.

In all five phases for which we have data, time paid for but not worked in road freight service increased relatively to total time paid for, and therefore to time worked (Chart 84). The rise in 1932–37 was slight and irregular, however, and that in 1927–29 was less rapid than in the following contractions, although not appreciably different from the average rise in the preceding one. On the whole, the ratio of not worked to paid for conformed inversely to the cycles in ton-miles.

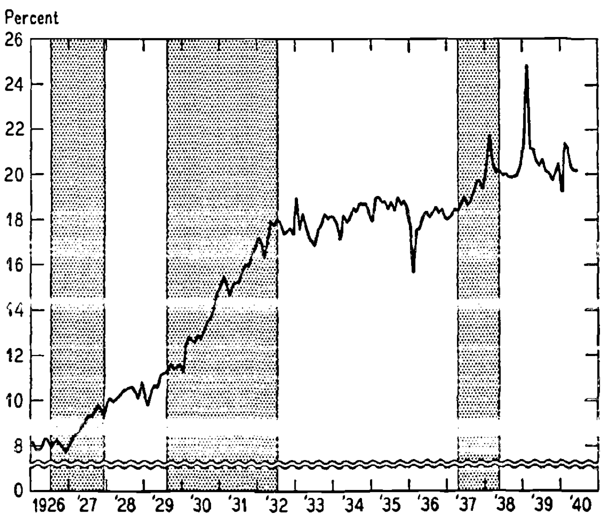
The curve for the ratio of unused to total hours in this service looks very much like the curve for the speed of freight trains (Chart 40). Because of faster movement, some trips that formerly required, say, 10 hours now consume only 9, others last 7 instead

[9] Extra hours are not paid for in all cases when the run is shorter than the standard day. Pay for work actually done is computed per hour or per mile, whichever gives the higher total. In some cases the mileage basis yields enough pay to equal or exceed the daily minimum; no hours not worked are then paid for.

of 9, still others 6 instead of 7. Higher speeds reduce the percentage of overtime in some situations, increase the percentage of time not worked in others, for similar reasons. Just as bringing a run that once required well over 8 hours closer to that limit curtails or eliminates overtime, acceleration of trips that previously took 8 hours or less creates or widens margins between the time that must be paid for and the time actually worked. If trains formerly traversed an operating division not more than 100 miles long in 9 hours and now cover it in only 7, each member of the train crew must be paid for 1 hour of time not worked instead of none as before. (His aggregate earnings for the trip, however, are smaller.) If runs are shortened from 7 hours to 5, unused time rises from one-eighth to three-eighths of the total paid for. The technological changes that encouraged the quicker completion of trips tended to raise the percentage of hours not used in all stages of cycles in ton-miles. The multiplication of stops and delays in expansion slowed the rise in 1927–29 and 1932–37. The diminution of stops and of congestion during contraction accentuated the rise in 1926–27, 1929–36, and 1937–38.

CHART 84

Man-hours Paid For but Not Worked: Percentage of Total Paid For, Freight Train and Engine Service, January 1926—June 1940

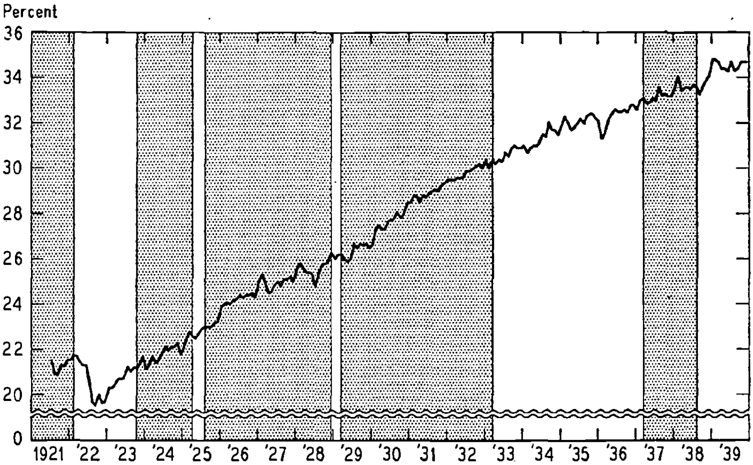


Shaded periods are contractions in revenue ton-miles.

In passenger service figures on time not worked are available as early as 1921. The most impressive feature of the ratio to total time paid for is the almost unbroken rise from 1922 to the close of our period (Chart 85). At the beginning about 21 percent, at the end about 33 percent of all hours paid for were not used. Although there are no continuous data on average passenger train speed, one would infer from this evidence, as from the overtime data, that it must have increased steadily.

CHART 85

Man-hours Paid For but Not Worked: Percentage of Total Paid For, Passenger Train and Engine Service, July 1921—December 1939



Shaded periods are contractions in passenger-miles.

There seems to be little relation between the ratio and cycles in passenger-miles. It rose in expansion and contraction alike. No difference in pace can confidently be observed on the chart, and a calculation indicates little conformity—3 comparisons score positive, 4 inverse (Table 64). The absence of cyclical changes probably arises from the intricate connection, discussed in Chapter 5, between train schedules and the habits and convenience of travelers.

The gaps between the length of tasks and the length of the nominal day have no analogue in yard train and engine service or in departments of work other than train operation. In passenger service there was no appreciable cyclical variation in the importance of unused hours. The inverse relation between traffic and the percentage of time paid for but not worked in all occupations lumped together must arise mainly from the situation in road freight service. In the absence of technological changes tending to accelerate trains, both the ratio for freight service and that for all man-hours would probably not only rise in contraction but fall in expansion.

HOW STABLE IS MAINTENANCE WORK?

Since railroad companies do not fully offset the deterioration of equipment by repairs (and new acquisitions) in contraction, and more than compensate for it in expansion (Ch. 6) one might suppose that the use of materials and labor in maintenance of cars and engines would decline relatively to current wear and tear in the former and rise in the latter. Presumably damage to vehicles is roughly proportional to the miles they travel. If mileage were closely related to traffic, the argument would lead us to expect that the expenditure of labor and materials would rise faster than traffic in expansion and fall faster in contraction. If this were true and if a similar situation prevailed in other industries, such perverse flexibility of maintenance policy would be a factor of some consequence in intensifying the amplitude of business cycles. For an initial change in the volume of patronage received by enterprises would lead to a disproportionate change in the employment of maintenance workers and in the consumption of commodities used in repairs.

Actually, however, the mileage of equipment does not rise or fall in proportion to traffic (Ch. 4 and 5). Diminishing business is likely to be accompanied by more, increasing business by fewer vehicle miles per traffic unit. Wear and tear, then, would not be augmented or abated in proportion to rises and declines in traffic. The number of vehicles rendered unserviceable probably does not increase or decrease in proportion to traffic. The smaller amplitude of fluctuations in that number might counteract in some degree the rise and fall in the percentage of needed repairs performed. On the other hand, vehicles deteriorate even when they are not in use.

Care of equipment, moreover, is only one part of maintenance work. Large quantities of materials and effort are required to keep the roadway and structures in sound condition. And there is reason to believe that some of these expenditures, at least, are but loosely related to traffic. Weather is an important factor. Rain continues to nibble away at embankments and wash soil into ditches whether the volume of business is great or small. In this department the work called for might increase relatively to falling traffic and diminish relatively to rising traffic. On the other hand, standards of maintenance could be raised or lowered. The roadbed could be allowed to become somewhat rougher when revenues were declining and less money was available; it could be made smoother when the companies grew more prosperous.

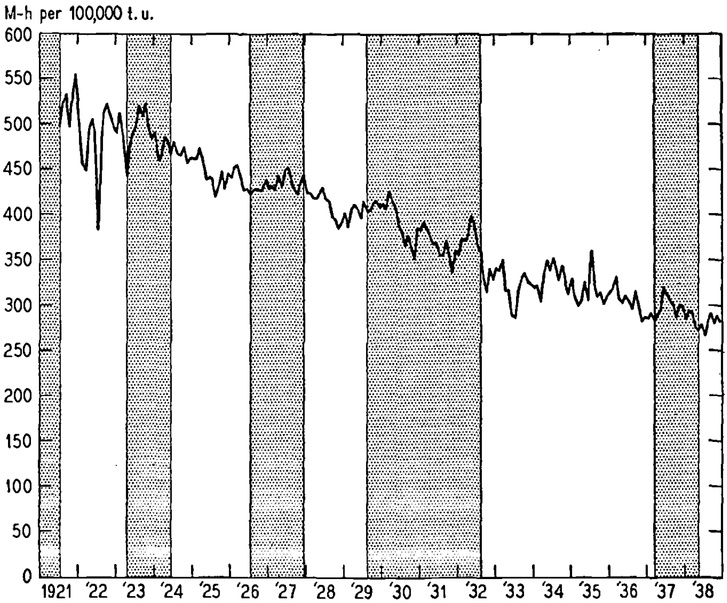
We have no adequate data on the quantity of materials used in maintenance. We do have figures, however, on man-hours of maintenance labor, which we can divide by traffic units. The quotient might be called 'labor requirements per unit'. In form it is the reverse of the ratios we have previously considered, which pertained to traffic units per man-hour. When we were dealing with 90 percent of all workers or with those directly engaged in handling traffic, it seemed natural to speak of that traffic as their product, although factors other than the labor directly involved, of course, contribute to any product. But this manner of speaking is less appropriate when we are discussing a minority (although a large minority) of workers who do not participate in the actual movement of goods and passengers.

On the whole, the facts do not seem to support the thesis of perverse flexibility. In all expansions, man-hours of maintenance work per unit of traffic diminished (Chart 86). In two contractions the ratio shows a net rise; in the other two it declined, but in one of these, comparison with adjoining phases indicates a less rapid fall than in expansion (Table 65). On the whole, maintenance work tended to decline relatively to traffic in expansion, and to increase relatively to traffic in contraction.

This conclusion becomes more remarkable when we remember that the man-hour statistics include some labor devoted to capital improvements rather than to current operations, and that the ratio of construction work to all work tends to rise and fall with traffic. The data on wages charged to improvement suggest, it is true, that the fluctuation in the percentage of all man-hours devoted to non-operating purposes is not large. But probably most such workers are classified in the maintenance groups. The percentage of their hours to total 'maintenance' man-hours must fluctuate considerably more than the ratios in Table 56. Yet despite this inflation of the statistics in expansion and their deflation in contraction, 'maintenance' man-hours tend to vary less than traffic. If the labor charged to capital accounts could be excluded from the figures, the inverse conformity of hours required per traffic unit would appear more decided than it does in Chart 86.

CHART 86

Man-hours Paid For in Maintenance Work per 100,000 Traffic Units, July 1921—December 1938



Shaded periods are contractions in traffic units.

Before we conclude that unit maintenance labor requirements are *inversely* related to traffic, however, we should note that the course of the ratio within a phase was sometimes quite erratic. In 1921–23, for example, it fluctuated violently although the net

Table 65

Maintenance Man-hours Paid for per 100,000 Traffic Units

Change per Month between Peaks and Troughs in Traffic Units, 1921–1938

Date of turn	July 1921	Apr. 1923	June 1924	July 1926	Dec. 1927	Aug. 1929	Aug. 1932	Mar. 1937	May 1938
Level of traffic units	Trough	Peak	Trough	Peak	Trough	Peak	Trough	Peak	Trough
Months from preceding date[a]						20	36	55	14
Man-hours per 100,000 traffic units[b]	510[c]	468	476	426	435	408	352	289	275
Change from preceding date									
Total	...	−42	8	−50	9	−27	−56	−63	−14
Per month									
To peak from trough[a]						−1.35	...	−1.15	...
To trough from peak[a]						...	−1.56	...	−1.00

[a] Shown only when needed to determine conformity.
[b] Three-month average; date of turn is middle month.
[c] Average for July and August only.

result for the phase as a whole was a fall. The sharp decline in July 1922 reflects the shopmen's strike; the other large irregularities are not as easily accounted for. There were notable perturbations in other phases also. Generally speaking, computations based on the end-stages of a phase are more helpful in disentangling the effect of cyclical fluctuation in traffic from that of other influences, because the differences in traffic itself are greatest and presumably most telling when measured between those points. Nevertheless, the large variation here within phases should make us somewhat chary of concluding that the amplitude of fluctuations in maintenance hours is likely to be less than that of those in traffic. But they hardly support the opposite conclusion. The evidence is that this kind of work is not regularly more variable than traffic.

The persistent downward trend in maintenance man-hours per unit perhaps deserves a little explanation. Some technological changes tended to minimize the deterioration of plant and equipment. Others enabled maintenance forces to make repairs with less effort.[10]

Burying drain pipe along particularly wet sections of track, and the growing practice of screening accumulated dirt out of ballast, prevented soggy spots in summer and upheaval by frost in winter. Impregnating cross-ties with preservatives against decay before they were laid, and the use of less abrasive tie-plates reduced the number of replacements. Traffic punishes rails most severely at their ends; treatment by heat at the rolling mills or after placement in the track made the ends more resistant. Reconstruction of battered ends by welding in place deferred the need for removal. Control of heat in manufacture, beginning about 1933, prevented the development of transverse fissures.[11] Lubricators at curves reduced the sharp wear of rails and wheels. Because the reciprocating parts of locomotives were lightened, and their counterbalance was improved, the damage they once inflicted on rails by producing rhythmic bumps had become of minor importance by 1938.[12] ICC data indicate a downward trend in the number of ties

[10] Our brief and incomplete account is founded in large part on the comprehensive review, 'A Quarter Century of Railroading Brings Many Changes in Maintenance and Construction', *Railway Engineering and Maintenance*, June 1941, pp. 396–421.

[11] John V. Neubert, Chief Engineer, Maintenance of Way, New York Central Railroad, *Official Proceedings*, New York Railway Club, Jan. 1938, pp. 101 ff.

[12] D. S. Ellis, Chief Mechanical Officer, Chesapeake and Ohio, p. 24, and H. R.

laid in replacement, beginning in 1920, and in the tonnage of rails laid beginning about 1926. Treatment of track bolts with heat diminished their tendency to stretch under strain; springier washers of alloy steel held them firmer; the heavy repetitive chore of tightening them in the track was alleviated. Substitution of soft for hard boiler water, or chemical treatment of hard water, prevented corrosion and thereby diminished repairs to locomotive flues and fireboxes.[13] Heaters eliminated the need for loosening up frozen switches.

The performance of maintenance work was largely mechanized. Cranes, power shovels, tractors, conveyors, clamshell buckets, drag-line scoops, bulldozers, spreaders pushed by locomotives, and dump cars took over many bulky jobs—keeping ditches deep, removing, cleaning and placing ballast, unloading and laying rails, clearing away snow. Great forces of trackmen laboring with picks, hand shovels, pitchforks or tongs were no longer needed. Other operations were quickened by the invention of tools guided by hand but driven by compressed air from portable field generators or by other sources of power. Pneumatic tie tampers, employed on the New York Central in 1913, apparently led the way.[14] They not only prodded the ballast into position under the ties with less labor but did a more permanent job.[15] Power-driven spike drivers, spike pullers, rail saws, adzers, wrenches, hammers, rivet cutters, drills, jacks, rotary brushes, and paint sprayers followed. Tools of this family found uses not only in maintenance of track, bridges, and buildings but also in repair of rolling stock.[16] Chemicals and flame throwers superseded hand pulling and hoeing in the control of weeds; mowing machines, instead of scythes, cut the grass along the roadside. Gangs traveled from task to task on rail motor cars and later in highway trucks; they arrived more quickly and free

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Clarke, Engineer, Maintenance of Way, Burlington railroad, pp. 33–4, *Official Proceedings*, Western Railway Club, March 1938.

[13] T. F. Powers, Assistant Superintendent, Motive Power and Machinery, Chicago and North Western, also M. A. Novak, General Boiler Inspector, Milwaukee railroad, Western Club, Dec. 1930, pp. 14 ff.

[14] On pneumatic equipment in general, see W. H. Armstrong, Manager of Tie Tamper Sales, Ingersoll-Rand Co., N. Y. Club, April 1929.

[15] Confirmed by William Elmer, Special Engineer, Pennsylvania railroad, comment, pp. 8883–4, on Armstrong.

[16] R. H. Johnson, Assistant Vice-President, Ingersoll-Rand Co., N. Y. Club, May 1940, p. 164.

from the fatigue induced by working the levers of the old-fashioned hand car.[17]

Table 66
Workers for Whom Days are Reported: Average Number, 1929

Executives, officers, chief clerks, foremen, supervisors, etc.[a]	66,448
Auditors, investigators, inspectors, etc.[b]	9,293
Professional workers, traffic agents, etc.[c]	20,991
Messengers and office boys[d]	6,168
Crossing and bridge flagmen and gatemen[e]	20,602
Total	123,502

[a] Occupational division numbers included, classification prevailing in 1929: 1, 2, 7, 8, 21, 24, 34, 35, 54, 55, 61, 62, 63, 64, 91, 93, 99, 126.
[b] Divisions 17, 26, 27, 28, 29, 65, 66, 120.
[c] Divisions 3, 4, 5, 6, 25.
[d] Division 19.
[e] Division 124.

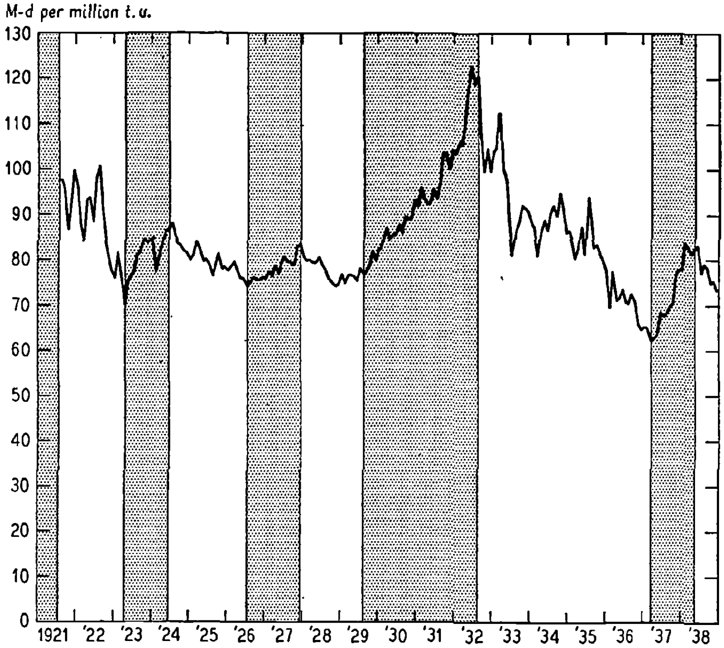
OVERHEAD JOBS WERE HIGHLY REGULAR

So far we have not examined the relation between traffic and the work of that relatively small group of employees for whom days rather than hours were reported. For many of them that relation must be remote. About half (66,000), in 1929, were engaged in supervisory tasks at some level, high or low (Table 66). Presumably a railroad company needs a president at all times, a yardmaster as long as a yard is open. Thirty thousand were investigators and experts of one kind or another, doubtless trained and skilled men with whom their superiors would be reluctant to part. Six thousand were messengers and office boys; in each of many departments, the number was probably quite small and therefore not gradually variable. Crossing watchmen and the like made a sizeable group. Even if the number of trains passing a highway intersection is cut from 20 to 10 a day it is still desirable to keep a man there to warn motorists and pedestrians. Since the duties of 'daily' workers were rather steady, the aggregate amount of their services required did not vary in proportion to traffic. Man-days paid for per million traffic units diminished in every expansion, increased in every contraction (Chart 87).

[17] Some of the innovations we mention were in fairly common use before 1920 and probably none had been adopted universally by 1938. But it is clear from the literature that all were spreading in the period covered by our statistics.

Chart 87

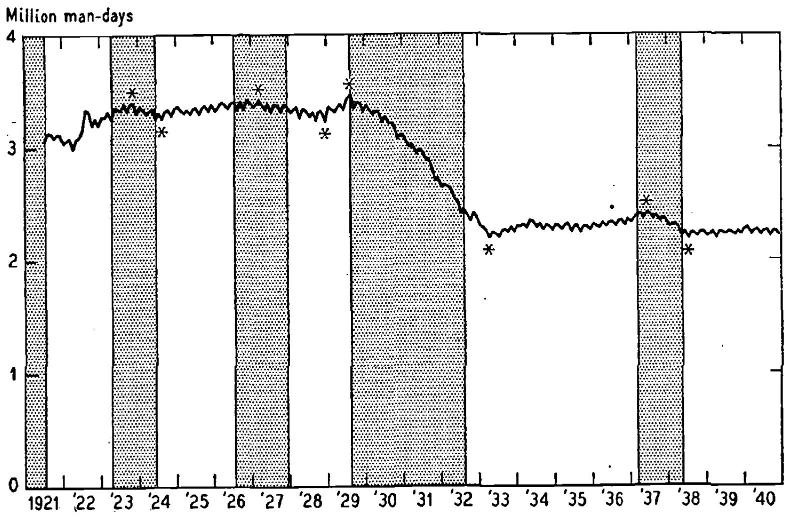
Man-days Paid For per Million Traffic Units, Occupations for which Days are Reported, July 1921—December 1938



Shaded periods are contractions in traffic units.

Chart 88

Man-days Paid For, Occupations for which Days are Reported, July 1921—December 1940



Shaded periods are contractions in traffic units.

Table 67
Days Paid for, Workers for whom Days are Reported
Percentage Change during Specific Phases, 1923–1938

Date of turn	Nov. 1923	Aug. 1924	Mar. 1927	Dec. 1928	Aug. 1929	Apr. 1933	June 1937	July 1938
Level of days paid for	Peak	Trough	Peak	Trough	Peak	Trough	Peak	Trough
Number of days† (thousands)	3,362	3,299	3,391	3,308	3,413	2,237	2,401	2,223
% change from preceding date	...	−1.87	2.79	−2.45	3.17	−34.46	7.33	−7.41

† Three-month average; date of turn is middle month.

Consideration of the full fluctuation between 'specific' turns does not alter the picture. The expansions and contractions in daily work itself were much smaller, percentagewise, than those in traffic (Table 67; cf. Table 54).[18] They were considerably smaller than those in the number of 'hourly' men (Table 54, last column). Comparison with the aggregate hours worked by the latter, or paid for, would indicate an even more striking contrast.

LABOR COST VARIED INVERSELY WITH VOLUME

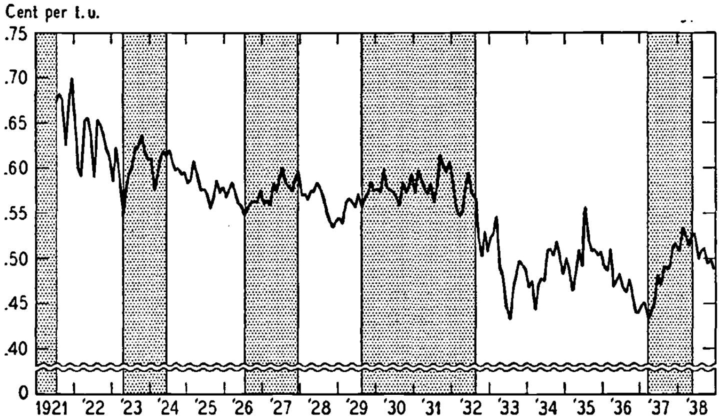
Since the number of man-hours and man-days required per unit of traffic, in all occupations collectively, tended to decline in expansion and rise in contraction, one might expect that expenditures for labor, per traffic unit, would vary similarly. Indeed this would necessarily be true if there were no changes in the relative amounts of work paid for at high rates and at low rates, or in the wage rates themselves. But we know that the ratio of overtime paid for at punitive rates to total time tended to vary directly with traffic. The effect on cost of cyclical fluctuations in requirements per unit must be counteracted to some extent by the opposite fluctuations in the percentage of overtime. Two of the important changes in wage rates during the period our monthly employment data cover tended also to offset the effect of changes in productivity. Late in the 1929–32 contraction rates were cut 10 percent.

[18] In most cases the aggregate days did not rise or fall until two months or more after the corresponding change in traffic had begun (Chart 88). The same number of days, 3,250,000, were worked in June 1924, the traffic trough, and August. We place the turn in days at the latter month in accordance with our uniform if arbitrary rule. For the same reason we place a peak in days 8 months after the traffic peak of 1926, although they were equally numerous 4 months after it.

During the following expansion the reduction was eliminated. Despite counter-effects, however, the ratio of aggregate compensation of labor to traffic decreased in every expansion, increased in every contraction except 1929–32 (Chart 89). Even in that phase, there was an upward general slope until near the end, and the average at the traffic trough, .5534 cents, was only a trifle below that at the peak, .5659 cents.

CHART 89

Compensation of All Workers per Traffic Unit, July 1921—December 1938



Shaded periods are contractions in traffic units.

Important readjustments of wages occurred in two other phases, 1921–23 and 1937–38. In these the alterations of rates tended to reenforce the effect on cost of cyclical changes in productivity rather than to oppose it. In 1937–38, however, cost would have risen, as in other contractions, even if the wage rates had not been raised, for the increases in the latter averaged roughly 8 percent, while the rise in unit cost was 19 percent. In the expansion of 1921–23, unit cost would have fallen without the rate cuts. They were equivalent to something like a 7 percent reduction for all occupations; the fall in unit labor cost was 15 percent.[19]

As noted previously, the aggregate compensation figures which we here divide by traffic units include a rising percentage of capital expenditure in expansion, a falling percentage in contraction. If such outlays, not chargeable to operations, could be excluded, the

[19] Changes in rates of pay will be discussed more extensively in Chapter 9.

cyclical variation in unit labor expense would prove to be even more pronounced than it appears to be on Chart 89. We would probably find a net rise even in 1929–32.

PRODUCTIVITY ROSE FROM CYCLE TO CYCLE

Although traffic units per man-hour rose and fell in rough correspondence with aggregate traffic, equal volumes of traffic in different cycles were not accompanied by equal output-input ratios. On the contrary, wherever we can compare a stage of one cycle with a stage of an earlier cycle in which volume was about the same or even somewhat larger, we find that output per man-hour was greater in the later cycle (Chart 90). In the last two stages of 1929–32, the ratio of traffic units to man-hours was much higher than in any stage of 1921–24, although volume was much lower. The curve of the relation between productivity and aggregate traffic appears to lie at a higher level in each expansion than in the preceding expansion, and in each contraction than in the preceding contraction. These data suggest what a detailed survey of changes in railway plant, equipment, and operating methods would doubtless confirm: in the 1920's and '30's the number of man-hours that would have been needed to handle a constant volume of traffic was steadily diminishing.

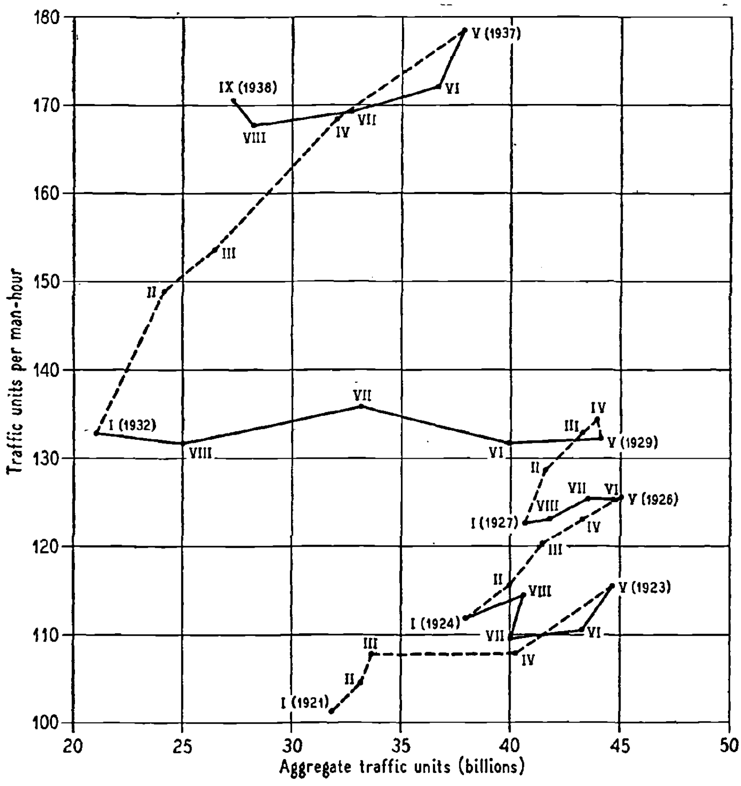
Recognition of the role played by these changes does not destroy the value of our previous finding that output per man rose in expansions. On first thought one might attribute the rises to improvements in the art of railroad transport rather than to growth of traffic. But on this interpretation there should have been increases in contractions too. When traffic diminishes new methods are not forgotten, improved plant and equipment do not disappear. Indeed the railroads then have an opportunity to conduct operations with the help of their better equipment and machinery only.[20] The volume of business is no longer so great that relatively archaic facilities must be pressed into emergency service. Yet output per man-hour declined. We must infer that it is affected by volume, independently of technical change. If so, the growth of traffic, as well as technological advances, must contribute to the

[20] During a depression the Erie, for example, studied the wage, fuel, and maintenance costs of various locomotives, and put the most expensive engines in storage. Robert E. Woodruff, System Operating Vice-President, *Official Proceedings*, New York Railway Club, Sept. 1930, p. 9298.

rise of productivity in expansions. There would have been some increase in product per hour even if technology had been stationary. In phases of rising traffic, volume and technology reenforced each other; in contractions, they opposed each other, and shrinking traffic was more powerful. Without developments in technique the cyclical rises in output per man-hour would have been smaller and the declines larger.

CHART 90

Traffic Units per Man-hour Worked, and Aggregate Traffic Units; Averages for Stages of Cycles in Aggregate Traffic Units, 1921–1938



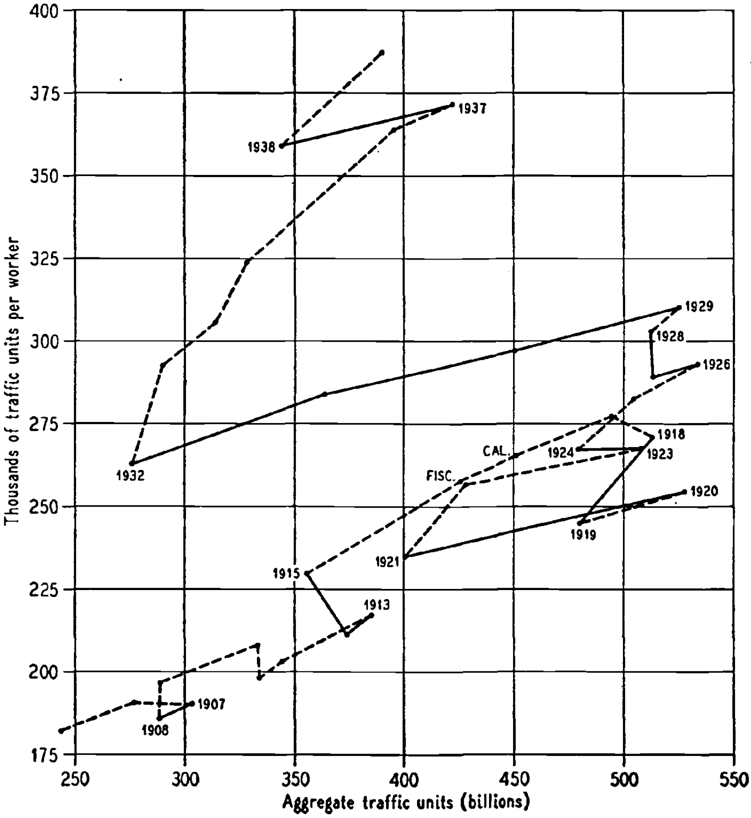
Annual figures on the number of workers enable us to compute cruder measures of productivity for a longer period (Chart 91[21]).

[21] Number of workers (divisor) is average of year-end figures for 1914 and prior years; thereafter the ICC average of several counts during year. Number at end of 1913 from Table 53. Years before 1905 not shown because traffic never subsequently receded to pre-1905 amounts.

In 1915–17 the level of the relation between traffic units per man and aggregate volume was apparently higher than in preceding expansions, although lack of a substantial overlap between the ranges of traffic somewhat impairs one's confidence in such a conclusion. Introduction of the 8-hour day after 1918 caused a general drop in level from 1915–18 to 1919–20. Thereafter the upward shift was resumed. The 1921–23 section of the curve, at least in its later portion, lies above 1919–20, and 1923–24 lies above 1920–21. The curve for the latter part of 1924–26 looks like a projection of that for 1915–17: the loss in output per man resulting from the 8-hour day seems to have been regained. Although traffic in 1932 was less than in 1908, product per worker was much greater.

CHART 91

Traffic Units per Worker, and Aggregate Traffic Units, 1905–1939



Before 1921 expansion usually created more jobs than were lost in the preceding contraction. For example, 1,699,000 men were at work on June 30, 1910; the number fell to 1,670,000 on the next June 30 but rose to about 1,831,000 on June 30, 1913 (Table 52). After 1921 this was no longer true. On the average there were 2,023,000 workers on Class I railways in 1920; for the three peak months in 1923 the average was only 1,843,000. And this comparison understates the difference, for, although we do not know the number in the three peak months of 1920, it was undoubtedly higher than the average for the entire year. The 1926 peak was below 1923, 1929 was below 1926, 1937 far below 1929 (Chart 75). In the old days experience suggested that after a contraction there would be more jobs than ever; in more recent times this consoling prospect was lost.

The reason is to be found in a combination of circumstances. Traffic itself no longer surpassed previous records by any wide margin; in 1937 it notably failed to reach them (Ch. 1–3). Meanwhile changes in the art of railroading made it possible to handle any specified volume of traffic with fewer men than the same traffic would have required some years earlier. Similar changes in technique were in progress long before 1921, but traffic at each peak exceeded its previous peak level so greatly that any effect of technological progress on employment was more than offset by the growth of business, except perhaps in 1920, when the increase in the number of workers over 1918 might not have occurred without the reduction in hours. (It is also possible that there was some reduction in hours per worker between earlier peaks.) After 1920, on the other hand, the expansion of traffic went so little beyond preceding high levels, even when it did not end below them, that it was no longer sufficient to offset the effect of changes in technique.

Some of the technological innovations that reduced unit labor requirements in the operations of road trains and in maintenance work were discussed in Chapter 4 and in preceding sections of this chapter. Progress occurred in other departments also; for example, in yard work. Where freight cars are formed into trains by letting them roll down a gradual slope, switches must be thrown to guide them to the proper track. Originally a number of men on the ground performed this task, but at some time before 1909 an electro-pneumatic system made it possible for a single towerman pressing buttons to handle it.[22] Meanwhile a rider was still needed on each cut of cars; he controlled the speed at which it moved by manipulating the brakes on the vehicles. At many yards, however, car retarders now do away with this dangerous job. They are brakes on the ground; when activated from the tower they squeeze the passing wheels. First employed at Gibson Yard near Chicago in 1924, they were in use at seven other yards in May 1927 and were being installed in four others.[23] In their voluminous office work the railroads have benefited from the numerous familiar inventions in the field of stenographic and bookkeeping machinery.

The upward trend in the length of hauls and journeys has probably contributed to the decline in unit labor requirements. Often it is just as easy to make out a waybill or sell a ticket for a long movement as for a short one, no harder to switch a car from its loading point to a road train or from the latter to the unloading point if the two points are 500 miles apart than if they are 50 miles apart. Longer movements must, however, have increased the number of intermediate terminal handlings per shipment and the amount of interline accounting per shipment or passenger, but perhaps not in proportion to distance.

THE QUALITY OF LABOR

Trained reserves in recent cycles

The virtually continuous improvement in productivity during expansions of traffic after 1920, and the absence of a consistent retardation toward their ends, can perhaps be explained in part at least by the fact that the companies did not have much occasion to take on 'green hands' in this period. In earlier cycles, the increase in aggregate labor requirements above previous peaks meant that many new workers had to be trained in railway duties. But during the postwar era to which our stage-by-stage figures pertain, the number of persons who had worked on a railroad at some time in the recent past must at all times have exceeded the

[22] A survey of 27 yards in that year revealed 3 with remote control. American Railway Engineering Association, *Proceedings*, 1909, Vol. 10, Part I, pp. 278–314.
[23] W. B. Rudd, Union Switch and Signal Co., *Official Proceedings*, N. Y. Club, May 1927, p. 8347.

number currently wanted. Of course, some of the men released in depression drifted into other employments and could not be enticed back; some died or became disabled. Nevertheless, the companies must have been able to fill their needs during expansion by rehiring their own former employees to a much greater extent than industries whose volume of business exceeded previous records by wider margins.

Older workers more likely to keep their jobs in contractions

Cyclical variations in traffic are probably accompanied by changes in the average age of railway employees. Because of seniority rules the older workers on each seniority roster are the last to be dismissed when traffic falls off; when the need for personnel rises, the men who come back or the new men who are taken on are likely to be younger than those already on the job.[24] Even in the absence of formal rules, managements would probably be inclined to keep their more experienced workers when employees must be dismissed; although they are perhaps inclined to dismiss those who are also more decrepit.

Little statistical information on this question is available. The Railroad Retirement Board ascertained the distribution by age of workers on thirteen railroads as of July 1, 1924, July 1, 1929, and December 31, 1933. We can therefore observe the net change in composition during two successive intervals. The dates do not coincide, it is true, with our traffic turns. In the first instance they do not even belong in the same phase, for we find an expansion from 1924 to 1926, a contraction to 1927, and another expansion to 1929. Nevertheless, traffic was about 13 percent higher on July 1, 1929 than five years earlier, and we can regard the period as one of net expansion. Likewise the interval from the second date to the third may be regarded as one of net contraction.

During both periods employment was affected by technological change as well as by the volume of business. This is obvious from 1924 to 1929, for although traffic increased, employment declined slightly, both on all roads and on the thirteen roads in the sample. The fall was concentrated in the younger age groups: the number of workers under 25 declined substantially, the number from 25

[24] Of course one man can be senior to another with respect to past employment and yet younger; but on the whole seniority must be related to age.

to 34 somewhat.[25] The four age groups over 34 all increased (Table 68).

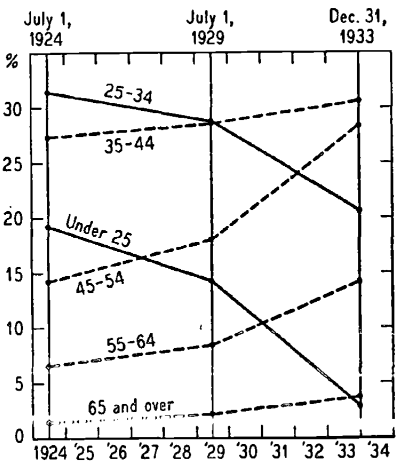
Table 68
Workers in Various Age Groups
Thirteen Railroads, July 1, 1924, July 1, 1929, and December 31, 1933

Age group	July 1, 1924		July 1, 1929		Dec. 31, 1933	
	No.	%	No.	%	No.	%
Under 25	52,940	19.2	39,164	14.2	5,261	2.8
25–34	86,321	31.4	78,892	28.7	39,034	20.6
35–44	74,987	27.3	78,794	28.6	57,994	30.6
45–54	38,936	14.2	49,416	18.0	53,740	28.3
55–64	17,990	6.5	23,043	8.4	26,799	14.1
65 & over	3,991	1.4	5,656	2.1	6,792	3.6
All	275,165	100.0	274,965	100.0	189,620	100.0

From Railroad Retirement Board, *Annual Report, 1937*, p. 66. The data appear to be about a 20 percent sample of all railroad employment.

CHART 92

Workers in Each Age Group: Percentage of Total in All Groups



Nevertheless, the younger groups maintained their relative importance much better in the expansion than in the contraction.

[25] It does not necessarily follow that a considerable proportion of the younger people at work in 1924 had lost their jobs by 1929. In five years many of them may simply have moved up into higher age groups. But it does suggest that rather few young people were taken on.

The ratio of workers under 25 and workers 25–34 to all workers declined much more rapidly in 1929–33 than in 1924–29 (Chart 92). The ratio of each of the four age groups over 34 to the total increased more rapidly in contraction than in expansion. The data strongly suggest that the average age tends to fall in expansion and rise in contraction.

If we had continuous figures on average age they would probably show for some or all of the expansions, 1921–23, 1924–26, and 1927–29, what the 1924–29 data imply—that the average rose, but more gradually than in contraction. After 1920 (to repeat) traffic did not grow very rapidly, while technological change continued. Prior to 1920 there was also much technological change; but traffic increased more rapidly and probably more than offset the effect of improved facilities on age composition. In those earlier days the working force probably became, on the average, younger in expansions.[26] What significance the figures may have for the productivity of labor is debatable. It depends on the importance of the supposed vigor and inventiveness of youth, on the one hand, and the supposed advantages of long training and experience, on the other. About such matters we are not in a position to say anything that would be both new and true. Meanwhile, the data have some independent interest in suggesting the effect of contraction on the opportunities available in old industries to young people who arrive at working age in hard times.

[26] This is what happened when traffic once more surpassed preceding high levels in World War II. In 1941 it exceeded all previous records; in 1942 it was much greater. Employment in 1940 was somewhat smaller than in 1937; the median age was 42.1 years. In 1941, however, the average number of workers was greater than in any preceding year later than 1931, and the median fell to 39.7. Further growth of employment from 1941 to 1942 was accompanied by a continued decline of the median to 38.5. Railroad Retirement Board, *Annual Report, 1942*, p. 124; *1943*, p. 45; *1944*, p. 62.