# INDUSTRIAL ACCIDENT RATES IN THE BUSINESS CYCLE

## A Study of the Experience of the California State Compensation Insurance Fund

BY

W. G. VOOGT AND A. H. MOWBRAY

In his presidential address at the May 1924 meeting, Mr. Leslie, recounting the future problems of casualty actuarial science, said among other things:

"But there is one that is so appealing to the imagination and that has such potentialities that I can not refrain from mentioning it, if for no other purpose than emphasis. It is the problem of relating the rise and fall of compensation costs with the standard index numbers for certain economic phenomena. . . .the answer is of vital importance to our business."[1]

Others have expressed themselves in like tenor recently.[2]

Believing the experience of the California State Fund peculiarly well adapted for use in an investigation into the question because of the general stability and uniformity of its business and steady regular growth, we have made a study of its experience for the five year period from January 1, 1918 to January 1, 1923 from this point of view. Our results seem to us to have sufficient significance to warrant their presentation to our professional colleagues in this Society. The particular point investigated was the variation over this period in rate of accident per unit of payroll exposure. When determined, this was compared with other data known to vary with the so-called Business Cycle.

### Data Used

For several years the State Fund has kept a monthly record of tabulatable accidents reported during that month. It has available, also, accident cards on all permanent and death cases showing date of injury, which we in this study have referred to as serious cases. We have in a combination of these records suitable material for allocating all losses, and separately serious

1. *Proceedings*. Vol. X, p. 102.

2. For example see Black—*Proceedings*. Vol. X, p. 45, Whitney—*Proceedings*, Vol. X, p. 148, *et seq*.

losses, to the month of occurence with only the insignificant inaccuracy involved in the assumption of a uniform interval between the date of accident and the date of report. If we could find a means of determining with sufficient accuracy the payrolls covered by months we could prepare accident rates by calendar months in suitable form to compare with other indices. We had the payrolls only in the form in which they are usually obtained and kept by the other companies, viz., advance estimates and audit corrections, and these were tabulated only by policy years. But by the methods we will describe we approximated to the monthly payrolls, as we believe, with a sufficient degree of accuracy.

For approximating the monthly payrolls we used

1. The initial and deposit premiums as recorded for each of the five years, 1918-1922 inclusive.

2. The additional premiums on periodical adjustments by quarters for the six years, 1918-1923 inclusive, and the first quarter of 1924.

3. The additional premiums on final adjustments by quarters for the same period.

4. The average effective premium rates shown by Schedules Z, 1917 to 1922 inclusive.

5. The pro rata unearned premiums as computed by the Fund at the end of each year 1917-1922 inclusive.

6. Certain data bearing on the seasonal character of California industry which we will indicate in connection with its use.

To permit checking of our work we quote these data in tabulated form in the appendices A to E.

## Determination of Monthly Payrolls

Our first step in the determination of monthly payrolls covered was the determination of calendar year earned premiums. These consist of two parts,

1. The earned portion of initial and deposit premiums taken *pro rata*, which is easily obtained by adjusting the net written figure by the balance of unearned at the beginning and end of the year.

2. That portion of the periodic and audit adjustments due to payrolls covered in the calendar year. This latter required some analysis of the Fund's business and certain assumptions based thereon.

It was found by study that the great majority of periodic adjustment policies were issued on a quarterly basis. It was also found that on the average there was a month and a half from the time the reports were due (shortly after the close of the period) until the bills were sent out and premiums entered up. On this basis we felt justified in assuming that the whole of the additionals on periodic adjustments of the first quarter of any year and one-half of those of the second quarter were earned in the preceding year and that the remainder were earned in the current year. A similar investigation of the annual adjustment business showed a lag of three months between the expiration date and the billing. On this basis and the assumption of uniform distribution of earnings over the policy year these additional premiums were apportioned as follows:

| Quarter | Assigned to preceding year | Assigned to current year |
|---|---|---|
| First | All | |
| Second | 21/24 | 3/24 |
| Third | 15/24 | 9/24 |
| Fourth | 9/24 | 15/24 |

The total of these last two gave the second part of our earned premiums. We admit there is chance for some error here but we do not believe it introduces serious inaccuracy.

Having thus obtained our earned premiums for each of the calendar years, we proceeded to convert them into the equivalent payrolls by dividing by the effective rates. Since the experience reported in Schedule Z for any policy year covers a portion of two calendar years, a given calendar year is covered by parts of two Schedules Z. We assumed as the effective rate for each calendar year the mean of the effective rates for Schedule Z for the preceding and current policy years. The detail is shown in Appendix C. Appendix D shows the annual payrolls thus derived.

If there were no seasonality in business activity we might take one-twelfth of the annual payroll as the monthly payroll, but since certain industries in California are peculiarly seasonal an adjustment for this was made.

We found that in Vol. IX p. 86 of the *Fourteenth Census of the United States* there is shown a tabulation of the number of

employees of California factories for each month of the year 1919 and in a separate volume dealing with mining and quarrying similar data are given for those industries. For the year 1921 similar data are given in the *Biennial Census of Manufacturers* (pp. 1290-1-Table 1038). As a test on these data we examined the actual audits of a large number of policies representing about 30% of the issues of 1922 to determine the seasonal spread of payroll. The several sets of seasonal indices were very similar yet with some differences. We did not feel justified in rejecting any of them as incorrect for their own year for some change in seasonality from year to year is to be expected. We, therefore, used these several indices for the years named. For the year 1918 we used the 1919 index and for 1920 the mean of the 1919 and 1921 indices.

The monthly payrolls as we have thus derived them are shown in Appendix E. We believe these figures represent as accurately as we could obtain them the actual payrolls covered, but we have submitted in this detail a description of our methods and the figures we used, in order that they may receive full criticism, and that such suggestions for improvements in the technique as may be called for by any weakness we may have overlooked may be illustrated by use of our data. We believe our results justify us in recommending the use of this method, as it may be improved, to other investigators of this problem.

## Accident Rates Developed

The numbers of accidents by months are shown in Appendix F and the accident rates in Appendix G parts 1 and 2.

## Analysis of Accident Rates

After careful study of these rates by the graphic method we were unable to determine any trend (independent of cyclic movement) either up or down. We have, therefore, taken it as level. In California the compensation law first came into effect in 1911 and was well known before 1918. Safety work has been actively carried on for many years and may be considered to have reached a temporary saturation point before 1918. This we feel justifies us in not allowing for trend.

A seasonal movement will be apparent in these rates which at

first puzzled us because we had allowed for seasonality in determining payrolls. But on studying the matter further we reached the conclusion that it was reasonable to expect this. Many of the more hazardous industries in California are seasonal in character and the increase in activity among these in the summer would tend to increase the average accident rates. We therefore applied a seasonal correction based on the simple method of monthly means. The results are shown in Appendix H parts 1 and 2 and graphically in Chart I.

Because of the irregularity of the series we have smoothed them somewhat by the use of a three months' moving average in the case of the total accident rate, and a five months' moving average in the case of the serious accident rate. We have also smoothed the all accident rate by a five months' moving average and computed the coefficient of correlation between the two series as so adjusted, finding it to be .823, indicating a high tendency for the serious accident rate to conform to the all accident rate.

### Comparison with Index of Production

Examining Chart I it is evident that both these rates varied approximately with the swing over the business cycle and the remaining problem is comparison with indices of other aspects of the cycle. Naturally the first index we would use would be one of physical volume of production. No such index for California exists, but Professor E. E. Day has computed an index for the Volume of Manufacture for the country as a whole. A description of the composition of this index and the values from January 1919 to November 1922 are given in the *Review of Economic Statistics*, Preliminary Volume 5, pp. 30-60 inclusive.

Chart II shows a comparison of it with the All Accident Rate. Correlation is evident, we think, but the accident rates do not follow the deep dip in 1921. An examination of Professor Day's article shows this to be due to low production in "Basic Materials and Pig Iron" not typical of California industries. Professor Day also shows an index for consumption goods which is compared in Chart II with the serious accident rate. While the correspondence is closer, Day's index shows higher movement in 1921 and 1922 than our accident rates.

An examination of the make-up of this index shows that the industries used are not generally typical of California, and we felt

some more characteristically California index should be found. We would have preferred a combination of freight car loadings and building permits, but the former were not available and the rapid development of the latter after 1919 was so great as clearly to require correction for trend and yet it was so recent as to make the determination of trend all but impossible.

We finally felt compelled to fall back upon bank clearings which measure the financial results of industrial activity though combined with other influences. We, therefore, took the clearings (as reported monthly in the *Commercial and Financial Chronicle*) of the five California cities of San Francisco, Los Angeles, Oakland, Sacramento, and Fresno, representing the bay region, Southern California, and the two interior valleys. These, after correction for price level, trend, and seasonal variation, we have shown in comparison with both accident rates in Charts II and III, in the former with Day's production indices, in the latter for sharpness of comparison, alone. The clearings series itself is shown in Appendix I.

Before commenting on the showing of this comparison we should probably briefly explain the derivation of our clearings index.

### Derivation of Clearings Index

The gross clearings were taken monthly to the nearest $100,000.00. Other investigations having found that the Cost of Living Indices of the U. S. Bureau of Labor were suitable for deflating such series, we first interpolated these indices for monthly values and divided the bank clearings by the index. This had the effect of reducing to the 1914 level.

We next took a more extensive set of clearings data annually from 1918 through 1924 inclusive to cover practically the period of a cycle and yet avoid war finance as far as possible and after deflating these fitted a straight line trend by the method of least squares. This gave us the equation

$$Y = 396.9 + 5.85\,X$$

where clearings ($Y$) are expressed in millions, time ($X$) in months, and the origin is mid January 1918.

The seasonal correction is by the method of monthly means.

We have applied to the resultant figure a three months' moving average to smooth it similarly to our accident data.

### Comparison with Clearings Index

The visible comparison is shown in Chart III.

We have computed a formal coefficient of correlation by Pearson's method and find it .562 which is significant but not high. We believe the actual relationship is closer than such a coefficient indicates. We have not tested it out for different periods of lag as the lag appears different at different periods of the cycle. We think we should expect the accident rates to lead on the downward swings because with the first recession employees dropped from the payroll are the less competent, those so constituted psychologically as to be most subject to accident. On the pick up we would expect the accident rate to follow, as it is not until the pressure has markedly increased from the low point that the employer feels compelled to again take on such help. Were we to break the series in two parts and lag them in opposite directions the coefficient of correlation would obviously be much higher.

The peak in 1921 we attribute to the revival of building activity, it being generally understood that the sudden revival of dormant industries or opening of new ones generally produces a temporary spurt in the accident rate.

While we feel reasonably sure the relations we have established will be found in the main to be duplicated elsewhere, we prefer for the present to defer discussion of their significance for rate making. We do feel ready to say that we doubt whether any index series can be found which forecasts so far in advance as to permit rates to be adjusted to the cyclic changes, though it may be possible to adapt underwriting practice.

If cyclic variation in accident rates is established its significance is connection with the length of the experience period and other features of the experience rating plan also should not be overlooked.

We are convinced that any flaws there may be in our technique are not responsible for the relationships found. We feel our results justify us in urging that other carriers undertake similar studies for we believe that even though the conditions of their records may require more effort to obtain dependable results than in our case, the value of establishing or disproving such relations as we think we have found is well worth the cost.

ACKNOWLEDGMENT

In closing we desire to acknowledge our indebtedness to Mr. W. N. Wilson, Fellow of this Society and Statistician of the California State Fund who participated in discussion of plans for this investigation and materially assisted in carrying out many details.

## APPENDIX A

| Calendar year | Initial and deposit premiums | Additional premiums on periodical ajdustments | Additional premiums on final adjustments |
|---|---|---|---|
| 1st Quarter.... | | 196,774 | 97,175 |
| 1918 2nd Quarter... | | 297,806 | 73,661 |
| 3rd Quarter.... | | 340,777 | 69,008 |
| 4th Quarter.... | | 373,455 | 102,786 |
| Total..... | 907,645 | 1,208,812 | 342,630 |
| 1st Quarter.... | | 228,005 | 124,014 |
| 1919 2nd Quarter... | | 399,562 | 155,503 |
| 3rd Quarter.... | | 372,034 | 136,014 |
| 4th Quarter.... | | 534,214 | 161,826 |
| Total..... | 1,140,802 | 1,533,815 | 577,357 |
| 1st Quarter.... | | 287,278 | 188,229 |
| 1920 2nd Quarter... | | 586,843 | 266,737 |
| 3rd Quarter.... | | 621,967 | 266,557 |
| 4th Quarter.... | | 624,540 | 242,876 |
| Total..... | 1,332,714 | 2,120,628 | 964,399 |
| 1st Quarter.... | | 624,378 | 321,650 |
| 1921 2nd Quarter... | | 549,212 | 258,453 |
| 3rd Quarter.... | | 571,425 | 244,897 |
| 4th Quarter.... | | 620,915 | 241,467 |
| Total..... | 1,555,719 | 2,365,930 | 1,066,467 |
| 1st Quarter.... | | 352,688 | 181,688 |
| 1922 2nd Quarter... | | 468,706 | 220,567 |
| 3rd Quarter.... | | 580,541 | 248,803 |
| 4th Quarter.... | | 643,167 | 250,120 |
| Total..... | 1,704,245 | 2,045,102 | 901,178 |
| 1st Quarter.... | | 580,455 | 299,022 |
| 1923 2nd Quarter... | | 626,669 | 294,903 |
| 3rd Quarter.... | | 731,424 | 313,468 |
| 4th Quarter.... | | 709,840 | 276,049 |
| 1924 1st Quarter.... | | 717,111 | 369,421 |

## APPENDIX B

CALENDAR YEAR EARNED PREMIUMS

| | 1918 | 1919 | 1920 | 1921 | 1922 |
|---|---|---|---|---|---|
| Initial and Deposit premiums | 907,645 | 1,140,802 | 1,332,714 | 1,555,719 | 1,704,245 |
| Unearned at end of year | 334,893 | 458,924 | 516,289 | 634,138 | 635,720 |
| Balance | 572,752 | 681,878 | 816,425 | 921,581 | 1,068,525 |
| Unearned at beginning of year | 234,176 | 334,893 | 458,924 | 516,289 | 634,138 |
| Total | 806,928 | 1,016,771 | 1,275,349 | 1,437,870 | 1,702,663 |
| Additional premiums on periodical adj. | 1,290,921 | 1,686,728 | 2,438,913 | 2,053,987 | 2,351,850 |
| on final adj. | 513,146 | 867,621 | 1,059,033 | 913,706 | 1,142,495 |
| Total calendar year earned premiums | 2,610,995 | 3,571,120 | 4,773,295 | 4,405,563 | 5,197,008 |

## APPENDIX C

| Year of Issue | Schedule Z average rate | 2 year moving average |
|---|---|---|
| 1917 | 1.49 | |
| 1918 | 1.71 | 1.60 |
| 1919 | 1.67 | 1.69 |
| 1920 | 1.54 | 1.60 |
| 1921 | 1.49 | 1.51 |
| 1922 | 1.52 | 1.50 |

## APPENDIX D

| | 1918 | 1919 | 1920 | 1921 | 1922 |
|---|---|---|---|---|---|
| Premiums | 2,610,995 | 3,571,120 | 4,773,295 | 4,405,563 | 5,197,008 |
| Average rate | 1.60 | 1.69 | 1.60 | 1.51 | 1.50 |
| Payrolls | 163,187,187 | 211,308,875 | 298,330,937 | 291,759,139 | 346,467,200 |

## APPENDIX E

### Monthly Payrolls for Calendar Years 1918-1922

| Months | 1918 | | 1919 | | 1920 | | 1921 | | 1922 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Seasonal index | Payroll | Seasonal index | Payroll | Seasonal index | Payroll | Seasonal index | Payroll | Seasonal index | Payroll |
| January | 95.58 | 12,997,859 | 95.58 | 16,830,752 | 97.09 | 24,137,458 | 98.60 | 23,972,876 | 87.70 | 25,320,977 |
| February | 91.00 | 12,375,028 | 91.00 | 16,024,256 | 94.00 | 23,369,256 | 97.01 | 23,586,295 | 85.95 | 24,815,713 |
| March | 92.33 | 12,555,894 | 92.33 | 16,258,457 | 95.27 | 23,684,990 | 98.20 | 23,875,623 | 98.48 | 28,433,408 |
| April | 95.68 | 13,011,458 | 95.68 | 16,848,361 | 98.04 | 24,373,637 | 100.40 | 24,410,515 | 102.09 | 29,475,696 |
| May | 99.18 | 13,487,421 | 99.18 | 17,464,679 | 99.23 | 24,669,482 | 99.29 | 24,140,638 | 108.06 | 31,199,371 |
| June | 102.21 | 13,899,468 | 102.21 | 17,998,234 | 100.68 | 25,029,965 | 99.14 | 24,104,168 | 108.34 | 31,280,213 |
| July | 111.89 | 15,215,845 | 111.89 | 19,702,792 | 106.38 | 26,447,037 | 100.87 | 24,524,787 | 106.73 | 30,815,369 |
| August | 114.61 | 15,585,736 | 114.61 | 20,181,759 | 112.47 | 27,961,067 | 110.33 | 26,824,822 | 108.16 | 31,228,243 |
| September | 112.49 | 15,297,439 | 112.49 | 19,808,446 | 110.31 | 27,424,071 | 108.13 | 26,289,930 | 108.02 | 31,187,822 |
| October | 100.55 | 13,673,726 | 100.55 | 17,705,923 | 101.50 | 25,233,826 | 102.44 | 24,906,507 | 97.17 | 28,055,180 |
| November | 92.51 | 12,580,372 | 92.51 | 16,290,153 | 94.11 | 23,396,603 | 95.72 | 23,272,654 | 95.75 | 27,645,195 |
| December | 91.97 | 12,506,938 | 91.97 | 16,195,064 | 90.92 | 22,603,540 | 89.87 | 21,850,329 | 93.55 | 27,010,005 |
| Totals | 1200.00 | 163,187,184 | 1200.00 | 211,308,876 | 1200.00 | 298,330,932 | 1200.00 | 291,759,144 | 1200.00 | 346,467,192 |

## APPENDIX F

### NUMBER OF ACCIDENTS BY MONTHS OF OCCURRENCE

| 1918 | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| All accidents.. | 1439 | 1381 | 1506 | 1759 | 1785 | 2137 | 2296 | 2688 | 2136 | 2137 | 1807 | 1784 | 22855 |
| Deaths..... | 6 | 9 | 7 | 15 | 17 | 10 | 11 | 6 | 7 | 12 | 15 | 7 | 122 |
| Major perms. .. | 14 | 14 | 10 | 13 | 12 | 16 | 13 | 9 | 17 | 18 | 20 | 12 | 168 |
| Minor perms. .. | 6 | 6 | 19 | 13 | 10 | 14 | 23 | 18 | 29 | 14 | 16 | 20 | 188 |
| Total serious.. | 26 | 29 | 36 | 41 | 39 | 40 | 47 | 33 | 53 | 44 | 51 | 39 | 478 |

| 1919 | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| All accidents.. | 1916 | 1751 | 2341 | 2410 | 2609 | 2540 | 2546 | 2739 | 2727 | 2730 | 2235 | 2691 | 29235 |
| Deaths..... | 10 | 6 | 2 | 15 | 12 | 12 | 6 | 11 | 14 | 8 | 2 | 10 | 108 |
| Major perms. .. | 25 | 16 | 9 | 18 | 22 | 26 | 26 | 19 | 20 | 16 | 20 | 23 | 240 |
| Minor perms. .. | 23 | 20 | 17 | 8 | 38 | 30 | 26 | 30 | 25 | 37 | 24 | 23 | 301 |
| Total serious... | 58 | 42 | 28 | 41 | 72 | 68 | 58 | 60 | 59 | 61 | 46 | 56 | 649 |

| 1920 | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug.. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| All accidents.. | 2962 | 2242 | 2545 | 3153 | 2821 | 3150 | 3185 | 3174 | 3512 | 3470 | 2547 | 2890 | 35651 |
| Deaths..... | 10 | 7 | 11 | 15 | 12 | 11 | 11 | 10 | 15 | 15 | 13 | 6 | 136 |
| Major perms. .. | 15 | 14 | 15 | 30 | 24 | 29 | 25 | 22 | 25 | 22 | 19 | 14 | 254 |
| Minor perms. .. | 35 | 30 | 33 | 25 | 25 | 32 | 29 | 42 | 40 | 31 | 31 | 22 | 375 |
| Total serious... | 60 | 51 | 59 | 70 | 61 | 72 | 65 | 74 | 80 | 68 | 63 | 42 | 765 |

## APPENDIX F—*Continued*

### Number of Accidents by Months of Occurrence

| 1921 | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| All accidents.. | 2426 | 2341 | 2845 | 2936 | 3015 | 3192 | 2958 | 3365 | 3124 | 3133 | 2871 | 2883 | 35089 |
| Deaths..... | 9 | 8 | 12 | 10 | 11 | 11 | 10 | 14 | 11 | 12 | 14 | 11 | 133 |
| Major perms. .. | 22 | 18 | 19 | 18 | 16 | 25 | 31 | 26 | 16 | 18 | 16 | 19 | 244 |
| Minor perms. .. | 22 | 19 | 28 | 23 | 29 | 33 | 41 | 27 | 30 | 29 | 25 | 28 | 334 |
| Total serious... | 53 | 45 | 59 | 51 | 56 | 69 | 82 | 67 | 57 | 59 | 55 | 58 | 711 |

| 1922 | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| All accidents.. | 2841 | 2339 | 2932 | 2945 | 3546 | 3846 | 3869 | 4426 | 3929 | 4454 | 3916 | 3584 | 42627 |
| Deaths..... | 11 | 17 | 9 | 10 | 7 | 14 | 12 | 61 | 12 | 9 | 17 | 13 | 192 |
| Major perms. .. | 23 | 14 | 17 | 23 | 20 | 23 | 25 | 19 | 22 | 27 | 20 | 25 | 258 |
| Minor perms. .. | 25 | 33 | 35 | 33 | 28 | 34 | 46 | 41 | 37 | 41 | 33 | 43 | 429 |
| Total serious... | 59 | 64 | 61 | 66 | 55 | 71 | 83 | 121 | 71 | 77 | 70 | 81 | 879 |

## APPENDIX G—PART I

ALL ACCIDENT RATES PER $100,000 PAYROLL

| Month | 1918 | 1919 | 1920 | 1921 | 1922 |
|---|---|---|---|---|---|
| January | 11.071 | 11.384 | 12.271 | 10.120 | 11.220 |
| February | 11.160 | 10.927 | 9.594 | 9.925 | 9.425 |
| March | 11.994 | 14.399 | 10.745 | 11.916 | 10.312 |
| April | 13.519 | 14.304 | 12.939 | 12.028 | 9.991 |
| May | 13.234 | 14.939 | 11.435 | 12.489 | 11.366 |
| June | 15.375 | 14.112 | 12.585 | 13.243 | 12.295 |
| July | 15.090 | 12.922 | 12.043 | 12.061 | 12.555 |
| August | 17.246 | 13.572 | 11.351 | 12.544 | 14.173 |
| September | 13.963 | 13.767 | 12.806 | 11.883 | 12.598 |
| October | 15.629 | 15.419 | 13.751 | 12.519 | 15.876 |
| November | 14.364 | 13.720 | 10.886 | 12.336 | 14.165 |
| December | 14.264 | 16.616 | 12.786 | 13.194 | 13.269 |

## APPENDIX G—PART II

SERIOUS ACCIDENT RATES PER $10,000,000 PAYROLL

| Month | 1918 | 1919 | 1920 | 1921 | 1922 |
|---|---|---|---|---|---|
| January | 20.00 | 34.46 | 24.86 | 22.11 | 23.30 |
| February | 23.43 | 26.21 | 21.82 | 19.08 | 25.79 |
| March | 28.67 | 17.22 | 24.91 | 24.71 | 21.45 |
| April | 31.51 | 24.33 | 28.72 | 20.89 | 22.39 |
| May | 28.92 | 41.23 | 24.73 | 23.20 | 17.63 |
| June | 28.78 | 37.78 | 28.77 | 28.63 | 22.69 |
| July | 30.89 | 29.44 | 24.58 | 33.44 | 26.93 |
| August | 21.17 | 29.73 | 26.47 | 24.98 | 38.75 |
| September | 34.65 | 29.79 | 29.17 | 21.68 | 22.77 |
| October | 32.18 | 34.45 | 26.95 | 23.69 | 27.45 |
| November | 40.54 | 28.24 | 26.93 | 23.63 | 25.22 |
| December | 31.18 | 34.58 | 18.58 | 26.54 | 29.99 |

## APPENDIX H—PART I

### CYCLES IN "ALL ACCIDENT" RATES PER $100,000 OF PAYROLL

| Year and month 1 | Accident rate 2 | Ratio to average 3 | Seasonal index 4 | (3) − (4) Index of cyclic and unaccounted for variation | 3 months moving average |
|---|---|---|---|---|---|
| 1918 | | | | | |
| January | 11.071 | 0.865 | .876 | − 1.1 | |
| February | 11.160 | 0.872 | .798 | 7.4 | 2.4 |
| March | 11.994 | .937 | .928 | .9 | 5.3 |
| April | 13.519 | 1.057 | .981 | 7.6 | 4.2 |
| May | 13.234 | 1.034 | .992 | 4.2 | 8.8 |
| June | 15.375 | 1.202 | 1.057 | 14.5 | 11.8 |
| July | 15.090 | 1.179 | 1.011 | 16.8 | 19.5 |
| August | 17.246 | 1.348 | 1.076 | 27.2 | 17.2 |
| September | 13.963 | 1.091 | 1.016 | 7.5 | 14.1 |
| October | 15.629 | 1.221 | 1.144 | 7.7 | 8.4 |
| November | 14.364 | 1.123 | 1.023 | 10.0 | 6.5 |
| December | 14.264 | 1.115 | 1.096 | 1.9 | 4.4 |
| 1919 | | | | | |
| January | 11.384 | .890 | .876 | 1.4 | 3.0 |
| February | 10.927 | .854 | .798 | 5.6 | 8.9 |
| March | 14.399 | 1.125 | .928 | 19.7 | 13.0 |
| April | 14.304 | 1.118 | .981 | 13.7 | 17.0 |
| May | 14.939 | 1.168 | .992 | 17.6 | 12.0 |
| June | 14.112 | 1.103 | 1.057 | 4.6 | 7.4 |
| July | 12.922 | 1.010 | 1.011 | − .1 | 1.0 |
| August | 13.572 | 1.061 | 1.076 | − 1.5 | 1.5 |
| September | 13.767 | 1.076 | 1.016 | 6.0 | 3.5 |
| October | 15.419 | 1.205 | 1.144 | 6.1 | 5.7 |
| November | 13.720 | 1.072 | 1.023 | 4.9 | 10.4 |
| December | 16.616 | 1.299 | 1.096 | 20.3 | 11.2 |
| 1920 | | | | | |
| January | 12.271 | .959 | .876 | 8.3 | 7.9 |
| February | 9.594 | .750 | .798 | − 4.8 | − 1.8 |
| March | 10.745 | .840 | .928 | − 8.8 | − 3.5 |
| April | 12.939 | 1.011 | .981 | 3.0 | − 5.2 |
| May | 11.435 | .894 | .992 | − 9.8 | − 4.7 |
| June | 12.585 | .984 | 1.057 | − 7.3 | − 8.0 |
| July | 12.043 | .941 | 1.011 | − 7.0 | −11.1 |
| August | 11.351 | .887 | 1.076 | −18.9 | − 9.1 |
| September | 12.806 | 1.001 | 1.016 | − 1.5 | − 9.1 |
| October | 13.751 | 1.075 | 1.144 | − 6.9 | − 8.5 |
| November | 10.886 | .851 | 1.023 | −17.2 | −11.3 |
| December | 12.786 | .999 | 1.096 | − 9.7 | −11.8 |
| 1921 | | | | | |
| January | 10.120 | .791 | .876 | − 8.5 | − 6.8 |
| February | 9.925 | .776 | .798 | − 2.2 | − 3.5 |
| March | 11.916 | .931 | .928 | .3 | − 2.0 |
| April | 12.028 | .940 | .981 | − 4.1 | − 1.8 |
| May | 12.489 | .976 | .992 | − 1.6 | − 2.6 |
| June | 13.243 | 1.035 | 1.057 | − 2.2 | − 3.5 |
| July | 12.061 | .943 | 1.011 | − 6.8 | − 6.2 |
| August | 12.544 | .980 | 1.076 | − 9.6 | − 8.7 |
| September | 11.883 | .929 | 1.016 | − 8.7 | −11.6 |
| October | 12.519 | .978 | 1.144 | −16.6 | −10.4 |
| November | 12.336 | .964 | 1.023 | − 5.9 | − 9.6 |
| December | 13.194 | 1.031 | 1.096 | − 6.5 | − 4.1 |
| 1922 | | | | | |
| January | 11.220 | .877 | .876 | .1 | − 4.2 |
| February | 9.425 | .737 | .798 | − 6.1 | − 6.1 |
| March | 10.312 | .806 | .928 | −12.2 | −12.4 |
| April | 9.991 | .781 | .981 | −20.0 | −14.2 |
| May | 11.366 | .888 | .992 | −10.4 | −13.3 |
| June | 12.295 | .961 | 1.057 | − 9.6 | − 7.6 |
| July | 12.555 | .981 | 1.011 | − 3.0 | − 3.1 |
| August | 14.173 | 1.108 | 1.076 | 3.2 | − 1.0 |
| September | 12.598 | .985 | 1.016 | − 3.1 | 3.3 |

## APPENDIX H—PART II

CYCLES IN SERIOUS ACCIDENT RATES PER $10,000,000 OF PAYROLL

| Year and month 1 | Accident rate 2 | 2 +27.047 Ratio to average 3 | Seasonal index 4 | 3 − 4 | Five months moving average |
|---|---|---|---|---|---|
| 1918 | | | | | |
| January | 20.00 | .739 | .922 | −18.3 | |
| February | 23.43 | .866 | .860 | .6 | |
| March | 28.67 | 1.060 | .865 | 19.5 | 6.0 |
| April | 31.51 | 1.165 | .945 | 22.0 | 9.2 |
| May | 28.92 | 1.069 | 1.008 | 6.1 | 10.5 |
| June | 28.78 | 1.064 | 1.084 | − 2.0 | 1.4 |
| July | 30.89 | 1.142 | 1.074 | 6.8 | 2.2 |
| August | 21.17 | .783 | 1.043 | −26.0 | 3.3 |
| September | 34.65 | 1.281 | 1.022 | 25.9 | 12.3 |
| October | 32.18 | 1.190 | 1.070 | 12.0 | 13.2 |
| November | 40.54 | 1.499 | 1.069 | 43.0 | 25.4 |
| December | 31.18 | 1.153 | 1.043 | 11.0 | 22.4 |
| 1919 | | | | | |
| January | 34.46 | 1.274 | .922 | 35.2 | 15.5 |
| February | 26.21 | .969 | .860 | 10.9 | 6.0 |
| March | 17.22 | .637 | .865 | −22.8 | 14.1 |
| April | 24.33 | .900 | .945 | − 4.5 | 13.3 |
| May | 41.23 | 1.524 | 1.008 | 51.6 | 11.2 |
| June | 37.78 | 1.397 | 1.084 | 31.3 | 17.1 |
| July | 29.44 | 1.088 | 1.074 | 1.4 | 19.6 |
| August | 29.73 | 1.099 | 1.043 | 5.6 | 13.3 |
| September | 29.79 | 1.101 | 1.022 | 7.9 | 6.6 |
| October | 34.45 | 1.274 | 1.070 | 20.4 | 11.0 |
| November | 28.24 | 1.044 | 1.069 | − 2.5 | 9.8 |
| December | 34.58 | 1.279 | 1.043 | 23.6 | 7.2 |
| 1920 | | | | | |
| January | 24.86 | .919 | .922 | − .3 | 4.2 |
| February | 21.82 | .807 | .860 | − 5.3 | 7.1 |
| March | 24.91 | .921 | .865 | 5.6 | .4 |
| April | 28.72 | 1.062 | .945 | 11.7 | .1 |
| May | 24.73 | .914 | 1.008 | − 9.4 | − 2.1 |
| June | 28.77 | 1.064 | 1.084 | − 2.0 | − 4.5 |
| July | 24.58 | .909 | 1.074 | −16.5 | − 5.7 |
| August | 26.47 | .979 | 1.043 | − 6.4 | − 5.3 |
| September | 29.17 | 1.078 | 1.022 | 5.6 | − 6.4 |
| October | 26.95 | .996 | 1.070 | − 7.4 | −10.2 |
| November | 26.93 | .996 | 1.069 | − 7.3 | −11.0 |
| December | 18.58 | .687 | 1.043 | −35.6 | −15.3 |
| 1921 | | | | | |
| January | 22.11 | .817 | .922 | −10.5 | −12.8 |
| February | 19.08 | .705 | .860 | −15.5 | −14.8 |
| March | 24.71 | .914 | .865 | 4.9 | −10.7 |
| April | 20.89 | .772 | .945 | −17.3 | − 9.1 |
| May | 23.20 | .858 | 1.008 | −15.0 | − 2.7 |
| June | 28.63 | 1.059 | 1.084 | − 2.5 | − 6.1 |
| July | 33.44 | 1.236 | 1.074 | 16.2 | − 7.1 |
| August | 24.98 | .924 | 1.043 | −11.9 | − 7.9 |
| September | 21.68 | .802 | 1.022 | −22.0 | −11.3 |
| October | 23.69 | .876 | 1.070 | −19.4 | −15.8 |
| November | 23.63 | .874 | 1.069 | −19.5 | −14.6 |
| December | 26.54 | .981 | 1.043 | − 6.2 | − 8.4 |
| 1922 | | | | | |
| January | 23.30 | .861 | .922 | − 6.1 | − 5.9 |
| February | 25.79 | .954 | .860 | 9.4 | − 4.4 |
| March | 21.45 | .793 | .865 | − 7.2 | −10.2 |
| April | 22.39 | .828 | .945 | −11.7 | −13.9 |
| May | 17.63 | .652 | 1.008 | −35.6 | −17.4 |
| June | 22.69 | .839 | 1.084 | −24.5 | − 8.1 |
| July | 26.93 | .996 | 1.074 | − 7.8 | − 9.4 |
| August | 38.75 | 1.433 | 1.043 | 39.0 | − 3.4 |
| September | 22.77 | .842 | 1.022 | −18.0 | − 1.2 |
| October | 27.45 | 1.015 | 1.070 | − 5.5 | 1.7 |

## APPENDIX I

### CYCLES OF CALIFORNIA BANK CLEARINGS

| Year and month | Clearings deflated 00,000 omitted | Trend value | Ratio actual to trend | Seasonal | Cycle | 3 months moving average of cycle |
|---|---|---|---|---|---|---|
| 1918 | | | | | | |
| January..... | $471,6 | $396,9 | 118.8 | 105.6 | 13.2 | |
| February.... | 386,0 | 402,8 | 95.8 | 86.0 | 9.8 | 9.6 |
| March..... | 442,0 | 408,6 | 108.2 | 102.5 | 5.7 | 7.8 |
| April..... | 432,1 | 414,5 | 104.2 | 96.3 | 7.9 | 7.5 |
| May..... | 451,1 | 420,3 | 107.3 | 98.3 | 9.0 | 7.4 |
| June..... | 438,8 | 426,2 | 103.0 | 98.2 | 5.2 | 9.0 |
| July..... | 489,9 | 432,0 | 113.4 | 100.6 | 12.8 | 8.4 |
| August..... | 455,5 | 437,9 | 104.0 | 96.8 | 7.2 | 5.0 |
| September... | 418,7 | 443,7 | 94.4 | 99.5 | — 5.1 | 2.2 |
| October..... | 503,9 | 449,6 | 112.1 | 107.7 | 4.4 | — 0.6 |
| November... | 456,4 | 455,4 | 100.2 | 101.3 | — 1.1 | 0.1 |
| December ... | 480,1 | 461,2 | 104.1 | 107.2 | — 3.1 | — 0.6 |
| 1919 | | | | | | |
| January..... | 504,6 | 467,1 | 108.0 | 105.6 | 2.4 | — 0.3 |
| February.... | 406,3 | 473,0 | 85.9 | 86.0 | — 0.1 | — 0.8 |
| March..... | 468,7 | 478,8 | 97.9 | 102.5 | — 4.6 | — 2.7 |
| April..... | 448,6 | 484,7 | 92.6 | 96.3 | — 3.7 | — 1.7 |
| May..... | 497,6 | 490,5 | 101.4 | 98.3 | 3.1 | — 0.5 |
| June..... | 483,1 | 496,4 | 97.3 | 98.2 | — 0.9 | 3.3 |
| July..... | 544,2 | 502,2 | 108.4 | 100.6 | 7.8 | 4.4 |
| August..... | 524,2 | 508,1 | 103.2 | 96.8 | 6.4 | 6.8 |
| September... | 543,2 | 513,9 | 105.7 | 99.5 | 6.2 | 6.1 |
| October ..... | 589,5 | 519,8 | 113.4 | 107.7 | 5.7 | 5.2 |
| November... | 551,3 | 525,6 | 104.9 | 101.3 | 3.6 | 5.7 |
| December ... | 611,0 | 531,5 | 115.0 | 107.2 | 7.8 | 5.7 |
| 1920 | | | | | | |
| January..... | 597,8 | 537,3 | 111.3 | 105.6 | 5.7 | 6.0 |
| February.... | 491,1 | 543,2 | 90.4 | 86.0 | 4.4 | 4.9 |
| March..... | 588,6 | 549,0 | 107.2 | 102.5 | 4.7 | 7.1 |
| April..... | 546,9 | 554,9 | 108.6 | 96.3 | 12.3 | 4.8 |
| May..... | 536,1 | 560,7 | 95.6 | 98.3 | — 2.7 | 3.7 |
| June..... | 565,4 | 566,6 | 99.8 | 98.2 | 1.6 | — 0.8 |
| July..... | 568,4 | 572,4 | 99.3 | 100.6 | — 1.3 | — 1.7 |
| August..... | 429,1 | 578,3 | 91.5 | 96.8 | — 5.3 | — 1.5 |
| September... | 594,0 | 584,1 | 101.7 | 99.5 | 2.2 | — 2.6 |
| October ..... | 607,7 | 590,0 | 103.0 | 107.7 | — 4.7 | — 1.6 |
| November... | 589,9 | 595,8 | 99.0 | 101.3 | — 2.3 | — 4.6 |
| December ... | 604.5 | 601,7 | 100.5 | 107.2 | — 6.7 | — 7.1 |
| 1921 | | | | | | |
| January..... | 567,5 | 607,5 | 93.4 | 105.6 | —12.2 | — 9.4 |
| February.... | 469,6 | 613,4 | 76.6 | 86.0 | — 9.4 | — 9.4 |
| March..... | 594,2 | 619,2 | 96.0 | 102.5 | — 6.5 | — 8.1 |
| April..... | 548,7 | 625,1 | 87.8 | 96.3 | — 8.5 | — 9.7 |
| May..... | 530,5 | 630,9 | 84.1 | 98.3 | —14.2 | —10.8 |
| June..... | 564,0 | 636,8 | 88.6 | 98.2 | — 9.6 | —13.0 |
| July..... | 546,6 | 642,6 | 85.0 | 100.6 | —15.2 | —11.9 |
| August..... | 558,0 | 648,5 | 86.0 | 96.8 | —10.8 | —12.3 |
| September... | 578,9 | 654,3 | 88.5 | 99.5 | —11.0 | —11.9 |
| October ..... | 619,7 | 660,2 | 93.9 | 107.7 | —13.8 | —10.6 |
| November... | 628,0 | 666,0 | 94.3 | 101.3 | — 7.0 | — 9.5 |
| December ... | 668,4 | 671,9 | 99.5 | 107.2 | — 7.7 | — 8.3 |
| 1922 | | | | | | |
| January..... | 646,7 | 677,0 | 95.5 | 105.6 | —10.1 | — 7.8 |
| February.... | 549,3 | 683,6 | 80.4 | 86.0 | — 5.6 | — 6.9 |
| March..... | 672,6 | 689,4 | 97.6 | 102.5 | — 4.9 | — 4.2 |
| April..... | 655,4 | 695,3 | 94.3 | 96.3 | — 2.0 | — 1.9 |
| May..... | 697,8 | 701,1 | 99.5 | 98.3 | 1.2 | — 0.3 |
| June..... | 689,6 | 707,0 | 97.5 | 98.2 | — 0.7 | — 1.4 |
| July..... | 683,6 | 712,8 | 95.9 | 100.6 | — 4.7 | — 1.8 |
| August..... | 695,2 | 718,7 | 96.7 | 96.8 | — 0.1 | — 1.3 |
| September... | 727,3 | 724,5 | 100.4 | 99.5 | 0.9 | 0.3 |
| October ..... | 787,5 | 730,4 | 107.8 | 107.7 | 0.1 | 0.4 |

## CHART I

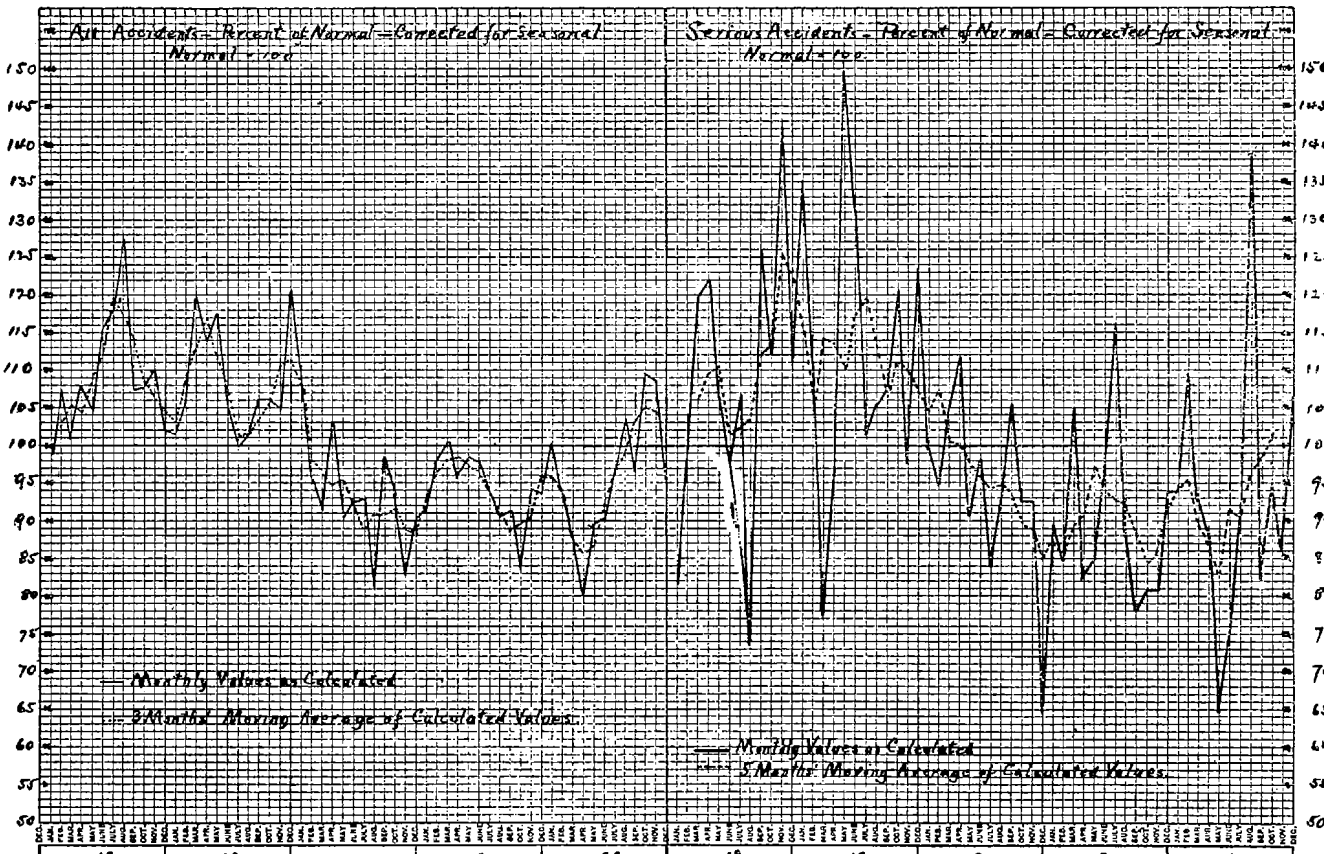
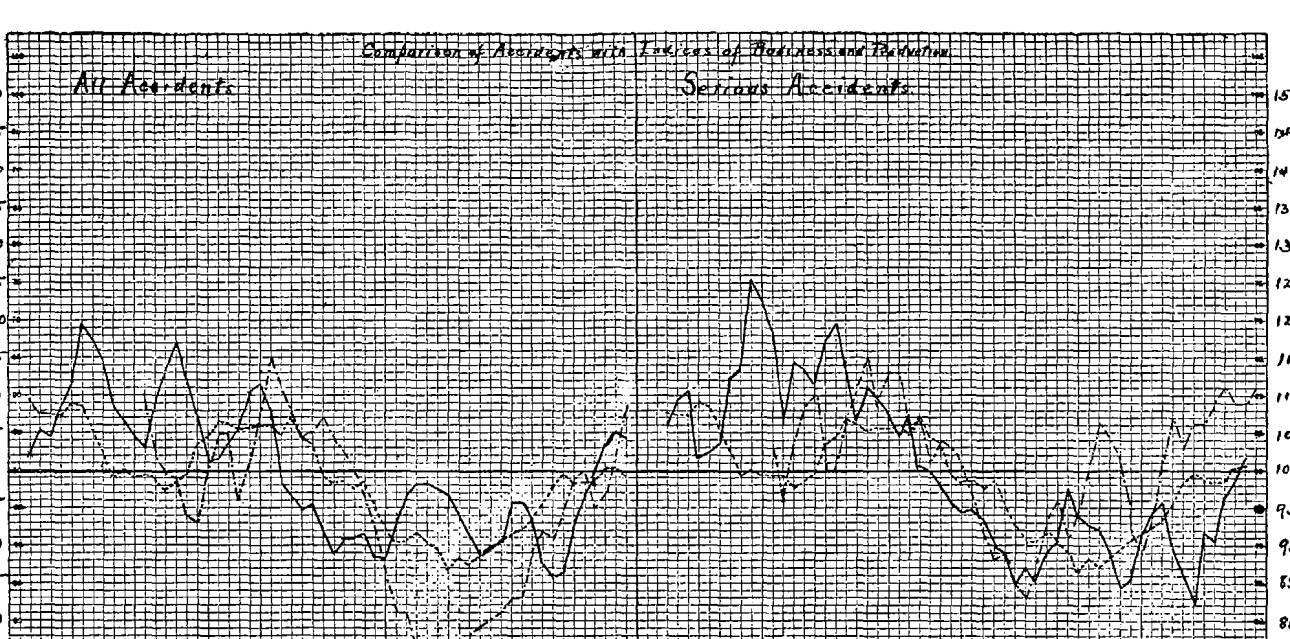
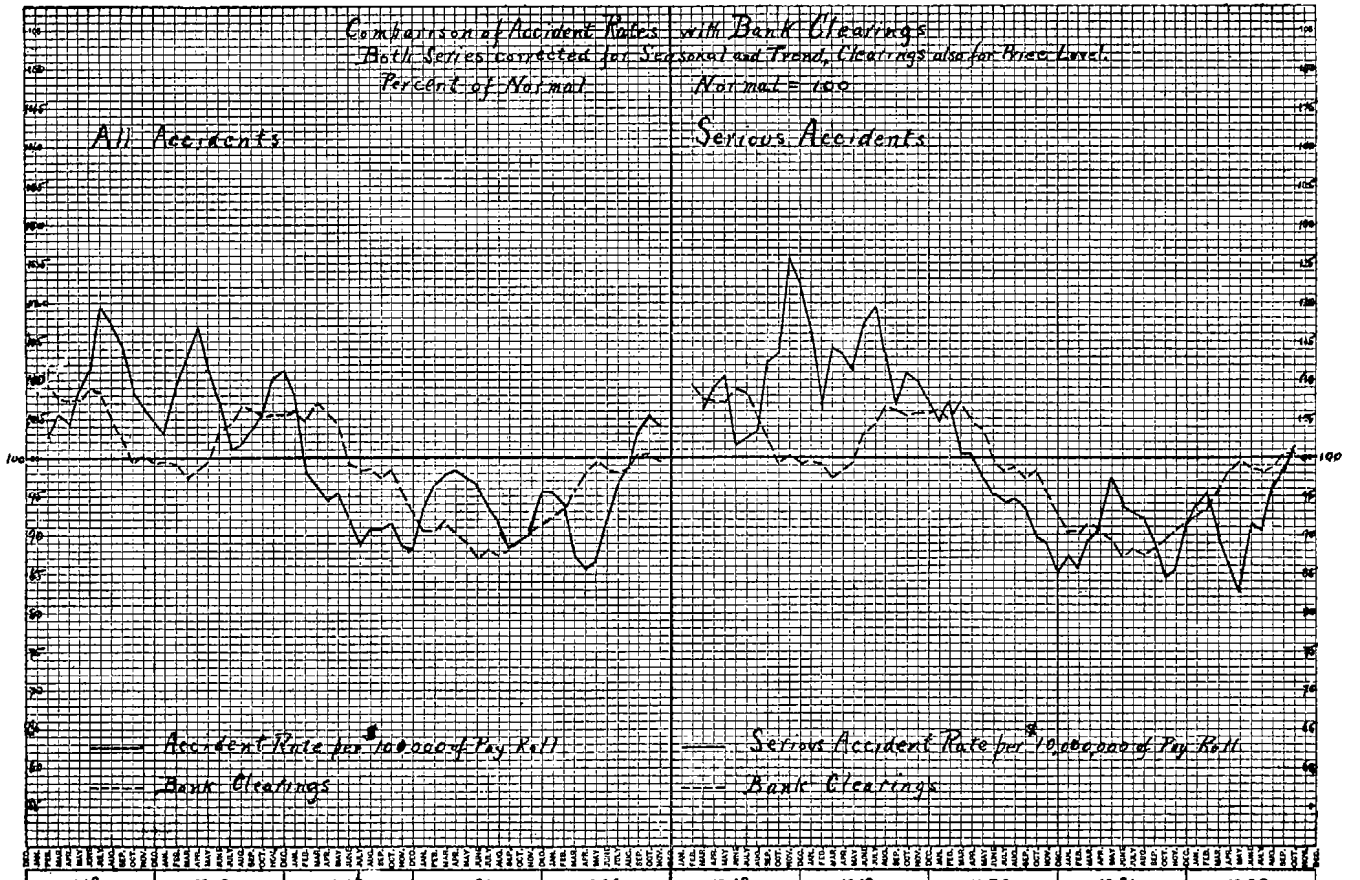

All Accidents—Percent of Normal—Corrected for Seasonal
Normal = 100
Serious Accidents—Percent of Normal—Corrected for Seasonal
Normal = 100
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
Monthly Values as Calculated
5 Months' Moving Average of Calculated Values
1918
1919
1920
1921
1922

CHART II


Comparison of Accidents with Indexes of Business and Production
All Accidents
Serious Accidents
Accident Rate per 100,000 of Pay Roll
Bank Clearings
Day's Index of Volume of Manufacturing Production All Commodities
Accident Rate (Serious) per 10,000,000 of Pay Roll
Bank Clearings
Day's Index of Production—Consumption Goods
1918
1919
1920
1921
1922
1923

## CHART III


Comparison of Accident Rates with Bank Clearings
Both Series corrected for Seasonal and Trend, Clearings also for Price Level.
Percent of Normal
Normal = 100
All Accidents
Serious Accidents
100
100
Accident Rate per $100,000 of Pay Roll
Bank Clearings
Serious Accident Rate per $10,000,000 of Pay Roll
Bank Clearings
1918
1919
1920
1921
1922
1918
1919
1920
1921
1922