THE INDUSTRIAL COMPENSATION RATING SCHEDULE, 1918.*

BY

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I.

Schedule rating, as applied to workmen's compensation insurance, practically began with the adoption of the Universal Analytic Schedule.† The Industrial Compensation Rating Schedule of 1916‡ was not merely the successor but the immediate derivative of the Universal Analytic,§ from which it differed only in matters of detail, and not always by any means improved detail. Both the Universal Analytic Schedule and its variant, the Industrial Compensation Rating Schedule of 1916, follow the same fundamental plan and the same broad criticisms apply to both. In what follows, therefore, to avoid constant repetition, both variants are covered by the original and more familiar name.

The Universal Analytic Schedule is designed to rate compensation insurance risks individually upon the basis of certain apparent hazards ascertained by inspection. The hazards to be taken into account are specified in a schedule or list of items to each of

* Special acknowledgment for assistance in the preparation of this paper is due to Mr. R. M. Pennock, of the State Workmen's Insurance Fund of Pennsylvania, a member of the National Reference Committee on Schedule Rating, and to Mr. Herbert G. Wiberg, of the Compensation Inspection Rating Board of New York, Secretary of the Committee.

† The application of schedule rating to compensation insurance was avowedly borrowed from fire insurance and seems to have occurred to several persons at about the same time. A number of rating schedules were, in fact, developed independently—notably the embryonic Massachusetts Schedule of 1913, the Employers' Mutual Schedule (Wisconsin) and the Prudential Casualty Schedule. None of these plans, however, attained any wide use or exercised any perceptible influence on the development of schedule rating.

‡ Adopted by the First Conference on Schedule Rating, New York, 1916.

§ The Coal Mine Rating Schedule of the Associated Companies (1915) was the first important attempt to develop a compensation rating schedule on lines differing radically from those followed by the Universal Analytic.

which a definite value is assigned by way of addition to (charge items) or subtraction from (credit items) the classification (manual) rate or premium. The result is a total rate or total premium for the individual risk which will be less or more than the premium at manual rate according as credit or charge items preponderate in the particular case. Charges are assigned to conditions which are presumed to be more hazardous and credits for conditions which are presumed to be less hazardous than the average for risks of the same industry class. The net aggregate result is expected to be a balance of premium increases and decreases. Where this expectation is not realized, the resultant premium deficit is offset by a loading in manual rates.* The item values are variously expressed: in flat amounts to be added to or deducted from total premium, in cents per $100 of payroll and in per cent. of manual rate. Catastrophe items, such as the hazard of fire or of boiler explosion, are valued in cents per $100 of payroll; morale items, such as safety organization or first-aid provisions, in per cent. of base rate; most other items carry flat values. Thus the employer is charged $.50 for each exposed set screw, $1.00 for an unlighted stair, and $.03 for each linear foot of unrailed balcony: all irrespective both of the number of employees and of the industry classification. The flat credits for general machine guarding, however, vary with the manual rate and the credit for individual motor drive is even a direct per cent. of rate. These different modes or bases of item valuation are recited at length because they have an important bearing upon the practical working of the schedule.

The great merits of the Universal Analytic Schedule are: (*a*) that it provides positive and generally accepted standards for the safeguarding of plant and equipment; (*b*) that it outlines certain effective methods of improving plant morale; and (*c*) that it offers a definite easily calculated pecuniary incentive to the carrying out of the suggested improvements.† The criticisms most often made

* The loading for schedule-rated classifications in 1917 (outside of Massachusetts and Pennsylvania) is nine per cent.

† For discussion and criticisms, of the Universal Analytic Schedule see Hansen, *Proceedings*, Vol. I, pp. 217–226; Rubinow, *ib.*, pp. 209–216; Senior, pp. 227–240; Mowbray, Vol. III, pp. 14–25; Downey, pp. 26–42; Black, p. 266; for a mathematical discussion of schedule rating in general, see Mowbray, *ib.*, Vol. I, pp. 241–249; Whitney, pp. 250–256.

The writer's general views on the principles of schedule rating are set forth in the paper above cited.

are: (1) that the item values have no demonstrable relation to the hazards which they purport to measure, (2) that the schedule is not readily amenable to statistical control as respects either item values or aggregate premium results, (3) that its application has usually resulted in a net premium deficit, (4) that it discriminates unfairly against small risks and low-rated industries, (5) that the incentives to hazard removal are nullified to some extent by arbitrary credit limits, and (6) that the rate results are affected in an undesigned and erratic fashion by the discrepancy between audited payroll and the payroll stated in the policy declaration.

Several of the foregoing criticisms have been sufficiently enlarged upon by other persons or in other connections. It obviously is impossible, e. g., to determine the premium value of one exposed set screw or one unguarded gear—exposures to injury are neither given nor obtainable in these terms. Obviously, also, it must be very difficult to control the premium results of a schedule whereof the item values are not readily convertible to a common denominator.* Other counts in the general indictment may be less apparent to persons not intimately acquainted with the practical working of the schedule.

It might be argued that an average reduction from manual rates by the application of a schedule is no more than reasonable, provided that the rate reduction reflects an actual improvement in plant conditions. This argument is predicated upon the lag between pure premium experience and manual rates; for any improvement in plant conditions must ultimately find expression in pure premiums. So soon, however, as manual rates are revised upon the basis of this improved experience, schedule credits for the same improvements will result in inadequate premiums.† No schedule, moreover, does, or can, take account of all the multi-

* The Pennsylvania Compensation Rating & Inspection Bureau succeeded in maintaining an approximate balance of debits and credits during 1916 and 1917 by means of detailed statistics of inspection results. For some unexplained reason no other Bureau has attempted to analyze the results of its rating schedule.

† It is alleged, for example, that Massachusetts experience upon paper box making has been greatly improved by the general guarding of corner staying machines, and the manual rate for that State has been reduced in consequence. Obviously a further rate reduction by means of schedule credit from manual rate for the guarding of these same machines would be unwarranted.

tudinous influences which bear upon accident hazard. Improvements in plant and equipment, which are a sufficient ground for rate differences as between individual risks, may be counterbalanced, in the industry as a whole, by concomitant changes in supervision, personnel or rate of work. For these and other reasons underwriters do not look with favor upon a persistent discrepancy between average adjusted rates and pure premium indications.

Granted the need of maintaining a certain rate level, this result can evidently be attained either by periodic revisions of the schedule or by loading the manual rates to offset the expected "merit" reduction—as was actually done for most jurisdictions in the rate revision of 1917.‡ The former method is extremely cumbrous, involving as it does either a change in item values which is likely to disturb such proportion as already exists, or a transference of items from credits to charges, which creates very embarrassing relations between insurer and insured. The method of rate loading would be unobjectionable if all risks in the classifications so treated were actually schedule-rated and if the schedule produced fairly uniform reductions in all classifications. Unfortunately for the hypothesis, neither of these conditions is realized in fact. On the one hand, very small plants (less than $50 annual premium) are not individually rated; on the other hand, the schedule gives average rate increases in certain industries offset by heavy reductions in other classfications. The practical effect of the loading, therefore, is unfairly to burden some employers for the benefit of others.*

The discriminatory effects of the Universal Analytic Schedule are by no means confined to the more or less fortuitous loading already spoken of. It will be seen from the subjoined exhibits, that, as applied in Pennsylvania, the schedule systematically produced an excess of debits upon small risks and low-rated industries, accompanied by an excess of credits upon large risks and high-rated classifications.

‡ See Report of the Augmented Standing Committee on Workmen's Compensation Insurance Rates—1917—Issued by the National Workmen's Compensation Service Bureau.

* The objections to the reverse condition—an excess of schedule debits over credits—are so patent that they need scarce be stated. There is much to be said for a schedule of charges only in the hands of a monopolistic insurer; under competitive conditions, however, such a schedule would be practically unworkable.

TABLE I.

EFFECT OF SCHEDULE RATING IN PENNSYLVANIA, 1917, BY SIZE OF RISK.

Risk Payroll (Annual Basis). 1.	No. of Risks. 2.	Total Payroll. 3.	Weighted Average Rate in Per Cent. of Manual. 4.
ALL RISKS.....	4,761	$199,045,200	98.8%
$ - 5,000.....	249	900,400	109.9%
5,000- 10,000.....	863	6,195,200	110.6%
10,000- 15,000.....	721	8,460,900	107.3%
15,000- 25,000.....	887	16,463,000	105.1%
25,000- 35,000.....	610	17,148,100	103.3%
35,000- 50,000.....	401	16,223,100	101.6%
50,000- 75,000.....	389	22,965,700	100.8%
75,000-100,000.....	206	17,500,500	99.2%
100,000-150,000.....	176	20,367,900	97.8%
150,000-200,000.....	101	16,974,300	95.1%
Over 200,000.....	158	55,846,100	91.5%

TABLE II.

EFFECT OF SCHEDULE RATING IN PENNSYLVANIA, 1917, BY MANUAL RATE.

Manual Rate. 1.	No. of Risks. 2.	Total Payroll. 3.	Weighted Average Rate in Per Cent. of Manual. 4.
ALL RISKS.....	4,761	$199,045,200	98.8%
$ .15- .20.....	317	21,970,600	104.2%
.20- .26.....	345	22,365,500	104.1%
.26- .45.....	410	22,435,000	104.2%
.45- .60.....	743	35,507,300	100.8%
.60- .90.....	769	30,174,200	100.2%
.90-1.20.....	970	28,573,800	98.8%
1.20-1.50.....	601	19,479,000	97.1%
1.50-2.00.....	411	11,809,800	98.1%
2.00-3.50.....	156	5,564,200	94.7%
Over 3.50.....	39	1,165,800	88.3%

These results are corroborated by experience with variants of the same schedule in other states.* They are, in fact, inherent in the structure of the schedule. Most of the charges are flat amounts, whereas most of the credits bear a direct ratio to manual rate. Hence of two plants having the same payroll and developing the same item charges and credits, that which belongs to a low-rated classification will receive a net premium increase, and that which belongs to a high-rated classification will obtain a net premium decrease.† The flat charges, of course, are based upon the assump-

* See * on page 330.

† Applied to a hosiery establishment (Pennsylvania rate $.30) with a payroll of $100,000, flat charges of $90 and rate credits of 10 per cent. will produce a net premium *charge* of 20 per cent. Applied to a can factory

tion that the hazards reflected by them are independent of manual rates.* But the total hazard of the industry is necessarily reflected by the pure premium from which the manual rate is derived; an average rate increase by the operation of the schedule implies an average degree of hazard not indicated by experience. The injustice done to small employers is less clear: no analysis has ever been made, so far as the writer is aware, to show whether the experience of small risks is better or worse upon the whole than the experience of large risks. Small plants will doubtless average worse in respect of physical conditions, perhaps also with respect to supervision, than large establishments. Apart from such considerations, however, the small plant will usually have more machines, more elevators, more stairways and more floor space in proportion to payroll than large plants in the same industry. The flat charges, accordingly, produce a greater rate increase in a small than in a large establishment with the same ratio of defective to total equipment and with the same relative exposure to hazard.†

If the flat charges thus tend to excessive premiums upon small and low-rated establishments, the flat machine credits produce anomalous and sometimes excessive rate reductions. The machine points of operation credits, e. g., may have the curious result that more credit is given for the guarding of a dangerous machine than for its absence. These points of operation credits, moreover, being independent of rate, are a higher proportion of total premium in low-benefit than in high-benefit jurisdictions—a result not justified by any theory of rate-making. Further, wherever the number of working machines exceeds the number of employees, the machine credits may become excessive. To meet this contingency an arbitrary stop limit of ten per cent. of rate was established, whereby it

(Pennsylvania rate $1.50) with the same payroll, the same flat charges and the same rate credits give a net premium *credit* of 4 per cent.

* Cf. Hansen, *Proceedings*, Vol. I, p. 222; Whitney, *ib.*, p. 254.

† Mr. Hansen (*loc. cit.*) argues (1) that the exposure to the flat-charge defects is constant, irrespective of the number of employees and (2) that fixed charges are necessary to secure the correction of these defects. But it is not true that the exposure to, say, a flight of stairs is the same in a ten-man plant as in a hundred-man plant. The excessive ratio of exposure points to payroll in small establishments is mainly due to the presence of equipment which is only partially utilized and does not represent a greater proportionate exposure thereto. As to the second consideration, a rating schedule must first of all produce an equitable distribution of premiums.

comes to pass that the maximum allowable credit may be obtained by safeguarding a part only of the mechanical equipment.

The flat values, lastly, are not in practice—what the theory requires—fixed premium amounts. In applying the schedule all items are finally converted into a rate, which rate, as respects the flat values, necessarily depends upon the payroll disclosed by the policy declaration.* If, therefore, as ordinarily happens, the payroll is materially understated, the adjusted rate is either higher or lower than the schedule-makers intended, according as flat charge or credit items preponderate in the individual case.† It is not

Declaration Payroll. 1.	Man. Rate. 2.	Rate Credits. 3.	Prem. Charges. 4.	Prem. Credits. 5.	Adj. Rate. 6.	Audited Payroll. 7.	Adjusted Premium. 8.	True Adj. Rate. 9.	True Adj. Prem. 10.
$100,000	$1.00	10%	$300	$100	$1.10	$200,000	$2,200	$1.00	$2,000
100,000	1.00	10	100	300	.70	200,000	1,400	.80	1,600
200,000	1.00	5	400	200	1.05	100,000	1,050	1.15	1,500

simply that the flat values themselves fluctuate by as much as one hundred per cent. from a mere difference in payroll estimate; the total rate upon the risk varies within wide limits from the same fortuitous occurrence. The occurrence is not even always fortuitous; brokers are shrewd enough to manipulate payroll estimates with an express view to schedule rating results.

II.

The National Reference Committee on Schedule Rating,‡ in the work of revision lately completed, undertook to correct ad-

* In the 1916 Pennsylvania Schedule an attempt was made to treat the flat charges as net premium additions, over and above the rate expressed in the policy. This practice would have realized the theory of the flat items—only the flat premium additions proved uncollectible in practice.

† This is concretely shown in the exhibit below. In the first case, owing to preponderance of flat charges, the employer is penalized $200 in his final premium for underestimate of payroll. In the second case, by following the same all but universal practice, the employer secures an unmerited reduction of 10 per cent. of his final premium. In the third case, by a lucky overstatement of payroll, the employer saves 10 per cent. in his final premium adjustment. Otherwise stated, in the first case the nominal flat charge of $300 has been raised to $600; in the third case $200 has been collected in lieu of a nominal premium charge of $400.

‡ Formerly the Standing Committee on Schedule Rating.

mitted defects of the Universal Analytic Schedule without sacrificing its valuable features. The result of their labors is known as the Industrial Compensation Rating Schedule, 1918.*

The standards of safeguarding were thoroughly overhauled with a view to conforming more closely with the best engineering practice and with the legal standards of the several states. These latter were found to differ widely among themselves so that it was necessary to enlist the co-operation of state and federal authorities in the task of reconciling statutory and administrative requirements. By dint of many conferences and subcommittees, substantial uniformity was secured with the official standards of New York, New Jersey, Pennsylvania, Wisconsin and the United States Government, as also with the standards of the National Safety Council and the American Society of Mechanical Engineers. The Industrial Compensation Rating Schedule, 1918, much more than any of its predecessors, may thus claim to embody universal safety standards. This highly gratifying result was, of course, made possible by the antecedent labors of schedule-makers during a period of years.

2. Inasmuch as the flat premium values of the Universal Analytic Schedule had proven especially unsatisfactory in practice, the Committee wholly abandoned this method of value expression. All items in the 1918 Schedule are valued either in per cent. of manual rate or in cents on payroll. In this way a schedule rate is produced which does not in any manner depend upon or vary with the estimated payroll disclosed by the policy declaration. Since, moreover, all compensation insurance rates are quoted in per cent. of payroll, the item values of the 1918 Schedule are, as respects any given risk or any given classification, not merely reducible, but already reduced to a common denominator.

3. The awkwardness of the Universal Analytic Schedule with respect to rate control was overcome by the device of rating formulae. Thus the charge for elevator defects is applied by the formula:

* The work of formal revision was begun in October, 1917, and was finally ratified by the Joint Conference of the Schedule Rating Committees of the National Workmen's Compensation Service Bureau, the Compensation Inspection Rating Board (New York), the Massachusetts Rating and Inspection Bureau, the Compensation Rating and Inspection Bureau of New Jersey, and the Pennsylvania Compensation Rating and Inspection Bureau, March 26, 1918.

$$\left(\frac{D}{E}\right) K = \text{Rate charge per \$100 of payroll,}$$

in which D represents the number of elevator defects in the particular risk, E the number of plant employees, and K the rate value assigned to elevator hazards. Obviously, the premium results of this formula can be modified to any desired degree by modifying the factor K without altering the relative weight of the several elevator items or changing any item from a charge to a credit. So also with the credits for general machine guarding, for guarded machine points of operation, and for motor drive and the charge for unguarded transmission: in each case the premium results can be controlled by a single constant in the rating formula. This high degree of flexibility in the schedule as a whole and in its several component items constitutes a distinct advance in schedule making.

4. Still more fundamental and far reaching is the committee's attempt to relate the item values of the schedule to accident cost. Every rating schedule purports to establish rates of individual risks which shall be proportionate to certain enumerated hazards thereof.

In Professor A. W. Whitney's expressive phrase, schedule rating is a refinement of classification rates by way of rate increases or decreases for the presence or absence of specified hazard characteristics which serve to differentiate the risk in question from others in the same manual classification. To this end a definite rate or premium value is assigned to each risk feature whereof the schedule takes account. If, and insofar as, the values so assigned do not correspond to probable loss cost the ostensible purpose of the schedule, as respects rate adjustment, is defeated. Scientific schedule-making, accordingly, must depend upon the statistical determination of partial pure premiums answering to the specific hazards—in the case of compensation insurance, the specific accident causes—covered by the schedule.

Unfortunately, neither insurance carriers nor state administrative bodies have thus far compiled accident statistics in the requisite form and volume. The insurance carriers, indeed, have heretofore made no analysis of their loss experience by cause of accident. The state statistics hitherto published, though covering a considerable exposure, have suffered from incompleteness of the data and from want of uniformity in cause classification.* Some guidance

* The Committee on Statistics of the International Association of Indus-

as to the relative importance of certain great groups of accident causes—working machines, machine points of operation, power transmission, elevators, cranes, stairways, balconies—was obtained from the published reports of Wisconsin, Massachusetts and Ohio. For the most part, however, the correlation of item values with pure premiums must await the development of suitable accident statistics.

Appreciating the inadequacy of present data, the committee nevertheless deemed it worth while both to make use of such statistical information as could be obtained and to throw the schedule into such form as to admit of ready comparison between item values and accident cost. The items of the 1918 Schedule are arranged in three broad groups corresponding, respectively, to structural hazards, mechanical hazards, and plant morale. The term "structural" is used in a broad sense to include buildings and such relatively fixed equipment as boilers, elevators, cranes and electric installation.* "Mechanical" is more narrowly defined as referring to the hazard of power machines and the driving mechanism appurtenant thereto. The actual sequence of items is mainly governed by considerations of convenience to inspectors and employers. Logically, the several catastrophe hazards, e. g., might well be brought together. For field use, on the contrary, it is more advantageous to group all items relating to buildings, all those relating to boilers, and so on. With few exceptions, however, it will be found that each item corresponds to a recognized subdivision in the standard classification of accident causes.

trial Accident Boards and Commissions have formulated a series of standard classifications which have been adopted for prospective use by New York, Massachusetts, Ohio, Wisconsin, Ontario and the United States Employees Compensation Commission. See Bulletin 201 of the United States Bureau of Labor Statistics and the *Monthly Review* of the same Bureau for October, 1917.

Essentially the same classifications have been adopted by the National Workmen's Compensation Service Bureau.

*The "structural" section—Items 100 to 231 inclusive—is admittedly somewhat hodge-podge. Fire exits, stairs, balconies, floors and floor openings are indubitably structural. Elevators and cranes may likewise be regarded as integral parts of the building, though possessing also a mechanical aspect. But it is a straining of language to apply the term to boilers, electric generators or an acid distributing system.

Structural Items.

The catastrophe items* are valued at a uniform rate per $100 of payroll, irrespective of industry classification, as was the case also in the Universal Analytic Schedule. The same treatment is applied to high voltage electricity and to acid distributing systems. The justification of this procedure is that the item values are small, that the variations therein from industry to industry are unimportant relatively to total rate, and that all employees in a given establishment are or may be exposed to the hazards in question.

The case is otherwise with respect to the non-catastrophe structural items. These features of plant construction and equipment —balconies, platforms and trestles, floors and floor openings, stairs, elevators, cranes—bulk large in point of accident cost, their importance relatively to total rate varies markedly from industry to industry and the hazards arising therefrom commonly affect a part only of the employees of a given establishment. The corresponding item values, accordingly, are not a simple function of either payroll or manual premium. These hazards, in fact, are nearly proportionate to the number of danger points per hundred employees. The differences between industries already spoken of are rather in the average exposure per danger point than in the magnitude of the individual hazards themselves. Given the same number of employees, an unrailed stair, an unguarded elevator entrance or a hole in the floor presents practically the same risk of injury in a silk factory as in a carpenter shop. Logically, therefore, risk deviations in respect to these hazards should be measured by the formula:

$$(1) \qquad \left(\frac{U-N}{N}\right) K = \text{cents on payroll,}\dagger$$

* Item 111, fire exits; 112, fire-fighting appliances; 203, boiler-room exits; 206, absence of boilers; 207, boiler inspection; 221 and 222, explosive vapors; 302, engine governors. Item 101, first floor occupancy, relates only in part to catastrophe. The schedule thus far has not attempted to deal with the serious catastrophe hazards of particular industries.

† This formula was suggested by Mr. R. M. Pennock, of the State Workmen's Insurance Fund of Pennsylvania. K might, of course, be written as a per cent. of manual rate, differing for each industry. But this would merely introduce two variables in the rating of each item. Since the hazard to be measured bears no derivative relationship to, and is not affected by, the specific hazard of the industry, it seems more advantageous to express K as a constant per $100 of payroll.

Cranes doubtfully belong in this group. It seems probable that the crane hazard bears a fairly close relationship to the materials, processes and products which characterize the specific industry.

where K is the rate value of the item, irrespective of the industry, U is the number of danger points per hundred employees in the individual risk and N the standard or normal number of such danger points per hundred employees for the industry classification. This formula, evidently, will give credits as well as charges, according as $(U-N)$ is negative or positive.

In practice, the importance of these items has not been deemed to warrant so much refinement in rating methods. The N values in the above formula would evidently vary both from industry to industry and from state to state; the ultimate statistical groups, therefore, are likely to be too small to give dependable averages. The use of many different values, moreover, would greatly enhance the clerical labor of rating. For practical purposes, it probably is sufficiently accurate to use average N values derived from schedule-rated industries as a whole. This simplification at once eliminates credits for less than average exposure—no one would wish, e. g., to credit a watch factory for the absence of locomotive cranes or even for the absence of defective flooring—and confines the structural items to charges for defective or substandard conditions as defined by the schedule. Thus simplified, the rating formula runs:

$$\left(\frac{D}{E}\right)KN = \text{cents on payroll}, \tag{2}$$

where K is the item rate value as before, D is the number of defect points in the individual risk, E the number of plant employees, and N the normal or standard number of employees per defect point in schedule-rated industries. Further simplification (in point of office procedure) can evidently be secured by means of weighted defect points such that D combines the frequency of occurrence (N value) with the rate value of the item, and K becomes uniform for all structural items.* This is the method adopted by the committee, giving the formula:

* Thus, if the rate value of the elevator-gate hazard be taken at \$.01 and the frequency of unguarded elevator entrances at two per hundred employees, one unguarded entrance in a twenty-five-man plant would be rated by formula (2):

$$(\tfrac{1}{25})(\tfrac{2}{1})(\$.01) = \$.02 \text{ on payroll.}$$

The same result, evidently, is attained by formula (3) with a K value of \$.125 and a weight of four points per elevator gate. Thus:

$$(\tfrac{4}{25})\ \$.125 = \$.02 \text{ on payroll.}$$

$$(3) \qquad \left(\frac{D}{E}\right)K = \text{cents on payroll,}^*$$

wherein E is the number of plant employees, D the number of defect points multiplied by the item weight of each and K is a constant per unit of payroll. The K value should, of course, be modified by the law differential of each state.

The committee formula, it will have been observed, gives a practically constant premium value per defect. Insofar, the flat values of the Universal Analytic Schedule appear to be confirmed by the latest attempt at schedule building. Indeed, pending the statistical determination of D, the actual judgment values of the former schedule were retained. The advantages of the formula are: independence of payroll estimates in the rating of risks, facility of rate control, and the ability to relate the item values to normal exposures and pure premium values so soon as these shall have been statistically determined.

Mechanical Items.

The mechanical hazards† stand in marked contrast with the structural in that they bear in general a close relationship to the total hazard of manufacturing industry. Not only does machinery far outweigh any other single group of accident causes in most branches of manufacturing;‡ the kind and amount of mechanical

* The number of employees is taken at a minimum of twenty-five which has the intended effect of reducing the premium value per defect upon very small plants.

K, at present, is uniform for all states. The committee recognized that the value should be proportional to the scale of compensation benefits, but felt that this refinement could well wait until the D values themselves are statistically determined.

† The mechanical hazards fall into three broad groups: power transmission, from the prime mover to the individual machine; machine hazards other than points of operation, being machine drives and sundry moving parts; and machine points of operation. The point of operation is the machine "tool" as distinguished from the mechanism of power transmission and control; that which acts directly upon the material and performs the cutting, shaping, pressing or forming action of the machine. The point of operation may be hazardous or non-hazardous. Circular saws and hand-fed stamping presses stand at one end of the hazard scale; at the other may be placed an automatic screw machine or a watchmaker's lathe.

‡ Foundries, blast furnaces, breweries and glass works—to bracket industries which have little else in common—are notable exceptions.

equipment, which go to determine the extent of mechanical hazard, are highly characteristic of each specific industry, being in fact closely dependent upon the materials worked with and the products turned out. For the same reason, the proportion of machine to total hazard varies pretty directly with the number of machines per hundred employees.

These considerations point to the rating formula:

$$(4) \quad \left(\frac{U-N}{N}\right) R = \text{per cent. deviation from manual rate,}$$

where U is the number of machine danger points per hundred plant employees in the particular risk, N the normal number of such danger points per hundred workmen in the industry class, and R the proportion of pure premium attributable to mechanical hazards. R and N will, of course, vary from industry to industry, while U will vary from plant to plant. In arriving at the values of U and N account should be taken of guarded as well as unguarded equipment; the best guarding removes the hazard of machinery only in part. For the purpose in hand it would perhaps be reasonable to take each guarded unit at a weight of one point and each unguarded unit at a weight of two points. The advantage of this method is that it allows for the wide differences in ratio of machine exposure which are actually encountered within the same industry. One hundred machines per hundred employees, all fully guarded, may well represent a greater hazard than forty similar machines per hundred workmen, though all unguarded. The formula above suggested takes account of both factors—the ratio of machine equipment to employees and the extent of guarding. It will, therefore, produce what has not hitherto been accomplished: a rate deviation proportionate to the hazard deviation from the classification norm.*

To apply this formula it would be needful to know with a fair degree of accuracy, for each classification, the average ratios of guarded and of unguarded machinery to employees and the ratio of machine accident cost to total pure premium. This information is at present unobtainable. What is known is the total number of machines per hundred employees for each of the principal schedule-

* For a fuller development of this point see *Proceedings*, Vol. III, pp. 38–39.

rated industries and a rough approximation to the proportion of machine accident cost for schedule-rated industries as a whole. Having in mind the limited information available, as also the difficulty of making a violent break with past practice,* the National Reference Committee adopted (for general machine guarding) the simplified formula:

$$(5) \qquad \left(\frac{G}{M}\right) RN = \text{Credit in per cent. of manual rate,}$$

wherein M is the number of machines in the particular plant, G the number of guarded machines, N the classification ratio of machines to employees, and R a uniform percentage of manual rate. With an R value of ten per cent., the allowable credit becomes fifteen per cent. where (as in cotton spinning) N is 1.5, and one and one-half per cent. where (as in blast furnaces) N is .15. The use of RN in lieu of a varying R is grounded on the hypothesis—for which there is both *a priori* and statistical warrant—that the proportion of machine to total hazard varies with the number of machines per hundred employees. It is, of course, a convenience in office rating. The weakness of the committee formula is that it ignores risk deviations from the classification machine ratio. An establishment with less than normal machine exposure is credited only in the sense of having to guard fewer machines to earn the same rate credit.† Transmission apparatus is treated in the same fashion except that here RN expresses a charge for unguarded equipment or a credit for direct motor drive. In this connection the assumption was made that the transmission exposure of a given industry bears a direct ratio to the machine exposure. Machine points of operation, lastly, are rated for credit in the same way, but with a different set of $N(n')$ values. For there are many

* In the past, *unguarded* transmission has been *charged,* motor drive, *guarded* machines and *guarded* points of operation have been credited. These distinctions may or may not be well founded; the point is that a change from charge to credit may seriously affect premium income whereas the opposite change will certainly create serious friction with the insuring public.

† Given a payroll of $80,000 and a manual premium of $1,200, a carpenter shop which has 100 machines would receive a premium credit of $1.20 per guarded machine. Another shop, with the same payroll and the same manual premium, but with only 40 machines, would receive a credit of $3.00 per guarded machine. This difference in premium credit is intended.

machines which have no point of operation hazard, so that no constant relation will hold between the classification ratio of machines to workmen and the like ratio of machine points of operation.* It is to be observed that the schedule treats transmission apparatus as normally guarded and charges for the unguarded units, whereas it considers machines and machine points of operation as normally unguarded and credits the guarded units.

Morale Items.

The moral items—safety organization, first-aid and hospital facilities, light, ventilation, general orderliness—relate to safety measures or practices which affect all employees in the given establishment and which have a preventive value directly proportionate to the total hazard of the industry. Very properly, therefore, these item values are expressed immediately in per cent. of manual rate.†

The writer has elswhere argued‡ that the effectiveness of those safety measures which are here in question can best be gauged by the accident experience of the plant. The factors affecting safety morale, as distinguished from physical safeguards, are legion and for the most part intangible. For the purposes of schedule rating it is necessary to judge plant morale by certain external criteria—the amount of litter in the aisles, the nurse's certificate of competency or the records of safety meetings. In the nature of the case, no definite standards can be set up which go to the root of the matter: the spirit in which supervision, discipline, education and accident treatment are administered. At the same time, it is not possible to relate the morale item values in any definite way to fractional pure premiums. Safety supervision, or the want of it, is not a specific cause of accidents; it operates by affecting for good or ill every specific source of danger. On these grounds it would seem preferable to confine the schedule to physical features of

* For flour mills the N value is 1.5 and N' .05, for planing mills, N is 1.0 and N' .9, for can manufacturing, N is .6 and N' .5.

† This justification will not hold for the per cent. of rate values assigned to such personal safeguards as respirators, eye protectors and foot and leg protectors. These safeguards do not affect the entire payroll of any establishment and the specific hazards—flying fragments in grinding or chipping, irrespirable dust or fumes, molten metal—which they are intended to counteract do not vary with the total hazard of the industry.

‡ *Proceedings*, Vol. III, p. 40.

plant and equipment and to measure morale, insofar as it is capable of measurement, by experience rating. The schedule rate would thus become a prediction of certain accident costs based upon the characteristics of the industry and the apparent hazards of the establishment. Experience rating would check up this prediction in the light of the establishment record. Insofar as the classification rate and the schedule values are correct, experience deviation from schedule-classification rate would indicate deviation from average morale.

It is questionable, however, whether the time is ripe for so drastic a step. Experience rating has yet to approve itself in practice as a fair measure of risk deviation from classification hazard. The schedule values have yet to be placed upon a sound statistical basis. Meanwhile, safety engineering and medical opinion asserts with great unanimity that certain positive measures—safety organization and education, first-aid treatment of wounds, appropriate eye, lung and foot protection against well-defined occupational hazards—have a high degree of efficacy in reducing the number and severity of accidental injuries. It probably is well worth while, therefore, for the present, to subordinate accuracy of rating in this particular to accident prevention and to hold out definite inducements in the schedule for the adoption of these measures. Reasoning thus, the committee retained the morale items with purely judgment values. With respect to the most important of these items, however, and the item which is most difficult to gauge by external criteria—safety organization—the extent of credit is made to depend upon the accident record of the risk.*

* It is possible to meet all the external tests that can practically be set up for safety organizations at relatively small expense and without achieving useful preventive results. The large credit in the Universal Analytic Schedule—ten per cent. of manual rate—consequently called into existence many "paper organizations," which went through the prescribed motions but exerted no perceptible influence on accident occurrence.

The National Reference Committee proposed to test the effectiveness of safety organizations by accident time loss computed in such a way that temporary accidents would count for full time loss and fatal and permanent injuries for a low arbitrary value. Purely from considerations of administrative convenience, the "all other" accident cost of the experience rating plan recently adopted by the National Reference Committee on Workmen's Compensation Insurance was substituted for this test.

III.

Two or three general observations upon the theory of schedule rating which underlies the foregoing discussion will bring this paper to a close.

1. Every plan of individual risk rating presupposes a classification rate to which the individual rating is applied by way of modification. On the one hand, with extremely few exceptions, the exposure of an individual insured risk is wholly insufficient to develop a stable experience. On the other hand, no rating schedule can take account of all the component hazards of industry or can accurately measure even those with which it attempts to deal. In any sound system of rate-making, therefore, the classification rate must remain the principal and controlling element in the rate of individual risks. The function of individual risk rating, whether by experience or schedule, is to establish risk deviations from the classification average.

Starting from this principle, the risk deviation in respect to any given hazard, as machines or elevator gates, would be expressed by the formula:

$$(6)\quad X=\left(\frac{U-N}{N}\right)r \quad \text{or} \qquad (7)\quad Y=\left(\frac{U-N}{N}\right)k,^{*}$$

wherein X is the item charge or credit in per cent. of manual rate, Y the item charge or credit per unit of payroll irrespective of manual rate, r the proportion of classification rate attributable to the hazard-group in question, k the absolute rate value of the item, N the number of danger points of the specified kind per unit of exposure in the industry classification at large, and U the number of such danger points per exposure unit in the individual risk. As between r and k, X and Y, preference should be given to value expression in terms of manual rate, because it is the manual rate in which the classification experience is summed up, and to which individual risk rates are to be related. Since the component hazards of industry are not in general cumulative—the elevator hazard does not affect the crane hazard nor does the crane hazard multiply the hazard of machines—the several items of the schedule may be taken additively. The risk deviation, in other words, is obtained by

* These formulae take no account of catastrophe hazards, which for most manufacturing industries are all but negligible.

adding the several X's and Y's to the classification rate. The general formula would thus be:

$$(8) \quad I = R + (Y_1 + Y_2 \cdots + Y_n) + (X_1 + X_2 \cdots + X_n),$$

I being the risk rate and R the classification rate. In practice, X would, of course, be reduced to cents on payroll by applying the given percentage to the classification rate.*

This general formula, if constructed and revised upon an adequate statistical basis, will automatically produce a balance of aggregate premium charges and credits, because it will produce such a balance upon each schedule item, since it lies in the nature of weighted averages that the total deviation is equal in both directions. A balance may, of course, be obtained in other ways: by the awkward revision of item values and the equally awkward interchange between credit and debit columns heretofore in use, by loading the manual rates to compensate for schedule decreases, or by applying a schedule of charges only to such percentage of manual rate as will serve to produce the desired premium income.† But, apart from other disadvantages, no one of these methods gives the true risk deviation from the classification rate with respect either to the schedule as a whole or to the schedule items severally.

The assignment of particular items to the credit column and of others to the debit column, as heretofore practised, is mainly arbitrary; the decision in any given case turns rather upon rate effect than upon any statistical determination of facts.‡ Even if it be true, as it doubtless is, that a majority of elevator entrances are guarded and a majority of machine belts unguarded, still the normal and prevalent condition, in both instances, is a certain proportion of guarded and a certain proportion of unguarded equipment. To make the one item wholly a matter of charge and the other wholly a matter of credit is to penalize or reward employers for

* Purely for illustration, assume a carpenter shop for which R is \$1.50, Y_1 (floors) is + \$.01, Y_2 (floor openings) is + \$.03, Y_3 (stairs) is + \$.035, Y_4 (elevators) is + \$.05, X_1 (transmission) is + 10 per cent., X_2 (general machine hazard) is — 20 per cent., and X_3 (machine points of operation) is — 5 per cent. I is then \$1.40.

† This last is the method adopted in the Coal Mine Compensation Rating Schedule of Pennsylvania.

‡ This is particularly notable in the forced and arbitrary definition of transmission equipment—Industrial Compensation Rating Schedule, 1918, Item 320 and 329(3).

conditions which are in part contemplated in the manual rate. This effect is especially marked in the case of items with respect to which it is difficult to say whether guarding or failure to guard is prevalent. Under the rating method above described, these difficulties disappear. Each item carries a charge or credit according as the risk hazard with respect thereto is greater or less than the average of its class.*

2. For the development of a rating schedule upon the lines here indicated, it is necessary to obtain statistics of plant equipment and statistics of pure premiums by cause of accident.

The requisite information under the first of these heads can be secured from schedule-rating inspections. Most of it, indeed, is already available upon existing inspection reports. Tabulation of these reports by the several rating bureaus† will readily develop the item norms. For the most important items, these norms should be known by industry "groups"; for other items it will be sufficient to establish norms for industry "schedules."‡ The norms will, of course, change—it is to be hoped, for the better—from year to year; to some extent, also, they will vary from state to state. Inasmuch, however, as schedule-rated plants are inspected annually, the information can always be kept well abreast of the latest pure premium developments.

* One serious practical difficulty is glossed over in the text—the difficulty, namely, of obtaining accurate employee exposures. It is, fortunately, not necessary, for the purpose in hand, to obtain exposures in terms of man years. In a given plant which has a given number of machines, belts, elevators, floor openings and what not, and employs a given number of workmen, the exposure per employee hour and per payroll unit is the same whatever the number of hours worked per day, week or year. What is needed, is the average number employed when the plant is in operation. Since this number fluctuates from day to day and from season to season—even from shift to shift—an actual count at the time of inspection may give results as erratic as the payroll estimates on policy declarations. It should be possible, however, to ascertain the approximate average from plant records taken at monthly or quarterly intervals.

† The Pennsylvania Compensation Rating and Inspection Bureau is already making this tabulation. Similar tabulation by all bureaus has been requested by the National Reference Committee on Schedule Rating.

‡ The terms "groups" and "schedules" are here used in the sense defined by the Statistical Committee of the International Association of Industrial Accident Boards and Commissions (Bulletin 201 of the United States Bureau of Labor Statistics) and by the "Code Manual" of the National Workmen's Compensation Service Bureau.

The ascertainment of fractional pure premiums corresponding to specific accident causes should not prove extremely difficult. It is understood, indeed, that most insurance carriers already have this information on punch cards. The precise bearing of the information when obtained may call for some further remark. Given that machine points of operation are responsible for one-fourth of total accident cost in the planing-mill group of industries, and that the normal exposure in this industry group is thirty guarded and sixty unguarded points of operation per hundred employees, what credit should be allowed for guarding one buzz planer in a hundred-man mill? Stated in these terms the problem appears at first blush insoluble. It is not possible to ascertain either the total number of machines which produced the pure premium in question nor the number of employees exposed thereto; in these directions the data will carry us no further than bare ratios. Still less is it practicable by mass statistics to determine the relative hazard of guarded and unguarded buzz planers or of buzz planers and buzz saws, individually considered. But because a perfectly accurate solution is unobtainable it is not necessary to reject every approximation. Knowledge, in practical affairs, always requires to be supplemented by that species of inference which is termed judgment; yet judgment is the surer the more full and exact the knowledge upon which it operates. The main use of statistics, indeed, is to limit the area and guide the direction of practical judgment.

In the instant case, there is abundant evidence from plant records that the cylindrical-head jointer is safer than the square-head type, that certain saw guards, feed roll guards and planer guards do reduce the number and severity of accidents, and that woodworking by power machinery is more hazardous than woodworking by hand somewhat in proportion to the machine employee ratio. It is no very violent assumption from the facts known that the guarding to standard of woodworking machines would reduce the point of operation hazard by one-half. On this assumption, the guarding of one point of operation in a hundred-man planing mill would be worth $\frac{1}{6}$ per cent. of manual rate and the complete elimination of one point of operation would deserve a credit of $\frac{1}{3}$ per cent. of manual rate.* These values will hold so long as the item norm and the corresponding fractional pure premium are

* Formula (6), counting each guarded machine as one and each unguarded machine as two. On the facts assumed, r is 25 per cent. and N is 150.

derived from the same experience. For the pure premium reflects the hazard of the total equipment as it existed at the time: divergence of the individual risk from the conditions reflected in this pure premium will warrant a proportional departure from the manual rate predicated thereupon.

3. The method of rating by means of deviations from item norms will, to a great extent, obviate the necessity of building separate schedules for different manufacturing industries. The same general accident causes are common to most branches of manufacturing; differentiation occurs, not so much in the presence or absence of specific causes, as in the intensity of hazard and the relative importance of the several cause groups. The same schedule items, accordingly, with appropriate variations of item norms and item values, are applicable to a wide range of industrial conditions. Certain items of little general importance may require to be inserted for specific industries; it may even be necessary to develop a separate schedule for such an industry as explosive manufacturing, the chief hazards of which are peculiar to itself. It should be possible, however, by a mere extension of methods already adopted,* to apply the same general schedule with a fair degree of equity to the great majority of manufacturing enterprises.

If the foregoing conclusions are at all correct, the Industrial Compensation Rating Schedule, 1918, constitutes an important advance upon its predecessors. It is more elastic in respect of adaptability to varying industrial conditions, more flexible in respect of statistical control, more organic in structure, more in accord with the theoretic requirements of individual risk rating. The standards have been improved in many points of detail, anomalies of the former schedule, as applied especially to small risks and low-rated industries, have been corrected; above all, it is believed that a foundation has been laid for future development. The erection of a sound and stable superstructure will mainly depend upon the accumulation and analysis of appropriate statistical data.

* In the 1918 Schedule, each classification carries specific N and N' values (normal ratios of machines and machine points of operation to employees). In addition, a number of items are restricted to specifically designated classifications.—See "List of Classifications Subject to Schedule Rating."