Sir Clifford Allbutt, K.C.B., F.R.S., Dr. R. T. Leiper, Professor Benjamin Moore, F.R.S., Mr. E. B. Turner, F.R.C.S., Professor J. S. Haldane, F.R.S.; and for the British Science Guild, Professor Bayliss, F.R.S., and Dr. Somerville (Chairman and Secretary of the Guild's Health Committee), Sir Alfred Keogh, G.C.B., and Sir Ronald Ross.

We have called attention to this matter in *Science Progress* over and over again, without any definite result hitherto. There is unlimited talk just now about the encouragement of science, but the vital point is almost always omitted. This point is that, unless you make it worth their while for men of great abilities to investigate nature, they will in many cases not be able to do so even though they have the strongest inclination in that direction. We are now spending large sums of money for scientific work, but most of it goes in providing laboratory facilities and small salaries to junior men for "potboiler work." This is certainly essential, and we lodge no objection to such expenditure; but, in addition, we must pay adequately for the best possible brains. There is only one way to do so—by paying for discoveries which have already been made. There is really no other way of detecting the best possible brain when it exists. The proof of the pudding is in the eating, and, of the best brain, in the result obtained by it. We therefore think that the world should organize a system of pensions, not only for medical, but for all work which has been of great value to the public at large without being remunerative to the worker. Such a thing is only common sense, common justice and common morality.

The case of the medical scientific worker is the strongest of all. Few people recognize that medical science brings in almost no payment even when it results in discoveries which are really revolutionizing civilization. The fact is that, of all great events in history, perhaps none exceed in importance the discoveries made during the last century regarding the nature of human diseases and their prevention and cure. Yet the people who have made these discoveries have generally lived, we might almost say, in extreme poverty. We believe that the salaries of pathological professors amount generally to only a few hundred a year, and seldom, if ever, exceed one thousand pounds a year. Even these posts appear to be seldom given to men who have themselves made leading medical discoveries. Some people seem to think that such men are remunerated by medical practise; but that is far from the case, and anyway it is a poor kind of remuneration which is given only by means of additional work. For example, Jenner, the great discoverer of vaccination, found that his reputation in this line actually ruined his medical practise; and it was partly for this reason that early last century the British Parliament (which was then a rational and virile body) gave him £30,000 as a reward. The reason for this is that everyone considers a famous discoverer to be only a faddist or a charlatan! Of course many other pursuits which are invaluable to civilization are in precisely the same boat—other branches of science, music, literature and sometimes even painting, travel, etc. Our proposal is that every nation should keep a pension fund for really great work in these lines. We do not suppose that the British Empire would have to pay more than, say, £30,000 annually for such pensions, as against many millions of pounds which it now gives as a subvention for loafing, incompetence, and unemployment.—*Science Progress.*

SPECIAL ARTICLES

A METHOD OF ASSIGNING WEIGHTS TO ORIGINAL OBSERVATIONS

PERSONS accustomed to making precise measurements know that the circumstances attendant upon their work vary to such a degree as to render some observations much more reliable than others. When a series of such results is adjusted, as by averaging the measurements on a single quantity, it is logical that some should be given greater voice in deciding upon the most probable value. This is done by assigning to each observation a number, called its *weight,* which represents the relative degree of reliability of the observation in question. The practical way of interpreting these weights is to give each observation a number of "votes," so to speak, equal to its weight; that is, to count its result that number of times in making up the average. An observation with weight 5, for example, is considered to be worth five times as much as one with weight 1, whatever that signifies. It merits as much confidence as the average of five observations with weight 1.

If each result to be weighted is actually the mean of a number of similar observations, the weighting is comparatively easy. But we refer to the weighting of the *original* observations; and how is one to decide, without indulging in mere guesswork, what this factor, to be assigned to each of such a series of results, should be?

Probably many scientific observers do not weight their measurements because they do not know how. They know that some results are much more trustworthy than others, but they are at a loss when it comes to expressing *how much* more. It is the purpose of this paper to suggest a simple means whereby any scientific worker may arrive at a consistent practise in this matter.

There are very few people engaged in work involving precise measurement who have not reached, through experience either as teachers or as students, a pretty well defined interpretation of the ordinary percentage grades assigned to pupils in school or college. When a boy comes home with a grade of only 72 in grammar, the occasion is not one for congratulation. The whole family knows that 72 stands for poor quality of scholarship, for the reason that the vast majority of pupils are assigned a higher grade than this.

Now, it is not difficult for an observer to assign percentage grades to his experimental results, passing judgment upon them very much as he would upon work done by a student in laboratory or classroom. He may even take separate account of the various factors which may affect the observation, such as weather conditions, visibility, constancy of temperature, etc., and combine all these in estimating the final grade of the result, just as a teacher combines recitations, notebooks, tests and examination in grading a student.

And if, when the several observations of a set have been thus graded, a means is at hand to translate the grades into relative weights, our problem is solved. Such a means is provided by the following considerations.

The *variable* conditions attending the making of measurements, which alone affect their relative weight, are of course fortuitous. The experimenter tries to have everything constant and to maintain a uniformly high standard of precision, just as a marksman tries repeatedly to hit the same target. But he can not control all the conditions, and these fluctuate in accordance with the well-known law of departures, based upon the theory of probabilities.

The theory puts no limit to these fluctuations, and one observation might, theoretically, be a thousand times more reliable than another; but practically no such range need be considered. Probably for most purposes, primarily assigned[1] weights need not go outside the simple scale of integers from 0 to 10; the weight 0 denoting absolute worthlessness (observation to be discarded) and the weight 10 denoting practical certainty. Either of these cases would be extraordinary and of very rare occurrence. The general run of results will vary from a little doubtful to a little more than usually reliable, being situated not far either way from weight 5, the middle of the scale.

When the unit of weight has been chosen with such significance that the distribution is as described, it is possible at once to predict what proportion of observations should, in the long run, have weight 2, what proportion should have weight 3, etc. This is done by means of the *probability integral,* tables of which are given in most books on the theory of errors. These proportions are here given as percentages, accurate to the second decimal place:

[1] This does not apply to weights computed for adjusted values based on long series of observations or upon indirect measurements of connected quantities. In such cases, large and even mixed fractional numbers may be consistently assigned as weights.

Percentage	having	weight	0	should	be	0.00
"	"	"	1	"	"	0.15
"	"	"	2	"	"	1.54
"	"	"	3	"	"	8.46
"	"	"	4	"	"	23.42
"	"	"	5	"	"	32.86
"	"	"	6	"	"	23.42
"	"	"	7	"	"	8.46
"	"	"	8	"	"	1.54
"	"	"	9	"	"	0.15
"	"	"	10	"	"	0.00

For the present purpose it will be more useful to express these same data in the following form:

Percentage having weight—

0	*or*	*above*	should	be	100.00
1	"	"	"	"	100.00
2	"	"	"	"	99.85
3	"	"	"	"	98.31
4	"	"	"	"	89.85
5	"	"	"	"	66.43
6	"	"	"	"	33.57
7	"	"	"	"	10.15
8	"	"	"	"	1.69
9	"	"	"	"	0.15
10	"	"	"	"	0.00

Now a similar tabulation may be made in the case of grades. An examination of the grades assigned by teachers shows a distribution which, while it is very far from having the bilateral symmetry of the theoretical departure law, nevertheless gives evidence of a somewhat similar continuous relation throughout the range of the assignment. The following data, based on the tabulation of over one hundred thousand grades from a large number of school and college teachers,[2] are probably fairly typical:

Percentage of grades which were—

50	*or*	*above*	was	100
55	"	"	"	99
60	"	"	"	98
65	"	"	"	96
70	"	"	"	94
75	"	"	"	89
80	"	"	"	83
85	"	"	"	70
90	"	"	"	56
95	"	"	"	32
100	"	"	"	9

[2] See article by author, "A Standard of Interpretation of Numerical Grades," *School Review*, Vol. XXV., p. 412, June, 1917.

Let us plot these two sets of data on the same diagram, so that they may be easily compared (Fig. 1). The method of translation from grades to weights may then be made

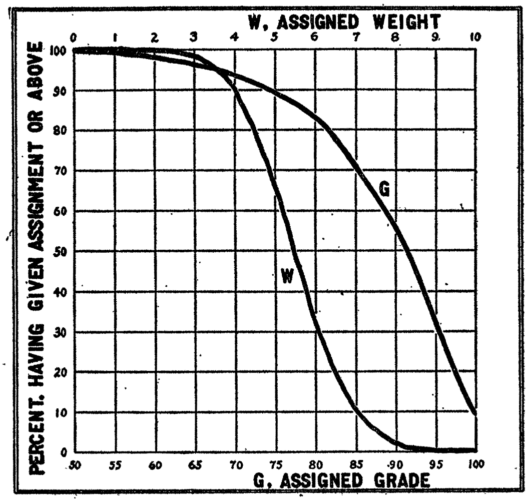

Fig. 1.

clear by a single illustration. The grade curve shows that the grade 85 *or above* is attained in 70 per cent. of all cases, while the

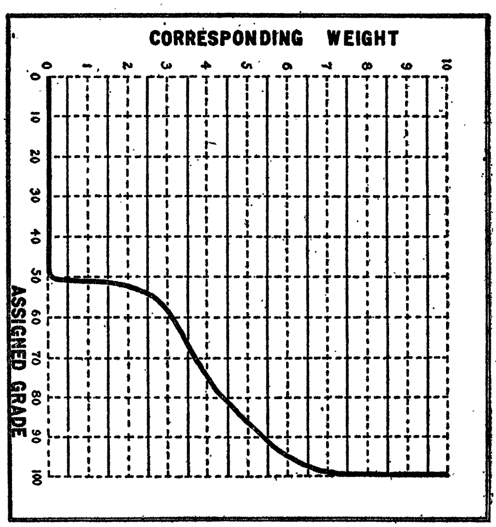

FIG. 2.

weight that should be attained in the same percentage of cases is shown by the weight curve to be 4.9 *or above.* It logically follows that the *grade* 85 corresponds to the *weight* 4.9; etc.

By obtaining a number of such corresponding points, the translation curve (Fig. 2) is constructed. Fractional weights being inconvenient, the most practical tabulation will probably be as follows:

TRANSLATION TABLE FROM PERCENTAGE GRADES TO WEIGHTS

Grades	Corresponding Weight
0– 50	0
50– 51	1
51– 54	2
54– 67	3
67– 82	4
82– 92	5
92– 97	6
97–100	7
100	8
Very exceptional	9
Practically certain	10

This table will serve our purpose in most cases. One further refinement may be desirable, especially if the observer suspects that his own habit in grading is far from normal; that is, if he is inclined to be either unusually severe or unusually lenient in assigning grades. The article previously referred to contains tables which afford the necessary correction. The writer, for example, is a grader of Type 6 as there classified, and in his case weight 5 corresponds to grades from 77 to 88, instead of from 82 to 92; etc. The difference will not usually be of extreme importance. A still better plan, when the observer makes and grades a very large number of similar observations, is to construct one's own grade distribution curve (corresponding to Fig. 1) from the tabulation of these gradings, and from it to prepare, as above explained, a translation table suited exactly to one's own peculiar grading characteristics.

Summarizing this method of assigning weights to original observations:

1. First grade the observations on a scale of 100 as you would students, averaging together the various factors that may affect their reliability. In doing this, endeavor to maintain the same mental attitude toward the experiments as you would toward the work of a class of students.

2. Then consult the above translation table (or one of your own making) for the proper weights to be assigned.

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THE AMERICAN CHEMICAL SOCIETY. III

DIVISION OF INDUSTRIAL CHEMISTS AND CHEMICAL ENGINEERS

H. S. Miner, *Chairman*

H. E. Howe, *Secretary*

Incendiaries used in modern warfare: Capt. A. B. Ray.

Gas masks in the industries: A. C. Fieldner. The Bureau of Mines is cooperating with the industries in the development of suitable modifications of the Army gas mask for industrial use. In the nine months that have elapsed since the signing of the armistice, the gas mask has made rapid progress in finding a wide application in protecting workmen from poisonous and irritating gases given off in various chemical operations; as for example, chlorine, phosgene, sulphur dioxide, oxides of nitrogen, hydrochloric acid, sulphur chloride and many organic vapors as carbon disulphide, benzol, carbon tetrachloride, aniline, chloroform, formaldehyde, etc. Fire departments have purchased many Army masks for use as smoke protectors. However, they must be used with caution around fires, as they given no protection from carbon monoxide, which may be present in smoky atmospheres. The Army gas mask, when fitted with special canister containing ammonia absorbents, has met with great success for use around refrigerating plants. On the whole, the gas mask is rapidly finding its proper place in the industries. It has not met all the requirements expected, especially in such cases where the workmen must wear it for long periods of time. Experience has shown that they simply will not wear a mask continuously if they can possibly get along without it, but for short periods and in emergencies, it has proved very useful. The possibilities of the gas mask principle are now pretty generally understood, and much improvement in design may be expected within the next year.

The physical character of hydrous ferric oxide: Harry B. Weiser.

Modern commercial explosives: R. H. Hill. Paper disputes the war-developed, current idea