EYE HAZARDS AND SAFETY PRACTICE: A REVIEW OF 14,722 EYE ACCIDENTS IN THE WEAR SIDE SHIPYARDS

PRELIMINARY REPORT

BY

A. KEFALAS

From the Wear Shipbuilders' Association

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Nature of the Inquiry

This inquiry is part of a larger one into 100,000 odd accidents of all sorts which occurred during the last four years of the 1939-45 war and which is in itself part of a review of current safety practice; and this object of the accident investigation should be kept in mind as it explains the lines the work has followed. The writer makes no apology for insisting on the truism that to attempt safety measures without knowing in detail what is happening is to court failure and, with this obvious but much neglected proposition in mind, the first step has been to ascertain as exactly as possible what the equipment or process actually does to the worker. For this purpose *every* accident is significant.

The group of accidents of which these 14,722 eye accidents are a part has been collected from 1942 to 1946 inclusive, and it will be well to define the word "accident." For the present purpose, an accident is any injury, irrespective of its degree of severity, sustained by a worker, whilst at work, which brings him to the ambulance room. In this area, that definition includes practically every injury because our workers have learned the danger inherent in any minor injury in an industry like ours and, with very few exceptions, are quick to seek help. We need concern ourselves, at the moment, neither with the extent of the several injuries nor with the accident-proneness of the several individuals although these will need attention at a later stage of the inquiry. It is, however, important to note three broad classes of accident, as follows:

1. Accidents involving no real incapacity and capable of treatment in the ambulance room.
2. Accidents needing to be sent to hospital either for treatment there, or to check diagnosis made or treatment given in the ambulance room.
3. Accidents proceeding to compensation, that is, all those causing incapacitation lasting three days or more.

We have an amicable and effective understanding with the general practitioners in this area by means of which hospital cases are sent for help without loss of time and by which we work together for the patients' benefit, and I would like to express a very lively appreciation of the kindly and helpful collaboration I have had here. Our accidents are thus treated with the minimum of delay and formality and we are able to keep track of them.

Definitions and Groupings

For the purpose in hand, these definitions have to be made:

Flash.—Affections of the eye by emissions from the electric welder's arc.

Burn.—Burn or scald from a flame, etc., or from a hot agent usually bigger than the average foreign body.

Injury.—Any hurt or wound caused by heavy impact, for example, by a hammer, ship's plate, heavy fall, etc.

Foreign Body.—Any unidentifiable particle or fragment. Particles are identified when possible and, if any one is mentioned specifically, it can be taken that the identification is certain.

Hot Foreign Body.—Any unidentifiable particle or small fragment hot enough to cause a recognizable burn.

It should be remembered that these definitions suffer from the defects of all such categories, in that they turn very largely on the "personal equation."

The identification of particles has been a matter of some difficulty during the war period in which these cases were collected. The many difficulties we then faced have been overcome; and our nurses, with the experience and training they have had, can, by questioning the patient in the light of their knowledge of the work he does and the tools and material he handles and by closely examining the foreign bodies (through the loup, if necessary), identify the great majority of the particles with certainty so that we now get at least 95 per cent. of all these foreign bodies identified. In this batch, the accident, in all doubtful cases, is entered in the "foreign body" class, and this

class, therefore, is large and ill-defined. Incidentally, this term "foreign body" should really read "unidentified foreign body not immediately irritant" and is abbreviated in the tables for obvious reasons. In the case of burns, the identification has been particularly dependent on personal estimate since one nurse will classify a given case as a "burn" whilst another might possibly classify the same case as a "hot foreign body." Hence, in the comparison tables, the burns and hot foreign bodies are combined into one class.

Whilst we are on the subject of grouping, these observations are indicated: it will be seen from Table 1 (in which the one- and two-digit items obviously are not to be taken as significant groups), and from Table 2, that some of the groups appear to be small, and the statistician will ask why they have been retained and not combined into groups bigger and therefore more significant statistically. The answer is twofold. In the first place, if we had ignored the flashes and unidentified foreign bodies and confined our attention to those cases in which identification was certain, we could have offered a reasonably sized sample of 3,500 accidents, and groups like "dust," "rust," etc., would have been quite acceptable. The second reason, which is much more important, is that this is not a statistical paper on a group of accidents but a review of the way in which material that was unsatisfactory from some points of view was put to very effective use. It was precisely for this latter reason that the least satisfactory fraction of the 100,000 odd various accidents was chosen as the subject of a preliminary paper. I should add that, in my opinion, much the same considerations apply to the three-digit figures in the first column of Table 5.*

A word is necessary regarding the classification of some of the occupations and trades cited in the tables:

Shipwright.—Includes loftsmen and carpenters but not labourers and apprentices.

Fitter.—Any skilled or semi-skilled worker in the mechanic class—fitters, turners, millwrights, and the like.

Joiner.—Joiners, cabinet-makers, wood-machinists, finishers, etc.

Painter.—Includes red-leaders.

Riveters.—Riveters, holders up, and any skilled man who actually works the rivet.

Riveter-boys.—Apprentice riveters, heaters, and catchers.

Burners and Caulkers.—Combined because caulkers generally act as burners as well.

Blacksmiths.—Includes strikers but not labourers.

Transporters.—All those, including crane-men, who drive mechanically propelled vehicles, including cranes.

Labourers.—All the labourers are combined to give another unskilled class.

Staff and Sundry.—Anyone who cannot be fitted into any of the trade groups used—foremen, supervisors, office staffs, etc.

* It is hoped that some really interesting information will be afforded later on when we compare the tables of this paper (and others omitted to save space) with similar ones of a group of eye accidents of comparable size in which practically all foreign bodies are accurately classified. We are collecting such a group.

TABLE 1

TYPES OF ACCIDENT AND VARIETIES OF FOREIGN BODIES ENCOUNTERED*

Flash	..	..	..	..	..	4,620
Burn	..	..	..	..	..	1,179
Injury	..	..	..	..	..	656
Unidentified inert foreign body	..	..	..	..	..	6,602
Hot foreign body	..	..	..	..	..	233
Dust	..	..	..	..	..	158
Rust	..	..	..	..	..	259
Steel	..	..	..	..	..	166
Hot steel	..	..	..	..	..	1
Lead	..	..	..	..	..	1
"Metal"	..	..	..	..	..	4
"Hot metal"	..	..	..	..	..	1
Brass	..	..	..	..	..	15
Slag	..	..	..	..	..	104
Hot slag	..	..	..	..	..	340
Cork	..	..	..	..	..	4
Sawdust	..	..	..	..	..	37
Wood	..	..	..	..	..	9
Emery	..	..	..	..	..	47
Grindstone	..	..	..	..	..	19
Grit	..	..	..	..	..	28
Hot solder	..	..	..	..	..	2
Scale	..	..	..	..	..	5
Hot scale	..	..	..	..	..	6
Felt	..	..	..	..	..	2
Glass	..	..	..	..	..	4
Asbestos	..	..	..	..	..	3
Sand	..	..	..	..	..	1
Salt	..	..	..	..	..	2
Cement	..	..	..	..	..	12
Concrete	..	..	..	..	..	1
Putty	..	..	..	..	..	1
Red lead	..	..	..	..	..	12
White lead	..	..	..	..	..	1
Bitumen	..	..	..	..	..	7
Creosote	..	..	..	..	..	2
Tar	..	..	..	..	..	1
Lime	..	..	..	..	..	3
Caustic soda	..	..	..	..	..	1
Paint	..	..	..	..	..	95
Bitumen paint	..	..	..	..	..	4
French polish	..	..	..	..	..	1
Oil	..	..	..	..	..	12
Disinfectant	..	..	..	..	..	3
Hot glue	..	..	..	..	..	2
Acid	..	..	..	..	..	9
Petrol	..	..	..	..	..	2
Paraffin	..	..	..	..	..	4
Hot tar	..	..	..	..	..	2
Fume	..	..	..	..	..	25
Smoke	..	..	..	..	..	6
Spark	..	..	..	..	..	2
Compressed air blow-back	..	..	..	..	..	4
Paint spray blow-back	..	..	..	..	..	1
Electric shock	..	..	..	..	..	1
Total	..	..	..	..	..	14,722

* Note failure in diagnosis indicated by preponderance of unidentified inert foreign bodies; this has been corrected by training and experience.

TABLE 2
CLASSES OF ACCIDENTS : TOTALS FOR GROUP OF SHIPYARDS

Trade groups	A Accidents affecting both eyes simultaneously						B Accidents affecting right eye only						C Accidents affecting left eye only						Totals					
	Flash	Burn and hot F.B.	Injury	Inert solid	Irritant solid	Irritant liquid	Irritant fume	Totals	Flash	Burn and hot F.B.	Injury	Inert solid	Irritant solid	Irritant liquid	Irritant fume	Flash	Burn and hot F.B.	Injury		Inert solid	Irritant solid	Irritant liquid	Irritant fume	
Shipwright ..	294	..	..	27	..	1	322	21	15	20	157	2	..	..	215	15	15	25	187	2	3	..	247	
Joiner ..	40	..	..	10	..	..	50	6	3	9	67	2	..	..	87	4	..	6	102	..	1	..	113	
Fitter ..	55	..	1	21	..	..	78	12	19	11	209	2	..	..	252	8	14	14	252	..	2	..	290	
Painter ..	14	..	2	35	..	6	79	8	..	5	81	25	..	..	127	3	3	3	76	5	12	..	102	
Riveter ..	203	13	11	66	..	..	293	26	220	39	394	2	5	..	686	30	273	33	446	1	1	..	784	
Riveter boys..	114	3	3	16	..	2	139	17	67	16	116	..	..	..	216	9	78	7	135	..	..	..	230	
Burner/caulker ..	297	4	4	95	..	3	409	27	69	23	287	..	..	1	408	32	98	26	351	..	..	..	508	
Welder ..	810	12	2	32	..	3	859	35	124	14	170	1	2	..	346	27	114	7	160	1	..	..	308	
App. B.W.C. ..	548	2	8	14	..	..	572	15	56	6	154	..	..	..	232	14	58	10	137	1	..	..	220	
Driller ..	82	2	3	73	..	..	160	9	31	12	245	..	..	..	297	14	29	14	235	..	2	..	294	
App. driller ..	6	..	..	7	..	..	13	1	3	5	46	..	..	..	56	1	5	3	41	..	..	..	50	
Blacksmith ..	65	2	..	8	..	1	76	10	40	10	97	..	..	..	159	4	48	11	98	..	..	..	161	
Plater ..	769	3	11	68	..	2	857	20	38	24	315	..	..	1	398	38	36	33	309	1	..	..	418	
App. plater ..	157	1	1	11	..	..	171	6	10	15	66	..	..	..	97	4	10	10	73	..	2	..	99	
Platers' helpers ..	246	3	7	13	..	..	269	6	19	24	229	..	..	..	278	24	27	22	241	..	1	..	315	
Electricians ..	53	2	..	6	..	..	61	6	2	4	39	..	..	4	55	1	6	6	47	1	2	..	63	
Transporters ..	..	..	..	..	..	3	4	..	1	..	17	..	..	..	20	..	3	1	16	1	1	..	21	
Labourers ..	116	2	4	28	..	1	167	17	11	31	255	4	5	..	323	16	21	39	230	2	5	..	313	
Plumbers ..	68	3	..	16	..	1	88	7	30	6	97	..	3	..	143	7	27	6	127	1	1	..	169	
Other apprent. ..	73	..	1	19	..	..	93	10	16	17	169	..	2	..	214	6	27	11	179	1	2	..	226	
Staff/sundry ..	49	..	3	14	..	..	67	2	20	10	88	..	..	..	120	5	18	5	94	2	2	..	126	
Sheet-iron workers ..	22	..	1	2	..	..	25	1	3	1	17	..	1	..	23	1	2	..	18	..	..	..	21	
Tinsmiths ..	3	..	..	..	..	..	3	..	..	..	5	..	..	..	5	..	1	1	1	..	..	..	2	
Boilermakers ..	9	..	..	..	..	..	9	1	..	..	6	..	1	..	9	..	1	1	4	..	..	..	8	
Brass smelters ..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	1	..	..	..	..	..	..	..	..	
Brass founders ..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	2	..	..	..	..	..	..	..	..	
Brass cleaners ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	
Totals ..	4,093	52	62	581	41	6	29	4,864	263	799	303	3,328	16	60	1	4,770	264	913	294	3,559	18	39	1	5,088

The remaining groups are self-explanatory. It will be obvious to those familiar with the industry that these groups are open to certain objections. The difficulty inherent in all statistical work is responsible for this. Groups ought to be big enough to yield reliable and useful information and, at the same time, their components must be of like kind. The apprentices cited separately under specific trades or trade-groups are either subject to certain definite risks or require to be compared with their corresponding journeymen or with some other trade. The remaining apprentices, although their risks vary a little, cannot be cited separately, chiefly because there are not enough of them, and they are lumped together on the basis of lack of experience and a lesser skill. There are many considerations to weigh—skill, experience, age, type of work, predominating risk, and so on. To divide accurately on type is to have groups which are too small. The grouping used here has been selected as giving the best and most homogeneous classes consistent with numerical significance and with risk factors well in mind. It is hoped to enlist the interest of other shipbuilding organizations so that higher numbers will yield finer distinctions which are statistically significant as well.

Range of Accidents Sustained

A glance at Tables 1 and 2 will show the wide range of accidents sustained and the great variety of foreign material which gets into the eyes. This is not surprising when it is realized, firstly, that most of the work is done in the open and that coasts are windy, secondly, that ours is a heavy industry and, thirdly, that there is a great variety of occupations to be found in a shipyard: for, in a good shipyard, not only is the ship herself made but practically all that goes into her as well. It will be seen, as would be expected, that the majority of these accidents come under the headings of "flash," "burns," "foreign bodies," "injuries," a few of the foreign bodies, like slag, steel, and rust, being specified. The remaining types of accident are rare. Table 6 gives a convenient general summary of the numbers of the main groups, and comparison is easy.

The accidents have been tabulated for both eyes simultaneously, for the right eye only and for the left eye only, because it is suspected that in certain shipyard trades the left eye is more exposed to accident than the right. Much of the work is done with heavy tools against large, immovable objects like the side of a ship; and, as the man operates the tool with his right hand and guides it with his left, he stands sideways to his job with his left shoulder advanced towards the target of his efforts. Very often, also, a right-handed man, when working two-handed, will advance his left shoulder and this is, in most cases, the position of natural choice—the "position of election" as some call it.

For reasons which are given below, the difference, as shown in Table 2b and c, is not considered statistically significant. This the more so because these tables include all accidents, and flashes almost invariably affect both eyes. The projection of the rays from the arc has to be very oblique indeed to miss the distal eye altogether.

In Table 4, the excess of the total accidents, less flashes, to one eye over the other are expressed as percentages of all accidents, less flashes, and the difference is more marked. Since so many of the men work in the way described above, there is a great temptation to regard all the workers showing a preponderance of left eye accidents as belonging to one group, irrespective of trade, because their common stance at work is presumably the cause of the difference observed. I am not yet satisfied that this can properly be done, for there are elements in the case which make the drawing of conclusions, at this stage, a difficult and very dubious business. Firstly, there are so many wide differences in the various trades that, at this juncture, the only safe procedure is to regard each trade as a separate universe, using that word in the statistical sense, and thus confining comparisons of right and left eye to each trade separately and independently of any other. Secondly, in certain cases (the use of the two-handed saw, the use of right-handed tools by the right hand only and to the right of the operator in a confined space, and so on) the *right* shoulder is advanced so that the position of natural choice is reversed. Certain of the men, many of the riveters especially, have taught themselves to be ambidextrous and these men often reverse the common position. Occasionally, the nature of the work reverses the position for various other reasons. Figs. 1 and 2 show the position of natural choice, and fig. 3 shows an ambidextrous man reversing it. We do not yet know either the proportion of such cases or the relative incidence of accidents to their two eyes. In my opinion, therefore, the only reliable indication of significance in the difference we now get would be a percentage of injured left eyes, in any trade considered, so much greater than the 50 per cent. of equality as not feasibly to be a chance result.

For all that, and despite the fact that the number of accidents is, in my view, too small to give results which are truly significant, the persistent bias towards the left eye, small though it be, can, I think, be regarded as highly suggestive since it is in line with the strong impression felt by all of us who have closely observed eye accidents in the shipyards here. It is evident that no firm conclusion can yet be drawn from Table 4, and I feel that the question needs settling by an appeal to the much larger figures

TABLE 3

CLASSES OF ACCIDENT REMOVED TO HOSPITAL: TOTALS FOR GROUP OF SHIPYARDS

Trade groups	Flash	Burn and hot F.B.	Injury	Inert solid	Irritant solid	Irritant liquid	Irritant fume	Totals
Shipwright ..	4	1	9	17	..	..	..	31
Joiner ..	..	..	3	11	..	..	..	14
Fitter ..	4	..	7	76	..	..	..	87
Painter ..	2	1	2	4	..	3	..	12
Riveter ..	7	28	10	125	..	1	..	171
Riveter boys ..	6	12	5	24	..	..	..	47
Burner/caulker ..	4	6	12	135	..	3	..	160
Welder ..	9	6	6	13	..	..	..	34
App. B.W.C. ..	6	5	1	36	..	..	..	48
Driller ..	3	13	3	135	..	..	..	154
App. driller ..	1	..	3	28	..	..	..	32
Blacksmith ..	4	3	4	22	..	..	..	33
Plater ..	11	8	10	72	..	..	..	101
App. plater ..	4	2	1	10	..	..	..	17
Platers' helpers ..	8	6	11	50	..	1	..	76
Electricians ..	..	..	1	7	..	1	..	9
Transporters ..	..	..	..	2	..	3	..	5
Labourers ..	5	..	12	36	3	2	..	58
Plumbers ..	1	5	3	20	..	1	..	30
Other apprent. ..	1	3	5	39	1	..	..	49
Staff/sundry ..	2	1	2	19	..	..	..	24
Sheet-iron workers ..	2	..	..	3	..	..	..	5
Tinsmiths ..	1	..	..	4	..	..	..	5
Boilermakers ..	..	..	..	2	..	..	..	2
Brass smelters ..	..	1	..	..	..	..	..	1
Brass-founders ..	..	1	..	..	..	..	..	1
Totals ..	85	102	110	890	4	15	..	1,206

which could easily become available from other sources in this industry.

Flash Injuries.—Flashes, as will again be obvious, present a difficult problem. Their high incidence depends on three main factors. Much welding is already done in the construction of a ship, whilst the amount is increasing and will continue to increase for a long time yet. The first factor turns on the fact that some of this welding, a good deal of which is at high amperage (600 amps. and more), is done under circumstances which make the proper screening of the arc very difficult, so that it is more often the man passing or working near by who gets the flash than the welder himself (fig. 4). The provision of adequate eye protectors to be worn by neighbouring workers is frequently not feasible either, for a ship in the course of construction is full of obstacles, awkward places, and all sorts of odds and ends, as are many places in the shipyard as well, so that anything which markedly reduces either the acuity or the field of vision can convert mere inconvenience into real danger. Figs. 4 and 5 illustrate this fairly well. Men are, therefore, very reluctant to wear goggles or coloured eye-shields except where they are absolutely satisfied that these protections can be worn safely.

The difficulties in the way of the universal application of adequate *and safe* protective measures will be apparent. It is, however, most important to remember that these cases are in the minority and that a good proportion of the welding arcs can be screened quite adequately with a very small amount of care and trouble on the part of the welders. Our welders are unbelievably careless and inconsiderate in this direction, and they are encouraged in this by the tacit consent and even complacency of their fellow-workers who supply the bulk of the victims.* In spite of provision by the managements of light, portable screens, the efforts of the safety staffs, and the strongest representations, a practically entire ignoring of these safety measures by the men continues. This brings us to the second factor: the actual injury from the great bulk of flashes is trivial and is often no more than a mild, quickly passing discomfort so that men do not worry about sustaining a flash. There is a further reason which is a more subtle one: long familiarity has taught the men that it is possible to stand much nearer to the arc without getting a flash than is generally believed (see fig. 4). A man is quite safe a yard or even less from the arc

* Welders and apprentice welders 1,449 flashes; other trades 3,171

as long as he does not look directly at it. Thus, the welders' neighbours have become incredibly over-confident and careless, and it is extremely difficult to wean them from their folly and to convince the welders of the necessity for care. In certain welding operations, notably in the joining of deck plates, the welder moves considerable distances along the junctions of the structures he is joining and the use of a screen puts him to the small amount of trouble needed to move his screen along with him; many of these welders just will not bother to do it.* We still press on with all the persuasion and information we can supply and, though we hope ultimately to have a different state of things, we find the combating of the almost universal contempt for the flash plus the bias caused by those cases in which screening is difficult or really impossible very uphill work indeed.

The injury from the arc is threefold. There is the intensity of the light as light, that is, the band of the spectrum from red to violet; there are the ultra-violet rays; and lastly there are the infra-red rays which are given off particularly by the high-amperage arc.

The common reaction is conjunctivitis which varies from a temporary discomfort to the painful attack which sometimes develops some hours after exposure. There is also a punctate keratitis which, incidentally, we do not appear to get here. Cases are described in which a trauma of the retina occurs on certain exposures to strong sunlight, even with the eyes protected to some degree, and it would seem certain that this, when it occurs, is due to infra-red rays helped, possibly, in those cases in which the eyes are unprotected, by the intensity of the light. We have kept a very careful watch for this trouble, but we have had no case and we believe that it can only occur from an arc of much greater power than any we use and at very close range indeed, that is, if it occurs from an arc at all. It should be remembered that the infra-red value of an arc depends on the amperage used and that it increases geometrically with the amperage.

The tables show that very few of the flashes we get give trouble capable of causing incapacity even of short duration, in other words, of causing anything more than a short-lived discomfort; and flashes rank lowest in our compensation incidence in spite of the great number we get. It will be seen from Table 9 that only one flash appeared to present residual damage. It is extremely difficult to assess this case for the man had gross old scarring of both corneae from previous injuries which were not flashes, and he appears to be one of those cases in

which a very small inflammatory condition of any kind superposed on his existing condition would be serious. We have remained keenly on the look-out for signs of cumulative effects, but we see none.

One trouble we have is that, except in the case of very small arcs, really adequate protection is afforded to the welder only by the most dense protective glass (Grade "E" or its equivalent) and that lower grades do not protect sufficiently. Unfortunately, some of the men have difficulty in seeing the junction they are welding when using "E" glass, and a certain number of them obtain and use "C" Grade which, in my opinion, most definitely is inadequate against the smallest arc. Even in these cases, we have detected no cumulative or permanent effects. It is needless to add that we stop the use of "C" glass whenever we find anyone using it.

The common reaction, as has been said, is a temporary interference with vision and an inflammatory reaction. The man, for a few minutes, can see little except a yellowish blur, and his eyes smart. He promptly reports to the ambulance room (even when the smarting is not severe), where he gets the routine palliative treatment.* If his trouble persists or recurs, he comes back again and is either treated again and rested or sent to hospital. Out of 4,620 flashes, 85 were sent to hospital and only 10 were incapacitated. With the exception of the case mentioned above, all of them recovered completely. It should be remembered that many of these flashes occurred when our nurses were less familiar with the trouble, and when many of the men were new to welding and occasionally apprehensive, so that far more cases were referred to hospital than are sent now.†

Statistical Method

In this investigation the question of statistical method introduced itself very early and a choice had to be made between a formal statistical approach and something simpler. It is here that the practical application of our information and the fact that it is primarily an exercise in safety-practice, as was mentioned at the beginning of this report, had to be considered. The usual and most accurate method of finding a "frequency rate" by dividing the sum of the total number of accidents, the number of accidental deaths, the number of partial disablements, and the number of total disablements by the sum of the total man-hours worked and the number of hours of overtime (less foremen and office staff), and of finding a "severity rate" by dividing the sum of the total man-hours lost through accident and the appropriate weights for all cases of death and partial and total

* Cold bathing followed by 0.25 per cent. homatropine in castor oil or 0.25 per cent. anethane with adrenaline.

† Sometimes there is no immediate reaction and the man first discovers he has had a flash when his eyes start to give trouble after he has gone home from work.

* We are trying out a modification in the screen which we hope will meet these cases.

TABLE 4

COMPARISON OF ACCIDENT INCIDENCE TO RIGHT AND LEFT EYE : FLASHES ARE EXCLUDED

Trade groups	Total accidents (actual numbers)	Per 100 total accidents				
		Both eyes	Right eye only	Left eye only	Excess right over left	Excess left over right
Shipwright	454	4	43	51	..	8
Joiner	200	5	41	55	..	14
Fitter	545	5	43	52	..	9
Painter	283	23	42	35	7	..
Riveter	1,504	6	44	50	..	6
Riveter boys	445	5	45	50	..	5
Burner/caulker	969	12	39	49	..	10
Welder	641	7	49	44	5	..
App. B.W.C.	447	5	49	46	3	..
Driller	646	12	45	43	2	..
App. driller	111	6	49	44	5	..
Blacksmith	317	3	47	50	..	3
Plater	846	10	45	45	..	..
App. plater	200	7	46	48	..	2
Platers' helpers	686	4	46	50	..	4
Electricians	119	7	41	52	..	11
Transporters	45	9	44	47	..	3
Labourers	654	8	47	45	2	..
Plumbers	318	6	43	51	..	8
Other apprent.	444	4	46	50	..	4
Staff/sundry	257	7	46	47	..	1
Sheet-iron workers	..	..	..	..	..	..
Tinsmiths	..	..	..	..	..	..
Boilermakers	..	..	..	..	..	..

disablement by the same divisor, and the further development, using the average number of men employed over the period, was rejected for two cogent reasons.

The first is that in this industry we are greatly at the mercy of the weather, and varying numbers of workers, ranging from a few to the great majority of "outside" men, are quite frequently precluded from working, often without warning, by inclement weather, and furthermore, that the employment of various trades fluctuates widely as the construction of a ship progresses. It would thus be both difficult and wasteful, with the staffs at present available, to record on a basis of man-hours worked, especially as a continuous record would be useless to any but the medical department.

The second reason, which would apply even if the difficulties just described did not exist, is that all kinds of personnel, safety staffs and the men themselves (when they can be induced to do so) have to apply the conclusions reached. A man applies information given to him with an enthusiasm which is in direct proportion to the degree to which he is able to understand it, the ease with which he can follow the methods by which it has been obtained, and the amount of conviction it produces in him. Most of these men have no time for conceptions like dispersion, variance, deviation, skewness, etc., and, indeed, such conceptions frequently arouse their profound distrust. Measures, therefore, had to be devised which, whilst being accurate enough for the purpose envisaged, had to be obtainable on the information available and, had not only to be simple and readily intelligible, but of such a nature as would enable

anyone to follow easily the methods by which they were obtained.

The first question asked by those concerned with safety measures is (or should be), "With the protection of whom should we most particularly be concerned?" and we are at pains to answer that question here. In the present case of eye accidents, we have taken the total number of accidents sustained by each trade-group and have divided it by the average number in that trade-group continually at work over the period covered by the inquiry. The lowest quotient in the list thus obtained is divided successively into all the others and the resulting indices express the accident liability of the different trade-groups as multiples of the lowest which then, of course, becomes unity. Table 5 shows the operation and its results.

In considering Table 5, Table 8, and the Safety Guide (Table 10), several things have to be borne in mind. The most important of these is that this paper is not put forward as a serious statistical work but as an exposition of a method which has enabled us to make the maximum practical use of the material available and to ensure the collection of really well differentiated data for future use. Incidentally it might be worth while stating that the present nursing staffs have been taken round the Holorith installation, have seen the cards punched, checked, and counted, and have watched the tabulator dealing with a sample from their returns. They have been taken through the tables shown in this paper (and other more detailed ones) and they realize what they must avoid. The result is that not only have we been able to

TABLE 5

SHOWING HOW RELATIVE ACCIDENT-LIABILITY IS OBTAINED

Trade groups	Total number of men	Total number of accidents	Accidents per head	Column 3 ÷ 0.22
Shipwright	481	784	1.63	7
Joiner	542	250	0.46	2
Fitter	340	620	1.82	8
Painter	270	308	1.14	5
Riveter	914	1,763	1.93	9
Riveter boys	597	585	0.98	4
Burner/caulker	283	1,325	4.68	21
Welder	221	1,513	6.85	31
App. B.W.C.	284	1,024	3.60	16
Driller	278	751	2.70	12
App. driller	76	119	1.57	7
Blacksmith	238	396	1.66	3
Plater	699	1,673	2.39	11
App. plater	226	367	1.62	7
Platers' helpers	1,364	862	0.63	3
Electricians	63	179	2.84	13
Transporters	204	45	0.22	1
Labourers	1,744	803	0.46	2
Plumbers	323	400	1.24	6
Other apprent.	790	533	0.69	3
Staff/sundry	494	313	0.63	3
Sheet-iron workers	66	79	1.20	5
Tinsmiths	..	..	..	..
Boilermakers	47	26	0.55	..

produce out of our figures a "rough and ready" guide to immediate action, to set going new and profitable trains of thought where they can do most good, and to start a line of propaganda calculated materially to improve our safety practice, but we have, in addition, got our nursing staffs really expert in the collection of the kind of data we require.

In an attempt to assess the power to inflict injury possessed by any particular injurious agent, a manoeuvre similar to the one last described has been used. We take each agent causing injury and count the number of accidents it has produced. The number of these which have become compensation cases, that is, in which an incapacity of three or more days' duration has resulted, is divided by the whole for this agent. This is done for every agent which causes incapacity, and if the quotients are likely to be very small they are all expressed as percentages. The lowest is then successively divided into all the others and the answers give the potentialities of each injurious agent in terms of the least powerful one, which then becomes unity. In order to avoid confusion with nomenclatures used in more elaborate and more formal tables on the same subject, I have called these indices "relative disabling power." A reference to Table 8 will make this clear. It will be seen from this table that rust, for example, has a relative disabling power of 42 and is, therefore, 42 times as likely to incapacitate a man, once he gets it into his eye, as is a flash. We have found that

where groups are small there is a strong bias towards results which are too high, and that the bias shifts towards true value as the groups increase in size. Figures which are thus likely to be inaccurate are mentioned in a footnote in the Tables. Since the indices are used to guide and check the application of safety measures, the errors are thus mostly on the right side and the indices will increase in accuracy as we progress with the collection of data. If the reverse happens, as, of course, it easily can, and the particular index comes out too small, the difficulty is met by an appropriate footnote as in the case of high values. It must be remembered that this figure in the example does *not* measure a man's chance of getting rust in his eye. It is a measure of the power of rust to do damage capable of causing incapacity *if it acts upon any individual*. This measure, along with the others, will be discussed again later.

It has been stated that the injury which a foreign body inflicts upon the eye depends on the speed at which it travels and that the man who hammers heavily is more prone to get serious injury than the man who drills or grinds. This is not our experience.

The results shown in Tables 2 to 5, and, indeed, throughout all the Tables, are not the expected ones. It will be seen that the irritant solids and liquids (with the possible exception of irritant oil) are

FIG. 1.—A riveter at work. This shows the position of natural choice. Most of the foreign bodies fly sideways from the hammered rivet and the added risk to the left eye is evident. This is the commonest stance. In this case the hammering is almost finished and the rivet has ceased to glow.

FIG. 2.—Again showing the position of natural choice. It also shows the number of obstructions above, below, and around the man and the desirability of unobstructed vision. This man is wearing goggles but he will remove them whenever he can. He is not actually riveting and this is a deliberately "posed" picture. At a later stage in the construction of this ship, he, or one of his mates, will be riveting exactly as he is shown.

FIG. 3.—A case in which the position of natural choice is the reverse of the usual one. The left eye is still by no means out of danger. The goggles afford a considerable amount of protection but a very great number of these men will not wear goggles which have side-pieces. It will be seen that this man has just started on a hot rivet.

FIG. 4.—This shows how difficult it is sometimes to screen the arc. It further shows the dangers which would result from any obstruction of vision and the liberties which can be taken with the arc, and explains the general carelessness in this direction. The picture is dark but is such a good illustration that it is presented despite its faults. These men did not know that they were being photographed.

FIG. 5.—This picture of a mast-yard again shows the dangers which would arise from obstructed vision, and also why men are so careless about the arc.

FIG. 6.—The experimental model of the spectacle eye-shield opened out. The device for adjustment will be seen above the nose-piece. This model is made of perspex, and a modified pattern made of suitable glass will shortly be tried out if this comes up to expectations.

FIG. 7.—Showing a man wearing the shield. The degree of protection is evident, as is the complete ventilation. If and when the appliance comes into general use, it will have to be made in suitable sizes. Note unobstructed vision.

relatively innocuous, that the grosser traumata classed as "injury" are not as high as would be expected, and that burns are less dangerous than one would think, whilst steel and rust are the most dangerous common agents with which we have to deal. Dust is surprisingly high on the list.* It is needless to suggest that oil would show a smaller figure in a bigger number of accidents.

A Foreign Body's Potency for Harm

We have reached the conclusion that the prime potency for harm which any foreign body has lies in two main characteristics: firstly and commonly, its capacity for setting up an inflammatory reaction; and, secondly, its power of penetration or of causing a relatively large amount of other mechanical injury. Both steel and rust can cause considerable local inflammation which undoubtedly starts as a chemical reaction. The following are the characteristics which I have found to count most:

1. **Chemical Composition.**—The body or material may irritate by means of matter it contains either directly, as is the case with irritant oils, or it may react with the secretions or cellular components of the eye to produce substances which irritate, stain, or otherwise damage.
2. **Size**; 3. **Speed**; 4. **Weight**; 5. **Direction**; 6. **Distance.**—These have to be considered together. Firstly, the force of impact depends on the momentum of the foreign body (mass multiplied by velocity) and a very small body, unless it be very sharp and angular, has to travel very quickly indeed to penetrate the wall of the eye. A larger one obviously needs less speed to take it into the interior of the eye. Very few of our small foreign bodies penetrate beyond the depth at which they can just remain firmly impacted. Direction also counts, for an impact at right angles is more powerful, whilst one at an acute angle tends to linear cut or abrasion. The distance between the eye and the point of departure of the missile counts enormously, for the force of a small travelling object is soon spent. This is brought out in the Blacksmith group where foreign bodies are frequent, tend towards size and weight, but have to travel further to reach the eye. Quite commonly they are found free on the surface of the eyeball and a vast number never reach the eye at all. The implication of distance is obvious.
7. **Nature of Substance.**—A piece from a hard mass requires greater force to separate it than one which is softer. Such a piece

travels faster and further and also tends to angularity, sharp edges or both.

8. **Spin.**—All small bodies broken off by force tend to revolve in their flight, and the greater the force or speed, the greater the spin. Some fragments certainly spin very rapidly and their cutting or tearing power is thus increased.
9. **Nature of Surface.**—Some foreign bodies have the kind of surface which causes them to stick, to irritate or to do both. Such physical configurations can sometimes make an otherwise harmless foreign body very troublesome.
10. **Visibility.**—A particle hard to see either through size, colour, transparency, refractive index, or what not is often missed (occasionally even in a consultants' eye department) and can give rise to great difficulty.

Thus we have come to the conclusion that it is quite wrong to suggest that hammering tends to dangerous foreign bodies whilst grinding does not. We believe, setting aside chemical effects and similar influences, that the power of a foreign body to inflict greater degrees of injury lies mainly in its momentum and, to a lesser extent, in its configuration. Its momentum obviously depends on its mass, its speed, and the distance it has travelled before it strikes the eye. Thus, if sweeping generalizations must be made it would be safest to say that heavy impact on, and heavy or very speedy abrasion of, material which is hard and brittle or tough and of low malleability would tend to the more severe injuries, provided always that the eye is near enough, whilst light impact and light abrasion would tend the other way. I have seen so many exceptions that I have little regard indeed for such propositions and the subject has been introduced only because the generalization has been made quite frequently.

Hot foreign bodies are considered separately because a different set of influences operate. These

TABLE 6
TOTALS FROM TABLES 2A, 2B, AND 2C

Type of injury	Total	Column in previous tables
Flash	4,620	1
Burn and hot F.B. .. .	1,764	2
Injury	659	3
Inert solid	7,468	4
Irritant solid	75	5
Irritant liquid	105	6
Irritant fume	31	7
Total	14,722	..

* On the data we have, these are but mere indications and are not to be regarded as firm conclusions. Even so, they have proved useful.

TABLE 7

NUMBER OF WORKING DAYS LOST BY INJURY AND NUMBER OF CASES GROUPED ACCORDING TO INJURIOUS AGENTS
(COMPENSATION CASES)*

Flash		Burn and hot F.B.		Injury		Foreign body		Dust		Rust		Steel		Sawdust		Slag	
Days off†	No. of cases	Days off	No. of cases	Days off	No. of cases	Days off	No. of cases	Days off	No. of cases	Days off	No. of cases	Days off	No. of cases	Days off	No. of cases	Days off	No. of cases
10	1	4	1	6	1	5	3	10	1	5	1	4	1	12	1	7	1
11	1	5	1	7	3	6	1	15	1	6	4	6	3	32	1	21	1
13	1	6	3	8	1	8	3	11	1	7	1	9	1	..	..	32	1
15	2	7	3	9	1	10	2	..	..	8	1	10	2	..	..	5	1
17	1	8	2	10	3	11	1	..	..	9	1	12	1	..	..	12	1
32	1	9	2	12	4	12	1	..	..	10	1	13	4	..	..	11	1
49	1	10	3	13	1	13	2	..	..	12	2	14	2	..	..	13	1
57	1	11	2	14	3	15	2	..	..	15	1	16	1	..	..	..	..
376	1	12	1	15	2	17	1	..	..	16	1	20	1	..	..	..	..
..	..	14	2	16	1	28	1	..	..	17	1	24	2	..	..	..	..
..	..	15	1	17	1	30	1	..	..	18	1	25	1	..	..	..	..
..	..	17	1	19	3	36	1	..	..	20	1	28	1	..	..	..	..
..	..	18	1	27	1	50	1	..	..	21	2	35	1	..	..	..	..
..	..	19	2	37	1	..	..	..	..	23	2	75	1	..	..	..	..
..	..	20	1	38	1	..	..	..	..	46	1	..	..	..	..	..	..
..	..	27	1	56	1	..	..	..	..	48	1	..	..	..	..	..	..
..	..	36	1	59	1	..	..	..	..	55	1	..	..	..	..	..	..
..	..	79	1	69	1	..	..	..	..	151	1	..	..	..	..	..	..
..	..	..	..	75	1	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	76	1	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	82	1	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	94	1	..	..	..	..	..	..	..	..	..	..	..	..
‡\$95	10	424	29	910	34	305	20	36	3	561	24	390	22	44	2	101	7
\$9		15		27		15		12		23		18		22		14	

* The totals to this table do not agree with the sum of the figures given, since some of the figures have been repeated.

† "Days off" or "days lost" in this paper always means working days lost.

‡ Totals.

|| Averages.

are size, temperature, thermal capacity, and speed. What matters is their power to burn, and this is usually quite small because the passage through the air in many cases cools them down considerably whilst in the majority of cases the secretion of the eye promptly quenches the heat. The body is usually small, and even those foreign bodies like molten slag from the electric welder's arc at great temperature (up to 4,000° C.) are immediately cooled down in most cases. The injury they commonly inflict is a surface burn represented by a small speck, and this usually heals quickly under simple antiseptic treatment without trouble: the man frequently does not cease work. Tables 6, 7, and 8 give a sufficient idea of their value as a menace. It is comparatively rarely that a small, hot foreign body burns deeply enough to leave a scar. It is, of course, understood that these remarks apply only

to cases which are promptly and correctly treated, and the corneal ulcers, attacks of ophthalmitis, and the rest of the results of neglect are not considered because they should not occur. Massive burns and the rare cases of small F.B. burns of exceptional severity are also excluded from notice here because their course and causes are obvious and well known.

Injuries

With regard to injuries, all one can do is to express astonishment at the number of times really great violence (a blow from a mass of iron weighing several hundredweights, for instance) fails to do more than inflict temporary damage. The more serious results are those to be expected, retinal detachment and the usual injuries to the lens choroid, iris, retina, etc.

TABLE 8

RELATIVE DISABLING POWER OF INJURIOUS AGENTS

Agent causing injury	Total accidents	Number disabled	Percentage disabled	Relative disabling power (= col 4 ÷ 0.22)
Flash	4,620	10	0.22	1
Foreign body	6,602	20	0.31	1
Burn and hot F.B.	1,764	29	1.64	7
Dust	158	3	1.90	9
Injury	659	34	5.16	23
Sawdust	37	2	5.07	23
Slag	104	7	6.73	31
Oil	11	1	9.09	41
Rust	259	24	9.27	42
Wood	9	1	11.11	51
Steel	166	22	13.25	60

Corrosives and Irritant Fume

The damage inflicted by corrosives depends upon how corrosive the material is and the amount of it which reaches the eye. In the case of solutions which are not too strong or in amounts not too great, the result seems to depend entirely on how quickly and liberally the eye is washed out. The few cases we have had arrived at the ambulance room after having been washed out on the spot by men whose belief in thoroughness was very evident indeed, and we have had no real trouble from them.

Fortunately, we are not much troubled by irritant fume. Such fume as we get—smoke, certain paint solvents, and the like—have not caused any significant damage. We have too little experience of them to offer an opinion on their general capacity for harm.

Safety Devices

In the consideration of eye accidents and, more still, in the combating of them, safety devices loom large but, as we have indicated, they present a special problem to us. In the ordinary machine-shop, assembly-room, work-bench, etc., eye protection is a comparatively simple matter. The operative either has a transparent guard fitted to his machine or he wears goggles with transparent fronts and ventilated sides, preferably also transparent. Our worker also needs eye protection from pieces coming from any direction and must have a protection similar to that afforded by the guards or goggles just mentioned. Goggles, however, which shut off *any but the smallest amount* of vision from the side are always a danger and sometimes a veritable death-trap. The reader is again referred to figs. 4 and 5, which show the extreme importance of unobstructed side vision and the absolute necessity that the man should be able to see his feet

without contorting his neck. It must also be remembered that there is very little work in a shipyard which is not heavy, and sweating round goggles is both uncomfortable and dangerous. We have tried all the transparent goggles which completely close in the orbit and have found them all unsatisfactory. Those which have transparent sides, even when they are liberally perforated by slatted holes, soon cloud up. Moreover they are, as has been noted, hot and uncomfortable. The same applies, though to a lesser extent, to vizors of various kinds. These have to be attached somewhere and the band of contact on the brow causes much local perspiration and great discomfort. Also, contrary to the claims of the vendors of various anti-fogging materials, it is impossible to keep the glass or plastic from fogging to an extent sufficient to constitute a danger in itself.

Our problem, therefore, was to devise a protective appliance which, whilst protecting the eye against danger from all directions, would give unobstructed vision all round, would not touch the face, would not close in the orbit, and would not fog. This was not as difficult as would appear at first sight for our close study of the accidents, particularly the ways in which they came about and the defects of the existing appliances, soon set us upon the track and an eye protector is being tried out. It consists of a rectangular shield covering the face from just above the eye-brows to a point below the malar prominences. A piece is cut out of the lower margin to allow for the configuration of the nose, and the whole sits on a nose-bridge similar to the one on an ordinary pair of spectacles and on which it is adjustable. The rectangle is wide enough to project beyond the outer margin of the orbit on each side, and to the vertical margin of this frontal piece is attached a wing of the same vertical

TABLE 9

CAUSES AND RESULTS OF ACCIDENTS BY TRADE GROUPS

(Note: All these cases resumed usual work)

Trade group	Agent	Days off	Further information	Trade group	Agent	Days off	Further information
Shipwright	Flash	376	Chronic conjunctivitis (recovered). Corneal scars both eyes, mainly the results of old injuries.	Riveter		8	
				—cont.		46	
						21	
						18	
						23	
	Hot slag F.B.	10			Steel	17	
		17				13	
Fitter		36				13	
		28			Slag Wood	7	
	Steel*	35*	Slight retinal damage to right eye.			118	Temporary corneal damage.
	Rust	21					
	Sawdust	48		Riveter boys	Flash Burn	15	
Painter		12				10	
	Injury	6				7	
						7	
Riveter	F.B.	11			Hot F.B.	11	
	Rust	7				9	
	Steel	6				27	
						8	
					Injury	14	
	Flash Burn	13				12	
		4			F.B.	15	
	Hot F.B.	20			Rust	16	
	Hot slag	19				23	
		6					
		7		Caulker	Flash Injury	32	
		36	Right corneal ulcer (recovered).			19	
		14			F.B.	59	
		6				13	
		14				8	
		79	Scar right sclers not affecting sight. Congenital myopia. Both eyes 6/9 after correction.			8	
						13	
						15	
					Rust	6	
						9	
						6	
	Injury	56	One eye with vision 6/18 after correction. No permanent damage from this accident.			5	
					Steel Slag	10	
						21	
						32	
		13					
		10		Welder	Flash	11	
		12			Hot slag	8	
		14			Injury	7	
		8				94	Scar of conjunctiva, sclera, and cornea.
		15					
		27*			F.B.	5	
		82			Slag	5	
		12				12	
		8				11	
	F.B.	5		Apprentice welders, burners, and caulkers	Flash	57	Right corneal scar. Vision 6/12.
	Dust	10			Hot slag	10	
	Rust	15				19	
		151	Right corneal ulcer with inflammation of pupil. Sight of right eye 6/18 due to injury in 1921.		Injury	17	
						7*	
						9	
					Slag	13	

TABLE 9—*cont.*

Trade group	Agent	Days off	Further information	Trade group	Agent	Days off	Further information
Apprentice welders, etc.— <i>cont.</i>	Steel	10 9 6		Plater's helper — <i>cont.</i>	F.B. Steel	30 50 13 25	
Driller	Dust Rust Steel	15 12 24 13 4 14 12		Transporter	F.B.	5	
				Labourer	Flash Injury	49 15 76	Left eye already blind. Horizontal linear scar of cornea across centre of pupil.
Apprentice driller	Injury Rust Steel	19* 12 6 16				10 17 10*	
Blacksmith	Injury Hot steel Steel	7 6 20			Dust Rust	11 55 10	
Plater	Burn Hot rust Injury	9 12 14 16 6 20 6			Steel Sawdust Oil	28 32 9	
	Rust	20		Plumber ..	Hot slag Injury	11 15	
	Steel	75	Penetrating scar of sclera, retinal scar, vision 6/12, 6/6 corrected.	Other apprentices	Hot slag Hot solder Injury	5* 15* 12 69	Eye excised.
Apprentice plater	Flash	10			F.B.	10 10	
Plater's helper	Flash Hot ash Injury	17 18 12 37 38			Steel	24 14	
				Sundry ..	Injury	75	
				Brass-moulder	Sand†	12	

* Injury to eyelid

†Included in F.B. in Table.

dimension which projects backwards parallel to the temple so as to afford protection from the side. It has spectacle ear-pieces which fasten either to the rear edge of each wing or to the most suitable point on the front rectangle.

The model on trial is made of perspex and is shown in figs. 6 and 7. If it proves as satisfactory as it promises, it will be manufactured and will be made in different models and sizes, some of which will be made of suitable glass. It touches only the ears and the bridge of the nose, does not fog, and is comfortable. It gives complete protection despite the aperture between the cheek and its lower margin, because any piece which might pass behind the shield through this aperture would pass at an angle at which it could not possibly reach the eye. It has the further advantage that a heavy blow will tend

rather to knock it off the nose than to smash it and drive the fragments back into the eye. It does not obstruct side vision at all and, indeed, the wearer is actually prone to forget that he has it on after a time. It is too soon to make any claim for it which is based on experience, but it promises well. It can be suitably tinted so as to afford that protection from the welder's arc which is so urgently needed for neighbouring workers, and may possibly, indeed, afford sufficient protection without tinting if the glass is properly selected.

General Remarks

The original intention of taking the statistical treatment of these figures much further and along lines more generally used is postponed for the simple and very evident reason that they are far

from big enough and are insufficiently differentiated. Something, of course, could be done if the accidents were treated as one series and not broken up as they have been in this paper but it is hard to see what useful purpose would have been served.

When we come to consider the remainder of the 100,000 odd various accidents, these figures will appear again, and it is hoped that the whole series will lend itself to really useful routine treatment. Our list of compensation cases, fortunately, is especially useless because it is so small. The most cursory inspection of the 153 cases shown in Table 9 and of Tables 7 and 8 is enough to show this.

Nevertheless, it is patently necessary that both

TABLE 10

SAFETY GUIDE NO. 1: EYE ACCIDENTS

Table A

Relative accident liability				
Transporters	..	..	..	1
Joiners	..	..	..	2
Labourers	..	..	..	2
Platers' helpers	..	..	..	3
Other apprentices	..	..	..	3
Staff and sundry	..	..	..	3
Riveter boys	..	..	..	4
Painters	..	..	..	5
Sheet-metal workers	..	..	..	5
Plumbers	..	..	..	6
Shipwrights	..	..	..	7
Apprentice drillers	..	..	..	7
Apprentice platers	..	..	..	7
Fitters	..	..	..	8
Blacksmiths	..	..	..	8
Riveters	..	..	..	9
Platers	..	..	..	11
Drillers	..	..	..	12
Electricians	..	..	..	13
Apprentice burners, welders, and caulkers	..	..	..	16
Burners/caulkers	..	..	..	21
Welders	..	..	..	31

Table B

Relative disabling power				
Flash	..	..	..	1
Foreign body	..	..	..	1
Burn and hot foreign body	..	..	..	7
Dust *	..	..	..	9
Injury	..	..	..	23
Sawdust *	..	..	..	23
Slag	..	..	..	31
Oil *	..	..	..	41
Rust	..	..	..	42
Wood *	..	..	..	51
Steel	..	..	..	60

* These 4 values are not quite accurate because there were not enough cases, but they are near enough to use as part of this guide.

Table C

Average number of working days lost							
Dust	..	..	..	..	..	..	12
Slag	..	..	..	..	..	..	14
Burn and hot foreign body	..	..	..	..	..	..	15
Foreign body	..	..	..	..	..	..	15
Steel	..	..	..	..	..	..	18
Sawdust	..	..	..	..	..	..	22
Rust	..	..	..	..	..	..	23
Injury	..	..	..	..	..	..	27
Flash	..	..	..	..	..	..	59
Uncomplicated flash	..	..	..	..	..	..	22

Table D

Highest and lowest number of working days lost							
Flash	..	..	..	..	..	..	10-376
Burn and hot F.B.	..	..	..	..	..	..	4-79
Injury	..	..	..	..	..	..	6-94
Rust	..	..	..	..	..	..	5-151
Steel	..	..	..	..	..	..	4-75
Slag	..	..	..	..	..	..	7-13

those concerned with the improvement of safety and the men at risk should have some idea of the severity of the possible injuries, and this requirement has been met by the two Tables 10c and D. Table C is simply the average length of the period of disablement in working days from such injurious agents as caused enough accidents to give an average of sorts, whilst Table D gives the range of each series. It is not pretended that these tables give anything more than the very crudest information, but they serve their purpose in that they give to the safety staffs that rough idea which they want; and the range, expressed as it is in simple language, is readily understood by all.

The information which we want to disseminate is given in the form of "Safety Guides." "Safety Guide No. 1 (Table 10)" gives to the executive and to the men firstly, the comparative risk of eye accident run by each trade-group (Table A), secondly, the direction in which to look for the risk according to its magnitude (Table B) and, thirdly, the penalties of carelessness or unwariness (Tables C and D).

It would have been better, perhaps, from our point of view, when taking out our Table C to have given the mode for each injurious agent and in Table D to have given as "top and bottom" incapacities (that is, the range) the number of men sustaining incapacities below a selected "short" period for the "bottom" and above a selected "long" period for the "top" (for example, the two appropriate deciles without mentioning the median) for it is a fact that many, perhaps most, people who

are not familiar with statistics confound the arithmetical average with the mode and, particularly in cases like this, tend to think in modes and not arithmetical averages. At the same time, they like the range expressed in the somewhat odd manner I have suggested. A man understands very well if we can tell him that "most of these men were off work so many days, the lowest group for less than so many days, and the highest group for more than so many days." I have used this device successfully several times. Our figures are small but serve our purpose.

The essence of our work is firstly to direct the attention of our workers to certain dangers and their origins, to seek measures to prevent their occurrence, and to do this without needlessly alarming them or undermining their confidence. This is why the information they get must give them a really true picture of what is happening, for exaggeration is otherwise inevitable. Our second object is to get into their minds certain notions and trends of thought which will inculcate habits of observation and personal care in their own protection. We work on the hypothesis that if we can set enough men thinking along the right lines we will not only get a great reduction of accident through a reduction of personal carelessness (the very commonest cause of accident) but will get a sort of mass drift towards awakened personal responsibility. Instruction in the origin and prevention of accidents and in safety practice generally must not only be what it purports to be but also a carefully calculated course of suggestion, and the latter quality must not be obvious. In my opinion it is worse than useless to concentrate on the direct approach. This, for what it is worth, is very thoroughly done already—unkind people say it is "worked to death"—and the more subtle way, although it may seem slow, gets real results.

This exercise in preventive work and in observation emphasizes the difficulties in the statistical method (which is the only really effective method) of industrial medical supervision. It also stresses the very great number of observations which are necessary before sensible and effective lines of approach to problems can be found. It has been a difficult task to collect even 14,722 eye accidents, and the paucity of information about disablement (and even of incidence) is very evident. At the same time, I believe that it equally emphasizes the real value of the information which can be extracted even from such comparatively small figures *provided always that the worker, whilst taking care to avoid the obvious statistical pitfalls, makes sure that all his methods and all his conclusions are readily intelligible to those without mathematical knowledge.* Here,

again, a word is indicated about statistical work of this kind. In a circumscribed area, small derivative figures and, indeed, small series sometimes, must be the rule and the utilization of them must be a matter of plain common sense. There is a time for formal statistics and there is equally a time when the worker must resolutely turn his back upon elaboration and make what use he can of his figures. Most of all must he keep in sight their value as a form of suggestion, and, provided he has adequately studied his normal psychology, he will realize the tremendous psychological effects he can achieve with them. This work relates to normal conditions and requires the methods of normal psychology. Errors, and even an occasional absurdity, should not deter him, provided these are either on the right side and promise future amendment or can be made obvious to all. A good example of this is afforded by the figures for sawdust, oil, and wood in Tables 8 and 10. These absurdities do no harm, for the figures in this example are on the right side and, taken at their face value, would merely result in the exercise of more care and closer observation than is necessary in those particular directions. Parts c and d of Table 10, although they approach heresy when taken as literally as they *are* taken by some workers, still achieve their purpose; for the information they give, though it is crude in the extreme, is true within its limits and the significance of any error is obvious to all those to whom it matters.

It is hoped most earnestly that other branches of this industry will co-operate, for it is plain that data capable of that more elaborate statistical treatment which is indicated is going begging. There is no good reason to doubt that, with such figures as would then become available, better and more accurate measures of accident liability, disabling power, severity rates, etc., should not be easily estimated and better methods used all round, and that the figures for local fields could be made to take on their full significance.

Work here has suggested certain hypotheses which need wider observation for their completion and thereafter for their testing. They promise fruitful lines of inquiry, and we have good reason to hope that they will lead to results of the utmost practical value.

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