PRACTICAL RESULTS ARISING FROM THE USE OF SAFETY DEVICES APPLIED TO MACHINES.

BY JOHN H. COOPER.

Much has already been done by the ingenious inventor and the careful manufacturer to prevent accidents to workmen, whose duties require them to be constantly attending to and handling machines.

To state here that a steam boiler, whose overcharge of steam pressure would prove very disastrous were it not supplied with an automatic safety valve, is not news for this journal, nor is it original information to tell of check and relief valves applied to pipes where escape of water from a steam boiler, or where the bursting of pipes and vessels would result from their inoperation or absence. These things have long been used with good results, as invariable as their application.

To the moving cages and platforms of passenger elevators and to all hoisting machines—such dread sources of accident—the application of “safety catches” has been regarded as absolutely necessary; indeed, no first-class “elevator” is now run without means of security against disaster by falling.

In cases where breakage of the machine is imminent from the nature of the work to be done, and the circumstances of use, a serviceable part of the machine is designed to receive, what might be called a safety or a “breaking piece,” of trifling cost, which will hold the parts in proper working place during all regular work, but which will yield to unusual strain and give warning of failure.

Instantaneously acting stop-motions, such as are applied to card-making machines, to weaving looms, and the like, for effecting a sudden stoppage of all working parts when the card wire has gone astray, or when the tardy shuttle has failed to pass the web; these are familiar illustrations of means for protecting the machine against serious breakage.

Usually, all parts of the machine itself are designed for harmonious action and for the production of a specific effect; nothing is left to chance. Its whole causation is intentional. If there be any lack, it exists in the region of approach between the machine proper and the operator, who may not always be on the alert. Something is needed to supply the deficiencies of human thought, or watchfulness; to serve as prompter or guard to the human hand, at the point of danger.

We are safe in saying that no machine can be called perfect, if not adapted in every particular to the needs of the operator, since the machine cannot be run without him. He who uses and guides it should have safe and efficient *handles*, so to speak, whereby he may approach and manipulate it safely and effectively, without danger to himself or injury to the machine. It is all very well to say, "beware;" "take care of yourself;" but the cheapest way in the end is to provide the safeguard and thus protect the operator. As new "hands" are coming into mills all the time, who are presumably ignorant of the dangers surrounding them and of the constant care which is necessary to be exercised over their persons at all times, and so may inadvertently meet with accident, it is certainly most important to perfect the safety elements of machines, as well as to enjoin all in observance of the usual plainly written and conspicuously posted rules.

Experience has shown that a great number of accidents is caused through loss of presence of mind by the eagerness of work-people to get through their work expeditiously, under threat of punishment, if they do not. The largest contributions to the list of accidents, it is said, are amputations and maimings of dexter hands, due to this eagerness. If urging must be done, these results call loudly for safeguards and warning mechanism, and the enforcement of stringent rules for safety.

Fortunately, we are not bound by the ancient law of the Hindoos, who wrote: "Under pretext of care for the creature, their authors imposed the fatal principle, that a

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man must not address himself to discovery or invention, as Heaven had provided him all things needful."

It is bad enough to have machines breaking down frequently, but the loss of an operative's hand or life is a more serious matter.

"What would one not do to save the life of a fellow-creature, and how heart-rending it is to find ourselves compelled to be an impotent witness of an accident to a human being! Should we not, therefore, adopt all possible precautions to prevent these accidents, often so terrible, which pass unnoticed only on account of the very frequency of their occurrence?"

These words were penned by a committee of the Industrial Society of Mulhouse, in Alsace, which has devoted the past twenty-five years to the invention, application and publication of appliances and apparatus for the prevention of accidents in factories.

The subject is a broad one, possessing commercial as well as humanitarian importance, either phase of which should commend itself to our earnest attention.

A critical investigation of most accidents has proved that they might have been avoided by an early application of means, which in many cases would have been attended with little expense.

Knowing this, it is safe and timely to re-state the warning words which have been formulated by the committee referred to above—"Indifference to such matters is furthermore no longer admissible. It is all the less pardonable, as here, contrary to the circumstances of ordinary life, the rescue is effected without personal danger of any kind"—the writer means to say that the device may be planned in the inventor's study and applied to the machine during the ordinary processes of its building.

After what has been said on the evident necessity of avoiding accidents to workmen, because of the certain threefold loss to the community where they occur, it appears plain enough that to argue the need of such care-taking would be as throwing words away, and whatever may be said for or against the objects of this society, it has

lived to see its labors crowned with success ; therefore, we may unhesitatingly ask our readers to consider these matters and to interest themselves also in the invention and application of them wherever they can be of service, remembering ever, that we owe our workmen other things than the wages given to them, as Mr. Dollfus said, a score of years ago, and among these may surely be named absolute personal safety from the moment they enter our factories and service.

The cause of labor is a common cause, and its benefits are reciprocal. Accident to an operative of a machine may result in irreparable damage, as, for instance, the loss of a skilful hand which may be indispensable to an important industry ; on the other hand, the evils arising from bad advice or misdirected training may in time, by proper instructions with renewed effort, be entirely overcome, restoring the man to future and to better usefulness, while the hand severed from a good right arm, the obedient instrument of a well-ordered, commanding brain, is lost forever—lost not only to the owner thereof but to his employer and to the community.

If as Bacon says: "Education consists in removing the difficulties of the mind," and we are made many times aware of the expense and effort to accomplish this in our plentitude of technical schools established among us, believing that we will realize great gain from them, may we not expect advantages by efforts made towards personal safety in the use of machines, not only by giving instructions how to avoid being injured while using them, but in the application of accident-preventing devices, or what is better, to so construct mechanism that accidents to the machine and to the man may be reduced to the least possible number ?

With the exercise of ingenuity and care for protecting the machine against injury to itself, the attendant may be protected also, and if proper safeguards be thrown around a machine, with ordinary care and training that may be given, the attendant can perform all the work necessary about and with the machine, with perfect safety to himself, thus preserving machine and man ; while the employer, who

may be held responsible for accidents occurring from exposed machinery which might have been protected at little cost, will have performed his whole duty.

Securing safety to the workman is clearly within the pale of engineering. It is just as commendable and desirable a proceeding as safety in the vehicle, securing immunity from disaster to "myself and family," so to speak, when we travel about home, or go abroad; and what a comforting sense of relief to the mind it is, to know that means are being regularly devised whereby accidents are greatly reduced in number and severity.

Whether American factory operatives are more or less the victims of accidents while running their machines than those of foreign countries is probably not known. It would therefore be interesting and profitable to have some well accredited statistics in this particular, whether the American operator of machines, as compared with his co-workers in other countries, has secured a large immunity from personal injury during service, which we may assume would result from his superior intelligence, independence and capability of care-taking. Indeed, we ought not to be satisfied with our methods until we have thrown the search-light of inquiry upon every running machine in the going of which accident may happen, and possibly a human being mutilated or incapacitated permanently for work.

We should be encouraged in this proceeding from its humanitarian possibilities, because good work has already been done as evidenced by the report about to be given; for the reason, it must be remembered, that profit attends the regularity and continuousness of processes, when not interrupted by the excitements incident to disasters, and for the comfort and confidence enjoyed by all when the liability to accident is removed alike from machine and man.

After this introductory, I need not apologize for offering the following report, just received, upon the results of systematic inspection and the enforcing of means for preventing accidents in factories.

The writer is indebted to M. M. Engel-Gros (President of the Association for Preventing Accidents in Factories, Mulhouse) for the following :

Note on the statistics of accidents in Alsace-Lorraine, taken from the official reports of the Imperial Insurance Office of the Empire of Germany, for the year 1887.

The Association of Mulhouse for the Prevention of Accidents in factories has been in existence nearly twenty-five years. It is indisputable that the inspections to which it submits the affiliated establishments have borne their fruits. It is recognized that many accidents, notably the gravest, have become less frequent, and we are agreed in saying that about fifty per cent. of the accidents have been avoided. But it is difficult to estimate, by means of figures furnished by the statistics, the positive results of the inspection, in order to form an idea, as exact as possible, of the number of accidents which have been prevented. Such an estimate is possible only by a comparison of the statistics of Alsace with those of other similar industrial countries in which the prevention of accidents has not yet been applied.

It is these statistics which have been wanting until now. When one seeks in effect to estimate the number of accidents occurring in an industrial region, one meets with many and great difficulties. There exists in many works, notably those which concern insurance against accidents, reports which have served to draw some conclusions. Some have been gathered in the hospitals, others have been collected by researches made in the establishments, or near insurance companies; the Association of Mulhouse from its foundation, has published each year a report of the accidents which have been brought to the knowledge of its inspectors, but all these statistics, while they have served to guide and instruct those who have established them, could not be utilized for a serious and comparative study; some, indeed, only mention serious accidents, others confound the most insignificant accidents with those which have brought prolonged or permanent incapacity for work, without its being certain that all cases are mentioned.

The first definite reports in this order of facts have been furnished by the Imperial Insurance Office of the Empire of Germany, which published, in 1890, a very well made *statistique* of the accidents of the year 1887.

This *statistique* is rigorously exact. It does not apply to all the accidents of which the declarations have reached the professional associations—declarations which are more or less conscientiously made for less serious accidents—but *only to those which have entailed incapacity for work for more than thirteen weeks ; to those, in a word, which have provoked inquiries and the intervention of professional associations.* This *statistique* is, beside, well made in order to establish a comparison between Alsace and Germany, because in 1887 the influence of the law upon obligatory insurance was scarcely yet felt, while in Alsace the preventive association has been making its inspections for almost twenty years.

Here are the principal indications which may be drawn from this *statistique*.

The number of persons insured in all Germany during the year 1887, 3,861,560; the number of accidents resulting in incapacity for work for more than thirteen weeks, 15,970; that is, 4.14 accidents per 1,000 insured.

In Alsace-Lorraine the proportion is less than in all the industrial countries of Germany.

The number of persons insured in Alsace during the year 1887, 148,221; the number of accidents resulting in incapacity for work for more than thirteen weeks, 440; that is, 2.97 accidents per 1,000 insured, and a difference of 1.17 per 1,000 compared with those in Germany.

Thus, if in all Germany the conditions had been the same as in Alsace; if the precautions had been taken there as in this country, they would have avoided :

$$\frac{3,861,560 \times 1.17}{1,000} = 4,518 \text{ accidents.}$$

The proportion of 2.97 per cent. applies to all the industries of Alsace and Lorraine; it includes therefore not only the textile industries, but also the industries of iron and steel, mines, buildings, wood-working and of flour mills, etc., of which some have been more dangerous than the textile industry (especially metallurgy and mining), and upon these latter industries the private inspection of the Association of Mulhouse has had no influence.

If we wish to make a still more exact comparison, only the figures which are given for the *statistique* for the textile industry must also be given. (The workshops of construction might be added to that, but the comparison would be less rigorous, because the great establishments only had subscribed to the association up to the time of the enforcing of the law of obligatory insurance.) As out of 1,000 workmen insured in Alsace, 398·1 are occupied in textile industry, this proportion is still sufficient to permit a comparison with other industrial centres.

On the other hand, the influence of the Association of Mulhouse has been exercised especially on accidents to machines, because it is difficult to reduce the number of the accidents due to the slipping of persons, to the fall of objects, to horses and carriages, etc. A rigorous comparison should then include only the accidents caused by certain kinds of machinery in the different countries.

As the above *statistique* does not permit the making of a similar comparison it was necessary to apply to the Imperial Insurance Office at Berlin, which has kindly sent a copy of all the declarations of accidents of more than thirteen weeks of incapacity, for the year of 1887 in the textile industry. As to the number of workmen employed in the different industries, this appears in the *statistique* published by the Imperial Office in 1885. We have extracted from these reports the figures relative to the spinning of cotton and of wool and to power loom weaving, choosing among the declarations all those which concern the accidents occurring to machines employed in spinning and to weaving looms, for the latter only accidents by leaping of shuttles have been taken into consideration.

TABLE I.—SPINNING OF COTTON AND WOOL.

COUNTRIES.	Number of Establishments.	Number of Workmen.	Number of Workmen per Establishment.	ACCIDENTS OCCURRING TO				Accidents Total.
				Beaters, Willows, etc.	Cards.	Spoolers, Flyers, Combing Machines.	Self-acting Ring Throates.	
				<i>per cent.</i>	<i>per cent.</i>	<i>per cent.</i>	<i>per cent.</i>	<i>per cent.</i>
Prussia,	710	33,602	47.3	20 = 0.59	73 = 2.17	38 = 1.13	44 = 1.34	175 = 5.21
Saxony,	241	18,681	77.5	9 = 0.48	33 = 1.76	23 = 1.23	37 = 1.97	102 = 5.45
Bavaria,	100	15,556	155.5	6 = 0.38	9 = 0.58	10 = 0.64	11 = 0.71	36 = 2.31
Wurtemberg, . . .	86	6,897	80.2	6 = 0.87	10 = 1.45	9 = 1.30	5 = 0.72	30 = 4.35
Other countries of Germany, . . .	119	3,976	75.4	3 = 0.33	9 = 1.00	6 = 0.66	10 = 1.11	28 = 3.12
Total,	1,250	83,712	66.6	44 = 0.52	134 = 1.60	86 = 1.02	107 = 1.27	371 = 4.43
Alsace-Lorraine, . .	94	26,011	277.6	4 = 0.15	15 = 0.57	14 = 0.53	17 = 0.65	50 = 1.91

In this branch of the textile industry there have been in Alsace, 1.91 serious accidents per 1,000 workmen insured, while in the rest of Germany there have been 4.43 per cent.; that is, 2.26 times more.

If in the spinning industries of Germany they had taken the same precautions as in Alsace they would have been able to avoid $4.43 - 1.91 = 2.52$ per cent. accidents; that is, 210.9 accidents.

According to the *statistique* of the Chamber of Commerce of Mulhouse for the year 1889, there were, at this time in Germany, 4,392,821 spindles for the spinning of cotton and wool, of which 1,348,473 in Alsace, and 3,344,348 in the other regions.

If we compare the number of accidents to these, we find: 111 accidents in Germany per 1,000,000 spindles; 37 accidents in Alsace per 1,000,000 spindles; that is, 0.24 per cent. in Alsace, against 0.50 per cent. in Germany, which makes a difference of 0.26 per cent., or 36.5 accidents which could have been avoided.

TABLE II.—POWER-LOOM WEAVING.

COUNTRIES.	Number of Es- tablishments.	Number of Workmen.	Number of Workmen per Establish- ment.	Accidents by leaping of shuttles and weaving looms.
				<i>per cent.</i>
Prussia,	984	78,815	97.7	39 = 0.49
Saxony,	357	30,365	85.3	19 = 0.62
Bavaria,	64	7,873	123.0	4 = 0.50
Wurtemberg,	39	4,786	122.3	2 = 0.41
Other countries of Germany,	186	20,073	107.9	7 = 0.34
Total,	1,630	141,912	87.0	71 = 0.50
Alsace-Lorraine,	125	20,511	164.0	5 = 0.24

Finally, there has been made a last comparison relative to the seriousness of the accidents occurring. To this end, we have compared for the textile industry the accidents followed by temporary incapacity to work with those which have entailed permanent incapacity (death, permanent incapacity or permanent partial incapacity for work united); that is to say, to those which have had permanent and irreparable results.

These are the results to which we arrive :

TABLE III.

COUNTRY.	Accidents having had lasting results.	Accidents which have only brought Temporary Incapacity for Work.	TOTAL.
	<i>per cent.</i>	<i>per cent.</i>	
Prussia,	479 = 89.0	59 = 11.0	538
Saxony,	220 = 92.8	17 = 7.2	237
Bavaria,	64 = 88.9	8 = 11.1	72
Wurtemberg,	54 = 94.7	3 = 5.3	57
Other countries of Germany,	80 = 97.6	2 = 2.4	82
Total,	897 = 91.0	89 = 9.0	986
Alsace-Lorraine,	95 = 76.0	30 = 24.0	125

We see that in the textile industry for 100 accidents occurring in Alsace, twenty-four have entailed only tem-

porary incapacity for work, while in Germany there have been nine per cent. of accidents not serious. From this point of view, then, the advantage rests with Alsace.

From all these comparisons we have the encouraging results that the efforts of the Association of Mulhouse have borne their fruits and that they have attained by private effort that which the official regulations alone have not been able to realize elsewhere.

A MIRROR GAUGE.

BY JOSEPH BECKER.

The following is a description of my mirror gauge; an instrument for measuring the thickness of any glass mirror without unframing it.

My gauge consists of a piece of plate glass (*Figs. 1, 2 and 3*), having on one face a graduation O , and on the opposite

face a mark or sight S . For reasons to appear further on, the sight S is so placed that in the right-angled triangle SVO the side OV is equal to one-half of the side VS .

In use, the gauge is placed (*Fig. 4*) with its graduated face against B , the mirror to be measured. Behind the silver backing C is formed the virtual image A' of the gauge. The observer places his eye so as to catch the ray of light OSE ; in other words, he places himself so as to see the inner ends of sights S and O meet and form a line SO , the general appearance of the graduations being as indicated in *Fig. 5*.