

THE ADOPTION OF THE METRIC SYSTEM IN OUR WORKSHOPS.

BY MR. ARTHUR GREENWOOD, *Member, of LEEDS.*

With the object of obtaining an expression of opinion of those connected with the mechanical engineering trades now assembled in Congress at Glasgow, the author has ventured to express his views as to whether the time has not now arrived when some steps should be taken towards the adoption in our workshops, in a more or less complete form, of the metrical system of weights and measurements now generally in use on the Continent of Europe.

At the risk of possible opposition, he is prepared to avow that, after a not inconsiderable experience in international trade, in which he has been personally engaged in pushing the sale of British machinery in foreign countries, in opposition to machinery made abroad, he would gladly see the adoption by this country of the metric system in its entirety—money, weights, and measurements, as established in France in 1799. Being moreover a Free-Trader in the widest sense of the word, he would not hesitate to adopt from the foreigner anything that is better than can be found at home. Possibly there may be some prejudice in favour of the French system arising from the fact of his having been educated in that country—now unfortunately more than forty years ago. The facility of learning the metric system as taught in French colleges made a strong impression upon him, as compared with his earlier

experience at school in England, in endeavouring to master the British weights and measures. The former is learnt with very little trouble, and is so simple and self-evident, that it remains lastingly impressed upon one's mind, whilst the latter is so complex and irrational that, although one may suppose it to be possible of acquisition, unfortunately it does not remain impressed on one's mind, seeing how often in after life one has to refer to books, when it is necessary to make a calculation outside the run of every-day work.

It would possibly be wiser to eliminate from this discussion the question of money and monetary standards, as being a subject of which we mechanics know little, leaving it to be settled by those who make more of it, and consequently may be assumed to know more about it; although it must be admitted that a system, which enables one to use the current coins of the realm as standards of weights and measurements, offers advantages that the humble mechanic would at times appreciate.

In the first place it will be expedient to consider what advantage would accrue to the mechanical engineering trade of this country by the adoption of the metric system. If this country could afford, or if it were possible, to build a wall round its Empire, and the engineers were to devote themselves simply to the manufacture of engines and machinery required in its own workshops and factories, neither selling nor desiring to sell anything outside the Empire, there would be no reason why they should not continue to muddle on with feet, inches, sixteenths, thirty-seconds, and hundredweights, quarters, pounds, &c., for all time, wasting the energies of the student in endeavouring to comprehend our harlequin system, or rather collection, of standard weights and measures, instead of giving them instruction that would be of permanent use to them; and employing hundreds of unproductive clerks in our offices when tens would suffice. It would be our own affair, and our own insular privilege to continue, if we thought fit, a system which has been condemned by most nations of the earth, and who might probably continue to laugh at our peculiarities and prejudices. But it may be assumed that the British mechanical engineer cannot afford, and has no desire to be

content with any such position. He is determined to continue the efforts he has up to now successfully made, in spite of what has been lately said and written as to his decadence, to push his manufactures in every market in the world. He has to meet competitors from America, Germany, and France in the countries of Europe and elsewhere where the metric system is universal. Germany has followed the lead of the Latin countries, and has abolished her many standards of feet, and Austria has done the same. Russia continued to honour us for years by using our standards, and still does so to some extent, but in Russia before very long the metric system will be as general as it is in Germany, thanks very largely to German propaganda in that country. If the British mechanical engineer is to hold his own in these markets, it is imperative that he should offer goods to conform to their usages in dimensions and weights. The author would appeal to those of his engineering colleagues who have doubtless found themselves in the same desperate position he has found himself, provided with a drawing of an elaborate machine carefully scaled to an inch or an inch-and-a-half to a foot, and with probably a very imperfect knowledge of the language of the country with which he desires to transact business, and endeavouring to answer the numerous questions of an inquisitive and intellectual foreigner who wants to know the dimensions in millimètres and weight in kilogrammes of particular parts of the machine. Under such circumstances the wonder is that orders could be obtained at all, and considering the disadvantage under which he has shown his wares, success in obtaining orders can only be considered a tribute to excellence of design. True, experience has taught many engaged in Continental trade to have plans drawn to tenth scale, thus somewhat mitigating the difficulty here alluded to, but no one can possibly maintain that the seller's position would not have been wonderfully improved, and his own and his prospective purchaser's temper less sorely tried, had he been provided with drawings in metric scale, and with weights indicated in kilogrammes instead of tons and hundredweights.

From consular reports they learn from time to time of England losing orders for hardware and textile goods, owing to manufacturers

not troubling to make them in accordance with the standards of other countries, and they do not hesitate to condemn their want of enterprise and old-fashioned practice, and point out to them that it is no wonder that Germans, for instance, who, above all nations, endeavour to offer goods to meet the wants of other countries, are obtaining trade that heretofore came to this country. The author could quote numerous cases of orders from France, Germany, Russia, Japan, and South America, that might have come to England, indeed would have come, but for the reason that the purchasers preferred buying machinery which admittedly was not so good or so suited to their requirements, but which conformed to their metric system. Is it not therefore beyond doubt desirable, from the point of view of international trade, that engineers should adopt the system of their customers.

It will probably be advanced that America, who is likely to be Britain's greatest competitor in many of these markets, still continues the foot and ton standard. This is certainly the case, but she has in addition universally adopted the decimal division of inches and tons, and, judging from what appears in American engineering journals, manufacturers there are being urged to adopt the metric system, and that if, as is undoubtedly the case, she really intends to grapple with the trade of Continental Europe, it may safely be predicted that before long she will avail herself of the additional advantages to be gained by offering goods made in accordance with the standards of her desired customers.

Assuming, then, that for the purpose of foreign trade, the metric system would be of use to mechanical engineers, it becomes necessary to determine the difficulties standing in the way of its adoption, and whether these are due to the system itself. This is certainly not the case, as anyone who has once tested it must admit it is simplicity itself. American and English critics have advanced the plea that the fault of the system is the unit; the millimètre is too minute, the centimètre is not large enough, and the mètre is too large, and that there is practically no convenient substitute for a foot or for an inch. With due respect to the gentlemen who have expressed these objections, they might be placed in the same category as a

distinguished member of the House of Commons to whom the author was endeavouring some years ago to explain the simplicity of the metric system, and how calculation and book-keeping generally would be simplified by its adoption as compared with the present system of hundredweights, quarters, pounds; and pounds, shillings and pence. His reply was: "What does it matter, you can have your ready-reckoner for a few pence, that does all that for you." These objections, to the author's mind, are not real, and may be put down to prejudice and that conservative feeling so strong in the Anglo-Saxon breast.

The one serious objection is the cost and trouble of making the change, but this is a difficulty that can be overcome if time is taken to bring about the change. Our legislators so long ago as 1864 made its use permissible, and it is for the leaders in the various trades most concerned to take the next step, and certainly to no trade is it so important as to that of the mechanical engineer; and it is for him to attempt its introduction in, at any rate, one of the branches of his business that is most connected with foreign trade. It is simply a question of rules, callipers, standards, drills, and reamers, which, after all, is not very serious. The equivalents can be made from existing standard leading screws in lathes by means of change-wheels.

The mention of screws at once calls attention to the most serious part of the suggested change; but that difficulty can be easily met. It would be worse than folly to attempt at present to change the standard pitch and form of screw threads so admirably standardized by Whitworth, and so widely adopted, until a better standard is agreed upon to put in its place.

Much as one would wish to see the metric system adopted in its entirety, it would be well at present not to advocate any departure from the Whitworth standard thread. The two systems can and do work admirably together side by side in many shops in France, Germany, Russia, and Sweden. France has attempted to establish a metric system of screws, and has not been successful, for in the majority of her shops the Whitworth standard remains. She, like America, attempted to alter the form of thread, and ignored the rounded top and bottom, so admirably established by Whitworth.

The screw question should be left to be settled, as it must be ere long, by the establishment of an international standard, the result of an international congress, for which the common sense of engineers—foreign and British—must before long see the necessity. Meanwhile, things can go on as they are, and probably Whitworth's will survive as the fittest, until some congress establishes a system which should, of course, be metric in pitch, but, let us hope, Whitworth in form of thread.

Much has been said lately about the metric system being made compulsory. Parliament has made it permissible, private initiative should demonstrate that it is practical and advantageous, and should then call upon Parliament to make it compulsory, but, above all, give time, as with the French. It would be a mistake to say two years—a period that has been advocated. Twenty years would be nearer the period in which to make it compulsory, but doubtless it would be generally adopted long before that time for that best of all reasons, namely self-interest.

It was suggested at the commencement of this Paper to leave the monetary standard alone, but a plea might be advanced that whatever unit is ultimately adopted, it may be decimally divided, as has been done by practically all nations.

The object of this Paper is to put forward a claim for the adoption of the metric system for weights and measures, the latter term applying also to lineal measures and surface, and to measures of capacity. Special standards for special articles in particular districts should be abolished, and the sale of precious substances and drugs at the rate of 5760 grains to the pound, and steel, beef and sugar at 7000 grains, be ceased. Civil engineers should give up expressing in yards, chains, and furlongs, and adopt a *mètre* standard, and let surveyors abandon their rods, poles, perches, roods and acres, and express themselves in ares, and the litre be substituted for gills, pints, quarts, and gallons. Solid cubic measures should be known as *stères*, and let mechanical engineers adopt the *mètre* and the gramme, instead of the present confusion of quarter-inches and sixteenths, and pounds and their perplexing multiples.

At the same time these measures should be adopted with their Anglicised French names, and thus avoid the confusion that has been made in Germany by attempting to hide the French origin; it would be a graceful act to perpetuate the French origin of the *mètre* standard. Nothing could be simpler than their adoption of Greek derivatives of Deca, Hecto, Kilo and Myria, for the multiple of units, and the Latin ones of Deci, Centi, and Milli, for the division of the units.

The scientific world have adopted the metric system, even enlarging upon it for chemical and other purposes of research, and having to deal with smaller units they have by international conference adopted the micron as the one-millionth part of the *mètre*. Let them follow their scientific leaders in this respect, and also in their adoption of the system of Celsius for the standards of heat and cold.

In conclusion, the author would like to add briefly his own experience of the metric system. For the past twenty-five years, the metric calliper-gauge has been often quite as familiar in the tool room at the Albion Works as the inch one, and very little difficulty has been met with from the men, who soon learn to work one system as well as the other. In the engineering works in Russia, in which he is interested, both metric and English standards are used, and little difficulty is experienced in their joint use. In Russia the standard is in a transition stage, and everything would point to the prevalence of the metric system in a short time. At the new workshops just completed at the author's works in Leeds for the manufacture of the De Laval steam turbine, the metric standard has been adopted in combination with the Whitworth standard of thread.

Discussion.

The CHAIRMAN said the Paper was one of very great value. It dealt with a question which he might describe as a somewhat unpopular necessity, he meant the necessity of manufacturers realising that for certain markets they must use the metric system. Mr. Greenwood had dealt with the matter in a very practical way, and had shown, he thought, that if they were to take time enough, the change could be made without any very undue loss to the firms who adopted it.

Mr. W. H. ALLEN said that the metric system had not been adopted at his works, but a considerable change for the better had been made by adopting the division of an inch into 1000 parts. This had now been at work there for the past five years with excellent results, although there was some slight difficulty and prejudice at first; it certainly did not require more than three months for the whole of the men to thoroughly understand what was meant by a thousandth of an inch. Bearing in mind that the object in reading this Paper was simply to discuss the metric system in conjunction with engineering work and allied industries, they need not go into the difficulties which would follow, if they attempted a similar introduction for agricultural purposes; in England the various descriptions in weight, measure, and names employed in various counties would present many difficulties.

He had frequently tested the efficiency of the decimal system in his works, and had noted from time to time the ease with which all classes of individuals, even down to the labourers, could speak of a measurement in figures instead of words. They must thank the author for his Paper as being one which had a very wide area, and which brought before them the fact that the metric system would be employed throughout every country in Europe at some future time.

Mr. HANS RENOLD said it was rather too late in the day to advance any plea on behalf of the decimal system, so admirably worked out by the French and adopted in their measure and weight system. Any one who had given this subject a thought must see that it has many advantages over the English want of a system. In 1881 and 1882 he adopted the *mètre* measure in his chain manufacture, but evidently before the times, for he had to give it up again. Since then he had been working in decimals of inches, and had found no difficulty in getting the workmen to understand them after a little instruction. Unfortunately in most Board schools decimals were not yet taught at the present day. He could not conceive how fine machinery or accurate work could be done without measuring in thousandths of an inch. A yard if decimally divided might be as good as a *mètre*, but in making a change it would be the height of folly not to fall in with what French, German, Swiss, and almost all commercial nations have adopted. As a nation, do what they would, they must export and import, and therefore might as well weigh and measure in the same system as those from whom they bought, and to whom they sold.

The question before this meeting, he took it, was:—"How were they going to get this metric system adopted in their engineering works?" To his mind, no help could be expected from the Government, and the only way to get this boon was to help themselves. If some fifty, sixty or a hundred of them there assembled would stand together and vow that each of them would, within a year, take steps to make a beginning in their own works and extend it, within three to four years it would be an accomplished fact.

Colonel P. E. HUBER, Zürich, said he would only express his opinion as to the application of the metric system to the threads of screws and nuts in general, as treated in the International Congress held at Zürich in October 1898, where the engineering societies of Germany, France, Italy, Holland, Russia, and Switzerland were represented. This congress accepted unanimously, on the ground of elaborate investigation of the committee, a new thread-system, named the International System (I.S.), based on metric measurements, and

(Colonel P. E. Huber.)

they recommended its adoption by those who wished to work on metric measurements. The promoters of that congress did not intend to do away with the two existing systems based on the English measurements—the well-known “Sellers” system, generally used in America, and the “Whitworth” system, used in England and adopted by a great number of firms on the Continent, but found it absolutely necessary that the first step to be done in the way of having a really universal thread system was to enforce a unification of the different systems of metric measurements, as metric measurement was already now used very extensively in different countries and enforced by all the continental railway companies, as well as by a large number of governments. The products of mechanical engineering were spread over the whole world, and there should be no difficulty anywhere in replacing bolts and nuts for repairing purposes. If there was only one system, based on English measurement, the question could have been raised to adopt this system, but there were two in existence, and as the metric system would sooner or later be adopted by the great majority of engineers, the resolution of the said congress would be very useful, as it had proved to be a real advance as compared with the Whitworth system. The following firms, well known for their excellent work in tools, were producing the dies and templates as well as all the tools necessary for the working of the I.S. system, which was already now very largely adopted on the Continent:—Messrs. Barriquand and Marre, Paris; J. G. Reinecker, Chemitz; Loewe and Company, Berlin; and Reishauer and Company, Zürich. He concluded with the hope that the metric system would be adopted more and more, not by enforcing it but by its own merits.

Professor ARCHIBALD BARR said he was delighted that Mr. Greenwood had taken up this matter so heartily, as he seemed to have done. He believed that there was no reasonable compromise between their present want of system and the adoption of the metric decimal system. If one might with all reverence say so, it might be unfortunate that Nature did not endow them with twelve fingers,

because then the whole system of digits would have been founded on the duodecimal system, but as it happened that nature had given five fingers on each hand, the decimal system of numeration had come naturally to be adopted, and there was no going back on that now. It was usually lost sight of that the decimal system was first propagated so fully upon the Continent through the advocacy of James Watt.* They had not the duodecimal system in this country. The yard was divided into three, and the inch into eight, and the quarter into twenty-eight. If they had a consistent system there would be something to be said for it, but he thought when a new system was adopted it must be the metric system, and be made universal for the reasons that the other speakers had already mentioned, and which were clearly set forth in Watt's letter. He would only disagree with the author on one point; he thought twenty years too long a time to allow for the introduction of the system. The use of the decimal division of the inch would be a step towards the ultimate adoption of the mètre, as it would familiarise workmen with working in decimals. He thought the Institution of Mechanical Engineers should take a strong stand in the matter.

The CHAIRMAN enquired whether the speaker used the metric system in his training in the University.

Professor BARR replied that it was not at present in use in the Engineering Department, but all the students were quite familiar with it, because it was always used in the Physical Department. The students were accustomed to both systems, and found no difficulty in working the metric system.

The CHAIRMAN said that would be a great aid to the adoption of the metric system as those students got into practical work.

* See Letter from James Watt to Mr. Kirwan, dated 14 November 1783, in Muirhead's *Life of Watt*, vol. ii, page 179.

Professor BARR said their machines, screws, &c., were not made upon the metric system, and that made it difficult to use the system in much of their work.

Professor SCHRÖTER was afraid that this subject was not just in his line of working. As they were aware, he was a professor and was very happy to say that, in Germany, they had only to do with one system; and if he imagined the state of mind of the students of Professor Barr who have to do with two standards, he did not envy them. It was his opinion, and he thought it was shared by almost all the gentlemen present, that it would be a benefit to the whole profession if only one system of measurement was adopted whatever it might be, and that this one system would be the metric system was doubtless. He had no need to dwell upon the point. He wanted in concluding to profit by the occasion and to thank this Congress and the Institution of the Mechanical Engineers for the good reception they had given to their foreign guests. He could only say that they were very much satisfied with the proceedings of the Congress and with the meetings they had had occasion to take part in, and they would take home with them the best recollections of this Congress.

Mr. F. HOWARD LIVENS said the merits of the metric system were not under discussion, but on the question of its adoption, the opinions of those making commercial work in this country were required, because they would be fully alive to the real difficulties; when a series of new patterns, templates, and jigs were to be made, it did not appear to be difficult to adopt metric measurements, but where there existed a large stock of patterns, &c., in continual use, from which machines have been supplied for years past, it was a very serious matter to make the change, as duplicates must be supplied as before. Engineers in this country using the metric system, such as Messrs. Willans and Robinson and the author, had apparently adopted it only for new specialties, and as might be gathered from Mr. Renold's remarks there was considerable difficulty in the way. The speaker, although greatly in favour of the change,

was of opinion it would require considerable effort on the part of the Institution of Mechanical Engineers. A committee would have to investigate and press the subject, and considerable time must be allowed, so that manufacturers could take it up step by step when getting out improved designs.

The CHAIRMAN said there was so much business to get through that morning, that he was afraid he must now close this discussion. The subject was a very important one, and he hoped that all who were interested in it would send written communications to the Secretary for inclusion in the Report. It was one to which the whole morning ought to be devoted. Professor Schröter had expressed very kindly the appreciation of the foreign delegates of their reception here. He was sure that any pleasure they had derived from coming to this Congress was more than equalled by their pleasure in seeing them here. He hoped this was only one of a number of occasions on which they would take part in such proceedings. He would now request Mr. Greenwood to reply to the discussion, but before doing so would ask them to give him a hearty vote of thanks for his Paper.

Mr. ARTHUR GREENWOOD said the reception which the subject had received did not leave him very much to say. He was in hopes that they might have had a more unfriendly discussion, and thus brought the discussion to a more acute state. There was a general consensus of opinion in favour of the metric system, and to use Dr. Barr's simile it was a pity they had not appreciated the purpose of their ten fingers sooner. His object in writing the Paper was principally from an international trade point of view, because that was, he took it, one of the main things that they as engineers had to consider. They did not want to be shut out from the trade of the rest of the world. If they waited for Government interference, they would have to wait a long time. Government never did anything until forced, and if they as engineers saw the economical and commercial value of the change they must make it themselves, and then put pressure on the Government to make it compulsory. Exception had been taken to

(Mr. Arthur Greenwood.)

the term of twenty years in which to make the change compulsory. That was merely a suggestion, because he thought that some of the Chambers of Commerce had rather injured the question by wishing to force the change too rapidly; and to make the change compulsory in two years would be very foolish indeed. He would particularly allude to Mr. Livens' remark that it would be a very serious matter for those who had standardised manufactures to change suddenly to the metric system. All good standard works have to be issued in new editions from time to time, and all he would suggest was that when a new edition came, let it be made in the metric system. The screw question was also a serious one. What had been adopted in Germany and in France, as described by Colonel Huber, appeared to be a step in the right direction, but he thought the question was such a great one that it could only be definitely and satisfactorily settled at a later period by international congress. He looked upon it as a matter of the greatest importance that they should bring this subject forward constantly at all their congresses, so that it might be impressed upon the public generally. With reference to Mr. Allen's question as to his personal experience, they had adopted and had used the decimal system in inches for a long time past in most of their departments. It was found impossible to work with the old system. They had adopted the metric system, for purely economic reasons, in their new works in Leeds in connection with the De Laval steam turbine, as that was an international machine, being made also in Sweden and France, so as to have only one set of standards, and in due time he looked to adopting it over the whole of their establishment.

NOTE.—For information about the working of the Metric System in workshops of the United States, see Paper by Mr. Coleman Sellers, American Society of Mechanical Engineers, 1880, page 7.—[SECRETARY, I. MECH. E.]