"God Save the Queen," everyone expressing themselves as having spent a most enjoyable evening.

During the evening the proceedings were enlivened by some excellent songs by Mr. D. Robertson, Mr. Bowes, Mr. Bell, Mr. McDonald, Mr. R. Mackie, and a laughable recitation by Mr. Chapman.

Yours truly,

"SAFETY."

## THE MECHANICAL PRINCIPLES OF WORK.

THE first of what is expected will be a series of very interesting lectures was given by Mr. John Galt, C. E., on Friday evening, March 27th, in the rooms of the Inventors' and Patentees' Association, Public Library Building, Toronto. The subjects treated of were the mechanical principles of work, and the expansion of steam. Mr. A. E. Edkins, President of the Society of Stationary Engineers, under whose auspices the lecture was held, occupied the chair. The meeting was largely attended.

Mr. Galt said it was a source of great pleasure to see an audience composed of practical men take so manifest an interest in something that was not intended to be a formal lecture, but a simple talk on scientific matters. The large audience present was sufficient to show the need of institutions for practical training, for evening schools to impart scientific knowledge which would be useful in the various trades. There were certain sciences that bore more directly upon each branch of trade, and the knowledge of them enabled a man to rise higher than a mere hewer of wood and drawer of water. To supply this want was recognized as an important part of the educational systems of England and the United States. Large sums were spent annually to give scientific instruction. When a boy left the public school he was merely on the threshhold of knowledge. There was an aching void between the public school and the University. The ordinary student could not step from one to the other. What was needed to supply the pressing want of the day was the missing link between the public schools and the University. He supposed all were aware that an agitation in this direction had long been going on in Toronto. It was pleasing to know that at last there was a prospect of obtaining the much needed workingmen's technical school. This was important from a national as well as a local standpoint. What the working classes wanted was a fair share of the public moneys spent on their behalf. They had only to make the demand, and it must be recognized.

Passing on to the subject of the evening, Mr. Galt said he did not intend to read a sermon. He proposed to give a practical talk upon the principles of mechanics as applied to work. To the mind work suggested something that was moving, therefore work was synonamous with motion. Work was active, not passive. A wall might support a great weight, and was an evidence of force without motion. Work was force in motion; to analyze force was a very difficult thing. Matter was endowed with this inherent principle. What causes motion must be defined as force. As in all sciences, it was here necessary that force should be reduced to some form of measurement. Every science had some typical instrument for measuring purposes. Astronomy had the divided circle. Chemistry had the balance. Heat was determined by the thermometer. So, also, the whole system of mechanical principles of work might be symbolized by a foot rule, set of weights and a clock. The rule determined distances, the weights gave the pressure, and the clock measured the time. One of these units of measurement did not mean anything. If he held up his hand and said "one" it would mean nothing, if he said "one pound," thereby combining two of the units of measurement, he at the same time gave a notion of work. All quantities in mechanics might be expressed in terms of units derived from the fundamental units of length, mass and time. The unit for length was one foot, the unit for mass was one pound, and the unit for time was one minute. From these three fundamental units were deduced the gallon measure and the cubic foot. Work is measured by the product of the existing force and the distance through which it is overcome. Whenever there was motion there must be something to produce it. The simplest conception of work is lifting against the force of gravity. The standard of work was the lifting of a pound weight one foot high. The question of time did not enter into this, but was connected with the question of power or the rate of doing work. Foot pound being the standard of work, all calculations were made upon that basis. Thus to raise ten pounds two feet, was equal to raising twenty pounds one foot. Work done in this way was overcoming the attraction of the earth at that point. Work was also done when two magnets were drawn asunder, or when a spring or electric cord was drawn out. Work being simply force in motion, it was only necessary to multiply the weight in pounds with the distance in feet traversed to get the work done.

The next point was to distinguish between work and power. The introduction of the unit of time into the calculation enables the scientist to calculate the power of a force. The term "power" meant the rate of doing work. It was very important to fully understand this definition. Take any quantity of work that was done in one minute, and if the same quantity were done in two minutes, the time of doing it being double, it would only require half the power to do it. Rate of work, therefore, was quantity performed in some given interval of time. The standard of power which had been generally adopted was called horse power. One horse power consisted in lifting 33,000 pounds one foot in one minute, or 1,980,000 foot pounds per hour. It never was supposed to be able to do one-tenth of this amount of work. From a swift footed race horse to a heavy draft, the product of their speed into the resistance overcome is a measurable quantity representing 33,000 foot pounds per minute. By means of a lever man could often best exert his power, but as the old proverb went, "What was gained in power was lost in speed." To gain power meant that it was possible to move a heavy weight by a small force, provided one loses time by doing it very slowly. This was illustrated by the mechanical principle of the wheel and axle, also by the reduplication of pulleys as found in pulley blocks. Where by any contrivance a man moved a great weight by a small force, the difference between the weight and the force was compensated for by the loss of time. It was impossible to increase power. No matter what mechanism was resorted to, there would be a loss of time in proportion to the power gained. If this simple fundamental principle were well known, much loss of inventive energy might be avoided. The doctrine of the conservation of energy was not very well understood; if it were there would be fewer attempts to invent perpetual motion, or to devise means for increasing power. The conservation of energy was as well demonstrated as the indestructibility of matter. The all-wise Creator had endowed all matter with energy, and it could never be destroyed. The energy which was utilized in the water fall was the same energy which propelled the steam engine.

Passing on to the expansion of steam the speaker explained the theory of expansion in the cylinder according to the parabolic curve. The power of an engine was calculated by the average pressure multiplied by the number of inches which gave the foot pounds, and this was multiplied by the feet travelled by the piston in a minute. From this the horse power was obtained, as already explained.

At the conclusion a hearty vote of thanks was tendered to Mr. Galt, Mr. Edward Meek and Dr Wm Fall speaking very highly of the lecture. They expressed the hope that there would be other lectures and that they would be equally successful.

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Since delivering his lecture, Mr. Galt has received the following letter of enquiry, the reply to which is appended.

219 CHURCH ST., TORONTO, March 28, 1891.

SIR,—Re H. P. of steam engine, I am the party who raised the question of rate of speed of horse. A H. P. is defined as a power that can lift or raise 33,000 lbs. 1 ft. high in one minute, but the same horse power may lift 40,000 lbs. the same height in the same time exerting less power. Then it becomes necessary to limit or define the rate of speed of horse. If the rate of speed of horse is not taken into account, why take speed of engine into account? You cannot compare superficial ft. with cubic ft. If the three units of the one are taken, the same units of the other must of necessity be taken in order to compare them. Watt defines a H. P. as a power that could lift 33,000 lbs. 1 ft. in one minute travelling at the rate of 220 ft. per. minute, which is the rate of travel in estimates of horses on public works, *i. e.*, railroads, canals, etc.

With due respect I write this, so that if possible that I may make myself clearly understood.

Yours truly,

D. A. ROSS,
C. & M. E.

TORONTO, ONT., 30th March, 1891.

D. A. ROSS, ESQ., City.

SIR,—You are still in error, friend, and likely to remain so until you fully and clearly comprehend that the standard horse power is the rate of doing work equal to 33,000 ft. lbs. per minute. Any force moving any distance in overcoming resistance and producing motion, the product of which for one minute will give 33,000 units of work, must be taken to equal and represent a standard horse power. If 40,000 lbs. is to be raised by a horse power, it must be done at the rate of .825 of a ft. per minute, for $\frac{40\,000 \times .825}{33,000} = 1$ H.P.

Your contention as to the usual rate of speed by canal horses may for argument's sake be taken as correct, but your deduction is wrong, because $33,000 \div 220 = 150$, as representing the force exerted by horse so as to give in one minute of time the proper standard, viz., 220 ft. $\times$ 150 lbs. = 33,000 ft. lbs. = one horse power. Notice that the speed of horse has everything to do with the force exerted, but nothing whatever to do with the result. Greater speed $\times$ lever force = slower speed $\times$ greater force = constant quantity of work in given time = 33,000 ft. lbs. per minute = 1 horse power.

The speed of the horse, therefore, is only one element in the calculation. The speed assumed, however, is a very good example in practice, viz., 220 ft. per minute, or 2½ miles per hour.

I hope these simple explanations will put my friend right.

Yours truly,

J. GALT.

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Prof. Silvanus Thompson says of Mitis metal in his recent lectures on "Magnets," that he has found it far superior to ordinary cast iron, and not much inferior to wrought iron, for electro-magnets. It is well known that the field magnets of dynamos and motors are made to certain forms, mainly to avoid expensive forgings on the one hand or inferior results with cast iron on the other. In most cases a compromise is made by using good wrought iron for the straight cores and cast iron for the pole pieces, the latter involving difficult work, if forged out of wrought iron.

Experiments were recently made by the Manchester Steam Users Association to determine the effect of showering cold feed water on red-hot furnace crowns. The boiler used for the purpose was of the Lancashire type, with plane furnace flues and single-rivetted lap joints not strengthened by flanged seams or encircling ring. It was found that the introduction of the cold feed did not lead to an explosion, even when the crown sheet was red-hot; but that, on the contrary, it was often followed by an actual *diminution* in steam pressure. The *Locomotive*, referring to the test, says. We should not recommend the introduction of cold feed-water at such a time, however, because it is likely that the consequent sudden chilling of the plates might, under some circumstances, produce strains in the shell that would hasten the failure of the crown-sheet, or of some of the tubes, so that the attendant might be scalded.