19TH APRIL, 1906.

ELECTRIC POWER TRANSMISSION IN WORKS AND FACTORIES.

(BY E. J. ERSKINE).

The introduction of Electric Power transmission into works and factories has metamorphosed many of the workshops of the world; but it was not until very recently that the high cost of motors was sufficiently reduced to admit of users generally seeing their way to face the initial cost, especially as the prospect was a large reduction in price in the near future.

The position to-day, however, is different. Electrical machinery generally and motors in particular have now reached what may be looked upon as bottom price unless some entirely new discovery is made. The diagram shown gives some idea of the rapid reduction in the prices of motors that has taken place in the last few years.

Referring to the diagram (Plate II.) it will be seen that a 20 h.p. motor which in 1898 cost £120 had been reduced in 1905 to £60.

The price of current is also naturally a large factor in the question of electric driving. In large shops or establishments it is generally cheaper to generate the current on the premises, but in small establishments this is often out of the question, and current must be purchased from a central station. The cost of current from central stations has been very considerably reduced, until to-day current for motor load is sold at twopence per unit, and in special circumstances, even at a penny, which was named many years ago as possible by one of the leading Electrical Engineers, who was much laughed at for the prediction.

In Sydney small shops and establishments being more prolific than large ones, it is perhaps right to deal with them first. The advantages to be gained in these shops are many, such as:—

(a) Economy in floor space;
(b) Freedom from vibration, noise and smell, thereby preventing complaints from residents around;
(c) Steady turning movement with a wide range of speed control easily applied;
(d) Absence of shafting and belts with consequent losses;
(e) Benefit of being able to so arrange the machinery to the best advantage as regards light, and also as regards the following on of work from tool to tool.

These advantages are very great, but it may be said if the cost of driving the shop is going to be much higher the advantages are outbalanced. There are cases where shops have been changed from steam to electric drive which has after a while been abandoned owing to the cost of running; but if these cases are investigated it will be found that the system on which the change was made was wrong. It is incorrect to suppose that you can deal with a motor as if it were an engine, and simply take out an engine, substitute a motor, run the same shafting as previously and expect economy. If such economy were realised, it would mean that the steam plant originally there was very inefficient. But if the shop were divided up into groups of machines, and in the case of machines that were only used intermittently separate motors had been installed, a different aspect would probably appear in the balance-sheet.

In most shops it can be taken that at least 50 per cent. of the power developed is consumed in the useless work of turning shafting, which shafting also requires attention and oil. With judiciously arranged motor drives a great deal of this shafting can be done away with, but in some shops there is a certain amount of emergency work, and it is in such cases that electric driving shows to best advantage. Suppose a rushed job comes in at 5 o'clock. If the shop is steam-driven it is necessary to keep back an engine-man as well as the workmen who are actually working on the job: whereas if the shop is electrically driven these wages can be saved, and in many cases this saving alone would pay the interest on the outlay of the installation.

It is not argued that by converting any shop to electric driving a large saving in running cost is necessarily going to be made, but if the position is carefully studied and each case considered on its merits, motors being installed to the best advantage, the cost of running will be found not to exceed the previous steam costs. It is claimed that the other advantages mentioned above are sufficient to balance the scales in favor of the electric drive.

Dealing now with larger establishments, as mentioned above, it is generally more economical to generate the current on the premises. Before going further, it is perhaps permissible to quote from a paper read by Mr. A. D. Williamson before the I.E.E. of London, in which he gives details of this class of work carried out by him for Messrs. Vickers, Sons, and Maxim.

Mr. Williamson states that the electrical energy, including interest and depreciation, costs only .716 pence per unit, or .53 per h.p., which is, of course, much lower than there appears any chance of purchasing at from a Central Station. Probably this price is lower than that at which current could be generated here, our establishments not being so large as that mentioned by Mr. Williamson; but there is a great margin before the cost at which current can be purchased here is reached.

The first question that arises when considering the installation in a large establishment is what system to adopt, viz.—whether direct or alternating. On this point there has been a great difference of opinion among engineers, but it seems that the advantages are all in favor of direct current.

The only apparent advantage the alternating motor has over its rival is the absence of commutator, but this is often made a great deal more of than is warranted by facts. In these days of carbon brushes, the life of a commutator when properly looked after is long, and the cost of renewal not great; and when the disadvantages of the alternating motor are considered the commutator trouble sinks into insignificance.

The speed reduction of an alternating motor is comparatively cumbersome, and the efficiency of the motor becomes very poor at the lower speeds, and it can be said that except under very exceptional circumstances direct current is the correct thing to use.

In establishments where the machinery is shut down at, say, 5 p.m., where they have a load curve such as those shown, it is advisable to instal an accumulator, which can be so arranged to be charging at times of light load, thereby reducing the peaks; and the current therefrom can be used for any small overtime work and the lighting of any particular parts of the premises.

Having settled the generating plant, we come to the question of distribution of motors. This can only be dealt with in a general way here, as each establishment must be considered separately and after careful study of the requirements; but speaking generally the aim should be:—

(a) To reduce countershafting as much as possible;

(b) To group machines which are likely to be running together on to one motor;

(c) To so arrange the tools as to make the following on of work easy;

(d) To arrange that tools which require different speeds for various work should have separate motors with speed controllers, in order to give best results.

On this last it may be well to once more quote from Mr. Williamson's paper. He says:—

"A portable vertical planer is driven by a 5 b.h.p. motor with a range of speed from 300 to 900 revolutions, the motor being attached directly to the machine. On the cutting stroke the motor runs at its slowest speed, and at the end of the stroke it reverses automatically. As soon as the reversal has occurred, a resistance is automatically inserted in the field winding, quickly raising the speed to 900 revolutions for the return stroke; at the end of the quick return stroke, immediately before reversal, the field is short circuited, providing a strong field to reverse in; the motor then reverses and makes its slow cutting stroke."

Such applications are only possible with electric drives, and enable a works manager to get the maximum amount of work out of his tools in a minimum of time; and the above is only an instance of what can be done in many places to attain this end.

In arranging for motors, it must be remembered that the slower the speed of a motor the higher the price per h.p. Hence to save first cost it is advisable in most cases to use gearing. It does not appear to be generally known to what a high state of efficiency the manufacturers of gearing have brought their apparatus. Gearings are now obtainable with a reduction of ten to one at an efficiency of 98 per cent., and this slight loss in current is amply compensated for by the saving in the first cost of the motor.

A great mistake is often made in cutting rather fine the size of motor for certain work. This is often done by engineers under the wrong impression that a large motor will take a deal more current than a smaller one doing the same work. As a matter of fact, a motor takes from the mains just sufficient energy to deal with the work in hand and to overcome the small internal friction and resistance of itself; hence the only loss is in efficiency, which is slightly lower if the motor is not working on full load but within limits. It is wise to work motors under their load rather than over, as maintenance will be reduced, and the life of the motor increased. At first this question of size of motor for machine tools caused a great deal of trouble, as there was a great difference of opinion as to what power various tools required, but now we have reliable data taken from absolute measurements of almost every tool used, and this difficulty is to a large extent overcome.

In order to meet the requirements of small users who may be unable to spend their capital in installing motors, several manufacturers in England supply motors on the hire-purchase system, the payments being extremely easy. There are three separate scales of charges:—

1st 5 quarterly payments.
2nd 9 quarterly payments.
3rd 13 quarterly payments.

This makes the position very easy for the small buyer. For instance, a 3 h.p. motor can be obtained by the third agreement for a payment of £2 3s. per quarter.

It is interesting to know that the Sydney City Council has decided to place a similar scheme before the users here; and while at present the proposed charges have not been made public, it is certain that the conditions and prices will be made as easy as possible in order to encourage a day load, which is the greatest aim of all central station engineers. With a scheme of this sort available a great number of smaller shops are certain to avail themselves of the opportunity of bringing their establishments up-to-date, and if the charge is made with discretion the result will be an increase in the profits.

There has lately been a strong feeling among engineers that the future source of power from an economical point of view will be that of the gas-engine with producer gas, and that this will be cheaper than electric motors. There is no doubt that the figures given for the cost of generating power by this means are seductive, and it is unlikely that for many years electricity will be obtained at anything approaching the price per h.p. claimed by the advocates of this gas power; but it must be remembered that the disadvantages that exist in driving by steam engine, such as countershafting, difficulty of regulating speed to suit various machines, etc., will still exist where gas-engines are used, with an additional disadvantage that probably the efficiency of gas producer plant will be found to fall considerably under conditions of abnormal fluctuation of load such as has been shown to exist in average establishments.

There is no question that the reason that electric lighting came to the front so rapidly some years ago was due to the then unsatisfactory gas burner. Had the incandescent mantle existed in the early days of electric lighting, there would have been a great deal harder struggle for Electrical Engineers, as many of their then sound arguments would have been discounted, but the strides made by the electric light compelled gas engineers to look round for some improvement, and brought the mantle into the market. But by that time the other great advantages of electric light had been realised, and whatever may be said to the contrary electric lighting is still making progress.

As the motor is becoming a popular source of power, there are bound to be those interested in other prime movers coming forward with new apparatus, and time alone can show what will be proved most beneficial. If it were to be decided purely on cost per horse power, the electrical engineer would have a nervous time before him. But, as in the case of electric lighting, we find people willing after serious consideration to pay more for the lighting of their establishments, owing to the other advantages to be gained. Is it not probable that those responsible for the driving of various forms of machinery will look a little deeper into the question than to simply compare the price per h.p. If it is shown them that owing to other facilities attainable only by electrically driving they can increase the output of their works, and add to the comfort of their own and their employees' existence, they will adopt this form of motive power.

It is interesting to note what the advent of electric driving has done for small clothing manufacturers. There are a number of these scattered throughout the city having their machines motor driven. It is an easy matter to put down a motor on an upper floor of a building where rent is comparatively cheap and drive twenty or more machines; whereas, with a gas engine, the only possible source of power, there might be a considerable difficulty, for a variety of reasons, such as insufficient foundation, annoyance to other occupiers, etc. There is no doubt that the motor has proved a great boon in these cases, and, as time goes on, other applications will be found, and we shall wonder how we managed before it was available.

There is one application that has not come into prominence here so far, although in England it is making good headway, motor driven refrigerating machinery on a small scale. Surely it would be a good thing if our hotels and butchers' shops had a cold room on the establishment, and this is now within their reach. A motor driven refrigerator would not take up much room, and would require little attention. The machine would, of course, not necessarily be continually running, and the starting of it when it was found necessary would be easy and quick. The cost of a plant such as this would only amount to about £400, including insulated rooms. In many cases, by this system, more than the interest on this sum would be saved in a year through reduction in deterioration, and in addition to this the comforts of the customers would be very largely increased.

In America especially has this motor refrigerator taken strides. It is said that in a restaurant the annual cost has been reduced from £130 to £90, the system formerly in use being ice refrigeration.

There seems to be a large field open in a hot climate like Australia enjoys, and this field has so far hardly been touched. The advantage to the central station can easily be imagined when it is remembered that this load would largely be on at times of comparatively light load; and it is possible that these supply stations might see their way to a reduction in price per unit, providing a time switch were inserted by which means the refrigerating machine could only run during the hours of light load.

Plate III., this curve is made from readings taken on an average day at Tooth's Brewery, and it will be seen that the load is extremely variable. Before the electric drive was introduced, there was a large engine driving the main portion of the machinery through long lengths of countershafting. It is easy to realise that in a case of this kind electric driving must prove more economical. Instead of keeping a large engine running for hours on a small load where probably the shafting took a great deal more power to turn than was being used in useful work, now it is possible to only use power when and where it is required. By having several units generating the current, it is only necessary to run one engine on the light loads, starting No. 2 engine as soon as No. 1 becomes loaded. In this way it is possible to get good economy from the plant. There is also a small battery of accumulators in connection with this plant, which is charged at light load times, and serves after the plant has been stopped to light the various departments and do any small driving work that may be necessary during the night.

The curve (Plate IV.) is taken at the Pyrmont refinery of the C.S.R. Co., and is most interesting, showing as it does the large variation in the amount of power used at various times. There are a number of motors placed throughout these large premises, some being geared, and some coupled direct on to the various machines. It is to be hoped that in the discussion we may hear from the Engineers of the Company some details of the results of the new system. In some cases the motors are of the vertical shaft pattern for driving special machines, and as this pattern is new in Australia it would be interesting to hear whether they have proved satisfactory in working, especially as these particular motors have to start under excessive loads, which is necessarily a severe test.

The two diagrams (Plate V.) are taken from a paper read by Mr. Williamson before the Institute of Electrical Engineers, London, and are so interesting that no apology is necessary for bringing them specially under notice. Fig. 1 shows the position of affairs in a factory driven by steam with shafting and belts, it will be seen that the amount of waste work is extremely large in proportion to the useful work performed.

Fig. 2 shows what is required is taken from the same if driven by motors from current generated on the premises, the saving is very apparent.

It must not, of course, be taken that similar economy is necessarily going to occur in all factories, and it is possible that in the one under notice uneconomical steam engines were replaced by economical ones driving to electric generators, and also the shafting may not have been so well installed and kept in repair as is the case in other places. At the same time it is safe to say that in a great number of cases, if curves were made of the kind here shown, it would be found that great economies could be made by a comparatively small outlay of capital.

Plate VI. is a similar curve made for readings taken at the workshop of the C.S.R. Co. These shops are driven by two motors, one of 55 h.p. and one of 20 h.p., and the curve is the result of the two motors. When the tools are all standing, it is found that 15 b.h.p. are absorbed in driving the shafting and loose pulleys. This at twopence per unit, assuming eight hours per working day, means that it would cost £312 per annum to do this work, most of which could be avoided by installing separate motors for various tools or groups of tools. It is necessary to point out that this was fully realised when the installation of the large motors was made, but as in this case the steam, after being used for the generation of current is used for other purposes, the question of economy of steam did not enter the equation to the extent it would in other cases, and it was, therefore, decided not to incur the additional first cost of a separate motor installation.

The figures given above are, however, so interesting that they must cause engineers who are considering the question of electric driving to pause before installing large motors driving countershafting; and it may here be repeated that it is only by a careful study of the question of cutting up the drives that the full benefit of electric driving can be made use of.

The following is a quotation from an article in "Engineering," in 1903:—

> "Electricity is an obedient servant never in the way and never out of the way.
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> "A motor only needs a pair of wires to connect it with the source of power, and is ready for action on the turning of a switch.
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> "It has a wide range of speed, and it as obedient as a wife according to the marriage service.
>
> "Hence it comes that when electric driving is introduced into a work it makes rapid progress and is never abandoned."