the conditions named, is evidently due to their passing through the magnetic circuit, or, as it is usually termed, cutting the lines of force. Where an electro-magnet is excited, a magnetic field, a magnetic circuit, or magnetic lines of force, whichever term be preferred, is created, and the secondary wire lying in their path, an E.M.F. is generated in it. The converse takes place when the primary circuit is broken, and this applies to all cases of electro-magnetic induction. A magnetic circuit is either created, broken, or varied, and in each conductor lying in the path of the circuit, an E.M.F. is generated.

From the above it naturally follows, that in conductors which run parallel to the directions of lines of force, no E.M.F. is generated, and so it happens that no induction takes place between two wires crossing each other at right angles.

For effective induction, where the secondary current is to be used apart from primary, as in induction coils used for experimental purposes, for telephone transmitters, for the transformers now being introduced into electric lighting, the primary and secondary coils must be insulated from each other, and the insulation should be proportionate to the E.M.F.s generated. With induction coils, by wrapping a long length of secondary wire round a shorter length of primary, it is possible to generate very high E.M.F.s in the former, using only very low E.M.F.s in the latter; each coil of the secondary that is brought within the influence of the lines of force adding to the E.M.F.s generated. Where high E.M.F.s are generated, and used for the purposes of electric light distribution, being converted into low E.M.F.s at the point of consumption, great care must be taken to insulate fully between the coils, or the inductive action will be destroyed to a large extent, and may give rise to serious accidents.

But though, where it is desired to use electrical induction as a servant, it is necessary to insulate the two coils from each other, induction will take place nevertheless without any insulation. One case has been given, where the coils of an electro-magnet generate an E.M.F. by acting inductively on each other; coils even are not necessary for induction. But it will take place within a wire itself.

Each portion of a conductor acts as a separate wire. Thus, a copper rod half an inch in diameter may be taken to consist of a number of small wires all grouped round a centre; and as apparently the first action of a current is mainly confined to the surface of a conductor, induction takes place between the outer wires, so to speak, and the inner, giving rise to many puzzling phenomena in connection with dynamo construction, and with lightning discharges; about which something will probably be said later on, Prof. Oliver Lodge's recent investigations having considerably modified our ideas with regard to the latter.

ELECTRIC CRANES.*

By Reginald Bolton.

The use of hoisting machinery forms a subject of interest to many engineers, while the question of its economies is of even deeper interest to all those engaged in the transport or movement of materials. The application of electricity to this particular purpose is one that at first sight may not present great apparent advantage, but a consideration of the conditions to be fulfilled will, on the contrary, show that there is no more suitable conjunction of force and duty, and even at the present stage, no purchaser of hoisting machinery can afford to disregard the claims of the conveyance of power by electricity, for reasons which the author hopes, succintly, to show.

There are three considerations which present themselves, and which, if answered affirmatively, cover the whole subject.

Naturally, the primary one is,

1. Its comparative economy.

The second in order is,

2. Its superior merits.

The only remaining consideration being,

3. Its practicability.

Under the first we have to look into a few of the figures of electric and steam motors on cranes.

Now, an electric motor is in itself a most economical transmitter of power, its efficiency running as high as 90 per cent. in regular work, and if worked under proper conditions, its life may be as long as that of any ordinary steam engine, while under the special safeguards designed by the author its durability would be far more prolonged. But the power must necessarily be generated and conveyed to this motor, and so the question of the economy of the generating dynamo and the power that drives it comes into question. Such directly-connected engines and dynamos as are used on board ship, and in numerous central-station installations on land, have repeatedly given a united efficiency of over 80 per cent. of the horse-power of the steam in the cylinder.

There are a far greater number of cases, however, where such a dynamo would receive its motion direct from a shaft driven by a larger engine, and in such a case an even superior result might be relied upon. It would, in fact, be safe to assume an output of 85 per cent. of the actual power put on to the dynamo pulley, in the shape of electrical force, and as, in the case of shop cranes, or wharf cranes, they would not be remotely situated from the generating dynamo, the loss in transmission would be small and can be stated at 1 per cent. to 2 per cent. only.

In the case of a large dock, with cranes situated at all parts, there would be greater distances to be dealt with, but even these would not exceed the limits of ordinary low-tension circuits, and the system would show a very favorable comparison in losses by transmission, as against the distribution of hydraulic power.

For all ordinary conditions, then, we may deal with the following figures:

One h. p. put into dynamo results in	.85	of 1 h. p.
Less by loss in transmission two per cent...	.00085	of "
Leaving the force put into motor as..................	.8415	of a h. p
Output of motor 90 per cent. =	.7573	of 1 h. p

Or a total loss of less than 25 per cent.

Now take the comparative case of a steam driven crane, say of two tons power, having two cylinders each 5½ in. diameter by 8 in. stroke, running at 150 revolutions per minute. Such engines are on full work linked up to cut off steam as late as ⅝ to ¾ of the stroke, and thus exhaust their steam at a considerable pressure. The usual boiler pressure is 70 lbs., maintained at an average of about 65 lbs., and wire drawn by pipes and connections to, say, 60 lbs. initial pressure. Under above conditions they indicate about 14½ horse-power, but their consumption of steam is very considerable, and cannot be assumed at less than 35 lbs. per horse-power per hour. An excellent authority gave, recently, instances of such small high-speed engines absorbing over 40 lbs. per horse power per hour. The net efficiency is still further reduced by the internal friction of the machines, which even in good engines would average 15 per cent., so that we arrive at a final efficiency of these engines used as motors on cranes of not more than 60 per cent.

On all small steam cranes, however, there is a further waste in the boilers, which, being small and of the vertical type, are far from economical in raising steam, and habitually consume 5 to 7 lbs. of fuel per horse-power per hour. In practice no crane is ever continually at work, and during the periods of lowering, changing gear and stops, &c., the fuel continues to burn, and there is also the cost of fuel and labor of raising steam in the morning for the day's work.

It is customary among crane builders to construct the boilers of steam cranes a good deal smaller than would be necessary if the engines were in constant running; the gain in pressure during the stops and changes mentioned compensating the loss of pressure during working, and the steam gauge is consequently constantly on the move. Now, against these figures we should have, in the case of a direct-driven dynamo, a better engine running with an earlier cut-off, and also necessary steam more economically raised. The motor when the crane is standing wastes no power, and the dynamo may be shut down or started at short notice. The crane driver need pay no attention to the crane when standing idle, and he starts without delay in the morning, the power being derived from the shop boilers. There would thus appear to be a very decided economy in favor of electric cranes, as against steam-driven machines. In the case of overhead travellers, there is the saving due to the absence of long square shafts running in movable bearings, and which, together with the cotton or wire ropes in rope-driven cranes, are kept constantly running even when the crane is out of use.

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Lines of force that have the same direction repel each other, while if they have opposite directions they attract each other.