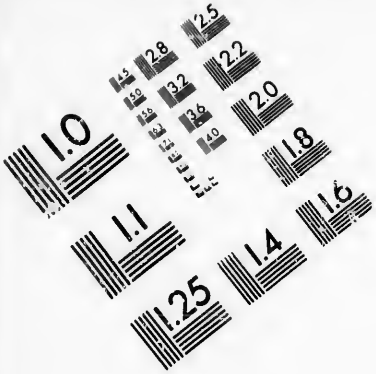

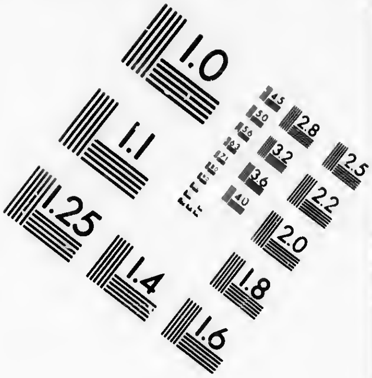

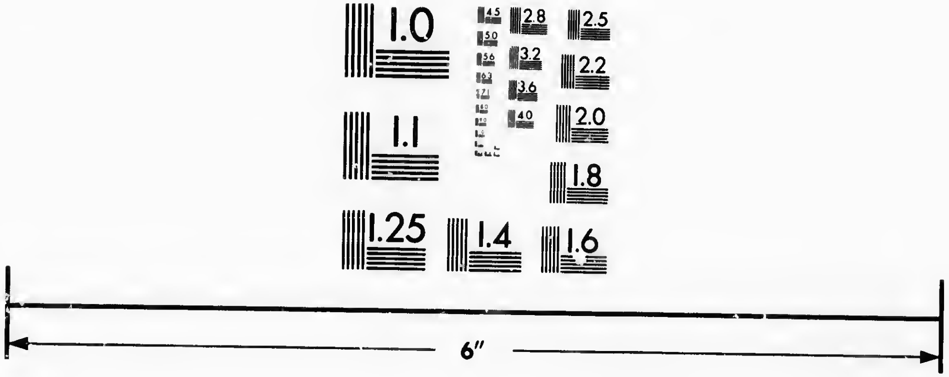
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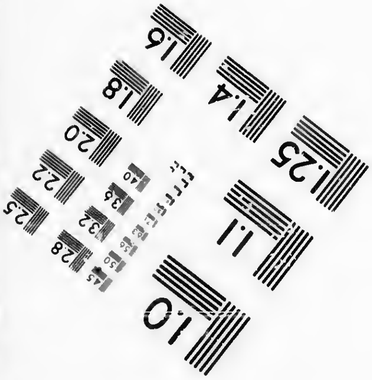

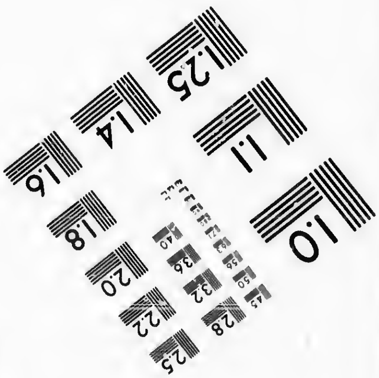

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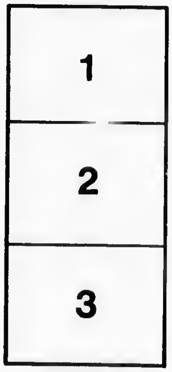

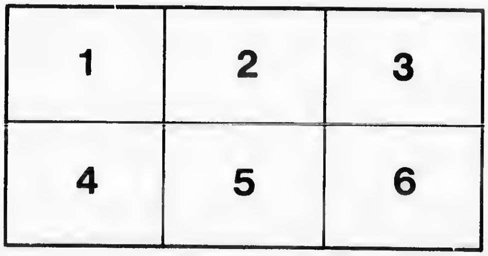

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INCORPORATED 1887.

TRANSACTIONS.

SOME APPLICATIONS OF ELECTRIC MOTORS.

By Fred. A. Bowman, B.E., A.M. Can. Soc. C.E., A.M. Am. Inst. E.E.

To be read Thursday, 26th April, 1894.

The intention is in this paper to deal with the subject more from the standpoint of the civil or mechanical engineer than from that of the electrical. A sketch of the method of applying motors to different kinds of work will be given with data regarding tho power called for.

Among the electrical papers that have been read before this Society, one by Mr. Th[illegible]berry gives an historical sketch of the dynamo, and one by Mr. Lawson describes the methods employed and advances made in the various systems of electric lighting. The writer will therefore make his historical notes brief.

The history of the electric motor goes back to the discovery by Faraday, in 1821, of electro-magnetic rotation, and the invention, in 1823, by Barlow of his rotating wheel. In 1840 Thomas Davenport built a motor in New York, which was used to drive a printing-press. The publication of a periodical called *Electromagnet* was begun by him, the printing being done in this press.

The fact that one dynamo used as a generator can be employed to give motion to another connected to it as a motor seems to have been first discovered at the Vienna Exhibition in 1873. Some of the earliest applications of this principle on a commercial scale were made at the sugar works in Sermaize by Messrs Chrétien and Felix. In 1878 M. Felix installed a chaplet lift in these works for unloading beet root from the vessels, by which means a saving of 10 per cent. in labour was effected.

In the following year it was decided to employ the engine at the works in the slack time which occurs during part of the year in the beet sugar industry, to furnish electric power for ploughing the field in the neighbourhood. The system employed was the same as in steam ploughing, a motor being placed on a trolley at each side of the field. The motors worked the drums on which the steel rope drawing the plough was wound and unwound, and also furnishing power for the forward motion of the trolleys. The speed of the plough was 55 per minute, and the work done was at the rate of 200 square feet per minute. This is about the same as would be done by a 5 or 6 horse-power Fowler steam-tackle.

The advantages of electric motors for use in driving the machinery in small industries are efficiency, reduced cost of attendance, cleanliness, reduced fire risk, and economy of power. Small engines and boilers are troublesome, calling for an amount of care and attention that is almost a constant; independent of the power generated, the attention given is generally of the unskilled kind that reduces the efficiency of tho plant below the low percentage inseparable from small units. The dirt and heat from a steam plant is always an annoyance and often a serious drawback. The risk from fire is of course greatly increased in any case by the presence of a steam boiler. The electric motor does not possess these disadvantages. As built by the best makers to-day, it has, except in the case of the very small sizes, a very high efficiency. There is no dirt, heat or smell ; it calls for a minimum of attention, occupies little floor space, or, as will be shown presently, none at all. It is economical of power, as when stopped there is no consumption of energy. If properly installed, it is absolutely safe as regards fire risk.

In the case of large factories with long lines of shafting, and these distributed on several floors in separate buildings, there is a great loss of power in driving by belting from floor to floor and in having either separate boilers in each building or lines of steam pipes from a central battery of boilers.

With electric motors, one or more can be placed on each floor, and thus all or only a part of the shafting can be driven, according as it is called for.

In the case of accident, a line of shafting can be stopped almost instantly—a matter oftentimes of life or death. Transmission of power by shafting from room to room necessitates holes in partition walls that are a serious source of danger in the case of fire.

The ordinary method of driving shafting is by belting from the motor pulley ; but in a few instances railway motors have been used, geared directly to the line shaft in the same way as to a car axle, the motor being bolted to the ceiling timbers.

In the case of a long line of shafting, unless it is torerably certain that it will be in constant use throughout its whole length, it is better to divide it into two or more lengths, with a motor to each. If economic handling of material will admit of it, those machines which are least used can be then grouped on one motor and those more used on another. This grouping often proves very convenient and economical where a night shift works on certain kinds of work only, and nothing need be kept running except the machines directly needed.

The belt from motor to shaft should be as nearly horizontal as possible, as most stationary motors run at a speed considerably higher than that of the shafting they drive ; consequently, the driving pulley and arc of contact are small. Light double leather belts will be found most suitable for this work.

In cases where floor space is valuable, or it is impossible to place the motor anywhere but directly under the shaft, it is better to place it on a platform slung from the ceiling by iron rods, at such a height that the motor shaft will be on a level with the shaft to be driven. The rods must be considerably larger than is necessary to support the weight in order to give the necessary stiffness to withstand the pull of the belt. The platform must be wide enough to permit of a man standing comfortably alongside of one side of the motor, at least to tend and clean it. The switch and starting apparatus may be placed in any convenient location. A light iron ladder can be attached to the platform, and if necessary it can be made to fold up and be pulled up to the ceiling when not in use.

The following examples from actual practice will show what size of motors have been installed to do certain kinds of work and under what unsatisfactory conditions they will continue to do it.

A Thomson-Houston shunt wound motor of 35 horse-power in a large machine shop drives a grind-stone, 18 planers, 8′ by 2′ bed, 3 milling machines "No. 3 Brainard," 12″ by 28″ bed, 1 speed lathe, 3 shapers 12″ by 20″. The motor runs 1,150 revs. per minute, the driven shaft at the usual speed of line shafting for this class of work. The belt is an 8″ double leather. The average distance from centre of motor pulley to centre of shaft is 20′ 10,″ making an angle of 24 ° with the horizon.

In the same shop a similar motor of 10 horse-power drives four 20″ drill presses, one 12″ ditto, one boring machine boring up to 6″ hole, one speed lathe, one milling machine 12″ by 18″ bed, one splining machine 12″ stroke, and one large slotting machine. It is on a platform such as has been described. The motor pulley is 8″ diam. by 6″

face with 1¾″ bore, and runs 1,600 revs. per minute. The driven pulley is 51″ diam by 8″ face with 2 7-16″ bore, and runs 245 revs. per minute. The distance from centre to centre of pulleys is 15′ and the belt runs horizontally. The following case shows what a motor will stand. A 5 horse-power Thomson-Houston shunt wound motor was used to drive a No. 4 Sturtevant blower in blacksmith shop, with 18 fires. Both were on a platform slung from the ceiling, the motor shaft being coupled directly to the blower shaft and running at 1,800 revs. per minute. The platform was almost directly over a large tempering furnace. The heat, smoke and dust to which it was exposed can only be realized by those who have had occasion to travel among the roof timbers of a large forge shop in full operation. The field coils and pole pieces on a hot summer's day were too hot to put your hand on. A similar 10 horse-power motor in the same shop was also mounted on a platform, but in a somewhat cooler corner. It drove a grindstone, a large pair of Beaudry shears and a Bradley helve hammer. The motor pulley was 9″ diam. by 6″ face with 1¾″ bore, with a speed of 1,600 revs. per minute. The driven pulley was 32″ diam. by 6¼″ face, with 2 7-16″ bore, with a speed of 442 revs. per minute. The belt 6″ wide with a distance between centres of 18′ 7,″ and running horizontally.

In a carpenter and pattern shop a 20 horse-power Thomson-Houston motor drives eleven circular saws, two grindstones, eight speed lathes, one drill press 5″ swing, one 8″ swing, one jig-saw, one moulding machine, one mortizing machine, three planers, two band saws, one engine lathe 6′ bed, one shaper 12″ stroke.

These machines are distributed over two floors, the motor being on the lower one. The motor pulley is 10″ diam. by 7″ face with 2″ bore, and a speed of 1,300 revs. per minute. The pulley on the line shaft is 48″ diam. by 8½″ face with $2\frac{7}{16}$″ bore and a speed of 264 revs. per minute. The distance from centre to centre of pulleys is 12′ 6″ at an angle of 57° with the horizon. An 8″ belt is used.

Messrs. Martin & Warneck's flouring mill at Ottawa is driven by a 100 kilowatt (133 horse-power) motor built by the Royal Electric Co. It is of the four pole type, and is run on a 500 volt. circuit. It is situated one mile from the power station, and runs continuously for 24 hours per day and six days per week, stopping for Sundays only. The motor pulley is 23½″ diam. by 20″ face, driving a jack shaft 18′ feet away by an 18″ belt. The mill was previously driven by a steam engine and the motor is belted to the original jack shaft. The machines driven consist of fifteen sets of 9″ × 24″ rolls, four purifiers, three scourers, one separator, four centrifugal reels, eight octagon reels 16′ long; in addition, there is a grain elevator separate from the mill, 84′ high, with a capacity of 1,200 bushels an hour. Experiments show that it requires a minimum of 75 horse-power to drive the mill, when it is once started and everything going right. The extra power is called for when there comes a "choke" and for starting up.

Electricity has come to be so largely used as a motive power for freight and passenger elevators and hoists, that several firms in the United States and at least one in Canada make a specialty of them. The cleanliness, compactness and ease of regulation of the electric motor adapt it admirably to this class of work, where the floor space available is often if not generally limited.

In small shops where an elevator works between two or three floors only, a simple stationary motor is belted to a countershaft that drives the drum, the attendant does not travel on the elevator, and the ordinary starting apparatus suffices. For the larger passenger and freight elevators, the motor and hoisting mechanism are all on one bed plate, and connected to each other by spur or worm gearing. Lately the Sprague-Pratt elevator for high speed passenger service has been brought out, in which multiplying sheaves are used as in hydraulic systems, but instead of a ram a screw driver by the motor operates the sheaves. In other cases motors are used to drive the pumps for hydraulic systems. This partakes more of pumping than elevator work.

To control the speed and to stop and start a hand line is generally run up and down the shaft, passing through the car as in other systems, and moving the controlling apparatus through suitable gear. This system has the advantage that the elevator can be worked either from the car or from any floor. Another system that can only be worked by an attendant on the car consists in running two bare copper wires up and down the shaft and to have the current regulator on the car. Sliding contacts attached to the car take the current from one wire, pass it through the regulator and into the other wire, by which it is conveyed to the motor.

Portable electric hoists should be carefully considered by all who have to handle heavy goods in warehouses or on wharves. They are small and compact, can be mounted on low truck wheels, and moved about a warehouse floor to wherever a pull on a rope is called for, or run out on a dock to unload cargoes. The supply of current is provided for in a very simple manner. Wires are carried from the source of supply of current to various points in and round the buildings, and terminate in small locked boxes. The hoist is furnished with a convenient length of flexible conductors which are quickly attached by suitable clips to the terminals in the nearest box.

At one of the largest refineries at Greenpoint, Brooklyn, N.Y., there is a long range of wharf and warehouses for the reception and storage of raw sugar, much of which comes in lighters which have no hoisting gear of their own. Portable electric hoists are used for the unloading of these vessels. Terminal boxes are arranged at suitable places along the walls of the warehouses so as not to necessitate too great a length of cable. The cable is allowed to lie low on the ground, a board being laid each side of it as would be done with a hose, if there is to be much crossing of it with trucks. Power is furnished by a 220 volt dynamo on the premises. The hoists were built by the Lidgerwood Co., and fitted with 10 horse-power motors. The motor is geared to the shaft of the drum, and the connection between shaft and drum for hoisting is through a band clutch. The lowering is done by a brake. There are two hand levers,—one working the motor regulator the other the clutch. The brake is worked by a foot lever.

The writer had the privilege of making a test run of half a day with the first of these installed at these works and unloaded a lighter of sugar with it. Three bags weighing over 3 cwt. each were placed in the sling at each lift. The lifts averaged 1000 lbs. each. There was no gain in hoisting more, as the three were just a truck load for a porter.

As the hold was cleared directly under the hatchway, the hoisting rope with some 20 ft. of chain attached was hauled in to where the bags lay. The machine had then to haul them to the hatchway with the chain dragging on the inner edge of the deck before the actual lift began.

Only two hitches occurred: once the hook caught the deck, and the hoist, failing to lift the lighter, started to climb the rope; the second hitch was due to the drum and friction clutch being new and a little stiff, and in consequence the rope did not pay out quite as easily as the stevedores wished when being taken back to the hold. So during the writer's temporary absence the captain of the lighter carefully *greased the face of the band of the clutch.* It took some little time to find out why a clutch that until now had held the heaviest loads with a reasonable pull of one hand suddenly called for the united strength of both arms to make it take hold at all.

At the wharves of Sanderson & Sons, Brooklyn, where the Wilson Line steamers lie, there are nine hoists in use, of the same pattern as the one just described. It has recently been stated that the whole bill for repairs on these for 2½ years has been $2.75 per hoist.

There are several points that should be carefully looked to in the design of an electric hoist. The armature of the motor must be waterproof. The resistance box and all wires must be so placed that oil from the bearings cannot drop on them, as, falling on the former, it is apt to catch fire, as the resistances are hot from the passage of the current and on the latter it ruins the insulation. This detail of location of parts would appear to be almost self-evident, but is mentioned, as the writer had trouble with both these faults in a hoist built by a leading electric Company. The foot plate of the break lever should be of good size; they are sometimes made so small that a man with a large foot cannot get it far enough on to apply his weight properly; it should also be as near the ground as is practicable. In order to work a brake quickly and lower the load to just where it is wanted the operator must not have to raise his foot high. He must be able to apply his whole weight without raising the other foot off the ground. The lever can be placed as low as needed, and hinged so that it can be raised out of the way when moving the hoist from place to place.

Were the advantages of these little hoists more thoroughly realized by engineers and contractors, they would soon be largely used wherever hoisting, pulling and hauling are to be done. Compact, strong and easily handled, they can be hauled about anywhere and used for hoisting material in or out of place, for shifting cars at freight sheds, or for hauling cars from face to dumping ground in excavation work or quarries. Those who have never handled them do not realize what a well built electric motor will stand in the way of overload and general abuse. When one sees as the writer has a 15 horse-power motor exert a force of 40 horse-power for a few moments, and a 25 horse-power run at 35 horse-power for 10 hours a day for several weeks, he becomes convinced that electric motors have passed the experimental stage and taken their place as thoroughly reliable machines.

Another branch of hoisting work to which electricity lends itself most admirably is that of travelling and jib cranes. Of course the designs of these are as numerous as the builders, but the leading practice in the case of travelling cranes is to employ not less than three motors, *i.e.*, one for each motion. A one-motor crane has very little advantage over one driven by ropes or a square shaft. The same complication of clutches is required as in the latter cases; and unless the motor is very large, only one motion can be performed at a time. When three motors are used, one is placed on the bridge near one end, and works the longitudinal travel of the crane. This is usually done by gearing the motor to a shaft running the length of the bridge and driving the truck wheels at each end. The other two motors are placed on the trolley: one of them works the tranverse motion and the other does the hoisting. All the controlling is done from the cage attached to the bridge in which is a small switchboard and the levers or handwheels for controlling the motions. This arrangement permits of the three motions being carried on together.

The current is generally transmitted to the switchboard from bare wires stretched the length of the travel over the crane. Trolley wheels over flexible arms carry the current from the wires to the switchboard in the same way as the trolley arm on electric street railway cars. The current comes from the generator by one wire, goes to the motors, and returns by the other wire. To get the current to the motors on the trolley, bare copper strips or wires are stretched along the bridge, and sliding contacts on the trolley take off the current. Occasionally a flexible cable is used to connect the switchboard and the motors on the trolley, but this is inconvenient, as means have to be provided for taking up the slack in the cable as the trolley moves to and fro. The connection between the armature shaft of the motor and the hoisting drum is either by spur gearing or endless screw and worm wheel. One of the great advantages of electricty for this heavy crane work is that there is no great muscular power called for to work the regulating levers. No matter how great the power transmitted, the only force the operator has to exert is that necessary to overcome the light rubbing friction in the contacts of the regulator, consequently, great delicacy of movement is obtained, and a weight of one hundred tons can be moved only one-sixteenth of an inch in any direction. This is unattainable where the operator has to exert considerable force to throw clutches in and out of gear. It is important to this delicacy of motion that there be as little lost motion as possible in the motion of the regulators. In many cases the arm that moves over the contacts of the regulator is held in a slot in such a way, that as soon as it moves off the last contact it drops to the lower end of the slot, thus making a quicker break than the hand motion alone would, and preventing the formation of an arc between itself and the last contact. There is a serious objection to this arrangement, for if the operator throws off this current with a quick jerk, as he often will in rapid work, the arm may strike the other end of the slot with sufficient force to make it rebound on to the contact, and start the crane unexpectedly. The writer prefers hand levers for moving the regulators with a notched quadrant and pawl similar to the reverse lever of a locomotive. One notch at the "off" position is all that is needed, as when at work the hand is rarely removed from the lever; and if it is, the friction is enough to keep it in place. Hand wheels are often used, and permit of very nice handling of the various motions, but do not sufficiently indicate the position of the regulator.

The switchboard in the cage should be made of incombustible material, such as slate or marble, and should be provided with a double pole switch, so arranged as to cut off the current from all the motor circuits. Suitable safety fuses should be placed in the circuit to each motor.

Magnetic brakes are often placed on the hoisting gear. They are applied by a heavy weight or strong spring, but are held off while the motor is in motion by a magnet round which the main current passes on its way to the motor. In this way anything which intentionally or accidentally interrupts the current to the motor destroys the power of the magnet and permits the brake to act.

Mr. H. Ward Leonard proposes a system for driving crane motors, hoists, elevators, etc., in which a small generator is used for each motor. The regulating devices, instead of controlling the motor directly, alter the field strength of the generator, and thus vary the pressure at which the current is supplied, and, consequently, the speed of the motor. Reversing is accomplished by reversing the magnetism of the generator.

As examples of large cranes may be mentioned one erected by the Morgan Engineering Co., in the testing house of the General Electric Company's factory at Lynn, Mass. The span is 45 ft. and the capacity of the crane 20 tons. A 10 horse-power railway motor is used for the longitudinal travel of the bridge. A similar motor is mounted on the trolley for hoisting, and one of 3 horse power for the cross travel of the trolley. There are two cranes of 100 tons capacity each, built by Wm. Sellers & Co., in the Baldwin Locomotive Works.

The writer believes that electric jib cranes could be substituted with great advantage for the large steam cranes now used on engineering works.

Take, for instance, a dry dock or canal lock. There will be a track laid all round the work on which steam cranes will travel, excavating the material or placing the blocks of stone in place. Each of these is provided with an independent boiler and one and two engines, and calls for a skilled man to run it. Somewhere near at hand there will be another boiler to supply steam for drills and pumps. All these small engines and boilers are a great source of waste and expense. The cranes do a great deal of work that is a very light load on their engines, and it is well known that the efficiency of a steam engine at half load is less than that of an electric motor under the same circumstances. One larger engine driving a dynamo could supply power to all the various machines used. A light trolley wire suspended over the track would convey power to the cranes, and cables would carry the current to pumps and drills with a fraction of the loss there is in carrying steam the same distance by pipes and hose.