CASSIER'S MAGAZINE.

VOL. VII. FEBRUARY, 1895. No. 4.

ELECTRICITY IN TEXTILE MANUFACTURING.

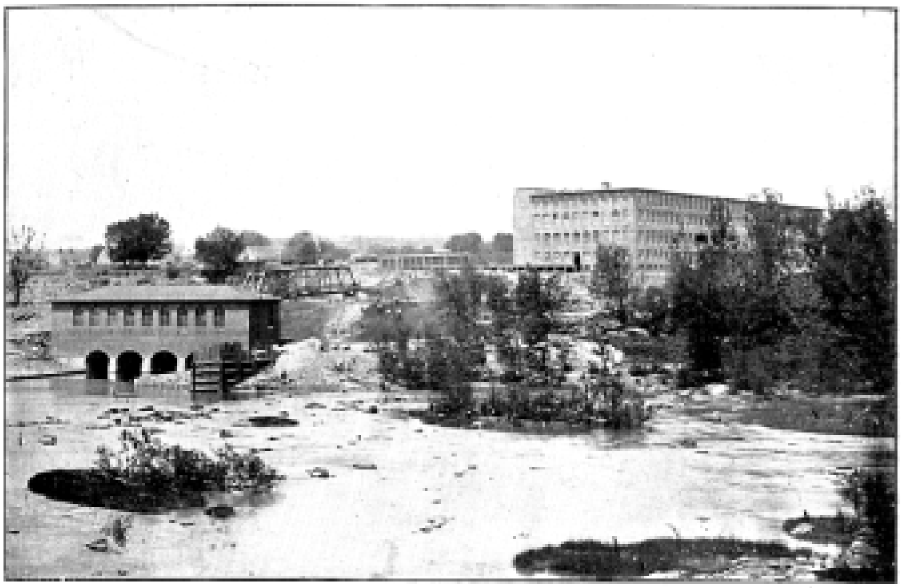
By Dr. Louis Bell.

IN no branch of modern industry is closer attention paid to economy and to every mechanical detail which goes to make up the commercial success of a manufacturing plant than in mill work as practiced to-day by the leading cotton and woolen manufacturing companies of America. Driven by the high cost of labor to seek every mechanical advantage that human ingenuity can suggest, the mill engineers of the United States are at once the most conservative and the most keen-sighted for improvements of any party of technical workers to be found. They are slow to act when new ideas are broached, but, having once made up their minds, carry out the work with the greatest sagacity and skill.

It thus happened that the electric motor found its way into manufacturing establishments of almost every kind before it was taken up by the textile industry, and perhaps this may be regarded as fortunate, for, as a matter of fact, the first cotton mill to adopt electric motors for the complete distribution of power throughout the plant, also took up the work in a very thorough and skillful manner, and left nothing undone to make a system as complete and perfect in its way as the system for the textile manufacture itself—and to say that is high praise, indeed. As a consequence, there is to-day in successful operation a perfect example of distribution of power throughout a large factory by electric motors exclusively, and, furthermore, by the most advanced type of electric motors, inasmuch as the three-phase system was chosen in the work and the induction motor is used throughout.

The plant in question is that of the Columbia Cotton Company at Columbia, in South Carolina—a corporation which, in spite of its Southern location, is backed by New England capital and made up of New England yankees, the president being Aretas Blood, of Manchester, N. H., long identified with manufacturing interests of various sorts. Lockwood, Greene & Co., of Boston, were the engineers of the projected mill, and after much deliberation, in consultation with Mr. S. B. Paine of the General Electric Company, they concluded to take the plunge which others had been contemplating at various times past and commit themselves irretrievably to the use of electric power in the operation of the mill.

The conditions were peculiar. The motive power was to be obtained from



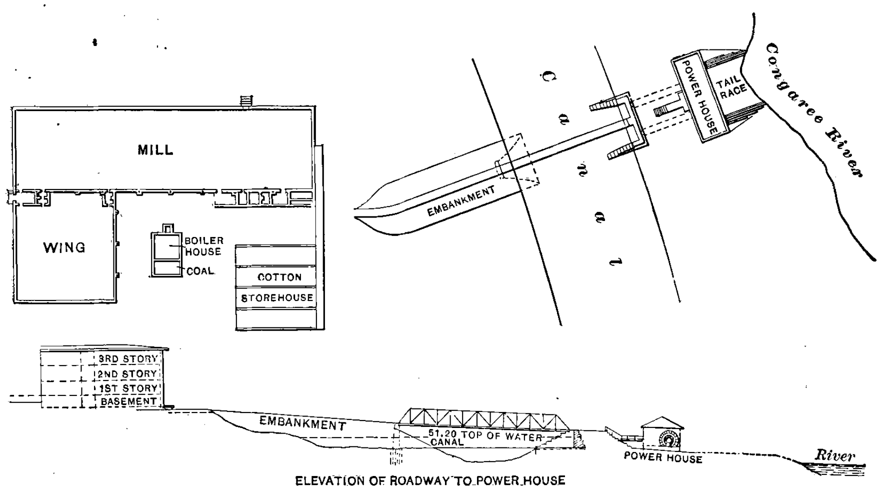
THE PLANT OF THE COLUMBIA COTTON CO., AT COLUMBIA, S. C.

the waters of the Congaree river, about half a mile from the city of Columbia proper. Owing to the topographical conditions, it was thought undesirable to place the mill directly on the river bank or, rather, upon the flat which one may, by courtesy, call a bank. To have so placed it, would have involved a great deal of trouble with foundations, a very undesirable location and considerable cramping of the territory available for extension. It therefore became necessary to place the mill in a suitable location and transmit the power to it from the water-wheels located close by the river banks.

For this work the advantages of electrical power transmission were very marked. Instead of facing the alternative of a very indifferent and troublesome site for the mill on the one hand, or rather inefficient transmission on the other, it became possible to transmit the power very readily from the water-wheels to the mill, placed in any convenient location, and then to distribute it through the mill, not by the long, power-consuming lines of shafting generally found, but directly to each floor and room where power was needed, driving, in fact, short and light shafts of such size as convenience might dictate.

With this idea in mind, the projectors of the new enterprise cast about for apparatus, mindful of the fact that the electrical conditions to be met were most severe. In the first place, it was necessary that the efficiency of transmission should be very high—high enough to compare favorably with the delivery of the same power by the best mechanical means, otherwise no great advantage could be gained. Motors, dynamos and line must work together, so that the power lost would not be greater than that involved by a cable transmission and shafting throughout the mills.

More than this, the system must be so arranged that the speed of driving the machinery throughout the mill should be almost uniform, irrespective of conditions of load. So long as all the shafting in a mill is linked together mechanically, the variation in load on the whole is so slow and small that the speed can be held almost absolutely uniform. If, however, the new system of distribution by motors were to be adopted, each motor must be able to drive its shafting at a uniform speed while the variations in the load put upon it might be considerable and rather sudden. As is well known to engineers, the speed of cotton machinery must be held very close to uniformity in order to procure its proper operation, especially as to looms. Assuming, then, motor units of about 65 horse-power; the specifications were drawn with the provision that the variation in speed of the motor from friction load to gated the subject. On looking into the matter carefully, the great simplicity and convenience of the motor without a commutator commended itself to the mill engineers, and the contract for the complete equipment of the mill on this basis was turned over to the General Electric Company. It involved the construction of two generating units suited for direct coupling to turbines at the very low speed of 108 revolutions per minute, each generator to be of 500 kilowatts capacity—the largest multiphase units that had been constructed anywhere, and, indeed, the largest that

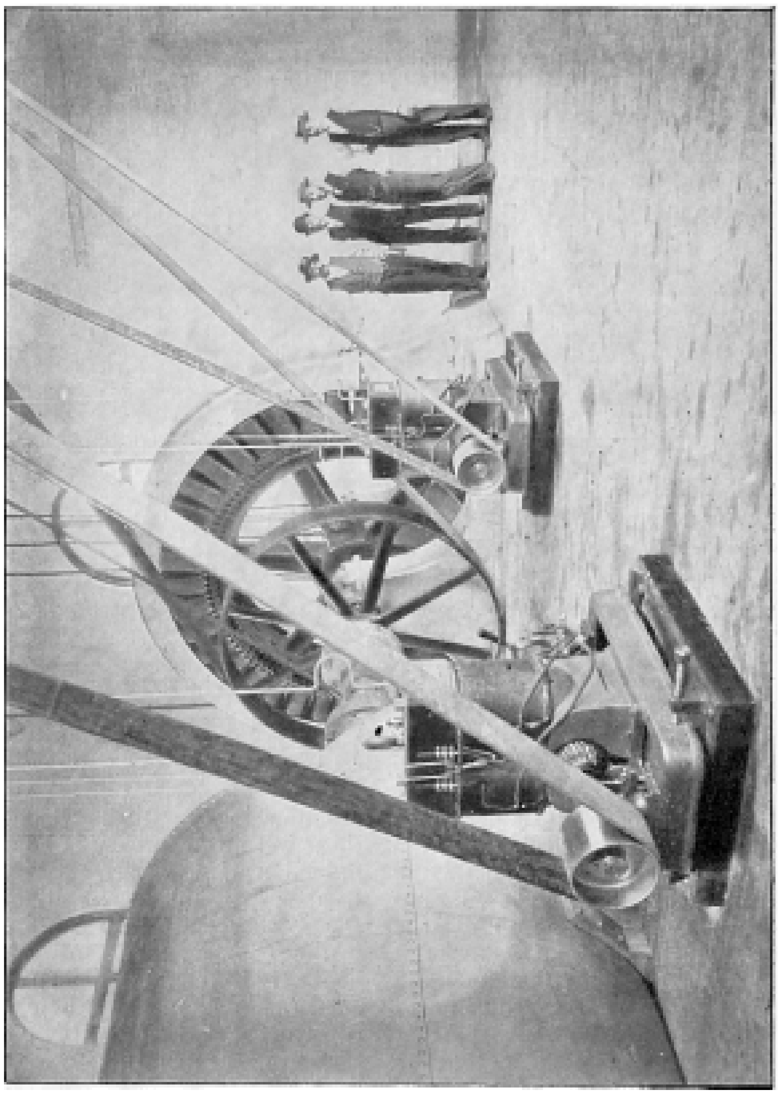


PLAN AND PROFILE SHOWING LOCATION OF MILL AND POWER HOUSE.

full load should not exceed 3 per cent.; furthermore, it was regarded as very desirable to place these motors on the ceilings of the various rooms so as to save space for looms and to get the whole driving mechanism as much out of the way as possible; therefore, the motors had to be so arranged as to require almost no attention.

It was at this stage of affairs that the writer suggested the use of three-phase induction motors for the entire work. This was even more of an innovation than the electrical driving, for induction motors were almost unknown in the United States at the time, and their real capabilities were appreciated only by a handful of engineers who had investi- are now in operation. Connected to these were to be twenty 65 horse-power induction motors, arranged for overhead suspension, and built under the severe specification for speed variation just mentioned; in other words, it was necessary to build machinery of a character that had not anywhere yet been constructed and to beat the direct current motor at its own game. How successfully this task was accomplished can best be judged from the accompanying detailed description of the plant and its operation.

The plan and profile on page 277 show very clearly why the transmission of power became desirable. The nature of the ground between the further side



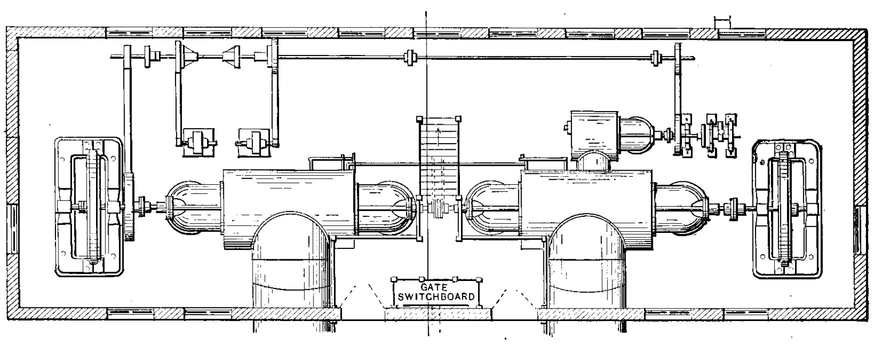
ONE OF THE 500-KILOWATT GENERATORS.

of the mill and the river is most undesirable, and the Congaree is liable, in any freshet, to rise so high that extreme precaution has to be taken in the power house to avoid its being flooded.

The photographic reproduction on page 276 gives an excellent idea of the general arrangement of the plant. The distance of transmission is very short, only a little over one-eighth of a mile. The water is brought through a canal of moderate length and of the approximate dimensions shown on the profile, and is delivered to two double horizontal turbines, each 48 inches in diameter, and enclosed in an iron casing. The working head is about 25 feet. Each turbine drives a 500 kilowatt 3-phase generator from which the current is taken at an initial pressure of about 575 volts, and delivered to the motors at the mill without the intervention of transformers.

So much for the general arrangement. The details are somewhat as follows: The power house, the situation of which is plainly shown on page 277, is a one-story brick structure. It is 112 feet long, 38 feet wide, and is arranged as shown in the plan given herewith. The two turbines occupy the centre of the power house, and their shafts are permanently aligned and fitted with a positive coupling, so that, whenever desired, they can be run as a single unit. Such, indeed, is the customary method, as the two generators are then permanently in phase with each other without any necessary electrical connection.

To the right and left of the wheels are placed the two tri-phase generators, which are duplicates of each other. Each machine has forty poles, and revolves at the rate of 108 revolutions per minute, giving, therefore, about 36 complete cycles per second in the resulting current. The armature is 10 feet in diameter and is wound—although this word is rather a misnomer—with rods dove-tailed into insulated slots in the armature iron, and connected at the ends by massive curved straps of copper. Each slot in the armature contains but a single bar, and the whole structure is almost as solid as if it were a single casting instead of a built-up armature. The weight of each armature is about sixteen tons, and that of the complete machine a little over fifty tons.

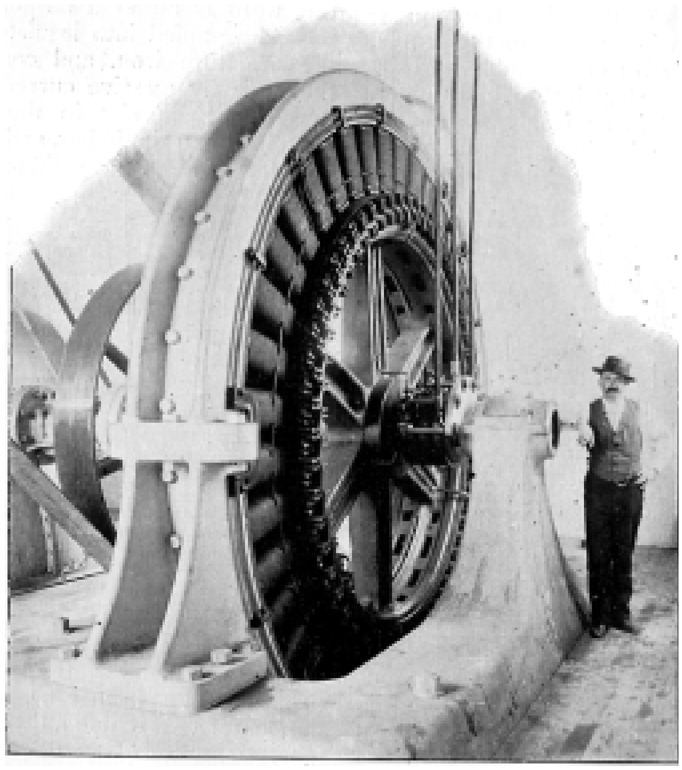


PLAN OF POWER HOUSE.

The voltage, as before stated, is 575, and each machine is constructed with a safe working margin of capacity over and above the 500 kilowatts, which are its nominal output. Like nearly all alternators, these generators are separately excited, and for this purpose a bi-polar generator of about 20 kilowatts capacity is furnished for each machine, and is driven at the requisite speed by means of a countershaft and belting. These exciters are very much larger than would be required merely for the purpose of feeding the field magnets, for it was intended so to arrange the plant that either exciter could furnish current for the fields of both dynamos, and, in addition, have a sufficient output to operate lights and motors in the mill at night after the large machines were shut down. To this end, a single 24-inch horizontal turbine, shown in the figure, can be used for running the countershaft, as well as for driving a directly-connected fire-pump if necessary. The two large dynamos are habitually operated in parallel by the mechanical connection aforesaid, although means are provided for running them in parallel, with electrical connection only.

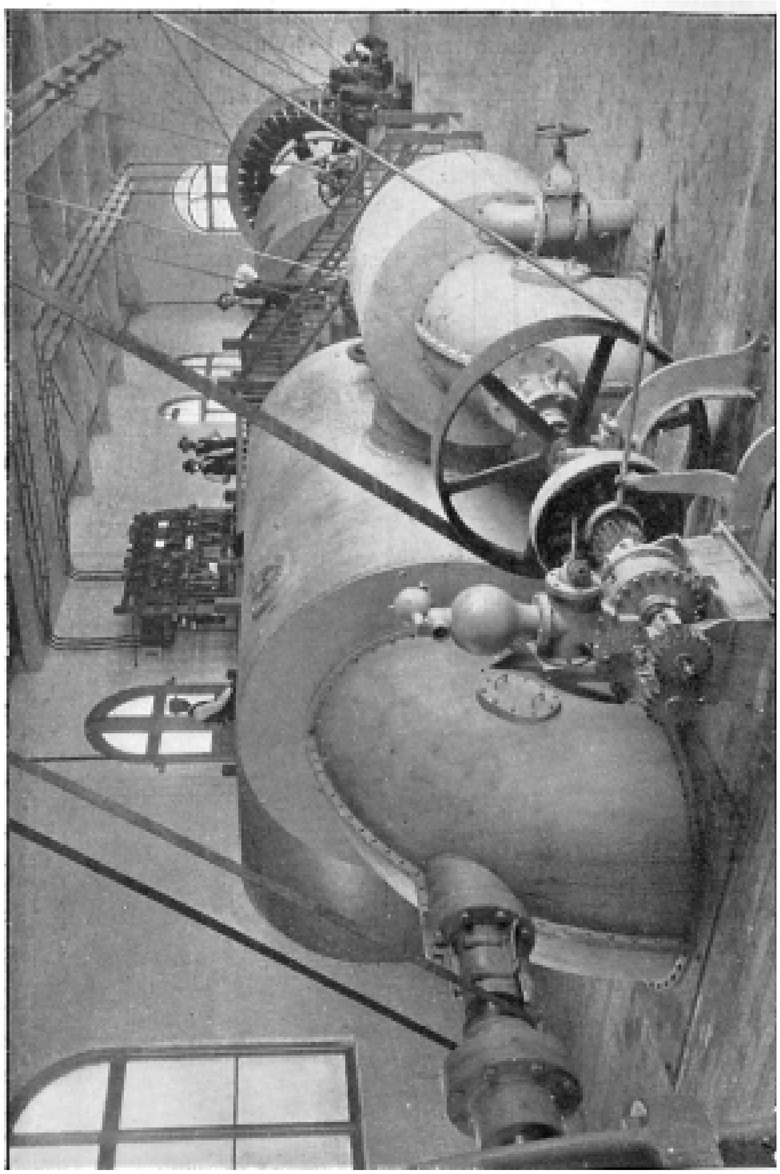
The cut on page 278 shows one of the 500-kilowatt generators in position with its exciter, while that on the page opposite shows the interior of the power house as viewed from a point near one end. The switchboard is on a raised platform, and consists of a skeleton frame, set out from the wall of the power house, so as to permit of ready access to the rear, and furnished with a complete set of instruments for each generator, as well as with the devices for throwing the two in parallel.

This completes the generating plant. The whole arrangement of it is singularly simple and straightforward, and was devised so as to require a very small amount of attention, one of the chief beauties of a water-power installation.



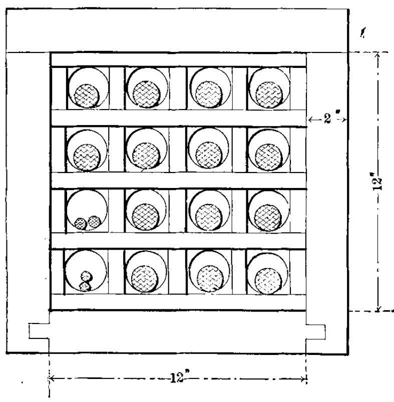
ANOTHER VIEW OF ONE OF THE BIG GENERATORS.

The line is of somewhat unusual construction. Both the nature of the ground and the large amount of copper required conspired to make an overhead line particularly unsightly and objectionable, so that, in the interest both of appearances and ultimate economy, it was decided to put the line per-



INTERIOR OF THE POWER HOUSE.

manently underground. This was, in itself, not an altogether easy task, but, once in place, the line should last indefinitely. The loss of energy in the line was limited to two per cent. in order to secure the necessary efficiency of the system, and the conductors were,

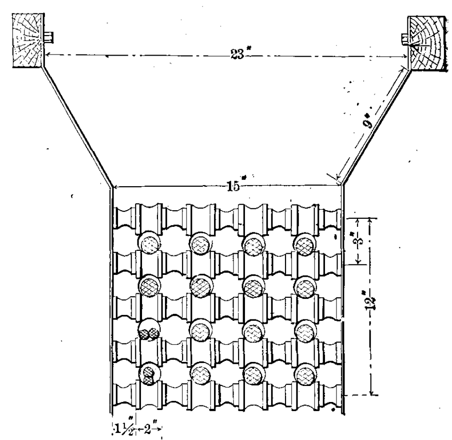


CROSS SECTION OF THE UNDERGROUND CONDUIT.

therefore, of very liberal cross section, exceeding even the specification. For each phase there were installed four cables, each of 450,000 circular mils. equivalent capacity. It was further desired to run incandescent lamps in certain parts of the mill at night when the main generators were shut down, and to operate a motor or two in the machine shop. For this purpose two No. 0000 cables were provided, and, in addition, there was installed a signal-bell circuit and a telephone circuit, each of twin-twisted cable. In all, sixteen separate cables were to be taken care of in the conduit.

This was accomplished in the following manner, illustrated in the diagram above: A massive, wooden conduit was constructed of 2-inch plank, 12 inches square on the inside and coated, like Noah's Ark, within and without, with pitch. About every three feet along this conduit a crib work was built up of insulating conduit tubing, as shown in the figure. Through the interstices of this crib work passed sixteen similar conduit tubes, 1½ inches in exterior diameter, and jointed so as to form sixteen continuous insulating tubes the whole length of the line. In these separate conduits were placed the sixteen cables, so arranged that the four cables of each phase were directly above one another for security against short circuits. The whole wooden conduit was then filled solid with pitch, melted and run in when the cables were laid. There was thus formed a solid mass of insulating material, sufficiently plastic to render cracking impossible, and absolutely impervious to moisture.

At the mill end of the line this construction is carried close to the mill, thence into it through a short brick conduit laid in Portland cement. At the other end of the line the bridge over the canal must be crossed. At the end of the wooden conduit, as it comes out under the bridge, the cables in their enclosing conduit tubes are sealed in with sulphur, run in for about 2 feet along the main conduit. The separate tubes are then taken across under the bridge, resting on porcelain insulators, strung on the iron structure



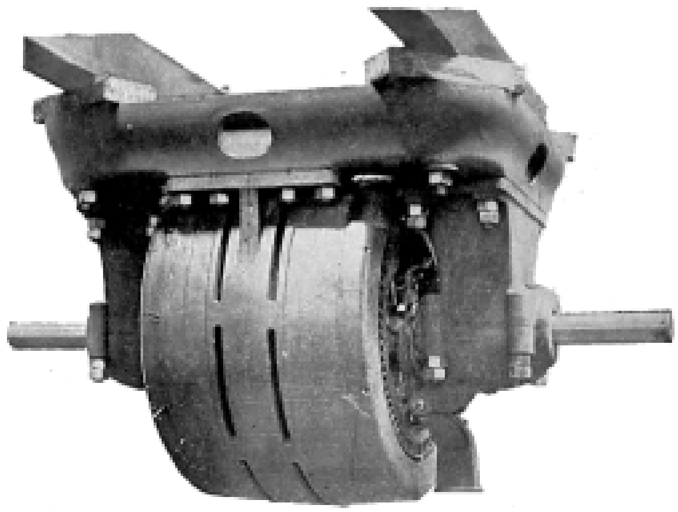
FRAME FOR CARRYING CONDUIT TUBES.

shown here. After the bridge is passed the box conduit is resumed, and the wires pass on to the power house. The line is thus described in detail on account of its decidedly unusual character. It is put in place to stay, and it would be most extraordinary if there should be any signs of leakage or a short circuit in a structure so constituted.

In the basement of the mill the conductors come out into a small brick room, whence the distribution conduits pass out over the mill, and where are installed the transformers for lighting the mill at times when the large generators are in operation. Eight hundred lights are installed in the building, the distribution being at 110 volts on the Edison three-wire system.

Having led the current safely to the mill, we may now take up the question of the motors and the somewhat extraordinary arrangements pertaining to them. The use of conduit tubing is continued throughout the mill, the risers being of brass-sheathed conduit. The motors installed in the mill have a nominal output of 65 horse-power each, and are of the three-phase induction type, without commutators or collecting rings of any sort, a point of special advantage in cotton mills on account of the amount of stray cotton fibre liable to float around in the atmosphere, and to become a source of danger from fire if sparks are at hand. The motors are uniform in size, and are all arranged to be suspended from the ceiling of the mill, from 10 to 16 feet above the floor. Each motor is provided with a separate glass-faced box, containing the switch and fuse box. These boxes are placed on the nearest post, and the risers run directly into them.

There are seventeen of these motors now in place, and three others are ready to be installed as the load grows heavier. The overhead shafting is light and arranged in short lengths. Two of the motors, those in the picker room, are direct coupled to the shafting; the others are fitted with two or four pulleys each, driving their appropriate sections of shaft. Where four pulleys are used, belts are taken both ways at each end of the motor, so tnat there is no twisting moment on the suspension of the motor. Where two pulleys are used, these are generally placed at the same end of the motor, thus securing the same advantage.



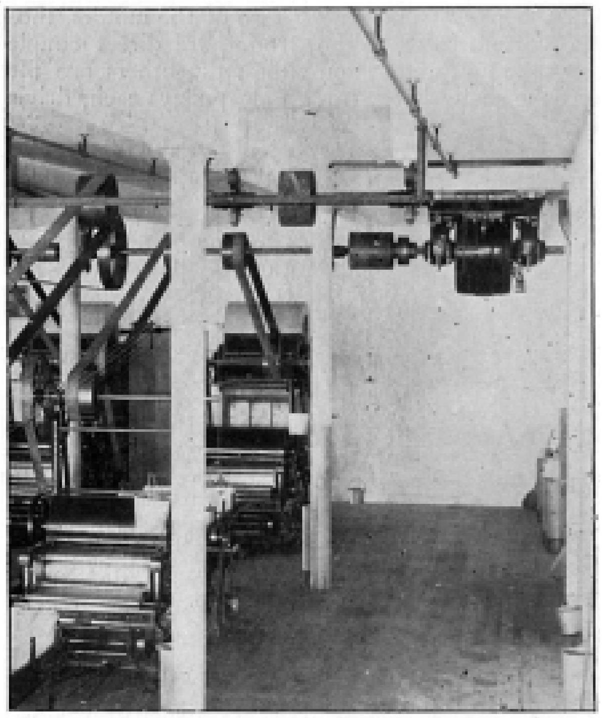
ONE OF THE TRI-PHASE 65-HORSE-POWER CEILING MOTORS.

The speed of the motors is the same in all cases—about 535 revolutions per minute. The variation in speed from friction load to full load was, according to specifications, not to exceed 3 per cent. As a matter of fact, the greatest variation in any individual motor was 2.2 per cent., and in the various motors from that figure down to 1½ per cent.

The motors are all fitted with resistances, placed within the armature spider. These resistances are used only in starting, and are cut out after the motor is nearly at speed by inserting a long lever into a socket and sliding a ring along the armature shaft until it short-circuits the resistance coils. These resistances are adjusted so as to start the motors on considerably less than their normal running current.

By the arrangement of motors just described all the parts of the mill are driven independently—sometimes a great convenience; all heavy shafting and belting is dispensed with, the whole floor space is available, there are no apertures for belts from floor to floor, and the whole arrangement is of the most simple and flexible character. The net efficiency of the whole system, from the shaft of the generator to the shaft of the motor, is not less than 82 per cent.—a figure considerably in excess of anything which could be obtained from the power house to the working shafts by any other known system of driving.

As to the actual operation of the plant, it has now been working steadily for over eight months without the slightest mishap and with singularly little attention, more than fulfilling both the guarantee made and the hopes of the mill engineers. It furnishes at once the largest multiphase plant now in operation, and the first sweeping application of the electric motor for driving machinery for textile manufacturing. It not only is a thoroughly successful specimen of electrical distribution of power, but a complete demonstration of the excellence of the multiphase system for power distribution aside from all questions of transmission. As such it certainly deserves the careful description which the writer has endeavored to give.



A CEILING MOTOR IN POSITION.