ELECTRIC DRIVING FOR WEAVING MACHINERY

By Albert Walton

APPLICATIONS OF INDIVIDUAL ELECTRIC MOTORS TO THE DIRECT OPERATION OF LOOMS.

It is probable that the operation of a loom by a direct-connected electric motor is one of the most difficult problems in electric driving. How successfully it has been accomplished is shown by Mr. Walton in this paper, a record of the result of patient work in the face of many obstacles. If the electric motor can be used satisfactorily for this work, it would seem as if there is no department of machine operation to which it may not be successfully applied.—THE EDITOR.

MACHINISTS have so long been accustomed to consider the driving of a single machine by a single motor as the accepted and recognized ideal in driving that many have forgotten the great uphill fight that was made by the believers in it through hard years of trials and tribulations, against the opposition of manufacturers and the prejudice of the machinists themselves. It is interesting to know that a very similar development is now in progress in another line, and, though the opposition and prejudice are manifested in no less degree, the victories of its advocates are just as convincing as they have been in the machine shops. Individual driving of textile machinery is comparatively a new idea in the United States. It is only within the last two or three years that motors suitable for this work have been available at prices which make it possible to apply them to the light-running machines of textile mills. When, however, such motors became available, a double task awaited the manufacturers, who, knowing the characteristics of their motors and backed by their successes in other fields, set out to develop the field commercially.

In the first place, it was necessary to study the requirements thoroughly and to produce motors exactly fitted for the work. The second and harder tasks lay in convincing the mill men of its superiority and inducing them to adopt it.

That the double task has been accomplished to so large an extent in so short a time is *prima facie* evidence that the merits of the new system were real and pronounced, for there is no more conservative and practical guild of manufacturers the world over than the spinners and weavers of cotton and worsted yarns. To enter a modern mill which is the direct outgrowth of the original old stone mill built on the same site a hundred years before and to proclaim to the grandson of the founder of that first mill that there is something new under the sun, and to convince him of it by demonstration, so that he buys and buys again—that is a test of merit. Yet there are mills in old New England where, were you able to pass the ever-alert cordon of watchmen, you would find looms, spinning frames, fly-frames, printing machines, mangles, calenders, each with its own motor operated by the usual help and producing yarn or cloth of better quality and in greater amount than is done with the century-old method of our forefathers.

It is rather strange that the last process in the mill was the first one to demonstrate the advantages of this new drive. There are at present more individual motors on looms than on the preparatory machines. This is partly due to the fact that a great deal of work had been done in Europe in this field to meet the peculiar conditions which exist where each peasant or villager has a loom or two in his home for the wife and daughter to work on during the day. The only way to drive an isolated machine of this sort was by electric power through an individual motor. Thus when the development was begun in America it naturally followed the lines of least resistance and began with the loom.

The nature of the work performed by a loom would make it appear remarkable that motors should be applied first to this machine except in the light of these facts. The loom is practically the only reciprocating machine in a textile mill, all the other machinery being distinctly rotary and mainly operated at high speed. Two reciprocating sections are essential in weaving. The shuttle must be thrown from side to side, and the thread left in the wake of the shuttle must be moved into position as one of the crosswise threads in the cloth. When it is considered that the shuttle passes from end to end of the loom from two to three times a second, and that the thread must be moved into place between trips, some idea of the rapidity of modern weaving may be had.

The operation is simple enough. The warp, or lengthwise thread of the cloth, is mounted on a huge spool at the back of the loom. This spool or "beam" may carry 1,000 to 5,000 threads, each of which is from 500 to 1,500 yards long. The threads are passed forward to the front of the loom. On the way they are threaded through the eyes of two frames, which are arranged to move alternately up and down. Every alternate thread passes through the eyes of one frame, or harness, and the remainder pass through the other. The harnesses are arranged on a rocker device, so that when one is up the other is down, the travel being about 7 inches. After the threads have been run through these harnesses they pass through a comb or "reed" on the reciprocating part of the loom. One thread passes between each two teeth. There is a track just in front of this comb on which the shuttle travels. At each end of the track is a box, one side of which is held in place by a spring. The shuttle is wedged into the box against the pressure of this spring, and the loom is ready to start (see Fig. 1). One harness being up and the other down, every alternate thread is raised and every other one lowered. The reed, with its shuttle track and boxes, is in its furthest back position, so as to be as near the harnesses as possible, for here the distance between the raised threads and the lowered threads is greatest and there is most room for the shuttle to pass. The shuttle is then shot through the "shed" thus formed and leaves in its trail one thread, which runs freely off the bobbin contained in the shuttle. The reed is then moved forward, pushing this thread up to the finished cloth, of which it then becomes a part (see Fig. 2). At the same time the harnesses reverse their position and raise the threads that were down and lower those that were above, and the shuttle is shot back again through the new shed so formed (see Fig. 3). Thus the threads which were over the one left by the shuttle on its first trip are under that left on the second trip, and so on. This process is done so rapidly the shuttle must travel at the rate of nearly a mile a minute each trip it makes.

In order to prevent damage to the threads or to the loom an arrangement is made whereby the loom stops instantly if the shuttle fails to get into the box at the end of its trip across the loom. In addition to this, the loom will stop if the thread in the shuttle breaks or runs out, or if any one of the thousand threads in the warp should break. As the thread in the shuttle is used up once in two or three minutes, the stops are extremely frequent. A device has been in use for several years which automatically refills the shuttle or supplies a complete new shuttle as desired, when this occurs;

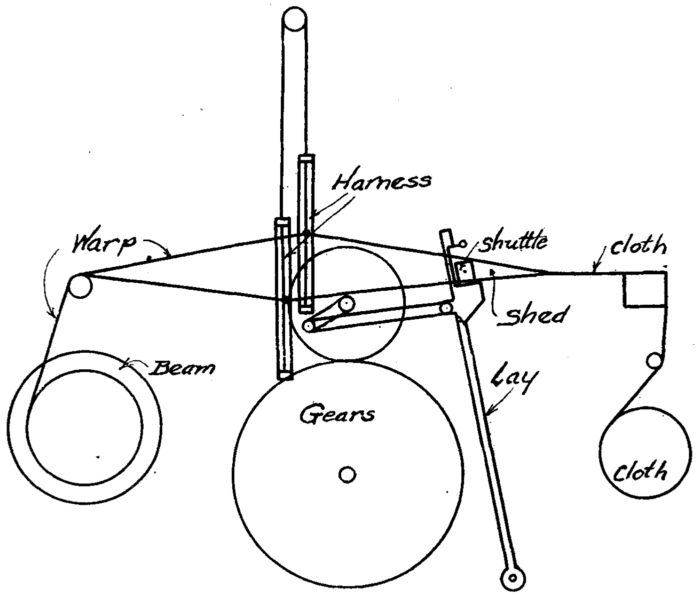

FIG. 1.—OUTLINE OF LOOM MECHANISM

Shuttle at near end of lay in position for "pick," which sends it through "shed" formed by warp threads above and below. Shuttle-throwing device not shown. Note position of harnesses. Every alternate warp thread passes through one harness, the remainder through the other harness. Thus each harness lifts half the warp.

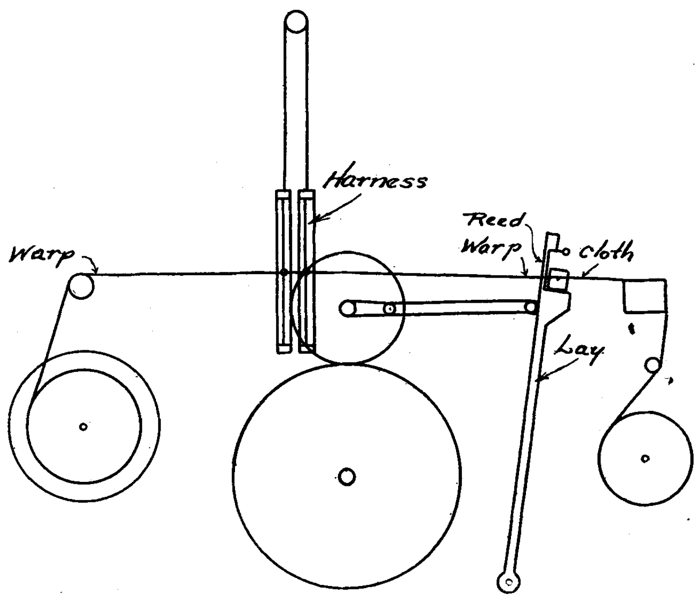

FIG. 2.—OUTLINE OF LOOM MECHANISM

Lay in forward position, forcing the thread left by the shuttle into position as one of the crosswise threads of the cloth. This is done by the "reed," which is a fine comb on the lay. One thread of the warp passes through each space of the reed.

Harnesses are just passing each other in their exchange of position.

but the ordinary loom is not so equipped, and the change must be made by hand. This is done in from ten to fifteen seconds by the usual skilled operative. In the meeting of the difficulties incident to this continuous stopping and starting lay the greatest problem in applying the single motor to the loom.

The mill conditions of atmosphere and labour, too, had to be met successfully. Owing to the incessant see-sawing of the warp threads up and down past one another, an immense amount of lint and dust is set free. The motor must work in this dust not only successfully, but without fire risk, for this lint is as inflammable as gunpowder. The motor also had to be fool-proof and require no attention. Furthermore, it had to replace the old belt drive without introducing new features for the weaver to learn. There must be no change in the weaver's work whatever.

Looms in their present form have been built for a hundred years. Long periods of close competition have reduced them to their lowest terms. They are built to do the work required of them and no more. It, therefore, was necessary to apply motors without adding in the least to the strains in the loom, which were already all that could be borne. For this reason it was not feasible to gear the motor rigidly to the loom. The momentum of the motor turning at one thousand revolutions per minute was too great to be absorbed instantly without danger to loom, motor and gears.

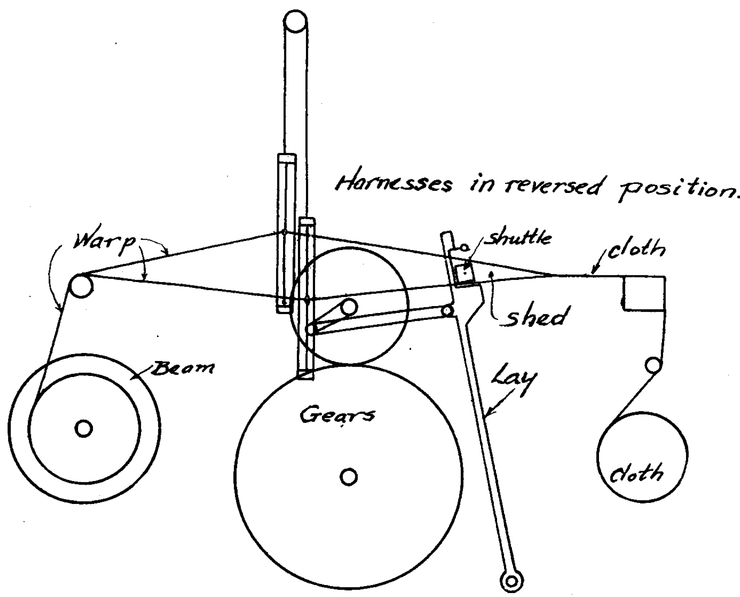

FIG. 3.—OUTLINE OF LOOM MECHANISM

Shuttle at far end of lay in position for return trip through shed. Note that threads which were above in first position are now below, and vice versa. This is accomplished by reversal of harnesses.

On account of the percentage of time during which the loom is shut down from one cause or another, it was very desirable to stop the consumption of power by cutting the motor off the circuit during these idle periods, even if they were of only a few seconds' duration each. This introduced the problem of starting the loom instantly by starting the motor and loom together from rest.

It is, as has been stated, of prime importance that the shuttle, after its travel across the loom, shall go "home" in the box ready for the next throw, or "pick" back in the opposite direction. This is as important on the first pick as any other. The loom must, therefore, be started with sufficient rapidity to ensure the shuttle's being thrown across the first time so as to jam hard into the opposite box. This means that the loom must be brought to speed from rest in about one-half a second—a severe test of the starting powers of any drive. Failing to do this, the loom will automatically shut down instantly before the completion of its first cycle of operation.

All this is accomplished by the old belt drive in two ways—by an ordinary tight and loose pulley with a belt-shifter, or by a pulley with one flanged side arranged as a friction surface, the entire pulley being moved about an eighth of an inch to press against a cork or leather disc to start the loom and being disengaged upon its stopping. Either of these devices is worked from a "shipper handle" at the operator's right hand, and either is also worked automatically by the stop-motion devices upon the breaking of a thread or the failure of the shuttle to jam in the box. The belt from the tight and loose pulleys or from the friction pulley runs from a driving shaft either overhead or under the floor. The overhead drive is an objectionable feature for many reasons. The belts are so numerous as to interfere with the supply of light from the windows or lamps. They carry dust to the ceiling, where it collects in quantities and falls into the work. They generate bothersome frictional electricity. They are always subject to a slippage because of the lint gathering on the running face, and because they are vertical belts from small pulleys. The shafting being over the work means constant trouble from dropping oil upon the woven goods.

With shafting under the floor, it means very short centers, with consequent high belt tension and frequent readjustment, to prevent slipping. It also necessitates large holes in the floor for the passage of the belts, and this is undesirable from the point of view of the fire underwriters. These points, in addition to the usual troubles incident to maintenance of alignment and cost of power wasted in friction in long lines of shafting, make it rather easier to show a mill man that individual drive is, after all, a consummation devoutly to be wished.

Coming to the motor itself, the first point to be decided upon was whether an alternating current or a direct-current motor should be used. The direct-current was immediately rejected, because of the cost of maintenance of so many small commutators and brushes, and because of the sparking and attendant fire risk incident to motors using brushes. The alternating-current motor, being brushless and sparkless, will stand indefinite use and some abuse without encountering these difficulties. It is a constant-speed motor, and, therefore, admirably suited to the work in a textile mill. This type has, therefore, been universally adopted.

In the first application of motors on looms in the United States the friction pulley device was reproduced, except that in place of the pulley with its crowned face a narrow gear with cut teeth was used. The motor pinion meshed directly into this friction gear. The motor switch was thrown in and the motor started in the morning and allowed to run till noon, started again at one o'clock and allowed to run till quitting time at night. The loom was operated just as with the belt, by moving the friction face against the disc to start and opening it up again to stop. This was very successful in increasing production, and several installations are still operating in this manner. Just why production is increased is at first hard to under-stand, since the speed of the loom is very little increased over that at which the belt drive is figured to operate. The fact is that the motor-driven loom always operates at the speed at which it is calculated to run, which is the maximum speed the loom will stand, while the belt-driven loom always falls below this desired point, due to the slippage of the many belts between the engine and the loom.

It was found, however, that the current taken by the water running the idle gear while the loom was shut down lowered the total efficiency of drive very materially. Steps were immediately taken to develop a method which would allow the motor to stop with the loom. This involved the surmounting of two difficulties: First, the ordinary induction motor has poor starting characteristics and could not get the shuttle across on the first "pick" in time to prevent the loom from shutting off automatically; second, to stop a high-speed motor instantly through a chain of gears involved too great a strain on the gear teeth and on the entire loom structure. Gearing the motor rigidly to the loom was abandoned after the first trial. A method in use in Germany has been advanced to overcome this; but, as it makes use of a belt, it is open to the old objections to belt drive, and has not met with favour in America. In this method the motor is mounted on a hinge on a stand below the loom pulley, so that the weight of the motor comes on the belt. The jar incident to the sudden stopping was absorbed by the slipping of the small motor pulley on the belt.

American practice has indicated gear driving as decidedly more advantageous, however, and with the exception of one installation of foreign origin the belt drive has not been adopted. One thing has been learned, however, and that is that by a slight alteration from the standard designs an induction motor could be built that would start a loom properly.

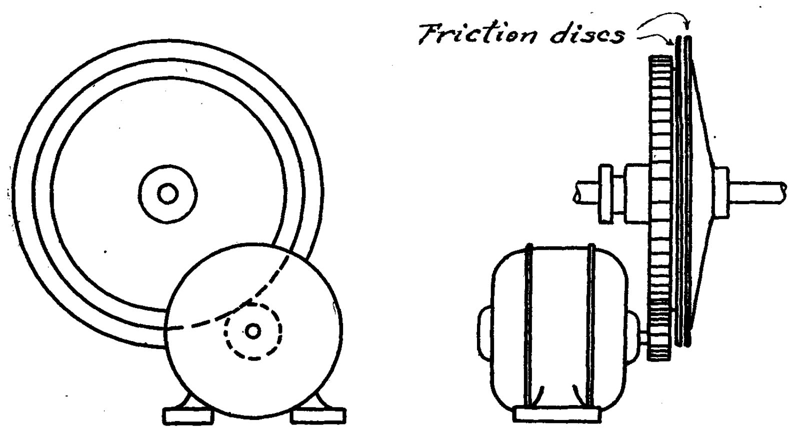

FIG. 4.—FRICTION-GEAR DRIVE

Gear attached to friction disc is pressed against disc which is keyed to loom shaft. Same motion operates motor switch. When friction is released, current is cut off. Motor starts when friction is thrown in again.

In order to counterfeit the belt slip of the German method one American firm brought out a motor which has the revolving part mounted on a quill, which drives through friction discs to the shaft and pinion. When the loom stops the motor-quill slips on the shaft somewhat, thus, in a way, cushioning the shock. This has not been tried out on a large scale as yet, and it has not, therefore, been demonstrated whether or not it is subject to too much wear and will necessitate too frequent adjustment to be anything more than a theoretical solution of the problem. It is open to the objection that, to take up on the plates in compensating for the wear, the motor must be dismantled and the revolving part removed, during which adjustment loom and motor must remain idle and out of commission.

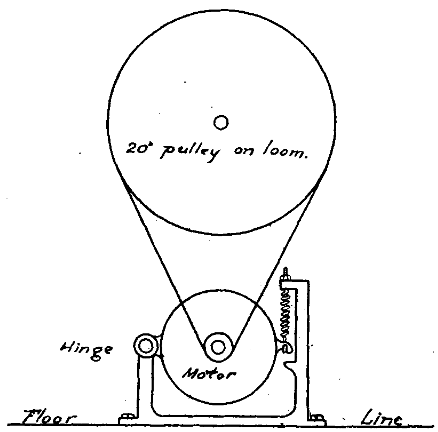

FIG. 5.—GERMAN METHOD OF DRIVE. MOTOR SUSPENDED IN BELT

Perhaps the most efficient and mechanical arrangement is, as is often the case, a compromise between the two methods. This utilizes the friction gear drive as first installed, but so arranged that the switch is opened when the loom stops, thus instantly shutting off all consumption of power. This works out very satisfactorily, for here the forces which were working against success now work for it. It is no longer necessary to absorb, and therefore lose the momentum of the motor and gear. They are cut off from the loom and the power circuit simultaneously and instantaneously, and are left free to revolve idly until brought to rest by their own friction. They will run idly thus for from thirty seconds to a full minute. As the usual stop is not over fifteen seconds, the motor is well above half speed when the friction and switch are again closed and the loom again started. The gains from this method are four-fold: (1) There is no shock to the loom, motor or gears on stopping. (2) The momentum helps to start the loom mechanically as well as by making it possible to take advantage of the excellent running properties of an induction motor at the time of severest load. (3) The electric circuit is not called on to supply the excessive current required to start an induction motor from rest, thus reducing line disturbances and motor heating. (4) Power is saved.

In the rare occasions—perhaps 5 per cent. of the cases—when the stop is so long as to allow the motor and gear to come to rest, it is simply on a par at the next start with the other method, for the motor is able to start the loom from rest if called upon to do so.

The success of this application is only another exemplification of the saying that successful engineering lies along the path of utilizing Nature's forces as they are manifested, rather in overcoming them, be it ever so masterfully done. Thus, after only two years of active development a distinctively American form of drive is being produced and perfected. Under strong competition the next few months will see mainly the refinement of the application through the design of special apparatus for the work and the esablishmen of definite and recognized standards dictating what methods best apply to each case as it arises.