by levers and apparatus whose action will be better de scrιbed while noticing the action of the machine.

The regular outward motion of the carriage, its time of rest when at its outward limit, to allow time for the twisting of the threads, and its rapid inward motion during the winding of the threads on the copes, is obtained from the change-shaft N in the following manner. The near end of the change-shaft carries a pinion O, which, through the wheels *a b c,* drives the shaft *c*. The shaft *c* is carried in the lower, and the shaft of the wheel *p* in the upper socket of a frame, called the vibrating frame, from its having a vibrating motion, by its axis turning in bearings *d d.* The further end of the shaft *c* carries a pinion of eight, nine, or more leaves, which works into the teeth of a peculiarly formed wheel P, called the regulating wheel ; and it is this wheel, by the motion derived from its singular line of teeth, which effects the varied movements of the carriage, by the spur-wheel *e* attached to it working into the teeth of the carriage-rack Q Q. When the pinion is working into the outer ring of the teeth, which, it will be observed, are re versed, the regulating wheel and its spur-wheel move in a regular manner, and roll the carriage outward. When the carriage has arrived at its outward limit, the pinion will have begun to act on those teeth of the wheel which are eccen tric, and which, lying nearly in the direction of a radius of the wheel, cannot give it rotatory motion ; it therefore stops, and the carriage of course is also stationary, while the pinion, rolling along the radial line of teeth, forces the vibrating frame, which carries its shaft, to vibrate round its axis, to enable the pinion to approach nearer to the centre of the regulating wheel. When it arrives at that part where the teeth begin to get concentric, it again puts the regulating wheel in motion, but in an opposite direction to its former motion, for the teeth are now outward. This causes the inward movement of the carriage, which is much more rapid than its outward movement, from the smallness of the circle of teeth. When the carriage, in its inward motion, has nearly reached the drawing rollers, the pinion will have begun to work into the opposite eccentric line of teeth ; this, as before, will be followed by a reverse vibration of the frame, and the simultaneous stopping of the regulating wheel, until the pinion have again arrived at the reversed teeth of the outer circle, when the same series of movements is again ready to take place, and these changes in the motion of the carriage are, by the peculiar form of the line of teeth, made in the most gentle manner. It is necessary that the carriage maintain perfect parallelism with the line of the drawing rollers throughout its course; nor will this appear to be easily effected, when we consider that it is sometimes fifty or sixty feet long, and that the force for moving it is applied either at one end or at the middle of its length. This parallelism of the carriage, which is technically called *squaring,* is effected in hand-mules by means of bands, called *squaring bands;* but in this machine it is effected in the following manncr. A long shaft or cylin der *f f* which, for the sake of lightness, is constructed of iron or tinplate, passes along the whole length of the car riage, and carries upon it at each end, and sometimes, in long carriages, in the middle also, toothed wheels *g g,* which, working into racks *hh,* attached to the races or railroad on which the carriage runs, insure perfect parallelism in its movements.

From the spur-wheel *e*, attached to the regulating wheel, the motion of the drawing rollers R is derived through the wheels *i k l;* but as the motion of the rollers is only in one direction, and continues only during the outward motion of the carriage, while the regulating wheel has a forward and backward motion, there is required a means of disconnecting them, when it is necessary that the rollers should stop Accordingly, the wheel *k,* through which the roller shaft *b* is driven, runs loose on that shaft, but has within it a ratchet

wheel fixed to the shaft, and the pauls of the ratchet are attached to the wheel *k.* Hence it follows, that when the spur-wheel is driven in that direction in which the pauls will slip over the ratchet, the ratchet-wheel, and consequently the shaft *l,* and the rollers, will remain stationary, and this they do while the regulating wheel is performing its back ward motion ; but when the regulating wheel is moving in the opposite direction, the pauls of the spur-wheel catch on the ratchet-wheel, and give motion to it and to the rol lers.

Having thus described the manner in which the motion of the carriage and rollers is effected, we will now show how the twisting and winding-on motion is communicated to the spindles of the carriage. The speed-shaft K, we have seen, is driven directly from the driving-shaft pulley I ; from the pulley R of the speed-shaft a band proceeds and passes over the stud pulley in the frame at R', and over the guide pul lies of the carriage at S, and thence to the drums 43, which act on the spindles in the usual way ; by this a uniform revolving motion is communicated to the spindles, while the carriage is running out, and during its pause at the end of the course. The speed-shaft must then be stopped, that the *backing Off* may take place, and while the carriage continues its inward motion, as, although the speed-shaft moves and drives the spindles during this inward motion, for the purpose of winding on the thread, yet the winding-on mo­tion being variable in speed, and the speed of the shaft being constant when driven by the driving-shaft pulley, it is necessary for winding on, to drive it by some other means. Accordingly, an apparatus is provided, which at this juncture throws the driving belt of the speed-shaft upon its loose pulley, and at the same time lets fall a break *m* upon a break pulley fixed upon the shaft, and thus allows the new moving parts or winding-on apparatus to come into play. The break is attached to the short end of a lever *n* to the upper part of whose long end a spiral spring is attached. The action of the spring tends constantly to force the breaks upon the pulley, but it is restrained by a catch which is withdrawn at the proper moment by the action of an apparatus to be afterwards described ; and when the winding on is completed, the break is withdrawn from the pulley, and the break lever again put on its catch, by the action of a cam fixed to the under socket of the vibrating frame pressing down the lever friction-pulley, as is better seen in detached fig. 3. To communicate the winding-on motion to the speed-shaft, when its twisting motion is stopped, there are three or more pauls o, attached within the rim of the break pulley, which, when the speed shaft is at rest, fall into a ratchet-wheel o', to which is attached a spur-wheel *ρ,* fitted loose upon the shaft ; but when the speed shaft is in full motion, the pauls, by the action of the centrifugal force, are thrown out of the ratchet-wheel, which, with the spur-wheel, may thus remain at rest, or be driven at any slower or quicker rate by the spur wheel *q* of the winding-on shaft *r,* which derives its motion from the roller shaft *t,* through the spur-wheels s, *r',* and it is plain that when the belt of the speed-shaft T is thrown on the loose pulley, causing the shaft to stop, and the paιds of the break pulley to fall into the ratchet-wheel *o'*, then the motion transmitted from the roller shaft to the spur-wheel *p,* to which the ratchet-wheel o' is attached, will be by it communicated to the speed shaft T. The motion thus transmitted from the roller shaft *t,* which is itself moved by the regulating wheel P, to the spindles, is capable of adjustment by a peculiar mechanism, so that the motion of the spindles, and the degree of ten sion which the threads undergo in winding on, may be modified in the degree required. This elegant differential movement, carried by the shaft *r*, is seen at fig. 4. An arm 1 is carried by the shaft *r*, from which a stud 2 projects, carrying a pinion 3 ; this pinion on the one side gears into a series of inverted teeth, extending round near the periphery