## BOX MOTIONS

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## INTRODUCTION

**1.** When it is desired to weave a cloth in which it is necessary to place more than one kind of filling, some method of inserting the filling must be employed that differs very materially from that found on a loom that carries only one shuttle and contains but one box at each end of the lay. Looms constructed for this class of work are known as **box looms,** though in the cotton trade they are frequently called **gingham looms.**

The principle on which these looms are constructed is that of having at one or both ends of the loom a number of boxes, which are generally operated by levers and other suitable mechanism that will bring the bottom of the desired box in line with the race plate of the loom and thus allow the picker to act on the shuttle contained in that box. By this means, several shuttles, each containing a different kind or color of filling, can be operated, and the one to be used at any given time selected automatically.

Several attempts were made to adapt the power loom to the production of checked and other fabrics requiring more than one kind of filling before a successful motion was obtained. At the present time, however, all methods of operating the boxes on a box loom are based on one of two leading principles of governing shuttles; these are known as the **drop-box** and **revolving-box motions.** The drop box was invented and applied to the hand loom about 1760, while the revolving-box motion, as applied to power looms, was invented in 1843. Both of these motions are now found in considerable variety of detail, but the revolving-box motion has not met with favor in the United States; in fact, it may be said that the drop-box motion is universally adopted in America. On this account this motion alone will be dealt with, and it should be understood that all mention of box looms refers to the drop box as applied to power looms.

In speaking of box looms, the number of boxes is designated by the number of boxes at each end of the lay with a multiplication sign between; thus, if a loom has four boxes on one end and one on the other, it is known as a 4 × 1 box loom; if it contains four boxes on each end, it is known as a 4 × 4 box loom. On looms weaving cotton goods, the drop boxes are generally placed only at one end of the loom. The number of shuttles that can be operated in a box loom is one less than the total number of boxes; thus, six is the largest number of shuttles that can be run in a 6 × 1 loom; four in a 4 × 1 loom; two in a 2 × 1 loom; etc. The statements made in the following pages should be accepted as referring to a 4 × 1 drop-box loom.

## CROMPTON 4×1 BOX MOTION

### CONSTRUCTION AND OPERATION

**2. Connection of Picker Stick at Box End.**—Fig. 1 shows one side of a Crompton loom with the box mechanism for a 4 × 1 box motion. The boxes *a* are arranged directly over one another, and are so connected to the end of the lay that they may be readily moved up or down without offering much resistance to the motive power of the loom. As the boxes receive an up-and-down motion while the picker receives a horizontal motion, some means must be provided by which the picker may be brought out of contact with the boxes during the time that the latter are being lifted or lowered. This is provided for by having a recess at this end of the lay, in which the picker rests during the time that it is not acting on the shuttle. The picker used at this end of the loom differs considerably from the ordinary

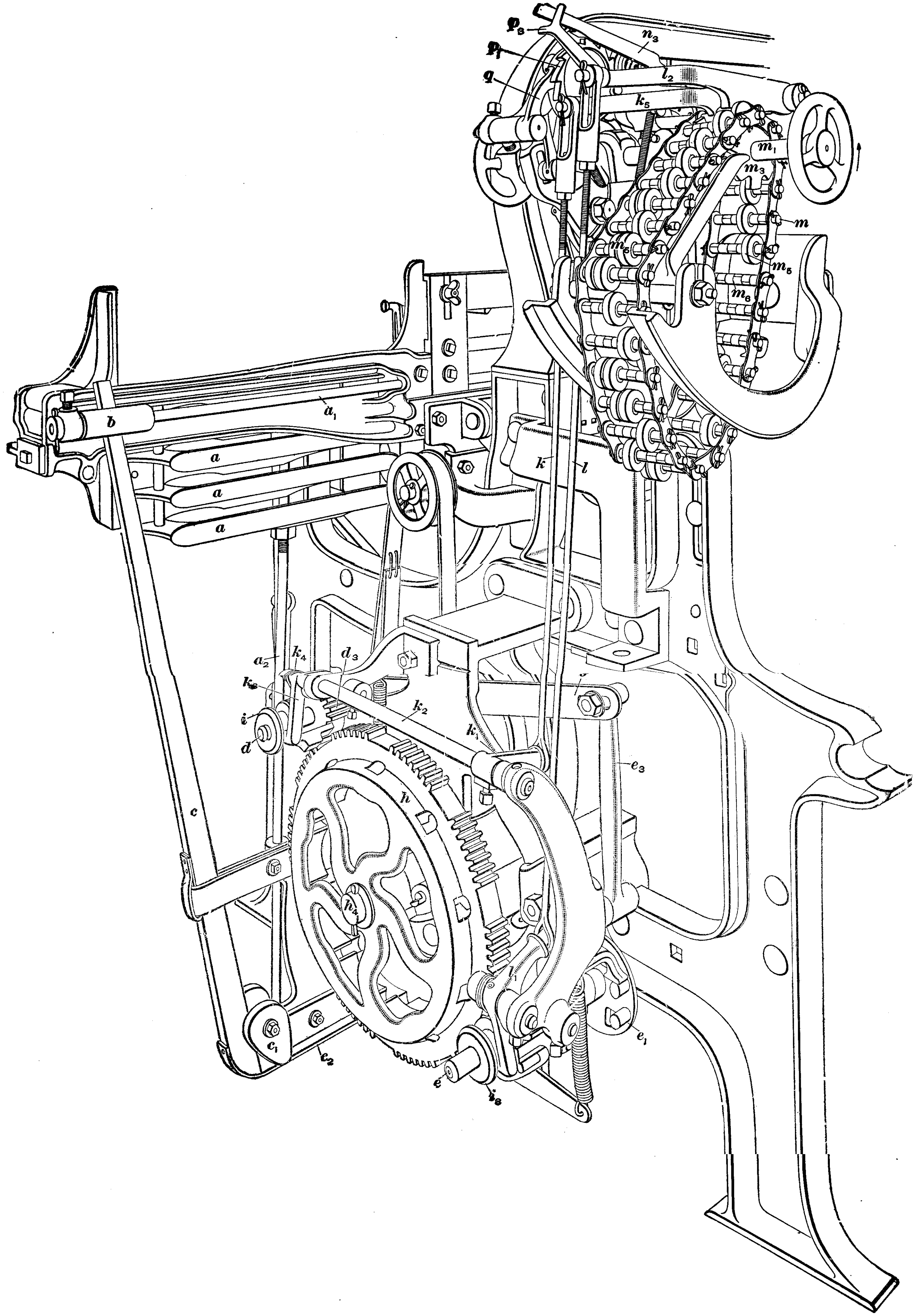
p3
p1
q
n3
l2
k5
m1
m3
m
m5
m6
a1
b
a
a
a
k
l
a2
k4
d3
k3
i
d
k2
k1
e3
c
h
h4
c1
c2
e
i3
e1

Fig. 1

picker and is shown at $b$, Fig. 1, and also in Fig. 2. The rod $a_1$ passes through the hole $b_1$ and serves as a support for this end of the picker, in addition to being a guide for the picker during its picking action. The other end of the picker passes through a slot that is provided at the back of each box. The picker stick $c$, Fig. 1, passes through the slot $b_2$, Fig. 2, of the picker, and is not connected to the picker in any other manner; it throws the picker forwards when picking the shuttle from this side of the loom. As the picker stick is not attached to the picker, any slightly higher elevation that the picker stick may assume in moving from one end of the box to the other will not in any way affect the picker; consequently, there is no necessity of adopting a parallel motion, the picker stick having simply a slight recess near its lower end that bears against a stud supported by the bracket $c_1$. The picker stick is held against the stud by means of the strap $c_2$, which at its other end is connected to a spring.

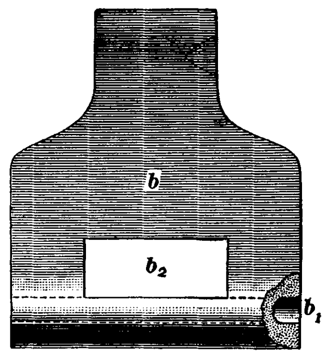

FIG. 2

**3. Lifting Lever.**—With a motion such as is shown in Fig. 1, if it is desired to use four colors of filling, four shuttles, each containing a different color, are placed in the boxes $a$. It is the object of the mechanism shown in this figure to bring the bottom of any one of the boxes level with the race plate of the loom, in order that the picker may act on the shuttle contained in that box. The boxes are raised and lowered by means of the lifting rod $a_2$, which is attached to the lower part of the bottom box. In designating the different boxes on a box loom the top box is spoken of as the first box; the next, as the second box; the next, as the third; and so on, the bottom box, where there are four boxes, being known as the fourth box.

The parts from which the rod $a_2$ receives its motion are more clearly shown in Fig. 3, which illustrates the different parts of the motion as they appear when looked at from the inner side. At its lower end, the lifting rod carries the stud $a_3$, to which is pivoted an arm $f$, connected to the upper end of which is another arm $f_1$, the two arms $f$, $f_1$ being held together by a spring $f_2$. Referring again to Fig. 1, there will be noticed the ends of two shafts $d$, $e$, known, respectively, as the front and back shafts of the box motion. Attached to the inner end of the back shaft, as shown in Fig. 3, is a circular flat disk $e_1$ that carries a crank $e_2$. Connected to this crank is a crank-arm $e_3$ that is pivoted at its other end to a stud attached to the lever $g$. On the inner end of the front shaft $d$ is also a circular plate $d_1$. This plate carries an eccentric $d_2$, on which works a collar $g_1$ that is a part of the lever $g$. At the point where the two arms $f$, $f_1$ are held in contact by the spring $f_2$, they are slightly hollowed out, thus forming a slot in which a stud $g_2$ that is carried by the lever $g$ is held.

When it is desired to raise or lower the boxes, one or both of the shafts of the box motion are given a half revolution. From Fig. 3 it will be noticed that if the parts connected to the front shaft $d$ are in the position shown in this figure and the shaft is given a half revolution, the eccentric $d_2$ will raise the collar $g_1$, which will also raise the lever $g$ at this point and result in the forward end of this lever assuming a higher position. On the other hand, if the parts connected to the back shaft $e$ are in the position shown in Fig. 3 and this shaft is given a half revolution, the crank $e_2$ will lower the crank-arm $e_3$, which will result in the back end of the lever $g$ being dropped and its front end raised. As the front end of the lever $g$ is raised, it will also raise the lifting rod $a_2$ by means of the connections formed by the stud $g_2$ and arms $f$, $f_1$.

**4. Method of Raising and Lowering the Boxes.** The amount of lift that is given to the boxes by means of the eccentric and crank arrangements will be seen from the

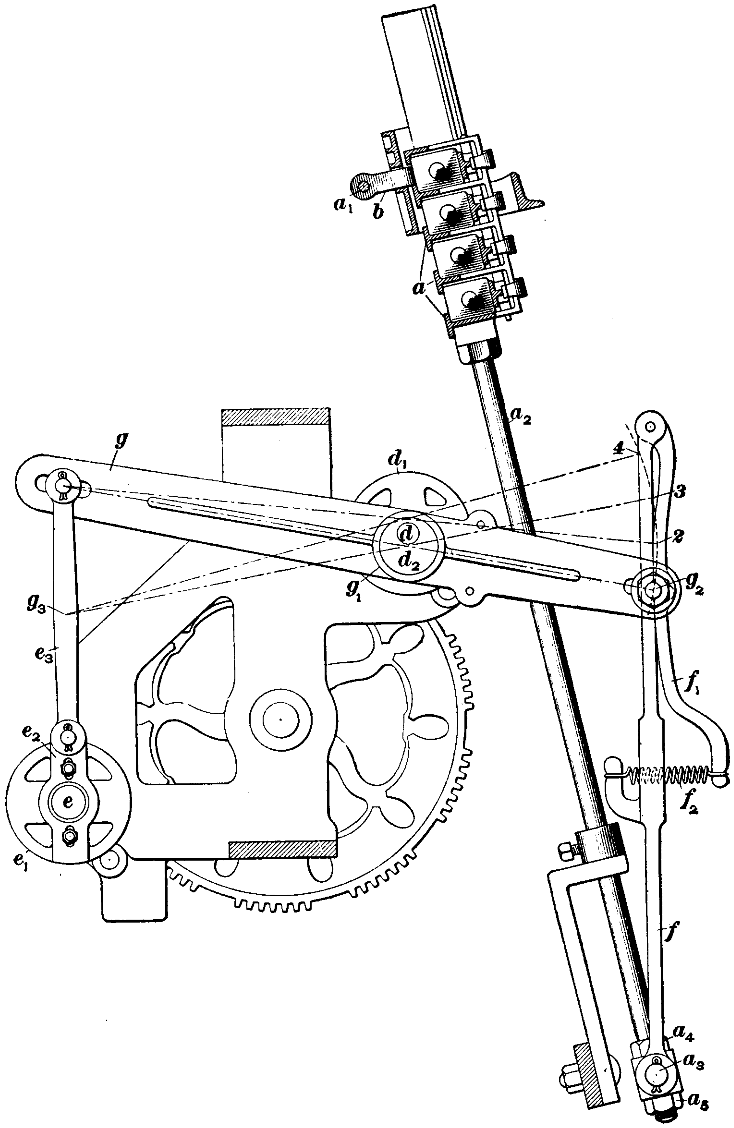


FIG. 3

following: The boxes as shown in Fig. 3 are in the position that they assume when the first, or top, box is level with the race plate. If, when the boxes are in this position, it is desired to raise the lifting rod $a_2$, and consequently the boxes *a*, so that the picker will act on the shuttle carried by the second box, the front shaft of the box motion will be given a half revolution, causing the eccentric on this shaft to raise the collar $g_1$ and consequently the lever *g* at its forward end. As no motion is given to the crank-arrangement at the back end of the lever *g*, the forward end of the lever will be brought up to the point *2*, Fig. 3, this lift being sufficient to bring the bottom of the second box level with the bottom of the race plate. When it is desired to bring the third box into position the eccentric arrangement of the front shaft *d* remains in the position shown in Fig. 3, while the back shaft *e* is given a half revolution, causing the crank-arrangement to lower the back end of the lever *g* to the point $g_3$, and the front end of the lever to be raised to the point *3*, which lift is sufficient to bring the bottom of the third box level with the race plate. If the different parts of the box motion are in the position shown in Fig. 3 and it is desired to bring the fourth box into position for the picker to act on the shuttle contained by that box, both the front and back shafts will be given a half revolution, which will result in the eccentric on the front shaft raising the lever *g* at this point, while the crank-arrangement on the back shaft will drop the back end of the lever *g* to the point $g_3$. This action of the two shafts will result in the forward end of the lever *g* being raised to the point *4*, which lift will be sufficient to bring the bottom of the fourth box level with the race plate.

**5.** In dropping the boxes, the motion given to the lever *g* will, of course, be opposite to that described for raising them, the motion being positive in both directions. However, in studying this mechanism, it should be understood that many different combinations of raising and lowering the boxes may be met with. For example, suppose that the bottom of the second box is in line with the race plate and it is desired to raise the boxes until the third box is in position. As previously stated, when the second box is in position, the eccentric $d_2$ on the front shaft is in its highest position, while the crank-arrangement on the back shaft is in the position shown in Fig. 3; consequently, if it is desired to bring the third box into position, it will be necessary to give both shafts a half revolution, resulting in the eccentric assuming the position shown in Fig. 3, while the crank-arrangement will be dropped, bringing the back end of the lever $g$ to the point $g_3$.

With this method of raising and lowering the boxes, any box may be brought into position at any time no matter which box was previously in position, although it is found in operating a loom that the best results are obtained by not giving the boxes a greater lift than the space occupied by one box; that is, if the first box is in position it is better to raise from the first to the second rather than from the first to the third, since in the former case not so great a strain is brought on the different mechanisms as in the latter case.

**6. Connection Between the Lifting Rod and Lever.**—Certain special points in regard to the manner of forming the connection between the lifting rod $a_2$ and the lever $g$ should receive careful attention. By referring to Fig. 3 it will be noticed that since the lifting rod $a_2$ is connected to the bottom of the boxes, this rod will necessarily have a backward-and-forward movement imparted to it by the motion of the lay, while on the other hand the forward end of the lever $g$ receives an up-and-down motion; for this reason it is impossible to make any rigid connection between these two parts. However, by connecting the arm $f$ to the lower end of the lifting rod and having the lever $g$ operate the arm $f$ this difficulty is overcome.

The method of connecting the parts $f$, $f_1$ with the lever $g$ provides a safety device in case any obstruction prevents the boxes from moving freely. When operating the boxes in a box loom it occasionally happens that a shuttle or the picker becomes caught in the boxes, thus preventing the boxes from rising or falling. If under these circumstances the lever $g$ is operated, the stud $g_2$ is forced out of the retaining slot formed by the arms $f$, $f_1$, the spring $f_2$ being extended sufficiently to allow this to be done without breaking any of the parts. It will readily be seen that under these conditions the lifting rod $a_2$ will not be moved. After the obstruction has been removed, in order to bring the parts into their proper position, it is simply necessary to extend the spring $f_2$ and raise or lower the arms $f$, $f_1$ until the stud $g_2$ slips into its retaining slot.

**7. Star Gear.**—It is next necessary to consider the method adopted to give the half revolution to the back and front shafts of the box motion. It should first, however, be understood that the motion of these shafts should be intermittent, since otherwise the boxes would constantly be changing. The motion of the front and back shafts is derived primarily from gear $h$, Fig. 1, which is known as the **star gear.** This gear is placed on a short shaft, or stud, $h_4$ and is driven by a cam on the end of the cam-shaft of the loom. This is somewhat more clearly shown in Fig. 4, which illustrates the different parts of the motion with the arms of the star gear removed, in order that the inner rim of this gear may be seen. As shown in this illustration, the outside face of this star gear consists of sections of 7 teeth each, blank spaces remaining between these sections. The inner rim of the star gear contains cut-outs $h_1$ with which the stud $h_3$ of the cam $h_2$ engages; consequently, as the cam-shaft revolves, the stud $h_3$ engaging with the cut-outs $h_1$ will turn the star gear until, through the revolution of the cam-shaft, the stud is brought out of contact with the star gear. In connection with this motion there are two points that should be carefully noted: (1) The stud $h_3$ at each revolution of the cam-shaft moves the star gear a distance that is equal to the space between the centers of two consecutive blanks on the outer rim of this gear. (2) Since the cam-shaft revolves only once every 2 picks, the star gear will be moved only once in that time; and during the time that the stud is not engaging with a cut-out, the star gear is held stationary by the concentric portion of the cam $h_2$ being engaged with the part of the star gear between two cut-outs.

**8. Operation of Front and Back Shafts.**—Keyed to each of the shafts $d, e$, as shown in Fig. 4, is a gear—$d_3$ on the front shaft and $e_4$ on the back shaft. Since both are alike and work in exactly the same manner, a description of

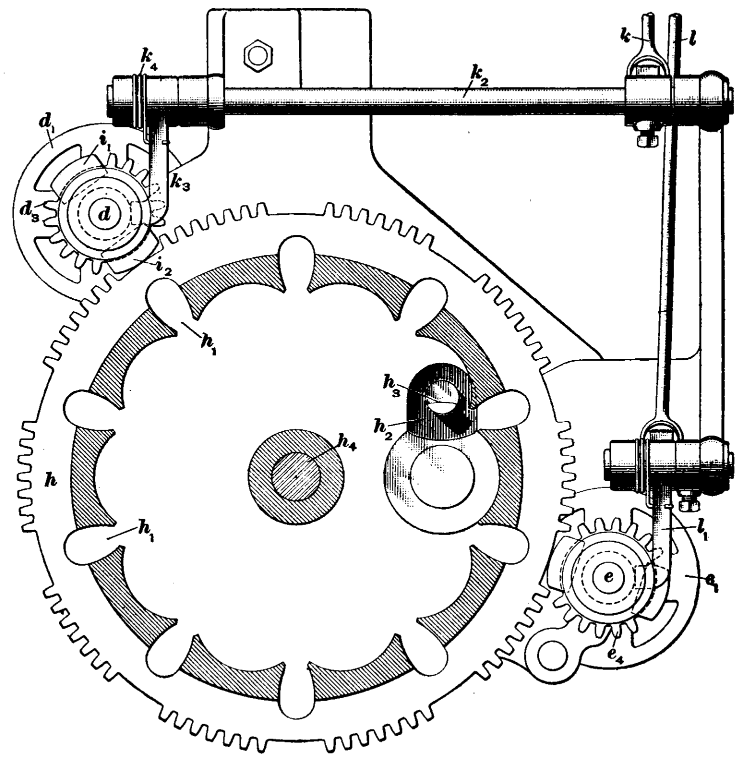


FIG. 4

one will serve to illustrate the action of both. Referring to Fig. 5, which shows the operation of these parts somewhat more clearly and shows the star gear, together with the front shaft $d$, it will be seen that this shaft carries a collar $i$ that slides loosely on the shaft and carries 2 projections $i_1$, $i_2$.

These projections extend into cut-outs on the outer rim of the gear $d_3$, which contains alternate sections of teeth and blanks; there are two blanks and two sections of teeth,

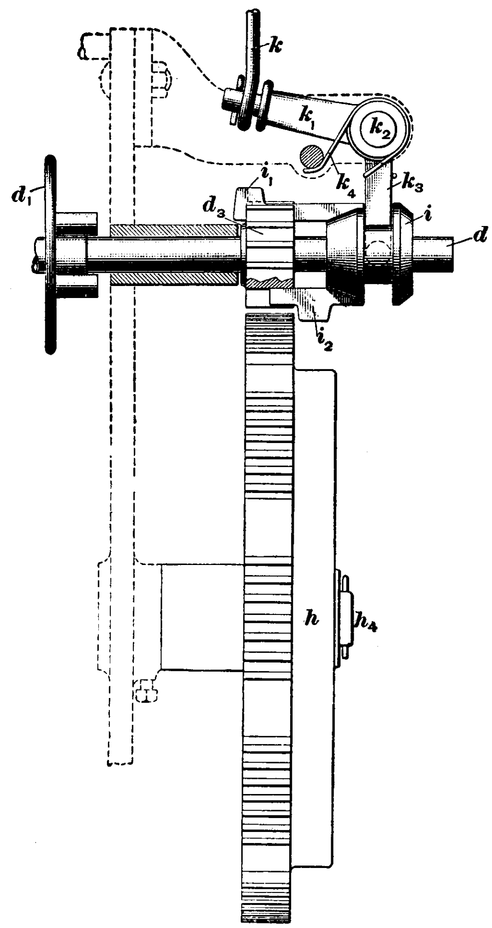


FIG. 5

each section containing 6 teeth. It will be noticed that the projections $i_1$, $i_2$ are sufficiently high to engage with the teeth of the star gear, provided that they are brought into the proper position. Assuming that the different parts are in the position shown in Fig. 5, then any motion of the star gear *h* will not be imparted to the gear $d_3$, since one of the blanks on this latter gear is being presented to the star gear and the high portion on the projection $i_2$ is not in such a position that the star gear will engage with it. If, however, any force acts on the collar *i* to move it toward the gear $d_3$, the high portion on the projection $i_2$ will engage with the star gear, and since this projection slides in one of the cut-outs in the gear $d_3$, the gear will be turned sufficiently to allow its teeth to engage with the teeth of the star gear. This action will result in the gear $d_3$ receiving a half revolution, when the blank filled by the projection $i_1$ will be presented to the star gear; and in case the collar *i* is not

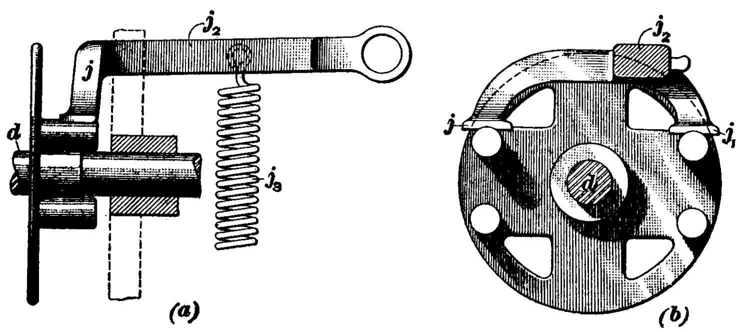


FIG. 6

moved back after the projection $i_2$ has engaged with the star gear, any further motion of the star gear will not be imparted to $d_3$, since the high portion of the projection $i_1$ will not come in the path of the teeth on the star gear. It should be noted in this connection that the construction of the projections $i_1$, $i_2$ is such that only one projection can be in the path of the teeth on the star gear at one time.

After the star gear has engaged with and turned the gear $d_3$ for half a revolution, the opposite blank on this latter gear is presented to the star gear; and in order that the gear $d_3$ may always assume its correct position there are on each of the inner plates of the front and back shafts of the box motion four studs, as shown in Fig. 6, (*a*) being a side view and (*b*) a front view, both partly in section. These studs are so placed that two fingers $j$, $j_1$ will rest squarely on two of the studs when the shaft $d$ is in the correct position to present a blank on the face of the gear $d_3$ to the star gear. The fingers $j, j_1$ are carried by an arm $j_2$ that is connected, at its other end, to the framework of the loom and carries a strong spring $j_3$ that is constantly tending to force the fingers $j, j_1$ on the studs carried by the plates.

**9.** Considering next the manner in which the sliding collars are operated, in order to throw the gears $d_3$, $e_4$, Fig. 4, in and out of connection with the star gear, there will be noticed in Fig. 1 two rods $k$, $l$ that extend from the upper part of the box motion to the lower part. Dealing first with the rod $k$, it will be noticed that at its lower end this rod is connected to an arm $k_1$ that is setscrewed to the short shaft $k_2$. This shaft is free to move in its bearing and has setscrewed at its other end a lever $k_3$, the lower end of which projects into the collar $i$. These different parts are more clearly shown in Fig. 5; in this figure, a spring $k_4$ is shown attached to the lever $k_3$. The action of this spring tends to force the lever $k_3$ outwards at all times. It will thus be seen that if any force acts on the rod $k$ to raise it, the shaft $k_2$ will be turned in its bearings; this action will throw the lower end of the lever $k_3$ in toward the loom, which will result in the sliding collar $i$ being pushed in, causing the projection $i_1$ to engage with the star gear and thus turn the gear $d_3$ sufficiently to allow its teeth to engage with one of the sections of teeth on the rim of the star gear. As the gear $d_3$ is given a half revolution its opposite cut-out will be presented to the star gear, but since the collar $i$ is in, the projection $i_1$ will not be in a position to engage with the star gear. Should, however, the force that lifted the rod $k$ be taken away, the spring $k_4$ will push the arm $k_3$ outwards, together with the collar $i$, allowing the projection $i_1$ to engage with the star gear and the gear $d_3$ to be given another half revolution.

The action of the rod $l$ is similar to that of the rod $k$, with the exception that this rod is connected directly with the lever $l_1$, Figs. 1 and 4, without the intervention of the short shaft noted in connection with the rod $k$.

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### BOX-CHAIN MECHANISM

**10.** The upper ends of the rods $k$, $l$ are connected to levers $k_5$, $l_2$, respectively, as shown in Fig. 1, which are fulcrumed on a stud fastened to the framework of the loom. These levers are operated by means of the box chain $m$, Fig. 1. This chain consists of risers $m_5$ and sinkers $m_6$, also sometimes known as rollers and washers, respectively. These risers and sinkers are placed on spindles and the spindles fastened together by links, the whole forming the box chain. A somewhat better idea of the construction of a box chain may be obtained by referring to Fig. 10. The washer, or sinker, $m_6$ is a short tube of metal of sufficient diameter to slide over the spindle, its principal object being to hold the rollers in their correct positions. The rollers $m_5$ are considerably larger in diameter and have at their center a hole sufficiently large to allow the spindle to pass through. After such a chain is built it is passed around the chain barrel $m_3$, which is fast to the chain-barrel shaft $m_1$, and the ends of the chain connected together. The chain barrel $m_3$ is operated by the pawl $n_2$, Fig. 8, which engages with the ratchet $m_2$ on the chain-barrel shaft. The pawl $n_2$ is connected to the lever $n$, which receives its motion from the rod $n_1$, which is operated by a cam on the cam-shaft of the loom. The chain-barrel shaft $m_1$ also carries another ratchet gear, in which works a stop-pawl that holds the chain barrel in the correct position to bring a bar of the box chain directly under the levers $k_5$, $l_2$, Fig. 1, after the chain-barrel shaft has been turned by the pawl $n_2$, Fig. 8. In connection with this motion, it should be noted that since the pawl $n_2$ derives its motion primarily from the cam on the cam-shaft of the loom, it will turn the ratchet gear $m_2$ 1 tooth during every 2 picks of the loom; consequently, one bar on the box chain serves for 2 picks. It is necessary to have the speed of the box chain bear this relation to the speed of the loom, since the shuttle must travel from the box end to the opposite end and back again before the boxes can change.

### OPERATION OF THE BOX MOTION AS A WHOLE

**11.** The different motions that have been described constitute all the principal mechanisms found on this box motion, and its action as a whole is as follows: When the motion is in its normal position, that is, with the first box in position to have its shuttle acted on by the picker, all the parts will assume the positions shown in Figs. 1 and 3. In case it is desired to raise the second box into position, a riser, or roller, that will operate the lever $k_6$ is placed on the bar of the box chain that will be forced under the lever during the 2 picks that it is desired to have the second box operate. On the same bar, sinkers, or washers, are placed so as to allow the lever $l_2$ to remain down. Raising the rod $k_6$ by means of a roller on the box chain causes the gear $d_3$ to engage with the star gear, thus giving the front shaft $d$ a half revolution. This half revolution of the front shaft causes the eccentric $d_2$, Fig. 3, to assume its highest position, thus raising the forward end of the lever $g$ sufficiently to lift the bottom of the second box on a level with the race plate.

If the first box is in position and it is desired to lift to the third box, a roller is placed on the box chain to operate the lever $l_2$, Fig. 1, while that part of the bar of the box chain on which the lever $k_6$ rests will contain sinkers, allowing this lever to drop. The lifting of the lever $l_2$ by the roller on the box chain raises the rod $l$, which throws the collar $i_3$ in toward the loom and allows the gear $e_4$, Fig. 4, to engage with the star gear, thus giving the back shaft $e$ a half revolution. This half revolution of the back shaft causes the rod $e_3$, Fig. 3, to be lowered, dropping the back end of the lever $g$ and raising its forward end sufficiently to bring the bottom of the third box on a level with the race plate.

If the first box is in position and it is desired to raise to the fourth box, rollers are placed on the box chain to raise both the levers $k_5$, $l_2$, Fig. 1, thus lifting the rods *k*, *l*, throwing both gears $d_3$, $e_4$, Fig. 4, into connection with the star gear and giving a half revolution to both the back and front shafts of the box motion. Revolving both shafts causes the eccentric $d_2$, Fig. 3, to assume its highest position, while the crank $e_2$ assumes its lowest position, thus giving a full lift to the forward end of the lever *g* and raising the bottom of the fourth box to a level with the race plate.

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### MULTIPLIER MOTION

**12. Construction.**—In the mechanism so far described one bar of the box chain serves for only 2 picks of the loom; consequently, if the pattern being woven contains a large

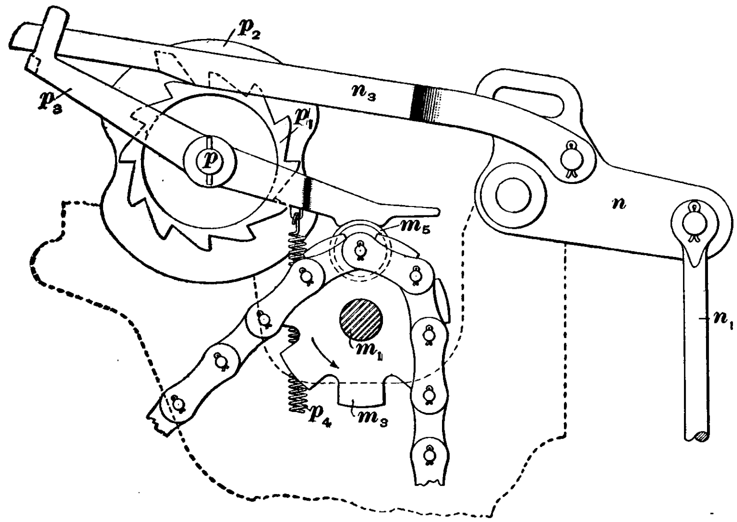


FIG. 7

number of picks of each color, it will be necessary to build a very long box chain. To overcome this difficulty, a mechanism known as the **multiplier motion** is applied to most box looms. By means of this motion, the box-chain bar that controls the box containing the required color will not have to be built for every 2 picks, since it will be possible to build any bar in such a manner that in addition to raising the required box it will also set in operation mechanism that will prevent the pawl $n_2$, Fig. 8, from operating on the ratchet $m_2$ and thus allow the box chain to remain in the one position until the required number of picks of that color or kind have been placed in the cloth.

Certain parts of this mechanism are shown in Fig. 1, but more detailed views of these parts are given in Figs. 7 and 8,

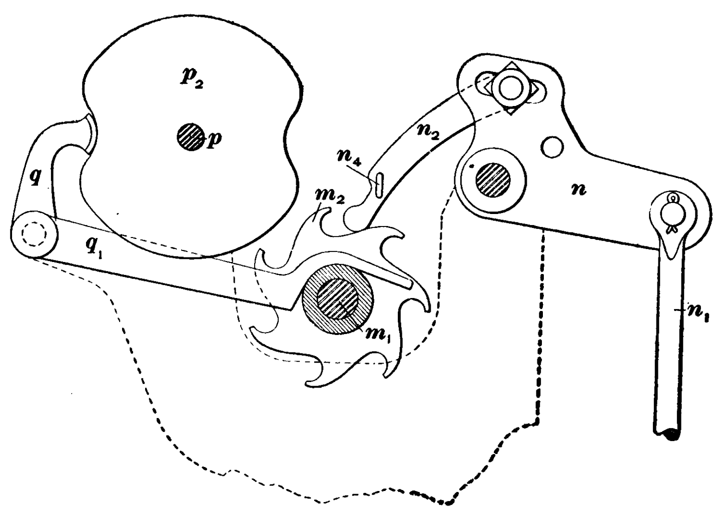


FIG. 8

which show the motion as looked at from the same point, but in each figure certain parts are removed in order to show more clearly the other parts. Referring first to Fig. 7, there will be noticed attached to the lever $n$ that carries the pawl for driving the ratchet of the chain barrel another pawl $n_3$, which engages with a ratchet $p_1$ that is on the stud $p$. The ratchet $p_1$ forms a part of the cam $p_2$, which contains two cut-outs, as shown. The action of the pawl $n_3$ on the ratchet $p_1$ is controlled by a lever $p_3$, one end of which is in contact with the pawl, while the other end rests on the box chain and is held in this position by a spring $p_4$. In case it is desired to have the pawl $n_3$ out of contact with the teeth of the ratchet, that part of the bar of the box chain that comes in contact with the lower end of the lever $p_3$ contains a washer, allowing the spring $p_4$ to depress this end as far as possible, raising the other end, which is in contact with the pawl $n_3$, and lifting it out of contact with the teeth of the ratchet. When, however, it is desired to have the pawl engage with the teeth of the ratchet, a half roller, so-called because it projects over the links of the box chain on the upper side of the chain, is placed on the bar of the box chain, which will raise the lever $p_3$ at its lower end, depressing the end that is in contact with the pawl $n_3$, and allowing the pawl to engage with the teeth of the ratchet $p_1$. An important point to be noted in this connection is that since the pawl $n_3$ that works the ratchet $p_1$ receives its motion from the lever $n$, it must necessarily move the ratchet $p_1$ 1 tooth every 2 picks of the loom.

Referring to Fig. 8, there will be noted working on the outer rim of the cam $p_2$ a finger $q$. Setscrewed to the same stud is another finger $q_1$, the inner end of which rests on the chain-barrel shaft. When the finger $q$ rests on that part of the rim of the cam that is cut out, which is the position shown in Fig. 8, the finger $q_1$ will be down, as shown in this figure. As the cam is turned by the action of the pawl $n_3$ on the ratchet $p_1$, it will force the finger $q$ outwards, turning the stud to which it is setscrewed and thus raising the inner end of the finger $q_1$. As the inner end of this finger is raised, it will come in contact with the pin $n_4$ on the pawl $n_2$ and thus lift the pawl out of contact with the teeth of the ratchet $m_2$.

**13. Operation.**—The action of this mechanism is as follows: Suppose that it is desired to place a large number of picks of some one color, say red, in the cloth consecutively and that the red is carried by the shuttle that is in the first box. A bar of the box chain containing washers at the point where the levers and the bar are in contact will be brought under the levers; there will also be placed on the end of this same bar of the box chain a half roller, which will raise the end of the lever $p_3$ with which it comes in contact, causing it to assume the position shown in Fig. 7 and allowing the pawl $n_3$ to engage with the ratchet gear $p_1$. As the ratchet gear is turned, the cam $p_2$ will also be turned, forcing the finger $q$, Fig. 8, from the cut-out to the extreme edge of the cam. This action will raise that end of the finger $q_1$ that is in contact with the chain-barrel shaft, causing it to lift the pawl $n_2$ out of contact with the ratchet $m_2$ and thus stop the box chain from turning. As the cam $p_2$, Fig. 7, continues to revolve through the action of the pawl $n_3$ on the ratchet gear $p_1$, the lever $q$, Fig. 8, will drop into the opposite cut-out on the rim of the cam, allowing the pawl $n_2$ again to engage with the ratchet $m_2$ and to turn the box chain until the next bar is brought under the levers $k_5$, $l_2$, Fig. 1. If this bar also contains a half roller, the different parts of the motion will be placed again in the same position they assumed when the previous bar was operating. On the other hand, if there is no half roller on this bar, the lever $p_3$, Fig. 7, will be pulled down by the spring $p_4$, raising the pawl $n_3$ out of contact with the ratchet gear $p_1$; the finger $q$, Fig. 8, will remain in the cut-out of the cam $p_2$ and allow the pawl $n_2$ to turn the chain barrel until a bar is brought under the levers containing a half roller, which will raise the lever $p_3$, Fig. 7.

By referring to Fig. 7, it will be noticed that the ratchet $p_1$ contains 12 teeth, and as the pawl $n_3$ while engaging with this ratchet moves it 1 tooth during every 2 picks of the loom, and since one bar of the box chain can cause the cam $p_2$ to make only half a revolution, then one bar of the box chain that is built to operate the multiplier motion will serve for 12 picks; that is, if a half roller is placed on a bar of the box chain, the shuttle that is brought into operation by that bar will run for 12 picks before a change is made.

The multiplier motion that has been described is known as the *12-pick multiplier*. It is, however, possible to have the motion control a different number of picks by means of having a different number of cut-outs on the cam, or by changing the number of teeth in the ratchet.

#### METHOD OF BUILDING BOX CHAINS

**14.** An illustration is given here showing the building of a complete chain when using a 12-pick multiplier, the filling being inserted as follows: 24 picks blue, 24 picks white, 12 picks red, 12 picks yellow, 12 picks red, 12 picks white, 12 picks blue, 4 picks white, 4 picks blue, 4 picks white, 4 picks blue, 4 picks white, 12 picks blue, 12 picks white, 12 picks red, 12 picks yellow, 12 picks red, 24 picks white, giving a total of 212 picks in one repeat of the chain.

Box chains are built from pattern drafts, which show the number of picks of each color in one repeat and the order in which they are placed in the cloth. A box-chain draft for the colors arranged as stated above is shown in Fig. 9. With this draft as a guide, it is necessary to build the box

| | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *1st* | *Blue* | 24 | | | | | | 12 | | 4 | | 4 | | 12 | | | | | | | | | | | | |
| *2d* | *White* | | 24 | | | | 12 | | 4 | | 4 | | 4 | | 12 | | | | 24 | | | | | | | |
| *3d* | *Red* | | | 12 | | 12 | | | | | | | | | | 12 | | 12 | | | | | | | | |
| *4th* | *Yellow* | | | | 12 | | | | | | | | | | | | 12 | | | | | | | | | |

FIG. 9

chain in such a manner that the exact number of picks of each color shown in the draft will be placed in the cloth in their proper order. One other point that should be noted is that in many cases the colors are so arranged that it is a difficult matter so to build the chain that serious jumps in the boxes will be avoided, for while it is possible to raise the boxes from the first to the fourth or to lower them from the fourth to the first, this should be avoided as much as possible; consequently, when building a box chain care should always be taken to place the different colors in the different boxes in such a manner that the least possible number of jumps will be necessary. A jump occurs when the boxes are moved through a greater space than is occupied by one box. By referring to Fig. 9, it will be noticed that by placing blue in the first box, white in the second, red in the third, and yellow in the fourth, the boxes will be lifted in regular order and no jumps will occur; whereas, if the red is placed in the second box and the white in the third, it will be necessary to jump the boxes in many cases.

Fig. 10 shows five bars of a filling chain, each bar showing a different arrangement of rollers and washers; the first, or top, bar contains the multiplier roll. It will be seen that, with the exception of this roll, the bar consists of washers; consequently, a bar built in this manner will give 12 picks of the first box. The next bar contains washers only and, as a result, the first box will be on a line with the race plate. The next bar contains a roll that will raise the lever $k_1$, Fig. 1, of the box motion and, as explained, this will raise the second box. The next bar contains a roll that will raise the lever $l_2$, Fig. 1, of the box motion and will result in the third box being brought into position. The bottom bar is built to give the fourth box.

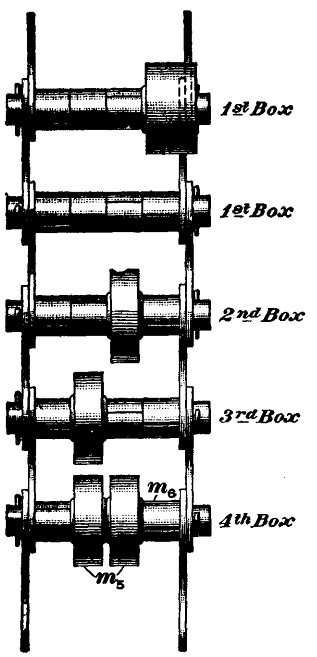


Fig. 10

When building a box chain for a loom, the side on which the box mechanism is placed should be carefully noted and the chain built in such a manner that the rollers and washers will come under their correct levers. In placing a box chain on the loom, the first bar is placed on the chain barrel at the back and the barrel turned by hand in the same direction that it moves when operating. Comparing Fig. 10 with Fig. 1, it will be seen that if the first, or top, bar is placed on the barrel $m_3$ in the manner described and the hand wheel turned in the direction of the arrow, the levers will be operated in the manner indicated.

**15.** Fig. 11 shows the complete chain built according to the chain draft. The first color called for in the draft is 24 picks of blue, which color is in the first box. To obtain these 24 picks of blue the first two bars of the chain, reading from the top, are built to give the first box and on the end of each bar is placed a multiplier roll. Since each bar containing a multiplier roll will give 12 picks, these first two bars of the chain will give 24 picks of the first box. The next color in the draft is 24 picks of white, which is in the second box. The next two bars are built in the same manner as the first two, with the exception that there is placed on each a roll that will raise the inside lever of the box motion and thus give the second box. By comparing each bar of the box chain with the filling draft it will be seen that the desired result will be given. However, it should be noted that when it is necessary to place only 4 picks of a color in the cloth, the multiplier cannot be used. In this case, two bars are built to give the desired box and, since each bar operates for 2 picks, the desired 4 picks will be given.

In case it is necessary to place a certain number of picks of one color in the cloth, this number being greater than 12 and yet not a multiple of 12, as many bars as possible will be built with multipliers and then the desired number will be completed by building a sufficient number of bars without multipliers. For example, suppose it is desired to place 30 picks of one color in the cloth; two bars containing multipliers will be built, which will give 24 of the required picks and in addition to these, three bars without multipliers will be built, which will give 6 more picks of the same color, thus completing the 30 picks.

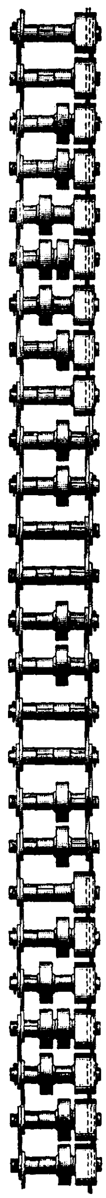

FIG. 11

### STILL BOX MOTION

**16.** On most looms it will be found that when the filling runs out, the loom will continue to run for 2 or 3 picks before being completely stopped by the filling stop-motion. On plain work this is generally of little or no consequence. When, however, it occurs on a box loom, if some method is not adopted to stop the operation of the box motion the exact pattern of the filling will not be placed in the cloth. To overcome this defect the rod that carries the pawl operating the box chain, instead of being connected directly to the cam on the cam-shaft, is connected to what is known as the **still box motion.**

**17. Construction.**—A view of this motion is shown in Fig. 12. The rod $n_1$ operates the pawl working the box chain. At its lower end this rod is connected to a lever $r$ fulcrumed at the point $r_1$. Fulcrumed at this same point is another lever $s$, which carries two arms $s_1$, $s_2$, held together by the spring $s_3$. On the cam-shaft of the loom is placed a double cam, one part of which $t_1$ operates the lever $s$, while the other part $t$ acts on the lever $r$. These levers have a point of contact at $r_2$, and are thus prevented from coming any closer together. The lever $r$ carries, at the point $s_4$, a stud that works in a recess formed by the two arms $s_1$, $s_2$. Thus, as the lever $s$ is raised by the action of the cam $t_1$, the lower arm of the lever $r$ will also be raised by means of the connection formed at $s_4$, provided that there is nothing to prevent its action. On the other hand, when the lever $r$ is depressed by the action of the cam $t$, the lever $s$ will also be lowered by means of this same connection. Connected to the upper end of the lever $r$ is an arm $u$ that rests and slides on the plate $u_1$. A rod $v$ passes through the brackets $v_1$, $v_2$ and contains a slot $v_4$ through which the arm $u$ passes in its backward and forward movement. At its upper end the rod $v$ carries a projection under which the finger $v_3$ passes; this finger is setscrewed to the rod beneath the breast beam and is operated by the filling stop-motion.

**18. Operation.**—The operation of this mechanism is as follows: So long as the shuttle contains the filling, the cams $t, t_1$ will give an up-and-down movement to the levers $s, r$, since although each cam acts on only one lever, by the connection at the point $s_4$ the action of each cam will be imparted to both levers. The motion of the levers being, in turn, imparted to the rod $n_1$, it will turn the box chain and thus give the desired pattern of the filling.

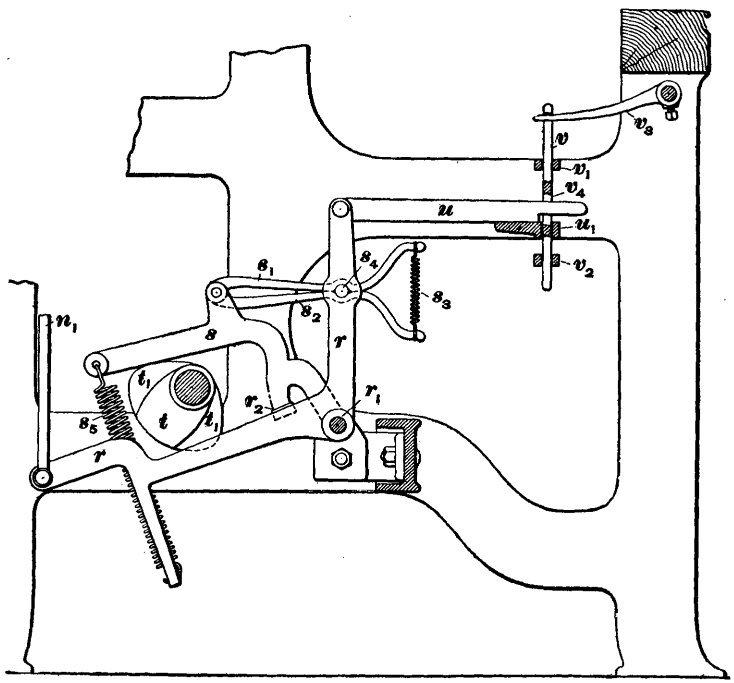


FIG. 12

When, however, the filling runs out, although the loom may run for two or more picks, yet by means of this device the rod $n_1$ will not operate the box chain. This is accomplished in the following manner: When the filling is absent, the filling-fork lever will engage with the filling-fork hook and move back the filling-fork slide. As this slide is pushed back it turns the rod beneath the breast beam to which is connected the finger $v_3$ shown in Fig. 12. As this rod is turned it will lift the finger $v_3$, which in turn will raise the rod $v$ and by this means bring the lower end of the slot $v_4$ above the level of the plate $u_1$ on which the arm $u$ slides. Thus, when the cam $t_1$ lifts the lever $s$ it will also tend to lift the lower arm of the lever $r$, but will be prevented from doing so by the arm $u$, which, in being pushed along the plate $u_1$, will come in contact with that part of the rod $v$ that is projecting above the plate. The stud $s_4$ will be pushed out of the notch formed by the arms $s_1$, $s_2$, the spring $s_3$ allowing this to be accomplished without the breaking of any parts. After the filling has been inserted and the loom started, the different parts of this motion will assume their former positions, since, as the pressure of the cam $t_1$ is taken from the lever $s$, the two levers will be brought together through the action of the spring $s_6$, which is extended when the lever $r$ is prevented from operating.

## FIXING OF BOX LOOMS

**19.** Although the fixing of box looms may be found to differ to a certain extent from the fixing of looms previously described, all the points that apply to plain looms apply equally well to the box loom, and should be carefully borne in mind when considering the additional difficulties connected with box looms.

**20. Timing the Boxes.**—When starting a box loom, the first object to be attained is the timing of the boxes in such a manner that they will not start to change before the shuttle is well into the box and will be completely changed before the loom commences to pick. This is very essential, since if the boxes commence to change before the shuttle is well boxed, the shuttle will be caught in the mouth of the box and will thus prevent the changing. On the other hand, if the loom commences to pick before the boxes are completely changed, the bottom of the box will not be level with the race plate when the shuttle is thrown.

There are several methods of timing the boxes, one probably being as good as another, so long as it accomplishes the result of changing the boxes in time. One method is to set the box-changing device so that the boxes will have moved about $\frac{1}{4}$ inch when the dagger on the protector rod strikes the bunter. On the Crompton loom, it is a good plan to set this motion so that the cam on the end of the cam-shaft will just commence to move the star wheel when the crank-shaft of the loom is on the bottom center. In whatever manner the boxes may be timed, the two results mentioned must always be accomplished. To set the cam that operates the box chain on the Crompton loom have the shuttle on the shipper side. Turn the loom until the crank-shaft is slightly beyond its front center; then set the cam so that it will just start to raise the connecting-rod that imparts the motion of the cam to the lever $n$, Fig. 8, operating the pawl $n_2$. When the pawl that operates the box motion is at its fullest throw, the risers and sinkers of the box chain should be directly beneath the levers and the cylinder should be held stationary after the pawl leaves the ratchet gear.

Another point that should be noted in connection with the setting of the Crompton box motion is the position of the sliding projections that engage with the star wheel. When there are no risers on the box chain under the levers, the star wheel and sliding projections should be in such a position that they will clear each other. There should also be a little loose motion in the rods connecting the sliding projections with the levers that rest on the box chain. When these are properly set, test the lift of the levers by placing a riser beneath them, making sure that the sliding projections are forced into such a position that they will engage correctly with the star wheel. Care should be taken that these sliding projections are not moved farther than is necessary.

**21. Leveling the Boxes.**—After the boxes have been timed so that when changing they will start and stop correctly, it is necessary to level them; that is, the lifting parts should be so adjusted that whenever a box is brought into position, the bottom of that box will be on an exact level with the race plate of the loom. This will sometimes be found to be a difficult matter, since in many cases all the boxes, with the exception of one, may be in a correct position, and yet changing the one that is a little out of true may so alter the lift of the others that, when they are again brought into position, they will be found to be either above or below the correct position they should occupy. The leveling of the boxes is a matter of leverage, and it is necessary to so set the different arms of the levers that they will give the exact throw required.

When leveling the boxes, bring the box motion into its normal position; that is, have the top box in such a position that the shuttle it contains will be acted on by the picker. Set the bottom of this box level with the race plate of the loom by adjusting the lifting rod by means of the check-nuts $a_4$, $a_5$, Fig. 3, placed at its lower end. After the first box has been leveled in this manner, bring the second box into position by turning the front shaft. Both the front and back shafts may be readily turned by hand in order to bring any desired box into position, and when leveling the boxes it is customary to turn the shafts in this manner so as to facilitate the operation. When the second box is in position, level it by means of moving the stud $g_2$, Fig. 3, in the slot at the forward end of the lever $g$. After leveling the second box return to the first and see that this box is in its correct position. Moving the stud $g_2$, in order to level the second box, may have thrown the first box slightly out of position; consequently, it will be necessary again to level this box by means of the nuts $a_4$, $a_5$. With the first and second boxes level, lift to the third box by means of turning the back shaft. If this box is not level it may be adjusted by moving the stud that connects the rod $e_3$ to the lever $g$, a slot in the back end of this lever provides for this adjustment. If this slot does not provide a sufficient adjustment the crank $e_2$, Fig. 3, may be moved up or down slightly by means of loosening the nuts that secure it to the plate $e_1$. Having leveled the third box, return to the first and second and if they are not level adjust them as described. With the first, second, and third boxes level, lift to the fourth by turning both the front and back shafts. If this box requires any adjustment it should be divided between the slots in the two ends of the lever *g* and the crank-adjustment. With the fourth box level, return to the other boxes and see that they are correct.

The boxes should work freely in the grooves in which they slide and yet not be so loose as to result in the shuttle being given an uneven throw when acted on by the picker. If they are tight in the grooves, they will be raised and lowered in a jerky manner, which is very liable to result in the picker being caught at some part of its throw, thus preventing the lifting of the boxes.

**22. Regulating the Binders and Shuttles.**—After the box motion has been properly timed and the different boxes correctly leveled, the shuttles and binders should be regulated. The binders on a box loom are made of malleable iron and, consequently, can be bent to any shape desired. It should be the aim of every fixer to see that the shuttle is checked in as easy and uniform a manner as possible. On the inner side of the binders are grooves, the edges of which should be kept perfectly smooth so that they will not cut the filling.

In the case of a $4 \times 1$ loom, the weaver should have at least six shuttles, all of which should be of an exact size and weight; otherwise, some of them will work in a perfect manner, while others will not work satisfactorily. When a new set of shuttles is started in a box loom, care should be taken to have them in such a condition that any shuttle will run as well in one box as in another.

**23. Shuttles Catching.**—A defect that probably occurs as frequently as any on a box loom is the catching of the nose of the shuttle in the picker, thus preventing the lifting of the boxes.

At the end of the lay on the box side, directly behind the picker, is a hollow space, which should be packed sufficiently to cause the front part of the picker to come on a line with the plate that serves for the back of the boxes. This packing generally consists of a roll of cloth and, in addition to preventing the shuttle from entering the box too far, also serves as a bunter for the picker, thus helping to check the shuttle more gradually and prevent its rebounding in the box.

On the Crompton box loom, there will be found on the picking cam that is placed at the box side of the loom, a device intended to prevent the shuttle from being too far in the box when the boxes are changing. This device consists of an extra stud on the picking cam placed in such a position that it will come in contact with the picking cone just as the shuttle comes to rest in the box. By this means, the picking stick will be moved in toward the loom about $\frac{1}{2}$ inch, which in turn will push the shuttle that distance, thus preventing any chance of its being caught. This additional point on the cam is not of course so large as the regular picking cam-point, but is only sufficiently large to accomplish the desired result.

**24. Attaching the Picker.**—As mentioned, the picker on a box loom slides back and forth on a rod, or spindle, $a_1$, Fig. 1. Before placing the picker on this spindle, care should be taken to see that it is perfectly straight, since in some cases pickers become so warped that the hole through which the spindle passes will not be shaped correctly and, consequently, will not allow the picker to move freely on the spindle. In such cases, the best plan is to place the picker in a vise and after making it as straight as possible, file out the hole of the picker sufficiently to enable it to work freely on the spindle. On the end of the spindle next to the loom end a piece of leather should be placed, in order to prevent, as far as possible, the strain that would otherwise come on the picker stick when it strikes the forward part of the box in being thrown forwards by the picking motion.

**25.** One other point should be noted in connection with box motions; namely, when they are applied to looms having the dobby, the chain operating the boxes should always be timed correctly with the chain operating the harnesses, in order to have the filling inserted at its proper place in the weave.

### POWER AND SPEED

**26.** The power required to drive a box loom is necessarily somewhat in excess of that required to drive a plain loom, owing to the additional motions that are brought into use. The required power will also depend to a certain extent on the number of boxes on the loom. A test made in a mill running box looms resulted as follows: One hundred and sixty $40\frac{1}{2}$-inch Crompton ($4 \times 1$) box looms running 158 picks per minute and weaving 27-inch plain goods consumed 58.19 horsepower, or an average of 2.75 looms per horsepower.

In many cases the box motion is applied to looms having dobbies attached and, in such cases, the necessary horsepower to drive the loom will be even greater. A test to show the marked difference in horsepower required between looms with and without box motions resulted as follows: Looms on 16-harness work without the box motion were running at the rate of 4.43 looms per horsepower, and when the same work was placed on box looms, it was found that $2\frac{1}{4}$ looms were consuming 1 horsepower.

**27.** It naturally follows that the speed of a box loom must be less than that of a plain loom. The exact speed at which the loom can be run will depend to a great extent on the number of boxes and to an even greater extent on the class of weave being run; that is, the character of the yarn and also the method of inserting the filling, whether it can be placed in the cloth by simply raising or lowering the boxes in regular order or whether it is necessary to resort to many serious jumps. A good speed for these looms may be anywhere between 140 and 160 picks per minute, the exact speed depending on the conditions mentioned.