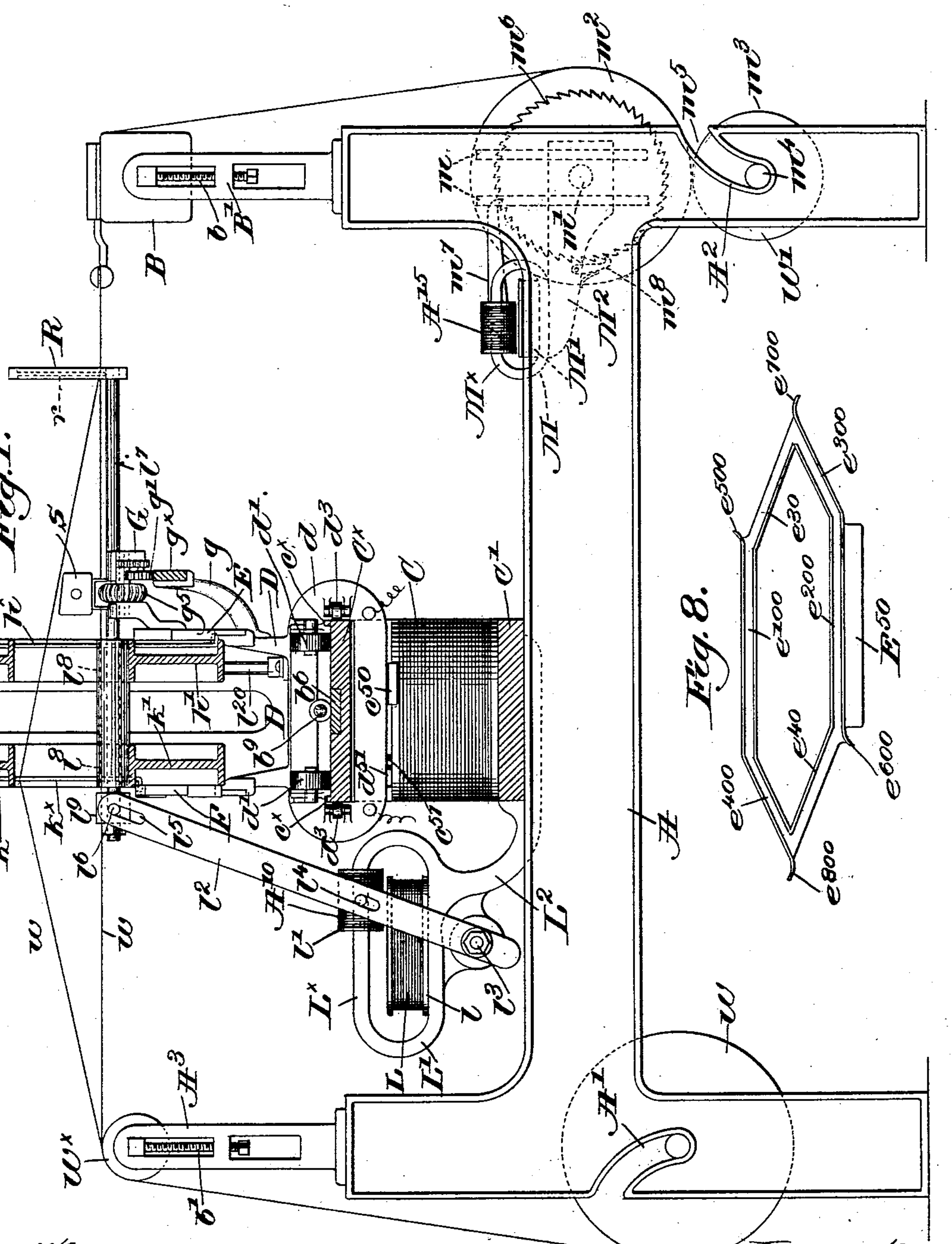
(No Model.) 4 Sheets—Sheet 1.

E. D. CHAPLIN & H. G. HALLORAN.

ELECTRICALLY OPERATED LOOM.

No. 588,101. Patented Aug. 10, 1897.



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(No Model.) 4 Sheets—Sheet 2.

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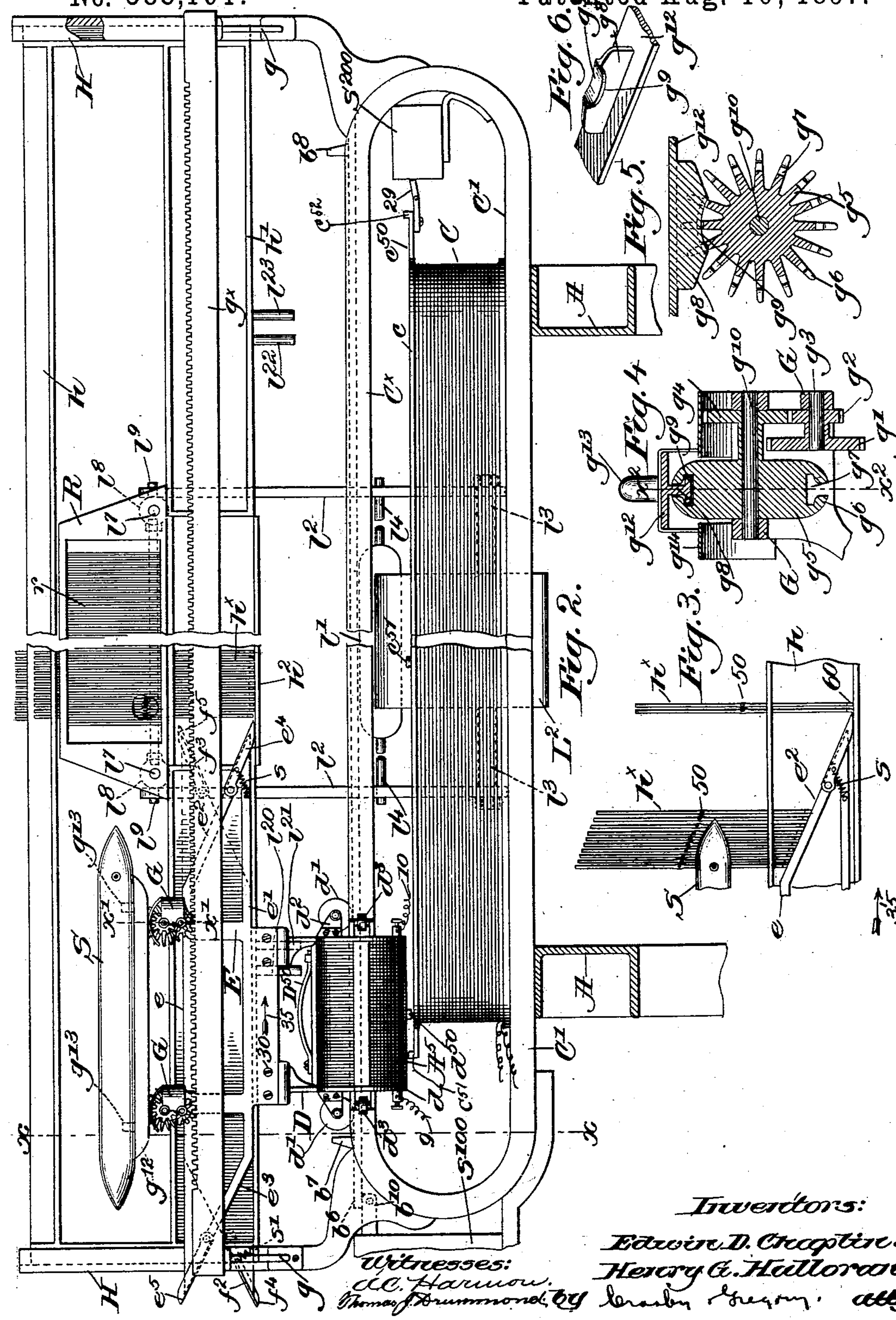

Fig. 2. Fig. 3. Fig. 4. Fig. 5. Fig. 6.

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(No Model.) 4 Sheets—Sheet 3.

E. D. CHAPLIN & H. G. HALLORAN.

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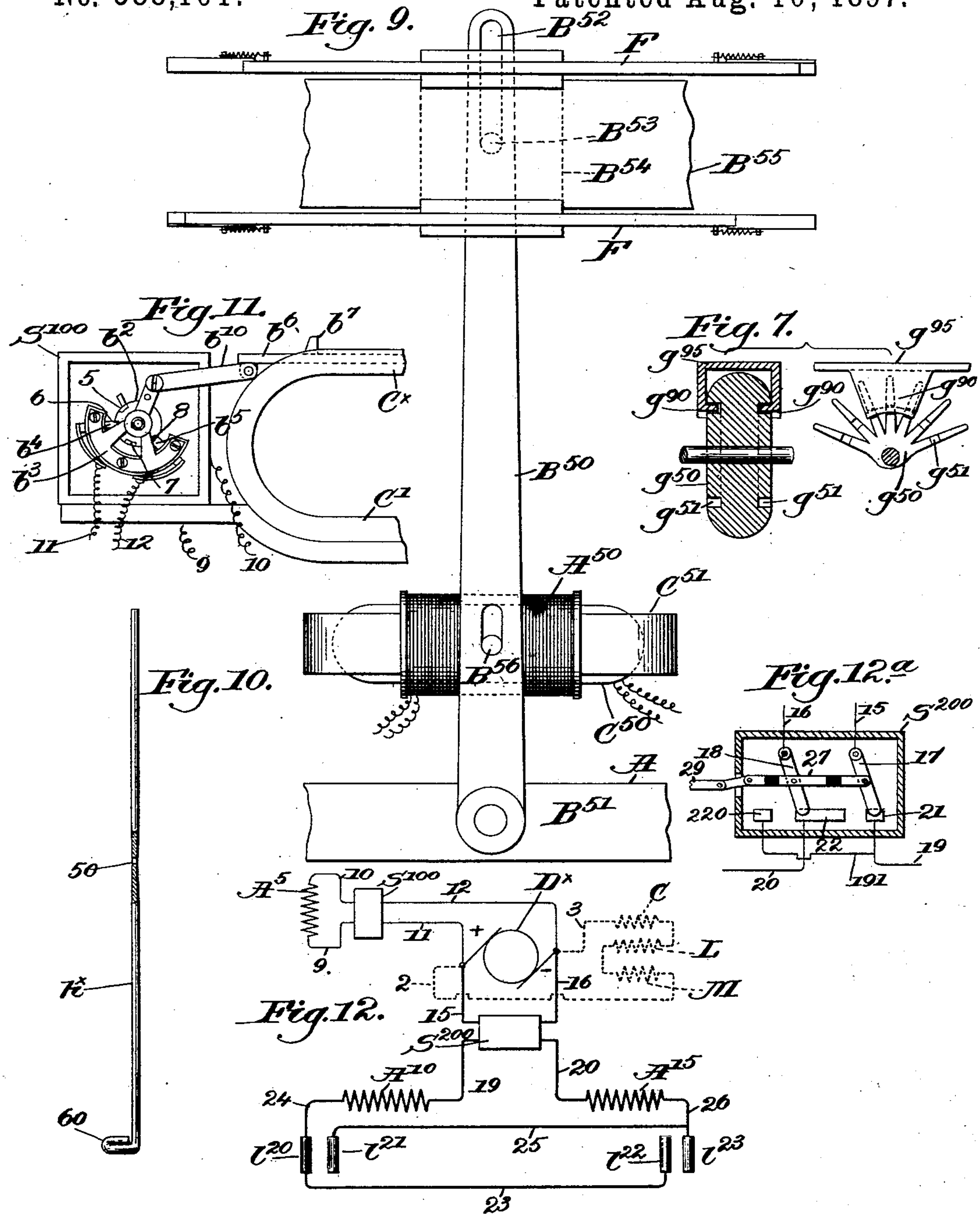

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(No Model.) 4 Sheets—Sheet 4.

E. D. CHAPLIN & H. G. HALLORAN.

ELECTRICALLY OPERATED LOOM.

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Fig. 14.

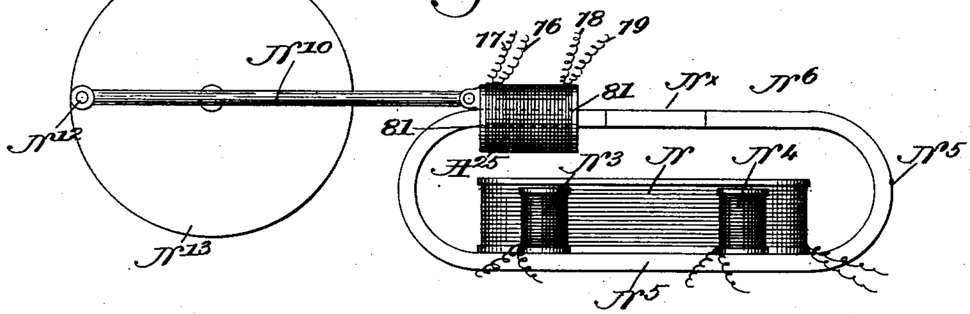


Fig. 15.

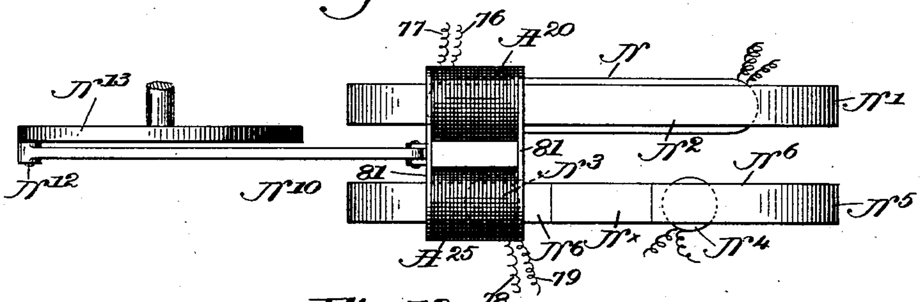
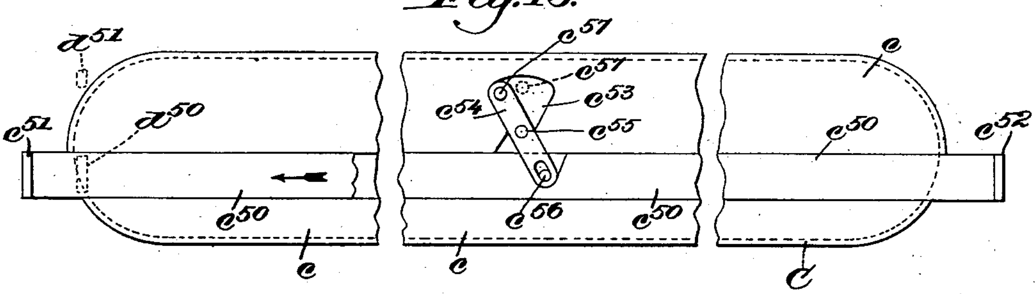


Fig. 13.



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UNITED STATES PATENT OFFICE.

EDWIN D. CHAPLIN, OF CAMBRIDGE, AND HENRY G. HALLORAN, OF BOSTON, MASSACHUSETTS.

ELECTRICALLY-OPERATED LOOM.

SPECIFICATION forming part of Letters Patent No. 588,101, dated August 10, 1897.

Application filed July 16, 1896. Serial No. 599,384. (No model.)

To all whom it may concern:

Be it known that we, EDWIN D. CHAPLIN, of Cambridge, county of Middlesex, and HENRY G. HALLORAN, of Boston, county of Suffolk, State of Massachusetts, have invented an Improvement in Electrically-Operated Looms, of which the following description, in connection with the accompanying drawings, is a specification, like letters and figures on the drawings representing like parts.

This invention has for its object the production of a loom operated electromagnetically, whereby the parts are reduced in number and simplified in construction, the shedding mechanism and shuttle-actuator embodying novel features hereinafter fully described.

By means of our invention we do away with the heavy lay, and the reed is operated by such light and easily running devices that the power necessary to operate the loom is greatly decreased.

The various moving parts of the loom depend for their operation upon a magnetic field and a coil-armature, one of which is reciprocable relatively to the other, the lines of force of field intersecting the coil of the armature, whereby the production of a current in the coil-armature will tend to cause relative movement of said field and armature in a direction depending upon the direction of the current.

Reversal of the current reverses the direction of relative movement of the two parts, so that by changing the direction of current in any suitable manner the movement of one of the parts relatively to the other becomes a reciprocation, which we herein utilize for operating the loom.

Figure 1, in side elevation and partially in section, represents a loom embodying our invention, looking to the right of the line $x\ x$, Fig. 2. Fig. 2 is a front elevation of the loom centrally broken out to save space, the shuttle being shown at one side of the shed-forming devices. Fig. 3 is a detached detail view showing the manner in which one set of heddles are moved to form one side of the shed as the shuttle advances. Fig. 4 is an enlarged transverse sectional view of the shuttle-carrier on the line $x'\ x'$, Fig. 2. Fig. 5 is a sectional detail view taken on the line $x^2\ x^2$, Fig. 4, of one of the rotatable connections between the shuttle-rest and its carrier. Fig. 6 is a perspective detail view of one of the connections of the carrier, to be described, turned upside down. Fig. 7 is a sectional detail of a modified form of connection between the shuttle rest and carrier. Fig. 8 is an elevation of a modified form of shuttle-actuator. Fig. 9 is a plan view of a modified mechanism for reciprocating the shuttle and heddle actuators. Fig. 10 is an enlarged detail, partially in section, of a heddle. Fig. 11 is a detail of a convenient form of current-reversing switch. Fig. 12 is a diagram view of the several armature-coils, showing their electrical connection together and with the dynamo or other source of current. Fig. 12ª is an enlarged plan view of a convenient form of switch for controlling the direction of current in the reed and take-up actuating armatures. Fig. 13 is a top view, partly broken out, of the main field-magnet, showing the switch-actuating device thereon, to be described; and Figs. 14 and 15 are side and plan views, respectively, of a modified form of actuating mechanism to be described.

The frame A, of suitable shape to support the operating parts, has slotted bearings A′ for the projections of the warp-beam w at the rear side of the loom, and at the front of the frame are slotted bearings A^2 for the cloth-roll w'.

The breast-beam B is herein shown in Fig. 1 as adjustably supported by screws b in slotted stands B′, erected on the loom-frame, while at the rear of the loom similar stands A^3, adjustably support, by means of suitable screws b', a guide-roll $w^{\times}$ for the warps as they pass to the shedding devices.

A main electro field-magnet, comprising a coil C, wound upon a suitable soft-iron core c and elongated in the direction of the width of the loom, is supported in place below the shed-forming devices, the core being suitably secured by bolts to a pole-piece C′, preferably of soft iron, having long horizontal sides parallel to each other and to the longer axis of the coil C, the upper side $C^{\times}$ forming a track or directrix for the shuttle-carrier.

A carriage D has secured thereto, depending from it, a preferably non-magnetic core or frame d, upon which a coil-armature A^5 is wound of insulated wire, the coil surrounding and being longitudinally movable upon the track or support $C^\times$. Antifriction-rolls d', journaled in ears d^2 of the carriage D, travel upon the upper surfaces of the directrix or support $C^\times$, which is preferably provided, as best shown in Fig. 1, with upturned ribs or rails $c^\times$, and guide-rolls d^3 are herein shown as mounted on the ends of the armature-core to bear against the sides of the support $C^\times$ and prevent lateral displacement of the carriage and armature.

When a current is passed through the field-coil C, the lines of force extend upwardly therefrom to the side $C^\times$ of the pole-piece and follow substantially the curved ends thereof in their path, making a substantially uniform magnetic field throughout its length, and a current produced in the coil-armature A^5 will cause movement of the armature through the magnetic field, and we have herein shown this armature-current as produced by a dynamo $D^\times$, Fig. 12, the direction of current in the armature A^5 being controlled by the latter. The dynamo is also employed to produce the current in the field-coils, as shown in Fig. 12 by dotted lines, the wires 2 3 connecting the field-magnet C and the other field-magnets, to be described, with the poles of the dynamo, so that the fields are constant.

In Fig. 11 we have shown a simple form of reversing-switch S^{100}, comprising a series of contacts 5, 6, 7, and 8, mounted on a support b^2, of insulating material, the contacts 5 and 8 being electrically connected with the wire 10 from one end of the armature A^5 and the contacts 6 and 7 with the wire 9 from the other end of the said coil. The movable switch member b^3 has two contacts b^4 and b^5, connected by wires 11 and 12 with the dynamo, said contacts b^4 b^5 simultaneously engaging the contacts 6 and 8, the current passing through the armature A^5 in one direction and in the opposite direction when b^4 b^5 are on the contacts 5 and 7. The support $C^\times$ is longitudinally grooved to receive a slide-rod b^6, having upturned lugs b^7 b^8 (see Fig. 2) in the path of and to be engaged by suitable bunters, one of which is shown at b^9, Fig. 1, secured to the carriage D, the bar b^6 being connected by a link b^{10} with the movable switch member b^3. If then the coil-armature A^5 has a current produced therein, the effect of the lines of force of the field C, intersecting mainly the lower or adjacent portion of the coil A^5, will be to move the latter through the field, and if the direction of current through the coil-armature is reversed the direction of movement of the armature will be reversed and it will be moved back through the field, such reversal of the current being herein effected by and at the end of each stroke of the armature to thus reciprocate it in the rear. The carriage D will thus be reciprocated from one to the other side of the loom, and upon this carriage we mount the shuttle-carrier, shuttle, and heddle controlling devices, now to be described.

Referring to Figs. 1 and 2, two pairs of cross-girths h' k' are rigidly secured to upturned standards H at the loom side, the upper girths h k being shown as ⊥-shaped in cross-section, while the girths h' k' are I-beams, with the webs in each case in vertical planes. The outer flanges of the upper girths and the upper flanges of the lower girths are perforated to receive the heddles $h^\times$ $k^\times$, supported in parallel series by the girths, as clearly shown in Fig. 1, and movable in vertical planes, one of the heddles (being shown on an enlarged scale in Fig. 10) having a warp-eye 50 and an outwardly-turned heel 60. The heels of the heddles are located below the upper flanges on the cross-girths h' k'. The carriage D reciprocates in a horizontal plane below the heddles and has mounted upon it and secured thereto, as by suitable screws or bolts 30, heddle-controlling devices for each series of heddles, herein shown as frames E F, one for each series of heddles. The frame E is shaped as a parallelogram, with horizontal upper and lower sides e e' and inclined ends e^2 e^3, the end e^2 inclining forward and downward from the upper side e of frame and moving in a path in the plane of the heels 60 of the heddles.

Referring to Figs. 2 and 3, it will be obvious that if the carriage is moved in the direction of the arrow 35 the heels of the heddles will be engaged one after another by the inclined surface e^2, and as the carriage moves forward the heddles thus engaged will be lifted in their guides or supports until the heels rest on the upper horizontal portion e of the frame E. This lifting of the heddles raises the warp-eyes above the line of travel of the shuttle S, so that the raised heddles lift their warps into the upper plane of the shed, and the shuttle, as will be hereinafter described, passes through the shed thus opened. As the carriage continues its movement to the right, Fig. 2, the heddles first engaged by the surface e^2 will be the first to leave the opposite end of the horizontal surface e, the heddles fitting snugly enough into their supports or guides to, as a general thing, remain lifted until positively depressed. Inasmuch, however, as it is absolutely necessary that the heddles resume their normal position before the next movement of the shuttle to the right, the surface e^2 on the return stroke of the carriage or in the direction opposite to the arrow 35 will engage and ride over the heels of the heddles, pressing them down until they are brought into normal depressed position.

It will be noted, referring to Fig. 2, that the lower flange h^2 of the cross-girth h' is throughout the extent of the series of heddles somewhat depressed, so that the tops of the heels are, when in normal position, about on a line with the under edge e' of the frame E, and in order that the heddles may be lifted on the movement of the carriage to the right we provide a pivoted shoe e^4 at the lower end of and projecting below the extremity of the surface e^2 to ride under the heels when going in one direction, but when the carriage is moving in the opposite direction the shoe is lifted and rides over the tops of the heels of the heddles, a light spring s retaining it in normal position.

A reversely-arranged frame F, secured to the carriage D at the rear of the girth k', has upper and lower horizontal surfaces and inclined end surfaces $f^2 f^3$ to coöperate with a series of heddles $k^\times$, it being obvious that when one series of heddles is lifted by the movement of the carriage the other series of heddles will be lowered, thus opening the shed, the normal level of the warp-eyes in both sets or series being below the path of the shuttle.

In Fig. 1 the shed is shown as open, the series $k^\times$ of heddles being raised to permit the shuttle to pass through the shed and leave a thread of filling after the reed, to be described, has been retracted, the said heddles $k^\times$ being depressed in advance of the shuttle as the heddles $h^\times$ are lifted. The inclined surface f' is provided with a shoe f^2, preferably spring-controlled, as by a spring s', (see dotted line, Fig. 2,) and we also prefer to mount shoes $e^5 f^5$ on the upper ends of the inclined surfaces $e^3 f^3$, respectively, to absolutely insure engagement with the heddle-heels. Brackets g on the standard h support a rack-bar $g^\times$, toothed at its upper edge and, as herein shown, in front of and adjacent the path of the carriage D, to engage gears g', mounted below each end of the shuttle carrier or support.

Referring to Fig. 4, each gear g' has secured to or forming part of it a pinion g^2, rotatable on a stud g^3, mounted in an ear G, extended from the frame E, the pinion in turn engaging a gear g^4, secured to or forming part of a peculiarly-shaped gear g^5, the long teeth g^6 of which are cut out to leave undercut open recesses g^7, which are entered one after the other by a foot g^8, having laterally-extended wings g^9 on a circular arc having as its center the stud or shaft g^{10}, on which the gears g^4 and g^5 are mounted. Said foot g^8, one being shown for each of the gears g^5 in Fig. 2, depends from a shuttle carrier or support g^{12}, having upturned projections g^{13}, which enter suitable holes in the bottom of the shuttle S. The feet g^8, with their wings g^9, connect the shuttle carrier or support g^{12} with the carriage D, the undercut recesses g^7 in the gears g^5, mounted to move with the carriage, preventing disengagement of the shuttle carrier or support and the said carriage. At each side of the gears g^5 are mounted grooved shields or guides g^{12} on the ears G, and the ends of the support g^{12} are upwardly and outwardly curved or beveled to form flaring guide-openings into which the lower sides of warps w enter as the shuttle passes through the shed. Each warp passes between two of the teeth g^6 and between the feet g^8 and the bottoms of the spaces between the gear-teeth, so that there is little or no friction exerted upon said warps, the speed of the shuttle and the rotative movement of the gears g^5 being substantially the same.

By means of the rack $g^\times$ and the intermediate gearing between it and the gears g^5 the latter will always be rotated in a direction opposite to the movement of the shuttle, so that the warps will be carried beneath it.

A field-coil L, having a suitable core l of soft iron, is mounted upon a bracket l^2, secured to the loom-frame and, as shown at Fig. 1, at the rear of the field-coil C, the said bracket being extended to form a pole-piece L', having a horizontal upper portion $L^\times$, upon which moves a preferably non-magnetic core l' of an armature-coil A^{10}. Links l^2, pivoted at their lower ends on the bracket L^2 at l^3, are connected by a slot-and-pin connection at l^4 with the armature-coil A^{10}, so that reciprocation of the latter will swing the links back and forth on their pivots. These links at their upper ends are longitudinally slotted at l^5 to engage pins l^6 on a reed-carrier, consisting, essentially, of horizontally-extended slide-rods l^7, rigidly connected at their forward ends by a reed-frame R, provided with suitable reed-dents r, said rods having bearings l^8 secured to the girths h' k', a cross-bar l^9 connecting the rear ends of the rods l^7.

The reed is reciprocated back and forth in a horizontal plane from a point immediately in front of the foremost series of heddles to the cloth-making point, the latter position being herein shown. A change in the direction of current in armature-coil A^{10} will cause it to change the direction of its movement through the field of the coil L, and as the said armature-coil is electrically connected with the dynamo-circuit, as will be described, the coil A^{10} is wound relatively to the winding in the coil A^5, that a movement of the former toward the back of the loom will be effected during the early part of the movement of coil A^5 to the right, Fig. 2, to carry the reed back of the path of the shuttle.

The take-up mechanism is controlled by a coil-armature A^{15}, reciprocable on the directrix $M^\times$ of a pole-piece M', forming a part of a field-magnet M, mounted, as will be hereinafter described, on a bracket M^2, Fig. 1.

Referring now to Fig. 12, the electrical connection between the dynamo $D^\times$ and the coil-armatures is clearly shown, the coil-armatures being connected in series, as are the field-magnets C, L, and M. (Shown in dotted lines.) Wires 15 16 connect the poles of the dynamo with movable contacts 17 18, respectively, of a circuit-changer or reversing-switch S^{200}, Fig. 12ª, while wires 19 and 20 lead from fixed contacts 21 22 to the coil-armatures A^{10} and A^{15}. Two pairs of fixed contacts l^{20} l^{21} and l^{23} l^{24} are mounted on one of the cross-girths, as h', and, as shown in Fig. 2, l^{20} l^{22} are connected by a wire 23 and to the armature-coil A^{10} by wire 24, while the contacts l^{21} and l^{23} are connected by wire 25 and to armature-coil A^{15} by wire 26.

The movable contacts 17 and 18 are shown in Fig. 12^a in engagement with the contacts 21 and 22, respectively, so that the current will pass from dynamo through wire 15, switch, wire 19 to coil A^{10}, and when circuit is closed at l^{20} l^{21} the current will pass by wires 25 and 26 to coil A^{15}, wire 20, switch, and back by wire 16 to dynamo. A circuit-closer is mounted on the carriage D and shown as a spring D^{50}, insulated from the rest of the carriage to connect necessarily the contacts l^{20} l^{21} and l^{22} l^{23} as the carriage moves to the right, Fig. 2. Supposing now that the reed R is forward when the contact D^{50} closes the circuit at l^{20} l^{21}, the winding of the armature-coil A^{10} is such that it moves to the rear, taking the reed back behind the path of the shuttle S in order the latter may pass through the shed and carry the filling across. As the carriage D proceeds, breaking the contact, the reed remains back, but when the contact D^{50} closes the circuit at l^{22} l^{23} the armature A^{10} again receives current, but in the opposite direction, due to movement of the reversing-switch S^{200}, as will be described, so that the reed R will be moved forward to beat up the filling. The carriage D in its further movement opens the circuit and operates the switch S^{100}, as has been described, to change the direction of current in the carrier-armature A^5, so that the carriage will be reversed and moved to the left, Fig. 2, and the circuit of the reed and take-up armatures A^{10} A^{15} will be closed in reverse order to move the reed back as the shuttle moves toward it and to the front again to beat up the filling as the shuttle is moved beyond it.

When the switch S^{200} is thrown, the current passes from dynamo by wire 15, contacts 17 and 22, wire 20 to coil A^{15}, then by wires 23 or 25 and wire 24 to coil A^{10}, back by wire 19 and branch 190 to a fixed contact 220 in the switch, and thence to contact 18 and back to dynamo by wire 16, the direction of current through the armatures A^{10} and A^{15} being thus reversed.

To operate the switch S^{200}, we have mounted in the top of the core c a slide-bar c^{50}, having lugs or projections c^{51} c^{52} at or near its ends to be engaged by a projection d^{50}, secured to the carriage to move the bar c^{50} in one or the other direction. The core c is recessed at about its center, as at c^{53}, Fig. 13, to receive an arm c^{54}, fulcrumed at c^{55} and attached by a slot-and-pin connection c^{56} to the slide-bar c^{50}, rocking of the arm c^{54} reciprocating the slide-bar c^{50}. A stud c^{57} on the free end of the arm is, when in dotted-line position, Fig. 13, in the path of movement of a second projection d^{51} on the carriage D to operate the slide-bar at about the middle of the stroke of the carriage, the slide-bar then being at mid-stroke. This movement is rendered necessary in order that the reed may be moved back and forth twice for each complete reciprocation of the shuttle.

When the carriage is nearing the end of its movement to the left, Fig. 2, the slide-bar c^{50} is in the position shown in Fig. 13, and just before reaching the end of its stroke the projection d^{50} on the carriage will engage the lug c^{51} and move the bar c^{50} in the direction of the arrow, Fig. 13, until the stud c^{57} assumes the dotted-line position in the path of the projection d^{51}, operating the switch S^{200} to cause the current to pass through the reed-armature in the proper direction to retract the reed.

The movement of the carriage having been reversed it begins to move to the right until the projection d^{51} engages the lug c^{57} and swings the arm c^{54}, the bar c^{50} being again moved in the direction of the arrow in Fig. 13, thereby returning the switch S^{200} to position to reverse the current, so that when the circuit is closed at l^{22} l^{23} the reed will be moved forward.

When the carriage reaches the right-hand side of the loom, the projection d^{50} engages lug c^{52} and moves the bar c^{50} again to central position, so that when the circuit is closed at l^{22} l^{23} on the return stroke of the carriage the reed will be drawn back. From its central position the bar c^{50} is thereafter moved by the projection d^{51} engaging the stud c^{57} and moving it from dotted-line position, Fig. 13, to full-line position.

The movable switch members or contacts 17 18 are connected together by a suitable bar 27 and by a link 29, Fig. 2, with the slide-bar c^{50}, to be partially rotated by longitudinal movement of the slide-bar, effected as hereinbefore described.

Any suitable current-reverser or switch may be used instead of the one herein shown.

The loom-frame A is provided on its inner sides below the breast-beam B, Fig. 1, with vertical guides m, which support and guide two like brackets M^2, one at each side of the loom, which brackets receive the journals m' of the take-up roll m^2, said roll resting upon the cloth-receiving roll m^3, the journals m^4 of the latter resting in slotted bearings m^5 in the loom-frame. As the cloth is wound upon the roll m^3 the diameter of the wound mass increases, and this raises the take-up roll m^2, its supporting-brackets, and the parts carried thereby. A ratchet-wheel m^6 is secured to the take-up roll to be engaged by a pawl m^7, pivotally mounted on the core of the coil-armature A^{15}, as shown in Fig. 1, so that as the said armature is moved forward the pawl will partially rotate the ratchet-wheel and the roll m^2. Retrograde movement of the take-up roll is prevented by a spring-detent m^8, mounted on the bracket M^2. The stroke of the armature A^{15} is short, only sufficient to move the take-up roll step by step the desired distance, and the armature A^{15} is so wound relatively to the armature A^{10} that when the latter retracts the reed the take-up roll will be moved forward, and when the reed comes forward the pawl m^7 will be retracted.

From the foregoing description it will be obvious that the reed is retracted behind the shuttle as the latter is moved across the warp, the heddles being actuated to open the shed in advance of the shuttle and to close it thereafter as the shuttle progresses, the reed beating up the filling after each shot of the shuttle, while the take-up is actuated at the proper time to take up the cloth.

All the various reciprocating parts are moved positively, and owing to the manner in which the shuttle is actuated it may be run at very high speed, the length of stroke of the shuttle being determined only by the length of the field-magnet C.

The switch S^{200} is operated only after the contact is made and broken by the circuit-closer D^{50}, so that there is no liability of sparking, as the circuit is open when the switch is operated.

In the modification shown in Fig. 9 for operating the shuttle-carrier and heddle-actuators a horizontally-movable lever-arm B^{50} is pivoted at B^{51} to a suitable part of the loom-frame A, said lever having a longitudinal slot B^{52} in its free end, to be entered by a pin or projection B^{53} on a block B^{54}, adapted to slide on a horizontal guide B^{55}. Said block has secured thereto the heddle-actuators E and F, such as hereinbefore described, to act upon a series of heddles as the block is reciprocated on its guide B^{55}. A field-magnet C^{50}, having a pole-piece C^{51} similar in shape to the pole-piece C' described, is extended in parallelism with the guide and near the fulcrum B^{51} of the lever-arm, while an armature-coil A^{50} is adapted to reciprocate on the pole-piece. A slot-and-pin connection at B^{56} connects the armature and lever-arm, so that the latter will be swung back and forth as the armature reciprocates in the electromagnetic field, such construction employing a smaller field-coil, as to length, than is necessary in the construction shown in Figs. 1 and 2. The shuttle-carrier is mounted on the slide-block B^{54} and the shuttle is attached to the carrier as hereinbefore described.

In Fig. 8 we have shown another form of heddle-actuator which is adapted to positively move the heddles from and thereafter back to normal position at each stroke. A frame E^{50} has on its side an upper cam-groove e^{100}, a lower groove e^{200} parallel thereto, and parallel inclined continuations e^{300} and e^{400}, extending from the opposite ends of the upper and lower grooves, respectively. The open end of groove e^{100} has an outwardly-flaring end or shoe e^{500} and the groove e^{200} is provided at its open end with a similar shoe e^{600}, while at the outer ends of the grooves e^{300} and e^{400} are oppositely-flared shoes e^{700} e^{800}, respectively. The inner walls of grooves e^{200} and e^{400} are connected by a wall e^{10} and the walls of grooves e^{100} and e^{300} by a wall e^{30}. Now when the cam-frame E^{50} is moved to the right the shoe e^{700} passes under the heels of the heddles, and the heels are thereafter engaged by the inclined wall e^{30}, which gradually raises the heddles to carry their warps into the upper plane of the shed, the heels running in the groove e^{100} as the heddle-actuator continues its movement. When the heels pass into the groove e^{400}, the heddles are gradually brought down to normal position, the shoe e^{800} completing such movement and leaving the heddles' heels in position to be engaged on their upper sides by the inclined wall e^{40} on the return stroke of the actuator. On this return stroke the wall e^{40}, acting on the heels, depresses the heddles to bring their warps into the lower plane of the shed, the groove e^{200} retaining the heddles in lowered position until the upturned groove e^{300} is entered by their heels. This groove lifts the heddles toward central position, the shoe e^{700} completing this movement, so that the heels will be in position to be engaged on their under sides by the wall e^{30} when the actuator E^{50} again moves to the right, viewing Fig. 8.

It will be understood that an actuator the reverse of the one shown in Fig. 8 will be moved therewith to act upon the other series of heddles, so that the heddles of one series will be raised and those of the other series lowered, thus opening the shed at each shot of the shuttle.

A modification of the connection between the shuttle and its carrier is shown in Fig. 7, the gear g^{50} having in each side an annular groove g^{51}, to be entered by inturned lugs g^{90} on the under side of the shuttle-support g^{95}, the grooves g^{51} being made in the sides of the teeth between their roots and faces.

In Figs. 14 and 15 we have shown a modification of the electromagnetic actuating mechanism, which may be used to operate one or an indefinite series of looms, depending on the power of the dynamo. A field-magnet N is provided with a pole-piece N', having its upper portion N^2 forming a directrix for a coil-armature A^{20}, substantially as hereinbefore described, the ends 76 77 of the coil leading to one or more coil-armatures (not shown) for actuating the shuttle-carriers of the series of looms. Two spool-coils or field-magnets N^3 N^4 are provided with a common pole-piece N^5, adjacent and similar to the pole-piece N', and a second coil-armature A^{25} is adapted to reciprocate on the part N^6 of the pole-piece as a directrix above the field-magnet N^3 N^4. The said magnets are in circuit with the exciting-dynamo, as is the field-magnet N, the field-magnets N^3 N^4 being so wound that the current passing through them gives them opposite polarity. The directrix N^6 is interrupted by a non-magnetic portion $N^{\times}$ between the two field-magnets N^3 N^4 to deënergize the coil-armature A^{25} as it passes thereover, said armature being included by wires 78 79 in circuit with the reed and take-up actuating armatures of the series of looms. The coils of the armatures A^{20} A^{25} are connected by a frame 81, which in turn is pivotally attached to a pitman N^{10}, connected to a wrist or crank pin N^{12} on a disk N^{13}, rotated positively in any suitable manner to positively reciprocate the armatures in their respective fields.

Inasmuch as the fields are constant, when armature-coil A^{20} is moving to the right, Fig. 14, the current through it and the connected carrier-armatures will be in one direction, and when the direction of movement of the armatures is reversed the direction of current will be reversed, so that the carrier-armatures will reciprocate in unison with the armature A^{20}. As the armature A^{25} passes through the field of the magnet N^3 the armature-current will be excited in one direction, to thereby energize the reed-armatures of the looms in the series, to retract the reeds, for instance, and the non-magnetic portion $N^{\times}$ of the directrix deënergizes the reed-actuating armatures. When the armature A^{25} reaches the field of the magnet N^4, the armature will again be excited, but the current will be opposite in direction, so that the reed-armature will move the various reeds forward to beat up the filling. The coil-armature A^{25} is then retracted, and its direction of movement having been thus reversed the current excited in it by its retrograde passage through the field of magnet N^4 will be again changed to retract the reed-armatures. After deënergizing, as before, the armature passes through the field of magnet N^3, and it is excited, but the direction of the current is such that the reed-armatures will move the reeds up to beat up the filling, so that the reeds are moved properly at each shot of the shuttles controlled by the coil-armature A^{20}. While the reed-armatures are operating, the take-up armatures will also operate to actuate the take-up mechanism in the various looms.

Our invention is not restricted to the precise construction and arrangement of parts as herein shown and described, for, obviously, changes may be made in the construction and arrangement of various parts without departing from the spirit and scope of our invention.

Having fully described our invention, what we claim as new, and desire to secure by Letters Patent, is—

1. In a loom, an electrofield-magnet, and a coil-armature wholly exterior to the coils of said magnet, one of which is reciprocable relatively to the other, a shuttle-carrier connected to the reciprocating member, a shuttle mounted on the carrier, means to produce a current in the armature, and a device for reversing the direction of the current at each stroke, whereby the shuttle is reciprocated, substantially as described.

2. In a loom, an electrofield-magnet, an armature reciprocable exterior to the coils thereof but intersecting the lines of force of the magnetic field, a shuttle-carrier connected with the armature, to move therewith, a shuttle mounted on the carrier, means to produce a current in the field-magnet and armature, and means to reverse the current of one of them at each stroke of the armature, substantially as described.

3. In a loom, an electrofield-magnet, an armature reciprocable exterior to the coils thereof but intersecting the lines of force of the magnetic field, a sliding carriage to support the armature, a shuttle-carrier on the carriage, a shuttle mounted on the carrier, means to produce a current in the field-magnet and armature, and means controlled by the carriage, to reverse the current of one at each stroke, substantially as described.

4. In a loom, an electrofield-magnet, including an elongated coil, a fixed directrix above said magnet, a carriage adapted to slide upon said directrix, an armature on the carriage reciprocable exterior to and in the direction of the length of the coil and in the magnetic field thereof, to thereby actuate the carriage, a shuttle, connections between it and the carriage, means to produce a current in the field and armature, and means controlled by reciprocation of the armature to change the direction of current therein as the armature is reciprocated, substantially as described.

5. In a loom, the shuttle, its carriage, means to reciprocate the carriage, heddles for the warps, and actuating means therefor to form the shed, a reed to beat up the filling, means to actuate it, including a field-magnet and a coil-armature, one of which is reciprocable relatively to the other, and means to change the direction of current in one of them, controlled by reciprocation of the shuttle-carrier, to thereby operate the reed, after each shot of the shuttle, substantially as described.

6. In a loom, a shuttle and its carriage, a coil-armature connected to the latter, a field-magnet having an extended pole to form a directrix for said armature, means to produce a current in the coil-armature, and means controlled by the shuttle-carriage to reverse the direction of current in the armature and thereby change its direction of movement, substantially as described.

7. In a loom, a shuttle, its carriage, a coil-armature movable therewith, an electrofield-magnet in the field of which the armature moves, means to change the direction of current in the armature or magnet at each stroke of the armature, to thereby cause the latter to reciprocate, a reed, a field-magnet and its coil-armature, to operate the reed, take-up mechanism, including an electrofield-magnet and its coil-armature, and means controlled by reciprocation of the shuttle-carriage, to operate the reed and take-up mechanism, substantially as described.

8. A plurality of looms each having a shuttle, its carriage, a coil-armature movable therewith, and an electrofield-magnet for, and in the field of which, each armature reciprocates, said fields and armatures being electrically connected, and means to positively reciprocate one of said armatures in its field,

to control the direction of current and thereby the direction of movement of the other armatures in their respective fields, the field-magnet current being constant in direction, substantially as described.

9. A plurality of field-magnets and their armatures, electrically connected, each field-magnet and its armature being relatively reciprocable, a shuttle-carriage connected with each movable member, and a shuttle mounted on each carriage, coöperating shed-forming mechanisms, means to produce a current in said fields and armatures, and means to reverse the current in accordance with the relative reciprocation of the field-magnets and armatures, whereby the series of shuttles are reciprocated across their respective sheds, substantially as described.

10. In a loom, the shuttle, a carriage therefor with which it is positively connected, means to reciprocate the shuttle-carriage, a reed independent thereof, and means controlled by the reciprocation of the shuttle-carriage to move the reed toward and from the fell, to beat up the filling, substantially as described.

11. In a loom, an electrofield-magnet and a coil-armature, one of which is reciprocable relatively to the other, means to establish a current in the armature, a shuttle adapted to be moved by the reciprocating member, and means to reverse the direction of current at each stroke of the reciprocating member, substantially as described.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

EDWIN D. CHAPLIN.
HENRY G. HALLORAN.

Witnesses:
JOHN C. EDWARDS,
AUGUSTA E. DEAN.