R. H. McLAIN.

MOTOR CONTROL SYSTEM.

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Fig. 1.

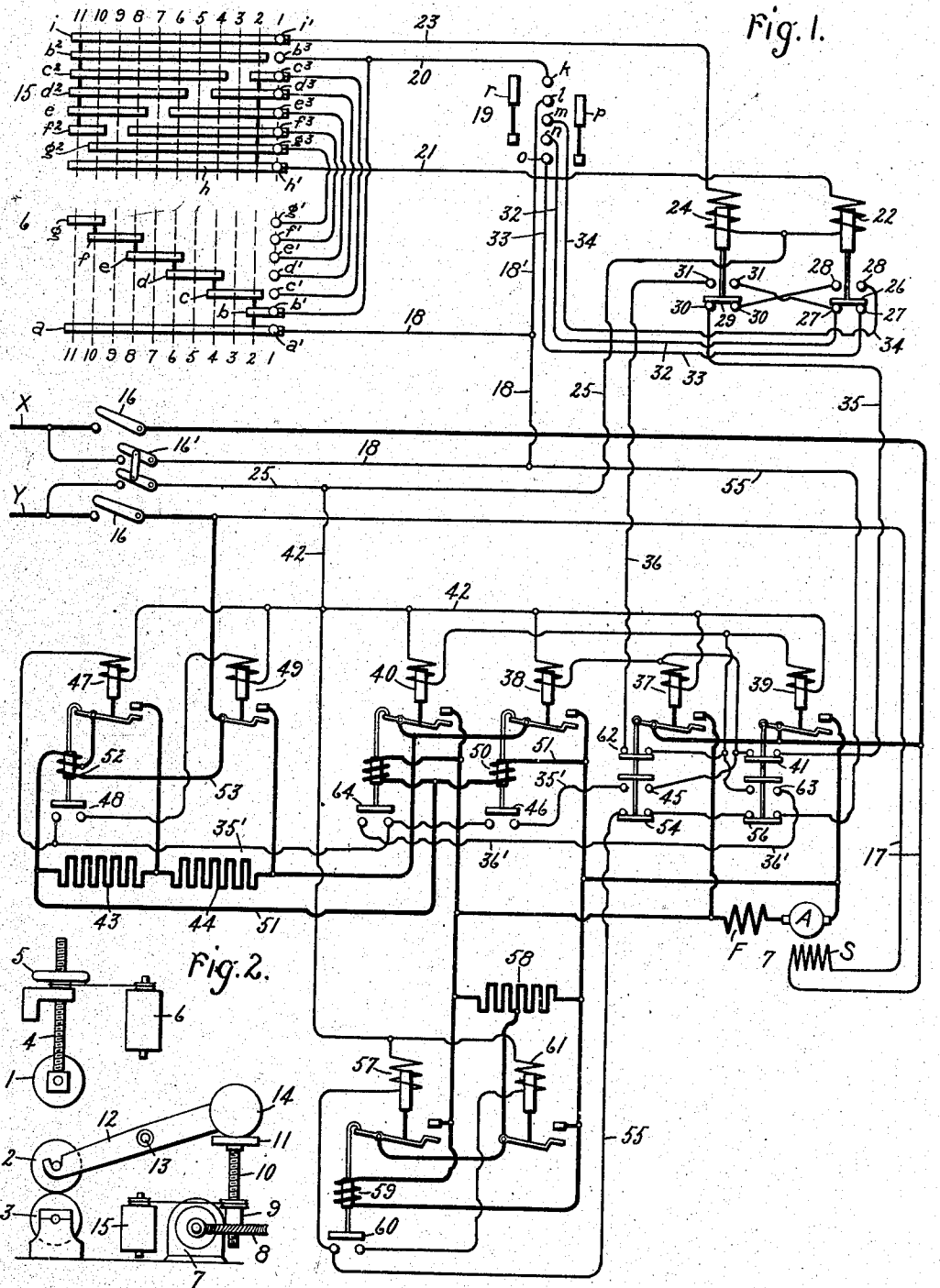

Fig. 2.

Witnesses,

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MOTOR-CONTROL SYSTEM.

1,041,137. Specification of Letters Patent. Patented Oct. 15, 1912.

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To all whom it may concern:

Be it known that I, ROBERT H. McLAIN, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Motor-Control Systems, of which the following is a specification.

This invention relates to means for controlling the operation of an electric motor driving part of a machine in such a manner that it will vary the extent of its operation in correspondence with the movement of some other element of said machine.

The invention is especially applicable to what are known as three-high plate rolling mills, in which a tier of three rolls is so arranged that the plate is passed alternately back and forth, moving in one direction between the lower roll and the middle roll and in the other direction between the middle and the upper rolls. At each pass the middle roll moves up or down into contact with the upper or the lower roll, as the case may be, in order that it may be rigidly backed up by said roll and thus be enabled to sustain the pressure when the plate passes between it and the other roll. To reduce the thickness of the billet to that which it is desired the plate shall have, the upper roll must be lowered more or less after each "pass" of the plate. This operation, by reducing the space between the upper and the lower roll in which the middle roll plays up and down, also necessitates some provision by which the means for shifting said middle roll shall be automatically varied in its action to correspond with the lessening range of movement of said middle roll. In the mill to which my invention relates, the middle roll is shifted by an electric motor, running in one direction to raise said roll and in the other direction to lower it. Assuming that a given number of revolutions must be made to effect the maximum shift of the roll, it is evident that as the range of movement of said roll lessens, so also the number of revolutions of said motor must lessen.

The object of my invention is to effect this result automatically by placing the motor under the control of the operator who handles the upper roll. In brief, I employ two limit switches, one geared to the screw-down mechanism of the upper roll and the other to the middle roll motor. Two relays control contactors which in turn control the motor circuit. One relay governs the motor when the roll is going up and the other relay when said roll is going down, and when both relays are down or up the motor will not run. If only one relay is up the motor can run, and that relay determines the direction of rotation of the motor. The limit switches have their segments overlapping so that for a given number of segments and fingers nearly twice as many stations or positions can be obtained.

The invention will be better understood from the following detailed description, reference being had to the accompanying drawing, in which—

Figure 1 is a diagram of the circuits embodying my system, and Fig. 2 is a diagrammatic sketch of a three-high mill with the limiting switches and roll-shifting motor.

Referring first to the sketch, Fig. 2, the three rolls 1, 2, 3 are seen to be arranged in a vertical tier, roll 3 being the lowest and journaled in stationary bearings. The upper roll 1 is arranged to be screwed down, the mechanism illustrated being a simple screw 4 and hand wheel 5; though in practice more elaborate mechanism is usually employed. Operatively connected to this screwdown mechanism, whatever its character may be, is a limit switch 6, preferably in the form of a drum of insulating material carrying conducting segments which cooperate with stationary contact fingers as usual. This drum should make a little less than one revolution during the extreme travel of the upper roll 1.

The middle roll 2 is arranged to move vertically in the space between the rolls 1 and 3, and is shifted by an electric motor 7. The sketch, Fig. 2, indicates this fact by showing the motor connected by worm gearing 8 to a nut 9 rotating in a fixed bearing and meshing with an upright non-rotatable screw 10 carrying on its upper end a platform 11. The middle roll is journaled in boxes which slide in vertical guides and the journals or projections on said boxes are engaged by the hooked ends of levers 12 suitably fulcrumed at 13 and carrying a weight 14 which overbalances the weight of the roll and rests upon the platform 11. The sketch, Fig. 2, shows this mechanism in a merely illustrative manner, as far more elaborate

and suitable mechanism would be used in actual practice. A second limit switch 15 rotates in synchronism with the movement of the roll 2 up and down, said switch being similar in construction to the switch 6. The sketch shows the nut 9 provided with a pulley which is belted to a pulley on the drum 15 and gives said drum a little less than one revolution during the extreme travel of the screw 10. It will be understood from this illustrative sketch that when the motor 7 rotates the nut 9 the screw 10 will travel up or down, raising or lowering the platform 11. When said platform is raised, it lifts the weight 14 and allows the roll 2 to move downwardly. When the platform is lowered, the weight follows it down and raises the roll 2. Whenever the motor runs the switch 15 turns also, making a little less than one revolution during the time that the roll 2 is traveling through its greatest range of movement. The two switches are electrically connected in such a manner that when they occupy a certain predetermined angular relation the motor circuit will be broken. This relation changes for each station to which the upper roll is adjusted.

Turning now to Fig. 1, the positive and negative mains appear at X and Y, respectively, controlled by a double-pole switch 16. The power circuits are shown by heavier lines than the control circuits, which receive current from the mains X Y through the switch 16'. The motor 7 is diagrammatically represented by the armature A, the commutating pole field coil F and the shunt field coil S, the latter being connected across the mains X Y by the conductors 17. The upper or screwdown limit switch 6 is shown in this figure below the other limit switch 15. Switch 6 has one continuous segment a and a plurality of short segments b, c, d, etc. each overlapping the next so that alternate positions 2, 4, 6, etc., have two segments available. All the segments are cross-connected. Fingers a', b', c', etc., coöperate with said segments.

Switch 15 has two continuous segments h, i, and a plurality of interrupted segments b^2, c^2, d^2, etc. The interruptions cover one position and are stepped in the opposite direction from the short segments on the screw-down switch. The ends of adjacent segments overlap so that their ends occupy the alternate positions 2, 4, 6, etc. The continuous segment h is connected with all the right-hand portions of the interrupted segments b^2, c^2, etc., and the continuous segment i is connected with all the left-hand portions of said segments. Fingers h', i' cooperate with the segments h i, respectively, and fingers b^3, c^3, d^3, etc., with their respective segments b^2, c^2, etc. The fingers which coöperate with the stepped segments in the screw-down limit switch 6 are connected respectively with the fingers bearing the same reference letters which coöperate with the interrupted segments in the limit switch 15, but inversely; that is, the lowest finger in switch 6 with the highest finger in switch 15, and so on. Finger a' of switch 6 is connected by the wire 18 with the main X through the switch 16', and by a branch wire 18' with a finger l in a master-switch 19. Finger b^3 in switch 15 is connected by wire 20 with another finger k in said master switch, as well as to finger b' in switch 6. Finger h' is connected by a wire 21 with a solenoid 22 forming part of the "up" relay and finger i' is connected by wire 23 with the solenoid 24 of the "down" relay. Both solenoids are connected by wire 25 with the negative main Y through the switch 16'.

The "up" relay has an interlock 26 which when down closes on two contacts 27 and when raised on two contacts 28. In a similar manner the interlock 29 of the "down" relay closes on the sets of lower and upper contacts 30 31. Contacts 27 are connected respectively by wires 32 33 with the fingers n o in the master switch. One of the contacts 28 is connected by wire 34 with the finger m in said switch. The other contact 28 is connected with a contact 30, and one of the contacts 27 with a contact 31. The second contact 30 and contact 31 are connected respectively by wires 35 36 with the motor controlling contactors. There are as many of these contactors as may be desirable. I have shown eight in all. Two of them 37 and 38, have their actuating coils in parallel and are controlled by the "up" relay. Two more, 39 and 40 also have their actuating coils in parallel and are controlled by the "down" relay. These two pairs of contactors serve to close the circuit of the motor 7 on both sides of the same. The two pairs send current from the mains X Y through said motor in opposite directions so it will shift the roll 2 up or down as the case may be.

Current coming along the wire 35 from the "up" relay passes through an interlock 41 controlled by the contactor 39, thence through the coils of the contactors 37 and 38 in parallel then to the wire 42 and the negative control conductor 25. When these contactors close, power current flows from contactor 37 through the field coil F and armature A from left to right and thence through contactor 38 to the resistance coils 43 44 (of which any desired number may be used) and so on to the negative main Y. When the contactors 37 38 pick up, they also close the interlocks 45 46 in a branch circuit 35' from the wire 35 which includes the coil of the contactor 47. The energizing of this coil short circuits the resistance coil 43 and closes an interlock 48 which controls a branch circuit through the coil of con-

tactor 49. This short circuits the other resistance 44 and puts the motor up to full speed. The interlock 46 has a high resistance holding coil 50 in a shunt 51 around the resistances 43 44; and the interlock 48 has a low resistance holding coil 52 in series with the power circuit. These coils 50 52 prevent their interlocks from closing until the current in the power circuit has dropped to a given value. A second interlock 54 is opened by the contactor 37 when it picks up, thereby opening a control circuit which branches from the control conductor 18 through the wire 55, passes through the interlocks 56 54 on the contactors 39 37 respectively, thence through the actuating coil of the contactor 57 and on out to the negative conductor 25. The contactor 57 short circuits part of a resistor 58 which is permanently connected across the terminals of the motor 7. A high resistance holding coil 59 in shunt to said resistor retards the closing of an interlock 60 which controls a contactor 61 whose closing short circuits the remainder of the resistor 58, and puts the motor on a dead short circuit. The resistor 58 is put back in circuit when the contactor 37 picks up and opens the interlock 54 in the control circuit 55. If the "down" relay is the one which has closed, then current will flow through the wire 36 to the interlock 62 controlled by the contactor 37, and will divide between the contactors 39 and 40. When these pick up they close the interlocks 63 64 controlling the branch circuit 36′ from the wire 36 which at the interlock 64 connects with the circuit 35′ and cuts out the resistance coils 43 44 as before. The motor will now be running at full speed, but the current flows through the field coil F and armature A from right to left, so that the direction of the motor is reversed.

Having thus described the motor control and power circuits and the connection therewith of the "up" and "down" relays, I will now turn to the limit switches 6 15 and the master switch 19. The "up" relay, which causes the motor 7 to raise the middle roll 2, is connected with the right hand or lower portion of the switch 15: the "down" relay being connected with the left hand portion thereof. During the rotation of this switch by the motor 7, the contact fingers k', etc. pass from one portion to the other in succession, breaking circuit at the gaps in the segments. The button l in the master switch is always alive, and the button k will become alive as soon as the fingers a' b' make contact with the segments a b of the screw-down switch. The operation can best be explained by taking an example or two. Assume that the middle roll 2 is resting on the lower roll 3 with the upper roll 1 at its highest position, that is, somewhere in the region indicated by the line 11. A billet has been passed between rolls 1 and 2 and is ready to be passed back between 2 and 3. In order to effect a reduction in the thickness of the billet, the space between rolls 2 and 3 must be less than that which now exists between rolls 1, and 2, and yet roll 2 must be backed up by the upper roll to give it rigidity. This means that the upper roll must be lowered by an amount equal to the desired reduction in the thickness of the billet. Moreover, the motor attached to the platform 11 must lower it far enough to let the counterweight 14 lift the roll 2 into firm contact with the lowered upper roll but must stop as soon as the platform has dropped slightly away from said counterweight. Assume that an attendant screws down the upper roll into the region indicated by the dotted line 9. This operation also rotates the switch 6 until the tier of fingers a', b', etc., register with the territory marked 9 in Fig. 1. The finger a' will be on segment a and the finger f' on segment f, all other fingers of this switch being out of contact with their segments. The middle roll being in its lowest position, its switch 15 will stand in the position shown. Current will then flow from the switch 16′ by way of the wire 18 to the finger a', segment a, segment f, finger f', finger f^3, right-hand part of segment f^2, segment h, finger h', wire 21, relay coil 22, and wire 25 to switch 16′. The "up" relay will at once pick up, causing the interlock 26 to bridge the contacts 28. An attendant now shifts the master switch until segment p rests on buttons l, m, and o. This sends current from the switch 16′ by way of wires 18, 18′, button l, segment p, button m, wire 34, contacts 28, contacts 30, and wire 35 to the coils of the "up" contactors 37 38, starting the motor, as before described, to let the roll 2 rise. The closing of the switch 16′ has placed the motor armature A and field coil F on a dead short circuit by cutting out the resistor 58. But the picking up of the power contactor 37 breaks the control circuit 55 at the interlock 54 and allows the contactors 57 61 to open again, thus restoring the resistor 58 to the shunt around the armature and series field and forcing the power current to flow through said armature and field.

As soon as the motor commences to run, the counterweight 14 begins to lift the roll 2, and the motor also rotates the switch 15. When the break in the segment f^2, arrives at the finger f^3, the ninth station has been reached, and this interruption of the circuit deënergizes the relay coil 22 so that the interlock 26 drops and opens the control circuit 35; the effect of which is to open the contactors 37 and 38 and cut off the power

current. The circuit 55 is also reëstablished, cutting out the resistor 58 which was in circuit while the motor was running, and closing the motor armature on a short circuit, containing no resistance, so that, running by momentum, said motor acts as a generator and stops almost instantly, with the platform 11 a short distance below the counterweight 14. The billet is now passed through between the middle roll and the lower roll, after which the middle roll must be brought down to its former position on the lower roll, and the upper roll must be lowered again to further reduce the space between it and the lowered middle roll to effect another reduction in the thickness of the billet.

A quick lowering of the middle roll can be effected by throwing over the master switch 19 until the segment r rests on the buttons k, l and n. This sends current from the switch 16′ by way of the wires 18 18′, button l, segment r, button k, wire 20, finger b^3 (which is now resting on the segment b^2 at position 9), segment i, finger i', and wire 23 to the "down" relay coil 24, and wire 25 to switch 16′. The "down" relay picks up, bridging the contacts 31 and closing a circuit from the segment r by way of button n, wire 32, one contact 27, contacts 31 and wire 36 to the down contactors 39 40. The motor at once begins to turn backward, raising the platform 11 and lowering the roll 2 and also rotating the switch 15 backward until the first or lowest position is reached, when the relay circuit is broken at the finger b^3, the "down" relay drops, and the motor stops as before with roll 2 resting on roll 3. The screw-down operator now screws down the upper roll to the desired new position; say somewhere in the territory of the station 8; the switch 6 turning to said position at the same time. Both relays are down and no current can flow to the motor until an attendant throws over the master switch to return segment p to its position on buttons l, m and o. Current then passes from the main X by way of the switch 16′ to wire 18, finger a', segment a, segments e f, fingers e' f', fingers e^3 f^3 and the right hand portions of segments e^2 f^2, segment h, finger h', and wire 21 to the "up" relay coil 22. Again the motor starts to let the roll 2 come up toward the eighth station, and the switch 15 turns with it. The finger e^3 arrives at the break in segment e^2 when it reaches the seventh position, but current continues to flow to the relay through finger f^3 until the eighth position is reached. The finger e^3 has now passed over upon the left hand portion of its segment e^2, so that although the "up" relay is still energized through the segment f^2, yet current will flow from finger e^3 to the segment i, finger i', wire 23 and solenoid 24, so that the interlock 29 will be opened and will break the control circuit 35 at contacts 30 and stop the motor. Both relays are now in their raised positions and yet the effect is the same as when both were down; that is, the motor cannot run. The middle roll is now shifted to its original position again by throwing over the master switch to bring the segment r into service. The relays are both raised, but the current by way of the button n will energize the "down" contactors as before. The "down" relay will drop when the switch 15, turning with the middle roll, arrives at position 1, and the finger b^3 runs off its segment b^2. The "up" relay still remains energized through the fingers e', f', e^3 f^2. Now if the operator screws down roll 1 to a new position, the fingers e', f' may slide off their segments, but the circuit of the relay coil 22 will be maintained by other fingers closing on their segments before e' f' open. When the upper roll and the switch 6 arrive at the new position and the plate has made the upper pass, the operator of the master switch 19 merely throws it over to bring segment p into service, which will send current through the "up" control circuit 35, and lift the middle roll to the position required for the lower pass. In this way, the upper roll can be gradually lowered, and after each upper pass of the plate the middle roll will lift just far enough to come into firm contact with the upper roll, ready for the lower pass. If the motor overruns at either end of its travel no harm will be done, owing to the loose contact of the platform 11 with the weight 14 at one end of the levers 12, and the similar connection of the open hooks at the other end of said levers with the journal boxes of the middle roll.

In case the middle roll has been lifted and the screwdown operator proceeds to screw down the upper roll and thereby push down the middle roll also, it is desirable that the motor be started to cause the platform to follow up the weight 14. Both relays are down. The limit switches stand at say position 9. When switch 15 moves to the next position (8) finger e' will make contact with its segment e and will send current to finger e^3 which is resting on the left hand portion of the segment e^2. This will cause the "down" relay to pick up and close the circuit from the button o in the master switch to the contacts 27 bridged by the interlock 26, contacts 31, and the "down" control circuit 36. The roll 2 will therefore be dropped by the motor at the same rate of speed that the upper roll is screwed down. If, on the other hand, the operator had screwed the upper roll upwardly while the middle roll was in contact with it, the "up" relay would have been energized again through segment g, the connected fingers g' g^3 and the segment g^2; so that the roll 2 would have followed up the upper roll.

In accordance with the provisions of the patent statutes, I have described the principle of operation of my invention together with the apparatus which I now consider to represent the best embodiment thereof; but I desire to have it understood that the apparatus shown is only illustrative, and that the invention can be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. The combination with an electric motor, of a movable machine element actuated thereby, a limit switch moving synchronously with said element, a second limit switch controlled by an attendant, and a master-switch controlled by an attendant.

2. The combination with an electric motor, of a movable machine element actuated thereby, contactors controlling the power circuit of said motor, relays controlling said contactors, and two limit switches controlling said relays, one limit switch being controlled by an attendant and the other moving synchronously with said moving element.

3. The combination with an electric motor, of a movable machine element actuated thereby, two or more contactors or sets of contactors controlling the direction of rotation of said motor, a relay controlling each contactor or set thereof, and each relay controlling both control circuits, said circuits being open when both relays are in either their upper or lower positions, and limit switches controlling said relays.

4. The combination with a three-high rolling mill, of an electric motor for raising and lowering the middle roll, "up" and "down" contactors controlling the power circuit of said motor, "up" and "down" relays both controlling the two control circuits of said contactors, a limit switch moving with the vertical adjustment of the upper roll, and a limit switch moving with the middle roll, said limit switches controlling said relays.

5. The combination with a three-high rolling mill, of an electric motor for raising and lowering the middle roll, "up" and "down" contactors controlling the power circuit of said motor, "up" and "down" relays both controlling the two control circuits of said contactors, a limit switch moving with the vertical adjustment of the upper roll, and a limit switch moving with the middle roll, said limit switches controlling said relays, and a master-switch provided with means for energizing the "down" relay when said middle roll switch is in any but its lowest position.

6. The combination with a three high rolling mill, of an electric motor for raising and lowering the middle roll and means whereby the amount of lift of said roll is controlled by the position of the upper roll.

7. The combination with a three-high rolling mill, of an electric motor for raising and lowering the middle roll, means whereby the lift of said roll is controlled by the position of the upper roll, and means for causing said middle roll, when lifted, to follow the changes in position of said upper roll.

8. The combination with an electric motor, of two relays controlling respectively its two directions of rotation, and two limit switches controlling said relays, said switches having a plurality of fingers and coöperating segments, and said segments overlapping at their ends so that a greater number of limit positions is afforded than the number of segments.

9. The combination with an electric motor of two controllers in circuit therewith, one having a plurality of stepped and overlapping segments, and the other having a plurality of interrupted segments, the interruptions being stepped.

10. The combination with an electric motor of two controllers in circuit therewith, one having a plurality of stepped and overlapping segments, and the other having a plurality of interrupted segments, the interruptions being stepped, a group of fingers for each controller, and connections between corresponding fingers in said groups.

11. The combination with an electric motor, of a plurality of contactors for controlling the same, a pair of relays each having an "up" and a "down" position for controlling said contactors, and means whereby said motor circuit is opened when both relays are in either the "up" or the "down" position.

In witness whereof, I have hereunto set my hand, this 18th day of August 1911.

ROBERT H. McLAIN.

Witnesses:
BENJAMIN B. HULL,
HELEN ORFORD.