Dec. 18, 1928. 1,695,886

W. M. DANN ET AL

TAP CHANGER SYSTEM

Filed March 31, 1926 5 Sheets-Sheet 1

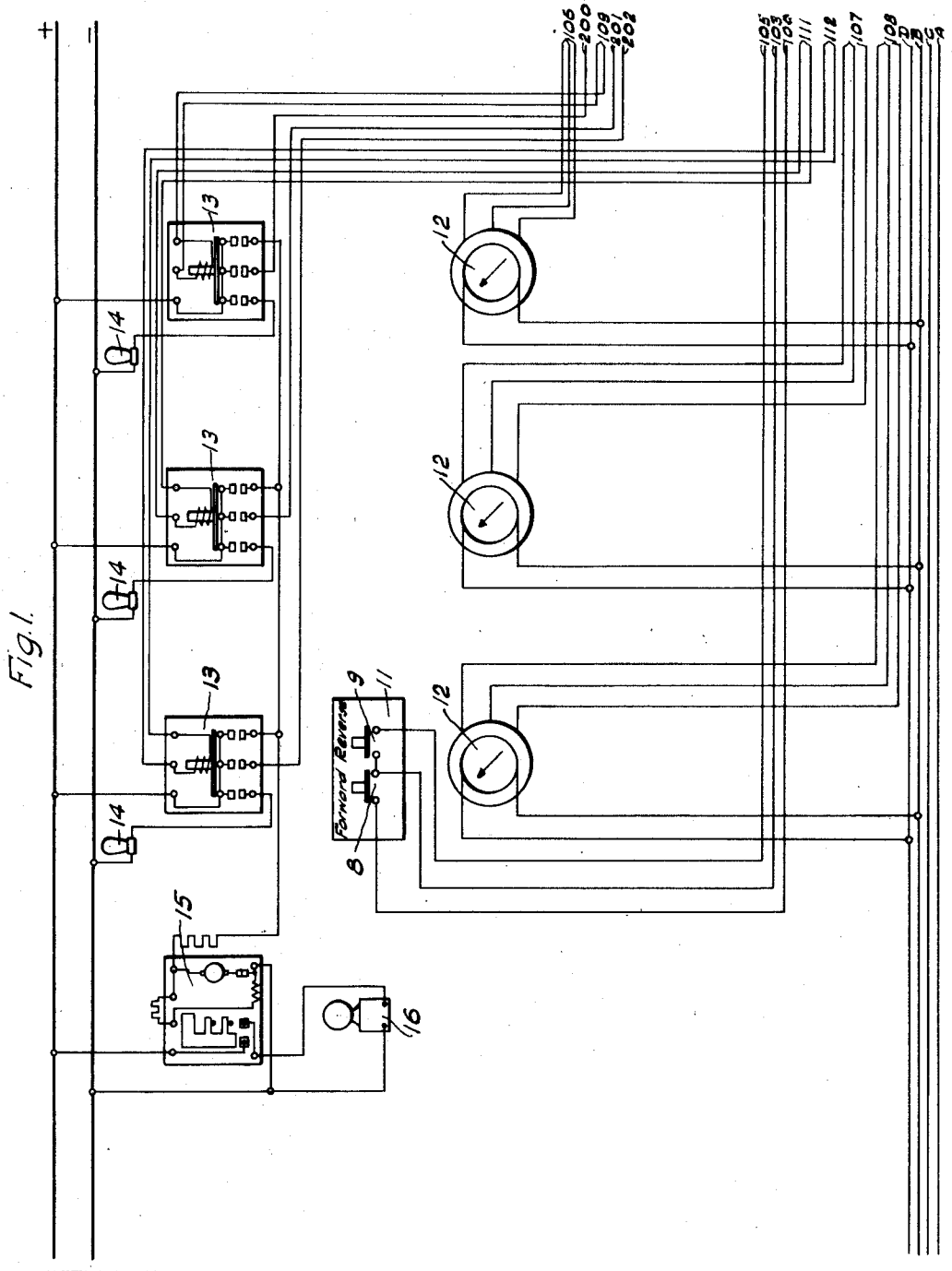


Fig. 1.

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TAP CHANGER SYSTEM

Filed March 31, 1926 5 Sheets-Sheet 2

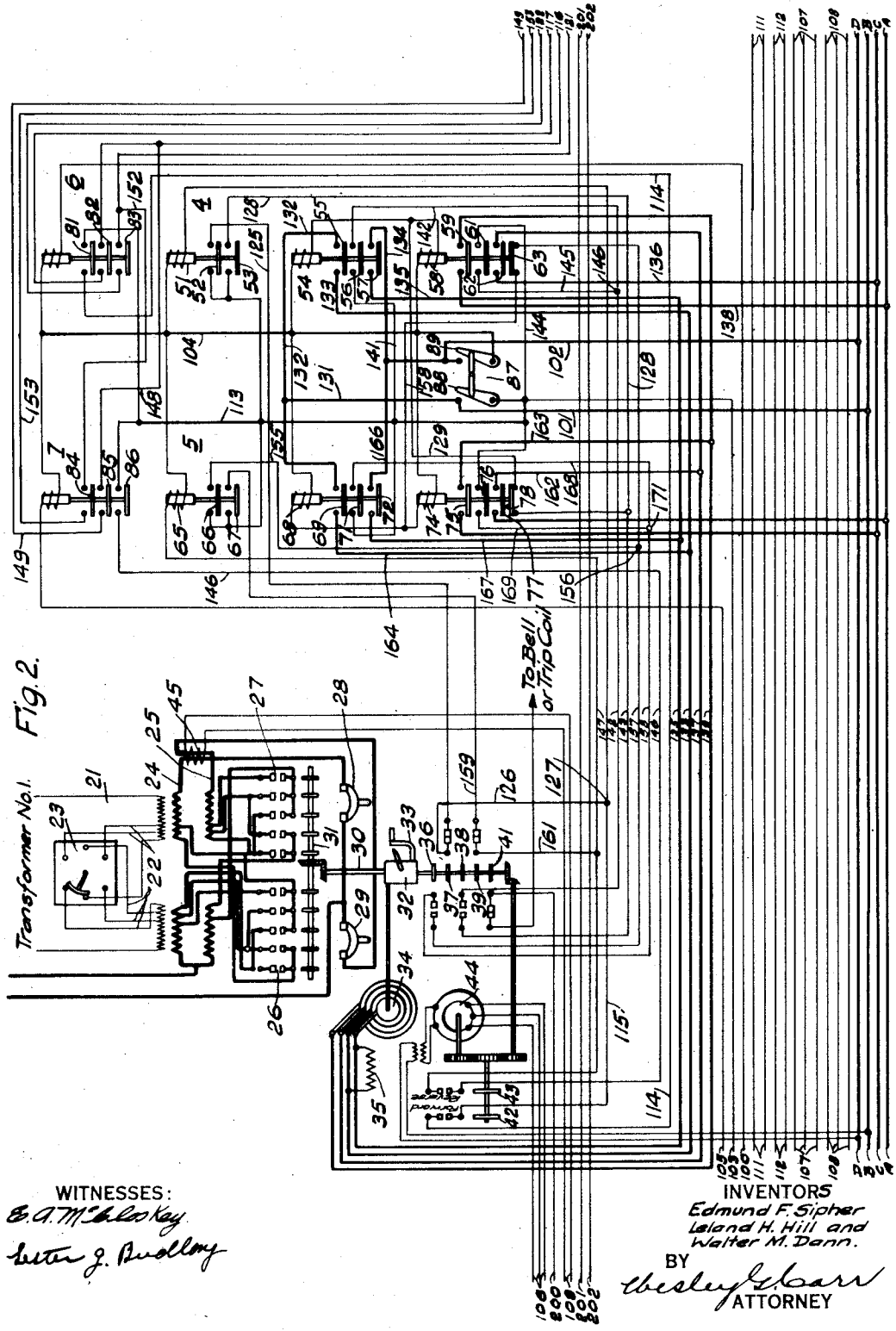


Fig. 2.

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TAP CHANGER SYSTEM

Filed March 31, 1926 5 Sheets-Sheet 3

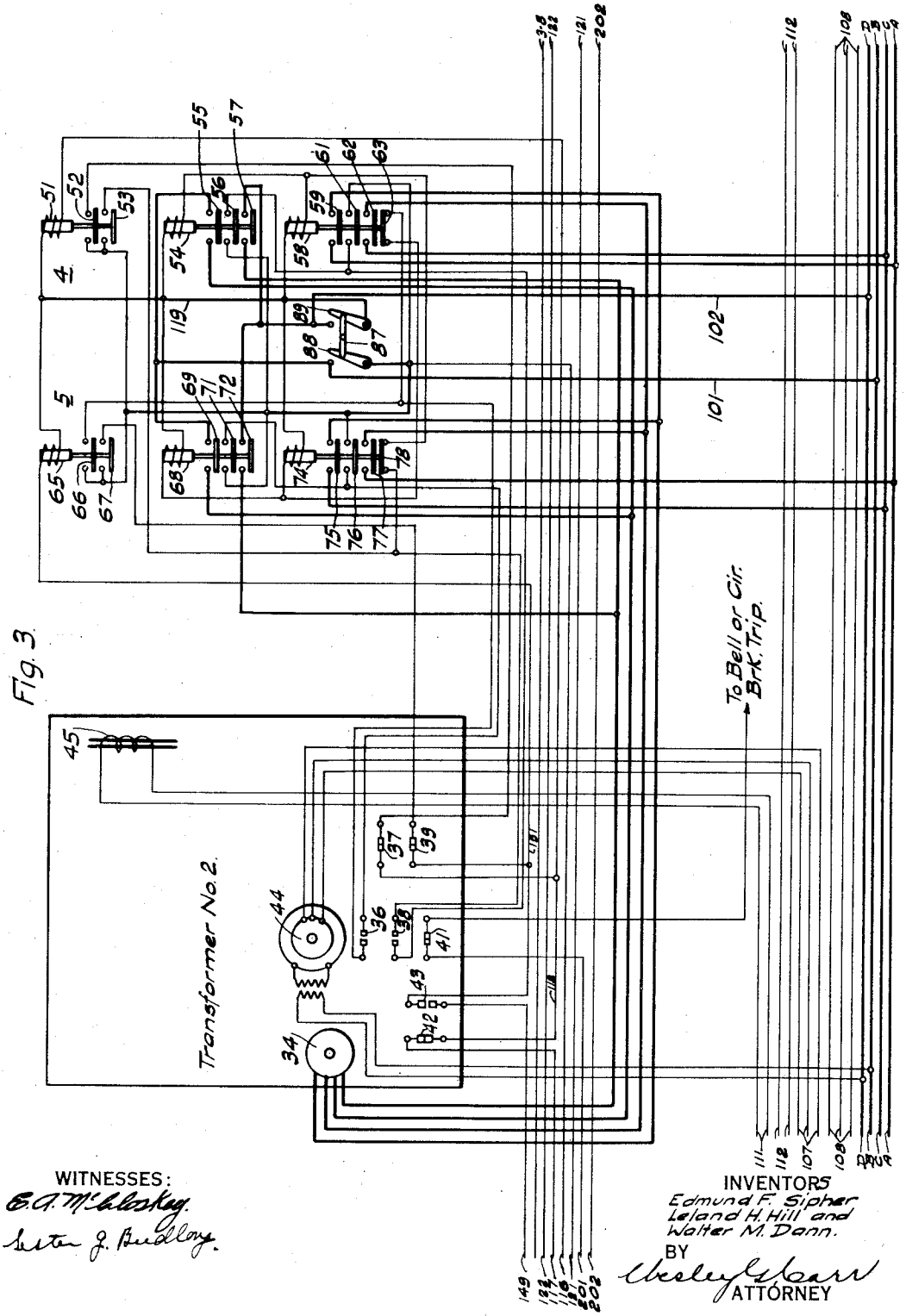


Fig. 3.

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TAP CHANGER SYSTEM

Filed March 31, 1926 5 Sheets-Sheet 4

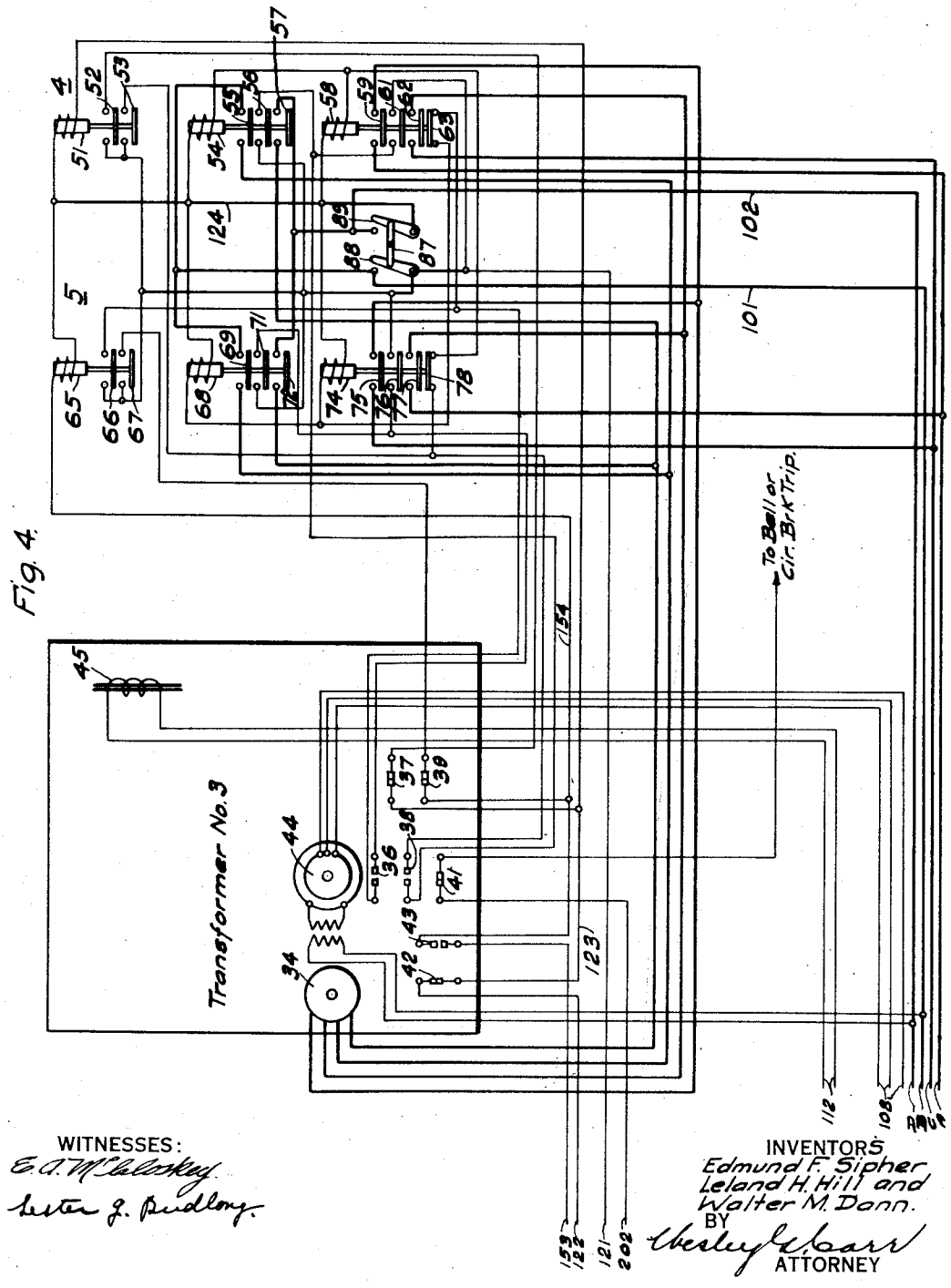


Fig. 4.

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TAP CHANGER SYSTEM

Filed March 31, 1926 5 Sheets-Sheet 5

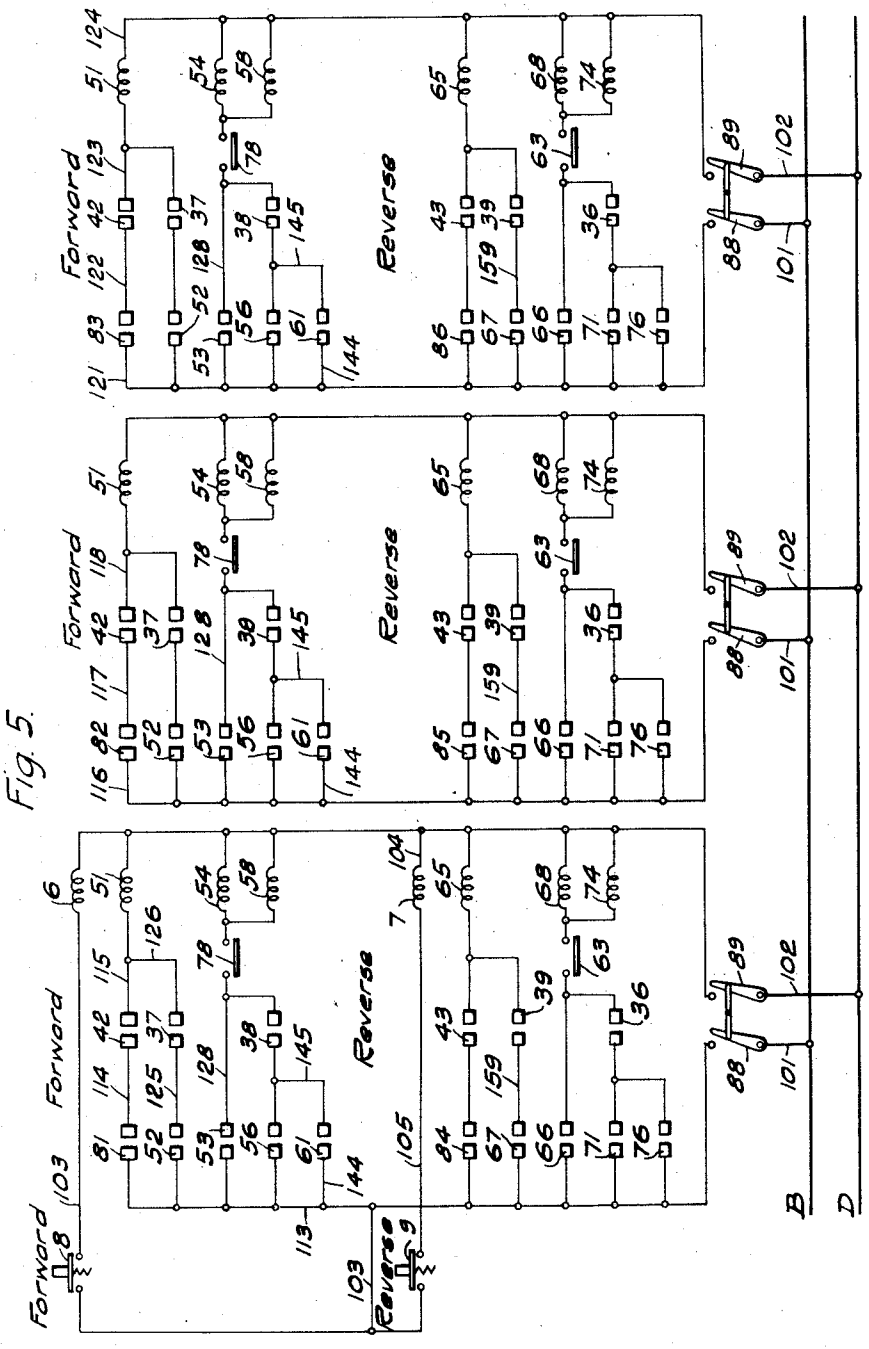


Fig. 5.

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Patented Dec. 18, 1928. 1,695,886

UNITED STATES PATENT OFFICE.

WALTER M. DANN AND LELAND H. HILL, OF SHARON, AND EDMUND F. SIPHER, OF WILKINSBURG, PENNSYLVANIA, ASSIGNORS TO WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA.

TAP-CHANGER SYSTEM.

Application filed March 31, 1926. Serial No. 98,826.

Our invention relates to transformer tap-changing apparatus and particularly to systems of control therefor.

One object of our invention is to provide a system for simultaneously controlling the changes in the voltage ratios of a plurality of connected transformers.

Another object of our invention is to provide a system of control for transformers supplying a circuit such that the transformer ratios of the individual transformers may be changed either independently or in unison.

Another object of our invention is to provide a system of control for a plurality of tap-changing mechanisms associated with separate transformers such that the operation of a single remotely disposed control switch shall initiate the operation of the several tap-changing mechanisms.

A further object of our invention is to provide a system of control for a plurality of tap-changing mechanism associated with separate transformers such that the tap-changing mechanisms may be operated in a forward or a reverse direction from a remotely disposed switch panel and in which system of control provision is made for insuring against damage to the component parts thereof by reason of the improper actuation of one or more switches on the switch panel.

Our system for controlling tap-changing mechanisms is particularly adapted for use with the tap-changing system shown and described in the copending application of Walter M. Dann, L. H. Hill, A. W. Thompson and C. L. Knotts, Serial No. 101,246, filed April 12, 1926, and which is assigned to the Westinghouse Electric & Manufacturing Company, although our invention is not necessarily limited to such application.

In the mechanism of the application, the low tension windings of the transformer comprise parallel windings, each of which is equipped with a plurality of tap connections. When it is desired to change the ratio of the transformer, one of these windings is opened, thereby causing the other winding to temporarily assume the entire transformer load, while the connections of the first mentioned winding are changed, after which that winding is put back in service and the tap connections of the other winding similarly varied.

The tap-changing mechanism comprises a shaft that is either motor driven or manually operable and that is geared to make one complete revolution for adjusting both parallel windings of a transformer through one step. A system of pilot switches are connected to the shaft for cooperation with a plurality of series of contactors to cause the motor to turn the shaft through one revolution upon the initiation of such operation by the manipulation of a suitable control switch. Our invention relates to the operative connections between the several series of relays, motors and controlling switches.

According to our invention, the several motors may be caused to move in a forward or a reverse direction by the selective operation of either of a pair of control switches placed on an operator's panel at any suitable point, either near, or remote from, the transformers

According to our system of control, the operation of one switch causes a master relay associated with one of the transformer units to be energized. The energization of the master relay causes a series of contractors associated with each of the transformers and connected to the pilot switches on the tap-changing mechanism to complete a predetermined cycle of operations independently of the initiating switch. In order to provide for both forward and reverse operation of the several motors, it is necessary to provide two series of contactors for each transformer unit which differ from each other only in that they change the connections of one of the phases of a supply circuit to the several motors.

In the accompanying drawings, Figure 1 is a diagrammatic view of circuits and apparatus comprising an operator's panel embodying our invention;

Fig. 2 is a diagrammatic view of circuits and apparatus representing the first trans-

former in a transformer bank, together with a control panel having a master relay thereon;

Figs. 3 and 4 are diagrammatic views of circuits and apparatus comprising the second and third transformer units, together with their control panels; and

Fig. 5 is a schematic wiring diagram of our control system applied to a three-phase transformer bank.

A complete wiring diagram of a three-phase transformer bank equipped with our invention is had by placing Figs. 1, 2, 3 and 4 end-to-end.

Our invention comprises, in general, three similar single-phase transformers 1, 2 and 3 each of which is provided with a similar tap-changing mechanism and a control panel that includes a series of contactors 4 and 5 for causing the associated tap-changing mechanism to operate in a forward or reverse direction, as the case may be.

The control panel for the transformer 1, in addition to the series of contactors 4 and 5, is provided with a pair of master relays 6 and 7 that are connected, respectively, to the several series of contactors 4 and 5 of all the transformers. The master relays 6 and 7 are respectively controlled by forward and reverse control switches 8 and 9 mounted on an operator's panel 11 at any suitable place remotely disposed from the transformer units themselves, such as a power house switchboard.

Referring particularly to Fig. 1, the operator's station comprises a plurality of position-indicating devices 12 that are connected to the several tap-changing mechanisms and a plurality of relays 13 that are also connected to the several transformers in the bank for controlling indicating lamps 14 and a time-limit relay 15 that controls a secondary alarm 16, such as a bell or a circuit interrupter. The several relays 13 are operated by conditions of unbalance existing in their associated transformers. The details of the connections and operation of the relay system comprising the relays 13 and 15 are shown and described in the application of H. W. Smith, Serial No. 98,703, filed Mar. 31, 1926, which is assigned to the Westinghouse Electric & Manufacturing Company, although other protective relay systems may be employed in combination with our system of control.

Referring particularly to Fig. 2, there are shown in outline the details of transformer No. 1 in the bank and its associated tap-changing mechanism. Inasmuch as the details of the transformers and tap changing mechanisms are identical for the several transformers in the transformer bank, only one of the tap-changing mechanisms is described in detail.

The transformer comprises a high-tension winding 21 that is provided with a plurality of tap connections 22 controlled by a manually-operated tap-changing device 23. The low-tension winding of the transformer comprises a pair of parallel connected windings 24 and 25, each of which is provided with a plurality of tap connections connected to a plurality of cam-operated switches constituting groups 26 and 27. Under normal operating conditions, one of the switches in each of the groups 26 and 27 is closed, thereby completing the secondary winding.

In order to prevent arcing between the switches of groups 26 and 27, circuit interrupters 28 and 29 are provided for interrupting and completing the circuits of the windings 24 and 25, respectively. The circuit interrupters 28 and 29 are mechanically connected to a main driving shaft 30 that also drives a shaft 31 on which are mounted the cams of the respective cam operated switches 26 and 27. The main driving shaft 30 is connected by a clutch 32 to either a manually operated handle 33 or a motor 34. For the purpose of the present invention, the operation of the tap changer by means of the handle 33 will not be discussed, as our invention relates to the control of the motor 34. The motor 34 is provided with a magnetic brake 35 to prevent overtravel.

The shaft 30 operates a plurality of cam-operated switches 36, 37, 38, 39, 41, 42 and 43. The switches 42 and 43 constitute forward and reverse limit switches, respectively, for the tap-changing device. The shaft 30 also drives a position indicator 44 that cooperates with, and controls the position of, the corresponding position indicator 12 shown in Fig. 1 through a circuit to be hereinafter described.

The pilot switches 37, 39 and 41 are normally closed when the transformer is in its operative position, that is, with both of the windings 24 and 25 in circuit. However, these switches open during the cycle of tap changing during which period the switches 36 and 38 are closed and opened, as will be more fully described hereinafter. The tap changing mechanism is so designed that one complete revolution of the shaft 30 will cause the voltage of windings 24 and 25 to be either raised or lowered by one step, as may be desired, and, accordingly, the pilot switches 36 to 41, inclusive, are caused to open and close their respective circuits once in each revolution of the shaft 30.

The switch 41 is connected to its associated relay 13 and to a bell or circuit breaker trip coil (not shown), and, accordingly, constitutes a portion of the protective relay system and need not be further considered for the purposes of the present invention. The transformer windings 24 and 25 are oppositely threaded through a current transformer 45 for energizing its associated relay

13 when a condition of unbalance exists between the windings 24 and 25.

The series of relays 4 consists of a two-pole contactor 51 having contact members 52 and 53; a three-pole contactor 54 having contact members 55, 56 and 57; and a three-pole contactor 58 having contact members 59, 61, 62 and a back contact member 63. The series of contacts 5 includes a two-pole contactor 65 having contact members 66 and 67; a three-pole contactor 68 having contact members 69, 71 and 72; and a three-pole contactor 74 having contact members 75, 76, 77 and a back contact member 78. The forward master control relay 6 has a three-pole switch having contact members 81, 82 and 83, while the reverse master relay 7 has a three-pole switch having contacts 84, 85 and 86. A two-pole knife switch 87 having blades 88 and 89 is provided for connecting the several control circuits to a source of electromotive force.

When closed, the blades 88 of the several switches 87 are connected by conductors 101 to the B conductor of a two-phase four-wire alternating current supply circuit comprising conductors A, B, C, and D and, when closed, the blades 89 are connected by conductors 102 to the D conductor of the supply circuit. Accordingly, the entire system is operative only to the extent that the several switches 87 are closed.

Referring particularly to Figs. 1 and 2, the forward control switch 8 is connected to the master relay 6 by a circuit which extends from the blade 88 of transformer unit No. 1 through a conductor 103, the switch 8, a conductor 100, through the operating coil of the relay 6 to the conductor 104 and the blade 89 of the switch 87 associated with the transformer unit No. 1. The reverse switch 9 is connected to the master relay 7 by a circuit which extends from the conductor 103 at one terminal of the switch 8 through the switch 9, a conductor 105, the operating coil of the relay 7 and the conductor 104 to the switch blade 89.

The indicating devices 12 are connected to the corresponding controlling devices 44 of the transformers 1, 2 and 3 by three-conductor cables 106, 107 and 108, respectively. The several relays 13 are connected to the current transformers 45 of transformer units Nos. 1, 2 and 3 by pairs of conductors 109, 111 and 112, respectively. The several controlling devices 44 are directly connected to the BD phase of the supply circuit.

Upon the energization of the master relay 6 by closing push-button switch 8, a circuit is completed that extends from the switch blade 88 of transformer unit No. 1 through conductor 113, contact member 81, conductor 114, forward limit switch 42, conductor 115, operating coil of the contactor 51 and conductor 104 to switch blade 89. The circuit just traced initiates the operation of the series of contactors 4 for transformer unit No. 1 in a manner to be hereinafter described.

The closing of the master relay 6 completes a second circuit that extends from blade 88 of switch 87 associated with the transformer unit No. 2 through conductor 116, contact member 82 of relay 6, conductor 117, forward limit switch 42 of transformer unit No. 2, conductor 118, operating coil of relay 51 and conductor 119 to blade 89 of switch 87, associated with transformer unit No. 2. This circuit initiates the operation of the series of contactors 4 associated with the transformer unit No. 2 as will be explained later.

The master relay 6 completes a third circuit, also, which extends from switch blade 88 of switch 87, associated with transformer unit No. 3 through conductor 121, contact member 83 of relay 6, conductor 122, forward limit switch 42 of transformer unit No. 3, conductor 123, operating coil of contactor 51 associated with transformer unit No. 3 and conductor 124 to blade 89 of switch 87 of transformer unit No. 3. This circuit initiates the operation of the series of contactors 4 associated with the transformer unit No. 3, as explained below.

Since the operation of the series of contactors 4 of the transformer units 1, 2 and 3 are alike in performance, after their several contactors 51 are energized, only the detailed operation of the series of contactors associated with transformer unit No. 1 will be described. Upon the closing of the contactor 51 of transformer unit No. 1, a circuit is completed which extends from blade 88 of switch 87 through conductor 113 to contact members 52 and 53 in parallel circuit; from the contact member 52, through conductor 125 pilot switch 37, conductor 126, terminal 127 attached to conductor 115, conductor 115, operating coil of contactor 51 and conductor 104 to the blade 89. This circuit energizes the operating coil of the contactor 51 independently of the master relay 6. The circuit through the contact member 53 extends through conductor 128, back contact 78 of the contactor 74, conductor 129, operating coils of the contactors 54 and 58 in parallel circuit and conductor 104 to switch blade 89. The completion of this circuit energizes the contactors 54 and 58 but dependent upon the continued closure of the contactor 51. Since the interlock 78 on the contactor 74 is in series with the operating coils of the contactors 54 and 58, it is impossible to energize the contactors 54 and 58 so long as the contactor 74 of the series of reverse contactors 5 is energized, whereby an electrical interlock exists between the series of contactors 4 and 5.

Upon the energization of the contactors 54 and 58, the circuits to the motor 34 are completed through contact members 55, 57, 59 and 62 by four circuits which are as follows:

(*a*) From B conductor of the supply circuit through conductor 101, conductor 131, conductor 132, the contact member 55, and conductor 133 to motor 34.

(*b*) From the D conductor of the supply circuit through conductor 102, conductor 134, contact member 57 and conductor 135 to motor 34.

(*c*) From the C conductor of the supply circuit through conductor 136, contact member 62 and conductor 137 to motor 34.

(*d*) From the A conductor of the supply circuit through conductor 138, contact member 59 and conductor 139 to motor 34.

The motor 34 is thus energized by having the brushes reading downwardly energized in the order A, C, B, D, which causes the motor to turn in the forward direction, thereby raising the voltage ratio of the transformer unit No. 1.

The energization of contactors 54 and 58 also completes two circuits for energizing their operating coils independently of the contact member 53 controlled by the contactor 51. One of these circuits extends from switch blade 88, through conductor 113, conductor 141, contact member 56, conductor 142, pilot switch 38, conductor 143, interlock 78, operating coils of the contactors 54 and 58 in parallel circuit and conductor 104 to blade 89. The other circuit extends from switch blade 88 through conductor 144, the contact member 61, conductor 145, terminal 146 connected to the conductor 142, pilot switch 38, conductor 143, and interlock 78 to the operating coils of the contactors 54 and 58.

Referring particularly to Fig. 5, the motor 34 having become energized turns the shaft 30 which causes the pilot switch 38 to close, thereby completing the circuits just traced after which the opening of pilot switch 37 results in the opening of the contactor 51, provided the operator does not continue to hold the switch 8 closed. The contactor 51, in opening, opens the contact members 52 and 53 with the result that the contactors 54 and 58 are energized through the contact members 56 and 61, the pilot switch 38 and interlock 78. The latter circuit is, accordingly, independent of the master relay 6 and the contactor 51. In the event that the operator still holds the switch 8 closed, no damage results to the apparatus and the tap-changing operation continues regardless.

At the end of the tap-changing operation, pilot switch 38 is opened, thereby interrupting the circuit through the coils of contactors 54 and 58 and the latter fall open, thereby interrupting the motor circuit through contact members 56, 57, 59 and 62. Shortly before the pilot switch 38 is opened, the pilot switch 37 is again closed, thereby placing the system in condition to repeat the cycle of operations, whenever it is desired to adjust the voltage ratio of the transformer through another step. In the event that the operator holds the switch 8 closed, there is no pause between the successive operations unless the tap-changing device has reached a position where the forward limit switch 42 has been opened, in which event it is impossible to energize the operating coil of the contactor 51.

When it is desired to reverse the direction of the motor 34 or to lower the voltage ratio of the several transformers, the operator presses the switch 9 which energizes the master relay 7, thereby completing the following circuits: (*a*) from the switch blade 88 of the transfromer unit No. 1, through conductor 113, contact member 86, conductor 146, reverse limit switch 43 of transformer unit No. 1, conductor 147, operating coil of relay 65 and conductor 104 to switch blade 89; (*b*) from switch blade 88 of transformer unit No. 2, through conductor 116, conductor 148, contact 85, conductor 149, reverse limit switch 43 of transformer unit No. 2, conductor 151, operating coil of relay 65 of transformer unit No. 2 and conductor 119 to switch blade 89 of transformer unit No. 2; and (*c*) from switch blade 88 of transformer unit No. 3, through conductor 121, conductor 152, contact member 84, conductor 153, reverse limit switch of transformer unit No. 3, conductor 154, and operating coil of contactor 65 of transformer unit No. 3 and conductor 124 to switch blade 89. Accordingly, the contactors 65 of the transformer units Nos. 1, 2 and 3 are energized and complete circuits for operating the series of contactor 5 of the several transformer units.

Referring particularly to transformer unit No. 1, the energization of the contactor 65 completes two circuits extending from switch blade 88 through conductor 113 to contact members 66 and 67 in parallel: (*a*) The circuit from contact member 67 extends through conductor 159, pilot switch 39, conductor 161, conductor 147, operating coil of contactor 65, conductor 104 to switch blade 89 and (*b*) from contact member 66, the circuit extends through conductor 155 to terminal 156 connected to conductor 157, interlock 63, conductor 158, the operating coils of the contactors 68 and 74 in parallel circuit to conductor 104 and the switch blade 89. The completion of this circuit controls the series of contactors 5 independently of the master contactor 7.

The energization of the contactors 68 and 74 connects the motor 34 across the supply circuit according to the following circuits:

(a) from the supply conductor A through contact member 77, conductor 162, and conductor 137 to the motor 34; (b) from the C conductor of the supply circuit through contact member 75, conductor 163 and conductor 139 to the motor 34; (c) from conductor B of the supply circuit through conductor 101, conductor 131, contact member 69, conductor 164 and conductor 133 to motor 34; and (d) from the D conductor of the supply circuit through conductor 102, conductor 166, contact member 72, conductor 167, and conductor 135 to motor 34. Accordingly, the motor leads reading down from top are connected in the order C, A, B, D which causes the motor to run in the reverse direction. In the forward direction of rotation, the order is A, C, D, B.

As the motor continues to rotate, the several pilot switches 36 to 41, inclusive, are opened and closed in the same manner as during the forward movement of the motor. This operation of the pilot switches, in conjunction with the contactors 68 and 74, completes the following circuits: (a) from switch blade 88 through conductor 113, contact member 71, conductor 168, conductor 158, pilot switch 36, conductor 157 to terminal 156, and thence to interlock 63, operating coils of the contactors 68 and 74 in parallel circuit. The completion of this circuit permits the energization of the contactors 68 and 74 independently of the master relay 7 and the contactor 65, and the contactors 68 and 74 are dependent upon the pilot switch 36 for their further energization; (b) from from the switch blade 88 through the contact member 76, conductor 169, terminal 171 on conductor 158, conductor 158, pilot switch 36, conductor 157, interlock 63 and the operating coils of the contactors 68 and 74 in parallel circuit, and conductor 104 to the switch blade 89.

Referring particularly to Fig. 5, the sequence of operation of the tap-changing units may be readily traced. For the forward operation of the tap-changing units, the operator closes switch 8 which energizes the master relay 6. The closing of the master relay 6 completes a circuit through its contact member 81 and the forward limit switch 42 to energize the contactor 51. The energization of the contactor 51 causes it to close its contact member 52 which completes a holding circuit through contact member 57 and the pilot switch 37. From this point, the operation of the series of contactors 4 is independent of the operator's switch 8.

The energization of the contactors 51 also closes its contact member 53 and completes a circuit through an interlock on the series of reverse contactors 5 to energize the contactors 54 and 58. The closing of the contactors 54 and 58 energizes the motor 34 which starts to turn, thereby moving the several pilot switches 36 to 41, inclusive.

At the same time, the contactors 54 and 58 close their contact members 56 and 61, respectively, so that, as soon as the pilot switch 38 is closed by the operation of the motor 34, they complete their own holding circuits through the interlock 78. Shortly thereafter, the motor causes the pilot switch 37 to open, thereby deenergizing the contactor 51 and permitting its contact members 52 and 53 to open. Then the pilot switch 37 is closed, but, as the operator should have previously released the switch 8, the contactor 51 cannot again become energized until the operator manipulates the switch 8. At the completion of the cycle of operations of the tap-changing mechanism, the pilot switch 38 is opened, thereby deenergizing the contactors 54 and 58 and stopping the motor.

Since the contractors 51 of the three transformer units are energized by the contact members 81, 82 and 83 of the master relay 6, their operation goes through the same cycle substantially simultaneously with transformer unit No. 1. Such discrepancies as may exist between the operation of the several transformer units may be shown to the operator by means of the position indicators 12 and he should not again close his switch 8 until all the transformer units are in their desired position. Long continued delay in the operation of any transformer unit is cared for by the several relays 13 and the time-limit relay 15, which relays may serve to warn the operator of the existence of such condition or remove the troublesome transformer entirely from the circuit. The tap-changing systems are automatically prevented from travelling too far by the existence of the forward limit switches 42 which prevent the energization of the several contactors 51 of the several transformer units when the tap-changing units are in their extreme position.

In order to reduce the voltage ratio of the several transformers, the operator manipulates the switch 9 which energizes the relay 7 and through the contact members 84, 85 and 86 of the relay 7, the several contactors 65 of the transformer units are energized. The energization of contactor 65 results in the contact member 67 being closed which, through the pilot switch 39, completes a holding circuit for the contactor that is independent of the master relay 7.

The contact member 66 of the contactor 65 completes a circuit through electrical interlock 63 in the series of contactors 4 for energizing the contactors 68 and 64. The energization of the contactors 68 and 74 connects the motor 34 to the supply circuit with one of the phases reversed with re-

spect to the connections for forward operation. The energization of contactors 68 and 74 completes circuits through their contact members 71 and 76, respectively, such that, when the pilot switch 36 is closed as a result of movement of the motor 34, these contactors are energized independently of the contactor 65. Thereafter, the motor 34 continues to turn and the pilot switch 39 is opened, thereby deenergizing the contactor 65 and opening its contact members 66 and 67. After further operation of the motor 34 and its connecting shaft 31, the pilot switch 39 is again closed, but the contactor 65 remains deenergized. Shortly thereafter, the pilot switch 36 is opened, thereby deenergizing the contactors 68 and 74, thus causing the motor 34 to come to rest. Overtravel of the tap-changing mechanism in the reverse direction is prevented by the reverse limit switch 43 which, when open, prevents the initial energization of contactor 65.

It will thus be seen that we have devised a system for controlling a tap-changing mechanism associated with a plurality of transformers such that the operator initially actuates a single switch for controlling the operation of the tap changer in any direction. This switch controls a master relay that initiates a cycle of operation in a series of contactors associated with each transformer unit. A series of pilot switches associated with the series of contactors serves to make and break holding circuits for contactors such that, after the initiation of the cycle of operations, that cycle continues independently of the initiating relay. The pilot switches serve to reset the circuits after they have been opened preparatory to another cycle of operation.

It is to be understood that such changes may be made in the arrangement, connection and disposition of the component parts of our invention as may fall in the scope of the appended claims.

We claim as our invention:

1. In a transformer tap-changing system, a plurality of groups of windings, each winding having a plurality of tap connections, separate mechanisms for changing the tap connections of each group of windings and controlling means for simultaneously initiating the operations of said mechanisms but permitting the separate operation of the several mechanisms after the simultaneous initiation of their operations.

2. In a transformer tap-changing system, a plurality of groups of windings, each winding having a plurality of tap connections, separate mechanisms for changing the tap connections of each group of windings, a remotely disposed switch and a series of switches operatively connected thereto for simultaneously initiating the operations of said mechanisms but permitting the separate operation of the several mechanisms after the initial simultaneous initiation of their operations.

3. In a transformer tap-changing system, a plurality of groups of windings, each winding having a plurality of tap connections, separate mechanisms for changing the tap connections of each group of windings, a remotely disposed switch and a series of contactors for each mechanism connected thereto for simultaneously initiating the operations of said mechanism, said series of contactors serving to control the several mechanisms independently of the switch after their operation is initiated.

4. In a transformer tap-changing system, a plurality of groups of windings, each winding having a plurality of tap connections, separate mechanisms for changing the tap connections of each group of windings, a plurality of remotely disposed switches, and a plurality of series of contactors associated with each mechanism, one of the series of contactors of each mechanism being connected to each of the switches, whereby the manipulation of any switch causes the several mechanisms to be simultaneously set in motion in the same cycle of operation by the associated series of contactors.

5. In a transformer tap-changing system, a plurality of groups of windings, each winding having a plurality of tap connections, separate mechanisms for changing the tap connections of each group of windings, a plurality of remotely disposed switches, and a plurality of series of contactors associated with each mechanism, one of the series of contactors of each mechanism being connected to each of the switches, whereby the manipulation of any switch causes the several mechanisms to be simultaneously set in motion in the same cycle of operation by the associated series of contactors, the several series of contactors operating independently of said switches after their operation is initiated.

6. In a transformer tap-changing system, a plurality of groups of windings, each winding having a plurality of tap connections, separate mechanisms for changing the tap connections of each group of windings, a plurality of remotely disposed switches, and a plurality of series of contactors associated with each mechanism, one of the series of contactors of each mechanism being connected to each of the switches, whereby the manipulation of any switch causes the several mechanisms to be simultaneously set in motion in the same cycle of operation by the associated series of contactors, the series of contactors associated with each mechanisms being interlocked, whereby only a single series of contactors is effective at any time to control each mechanism.

7. In a transformer tap-changing system, a plurality of groups of windings, each winding having a plurality of tap connections, separate mechanisms for changing the tap connections of each group of windings, a plurality of remotely disposed switches, and a plurality of series of contactors associated with each mechanism, one of the series of contactors of each mechanism being connected to each of the switches, whereby the manipulation of any switch causes the several mechanisms to be simultaneously set in motion in the same cycle of operation by the associated series of contactors, the series of contactors associated with each mechanism being electrically interlocked whereby only a single series of contactors is effective at any time to control each mechanism.

8. In a transformer tap-changing system, a plurality of groups of windings, each winding having a plurality of tap connections, separate mechanisms for changing the tap connections of each group of windings, two series of contactors associated with each mechanism for controlling the direction of movement of the mechanism, and a remotely disposed switch connected to each of the series of contactors for initiating its operation.

9. In a transformer tap-changing system, a plurality of groups of windings, each winding having a plurality of tap connections, separate mechanisms for changing the tap connections of each group of windings, a remotely disposed switch and a series of contactors for each mechanism connected thereto for simultaneously initiating the operations of said mechanism, said series of contactors serving to control the several mechanisms independently of the switch after their operation is initiated and until a predetermined cycle of operation is completed.

In testimony whereof, we have hereunto subscribed our names this 2nd day of March, 1926, and this 26th day of March, 1926.

WALTER M. DANN.
LELAND H. HILL.
EDMUND F. SIPHER.