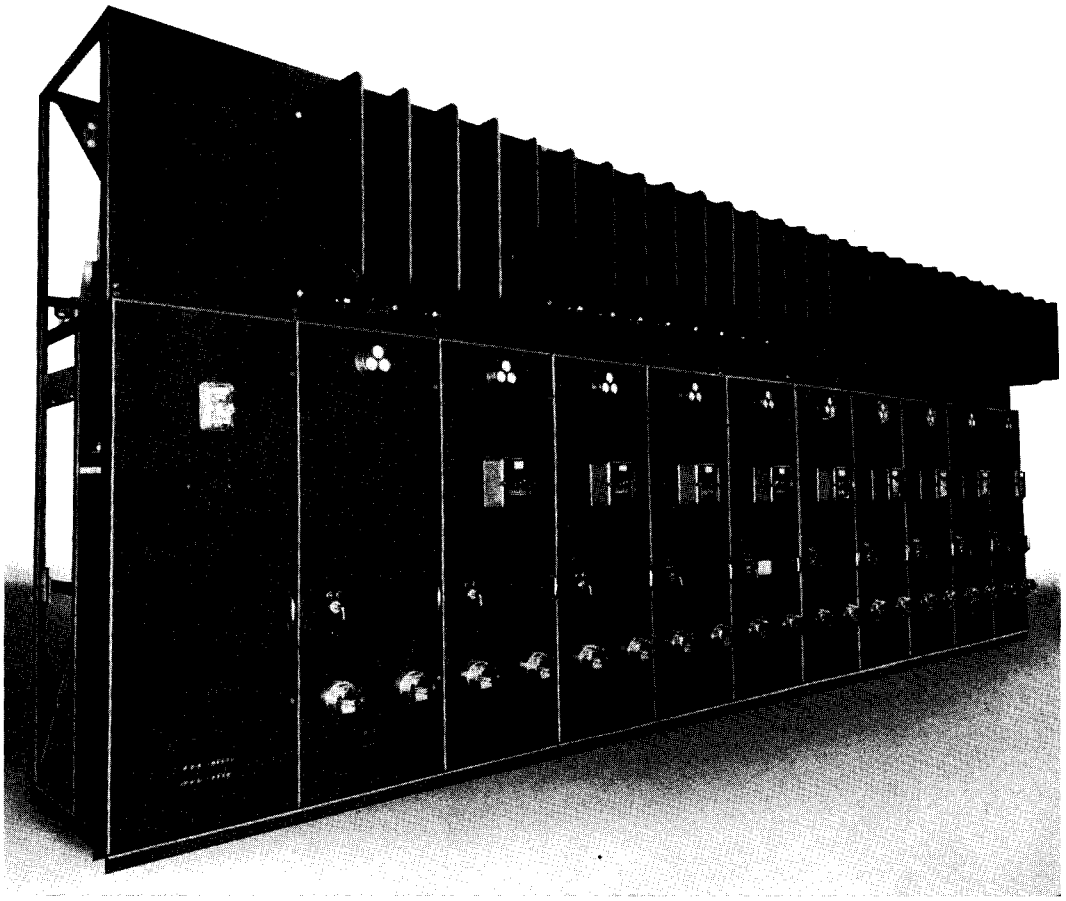
Westinghouse

Automatic Alternating-Current Feeder Reclosing Equipment

INSTRUCTION BOOK



A Typical Indoor Feeder Installation

Westinghouse Electric & Manufacturing Company

East Pittsburgh Works

East Pittsburgh, Pa.

I.B. 5466

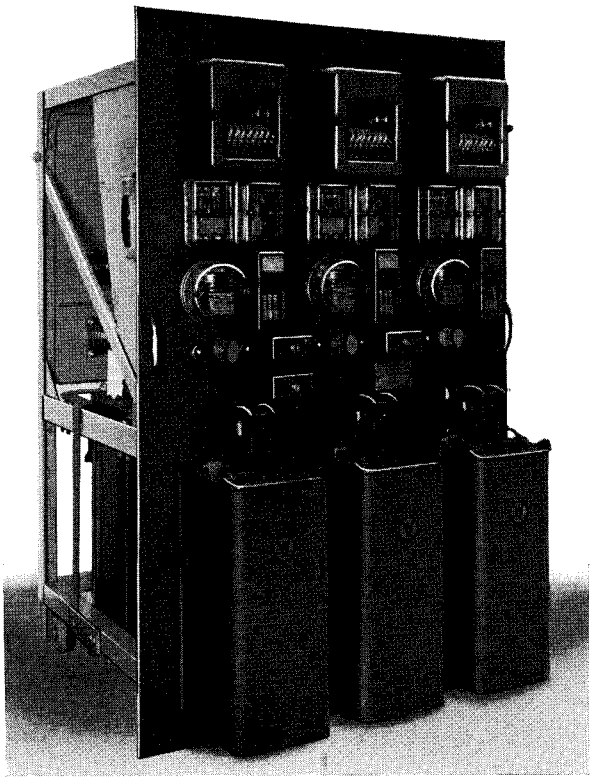


FIG. 1.—TYPICAL TRUCK FOR THREE-PHASE 4-WIRE SERVICE, EMPLOYING SINGLE POLE BREAKERS; EACH POLE WITH SEPARATE RECLOSING AND PROTECTIVE RELAY EQUIPMENT.

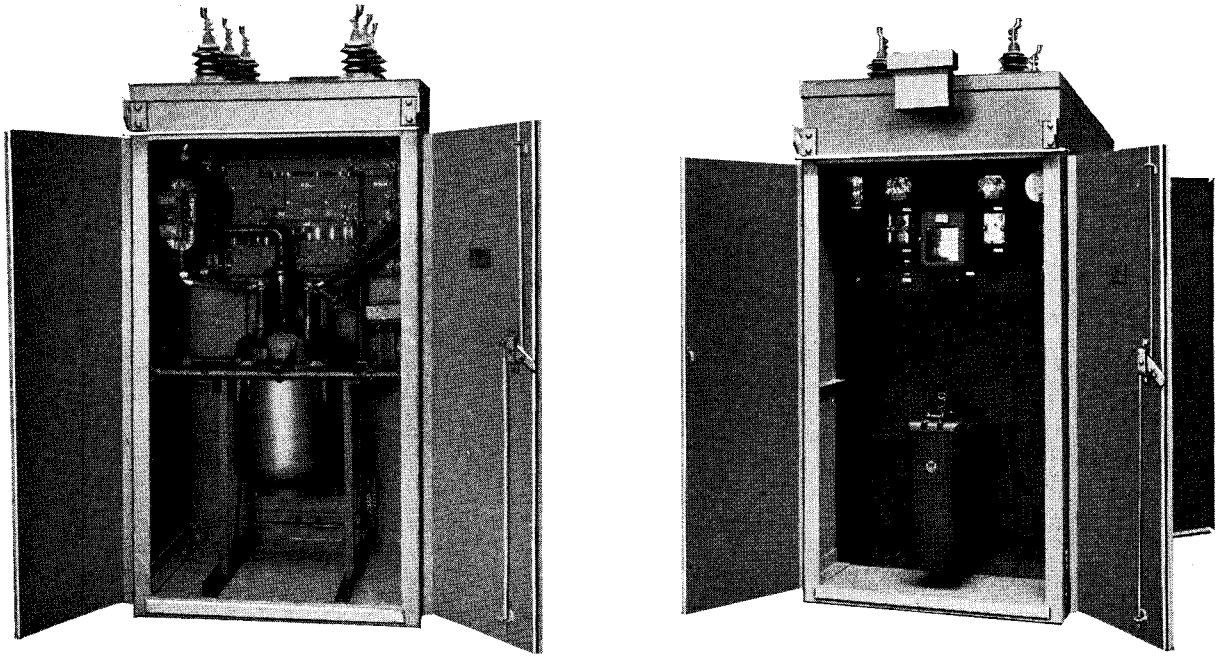


FIG. 1A—OUTDOOR SWITCHHOUSE WITH A-C. RECLOSING EQUIPMENT

Westinghouse
Automatic Alternating-Current Feeder Reclosing Equipment

Preliminary

In an attended station, the usual operating instructions direct that, when a feeder breaker opens due to a fault, the operator wait a definite length of time and then reclose the breaker. If after this first reclosure the breaker fails to remain closed, the operator follows a definite schedule for closing the breaker a predetermined maximum number of times. Reclosing Equipment described in this book operates to perform this closing function automatically in a manner simulating the action of an operator, the breaker being reclosed a predetermined maximum number of times. If the fault has not cleared the opening of the breaker an added time results in the locking out of the breaker, the automatic reclosing equipment being inoperative until the breaker is reclosed by an attendant. The periods between reclosures and the number of reclosures before an equipment is locked out are determined by the duty to which a breaker is subjected on a particular application. In general, it has been found that a cycle whereby a breaker is closed 15 seconds after its first opening, 30 seconds after its second opening, 75 seconds after its third opening and locked out on a fourth opening may be considered as a desirable standard. If the derating of a breaker for the above cycle makes it hazardous to use this particular timing a schedule imposing less hardship on the breaker should be arranged.

Automatic a-c. feeder reclosing equipment is suitable for controlling panel, cell, pipe frame, truck or outdoor frame mounted oil circuit breakers. The reclosing equipment may be panel mounted controlling outdoor breakers; may be mounted together with an indoor breaker in a steel switchhouse to form an outdoor equipment; or in the case of large outdoor oil circuit breakers may be supplied in a small switchhouse mounted on the breaker frame.

The main factor in determining the two classes of a-c. feeders is the type of control used for operating the breaker. In general, it may be said that direct current control is used for equipments associated with larger distribution stations while alternating current control is used for smaller stations and isolated feeders, both of the indoor and outdoor type. Where d-c. control is used, the breakers are commonly equipped with solenoid mechanisms although motor mechanisms can be supplied for d-c. operation. Where a-c. control is used, motor operated mechanisms of the CF, CF-1 or CF-2 type are used. Standard a-c. controlled units are supplied for operation on 110 or 220 volts, 60 cycle. Standard d-c. controlled units are supplied for operation at 125 volts. Other voltages and frequencies are special.

Outdoor switchhouses are shown in Fig. 1, outdoor breakers with the reclosing equipment installed in a small steel switchhouse as shown in Fig. 2 and indoor reclosing units as shown in Fig. 3 are completely assembled, tested and wired at the factory. In any of the above cases the units are such that they may be placed where desired and the only connections which it is necessary to make for these units are the main power connections to studs or roof bushings provided for that purpose and the control leads for electrical operation.

Where the reclosing equipment is part of a truck-type switching equipment the instructions given in IB 5326 should be closely followed to insure

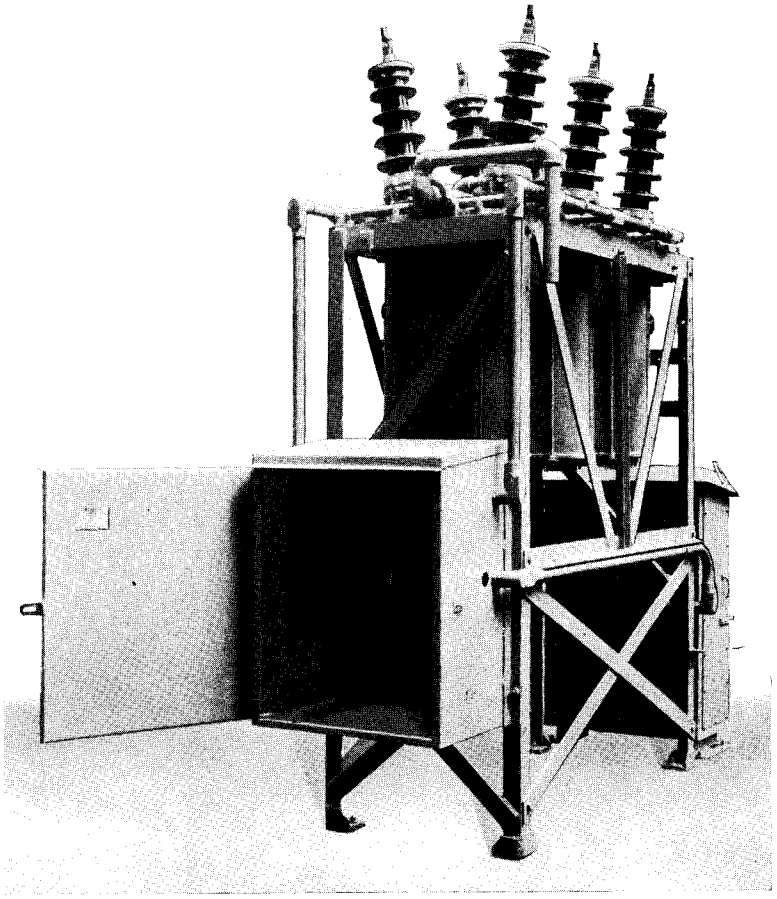


FIG. 2—OUTDOOR BREAKER WITH RECLOSING EQUIPMENT IN SMALL SWITCHHOUSE

proper alignment and operation. For truck-type feeder units a set of connections to the main control bus, in addition to the main incoming power line connections and outgoing feeder conduit connects, is all that is usually required. The other interconnections are self-contained on the truck.

Where the breakers of either the indoor or outdoor type are controlled from remotely located switchboards on which are mounted the metering and reclosing devices, the necessary connections from the breaker and instrument transformers are brought to terminal blocks mounted on the rear of the switchboard. The diagram accompanying a unit is clearly marked to show the necessary conduit connections. Instructions for assembly of panel type switchboards are given in IB. 5201.

Alternating-Current Control

Type CF Mechanism

The schematic diagram shown in Fig. 10 illustrates the standard scheme of control for automatic reclosing on which alternating current is used to operate a type "CF" breaker mechanism. The "CF" mechanism is used to operate breakers of the F-22, B-2, B-13, B-16, B-20 and B-26 indoor type, as well as the FO-24 outdoor type. This diagram shows the two alternate forms of tripping which are most frequently used in combination with the CF mechanism. (A discussion of the several most frequently used forms of tripping will be found later in this book). In addition to the usual metering and indicating equipment, the reclosing equipment shown on this diagram consists of:

Device #101—1—Type "W" control switch.

Device #108—1—Control power switch.

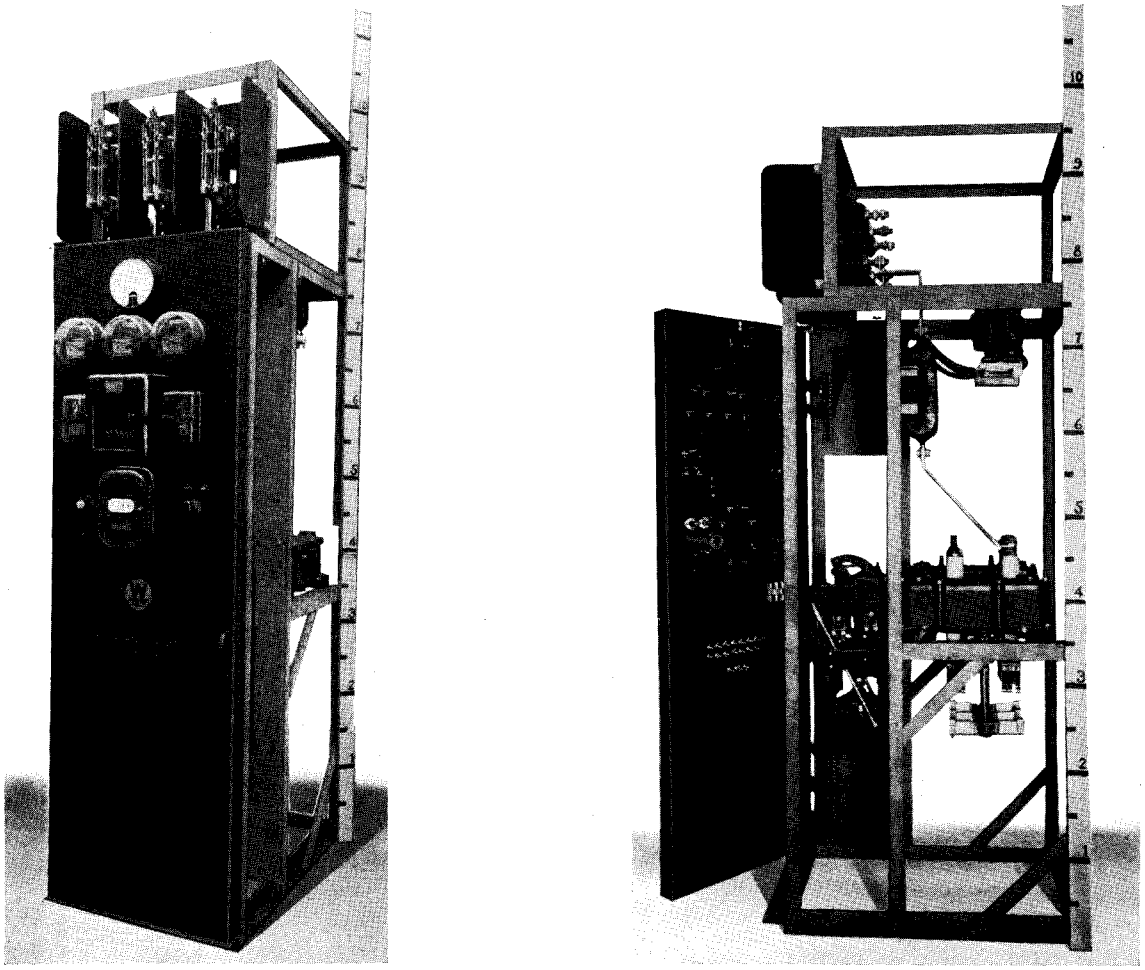
Device #151—1—Type "CO" overload relays (Protective Equipment).

Device #152—1—Oil circuit-breaker complete with motor mechanism and auxiliary switches.

Device #152X—1—Type "30-F-2" breaker control relay.

Device #179—1—Type "GR" reclosing relay.

Device #179X—1—Auxiliary set-up relay element (mtd. in the case with relay 179).



FRONT VIEW — SIDE VIEW

FIG. 3—INDOOR RECLOSING UNIT

The description of the various pieces of apparatus used in this scheme is as follows:

Device 101. The type "W" control switch shown in Figure 4 is essentially a double throw rotary type switch. This switch is provided with a spring return mechanism which causes it to return automatically to its "off" position when released from either operating position; the operating positions being the positions at which the "close" and "trip" contacts are engaged. In addition to "close" and "trip" contacts the control switch is provided with an automatic cut-out contact which may be considered as a master element. This contact functions to establish a circuit for the automatic reclosing relays when the switch is turned to the "close" position, the circuit remaining closed until the switch is turned to the "trip" position. The automatic cutout contact then opens, remaining open until the switch is again turned to the "close" position. Since the automatic reclosing features are operated from a circuit in series with this contact, unintentional reclosing following a control switch trip operation is prevented by this feature. A signal lamp cutout on the control switch makes possible the interruption of the lamp circuit when a feeder is out of service. This circuit may be opened by pulling the handle "out" while held in the "trip" position.

Device 108. The control power switch for this reclosing equipment is a push button type switch. This switch is of the "walking-beam" type being a 2 P.S.T. switch. The size of the switch is adequate for the control required for this mechanism and it is of a type which lends itself to steel panel mount ng where desired.

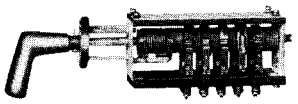


FIG. 4—TYPE W CONTROL SWITCH

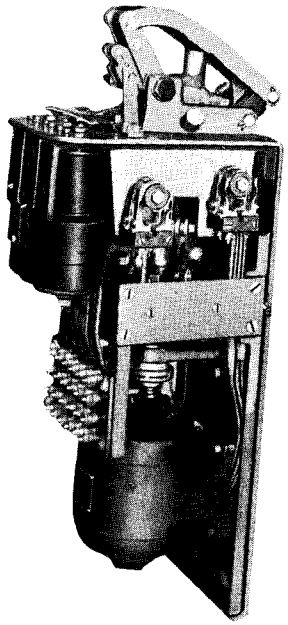


FIG. 5—TYPE CF MOTOR-OPERATING MECHANISM

Device #152. The type "CF" motor operated mechanism, Fig. 5, is used to operate several types of breakers. Complete instructions for the circuit breaker units are found in an Instruction Book accompanying each breaker. This mechanism is held in the closed position by a mechanical latch, and is trip-free in all positions through the usual current transformer and shunt trip coils. The driving motor is of fractional hp. and operates at a comparatively high rate of speed. The motor rotates a pair of weights which, as the speed is increased, straighten out a toggle link to operate the main closing lever of the mechanism which is attached to the breaker. The mechanism may be operated when desired by a handle supplied for manual operation. The mechanism is ordinarily provided with two 2 P.S.T. rotary type auxiliary switches directly connected to that point of the mechanism which effects the closing of the breaker. One 2 P.S.T. switch is connected to the part of the mechanism which follows the motion of the centrifugal weights. One pole of this auxiliary switch is known as the "limit switch" and is used to cut off the breaker control relay when the breaker has proceeded sufficiently far in the closing operation to insure a positive latching action. The position of each of the switches is adjustable and the 152-LS, limit switch, is set for a particular breaker at the factory. For detail instructions on the installation, care and maintenance of the CF mechanisms, see Instruction Book IB-5334.

Device 152X. The breaker control relay is a single pole alternating current contactor of the 30-F-2 type. This contactor is of the floating armature type giving quiet operation and positive contact. The contacts roll against each other with a slight wiping action, this construction tending to keep them clean and in good condition. Since the surface of a new contact will not fit that of one worn they should always be replaced in pairs, never singly. The contactor shaft is supported in bearings which are self-aligning resulting in perfect alignment between the armature and field member.

Device 179. The type "GR" automatic reclosing relay, Fig. 6, consists of a motor driven drum on which is located a contact ring forming the control element for the relay motor, and segments which form the moving elements of the main relay contacts. The driving motor is a split phase induction motor of fractional horsepower. A small reactor mounted on the motor base is alternately connected in series with the two sections of the armature winding to secure reversal of the motor. The motor connections are shown schematically in Fig. 10. Referring to Fig. 10, it will be seen that the three contact fingers 1, 2 and 3 are in engagement with a single ring. These three fingers in their contact relations with the relay segments and breaker auxiliary switches govern the starting, reset stopping, and lockout of the relay. In Fig. 10 the drum is shown

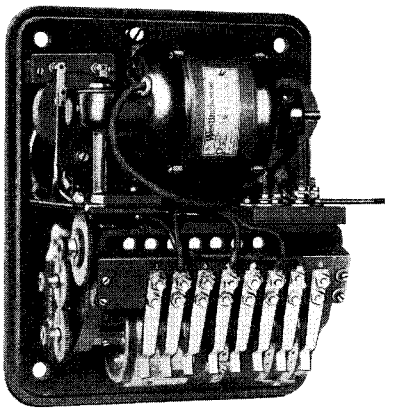


FIG. 6—TYPE GR RELAY

in the position assumed following a successful reclosure, that is, in what may be known as its initial position. In this position, fingers 1 and 2 are making contact with the motor contact ring while finger 3 has just broken contact. The gap under finger 1 is used to stop the motor when the lockout position of the relay has been reached, finger 2 is the common feed point for fingers 1 and 3 and remains in contact throughout the entire drum revolution and the gap under finger 3 functions to cut off the relay following a successful reclosing operation. The lockout position is reached only after the predetermined reclosures have been made and following an operation in which the drum has traveled in what is known as the "forward" direction of the drum, this being the clockwise direction of rotation when viewed from the gear end of the relay.

The remainder of the drum, that is, that part which may be used in combination with fingers 4, 5, 6, 7 and 8 has its periphery divided into 27 sectors, each sector being drilled to accommodate contact segments. Fingers 4 and 5 are bridged by "set-up" segments, which prepare for the closing function as explained under "operation".

Contact segments which bridge fingers 6 and 7 function in conjunction with a 179-X relay contact to cause the closing of the oil circuit breaker as explained under "operation". Finger 7 is used as the feed point for the segments bridging fingers 6 and 7. Thus a single contact segment placed on the drum, just before the lockout position is reached, to bridge fingers 7 and 8, may serve to establish an alarm circuit.

The closing segments are so set when the relay leaves the factory that closing is accomplished at 15—30—75 second intervals. This cycle of closing is accomplished with a one to two gear ratio on the contact drum. This gear combination allows for a total drum period of a little over two minutes. By using a second pair of gears supplied with the relay or inter-changing the small and large gears, the period for a drum revolution can be changed from two to either four or eight minutes. By changing the position of the closing segment on the drum the periods between reclosing may be varied from approximately 15 seconds for a first reclosure to any value up to a limit of eight minutes for the three reclosures. Likewise by removing segments, the total number of reclosures may be changed. In this connection it should be noted that the total number of reclosures should not be made more nor should the total period for reclosure be made less than that given for the standard cycle unless a consideration is made of the consequent derating of the oil circuit breaker involved.

In making a rearrangement of the contact segments on the drum, it should also be borne in mind that for this equipment, where the set-up relay principle is used, the set-up and reclosing segment should never be placed on adjacent positions on the drum periphery. Thus, if the first reclosure is effected when the drum is in position 4, the set-up segment should bridge fingers 4 and 5 on position 2.

Standard "GR" relays are shipped from the factory with a gearing arrangement requiring slightly more than two minutes for a complete drum revolution. By the use of the spare gears which are of 1:1 ratio, or by reversing the position of the service gears, the time required for a drum revolution may be multiplied by 2 or 4.

Device 179X. The device shown in the upper left hand corner of Fig. 6 is really an independent two pole contactor type relay. Since the function of this relay is inherently tied up with the GR reclosing relay, it is included in the same case and the interconnections are made in the factory. The function of this relay is to prevent the breaker "pumping" if opened due to a fault while the closing segment is bridging fingers 6 and 7 and to prevent premature reclosing by insuring that the breaker has been open the length of time necessary for the relay to pass from a set-up to a closing segment. The relay is picked up by the set-up segment on relay 179 and then shunts the set-up segment with one of its contacts, remaining energized until the opening of the breaker limit switch allows its return to its de-energized position. Since the set-up segment has cleared in the meantime, premature or inadvertent reclosures are avoided by this arrangement.

The overload protective devices vary for varying equipments. The types most often encountered are described in a summary later in this book.

Operation

Refer now to the schematic shown in Fig. 10 and note that the equipment is shown in the normal de-energized position, that is, the devices are in the position they hold at an initial installation, all relay circuits being open and all relays deenergized. After a check to determine the presence of proper control voltage, the control power switch 108 should be closed. Then when the master control switch 101 is turned to the closed position, the motor mechanism should operate and close the breaker. The 101-AC (control switch auto cut-out contact) is established simultaneously by the operation of the control switch to the close position.

Consider a fault occurring on the line being controlled by the breaker. The protective relays operate to trip the breaker after which the following sequence of operation takes place. The breaker auxiliary switch shown in series with contact finger 1 on relay 179 is closed, completing the relay motor circuit and resulting in the travel of the motor relay in the "forward" direction, this being the direction indicated by the arrow on the sketch showing the relay drum development. After a few seconds, fingers 4 and 5 are bridged by the first "set-up" segment. This completes the circuit to the coil of auxiliary relay 179X, this circuit being from control power switch 108, through the auto cut-out contact 101-AC, through fingers 5 and 4 on the reclosing relay 179, through 179X coil circuit, through 152 LS to the other pole of the control power switch 108. Front contacts of relay 179X then operate to shunt fingers 4 and 5, sealing-in the 179X coil circuit until the breaker limit switch 152-LS opens. Relay 179 continues to drive its drum in the forward direction until the first closing segment bridges fingers 6 and 7. A preliminary circuit already having been established by a 179X contact, the bridging of the contact fingers 6 and 7 results in the operation of the breaker control relay 152X by the completion of the following circuit.

From control power switch 108, through the 101-AC contact, through fingers 7 and 6 of the GR relay, through a contact on 179X, through 152X coil, through 152 LS to the other pole of control power switch 108.

The main contact 152X energizes the breaker mechanism motor 152M, thus closing and latching the breaker. As soon as the breaker mechanism has advanced sufficiently to insure positive latching, 152 LS opens, causing relays 179X and 152X to drop open. The opening of 152X cuts off the motor mechanism circuit which is not re-established until another set-up segment has bridged fingers 4 and 5.

The breaker closure causes a change in the position of the breaker auxiliary switches whereby the reverse winding of relay 179 is energized causing the driving of the drum in the reverse direction. The relay continues to run in the reverse direction as long as the breaker remains closed or until finger 3 runs off the contact ring thus stopping the relay in its initial position.

If the fault remains, the circuit breaker opens again before relay 179 has proceeded far in the reverse direction. The time lapse between the breaking of the closing contact on relay 179 and the re-bridging of the set-up contacts when the relay is traveling in the reverse direction must be sufficient to allow the protective relays to trip the breaker. Then the bridging of the closing contacts a second time by the first drum closing segment with the relay again moving in the forward direction does not effect a breaker closure, the set-up relay contacts being open. After approximately thirty seconds the breaker is again closed, this being accomplished by the bridging of the relay set-up and closing fingers by the second set-up and closing segments. This second closing operation is exactly similar to the first.

In case of continued trouble, the cycle described above is repeated, the breaker being closed a third time after a 75" second interval. In case the breaker should open after the third or final reclosure, the relay motor is stopped soon after when contact finger 1 breaks contact with the motor ring. This locks out the breaker until it is reclosed by hand, all relays being de-energized. In this lockout position fingers 7 and 8 are bridged by a segment which may be used for operating an alarm device.

After reclosure by hand, that is, by the control switch, relay 179 returns to its normal position, the reverse winding being energized by a breaker "make" auxiliary switch. It is understood that in the meantime the fault has been removed from the line.

Note—Since relay 179 travels in the reverse direction only when the breaker is closed, the passing over of the set-up and closing segments of the relay while traveling in the reverse direction does not result in any auxiliary relay action due to the fact that the auxiliary relay circuits are only energized through the breaker limit switch 152-LS and this limit switch has its contacts open when the breaker is closed.

An advantage in the set-up relay arrangement where a-c. control is used is that no false operation of the circuit breaker can result from a failure of the control source or from a voltage drop such as may occur during a reclosing cycle as a result of closing against a fault. Should voltage fail during the reclosing cycle, the closing relay 179 is stopped and the set-up relay drops out, opening its front contacts. On return of voltage the reclosing relay again travels in the forward direction but the set-up relay is not picked up until the next set-up segment bridges fingers 4 and 5, thus continuing the reclosing cycle in the proper sequence. Through this system a suitable time interval is secured before a reclosure takes place after a restoration of control voltage.

The CF motor mechanism is a mechanically trip free device and hence the mechanism and limit switch continue forward even though the breaker is tripped immediately. As soon as the arcing tips of the breaker close, the tripping circuit is established. If the fault is present at the time of the breaker closure the breaker contacts open immediately due to the action of the protective relay contacts. Being trip-free in all positions, this opening of the breaker in no way prevents the mechanism continuing until the 152 LS is opened resulting in the proper cutting off of the breaker set-up and control relay.

Manual Operation

For manual operation of the breaker and as a master element, a type "W" control switch, Device 101, with an auto-cut-out contact is supplied. By means of this switch the breaker may be closed or tripped at any time, the auto-cut-out contact functioning to prevent reclosing after a manual tripping until the switch is again turned to its "close" position.

Instructions For Installation

Before placing this equipment in service, follow the procedure outlined below to insure the proper functioning of the various contactors, relays and devices.

The equipment should be erected in line with the standard instructions for that class of apparatus,—that is switch house, panels, trucks, etc. If any step in the following sequence is not performed as outlined, make a careful check of the contacts, connections, coils, circuits, etc., for the entire circuit involved. This check should be made in line with the diagram accompanying the equipment and with the information furnished on the detail pieces of apparatus.

If disconnecting switches are installed ahead of the oil circuit breaker, open these devices, in their absence remove supply leads from the breaker terminals. Then check the closing of the oil circuit breaker, 152, by means of the hand closing lever and the tripping by means of the tripping lever on top of the mechanism. Make this check in line with the detail instructions accompanying the oil circuit breaker, especially noting the alignment of the main breaker contacts and freedom of all moving parts from binding. Then check to see that the auxiliary switches make positive contact and that trip coil plungers are free to move and release the breaker latch.

Make a check of the control voltage and if it is found to be within the correct operating range, that is, between 100 and 130 volts, close control power switch 108. Next turn the control switch, 101, to the "close" position. This establishes the automatic reclosing circuit through contacts 101-AC (Figure 10).

As soon as the mechanism weights have come to rest, in approximately eight seconds, trip the breaker by rotating a disc on a protective relay until its contacts engage—if d-c. is used for tripping. In the case of a-c. tripping, either superimpose enough current on the tripping circuit to cause the tripping of the breaker or trip the breaker by operating the lever on the mechanism. The opening of the breaker, 101-AC contacts being engaged, causes the GR relay 179 to rotate in the forward direction, this being the clock-wise direction

of rotation when viewed from the geared end of the relay.

If the motor drives the drum in the reverse direction, interchange the green and red leads of the relay motor terminal board. If the motor does not rotate, check the circuit from the control power switch 108, through the 101-AC contacts, through fingers 2 and 1 on relay 179, through the "break" auxiliary switch 152 on the breaker, through the relay motor winding to the other side of the line. After a few seconds with the drum rotating in the forward direction, contact fingers 4 and 5 are bridged by the first set up segment on the contact drum. This causes the picking up of the auxiliary relay 179X, the breaker limit switch contacts 152-LS being closed.

Relay 179 continues in the forward direction until the set-up segment breaks contact with fingers 4 and 5.

Auxiliary relay 179X continues in its energized position due to a seal-in circuit established by one of the auxiliary relay contacts. This seal-in circuit keeps the relay energized until 152-LS is opened. Relay 179 continues in the forward direction until after a few seconds, making a total of approximately 15 seconds after the opening of the breaker, contact fingers 6 and 7 are bridged by the first closing segment on the relay drum. This results in the picking up of breaker control relay 152X, the operation of the control relay completing the circuit for the mechanism motor 152M, causing the closing and latching of 152. If relay 152X is not operated, check the contact of reclosing relay fingers 6 and 7 with the drum segment, the 179X relay contacts and the connections leading to the contactor coil. The correction of any contactor wiring faults will result in the operation of this relay. If the operation of 152X does not effect the breaker closing, check the 152M circuit carefully to determine correctness of connections.

Relay 152X and 179X should remain energized until the mechanism has carried the breaker to within a short distance of its "close" position, that is, the devices should remain energized until a positive latching of the breaker is assured. If 152-LS is being opened too early change the position of the contacts to secure a later "cut-off" being careful at the same time not to advance the contacts to such a position that no contact is made when the main breaker contacts are entirely open.

The closing of the breaker causes the breaker auxiliary switches to reverse their contact positions thus reversing 179 relay motor and drum. If the motor does not reverse, check the reverse winding circuits through finger 3 on the reclosing relay, the make auxiliary switch on the breaker, to the relay winding. If this circuit is found to be satisfactory, relay 179 will reverse upon the closing of the breaker. Wait a sufficient length of time to see that the breaker latches positively and that fingers 6 and 7 break contact with the first closing segment and then trip the breaker a second time by means of a second relay contact or the tripping lever on the motor mechanism.

The second tripping of the breaker results in the starting of relay 179 in the forward direction again. Note that the bridging of the contact fingers 6 and 7 a second time by the first closing contact on the relay drum causes no relay action, the set-up relay having been dropped out on the opening of 152-LS.

Relay 179 continues in the forward direction until the bridging of the set-up and relay contacts by the second set of drum segments causes the breaker to close in a manner identical to that described for the first closing operation.

Then trip the breaker a third time and note that the third reclosure should follow the sequence outlined above, this third reclosure occurring approximately 75 seconds after the second reclosure.

Trip the breaker a fourth time checking to see that relay 179 continues in the forward direction until finger 1 breaks contact with the motor ring resulting in the stopping of the relay in this, the "lockout" position.

A contact bridging fingers 7 and 8 in this lockout position may be used to establish an alarm circuit.

After establishing the lockout condition, close the breaker by means of the control switch noting that this should result in the establishment of the reverse winding for relay 179, finger 3 still being in contact with the motor ring.

Relay 179 should continue in the reverse direction until finger 3 breaks contact with the motor contact ring at which time the relay stops in its initial reset position. The relay in returning to its reset position will bridge set-up and closing segments without relay action since 152-LS is open when the breaker is closed.

The foregoing sequence is for a typical standard reclosing equipment, it being understood that when special features are embodied in a particular control scheme, slight variations from the standard diagram will be encountered and the diagram covering a particular equipment is to be considered and the actual check made in line with the specific diagram accompanying the job and not any diagrams in this book. With the above sequence of operation successfully checked, the equipment is in satisfactory service condition and the main leads or disconnecting switches may be reconnected and the equipment placed in service.

If any relay, contact, auxiliary switch or in fact any device fails to perform as outlined above it will indicate a defective contact, wiring connection, bearing fit or a local fault. The devices going to make this equipment are ruggedly constructed and the correction of a local fault should allow the equipment to continue the sequence being carried through.

Type CF-1 Mechanism
Type CF-2 Mechanism

The schematic diagram shown in Fig. 11 illustrates the standard scheme of control for automatic reclosing on an equipment on which alternating current is used for operating a type CF-1 or CF-2 breaker mechanism.

The same reclosing equipment is used with these mechanisms as is used with the type CF breaker mechanism.

The CF-1 mechanism is used to control type B-6, B-32, OE-6, OE-7, G-10, and 0-241 Breakers as well as the type G-22 up to 88 kv.

This mechanism shown in figure 7, is of the motor operated centrifugal type and is provided with a light load trigger which can disengage the breaker from the centrifugal mechanism at any point in the stroke. Motor driven weights through proper linkage force the main lever to rotate in a counter clockwise direction. In closing, the main lever and full automatic lever act as one, being held together by the trigger and trip

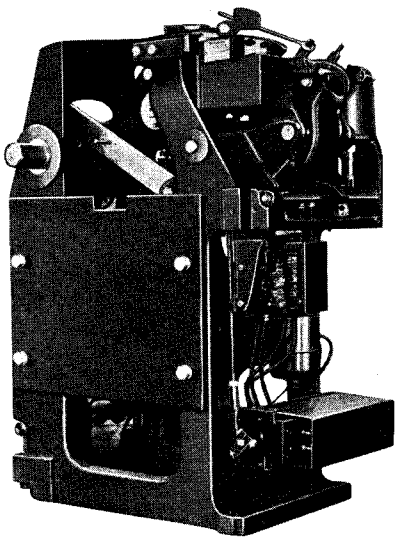


FIG. 7—TYPE CF-1 MOTOR-OPERATING MECHANISM

free lever. The full automatic lever is connected through a link of the operating lever which in turn is connected to the pull rod of the breaker. This mechanism is supplied with a wrench type hand closing lever, the mechanism being mechanically trip free from any position when actuated by either the motor mechanism or the hand closing lever.

Complete instructions for operating this mechanism are to be found in Instruction Book No. 5455.

The CF-2 mechanism is used to control 110 kv. to 220 kv. type G-11 and G-22 breakers as well as 3000 ampere type O-331 breakers. Figure 8 shows the mechanical arrangement of this mechanism and the method of mounting with a typical outdoor oil circuit breaker.

This mechanism operates on a centrifugal principle whereby the rotating of weights causes them to swing outward and in so doing move on the shaft which is attached to the mechanism lever through a combination radial thrust ball bearing. Links attach the main lever to the bearing housing. The main lever is pivoted at a bearing in the main frame at the right hand end of the mechanism. The bearing is on the same centerline as the bearings for the roller latch. When the latch engages with the roller, the toggle lever can pivot about the same centerline as the main lever. The mid point in the toggle lever has a permanent bearing in the main lever. When the latch is released the toggle lever can then be rotated on its own bearing in the main lever. The left hand end of the toggle lever is connected through a toggle link to the operating lever which is pivoted in the main casting. From the operating lever a rod extends from the upper part of the mechanism connecting to an intermediate lever which is for the purpose of obtaining the same travel that is had at the bell crank in the circuit breaker. For complete instructions for operating and maintaining this mechanism, see I.B. 5331.

Operation

A comparison of the scheme of connections shown in Fig. 11 for reclosing equipment using CF-1 and CF-2 mechanisms with the scheme shown in Fig. 10 for the CF mechanism will show that the two are absolutely identical up to the engaging of the closing segment with contact fingers 6 and 7 of the re-

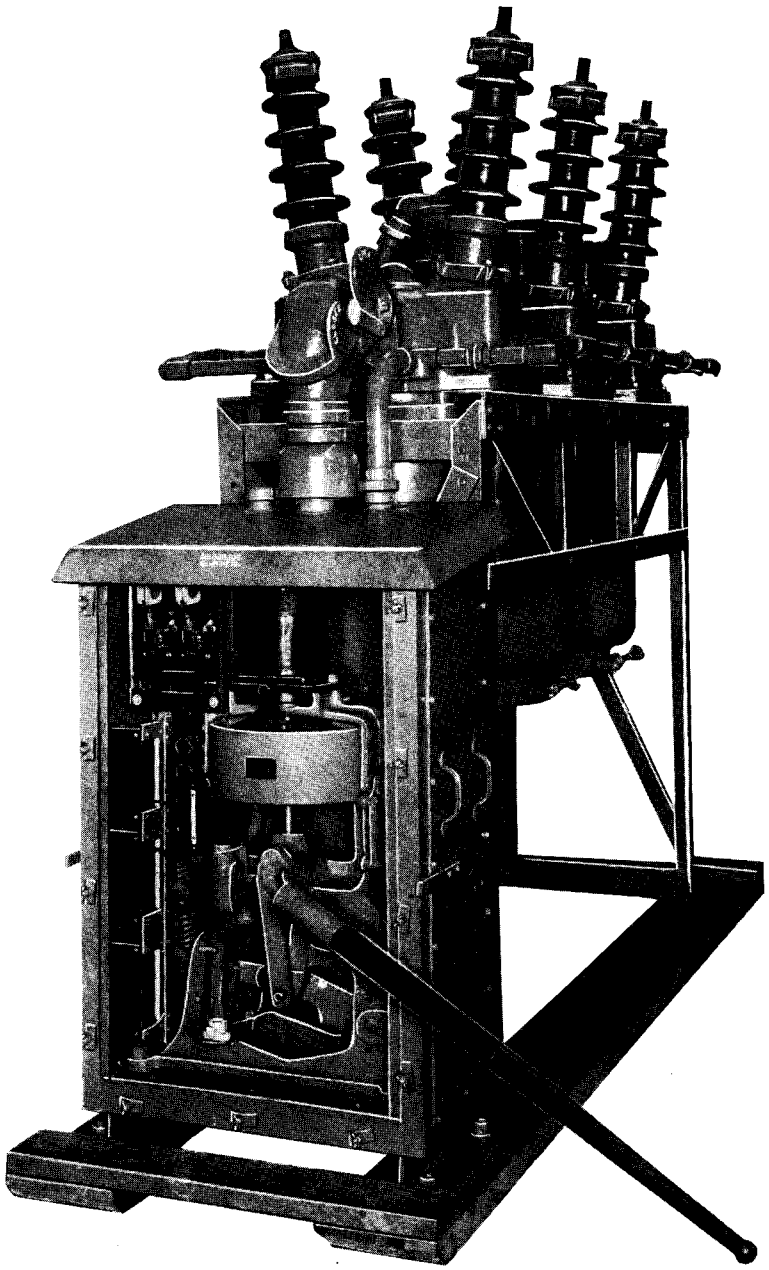


FIG. 8—TYPE CF-2 MOTOR MECHANISM OPERATING TYPE O-221 OUTDOOR OIL CIRCUIT-BREAKER

closing relay. Both the CF-1 and CF-2 mechanisms are supplied with breaker relay arrangement consisting of two alternating-current contactors so connected as to insure a complete closure when an impulse is once started regardless of whether or not the impulse, as in the case of the control switch is interrupted before the closing sequence is finished. In addition to these two control relays, a 2 pole contactor and a resistor form a dynamic braking system which is utilized to lessen the time required for resetting following a breaker closure. This dynamic braking scheme reduces the time of resetting of the mechanism, following a breaker reclosure to within ten seconds.

The sequence of this equipment after the bridging of fingers 6 and 7 is as follows:—Relay 179X being held energized by one of its front contacts, breaker control relay 152X is operated. One of its front contacts shunt the 179X relay circuit and fingers 6 and 7 on the reclosing relay, keeping 152X coil energized until 152Y operates. The main contacts on relay 152X complete the circuit for the breaker mechanism motor 152-M, resulting in the closing and latching of the breaker. A break auxiliary switch on the breaker opens the circuit for the set-up relay 179X allowing this relay to drop out. A make limit switch on the breaker mechanism completes the circuit for auxiliary cut-off relay 152Y, causing the operation of this relay. 152-Y operates and one of its "break" contacts interrupts the 152X coil while one of its "make" contacts keeps the relay energized as long as the closing impulse is kept on the circuit.

If the breaker remains closed, the dynamic braking scheme is not put into operation. The opening of the breaker at any time before the mechanism and the breaker have relatched, completes the circuit for the auxiliary shunting relay 152-Z, the circuit being from one side of the control circuit through a 152X break contact, through a limit switch which remains engaged until just before the breaker and mechanism latch, through the 152-Z relay coil, through the break auxiliary switch 152 to the other side of the line. Relay 152Z immediately picks up and utilizes one main contact to shunt the mechanism motor armature while its other main contact completes a circuit through a suitably chosen resistor for the main series field.

The shunting of the motor armature by the 152Z contact, the motor field being energized in the meantime, serves as an effective dynamic brake to retard the speed of the motor bringing the mechanism to rest in less than ten seconds. The CF-1 and CF-2 motor operated breakers operate similarly to the CF operated units as regards number of reclosures, lockout, etc.

Manual Operation

A type "W" control switch is furnished for manual closing and tripping of the breaker. For control switch operation, the holding-in of relay 152Y by the control switch close contact gives a control relay arrangement which is electrically trip-free since 152X cannot be re-energized until 152Y is released through the opening of control switch contact. The master control element 101-AC for this switch functions identically for this application as for the CF mechanism scheme of control.

Instructions given for the "CF" operated units should be followed, for a check of performance, before breakers controlled by either the CF-1 or CF-2 mechanisms are placed in service.

Direct-Current Control

The schematic and connection diagram shown in Fig. 12 illustrates the standard scheme of control for an automatic reclosing equipment on which direct current is used to operate a solenoid type breaker mechanism. In addition to the usual metering and indicating equipment the reclosing equipment shown on this diagram is comprised of:

Device 101—1—Type "W" control switch.
Device 108—1—Control power switch.
Device 151—Type "CO" overload relays.
Device 152—1—Oil circuit breaker complete with solenoid mechanism and auxiliary switches.
Device 152X—1—Type "S-1" breaker control relay.
Device 152Y—Release coil for "S-1" relay.
Device 179—1—Type "GR" reclosing relay.

The description of the various pieces of apparatus not described under Alternating Current Control but which are used in the direct current control scheme follows:

Device 152—Where d-c. control is used the breaker mechanism is ordinarily equipped with a direct current closing coil and a direct current trip for the voltage specified for the application. The types of solenoid mechanisms and the manner in which they are connected to the breaker units vary considerably for the types of breakers available for reclosing duty. Separate instructions covering the points to be noted in erecting and maintaining these breakers and mechanisms are included with individual breakers.

Device 152X—152Y—The standard control relay for direct current operated breakers is the type S-1 relay shown in Fig. 9. This relay is an electrically trip free relay and has a main operating and a release coil. The inherent trip free characteristics of this relay, whereby the relay contacts are held open following a breaker closure while the main coil is energized, are made use of in this reclosing scheme.

This relay is essentially a trip free contactor type relay which has its main contact mechanically coupled to the relay armature when both relay coils are de-energized. Then when the main coil 152X is energized the relay contacts are closed. The energization of the release coil 152Y results in the operation of a cam which releases the trigger which has been holding the main contact in engagement with the relay armature. The operation of this trigger results in the mechanical uncoupling of the relay contact and main armature. This relay contact and armature remain uncoupled for as long a period of

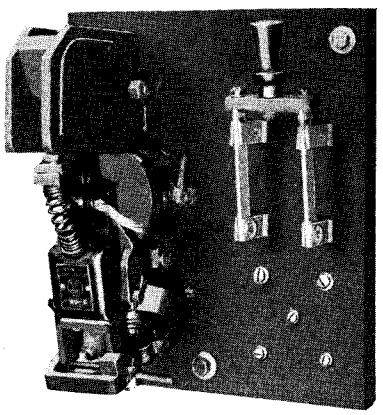


FIG. 9—TYPE S-1 CONTROL RELAY ON PANEL (COVER REMOVED)

time as either the main or release coil is energized.

Device 179—The "GR" reclosing relay for direct current controlled breaker reclosing differs from the alternating current relay in the following respects. The driving motor is a double shunt field d-c. motor connected as shown in Fig. 12. The gearing between the motor and the rotating drum as well as the motor contact ring is identical with the a-c. relay. The arrangement of contact segments on the drum is somewhat different, however. The location of the closing segment is the same as for the a-c. operated relay, but instead of a set-up segment functioning to establish and seal in a circuit, an inherent characteristic of the "S-1" relay allows a sort of reverse process to be used.

Referring to Fig. 12 it will be seen that fingers 4 and 5 on the reclosing relay are bridged by segments ahead of the bridging of the closing fingers 6 and 7. Then instead of this bridging acting to pick up a relay it acts through a series resistor, to prevent dropping out of the main coil of the "S-1" relay when once it has been operated. Since it does function to cause a holding circuit this bridging of fingers 4 and 5 is continued to where the segments for 4 and 5 overlap those for 6 and 7. Briefly the sequence that when fingers 4 and 5 are bridged no action takes place. Then when fingers 6 and 7 are bridged the resistor being shunted the "S-1" relay operates. Closing of the breaker causes the operation of the release coil on the "S-1" relay. The resistor is so chosen that it passes insufficient current to allow the operation of the "S-1" relay but it passes sufficient current to guarantee the holding in of the relay armature when once it has been operated. By this arrangement should a breaker open within a few seconds after a reclosure, resetting action does not take place until the second reclosing segment has been reached due to the holding in the "S-1" relay armature until fingers 4, 5, 6 and 7 are no longer bridged by the holding circuit on the relay.

Operation

Refer to the schematic diagram Fig. 12 and note that the equipment shown thereon is shown in the normal de-energized position, that is, the devices are in the positions they would assume at an initial installation. Consider a fault occurring on the line being controlled by the breaker, 108 being closed and the control switch having last been turned to its "close" position. The usual protective relays operate to open the breaker after which the following sequence of operation takes place:

The breaker auxiliary switches 152 shown in series with contact finger 1 on relay 179 are closed resulting in the travel of the relay in the forward direction, this being the direction indicated by the arrow on this sketch showing the relay drum development. After a few seconds fingers 4 and 5 on the relay are bridged by the first set-up segment on the relay drum. This energizes the main coil of relay 152-X through the resistor, no relay action resulting. After an additional few seconds totalling 15 seconds after the breaker opening, contact fingers 6 and 7 are bridged, the segment bridging 4 and 5 overlapping the point at which segments 6 and 7 are first bridged. The bridging of contacts 6 and 7 results in the shunting out of the resistor and the subsequent operation of the relay to close the breaker by energizing the breaker closing coil 152-C through the main contacts of 152-X. The breaker in closing closes the auxiliary switch contacts which have been open and opens auxiliary switch contacts which have been closed. Thus the direction of rotation of relay 179 is reversed and at the same time the main contacts of the breaker control relay 152-X are opened due to the energization of the relay release coil 152-Y. Then for the breaker control relay to be operated again it is necessary that its armature be released so as to be mechanically recoupled with the main contact arm. The resistor placed between finger 4 of the reclosing relay 179 and the 152-X coil circuit prevents this recoupling for a period of time greater than that necessary for the action of the protective relay contacts.

After the breaker closure the reclosing relay 179 continues in the reverse direction as long as the breaker remains closed or until finger 3 runs off the contact ring resulting in stopping the relay in its initial position.

If the fault remains the circuit breaker opens again before the relay has proceeded far in the reverse direction. The second opening of the circuit breaker causes relay 179 to again proceed in the forward direction. Since the breaker control relay coil 152-X was held energized through the resistor no action takes place until contact fingers 6 and 7 break contact with the first closing segment at which time the breaker control relay returns to its de-energized position where the armature and contact are recoupled.

Relay 179 continues to travel in the forward direction until after 30 seconds, bridging of fingers 4 and 5, and 6 and 7 by the second group of set-up and closing segments results in a second closure of the breaker, this second closure being identical in operation with the first closure described above. In case the fault is a "permanent" one the cycle described above is repeated the third reclosure coming 75 seconds after the breaker opening. In case the breaker opens after the third or final reclosure contact finger 1 breaks contact with the motor ring thus locking out the breaker until reclosed by hand. A contact bridging fingers 7 and 8 in the lockout position may be used to establish an alarm circuit.

After the reclosure by hand, (that is, by the control switch) relay 179 returns to its initial position, it being understood that in the meantime the fault has been removed from the line. Since relay 179 travels in the reverse direction only when the breaker is closed, the bridging of fingers 4 and 5, and 6 and 7 by the set-up and closing segments of the relay while traveling in the reverse direction, does not result in the undue "soaking" of the breaker closing coil due to the energizing of and latch release action of 152Y relay coil.

Manual Operation

For manual operation of d-c. controlled breakers, a type "W" control switch is supplied. It is supplied with an automatic cutout contact for automatic, non-automatic control. Referring to Fig. 12 it may be seen that the trip-free feature of breaker control is retained for control switch operation by preventing the recoupling of the S-1 control relay, 152-X as long as the control switch is held in the "close" position.

Instructions For Installation

Before placing this equipment in service, follow the procedure outlined below to insure the proper functioning of the various contacts, relays and devices.

Follow the general preliminary inspection outlined under "Instructions for Installation of A-C. Controlled Equipment".

Then check the control voltage and if found to be within the correct operating range, that is, between 100 and 140 volts, close control power switch 108 together with the knife switch on the control relay panel. If the breaker is in the closed position, trip it by turning the control switch to the trip position and then close by turning the control switch to the close position. Turning the control switch to the "close" position establishes the automatic cutout contact shown as 101-AC on schematic diagram Fig. 12. Trip the breaker by rotating the discs on a protective relay until stationary and moving contacts are engaged.

The opening of the breaker, 101-AC contact being engaged, results in relay 179 moving in the forward direction, this being the clockwise direction of rotation when viewed from the gear end of the relay. If the motor drives the drum in the reverse direction, interchange the A+ and A— connection on the motor terminal board.

With the motor rotating in the forward direction, the bridging of contact fingers 4 and 5 of relay 179 completes a circuit through a resistor for the main coil of the breaker control relay 152X. Note that the resistor used in series with the main coil has been chosen to prevent the operation of the relay as long as the resistor is in the circuit. Should relay 152X be picked up even though a check of the circuit shows that the connections are correct and that the resistor is in series with the coil, the resistor should be checked to see that it has the right ohmic value, approximately 1250 ohms being satisfactory for 125 volt operation.

Relay 179 continues to travel in the forward direction and fifteen seconds after the opening of the breaker, contact fingers 6 and 7 are bridged through the first closing segment it being noted that contact fingers 4 and 5 are still in engagement with a drum segment.

The bridging of fingers 6 and 7 results in the shunting out of the resistor in series with the 152X relay coil resulting in the picking up of this relay. The main contacts of relay 152X complete the circuit for the breaker solenoid coil, resulting in the closing and latching of the breaker.

With the closing of the breaker the auxiliary switch contacts change position, resulting in the reversal of 179 relay. If the motor fails to operate in the reverse direction, check the circuit running from 101-AC contact through contact fingers 2 and 3 on the GR relay 179, through the make auxiliary switch lying in the relay armature circuit, through the relay armature to the other side of the line. Also check from finger 3 through the reverse field winding, through a make auxiliary switch on the breaker to the other side of the line. If the component parts and connections are satisfactory the relay rotates in its reverse direction. Changing the position of the auxiliary switches also results in the energization of the 152-Y coil resulting in the release of the main contacts of the breaker control relay 152X and the de-energization of the solenoid closing coil. If the release coil fails to function check the wiring from fingers 6 on relay 179 to the junction of coils 152X and 152Y. Then check through from this junction to coil 152Y, to the make auxiliary switch 152, to the other side of the line. If the circuit is found satisfactory and the relay still does not function, check the mechanical details as outlined in instructions for this piece of apparatus.

Immediately after the reversal of relay 179, contact fingers 6 and 7 should break contact with the first closing segment but the armature of relay 152X should be held engaged through the hold-in circuit established through the resistor tube connected to finger 4 of the reclosing relay 179, the holding circuit being continuous and extending beyond where the closing circuit breaks contact on a reverse operation.

Wait a sufficient length of time to determine that the holding circuit functions when the relay is traveling in the reverse direction by noting that the 152X armature is engaged after 6 and 7 have broken contact with the closing segment. Then trip the breaker a second time by means of a second breaker relay contact.

Relay 179 should again reverse its direction of rotation driving the drum in the forward direction a second time. The engagement of fingers 6 and 7 a second time with the first drum closing contact segment should not result in any relay action, the relay armature being held energized thus preventing a mechanical relatching. The relay should continue in the forward direction until the breaking of contact fingers 4 and 5 from 6 and 7, simultaneous results in the release of relay 152X armature. The relay should then be mechanically relatched, as outlined in the description of this device appearing earlier in this book.

The relay continues in the forward direction until fingers 4 and 5 are bridged by the second set of segments. After a few seconds, approximately 30 seconds after the second opening, fingers 6 and 7 will be bridged by the second closing segment resulting in the energization of the breaker control relay and the closing of the breaker in line with the sequence indicated above for the first reclosure.

After noting that the breaker has closed and definitely latched, trip it a third time by means of a protective relay contact. The functioning of relay 179 in conjunction with breaker control relay 152X results in the third closure of breaker approximately 75 seconds after the third opening.

Trip the breaker immediately following the third reclosure, thus allowing relay 179 to proceed in the forward direction until finger 1 runs off the motor control ring resulting in the stopping of the relay and the lockout of the breaker. As soon as relay 179 has reached its lockout position and stopped, close the breaker by means of the control switch. The reclosing of the breaker completes the reverse winding of the relay allowing it to return to its reset position, finger 3 being engaged in the lockout position. The reset position is reached when finger 3 runs off the relay motor ring thus stopping the relay in its initial reset position.

As the relay proceeds to the reset position, note that the bridging of contact fingers 4 and 5, and 6 and 7 should not cause the closing of the main contacts on breaker control relay 152X, due to the energization of the release coil 152Y simultaneously with the energization of the main coil 152X.

Upon the completion of the above sequence of operation, the equipment can be considered in satisfactory service condition and the main leads or disconnecting switches may be reconnected and the equipment placed in service.

Breakers Equipped With Control Relays Other Than The Type S-1.

Where breakers are not equipped with Westinghouse type S-1 control relays a scheme of control similar to that for the breakers using alternating-current control is used. In this case a direct current reclosing relay is used but it is necessary to supply a separate set-up relay similar to the internal relay supplied as standard equipment with the alternating current reclosing equipment. The scheme of control for such equipment is shown in Fig. 13. Refer to this figure and note that the set-up relay 179X is furnished with a series resistor. Where breakers are not equipped with adjustable limit switches or with trip-free relays similar to the type S-1, it is necessary that the set-up relays be held energized until the breaker has advanced in its closing stroke to the point where the "make" auxiliary switches are engaged. This guarantees sufficient time for a positive latching operation even though the breaker control relay is instantaneous in its release.

Type CF, CF-1 and CF-2 motor mechanisms can be supplied for d-c. operation. Where these mechanisms are used, standard control schemes for the types of motor mechanisms are employed, the only difference being that the various coils, motors, etc. are energized from a d-c. control source rather than from an a-c. control source. The foregoing does not mean that every equipment is supplied with all devices interchangeable for a-c. or d-c. voltage, but that where required, reclosing equipment can be supplied for d-c. operated motor mechanisms.

Where for any particular reason it is not desirable that a d-c. operated breaker be closed unless the station bus is energized, the common practice is to supply an a-c. motor for the reclosing relay, the drum development depending on whether the breaker governed is a solenoid or motor operated unit. In either case, the motor alone is energized from an a-c. bus and the remainder of the equipment from the regular d-c. control source. With this arrangement, upon the opening of the breaker on faults, no action results until the energization of the station bus permits the GR relay to start the reclosing function.

Methods of Tripping

The tripping of a breaker by a fault condition is entirely independent of the reclosing equipment. Standard reclosing units are supplied mainly for stub end feeder applications and on these overload protection is usually all that is required.

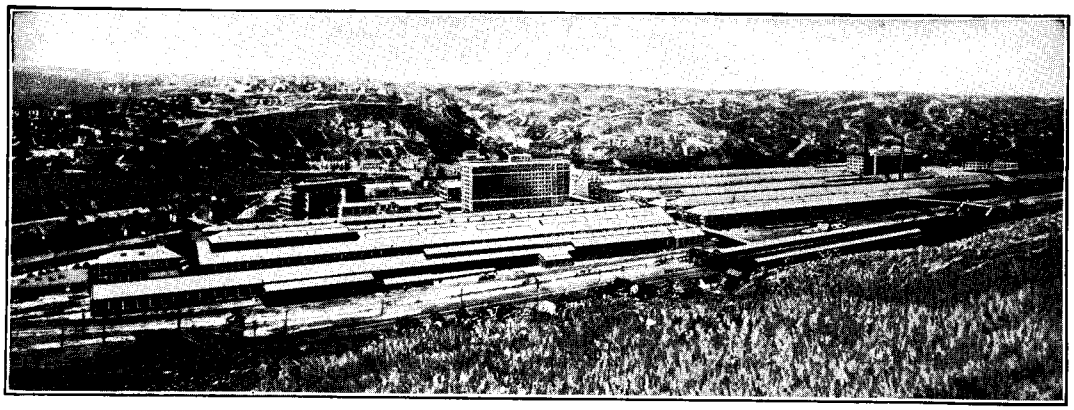
Tripping of a breaker may be accomplished by a direct current shunt trip coil having its circuit completed by the closing of current relay contacts or by one of two forms of current devices operating to trip the breaker direct.

Direct current tripping is supplied wherever it is possible to secure a dependable source of direct current for this duty. It is the most desirable method since it is completely independent of the circuit controlled. The shunt trip coil itself is simpler than any form of current tripping and places no burden on the current transformers. Only one direct current shunt trip coil is required for a breaker, this coil being used for both protective relay and control switch operation. D-c. shunt tripping is standard for all solenoid operated breakers, usually being operated from the same control battery which is used to energize the breaker closing coils. Direct current tripping is also standard on type CF-2 motor mechanisms and forms the most desirable form of trip-tripping for both the CF and CF-1 mechanism. Where d-c. is used for tripping only, a 24 volt storage battery kept charged by a trickle charger furnishes a very dependable shunt tripping source. The actual mechanical details of shunt tripping devices are described in the circuit breaker instruction books and the freedom of the plunger, necessary over travel, etc., should be checked on each breaker in line with the accompanying instructions before it is placed in service.

The circuit for the shunt trip coil is completed by inverse timing overload relays—usually type "CO". If the relays are type "CO" their disc contacts are shunted by an internal contactor switch the coil for which is placed in series with the breaker trip coil and the protective relay contacts. By means of this contactor the slow moving disc contacts are relieved of excessive duty and a tripping action is assured whenever the disc contacts engage even though only momentarily. Complete instructions for "CO" relay current settings, operating characteristics and maintenance are given in IB-5319.

The type "CF" and "CF-1" mechanisms can be provided with transformer trip coils or with transformer trip coils used in conjunction with direct trip attachments. The transformer trip coil may be used where definite time delay is not required. Where definite inverse time delay is required the direct trip attachment in conjunction with a type CO relay and transformer trip coil is supplied. A direct trip consists of two coils in opposition, the holding coil preventing the operation of the tripping armature until the "CO" relay contacts short circuit the relay coil in the attachment causing the demagnetization of the holding coil and allowing the transformer trip coil to operate the trip lever.

When either transformer or direct trip tripping is used an a-c. shunt trip coil is also supplied for control switch operation. An important item to be noted on a direct trip attachment is that the armature must seat properly or false operation before the closing of the "CO" relay contacts may result. The number of current devices is dependent on the type of line controlled, two being necessary for 3 phase, 3 wire lines and three being required for 3 phase, 4 wire lines. To increase the safety factor, three devices are frequently supplied on 3 phase, 3 wire lines. By so doing, protection is provided against double grounds on an undergrounded system and two contacts are placed in parallel on phase to phase faults.



The Company's Works at East Pittsburgh, Pa.

Westinghouse Products

A few of the Westinghouse Products are listed below and will furnish some idea of the great variety of electrical apparatus manufactured by the Company and the many extensive fields for their use.

For Industrial Use

Instruments
Motors and controllers for every application, the more important of which are: Machine shops, woodworking plants, textile mills, steel mills, flour mills, cement mills, brick and clay plants, printing plants, bakeries, laundries, irrigation, elevators and pumps.
Welding outfits
Gears
Industrial heating devices, such as: Glue pots, immersion heaters, solder pots, hat-making machinery and electric ovens.
Lighting systems
Safety switches

For Power Plants and Transmission Lines

Carrier current equipment
Circuit-breakers and switches
Condensers
Controllers
Control switches
Frequency changers
Fuses and fuse blocks
Generators
Insulating material
Instruments
Lamps, incandescent and arc
Lightning arresters
Line material
Locomotives
Meters
Motors
Motor-generators
Portable Power Stands, 110 volts
Rectifiers
Regulators
Relays
Solder and soldering fluids
Stokers
Substations, portable and automatic
Switchboards
Synchronous converters
Transformers
Turbine-generators

For Transportation

Locomotives
Railway equipment
Marine equipment

For Mines

Automatic substations
Lamps
Locomotives
Motors for hoists and pumps
Motor-generators
Portable substations
Switchboards
Line material
Ventilating outfits

For Farms

Fans
Household appliances
Motors for driving churns, cream separators, corn shellers, feed grinders, pumps, air compressors, grindstones, fruit cleaning machines and sorting machines.
Generators for light, power and heating apparatus.
Portable Power Stands, 32 Volts
Radio Apparatus
Transformers

For Office and Store

Electric radiators
Fans
Arc lamps
Incandescent lamps
Sol-Lux lighting fixtures
Small motors for driving addressing machines, dictaphones, adding machines, cash carriers, moving window displays, signs, flashers, envelope sealers, duplicators, etc.
Ventilating outfits

For Electric and Gasoline Automobiles and the Garage

Battery charging outfits
Charging plugs and receptacles
Lamps
Instruments
Motors and controllers
Small motors for driving lathes, tire pumps, machine tools, polishing and grinding lathes.
Solder and soldering fluids
Tire vulcanizers

For the Home

Electric ware, including: Table stoves, toasters, irons, warming pads, curling irons, coffee percolators, chafing dishes, disc stoves, radiators and sterilizers.
Automatic electric ranges
Fans
Incandescent lamps
Radio apparatus
Sol-Lux lighting fixtures
Small motors for driving coffee grinders, ice cream freezers, ironing machines, washing machines, vacuum cleaners, sewing machines, small lathes, polishing and grinding wheels, pumps and piano players
Sew-motors.

Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

WESTINGHOUSE SALES OFFICES

ABILENE, KAN., 300 Cedar St. N.
AKRON, OHIO, 714 United Bldg., Main and Market Sts.
ALBANY, N. Y., Home Savings Bank Bldg., 11 Pearl St. N.
AMARILLO, TEX., Third and Filmore Sts.
*ATLANTA, GA., Westinghouse Elec. Bldg., 426 Marietta St.
BAKERSFIELD, CALIF., 2224 San Emedio St.
BALTIMORE, MD., Lexington Bldg., Lexington and Liberty Sts.
BAY CITY, MICH., 2109 Sixth St.
BEAUMONT, TEX., 1012 Pennsylvania Ave.
BIRMINGHAM, ALA., 1406-11 Comer Bldg., Second Ave. and 21st St.
BLUEFIELD, W. VA., Peery Bldg., Bland and Federal Sts.
*BOSTON, MASS., Rice Bldg., 10 High St.
*BRIDGEPORT, CONN., Bruce Ave. and Seymour St.
*BUFFALO, N. Y., Ellicott Square Bldg., 814 Ellicott Square
BURLINGTON, IOWA, Room 206 Medical Arts Bldg.
*BUTTE, MONT., Montana Elec. Co. Bldg., 52 E. Broadway
CANTON, OHIO, First Nat. Bank Bldg., Market Ave. and Tuscarawas St.
CEDAR RAPIDS, IOWA, 1400 Second Ave.
CHARLESTON, W. VA., Kanawha Nat. Bank Bldg., Capitol and Virginia Sts.
*CHARLOTTE, N. C., Westinghouse Elec. Bldg., 210 E. Sixth St.
CHATTANOOGA, TENN., 811 Tenn. Elec. Power Bldg., 536-540 Market St.
*CHICAGO, ILL., Conway Bldg., 111 W. Washington St.
*CINCINNATI, OHIO, Westinghouse Elec. Bldg., Third and Elm Sts.
*CLEVELAND, OHIO, Westinghouse Elec. Bldg., 2209 Ashland Rd. S. E.
COLUMBUS, GA., 1225 Fifth Ave.
COLUMBUS, OHIO, Interurban Terminal Bldg., Third and Rich Sts.
*DALLAS, TEX., Magnolia Bldg., Akard and Commerce Sts.
DAVENPORT, IOWA, United Light and Power Bldg., 208 E. Second St.
DAYTON, OHIO, 1334 Third National Bldg., 36 Main St. N.
*DENVER, COLO., Gas and Electric Bldg., 910 15th St.
DES MOINES, IOWA, Equitable Bldg., W. Sixth and Locust Sts.
*DETROIT, MICH., Westinghouse Elec. Bldg., 5757 Trumbull Ave.
DUBUQUE, IOWA, 303 Federal Bank Bldg.
DULUTH, MINN., Bradley Bldg., Lake Ave. and Superior St.
ELMIRA, N. Y., Hulett Bldg., 338-42 E. Water St.
*EL PASO, TEX., 910 Mills Bldg., Oregon and Mills Sts.
ERIE, PA., Erie Trust Bldg., State and Tenth Sts.
EVANSVILLE, IND., Box 457
FAIRMONT, W. VA., 602 Cleveland Ave.
FERGUS FALLS, MINN., Kadatz Hotel
FORT WAYNE, IND., 1010 Packard Ave.
GARY, IND., 1514 W. Fifth Ave.
GRAND RAPIDS, MICH., 507 Monroe Ave. N. W.
HAMMOND, IND., 135 Oakwood Ave.
*HOUSTON, TEX., Union Nat. Bank Bldg., Main St. and Congress Ave.
*HUNTINGTON, W. VA., Westinghouse Elec. Bldg., Second Ave and 9th St.
*INDIANAPOLIS, IND., Westinghouse Elec. Bldg., 820 Senate Ave. N.
JACKSON, MICH., Consumers Power Bldg., 212 W. Michigan Ave.
JACKSON, MISS., 820 Carlisle St.
JOHNSTOWN, PA., 47 Messenger St.
JOPLIN, MO., P. O. Box 653
*KANSAS CITY, MO., Westinghouse Elec. Bldg., 2124 Wyandotte St.
KNOXVILLE, TENN., 413 Bankers Trust Bldg.
LOUISVILLE, KY., Heyburn Bldg., 4th and Broadway
*LOS ANGELES, CALIF., Westinghouse Elec. Bldg., 420 San Pedro St. S.
MADISON, WIS., 508 Edgewood Ave.
MEMPHIS, TENN., Exchange Bldg., 130 Madison Ave.
MIAMI, FLA., 1125 Ingraham Bldg., 25 Second Ave. S. E.
MILWAUKEE, WIS., First Wisconsin Nat. Bank Bldg., 425 E. Water St.
*MINNEAPOLIS, MINN., Northwestern Terminal, 2303 Kennedy St. N. E.
NASHVILLE, TENN., 207 Chamber of Commerce Bldg., 309 Fourth Ave. N
NEWARK, N. J., Academy Bldg., 17-25 Academy St.
NEW HAVEN, CONN., Liberty Bldg., 152 Temple St.
*NEW ORLEANS, LA., 708 Masonic Temple Bldg., 333 St. Charles St.
*NEW YORK, N. Y., Westinghouse Elec. Bldg., 150 Broadway
NIAGARA FALLS, N. Y., Gluck Bldg., 205 Falls St.
NORFOLK, VA., National Bank of Commerce Bldg., 300 Main St.
*OKLAHOMA CITY, OKLA., Perrine Bldg., Robinson and First Sts.
OMAHA, NEB., 712 Electric Bldg., 409 17th St. S.
ORLANDO, FLA., P. O. Box 98 (Telegrams 806 Lucerne Terrace)
PEORIA, ILL., 104 State St.
*PHILADELPHIA, PA., Westinghouse Elec. Bldg., 30th and Walnut Sts.
*PHOENIX, ARIZ., 412 Luhrs Bldg., 11 W. Jefferson St.
PINE BLUFF, ARK., 1603 W. 17th Ave.
*PITTSBURGH, PA., Chamber of Commerce Bldg., Seventh Ave. and Smithfield St.
PORTLAND, ME., 61 Woodford St.
*PORTLAND, ORE., 901-3 Porter Bldg., Sixth and Oak Sts.
PROVIDENCE, R. I., 393 Harris Ave.
PUEBLO, COLO., 222 Colorado Bldg., Fourth and Main Sts.
RALEIGH, N. C., 803 Person St. N.
RICHMOND, VA., Electric Bldg., Seventh and Franklin Sts.
RIVERSIDE, CALIF., 176 Rosewood Place
ROCHESTER, N. Y., Gas and Electric Bldg., 89 East Ave.
ROCKFORD, ILL., 414 Stewart Bldg., 206 Main St. S.
SACRAMENTO, CALIF., Forum Bldg., 1107 Ninth St.
*SALT LAKE CITY, UTAH, McCornick Bldg., First South and Main Sts.
SAN ANTONIO, TEX., 403 Frost National Bank Bldg.
SAN DIEGO, CALIF., 411 Electric Bldg., 863 Sixth St.
*SAN FRANCISCO, CALIF., Crocker First National Bank Bldg., 1 Montgomery St.
*SEATTLE, WASH., Lloyd Bldg., Sixth and Stewart Sts.
SHREVEPORT, LA., 219 Wilkinson St.
SIOUX CITY, IOWA, 2311 George St.
SOUTH BEND, IND., 523 Sherland Bldg.
SPOKANE, WASH., 1322-23 Old Nat. Bank Bldg., Riverside and Stevens Sts.
SPRINGFIELD, ILL., Public Service Bldg., 130 Sixth St. S.
SPRINGFIELD, MASS., 395 Liberty St.
*ST. LOUIS, MO., Ambassador Bldg., 411 Seventh St. N.
SYRACUSE, N. Y., 801 Loew Bldg., Salina, Jefferson and Clinton Sts.
TACOMA, WASH., 1004 Washington Bldg., 1021 Pacific Ave.
*TAMPA, FLA., Westinghouse Elec. Bldg., 417 Ellamae Ave.
TERRE HAUTE, IND., 309 Terre Haute Trust Bldg., Seventh and Wabash Sts.
TEXARKANA, ARK., P. O. Box 662
TOLEDO, OHIO, Ohio Bldg., Madison Ave. and Superior St.
*TULSA, OKLA., Mid-Continent Bldg., Fifth St. and Boston Ave.
*UTICA, N. Y., Utica Gas and Electric Bldg., Genesee St.
WASHINGTON, D. C., Washington Bldg., 15th St., G St. and New York Ave. N. W.
WATERLOO, IOWA, 305 W. Fourth St.
WICHITA, KAN., P. O. Box 1226
WILKES-BARRE, PA., Westinghouse Elec. Bldg., 267 Pennsylvania Ave. N.
WILMINGTON, CALIF., 303 Avalon Blvd.
WORCESTER, MASS., Park Bldg., 507 Main St.
YOUNGSTOWN, OHIO, 810 First National Bank Bldg., 16 Central Square
The HAWAIIAN ELECTRIC CO., Ltd., Honolulu, T. H.—Agent
*Warehouse located in this city.

WESTINGHOUSE AGENT JOBBERS

ABILENE, KAN., Union Electric Co.
ALBANY, N. Y., H. C. Roberts Elec. Supply Co.
ASHEVILLE, N. C., Carolina States Electric Co.
ATLANTA, GA., Gilham Electric Co.
BALTIMORE, MD., H. C. Roberts Elec. Sup. Co.
BINGHAMTON, N. Y., H. C. Roberts Electric Supply Co.
BIRMINGHAM, ALA., Moore-Handley Hdw. Co.
BLUEFIELD, W. VA., Superior Supply Co.
BOSTON, MASS., Wetmore-Savage Elec. Sup. Co.
BROOKLYN, N. Y., Alpha Electric Co.
BUFFALO, N. Y., McCarthy Bros. & Ford
BUTTE, MONT., Fobes Supply Co.
CANTON, OHIO, The Moock Electric Sup. Co.
CHARLOTTE, N. C., Carolina States Elec. Co.
CHATTANOOGA, TENN., Mills & Lupton Supply Co.
CHICAGO, ILL., Illinois Electric Co.
CINCINNATI, O., The Johnson Elec. Sup. Co.
CLEVELAND, OHIO, The Erner Electric Co.
COLUMBIA, S. C., Mann Electric Supply Co.
COLUMBUS, O., The Hughes Peters Elec. Corp.
DALLAS, TEX., Electric Appliance Co., Inc.
DENVER, COLO., The Mine & Smelter Sup. Co.
DES MOINES, IA., Julius Andrae & Sons Co.
DETROIT, MICH., Commercial Elec. Sup. Co.
DULUTH, MINN., Great Northern Elec. App. Co.
EL PASO, TEX., The Mine & Smelter Sup. Co.
ERIE, PA., Star Electrical Co.
EVANSVILLE, IND., The Varney Elec'l Sup. Co.
FARGO, N. D., Great Northern Elec. App. Co.
FLINT, MICH., Commercial Elec. Sup. Co.
GRAND RAPIDS, MICH., Com'l Elec. Sup. Co.
GREENSBORO, N. C., Carolina States Elec. Co.
GREENVILLE, S. C., Mann Electric Supply Co.
HOUSTON, TEX., Tel-Electric Co.
HUNTINGTON, W. VA., Banks-Miller Sup. Co.
INDIANAPOLIS, IND., The Varney Electrical Supply Co.
JACKSONVILLE, FLA., Pierce Electric Co.
JERSEY CITY, N. J., Newark Elec'l Sup. Co.
KANSAS CITY, MO., Columbian Electrical Co.
LOS ANGELES, CALIF., Illinois Electric Co.
LOUISVILLE, KY., Tafel Electric Co.
MASON CITY, IOWA, Julius Andrae & Sons Co.
MEMPHIS, TENN., Commercial Elec'l Sup. Co.
MIAMI, FLA., Pierce Electric Co.
MILWAUKEE, WIS., Julius Andrae & Sons Co.
MINNEAPOLIS, MINN., Great Northern Electric Appliance Co.
NEWARK, N. J., Newark Electrical Supply Co.
NEW HAVEN, CONN., The Hessel & Hoppen Co.
NEW ORLEANS, LA., Electrical Supply Co.
NEW YORK, N. Y., Alpha Electric Co.
NEW YORK, N. Y., Times Appliance Co., Inc.
OAKLAND, CALIF., Fobes Supply Co.
OKLAHOMA CITY, OKLA., Electric Appliance Co., Inc.
OMAHA, NEB., McGraw Electric Co.
PEORIA, ILL., Illinois Electric Co.
PHILADELPHIA, PA., H. C. Roberts Electric Supply Co.
PHOENIX, ARIZ., Illinois Electric Co.
PITTSBURGH, PA., Iron City Electric Co.
POCATELLO, IDA., Inter-Mountain Elec. Co.
PORTLAND, ORE., Fobes Supply Co.
PROVIDENCE, R. I., Wetmore-Savage Electric Supply Co.
RALEIGH, N. C., North State Elec. Sup. Co.
READING, PA., H. C. Roberts Elec. Supply Co.
RICHMOND, VA., Tower-Binford Elec. & Mfg. Co.
ROCHESTER, N. Y., Rochester Elec'l Sup. Co.
ST. JOSEPH, MO., Columbian Electrical Co.
ST. LOUIS, MO., Commercial Elec'l Sup. Co.
ST. PAUL, MINN., Great Northern Elec. App. Co.
SALT LAKE CITY, UTAH, Inter-Mountain Electric Co.
SAN ANTONIO, TEX., Electric Appliance Co.
SAN FRANCISCO, CALIF., Fobes Supply Co.
SCRANTON, PA., Penn Elec'l Engineering Co.
SEATTLE, WASH., Fobes Supply Co.
SIOUX CITY, IOWA, McGraw-Electric Co.
SPOKANE, WASH., Fobes Supply Co.
SPRINGFIELD, MASS., Wetmore-Savage Electric Supply Co.
SYRACUSE, N. Y., H. C. Roberts Elec. Sup. Co.
TAMPA, FLA., Pierce Electric Co.
TRENTON, N. J., H. C. Roberts Elec. Sup. Co.
TULSA, OKLA., Electric Appliance Co., Inc.
UTICA, N. Y., H. C. Roberts Elec. Supply Co.
WASHINGTON, D.C., H.C. Roberts Elec. Sup. Co.
WATERLOO, IOWA, Julius Andrae & Sons Co.
WILMINGTON, DEL., H.C. Roberts Elec. Sup. Co.
WORCESTER, MASS., Wetmore-Savage Electric Supply Co.
YOUNGSTOWN, O., The Moock Elec. Sup. Co.

WESTINGHOUSE SERVICE SHOPS

ATLANTA, GA., 426 Marietta St.
BALTIMORE, MD., 501 East Preston St.
BOSTON, MASS., 12 Farnsworth St.
BRIDGEPORT, CONN., Bruce Ave. and Seymour St.
BROOKLYN, N. Y., 160 Seventh St.
BUFFALO, N. Y., 141-157 Milton St.
CHARLOTTE, N. C., 210 E. Sixth St.
CHICAGO, ILL., 2201 W. Pershing Road
CINCINNATI, OHIO, Third and Elm Sts.
CLEVELAND, OHIO, 2209 Ashland Rd. S. E.
DENVER, COLO., 1909-11-13-15 Blake St.
DETROIT, MICH., 5757 Trumbull Ave.
FAIRMONT, W. VA., 602 Cleveland Ave.
HOUSTON, TEX., 2311-19 Commerce St.
HUNTINGTON, W. VA., 9th St. & 2nd Ave.
INDIANAPOLIS, IND., 814-820 N. Senate Ave.
JOHNSTOWN, PA., 47 Messenger St.
KANSAS CITY, MO., 2124 Wyandotte St.
LOS ANGELES, CALIF., 420 S. San Pedro St.
MILWAUKEE, WIS., 37 Erie St.
MINNEAPOLIS, MINN., 2303 Kennedy St. N.E.
NEW YORK, N. Y., 467 Tenth Ave.
PHILADELPHIA, PA., 30th and Walnut Sts.
PITTSBURGH, PA., 6905 Susquehanna St.
PROVIDENCE, R. I., 393 Harris Ave.
SALT LAKE CITY, UTAH, 346 Pierpont Ave.
SAN FRANCISCO, CALIF., 1466 Powell Street, Emeryville, Calif.
SEATTLE, WASH., 3451 East Marginal Way
SPRINGFIELD, MASS., 395 Liberty St.
ST. LOUIS, MO., 717 South Twelfth St.
TOLEDO, OHIO, 205-207 First St.
UTICA, N. Y., 113 North Genesee St.
WILKES-BARRE, PA., 267 N. Pennsylvania Ave.

WESTINGHOUSE ELECTRIC INTERNATIONAL CO.
150 BROADWAY, NEW YORK, U.S.A.

Westinghouse Press—Printed in U.S.A.—1-29

CANADIAN WESTINGHOUSE CO., Limited
HAMILTON, ONTARIO