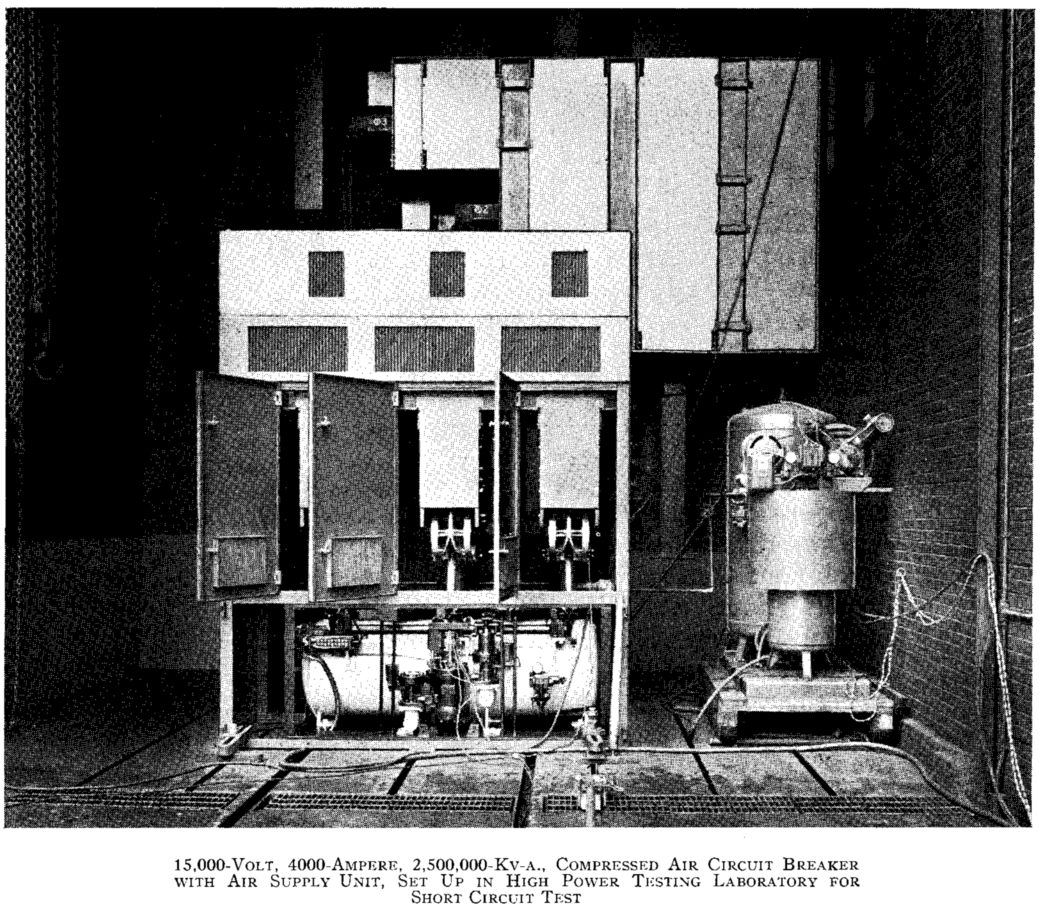
Westinghouse

Type CA Indoor Compressed Air Circuit Breakers

INSTRUCTION BOOK

INSTALLATION

OPERATION   MAINTENANCE



15,000-Volt, 4000-Ampere, 2,500,000-Kv-a., Compressed Air Circuit Breaker with Air Supply Unit, Set Up in High Power Testing Laboratory for Short Circuit Test

Westinghouse Electric Corporation

East Pittsburgh, Pa.

I. B. 7098

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LIST OF ILLUSTRATIONS

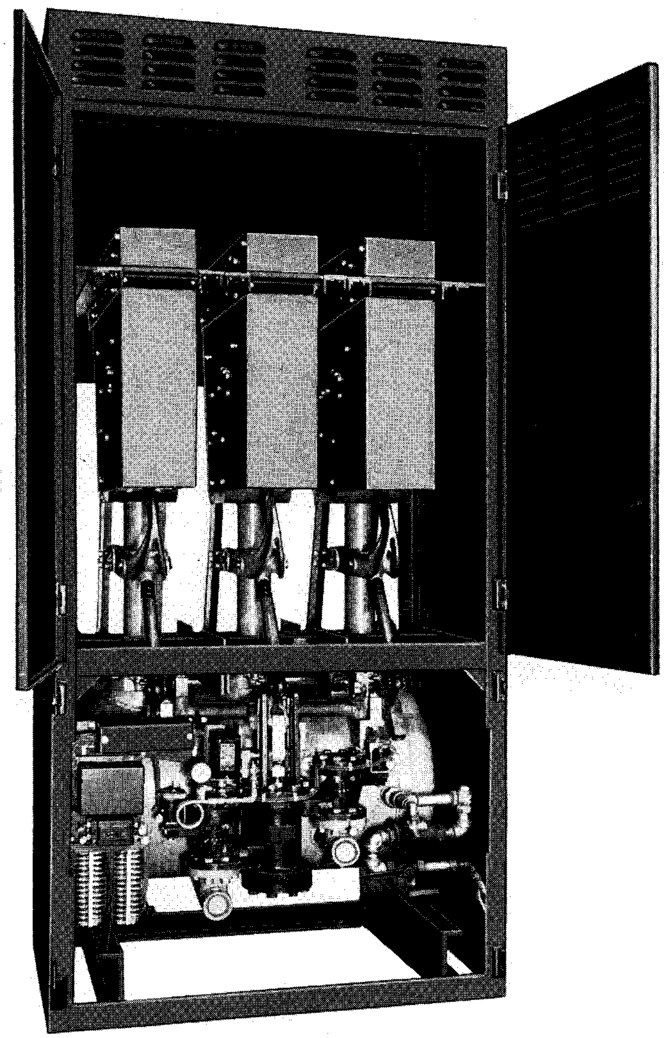

Fig. 1—15,000-Volt, 1200-Ampere, Compressed Air Breaker in Steel Enclosure, (Bottom Doors Removed)

Westinghouse

Type CA Indoor Compressed Air Circuit Breakers

INSTALLATION, OPERATION AND MAINTENANCE

GENERAL INFORMATION

The Type CA, indoor, compressed air circuit breaker is designed for power-house and substation service at alternating-current voltages from 11,000 to 33,000; in current ratings of 1200, 2000, 3000, 4000 and 5000 amperes at frequencies of 25 and 60 cycles, and for interrupting duty from 500,000 to 2,500,000 kv-a. Supplemented by the Type DH and Type U circuit breakers for the lower voltage and kv-a. ratings, the Type CA units complete a line of air-insulated switching equipment operating entirely without liquid insulation for all indoor central station service from 2300 to 33000 volts and from 100,000 to 2,500,000 kv-a.

Description—Utilizing compressed air as a means of opening and closing its contacts, as well as for arc rupture, the Type CA circuit breaker is essentially electro-pneumatic in operation. While power for operation is applied to a piston in a compressed air cylinder, air is admitted to this cylinder through an electrically operated valve thus rendering the equipment applicable to any electrical control circuit in use for conventional solenoid or motor-operated circuit breakers.

As shown in Fig. 1, the compressed air breaker follows essentially the conventional air-insulated form of breaker construction, the operating equipment being segregated in a low voltage compartment completely isolated from the high voltage breaker compartment above it. While the breaker is here shown in a steel cell it is equally well adapted to mounting in a masonry cell, or to installation in any of the conventional types of metal-clad switchgear.

Contacts—The main current path through each pole of the breaker, best shown in Fig. 2, forms a parallel-side loop in a vertical plane, the entering and leaving points being the upper and lower terminal connections at the rear. The movable contact arm forms a portion of this loop, completing or interrupting the current path upon movement of the air operating piston. This current carrying loop is supported on a central, hollow insulating column in the general contactor type of construction. The hollow column is also utilized to conduct a blast of compressed air across the parting contacts for arc interruption.

The contacts themselves are of the conventional blade and finger type, the stationary element being mounted at the top of the central column while the movable element is hinged midway of it. For the 1200 and 2000-ampere ratings a single movable contact member with a double hinge point acts both as main-current-carrying and arc-drawing contact. The arc, due to magnetic effect of the looped current path and action of the air blast, is drawn on a portion of the contact surface not normally used for load current purposes.

For current ratings of 3000 to 5000 amperes this contact is supplemented by two other contacts, one on either side, hinged from the same point but engaging stationary elements of their own. These supplementary contacts part first on opening and are designed for load carrying purposes, the arc being drawn on the central member alone.

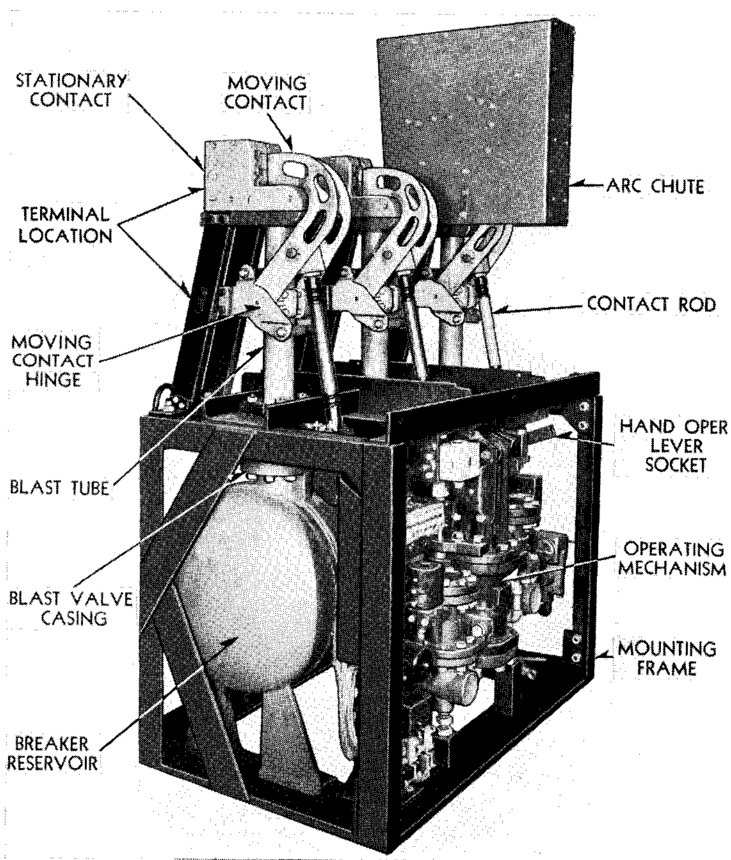

FIG. 2—15,000-VOLT, 1200-AMPERE, 500,000-KV-A., COMPRESSED AIR CIRCUIT BREAKER, (TWO ARC CHUTES REMOVED)

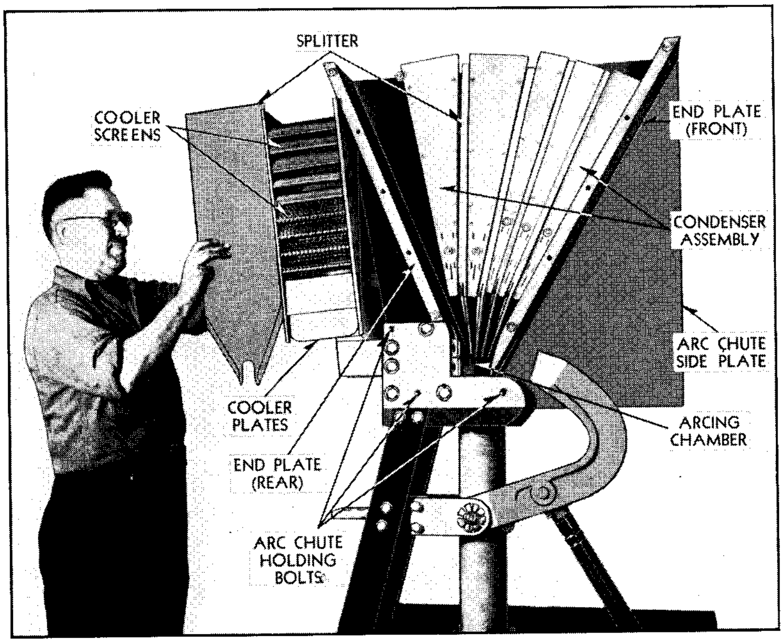

FIG. 3—500,000-KV-A., COMPRESSED AIR ARC CHUTE, (PARTIALLY DISASSEMBLED)

The movable contact arms together with the other main current-carrying members, are made of a special copper alloy developed for the purpose of obtaining the best combination of high mechanical strength and high electrical conductivity. The stationary contact elements are of rugged finger type construction previously developed for heavy duty oil breaker service, and incorporated in compressed air breakers without modification as a type proven by years of service.

Insulation—All compressed air breakers in the 15-kv. class from 500,000 kv-a. upward are subjected to a one-minute withstanding, 60-cycle potential test of 50,000 volts before shipment. Compressed air breakers for 22 and 33 kv., indoor service are given the A.I.E.E. standard potential test for their ratings, 60,000 and 80,000 volts respectively, at 60 cycles.

In the type of construction used for Type CA indoor breakers, live parts of each pole unit involve creepage across potentials with the contacts open, and from line to ground, at a minimum number of points. The central, hollow column supports both the stationary contact element and the movable contact hinge thus providing insulation across potentials as well as to ground. Wound with the Micarta process, using a fabric base, this column is the best grade of Micarta tubing available in both dielectric and mechanical strength. The rear struts, two in the 1200 and 2000-ampere ratings and three in the 3000 to 5000-ampere ratings, brace the contact members rigidly against magnetic forces of heavy short circuit currents also providing insulation across potentials and to ground. Made from specially prepared, paper-base Micarta plate of high density to guard against moisture absorption, they are particularly well adapted to this application.

The only remaining point of insulation to ground is the contact operating rod made of wood-base Micarta, a product proven in reliability by many years of service in both liquid and air-insulated breakers. Potential tests on compressed air breakers have shown these materials withstanding 60-cycle voltages more than 25% above standard test voltages for their class, flashover occurring across a gap of clean air to adjacent grounded objects. It is recommended that where possible, phase spacing for compressed air breaker applications be such as to permit use of metal interphase barriers. Where installation space is limited these barriers may be of insulating material.

Arc Chutes—Shown in detail in Fig. 3, the arc chute for air blast breakers follows in general the relatively narrow, flaring outline of chute made familiar by long use on low voltage, air-break circuit interrupters. Internally it is quite different, being adapted to the handling of an arc driven by a strong blast of air rather than by a magnetic field. The

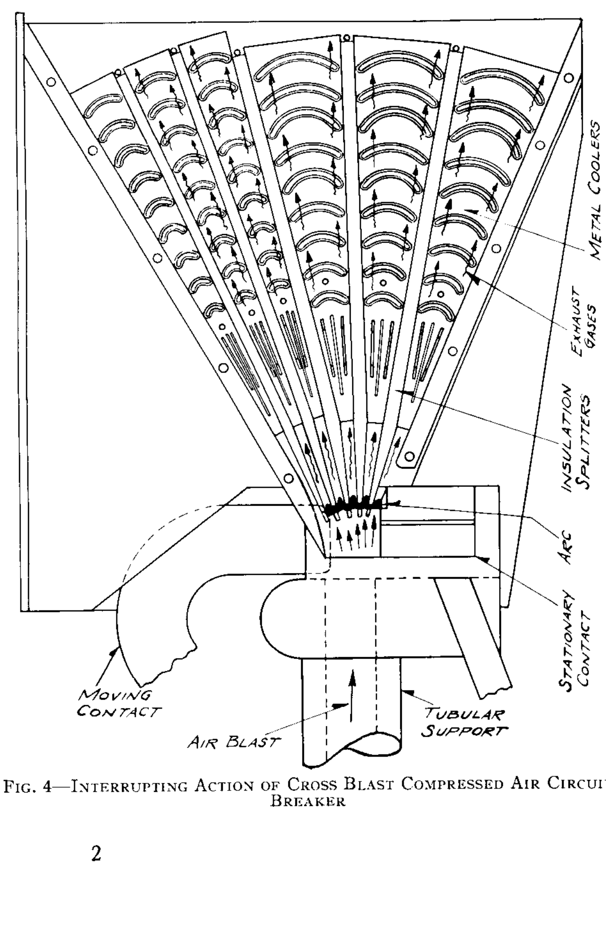

FIG. 4—INTERRUPTING ACTION OF CROSS BLAST COMPRESSED AIR CIRCUIT BREAKER

chute is mounted on the same platform which supports the stationary contact element at the top of the central column, and completely encloses that element except for a narrow slot at the front of the chute through which the movable contact enters and leaves when closing and opening the circuit.

Fundamentally the arc chute is a box-like structure enclosed on four sides by insulating material and open at the top. Internally it is fitted with a number of hard fiber plates known as splitters and arranged longitudinally so as to form a succession of quite narrow gaps across the chute adjacent to the arc-drawing space near the contacts, but diverging to form constantly widening passages to the open top of the chute. Each passage thus formed contains a series of coolers: solid metallic plates at the lower end nearest the arc; coarse-mesh metal screening midway of the chute, and finer mesh screening at the upper or exhaust end of the chute.

These coolers are designed to reduce the temperature of the blast passing upward through the chute on arc rupture to the point of little or no luminosity when exhausted at the top. For compressed air breakers of 1,000,000 to 2,500,000 kv-a. rating where arc products from the higher currents encountered are greater in volume, a muffler is added at the top of the chute as shown in Fig. 4, interposing still more heat-absorbing material in the path of the blast.

It will be noted that while the pole units of a multi-pole breaker are isolated by interphase barriers through a greater portion of the vertical height of the high voltage breaker compartment, the blast from the several arc chutes is exhausted into a single expansion chamber at the top of the breaker enclosure. This involves no hazard of electrical breakdown since the coolers in the chutes and mufflers have removed any ionization collected by the blast as it passed through the arc-drawing space. The single expansion space acts as a diffusion chamber, reducing the pressure and velocity of the blast to a point where it may be passed out through vents to the outside atmosphere without harmful effect on surrounding objects such as suspended lights.

The expansion chamber is formed by a tight horizontal barrier extending the full width and depth of the breaker enclosure, slightly below the top of the arc chutes as shown in Fig. 1. This barrier, of insulating material, serves a threefold purpose: (1) it completes the expansion chamber; (2) it prevents the exhaust blast from blowing dirt onto insulating surfaces, or dust through insulating air gaps in the high voltage

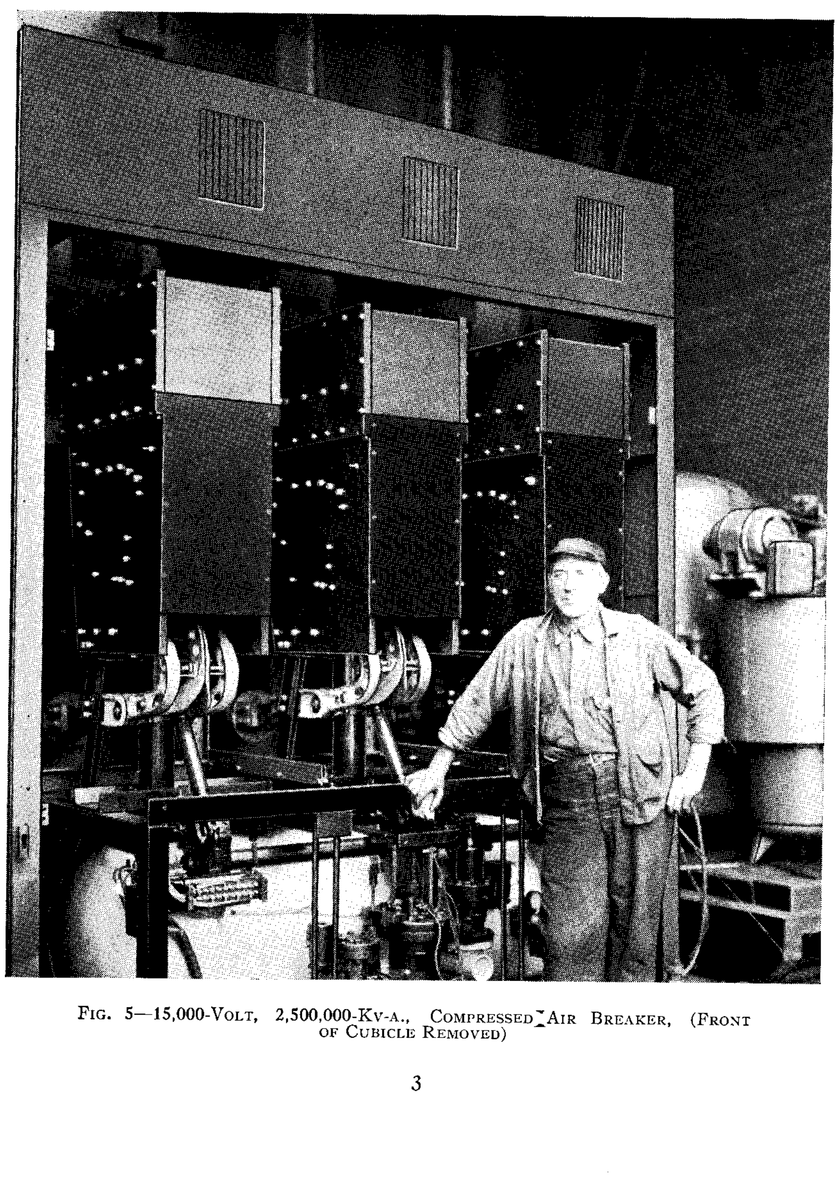

FIG. 5—15,000-VOLT, 2,500,000-KV-A., COMPRESSED AIR BREAKER, (FRONT OF CUBICLE REMOVED)

breaker compartment, and (3) it server as a horizontal bracing member for the arc chutes, reducing vibration of the breaker structure during operation. Since the vertical arc chute sides are of insulating material there is no danger of the horizontal surface of this barrier forming a breakdown path between phases due to collection of dirt.

Operating Mechanism—As shown in the various illustrations the operating mechanism for compressed air circuit breakers consists essentially of a storage reservoir for the air; a main operating cylinder to which air is admitted through a system of electrically operated valves, and an operating shaft direct-connected to the operating cylinder piston. Rotation of the shaft by movement of the piston opens and closes the breaker contacts through the insulating pull rod on each pole unit. These together with the necessary control panel, switches and air devices, are mounted in a steel frame which serves as an enclosure, completely isolating the low voltage control compartment, and as a mounting platform for the high voltage breaker structure above it.

Referring to the sectional view, Fig. 6, the main operating cylinder is in the center. Air admitted to the top of the cylinder, above the piston, moves the piston downward opening the breaker contacts through rotation of the operating shaft located just above the cylinder. Air admitted to the bottom of the cylinder, below the piston, moves the piston upward closing the breaker contacts. The opening valve admitting air to the top of the cylinder is at the right and the closing valve admitting air to the bottom of the cylinder is at the left.

Both the opening and the closing valve are mounted on tubular extensions of the main air reservoir, these extensions forming auxiliary reservoirs which apply reservoir pressure to the operating valves continuously. When the valves are opened they permit the passage of air directly from the auxiliary reservoir. An open passage built into the operating valve casings permits the application of reservoir pressure also to a small solenoid

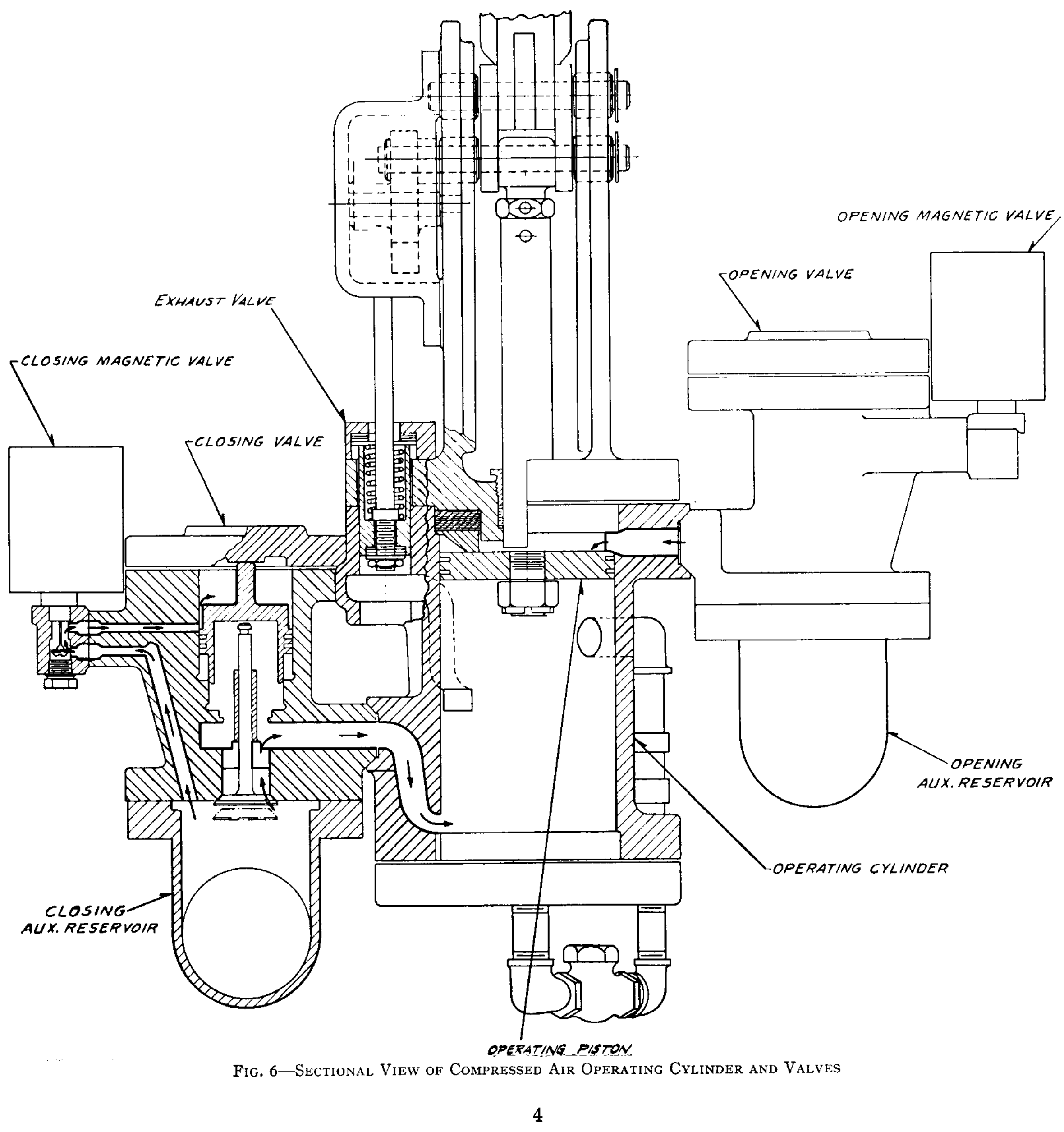

Fig. 6—Sectional View of Compressed Air Operating Cylinder and Valves

magnet valve mounted on the side of each operating valve near its top flange. The construction is such that reservoir pressure tends to keep both of these valves closed tightly against their seats when not actually operating the breaker.

The auxiliary reservoirs extend into the main breaker reservoir and are fed from it, but a throttled opening limits the rate at which the auxiliary reservoirs will refill. By this means the expanding force of a relatively small volume of air in the auxiliary reservoir is applied to the operating piston rather than expansion of the full volume of the main reservoir. Pressure is thus reduced as the piston nears the end of its stroke, decreasing the slam. The auxiliary reservoirs on these breakers will recharge to full reservoir pressure in one-quarter to one-third of a second.

The action of this system of valves is as follows. Control voltage applied to the solenoid magnet coil depresses the armature, opening the magnet valve. Opening the magnet valve admits air from the auxiliary reservoir to the top of a small piston in the closing valve cylinder. This piston moves downward, pushing the closing valve at the lower end of the piston stem away from its seat and admitting air from the auxiliary reservoir through the port connecting the closing valve with the main operating cylinder. Reservoir pressure thus admitted to the operating cylinder moves its piston upward, closing the breaker contacts.

De-energizing the solenoid magnet coil allows the magnet valve to close through action of a spring assisted by reservoir pressure on the under side of the valve. Closing the magnet valve shuts off the supply of air to the closing valve piston; residual air above the piston is exhausted through vents, and the closing valve closes through spring action assisted by reservoir pressure. The same sequence of operations is followed in the opening valve with the single difference that air through the opening valve is admitted above the main operating piston.

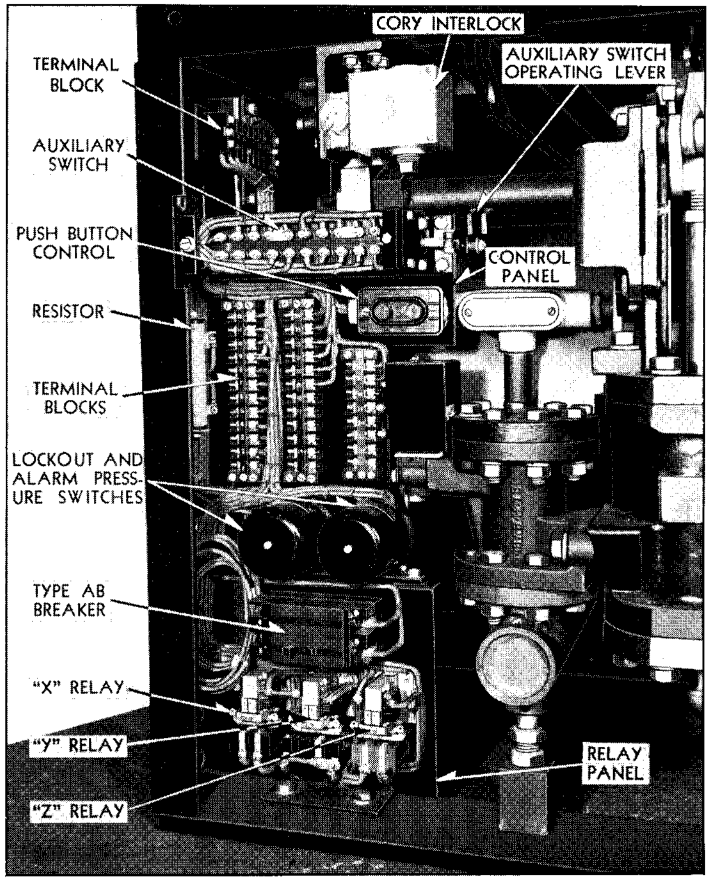

Fig. 7—Typical Control and Relay Panels for Compressed Air Circuit Breakers

Control — Fundamentally, the conventional, electrical control set-up heretofore used for general circuit breaker applications is applicable to compressed air circuit breakers as well. However, certain features of air operation require some modification in the control circuit. A typical control panel is shown in Fig. 7, and a wiring diagram in Fig. 8. Variations in this typical arrangement may be made to meet the requirements of any given application provided certain fundamental features are retained.

The conventional, rotary-type, auxiliary switch shown at the top of the control panel, is operated by a link from the main breaker operating shaft. A Type AB "De-ion" breaker is supplied as standard equipment for isolation of the breaker from remote control during inspection and maintenance periods. A thermal cutout on this breaker also provides protection against overload, replacing the conventional fuse protection. A push-button switch for electrical operation at the breaker may be supplied. The DN-00 operating relays and the alarm and lockout valves are customarily mounted on a separate panel secured to the floor member of the mounting frame to assure protection against vibration during breaker operation.

The general "X-Y-Z" scheme of control is used, the diagram here being shown for the open position of the breaker contacts. The purpose of this scheme of control is to insure that, an operating impulse having been initiated at the control switch, the proper timing and sequence of valve operations will be carried through without further reference to the control switch. The sequence of operations is as follows.

To close the breaker, the control switch at the operator's desk is turned to "close" position. This energizes the "X" relay which through its two contacts seals in and completes the closing magnet valve coil circuit thus initiating the operation of air valves as described under "Operating Mechanism". Once the "X" relay has sealed in, an unsuccessful closing operation due to release of the control switch handle is no longer possible and the closing operation continues regardless of the control switch position.

As the breaker operating shaft rotates toward the closed contact position, the "a" contacts on the auxiliary switch close and energize the "Y" relay. The "Y" relay picks up and opens the "X"

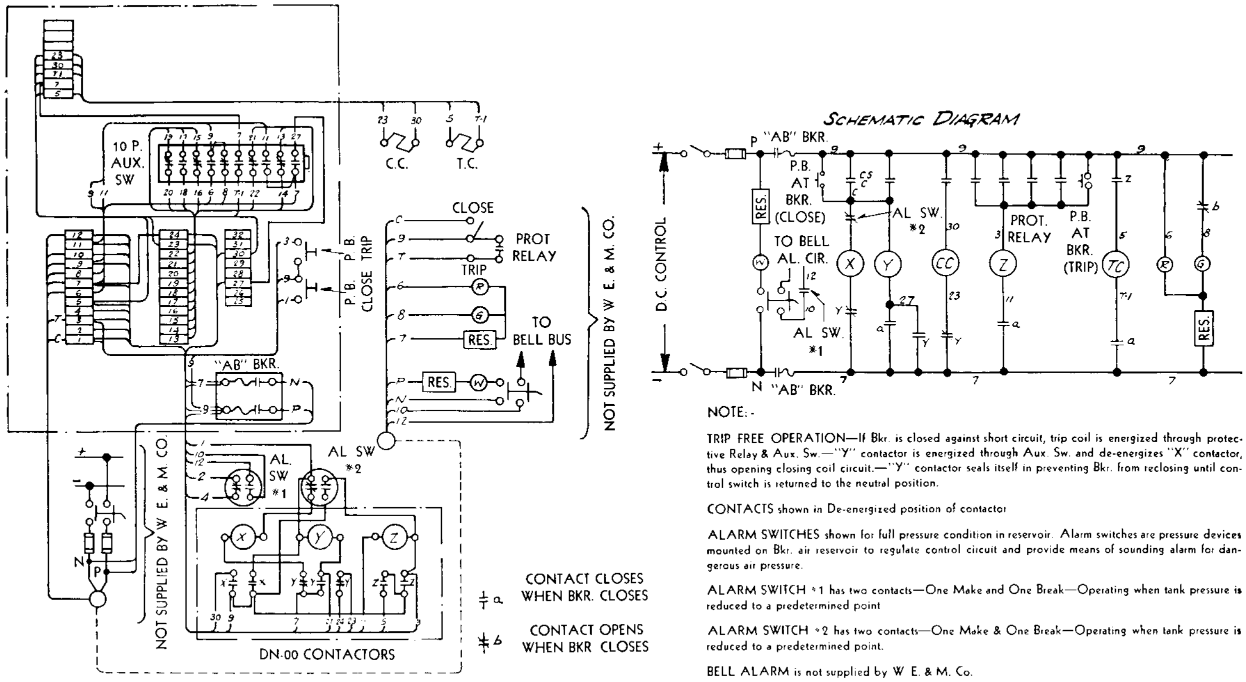

FIG. 8—TYPICAL CONTROL WIRING DIAGRAM FOR COMPRESSED AIR CIRCUIT BREAKERS

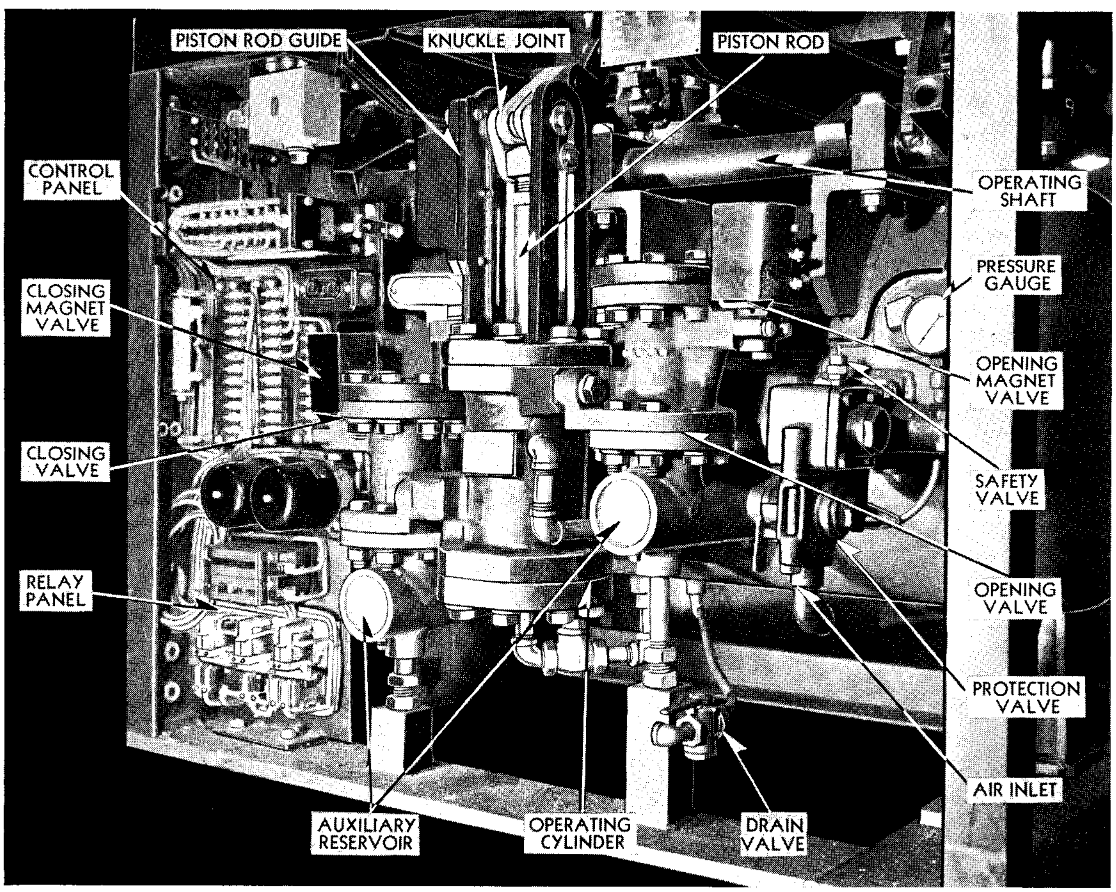

FIG. 9—COMPRESSED AIR OPERATING MECHANISM FOR 500,000-KV-A. BREAKER

relay circuit and the closing magnet valve coil. At the same time the "Y" relay seals in and maintains the "X" relay in its de-energized state so that in the event of protective line relay action calling for an immediate automatic opening, an attempt to reclose can not be made through the control switch handle has been held in the "close" position throughout this period. The handle must again be returned to neutral position before a second closing operation can be made.

To open the breaker, the control switch handle is turned to "trip" position which energizes the "Z" relay. This relay seals in and closes the opening magnet valve coil circuit, initiating the operation of air valves as previously described.

Two pressure-actuated switches, both responsive to pressure in the breaker reservoir, are shown in Fig. 7, mounted at the top of the relay panel. Electrical connections for both switches are shown in the wiring diagram. The function of one of these switches is to lock out electrical control when air pressure in the reservoir has been reduced to a point at which it is no longer adequate for arc rupture. This lockout function is necessary because the breaker may be operated mechanically with air pressure lower than that at which it is safe to attempt circuit interruption.

This switch may be connected to operate in either one of two ways. When the lockout point in pressure is reached: (1) it may lock the electrical control with the breaker contacts in the position in which they stand when the low pressure point is reached, or (2) it may operate to open the breaker contacts and lock them open. The function of the second switch is to provide an alarm, either audible or visual, at some predetermined point before lockout as a warning to the operator that pressure is becoming low.

Trip-Free Operation—It will be noted that the compressed air circuit breaker has no latch. The contacts are maintained in the closed position by an over-center toggle formed by the arm of the operating shaft and the contact pull rod for each pole unit. They are locked in this position by action of a knuckle joint at the top of the operating piston rod which drops into a recess at the upper end of the piston rod guide as the piston reaches the end of its upward stroke. This is shown in Fig. 9.

Forces tending to move the contacts toward the open position, whether magnetic forces on the contacts themselves or manual force applied through the hand operating lever, serve only to lock the breaker more tightly in the closed position and the knuckle joint must be pushed out of the recess before the breaker can be opened with the hand operating lever. The recess is so shaped, however, that it offers no appreciable resistance to movement of the operating piston and the contacts will move to the open position immediately upon admission of air to the operating cylinder.

This breaker is, then, not tripped in the sense in awhich that term is ordinarily used in switching service, namely, by releasing a latch and permitting the contacts to move to the open position through spring action without reference to the operating mechanism. The compressed air breaker is driven open by air pressure on the operating piston just as it is driven closed by air on the opposite side of that piston.

It will be apparent from this that the term "mechanically-trip-free", familiar from long usage in the case of solenoid and motor operated breakers, does not apply to compressed air breakers. These breakers are, however, "electrically and pneumatically trip-free". The electrical function in this operation is explained by the "X-Y-Z" relay scheme described under "Control". Pneumatically, this operation is carried out through use of an exhaust valve in the main operating cylinder.

As shown in Fig. 6, the main operating cylinder has an open port in its side wall midway of its length. This port opens into a small, vertical auxiliary cylinder, open at its lower end, in which moves a close-fitting plunger. The stem of this plunger is connected to a rocker arm pivoted on the side of the operating piston guide above, and so arranged that as the piston rod moves upward in its guide the exhaust valve plunger in the auxiliary cylinder is raised to the point of uncovering the port in the side wall of the main operating cylinder, permitting air below the operating piston to exhaust to the outside atmosphere.

The adjustment of this exhaust valve is such that uncovering of the exhaust

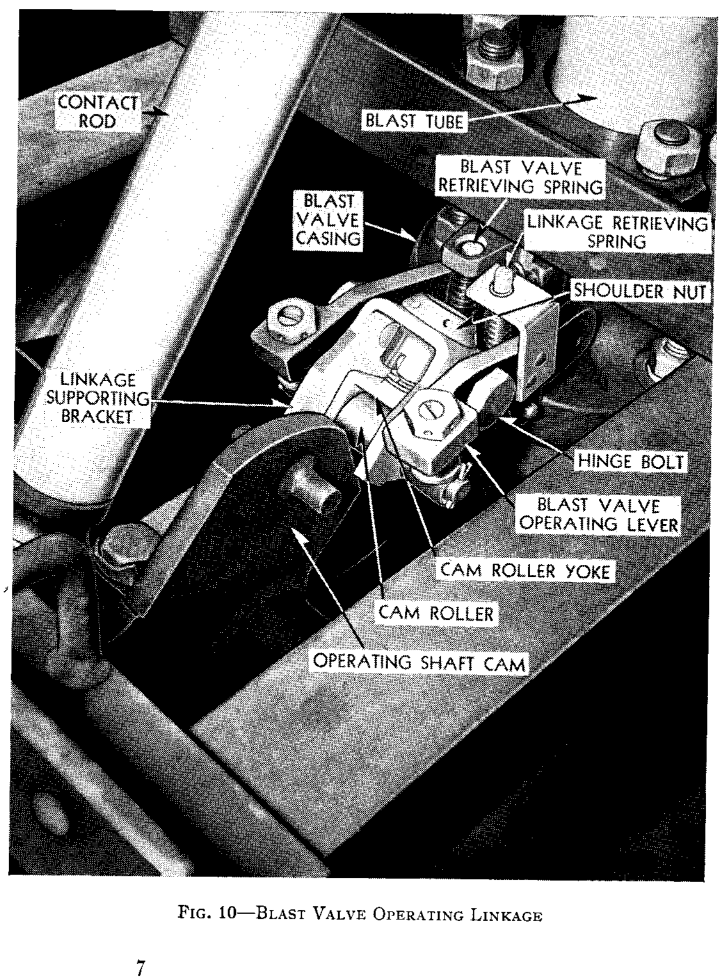

Fig. 10—Blast Valve Operating Linkage

port is delayed sufficiently to insure that the breaker contacts will pass on to the full-closed position in an ordinary closing operation but is early enough to permit exhaust of residual air below the operating piston in the event of the closing movement being followed immediately by an opening operation. As explained under "Control", closing air cannot be maintained on the closing piston after the "Y" relay has sealed in, and the exhaust valve provides for exhaust of residual closing air under the piston. It will thus be apparent that full provision is made for "trip-free operation."

Blast Valves—The air blast through the arc on opening the contacts is controlled by a blast valve located on top of the main reservoir, one for each pole unit. The blast valves are operated mechanically through movement of the breaker operating shaft, the operating linkage being so designed that a blast of air is passing through the arc-drawing space at the time the contacts part. As shown in Fig. 4, opening the blast valve admits air through the hollow central column or blast tube, across the contact opening and out through the arc chute to the expansion space at the top of the enclosure, or to atmosphere in the case of an unenclosed breaker.

The valves are of the metal-to-metal seat type, the valve member being free-seating in its casing. In closing, the conical valve rises against a seat so machined as to prevent a bearing surface approximately $\frac{1}{32}''$ in width, reservoir pressure tending to hold the valve against its seat when not operating. All blast valves and their casings are carefully machined, ground in and tested for leakage in position on the breaker with which they are shipped from the factory.

Operation of the blast valve is obtained through an operating lever pivoted in a split bearing in the side wall of the valve casing as shown in Fig. 10. A trunnion mounted linkage is supported between the parallel arms of the valve operating lever outside the valve casing, so arranged that a cam surface on the main breaker operating shaft engages a cam roller in the linkage on the opening breaker stroke, raising the blast valve lever, depressing the valve and admitting air to the blast tube. On the closing breaker stroke the linkage folds back, trailing over the cam surface without raising the blast valve lever, the high closing speed of these breakers making an air blast unnecessary when closing the circuit.

Compressed Air Supply—An air supply unit, shown in Fig. 11, may be supplied to provide adequate air pressure for the operation of compressed air circuit breakers. This supply unit comprises a Westinghouse Air Brake Company, two-stage, motor-driven compressor with the necessary storage reservoirs, cooling coils, control equipment, safety devices and piping, built into a compact unit ready for service. It may be installed in any convenient location, remote from the breaker if desired, and connected to the individual circuit breaker reservoirs by suitable air delivery mains.

In addition to providing a supply of compressed air for breaker operation,

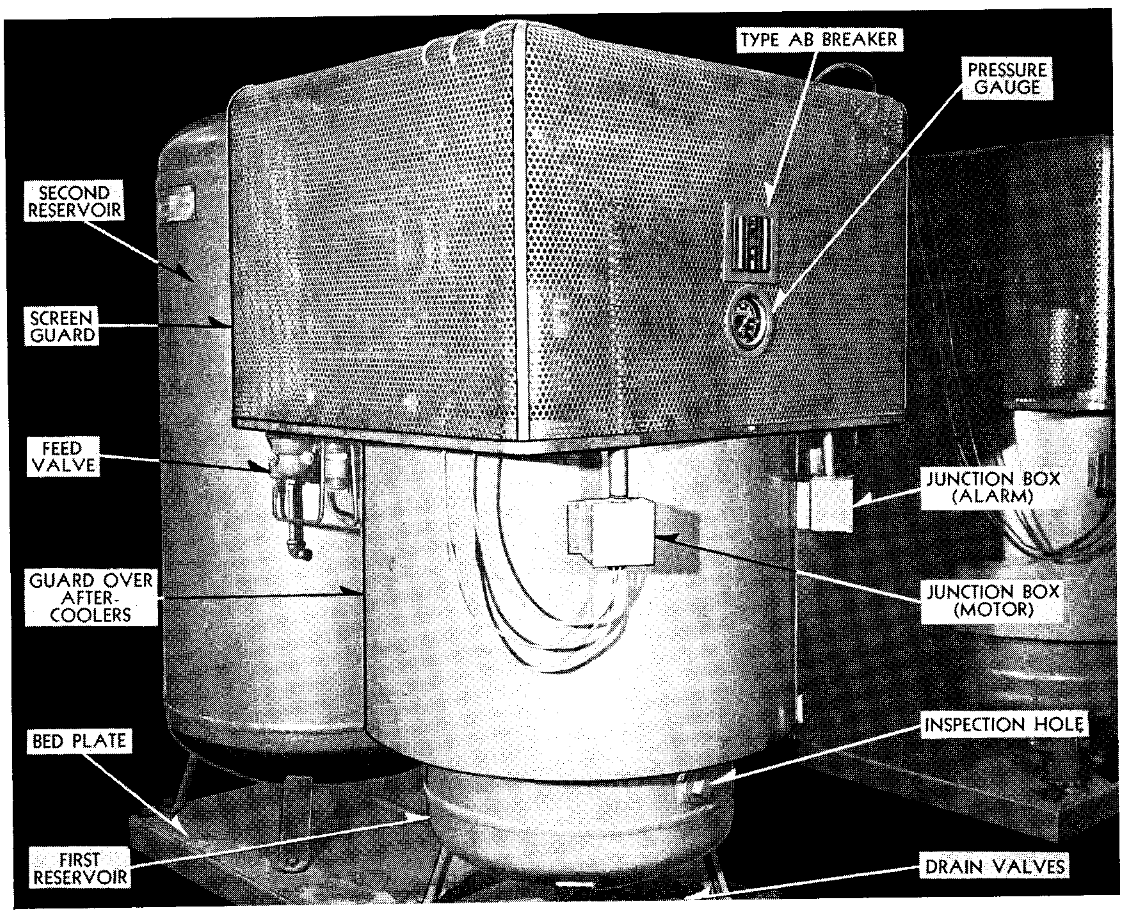

Fig. 11—Compressed Air Supply Unit

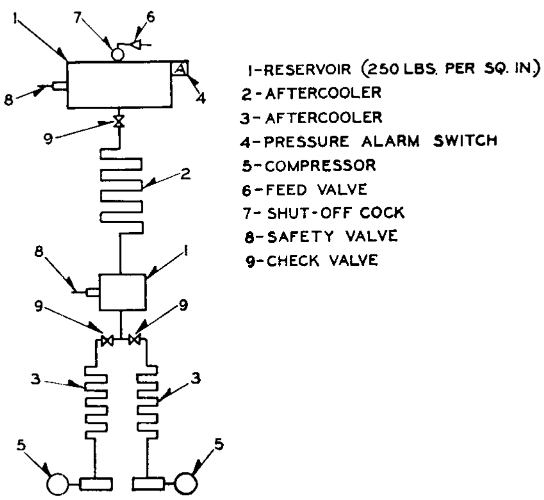

FIG. 12—SCHEMATIC ARRANGEMENT OF AIR SUPPLY UNIT, (TWO COMPRESSORS)

the unit is designed to remove moisture from the air supply by first compressing it to high pressure, then cooling it. Two storage reservoirs are ordinarily supplied, normal working pressure for both reservoirs being 250 psi. Air is fed from the supply unit through a pressure-reducing feed valve whose function is to maintain a constant pressure of 150 psi in the air delivery mains, this being normal working pressure in the breaker reservoirs.

General arrangement of the unit is shown in the schematic diagram, Fig. 12. The compressor, with a filter on the intake side, carries an intercooler between the two stages of compression and an aftercooler between its high pressure cylinder and the first storage reservoir. A second aftercooler is placed between the two reservoirs. These are finned cooling coils, designed to reduce the temperature of the air at the outlet of the second reservoir to ambient temperature.

Air from the compressor, cooled between stages of compression, is passed into the first (small) reservoir through a cooling coil, the major portion of moisture being condensed and deposited in this reservoir. From here the air passes through another cooling coil to the second (large) reservoir, some further condensation taking place in the process if the rate of flow is high as in the case of first filling the system. By this means the percentage of humidity in the air supplied to the circuit breakers is reduced to the point at which no appreciable amount of moisture is introduced into the air delivery mains or breaker reservoirs.

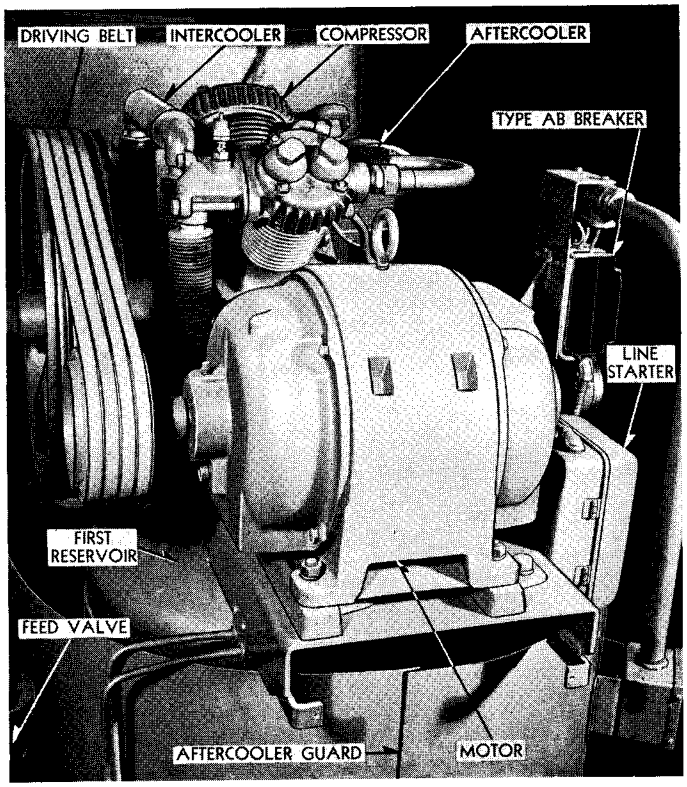

FIG. 14—AIR COMPRESSOR FOR SUPPLY UNIT

Operation of the compressed air supply unit is entirely automatic. Motor power leads are brought into the unit through a Type AB "De-ion" circuit breaker connected to a Westinghouse line starter. Once the AB breaker has been closed, the compressor starts running and continues until supply pressure is raised to 250 psi when an automatic, pressure-actuated governor cuts off the motor. This governor cuts the motor in again when pressure has been reduced to 240 psi.

Another pressure-actuated switch provides for an alarm, either audible or visual, when pressure in the unit has been reduced to 200 psi or slightly over.

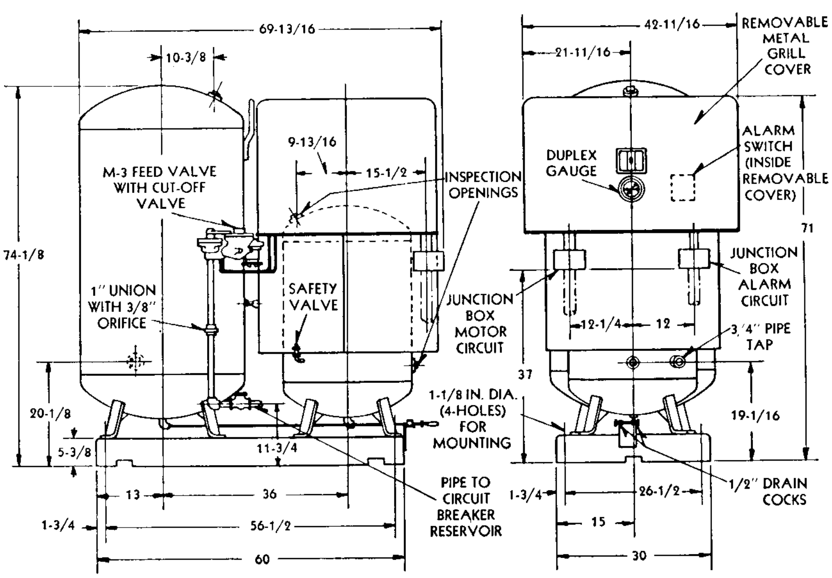

FIG. 13—AIR SUPPLY UNIT WITH SINGLE COMPRESSOR

A dual pressure gauge shows air pressure in the supply unit and also on the line side of the feed valve. Safety valves are supplied on the supply reservoirs and on the compressor. Drain valves are provided for removal of moisture from the reservoirs.

Air Storage—The unit regularly supplied provides a storage volume of 32 cu. ft. which at 250 psi permits storage of approximately 540 cf of free air. The compressor ordinarily supplied with this unit has a delivery of 6.5 cfm of free air. For installations of average switching activity this unit should provide an adequate supply of air for the operation of from four to eight circuit breakers, depending on their interrupting rating.

This compressor will charge the supply unit reservoirs to 150 psi in 50 minutes. Adding to this time 20 to 35 minutes for each breaker reservoir to be charged (volumes of breaker reservoirs vary with their interrupting rating), will indicate the approximate time required to charge any given installation of breakers to their normal working pressure of 150 psi. An additional 35 minutes will be required to complete the charging of the supply unit to its normal working pressure of 250 psi.

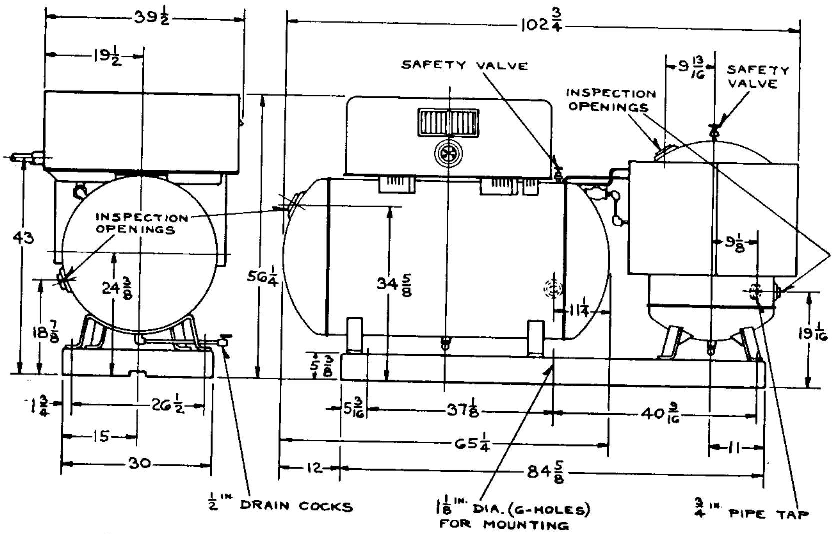

Fig. 16—Air Supply Unit with Two Compressors for Small Breaker Installations

For applications where possible emergency conditions may necessitate shorter charging times, and where a separate source of clean, dry air is available, the complete breaker system may be given an initial charge from this separate source up to the limit of its pressure (usually 70 to 90 psi), the regular supply unit then completing the charge. A booster connection for this purpose is ordinarily supplied in the first (small) reservoir of the supply unit.

It is recommended, however, that a spare supply unit be installed in order to insure uninterrupted service during maintenance periods. Even though the second compressor be kept as a stand-by, its reservoirs may be maintained at 250 psi to obtain the extra storage for emergency use.

For small installations of one to three breakers, where there is no prospect of future extension, the same unit may be supplied with two smaller compressors as shown in Fig. 16. The two compressors may both operate together or one may serve as a stand-by. Supply units of other storage volumes, and compressors with other delivery ratings may be supplied for installations where the standard unit does not meet all requirements.

In the design of the air supply unit careful attention has been given to elimination of the fire hazard sometimes found present in heavy duty compressor systems. Such hazard in the past has been traced to long continuous duty on the compressor to the point of excessive heating at the high pressure outlet, coupled with the presence of oil vapor in the air stream.

Compressors supplied with these units work well within their rating and are subject to intermittent duty only. They are equipped for a forced circulating

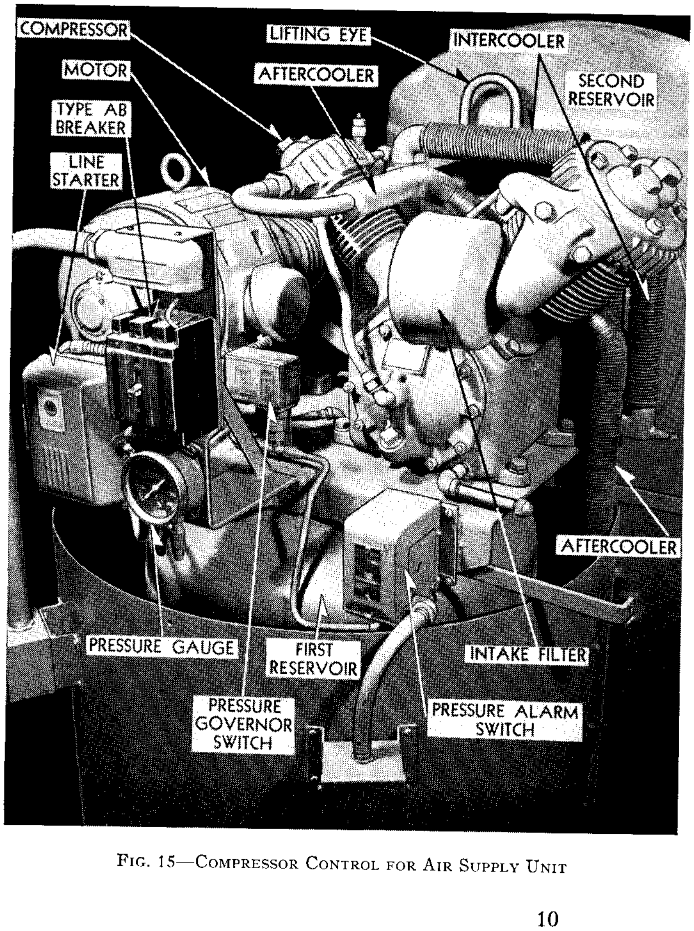

Fig. 15—Compressor Control for Air Supply Unit

lubrication system rather than a splash system, thus reducing the amount of oil carried to the vicinity of the compression chamber. The compressor pistons are supplied with an oil ring in addition to the conventional sealing rings, again reducing the amount of oil or oil vapor which may pass into the compression chamber. The cooling system of moisture removal utilized in this unit readily condenses any remaining trace of oil vapor and deposits it in the first storage reservoir where it may be drawn off with the water collected there. All possibility of oil being carried over to the circuit breaker air system is thus removed.

Air Delivery System—For circuit breaker installations where the air supply unit is remote from the breakers, a suitable system of piping is necessary for delivery of air to the breakers. This piping system, not regularly supplied by the manufacturer, is an important element in the installation from the standpoint of providing trouble-free and reliable operation. It is necessary that the system provide ample capacity for carrying the required amount of air; it must be clean; must be free from scale and erosion, and must be so installed that possibility of leakage or breakage is minimized.

Fig. 17 shows a typical schematic arrangement of the delivery system for a battery of circuit breakers with two air supply units. Provision is made by suitably located shut-off valves for completely isolating either supply unit for maintenance or inspection purposes while the other unit continues to feed the system.

It is recommended that copper tubing, 1⅛″ outside diameter, the equivalent of Chase Type K tubing, be used for the delivery system and that all joints and connections be made with solder-type, brass fittings of sufficient weight to withstand a working pressure of not less than 150 psi. Brass tubing of equivalent size and weight may be substituted if desired. For larger installations or where delivery over several floors is contemplated, larger sizes of tubing may be necessary to provide against excessive friction losses.

Iron pipe or steel tubing may be used only with some attending hazard. Where it is absolutely necessary to use this material the internal surfaces should be thoroughly freed from all scale and rust, and these surfaces should then be treated with a durable, rust-resisting coating which will not crack or flake off. Frequent inspections should be made of such lines to insure that they are free from rust.

All soldered, sweated or brazed joints should be made in the manner specified by the manufacturers of the tubing and fittings used, in order to provide adequate, leak-proof joints. All tubing should be properly supported and braced, and should be protected from injury by contact with other equipment.

At the point of connection to supply unit or circuit breaker reservoirs the installation should be such as to minimize mechanical stresses on the tubing or joints. At points where the tubing may be installed near or attached to apparatus involving excessive vibration, suitable precautions should be taken to cushion the tubing from these vibrations.

Protective Air Devices—A protection valve is supplied with each circuit breaker at the point of connection of the air delivery system to the breaker reservoir, shown in Fig. 6 at the right hand end of the reservoir. Incorporating several functions in a single casing, this valve is intended primarily as protection against complete loss of air from the delivery system or the breaker reservoir in the event of a broken pipe line or other emergency. It is recommended that a similar valve, not regularly supplied, be installed in the air delivery system at the outlet of each supply unit, as shown in the schematic diagram. Fig. 17, for installations of two or more supply units.

The protection valve as applied to the circuit breaker incorporates: a solder-type connection point for the air delivery system; a lever-handle shut-off cock to isolate the breaker from the delivery system; a filter; a one-way check valve to prevent reverse flow of air from the breaker reservoir; a two-way check valve designed to operate on a differential in pressure between its two sides and to close on a high rate of air flow in either direction such as might result from breakage of an air line or other emergency; an exhaust valve to exhaust air from the breaker reservoir; a safety valve, and a gauge showing reservoir pressure.

Caution

The manufacturers of this equipment have complied in all respects with the A.S.M.E. Code for Unfired Pressure Vessels. All air reservoirs supplied with the equipment are built and tested under Inspection of the National Board of Boiler Inspectors and each reservoir carries a name plate with a serial number which is on file at National Board Headquarters. However, since the manufacturers do not make the complete installation, plans for such installations should be made with due reference to rulings of the Indemnity Company writing insurance for the particular property in question.

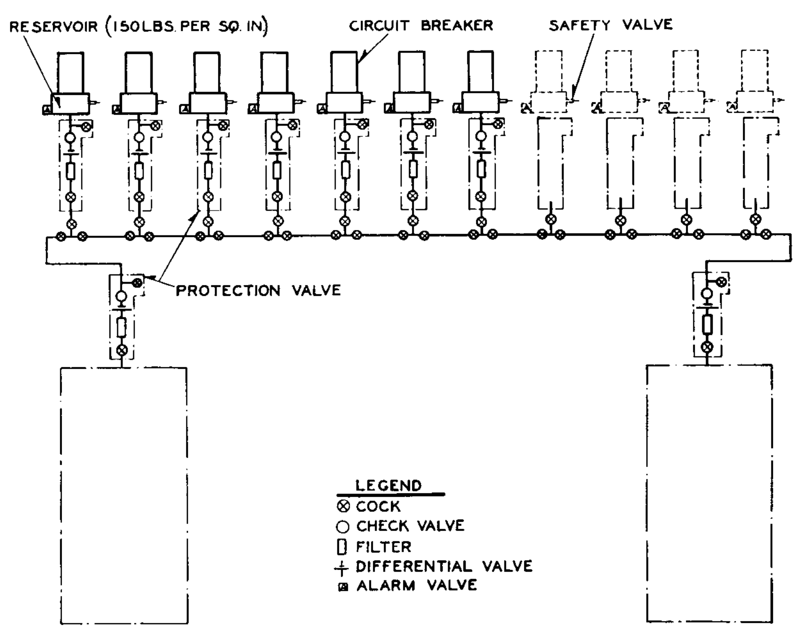

Fig. 17—Typical Diagram of Compressed Air Delivery System

It should further be borne in mind that many states have Codes covering such installations, these Codes being by no means uniform throughout the country. In addition, many municipalities and local districts have ordinances not always conforming to the Code of the state in which they are located. State and local rules governing such matters should be studied in planning compressed air installations.

INSTRUCTIONS FOR INSTALLATION

General—Circuit breakers operating without liquid dielectric depend to some extent upon the integrity of organic materials for their insulation strength. These materials are chosen as the best available for the purpose they are to fulfill and they are tested before leaving the factory to insure that they meet fixed standards of insulating value. Whether or not they retain this dielectric value depends upon the treatment accorded them after they leave the factory. Compressed air circuit breakers received before preparations for installation are completed should be stored in a clean, dry location where they will not be exposed to an accumulation of dirt from building operations or moisture from exposure to outside atmosphere.

Immediately upon receipt of a circuit breaker, an examination should be made for any evidence of damage sustained while enroute. If injury is evident, or indication of rough handling is visible, a claim for damage should be filed at once with the carrier (Transportation Company) and the nearest Westinghouse Sales Office should be notified promptly.

Unpacking — The circuit breaker should be moved as near as possible to the point of installation before removing it from the packing case. Care should be taken in unpacking to insure that delicate parts of the mechanism are not injured. Do not open the packing case with a sledge hammer or heavy bar—use a nail-puller.

Examine the apparatus carefully for breakage, distortion or anything else that might cause improper operation, and see that all packing blocks are removed from the mechanism. Remove all excelsior, dirt or other foreign matter, and look over the moving parts of the breaker and its auxiliaries carefully to see that they are in proper operating condition.

Do not lift the breaker by slings placed under projecting parts of the mechanism; to do so may distort it—use the lifting eyes provided for this purpose. Breakers used during the period of installation for a step-ladder, platform or other purposes for which they are not intended may not give satisfactory performance when placed in service—some of the adjustments are delicate.

Installation—The compressed air circuit breaker is shipped from the factory as a completely assembled unit except for the arc chutes which are shipped in a separate packing box for greater protection. The main breaker unit as unpacked is ready to be moved into its cell or other enclosure and bolted to the floor through holes in the base of the mounting frame provided for the purpose. The most satisfactory anchorage will be obtained by bolts passing completely through the floor with plate washers on the under side of the floor. Where this is not feasible, one of the various types of commercial anchor bolt may be used with the anchor portion leaded firmly into the floor.

Before assembling the arc chutes on the breaker structure, trial operation of the contacts should be made with the hand operating lever. The lever should be inserted in a socket provided for that purpose at the right hand end of the breaker operating shaft. Raising the handle upward closes the contacts and lowering the handle opens them. Do not leave the handle in its socket when not operating the breaker.

Note that in the closed position of the breaker contacts a knuckle joint at the top of the main operating piston rod slips into a socket at the upper end of the piston rod guide. This provides a lock for the closed contact position and the knuckle joint must be pushed or pried out of the socket before the contacts can be opened with the hand operating lever

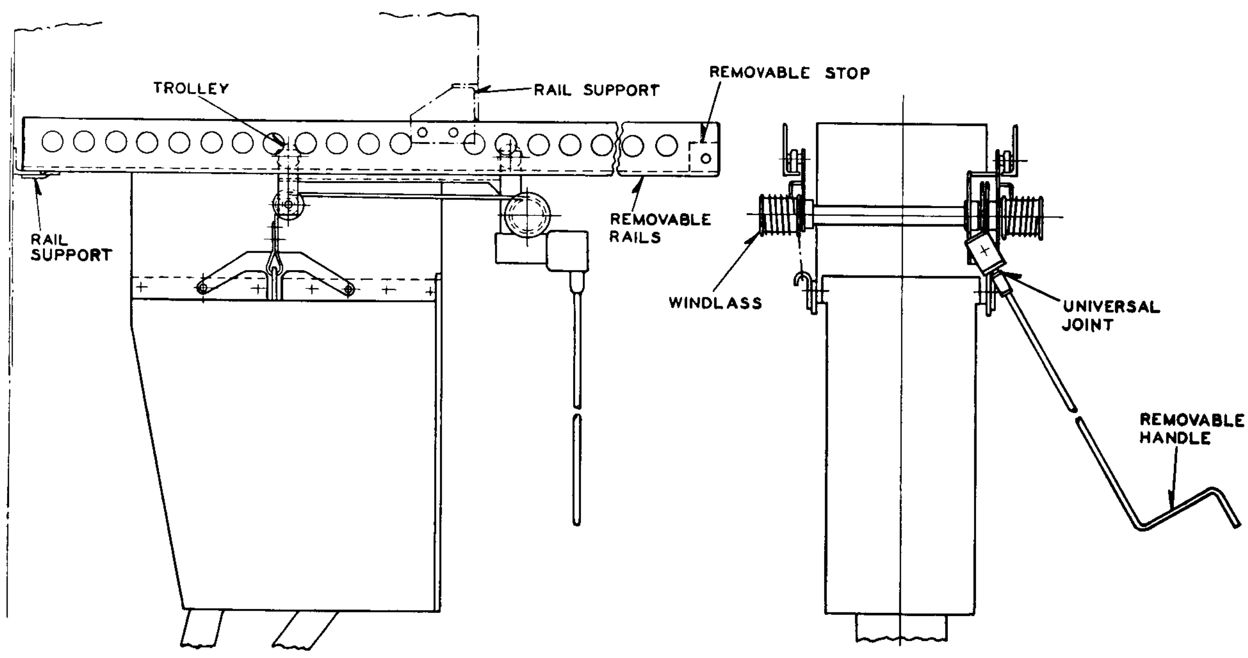

Fig. 18—Lifting Device for Arc Chute

This lock offers no appreciable resistance to air operation by the operating piston.

Open and close the contacts several times to insure that they engage properly and that they are free to move through the complete contact stroke. In the closed contact position the stop bolts at either end of the operating shaft should engage the rubber bumpers on the shaft mounting bracket but will lift about 1/8″ off these bumpers when the knuckle joint on the piston rod slips into its socket. In the open contact position the lock nut at the top of the piston rod should come to rest from 1/8″ to 1/2″ above the top of the bushing in the operating cylinder cover.

The arc chutes may now be assembled on the breaker structure. From the various illustrations in this book it may be seen that the chute is mounted on the insulating block at the top of the central hollow column which supports the stationary contact member, and is bolted to it. Note that the chute cannot be lowered into its final position from above. The best method of assembling is to rest the rear bottom edge of the chute on the front top edge of the block and push the chute back into position. A chute lifting device may be supplied for handling the heavier chutes on breakers of the higher interrupting ratings.

When the chute is in its proper position the holes in the lower portion of the chute side plates will line up with corresponding holes in the contact mounting block and it may be bolted in place. Tighten the bolts securely and lock with the locking clips provided for the purpose. Trial operation of the breaker contacts should now be repeated, using the hand operating lever, to insure that the moving contacts enter the slots in the front of the arc chutes properly.

With the arc chutes in position, the horizontal insulating barrier members located near the tops of the arc chutes may be placed in position in accordance with the drawing supplied with the breaker. For breakers installed in masonry cells or in steel enclosures not supplied by the manufacturer, supports for this barrier will be necessary on the rear and side walls of the cell or enclosure.

Information for the provision of these supports will be supplied where enclosure details are made known when the breaker is ordered. When steel cells or cubicles are supplied with the breaker these supports will be provided. With the horizontal barrier in position, the vertical interphase barriers may be slid into position in the grooves or clips provided on the top of the breaker frame and on the underside of the horizontal barrier.

Caution

For installations where the breaker is not accessible from the rear, the structure has been designed to leave a space of about 12″ from the floor to the bottom of the reservoir, and a space of not less than 8″ from the reservoir to the rear wall of the enclosure. This space is for inspection of the breaker reservoir. Permanent structures in the enclosure, other than the circuit breaker, should not be allowed to encroach on this space without referring the matter for approval to the Indemnity Company which insures the property in question.

Wiring—Control wiring should be installed in accordance with the wiring diagram supplied with the breaker. The breaker unit has been wired complete and tested before leaving the factory; no additional wiring or changes should be necessary. Connections from the station control should be made at the points on the control panel terminal blocks designated on the diagram. Closing the Type AB "De-ion" breaker on the control panel will then apply control voltage to the breaker operating auxiliaries. For control schemes arranged to open the breaker when the low pressure point is reached, either the contacts must be open or the reservoir must be charged above the low pressure point to apply control voltage to the breaker.

The Type AB breaker supplied with these control panels carries a thermal cutout as protection against overload or short circuit on the control. After an automatic opening this breaker is reset by moving its handle to the **extreme** open position, then closing it. In event of failure to secure control voltage at the breaker, check by this reset operation to see if there has been an automatic opening.

Air Connections—Connection with the air supply system should be made at the inlet connection provided on the under side of the protection valve casing at the right hand end of the breaker reservoir. A shut-off cock is provided in the protection valve casing and no additional shut-off means need be installed at this point. An exhaust valve is arranged in the same valve, just behind the inlet connection, to exhaust air from the reservoir if necessary. Check to see that the breaker is shut off from the supply system before opening the exhaust valve.

The two-way check valve incorporated in the protection valve will be closed under the condition of no pressure in the breaker reservoir. In order to fill the reservoir it will be necessary to move the reset handle, projecting from the right side of the casing, toward the valve casing and hold it there until the pressure gauge has reached 90 to 100 pounds, after which the valve action will be automatic. Allow line pressure in the air delivery system to rise to about 150 psi before admitting air to the breaker reservoir.

Caution

Work safely. Be sure that air has been exhausted from the reservoir before loosening any bolted connection where air pressure may be present.

Make a habit of removing the hand operating lever from its socket after any hand operation. Air operation with the hand lever in its socket may result in serious personal injury.

When inspecting or repairing the breaker, disconnect the control through the AB breaker on the control panel to remove possibility of operation from a remote point.

Do not attempt to operate the breaker with the hand operating lever when the main power leads are energized.

When admitting compressed air to an empty breaker reservoir, the air blast valves controlling passage of air from the reservoir through the hollow blast tubes to the breaker contacts, may be hanging away from their seats, permitting air to escape through the blast tubes. These valves may be closed by pressing downward on the blast valve operating levers which extend out over the operating shaft. A few pounds of pressure in the reservoir is sufficient to hold these valves closed.

If, when the reservoir has been filled to the full working pressure of 150 pounds per square inch, it appears that air is still escaping through these valves, the cause may be found in dirt or other foreign matter dropped into the valve during the shipping or storage period. Place a bar under the blast valve operating lever, lifting the lever slightly to open the valve and allow air to blow through it, then dropping the bar away

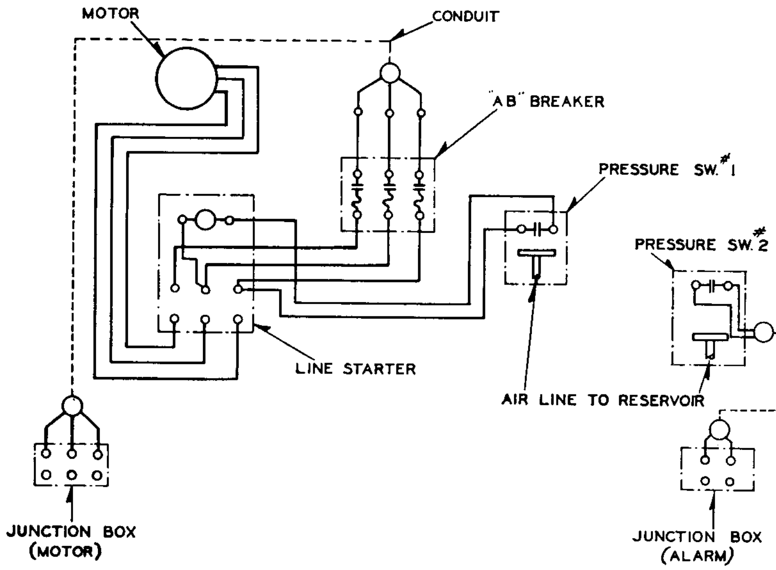

Fig. 19—Typical Wiring Diagram for Compressed Air Supply Unit, (Single Compressor)

quickly to permit the valve to slam closed through reservoir pressure. Repeat this operation several times. If the condition still exists, trial operation as described in the following paragraphs may be necessary to seat the valves properly.

Trial Operation—When control wiring has been connected in accordance with the wiring diagram and air in the breaker reservoir has been raised to 150 psi working pressure, the breaker should be operated several times through the control circuit, watching the various operating members to ascertain that all parts move freely.

Do not attempt to open the breaker with the hand operating lever while there is pressure in the reservoir;—to do so may result in complete loss of reservoir pressure through blast valve action. If absolutely necessary to do this, it may be done by folding back the roller trunnions in the three blast valve levers and holding them back during the opening movement so that action of the cam surfaces on the operating shaft will not raise the blast valve levers and open the valves. The Type AB breaker should be open when this is done. Be sure that the hand operating lever is removed from its socket before electrical operation is started.

None of the adjustments of the circuit breaker should be disturbed unless they have plainly been displaced since the breaker was operated at the factory. It should not be necessary to alter any of these adjustments as the circuit breaker is not dismantled for shipment, and should arrive at the point of installation in exactly the same condition in which it left the factory.

Shut off the breaker reservoir from the air supply line and exhaust the reservoir air slowly. Remove the covers from the lockout and alarm switches, located on the relay panel and note the action of the contacts in these switches. The lockout switch should operate to lock out the control at not less than 105 pounds and the alarm switch should give its signal at from 5 to 10 pounds above this point. On breakers of highest kv-a. rating the lockout point may have been set higher than this. These settings should not be changed without referring the matter to the manufacturer.

If, in the course of trial operation, reservoir pressure has been reduced to 90 pounds or less it will be necessary to operate the hand reset lever on the protection valve as previously described, before more air can be admitted to the reservoir.

Power Leads—After the breaker has been operated satisfactorily through the control circuit the power leads may be connected to the breaker terminals. Care should be taken that these leads are adequate in capacity to carry their normal current load without excess heating, and properly braced against the magnetic forces of momentary currents to which they may be subjected. The ability of these circuit breakers to carry rated load currents within prescribed limits of temperature rise, and to carry their rated momentary currents without damage, is based on the adequacy of their line connections as well as on the design of the breakers themselves.

Caution

Exposed portions of compressed air breakers in the high voltage breaker compartment carry line potential. Where these breakers are installed in enclosures not supplied with them, care should be taken to insure that adequate electrical clearances are maintained between live parts and ground as well as between phases. Before applying power to the breaker see that no grounded objects are touching live parts, and that no tools or other materials have been left on the breaker at points where they may form a connection across potentials when the contacts are open.

Air Supply Unit—The air supply unit for compressed air circuit breakers is shipped from the factory as a completely assembled and tested unit ready for operation. The storage reservoirs, compressor and control are mounted on a single bedplate requiring only to be bolted to the floor in its installation space. Instructions previously given for moving, unpacking and examining the circuit breaker apply to the supply unit as well.

Supply Unit Wiring—Fig. 19 shows a typical wiring diagram for an air supply unit with one compressor, and Fig. 20 shows the same for a double compressor unit. This wiring is brought out to the junction boxes shown in Fig. 11, where electrical connections should be made on installation. One box is provided for the motor power leads, the remaining control leads being brought to the other box.

For supply units with two compressors it will be noted that two line starters are provided in order that the motors may receive power from two different sources of supply if desired. The wiring is so arranged through two Type AB "De-ion" breakers that either one or both motors may operate at one time. Opening one AB breaker will prevent its motor from running but will not completely isolate that motor and line starter as the two line starter coils are connected in parallel. Both AB breakers should be open when inspecting or working on the unit.

Before starting the compressor see that it is filled to the proper level with lubricating oil. These compressors are equipped with an unloading oil interlock. If the oil is low, the compressor may not charge the reservoirs to full working pressure.

See that all valves in the air delivery system are set to supply the desired breaker reservoirs and that air is shut off from other delivery points in the system where it may be wasted or cause injury. If an initial booster charge is applied to the system from some other source of air supply, see that connection to the other source is shut off before the supply unit compressor is started. It is recommended that delivery system pressure be raised to about 150 psi before air is admitted to the breaker reservoirs.

Closing the Type AB "De-ion" breaker on the supply unit control panel will start the compressor, and operation thereafter will be controlled by an automatic governor set to cut the motor off at 250 pounds pressure, cutting it in again at approximately 240 pounds. As the pressure in the unit builds up, check the pressure gauge to see that supply to the air delivery system is cut off by the feed valve on the unit at 150 pounds. The alarm switch on these units is set to give a signal at from 200 to 210 pounds.

INSTRUCTIONS FOR OPERATION AND MAINTENANCE

General—The compressed air circuit breaker when shipped from the factory has been completely adjusted and tested to give satisfactory performance of the service for which it is intended. Whether or not it continues to give satisfactory performance depends to a considerable extent on the care and maintenance which is given to it. The following information on adjustments is given as a guide for such maintenance and to facilitate reassembling of the parts in case they have been removed for any reason or require replacing at any time. It should not be necessary to check these adjustments unless they have been disturbed by disassembling, or unless there is plain evidence of their having been otherwise disturbed.

Contacts—1200 and 2000 Amperes—These contacts are of the blade and finger type with a liberally wide blade for the moving element and two pairs of heavy duty fingers for the stationary element. The moving contact has its entering end cut at an angle so that its upper edge leaves the stationary fingers last as the contacts open. This, together with the magnetic effect of the current loop through the breaker members and upward pressure of the air blast which is flowing at the time of contact parting, causes the arc to be drawn on the uppermost portions of the contact surfaces, these portions being fitted with a silver-tungsten alloy highly resistant to arc burning. This leaves a major portion of the silver-plated contact surfaces untouched by arc action and in condition to carry normal current loads without excess heating.

In average service this arrangement of contacts should give long life. The movable contact is withdrawn from the arc chute in the open breaker position and its condition may be observed without disassembling. The condition of the stationary contact surfaces may be judged from that of the moving contact and this judgment may be verified by inspection through the entering slot in the arc chute with the assistance of a flash light. Since these contact surfaces are liberally designed, a moderate roughening should not impair their current-carrying ability.

Where this rough surface is considered excessive the moving contact surfaces may be repaired readily with a fine file or emery cloth. If any attempt is made to work on the stationary contacts in the same manner through the slot in the arc chute, the blast tube opening in the bottom of the contact chamber should be carefully covered with paper or cloth to prevent fine particles from dropping into the blast valve and becoming embedded in the valve seat. Clean out the contact chamber thoroughly after any such work and "crack" the blast valve slightly with a bar under the blast valve operating lever to blow out any residue of dirt.

When it becomes necessary for any reason to replace the stationary contacts the procedure should be as follows. Remove the marked bolts on each side of the arc chute which secure it to the contact mounting block. Draw the arc chute toward the front of the breaker until it can be lifted from the breaker structure. Instructions will be found elsewhere for the use of a chute lifting device where this accessory is supplied.

The complete stationary contact assembly may now be removed from its mounting on the insulating block. In assembling the new contact be sure that the holding bolts are drawn up tightly and securely locked. The gap between the fingers in their free position should be $\frac{1}{16}''$ to $\frac{3}{32}''$ less than the thickness of the moving blade which enters them. This gap is adjusted by changing the pressure of the spring which bears against the outer surface of each finger. Use a feeler gauge to insure that each finger bears over the full surface of the moving blade when engaged, freeing the holes around the finger retaining pins if necessary to secure this result. The arc chute may now be reassembled, drawing up and locking its holding bolts securely.

The moving contact may be disassembled by removing the special

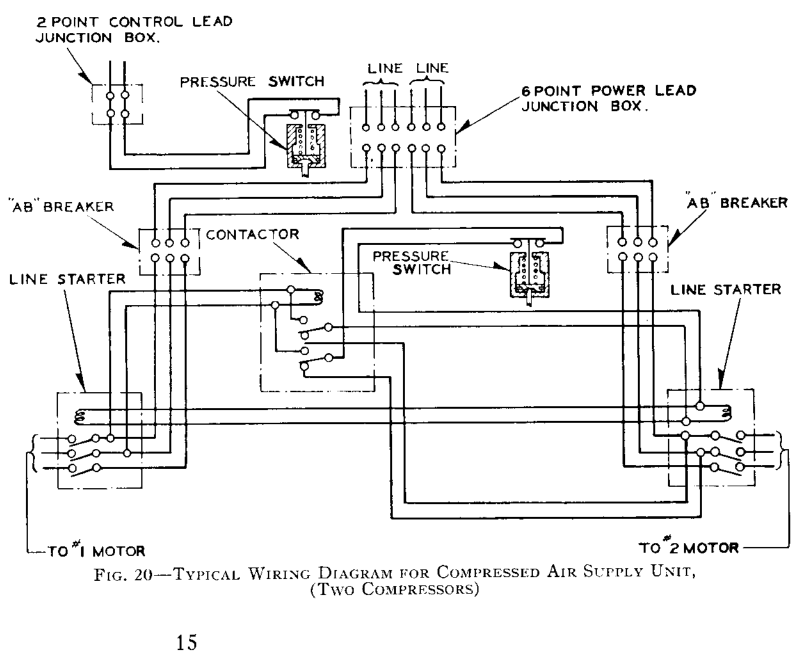

Fig. 20—Typical Wiring Diagram for Compressed Air Supply Unit, (Two Compressors)

castelated nut and spring washer from the hinge pin. On breakers shipped from the factory this hinge joint has been given a light application of graphite-grease compound to prevent galling or excessive friction. This compound will not interfere with the current-carrying ability of the hinge and its use is recommended. In replacing the contact spring washer, turn up the castelated nut as far as possible with the fingers, making sure that the thread is free-running, then turn it 1/6 of a turn more with a wrench and pin the nut.

In replacing the moving contact member care should be taken to insure that it enters the stationary fingers without stubbing action. The stationary contact may require shifting on the clearance in its holding bolt holes and it may be necessary to adjust the hinge pins slightly. The latter adjustment is made by loosening the bolts that clamp the main hinge casting to the blast tube column and rotating it until the desired result is obtained. After the arc chute has been reassembled in position another check should be made to insure that the moving blade enters the front slot in the chute properly. Be sure to tighten and lock all holding bolts securely after any adjustment.

Contact Pull Rod—Assembling a new moving contact may necessitate adjustment of the contact pull rod. First rotate the operating shaft toward the closed position until the center of the pin connecting the pull rod to it has passed 2¼″ beyond the vertical center line of the operating shaft. In this position the stop bolts on the shaft arms should engage the rubber bumpers on the shaft bearing brackets, and the pull rod pin should be ½″ to $\frac{9}{16}$″ over toggle center as measured from an extension of the pull rod center line to the center line of the operating shaft. Also, in this position the inside of the curved portion of the moving contact may bear lightly on or be clear of the front of the insulating block on which the stationary contact is mounted.

Now let the operating shaft rotate back toward the open position until the knuckle joint at the top of the operating piston rod is resting in its locked position in the socket at the upper end of the piston rod guide. In this position the contact pull rod should not be rigid but should be sufficiently free on the clearance in its connecting pin holes to be shaken by the hand. Adjust the length of the pull rod until these results are obtained.

Contacts—3000 to 5000 Amperes—In general, the adjustment of contacts for the higher current ratings follows the same procedure as for the lower-current, single-contact breakers. The central, arc-drawing contact should be adjusted first in accordance with the instructions previously given for the 1200-ampere contacts.

This being done, the main current carrying contacts are mounted on the same hinge pins and the stationary contact blades brought into alignment with the moving members. Care should be taken that the clamp plates bearing on the hinge portion of the main contacts make contact over the full surface of the hinge.

Insulation—Insulating materials on compressed air circuit breakers should be kept free from accumulations of dirt and dust. Loose dust may be blown off with dry compressed air, or the various parts may be wiped with a clean dry cloth. Steam waste is not recommended for this purpose due to its tendency to leave a residue of lint on insulating surfaces. If the breaker has stood for some time without operating, it may be opened once or twice with air in order that blast valve action may blow out any accumulation of dirt inside the arc chute.

Spare parts of insulating material such as arc chutes and pull rods, should be stored in a clean dry place and protected from deposits of oil or dirt, and absorption of moisture. Since fibrous materials are subject to warpage under changing atmospheric conditions, insulating material in the form of plates should be laid flat while in storage.

Heaters—For applications where it may be necessary to install compressed air breakers in an unheated room, or where for any reason ambient temperature at the breaker may drop to the freezing point, it is recommended that space heaters be installed in the breaker enclosure.

This applies particularly to applications where ambient temperature at the breaker may be lower than at the air supply unit since this condition is conducive to further condensation of moisture after air has been delivered to the breaker reservoir. Under these conditions freezing temperatures may result in sufficient icing at the breaker mechanism valves to impair their operation. These heaters need not be energized when atmospheric conditions are favorable, or when heat losses from load current through the breaker are sufficient to prevent ice formation within the breaker enclosure.

Blast Valves—The blast valves for compressed air breakers, shown in Fig. 10, are of the metal-to-metal seat type with the valve member free seating in its casing and no adjustment of the valve itself is provided. The valve is ground in and tested at the factory for a minimum of leakage and experience indicates that these valves may be expected to wear themselves in to an even better seat in operating service. Altering the pressure of the flange bolts holding the valve casing to the reservoir may tend to distort the valve seat, causing increased leakage. It is recommended that these valves be not disturbed unless it is plainly evident that they are not operating satisfactorily.

When it becomes necessary to remove a blast valve the complete valve casing should be removed as a unit. This is done by screwing down the cap nut which closes the gap between the top of the blast valve casing and the lower end of the blast tube, as far as it will go. Then loosen the flange bolts holding the casing to the reservoir flange and slide the unit out of the breaker frame. The valve may then be released from its operating lever and the lever withdrawn from the casing. Air should be exhausted from the reservoir before the flange bolts are loosened.

Some compressed air breakers of higher interrupting rating may be equipped with blast valve units which are made up in two sections. The operating lever of this type of blast valve is not direct-connected to the valve member but operates to push the valve downward away from its seat on opening. On closing, the valve rises to its seat under reservoir pressure along a set of guides which maintain it in proper alignment at all times. After the valve casing has been removed as previously described, the guide casting with the valve may be lifted from its recess in the reservoir.

The stationary valve seat is machined so as to present only a very narrow surface to the valve, about $\frac{1}{32}$″ in width. The valve surface engaging this seat is a single conical surface. With an application of Prussian Blue, revolving the valve on its seat by hand will determine whether or not the valve is engaging its seat properly. If the departure from a full seat is only slight, the difficulty may be remedied by grinding the valve in, using a fine grinding compound mixed with oil. Valves which have been deeply scored by foreign matter, or seats which have been badly distorted, may not answer to this treatment.

When reassembling the valve casing on the breaker see that it is lined up so that the roller trunion engaging the cam surface on the operating shaft, is approximately centered with the cam. Then pull down the holding bolts in the valve casing flange evenly all around and test the valve with air pressure in the reservoir. If the valve shows leakage go over the holding bolts again, loosening one side and tightening the other side until the best condition has been obtained. Screw the cap nut at the top of the valve casing up against the lower end of the blast tube. It is not essential that this cap nut be locked tightly in position since the blast of air flowing to the open, upper end of the blast tube is only momentary and pressure conditions at this point are such that only a negligible amount of air can be lost.

If the blast valve operating lever has been removed from the casing during this operation, care should be taken to see that its shaft is turning freely in the split bearing at the side of the casing. Draw the holding bolts up evenly on the bearing clamp, tapping the shaft hub and bearing clamp lightly with a hammer if necessary.

Blast Valve Operating Linkage. As shown in Fig. 10, a hinged linkage is mounted on a trunnion between the parallel arms of the blast valve operating lever. In operation this linkage serves to engage the cam surface on the main operating shaft during the opening contact stroke, thus raising the blast valve operating lever, opening the blast valve and admitting a blast of air through the blast tube past the parting contacts. During the closing contact stroke this linkage is folded back on its hinge, trailing over the cam surface without opening the blast valve, thus conserving the reservoir air.

As received from the factory this linkage has been adjusted to open and close the blast valves in proper time relation to the opening contact movement and these adjustments have been locked. If for any reason the linkage has been disassembled or parts require replacement, the assembly should be as follows:

Screw the cam roller yoke into the shouldered sleeve nut and pass the sleeve nut through the clearance hole in the U-shaped main member of the linkage. With the main shoulder of the sleeve nut bearing against the main member, assemble the clamp nut on the projecting end of the sleeve nut and secure it in position with the clamp nut bearing against the secondary shoulder of the sleeve nut; as shipped from the factory the clamp nut is tack-welded in this position. For breakers in which the clamp nut is provided with a thread, the thread may be prick-punched at four points after the clamp nut has been made up loosely against the main member so as not to prevent turning.

Turning the clamp nut now will raise and lower the cam roller. Adjust the cam roller so that there is a gap of $\frac{9}{32}''$ between the top of the roller supporting yoke and the bottom of the sleeve nut. Assemble the cam roller pin through the slotted holes in the main supporting member. Assemble the linkage retrieving spring on its guide rod and pin the guide rod to the main member.

The linkage as a unit may now be assembled in the blast valve operating lever by inserting the two shoulder bolts which tap into the lever, extending through the sides of the main supporting member to act as hinge pins. Care should be taken to see that these hinge bolts are not drawn up so tightly as to prevent the linkage from swinging freely on them. Enter the spring retaining rods at the rear of the linkage into the guide holes provided for them and assemble their hinge pin in the blast valve operating lever.

Assemble the spacing collars on the ends of the cam roller pin so that they will engage the two arms of the blast valve operating lever when the cam roller is raised. Adjust the set screws in the ends of the blast valve lever so that the screw heads bear against the spacing collars on the ends of the cam roller pins and the ends of the screws are approximately flush with surface of the lock nuts at their upper ends. Air should be exhausted from the reservoir before testing this linkage.

Now rotate the main operating shaft slowly, using the hand operating lever. See that the blast valve operating lever is not pushed solid in its extreme upper position when the cam roller is riding on the highest part of the cam surface during the opening stroke. See that the cam roller has passed clear of the high portion of the cam surface at the full-open position, and that it is in position to trail the cam surface on closing without lifting the blast valve lever. See that the cam roller snaps forward clear of the cam surface in the full-closed position, ready to be engaged by the cam on opening.

Now check the operation of the linkage on the three poles to see that all cam rollers engage and leave the cam surface at approximately the same time. As long as action is positive, slight variations in this timing may be permitted. Slight readjustment from the initial settings given in the previous paragraphs may be necessary to secure all of these results. Lock all adjustments and hinge pins securely, assemble all cotters and washers and operate the breaker several times by hand to insure that it is in proper working order.

Air Operating Cylinder—Fundamental parts of the main operating cylinder are fixed in design and require little in the way of adjustment. Certain essentials, however, should be observed. The stop bolts on the operating shaft and the knuckle joint at the upper end of the piston rod form definite closed position stops and the operating piston should not engage the top of its cylinder when moved to the full-closed position with the hand operating lever.

If any adjustment has been made in the contact pull rod or in the over-center travel of the operating shaft toggle as previously explained, a check of the piston position should be made. Apply closing air to the operating cylinder while the breaker is in the closed position and note whether the piston will attempt to travel farther upward. If control is not available, pry up on the yoke at the upper end of the piston rod to see if there is any slack in the pins.

If a complete new set of adjustments is being made set the yoke at the upper end of the piston rod to a gap of $1\frac{1}{4}''$ between the under side of the yoke and the top of the piston rod into which it is screwed. This may require altering slightly when a balance among the other adjustments has been arrived at. The 1¼″ gap may be shortened as long as the knuckle joint locks positively in its recess. Be sure to pin both the lock nut and the piston rod to the yoke when the adjustment is completed.

The bottom of the operating cylinder is the point at which the piston finally comes to rest on the opening stroke, no other open-position stop being provided. Advantage is taken of the residual air in the cylinder below the piston, to act as a dashpot in cushioning the force of the opening stroke.

In order that final compression of the air cushioned at the end of the downward piston stroke may become high enough to absorb the kinetic energy of the moving parts, a by-pass connection is provided from slightly above the midpoint of the cylinder to its bottom cover. As the piston moves downward on its open-stroke it has completed nearly one-half of its travel before the upper by-pass opening is uncovered. At this point air begins to by-pass the piston and continues until pressure above and below the piston has become equalized, thus removing the force tending to drive the piston downward.

However, kinetic energy of the moving parts continues to force the piston downward, compressing the air underneath it. A check valve in the by-pass piping prevents reverse flow of air to the upper side of the piston and the trapped air below it is compressed to the point of absorbing the kinetic energy, bringing the piston to rest without excessive shock.

In order that the piston may travel its full stroke without excessive rebound, the trapped air is exhausted through the port connecting the cylinder with the closing valve, and then through vents in the closing valve to atmosphere. These vents to atmosphere consist of a number of small tapped holes in the wall of the closing valve casing, adjustment being made by plugging the necessary number of holes with machine screws, or by opening more holes.

As it leaves the factory, vent holes in each breaker have been adjusted to give the most satisfactory operation, using a device which records contact movement. This adjustment should not be changed unless there has been a general readjustment of the breaker mechanism, and then only with the aid of a suitable device for recording contact movement and speed. If operation of the breaker in service suddenly appears to change, examine the check valve in the by-pass to see that it has not become stuck or otherwise inoperable.

The by-pass connection has no effect on the closing operation since the piston passes the upper outlet slightly beyond the midpoint of its stroke, giving full force to the closing air below the piston during the critical portion of the closing stroke.

Residual air above the operating piston at the end of the closing stroke, is forced back through the port connecting the cylinder with the opening valve, and exhausted to the atmosphere through a row of vents around the side wall of the opening valve casing. As shipped from the factory the number of these vents left open has been determined by operation of each breaker, to give the best condition of fast, positive closing performance without excessive slam. The number of open vents may not necessarily be the same for all of the breakers delivered for a single installation.

If, as the bearings and pin joints become relieved of friction through service, the closing slam has come to be considered excessive, additional vent holes in the valve casing may be filled. After making any change in the number of vent holes a check should be made to insure that the breaker is locking properly on closing. Extreme care should be taken in changing the closing condition of any compressed air circuit breaker which may be called upon to close against peak currents of 150,000 amperes and above.

Exhaust Valve—In order that the breaker may be able to open immediately after a closing stroke, as in the case of closing against a short circuit, means have been provided for exhausting the closing air pressure as the piston approaches the end of its stroke. A port in the side wall of the operating cylinder, midway of its length, connects to a small auxiliary cylinder on the outside of the main cylinder casting. This auxiliary cylinder, open at its lower end, carries a plunger operated through linkage by movement of the piston rod yoke in its guide.

As the piston passes the midpoint of its upward travel, the port to the exhaust valve is opened but the exhaust valve plunger has not yet opened the outlet to the atmosphere through the exhaust valve cylinder. This occurs much nearer the end of the piston stroke and air under the piston is then exhausted to atmosphere and the breaker is ready for immediate opening if called upon to do so.

If for any reason it has been necessary to disassemble the exhaust valve linkage, the pull rod connecting its plunger with the linkage above should be set so as to leave the top of the plunger ⅝″ above the upper machined surface of the operating cylinder casting when the knuckle joint at the upper end of the piston rod is in the locked position in its socket. After making this adjustment apply closing air to the operating cylinder with the breaker in the closed position and check to see that air is exhausting freely around the open (lower) end of the exhaust valve cylinder. Some variation in this adjustment may be found necessary to insure positive locking when closing the breaker with air pressure near the control lockout point.

Opening and Closing Valves—The opening and closing valves, admitting air to the top and bottom of the main operating cylinder, are fixed in their operation and no adjustment is provided. It should be noted, however, that the ports connecting these valves with the operating cylinder are fitted with a throttle in the form of a piece of sheet metal having an opening somewhat smaller than the area of the port.

The size of the opening in these throttles is determined by operating tests to give the most satisfactory performance. For any given design the throttle openings may not be the same size for both the opening and closing ports. Where breakers of different rating are supplied for the same installation the throttle openings may not be the same for the different sizes of breaker. When any disassembling of the operating valves is attempted, care should be taken to see that these throttles are returned to the position from which they were taken.

Magnet Valves—Magnet valves may be removed for repair from the operating valve casing on which they are mounted, or the valve stem may be removed by taking out the screw plug at the bottom of the valve. In either case air should be exhausted from the reservoir before loosening the connections since there is continuous reservoir pressure on the under side of the valve. No adjustment is provided.

The magnet valve coils draw from ⅓ ampere to five amperes, dependent on the circuit in which they are applied. The coils of the opening and closing magnet valves are not necessarily the same and care should be taken when disassembling to see that the magnets are returned to the position from which they were removed. If necessary to order a new coil be sure to give the Style No. or the S.O. No. on the name plate which will be found on the side of the magnet frame toward the operating valve on which it is mounted.

Auxiliary Switch—Type W auxiliary switch regularly supplied with compressed air circuit breakers has removable contact discs which may be removed from its shaft for replacement if damaged, or may be reassembled on the switch shaft at some other angle if a change in the time of making or breaking contact is desired.

If a change in the timing of the entire series of contacts on the switch is desired, it may be obtained by suitable adjustment of the operating arm and link connecting the switch operating shaft with the main breaker operating shaft. After any adjustment has been made, check the switch contacts in both the open and closed positions to insure that full contact or full break is obtained. For applications where the auxiliary switch contacts are called upon to interrupt 250-volt control current, it is recommended that two contacts be connected in series.

Pressure Switches—The alarm and lockout switches operate by air pressure against a spring, the spring acting to throw a snap switch lever over center at some predetermined pressure thus opening or closing the switch contacts. It should be noted that when these switches have operated to give an alarm or lock out the control, reservoir pressure must be raised 25 to 35 pounds above the point at which they are set to operate before they will reset.

The operating point may be changed by adjusting the setting of the switch actuating spring, but the range in pressure before the switch contacts will reset will remain practically constant. Thus if the operating point of the valve is set too high the contacts may not reset at the normal reservoir pressure of 150 pounds.

Safety Valve—Safety Valves on these breakers are set to relieve reservoir pressure at approximately 165 pounds. These valves do not pop when opening and may be barely audible when they start to exhaust. If found to be leaking the valve stem should be raised by hand several times so that escaping air may blow out any dirt that may have collected in the seat. The setting may be changed over a limited range by adjusting the screw cap through which the valve stem passes thus changing the pressure of the spring on the valve seat.

Air Supply Unit—For instructions concerning operation and maintenance of the compressor and air supply unit see the Instruction Book supplied with the unit.

Arc Chute—It should not be necessary to disassemble the arc chute completely unless it is plainly evident that it is not functioning properly. It may be taken from the breaker as a unit by removing the marked bolts securing it to the insulating block on which the stationary contacts are supported, then slide it toward the front of the breaker until it can be lifted free from its support.

Internal materials of the chute against which the arc impinges, are chiefly of hard fiber which has the property of being self-cleaning under arc action, and the air blast at each opening of the breaker should keep the interior of the chute free from loose dirt. Any soot or dirt which may have settled in crevices near the arc-drawing chamber may be wiped off with a clean cloth or brush.

The fiber splitter plates fanning out lengthwise of the chute, will be the first to show erosion under arc action although these plates should show relatively long life under average switching conditions. Each splitter has a notch or slot cut in its lower end, these notches lining up into an intermittent groove through which the moving contact passes.

As assembled at the factory the gap between the top of the moving contact blade and the upper end of the notch in the rear splitter plate (first plate to be passed by the moving contact tip on opening) is ⅜″ to ½″. This gap may increase toward the front of the chute until at the front splitter plate (the last to be passed by the moving contact tip on opening) it is ¾″ to 1″ without any bad effect on interrupting performance. However, when the gap at the rear splitter plate has been burned to 1″ the plate should be replaced.

Splitter plates are held in position in the chute by a row of parallel grooves in the fiber block at the bottom of the chute, and by studs passing through the arc chute sides at the upper end of the splitters. They are disassembled by removing the one stud in each splitter and pulling out from the upper end of the chute. The condenser units, carrying the cooler plates and screens, are disassembled in the same manner. While it is possible to replace one splitter plate at a time without a general dismantling of the chute, it is advisable on replacing any splitter to dismantle the remainder of the chute for inspection. This work is best done with the chute removed from the breaker.

Arc Chute Lifter—For installations where there are many breakers to be handled, or where there are breakers of higher interrupting rating involving heavy arc chutes, maintenance work may be sim lified by the use of a lifting device for assembling and disassembling the chutes. This lifting device (shown in Fig. 18) is of the windlass type similar in design to that supplied with earlier forms of air-insulated circuit breakers.

When some form of steel enclosure is supplied with the breaker, supports for the lifter rails may be made a permanent part of the steel structure. When breakers are installed in masonry cells or other enclosures lifter rail supports should be provided. Information for the necessary details will be supplied with the breaker for installations where the size and construction of the enclosure is given.

To use this device mount the rails on their supports, one on either side of the chute, and bolt firmly in place taking care to see that the rear ends of the rails are secured against tipping up when the load is moved out beyond the front support. Place the trolleys in position on the rails with the windlass across the front of the chute. Remove the nuts from two of the tie studs through the chute and clamp the lifter arms on these studs using the same nuts to secure them in position. These studs should be chosen from the row near the top of the chute

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Other Than Westinghouse Electric Supply Company

AKRON 8, OHIO, The Moock Electric Supply Co.
BIRMINGHAM 2, ALA., Moore Handley Hdw. Co.
BLUEFIELD, W. VA., Superior-Sterling Co.
BUFFALO 2, N. Y., Buffalo Electric Co., Inc.
CANTON 2, OHIO, The Moock Electric Supply Co.
‡CHATTANOOGA, TENN., Mills & Lupton Supply Co.
CHICAGO 6, ILL., Hyland Electrical Supply Co.
†DENVER 17, COL., The Mine & Smelter Supply Co.
†EL PASO, TEX., The Mine and Smelter Supply Co.
HUNTINGTON 6, W. VA., Banks Miller Supply Co.
KANSAS CITY 8, MO., Columbian Elec'l. Co.
KANSAS CITY 8, MO., Continental Elec. Co.
LEXINGTON 31, KY., Tafel Elec. & Supply Co.
LOUISVILLE 2, KY., Tafel Electric & Supply Co.
NASHVILLE 2, TENN., Tafel Electric Supply Co.
§NEW YORK 10, N. Y., Times Appliance Co., Inc.
RENO, NEV., Saviers Electrical Products Corp.
SAN DIEGO, CALIF., The Electric Supplies Distributing Co.
SCRANTON 9, PA., Penn Electrical Eng'nrg Co.
YOUNGSTOWN 1, OHIO, The Moock Electric Supply Co.

* Sales Office † Mfg. and Repair Shop x Works ƒ Warehouse § Merchandising Products Only z Headquarters ʃ District Eng. and Service Dept.

①Changed or added since previous issue.

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