PART I - RECEIVING, HANDLING AND STORING

RECEIVING

When the circuit breaker reaches its destination, the Purchaser should check the material actually received against the shipping lists to be sure that all parts have been received. This will avoid delays in installation. If damage is found or suspected, file claims as soon as possible with the transportation company and notify the nearest representative of the Westinghouse Electric Corporation.

HANDLING

Since shipping clearances permit shipping the 138 KV breaker with the doors in place, these breakers are shipped with an air-nitrogen mixture of approximately 5 psig in the tanks. This insures a dry atmosphere in the breaker during transit to protect the insulation and also serves as a check against leaks that might develop during shipment. The temperature and pressure at the time of charging the breaker at the factory are recorded on a tag which is affixed to the piping inside the mechanism housing. A warning tag on each of the tank doors directs that the temperature and pressure of the mixture be recorded before the doors are opened. Substitution in the formula

$$P_1 = P_f \left(\frac{T_1}{T_f}\right)$$

Where P_f = Pressure at Factory - PSIA (Gauge + 14.7)
T_f = Temperature at Factory - ($^\circ F$ + 460)
T_1 = Temperature at Destination
P_1 = Theoretical Pressure at Destination
P = Actual Pressure at Destination

of the data given on the tag and the readings taken at the destination will indicate by comparing P & P_1 the leakage, if any, that has occured. Since the low and high pressure systems are equalized by having valves 1-2-3 (Fig. 29) open, this pressure test indicates only leakage to the outside.

Since shipping clearances do not generally allow shipping the 230 KV breaker with the doors in place, reliance must be placed solely on the desiccant in the tank for keeping the insulation dry. Therefore if these breakers are not going to be placed in service right away, the doors should be assembled and sealed and dry nitrogen introduced to protect the breaker during storage.

Shipping braces Fig. 10 should not be removed until the circuit breaker has reached the point of installation. This circuit breaker is shipped completely assembled, when clearances permit, with the three pole units rigidly mounted on a steel "H" beam base Fig. 33. The total weight of the three pole breaker is given on the nameplate. This information should serve as a guide to the strength of cranes or other lifting means required for handling the breakers.

When using cable slings for lifting the breaker Figs. 31 & 32, do not allow the slings to strike the bushings, as any stain may cause the porcelain to crack or break. Lifting bars for attaching the slings are located on the "H" beam base adjacent to No. 1 & 3 tanks.

STORING

If the circuit breaker is not to be installed immediately, storage facilities should be arranged to prevent any damage to it during this period. The internal parts of the breaker should be protected from corrosion and moisture by the use of silica gel, activated alumina or similar dehydrating agents. During the storage period the tank doors should be closed and sealed. For extended storage periods, in addition to the precautions, suggested above, it is recommended that a positive pressure of about 5 psig be maintained in the tanks by super imposing dry nitrogen with the air, and the tank heaters energized if possible.

Protection from moisture and corrosion for the mechanism may be accomplished by closing the mechanism housing and energizing the space heaters provided in it. In case this is impracticable, all machined parts, especially the surfaces of the latch and rollers, should be coated with grease or some other rust inhibiting material. Additional protection may be obtained by the use of silica gel, activated alumina or similar dehydrating agents. Two or three small bags of the material may be hung in the mechanism housing near the parts requiring protection.

PART II - DESCRIPTION

INTRODUCTION

The Modern High-Speed Circuit Breaker is an essential component of present day high voltage transmission systems, depended upon for both routine switching operations and the critical task of high current fault protection. It should not be installed where it will be called upon to operate at voltages or currents greater than those given on the nameplate. The short-circuit conditions to be imposed upon the breaker must not exceed those specified at the time the breaker was purchased.

Proper installation and maintenance are necessary to assure continued satisfactory operation of the circuit breaker. Attention is called to Section 19 of the "Standards of the American Institute of Electrical Engineers" and to the "NEMA Switchgear Standards" published by the National Electrical Manufacturers Association. A number of the instructions for the general installation and care of circuit breakers have been copied without change from the "NEMA Standards".

SALIENT FEATURES AND CHARACTERISTICS OF SULFUR HEXAFLUORIDE

Sulfur hexafluoride in a pure state is inert and exhibits exceptional thermal stability. More recently it has been found to have excellent arc quenching properties. These characteristics combined with its exceptionally good insulating properties make it an excellent medium for use in circuit breakers.

Sulfur hexafluoride remains a gas without condensation down to 48°F at 220 psig. The density of SF_6 is about five times that of air (molecular weight equal to 146). Heat transfer by free convection is 1.6 times that of air at atmospheric pressure and 2.5 times the value of air at 30 psig.

Chemically, SF_6 is one of the most stable compounds. In the pure state it is inert, nonflammable, nonpoisonous, odorless, and produces no harmful effects on personnel. However, after the gas has been exposed to an electric arc, there will be some breakdown of the gas. Activated alumina filters are used in the apparatus to remove most of the gaseous by-products and some of the gas-borne powders. These by-products are injurious and exposure to them should be avoided by maintenance personnel. The precautions to be followed in handling the gas are covered in detail under Maintenance.

At three atmospheres (30 psig) pressure, the dielectric strength is about 2.4 times that of air and about the same as oil.

There is some depreciation of the gas after extended periods of arcing; however, such decomposition is very slight and has a negligible effect upon dielectric strength and arc interrupting ability. Furthermore, the solid arc products formed at arc temperatures are the metallic fluorides, which are good insulators under the conditions used in the breaker.

Sulfur hexafluoride is furnished in standard industrial type cylinders, color coded green at the top end and the balance silver for easy identification. The cylinders have special size (.965" dia.-14 thds/inch Nat. Std. left hand) pressure connections for absolute safety. The adapter for connection to the cylinder is a CGA #590 bullet shaped coupling nipple with .960 left hand, external male thread, 14 thds/inch Fig 23. The gas is stored in the cylinders at 300 pounds pressure and each cylinder contains 100 pounds of gas.

When transfering the gas from the bottles to either the gas service trailer or the breaker, it is recommended that the bottles be set in a container of hot water. Due to the enormous amount of heat of vaporization required to vaporize the SF_6, it will probably be found that the water will not boil until the bottle is empty. It takes about 10 to 15 minutes to empty a bottle of gas.

The pressures developed while operating are only a fraction of those developed in a liquid medium. The pressure from arcing in SF_6 is generated from the thermal expansion of the gas rather than from the formation of a large amount of dissociation products, such as occurs in a liquid medium. Furthermore, shock pressures are neither produced nor transmitted as in the liquid medium.

GENERAL DESCRIPTION

The circuit breakers illustrated in Figure 33 and described in this instruction book consist basically of three large cylindrical steel tanks mounted horizontally and parallel to each other. Each tank contains sulfur hexafluoride gas (SF_6) at a pressure of approximately 45 psig. Entrance bushings located vertically near the ends of each tank support a multi-break type of interrupter which is mounted coaxially within each pole unit. A high pressure gas reservoir is an integral part of each interrupter. Auxiliary high pressure gas reservoirs are installed under each pole unit.

Each pole unit is welded to a common "H" beam base which, at one end, supports a housing (Figure 7) containing the operating mechanism and the equipment for handling the gas. Provision is made for securing the base rigidly to a suitable foundation. A standard pneumatic mechanism closes the contacts and compresses the springs which provide the energy for opening the breaker. Operating rods Fig. 19 between the pole units are connected to the interrupter operating linkage to mechanically tie the contacts together, insuring synchronous operation of the interrupters.

The transformers (when ordered) are located around the outside of the entrance bushing supports, Fig. 16. A potential signal is available from cylinders in each tank bushing support. A transistorized potential device (when ordered) is used with these cylinders.

The components briefly referred to in the preceding paragraphs are described in detail under respective designations on pages to follow.

TANKS

The tanks, comprised of the large interrupting chamber and the smaller auxiliary reservoir located underneath, are designed and constructed in compliance with the ASME Boiler and Pressure Vessel Code for unfired pressure vessels, Section VIII.

The large cylindrical tank has flanged elliptical heads at either end attached to the tank by hinges, providing access to the inside. The tank flange faces have two annular grooves containing "O" rings, providing a gas tight seal. A tapped radial inspection hole in the flange connects with the outer groove to provide a means of detecting gas leakage past the inner "O" ring seal. A pipe plug in the inspection hole seals the outer ring, and thus both "O" rings serve as gas seals. Each door when closed is fastened by 24-3/4" hex. head steel bolts, providing uniform pressure on the "O" ring seals. To facilitate lining up the bolt holes in the flanges when closing the doors, matching dowel holes and a dowel pin are provided.

One door on each pole unit contains a rupture disc assembly (Figure 1) as protection against excessive pressures being developed within the vessel. It should be noted that the convex side of the carbon rupture disc is assembled inward, and if replacements are ever made it is important that this position be followed, as reversing the position affects the blowout pressure. A thin Micarta weather cover protects the carbon disc from the elements, and a steel deflection shield controls the direction of fragments in the event of rupture. The neoprene rubber disc on the inside of the door will probably by bubbled out. This results from evacuating the tanks and is no cause for alarm.

The bushing supports consist of two parallel vertical cylinders located near either end of the tank. A reinforcing collar is provided where the cylinders join the tank to reinforce the joint in compliance with the Unfired Pressure Vessel Code. The flange face for the bushing seat has a volume controlled flat gasket to provide the gas seal.

Steel covers fastened on the supporting legs of the large tanks provide enclosures for the auxiliary high pressure reservoirs. These reservoirs, located under the large tanks, are encased with thermal insulation to minimize the heat loss. The inspection plugs in the high pressure reservoir and the boiler code nameplate are accessible by removing the covers. The gas connection between the two tanks is welded to insure gas-tight joints. The high pressure tank has two gas-tight wells for receiving emersion type heaters. The heaters are accessible through a cover plate located on the left hand side of the enclosure, and may be removed while there is gas pressure within the tank. The boiler code nameplate for the large tank is located on the side of the tank midway between the two bushing openings, and on the high pressure reservoir midway between the inspection openings.

Four radial brackets on the bushing support cylinders provide the mounting for the bushing current transformers.

The pressure and temperature instrumentation for the gas is located on the pole unit nearest the mechanism housing (Pole Number 1). A boss on the high pressure reservoir on the end opposite the heater wells provides the connection to the high pressure reservoir, and a boss on the underside of the large tank provides the connection for the low pressure tank.

The interior of both tanks has a protective coating of paint. White paint is used on the large tank to improve visibility during inspection and maintenance.

A cylindrical shield is located inside each bushing support cylinder to provide a potential source. A potential tap (Figure 8) is brought out through a gas seal in the neck of the bushing support to provide a convenient connection for the potential device cable.

BUSHINGS

The bushings on these breakers are SF_6 insulated. The conductor consists of a copper tube supported at either end by the upper and lower porcelain shields. The upper shield has weather sheds but the lower porcelain has a smooth truncated conical surface. Heavy springs keep a compressive load acting on the gasket seals located on the top and bottom caps and also the supporting flange to provide gas-tight seals. The SF_6 gas is supplied from the main breaker tank. It passes up through the center of the lead and then out through several radial holes at the top end of the lead into the volume between the conductor and the inside of the porcelains. A filter in the lower end of the conductor insures the absence of moisture or arc products within the bushing. The filter is mounted in the lower end of the bushings by means of a snap ring, providing access for removal or inspection. The NEMA Standard threaded stud at the upper end of the bushing provides the means for attaching a line connector. The external surface of the lower porcelain is protected with a "Limitrak" coating which is highly resistant to the arc products and provides a smooth surface so that the porcelain can be easily cleaned.

INTERRUPTER

The interrupter is a multi-break double pressure unit, Fig. 16. Essentially it consists of combination cross-blast axial-flow interrupter units, a high pressure gas reservoir, single blast valve, passages for conducting the gas flow from the blast valve to the interrupter units, electro-static shields, and a spring which biases the moving contacts to the open position. Insulating bars which extend the full length of the interrupter provide the main structural support member for the interrupter assembly.

The interrupter unit, Figure 2, is comprised of stationary current carrying fingers, arcing horn, combination moving contact-orifice, teflon interrupting chamber, and fingers which transfer the current between the moving and stationary components. The moving contact of each interrupter unit is mounted on a common pair of insulating rods in a "ladder" type assembly. This assures simultaneous contact motion in each of the breaks of a pole unit.

In the closed position, the current path is from a set of stationary contact fingers into the side wall of the moving contact, Fig. 15. Finger clusters on the moving contact guide carry the current to the adjacent stationary contact. This sequence is repeated in each interrupter unit. The contacts are constructed to minimize arc erosion on the surfaces which conduct current when the breaker is closed. An arcing horn (Figure 13) located within the finger cluster projects a short distance beyond the end of the fingers and into the hollow moving contact. Upon opening, the arc is drawn between the moving contact tip and the stationary contact fingers. However, it quickly transfers from the fingers to the arcing horn to minimize burning of the fingers. The tips of the moving contact, stationary fingers, and arcing horn are faced with copper tungsten arc resistant material.

The interrupting function is performed by a combination cross-blast and axial high velocity flow of SF_6 gas through the orifice (center of moving contact) (Figure 2). During normal operation, the high pressure gas reservoir is maintained at a normal pressure of 220 psig. At the start of motion of the contact on an opening operation, the blast valve is opened mechanically (Figure 3C). Opening the blast valve allows high pressure gas to flow through the passages to the interrupting chambers. Although the flow paths are different lengths, flow is essentially uniform at each break by the time the contacts part. As the contact linkage moves to the open position (Figure 3C), the pawl, which has engaged the teeth on the blast valve operating lever, is disengaged by the stationary cam, allowing the blast valve to close under the action of the blast valve retrieving spring (Figure 3B).

Distribution of voltage across the interrupting breaks is obtained by the use of capacitor assemblies, Fig. 16. These units are tapped in across each of the breaks. Electrostatic shields around the metal portions of the assembly provide for control of the electrical field between the interrupter and the tank.

MECHANICAL LINKAGE

The motion of the pneumatic mechanism is transmitted through a bell crank (Figure 5) to a horizontal pull rod assembly (Figure 19) connecting the pole units. The motion of the pull rod assembly is transmitted through a shaft and lever assembly (Figure 4) to a lever on the inside of each tank. This lever is connected by an insulated rod to a lever assembly (Figure 3) on each interrupter that performs two functions: (1) it operates the "ladder" assembly carrying the moving contacts, and (2) it opens the blast valve.

BLAST VALVE

The blast valve piston (Figure 3) located in the end of the high pressure reservoir controls the flow of gas from the reservoir to the interrupter units. Holes in the end of the piston partially equalize the pressure on either side of the piston, when the valve is closed. Two compression springs bias the piston in the closed position. The flow of gas from the high pressure reservoir to the interrupter unit is sealed by (1) the beveled face of the piston bearing against a neoprene seat and (2) a Teflon ring acting as a piston ring.

SHAFT SEAL

Figure 4 shows the shaft supported at either end by roller bearings having a light press fit in the housing. The gas seal is provided by a series of Teflon "V" rings which are expanded against the shaft and the housing by the axial loading of several Belleville spring washers.

BELL CRANK

The bell crank assembly (Figure 5) located within the mechanism housing (Figure 7) serves to change the direction of motion 90° between the vertical motion of the mechanism and the horizontal motion of the pull rod assembly. There are three heavy duty shock absorbers connected to the bell crank which serve to decelerate the moving parts near the end of the opening stroke. Slots in the frame insure no retarding action until after the breaker contacts have parted. The bell crank also operates a position indicator to indicate the open or closed position of the breaker.

ACCELERATING SPRINGS

The accelerating spring assembly (Figure 6) located on the third pole unit is operated by the horizontal pull rod assembly. The spring, operating over approximately the last 2/3 of travel, is compressed during the closing motion of the breaker and supplies part of the energy to accelerate the breaker on opening. The balance of the opening force is supplied by accelerating springs acting directly on the moving contacts in each interrupter assembly, Fig. 16. The main accelerating spring is adjustable to permit varying the opening speed of the breaker.

OPERATING MECHANISM

The type AA-10 pneumatic operating mechanism is described in detail in Instruction Book 33-125-C3C which will be found at the end of the breaker portion of this Instruction Book Tab 7. It will be noted, however, that on this breaker the mechanism is mounted in an inverted position from that shown in the mechanism instruction book. The minor differences in the operating mechanism for this application are a spring bias on the selector lever, a spring bias on the trip coil plunger, a 1/8" air gap on the trip armature, and a drain pipe on the pilot valve to allow the removal of condensation from the operating valve seat. Since the piston rod protrudes upward out of the spring housing when the mechanism is in the closed position, a guard has been added over the opening in the spring housing to protect personnel during operation of the mechanism.

If it is desired to open and close the breaker with the manual closing device during maintenance on breakers equipped with Kirk type interlocks, it is necessary to either (1) return the key to the interlock after the disconnect switches have been opened and release the hand trip (provided the interlock scheme employed permits this procedure), or (2) disconnect the trip rod at the lever that raises the trip armature to release the selector lever and trip armature.

With the manual closing device in place and the breaker in the closed and latched position, if it is desired to open the breaker slowly with the manual closing device, the non-trip-free trigger must first be released. This is done by pressing down on the trip armature using a piece of wood about 12" long by 1" square and the mechanism frame as a fulcrum.

The sheet metal housing (Figure 7) has been enlarged sufficiently to include the SF_6 compressor, activated alumina filters, pressure switch panel, etc.

CONTROL SCHEME

The "X" - "Y" control scheme is described in detail in Instruction Book 33-125-C3C. One difference as employed for the control scheme for this breaker is the introduction of a low pressure cutout switch in series with the closing circuit. This contact is actuated by the gas pressure in the high pressure system of the SF_6 breaker. It opens, preventing the closing of the breaker, when insufficient gas pressure is available to perform a successful opening operation. A second contact of the low pressure cutout switch is introduced in the trip circuit. This switch is arranged to trip the breaker as low gas pressure is reached. Another difference is the use of a type AM relay in the closing circuit to slow up the inherently fast reclosing time of these breakers to insure time for de-ionizing the fault.

TANK HEATERS

There are two gas tight wells in each high pressure tank. Each heater assembly consists of two 1500 watt elements. In order to increase the service life of the heater, the two elements are connected in series putting half voltage across each element. As connected, each heater assembly produces 750 watts. Although there is a separate assembly for each well, one heater assembly is sufficient to maintain the temperature in the high pressure tank above liquefaction. However, a duplicate heater assembly is provided to insure continuity of service. It is recommended that the two heater assemblies operate from independent sources to insure uninterrupted service. Each heater unit is controlled by an independent thermostat set to energize the heaters at 55°F.

GAS SYSTEM

The operation of this breaker requires a flow of gas from a high pressure to a low pressure, and since the cost of this gas requires a closed system for conservation, means are provided for reclaiming the gas used during each operation and restoring the proper pressure in the high pressure system (Figure 29).

On the three pole breaker, the auxiliary equipment for handling the gas is located within the same house as the pneumatic mechanism.

This equipment (Figure 7) consists of a filter system for removing the small amount of gaseous arc decomposition products in the gas, a refrigeration type compressor for circulating and storing the gas, a relief valve for maintaining the high pressure system within the required limits, a solenoid operated unloader valve to remove the high pressure from the compressor during starting, hand valves and various control indicating instruments for maintaining the proper pressure relationships.

These instruments are described as follows:

Thermostat

A thermostat operates the heaters for controlling the temperature of the high pressure gas. A separate one is used for each of the two heater circuits.

Governor Switch

A temperature compensated pressure switch responsive to pressures in the high pressure system operates after each breaker operation to maintain gas pressure in the high pressure system at normal operating pressure.

High Pressure System - Low Pressure Alarm

A temperature conpensated pressure switch, responsive to pressures in the high pressure system, operates an alarm at an intermediate pressure between normal operating pressure and the pressure at which the low pressure cutout switch opens to give a warning that a malfunction exists that should be corrected before the breaker becomes inoperative.

High Pressure System - Low Pressure Cutout

The temperature compensated pressure switch opens the breaker closing control circuit to prevent closing the breaker when there isn't sufficient gas pressure for a successful opening operation, and also cause tripping for low pressure if the breaker is closed.

Low Pressure System - Low Pressure Alarm

A temperature compensated pressure switch responsive to pressures in the low pressure system operates an alarm in the event of loss of pressure in the low pressure system to a point at which dielectric strength may be impaired.

Low Pressure System - Low Pressure Cutout

A temperature compensated switch responsive to pressures in the low pressure system with its contacts in series with the gas compressor Linestarter coil and the contacts of the governor switch. In the event of a leak to atmosphere of the gas in the high pressure system, this switch functions to prevent the compressor from attempting to maintain the pressure in the high pressure system, which would ultimately result in all the gas being lost to atmosphere. It also operates in the same manner for a leak in the low pressure system.

Since the gas pressure in the tanks will vary with the ambient temperature, all of the pressure switches are temperature compensated in order to maintain a constant gas density.

High Pressure System - Pressure Gauge

A Bourdon tube type pressure gauge indicates the pressure in the high pressure system.

High Pressure System - Temperature Gauge

A Bourdon tube type temperature gauge indicates the temperature in the high pressure system. The bulb at the end of the capillary tube is located in the high pressure tank nearest the mechanism housing. The changing temperature surrounding the case and tubing do not effect the accuracy of indication.

High Pressure System - Low Temperature Alarm

The high pressure system - temperature gauge above is equipped with adjustable arms having electrical contacts that make contact with electrical contacts on the indicating pointer when the temperature of the gas drops to the pre-determined setting of the adjustable arm. The function of this switch is to alert the operator that the heaters are not maintaining the gas at a temperature high enough to prevent liquefaction.

Low Pressure System - Pressure Gauge

A Bourdon tube type gauge indicates the pressure in the low pressure system.

Low Pressure System - Temperature Gauge

A Bourdon tube type temperature gauge indicates the temperature in the low pressure system. The bulb at the end of the capillary tube is located in the large tank nearest the mechanism housing. Changing temperature surrounding the case and tubing do not effect the accuracy of indication.

Elapsed Time Meter

The elapsed time meter will keep an accumulative record of the operating time of the SF_6 gas compressor.

Relief Valve

The relief valve is located on the discharge side of the compressor and serves two functions: (1) it protects the compressor and piping from excessive pressures and (2) serves as a safety valve for the high pressure system. The discharge side of the valve is piped to the intake side of the compressor to prevent loss of the SF_6 gas in the event that the valve is called upon to operate. The valve is set to open at 310 psig.

Unloader Valve

The solenoid operated unloader valve is connected between the inlet and discharge sides of the compressor. The valve is normally open but is closed when the solenoid is energized by a contact on the compressor motor Linestarter.

AUXILIARY TANKS AND HEATERS

Auxiliary reservoirs are located beneath each pole unit to provide sufficient gas for several breaker operations without the compressor operating. Since the gas at 220 psig liquefies at approximately 48°F., (See Curve Fig. 34) a heating arrangement is provided in these reservoirs to keep the temperature above the liquefaction point. These heaters are controlled by the thermostats located on the reservoir nearest the mechanism.

GAS COMPRESSOR

The model 3HS2 Worthington compressor is a vertical 2-cylinder reciprocating type compressor.

The compressor is designed with a one-piece cylinder and crank case, resulting in a minimum of joints for possible leaks to develop. For a more detailed description, see *Part VI - Gas Compressor.*

FILTERS

Although most of the decomposition products of the arc recombine to form SF_6 immediately upon extinction of the arc, a very small percentage remains. It is this remainder which is removed by activated alumina filters located in the gas circulation path (Figures 20 & 29).

BUSHING CURRENT TRANSFORMERS

The breaker is normally equipped with six multi-ratio bushing type current transformers, one per bushing. Space, however, is available for mounting two per bushing or 12 per breaker. These may be any combination of relaying and metering transformers or linear couplers for bus differential relaying.

Each transformer is contained within a metal housing and is imbedded in an epoxy resin, completely sealing out all moisture. The transformers are mounted around the bushing supports on the tank and are supported by four projecting arms (Figure 33). The taps are brought out to a sheet metal enclosure on each transformer. Conduit on either side of the breaker carries the secondary leads to terminal blocks in the mechanism housing, providing a convenient location for selecting the desired ratio.

The current transformer may be removed over the bushing without disturbing any internal parts or adjustments.

POTENTIAL TAPS

A cylindrical shield insulated from ground is provided inside the bushing support on each tank, Fig. 16. A gas-tight connection is brought out through the wall of the tank to provide the potential for operating a transistorized potential device. A grounding cover (Figure 8) over each potential tap is installed except on those positions to which coaxial cable connections and protective tubes are connected when a potential device is supplied.

CAUTION

Do not energize the breaker unless the grounding caps are on the potential tap receptacles or unless tap leads are connected to the potential device. Otherwise, potential lead insulation may be punctured.

For those breakers equipped with transistorized potential devices, refer to the complete description of this device in I.B. 33-357-3.

PART III - INSTALLATION

LOCATION

The breaker should be located so that it will be readily accessible for cleaning and inspection. Sufficient aisle space must be provided on one side of the breaker to allow the removal of the interrupter unit for inspection and maintenance. The aisle space required is shown on the outline drawing, Figs. 31 & 32. While the outline drawing shows the interrupter being removed from one side, it can be removed equally well from either side. The breaker foundation should be sufficiently high so that water will not enter the breaker mechanism housing during flood conditions.

MOUNTING

All circuit breakers should be set reasonably level. Since the SF_6 circuit breaker has practically no impact loading, the foundation need only be strong enough to support the dead weight of the breaker as shown on the nameplate. Mounting the three-pole welded unit is quite simple, since the individual poles are already aligned with one another. After the unit is level, tighten the holddown clamps securely: -- see drilling plan on outline drawing for placement of clamps.

CONTROL WIRING

All control wiring to the circuit breaker should be run in conduit when practical. A diagram located in the mechanism housing door-pocket is supplied with each breaker which shows the proper connections for operating circuits and indicating lamps.

The wire size should be selected to keep the voltage drop within reasonable limits. Excessive line drop will slow up the tripping time of the breaker, and hence the interrupting time.

Check the control wiring to see that all connections are tight. Small nuts and clips may have become loosened during transit and handling.

STARTING AIR COMPRESSOR

Since it takes the air compressor about 30 minutes to pump up to normal operating pressure from atmospheric, it is suggested that the compressor be started and this build-up of pressure be done while other installation work is in progress. It will also afford an opportunity to check, and repair if necessary, any leaks in the piping system that may have developed during transit.

Although the compressor is shipped with oil in the crank case, it is recommended that the oil level be checked before starting. After removing the oil filling plug, located on the front side of the crank case, check to see that the oil level is up to the tapped opening. If necessary, fill the crank case with high grade automobile engine oil -- SAE-20 for temperatures above freezing or SAE-20W for temperatures below freezing.

Oil vapor is drawn in through the air intake to the compressor just prior to shipment to insure a coating of oil on the cylinder walls and working parts. This oil may show up in the condensate in the reservoir tank and will appear in the condensate when the siphon drain valve on the reservoir is opened the first time.

REMOVING SHIPPING BRACES AND COVERS

To provide sufficient rail clearances in some cases, it may be necessary to use temporary covers over the ends of the tanks in order to keep the shipping width to a minimum. These covers should be taken off and discarded.

Steel angle bracing between the bushing supports (shown on Figure 9) should be removed and discarded. The bolts used to attach the shipping braces to the bushing supports, should be discarded and replaced with shorter bolts which are shipped separately. The internal shipping braces that support the interrupter to the sides of the tank, (see Figure 10) should also be removed and discarded.

GAP ELECTRODES

On some breakers shipping clearances may prohibit shipping the breakers with the electrodes mounted in place. In those instances where they have been removed and shipped separately, the procedure for mounting them on the bushings is shown on Figure 11.

MOISTURE PRECAUTIONS

To guard against condensation forming on the inside of the breaker where circumstances necessitate leaving the breaker stand overnight without dry gas in the tanks, it is recommended that heaters be placed in the tanks. The leads to the heaters can be brought to the outside by removing the rupture discs. Also energize the high pressure tank heaters.

INSTALLING END DOORS

The 138 KV breakers can be shipped with the doors in place. However shipping clearances do not permit shipping the doors in place on the 230 KV breakers.

Since the end doors weigh approximately 300 pounds, a hoist will be required for lifting them into place. Special care should be exercised in handling to insure that neither the grooves on tank flanges nor the flange face on the door flanges are damaged as this would impair the gas seal. The slushing compound on the flange faces, used to protect them during shipment, can be removed with either kerosene or gasoline.

INSPECTING BREAKER

Examine the shield hardware to make sure that it hasn't loosened during shipment. While closing the breaker for "Checking the Mechanical Operation" (see next page) light-out across each interrupter break to make sure that they all make within ± 1/16 of the same travel as measured on the horizontal pull rods. If the contacts are properly synchronized and a cursory inspection of the outside of the interrupter gives no reason to be suspect of the internal parts, it won't be necessary to remove the interrupters from the breaker as they have been carefully adjusted and tested of the factory prior to shipment.

CHECKING MECHANICAL OPERATION

Remove the guard on the spring housing of the AA-10 pneumatic operating mechanism and attach the hand closing jack. Close the breaker slowly by hand until the non-trip-free trigger snaps back into position behind the holding latch. Reverse the jack and transfer the load onto the main latch. In this position, there should be .030/.040 inch clearance between the operating lever, as shown in view "X" Figure 19 and the stop, and also .075/.125 inch clearance between the operating lever and the stop on the first interrupter casting of each pole unit, Fig. 16. The outside lever stops have been set at the factory. If this clearance needs adjusting it is done by varying the length of the horizontal pull rods. These rods have right hand and left hand threads at opposite ends, which permit loosening the clamping bolt on the rod ends and turning the rods. If the clearance is not correct between the operating lever and the boss of the first interrupter casting, this clearance is changed by changing the length of the insulated rod between the interrupter and the lever in the bottom of the tank. If either of these adjustments need attention, the breaker must first be opened to remove the load from the rods.

Open the breaker slowly by hand and observe that the breaker opens smoothly and keeps a positive load on the jack throughout the opening motion. In order to preclude any possible damage to the blast valve by operating it without the cushioning afforded by gas pressure in the high pressure system, the high pressure system should be charged to 130 psig by either (a) opening valves 2 and 4, closing valves 1-3-5, (Fig. 29) removing the cap on the service connection, and running the compressor to charge the system with dry air or (b) attaching a nitrogen cylinder to the service connection, closing valves 1-3-4, opening valves 2-5 and charging the high pressure system with dry nitrogen. It is adviseable to use a reducing valve in the line to preclude accidently excessive pressures in the breaker.

Remove the hand closing device and close the breaker by means of the pushbutton on the pilot valve on the pneumatic mechanism. The breaker can be opened by operating the manual trip. Several operations should be made to make sure that the mechanical operation is satisfactory.

CHECKING BLAST VALVE

Since the doors are open, the high pressure system must be isolated by closing valves 3-4 and opening valves 2 & 5, (Fig. 29).

Connect a cylinder of nitrogen gas to the service connection on the mechanism housing and charge the high pressure system to 200 psig. Close valves 1-2-5. The drop in pressure should not exceed 5 psig per hour.

If the leak rate exceeds the allowable rate, proceed as follows to isolate the trouble. (1) Check the piping joints in the mechanism housing with leak-tec or soap bubbles and check for leakage through the compressor, unloader and relief valve by closing valves 1-3-5 and opening valves 2 and 4. Loosen service connection cap and check for leaks with soap bubbles or leak-tec at the threads. (2) Check feed tube elbow flange connections with leak-tec (3) If these plumbing checks are all negative it indicates that the leak is in one or more of the blast valves. To locate the faulty blast valve (4) Remove the cap on the service connection and open valves 2 & 5 to reduce the pressure to atmospheric in the high pressure system. (5) Remove one elbow casting at the lower end of the feed tube and block the entrance from the high pressure tank in that pole unit with a gasketed blind flange. (6) Introduce nitrogen to the system to re-establish the 200 psig test pressure, check the blind flange for leaks, and check the leak rate. (7) Repeat this process from pole unit to pole unit until the leak is located.

When the blast valve is located that is leaking, the interrupter should be removed from the pole unit on the service rails. (See PART V Pg. 6). The reservoir must be removed for inspection and repair as outlined in PART V Pg. 9.

After repairs have been completed and the interrupter reassembled in the breaker (See PART V Pg. 11), it is suggested that the overall leak rate of the high pressure system be rechecked.

CHECKING OPERATIONAL TIMING

Assemble the Cincinnati Timer Instrument on the end of the accelerating spring housing as shown on Figure 38. Make a closing, close-open, and an opening operation. Check the times obtained against the typical timing curves Figures 39-40-41 included in the back of the book. These tests should be made with high pressure nitrogen at 200 psig in the high pressure system, but the tank doors can be left open.

INSTALLING FILTERS

Remove the covers from the two filter cylinders in the mechanism housing (Figure 7) and withdraw the filter cartridges. (Figure 20). It is recommended that the activated alumina in the cartridges be removed and replaced with dry activated alumina shipped in sealed containers along with the breaker. Remove the covers on the basket under the reservoir casting in each pole unit and reassemble with a five pound bag of activated alumina. The special dacron bags supplied must be used. (See Filters, Section V, Page 12). Since the desicant absorbs moisture rapidly when exposed in a humid atmosphere, this work should be expedited as much as possible. Keep the containers covered at all times except when removing the alumina.

LEAK TESTING OF COMPLETE BREAKER

In preparation for closing the housing doors, coat both flanges including the grooves of the flange on the tank with Westinghouse grease 9921-4 (supplied with the breaker). Close the doors carefully and slowly to insure against pinching the "O" ring seals. Using the drift pin to align the bolt holes in the flanges, put in 4 bolts, 90° apart and snug them up to retain the doors in place while putting in the balance of the bolts. In tightening the bolts, it is recommended that 120 foot-pounds of torque be used. Bolts on diametrically opposite sides should be tightened as you progress around the door. After completely tightening the bolts around once, it is suggested that the bolts be checked progressively around the door a second time.

Open valve #3 (Figure 29) in the mechanism housing which will allow the mixture of air and nitrogen to exhaust into the large tank and equalize the pressure throughout the system. If the pressure as indicated on the pressure gauge in the mechanism housing is not in the order of 30 to 40 psig, it will be necessary to add additional nitrogen to bring the unit up to this pressure. Although the breaker has been thoroughly leak tested at the factory, it is well to examine each joint in the piping and around all flanged joints such as doors, bushing flanges, and potential device covers for leaks by brushing on a soap solution. or leak-tec. All discernible leaks should be corrected.

EVACUATION OF AIR

Remove the cap on the service connection and open all of the valves in the gas piping system in the mechanism housing to exhaust the air-gas mixture.

Connect the flexible hose on the gas servicing unit (Figure 21) to the service connection on the side of the mechanism housing. Plug in the extension cord on the gas servicing unit to the three-phase receptacle on the right-hand side of the mechanism housing. Energize the tank heaters. Close all valves on the gas servicing trailer. Before starting the vacuum pump, check the sight glass located in the base of the vacuum pump and observe whether the oil level is at the center line mark on the gauge. Open the vacuum break valve, located on the side of the pump just below the motor. Turn the pump for one complete cycle by hand to remove the excess oil from the cylinder. Start the motor momentarily and check the direction of rotation as indicated by the arrow on the end of the fly-wheel pulley. If the direction of rotation is not correct, change the wiring at the plug-in receptacle in the mechanism housing. Start the motor, and when it is up to speed, close the vacuum break valve on the side of the vacuum pump. After the pump has been running about three minutes, check the sight tube on the right-hand side of the pump. This tubing must be full of oil at all times. If there is no oil in the sight tube, remove the two small square-head pipe plugs, one of which is located on the side cover of the pump near the bearing, and the other on top of the sight tube fitting near the oil filter. This will allow the enclosed air to escape. When the oil starts running out of the lower plug hole, reinstall this plug. Reinsert the plug in the top of the sight fitting as soon as the tube is completely filled with oil. Recheck the oil level in the crankcase as indicated by the sight glass and add additional oil as necessary with the pump running. It is well to recheck the tygon sight tubes occasionally as the pump is running to insure proper oil circulation to the bearings. If at any time these tubes are not found full of oil repeat the process described above. It is perfectly normal to observe a light blue smoke emerging from the discharge port on the vacuum pump. Open the vacuum pump inlet valve and continue pumping until a vacuum of two millimeters of mercury or 2,000 microns is obtained. Inability to obtain this vacuum indicates that a leak of such proportions exists that it should be located and corrected. The compound gauge on the manifold of the service unit will indicate when this point is approached and at that time an electrical type vacuum gauge such as the Stokes model TP-3 or the Hastings model SP-1 can be attached to the vacuum pump line where a connection and shut-off valve is provided. Connect the probe on the electrical type vacuum gauge to the connection provided for it on the servicing trailer. It should be noted that this instrument operates from a source of single phase 60 cycle 115 volts.

As soon as the desired vacuum is reached, close the vacuum pump inlet valve and shut off the pump.

FILLING WITH SF_6 GAS

The 1380SF10000 breaker takes about 640 lbs. of SF_6
The 2300SF15000 breaker takes about 700 lbs. of SF_6

a. Using Gas Servicing Unit

Before filling the breaker with SF_6 gas, be sure that valves #5 and #3 (Fig. 29) in the mechanism housing are closed and the other three valves #1, #2, and #4 are wide open. If possible energize the heaters on the servicing unit about 15 minutes before starting to fill the breaker. Open the breaker refill valve slowly. Before starting the gas compressor in the mechanism housing, make sure that the oil in the crank case on the compressor is up to the full mark as indicated on the sight glass. In the event that it is found necessary to add oil to the crank case, be sure and close valve No. 1 and open valve No. 4 before removing the oil filling plug as the intake connection on the compressor communicates with the crank case. During shipping and storage periods, lubricating oil has a tendency to flow out of bearings and may result in scoring if not properly lubricated prior to placing in service. The filler plugs located above each bearing should be removed and a small amount of oil added to provide an oil film during the start-up period. Start the compressor and let the gas flow from the gas servicing unit to the breaker until the compressor shuts off. This indicates that the high pressure system is up to its normal value (Refer to Fig. 34). The low pressure system is then set using the constant density chart (Figure 35). Close the breaker refill valve on the service trailer first, and then valve #4 in the mechanism housing.

WARNING

Attention is called to the fact that valve #4 is to be opened BEFORE admitting gas through the service connection either from cylinders or service trailer. The manifold valves are spring biased open, and since some like #4 & 5 as examples, carry gas in both directions under certain conditions, they cannot be oriented to prevent blocking closed for pressures above 150 psig. If valves 4 & 5 are accidently left closed and gas admitted via the service connection, they will remain closed regardless of the position of the hand wheel until the pressure is relieved by loosening the hose connection at the service connection. While there are no service conditions calling for operating the compressor while valves 2 & 5 are closed, should this occur accidently, valve 2 would be blocked closed. If this occurs open valve 5 momentarily.

b. Alternate Method

If a gas servicing unit is not available, it is required that at least a vacuum pump be available for evacuating the air. The procedure from here on is quite similar to that described above with the exception that the cylinders of SF_6 gas will be connected directly onto the service connection with the same valving arrangements as described above.

TRANSFORMER WIRING

The current transformers are shipped assembled on the breaker. Leads from the taps on the transformers are run through conduit to terminal blocks located in the mechanism housing. The lettering on these terminals corresponds to the transformer ratio and connection diagrams. *CAUTION: Be sure that the proper transformer connections are made and a burden or short circuit is placed across the terminals at the blocks before the breaker is closed on a line. Otherwise, dangerous voltages may appear across the open secondary terminals.*

LINE CONNECTIONS

Line connections should be sufficiently flexible to prevent undue strains on the bushings. Clamp-type connectors are ordinarily used between the bushing stud and the line conductor. Cable conductors should be so supported that heavy loads will not be imposed on the bushing. If tube conductors are used, they should be so shaped and supported so that heavy expansion strains are not placed on the bushings. Conductor and connector should be of adequate current carrying capacity to avoid heat being transmitted into the bushing. All joints must be clean, bright, and free from burrs or surface roughness.

Do not connect an aluminum conductor to a copper alloy connector unless the latter has plating suitable for such a connection. The galvanic action resulting from a joint of aluminum to copper will, in time, cause considerable corrosion.

GROUNDING CONNECTIONS

Each three-tank assembly is provided with two copper-alloy pads on diametrically opposite corners of the base for a ground connector. Each of these pads has two 1/2 - 13 tapped holes located 1-3/4 inches apart according to AEIC Specifications (Association of Edison Illuminating Companies).

A permanent low resistance ground is essential for adequate protection. A poor ground may be worse than none at all, since it gives a feeling of safety to those working around the equipment.

PART IV - OPERATION

CLOSING OPERATION

The closing operation is initiated by energizing the pilot valve coil, opening the pilot valve. This opens the mechanism control valve and admits air to the closing cylinder, forcing the mechanism piston up. The motion of the piston is transmitted through the vertical pull rod, bell crank, horizontal pull rods, and the levers on each interrupter to the moving contacts. At about the point in the closing motion where the moving contact engages the stationary contact fingers, the pawl is in position to engage the first tooth on the blast valve operating lever. In the event that the breaker should be called upon to open before reaching the fully closed position, the engagement of the pawl with the teeth on the blast valve operating lever readies the blast valve for an immediate opening. In the fully closed position, the moving contact has about 1-5/8 inch contact overlap with the stationary contact fingers. The stops on the main lever have 5/64 inch clearance with the stops on the first interrupter casting. As the operating mechanism nears the closed position, the "aa" auxiliary switch contact closes, energizing the cutoff relay which shuts off the flow of air to the operating cylinder. The mechanism latches hold the breaker in the closed position.

OPENING OPERATION

The opening operation is started by energizing the trip coil, which releases the mechanism latches and allows the breaker to be accelerated to the open position by the action of the accelerating springs on each interrupter, and one accelerating spring located at the end of the horizontal pull rods on number three tank. Simultaneous with the start of motion of the moving contacts, the blast valve operating lever opens the blast valve, which is held in the closed position by a combination of the high pressure gas in the reservoir and the piston retrieving springs. As soon as the high pressure gas starts to flow from the reservoir, a differential pressure is created on the blast valve piston which rapidly moves it to its full open position. The high pressure gas flow efficiently extinguishes the arc. As the breaker continues to move toward the open position, the stationary cam disengages the pawl from the teeth in the blast valve operating lever (Figure 3C). As soon as the gas pressure equalizes on each side of the blast valve piston via communication holes in the face of the piston, the retrieving spring rapidly closes the blast valve, stopping the flow of high pressure gas from the reservoir (Figure 3B). At the end of the opening motion, the moving contact assembly is cushioned at the end of its stroke by mechanical bumpers located at the end of each interrupter. After the breaker contacts have parted, the "a" auxiliary switch contacts in the trip coil circuit de-energize the trip coil.

CLOSE-OPEN OPERATION

The close-open operation is a combination of the opening and closing operations described above. As the breaker contacts approach their makeup position, the auxiliary switch "a" contacts on the mechanism make up the trip coil circuit. Assuming the breaker is closed on a fault, as soon as the breaker contacts close, the protective relay will energize the trip coil disengaging the trip free trigger, which allows the breaker to reverse its forward motion and move to the open position. In the event that this reversal of motion is rapid enough so that the breaker has not reached the fully closed position, a series of teeth on the blast valve operating lever permits the pawl to open the blast valve at the instant the motion is reversed.

The opening motion and action within the breaker will be as described above. The closing piston on the mechanism however, will continue to the fully closed position since the mechanism is mechanically trip free. The "aa" contact on the mechanism, through the action of the "XY" control scheme, keeps the closing circuit locked out as long as the operator maintains the control switch in the closed position. Releasing the control switch to the neutral position allows the relays to reset in preparation for a subsequent closing operation.

OPEN-CLOSE OPERATION

The operation is initiated by energizing the trip coil which disengages the non-trip free trigger and latch on the mechanism releasing the breaker. The pawl opens the blast valve as soon as the breaker starts to open and the blast valve subsequently recloses following the release of the pawl. As soon as the mechanism has opened sufficiently to close the "bb" switch contacts on the 2 pole switch, the AM relay is energized to introduce a time delay before the closing circuit is energized. As soon as the pilot valve opens admitting air to the closing cylinder the opening motion is reversed and the breaker recloses.

MANUAL TRIP OPERATION

The breaker is equipped with a manual trip device which is operated by pulling the handle projecting from the left hand side of the mechanism housing. The operation of this device is explained more fully in the Mechanism Instruction Book 33-125-C3C.

MANUAL CLOSE

See instruction book 33-125-C3C, page 10 except that the safety cover over the piston rod must be removed before the jack can be attached.

PART V - ADJUSTMENT AND MAINTENANCE

GENERAL PROCEDURE

It is recognized that the inspection and maintenance program will vary from one user to another. The important consideration is that a system of regular inspection be established, and the frequency determined by operating experience. By compiling operating data on individual breakers, the programming of maintenance can be scheduled with assurance.

The slight decomposition of SF_6 gas after many arc interruptions has a negligible effect on the dielectric strength and arc interrupting ability of the breaker. By taking advantage of the extended life designed into the contacts, it will be found that SF_6 breakers can be operated over long periods of time without the necessity for any general maintenance. Unless the breaker has experienced an exceedingly high number of heavy interrupting faults, it will probably not be found necessary to inspect the internal parts of the breaker more frequently than three to five years. The main reasons calling for internal inspection of the SF_6 type breaker oftener than this would be excessive loss of gas, too frequent operation of the gas compressor, high contact drop, a marked increase in the power factor reading, or radical change in operating speed.

The following are some of the factors to be considered in determining the frequency of a general inspection procedure.

1. Time
2. Number of switching and testing operations
3. Number of overload and fault operations
4. Severity of fault operations
5. Frequency of compressor operation

It is recommended that frequent visual inspections be made by operators while touring the switchyard in order to catch any obvious abnormal conditions. It is also considered good practice to operate the breaker from the switchboard at regular intervals to insure the integrity of all electrical circuits, as well as proper mechanical functioning of the breaker.

ROUTINE INSPECTION (Tanks Closed)

It is recommended that the breaker be given a ROUTINE INSPECTION annually consisting of the following procedures:

1. Check the mechanical operation of the breaker. See operating mechanism instruction book for specific procedure on operating mechanism.

2. Measure contact engagement by closing the breaker manually until the breaker lights out across the bushing studs and then observe the travel of the horizontal pull rods to the closed and latched position. This should be about 1-13/32 $\pm$ 1/16.

3. Check the high and low pressure system pressure gauges, and by noting the temperature gauges for both systems check the pressure for the ambient temperature observed by consulting curves, Figures 34 & 35.

4. Check the contact resistance across the bushing terminals. This should not be over 90 micro-ohms for the 1380 SF 10000, and 120 micro-ohms for the 2300 SF 15000 breaker.

5. Check the clearance on the horizontal pull rod lever stops. This should be .030 to .040 in the closed position and 0 to .005 clearance in the open position, (Fig. 19).

6. With the breaker open and the mechanism reset, there should be 1/32 to 1/16 clearance between the trip free trigger and the roller on the trip free lever. If readjustment is necessary, see explanation under mechanism adjustments in Instruction Book 33-125-C3C.

7. With the mechanism in the closed position, depress the manual operating button on the pilot valve and observe the overtravel of the vertical pull rod. There should be approximately 1/32 minimum to 3/32 maximum overtravel. Adjustment is made by varying the length of the vertical pull rod between the mechanism and the bell crank.

8. Check control wiring for loose connections.

9. Check closing and tripping operations, using all usual relays and circuits involved in the operation of the breaker. Be sure all relay contacts are clean and tight.

10. Check closing and tripping at reduced voltage to insure a safety margin.

11. Check the strip heaters in the combination mechanism and gas housing.

12. Crack valve No. 3 (Fig. 29) and slowly bleed down the pressure in the high pressure system to the low pressure chamber, and by observing the high pressure system pressure and temperature gauges note the pressure at which the governor switch starts up the gas compressor. (Refer to Fig. 34). Note that differential for this switch is 10 psig ± 3 psig.

13. Open the switch on the control panel in the gas compressor motor circuit and by continuing to bleed the pressure from the high pressure to the low pressure side, observe the pressure at which the alarm switch contacts operate, and the pressure at which the high pressure cutout switch operates, (Fig. 34).

14. Close valve #3 and the switch in the gas compressor motor circuit and as the gas compressor restores the pressure in the high pressure system observe the point where the cutout switch, alarm switch, and governor switch operate, (Fig. 34).

15. If the gas service trailer (Fig 21) is available, connect the flexible hose to the service connection, close valve No. 2 and open valve No. 4 (Fig. 29). Start up the compressor on the service unit and pump down the low pressure system observing the point where the low pressure alarm and low pressure cutout switch operate (Refer to Fig. 35). Stop the compressor and energize the tank heaters on the service unit, open the breaker refill valve on the service unit and return the gas to the low pressure system in the breaker observing the point where the lockout and alarm switch contacts operate. Shut off the flow of gas to the breaker when the pressure gauge on the low pressure system indicates a return to normal pressure. Disconnect the gas service trailer, and open valve No. 2 and close valve No. 5.

16. By means of an ammeter inserted in the heater circuit at the control panel, check the current taken by the tank heaters in each circuit by placing a jumper around the thermostat.

This also checks the operation of the heater contactors. If the current in either circuit is less than 9 amperes indicating one or more heaters is open circuited, "light-out" each individual heater unit in the high pressure tanks.

17. Check the oil level in the gas and air compressor crank cases.

GENERAL INSPECTION PROCEDURE (Tanks Opened)

Before the tank doors are opened, it is recommended that the leak rate of the high pressure system be checked. It is assumed that all piping joints, etc. are leak tight and the observed leak rate is attributable to the blast valve. If the pressure in the high pressure system isn't up to normal crack valve No. 3 to drop the pressure in this high pressure system. This will start the compressor. As soon as the pressure is up to normal for the ambient temperature, the compressor will cut off. Observe the pressure drop over a timed interval of 30 minutes. If the rate exceeds 5 psig per hour, it indicates that the blast valve should be examined as part of the General Maintenance Procedure.

Except in extreme emergencies, the pole unit tanks should only be opened on a clear day as the interrupter must be rolled out of the breaker on servicing rails in order to work on the interrupter. If the servicing work necessitates leaving the breaker over night or longer without gas in the tanks, it is recommended that heaters be placed in the tanks. The leads to the heaters can be brought to the outside by removing the rupture disc. The heaters in the high pressure tanks should also be energized.

Any time that the gas is evacuated and air admitted to the inside of the tanks, all tanks should be opened to remove the powders. See Opening the Breaker Page 6 Part V.

EVACUATING THE SF_6 GAS (Using Service Trailer)

Before an internal inspection can be made on the breaker, it is first necessary to evacuate the SF_6 gas into storage tanks as it is not economically feasible to exhaust this gas to the atmosphere.

In order to facilitate the servicing of SF_6 breakers, a gas servicing trailer Figure 21 consisting essentially of a large storage tank, a motor driven gas compressor, and a motor driven vacuum pump has been made available on order.

In the following procedure, it is assumed that the service trailer is available. An alternate method is described at the end of this section in the event a service trailer is not available.

It is further assumed that the gas servicing unit has been previously purged of air, and has SF_6 gas stored at approximately 45 lbs. psig in its reservoir and piping.

The electric motors on the gas servicing trailers are for 208/220/440 volts - 60 cycle - 3 phase service. A plug-in receptacle in each mechanism housing provides a convenient source of power for operating these motors.

Connect the flexible hose on the gas servicing trailer to the service connection on the left hand side of the mechanism housing, and plug in the electrical cable to the receptacle in the mechanism housing, and proceed to evacuate the air in the hose connection as described under Part III "EVACUATION OF AIR". As soon as the vacuum pump is operating properly, open the vacuum pump inlet valve and evacuate the air from the flexible pipe connection between the breaker and service trailer. A couple of minutes operation is all that is necessary to sufficiently evacuate the air from this tubing. Close the valve on the vacuum probe connection and disconnect the vacuum gauge probe. Close the vacuum inlet valve and shut off the vacuum pump. Before starting up the compressor, check the level of the oil in the crankcase as indicated by the dip stick. Check the direction of rotation by momentarily starting the motor. The compressor must turn counter-clockwise facing the sheave end as indicated by the arrow on the sheave. If the direction of rotation is not correct (and the direction of rotation on the compressor unit in the housing is correct) reverse the leads at the receptacle plug in the mechanism housing. If the direction of rotation of both compressors is wrong, the change can be made where the AC source is brought into the terminal blocks in the housing.

The compressor start button must be held in for several seconds until the oil pressure builds up to approximately 25 psig as indicated by the gauge on the compressor unit. Check the compressor oil pressure. If the gauge fails to register a minimum pressure of 40 lbs. after approximately 3 seconds, stop the machine and ascertain the cause of failure.

Open the main tank cutoff valve and the compressor inlet valve and start the compressor. Open all valves 1 to 5 to Fig. 29 in the gas housing and let the compressor run until it automatically stops. The compressor is arranged with a low oil pressure cut-out switch which will automatically stop the compressor when it has reached a vacuum of approximately 28 inches of mercury. Close the main tank cut-off valve, and the compressor inlet valve. Open the valve on the vacuum probe connection to allow the inside of the breaker to come up to atmospheric pressure after the bolts have been removed from the end doors on the tanks.

ALTERNATE METHOD OF GAS HANDLING

If a gas servicing trailer is not available the following alternate procedure is suggested:

The compressor in the mechanism housing can be used to pump the gas out of the breaker, but a vacuum pump capable of pulling a vacuum of 2 mm Hg is required to evacuate the air from the breaker prior to refilling with SF_6 gas. Standard commercial SF_6 gas cylinders can be used to store the gas. In order to keep the number of cylinders to a minimum they can be cooled by immersion in a bath of alcohol and dry ice as illustrated in Figure No. 22.

Referring to Figure 22, connect the cylinder to the service connection on the side of the mechanism housing. A tapped hole in the cover over the regular service connection fitting provides a means for connecting the piping from the cylinders. Open valves #2 and #5 and close valves #1, #3 and #4, (Fig. 29). This will allow the gas to flow by pressure head from the high pressure system to the cylinder. The cylinders should be weighed as the gas flows into them in order to limit the weight of gas stored to not over 100 lbs per cylinder. This is necessary in order to insure that the pressure in the cylinder does not exceed 300 psig when removed from the dry ice bath. When the pressure head drops to a point where the gas is no longer transferred from the breaker to the cylinder, close valves #2 and #4, open valves #1, #3, #5 and start up the compressor. Continue to pump down the breaker until it is no longer possible to transfer the gas indicating that the compressor has probably reduced the pressure in the tanks to about 5 psia. Removing the connection to the cylinder will allow the air to establish atmospheric pressure inside the breaker tank so that the end doors can be opened.

After the servicing is completed, the system has been checked for leaks (See Part III, Checkihg Blast Valve and Leak Testing the Complete Breaker) and the end doors have been closed, it is necessary to evacuate the air from the breaker prior to refilling with SF_6 gas.

In order to ascertain when a vacuum of 2 mm Hg is reached, it will be necessary to have available an electrical type vacuum gauge such as the Stokes Corp. Model TP-3 or the Hastings-Raydist Corp. Model SP-1. A tee connection with a valve and 1/8" IPS female thread fitting for attaching the probe from the gauge should be provided for in the hose connection between the vacuum pump and the service connection on the breaker. The hose connection to the breaker from the vacuum pump should have an end fitting to fit the Parker Co. fitting piece No. 20 FTX.

Connect the hose from the vacuum pump, open all valves #1 to #5 Fig. 29 and evacuate the air from the breaker down to a maximum of 2 mm Hg pressure as indicated by the vacuum gauge. Close valves #4 and #5 and disconnect the hose from the vacuum pump. Connect the piping from the cylinders to the service connection. Close valves #1 and #5 and open valves #2, #3 and #4. Start the compressor and transfer the gas to the breaker from each cylinder in turn. It will be necessary to jumper the low pressure system, low pressure cut-out switch contact in the compressor motor circuit until the pressure in the low pressure system exceeds the operating point of the pressure switch in order to run the compressor. Since the compressor is only capable of pumping down to about 5 psia, some gas will be lost in filling the cylinders and again in filling the breaker, so it will probably be found necessary to add some make up gas from a new cylinder. If the gas is transferred too fast from the cylinders, it may not be possible for the gas to draw the latent heat of vaporization fast enough from the surrounding air to prevent freezing of the gas. If this happens, the rate should be reduced or heat can be applied cautiously to the cylinders. A safe way to do this is to place the cylinders in a container of boiling water.

If the compressor is allowed to run during the transfer of the gas, the governor switch will automatically stop the compressor when the correct pressure in the high pressure system is reached. After the compressor stops, bring the pressure in the low pressure system up to the required value as determined from the curve Fig. 35 and then stop the transfer of gas.

PRECAUTIONS TO BE OBSERVED WHEN HANDLING ARCED SF_6

WARNING

Sulfur-hexafluoride gas in the pure state is colorless, odorless, tasteless, and has a low order of toxicity. Beware of oxygen deficiency if large volumes of gas are breathed. Toxic decomposition products are formed in the gas when arcing occurs in it. Do not breathe gas containing these toxic products, especially within a few minutes after the doors are opened and until the decomposition products are safely diluted with air.

Activated alumina is incorporated in all SF_6 *breakers. This material has been found to be quite efficient in removing the chemically active products formed during arcing. A sufficient amount of this material is used to remove the toxic arc products expected to be produced between maintenance operations on the breaker. The small percentage of gas which remains after the salvaging operation is allowed to escape to the atmosphere on opening the breaker. As a result, operating personnel should not be exposed to a significant amount of gas when the breaker is opened.*

If, for some reason, a significant amount of gas is present, certain warning indications such as a pungent and unpleasant odor, and/or irritation of the upper respiratory tract and eyes will give an early and sufficient warning within seconds to personnel in the vicinity before a significant toxic reaction should occur. The absence of any odor or irritation should indicate safe working conditions.

OPENING THE BREAKER

After the vacuum is broken, it is recommended that the pole units be opened immediately. After the doors are opened, the interior should be flushed with compressed air or nitrogen. This will dilute any remaining SF_6 and also blow the small amount of arc product powders from the tank walls. These powders should also be immediately flushed from the exterior surfaces of the interrupters. Caution should be observed to prevent the inhalation of the fine metallic fluoride dust. A dust mask should be worn while doing this work, and it is also advisable to avoid skin irritation by wearing gloves and keeping other parts of the body covered, especially if perspiring. To insure against moisture condensation in the high pressure tanks while the doors are open and work is being performed, the heaters in the tanks should be kept energized.

ATTACHING SERVICING RAILS

Remove the electrostatic aluminum shields at either end of the interrupter and the aluminum shield over the accelerating spring.

Remove two bolts on each interrupter supporting bracket nearest the center of the tank. Slide the two rails, Figure 12, through the tank and raise them up and bolt them into position on the flange faces. Due to manufacturing tolerances, the lugs on the rails may not fit snugly against the tank flanges. If this occurs, tighten the bolts firmly on one end of the rails and just snug up the bolts on the other end of the rails. The trollies with the shorter arms should be placed on the rail from the reservoir end of the interrupter (right-hand side) and the two trollies with the longer arms should be inserted over the rails from the opposite end. While Figure 12 shows the servicing rails attached to the tank at the accelerating spring end of the interrupter, they can be attached equally conveniently to the opposite end of the tank.

REMOVING INTERRUPTER FOR INSPECTION

Roll the trollies in from either end until the pins can be inserted down through the brackets on the interrupter and the eyes on the trollies. Next, attach the extension rails, Figure 12, and secure to the end brace, selecting the proper set of holes so that the rails will be approximately horizontal. Remove the pin through the upper rod end of the operating rod and lower it to the bottom of the tank. Disconnect the elbow at the upper end of the feed tube from the reservoir by removing the 3 socket head screws. As a precautionary measure to prevent possible damage while rolling the interrupter in or out on the rails it is suggested that the combination sediment trap and aluminum seal be removed and set aside. Remove the remaining two bolts from each interrupter supporting bracket holding the interrupter to the bushings. This will lower the interrupter onto the trollies. The interrupter is now ready to be rolled out for inspection, (Fig. 36).

INSPECTION AND ADJUSTMENT OF INTERRUPTER

Immediately wipe the remaining traces of powder from the interrupter, paying particular attention to the insulating surfaces. These powders, while sealed in the breaker in the absence of moisture, have a high dielectric strength, but are hygroscopic and when exposed to the atmosphere can materially reduce the insulation level of the breaker. The remaining interrupter electro-static shields and the capacitor assembly should be removed, and the capacitor assembly wiped clean. The plate on the first interrupter casting is not removed as the capacitor assembly slips into the six holes. Withdraw the Micarta blast shields from each break. This is done by removing the two Micarta screws holding one shield support to the

Micarta tie bar, removing the support, and sliding the shield along the contacts toward the accelerating spring end of the interrupter. It is not necessary to remove the screws in the support, as they only pin the shield in position. Remove the four Micarta bolts in the Teflon interrupting chamber retaining ring and remove the chamber. A slight pitting may be observed on the inside of the surface, but this will not affect the proper functioning of the breaker. Also inspect the Teflon lined blast shields for loose or ruptured linings. The stationary fingers, arc horn, and moving contact assembly are now exposed for inspection (See Fig. 13). The feedpipe tube and the operating rod, which remain in the tank, should be cleaned at this time. The tank walls and the lower bushing porcelains should also be wiped clean.

WARNING: An aluminum framework, or strong-back, Fig. 24 is provided which must be bolted to the interrupter supporting brackets to insure that contact alignment is maintained before closing the interrupter with the manual closing device. A manual closing device (Figure 14) is furnished with the breaker. Bolt the two brackets to the inside face of lugs on the lower side of the first interrupter casting. The side of the brackets with the slot in it face the accelerating spring end of the interrupter. Attach the rod with the ACME threads to the lever where the operating rod was disconnected. Place the bearing plate in the slots and screw the jack onto the rod.

INSPECTION AND ADJUSTMENT OF CONTACTS

Very little pitting or erosion should be found on the stationary contact fingers as the arc is rapidly transferred to the tungsten tipped arcing horn during interruption. Any slight roughness due to erosion or pitting can be smoothed up sufficiently with a fine file without removing the stationary contacts from the interrupter. Do not apply too much pressure in the filing operation or the alignment of the fingers may be affected. If the stationary contact fingers cannot be dressed properly in place, they can be removed for bench work by removing the two socket head cap screws which hold the arcing horn and fingers to the first interrupter casting. (See Figure 15).

Pitting or erosion of the contact tip on the arcing horn can be expected, but little corrective action is necessary as long as the tungsten cap is essentially intact. Any sharp points should be smoothed up.

Any pitting and eroding of the moving contact will occur principally on the inside diameter, and hence this pitting need not be corrected. The radius on the outside tip of the moving contact should be smoothed up to provide a smooth surface between the moving contact and the stationary finger on engagement. Occasionally it will be necessary to remove the moving contact for replacement or smoothing up. Close the interrupter by hand approximately 1 inch. Remove the two pins holding the moving contact cross bar to the side operating rod and remove the four socket head cap screws holding the contact guide casting to the adjacent interrupter casting. The whole unit can then be removed as one assembly. (See Figure 15). On reassembly, the unit can be slipped into place and the bolts and pins installed with little chance of misalignment.

After the inspection and/or dressing of the contacts is completed, slowly close the interrupter by hand until the moving contacts are about 1-1/2 inches from engaging the stationary contact fingers. In closing the interrupter slowly by hand, there should be a gradual increase in the closing effort between the open and closed position with no sudden increase in effort. If a sudden increase is observed, the closing operation should be stopped and the cause determined. All fingers on any one break should engage the moving contact nearly simultaneously.

Insert the contact gauge tool under the stationary contact fingers and over the moving contact. Rotate the gauge completely around the moving contact, keeping the larger end of the gauge in contact with the moving contact. If there is any interference between the gauge and the fingers, realignment is made as follows; (1) loosen the four button head screws (section AA Fig. 15) and shift the moving contact and guide sleeve in the direction indicated and retighten the button screws to 20 ft. lbs torque. For slight misalignment, this adjustment is usually found to be sufficient. Recheck the alignment with the gauge. If the alignment is still unsatisfactory, the ratchet on the closing device should be reversed and the moving contact moved to the full open position. This will permit loosening the two socket head cap screws and shifting the position of the stationary contact as permitted by the clearance holes in the contact. (See Figure 15). Check the clearance of the arc horn to the moving contact (1/8" ± 1/64) and adjust if necessary. Close the moving contact and recheck the contact alignment as described above. Any time that it is found necessary to readjust the contacts always check the free entry of the moving contact into the Teflon arc chamber. Clearance holes in the Micarta retaining ring provide for limited shifting of the arc chamber. If this clearance is found to be inadequate do NOT enlarge the opening in the arc chamber. Additional clearance can be obtained by enlarging the clearance holes in the retaining ring. Tighten the Micarta bolts to 8 ft-lbs torque.

NOTE: All breaks may not make up at the same time. A 1/16 inch difference is permissible.

Check the other breaks in the same manner.

ADJUSTMENT OF INTERRUPTER

Close the interrupter until the machined stops on the main operating lever have 1/16 clearance with the stop pads on the first interrupter casting. (See Figure 16). Check the spacing between the spring seat on the interrupter end bracket and the accelerating spring follower. This dimension should be 8-7/8" ± 1/16. Due to progressively less contact travel between No. 1 pole unit and No. 3 pole unit, it will probably be found that the interrupter in No. 1 pole will be adjusted to 8-13/16 and the interrupter in No. 3 pole unit adjusted to 8-15/16 as received from the factory. Any setting within these limits is considered normal and acceptable. If adjustment is found necessary, the interrupter should be moved to the open position to remove the heavy accelerating spring load from the adjusting nuts.

Reverse the jack and slowly open the contacts. As the contacts are opened, the pawl will rotate the blast valve lever, opening the valve. The cam will disengage the pawl from the blast valve lever. The lever should snap back and engage the pawl again. As the contacts are opened further, the pawl will be disengaged again and the blast valve lever will return to its original position. While the contacts are being opened, there should always be a positive load on the jack throughout the full 7 ± 1/16 travel. If there is not, this is an indication that there is undue friction or binding in the assembly. In the full open position, as determined by pulling vigorously on the accelerating spring follower to insure that it is against the bumper assembly, the distance between the end bracket casting and the spring follower should be 15-7/8" on all 3 interrupters.

The inner spring on the accelerating spring assembly is a "kickoff" spring operating only over part of the stroke. Its adjustment is not critical but in the open position, it should be just free with no initial compression.

With the interrupter closed, check the top steel disc on the bumper assembly (Figure 30) to make sure that it is up against the cover. This indicates that the neoprene bumpers are still resilient.

BLAST VALVE

As the interrupter is jacked in and out observe the action of the pawl and ratchet assembly. Operation should be smooth and positive, Fig. 3.

Examine the teeth on the blast valve operating lever and also the engaging tooth on the pawl for signs of chipping or rounding off. Slight nicks or brinelling can probably be corrected satisfactorily with a three cornered file, but if more serious wear is indicated it is recommended that these parts be replaced.

To check the resiliency of the pawl retrieving springs pull down on the pawl just in back of the engaging tooth. The load should be about 15 lbs. initial and 20 lbs. in the final position. If evidence of weak springs is observed, they should be replaced as this lever performs an essential function in the proper operation of the breaker. Check that there is no interference between the small springs and the spring retainer tube.

Normally it is not necessary to inspect the blast valve. However, if excess leakage or signs of galling or jamming are observed, the blast valve piston and seat should be inspected. Since the blast valve is contained in the reservoir casting, the reservoir which is bolted to the first interrupter casting, must be removed from the interrupter assembly. The trollies which support this end of the interrupter on the rails are attached to the reservoir, therefore, the interrupter must be supported by other means before the reservoir can be removed. This can be accomplished easily by means of a rope sling tied to the rails and passing under the interrupter.

To unbolt the cover plate on the end of the reservoir, remove 3-equi-spaced bolts and replace with 4" long bolts. After the remaining bolts have been backed off evenly to allow the cover plate to back off about 1/2", screw down the jacking bolts to take up the spring load and remove the other bolts entirely. Continue backing out the jack bolts evenly until the spring load has been relieved entirely. This will permit inspection of the neoprene rubber seat. Examine it carefully for nicks and also resilience of the rubber. Also examine the machined valve seat on the blast valve piston. Remove the blast valve piston and check the cylinder walls for signs of scoring, etc. Also examine the Teflon ring. If the Teflon ring is found scored, the whole piston and ring assembly must be replaced with a spare assembly as special equipment, not generally available except at the factory, is required to shrink the ring into the groove on the piston. If the piston itself is not damaged, it can be returned to the factory for installation of a new ring and then kept available as a spare. Check the free length of the springs for possible permanent set. The free length of the outer spring is 9-27/32"; the inner 8-5/8". A set of 3/4" is acceptable but anything more than that calls for replacement. In reassembling piston in cylinder, reverse the process of removal described above being very careful that the ring enters the beveled end of cylinder evenly and concentrically. After assembly is completed, work the piston up and down several times to ascertain that it moves freely without binding. It is recommended that a leak tight piping adaptation be improvised between a nitrogen bottle and the reservoir including a pressure gauge and the leak rate of the blast valve be verified before assembling the reservoir on the interrupter. The allowable leak rate is 10 lbs/hr.

ASSEMBLY OF INTERRUPTER

After the previous steps have been completed, reassemble the interrupter. Fasten the capacitors in place and bolt on the static shields around the interrupter units, (See Fig. 16).

BUSHING FILTERS

It is recommended each time the breaker is opened for general maintenance that all activated alumina filters be renewed. There is a filter in the lower end of each bushing which must be renewed before the interrupters are bolted in place. Each filter is held in place by a triangular snap ring in the lower end of the lead. The complete filter cartridge should be replaced.

REMOVAL OF TOP PORCELAIN ON BUSHINGS

If the top porcelain on the bushing is damaged and needs replacement, it may be done without removing the bushing from the tank. See Fig. 28

LUBRICATION

Do not use ordinary grease on moving parts inside the tank. A one ounce tube of special grease is included with each breaker when shipped identified as Style No. 424D865H41. A very thin film is sufficient and should be used on the slots in the moving contact guide casting that guide the pin linking the crossarm and moving contact together, on the sliding surfaces of the blast valve piston, and on all of the pins in the interrupter linkage system. This grease may be obtained from Westinghouse by ordering it by S#424D865H41 or it may be secured directly from the supplier Hooker Electro Chemical Corporation, as "Fluorolube" grade GR-362.

The roller bearings on the shaft that transmits the motion from the pull rods to the moving contacts have been packed with this special grease at the factory and should not require removal and repacking oftener than once every ten years. Unless there is reason to be suspicious of the gas seal around this shaft, it will not be necessary to disassemble the gas seal details during general maintenance.

However, in the event that there is reason to suspect that trouble needing correction does exist, such as leakage of gas past the seal or undue friction in the bearings, the seal assembly can be disassembled as covered under "INSPECTION OF SHAFT SEAL".

The special wide temperature range grease identified as Westinghouse No. 9921-4 is used in lubricating the bearings in the mechanism, and throughout all moving joints in the linkage external to the tanks. This grease is available from Westinghouse in 4 oz. tubes identified as S#1802395 or may be procured direct in larger quantities from Esso Standard Oil Company or the Texas Company identified as Beacon Lubricant 325. Packaged in 4 oz. tubes as supplied by Westinghouse provides a convenient dirt free means of storing and application.

INSPECTION OF SHAFT SEAL

The shaft seal (Figure 4) should only be disassembled if some malfunction develops or a 10 year interval has elapsed since the last lubrication. It should be disassembled in the following sequence: -

1. Remove the cover plate on the under side of the lever box located on the underside of the large tank on the right hand side of the breaker.

2. Disconnect the horizontal pull rods by removing the pin connecting the rod ends to the lever and close the mechanism by the manual closing device to move the rod end clear of the lever.

3. Remove the lever from the end of the shaft inside the breaker.

4. Remove the housing from the tank for a bench work.

5. Remove the lever from the other end of the shaft.

6. Remove the lever stops and cover over the end of the shaft seal assembly.

7. Extract the shaft by pulling up through to the end normally inside the tank.

8. The outer race of the bearings is a light press fit in the bearing housing, therefore DO NOT attempt to drive the assembly out by forcing from one end as this will deform the Teflon "V" rings which are no longer retained on the I.D. with the shaft removed. The upper roller bearings should be extracted first by shifting the flat washer directly above it off center which will expose a lip on one side. Using a drift and working from the Belleville washers end, tap the exposed lip working the washer around to drive the bearing out evenly.

9. The Belleville washers and the Teflon "V" rings can now be easily removed.

10. The other roller bearing can be removed easily. Before reassembling the bearings wash them out with a solvent and repack with the special Fluorolube grease S#424D865H41. To reassemble insert the upper-roller-bearing and shaft first. Be sure that the Belleville washers are alternately reversed so that the convex side is up on one washer and down on the next washer. Otherwise insufficient compression and load on the "V" rings will result.

    In reassembling the "V" rings, be sure that the concave side faces the inside of the tank so that the internal gas pressure will tend to expand the rings against the housing and shaft. Draw the cover-plate down evenly by tightening each bolt one flat at a time moving progressively around the cover.

FINAL ADJUSTMENTS

Roll the interrupter into position in the tank and bolt the interrupter supporting brackets to the lower end of the bushings using 85 ft-lbs torque.

To compensate for manufacturing tolerances, particularly in the bushing seats on the tanks, beveled ring seats located on the lower end of the bushings provide a means of insuring a co-planer surface for attaching the interrupter. These have been set at the factory with a gauge and normally should not require readjusting. In the event that realignment is called for, the "strong back" will serve as a suitable reference plane. Loosen the 3 screws holding the bevel ring, realign the bevel seat with the face plate on the strong back, and retighten the holding screws. (Note: The mounting feet on the interrupter are not considered reliable enough to serve as a reference plane for setting the bevel rings.)

Before replacing the feed tube, make sure that the ends of the tube are firmly against the shoulder in both elbows. If either elbow is not tight, loosen the two Allen head bolts on the gland packing, seat the tube, and retighten the bolts to 35 ft-lbs torque. (See Fig. 17). In replacing the tube assembly, attach the elbow on the lower end first with the bolts only finger tight. In placing the combination gasket ring and sediment trap in the counter bore in the upper elbow be careful that the "O" rings are in the grooves in the ring. A coating of the fluorolube grease in the grooves will help to retain the "O" rings during assembly. Applying an axial load on the tube, raise it into place making sure that the serrations on the elbow and reservoir flange engage. Tighten the 3 bolts to 45 ft. lbs. Next tighten the bolts on the other elbow to the same torque while maintaining an axial thrust on the elbow and tube. Reconnect the insulated operating rod.

BELL CRANK

The setting of the bell crank is checked in the closed position (Figure 5). The machined flat on the lever should be level within ± 1/2 bubble when the lever is in the correct position. When the mechanism is latched, be sure the interrupter and lever stops are not solid. This setting is changed by varying the length of the vertical pull rod between the mechanism and bell crank. Any adjustment in the length of the vertical pull rod should be made with the mechanism in the open position in order to remove the load from the rod.

HORIZONTAL PULL ROD LEVER

In the closed position of the breaker, the distance between the center lines of the pull rod pin and the lever shaft should be 2-11/16 inches ± 1/32. (Figure 19). The position of this lever is adjusted by varying the length of the horizontal pull rods. The opposite ends of the pull rods have right and left hand threads which make possible varying the distance between rod ends by loosening up the clamping bolts on the rod ends and turning the rods. Any adjustment of course is only done with the breaker in the open position in order to remove the load while the rod end clamps are loosened. With the lever in the proper position, the stops should be set to .030 to .040 of an inch in the closed position and 0 to .005 clearance in open position of the breaker.

OPERATING RODS

With the horizontal pull rod operating levers in proper adjustment, close the breaker until the mechanism is closed and latched and check the clearance between the stop pads on the contact operating lever and the machined stops on the first interrupter casting, (Fig. 16). This clearance should be between .075 to .125 of an inch. Adjustment is made by varying the length of the insulated operating rod.

LEAK TEST OF HIGH PRESSURE SYSTEM

Before closing the doors on the tanks, it is suggested that the high pressure system inside the breaker be checked for leaks by attaching nitrogen cylinders to the gas service connection and bringing the pressure in the high pressure system up to about 200 psig. Since pressures in a nitrogen cylinder may be as high as 3000 psig, as a safety precaution to guard against excessive pressures damaging valves, gauges etc. it is recommended that a reducing valve be introduced between the cylinder and the attachment to the service connection. The joints at either end of the gas feed pipe can be checked by a soap bubble test, and the blast valve seat can be checked by observing the pressure gauge over a timed interval. The loss of gas from the high pressure system should not exceed the rate of 5 lbs. per hour.

FILTERS

It is recommended each time the breaker is opened for general maintenance that all activated alumina filters be renewed. In addition to the bushing filters already covered, there is a bag of activated alumina in a metal basket underneath each high pressure reservoir. There are also two large activated alumina filters in canisters located inside the mechanism housing. It is recommended that these filters be renewed just prior to closing the breaker for evacuation of the air in order to minimize the possibility of moisture absorption. The felt mechanical filters should be removed and brushed clean. These are used to prevent any alumina dust from entering the breaker.

To renew the activated alumina will require about 35 lbs. This can be secured either from Westinghouse by specifying material No. 52513BJ or from an outside supplier identified as H151-1/8" pellets.

Each canister in the mechanism house takes about 10 lbs., each bag filter on the interrupter takes 5 lbs.

CLOSING UP THE BREAKER

Based on the recommendation of the rupture disc manufacturer, the rupture discs should be replaced every five years.

Before closing the tank doors examine the "O" rings carefully, and replace any rings that show evidence of deterioration or nicks. A liberal dressing of grease 9921-4 in the grooves will help to retain the "O" rings in place while the door is being closed, but every precaution should be observed in making sure that the "O" rings are not pinched or jammed as the door is closed. Coat all machined surfaces on the flanges with the grease to prevent corrosion. (See PART III Page 4 LEAK TESTING for suggested procedure in closing doors.)

After the high pressure system has been checked, close the tank doors and bolt them down evenly all around.

Open valve #3 (Fig. 29) and exhaust the mixture of air and nitrogen to the large tank.

Make a leak test as described under PART III Page 4.

Connect the hose from the gas servicing trailer to the service connection on the mechanism housing and open all valves #1 to #5. Evacuate the air from both the high and low pressure systems as covered under Part III Page 4 EVACUATION OF AIR.

The procedure for refilling the breaker with SF_6 gas is also covered in detail under Part III Page 5.

CHECKING THE GAS

Before the breaker is filled, the SF_6 gas should be checked. The purity of SF_6 gas can be checked with a gas density meter such as an Edwards Gas Density Balance. If the proportion of air in the SF_6 exceeds 10%, then the gas should be purified by pumping it into standard cylinders and cooling the cylinders in an alcohol and dry ice bath. See Figure 22 and "Alternate Method of Gas Salvage." The SF_6 gas will be liquified and the air will collect on top where it can be bled off by opening the valve at the top of the cylinder.

If a gas service trailer is available (See Fig. 21), the dry ice and alcohol can be dispensed with since the compressor on the trailer is capable of operating at much higher pressures. The following is the procedure to follow: (1) Connect service hose on trailer to the service connection at the mechanism housing, (2) Improvise a pressure tight piping connection between the 1/4" sampling valve (located adjacent to the Main Tank Cut-off valve on the service trailer) and an empty cylinder. A pressure gague with a pressure scale of at least 600 psi should be located in this line. (3) It will also be found advantageous to have a good size (16" or larger) cooling fan directed onto the cylinder, (4) Open all valves 1 to 5 (Fig. 29) in the mechanism housing, (5) Set cylinder on scales and record the tare weight, (6) Open the valve on the cylinder and start the compressor, (7) Regulate the Compressor Inlet Valve on the service trailer to keep the inlet pressure on the compressor between -10 and -15 psig as indicated by gauge on trailer panel. This indirectly keeps the discharge pressure between 530 and 550 lbs. as read by gauge located in piping to the cylinder, (8) Maintain a nearly constant check on the high pressure gauge as a rapid rise indicates accumulation of air above the liquid SF_6. When this occurs, stop the compressor shut off the sampling valve and cylinder valve and crack the connection at the cylinder to let the air escape, (9) When the pressure drops to near zero, retighten the hose connection, open the sampling and cylinder valves and restart the compressor. (10) Repeat this process until the scale indicates that the cylinder contains 100 lbs. of SF_6 gas. Continue the process until the gas is all removed from the breaker. It takes about 1 hour per cylinder. The gas can either be returned to the breaker directly by connecting the bottles to the service connection or placed in the tank on the service trailer and returned by the regular service hose. Setting the cylinders in a container of boiling water will expedite the flow of gas from the cylinders.

The gas as received in the cylinders is warranted as having a moisture content not exceeding 20 parts per million by weight. If however through mishap or miscalculation there is reason to suspect that the moisture content is more than 300 parts per million, it can be removed readily by the following method; (1) Attach the manual closing device, (2) Pull the breaker slightly into the overtraveled position to remove the load from the non trip free trigger, (3) Raise the trip armature to disengage the non trip-free trigger and at the same time reverse the ratchet on the jack and slowly open the breaker. After the breaker has opened slightly the trip armature can be released. (4) Continue to open the breaker with the manual closing device until the pawl has moved the blast valve operating lever sufficiently to open the blast valves. The sudden escape of the gas from the high pressure system can generally be heard indicating that the valves are open, but attention to the high pressure system pressure gauge on the panel in the housing is a more positive indicator. With hand valves 3-4-5 closed and valves 1 & 2 open (Ref. Fig. 29) let the gas compressor in the mechanism housing run for about 3 hrs. (5) Stop the compressor, (6) Close valves 1 & 2, (7) Replace the activated alumina in the filters in the housing, (8) Open valve 5, remove the cap on service connection, (9) Open valve 1 and run the compressor for about 30 seconds to purge the air from the filters and compressor, (10) Close valve 5 and stop the compressor. (11) Reverse the ratchet on the manual closing device and close and latch the breaker. Opening valve 2 restores the breaker to service.

ACCELERATING SPRING

The accelerating spring assembly Figure 6 is located on the third pole unit and is operated by the horizontal pull rod assembly. This spring provides the only means for adjusting the opening speed of the breaker. If this is found necessary, all adjustments should be done with the breaker in the open position. Remove the four 5/16 bolts holding the thin cover on the end of the spring housing which makes the adjusting nut accessible. Loosen the two 3/8 hex, head clamping bolts. This permits running the nut in or out on the operating rod. Be sure and lock the two 3/8 hex. head bolts before returning the breaker to service.

TANK HEATERS AND THERMOSTAT

The heaters are located in each high pressure tank on the right hand side of the breaker. Gas tight heater wells permit removal of the heaters for inspection without evacuating the breaker. They are accessible by removing a cover on the high pressure tank enclosure. The heaters are controlled by two thermostats located near the bottom of the pressure switch panel in the mechanism housing. One thermostat controls one heater unit in each of the 3 high pressure tanks and the other thermostat controls the other heater unit in each high pressure tank. To protect the contacts of the thermostat, a relay is interposed between the thermostat and the heater. The thermostat should be set to energize the heaters at a temperature of 55°F. A graduated scale on the adjusting knob provides a rough indication of the thermostat setting. However, a more accurate check can be made by observing the temperature gauge on the panel and the operation of the heater relays. It is recommended that this setting be verified each fall as the temperatures drop to the vicinity of 55°F.

If the calibration of the thermostat is found off, it can be corrected as follows: Hold the micrometer knob and turn the calibrating screw located in the center of the micrometer knob clockwise to lower or counter clockwise to raise the operating point for a given temperature. The operating point can easily be determined as the point at which the heater contactor picks up. This is a rather delicate adjustment as the quarter turn of the screw changes the operating point approximately 17°F.

It is recommended that an ammeter be installed and located in each of the heater supply circuits in the control room as an indication of whether or not the heaters are functioning properly. For ambient temperatures below 50°F, loss of the heaters in any of the reservoirs could seriously impair the functioning of the breaker.

PRESSURE SWITCHES

The operating pressures for the pressure switches are given on a nameplate located on the pocket inside the mechanism housing doors. If the operating point of any of the switches is different from that shown on the nameplate, the switch may be adjusted as follows: After removing the cover on the switch, which is held by four small screws, turn in the screw on the switch mounting arm to raise the pressure and lower the temperature setting, or turn out the screw to lower the pressure setting and raise the temperature setting. To change the switch differential, remove the small plate on the under side of the switch held on by two screws. Turn in the screw located on the under side of the micro-switch for a closer differential or out for a greater differential.

AUXILIARY SWITCHES

Inspect the contacts of the 11 pole and 2 pole auxiliary switches located in the mechanism housing. If the contacts are slightly burned or pitted they can be smoothed up using a fine file or emery cloth. Check the operation of the switch in both the open and closed position of the breaker to make sure that the contacts have a positive "make" and "break" in both positions. Check all wiring connections for tightness.

CONTROL RELAYS

Inspect the contacts, and if any are found slightly burned or pitted, smooth up using a fine file or emery cloth. Check the operation of the relays electrically to make sure they are picking up positively and sealing in.

AIR COMPRESSOR

For maintenance suggestions for the air compressor see Instruction Book 33-125-C3C.

RENEWAL PARTS

A list of renewal parts recommended to be maintained in stock will be furnished on request through the nearest district office. When ordering renewal parts, specify the name of the part, giving the name and item number shown in the illustrations in this book or the mechanism instruction book. Identify the particular breaker by giving the breaker type, amperes, volts, and shop order (S.O.) number as found engraved on the breaker nameplate.

PART VI - GAS COMPRESSOR

DESCRIPTION

The model 3HS2 Worthington Compressor is a vertical 2-cylinder reciprocating type compressor.

The compressor is designed with a one-piece cylinder and crank case, resulting in a minimum of joints for possible leaks to develop. The compressor, of the eccentric type, uses a straight compressor shaft of forged steel on which is assembled a double eccentric of one-piece cast iron construction. The eccentric is keyed to the shaft and held in place by a clamp bolt. Connection from the eccentric to the piston is accomplished by means of eccentric straps or rods.

The pistons are cast iron using four cast iron piston rings for each piston, two rings being compression rings and the other two oil scraper rings. The piston pin is precision ground hardened steel and is held in place by a retainer spring inserted in a groove cut in the piston on either side. The piston pin passes through a bronze bushing type of bearing in the eccentric strap.

The compressor uses a rotary type shaft seal. The lateral movement of the compressor shaft is controlled by the spring tension on the shaft seal and a thrust ball in the end of the shaft at the end opposite the seal. The end of the shaft at the seal end of the compressor which projects beyond the seal is tapered and threaded for assembly of the fly wheel. A key is also provided for positive holding of the fly wheel in place on the shaft. A V-belt grooved fly wheel is provided with a tapered bore to fit the shaft. The fly wheel is balanced to eliminate any vibration.

The compressor is equipped with the patented Worthington feather valve type head. This has the suction and discharge valves incorporated in the valve plate.

The suction and discharge line connections to the compressor are by means of two bolt flanges. The discharge line, located on the left hand side of the head as you face the fly wheel end of the compressor, connects directly to the discharge side of the head.

The suction line is located on the right hand side of the cylinder block as you face the fly wheel end of the compressor, close to the top of the cylinder. It is connected to the suction side of the compressor head by means of a cored passage in the cylinder casting.

The compressor is splash lubricated. There are suitable openings in the crank case for draining the oil and filling the crank case with new oil. An oil sight glass is located in the lower part of the crank case on the end opposite the fly wheel for the purpose of observing the oil level.

Each compressor is equipped with a crank case check valve. The check valve is located in the crank case of the compressor. It is screwed into a tapped opening in the bottom of the cored passage, which is located between the cylinders on the right hand side of the head.

The purpose of this check valve is to permit return of the oil, which separates from the gas in the suction side of the head, to the crank case and yet prevent oil from leaving the crank case during the starting.

The oil check valve assembly consists of a flapper valve attached to a 5/8 inch truncated fitting with a drilled orifice.

In normal operation, the flapper valve is off its seat, permitting oil from the suction port of the compressor to flow through the check valve opening to the crank case. During the starting period, the flapper valve, due to pressure developed in the crank case, is pushed upward and seated in a slot. This allows the vapor to escape through the drilled orifice to the suction side of the compressor, but prevents any rapid boiling of the oil in the crank case and resulting loss of the oil charged to the other parts of the system.

All moving parts of the compressor are balanced and the eccentrics are equipped with counter balances to provide quiet operation.

LUBRICATION

In general, the 3HS2 compressor would be considered to be of the splash lubricated type. The crank case of the compressor is provided with an oil drain opening, located near the bottom on the right hand side as you face the fly wheel. This oil drain opening is tapped with a 3/8" iron pipe plug thread, and a special 3/8" hex. head plug and copper gasket are provided for plugging the oil drain opening. An opening is provided on the end of the compressor opposite the fly wheel and directly above the main bearing for filling the crank case. (See Part III "Filling with SF_6 Gas"). This opening is the same size as the oil drain opening and the same plug and gasket are used for both. A plugged opening will be noted on the fly wheel end of the crank case directly above the bearing. This is an opening made for manufacturing purposes and has no service benefit. In case of a leak at this point, replace gasket washer with a new one. The crank case is filled with oil to a height of 3/4" on the bulls eye oil sight glass. Weights on the eccentric dip in the oil and splash it up into the oil wells on top of each main bearing. Oil from the bearing on the seal end feeds into the seal housing to lubricate the seal. The pistons and cylinder walls are lubricated by the oil thrown up by the counter weights. A drilled pocket in the eccentric forces oil up to the drilled rod each time the eccentric dips into the oil.

Oil as required for lubricating Worthington compressors may be purchased from any reputable oil company and should be purchased subject to the guarantee by the supplier as to the suitability for the use intended. *WARNING: Use of incorrect oil may damage parts of unit and void your warranty.*

Worthington will not be responsible for damage to units caused by the use of incorrect oil. The following brands are considered acceptable by Worthington Corporation:

BRAND	MANUFACTURER	POUR POINT °F
Suniso 3	Sun Oil Co.	-35°F
Algol 525	Texas Co.	-15°F
DTE-103	Mobil Co.	+10°F

For ambient temperatures below those listed, consult an oil company or Worthington Corporation, Holyoke, Mass. for their recommendations. An oil change for the Model 3HS2 compressor requires 4 pints. When the compressor has just been overhauled, the crankcase may be filled through the opening in the crank case above the main bearing opposite the seal end, using a clean funnel. After the oil has reached the 3/4" level in the bulls eye oil sight glass, replace the oil filler plug, being sure the gasket is in good shape and in place.

A small amount of oil should be poured through the opening above the seal and bearing to provide lubrication during start up period.

It is not suggested that the compressor be dismantled during regular maintenance periods; however, in the event that some malfunction does develop, the steps necessary for a major overhaul of the compressor are described in the following paragraphs. If a spare compressor is available, it is suggested that the damaged unit be returned to the Worthington factory where personnel experienced with the unit are equipped to perform any major servicing required.

BELTS

To keep V-belt wear to a minimum, the compressor flywheel and motor pulley must be in exact alignment and the belts kept free from water and oil. Do not use belt dressing. Replacement of V-belt should only be made in matched sets.

See detailed instructions for care of belts as covered by instruction tag furnished with each unit.

REMOVING BELTS

(a) Open motor disconnect switch on pressure switch panel.

(b) Loosen the two nuts on the underside of the motor platform.

(c) Raise the motor towards the compressor to allow easy removal of belts from motor sheave.

(d) Remove belts. Do not pry belts off or attempt to force them.

REINSTALLING BELTS

If installing new belts, always use a complete set of new matched belts. Never use a mixed set of new and old belts as the old belts will be stretched and will place a strain on the new belts.

(a) Be sure motor is raised toward the compressor far enough to allow the installation of the belts without forcing.

(b) The belt tension is determined by the position of two nuts immediately below the motor platform. When installing new belts, it will probably be found necessary to run up both nuts from their previous location. Tighten belts sufficiently to prevent belt squeal, but too much tension merely overloads the bearings and shortens the belt life. A good way to check belt tension is to place your finger on one of the belts at a point midway between the fly wheel and motor sheave and press down. You should be able to depress the belt approximately 1" beyond the adjacent belt if belts are properly tightened.

(c) With belts properly tightened and motor square, tighten the nuts on the motor platform.

REMOVING COMPRESSOR

(a) Remove belts as covered under "Belts".

(b) Remove bolts which fasten suction line and discharge line to compressor. Remove bolts which hold compressor to base and slide compressor off the base.

(c) After removing the compressor be sure all openings to the atmosphere are closed to prevent moisture and dirt entering compressor and causing corrosion.

(d) Remove the compressor fly wheel by removing the sheave locknut and lockwasher and pulling the flywheel from the shaft with the use of a flywheel puller.

(e) If it is found necessary to return the compressor to the factory, crate the compressor, being sure that the shaft is in the clear but is protected against damage. The threads on the end of the crankshaft should be taped to prevent damage to the threads during shipment. Return compressor less the fly wheel, shaft locknut, lockwasher and shaft key to the factory.

REINSTALLING COMPRESSOR

(a) Install the compressor flywheel, being first sure that the shaft and bore of the sheave are free from dirt and foreign matter such as paint, and that the shaft key is properly in place. Install the lockwasher and locknut and tighten sheave in place by pulling up on the locknut. After the flywheel is tightened, secure locknut by bending lip of lock washer over into one of the notches in the locknut. Always be sure the flywheel is tight on shaft as a loose flywheel will knock and cause noisy compressor operation.

(b) Remove the plugs or blind flanges from suction and discharge connection openings on the compressor.

(c) Place compressor in position on the base and tighten the hold down bolts.

(d) Connect the suction and discharge line flanges and pull up on all bolts evenly to assure a proper seat on the gaskets to prevent leaks. Use a new gasket between the flanges and compressor, first being sure that both gasket surfaces are clean.

(e) Reinstall belts as covered under "Belts".

REMOVING MOTOR

(a) Remove belts as described under "Belts".

(b) After removing the motor from the base, remove the motor sheave by loosening the set screws and pulling the sheave with a puller. Do not drive sheave off as you may damage sheave or motor shaft.

REINSTALLING MOTOR

If a new motor is being used, check the electrical characteristics of the motor to be sure that the motor is the same as the power supply and is of the correct size and type.

(a) Install motor sheave before assembling motor on motor platform.

(b) Before soldering motor connections, be sure that the motor is rotating in the right direction.

(c) Solder wiring connections and tape with both rubber and friction tape.

(d) Reinstall belts as covered under "Belts".

TO REMOVE CRANKCASE COVER

(a) Remove compressor from base.

(b) Drain oil from compressor by removing oil drain plug.

(c) Support compressor on bench on head, with crankcase cover up.

(d) Remove all crankcase cover bolts.

(e) Loosen gasket joint between crankcase and cover by inserting the point of a screwdriver or chisel between the crankcase and cover and prying crankcase cover up. Be careful not to damage gasket surfaces.

(f) Remove old gasket material from gasket surface on crankcase cover and crankcase.

TO REINSTALL CRANKCASE COVER

(a) Using a new crankcase cover gasket, set crankcase cover in place.

(b) Install the crankcase cover bolts and tighten them in rotation to insure even pressure around the gasket.

(c) Apply air pressure to compressor body and test gasket joint for leaks before reinstalling compressor on unit.

(d) Replace oil drain plug and fill crankcase with correct quantity (4 pints) of new oil.

OIL SIGHT GLASS

The oil sight glass is located near the bottom of the compressor on the end opposite the flywheel.

A leak in the oil sight glass is usually due to a cracked oil sight glass or a defective gasket or seal ring. It is recommended that a new gasket and a new seal ring be installed when installing a new oil sight glass.

REMOVING OIL SIGHT GLASS

(a) Drain oil from compressor by removing oil drain plug.

(b) Remove oil sight glass retaining nut, washer and seal ring.

(c) Lift out oil sight glass and remove gasket from bottom of oil sight glass housing.

REPLACING OIL SIGHT GLASS

(a) Insert new gasket in bottom of oil sight glass housing. Be sure that gasket surface in bottom of housing and the entire housing is clean and free of all dirt and foreign matter.

(b) Insert new oil sight glass with small end out.

(c) Insert special seal ring being sure that seal ring fits properly around the oil sight glass, with the inner bevelled face of seal ring against bevelled face of oil sight glass.

(d) Insert washer in place and screw retainer ring in housing.

(e) Tighten retainer ring being sure it does not bind on oil sight glass. Any binding is apt to crack or chip the oil sight glass. Retainer rings should be tightened sufficiently to compress seal ring around oil sight glass but not enough to place any undue pressure on oil sight glass.

(f) Apply air pressure to compressor body and test oil sight glass for leaks.

REMOVING CRANKCASE CHECK VALVE

(a) Remove compressor from base.

(b) Remove crankcase cover.

(c) Remove check valve by means of a long handled 5/8" socket wrench.

REPLACING CHECK VALVE

(a) Install check valve in tapped hole in bottom of suction passage.

(b) Tighten check valve in place with long handled 5/8" socket wrench.

(c) Reinstall crankcase cover.

ROTARY TYPE SHAFT SEAL

The Rotary Type Shaft Seal Unit consists of a semi-steel face plate, face gasket, carbon seal plate nose assembly, and a seal spring designed to apply proper pressure to the seal nose assembly and provide correct seating of the carbon seal nose against the face plate, under all operating conditions of the compressor. The seal unit as assembled on the shaft is illustrated on Figure 25. A special seal nose assembly rotates with the shaft, and a flexible sliding gas-tight fit between the shaft and the seal nose assembly is provided by a Neoprene friction ring. The carbon seal nose face of the seal nose assembly rotates against a polished face machined on the seal face plate which provides the rotating gas tight shaft seal.

The Rotary Type Seal Unit provides a long life, trouble free shaft seal with a minimum number of parts and is easily replaced when necessary.

REMOVING ROTARY SEAL UNIT

(a) Remove the compressor from the base.

(b) Raise the lip of lockwasher and remove locknut with a spanner wrench.

(c) Remove sheave. (Do not use a hammer or force which may bend shaft; use a wheel puller). Remove key from shaft.

(d) Remove cap screws from seal face plate. Remove seal face plate and withdraw Rotary Seal Assembly.

Though the carbon seal nose may be lapped on 10/0 sandpaper and the steel seal face plate lapped on emery cloth, only minor scratches can be removed. For more serious damage, it is advisable to obtain a new rotary seal assembly and face plate from the factory.

Before installing a lapped or new seal, make certain the carbon seal nose as well as the lapped surface of the seal face plate are clean and free from scratches,

REINSTALLING ROTARY SEAL UNIT

(a) Clean shaft surface very carefully with fine emery cloth.

(b) Slip seal spring spacer ring over shaft and push back against shaft shoulder.

(c) Cover the inside diameter of the friction ring in seal nose assembly with a layer of clean light grease or vaseline, and slip seal nose assembly (special carbon seal nose to the outside) over shaft and push back against spring. Be sure spring is centered on back of seal nose assembly.

(d) The seal faces, both the carbon ring face and the seal face in the plate, should be wiped perfectly clean with a chamois skin and both surfaces covered with a clean light oil.

(e) Assemble new seal face plate and gasket to seal housing. Tighten cap screws in rotation to prevent breakage of seal plate.

(f) Replace shaft key and remount flywheel. Replace lockwasher and tighten the sheave lock-nut. Make sure the compressor sheave is up tight in place as a loose sheave will run out of true and may cause a knock.

(g) Remount compressor on base. Replace belts and let the compressor idle for a short period of time.

(h) Test seal for leaks using a soap bubble test after unit has been in operation for several hours.

RUNNING GEAR (Crankshaft, etc.)

The model 3HS2 compressor uses an eccentric type crankshaft made up of two pieces, consisting of a straight shaft with an eccentric assembly keyed and clamped to the shaft by means of a clamp bolt.

REMOVING SHAFT AND ECCENTRIC

(a) Remove compressor from base.

(b) Remove crankcase cover as covered under "Crankcase".

(c) Remove seal as covered under "Shaft Seal".

(d) Remove four (4) bolts and remove end plate and gasket.

(e) Remove thrust ball which is between end of shaft and adjustment screw.

(f) Remove elastic stop nut from eccentric clamp bolt and remove bolt from the eccentric assembly.

(g) Rotate shaft so that key in shaft lines up with slot in main bearing on flywheel end of compressor. This will be when flywheel shaft key slot is pointed towards the head of compressor.

(h) Place point of long center punch or drift punch in the end of shaft opposite flywheel end of compressor (end that thrust ball was removed from) and by gently tapping end of punch with a hammer, drive shaft out through end of compressor. *NOTE: Eccentric shaft key must be exactly lined up with slot into bearing or shaft cannot be removed.*

(i) With shaft removed the complete assembly of eccentric, connecting rods, pistons etc., are removed as a unit by lifting out through bottom of crankcase.

(j) Remove elastic stop nuts from bolts that hold counterweights to eccentric and remove bolts.

(k) Remove counterweight from eccentric.

(l) Remove eccentric from connecting rods.

REINSTALLING SHAFT AND ECCENTRIC

After necessary repairs or replacements have been made to the pistons, rods, etc., proceed as follows. *NOTE: All parts must be clean and free from foreign matter.*

(a) Assemble connecting rods and pistons (which have been previously assembled) onto the eccentric.

(b) Assemble counterweight to eccentric. Tighten bolts in place.

(c) *NOTE: If new parts have been used in the compressor or the thrust screw has been loosened in the end cover, it will be necessary to reset the end thrust clearance of the shaft. See "Shaft Thrust Adjustment". It is advisable to check this clearance in any event.*

(d) Insert eccentric, rods, and piston assembly into compressor through bottom of crankcase. Start the pistons into the cylinders (the bottom of the cylinders are chamferred to assist in guiding piston and piston rings into place) and with the piston rings centered on the piston, tap bottom of connecting rod to work pistons into cylinders. *NOTE: This operation must be performed carefully to prevent breaking or damaging some of the parts. Both pistons will have to be worked into cylinders at the same time.*

(e) Work eccentric, rod and piston assembly into compressor until shaft hole in eccentric is in line with main bearing holes. Rotate eccentric so that keyway is in line with slot in main bearing on seal end of compressor.

(f) Clean and oil crankshaft and main bearings. Check to see that eccentric key is properly in place in shaft.

(g) Insert shaft through main bearing on seal end of compressor (tapered end of shaft out). Line up eccentric key in shaft with slot in main bearing and keyway in eccentric and push shaft in place. NOTE: *If shaft does not go in easily, screw shaft locknut on end of shaft so that outside face of locknut is flush with end of shaft and using a wooden block or babbitt hammer, tap end of shaft to drive shaft in place.*

(h) After shaft is in place remove locknut.

(i) Place thrust ball in end of shaft opposite flywheel end and assemble thrust adjustment screw and end plate assembly onto compressor with bolts. Use a new gasket. Tighten bolts evenly and in rotation.

(j) Reinstall shaft seal assembly; see "Shaft Seal".

(k) Locate eccentric in proper position on shaft. Proper location can be checked by use of a feeler gauge between face of seal end main bearing and end of eccentric. Measurement should be .003" to .005". Clamp eccentric to shaft with bolt and nut.

(l) Reinstall crankcase cover.

(m) Fill compressor body with proper quantity (4 pints) of new oil.

(n) Install flywheel and let compressor idle (without load) for several hours to run in and properly seat the seal and any other new parts.

(o) Apply gas pressure to compressor and test for leaks.

SHAFT END THRUST ADJUSTMENT

Adjustment of the lateral thrust clearance on the compressor shaft is accomplished by means of the threaded adjustment screw in end cover plate. A locknut and lockwasher are provided to lock adjusting screw after adjustment has been made.

A special thrust gauge will be required to make the thrust adjustment. Thrust gauge may be ordered from the factory.

Thrust adjustment should be made before any of the parts are assembled into the compressor. To make thrust adjustment refer to Figure 26 and proceed as follows:

(a) Insert shaft in place in compressor body (without eccentric and piston assembly).

(b) Clean face of thrust gauge and install in seal housing. Bolt thrust gauge solidly in place using three of the regular bolts.

(c) Position shaft so that shaft shoulder is solid against thrust gauge face.

(d) Place thrust ball in normal position in end of shaft, and with a depth gauge measure the distance from face "A" of thrust ball to face "B" of crankcase. To this dimension add .020 for thickness of gasket. NOTE: *A small amount of clean cup grease placed in hole end of shaft will hold thrust ball in place.*

(e) From the dimension obtained in "D" subtract .010" (the standard thrust clearance), and set adjustment screw so that distance from face "C" of adjustment screw to face "D" of end cover is equal to this measurement. Lock adjustment screw in position with locknut and lockwasher.

(f) Assemble end cover in place with gasket. (Two or three bolts will be sufficient for trial purposes).

(g) As a check, move shaft laterally in compressor body to make sure that it has a slight amount of movement.

(h) After correct thrust adjustment has been obtained, remove end cover assembly, thrust ball, thrust gauge and shaft, and proceed with assembly of compressor parts.

(i) *WARNING: Once the thrust adjustment has been made, the adjusting screw must not be loosened in end cover.*

NOTE: If a depth gauge is not available to take measurements required in "D", a reasonably satisfactory thrust adjustment can be obtained by trying end cover in place on compressor with various adjustments of the adjustment screw until an adjustment is found which allows a slight amount of movement of shaft between thrust gauge and adjustment screw. Thrust ball and gasket must be in place when checking movement of shaft. This method of adjustment is not recommended as it is difficult to obtain a close enough adjustment to have a quiet running compressor and avoid seal trouble, but can be used in an emergency to obtain a reasonably satisfactory thrust adjustment.

MAIN BEARINGS

The two bearings for the compressor shaft are bronze sleeve type bearings which are pressed in place in either end of the compressor crankcase and are precision bored in place for correct clearance to size of shaft and proper alignment. The main bearing for the end opposite the flywheel is a straight sleeve, whereas the main bearing for the flywheel end has a small lip on the inside of the crankcase, which holds the bearing in place and prevents any excessive lateral motion of the shaft and eccentric assembly. The main bearings are oiled from oil wells above the bearings, which are cast in the crankcase casting and filled with oil by the oil slung up by the counterweights on the eccentric assembly. A drilled hole in the bottom of each bearing oil well connects with the oil groove in the bearing. It is not recommended that replacement of the main bearings be made in the field. If a compressor is found with damaged main bearings, it should be shipped to the factory for repair or exchange for a new or factory rebuilt compressor.

CONNECTING ROD

The Model 3HS2 compressor uses an eccentric type connecting rod. The rod is drilled through the center to provide a passage for oil to be forced to the piston pin bushing. The eccentric is designed so that a small quantity of oil is forced into a port in the eccentric during each revolution. This oil passes up through the drilled passage in the center of the rod. The design of the connecting rod is such that it will give long life. Should a compressor be found with a connecting rod worn at either the eccentric or piston pin end, the piston pin and eccentric should be replaced with the connecting rods as an assembly, in order to assure a quiet and efficient operating compressor. Since the connecting rod is of the eccentric type, no adjustment is necessary.

REMOVING CONNECTING RODS

(a) Remove compressor from base.

(b) Remove crankcase cover plate as covered under "Crankcase".

(c) Remove seal as covered under "Shaft Seal".

(d) Remove crankshaft and eccentric as covered under "Running Gear".

(e) Remove piston pin lock springs from each end of piston pin.

(f) Push piston pin out of piston and remove piston from rod.

REINSTALLING CONNECTING RODS

If new parts are being used they should be checked to see that they fit properly before assembly, i.e., piston pin in rod bushing, rod on eccentric, etc.

(a) Insert piston pin end of rod into piston and line up piston pin hole in rod with piston pin holes in piston.

(b) Push piston pin through piston and rod.

(c) Install piston pin lock springs in place at each end of piston pin. *NOTE: Be sure ring fits properly into groove in pin boss of piston. If a lock spring comes out while compressor is in operation, it will cause major damage to the compressor.*

(d) Assemble rod and piston assemblies to eccentric and install in compressor with shaft as covered under "Running Gear".

(e) Reinstall seal as covered under "Shaft Seal".

(f) Reinstall crankcase coverplate as covered under "Crankcase".

(g) Fill compressor with oil and let compressor idle (without load) to run in seal and any new parts.

(h) Apply air pressure to compressor body and test for leaks.

PISTON AND PISTON PINS

The pistons are special cast iron, resulting in a minimum of wear on the cylinder walls. Each piston is fitted with two compression type piston rings and two oil scraper type piston rings, which are also made of special cast iron. The rings are carefully fitted to the cylinder for proper size and clearance. Each piston is fitted with a steel, precision ground piston pin to fasten the piston to the connecting rod. The pin is held in place in the piston by lock rings, which fit in a groove in the piston boss (piston pin support) on each end of the pin. Most of the normal wear will take place on the piston rings and can be corrected by installing a new set of rings. Should the clearance become excessive between cylinder and piston it will cause a piston knock; in this case the pistons should be replaced. It will seldom be found necessary to replace the piston pins unless the pin hole in the rod is worn and needs replacing, as described under "Connecting Rod". When new rods are being installed new piston pins should always be used.

Instructions for removal of the pistons and piston pins from the compressor and from the connecting rods, and reinstalling is covered under "Running Gear", and "Connecting Rods", and will not be repeated here.

The piston rings may be removed from the piston by using a thin bladed knife or hack saw blade and carefully working the ring out of the groove and off of the piston. Care should be used in removing the rings as they will be broken if pried out of the ring groove too far. New rings should be fitted into the cylinder before installing on the piston. If the gap between the ends of the ring is too small it should be increased by filing. About .003 to .005 is proper clearance. The rings should also be checked to see that they fit properly in the ring groove on the piston. They should not be too tight or too loose, but just fit freely. Before installing new rings, the ring grooves should be carefully cleaned of dirt or carbon. To install the rings, work down over the piston to their proper groove using a thin bladed knife or hack saw blade. The oil scraper rings go in the bottom grooves with the scraper edge to the upper side of the groove (toward the top of the piston). The two upper grooves each get a compression type ring.

The clearance between piston and cylinder should be checked before reinstalling the pistons, etc.

CYLINDERS

The cylinders on the 3HS2 compressor are an integral part of the crankcase casting. A special cast iron alloy is used for this casting which gives it high physical strength and exceptionally good wearing qualities. Thus with the design of the pistons and piston rings used, it will seldom be found necessary to replace the cylinders. Should for any reason, the cylinders become scored or need replacing, it is best to obtain an exchange compressor body from the factory.

CYLINDER HEAD

The cylinder head is cast from the same material as the cylinder crankcase casting. A partition runs lengthwise through the head in such a manner as to provide separate passages for the suction and discharge gases. The suction gas enters the head from the suction connection on the side of the compressor through a cored passage in the cylinder block. The discharge connection is directly to the discharge side of the head. The cylinder head is fastened to the cylinder by 3/8" hex. cap screws.

SUCTION AND DISCHARGE VALVES

The compressor valves are of the direct lift and flexing Worthington Feather valves, which are highly efficient. The valve service consists of one valve plate, four valve guards. four valve strips and four valve springs. The valve plate is machined to form a seat for the discharge valves while the suction guards act as a seat for the suction valves. The valve plate has a machined recess to accommodate the suction strips, therefore, both suction and discharge guard assemblies are mounted on the top side of valve plate.

REMOVING SUCTION AND DISCHARGE VALVES

(a) Remove bolts that hold discharge line valve to head and loosen valve from head.

(b) Remove cylinder head bolts.

(c) *Remove cylinder head and valve plate from compressor.

(d) *Separate head from valve plate.

(e) Remove holo-chrome cap screws from valve guards on both head and valve plate.

(f) Remove valve guards, valve strips and valve springs from valve plate and head.

(g) Clean all old gasket material from gasket surfaces on head, valve plate, top of cylinder and discharge line valve.

*NOTE: *If gasket joints between valve plate and cylinder, head and valve plate, or discharge valve and head are stuck, they can be loosened by inserting a sharp pointed screw driver into joint and tapping screw driver lightly. Care must be used not to damage parts.*

Inspect valve strips, valve springs and valve seats carefully. If any of the valve strips or valve springs are broken or worn they should be replaced with new strips and springs. Should the valve seats on the valve plate be worn, pitted, etc., it will be necessary to use a new valve plate. The surface of the valve plates can be reground and relapped, but it is not recommended as an operation for the field or dealer's shop.

Valve springs and valve strips should be tried in valve guards before assembly, to be sure that the profile of valve strips match the end of the guard and that strips have the required .005" to .010" lateral movement in the valve guard required for satisfactory operation. (See Figure 27).

REASSEMBLING SUCTION AND DISCHARGE VALVES

(a) Hold valve guard in hand with curved recess side up. Place valve springs in guard curved side down. Place valve strips on top of the valve springs. Depress valve strips and springs into guard and slide retainer clip over strips, springs and guard to hold strips and springs in place in guard. See Figure 27.

(b) **Fasten guard and strip assembly in place on valve plate with holo-chrome screws. Use new copper washers under heads of screws.

(c) Remove retainer clips.

(d) Proceed as in (a) and (b) until all valve strips, valve springs and guards are in place.

(e) Using a new gasket, fit valve plate to cylinder head.

(f) Using a new gasket, assemble valve plate and head assembly to compressor cylinder.

(g) Install all bolts and tighten evenly and in rotation to prevent damage to head and provide an even pressure on the gasket joints

**NOTE: *Care must be used to see that valve strips and springs are not clamped between edge of valve guard and seat or in any way restrained from the .005" to .010" lateral movement required for satisfactory operation.*

(h) Using a new gasket between discharge line valve and compressor head, bolt discharge line valve to head.

(i) Apply air pressure to compressor body and test for leaks.

MANIFOLDS

The suction line is fastened to a machined pad on the side of the cylinder block with two cap screws. A corded passage in the cylinder block conducts the suction gas to the suction side of the cylinder head. Any oil in the suction gas will usually separate in the cored suction passage and drain to the crankcase of the compressor through the "Crankcase Check Valve" installed in the bottom of the passage.

The discharge line valve is fastened to a machined pad on the side of the cylinder head with two cap screws. Discharge gas is taken directly from the discharge side of the cylinder head. The size and types of suction and discharge connection lines will be found in the specification table for the units.

PART I - RECEIVING, HANDLING AND STORING

RECEIVING

When the circuit breaker reaches its destination, the Purchaser should check the material actually received against the shipping lists to be sure that all parts have been received. This will avoid delays in installation. If damage is found or suspected, file claims as soon as possible with the transportation company and notify the nearest representative of the Westinghouse Electric Corporation.

HANDLING

Since shipping clearances permit shipping the 138 KV breaker with the doors in place, these breakers are shipped with an air-nitrogen mixture of approximately 5 psig in the tanks. This insures a dry atmosphere in the breaker during transit to protect the insulation and also serves as a check against leaks that might develop during shipment. The temperature and pressure at the time of charging the breaker at the factory are recorded on a tag which is affixed to the piping inside the mechanism housing. A warning tag on each of the tank doors directs that the temperature and pressure of the mixture be recorded before the doors are opened. Substitution in the formula

$$P_1 = P_f \left(\frac{T_1}{T_f}\right)$$

Where P_f = Pressure at Factory - PSIA (Gauge + 14.7)
T_f = Temperature at Factory - (°F + 460)
T_1 = Temperature at Destination
P_1 = Theoretical Pressure at Destination
P = Actual Pressure at Destination

of the data given on the tag and the readings taken at the destination will indicate by comparing P & P_1 the leakage, if any, that has occured. Since the low and high pressure systems are equalized by having valves 1-2-3 (Fig. 29) open, this pressure test indicates only leakage to the outside.

Since shipping clearances do not generally allow shipping the 230 KV breaker with the doors in place, reliance must be placed solely on the desiccant in the tank for keeping the insulation dry. Therefore if these breakers are not going to be placed in service right away, the doors should be assembled and sealed and dry nitrogen introduced to protect the breaker during storage.

Shipping braces Fig. 10 should not be removed until the circuit breaker has reached the point of installation. This circuit breaker is shipped completely assembled, when clearances permit, with the three pole units rigidly mounted on a steel "H" beam base Fig. 33. The total weight of the three pole breaker is given on the nameplate. This information should serve as a guide to the strength of cranes or other lifting means required for handling the breakers.

When using cable slings for lifting the breaker Figs. 31 & 32, do not allow the slings to strike the bushings, as any stain may cause the porcelain to crack or break. Lifting bars for attaching the slings are located on the "H" beam base adjacent to No. 1 & 3 tanks.

STORING

If the circuit breaker is not to be installed immediately, storage facilities should be arranged to prevent any damage to it during this period. The internal parts of the breaker should be protected from corrosion and moisture by the use of silica gel, activated alumina or similar dehydrating agents. During the storage period the tank doors should be closed and sealed. For extended storage periods, in addition to the precautions, suggested above, it is recommended that a positive pressure of about 5 psig be maintained in the tanks by super imposing dry nitrogen with the air, and the tank heaters energized if possible.

Protection from moisture and corrosion for the mechanism may be accomplished by closing the mechanism housing and energizing the space heaters provided in it. In case this is impracticable, all machined parts, especially the surfaces of the latch and rollers, should be coated with grease or some other rust inhibiting material. Additional protection may be obtained by the use of silica gel, activated alumina or similar dehydrating agents. Two or three small bags of the material may be hung in the mechanism housing near the parts requiring protection.