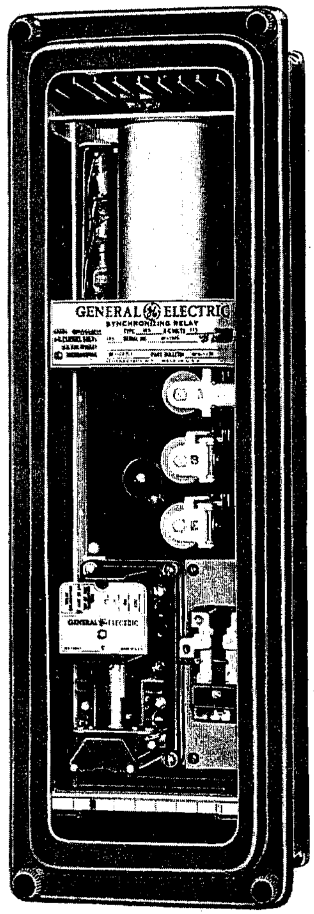
INSTRUCTIONS

GEI-68703

SUPERSEDES GEI-28767A

SYNCHRONIZING RELAYS



Type GES11F

LOW VOLTAGE SWITCHGEAR DEPARTMENT

GENERAL ELECTRIC

PHILADELPHIA, PA.

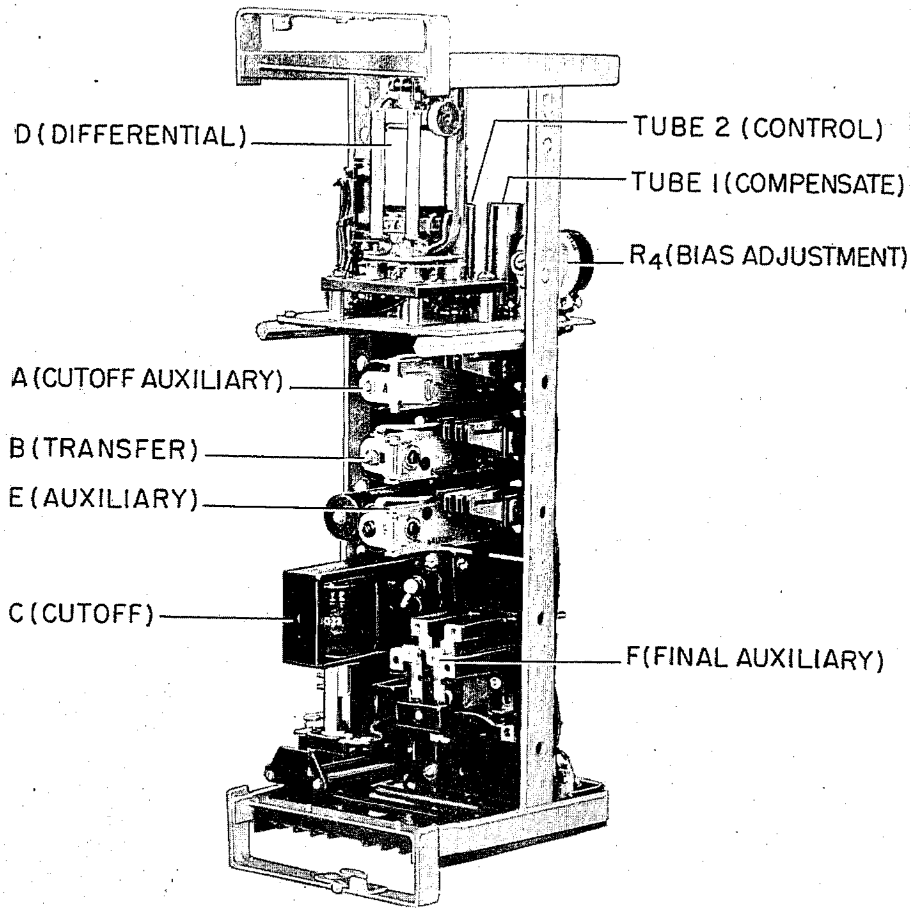


Fig. 1 Type GES11F Relay Removed from Case. (Cover of Differential Relay D Removed)

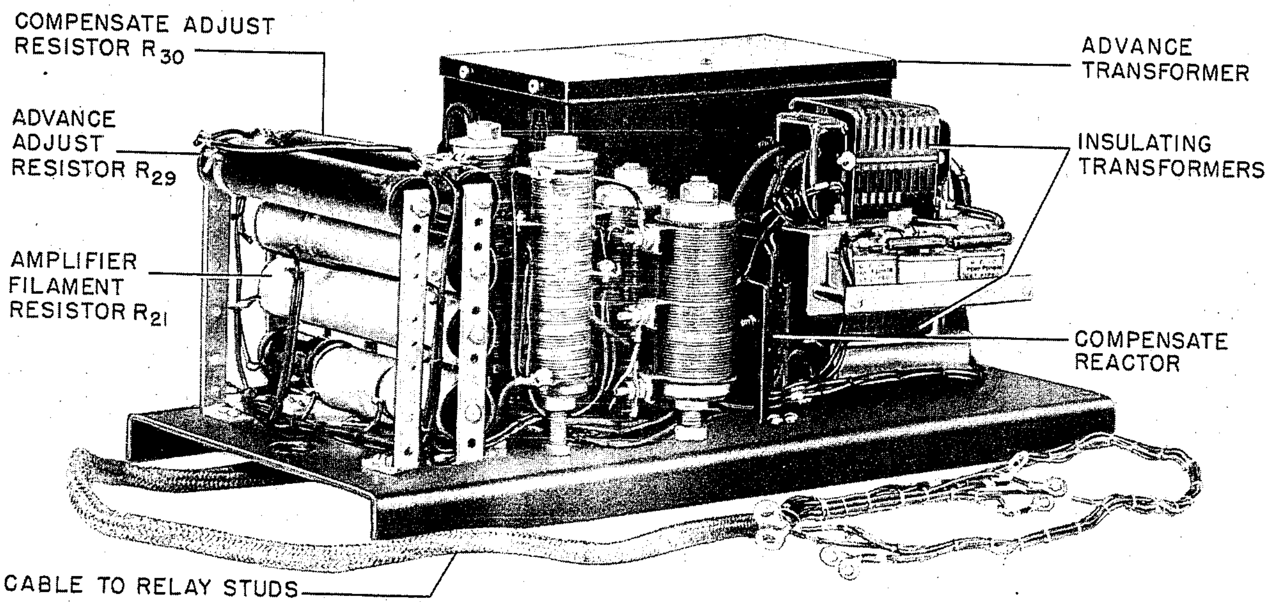


Fig. 1A Auxiliary Box for Type GES11F Relay

Fig. 1 (8024876)

Fig. 1A (8024875)

Cover (8008230)

SYNCHRONIZING RELAYS

TYPE GES11F

INTRODUCTION

The Type GES11F synchronizing relay is designed to give the closing indication to a circuit breaker for connecting together two a-c sources between which there is a small frequency difference. The closing indication is given at a slight angle in advance of synchronism to secure closure of the breaker main contacts at approximately the instant of zero phase difference between the two sources, regardless of the amount of frequency difference. However, means are included to block the closing indication if the frequency difference is excessive.

The relay consists of (1) a network which produces a d-c voltage that reverses polarity at the instant the closing indication should be given, (2) a tube amplifier controlled by this voltage, and (3) a group of interlocking and auxiliary relays. The amplifier and relays are mounted in a standard drawout case and are shown in Fig. 1. The network components are mounted in a steel auxiliary box (9-1/2 by 17 by 12 inches) which is mounted behind the panel and connected to the relay terminal studs through a cable, so that all panel wiring runs only to the relay terminal studs.

The GES11F relays which are designed for use with 220-250 volts D.C. control circuits are similar to the 110-125 volt D.C. relays described, except for minor internal wiring changes affecting the E and F auxiliary relays, and the stud connections for D.C. control volts. The elementary wiring diagram and the internal connections diagram are shown in Figs. 2A and 6A respectively for the 220-250 volt D.C. relays.

APPLICATION

Typical external connections of the Type GES11F relay are shown in elementary diagram form in Fig. 5, although the connections used may differ considerably from this diagram in any given installation, depending on the remainder of the control scheme. The basic precautions to be followed for best operation are outlined below, with reference to Figs. 2A and 5. Numbers in parentheses represent stud number of the 220-250V D.C. GES relays.

1. The amplifier filament circuit, studs 4-5 (9-5), should be energized for about 4 seconds before energizing the interlocking relay circuit, studs 9-10 (5-10).

2. Both a-c voltages should be applied for at least 2 seconds before energizing the interlocking relay circuit, studs 9-10 (5-10). This delay may be provided as a 4 second delay, by the same device that provides the filament heating time described in paragraph 1.

3. The connections should be arranged so that the interlocking relay circuit will be de-energized whenever either a-c voltage is removed. This can be done on ordinary equipments by using a single device for switching the a-c supply and the d-c control source. Where slightly greater security is desired against accidental loss of a-c due to blown fuses, dirty contacts, or loose connections, two instantaneous undervoltage relays may be used.

4. Where one synchronizer is used with two or more units, at least a 1/2 second delay should be allowed for the E and F relays to clear after F closes the breaker of the first unit, before connecting the F relay contact to the closing relay coil of the other breaker. In addition, the delay between connection of the a-c and closure of the interlocking relay circuit, studs 9-10 (5-10), should be repeated.

A contact of relay B (which operates at the instant that the closing indication would be given) is connected across studs 2 and 3 so that it may be used to control an indicating lamp if the GES is used as a check on manual synchronizing.

CONTACT RATING

The contacts of the F or final auxiliary relay (studs 1 and 2) have the following current ratings:

Make and carry	30 amps for 1 minute
Break	15 amps at 115 volts a-c
Break	10 amps at 230 volts a-c
Break	1.0 amp at 125 volts d-c
Break	.25 amp at 250 volts d-c

BURDEN

The burden on each a-c source is 7.5 volt-amperes for 60 cycle ratings, at 180 degrees phase displacement; it decreases somewhat as the operating zone is approached, but is greater at the lower frequency ratings.

The d-c burden is 0.68V watts, including filament supply where V is the D.C. control voltage.

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

RECEIVING, HANDLING AND STORAGE

The relay and auxiliary box, which have been tested together and are marked with the same serial number for identification purposes, are shipped in cartons designed to protect them against damage. Immediately upon receipt of the relay and box an examination should be made for any damage sustained during shipment. If injury or rough handling is evident, a damage claim should be filed at once with the transportation company and the nearest General Electric sales office should be notified promptly.

Reasonable care should be exercised in unpacking the relay, in order to prevent damaging any of the parts or upsetting any of the adjustments.

If the relay and auxiliary box are not to be installed immediately, they should be stored in their original cartons in a place that is free from moisture, dust and metallic chips.

INSTALLATION

CONNECTIONS

Connections between the relay and auxiliary box are made by means of a cable which is permanently connected to the auxiliary box at one end and has numbered terminals at the other end. The numbers on these terminals correspond to the stud numbers on the GES relay. R41 (when used) is to be mounted externally and wired directly across the appropriate relay studs.

After the auxiliary box and R_{41} have been mounted (usually on the rear of the panel and near the GES relay) connect the cable leads to the corresponding studs on the relay. See Fig. 9 for the numbering of relay studs. Make external connections as shown in Figs. 2A and 5.

ADJUSTMENTS

It is assumed that the factory adjustments necessary for correct operation have not been disturbed, so this section describes only the adjustments that are used to adapt the relay to the requirements of a particular installation.

Only two adjustments are required for this purpose, one to match the advance time of relay D with the closing time of the synchronizing breaker, and the other to determine the maximum frequency difference at which the relay will close.

Advance Time

The advance adjusting resistor is marked by the manufacturer at the tenth of a second nearest the closing time specified on the requisition, and also at the next tenth above and below this mark. The location of these markings is determined with the aid of special testing equipment which applies an adjustable constant frequency difference and measures the advance time. Recalibration should not be necessary; but, in any case, it cannot ordinarily be done in the field, because of the difficulty of measuring frequency difference and relay closing angle or advance time.

The advance time setting should be the same as the measured closing time of the breaker plus its closing relay under normal conditions. No reduction in synchronizing error due to frequency variations on either source can be obtained by setting the advance time either greater or less than the breaker time.

If one synchronizer is used with two or more breakers having unequal closing times, the advance time setting should ordinarily match more closely the closing time of the slowest breaker, in order to reduce to a minimum the sum of (1) the error caused by the inequality between the relay advance time and the breaker closing time and (2) the error due to the frequency difference variation of the sources during the closure of the breaker. Also, the faster breakers are likely to be on the smaller machines, which would cause less disturbance on the system than the larger machines, for a given angular error.

Frequency-difference cut-off

This is adjusted by changing the dropout of the C relay. Decreasing the dropout decreases the frequency difference cut-off and increasing the dropout increases the frequency difference cut-off.

The cut-off setting is made by the manufacturer at the value of slip frequency corresponding to 45 degrees advance unless that slip frequency is more than one-third cycle per second, in which case one-third cycle is used as the cut-off setting. This cut-off setting is identified by the lower of four marks on the calibrating tube of the C relay, and is referred to as the 100% maximum slip setting. Other marks on the calibrating tube represent cut-off calibrations at 80, 60, and 40 per cent of the maximum setting.

Before decreasing the cut-off setting, full consideration should be given to the fact that unless the frequency difference between the two sources is adjustable and stable, the chances of synchronizing decrease much faster than in direct proportion to the reduction in cut-off setting. A small difference in cut-off setting may therefore cause a relatively large increase in synchronizing time (exclusive of the time required for adjusting the average frequency difference to zero).

Although the C relay can be adjusted to give cut-off settings higher than the calibrated 100 per cent maximum, it is not recommended that such a change be made. At frequency differences above the original maximum, the advance time will be somewhat less than the value indicated on the advance adjusting rheostat. Also, the increased drop-out of C that is necessary for an increased cut-off setting tends to raise the pick-up above the maximum applied voltage. If an increase in cut-off setting proves necessary, it should be made with caution, observing carefully the operation in the new zone of higher slips.

The dropout of the C relay is adjusted by turning the armature on the plunger rod, and the calibrating marks are intended to line up with the bottom of the armature with the relay in the de-energized position. If it is necessary, for any reason, to increase the dropout of the C relay, the pick-up should also be checked to be sure that it is less than the minimum value of the sum of the applied voltages at 180 degrees phase angle. The maximum allowed at the factory is 178 volts, based on each 115 volt source having dropped to .8 normal, but local conditions may permit an increase in this value.

PRINCIPLES OF OPERATION

The operation of the Type GES11F relay can best be understood by reference to Figs. 2 and 3. Briefly, the network contained in the auxiliary box produces two voltages to control the operation of the D (differential) and C (cutoff) relays. The voltage which controls relay D causes it to close its 1-4 contacts at a definite time (equal to the breaker closing time) in advance of synchronism. The voltage which controls the C relay causes it to drop out at a definite angle in advance of synchronism. Since for a constant time the D relay must operate at smaller angles at the lower slip frequencies and at greater angles at the higher slip frequencies while the C relay operates at a fixed angle regardless of slip, the C relay is able to determine if the slip frequency is excessive and to block operation of the F, or final auxiliary relay, if it is excessive.

A vacuum tube amplifier, compensated to minimize the effect of changes in d-c control voltage, is interposed between relay D and the voltage which controls it. A component of this voltage is provided by a circuit which compensates for differences in magnitude of the two source voltages so that the definite time of advance of relay D is not seriously affected by unbalanced voltages.

The operation of the synchronizing relay is traced in more detail in the following paragraphs:

Voltage which controls D

The voltage which controls the operation of the D relay consists of three components, as sketched for one slip cycle in Fig. 3 and as listed below:

(1) "Phasing" voltage - proportional to phase angle at equal voltages.

(2) "Advance" voltage-proportional to frequency difference in operating zone.

(3) "Compensating" voltage - proportional to the unbalance of source voltages.

Referring to Fig. 2, the phasing voltage is taken from a rectifier supplied by the X_1-X_2 secondaries of two 2:1 insulating transformers. The primaries of these transformers are connected to the two sources to be synchronized, and the secondaries are connected in opposition so that the resultant is zero when the voltages are equal and in phase, and a maximum when they are 180 degrees out of phase. For purposes of adjustment, the phasing voltage is drawn from a potentiometer circuit across the 6RC3B127 rectifier. This circuit consists of a 1000 ohm resistor, a 3000 ohm "advance adjusting resistor" and the primary of the "advance transformer". The phasing voltage component, then of the voltage which control D, is the voltage from stud 5 to the tap on the advance adjusting resistor, reading from positive to negative. (See Fig. 3C.)

As the phase angle increases toward 45 degrees, the vector difference voltage increases less rapidly than in direct proportion to phase angle; the saturation of the compensating reactor tends to correct for this condition.

The advance voltage is induced in the secondary of the advance transformer, by the change in primary current of this transformer as the phase angle changes. The connections are made so that when the phase angle is decreasing, this voltage opposes the phasing voltage, the left end in the diagram (see Fig. 3C) being negative and the right end toward stud 6 being positive.

Where the machine and bus voltages are equal, the resultant voltage is the sum of the phasing and advance voltages, as shown in Fig. 3A, since the compensating voltage is zero. Because the advance voltage is proportional to frequency difference, the resultant voltage reverses polarity at a variable angle but a definite time in advance of synchronism.

The compensating voltage is produced as follows:

(1) The two source voltages, after transformation, are drawn from secondaries X_3 and X_4 of the transformers to two 6RC2K15 rectifiers which thus produce two d-c voltages proportional to the two source voltages.

(2) These two rectifiers are joined at their negative terminals and each one is loaded by a 1500 ohm

DEVICE NO.	DEVICE TYPE	INCL. UNIT	LEGEND DESCRIPTION
25	GES		AUTOMATIC SYNCHRONIZING RELAY
		A	AUXILIARY CUTOFF RELAY
		B	AUXILIARY RELAY
		C	CUTOFF RELAY
		D	DIFFERENTIAL RELAY
		E	SET UP RELAY
		F	FINAL AUXILIARY RELAY

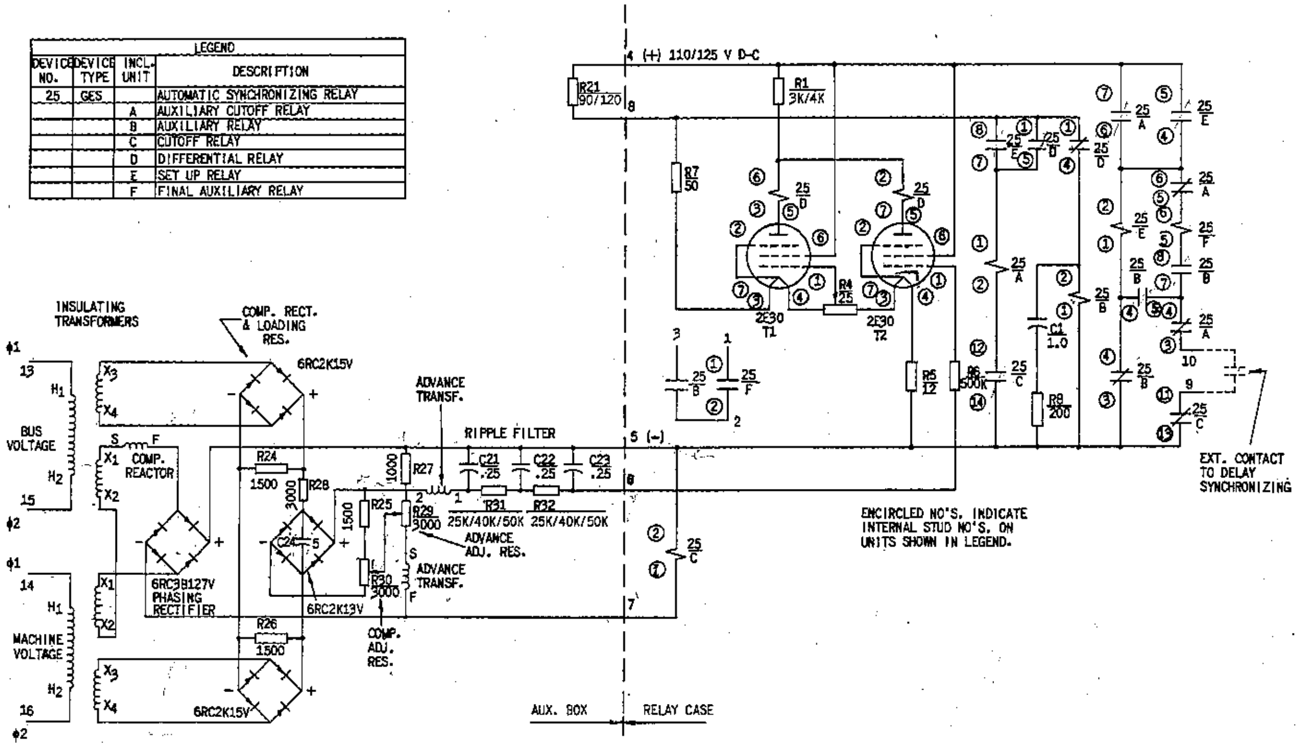


Fig. 2 (264B461)

Fig. 2 Elementary Diagram of Internal Connections Type GES11F Relay and Auxiliary Box

DEVICE NO.	DEVICE TYPE	INCL. UNIT	LEGEND DESCRIPTION
25	GES		AUTOMATIC SYNCHRONIZING RELAY
		A	AUXILIARY CUTOFF RELAY
		B	AUXILIARY RELAY
		C	CUTOFF RELAY
		D	DIFFERENTIAL RELAY
		E	SET UP RELAY
		F	FINAL AUXILIARY RELAY

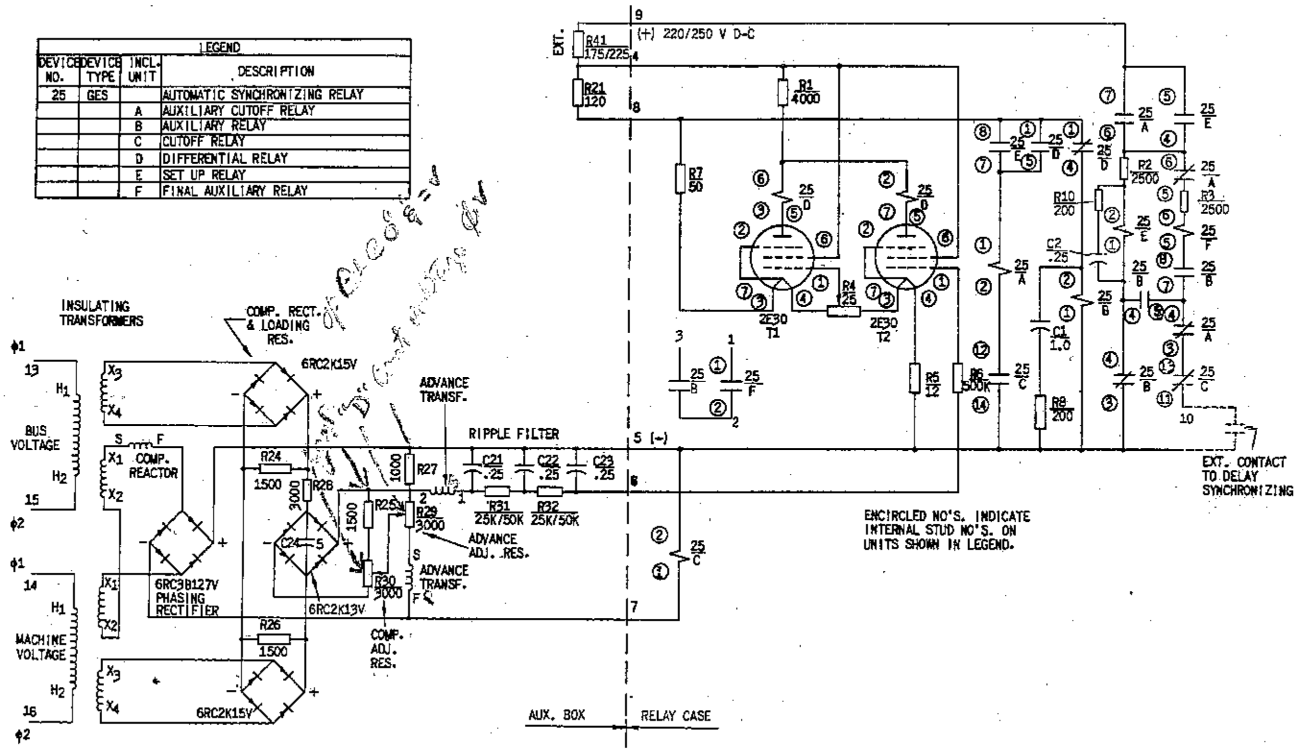


Fig. 2A (264B462)

Fig. 2A Elementary Diagram of Internal Connections Type GES11F Relay and Auxiliary Box (220-250V D.C.)

resistor which provides a path for current to flow in response to the difference between the two voltages.

(3) The difference between the two voltages is fed through a 6RC2K13 rectifier to obtain a difference voltage of constant polarity. A 5 mu f capacitor across the input reduces the ripple component of the voltage difference, which exists at all phase angles except zero and 180 deg.

(4) This difference voltage of constant polarity is fed to a potentiometer for purposes of adjustment. This potentiometer consists of a 1500 ohm resistor and a 3000 ohm compensation adjusting resistor.

(5) The compensating voltage (see Fig. 3C) is the voltage from (a) the junction of the advance transformer secondary and the compensation adjusting resistor to (b) the tap on this resistor, reading from positive to negative. It always opposes the phasing voltage, and the potentiometer is set so that it is approximately equal to the phasing voltage at zero deg.

The resultant voltage which controls D is shown with its components in Fig. 3B for the condition where the machine and bus voltages are unequal. It is applied across studs 5 and 6 and is negative at 180 deg. phase displacement, zero at a definite time in advance of snychronism, and positive from that instant until synchronism is reached; it then reverses and remains negative through 180 deg.

Amplifier

The amplifier causes the 1-5 contact of the D relay to close when stud 6 is sufficiently negative with respect to stud 5, and causes the 1-5 contact to open and the 1-4 contact to close as the voltage from stud 6 to stud 5 decreases to zero.

The control tube (tube 2 in the elementary diagram, Fig. 2, or left-hand tube in relay, front view) responds to the changes in voltage across studs 5 and 6. Changes in d-c control voltage affect the compensating (tube 1, Fig. 2) tube in the same way as the control tube so that they do not affect the difference between the plate currents materially. The windings of relay D being connected in opposition, the operating point of the relay is determined almost entirely by the voltage across 5 and 6 and is only slightly affected by the control source voltage.

Circuit of C

The voltages of the two sources to be synchronized are applied to the primaries of two 2:1 insulating transformers. The secondaries (X_1-X_2) are connected in opposition so that the resultant is zero when the two voltages are equal and in phase, and is a maximum (about 115 volts) when they are 180 degrees out of phase.

The resultant voltage is fed through the compensating reactor (whose function has been described under Voltage Which Controls D) to the 6RC3B127 phasing rectifier. The d-c voltage thus obtained is applied directly to the coil of relay C through relay studs 5 and 7.

Sequence at High Slip Frequency

(1) Beginning with machine and bus voltages 180 degrees out of phase full negative voltage on 7 and on 6 (with respect to 5) closes the C-A contact of C and the 1-5 contact of D, picking up A.

(2) The 5-6 contact of A picks up E, which seals itself in around A, and also seals in the A relay around the 1-5 contact of D.

(3) As the phase angle between machine and bus voltage decreases, D opens its 1-5 contact and closes its 1-4 contact, picking up B; C also drops out, de-energizing A by opening its C-A contact. Either C or D may operate first, depending on how high the slip is.

(4) Relay A has a time delay on dropout, so that when B opens its 1-2 and closes its 2-3 contact, the circuit of E is opened and E drops out.

(5) When A finally drops out, the circuit of F is not completed because E is open and the 5-6 contact of A opens before the 1-2 and 4-5 contacts close.

Sequence at Low Slip Frequency

(1) and (2) are the same as at High Slip Frequency, described above.

(3) As the phase angle decreases, C drops out at a definite phase angle, de-energizing A by opening its C-A contact.

(4) A drops out after a definite time, opening its 5-6 and closing its 1-2 and 4-5 contacts.

(5) As the phase angle decreases still further, D closes its 1-4 contact at a definite time in advance of synchronism, picking up B.

(6) The 1-2 contact of B opens the coil circuit of E, but the 2-3 contact of B re-establishes the circuit before E has had time to drop out.

(7) The 5-6 contact of B energizes F, which closes the control circuit for the synchronizing breaker.

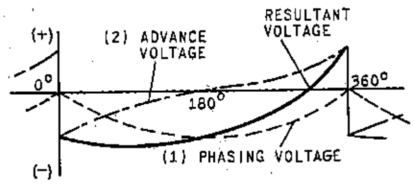


Fig. 3A Components of Voltage that Control D when Bus and Machine Voltages are Balanced

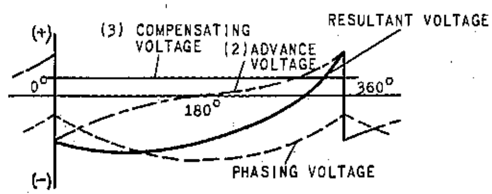


Fig. 3B Components of Voltage that Control D when Bus and Machine Voltages are Unbalanced

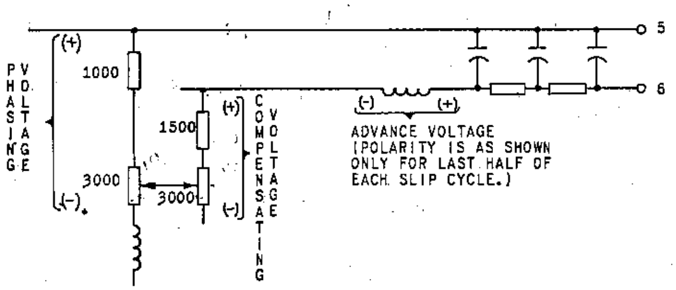


Fig. 3C Elementary Diagram-Components of Voltage that Control D Relay

Fig. 3 (K-6400799)

MAINTENANCE

PERIODIC INSPECTION

A check of several points should be made at intervals depending on the severity of service; an initial interval of three months is recommended, and this interval can be increased as indicated by experience under local conditions.

(1) Check the tightness of connections and adjustments.
(2) Check that all five relays have wipe.
(3) Check the operating point of relay D.

All contacts may be cleaned with a burnishing tool supplied with the relay tool kit.

SERVICING

The Type GES11F relay has been adjusted at the factory but if a check shows that the adjustments have subsequently been distrubed, the following points should be observed in restoring them:

A. Upper Unit

Relay D

This relay was adjusted at the factory for use with the particular tubes shipped with the syncrhonizing relay, but it may require an occasional check and readjustment to compensate for gradual changes in tube characteristics.

The tubes should have a long life because of the moderate loading and intermitent service, but when their replacement does become necessary, relay D must be readjusted to correspond with the characteristics of the new tubes.

When the tubes are replaced, adjust the bias potentiometer R_4 until the plate currents of the two tubes are equal, with both tubes in the relay and a temporary jumper across studs 5 and 6. The plate currents should be greater than 2 milliamps.

Be sure to remove the temporary jumper from 5-6.

To adjust the relay, first connect a + 6 to - 24 v grid control source per Fig. 4, block C closed so that A can operate, and insulate the 1-2 contact of E so that A cannot seal in.

Apply minimum control voltage (not less than 0.8 rated value) and see that the right contact closes (indicated by A picking up) as the grid voltage is changed from positive to maximum negative. Then apply normal control

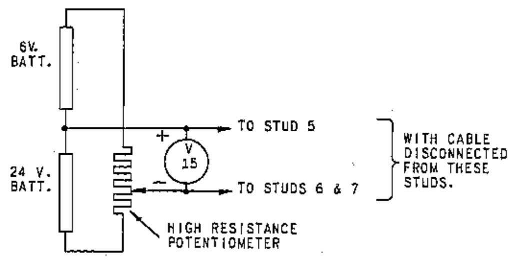


Fig. 4 Amplifier Test Connections

voltage and adjust the left contact or pole piece slightly so that the contact closes (indicated by B picking up) at a value between 0.1 v before zero and 0.2 v after zero as the grid voltage is changed from maximum negative to positive. Note that the voltmeter reads positive when the grid voltage is negative. If the contact chatters, the true operating point is the voltage at which the first closure occurs. Turning either the stationary contact or the pole piece in toward the center will cause the contact to close earlier, and vice versa.

In deciding whether to move the contact or the pole piece, one should remember that (a) a large gap between armature and pole piece in the closed position of the adjacent contact gives a weak operating force and a small total contact gap, but (b) some gap must be maintained between the armature and pole piece at the point where the contact just closes, in order to permit wipe and to insure that the available operating current can release the armature to close the other contact; these notes apply equally to the right contact. If contact chatter is encountered, as mentioned above, the wipe should be reduced as much as possible, as this tends to eliminate chatter.

After adjusting the left side at normal d-c voltage, check that the right side still closes at minimum voltage. If the right side has to be readjusted, check the left side again afterward, at normal voltage, readjusting if necessary, and so on back and forth until the desired operating values are obtained with just a small pole piece gap on each side when the corresponding contact is barely closed. Make sure the pole pieces are locked securely, and recheck operating values if the locknuts were found loose.

B. Middle Unit

(1) Adjustments common to all three relays, A, B, and E:

Bend the stationary back stop of the armature arm so that the insulator on the armature arm clears the inner moving contact slightly in the de-energized position.

Bend the middle stationary contact so that it is midway between the two moving contacts in the de-energized position.

Bend the outer stationary contact so that it closes at about the same point in the closing stroke as the inner one.

Bend the armature arm so that the "a" contacts just make in the energized poition with a 6 mil feeler between the pole piece and the armature.

(2) Adjustments not common to all three relays.

Relay A

The drop-out time of the A relay should be approximately one-quarter of a second. This is adjusted by the residual screw in the armature, and by the gap between the armature and the frame.

Relay B

Adjust the residual screw to give about 2 mils armature gap in the energized position, and lock the adjustment. See that the gap between the armature and the frame in the energized position is about 5 mils.

Relay E

See that the gap between the armature and the frame is about 5 mils in the energized position. Adjust the residual screw so that when operating at minimum d-c dontrol voltage (not less than .8 normal) and medium slip frequency, E releases visibly when B picks up, and yet it holds in. An occasional failure to hold in at this minimum voltage is permissible and indicates correct adjustment.

C. Lower Unit

Relay C

All nuts, bolts, and connections should be tight.

The flexible contact leads should be free, that is, should not touch any part of the relay except the terminals to which they are connected.

The normally closed (b) contact should have 1/16" wipe.

There should be at least 1/32" gap on the "a" contact with the "b" contact just open.

Relay F

The wipe on the normally open "a" contacts should not be less than 1/32 inch measured between the upper extremity of the armature and the pole piece.

RENEWAL PARTS

When ordering renewal parts, address the nearest Sales Office of the General Electric Company, refer to part bulletin GEG-1178, specify the quantity required, and give the catalog number.

If it is necessary to replace the tubes, refer to the section on Operation and Maintenance for the necessary readjustment of relay D.

Although minor repairs and replacements may be done in the field, it is recommended that the relay and auxiliary box be returned to the factory if major repairs are necessary.

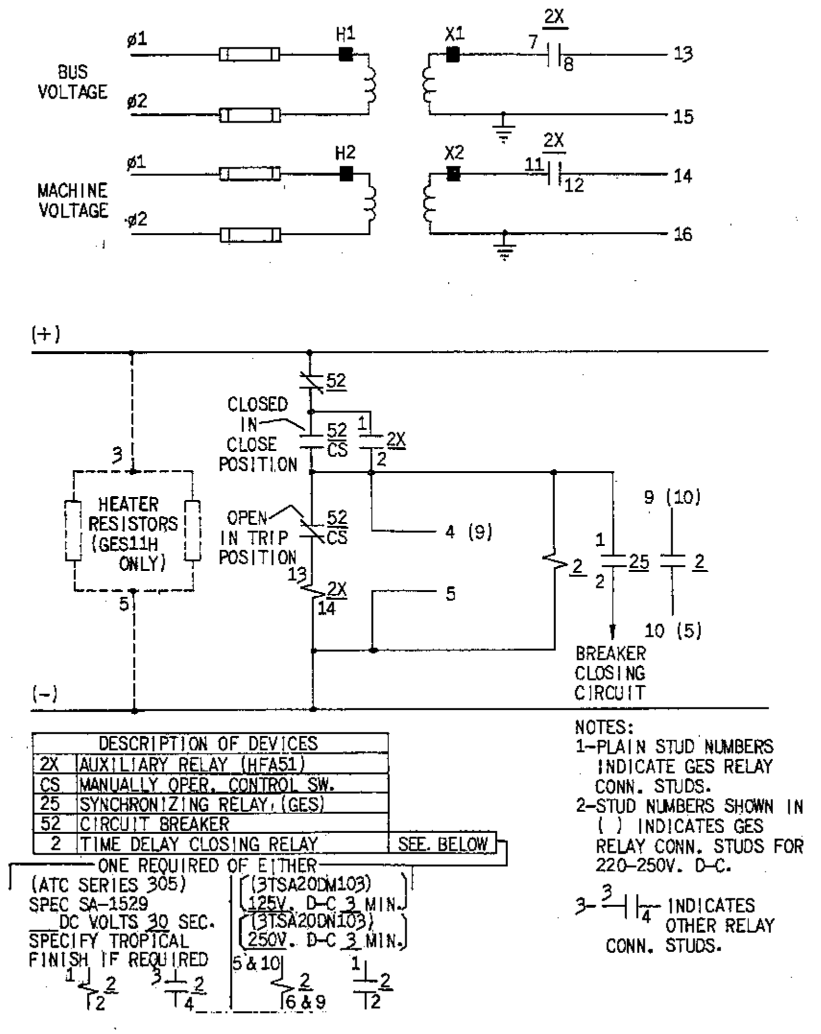


Fig. 5 (104A8536)

Fig. 5 Typical External Connections for GES11F and GES11H Relays

Fig. 6 (459A291) Fig. 6A (459A292) Fig. 7 (6154728) Fig. 8 (403A119)

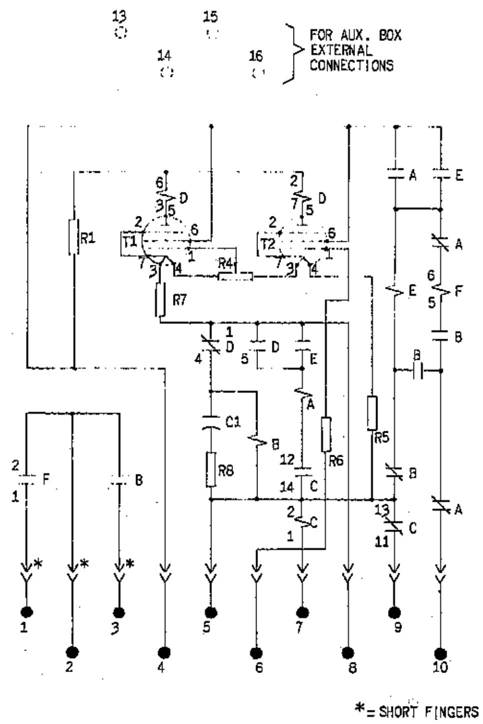


Fig. 6 Internal Connections of Type GES11F Relay (Front View)

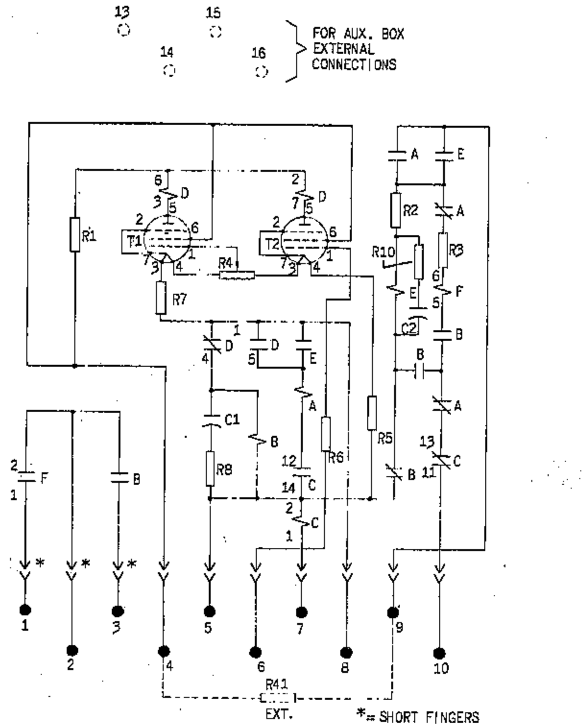


Fig. 6A Internal Connections of Type GES11F Relay (220-250V D.C.) (Front View)

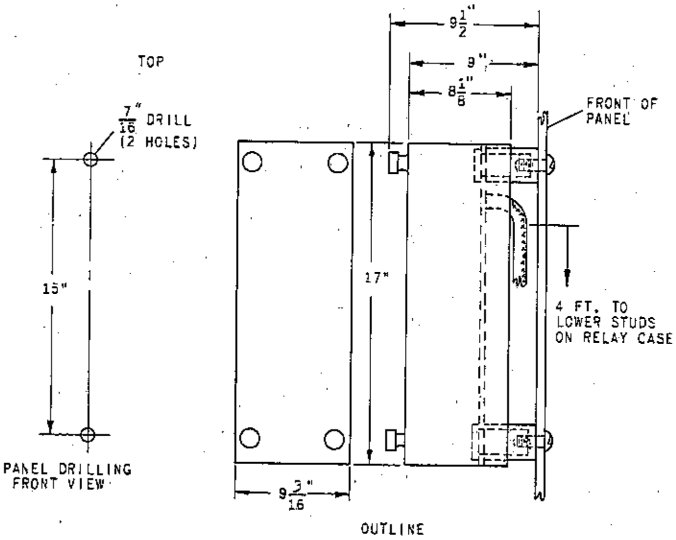


Fig. 7 Outline and Panel Drilling for Auxiliary Box

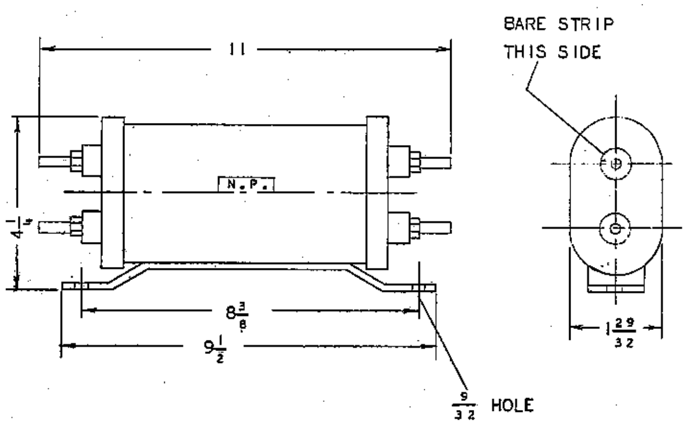


Fig. 8 External Resistor Outline (R_{41}) (220-250V D.C. Only)

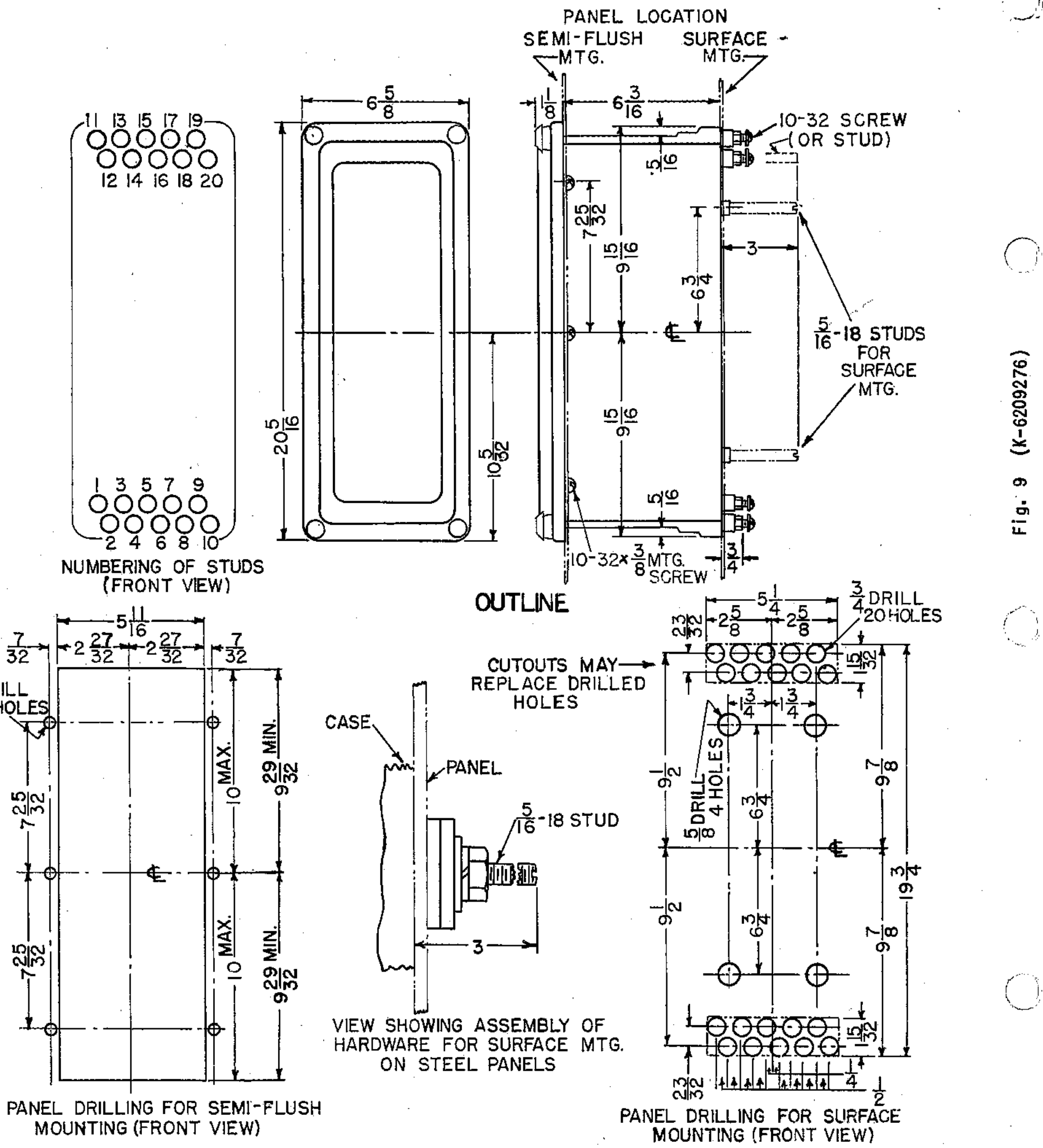


Fig. 9 Outline and Panel Drilling for Type GESIIF Relay