XASV Automatic Generator Synchronizing System

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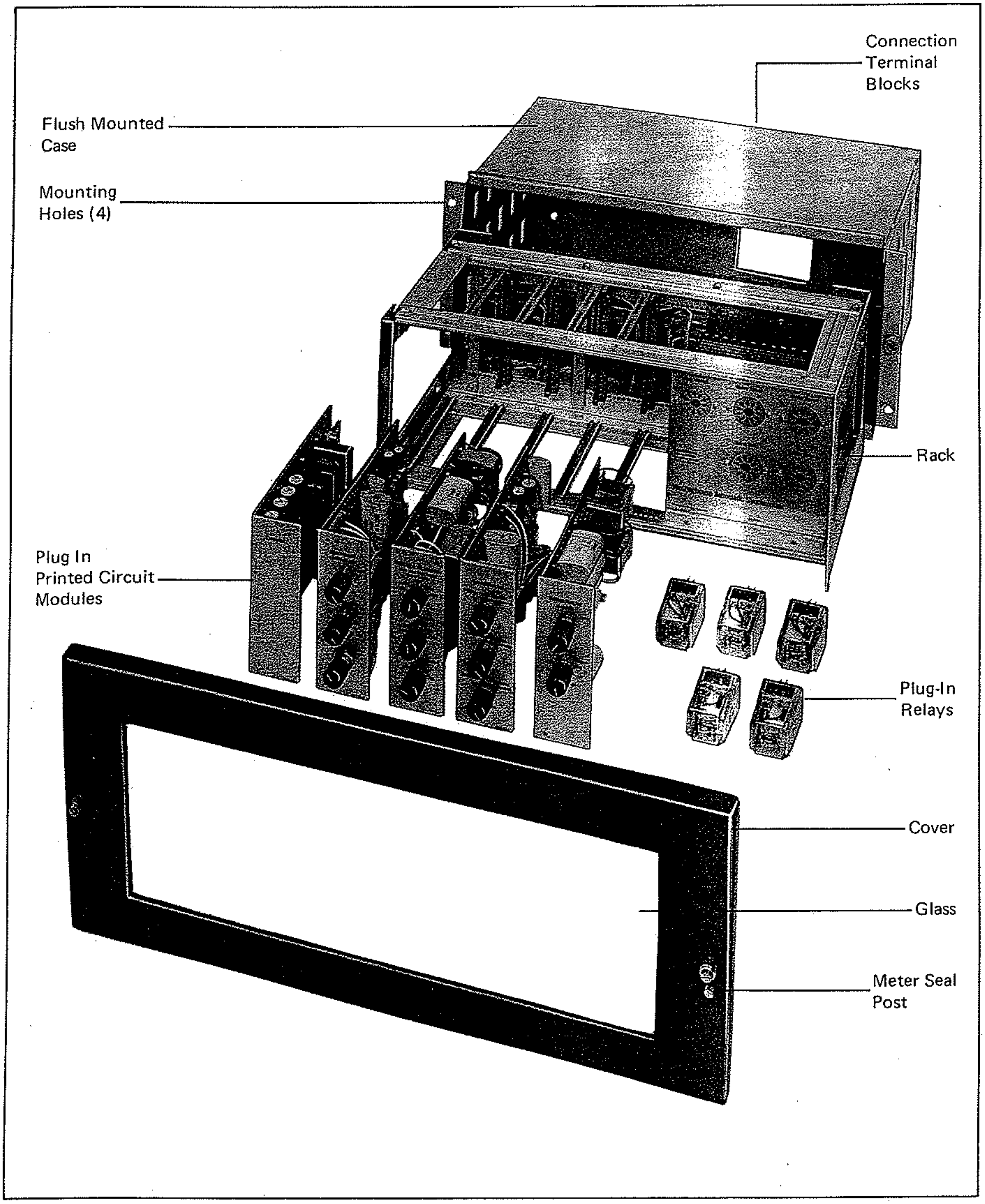


Fig. 1 Expanded View of XASV Synchronizing Unit

I PURPOSE AND APPLICATION

The XASV automatic generator synchronizing device is a single package which houses a synchronizer, with a voltage-limit option, a speed matching option and a voltage matching option. These options permit various combinations of functions for particular generator synchronizing schemes.

The XASV system, shown in an expanded view in Fig. 1, can manipulate the speed of the generators' prime mover, manipulate the voltage of the incoming generator, then close the connection between the incoming generator and the running bus only when conditions are satisfactory for synchronizing.

The name XASV is derived from the following basic functions that make up the system:

X - Automatic Synchronizer

This function is used to close the connection between an incoming power generator and the running bus when they are at a slightly different frequency. The synchronizer is designed to energize the closing circuit of the connecting circuit breaker at a constant time before the point of synchronism is reached. This time is set equal to the breaker closing time. The synchronizer also limits the maximum phase angle before the point of synchronism at which the breaker closing circuit may be energized.

This basic synchronizer (X) consists of the case and rack assembly furnished with a regulated power supply, a plug-in converter printed circuit module, a plug-in synchronizer printed circuit module, and a synchronizer relay.

The printed circuit modules described are shown on Fig. 1 from left to right.

A - Voltage Acceptor

This option is a voltage lock-out device which inactivates the synchronizer if the generator and/or bus voltages are outside set limits. It is the third plug-in printed circuit module shown in Fig. 1.

S - Speed Matcher

This option provides raise or lower signals to the speed control of the prime mover governor to correct the frequency of the oncoming generator to the frequency of the bus. It consists of the fourth plug-in printed circuit module and a pair of relays.

V - Voltage Matcher

This option provides raise or lower signals to the voltage adjuster of the incoming generator. It is a pulse and wait controller which brings the generator voltage to within the set values of the voltage acceptor card to allow synchronizing. It consists of the fifth plug-in printed circuit module and a pair of relays.

The following combinations are available:

Type	Style No.	Components Included
XASV	127D741G01	Automatic Synchronizer, Voltage Acceptor, Voltage Matcher and Speed Matcher
XAS	127D741G02	Automatic Synchronizer, Voltage Acceptor, and Speed Matcher
XS	127D741G03	Automatic Synchronizer and Speed Matcher
XA	127D741G04	Automatic Synchronizer and Voltage Acceptor
X	127D741G05	Automatic Synchronizer

NOTE

The rack assembly is furnished with all the printed circuit card module connectors and their wiring. Thus, any synchronizer unit originally furnished from the factory without options can have these options added in the field by merely plugging in the option p.c. card modules and plug-in relays.

A typical XASV application for synchronizing an incoming generator to a running bus system is shown in Fig. 2. The two generators in the scheme have breakers with different closing times. A type EQ breaker closing time equalizer, described in I.B. 127D742, is included in the generator No. 2 breaker closing circuit, permitting the XASV system to be used with common synchronizing settings for both generators.

For synchronizing generator No. 1, switch SS1 is closed. The synchronizing switches SS1, SS2, etc., are operated by a common handle removable only in the off position. Thus, all switches are in the off position except the one in use. When in the automatic position, switch SS1, for example, connects generator No. 1 potential source to the converter module and the bus potential source to the power supply and converter module. Connections are also made to Generator No. 1 breaker as well as its speed and voltage controllers.

II DESCRIPTION

a. Type X Automatic Synchronizer

The Type X Automatic Synchronizer is used as a means of recognizing conditions of synchronism between two a.c. systems and appropriately energizing the closing circuit of the circuit breaker that ties the incoming system to the running system. Any circuit breaker will have a definite operating time and the synchronizer recognizes this by energizing the closing circuit at a constant time before the exact point of synchronism. The closing circuit of the breaker is therefore energized while the systems are still out of synchronism. This is done at an advance angle that is computed from the rate at which the systems are reaching synchronism. For example, if the systems are coming into synchronism rapidly, the closing circuit must be energized at an angular position well in advance of synchronism in order that there be enough time for the circuit breaker to close. On the other hand, if the systems are coming into synchronism at a slow rate, the circuit breaker closing circuit is energized at a small advance angle, since the systems will change their relative angle very little while the circuit breaker is closing.

It is undesirable to tie two systems together when they are approaching synchronism very rapidly. Consequently, the Type X Automatic Synchronizer will lock out if the angle in advance of synchronism at which the circuit breaker closing circuit must be energized exceeds a specific value. This advance angle is adjusted on the synchronizer module and has a range of 0 to 40 degrees. The other adjustment on the synchronizer p.c. module is labeled "Breaker Closing Time." One control knob of this adjustment allows a range of .10 to .20 seconds while another knob operates a 3 position switch which multiplies the range by 1, 2 and 4 respectively providing a breaker closing time range from .1 to .8 seconds.

A breaker anti-pump circuit is incorporated in the Type X synchronizer so that if the generator breaker does not remain closed for approximately 15 seconds after the closing command is given by the synchronizer, the synchronizer is locked out.

b. Type A Voltage Acceptor

A lockout circuit on the optional voltage acceptor p.c. module inactivates the synchronizer if voltages are outside of set values. It has three adjustments:

1. Lower Voltage Limit - A five-position under-voltage lock-out switch has settings of 80, 90, 100, 110 and 120 volts. If either the generator voltage or the bus voltage falls below the selected setting, a lockout signal is given to the synchronizer.

2. Upper Voltage Limit - A five-position over-voltage lock-out switch has settings of 90, 100, 110, 120 and 130 volts. If either the generator voltage or the bus voltage is above the selected setting, a lock-out signal is given to the synchronizer.

3. Voltage Difference Limit - A five-position difference-voltage lock-out switch has settings of 1, 2, 5, 10 and 50 volts. If the voltage difference between the generator and bus exceeds the selected setting, a lock-out signal is given to the synchronizer.

c. Type S Speed Matcher

The Type S speed matcher option is used to automatically provide raise or lower signals to the prime mover governor of the oncoming generator. It becomes operable when the generator frequency is within ± 10% of the bus frequency. It is a proportional type signalling device which gives a speed correction pulse each beat cycle, i.e., the time interval between correction pulses become increasingly longer as the frequency (speed) of the incoming generator approaches the frequency of the bus system. The pulses, having a duration time adjustment control, occur at the 50 degree past phase coincidence point.

Should the incoming generator stabilize at the exact speed of the bus for an extended period of time, the speed matcher will energize the raise relay to slightly increase the generator speed. This kicker-pulse will cause the incoming generator to pass through synchronism rather than possibly remain in an "out of phase" position. The kicker pulse range is adjustable.

The three speed matcher module adjustments are:

1. Raise Speed Relay Closure Time - The range of adjustment is from .1 to .4 seconds.

2. Lower Speed Relay Closure Time - The range of adjustment is from .1 to .4 seconds.

3. Raise Relay Kicker Pulse - The range of adjustment is from 10 to 40 seconds.

d. Type V Voltage Matcher

A pulse-and-wait regulator is built into the voltage matcher to automatically manipulate the motor driven voltage adjustor of the incoming generator. A pulse, with adjustable duration of .25 to 2 seconds, and a fixed wait time of 6 seconds is delivered to the raise or lower circuit of the voltage adjustor until the voltage of the incoming circuit is within the set point selected on the voltage matcher. The set point is adjustable from 1 to 5 volts. When the voltages are this close together, the voltages fall within the dead band of the voltage matcher and its regulating action on the motor operated voltage adjustor stops.

III OPERATION

a. Type X Synchronizer

Accuracy of synchronization is accomplished by using semi-conductors to develop a triangular waveform voltage which precisely represents the phase relationship between the generator and bus system potentials. This triangular waveform has a maximum value at phase coincidence of the two potentials. Also it is linear from the maximum value at phase coincidence to a zero value at the 180 degree relationship between the generator and bus system potentials. In the synchronizing procedure, the frequency (speed) of the generator is slightly different from the bus. Thus, the phase difference between the generator and bus voltage of a different frequency is a linear function of time. The triangular phase difference waveform, therefore, represents exact variation of phase difference with time permitting accurate phase coincidence prediction. With this technique, the Type X synchronizer provides a closing command to the generator breaker within three degrees of phase coincidence.

The Type X synchronizer includes the converter card and synchronizer card. The circuitry for developing the triangular waveform voltage is located on the converter printed circuit module. As shown on Fig. 4, the generator and bus sine wave inputs, terminals 11, 12, 14 and 15, are applied to transformers whose secondaries drive switching transistors. The outputs from the switching transistors are square waves of constant amplitude (12 volts) but different frequencies, terminals 19 and 20. These square waves are taken to the speed-matcher module.

These square waves are also mixed in an "exclusive or" circuit on the converter card to develop the triangular phase difference voltage e_1 at terminal 1. This voltage is at maximum value of approximately 39 volts at phase coincidence of the two sine wave inputs. The low pass filter eliminates the high frequency ripple from the output.

The synchronizer module, Fig. 5, will allow synchronizer relay 25 to close only when the following conditions are satisfied.

1. The generator breaker is open.
2. The optional voltage acceptor module gives a release signal indicating that the generator and bus voltages are within required limits.
3. The rate at which the systems are approaching synchronism is such to allow the breaker to close at exact phase coincidence with minimum disturbance to the systems.
4. The incoming voltage which energizes the internal power supply of the synchronizer is above a minimum value.
5. The synchronizer has been energized for one second.

As stated under purpose and application, the closing circuit of the breaker must be energized while the incoming generator and the running bus system are still out of synchronism. The advance angle at which this is to be done is shown on the curve Fig. 9.

The two level detectors in Fig. 5 constitute the basic synchronizer circuit. One is a phase advance level detector. It is connected directly to the triangular output e_1 of the converter card, to give an output shown as e_{11} in Fig. 5 at a definite phase angle before synchronism. This has an adjustable range from 0 to 40 degrees.

The second level detector produces a pulse at a definite time before phase coincidence. It is the breaker closing time detector and is fed by the output of a differentiator and summing network. This signal is shown as e_2 in Fig. 5 and it produces an output e_{21} at a definite time before synchronism. This breaker closing time setting has an adjustable range from .1 to .8 seconds.

Assume that the frequency difference is too large for desired synchronization; the speed of the incoming generator is too slow or too fast. The resultant beat period, that is, the time in seconds for a synchroscope to make one complete revolution, is shown as T_{NP} in Fig. 4.

This condition results in the output signal from the breaker closing level detector e_{21} occurring ahead of the output from the advance angle level detector e_{11}. The synchronizer logic circuit recognizes this as an unfavorable synchronizing condition and therefore blocks relay 25 from being energized.

Thus, it is required that the speed of the generator be brought closer to that of the bus system to result in a smaller frequency difference, that is, the beat period must be lengthened. This speed change must be sufficient to make the phase angle level detector signal e_{11} occur ahead of the breaker closing time level detector signal e_{21}. This is shown as T_P in Fig. 4. The logic circuit then, noting pulse e_{11} preceeded pulse e_{21}, allows relay 25 to be energized since, at this new frequency difference, there is now sufficient time for the breaker to close within the set advance angle.

The dotted example shown on Fig. 9 illustrates an installation having a breaker with 0.4 second closing time. For a desired frequency difference of 0.2 hertz (5 seconds for one complete revolution of the synchroscope), the advance angle setting would be 31 degrees. Thus, the synchronizer will stay locked out until the frequency difference is 0.2 hertz or lower.

A breaker anti-pump feature is included in the synchronizer scheme. It is shown as a timer in Fig. 5. The object of the timer is to disable the synchronizer for approximately 15 seconds after the breaker closes. If the breaker remains closed during this period, the synchronizer is automatically reset. However, if the breaker trips within the 15 second period, the synchronizer remains disabled until it is de-energized, allowing for the fault to be corrected and then turned on again. This circuit requires the use of an "a" contact of the generator breaker, terminal 3. The breaker "b" contact, terminal 16, is in the relay 25 circuit to lock out the synchronizer.

b. Type A Voltage Acceptor

Since the triangular phase difference wave form, e_1 on the converter card, is developed independent of the input voltage magnitudes, the synchronizer will close accurately at wide generator and bus voltage limits. The type A voltage acceptor module will prevent synchronization unless the generator and bus voltage are within specified limits. This module, shown in Fig. 6, necessitates that the generator and bus voltage to be above a minimum value, below a maximum value, and within a difference value to give a release signal to the synchronizer. This lock out value at terminal 12 is approximately 1 volt with a release value of approximately 35 volts.

The lower-voltage limit sensing circuit, Fig. 6, is a three transistor level detector. If either input falls below the selected value, the output transistor will give the synchronizer module a lock-out signal.

The upper voltage limit circuit operates in a similar manner.

The voltage difference level detector compares the difference value of the generator and bus voltages to the selected permissive difference value.

c. Type S Speed Matcher

The Type S speed matcher option is used to automatically provide raise or lower signals to the prime mover governor of the oncoming generator. It becomes operable when the generator frequency is within ± 10% of the bus frequency.

The inputs to the speed matcher module are the generator and bus square waveform voltages, terminals 7 and 13 and the triangular phase difference waveform voltage terminal 1 from the converter module. By taking the generator square waveform into a pulse shaper and combining it with an "AND" circuit from the bus square waveform, it can be determined whether the generator speed is faster or slower than the bus. If the generator speed is slower, the output of this speed determining circuit will set the flip-flop shown in Fig. 7. Conversely, if the generator speed is faster than the bus, the bus speed determining circuit will reset the flip-flop.

The 50 degree level pulse circuit samples both outputs of the flip-flop. If the flip-flop is set when the 50 degree sampling occurs, a raise signal is given. If the flip-flop is reset, then a lower signal is given. Should the 50 degree sampling pulse not occur during the time set on the kicker pulse adjustment, a timer will actuate the raise circuit.

d. Type V Voltage Matcher

The voltage matcher compares the magnitudes of the generator and the bus voltages. Should the generator voltage be too low, a pulse is given to the voltage adjuster to slightly increase the generator voltage. A fixed wait period of 6 seconds duration appraises the correction and delivers another pulse if the corrected voltage is not within the accuracy setting of the voltage matcher.

As shown in Fig. 8, the line and bus voltages obtained from the potential transformers are fed to isolation transformers, each with double secondary windings. All the secondary voltages are rectified and filtered. These d.c. voltages are connected to a difference amplifier. The two outputs of the difference amplifier indicate which of the input voltages is larger and gives the proper raise or lower pulse accordingly. The timer determines the length of pulse duration.

IV BURDENS

The XASV synchronizer system is designed to operate from potential transformers having 120 volt secondaries on either 50 or 60 hertz systems. The intelligence circuits impose burdens of approximately 5 voltamperes on the generator and bus potential transformers. The systems power supply, having a burden of 45 voltamperes, is normally served from the bus potential through jumper connections at the terminal blocks at the rear of the case. These jumpers are furnished by the factory between terminals 1 and 3 and between terminals 2 and 4.

Should the power supply burden prove to be excessive for special bus sources, such as capacitor potential devices, the terminal block jumpers can be removed and the power supply connected to an auxiliary a.c. source to terminals 1 and 2.

The power supply of the XASV system will function with its input voltage as low as 70 volts. The synchronizer will lock out if the voltage falls below this value.

V SENSITIVITY

The Type X synchronizer is designed to close the breaker within 3 degrees of phase coincidence under the worst possible combinations of voltage magnitudes, frequency difference and temperature (-25 degrees C to +65 degrees C). As stated under description, the triangular signal used for determining phase position between the inputs, is developed independent of input voltage magnitude. Therefore, the Type A voltage acceptor is required where monitoring of the generator and bus voltage magnitudes and difference is required.

VI RELAY RATINGS

The five relays of the system; synchronizer, raise and lower speed, and raise and lower volts are plug-in types with dust covers. Their contacts are rated 5 amp continuous with an interrupting rating of 1 amp resistive at 125 V d.c. Interposing relays of higher rating can be added externally if required.

VII SHIPPING INSTRUCTIONS

The XASV synchronizer unit is shipped in a carton having measurements of 20 x 12 x 10 inches and having a gross weight of 45 pounds. (Net weight of the XASV unit is 40 pounds.)

Should it be necessary to return any p.c. card to the factory for recalibration or repair, special effort should be taken in packing the p.c. card so that the card components do not get damaged in shipment.

VIII VOLTAGE CORRECTION TRANSFORMER

The XASV system takes its intelligence from the secondaries of the generator and bus potential transformers. A serious voltage mismatch occurs at the input to the XASV unit if these potential transformer ratio differences are significant.

An auxiliary voltage correction transformer can be connected between the generator potential transformer and the XASV input to offset any ratio errors. S# 1649626 or equivalent, shown on Fig. 12, can be connected as an auto-transformer to be either additive or subtractive in 2 volt steps.

IX SYNCHRO-VERIFIER NOTE

The Type X synchronizer is not applicable for closing breakers where there is no frequency difference between the voltages on the two sides of the breaker such as occurs with the last open breaker in a transmission loop. Under these conditions there will be no phase rotation between the two voltages although there may be a phase angle displacement between them. A Type CVE synchro-verifier relay is recommended for synchronizing under such conditions.

X SYNCHRONISM CHECKING DEVICE

The XASV system is designed to be as fail safe as circuitry will permit. Conservative application of components coupled with liberal width of printed circuit conductors and with liberal spacing of these conductors assures near infinite life of the device. Interlocking of circuit functions also aids in approaching fail safe operation. For those applications where the contingencies of failure warrant verification of the synchronizer's action, a second device is used redundantly in series connection to the breaker closing circuit to supervise the synchronizer operation itself. It is the Type Y synchro-acceptor.

The Type Y synchro-acceptor is covered in detail in I.B. 587C887. It performs the function of identifying the acceptable zone in which the automatic synchronizer must give a closing signal to the generator circuit breaker. The zone of closing recognized by the synchro-acceptor is broad enough to permit a precise choice of phase angle and rate of change of phase angle by the automatic synchronizer and yet it is narrow enough to prevent closing in situations that would constitute mal-performance of the Type X synchronizer.

XI INITIAL SETTING ON ALL THE P.C. CARD MODULES

NOTE

Never make changes on the printed circuit card controls while the synchronizer is energized. Be sure to remove the power to the synchronizer before changing these p.c. card settings.

a. Synchronizer (Setting of Breaker Closing Time and Advance Angle)

The converter card has no adjustments. On the synchronizer card, the breaker closing time and the advance angle settings need to be made. Set the breaker closing time of the actual breaker using the 0.1 to 0.2 second potentiometer and the 1, 2 or 4 multiplier switch.

For the Advance Angle setting, refer to curve on Fig. 9.

1. Select the curve of Fig. 9 that corresponds to the frequency difference above which it is desired that the synchronizer prevent the breaker from closing.

2. Find the point on the abscissa of Fig. 9 that corresponds to the breaker closing time and draw from there a vertical line to the curve selected in (1) above.

3. From the intersection of the two lines, draw a line horizontally which will intersect the ordinate at the necessary phase angle setting.

EXAMPLE:

Given: Breaker closing time = 0.4 seconds
Desired lock out frequency difference = 0.2 Hz

Wanted: Advance angle setting. Draw a line vertically from 0.4 sec. on the abscissa to the line representing 0.2 Hz frequency difference. (This corresponds to a synchroscope making one complete revolution in 5 seconds.) A line drawn horizontally from the intersection meets the ordinate at a point of 28.8 degrees advance angle setting.

4. Set the advance angle and breaker closing time controls to their respective values.

b. Voltage Acceptor (Setting of Upper Limit, Lower Limit and Difference Limit)

Select on the upper limit, the desired voltage at which the synchronizer should lock-out if either the generator voltage or bus voltage should exceed this setting. The five choices on this upper limit setting are 90, 100, 110, 120 or 130 volts.

Select on the lower limit the desired voltage at which the synchronizer should lock-out if either the generator voltage or bus voltage should fall below this setting. The five choices on this lower limit setting are 80, 90, 100, 110 or 120 volts.

Select the difference value between the generator voltage and bus voltage desired for synchronizing. The five choices are 1, 2, 5, 10 or 50 volts.

c. Speed Matcher (Setting of Raise Pulse Duration Time, Lower Pulse Duration Time and Kicker Pulse Duration Time)

The raise or lower relays are operated once each beat cycle between the generator and bus system at 50 degree point past phase coincidence. The raise or lower relay will close its contacts for the time set on their control potentiometer. The range for this closure time is 0.25 to 2 seconds. Set these potentiometers at the time which suits the response characteristics of the governor control.

The kicker pulse will actuate the raise relay in the situation where the generator is running synchronously with the bus system for an extended period of time to permit the generator voltage to go thru synchronism. The range of this setting is 10 to 40 seconds.

d. Voltage Matcher (Setting of the Accuracy Limit and of the Relay Closure Time)

The voltage matcher will operate either the raise or lower relay until the generator voltage matches the voltage of the bus within the setting of the accuracy adjustment. The range of the accuracy setting is 1 to 5 volts. The setting of the accuracy should be set below the setting of the difference adjustment on the voltage acceptor card. This is to assure that the voltage difference on the acceptor card is proper to give a release signal to the synchronizer.

The fixed time duration between pulses of the relays is approximately 6 seconds. The duration of pulse closure time is adjustable from 0.25 to 2 seconds. This setting should be set to suit the characteristics of the motor operated voltage adjuster on the voltage regulator.

XII INSTALLATION AND CHECKING PROCEDURE

Wiring to the XASV unit is made to the two terminal blocks at the rear of the case as shown on the interconnection diagram of Fig. 3. The wiring to the unit should be made with #14 or #12 wire.

The leads from the generator breakers' 'a' contact to terminals 7 and 8 of the XASV unit and the leads from the generator breakers' 'b' contact to terminals 9 and 10 of the XASV unit should be made with twisted pairs of wires.

The equipment is tested and calibrated completely at the factory and should be in calibration when installed in the field. However, damage in shipment or changing of calibrated settings by random hands require a check-out of the equipment upon installation in the field.

Should the equipment fail to perform correctly per these instructions, refer to the Test Instructions in Section XIII.

The preferred method in checking out the synchronizing system in the field is to use the manual control of the speed governor of the generators prime mover, and manual control of the voltage regulator. This manual control, with the aid of the switchboard voltmeters indicating the generator and bus system voltages, and the synchroscope indicating the phase position, checks the equipment to the actual generator condition.

An alternate method is to use a stable oscillator and amplifier to simulate the incoming generator. Still another method is to use a variable-speed motor driven phase shifter to simulate the incoming generator.

Checking the XASV unit using manual speed control and manual voltage regulator control.

a. Synchronizer

1. Check that the synchronizer is properly connected per the interconnection diagram shown in Fig. 3. Be sure that the generator and bus voltages are of the correct polarity as shown in Fig. 3.
2. Place the main generator breaker in the test position so that its primary contacts will not close into the live bus system.
3. With the XASV equipment in the de-energized position, make all settings on the p.c. card modules as described in Section IX.
4. With the synchronizer unit de-energized, manually bring the generator speed up to within one cycle difference of the bus system. This will be observed on the synchroscope in taking one second to make a full revolution.
5. The voltage of the generator should be manually set at the same value as the bus system.
6. Energize the automatic synchronizer.
7. Using the manual speed control, gradually bring the speed of the generator to that of the bus system. When the frequency difference between the systems is reached as set on the advance angle curve, the generator breaker should close with the synchroscope indicating exactly zero phase. NOTE: Since the breaker is in the test position, the generator output is not connected to the live bus system.
8. If available, a high speed chart recorder, connected to the sine wave generator voltage and the bus system voltage, will show precise phase coincidence at the time the breaker closes.
9. If the phase coincidence is not absolute at the time the generator breaker contacts close, make a fine correction adjustment of the breaker closing time knob.
10. Repeat test steps 7, 8 and 9 until the generator and bus voltages are in the precise phase coincidence.

b. Voltage Acceptor

1. Manual control of the generator voltage is required to check the operation of the voltage acceptor card.
2. With the generator breaker still in the test position, bring the generator speed up to within one cycle difference of the bus system as per step XII-a-4.
3. Set the generator voltage at a value beyond the settings on the voltage acceptor card.
4. With the generator voltage outside the set values on the voltage acceptor card, bring the speed of the generator to within the allowable frequency difference as set in step XII-a-7.
5. Holding the speed of the generator at the allowable frequency difference, slowly adjust the generator voltage until it falls within the limits set on the acceptor card.
6. The voltage acceptor card will give the synchronizer card a release signal and allow the generator breaker to close.

c. Speed Matcher

The speed matcher card receives its intelligence from the converter card.

1. Manually bring the speed of the generator to within one cycle difference of the bus system as per step XII-a-4.

2. Note on the synchroscope that the raise speed relay closes for the time set on the p.c. card at the 50 degree point past phase coincidence.

3. Bring the speed of the generator closer to that of the bus system and note that the raise pulse still occurs at the 50 degree point past phase coincidence.

4. With the manual speed control, run the speed of the generator faster than that of the bus system.

5. Note that the lower speed relay closes at the 50 degree point past phase coincidence.

6. With manual speed control, run the speed of the generator exactly the same as the bus system. The synchroscope pointer, will stay in a fixed position simulating a "hung-scope" condition. Note that the raise speed relay will operate to the time setting of the kicker pulse knob on the speed matcher module.

d. Voltage Matcher

1. Manually bring the speed of the generator to within one cycle difference of the bus system as per step XII-a-4.

2. Manually lower the generator voltage to a value outside the accuracy setting of the voltage matcher card.

3. Note that the raise voltage relay will close for the time setting of the pulse duration time knob on the voltage matcher module.

4. Note that the time between pulses is approximately seven seconds.

5. Manually raise the generator voltage to a value just within the accuracy setting on the voltage matcher module.

6. Note that the raise volts relay ceases to pulse.

7. Manually raise the generator voltage to a value outside the accuracy setting of the voltage matcher card.

8. Note that the lower voltage relay will close for the time setting of the pulse duration time knob on the voltage matcher card.

9. Note that the time between pulses is approximately seven seconds.

10. Manually lower the generator voltage to a value just within the accuracy setting on the voltage matcher card.

11. Note that the lower volts relay ceases to pulse.

XIII TEST INSTRUCTIONS AND TROUBLESHOOTING

These instructions are required only if difficulty has been encountered in the performance of the synchronizing unit. They are to determine if a fault lies within a printed circuit module, the power supply or one of the relays.

Should it be determined that a printed circuit card module is malfunctioning, the card should be returned to the factory for repair. No attempt should be made in the field to repair or replace a component on the p.c. card.

Trouble shooting requires the use of a multi-meter having a d.c. sensitivity of at least 20 K ohms/volt. The leads of the voltmeter are to be connected to the plug terminals on the p.c. cards. Caution must be exercized when placing the voltmeter leads on the p.c. card terminals in order not to short out to adjacent terminals of the card. A universal card extender S# 588C549G01, which can be ordered from the factory can prove a valuable aid in trouble shooting and maintaining the synchronizing unit.

When troubleshooting refer to the block schematic shown in Fig. 3. The scheme shows the interconnections of the p.c. cards, the power supply, the relays and external terminal blocks. As noted in the scheme, the p.c. card modules receive the power from the 50 volt dc supply which is mounted behind the relay panel.

The following is a description of the normal sequence of operation of the XASV system in bringing an incoming generator to synchronism with the bus system. Should the equipment fail to operate in this normal sequence, check for applicable symptom and defect location explained in this section. Also refer to typical voltage values as an aid for pin-pointing location of trouble.

When the generator is brought up in speed to within 10 hertz difference of the bus system, the raise speed relay will operate when the synchroscope indicates 50 degrees past phase coincidence. This operation of the raise speed relay will operate each slip cycle at the 50 degree phase point. At no time will the lower speed relay operate as the generator approaches the bus frequency.

If the speed of the generator is held to exactly the same speed of the bus system, the raise relay will be energized at the time set on the kicker pulse setting.

The raise voltage relay will operate while the generator is being brought up to speed, if the generator voltage is lower in value from the bus system as set on the voltage matcher card.

Conversely, the lower voltage relay will operate if the generator voltage is higher than the bus as the generator comes up in speed. At no time, however, will both raise and lower voltage relays operate simultaneously.

When the generator speed is brought within the frequency difference of the bus as selected on the advance angle curve, the synchronizer relay will close at the advance angle equal to the breaker closing time for the actual frequency difference. This, of course, will occur only if the generator and bus system voltages satisfy the settings on the voltage acceptor card.

When the generator breaker closes, all of the relays on the XASV unit will cease to operate, since as shown in Fig. 3, the generator 'b' contact removes the 50 volt supply from the relay circuits.

Should for some reason the generator breaker just close momentarily, the breaker 'a' contact, not being closed for 15 seconds, prevents the breaker anti-pump timing circuit from timing out. Thus, the synchronizer will automatically stay locked out. To reset the synchronizer, the power to the unit must be removed, then reapplied.

Had the generator breaker remained closed for more than 15 seconds, then opened, the synchronizer would proceed to reclose the breaker when synchronizing conditions were satisfactory.

The following lists various trouble symptoms and the possible defects when attempting to localize the malfunction.

Sympton - No action of any of the relays.

Possible Defect - Defective power supply, loss of a-c source to the power supply, generator breaker 'b' contact open or 'a' contact closed.

Sympton - Speed and Voltage Matcher relays operate but the synchronizing relay does not.

Possible Defect - Defective voltage acceptor card; check to be sure generator and bus system voltages are well within the voltage acceptor settings. Check for 35 volt release signal from terminal 12 to 10 on the voltage acceptor card.

Symptom - Speed matcher relays will not operate - Voltage matcher and synchronizer relays do operate.

Possible Defect - Defective speed matcher card - Remove speed matcher card and measure for correct voltages from terminals 11 and 20 to terminal 5 (common) of the converter card.

Symptom - Voltage matcher relays do not operate - Speed matcher and synchronizer relays do operate.

Possible Defect - Defective voltage matcher card - Check ac voltages at terminals 3 and 4 and 5 and 6 on voltage matcher card to determine if voltages are truly matched at these points.

Symptom - Voltage matcher relays only operate speed matcher and synchronizer inoperative.

Possible Defect - Converter card malfunction. Phase difference output voltage from terminal 1 to 5 does not vary from 0 to 39 volts as phase rotation occurs.

The following lists typical voltages at various p.c. card terminals. Caution must be exercised when measuring these voltages at the terminals not to short to adjacent terminals. The card extender is very useful in making these measurements. Always remove power from the unit when removing or replacing the p.c. cards.

The converter card voltages can be measured with all the other cards removed.

The synchronizer card check requires the converter card being plugged in the rack.

The voltage acceptor card check requires the synchronizer card being plugged in the rack.

The speed matcher card check requires the converter and the synchronizer card being plugged in the rack.

The voltage matcher card check requires the synchronizer card being plugged in the rack.

NOTE

The name of each p.c. module is stamped on the rack to locate the proper position of each card.

Converter P.C. Module

Term 5 to 7	39 V
Term 5 to 13	12 V
Term 5 to 3	50 V
Term 5 to 19	5 V
Term 5 to 20	5 V
Term 5 to 1	39 V (In Phase)
Term 5 to 1	0 V (180° Out of Phase)

Synchronizer

Term 9 to 1	50 V
Term 9 to 5	35 V (Acceptor Release Signal)
Term 9 to 5	1 V (Acceptor Block Signal)
Term 9 to 10	12 V
Term 9 to 11	39 V
Term 9 to 3	0 V (Gen. Bkr. "a" Contact Open)
Term 9 to 15	50 V
Term 9 to 17	50 V
Term 9 to 20	39 V (In Phase)
Term 9 to 20	0 V (180° Out of Phase)

Voltage Acceptor

Term 10 to 20	50 V
Term 10 to 12	35 V (Release Voltage)
Term 10 to 12	1 V (Block Voltage)

Speed Matcher

Term 10 to 9	50 V
Term 10 to 1	39 V (In Phase)
Term 10 to 1	0 V (180° Out of Phase)
Term 10 to 19	5 V
Term 10 to 20	5 V
Term 10 to 16	0-50 V (Depends on Action of K2)
Term 10 to 3	0-50 V (Depends on Action of K2)

Voltage Matcher

Term 19 to 20	50 V
Term 19 to 18	0-50 V (Depends on Action of K4)
Term 19 to 15	0-50 V (Depends on Action of K5)

An easy means in checking or trouble shooting the equipment is to temporarily connect the bus system input to both the bus system and the generator inputs. This can be done by disconnecting the generator leads from terminals 5 and 6 on the XASV terminal block.

Temporarily connect a jumper from Bus input terminal 3 to terminal 5 and from Bus input terminal 4 to terminal 6. This then presents an exact in-phase condition to the synchronizing unit. All the voltages on the p.c. cards can be checked pertaining to the in-phase condition.

Temporarily interchange lead of terminals 5 and 6 to represent an exact out-of-phase condition to the synchronizing unit. All the voltages on the p.c. cards can be checked pertaining to the out-of-phase condition.

The power supply has been precisely set for 50 volts at the factory and should not require any readjustment in the field.

Care should be used in removing the plug-in relays. They should be pulled straight out of their sockets. Pulling them out at an angle may damage the guide pin of the relay.

XIV SPARE PARTS

For stations having but one synchronizing unit, it is not recommended to carry any spares. The five printed circuit card modules are carried in stock at the factory and can be furnished on short delivery.

For stations having several synchronizing units, it is recommended to carry one each of the following:

Converter Card S# 587C358G01
Synchronizing Card S# 587C359G01
Voltage Acceptor Card S# 587C361G01
Speed Matcher Card S# 587C363G01
Voltage Matcher Card S# 587C884G01
Dust Covered Relay S# 347A023H04
P.C. Card Extender S# 588C549G01

XV DRAWINGS

Page

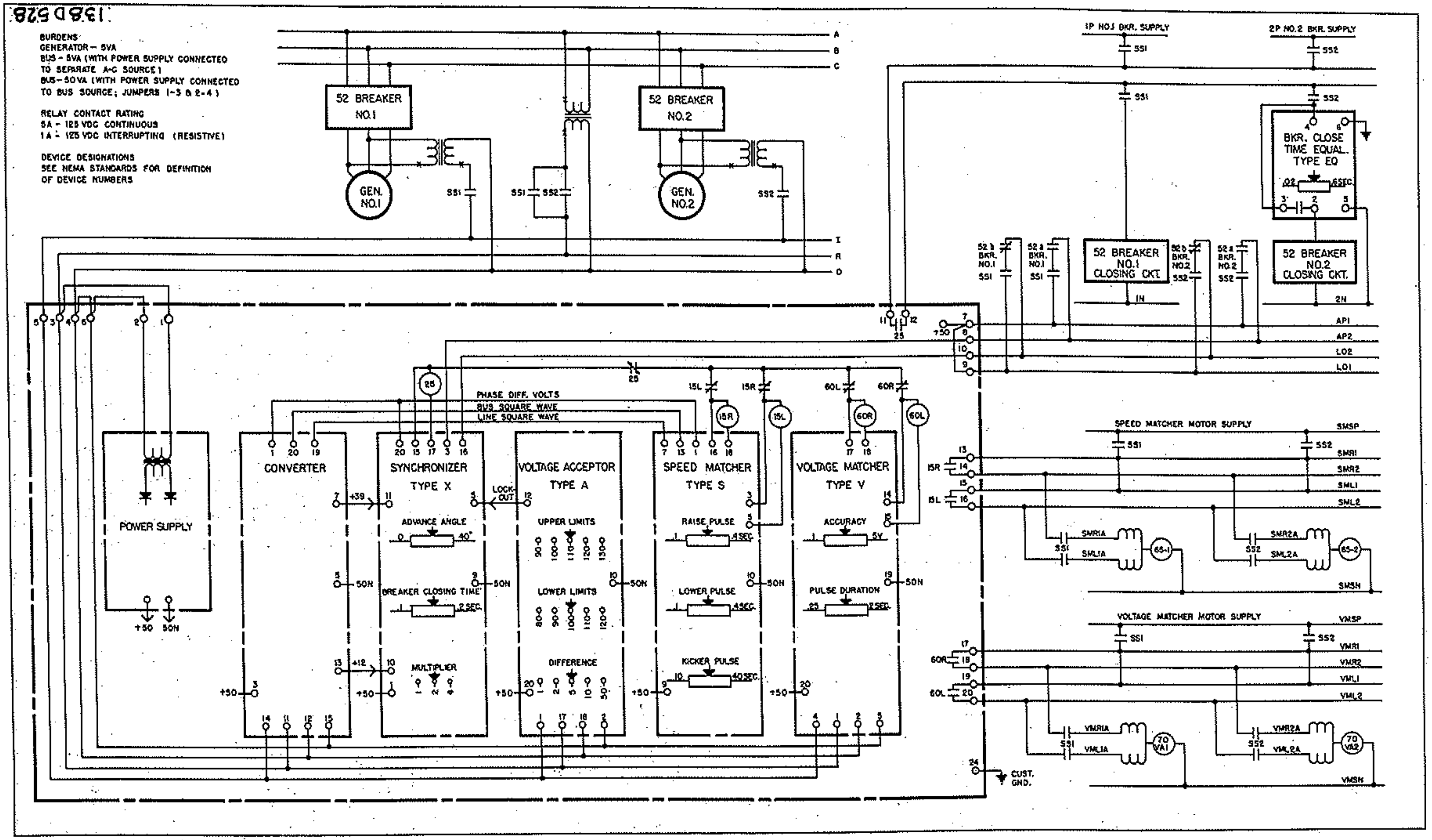


Fig. 2 Typical Application Drawing

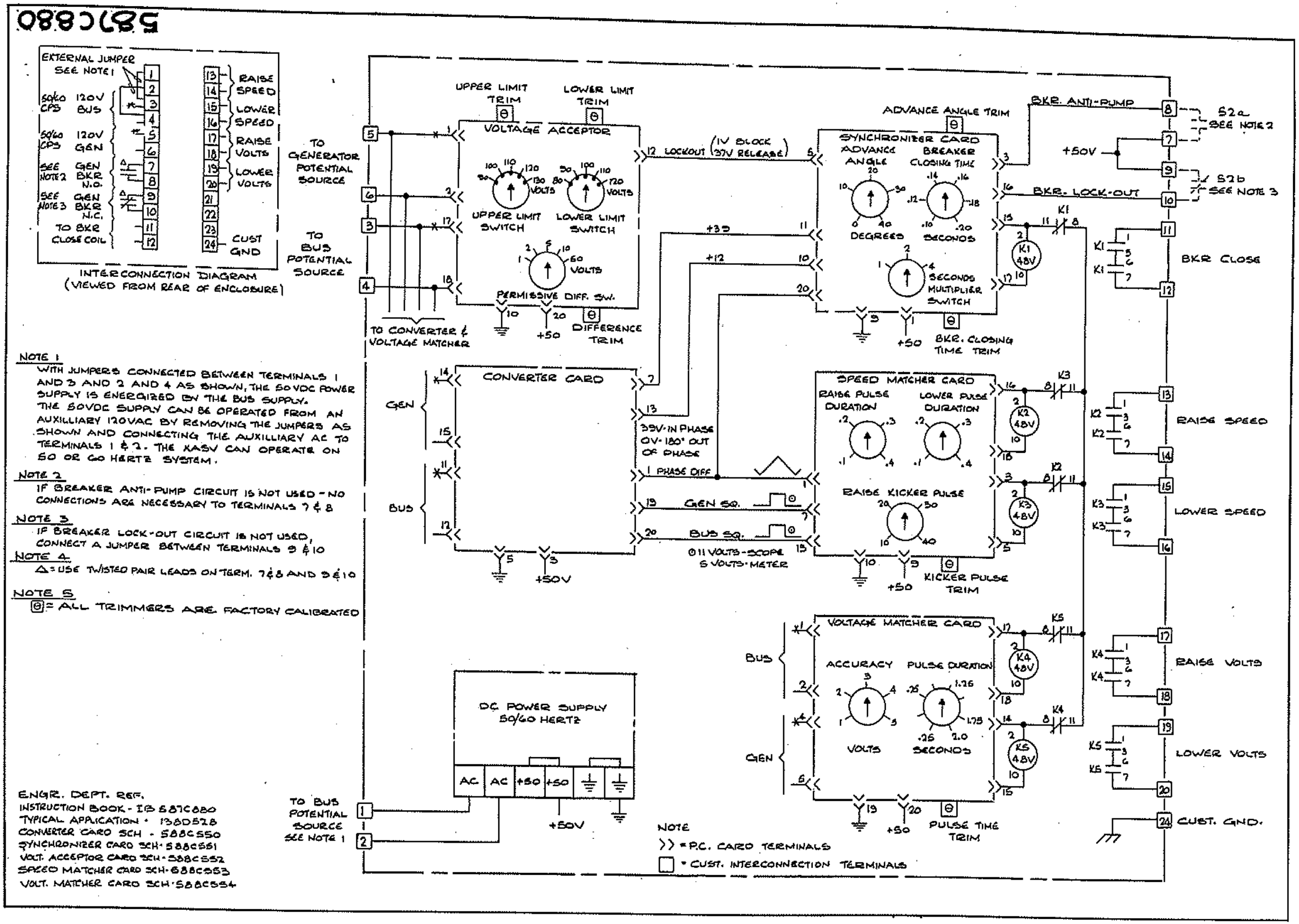


Fig. 3 Block Scheme and Interconnection

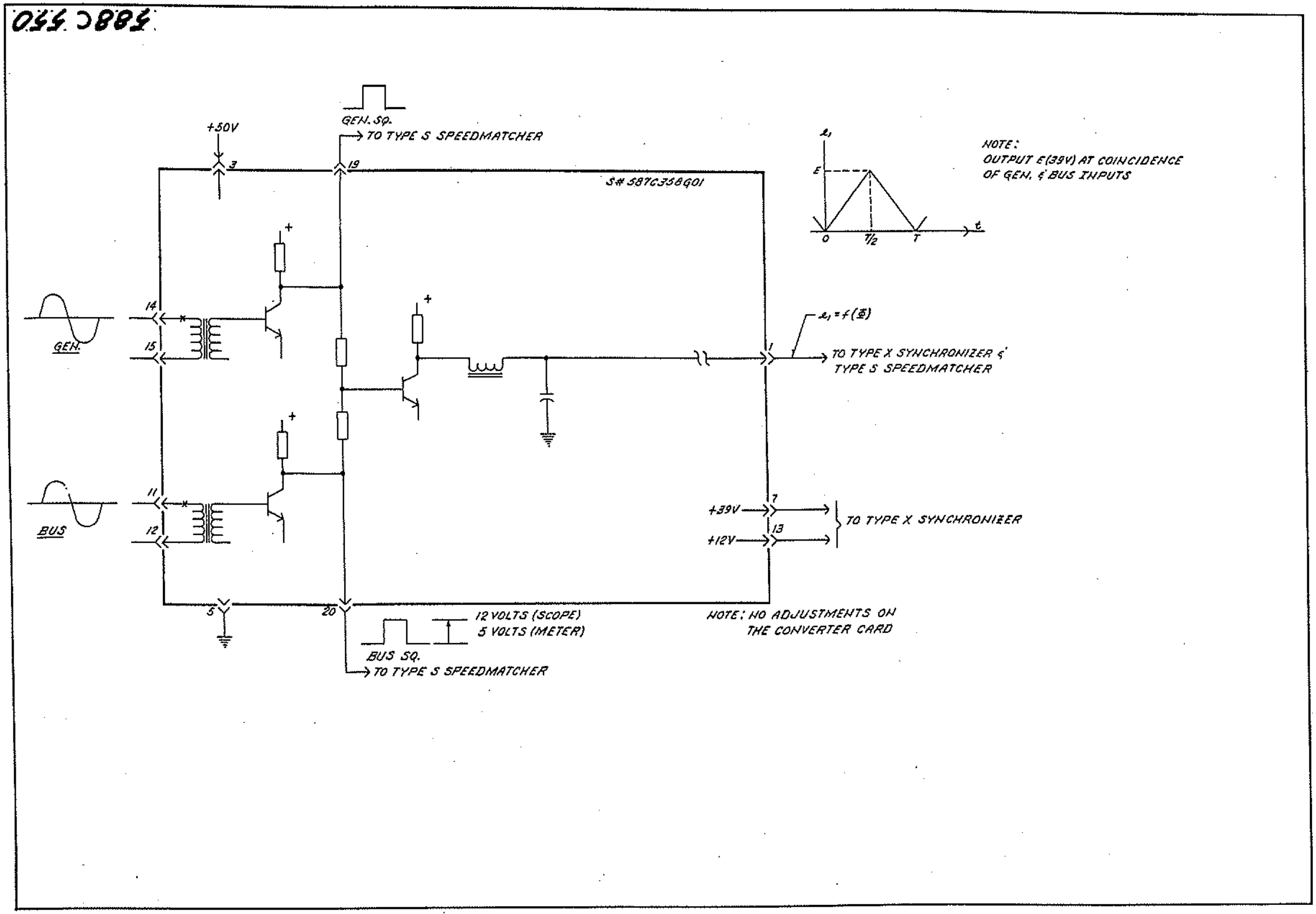


Fig. 4 Converter Module Scheme

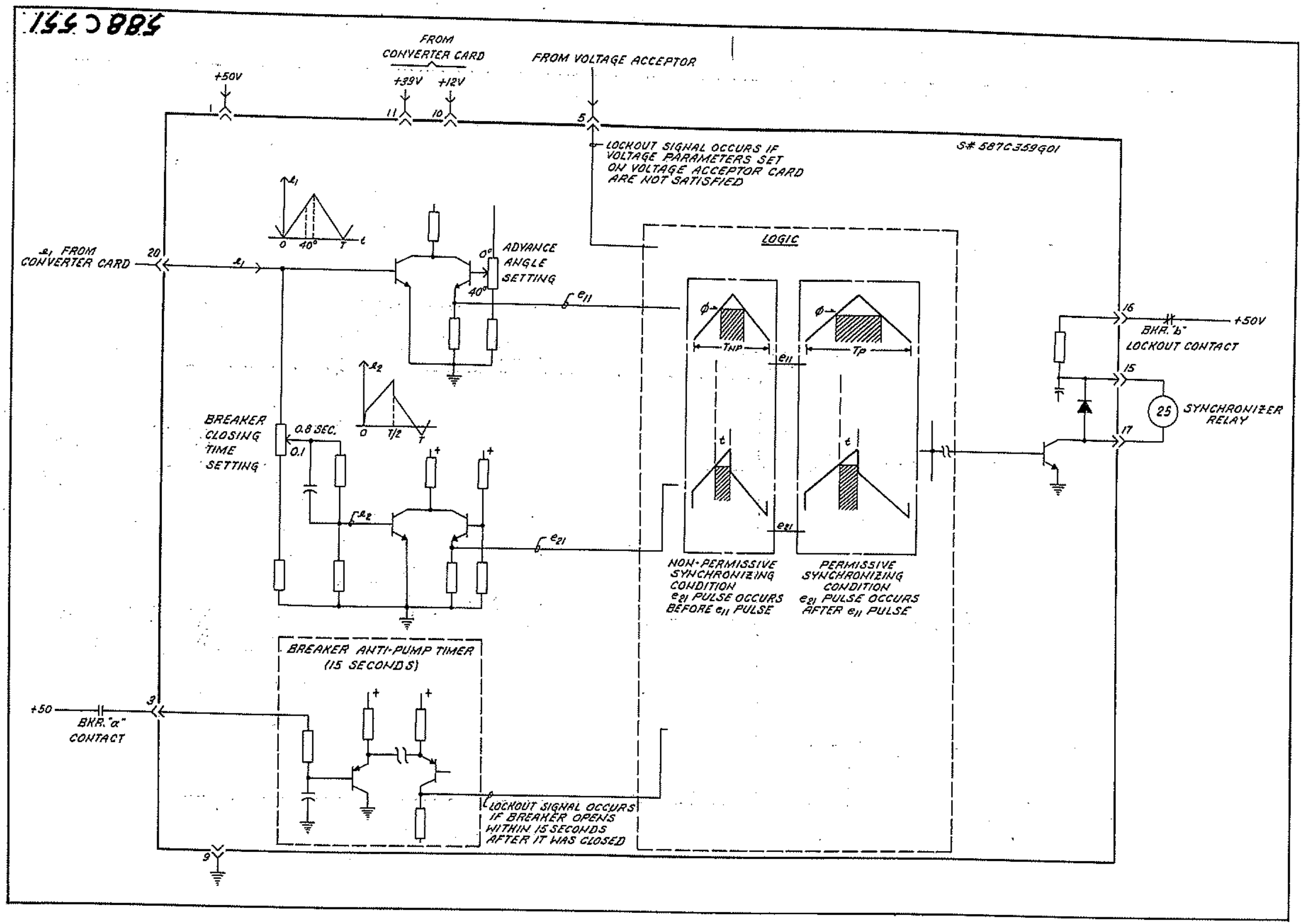


Fig. 5 Synchronizer Module Scheme

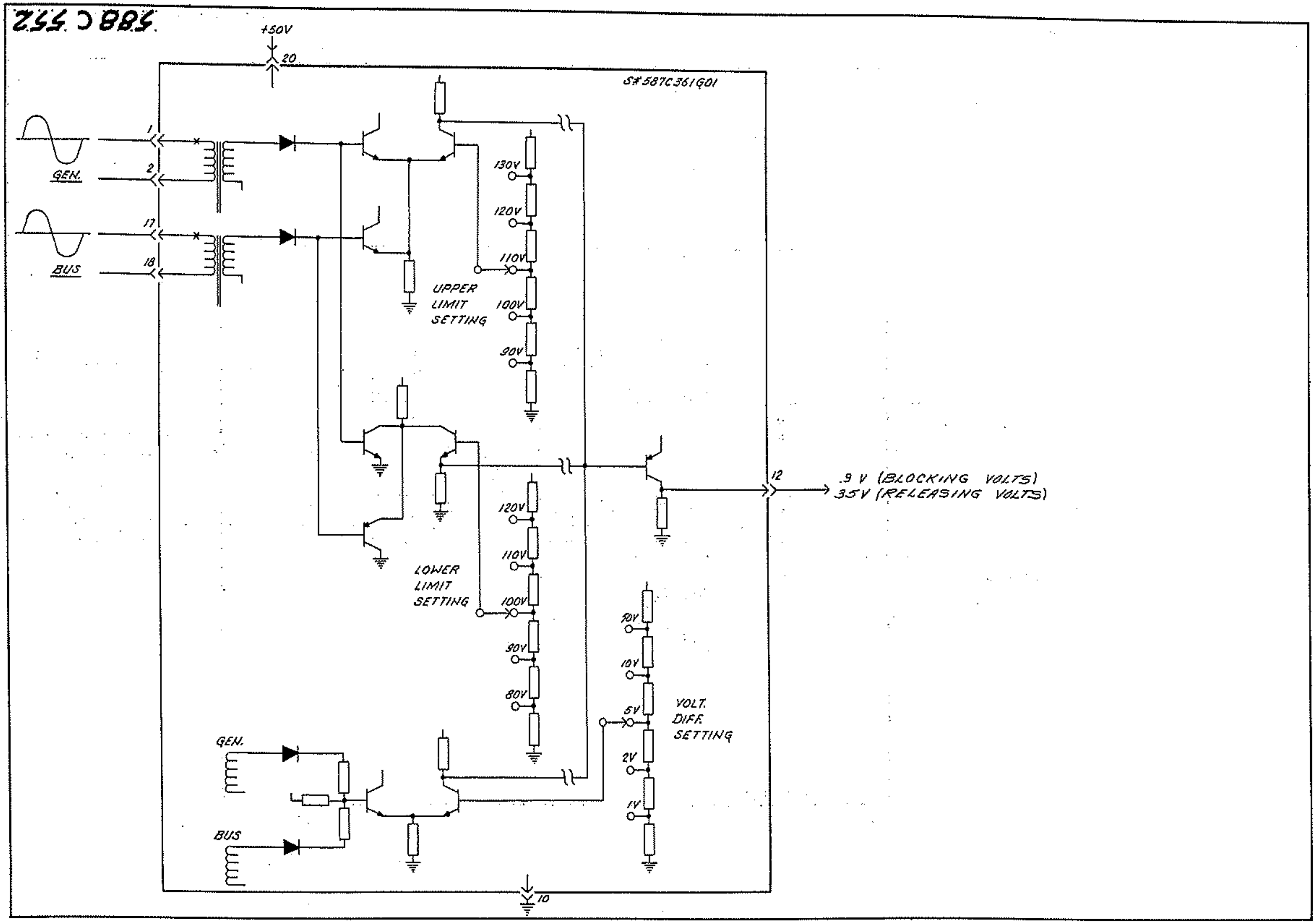


Fig. 6 Voltage Acceptor Module Scheme

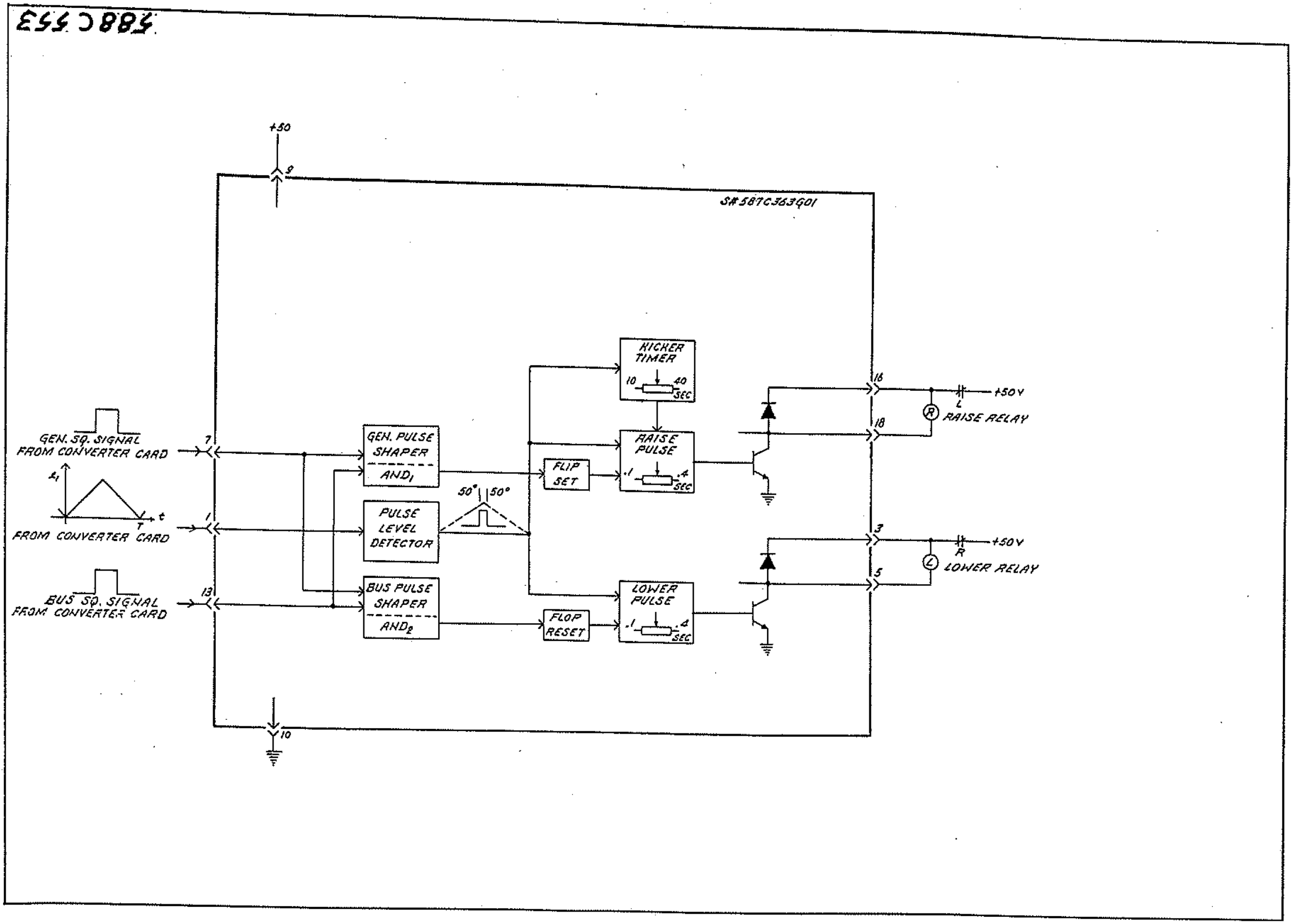


Fig. 7 Speed Matcher Module Scheme

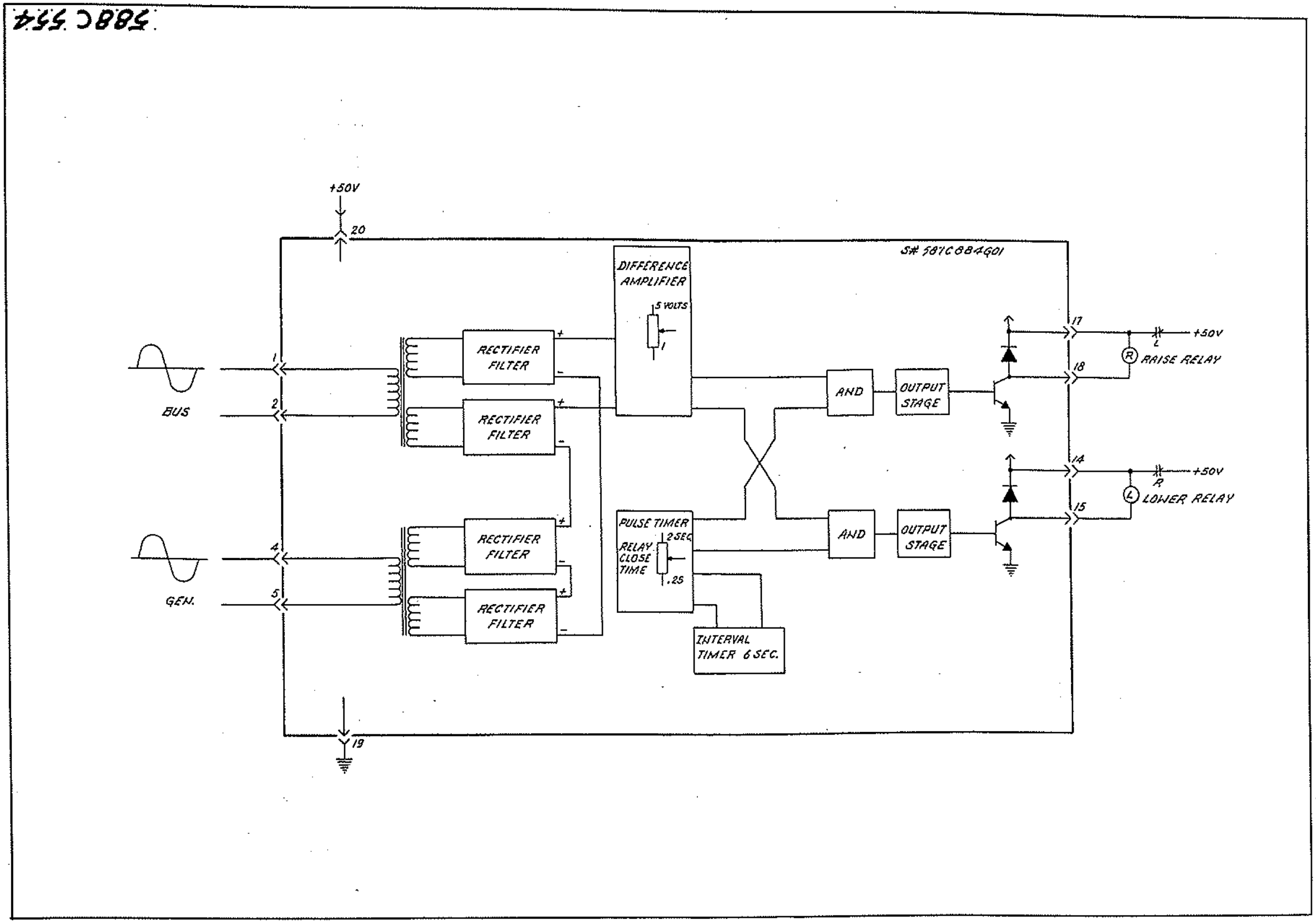
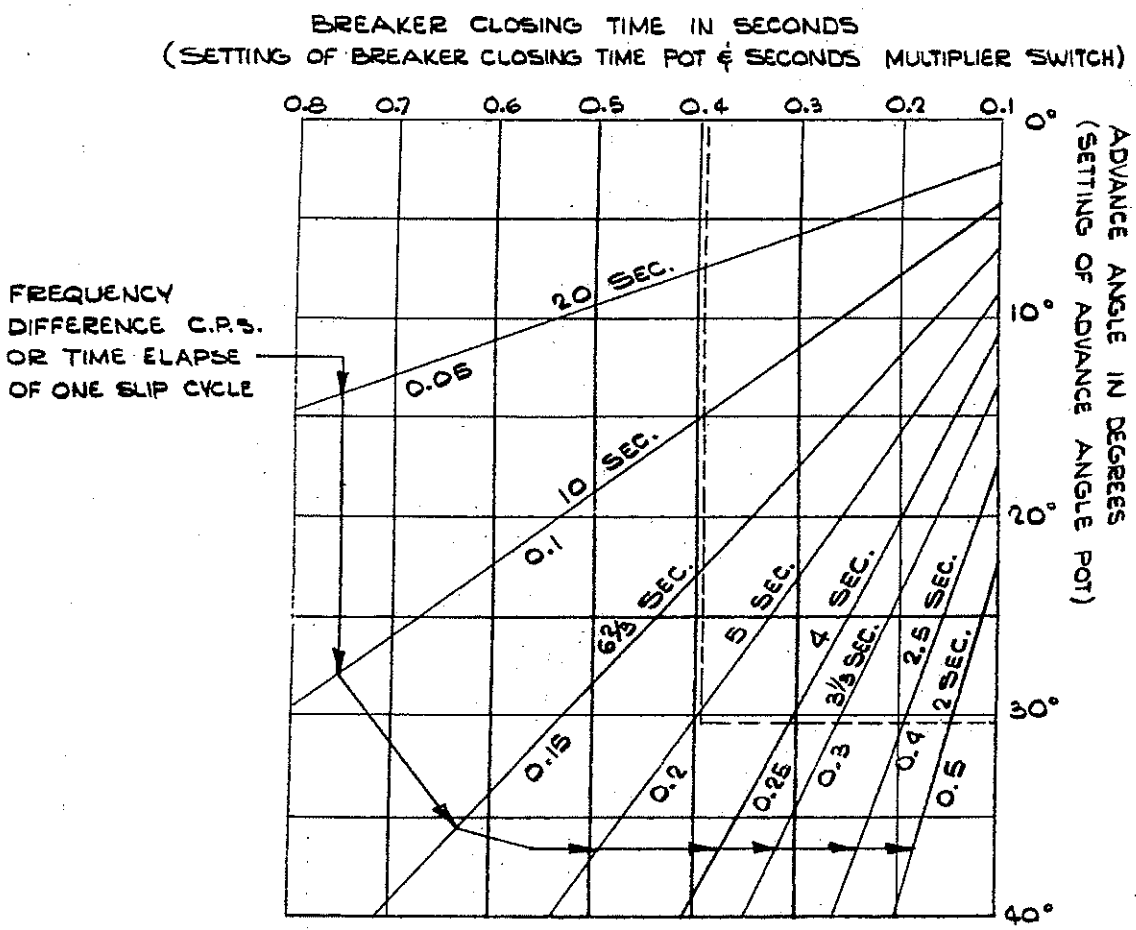


Fig. 8 Voltage Matcher Module Scheme



CURVE SHOWING BREAKER CLOSING TIME SETTING AND ADVANCE ANGLE SETTING IN RELATION TO VARIOUS FREQUENCY DIFFERENCES.

THE DOTTED LINE IS AN <u>EXAMPLE</u> SETTING FOR A BREAKER HAVING A CLOSING TIME 0.4 SECONDS AND A FREQUENCY DIFFERENCE OF 0.2 CYCLES PER SECOND. WITH THIS EXAMPLE, THE ADVANCE ANGLE SETTING WILL BE 31 DEGREES. THE SYNCHRONIZER WILL LOCK-OUT AT FREQUENCY DIFFERENCES GREATER THAN 0.2 CYCLES PER SECOND.

Fig. 9 Advance Angle Curve (Ref. 784A014)

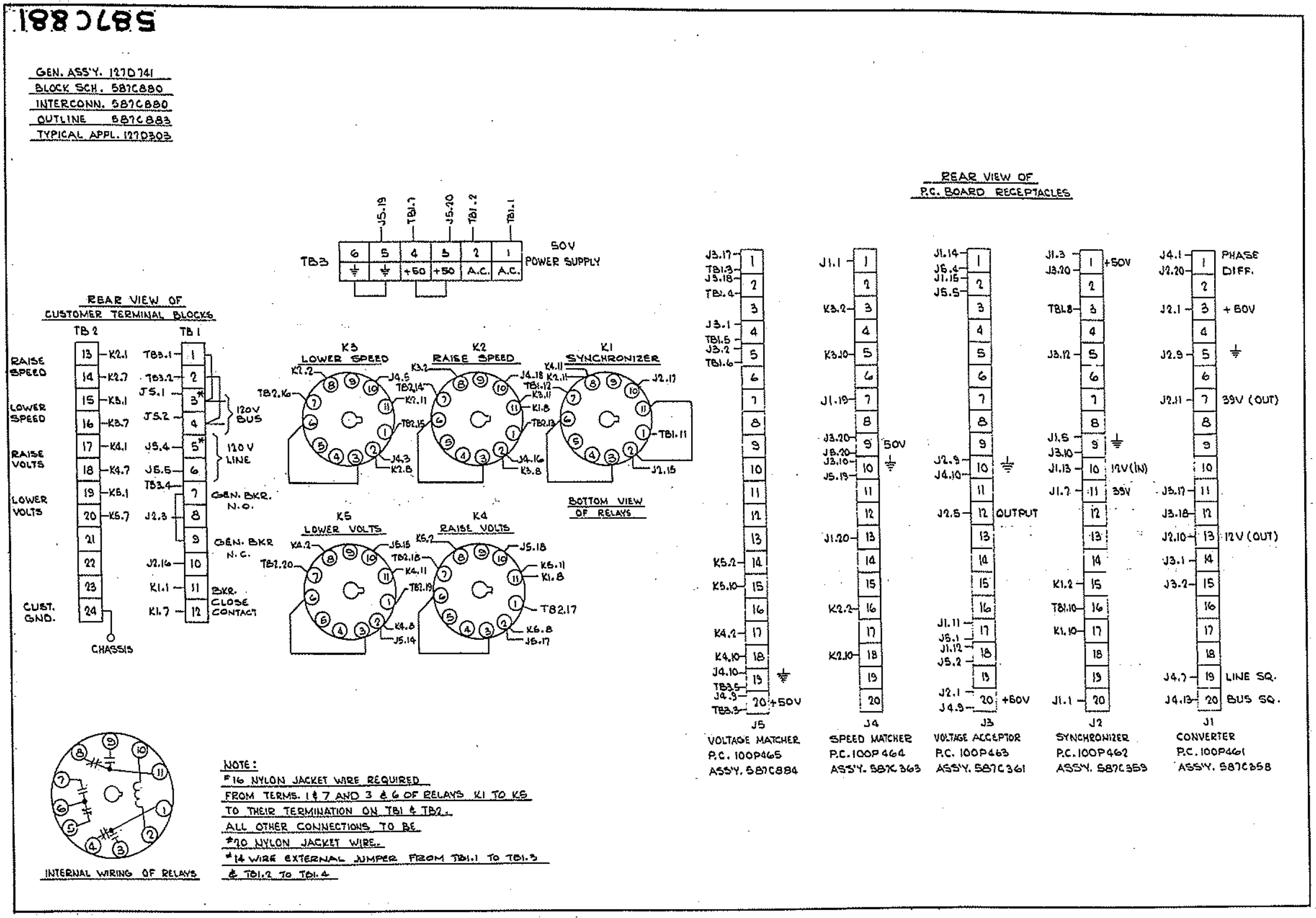


Fig. 10 Synchronizer Connection Diagram

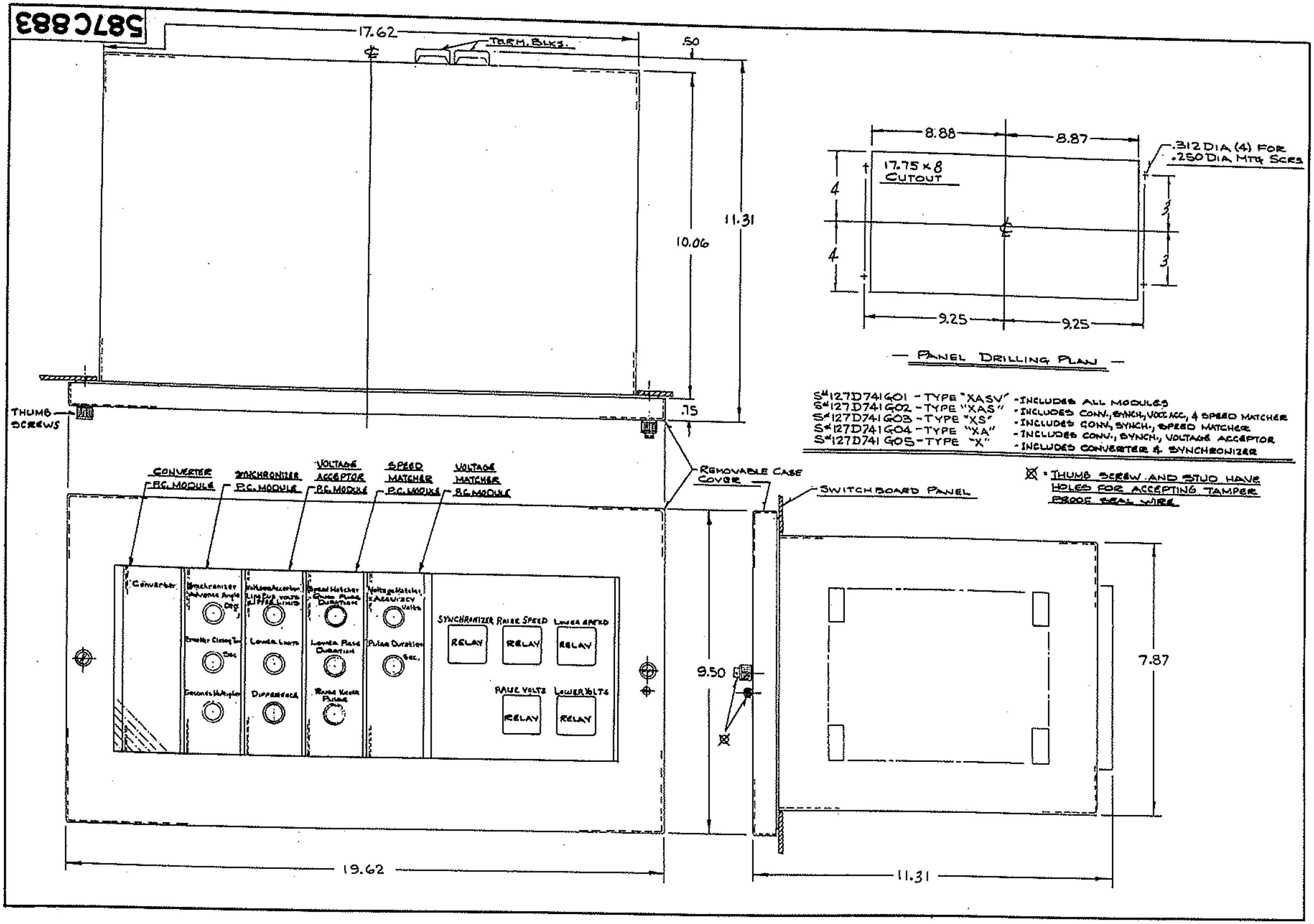


Fig. 11 XASV Outline and Drilling Plan

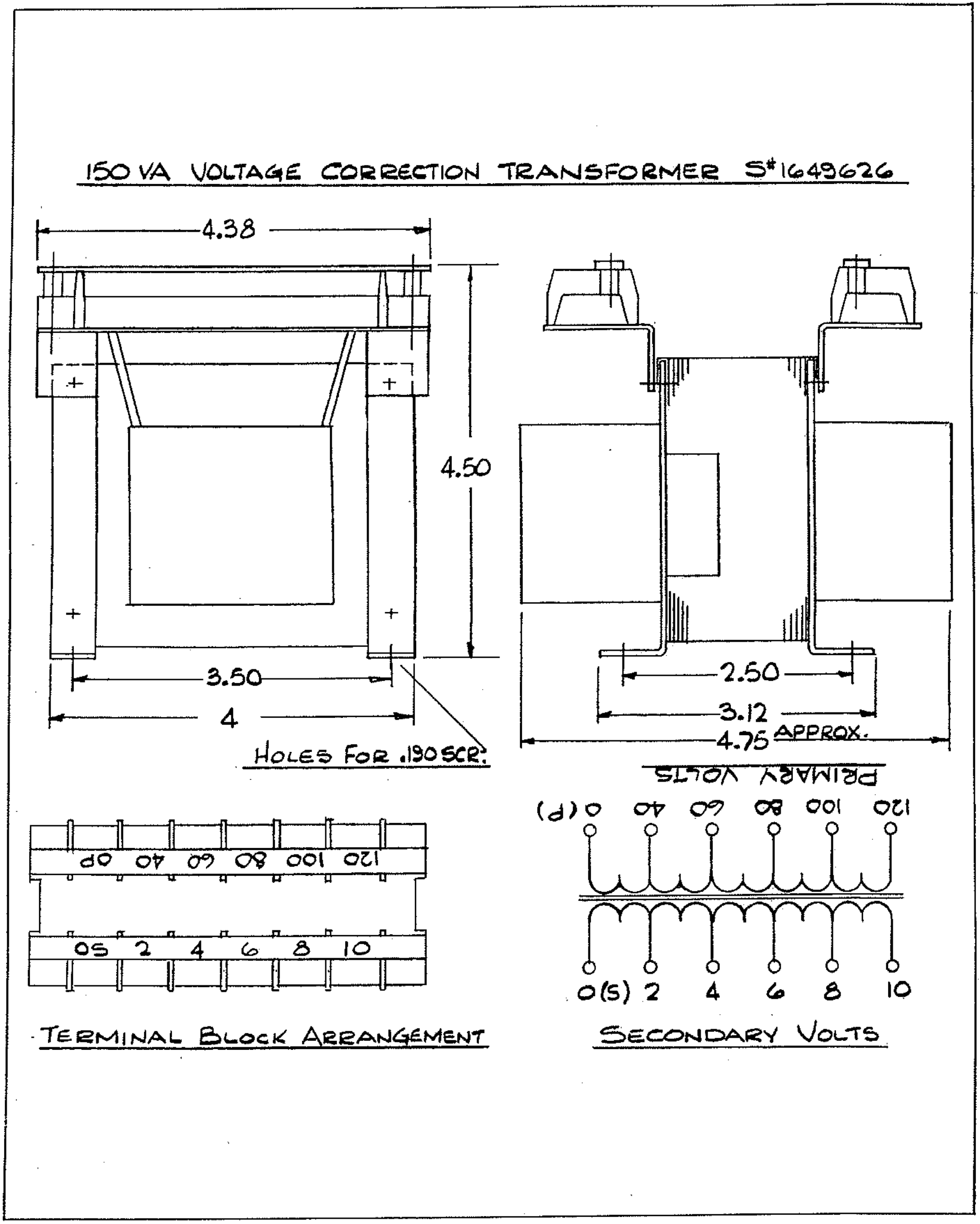


Fig. 12 Voltage Correction Transformer Outline (Ref. 784A214)

Memorandum

Memorandum