

# INSTRUCTIONS

GEK- 36851



STATIC FREQUENCY RELAY

TYPE SFF22A

**POWER SYSTEMS MANAGEMENT DEPARTMENT**

**GENERAL  ELECTRIC**

**PHILADELPHIA, PA.**

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STATIC FREQUENCY RELAY  
TYPE SFF22AINTRODUCTION

The SFF22A is a static frequency relay designed to protect a-c systems against abnormal frequency conditions. The relay employs solid state components to provide a very accurate, stable and reliable method of checking the frequency of a system. The relay consists of two functional elements called the tripping element and restore element, each containing independent frequency setting capability. When the system frequency reaches the set point frequency of either element, the relay provides an output accordingly.

DESCRIPTION

The SFF22A is a static single set point underfrequency relay with a single set point overfrequency restoration feature. It operates on a digital principle and utilizes integrated circuits to provide a highly accurate and stable detection of frequency conditions on a power system. The underfrequency trip, and overfrequency restore points of these relays may be set independently in integral steps of 0.05 hertz. These settings are repeatable within plus or minus 0.005 hertz over the complete range of rated temperature and voltage variation.

The SFF22A relay is basically a high speed device. However, adjustable time delay is included for operation with the underfrequency tripping function. There is no significant time delay in the restoration function. An external timer should be utilized for this function where time delay is required.

The underfrequency tripping output of the SFF22A incorporates two electrically separate normally open contacts with target seal-in units. These contacts close on underfrequency. The overfrequency restore output is comprised of two electrically separate normally open contacts without targets. These contacts close whenever the frequency is above the restore setting. In the deenergized condition all contacts are open.

Also included as an integral part of the SFF22A relay is a voltage cut-off feature. This is adjustable in the range of 20-90 percent of the rated AC voltage and it blocks all outputs when the voltage gets below the cut-off setting.

The SFF22A relays are furnished in M2 drawout cases. The outline and internal connections are shown in figure 6 and 3 respectively.

GENERAL APPLICATION

The SFF22A frequency relays find application wherever an extremely stable device is required to detect underfrequency, initiate load shedding, and then initiate restoration of this load when the frequency returns to normal or near normal. The minimum operating time (no intentional time delay) of the underfrequency trip output is 4.5 cycles as measured from the beginning of the first full positive going cycle of underfrequency voltage applied to the relay. Time delay up to a maximum of approximately 1.3 seconds is available by adjustment. The operating time of the restoration output is 6-8 cycles with no adjustment available. This is deemed satisfactory because restoration will generally be on a relatively long time basis for which a suitable external timer would be required as well as additional auxiliary equipment.

UNDERFREQUENCY TRIP CONSIDERATIONS

The underfrequency trip function of the SFF22A was specifically designed to be applied in underfrequency load conservation schemes where the accuracy and repeatability of the measurements are important. If a system disturbance results in some loss of generating capacity such that the load exceeds the generation, the system is in danger of collapse. The first indication of impending difficulties is a slowing down of the generators which results in a proportionately lower frequency. SFF22A relays distributed around the system will detect this condition and operate to disconnect system load in a programmed manner

***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.***

in order to compensate for the loss of generation. Such action must be taken promptly and must be of sufficient magnitude to enable the system to recover and so conserve the major part of the total system load. By preventing a complete system shutdown, restoration of the entire system to normal operation is greatly facilitated and expedited.

An overall load conservation scheme can be arranged to trip off non-essential or interruptible load as follows:

- a. Trip off blocks of load in several steps with several relays set at successively lower frequency values.
- b. Trip off blocks of load in several steps on a time basis at one level of frequency, so that as each time step is reached additional load is dropped.
- c. Any combination of (a) and (b).

It should be recognized in the application of the SFF22A relay, that during an underfrequency condition on the system if for any reason the frequency of the system goes above the underfrequency setting of the relay, for 1 cycle or more during the operating time delay, the relay will reset and the entire timing sequence will begin again. Also, these relays include an adjustable voltage cut-off feature arranged so that when the applied AC voltage gets below the cut-off setting for a time that is long enough to cause the cut-off feature to operate, the underfrequency operation is incapacitated. After the voltage returns to prior levels and the cut-off unit resets, the normal timing sequence will start. The operating level, operating time, and reset time of the undervoltage cut-off feature are described in the section entitled "RATINGS AND CHARACTERISTICS."

When applying these relays in a system load conservation program, it must be recognized that a low frequency condition does not begin to be corrected until a circuit breaker operation occurs which disconnects some load. The family of curves shown in Figure 2 is constructed to show frequency vs time to open the breaker after the disturbance starts. This is shown for a number of different rates of change of frequency. These curves can be read directly to determine the system frequency at which the load is actually removed.

The underfrequency operating characteristics of the SFF22A relay are such that an underfrequency condition must persist continuously for a minimum of about 4.5 cycles to a maximum of about 80 cycles depending on setting, before a tripping output is produced. The relay bases its measurement of frequency on the time between successive positive going zero crossings of the voltage wave. If this voltage wave is distorted in a manner so as to affect the zero crossings, and if this distortion persists for the time delay setting on the relay, it is possible for the relay to make an incorrect measurement of fundamental system frequency. Longer time delay settings make this less likely to occur.

In the application of underfrequency relays the location of the potential source from which the relay makes its frequency measurement is an important consideration. In general it is not good practice to supply a relay from a potential source that is connected to one bus section and use that relay to shed load on another bus section. Experience has indicated that the voltage and frequency of circuits to which motor load is connected do not go to zero immediately when the circuits are deenergized. Rather, both the voltage and the frequency often decay at different rates depending on the characteristics of the circuit and the load. An underfrequency relay supplied from a potential source that is connected in a motor circuit could operate when the motor circuit is deenergized and the frequency decays to a value below the trip setting. Thus, if an underfrequency relay is supplied with potential from a source on a motor circuit and is connected to trip a second circuit, loss of the motor circuit could cause the relay to operate, as the frequency decays, and this would result in the loss of the second circuit also. In summary, this faulty operation is caused by frequency decay, if the voltage remains above the under voltage cut-off level until the relay time delay setting (if any) expires.

It is obvious that the most desirable solution to this possible source of trouble is to arrange the underfrequency relays on the system in such a way as to eliminate the opportunity for this type of undesired operation.

Where this cannot be accomplished, longer time delay settings and/or a higher voltage cut-off setting will make the scheme less susceptible to operations of this kind.

### OVERFREQUENCY RESTORE CONSIDERATIONS

The overfrequency restore function of the SFF22A was designed to operate in conjunction with the underfrequency trip function in load conservation schemes where extreme accuracy and repeatability of setting is required to insure the desired load restoration pattern.

Load restoration is most desirably accomplished at normal system frequency. However, in order to expedite the process, it may be desirable to begin slightly below this value. In any case, automatic restoration should not be permitted until the frequency is substantially above that which may damage turbines or significantly curtail the outputs of generator auxiliary motors. It must also be sufficiently above the underfrequency trip setting so that pumping does not take place as blocks of load are restored.

If the restore frequency setting of this relay is at or very close to rated frequency, and if the continuous variations in normal frequencies are such that the restore function output relay will pick-up and drop-out continually, the life of the output relay may be shortened. For such applications another type of SFF relay is available in which facilities are included that permit the restore function to be incapacitated except during the interval from after the relay has operated to shed load until the load shed by the relay has been restored. Contact your local General Electric Sales Office for more information on this device.

In general, substantial time delay (in the order of minutes rather than cycles) should be used in the automatic restoration scheme. Also, it appears desirable to time-step the restoration so that the total shed load is restored in small blocks with significant time between each step. In this way as each small block of load is restored, the system has a chance to absorb this load and settle at its new frequency. If this frequency does not fall below the restoration frequency then the next load block is switched on after a time delay. If the restoration of a load block causes a drop in frequency below the restoration point, this signifies that the system is loaded beyond its full capacity and the restore contacts on the SFF22A relays will open to prevent any further restoration until action is taken to increase the system capability.

It is obvious that a load conservation scheme including automatic restoration will require auxiliary functions in addition to the SFF22A relays. The functions will depend on the exact scheme to be employed which in turn would to some degree depend on such factors as, the presence of automatic reclosing relays, the presence of supervisory control, the desire for voltage magnitude supervision, and possibly power pool agreements. However, regardless of the exact scheme, a long time delay will be required for the restoration function. The characteristics of this timer could be an important factor in the overall performance of the restoration scheme.

Since the restoration timers will be set for long time delays, it is essential that they do not reset as a result of transient system disturbances that may momentarily reset the restore output of the associated SFF relays. For example, if such a disturbance causes the a-c voltage to the SFF22A relay to drop below the voltage relay cut-off setting this will incapacitate the restore function and tend to reset (open) the output contacts. This action is explained in the section under CHARACTERISTICS. However, the output relay in the restore function has been provided with a time delay drop out of about 15 cycles. Therefore, once the restore contacts close on overfrequency, they will not open as a result of short duration loss or reduction of a-c and/or d-c inputs to the relay. Specifically, the performance of the SFF22A is such that the restore feature, once operated, will provide a continuous output (closed contacts) even in the face of loss of a-c and/or d-c inputs for as long as 8 cycles out of every 15 cycles. This would override high speed clearing of transmission line faults that might occur during the restoration period.

It appears quite possible that during the restoration process, the system frequency could momentarily drop below the restoration setting of the SFF relays. This would cause the restore outputs of all these relays to reset which would leave the associated timers without input. If the timers are quick to reset, the restoration program will be delayed. Thus, consideration should be given to the employment of a slow reset or integrating timer; that is, one which does not reset when the input is removed even for significant times, but rather "notches up" as the input is applied and removed.

Since there is no "standard" scheme for the application of load conservation with automatic restoration, no complete external connection diagram is included. However, figure (4) illustrates the a-c and d-c input connections as well as the contact trip and restore outputs.

### RATINGS AND CHARACTERISTICS

Type SFF22A relays are intended for use on 60 Hz power systems with rated voltage of 120 volts. A 50 Hz relay is available.

FREQUENCY SETTING RANGES

On the front of the relay there are 2 frequency set point blocks. The upper block is for trip point settings and the lower one for restore point settings. Each block has 10 two position tap plugs. The upper position denotes a binary "0" and the lower position a binary "1".

Both the trip and restore functions can be set independently in the range of 54.2 Hz to 60.9 Hz in increments of 0.05 Hz. Refer to Table I for tap plug positions versus operating frequency.

SET POINT ACCURACY

Both the trip and restore functions are accurate to  $\pm 0.005$  Hz.

RELAY AMBIENT TEMPERATURES

The SFF22 relay performance is designed for operation in environments where the case ambient temperature ranges from  $-20^{\circ}\text{C}$  to  $+60^{\circ}\text{C}$ .

TIME DELAYSa. TRIP TIME DELAY

The time delay from occurrence of a system underfrequency condition to closure of the trip (TR) telephone relay contacts is  $4\frac{1}{2}$  to 80 cycles, continuously adjustable. Repeatability is  $\pm 1\%$  of the setting which is adjusted by means of time delay rheostat located on the front panel.

The time delay from the absence of a system underfrequency condition to opening of the "TR" relay contacts is 4 to 6 cycles. One and one half cycle maximum of this time delay is in the frequency sensing element. The rest is in the TR telephone relay. Note that time measurement is made on a 60 Hertz basis.

b. RESTORE TIME DELAY

The time delay from occurrence of a system "non-restore" condition to opening of the restore (RS) telephone relay contacts is a fixed 15 to 16 cycles, 15 cycles of which is attributed to energy storage in the RS relay.

The time delay from the occurrence of a system "restore" condition to closure of the "RS" relay contacts is a fixed 6 to 8 cycles, 5 cycles of which is attributed to the restore frequency sensing circuitry.

UNDERVOLTAGE INHIBIT

An undervoltage circuit inhibits operation of both the trip and the restore telephone relays when the system voltage falls below the voltage setting. The operating point is adjustable from 20% to 90% of the rated AC voltage by a rheostat mounted on the front of the relay.

EXTERNAL RESTORE TIMER CHARACTERISTICS

It appears quite possible that during the restoration process, the system frequency could drop below the restoration setting of the SFF relays. This would cause the restore outputs of all these relays to reset which would leave the associated timers without input. If the timers are quick to reset, the restoration program will be delayed. Thus, consideration should be given to the employment of an integrating timer; that is, one which does not reset when the input is removed even for significant times, but rather "notches up" as the input is applied and removed.

Since there is no "standard" scheme for the application of load conversation with automatic restoration no complete external connection diagram is included. However, figure (4) illustrates the a-c and d-c input connections as well as the contact trip and restore outputs.

BURDENS

The burden on the AC input terminal pair (studs 2-4), is 3.1 Volt-Amperes; 2.70 Watts, 1.60 Vars (inductive) at 115 Volts, 60 Hz.

DC control power burden is 0.6 amps or less.

CONTACTS

Contact ratings ("TR" and "RS" telephone relays) for the SFF22A are listed in Table II.

VERY LOW FREQUENCIES

At frequencies below approximately 40 Hz the trip unit will open its contacts. The restore unit will not close its contacts.

TABLE II

TELEPHONE RELAY CONTACT INTERRUPTING RATINGS

VOLTS	INTERRUPTING AMPS	
	INDUCTIVE*	NON-INDUCTIVE
24/48 DC	1.0	3.0
125 DC	0.5	1.5
250 DC	0.25	0.25
115-60 CYC.	0.75	2.0
230-60 CYC.	0.5	1.0

\* Inductance of average trip coil.

TARGETS

Target ratings are shown in Table III.

TABLE III

TARGET COIL

	2 AMP TAP	0.2 AMP TAP
DC RESISTANCE	0.13 OHMS	7 OHMS
MINIMUM OPERATING	2.0 AMPS	0.2 AMPS
CARRY CONTINUOUSLY	3.0 AMPS	0.30 AMPS
CARRY 30 AMPS FOR	4 SECONDS	-----
CARRY 10 AMPS FOR	30 SECONDS	0.2 SECONDS

If the trip current exceeds 30 amperes, it is recommended that an auxiliary tripping relay be used.

OPERATING PRINCIPLES

BASIC FREQUENCY MEASURING CONCEPT

The SFF22A relay measures the power system frequency by comparing it with a reference frequency internally generated by a precise, crystal controlled oscillator. It does this by measuring the time period of each power system voltage cycle and comparing it to a fixed time interval produced from the internal frequency reference. The period of a sine wave and its frequency are related by the formula

$$T = \frac{1}{F}$$

Where T is the period in seconds and F is the frequency in Hertz or cycles per second

so that a measurement of the period contains the same information as a measurement of frequency but in a different form. A larger (longer) period corresponds to a smaller (lower) frequency. For example, 60 Hz corresponds to 0.01667 seconds, 55 Hz to 0.018182 seconds and 50 Hz to 0.020000 seconds.

An underfrequency condition exists when the system frequency is below the frequency setting of the relay. This corresponds to a system period longer than the fixed period set in the relay.

A detailed description of the relay follows. The numbers in parenthesis refer to the relay block diagram, Figure 5.

The SFF22A relay receives its power from the station battery (48, 125 or 250VDC). The power is first fed into an RF filter (18) which consists of a Pi L-C filter. This filter prevents surges from getting into the logic DC power. The filtered DC is then fed into the shunt zener regulator power supply (19) where reference voltages of +10 VDC, +5VDC, -10VDC are derived. The residual voltage from the battery is dropped across an externally mounted power resistor. As shown on the diagram, these DC voltages are then fed to the various logic elements of the relay.

As in the case of the DC, the power system voltage to be monitored is fed into an RF L-C filter (1) to prevent AC system surges from entering the circuitry. The filtered AC is then fed into a step-up isolation transformer. This output goes to two function elements: signal conditioning (2) and under-voltage detection (7). The signal conditioner minimizes the effects of DC offset and other transients. In addition to filtering, the signal conditioner also "slips" the AC voltage to logic levels.

The zero crossing detector (3) takes the clipped AC signal and senses each positive going zero crossing. Its output is in the form of a very narrow negative going pulse at each positive going zero crossing. The time between pulses is then the time period for the system voltage. If the system frequency decreases then the time between pulses will increase.

Function block (4) is a fixed 2 MHz crystal controlled clock generator (this clock would be a 1.67 MHz clock in a 50 hertz relay). The buffer amplifies (5) divides the 2 MHz sine wave clock signal by 4 giving a 500 K Hz signal. Its output is a fixed amplitude square wave. This 500 K Hz signal is the input to the binary counter. Its period is 1/500 K Hz or 2 microseconds. However it is positive (high) for one half of its period or 1 microsecond and negative (low) for the other half so that it can be said to have a base (half cycle period) of one microsecond. The binary counter (6) consists of 14 cascaded integrated circuits each one of which has an output whose frequency is one half its input. The number of base 1 microsecond intervals in the output of each of the 14 integrated circuits are as follows:

Half cycle period (Base) in microseconds

1 <sup>st</sup>	--	2
2 <sup>nd</sup>	--	4
3 <sup>rd</sup>	--	8
4 <sup>th</sup>	--	16
5 <sup>th</sup>	--	32
6 <sup>th</sup>	--	64
7 <sup>th</sup>	--	128
8 <sup>th</sup>	--	256
9 <sup>th</sup>	--	512
10 <sup>th</sup>	--	1024
11 <sup>th</sup>	--	2048
12 <sup>th</sup>	--	4096
13 <sup>th</sup>	--	8192
14 <sup>th</sup>	--	16384

Note that 16384 1 microsecond bits amount to 16.384 milliseconds of time which converted to frequency equals approximately 61 hertz, the upper end of frequency range for the SFF22A.

By adding combinations of output bits from the first 10 integrated circuits through adjustment of the frequency set blocks (8) and (9), a total of (16384 + 2046) equals 18430 bits can be accumulated which, in time, amounts to 18.43 milliseconds or a frequency of approximately 54.2 hertz, the lower end of frequency range for this relay.

The zero crossing pulses reset the counter every time they appear. If the time interval between zero crossing pulses is long enough to allow the counter to count all the bits prescribed by the trip frequency set block (8) without resetting, then the trip comparison logic (10) senses an underfrequency condition and puts out a negative going "underfrequency pulse". Conversely, if the time interval between zero crossing pulses was so short so as to reset the counter before the set block prescribed number of bits have been counted, then NO underfrequency pulse appears at the output of (10) and the relay begins to monitor the next cycle.



### TRIP COMPARISON LOGIC

The trip comparison logic (10) senses that the counter (6) has counted the number of pulses set in the trip frequency set block and puts out a pulse. It will continue to put out one pulse each power system cycle as long as the power system frequency remains below the trip set point.

If the counter (6) is reset by the next positive going zero crossing pulse before it reaches the number set in the trip frequency set block then the frequency is higher than the set point. In this case the trip comparison logic does not put out a pulse.

The "count of 3 cycles" function block (11) counts 3 underfrequency pulses coming from (10) (3 underfrequency cycles) before the adjustable trip timer (12) is allowed to begin timing. In the absence of an underfrequency condition, no underfrequency pulses come from (10). The uninhibited relaxation oscillator (13) with a 24 millisecond period, puts out reset pulses to both the "count of 3" circuit (11) and the actuating circuit (14) every 24 milliseconds. When underfrequency is sensed, the first and subsequent underfrequency pulses from (10) immediately inhibit (13) from preventing (11) and (14) to operate. Function (11) then counts 3 underfrequency pulses and puts out a DC signal when the count is filled. After 3 cycles of time, function (12) begins timing out. If the underfrequency condition lasts longer than the setting on the adjustable trip timer (0-77 cycles...60 Hz basis), function (12) transmits a signal to function (14) which immediately energizes the trip telephone relay (TR). The TR contacts will close less than 1 cycle from the time that function (14) energizes the "TR" relay.

If the underfrequency condition disappears before the adjustable timer (12) times out, the absence of underfrequency pulses from (10) allows the 24 millisecond timer (13) to run freely again, thereby resetting both functions (11) and (14) simultaneously, preventing closure of the TR relay contacts. Note that resetting function (11) automatically resets the adjustable timer. Note also that once the actuating circuit has been energized by (12) it will stay in this state until the underfrequency condition has disappeared.

### RESTORE FUNCTION BASIC CONCEPT

Referring to functional block diagram (Figure 5) the basic clock generation, zero crossing detection and binary counting for the restore function (RS) are the same elements as for the trip function described in the previous section.

The difference first appears at the comparison logic elements....(10) for trip, (15) for restore. In essence, the trip frequency set block (8) and the restore frequency set block (9) are parallel elements which provide an independent means of adding multiples of time bits per the previous discussion.

The restore scheme works in an "inverse" fashion to that of the trip scheme. Like the trip function when the system frequency is below the setting of the restore function, pulses appear at both the A and B outputs of (15). The pulses out of "A", however, inhibit the fixed 5 cycle restore timer (16) from timing out. Similarly, the pulses out of "B" reset the restore actuating and output circuit (17) and prevent it from operating. Thus, for underfrequency conditions with respect to the restore setting, the RS relay remains open.

When the system frequency is above the restore setting, the restore comparison logic outputs "A" and "B" respectively, stop pulsing. The absence of pulses at "A" permits the function (16) to begin timing out while the absence of pulses at "B" prevents resetting the actuating circuitry (17). Five cycles after the overfrequency condition has occurred, function (16) will have timed out and the restore actuating circuitry will be energized. Since the "RS" relay contacts will close approximately two cycles after the output circuitry is energized, the overfrequency condition must last for at least 7 cycles before closure of the RS contacts can be realized. Should an underfrequency condition occur before the 7 cycles of time have expired, then the underfrequency pulses at "A" and "B" would automatically reset both the timer and the actuating circuit and no contact closure would result. If, however, the overfrequency condition lasts for greater than 7 cycles allowing the RS relay to pick up, the RS contacts would stay closed for at least 15 cycles due to energy storage in the telephone relay copper slug. The restore actuating circuit and 5 cycle timer, however, will immediately reset when frequency drops below the restore set point.

### UNDERVOLTAGE DETECTION

Function (7) consists of a continuously adjustable voltage detector (20% to 90% of rated input voltage) which monitors the system voltage. On many power systems, it is practical and desirable to prevent frequency relaying functions from operating when the magnitude of the system voltage dips below a certain level. The undervoltage detector (7) operates in less than 12 milliseconds when the system

voltage drops below its setting to prevent either the TR or RS contacts from closing. If before the disturbance, the "RS" contacts were closed, they will open in about 15 3/4 cycles. Similarly, if the "TR" contacts were open before the disturbance, they will remain open.

When the detector senses an undervoltage condition, output D of function (7) immediately stops the clock thus preventing any further accumulation of bits in the counter. The next positive zero crossing erases any previously stored counts on the counter and the trip function is inhibited at least until the undervoltage condition has passed. Since the restore circuitry operates in the absence of pulses (clock is stopped), output C of function (7) must also supervise the restore comparison logic (15) and actuating a circuit (17) in order to prevent operation of the RS telephone relay. In any event, the RS contacts will remain open at least until the system voltage rises above the setting of the undervoltage detector.

CONSTRUCTION

The greater part of static circuitry is located on the three printed circuit boards contained in the relay. The PC board name assignments and respective part number are as follows:

<u>Board Number</u>	<u>Function</u>	<u>Assembly Number</u>
(3)	Clock Generator Board	0138B7935G-3
(2)	Main Counter Board	0138B7937G-11
(1)	Frequency Set Point Board	0108B9220G-1

These boards are fastened vertically to the cradle: Board #1 is the outermost, #2, the middle, and #3, the innermost. Board (1) and Board (2) are interconnected by a 29 conductor socket and cable assembly in addition to the conventional terminal post.

The trip time delay rheostat is the uppermost of the two rheostats mounted on the front panel. The lower of the two is the undervoltage level adjust.

The (2) trip target and seal-in units are located in the upper corners of the relay.

The larger telephone relay with the copper slug on the left side of the relay is the restore (RS) relay.

The small telephone relay on the right side of the relay is the trip (TR) relay.

The upper set point block on the front of the SFF is for TRIP function frequency settings. The lower block is for RESTORE function frequency. On both set point blocks, the upper plug position is the zero position and the lower is the one position.

CALCULATION AND METHOD OF SETTINGS

The "TRIP" frequency set block is the upper of the two set blocks on the front of the relay. The other is the "RESTORE" frequency set block. The upper of the two plug positions on a set point block represents a binary "0", the lower similarly represents a binary "1".

The difference in operating frequency between the "TR" and "RS" functions for identical set plug positions is  $\pm 0.001$  Hz.

The relation of set plug combinations (for both the "TR" and "RS" functions) for operating frequencies in the range of 54.20 Hz to 60.90 Hz in increments of 0.05 Hz is given in Table I. Closer settings, if required, can be specified by referring the matter to the General Electric Company.

For illustration purposes, assume that the following operating frequencies are desired:

TRIP = 57.75 Hz  
 RESTORE = 59.25 Hz

The set plugs will be placed in the following combinations per Table I to obtain a trip frequency of  $57.75 + F_c$  Hz and restore frequency of  $59.25 + F_c$  Hz.

	A	B	C	D	E	F	G	H	J	K
	TRIP									
0	X	X	X		X	X	X			
1				X				X	X	X
	RESTORE									
0		X			X		X	X		
1	X	X	X	X		X			X	X

Note, that  $F_c$  (Calibration Frequency) is a number stamped on the nameplate and marked on the relay cradle usually of value less than  $\pm 0.006$  Hz. Note, also, that algebraic sign associated with this number is significant.

Assuming for a particular relay that the value of  $F_c$  is  $+0.008$  Hz, the actual trip and restore operating frequencies per the above settings become:

$$\begin{aligned} \text{TRIP} &= 57.7508 \text{ Hz} \\ \text{RESTORE} &= 59.2508 \text{ Hz} \end{aligned}$$

FREQUENCY SETTINGS FINER THAN 0.05 HZ

Settings can be made for frequency between those given in the tables by using interpolation and the table of weights below.

POSITION	A	B	C	D	E	F	G	H	J	K
WEIGHT	1	2	4	8	16	32	512	256	128	64

Example: The desired setting is 58.98 Hz.

The tap plugs in the lower position (the 1 position) for a frequency setting of 58.95 Hz are (from the frequency setting table) D, E, and H. Their weights from the table above are  $D = 8$ ,  $E = 16$ , and  $H = 256$ . The sum of these weights is 280. Similarly, the sum of the weights for a frequency setting of 59.00 Hz is 273. The difference of 273 and 280 is 7. This is the distance in weight units between 58.95 Hz and 59.00 Hz.

The difference in frequency between 58.95 and 59.00 Hz is 0.05 Hz. The difference between 58.95 Hz and 58.98 Hz is 0.03 Hz. The ratio of these differences is  $0.03 \text{ Hz} / 0.05 \text{ Hz} = 3/5 = 6/10 = 0.6$  of the distance between 58.95 Hz and 59.00 Hz.

We desire to change the setting for 58.95 Hz by  $6/10$  of the distance to 59.00 Hz. The distance to 59.00 Hz in weight units is 7.  $0.6$  times 7 is 4.2. Round this off to 4. We desire to go 4 weight units from the setting of 58.95 which is 280 weight units toward the setting of 59.00 which is 273 weight units. We therefore subtract 4 from 280 getting 276. By examining the table of weights we find the plugs which must be in the lower position (the 1 position) are  $H = 256$ ,  $E = 16$ , and  $C = 4$ .  $256 + 16 + 4 = 276$ . Thus the correct setting for 58.98 Hz is 0010100100.

If there is a frequency correction stamped on the right side rail it should be added to or subtracted from the desired setting frequency (as its signal indicates) before interpolating as above. Thus, if the desired frequency setting was 58.98 Hz and the frequency correction was  $F_c = -0.003$  Hz the interpolation should be performed using 58.977 Hz as the desired frequency.

ACCEPTANCE TESTS

VISUAL INSPECTION

Remove the relay from its case and check that there are no broken, loose, or cracked component parts. Check also that the mounting screws are tight.

OPERATING CHECK

Place both the TR and RS function set blocks in the 00000-00000 mode. Apply rated DC to the relay (+) at term 8; (-) at term 10 with the rated external dropping resistor across relay terminals 7 and 9.

Apply 120Vrms, 60 Hz to relay terminals 2 and 4. Check that the "RE" telephone relay is picked up and that the "RS" telephone relay is dropped out.

Set both function set blocks in the 11111-00100 mode. With the above conditions, check that the TR relay is dropped out and that the RS relay is picked up. Return all frequency set point plugs to their original positions and insert fully. When doing PERIODIC TESTING it may be required that the relay setting not be disturbed. In this case a variable frequency AC power source may be used to check the relay.

TRIP UNIT

Apply a frequency below the relay frequency setting with a voltage above the undervoltage setting. The relay should trip after the set time delay. Lower the applied voltage (leaving the frequency constant). The relay should reset when the applied voltage drops below the undervoltage setting. Return the voltage to a level above the undervoltage setting. The relay should again trip with the set time delay. Raise the frequency of the applied voltage above the frequency setting. The relay should reset. In the above tests all trips should occur after the set time delay but all resets should occur in less than 50 milliseconds. This test, of course, can also be used for the initial acceptance test if the equipment is available.

RESTORE UNIT

Apply a frequency above the restore setting with a voltage above the undervoltage setting. The restore unit should operate after 100 to 135 milliseconds. Reduce the voltage below the undervoltage set point. The restore unit should drop out after 250 to 270 milliseconds. Increase the voltage to a point above the undervoltage setting. The restore unit should again operate. Lower the frequency below the restore set point. The restore unit should drop out.

NOTE:

When checking the trip frequency setting, if highest accuracy is required the time delay should be set at minimum. This is necessary because the relay will not trip unless the highest frequency during the trip time delay is lower than the set point. If the ac power source has slight variations in frequency, the frequency indication of the AC power source will usually be the average rather than the highest frequency and this indicated value will not be the true operating point of the relay.

INSTALLATION PROCEDURELOCATION

The location should be clean and dry, free from dust and excessive vibration, and well lighted to facilitate inspection and testing.

MOUNTING

The relay should be mounted on a vertical surface. The outline and panel drilling dimensions are shown in Figure (6).

PERIODIC CHECKS

In view of the vital role of protective relays in the operation of a power system it is important that a periodic test program be followed. It is recognized that the interval between periodic checks will vary depending upon environment, type of relay, and the user's experience with periodic testing. Until the user has accumulated enough experience to select the test interval best suited to his individual requirements it is suggested that the points listed under Acceptance Tests be checked at an interval of from one to two years.

SERVICINGGENERAL

Before removing the cover, remove any dust or foreign matter which has accumulated on the top of the cover. Otherwise it may find its way inside when the cover is removed and cause trouble in the operation of the relay.

CONTACT CLEANING

For cleaning contacts, a flexible burnishing tool should be used. This consists of a flexible strip of metal with an etched roughened surface, resembling in effect, a superfine file. The polishing action is so delicate that no scratches are left, yet corroded material will be removed rapidly and thoroughly. The flexibility of the tool insures the cleaning of the actual points of contact.

Contacts should not be cleaned with knives, files or abrasive paper or cloth. Knives or files may leave scratches which increase arcing and deterioration of the contacts. Abrasive paper or cloth may leave minute particles of insulating abrasive material in the contacts, thus preventing closing.

The burnishing tool described above can be obtained from the factory.

RENEWAL PARTS

It is recommended that sufficient quantities of renewal parts be carried in stock to enable the prompt replacement of any that are worn, broken, or damaged.

ULTRA PRECISE SETTINGS

The listing of settings under Table I is in increments of 0.05 Hz, which should be adequate for most conditions. If a closer setting is desired for an unusual situation, refer to the nearest General Electric Company Sales Office which can furnish information to calculate and obtain the set screw settings for any given increment desired.

Settings as fine as 0.008 Hz are obtainable.

It should be noted that the calibration frequency ( $F_c$ ) is characteristic of the particular relay and is so stamped on the nameplate. If, in the future, replacement in whole or part of any of the printed circuit boards is necessary, the calibration frequency ( $F_c$ ) is naturally no longer valid. Determination of a new calibration would demand that the relay be returned to the factory.

TRIP TIMER SETTING

The time duration from switching on the AC input to closure of the "TR" relay contacts is  $4\frac{1}{2}$  to  $5\frac{1}{2}$  cycles minimum when the trip setting of the relay is above the applied frequency. The following is a breakdown of this total minimum time.

0 - 1 cycle	-----	Voltage incidence of first cycle
3 cycles	-----	"Count of 3" circuit
$\frac{1}{2}$ cycle	-----	Output timer minimum time
1 cycle	-----	Max. "TR" relay operating time
<hr/>		
		$4\frac{1}{2}$ - $5\frac{1}{2}$ cycles - Total minimum operating time

To set the timer with a 120Vrms, 60 Hz test source, use the following procedure:

Place the trip set plugs in the 00000-00000 mode. This makes the 60 Hz system voltage "look" like underfrequency with respect to the TR frequency sensing element (Be sure the undervoltage detector pot is fully counter-clockwise). Connect a timer so that the application of the AC power starts it and the closing of the relay trip contacts (either 11-12 or 14-15 as desired) stops it. Turn the timer potentiometer on the front panel fully counter-clockwise. Close the AC switch several times and note that the time from closure of this switch till the TR relay operates is in the range of  $4\frac{1}{2}$  -  $5\frac{1}{2}$  cycles (75 - 92 milliseconds). Slowly turn the time pot clockwise while monitoring the operating time till the desired time delay is obtained.

The true timer delay is the total time delay minus 4-5 cycles.

Lock the time rheostat by turning its hexnut screw. Again, check the final time delay.

UNDervOLTAGE DETECTOR SETTING

The undervoltage level detector inhibits both the "TR" and "RS" units at a particular level setting (20% - 90% of rated AC). Using a variable AC voltage source, and the same set plug combination as used above in the "trip timer setting" section (00000-00000), set the AC voltage to whatever inhibit level is desired. Slowly turn the "undervoltage adjust" pot clockwise till the "TR" relay just begins to chatter.

Lock the pot and check that the TR relay stays open for input voltage below the intended setting.

#### RECEIVING, HANDLING AND STORAGE

These relays, when not included as part of a control panel, will be shipped in cartons designed to protect them against damage. Immediately upon receipt of a relay, examine it for any damage sustained in transit. If injury or damage resulting from rough handling is evident, file a damage claim at once with the transportation company and promptly notify the nearest General Electric Apparatus Sales Office.

Reasonable care should be exercised in unpacking the relays. If the relays 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. Foreign matter collected on the outside of the case may find its way inside when the cover is removed and cause trouble in the operation of the relay.

Also check the nameplate stamping to insure that the model number and the rating of the relay received agree with the requisition. Check the telephone relay operation manually (RS and TR) and check that the contact gap and wipe agree with the values given under the section MECHANICAL CHECK.

When ordering renewal parts, address the nearest Sales Office of the General Electric Company, specify quantity required, name of the part wanted, and give complete nameplate data. If possible, give the General Electric Requisition number on which the relay was furnished.

#### RENEWAL PARTS

It is recommended that sufficient quantities of renewal parts be carried in stock to enable the prompt replacement of any that are worn, broken, or damaged.

It is not recommended that renewal parts obtained from sources other than the General Electric Company be used. Many parts in relays which appear superficially similar to parts generally available have special feature or construction which is not apparent on inspection. This is true in some cases even though the parts have the same manufacturer's part number. Other parts, while the same as those generally available, are specially selected or tested for their specific application.

Should a printed circuit card become inoperative, it is recommended that this card be replaced with a spare. In most instances, the user will be anxious to return the equipment to service as soon as possible and the insertion of a spare card represents the most expeditious means of accomplishing this. The faulty card can then be returned to the factory for repair or replacement.

Although it is not generally recommended, it is possible with the proper equipment and trained personnel to repair cards in the field. This means that a trouble-shooting program must isolate the specific component on the card which has failed. By referring to the internal connection diagram for the card, it is possible to trace through the card circuit by signal checking and, hence determine which component has failed. This, however, may be time consuming and if the card is being checked in place in its unit, as is recommended, will extend the outage time of the equipment.

**CAUTION:** GREAT CARE MUST BE TAKEN IN REPLACING COMPONENTS ON THE CARDS. SPECIAL SOLDERING EQUIPMENT SUITABLE FOR USE ON THE DELICATE SOLID-STATE COMPONENTS MUST BE USED, AND, EVEN THEN, CARE MUST BE TAKEN NOT TO CAUSE THERMAL DAMAGE TO THE COMPONENTS, AND NOT TO DAMAGE OR BRIDGE OVER THE PRINTED CIRCUIT BUSES. THE REPAIRED AREA MUST BE RECOVERED WITH A SUITABLE HIGH-DI-ELECTRIC PLASTIC COATING TO PREVENT POSSIBLE BREAKDOWNS ACROSS THE PRINTED CIRCUIT BUSES DUE TO MOISTURE OR DUST.

**ADDITIONAL CAUTION:** DUAL IN LINE INTEGRATED CIRCUITS ARE ESPECIALLY DIFFICULT TO REMOVE AND REPLACE WITHOUT SPECIALIZED EQUIPMENT. FURTHERMORE, MANY OF THESE COMPONENTS ARE USED IN PRINTED CIRCUIT CARDS WHICH HAVE BUS RUNS ON BOTH SIDES. THESE ADDITIONAL COMPLICATIONS REQUIRE VERY SPECIAL SOLDERING EQUIPMENT AND REMOVAL TOOLS AS WELL AS ADDITIONAL SKILLS AND TRAINING WHICH MUST BE CONSIDERED BEFORE FIELD REPAIRS ARE ATTEMPTED.

When ordering renewal parts, address the nearest Sales Office of the General Electric Company, specify quantity required, name of the part wanted, and the complete model number of the relay for which the part is required.

TABLE I

60 HZ RELAY OPERATING POINT SETTINGS

TABLE I (CONT'D)

SET SCREWS COMBINATION	OPERATING FREQUENCY	PERIOD
A B C D E F G H J K	(HZ)	MICRO SECONDS
1 0 0 1 0 0 0 0 0 0	60.90	16420
1 1 1 1 0 0 0 0 0 0	60.85	16433
0 1 1 0 1 0 0 0 0 0	60.80	16447
1 0 1 1 1 0 0 0 0 0	60.75	16460
0 0 1 0 0 1 0 0 0 0	60.70	16474
0 1 0 1 0 1 0 0 0 0	60.65	16488
1 0 0 0 1 1 0 0 0 0	60.60	16501
0 0 0 1 1 1 0 0 0 0	60.55	16515
1 1 1 1 1 1 0 0 0 0	60.50	16528
0 1 1 0 0 0 0 0 0 1	60.45	16542
1 0 1 1 0 0 0 0 0 1	60.40	16556
1 1 0 0 1 0 0 0 0 1	60.35	16570
0 1 0 1 1 0 0 0 0 1	60.30	16583
1 0 0 0 1 0 0 0 0 1	60.25	16597
0 0 0 1 0 1 0 0 0 1	60.20	16611
1 1 1 1 0 1 0 0 0 1	60.15	16625
0 1 1 0 1 1 0 0 0 1	60.10	16638
1 0 1 1 1 1 0 0 0 1	60.05	16652
0 0 1 0 0 0 0 0 1 0	60.00	16666
1 1 0 1 0 0 0 0 1 0	59.95	16680
1 0 0 0 1 0 0 0 1 0	59.90	16694
1 0 0 1 1 0 0 0 1 0	59.85	16708
1 1 1 1 1 0 0 0 1 0	59.80	16722
1 1 1 0 0 1 0 0 1 0	59.75	16736
0 1 1 1 0 1 0 0 1 0	59.70	16750
1 0 1 0 1 1 0 0 1 0	59.65	16764
1 1 0 1 1 1 0 0 1 0	59.60	16778
1 1 0 0 0 0 0 0 1 1	59.55	16792
0 1 0 1 0 0 0 0 1 1	59.50	16806
1 0 0 0 1 0 0 0 1 1	59.45	16820
0 0 0 1 1 0 0 0 1 1	59.40	16835
1 1 1 1 1 0 0 0 1 1	59.35	16849
0 1 1 0 0 1 0 0 1 1	59.30	16863
1 0 1 1 0 1 0 0 1 1	59.25	16877
0 0 1 0 1 1 0 0 1 1	59.20	16891
1 1 0 1 1 1 0 0 1 1	59.15	16906
0 1 0 0 0 0 0 0 1 0 0	59.10	16920
0 1 0 1 0 0 0 0 1 0 0	59.05	16934
1 0 0 0 1 0 0 0 1 0 0	59.00	16949
0 0 0 1 1 0 0 0 1 0 0	58.95	16963
1 1 1 1 1 0 0 0 1 0 0	58.90	16977
0 1 1 0 0 1 0 1 0 0 0	58.85	16992
1 0 1 1 0 1 0 1 0 0 0	58.80	17006
1 0 1 0 1 1 0 1 0 0 0	58.75	17021
0 0 1 1 1 1 0 1 0 0 0	58.70	17035
0 0 1 0 0 0 0 0 1 0 1	58.65	17050
1 1 0 1 0 0 0 0 1 0 1	58.60	17064
0 1 0 0 1 0 0 0 1 0 1	58.55	17079
1 0 0 1 1 0 0 0 1 0 1	58.50	17094
1 0 0 0 0 1 0 1 0 1 0 1	58.45	17108
0 0 0 1 0 1 0 1 0 1 0 1	58.40	17123
1 1 1 1 0 1 0 1 0 1 0 1	58.35	17137
1 1 1 0 1 1 0 1 0 1 0 1	58.30	17152
0 1 1 1 1 1 0 1 0 1 0 1	58.25	17167
1 0 1 0 0 0 0 1 1 0 1 0	58.20	17182
1 0 1 1 0 0 0 0 1 1 0 1	58.15	17196
0 0 1 0 1 0 0 0 1 1 0 1	58.10	17211
0 0 1 1 1 0 0 0 1 1 0 1	58.05	17226
1 1 0 0 0 1 0 1 1 1 0 1	58.00	17241
0 1 0 1 0 1 0 1 1 1 0 1	57.95	17256
0 1 0 0 1 1 0 1 1 1 0 1	57.90	17271
1 0 0 1 1 1 0 1 1 1 0 1	57.85	17286
1 0 0 0 0 0 0 0 1 1 1 1	57.80	17301
0 0 0 1 0 0 0 0 1 1 1 1	57.75	17316
0 0 0 0 1 0 0 0 1 1 1 1	57.70	17331
1 1 1 0 1 0 0 1 1 1 1	57.65	17346

A B C D E F G H J K	(HZ)	MICRO SECONDS
1 1 1 1 1 0 0 1 1 1 1	57.60	17361
0 1 1 0 0 1 0 1 1 1 1	57.55	17376
0 1 1 1 0 1 0 1 1 1 1	57.50	17391
1 0 1 0 1 1 0 1 1 1 1	57.45	17406
1 0 1 1 1 1 0 1 1 1 1	57.40	17421
1 0 1 0 0 0 1 0 0 0 0	57.35	17436
0 0 1 1 0 0 1 0 0 0 0	57.30	17452
0 0 1 0 1 0 1 0 0 0 0	57.25	17467
0 0 1 1 1 0 1 0 0 0 0	57.20	17482
1 1 0 0 0 1 1 0 0 0 0	57.15	17497
1 1 0 1 0 1 1 0 0 0 0	57.10	17513
1 1 0 0 1 1 1 0 0 0 0	57.05	17528
0 1 0 1 1 1 1 0 0 0 0	57.00	17543
0 1 0 0 0 0 1 0 0 0 1	56.95	17559
0 1 0 1 0 0 0 1 0 0 1	56.90	17574
1 0 0 0 1 0 1 0 0 0 1	56.85	17590
1 0 0 1 1 0 1 0 0 0 1	56.80	17605
1 0 0 0 0 1 1 0 0 0 1	56.75	17621
1 0 0 1 0 1 1 0 0 0 1	56.70	17636
0 0 0 0 1 1 1 0 0 0 1	56.65	17652
0 0 0 1 1 1 1 0 0 0 1	56.60	17667
0 0 0 0 0 0 1 0 1 0 1	56.55	17683
0 0 0 1 0 0 1 0 1 0 1	56.50	17699
0 0 0 0 1 0 1 0 1 0 1	56.45	17714
1 1 1 0 1 0 1 0 1 0 1	56.40	17730
1 1 1 1 1 0 1 0 1 0 1	56.35	17746
1 1 1 0 0 1 1 0 1 0 1	56.30	17761
1 1 1 1 0 1 1 0 1 0 1	56.25	17777
1 1 1 0 1 1 1 0 1 0 1	56.20	17793
1 1 1 1 1 1 1 0 1 0 1	56.15	17809
1 1 1 0 0 0 1 0 1 1 1	56.10	17825
1 1 1 1 0 0 1 0 1 1 1	56.05	17841
1 1 1 0 1 0 1 0 1 1 1	56.00	17857
1 1 1 1 1 0 1 0 1 1 1	55.95	17873
1 1 1 0 0 1 1 0 1 1 1	55.90	17889
1 1 1 1 0 1 1 0 1 1 1	55.85	17905
1 1 1 0 1 1 1 0 1 1 1	55.80	17921
1 1 1 1 1 1 1 0 1 1 1	55.75	17937
1 1 1 0 0 0 1 1 0 0 1	55.70	17953
1 1 1 1 0 0 1 1 0 0 1	55.65	17969
1 1 1 0 1 0 1 1 0 0 1	55.60	17985
1 1 1 1 1 0 1 1 0 0 1	55.55	18001
1 1 1 0 0 1 1 1 0 0 1	55.50	18018
1 1 1 1 0 1 1 1 0 0 1	55.45	18034
1 1 1 0 1 1 1 1 0 0 1	55.40	18050
1 1 1 1 1 1 1 1 0 0 1	55.35	18066
0 0 0 1 0 0 1 1 0 1 1	55.30	18083
0 0 0 0 1 0 1 1 0 1 1	55.25	18099
0 0 0 1 1 0 1 1 0 1 1	55.20	18115
0 0 0 0 0 1 1 1 0 1 1	55.15	18132
1 0 0 1 0 1 1 1 0 1 1	55.10	18148
1 0 0 0 1 1 1 1 0 1 1	55.05	18165
1 0 0 1 1 1 1 1 0 1 1	55.00	18181
1 0 0 0 0 0 1 1 1 0 1	54.95	18198
0 1 0 1 0 0 1 1 1 0 1	54.90	18214
0 1 0 0 1 0 1 1 1 0 1	54.85	18231
0 1 0 1 1 0 1 1 1 0 1	54.80	18248
0 1 0 0 0 1 1 1 1 0 1	54.75	18264
1 1 0 1 0 1 1 1 1 0 1	54.70	18281
1 1 0 0 1 1 1 1 1 0 1	54.65	18298
0 0 1 1 1 1 1 1 1 0 1	54.60	18315
0 0 1 0 0 0 1 1 1 1 1	54.55	18331
0 0 1 1 0 0 0 1 1 1 1	54.50	18348
1 0 1 0 1 0 1 1 1 1 1	54.45	18365
1 0 1 1 1 0 1 1 1 1 1	54.40	18382
1 0 1 0 0 1 1 1 1 1 1	54.35	18399
0 1 1 1 0 1 1 1 1 1 1	54.30	18416
0 1 1 0 1 1 1 1 1 1 1	54.25	18433
1 1 1 1 1 1 1 1 1 1 1	54.20	18450

TABLE II

50 HZ RELAY OPERATING POINT SETTINGS

SET SCREW COMBINATION	OPERATING FREQUENCY	PERIOD
A B C D E F G H J K	HERTZ	MICRO SECONDS
0 0 0 0 0 0 0 0 0 0	50.90	19646
0 0 0 1 0 0 0 0 0 0	50.85	19665
0 0 0 0 1 0 0 0 0 0	50.80	19685
0 0 0 1 1 0 0 0 0 0	50.75	19704
0 0 0 0 0 1 0 0 0 0	50.70	19723
0 0 0 1 0 1 0 0 0 0	50.65	19743
0 0 0 0 1 1 0 0 0 0	50.60	19762
1 0 0 1 1 1 0 0 0 0	50.55	19782
1 0 0 0 0 0 0 0 0 1	50.50	19801
1 0 0 1 0 0 0 0 0 1	50.45	19821
1 0 0 0 1 0 0 0 0 1	50.40	19841
1 0 0 1 1 0 0 0 0 1	50.35	19860
0 1 0 0 0 1 0 0 0 1	50.30	19880
0 1 0 1 0 1 0 0 0 1	50.25	19900
0 1 0 0 1 1 0 0 0 1	50.20	19920
0 1 0 1 1 1 0 0 0 1	50.15	19940
1 1 0 0 0 0 0 0 0 1 0	50.10	19960
1 1 0 1 0 0 0 0 0 1 0	50.05	19980
1 1 0 0 1 0 0 0 0 1 0	50.00	20000
0 0 1 1 1 0 0 0 0 1 0	49.95	20020
0 0 1 0 0 1 0 0 0 1 0	49.90	20040
1 0 1 1 0 1 0 0 0 1 0	49.85	20060
1 0 1 0 1 1 0 0 0 1 0	49.80	20080
1 0 1 1 1 1 0 0 0 1 0	49.75	20100
0 1 1 0 0 0 0 0 0 1 1	49.70	20120
0 1 1 1 0 0 0 0 0 1 1	49.65	20140
1 1 1 0 1 0 0 0 0 1 1	49.60	20161
1 1 1 1 1 0 0 0 0 1 1	49.55	20181
0 0 0 1 0 1 0 0 0 1 1	49.50	20202
0 0 0 0 1 1 0 0 0 1 1	49.45	20222
1 0 0 1 1 1 0 0 0 1 1	49.40	20242
1 0 0 0 0 0 0 0 1 0 0	49.35	20263
0 1 0 1 0 0 0 0 1 0 0	49.30	20283
1 1 0 0 1 0 0 1 0 0 0	49.25	20304
1 1 0 1 1 0 0 1 0 0 0	49.20	20325
0 0 1 0 0 1 0 1 0 0 0	49.15	20345
1 0 1 1 0 1 0 1 0 0 0	49.10	20366
1 0 1 0 1 1 0 1 0 0 0	49.05	20387
0 1 1 1 1 1 0 1 0 0 0	49.00	20408
1 1 1 0 0 0 0 0 1 0 1	48.95	20429
1 1 1 1 0 0 0 0 1 0 1	48.90	20449
0 0 0 1 1 0 0 1 0 1 0	48.85	20470
1 0 0 0 0 1 0 1 0 1 0	48.80	20491
0 1 0 1 0 1 0 1 0 1 0	48.75	20512
0 1 0 0 1 1 0 1 0 1 0	48.70	20533
1 1 0 1 1 1 0 1 0 1 0	48.65	20554
0 0 1 0 0 0 0 1 1 0 0	48.60	20576
1 0 1 1 0 0 0 0 1 1 0	48.55	20597
0 1 1 0 1 0 0 0 1 1 0	48.50	20618
1 1 1 1 1 0 0 0 1 1 0	48.45	20639
1 1 1 0 0 1 0 1 1 0 0	48.40	20661
0 0 0 0 1 1 0 1 1 0 0	48.35	20682
1 0 0 1 1 1 0 1 1 0 0	48.30	20703
0 1 0 0 0 0 0 0 1 1 1	48.25	20725
1 1 0 1 0 0 0 0 1 1 1	48.20	20746
0 0 1 0 1 0 0 0 1 1 1	48.15	20768
1 0 1 1 1 0 0 0 1 1 1	48.10	20790

TABLE II (CONT'D)

A B C D E F G H J K	HERTZ	MICRO SECONDS
0 1 1 0 0 1 0 1 1 1	48.05	20811
1 1 1 1 0 1 0 1 1 1	48.00	20833
0 0 0 1 1 1 0 1 1 1	47.95	20855
0 1 0 0 0 0 1 0 0 0	47.90	20876
1 1 0 1 0 0 1 0 0 0	47.85	20898
0 0 1 0 1 0 1 0 0 0	47.80	20920
1 0 1 1 1 0 1 0 0 0	47.75	20942
0 1 1 0 0 1 1 0 0 0	47.70	20964
1 1 1 1 0 1 1 0 0 0	47.65	20986
0 0 0 1 1 1 1 0 0 0	47.60	21008
0 1 0 0 0 0 1 0 0 1	47.55	21030
1 1 0 1 0 0 1 0 0 1	47.50	21052
0 0 1 0 1 0 1 0 0 1	47.45	21074
1 0 1 1 1 0 1 0 0 1	47.40	21097
1 1 1 0 0 1 1 0 0 1	47.35	21119
0 0 0 0 1 1 1 0 0 1	47.30	21141
1 0 0 1 1 1 1 0 0 1	47.25	21164
1 1 0 0 0 0 1 0 1 0	47.20	21186
0 0 1 1 0 0 1 0 1 0	47.15	21208
0 1 1 0 1 0 1 0 1 0	47.10	21231
1 1 1 1 1 0 1 0 1 0	47.05	21253
0 0 0 1 0 1 1 0 1 0	47.00	21276
0 1 0 0 1 1 1 0 1 0	46.95	21299
1 1 0 1 1 1 1 0 1 0	46.90	21321
1 0 1 0 0 0 1 0 0 1 1	46.85	21344
0 1 1 1 0 0 1 0 1 1	46.80	21367
0 0 0 1 1 0 1 0 1 1	46.75	21390
0 1 0 0 0 1 1 0 1 1	46.70	21413
1 1 0 1 0 1 1 0 1 1	46.65	21436
1 0 1 0 1 1 1 0 1 1	46.60	21459
0 1 1 1 1 1 1 0 1 1	46.55	21482
0 0 0 1 0 0 1 1 0 0	46.50	21505
0 1 0 0 1 0 1 1 0 0	46.45	21528
1 1 0 1 1 0 1 1 0 0	46.40	21551
1 0 1 0 0 1 1 1 0 0	46.35	21574
1 1 1 1 0 1 1 1 0 0	46.30	21598
0 0 0 1 1 1 1 1 0 0	46.25	21621
0 1 0 0 0 0 1 1 0 1	46.20	21645
0 0 1 1 0 0 1 1 0 1	46.15	21668
0 1 1 0 1 0 1 1 0 1	46.10	21691
0 0 0 0 0 1 1 1 0 1	46.05	21715
0 1 0 1 0 1 1 1 0 1	46.00	21739
1 1 0 0 1 1 1 1 0 1	45.95	21762
1 0 1 1 1 1 1 1 0 1	45.90	21786
1 1 1 0 0 0 1 1 1 0	45.85	21810
1 0 0 0 1 0 1 1 1 0	45.80	21834
1 1 0 1 1 0 1 1 1 0	45.75	21857
1 0 1 0 0 1 1 1 1 0	45.70	21881
1 1 1 1 0 1 1 1 1 0	45.65	21905
1 0 0 1 1 1 1 1 1 0	45.60	21929
1 1 0 0 0 0 1 1 1 1	45.55	21953
1 0 1 1 0 0 1 1 1 1	45.50	21978
1 1 1 0 1 0 1 1 1 1	45.45	22002
1 0 0 0 0 1 1 1 1 1	45.40	22026
0 0 1 1 0 1 1 1 1 1	45.35	22050
0 1 1 0 1 1 1 1 1 1	45.30	22075
1 1 1 1 1 1 1 1 1 1	45.25	22099



FIG. 1A (Photo Not Available) Type SFF22A Relay Out Of Case (Front View)

FIG. 1B (Photo Not Available) Type SFF22A Relay Out Of Case (3/4 Left Rear View)

FIG. 1C (Photo Not Available) Type SFF22A Relay Out Of Case (3/4 Right Rear View)

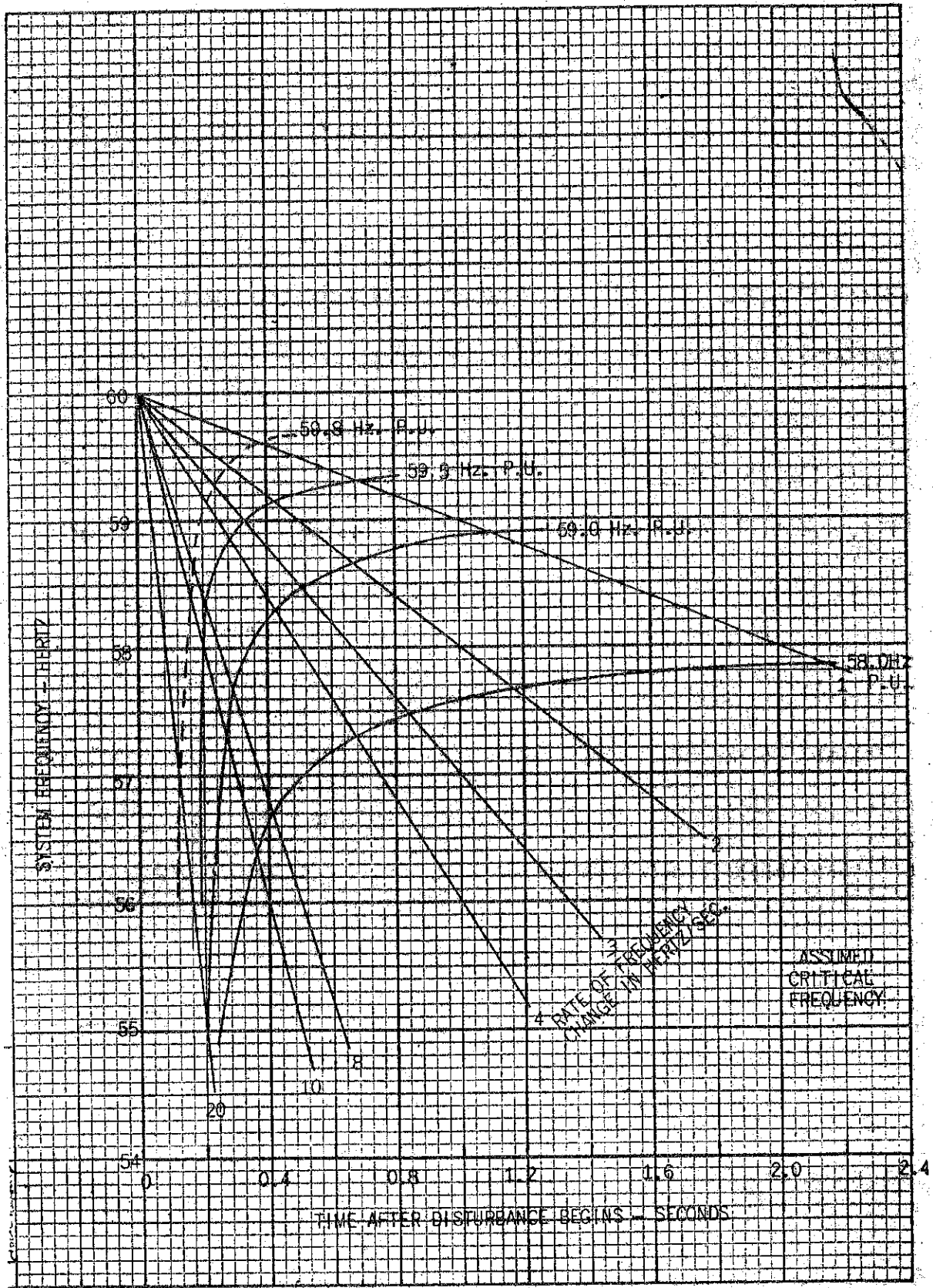


FIG. 2 (0208A3902-1) Total Operating Time Of The Trip Unit For Various Rates Of Change Of Frequency

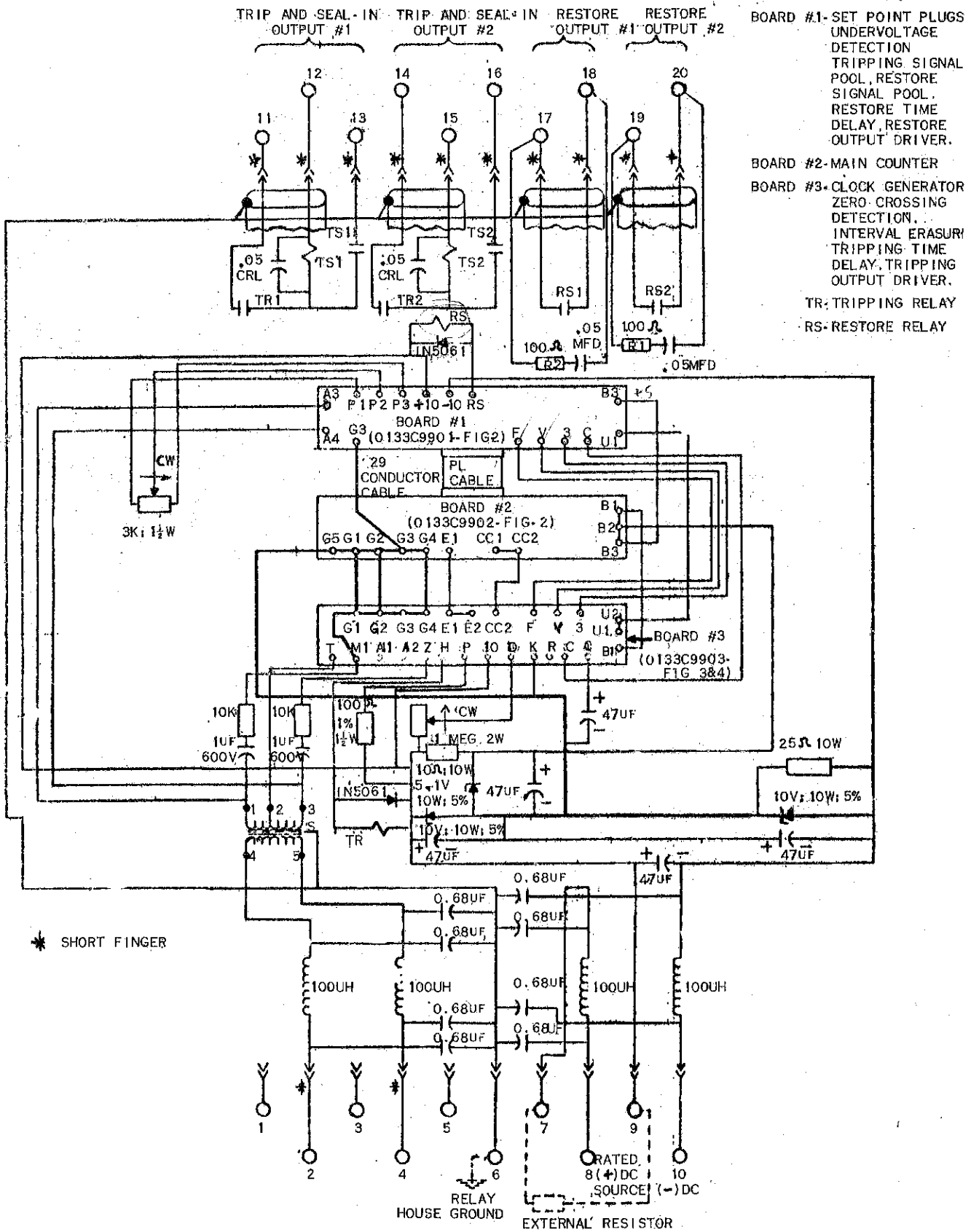
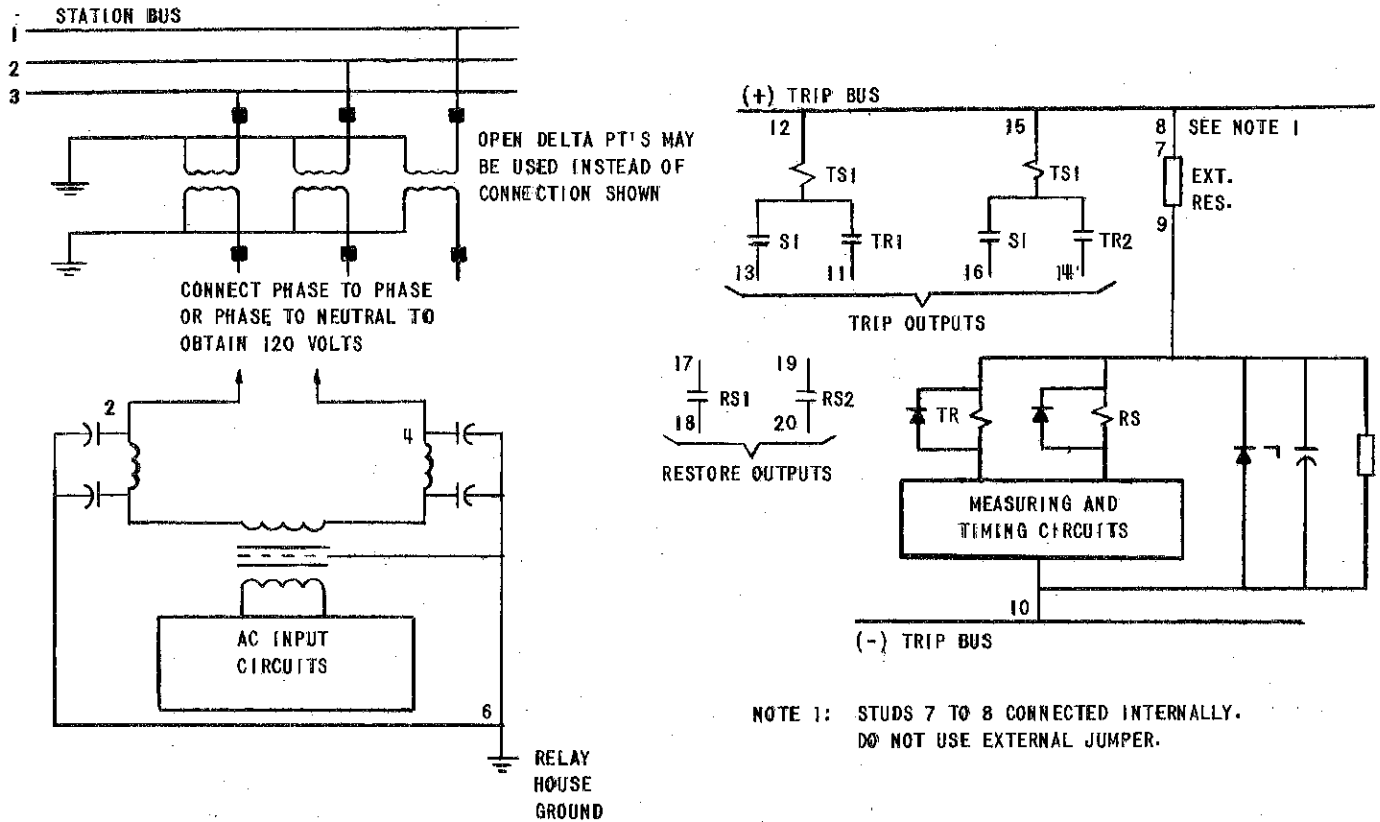


FIG. 3 (0246A6878-0) Internal Connections Diagram For The SFF22A Relay



LEGEND		
DEVICE	COMP	DESCRIPTION
SFF22A	TS1	UNDER FREQUENCY RELAY TARGET SEAL-IN
	TR	TRIP RELAY
	RS	RESTORE RELAY
INTERNAL CONNECTIONS Q226A6878		

FIG. 4 (0246A6896-0) External Connection Diagram For The SFF22A Relay

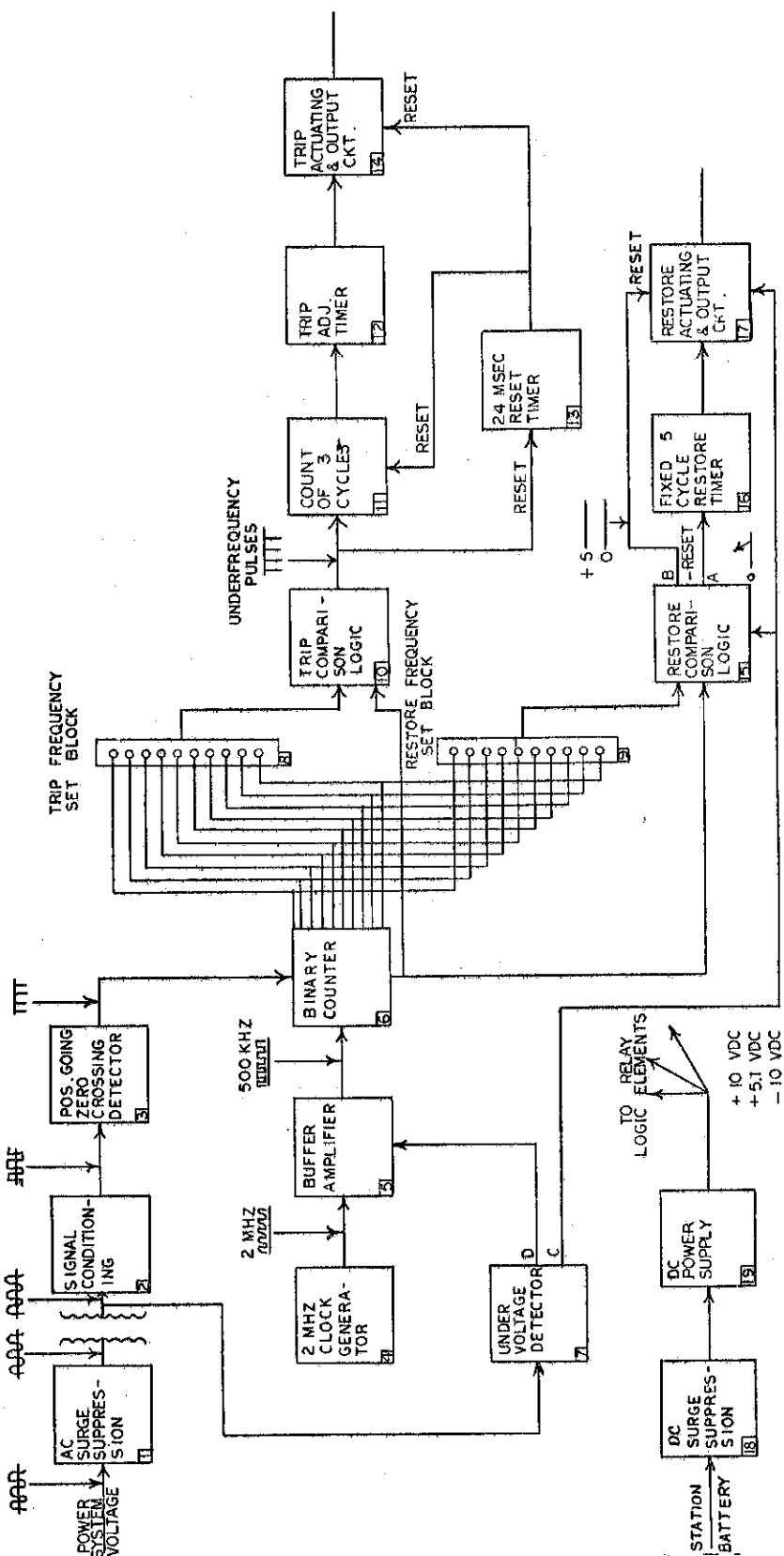


FIG. 5 (0165B2413-1 SH. 1) Functional Block Diagram For The SFF22A Relay



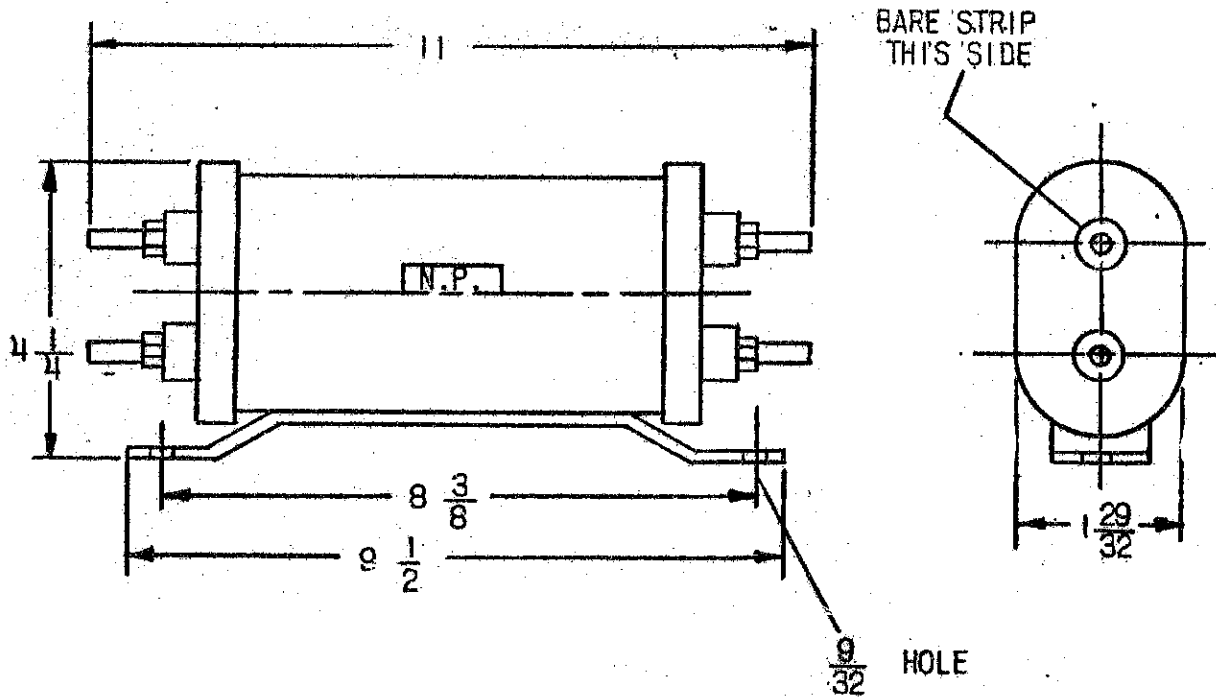


FIG. 7 (403A119-1) External Resistor Outline For SFF22A (125 And 250 Volt DC Control Voltages)

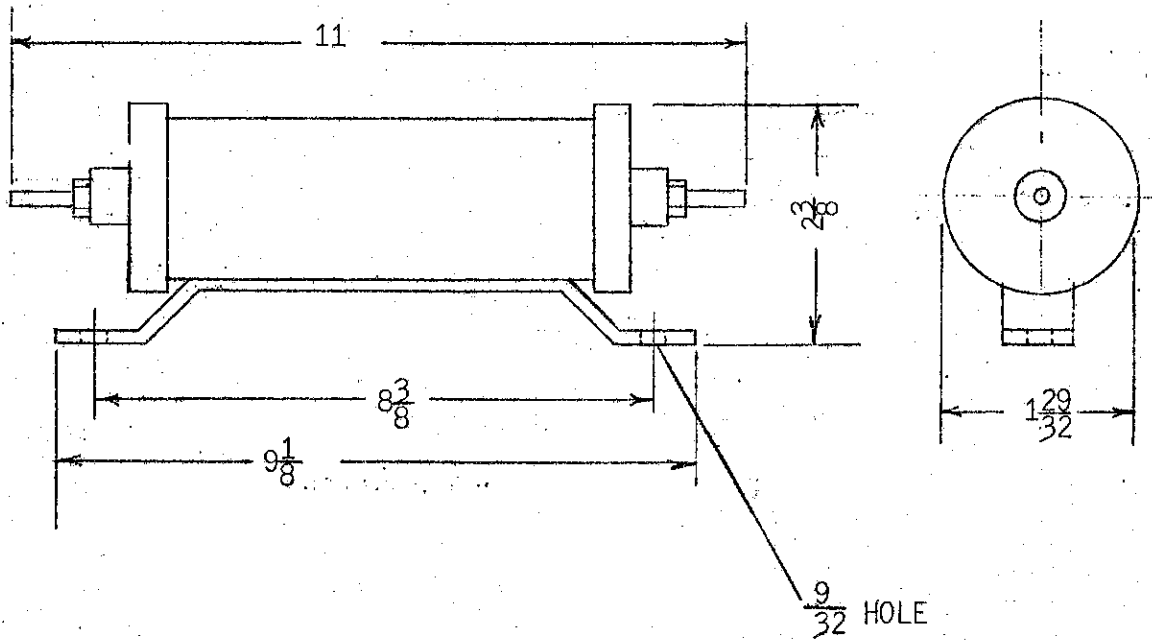
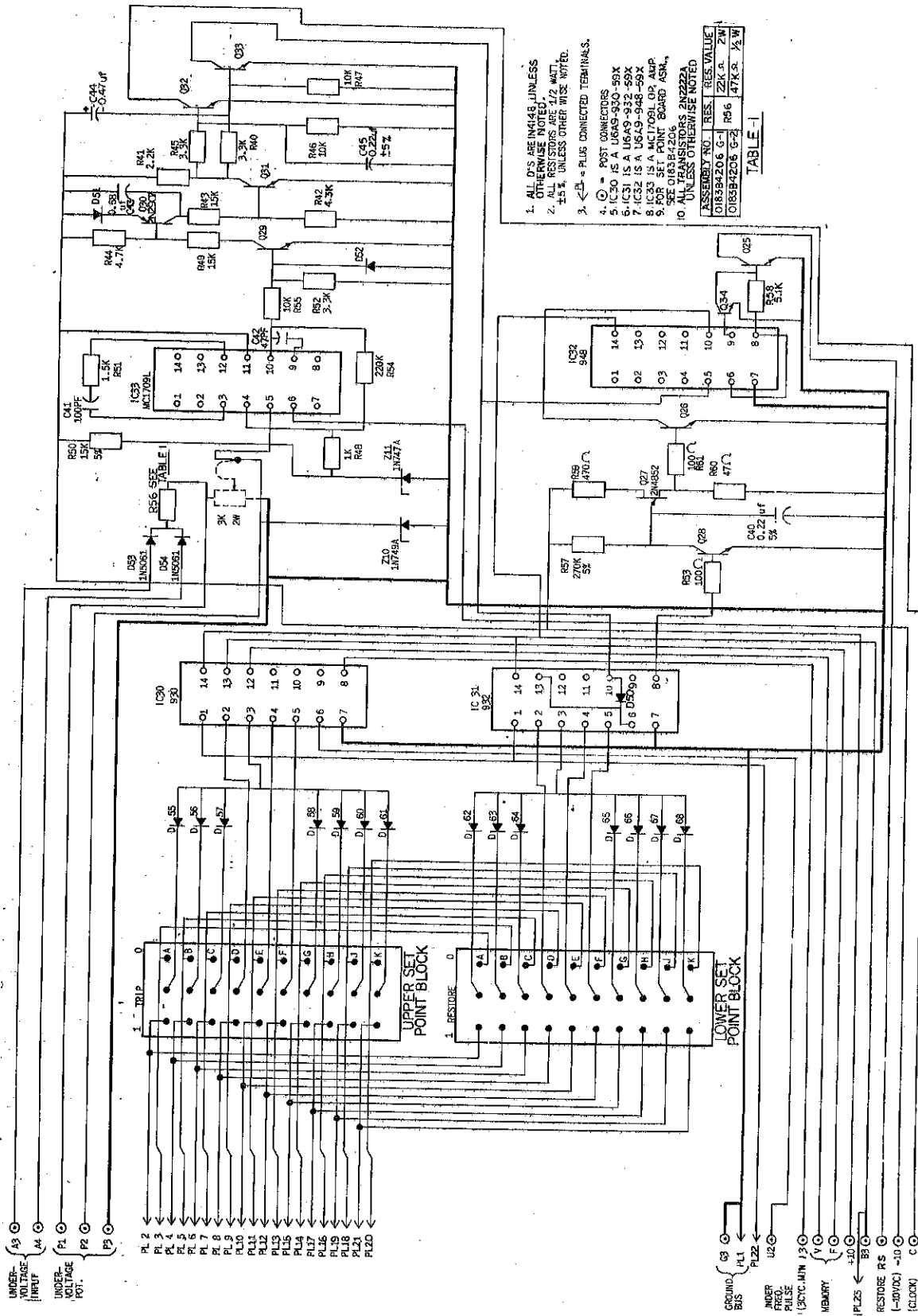


FIG. 8 (389A752-1) External Resistor Outline For SFF22A (48 Volt DC Control Voltage)





1. ALL D'S ARE IN 1/48 UNLESS OTHERWISE NOTED.
2. ALL RESISTORS ARE 1/2 WATT ±5% UNLESS OTHER WISE NOTED.
3. ← = PLUS CONNECTED TERMINALS.
4. ⊙ = RESET CONNECTORS.
5. IC30 IS A U6A9-930-50X
6. IC31 IS A U6A9-932-50X
7. IC32 IS A U6A9-948-50X
8. IC33 IS A U6A9-948-50X
9. FOR SET POINT BOARD ASK, SEE 018384206 UNLESS OTHERWISE NOTED.
10. UNLESS OTHERWISE NOTED.

ASSEMBLY NO.	RES.	RES. VALUE
018384206 G-1	R66	22K Ω 2W
018384206 G-2	R66	47K Ω 1/2 W

TABLE - 1

FIG-2

FIG. 9 (0133C9901-0 SH. 2) Set Point Board Internal Connection Diagram

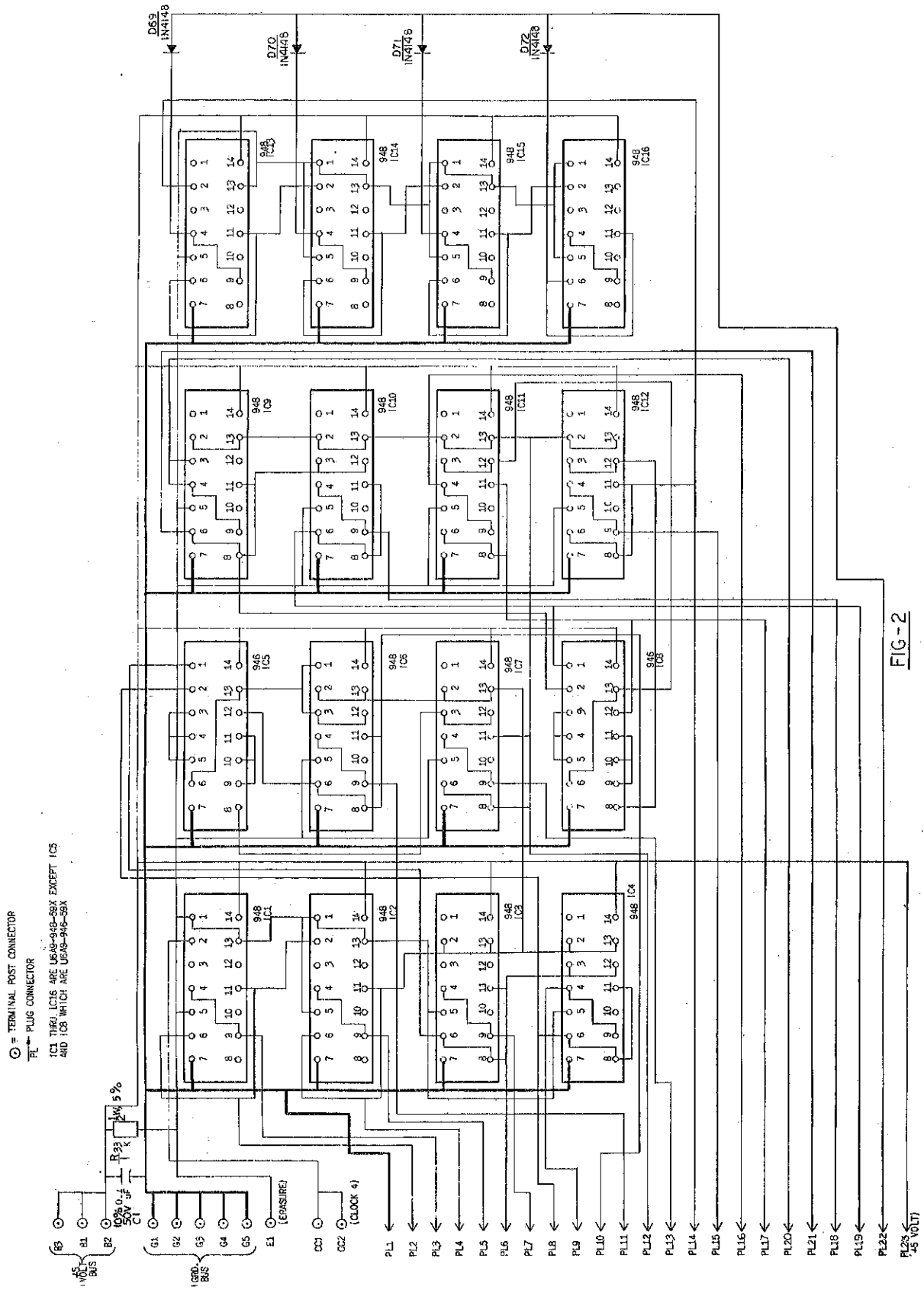


FIG-2

FIG. 10 (0133C9902-0 SH. 2) Main Counter Board Internal Connection Diagram

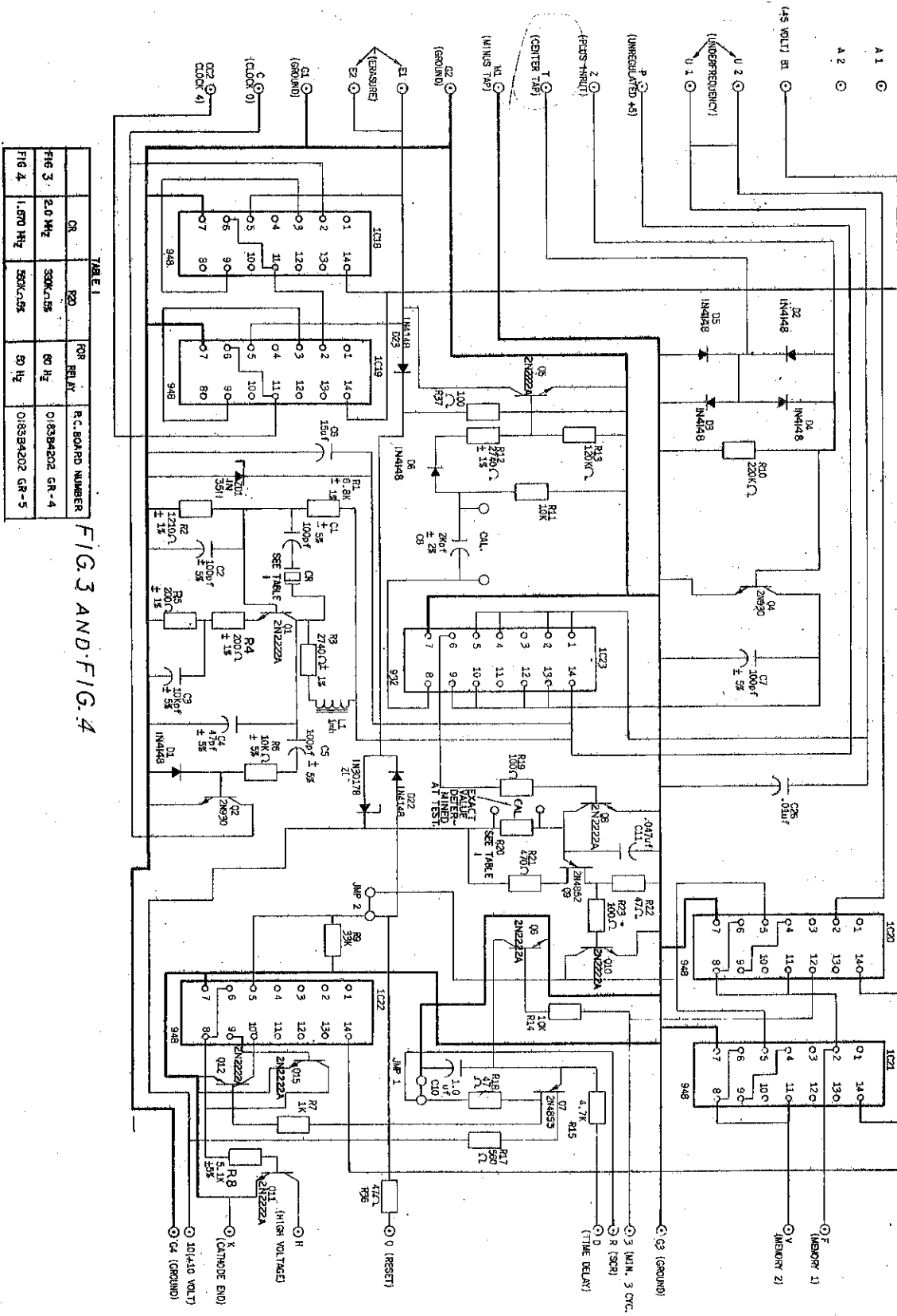


TABLE 1

GR	R20	FOR RELAY	R.C. BOARD NUMBER
716 3	2.0 MHz	380K-C55	0183B4202 GR-4
716 4	1.670 MHz	550K-C55	0183B4202 GR-5

FIG 3 AND FIG 4

FIG. 11 (0133C9903-0 SH. 3) Clock Generator Board Internal Connection Diagram

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