INSTRUCTIONS

GEK- 36849

STATIC UNDERFREQUENCY RELAY

TYPE SFF21A

POWER SYSTEMS MANAGEMENT DEPARTMENT

GENERAL ELECTRIC

PHILADELPHIA, PA.

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STATIC UNDERFREQUENCY RELAY

TYPE SFF21A

INTRODUCTION

The SFF21A relay is a static underfrequency relay that operates on a digital principle and utilizes integrated circuits to provide a highly accurate and stable detection of underfrequency conditions on a power system. This relay may be set in integral steps of 0.05 hertz and is repeatable within plus or minus 0.005 hertz over the complete range of rated temperature and voltage variations.

The SFF relays are basically high speed devices but adjustable time delay is included for use where it is required. The output of the SFF is one normally open and one normally closed contact and one target seal-in unit. The relay is furnished in an M1 drawout case.

APPLICATION

The SFF21A static underfrequency relay finds application wherever an extremely stable device is required to provide accurate detection of underfrequency conditions either with or without time delay. It has a minimum operating time of 4 cycles (no intentional time delay) and a maximum time delay in the order of 1.3 seconds.

These SFF underfrequency relays were 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. SFF underfrequency relays distributed around the system will detect this condition and operate to disconnect system load in a programmed manner 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 interruptable 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).

While the SFF relays will be applied principally on electric utility power systems, they are also well suited for use on industrial systems. One such application is a case where an industrial installation is tapped off a power company through-transmission circuit that utilizes high speed automatic reclosing. For faults on the through-transmission line, the power company will trip both ends of their circuit and then they generally initiate high speed reclosing of the line. Since this reclosing is not synchronized, it is important for the industrial load to disconnect prior to reclosure in order to prevent damage to motors and/or generators that may have slowed down during the interruption. An SFF21A relay at the industrial plant could detect the drop in frequency that would occur during the time that the power company supply is open. The relay could then trip the incoming breaker to the industrial plant and separate the plant from the power company system before reclosing takes place.

It should be recognized in the application of the SFF relays that if for any reason the frequency of the system gets above the underfrequency setting of the relay, even for 1 cycle, during the operating time delay of these relays, they will reset and the timing sequence must start again from the beginning. Also, all the SFF21A relays include a voltage cut-off feature. When the applied voltage gets below the cut-off value 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 under CHARACTERISTICS.

When applying the underfrequency relay 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 include:

1. An allowance of six cycles for total breaker clearing time.

2. The frequency relay inherent delay of four cycles.

3. Various frequency pickup settings on the relay.

If any of these factors change, then a new curve should be plotted. The curves can be read directly to determine the system frequency at which the load is actually removed.

The operating characteristics of the SFF relay are such that an underfrequency conditon must persist continuously for a minimum of 3 cycles to a maximum of 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 of 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 decay at generally different rates depending on the characteristics of the circuit and the load. An underfrequency relay supplied from a potential source that is connected to such a circuit could operate when the 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 one circuit and is connected to trip another circuit, loss of the first circuit could cause the relay to operate, as the frequency decays, and this would result in the loss of the second circuit also. In order for this to result, the frequency must decay but the voltage must stay 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 obviate the opportunity for undesired operations. Where this cannot be accomplished, longer time delay settings will make the scheme less susceptible to operations of this kind.

RATINGS AND CHARACTERISTICS

This relay is presently available for use on power systems of 60 Hz nominal frequency and 120 volts nominal voltage. A 50 Hz version is available.

UNDERFREQUENCY SETTING RANGE

54.20 to 60.90 Hz(45.25 to 50.9 Hz for 50 Hz model) in the increments of 0.05 Hz. The adjustment increment is accomplished by proper setting of plugs on the "Frequency Set Block". Refer to Table I for plug settings position vs. frequency.

SET POINT ACCURACY

±0.005 Hz.

RELAY AMBIENT TEMPERATURE

The SFF relay is designed for operation with case ambient temperatures from -20° to 60°C.

TRIPPING TIME DELAY

The time delay from the occurance of the first cycle of continuous underfrequency to pickup of the telephone type auxiliary relay is continuously adjustable from .070 to 1.33 seconds. The setting is adjustable by means of a rheostat on the front panel. Repeatability of the tripping time delay unit is within ±1%.

INPUT SIGNAL REQUIREMENT

The relay will operate correctly with a continuous input signal of 50% to 115% of rated voltage. Below 50% rated voltage operation is prevented by the undervoltage detector.

UNDERVOLTAGE CUTOFF

The undervoltage cutoff prevents incorrect relay operation on loss of AC potential. It is set for 50% ±10% of rated AC voltage. It operates on loss of potential in 16 milliseconds or less and resets in 25 milliseconds or less.

BURDENS

The burden on input signal terminal pair (studs 4-5) is 3.09 Volt-Amperes, 2.65 Watts, 1.58 Vars (Inductive) at 120 volts, 60 Hz.

DC control burden is 0.6 amperes at the rated DC control voltage. The relay will operate properly at any DC control voltage within the range of +10% to -20% of rated voltage.

CONTACTS

Contact interrupting ratings for the auxiliary telephone relay are listed in Table III.

TARGET

Target ratings are shown in Table IV. If the trip current exceeds 30 amperes, it is recommended that an auxiliary tripping relay be used.

OPERATING PRINCIPLES

BASIC CONCEPT (Refer to Figure 5)

The SFF relay uses a crystal controlled static counter to establish a reference frequency. A tap block (Frequency set block) is used to modify the reference frequency to produce a frequency which is the SFF setting. Every cycle the monitored frequency is compared with the SFF set frequency. If, for three consecutive cycles, the time for each cycle of the monitored system voltage is longer than the time for a cycle of the SFF set frequency, then the counter which counts these events starts an adjustable auxiliary timer. This timer provides a trip output signal after a predetermined time delay. If the system underfrequency condition disappears at any time before the trip output signal is given then the SFF resets immediately.

MORE DETAILED EXPLANATION

The "counter" counts a certain number of cycles of the oscilloscope (which has a 2 MHz frequency)* to establish the relay set frequency. Each time the voltage of the monitored system has a positive going zero crossing, it resets the counter to zero. After the counter is reset, it starts counting again. If the next positive going zero crossing of the monitored system voltage occurs before the counter reaches its output setting, then the counter resets and starts over again. If the counter reaches its output setting before it is reset, then the elapsed time of a cycle of the monitored system voltage indicates that the system frequency is below the SFF set frequency. When this occurs, the preset logic (Fig. 5 - Item 8) produces an overflow output. Three consecutive overflow outputs confirm that a valid underfrequency condition exists and start the auxiliary timer.

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* (50 Hz model uses a 1.67 MHz Oscillator)

The monitored power system a-c voltage is supplied to the relay circuits through an electrostatically shielded transformer as shown in the functional·logic of Fig. 5. The signal conditioner (1) minimizes harmonics and transients as well as the effect of d-c offset. The voltage signal is converted to well shaped pulses corresponding to each positive-going zero crossing in the detector (2). These pulses are used to clear the binary counter (7) and reset it to zero each power system cycle.

The clock generator (3) is a crystal controlled oscillator which continuously supplies 2 MHz* pulses to the binary counter (7) through the buffer amplifier (5) unless inhibited by a signal from the undervoltage detector (6). The undervoltage detector (6) will supply an inhibit signal whenever the incoming a-c voltage falls below 50% of rated volts. Also, when the relay is first energized with the normal a-c voltage or if the a-c voltage returns to normal after having decreased below 50% of rated volts, the undervoltage detector will delay relay operation on underfrequency for an additional 24 ms.

The binary counter (7) will be reset to zero each cycle of the monitored system voltage. The outputs of the binary counter are monitored by the preset logic (8). A preset count is placed in the preset logic by means of the setting of the tap plugs in the frequency set block. If the binary counter is not reset before this preset count is exceeded, it will send out a negative going pulse to the count-of-three unit (9). This pulse is called overflow. The presence of the overflow indicates one power system cycle of operation at a frequency below the set value and the overflow pulse will repeat once per cycle as long as the system frequency remains below the set value.

The underfrequency condition must occur for a minimum of three consecutive cycles to provide an output from the count-of-three unit (9). As long as the system frequency remains above the set value, there will be no pulses from the preset logic (8) and the 24 ms timer (10) will provide a signal every 24 ms which resets both the count-of-three unit (9) and the auxiliary timer (11). An overflow pulse from the preset logic resets the 24 ms timer which will immediately start timing again. If the overflow pulses continue to occur at one cycle intervals, the count-of-three unit plus the auxiliary timer will time out and energize the actuating circuit and output (12). Hence, the underfrequency condition must persist continuously throughout the delay period. If the system frequency recovers above the preset level even for just one cycle before the time delay period elapses, the 24 ms timer will operate to reset both the count-of-three unit and the auxiliary timer. When the actuating circuit and output (12) is energized, a trip output is provided by a telephone type relay which has an operating time of approximately 16 milliseconds.

After tripping has occured the actuating circuit will be continuously triggered until the system frequency is restored to a level above the preset point. At this point the entire circuit will reset with no intentional delay.

CONSTRUCTION

Most of the circuitry is located in two PC boards. These boards are fastened to the cradle on the lower part of front panel under the nameplate.

Time delay setting rheostat is located on the upper part of the front panel.

CALCULATION AND METHOD OF SETTINGS

UNDERFREQUENCY TRIPPING POINT SETTING

The frequency set block is located just below the nameplate. It consists of removable plugs and fixed sockets mounted in the printed circuit card. When the plug is in the upper position, it is called "0" position, and when it is in the lower position, "1" position. The plugs must be fully inserted in the required positions. The relation of plug combinations for tripping frequencies from 54.20 Hz to 60.90 Hz in increments of 0.05 Hz are given in Table 1.

FREQUENCY SETTINGS FINER THAN 0.05 HZ

Settings can be made for frequencies 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 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 Hz/0.05 Hz = 3/5 = 6/10 = 0.6 of the distance between 58.98 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 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 it should be added to or subtracted from the desired setting frequency (as its sign indicates) before interpolating as above. Thus if the desired frequency setting was 58.98 Hz and the frequency correction was Fc = -0.003 Hz the interpolation should be performed using 58.977 Hz as the desired frequency.

TIME DELAY SETTING

The time duration from the switch-on of the AC input signal until the closing of actuating contact is roughly the tripping time delay. Actually, the real tripping time delay is time measured above minus 1.5 cycle due to the under voltage circuit built-in delay: A combination setting method is as follows:

Set Frequency Set Block at position "00000-00000", which corresponds to 60.98 Hz. Assuming a make-start, make-stop time counter is available, let make-start of the counter be synchronized with switch-on of AC input signal to the relay and connect make-stop terminals of the time counter to 1-2 terminals of the relay. 60 Hz, 115 VAC conventional power system voltage is suitable, since underfrequency setting is now 60.98 Hz. The time delay can be adjusted by a rheostat on the upper front panel and be locked.

NOTE: The time delay is "the time measured by above method minus 1.5 cycle."

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 nearest General Electric Apparatus Sales Office.

Reasonable care should be exercised in unpacking the relay. 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 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 operation manually and check that the contact gap and wipe agree with the values given under the section MECHANICAL CHECK.

ACCEPTANCE TESTS

VISUAL INSPECTION

Remove the relay from its case and check that there are no broken or cracked component parts and that all screws are tight.

ELECTRICAL INSPECTION

Set Frequency Set Block at "00000-00000". Apply 60 Hz, 120 VAC conventional power system signal to 4 and 5 of relay. Check that the relay trips. Set Frequency Set Block at "11111-00100", which is 58.90 Hz, with the previous signal the relay should not trip. Return the frequency set block to its original setting and insert all plugs fully. When doing **PERIODIC** TESTING it may be required that the relay settings not be disturbed. In this case a variable frequency AC power source may be used to check the relay. 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.

NOTE:

When checking the 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.

ADJUSTMENT AND INSPECTION

MECHANICAL CHECK

Before installation, the telephone-type relay unit should be checked mechanically to see that it operates smoothly and that the contacts are correctly adjusted.

With the relay deenergized each normally open contact should have a gap of .010" - .015". Observe the wipe on each normally closed contact by deflecting the stationary contact member towards the frame. Wipe should be approximately .005".

The wipe on each normally open contact should be approximately .005". This can be checked by inserting a .0025" shim between the residual screw and the pole piece and operating the armature by hand. The normally open contacts should make before the residual screw strikes the shim.

INSTALLATION PROCEDURE

LOCATION

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 5.

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.

SERVICING

GENERAL

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.

It is not recommended that renewal parts obtained from sources other than the General Electric Company be used. Many parts used in relays which appear superficially similar to parts generally available have special features or construction which is not apparent on inspection. This is true in some cases even though the parts may have the same manufacturer and manufacturer's stock number.

Other parts, while the same as those generally available, undergo testing and inspection different than those generally available.

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: 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 ON 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

SET SCREWS COMBINATION A B C D E F G H J K	OPERATING FREQUENCY (HZ)	PERIOD 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 0 1 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 1 0 0	59.10	16920
0 1 0 1 0 0 0 1 0 0	59.05	16934
1 0 0 0 1 0 0 1 0 0	59.00	16949
0 0 0 1 1 0 0 1 0 0	58.95	16963
1 1 1 1 1 0 0 1 0 0	58.90	16977
0 1 1 0 0 1 0 1 0 0	58.85	16992
1 0 1 1 0 1 0 1 0 0	58.80	17006
1 0 1 0 1 1 0 1 0 0	58.75	17021
0 0 1 1 1 1 0 1 0 0	58.70	17035
0 0 1 0 0 0 0 1 0 1	58.65	17050
1 1 0 1 0 0 0 1 0 1	58.60	17064
0 1 0 0 1 0 0 1 0 1	58.55	17079
1 0 0 1 1 0 0 1 0 1	58.50	17094
1 0 0 0 0 1 0 1 0 1	58.45	17108
0 0 0 1 0 1 0 1 0 1	58.40	17123
1 1 1 1 0 1 0 1 0 1	58.35	17137
1 1 1 0 1 1 0 1 0 1	58.30	17152
0 1 1 1 1 1 0 1 0 1	58.25	17167
1 0 1 0 0 0 0 1 1 0	58.20	17182
1 0 1 1 0 0 0 1 1 0	58.15	17196
0 0 1 0 1 0 0 1 1 0	58.10	17211
0 0 1 1 1 0 0 1 1 0	58.05	17226
1 1 0 0 0 1 0 1 1 0	58.00	17241
0 1 0 1 0 1 0 1 1 0	57.95	17256
0 1 0 0 1 1 0 1 1 0	57.90	17271
1 0 0 1 1 1 0 1 1 0	57.85	17286
1 0 0 0 0 0 0 1 1 1	57.80	17301
0 0 0 1 0 0 0 1 1 1	57.75	17316
0 0 0 0 1 0 0 1 1 1	57.70	17331
1 1 1 0 1 0 0 1 1 1	57.65	17346

TABLE I (CONT'D)

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

TABLE II

50 HZ RELAY OPERATING POINT SETTINGS

SET SCREW COMBINATION A B C D E F G H J K	OPERATING FREQUENCY HERTZ	PERIOD 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 1 0	50.10	19960
1 1 0 1 0 0 0 0 1 0	50.05	19980
1 1 0 0 1 0 0 0 1 0	50.00	20000
0 0 1 1 1 0 0 0 1 0	49.95	20020
0 0 1 0 0 1 0 0 1 0	49.90	20040
1 0 1 1 0 1 0 0 1 0	49.85	20060
1 0 1 0 1 1 0 0 1 0	49.80	20080
1 0 1 1 1 1 0 0 1 0	49.75	20100
0 1 1 0 0 0 0 0 1 1	49.70	20120
0 1 1 1 0 0 0 0 1 1	49.65	20140
1 1 1 0 1 0 0 0 1 1	49.60	20161
1 1 1 1 1 0 0 0 1 1	49.55	20181
0 0 0 1 0 1 0 0 1 1	49.50	20202
0 0 0 0 1 1 0 0 1 1	49.45	20222
1 0 0 1 1 1 0 0 1 1	49.40	20242
1 0 0 0 0 0 0 1 0 0	49.35	20263
0 1 0 1 0 0 0 1 0 0	49.30	20283
1 1 0 0 1 0 0 1 0 0	49.25	20304
1 1 0 1 1 0 0 1 0 0	49.20	20325
0 0 1 0 0 1 0 1 0 0	49.15	20345
1 0 1 1 0 1 0 1 0 0	49.10	20366
1 0 1 0 1 1 0 1 0 0	49.05	20387
0 1 1 1 1 1 0 1 0 0	49.00	20408
1 1 1 0 0 0 0 1 0 1	48.95	20429
1 1 1 1 0 0 0 1 0 1	48.90	20449
0 0 0 1 1 0 0 1 0 1	48.85	20470
1 0 0 0 0 1 0 1 0 1	48.80	20491
0 1 0 1 0 1 0 1 0 1	48.75	20512
0 1 0 0 1 1 0 1 0 1	48.70	20533
1 1 0 1 1 1 0 1 0 1	48.65	20554
0 0 1 0 0 0 0 1 1 0	48.60	20576
1 0 1 1 0 0 0 1 1 0	48.55	20597
0 1 1 0 1 0 0 1 1 0	48.50	20618
1 1 1 1 1 0 0 1 1 0	48.45	20639
1 1 1 0 0 1 0 1 1 0	48.40	20661
0 0 0 0 1 1 0 1 1 0	48.35	20682
1 0 0 1 1 1 0 1 1 0	48.30	20703
0 1 0 0 0 0 0 1 1 1	48.25	20725
1 1 0 1 0 0 0 1 1 1	48.20	20746
0 0 1 0 1 0 0 1 1 1	48.15	20768
1 0 1 1 1 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 1 1	46.85	21344
0 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

TABLE III

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

TABLE IV

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 Secs.	---------
Carry 10 Amps For	30 Secs.	0.2 Secs.

PHOTO NOT AVAILABLE AT THIS TIME

FIG. 1A (   ) Type SFF21A Relay Removed From Case (3/4 Front View)

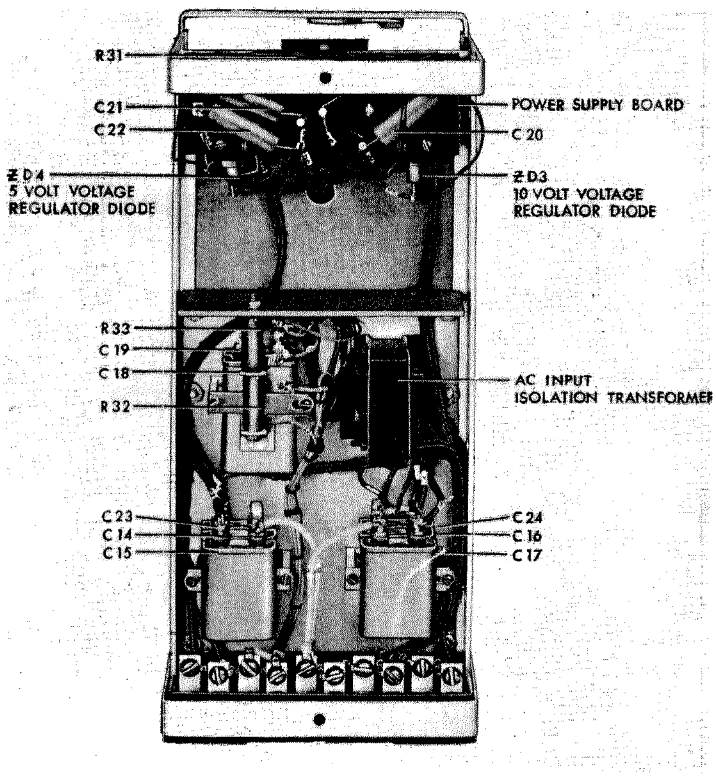


FIG. 1B (8039875) Type SFF21A Relay Removed From Case (Rear View)

TYPE SFF RELAY, FREQUENCY VS TIME CHARACTERISTICS FOR TOTAL CLEARING TIME

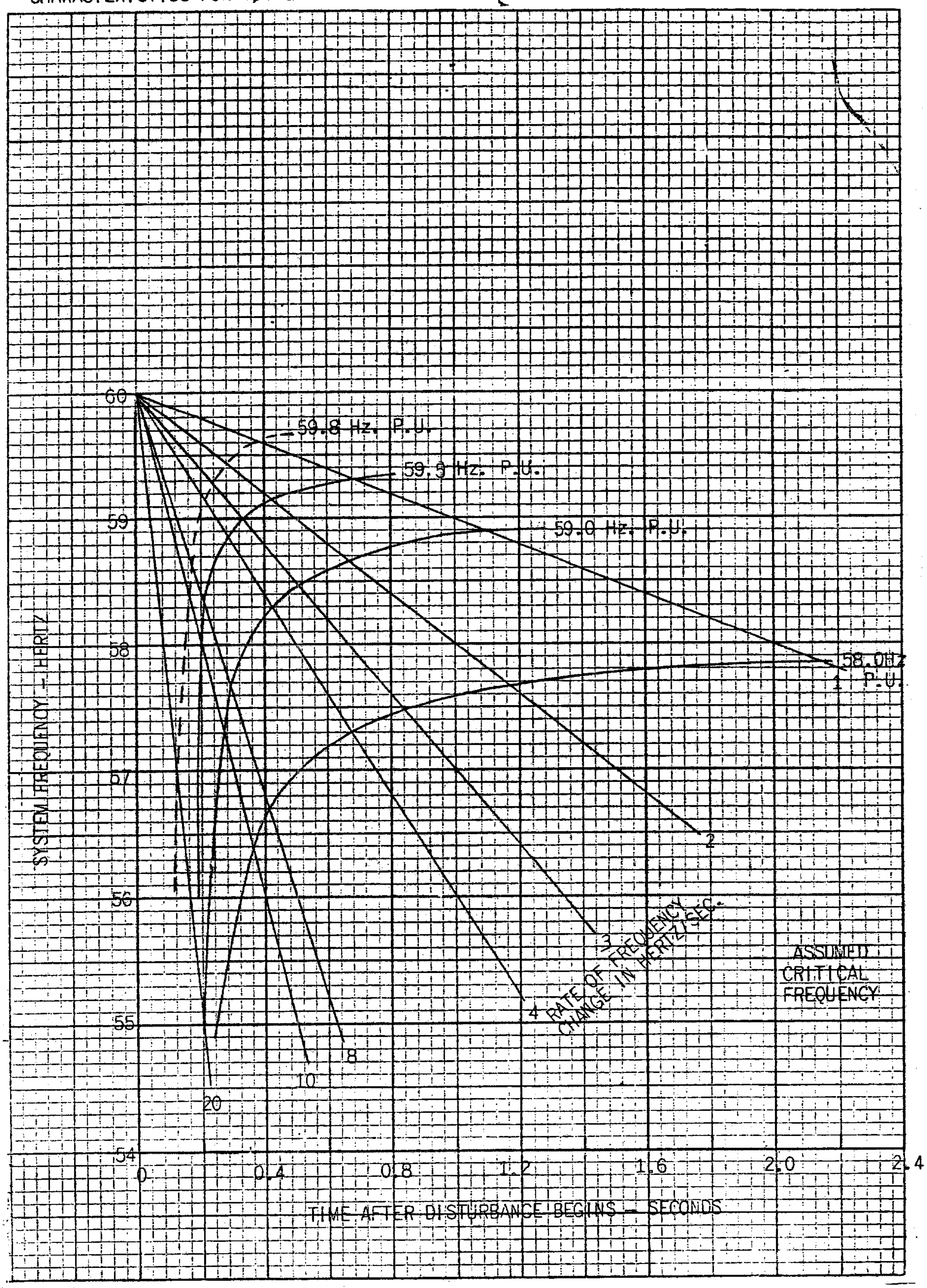


FIG. 2 (0208A3902-2) Time Required To Remove Load And Frequency When It Is Removed

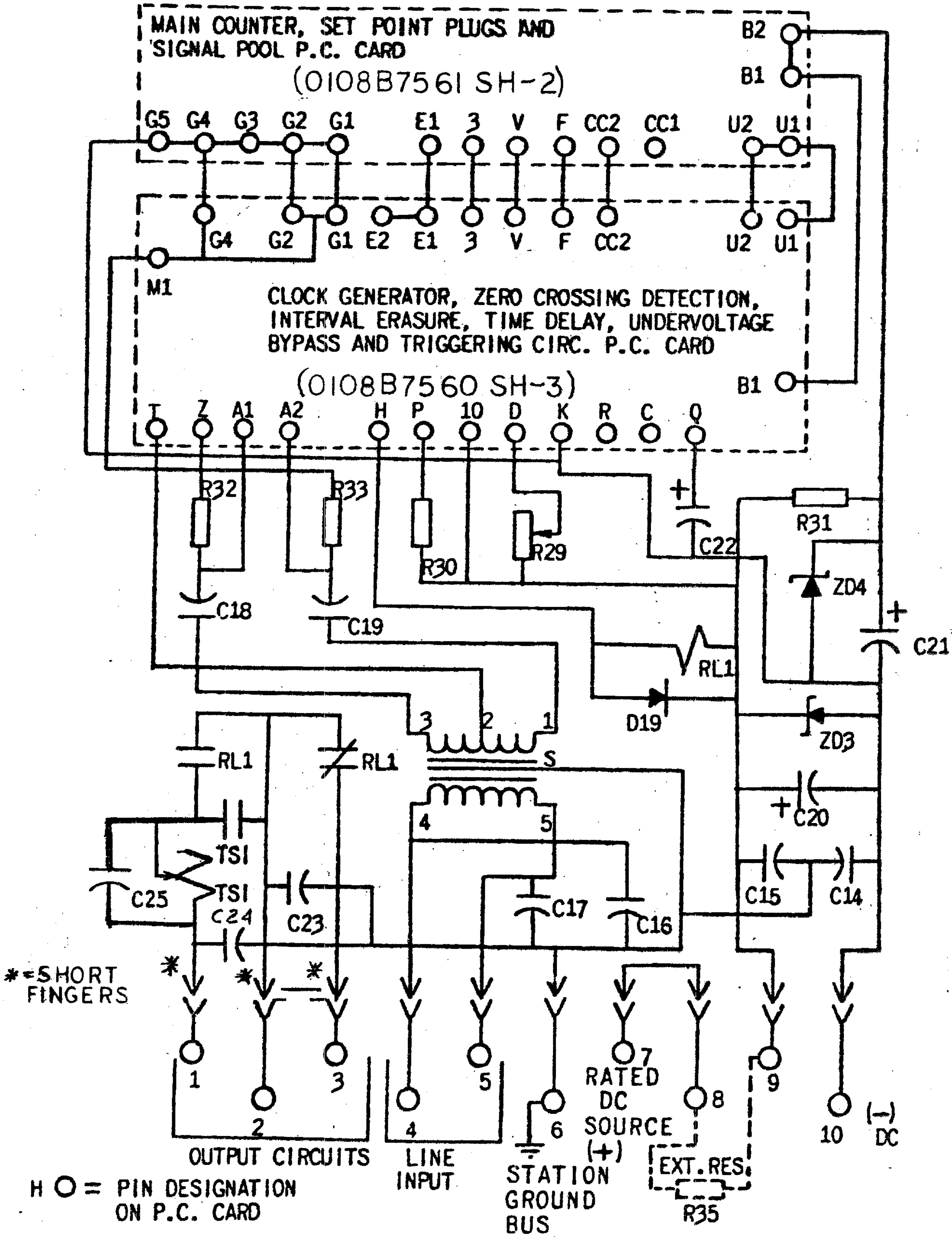
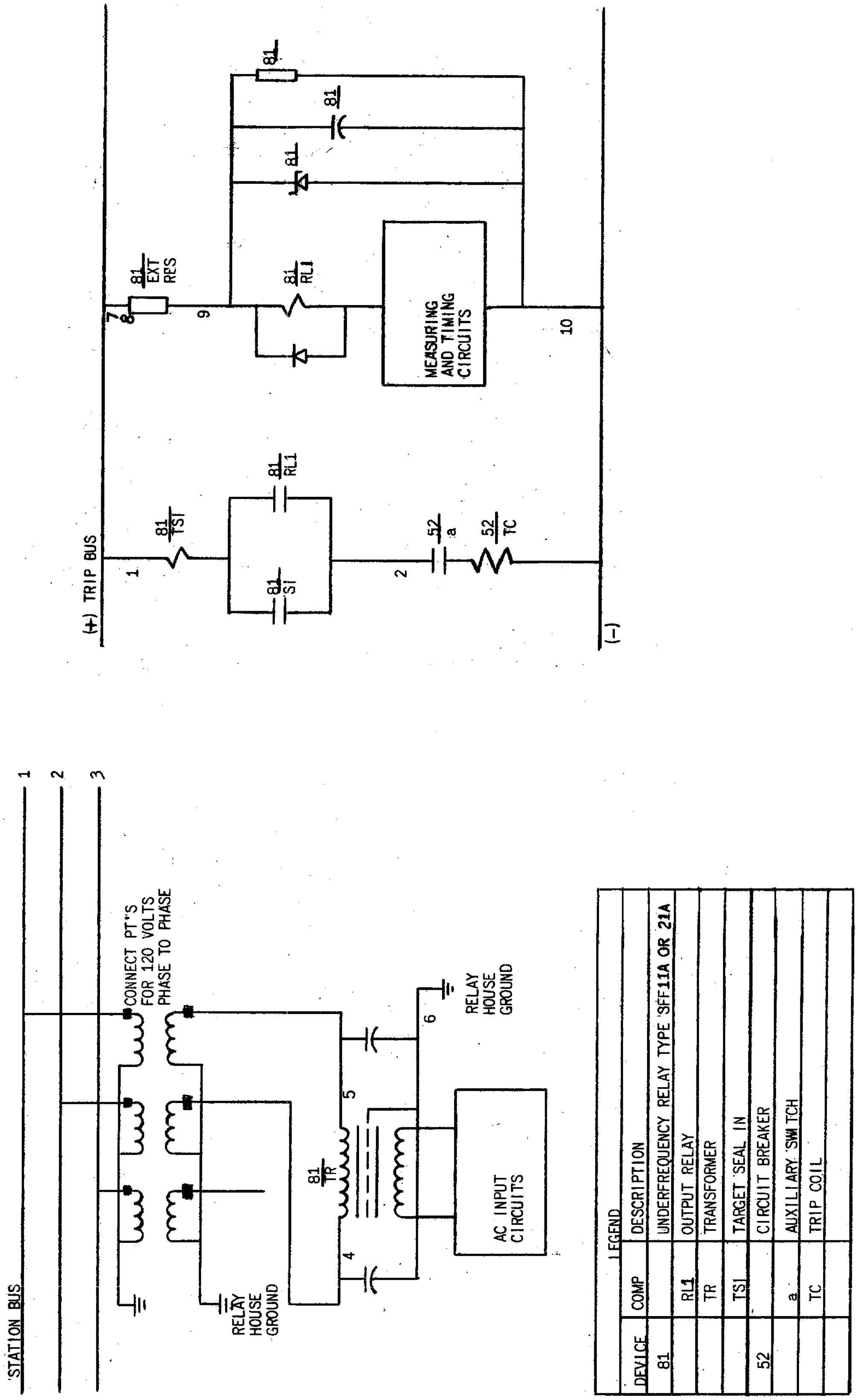


FIG. 3 (0246A6872-0) Internal Connections Diagram For Type SFF21A Relay



LEGEND

DEVICE	COMP	DESCRIPTION
81		UNDERFREQUENCY RELAY TYPE SFF11A OR 21A
	RL1	OUTPUT RELAY
	TR	TRANSFORMER
	TS1	TARGET SEAL IN
52		CIRCUIT BREAKER
	a	AUXILIARY SWITCH
	TC	TRIP COIL

FIG. 4 (0165B2247-2) External Connections Diagram For Type SFF21A Relay

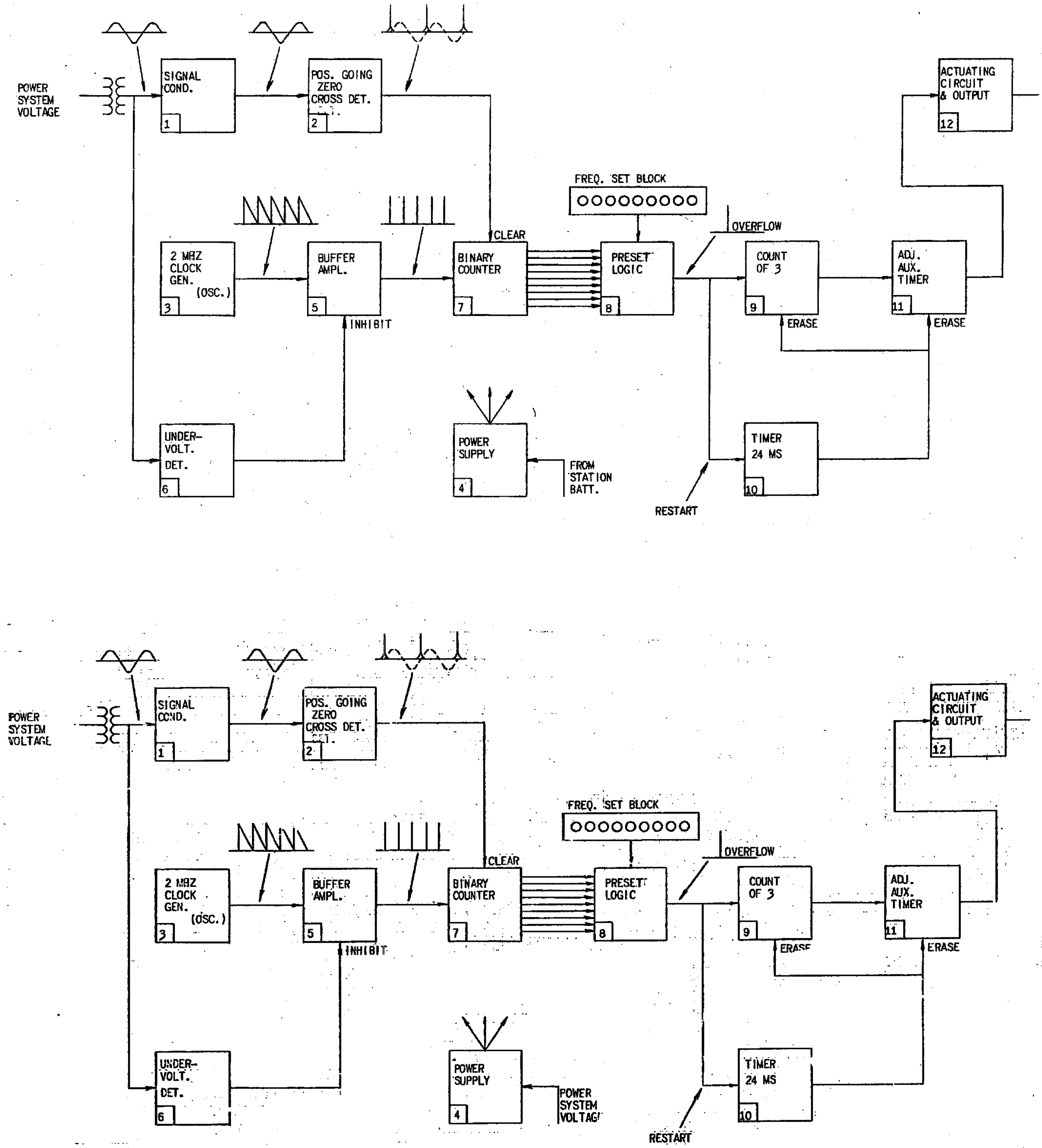


FIG. 5 (0165B2279 SH. 1 & 2) Functional Block Diagram For Relay Type SFF21A

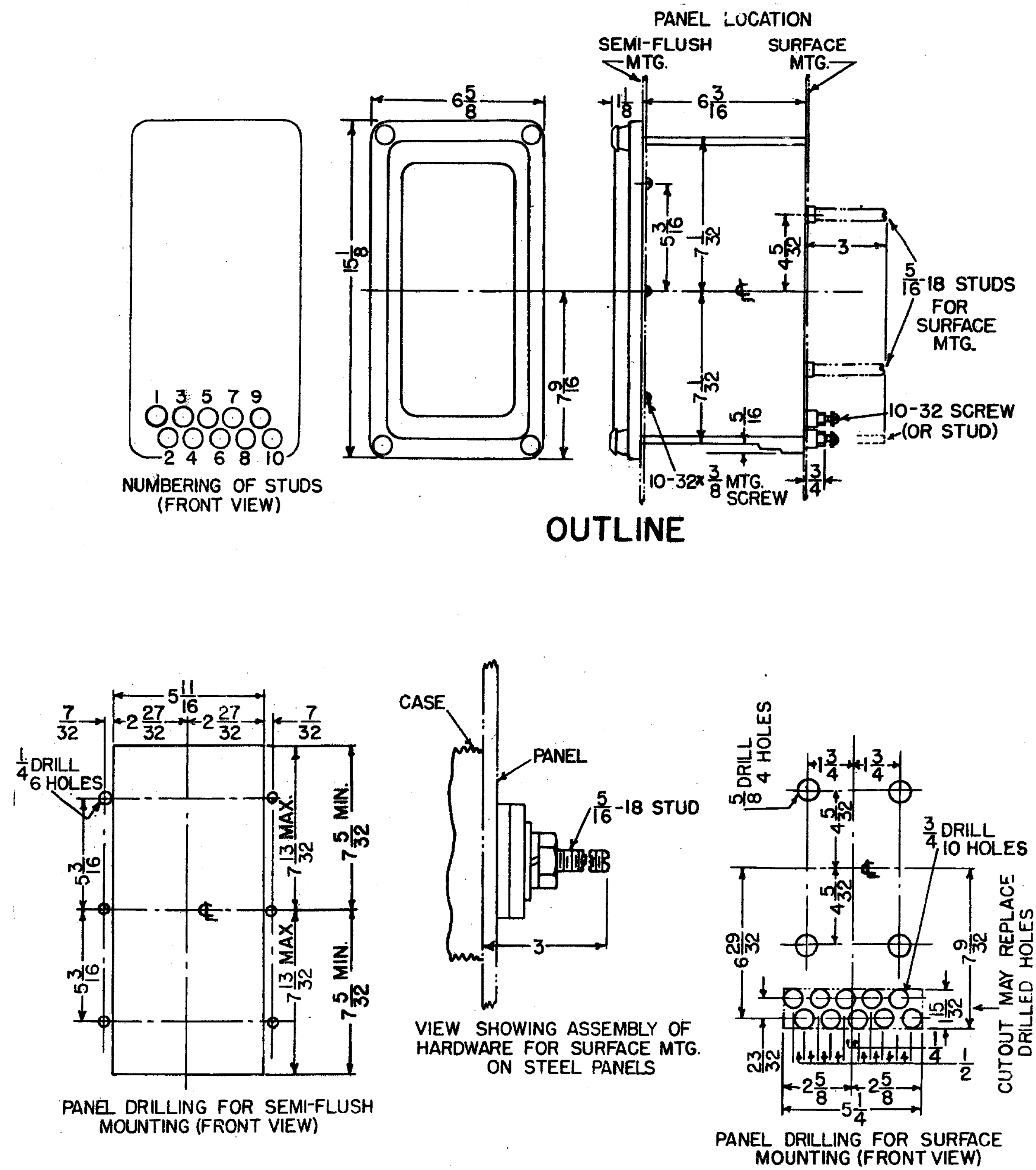


FIG. 6 (K-6209273-2) Outline And Panel Drilling Dimensions For M1 Case Used For Type SFF21A Relay

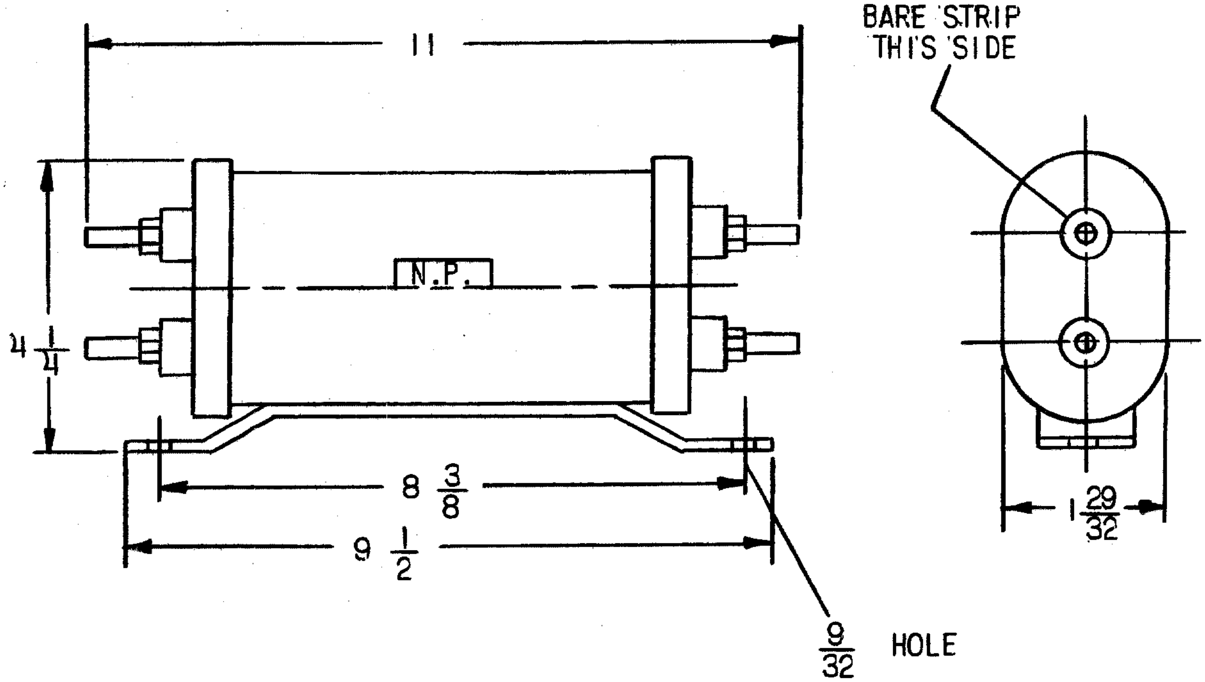


FIG. 7 (403A119-1) Outline Of External Resistor For Type SFF21A Relay (125 And 250 Volt DC Control Voltages)

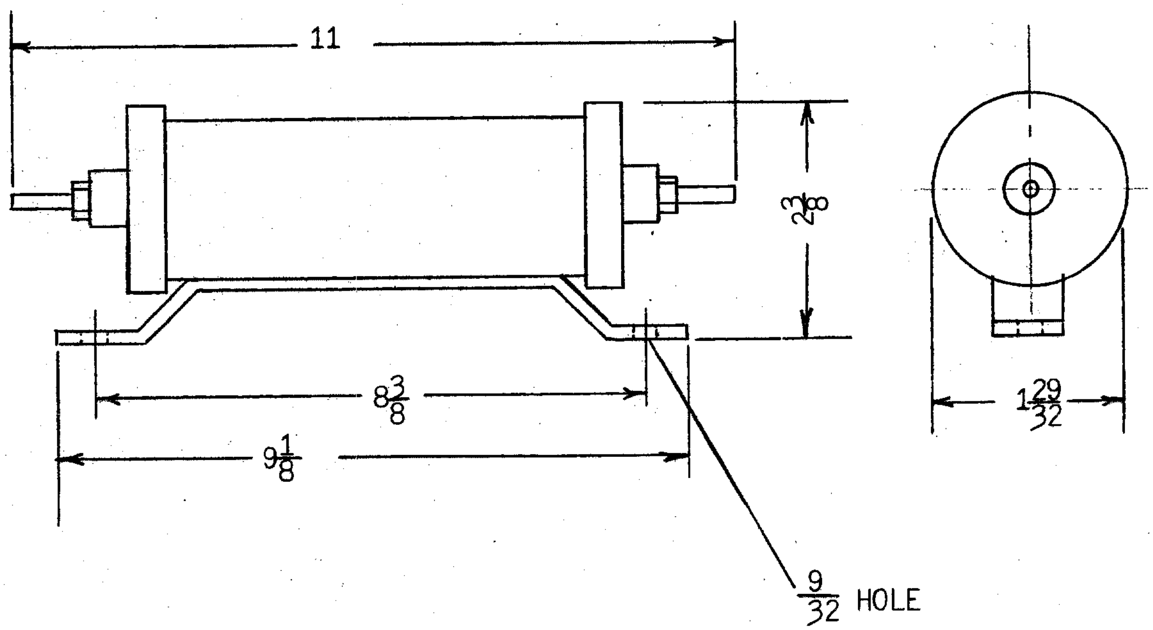


FIG. 8 (389A752-1) Outline External Resistor For Type SFF21A Relay (DC Control Voltages Below 60 Volts)

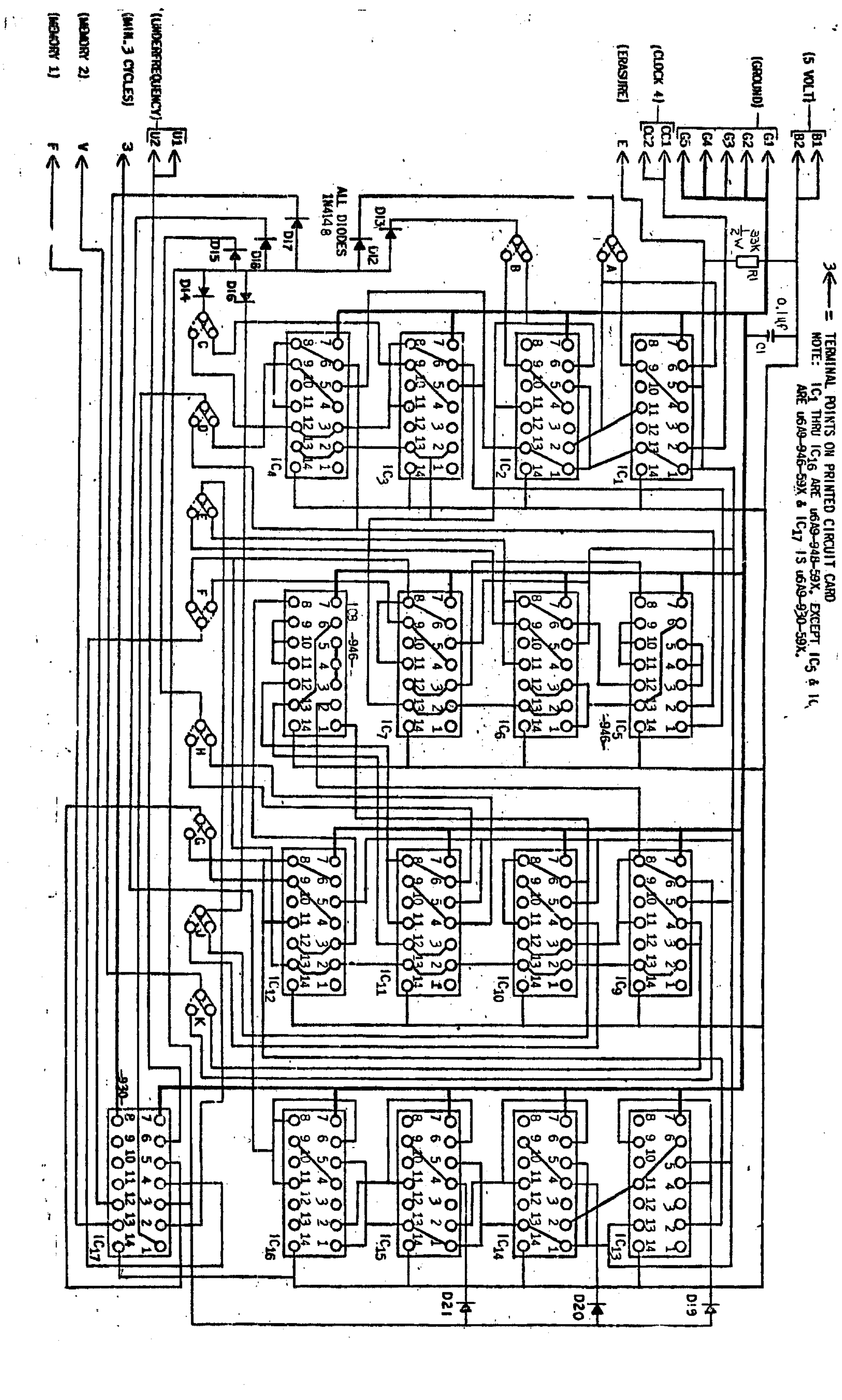


FIG. 9 (108B7561-0 SH. 2) Set Point Board Internal Connections Diagram

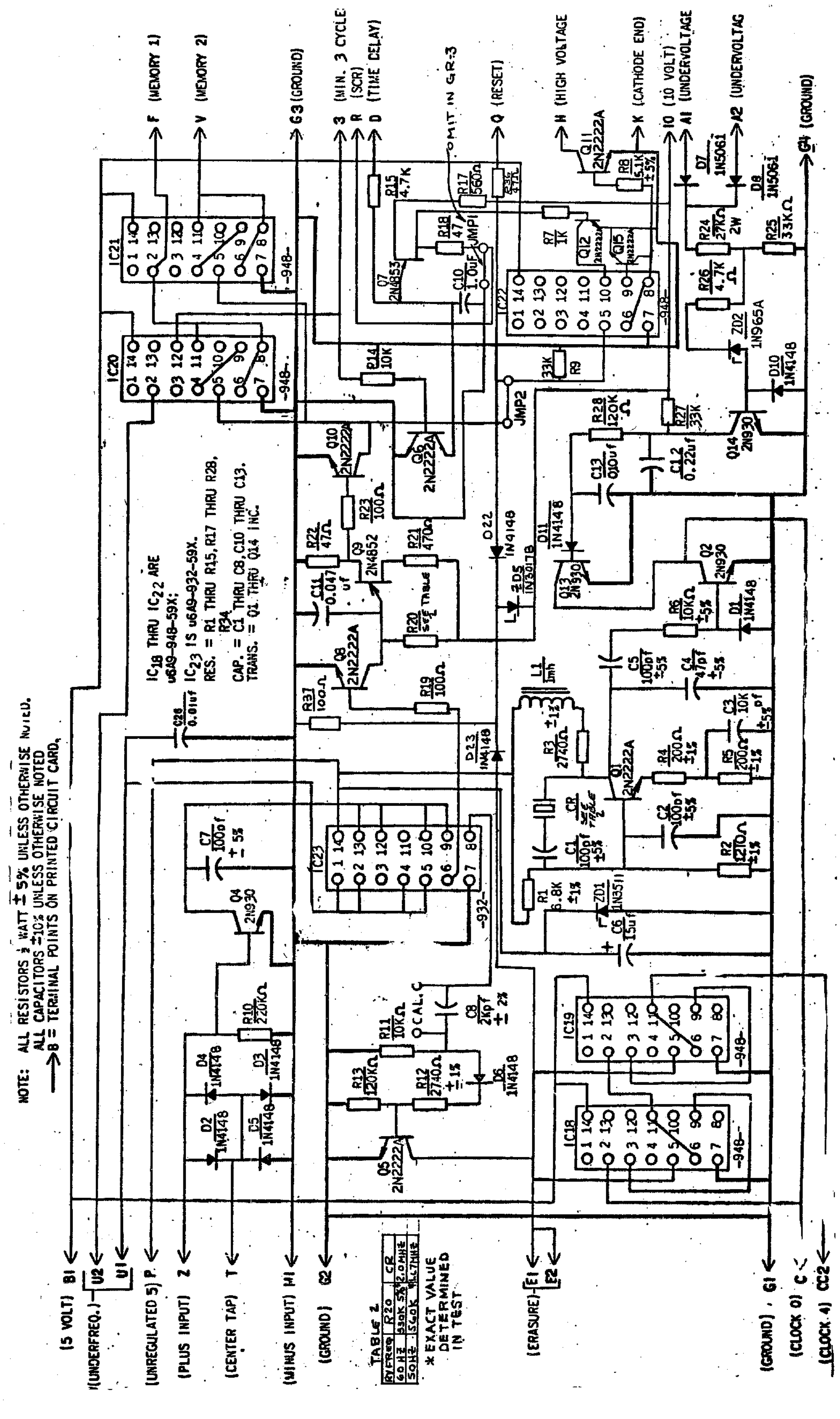


FIG. 10 (108B7560-0 SH. 3) Clock Generator Board Internal Connections Diagram

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