PROXIMITY SWITCH

INTRODUCTION

The instrument primarily detects the approach of a human body, but it can be used to detect and signal any event that is accompanied by a change of capacity. This means that, with proper arrangement of the sensor (which is a mere piece of wire), it can detect nearness or movement of nearly any physical object.

These are only a few of its applications: Burglar alarm; detection of illegal entry, crossing a room or a fictitious line; verification of presence or absence of a small object or animal in a predetermined area; detection of minimum/maximum level of a liquid, powder or grain; starting or stopping of a machine by merely approaching it, or by simple hand or finger movement; magic tricks; secret signaling; inconspicuous actuation of an alarm or defense device by slight movement of the body; self-activation of cameras, or traps for small animals or birds; counting of drops of liquids, or objects passing along an assembly line; automatic lighting of rooms or shop windows; opening of doors; etc.

Some additional circuits, including the lock, timer, siren and several DC and AC switches, are described in the Appendix for application requiring higher current or voltage, operation on AC lines or with certain logical functions.

HOW IT WORKS

Referring to the block diagram in Figure 2, note that a network consisting of radio transformer Tr and capacitors C1 and C2 is connected to the input of an amplifier, the output of which is fed back to the transformer. The transformer windings are arranged in such a way that the right branch, L1 and C1, produces a negative feedback, whereas the left branch, L2 and C2, provides positive feedback. C1 is adjusted so that the negative feedback is slightly greater and fully balances the positive feedback. Under this condition, the system is in a stable state.

Now when some object is brought near the sensor, the sensor's capacity (represented as C2) increases. As a result, the positive feedback also increases until it is no longer fully canceled, and the system begins to oscillate. The oscillation voltage is then rectified and fed to a DC amplifier, which in turn produces an output that can control some of the circuits described in the Appendix.

Figure 1 shows the complete schematic diagram of the proximity switch and its block symbol (Px), which is used in the Appendix. Note that three padders form the capacity C1 shown in the block diagram. Padder 2 provides a coarse adjustment, padder 1 a fine adjustment. If the sensor wires are too long or are connected to a large metallic object, the combined capacity of padders 1 and 2 may not be large enough. In this case, another padder (3) can be connected into the circuit by a means of the switch (13). Because of its connection to the transformer, the capacity of this padder is virtually multiplied by a factor of 10, which should be sufficient for all cases.

HOW TO BUILD IT

The instrument can be built on a board, such as shown in Figure 3, or into any box, preferably a metal case, which, when connected to terminal d will provide shielding and eliminate the influence of hand capacity during adjustment of C1. In any event, the mechanical construction should be rigid.

The current drawn in the stable state (no alarm) is so small that there is no need for a battery switch. If the unit is to be idle for a prolonged period of time, the battery (which can be 6 to 12 volts, any type and size) should be removed.

Winding data for the transformer are given in Figure 4. Care should be taken to connect the start (S), the tap (T), and the finish (F) of each winding precisely as indicated in Figure 2.

HOW TO MAKE IT WORK

Connect a 9-volt battery to terminals + and -, solder one end of an insulated hoop-up wire to terminal a, and connect a voltmeter (set to 10-volt range) between terminals - (minus) and e (plus), set padders 1 and 2 to minimum capacity (their screws completely out), and switch off padder 3. (See Figure 5.)

The meter should now read 9 volts (full battery voltage), giving an indication that the system is oscillating. Slowly increase the capacity of C1 until the meter reads nearly zero. If you now reach towards the sensor wire, the meter will quickly register the full voltage.

Some experimentation will quickly show how to arrange the sensor wires for maximum sensitivity. Two wires, three to six feet long and about six inches apart, give very satisfactory results. Such a twin line can be tucked under the carpet, where no one can cross it without causing an alarm, or it can be wall-mounted at a height approximately three feet above the floor, enabling detection of a person at a distance of one or two yards, provided that the padders are properly adjusted for maximum sensitivity. Maximum sensitivity can be achieved only if terminal d is somehow returned to ground: Outdoors by connection to a wire fence or to a large nail driven into the soil, or indoors by connection to a heater or to a water pipe.

For the detection of smaller objects it is best to use a small metallic plate or a piece of aluminum foil as a sensor. A typical size would be about one square foot or less.

To detect small movements of objects, use a metallic plate placed close to the object. A good rule of thumb is to make the gap between the object and the sensor about twenty times larger than the amount of movement to be detected. However, take care to make the arrangement rigid, otherwise you will end up with a seismometer.

For applications requiring maximum sensitivity, the padders must be adjusted to just below the point where oscillations start. Hand capacity introduced while making these adjustments generally makes precise settings difficult. The perfect solution is to build the proximity detector into a metal box, to connect the box to terminal -, and to use double shielded cable as depicted in Fig. 6. Two to three feet of this cable give excellent results. Just remember that the "sensing" starts at the point where the cable and sensor wire are connected.

If for any reason the proximity detector and the sensor must be separated by more than three feet, double shielded cable becomes a necessity. In cases where the cable length exceeds six feet, capacitor 4 (Figs. 1 and 3) should be removed to prevent loss of sensitivity.

Some experimentation will show you that the proximity switch is an extremely sensitive and dependable device. However, to take full advantage of its capabilities, some logical elements and a power switch must be added . Please refer to APPENDIX for details.

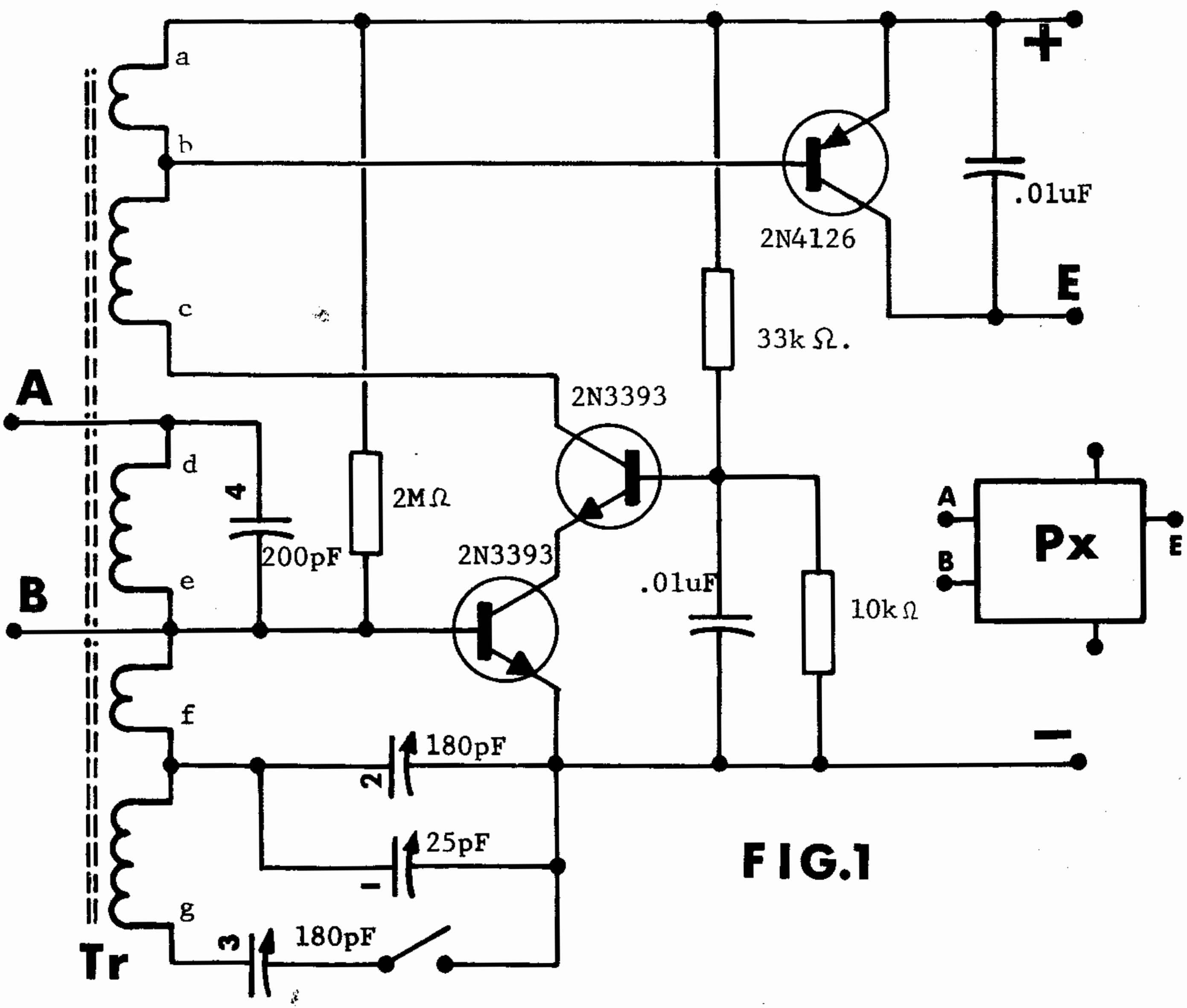


FIG.1

PARTS LIST:

Transistor 2N3393 (2 pieces)
Transistor 2N4126
Resistor 2MΩ (any wattage)
Resistor 33kΩ ,,
Resistor 10kΩ ,,
Padder 2-25 uuF (value not critical)
Padder 20-180uuF ,, 2 pieces
Capacitor 200uuF (any kind, voltage)
Capacitor .01uF ,, 2 pieces
Switch (optional) SPST
RF Transformer special; see text.

fig.5

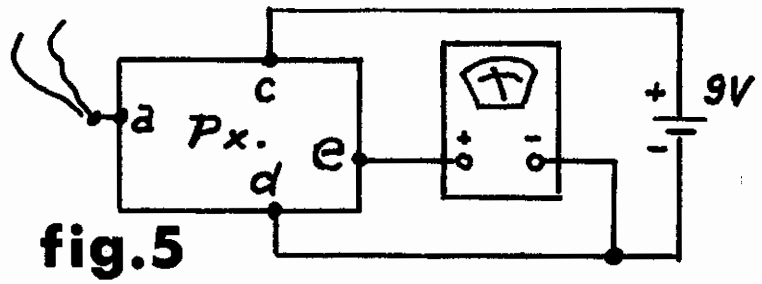


fig.6

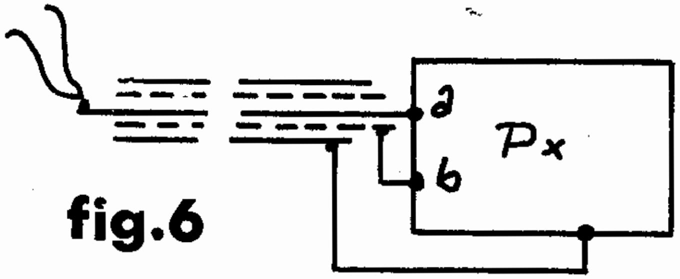


FIG.2

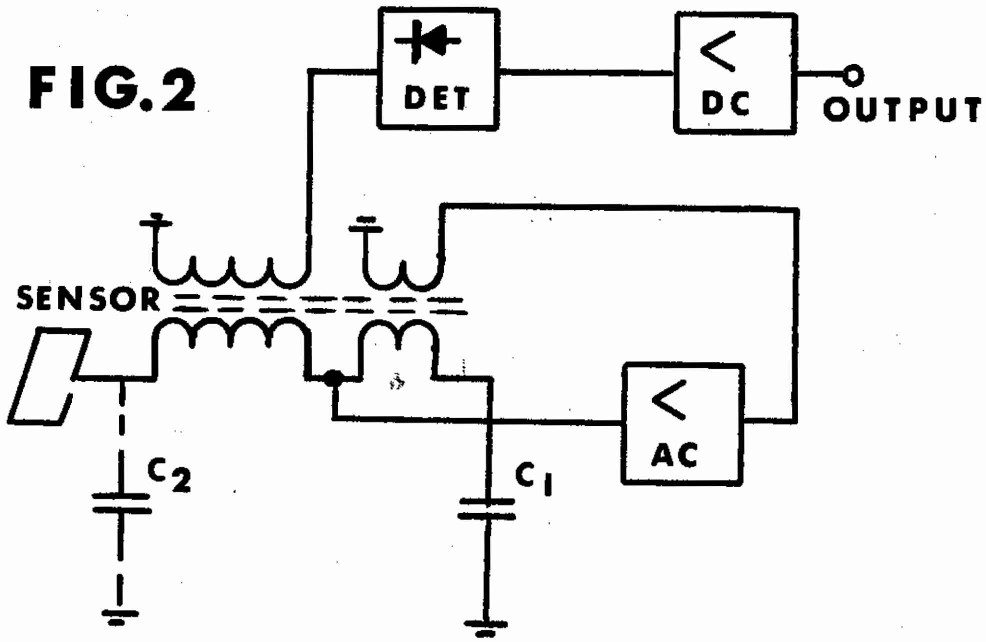


fig.3

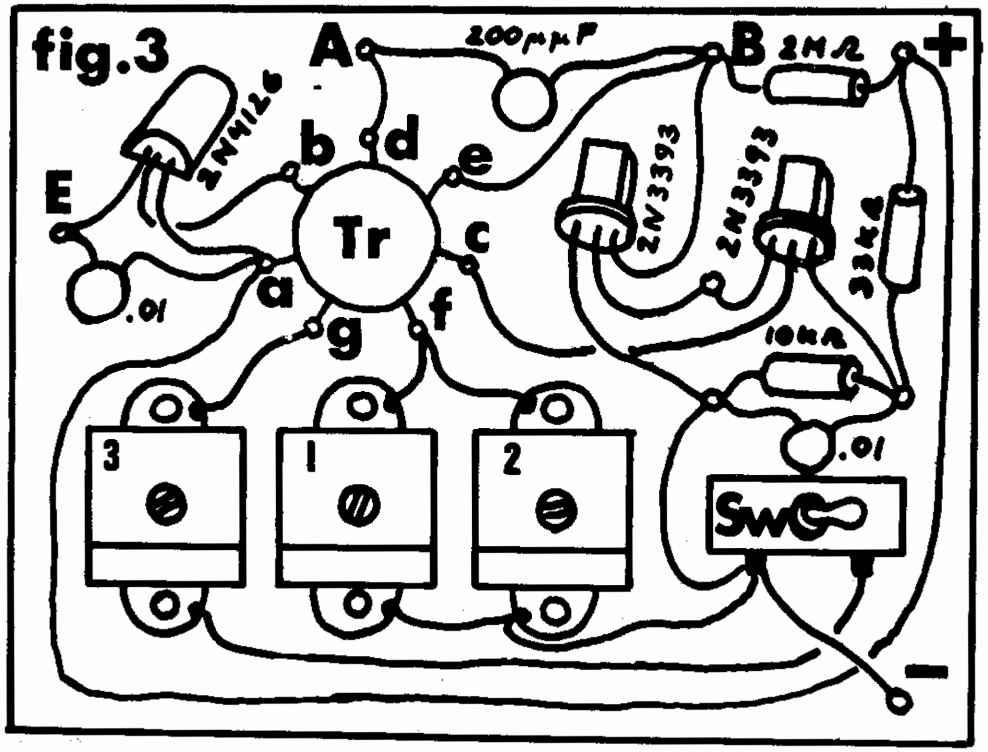
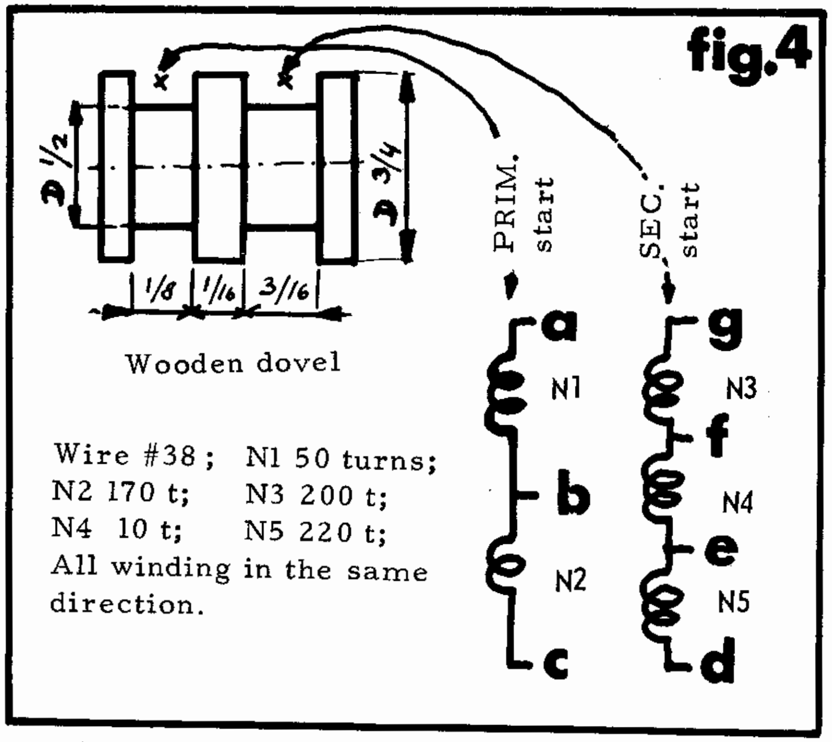


fig.4



APPENDIX.

For the benefit of those who are not familiar with electronics, we have chosen a domino-like approach. Each circuit is described and its symbol is given. You will see that the circuits are easy to build, that their inputs and outputs are fully compatible, and that you can simply string them together for any desired effect. Fig.7 shows the "domino" approach for a simple case--the proximity switch directly driving a load (in this case a siren.) Note that all the + and - terminals are connected together, and that the output terminal e of the proximity switch is connected to the input terminal w of the siren. From the timing diagram you see that when the object comes near to the sensor, the proximity switch is activated, when the object departs, the proximity switch turns off. The siren (second line) follows the switch (but only in this case),which means it starts to sound when the object approaches the sensor and stops when it moves away. This case can be described as: "The load is ON whenever Px is ON.

Just the opposite is shown in Fig.8, the load is OFF whenever Px is ON. A typical application is to stop a machine whenever a part of a body is in a dangerous area.

If you are a novice in electronics, the many drawings that follow may scare you a little. However, Figures 3, 4 and 5 are the only drawings that you need be concerned with at this time. All you have to do is to build the Px according to these three figures. As soon as you gain some experience with the basic unit, you will begin to discover (and appreciate) other possibilities using other drawings. Good luck!

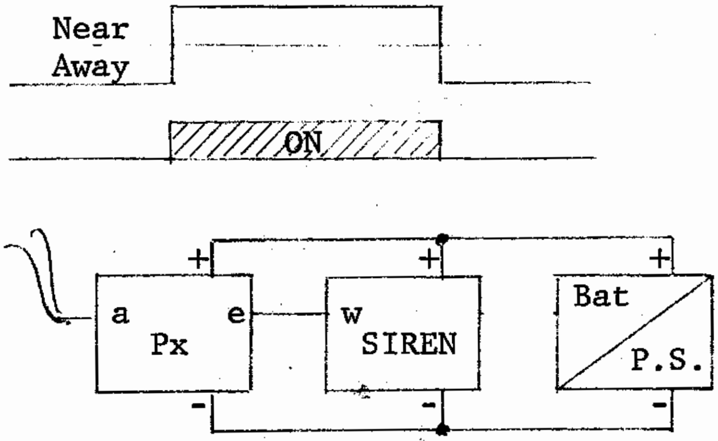


FIG.7 the load is ON whenever Px is ON.

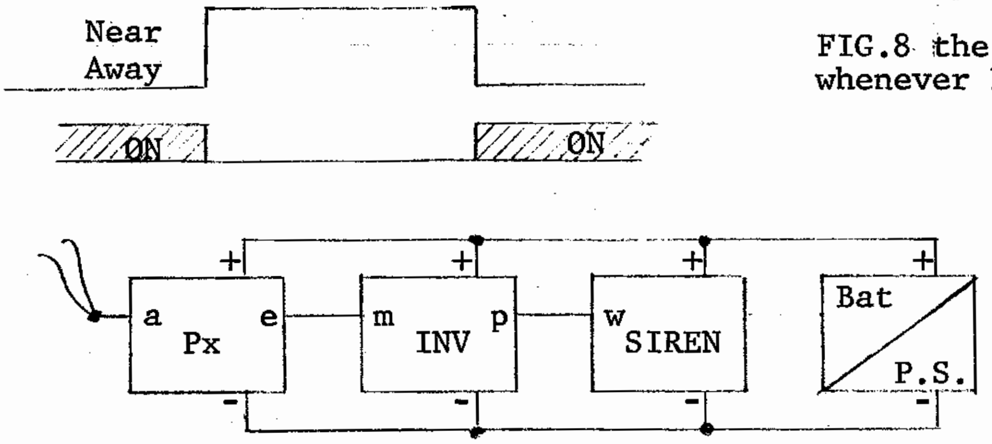


FIG.8 the load is OFF whenever Px is ON.

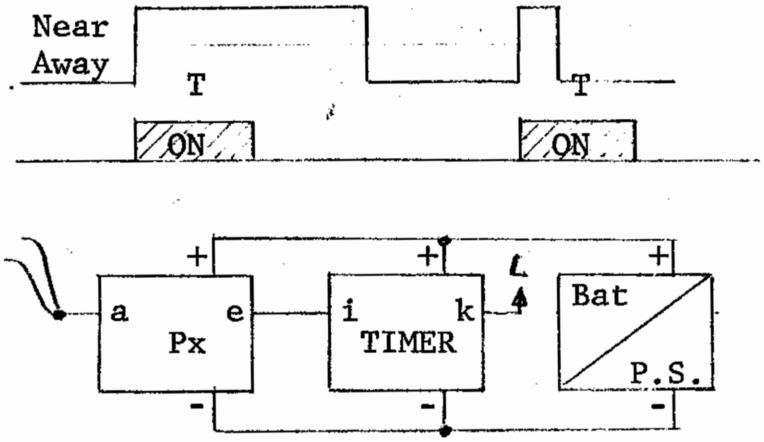


Fig.9 the load is switched ON together with Px and stays ON only for a predetermined time T regardless of the duration of Px.(Constant-time switching)

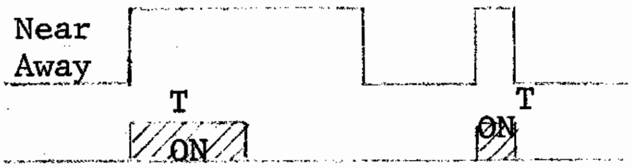
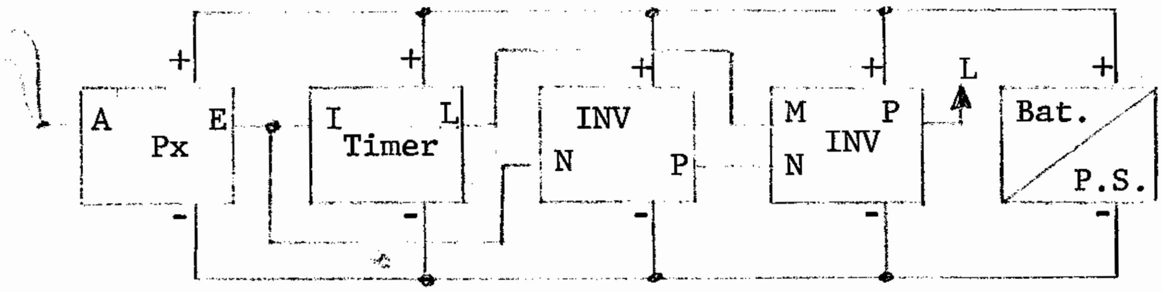


FIG.10. The load is switched ON together with Px and stays ON for a predetermined time T or for the duration of Px, whichever is shorter. (Maximum-time-limit)



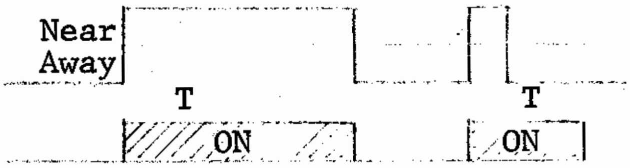
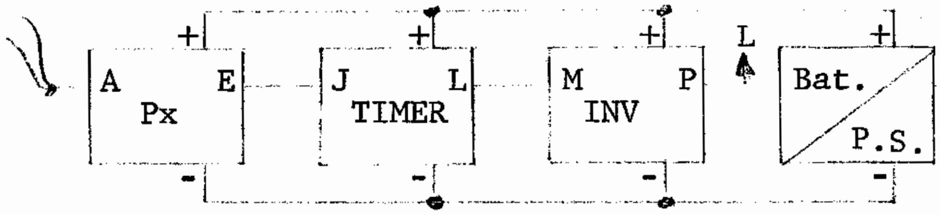


Fig.11. The load is switched ON together with Px, and stays ON for a predetermined time T or for the duration of Px, whichever is longer. (Minimum-time-limit switching)



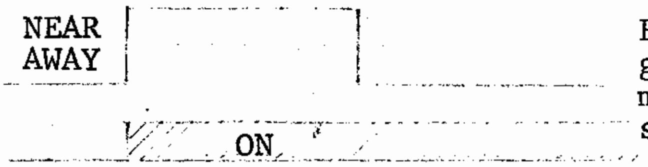
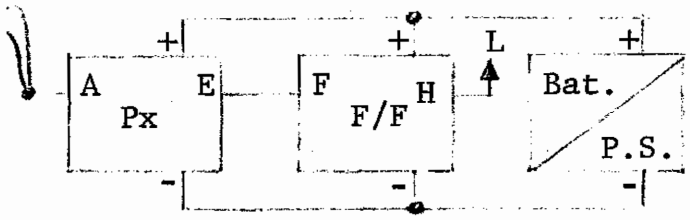


FIG.12. The load is switched together with Px and stays ON until manually reset. (continuous mode switching)



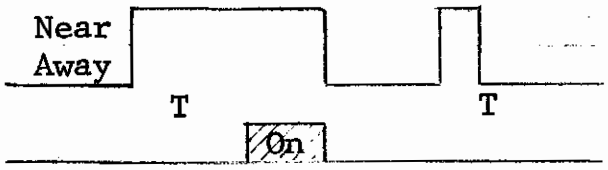
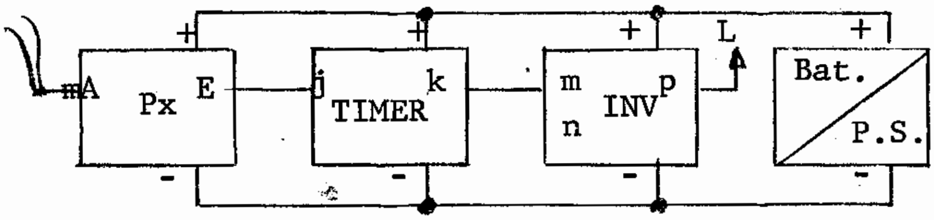


FIG.13. Switching ON the load is is delayed by time T; load stays ON for the rest of duration of Px--if any.



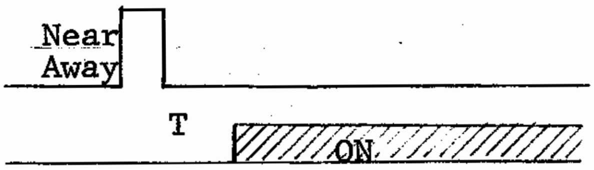
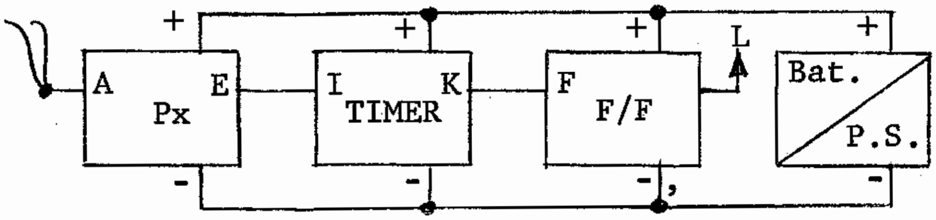


FIG.14. The load switching is delayed by time T, it stays ON until manually reset.



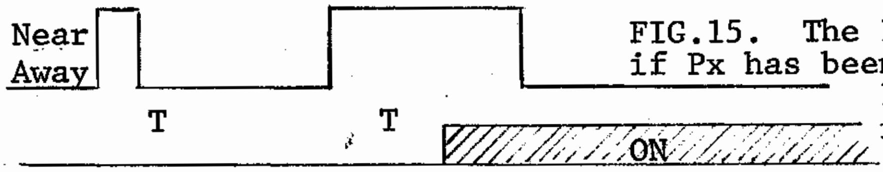
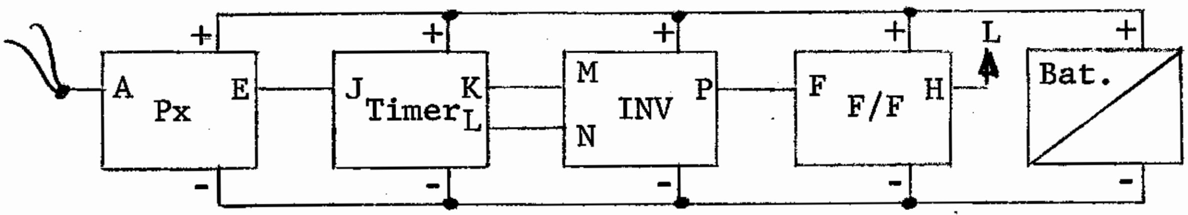


FIG.15. The load is switched ON only if Px has been ON for at least time T. It stays ON until manually reset.



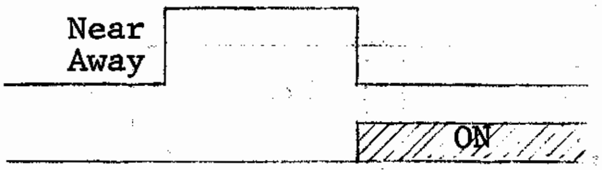
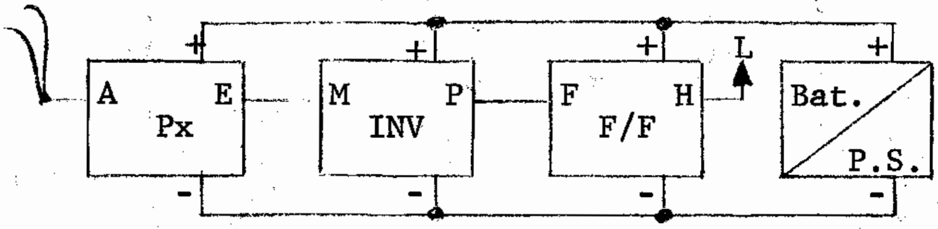


FIG.16. The load is switched ON after Px switches OFF and stays ON until manually reset.(continuous)



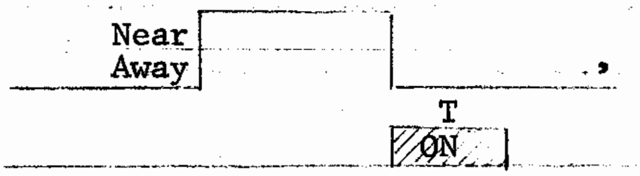
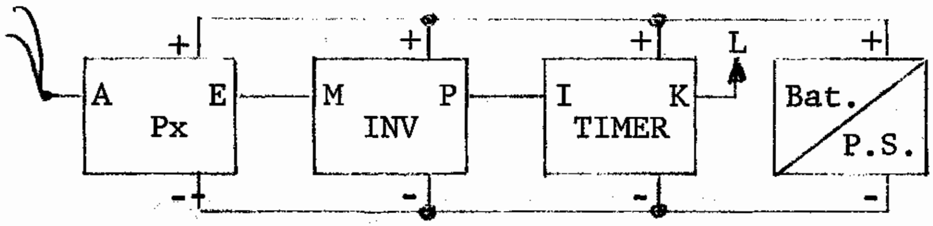


FIG.17. The load is switched ON after Px is switched OFF and stays ON for a predetermined time T.



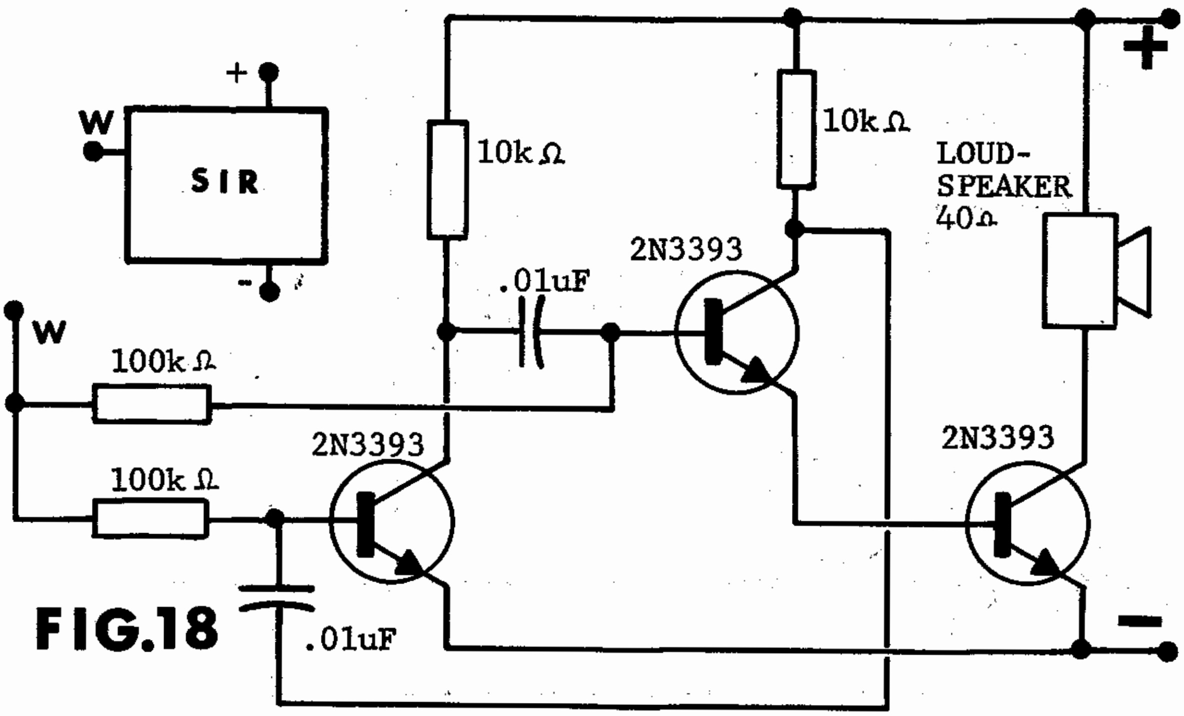


FIG.18

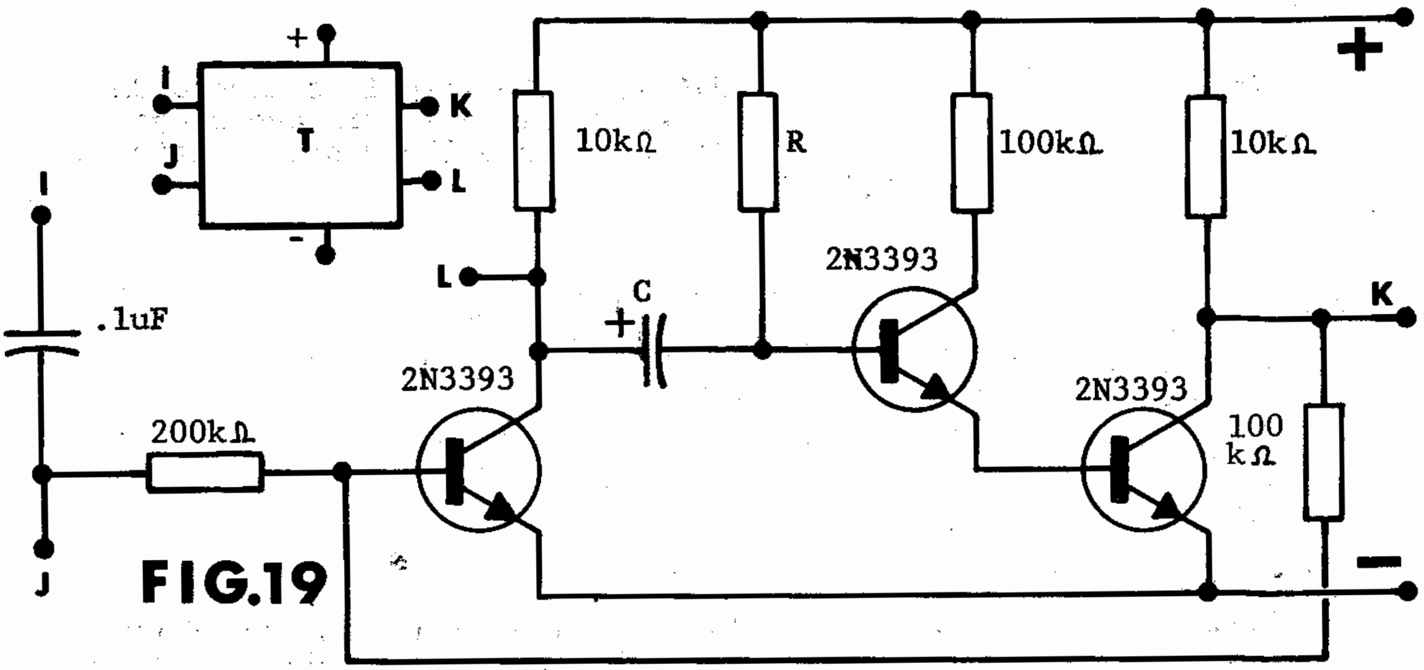


FIG.19

TIME	sec	0.1	0.2	0.5	1	2	5	10	20	50
R	MΩ	0.2	0.4	1	2	2	2	2	2	2
C	μF	1	1	1	1	2	5	10	20	50

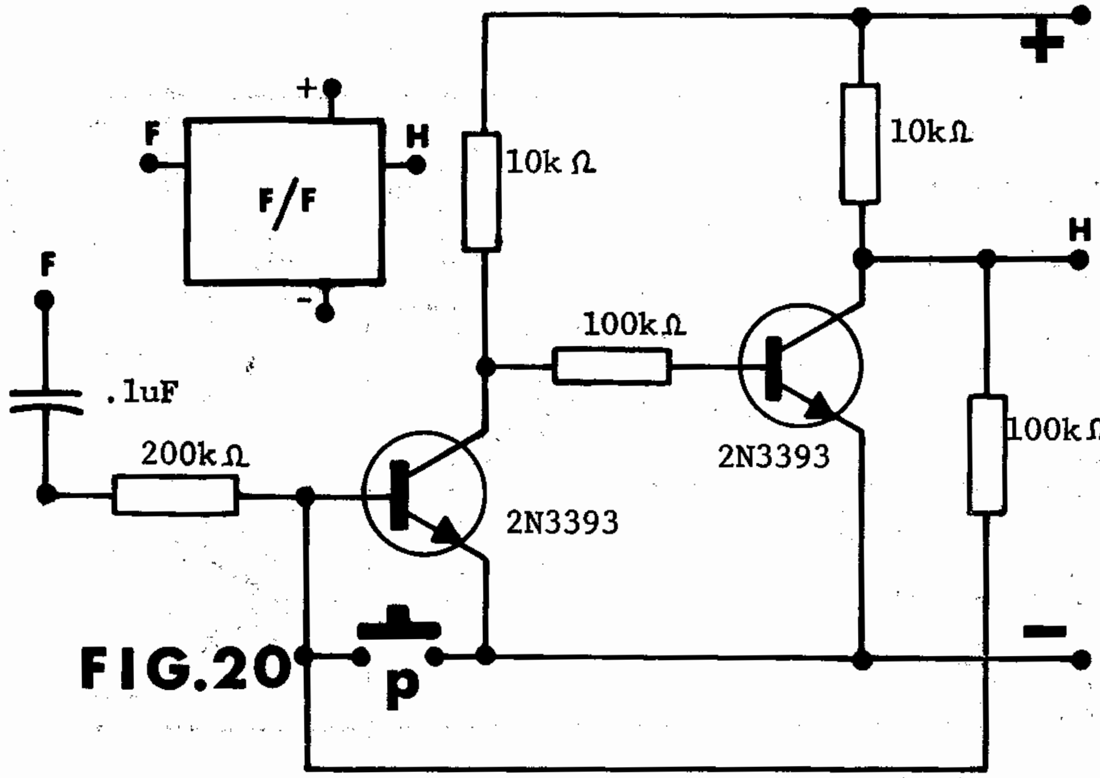


FIG.20

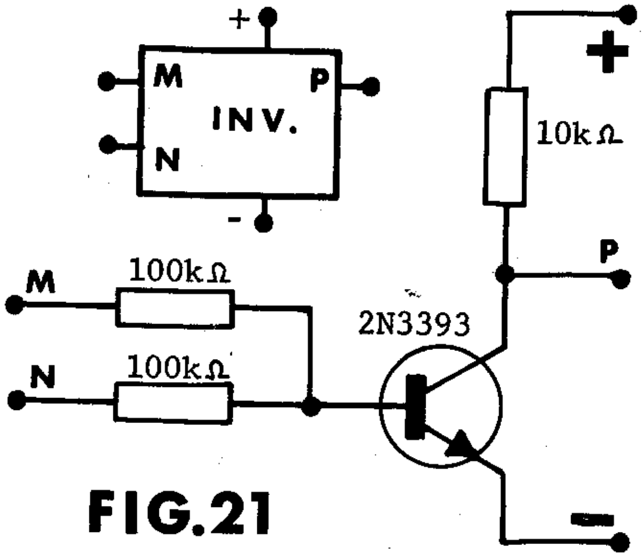


FIG.21

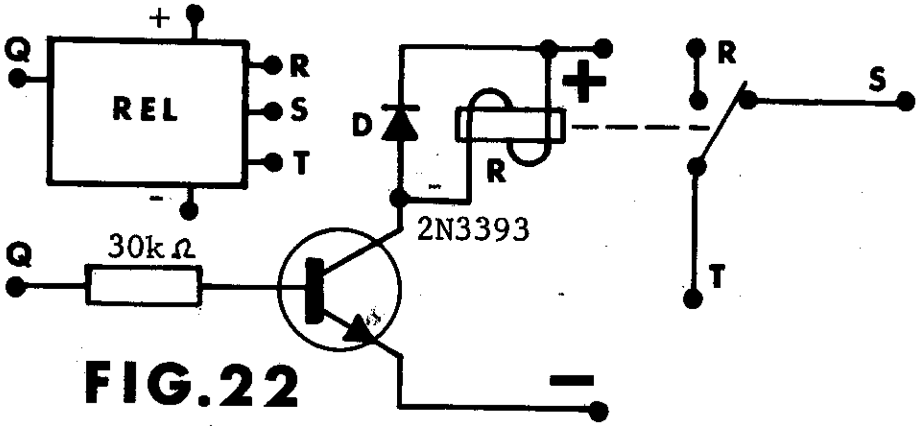


FIG.22

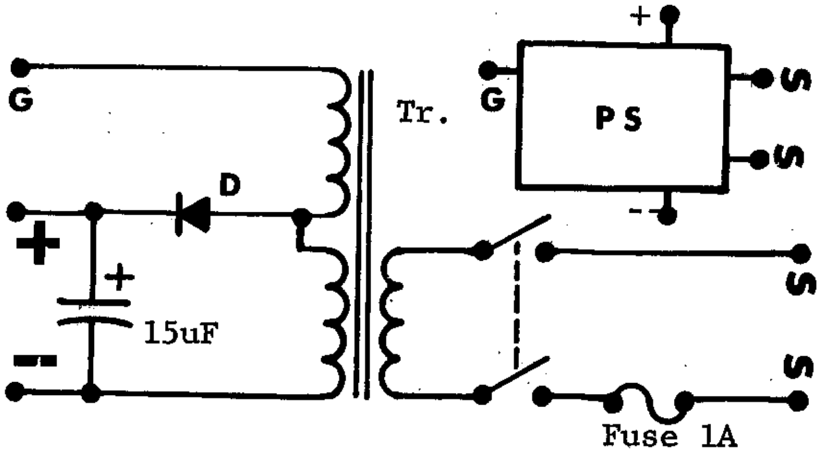


FIG.23

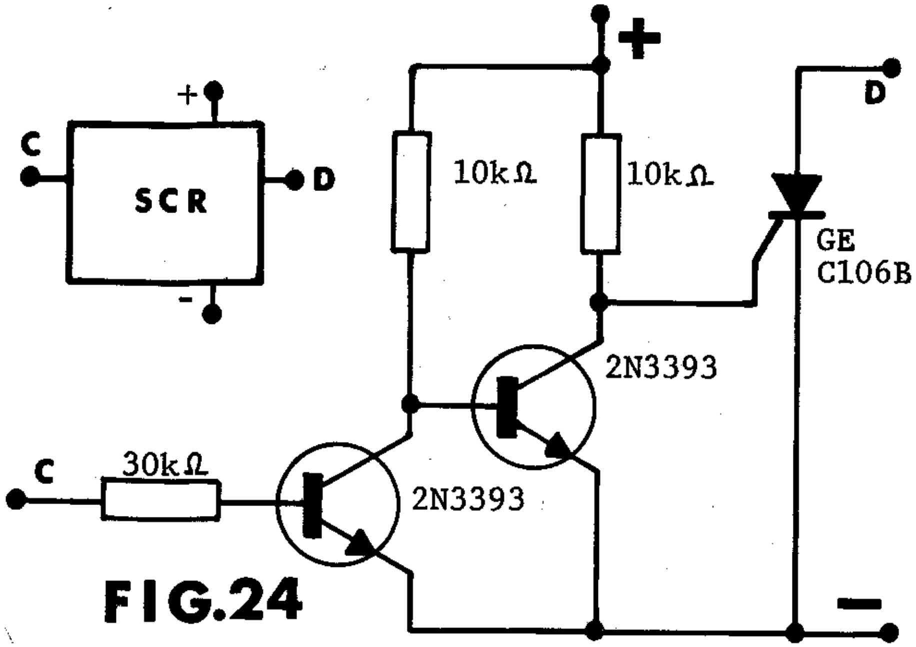


FIG.24

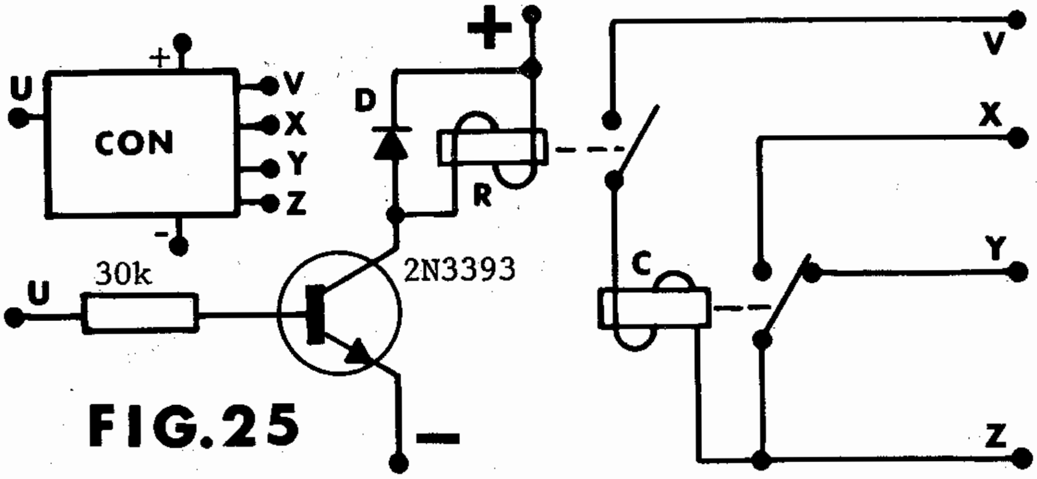


FIG.25

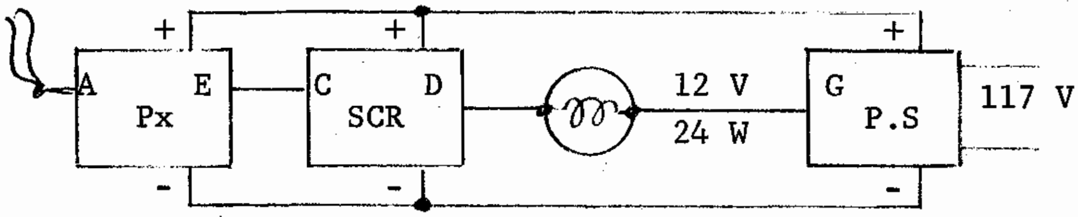


Fig.26. Application using an SCR DRIVER.

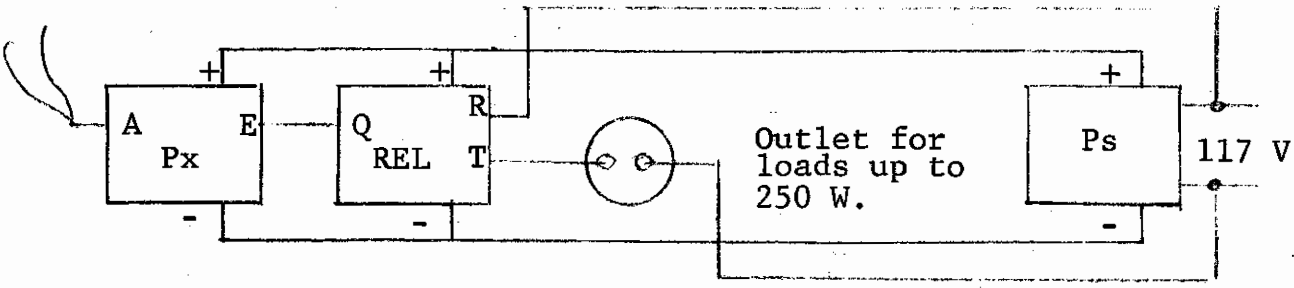


Fig.27. A.C. switching with RELAY DRIVER.

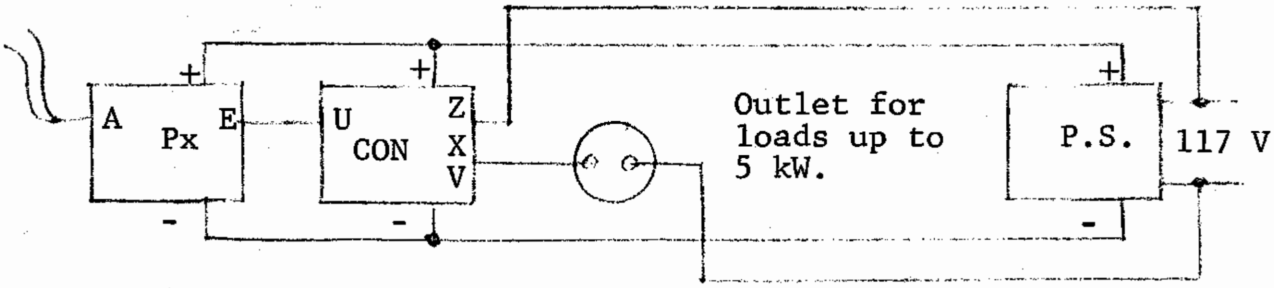


Fig.28. A.C. switching using CONTACTOR.

FIG. 18. The SIREN'S input W is compatible with any output. In other words, it can be connected to any of the outputs E, L, K, H, P. The siren sounds whenever its input is brought to plus. The pitch of the tone can be changed by varying the value of both capacitors. For example, doubling the capacity gives a tone one octave lower, and vice versa.

FIG. 19. The TIMER'S inputs I and J are also compatible with any output. The time can be varied by changing the values of R and C according to the table in Fig. 19.

FIG. 20. The MEMORY (Flip-Flop, Latch). Input F is also compatible with any output. After a signal is applied to the input, the output goes to plus and remains there until reset by pushbutton p.

FIG. 21. The INVERTER'S inputs M and N are also compatible with any output. With no signal at either input, the output is at plus. A signal at either input brings the output low.

FIG. 22. The RELAY DRIVER provides DC or AC power switching up to a maximum of 2A. For heavier loads (up to 50 A), use the CONTACTOR of Fig. 25. The relay should operate from 6 or 12 volts, depending on the battery you are using, and its resistance should be no lower than 1K.

FIG. 23. The POWER SUPPLY can be used instead of the battery. Terminal G can be used with the SCR DRIVER of Fig. 24 (for loads up to 4 A). The transformer can be any 12-volt filament type with a center-tapped secondary. For a typical application see Figures 26, 27 and 18.