A TIMER AND SEQUENCER for Slide Projectors

Here is a device which will sequence a slide presentation at a rate predetermined by the narrator, giving him a few seconds warning that a slide change is about to occur. It can operate an automatic projector directly or give an appropriate change signal to a manual operator. A further use of the timer is as a camera pulser for time-lapse movies.

Design by Anthony Leo

The problem which the device is intended to cope with is a fairly familiar one: a devoted colour slide photographer — of which there are many in the community — is invited to show his slides to an interested group of people — a social group, a church group, a hobby class or such like. The slides may be flower or animal studies, scenic gems, a tour, or a coverage of some scientific subject.

The exhibitor very carefully selects his slides, counts them, mentally rehearses what he plans to say about each one and works out that it should take the neat hour, or whatever his allotted time may be.

But alas, his careful planning counts for little at the actual presentation. He may talk at such length about the early slides that an hour sees him only half-way through. He may continue to ramble on, to the embarrassment of the audience, or suddenly discover that he has to forget the rest of the slides or push them through so hurriedly that their value is largely lost.

The reverse can happen, of course, the lecturer being so apprehensive about talking too long, or boring the audience, that he hurries through the presentation, quite unnecessarily and to its detriment.

The slide-enthusiast who owns a timer like the one illustrated above can be saved from this kind of embarrassment. Knowing the time available for presentation, he can select a suitable number of slides and set the timer to sequence them at a suitable rate. He can prepare and rehearse his commentary so that it fits into the allotted time. At the actual screening, the slides will come up at the same rate, automatically disciplining any tendency to become too talkative or too terse in front of an audience.

The device can also be boon to a compere or chairman needing to cope with a lecturer whose abilities or tendencies are unknown. Before proceedings begin, and without embarrassment, he can reach agreement with the lecturer on the time available and the number of slides to be shown. The sequencer can be set for the appropriate presentation rate, thereafter providing a powerful incentive to the lecturer to suit his remarks to the time available.

To be sure, a device which allots an exact predetermined projection time to each slide might be criticised as too "mechanical" and it would be quite redundant, both for the expert lecturer, and the person who is able to pre-record his commentary on tape. In fact, it is not intended for such people but rather for those — in the majority — who cannot rely either on expertise or on pre-recording.

What is more, it is not nearly as impersonal as might appear at first glance. The device switches on a signal light a few seconds before each slide change is due, so that the lecturer can round off his remarks or merge them smoothly into the next commentary segment.

Where a large number of slides have to be put through in a limited time, they can be shown at the rate of about 4 per minute. The other extreme, a very leisurely rate, would be 1 per minute. A good average figure is 3 slides per minute, which means a change every 20 seconds.

It is suggested that the warning light be set to come on 6 seconds before each change so that the "average" sequence would be: change — initial period 14 seconds — warning light for 6 seconds — change.

If interest in a particular slide does warrant more time or less time than the automatically selected value, the lecturer can operate one or other of two switches to delay or hasten the change. This over-ride facility will not change the total screening time unduly, provided the lecturer uses the buttons only when necessary and for both purposes: accelerate as well as delay!

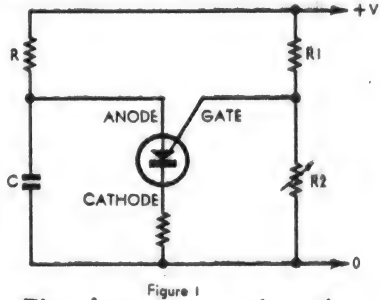


Figure 1

The above diagram shows how a programmable transistor is used in a basic timing circuit. By varying bias applied to the gate electrode the device can be programmed to fire at a particular anode voltage.

When the "Advance" button is pressed the normal timing cycle of the unit is terminated and the device immediately cycles the projector or signals the projectionist. If the Advance button is held down continuously, the projector control circuit will remain closed and this will cause many automatic projectors to cycle continuously.

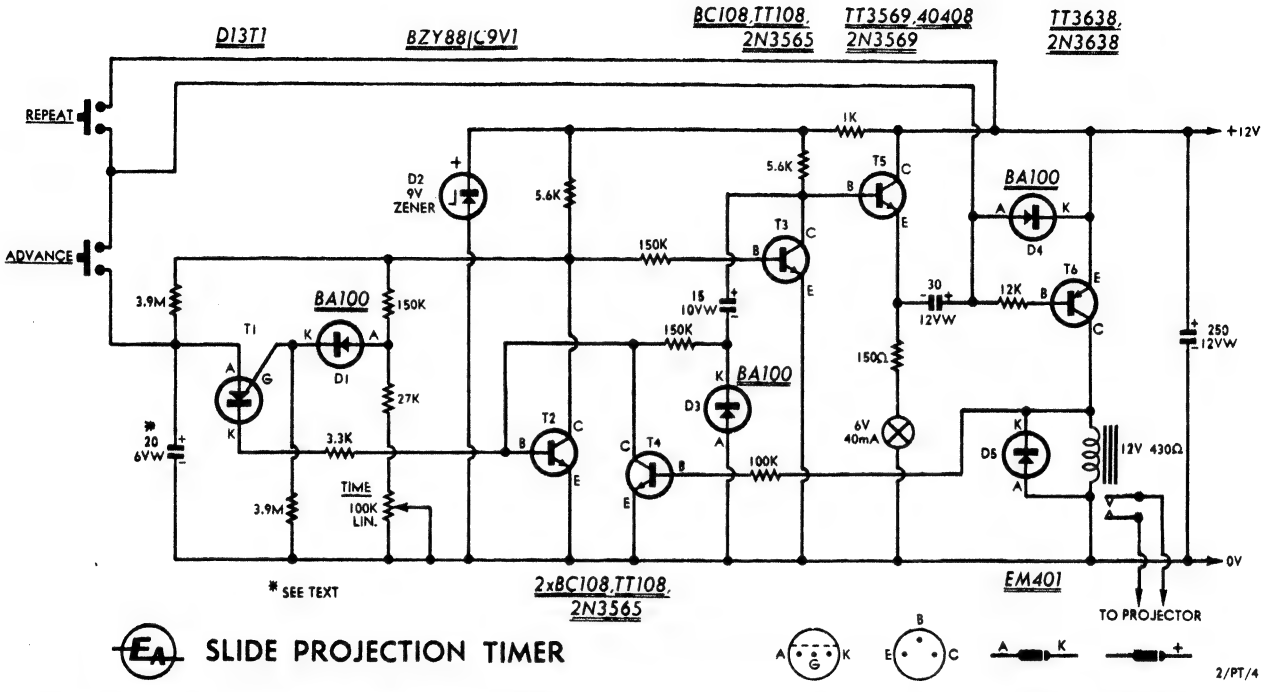
Pressing the delay or "Repeat" button does not interfere with the basic timing cycle but simply inhibits closing of the output control contacts. When the signal light comes up, indicating an impending change, the lecturer needs only to hold the Repeat button down until the light goes out and no impulse will reach the projector or projectionist. If the Repeat button is held down continuously, the lecturer can hold a slide for as long as he desires. The slide will change at the end of the cycle during which the button is released or the change can be initiated immediately by pressing the Advance button.

The basic circuitry can be adapted to meet a variety of situations. In the unit as pictured, the timing control, the over-ride buttons and the signal light are all in the one box which can be placed handy to the lecturer, so that he will be aware of the signal light, even when looking at the screen.

The unit as shown needs to be connected to a power point and a two-wire lead runs away to the projector position, serving the same purpose as a two-wire lead from an ordinary press button. This can close the control circuit to an automatic projector, or to a signal light near a manual projector, or even to a Sonalert (See our November 1968 issue) if the projectionist is in a separate booth.

Obviously enough, various facilities can be deleted or transferred elsewhere, leaving the lecturer with nothing at all, or just a light to warn him of an impending slide change. Different constructors may have their own ideas of how things should be arranged.

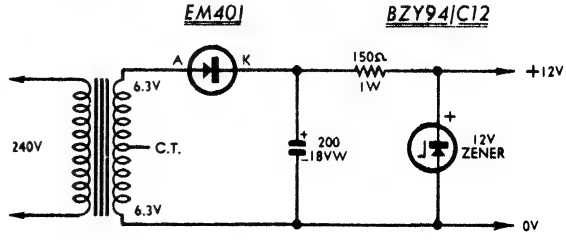
A programmable unijunction transistor, or PUT for short, is the basis of the slide timer circuit. Essentially, the PUT is a four layer NPNP device similar to a normal thyristor or



SLIDE PROJECTION TIMER

The slide timer circuit diagram is shown above. On the diagram a relay is shown as having one pair of closing contacts, required for projector operation, but other contacts may be provided and used for other functions.

Shown at right is a 12V power supply which is suitable for use with either of the timing circuits described here. In some cases the AC supply may be derived from the projector.



silicon controlled rectifier, but having an anode gate rather than a cathode gate. A more detailed description of the device and operating principles is available in the December, 1968, issue under the title "Keeping Up With Semiconductors."

In simple terms, it differs from the thyristor in that it can be programmed to turn on when a specific anode voltage is exceeded, rather than cathode voltage. The anode voltage at which it turns on is determined by the voltage applied to the gate electrode.

Thus a PUT can be used with a capacitor charging network to perform a timing function, as shown in figure 1. When the capacitor charges to a required anode firing voltage the PUT conducts and discharges it through a current limiting resistor in series with the cathode.

Provision to vary the time cycle can be made in two ways. The time constant of the RC combination may be varied, by varying either R or C, or both, or we may alter the anode firing voltage by varying the gate voltage. The latter is much the neater way and can be easily provided by making resistor R2, part of the gate potential divider network, variable.

Essentially, the charging rate of a capacitor is exponential, charging rapidly at first and then tapering off as the voltage increases. So that the time control function might be reasonable, it is desirable to change this to more nearly approximate a linear law.

The simplest approach is to use only the early part of the charging cycle, where the law is more nearly linear. Thus we might arrange for the PUT to breakdown at only one-third of the voltage to which the capacitor would charge if allowed to complete the cycle. We may further improve the linearity if the current which is charging the capacitor is derived from a constant current source. This is approximated if we use a large value of charging resistor R. We could introduce the constant current characteristic of a transistor if the linearity was critical, but such a step is not justified in this case.

If the resistor R is larger than a certain critical value the PUT will come out of the conducting mode when C is discharged. If R is less than the critical value the PUT will latch up, i.e., it will remain in the conducting mode while ever anode voltage is applied.

Thus the basic circuit of figure 1 can be made to have either of two operating modes. Using the larger value of R it becomes a regenerative relaxation oscillator-type timer, delivering pulses at a regular pre-determined rate. Using the smaller value, it becomes a "one shot" timer which has to be manually reset.

From the elementary circuit of figure 1 we have developed two practical circuits. The main one, featuring all the facilities we have discussed is shown on this page. A simpler version, still suitable for projector or other functions, is shown on page 67.

In both circuits the resistor R is

PARTS

1 Metal box (see text).
2 Miniature push buttons.
1 Pilot lamp, 6V 40mA.
1 Speaker socket with plug.
1 Miniature relay, 12V 430 ohms (see text).

TRANSISTORS

1 Programmable unijunction transistor, type D13T1.
3 BC108, TT108, 2N3565 or similar.
1 TT3569, 40408, 2N3569 or similar.
1 TT3638, 2N3638 or similar.

DIODES:

1 BZY98/C9V1.
3 BA100, or similar low power silicon diode.
1 EM401, or similar power diode.

RESISTORS

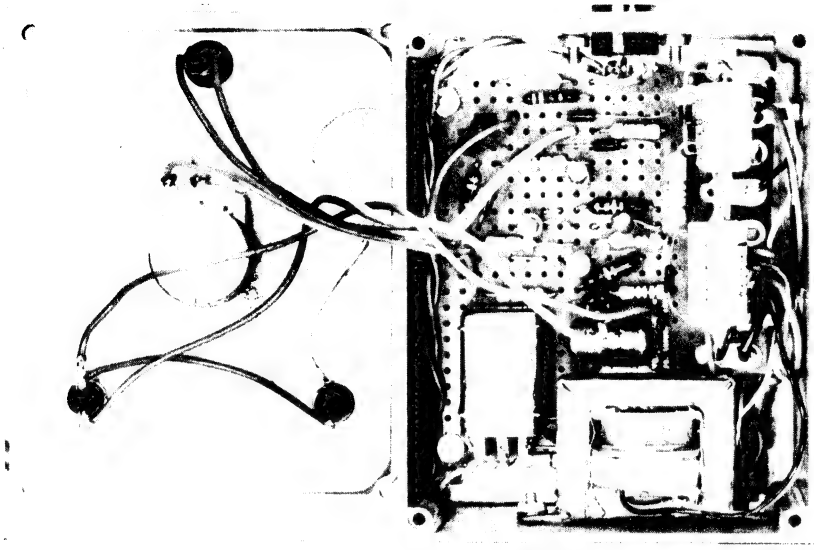
1 100K potentiometer, linear taper.
2 3.9M, 3 x 150K, 1 x 100K, 1 x 27K, 1 x 12K, 2 x 5.6K, 1 x 3.3K, 1 x 1K, 1 x 150 ohms.

CAPACITORS

1 250uF 12VW electrolytic.
1 30uF 12VW electrolytic.
1 20uF 6VW tantalum electrolytic.
1 15uF 10VW tantalum electrolytic.

POWER SUPPLY COMPONENTS

1 Miniature power transformer, 240V to 12.6V at 150mA.
1 BZY94/C12 zener diode.
1 EM401 diode.
1 150 ohm 1 watt resistor.
1 200uF 18VW electrolytic capacitor.
1 Length of mains flex and plug (see text).



An inside view of the timer is shown above together with the lid assembly. The transformer and other power supply components are clearly visible, the latter being mounted on an 8-lug tag strip. Note also the method of fixing the relay to the Veroboard using wire straps.

quite large, 3.9M in one case and 4.7 in the other, while the timing capacitor is 20uF. Because small charging currents are involved it is essential that the capacitor should have very low current leakage. Hence it is necessary to use a tantalum dry-electrolyte capacitor; regular electrolytic capacitors are not suitable.

Typical of all silicon junctions, the voltage between the anode and gate of the PUT will vary with temperature. To make the firing voltage less dependent upon temperature a silicon diode is included in series with the gate electrode.

By exploiting the temperature characteristic of the silicon diode, which is similar to that of the PUT, we effectively compensate for temperature changes. A 3.9M resistor to the negative rail provides the diode with the necessary forward bias.

The complete timing cycle really consists of two smaller timing cycles, operating consecutively. Thus, we use the PUT circuit to provide the major timing cycle of, say, 14 seconds. The completion of this cycle is then used to initiate a minor cycle, say 6 seconds, at the end of which a total of 20 seconds has elapsed, and the slide change function is initiated. The purpose of the minor cycle is to turn on the warning lamp.

The complete timing cycle may be varied over a range from 15 seconds or 4 slides per minute, to 1 slide per minute. It would be possible to increase both the minimum and maximum times available by increasing the value of the 20uF timing capacitor. In addition, the total range over which the timer can be varied could be increased be increasing the value of the 100K potentiometer.

Timing for the minor cycle is provided by means of a monostable multivibrator. This circuit uses two transistors, T2 and T3, with the usual base-to-collector coupling for one transistor, but with an RC time constant network for the other.

In combining these two circuits we must arrange, first, for the major timer to initiate the minor cycle at the end of 14 seconds and, second, for the minor timer to disable the major timer during the 6 second period, so that it does not commence a new 14 second cycle until the end of the minor cycle, i.e., after a total of 20 seconds.

The complete circuit function is as follows. Initally, T2 is cut off with collector at supply potential, and the PUT timer commences. After a set time the PUT discharges the timing capacitor into the base of T2, switching it into saturation, whereupon its collector voltage drops. As a result, T3 is cut off and its collector voltage rises toward supply potential.

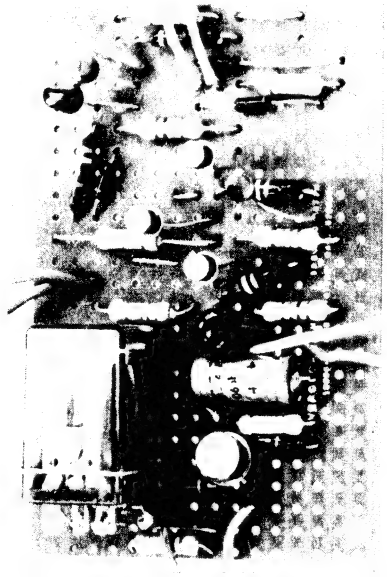
With T3 collector near supply potential, the emitter follower (T5) conducts and lights the 6V lamp. Also the 15uF capacitor, which should also be a tantalum type, commences to charge through a 150K resistor into the base of T2. Thus T2 is held in saturation until the capacitor has charged to a point — after about six seconds — where its charging current will no longer saturate T2.

At this point T2 is turned off and, as a result, T3 is switched on and its collector voltage falls with T5's emitter following it and extinguishing the lamp. While ever the multivibrator is in its timing mode, voltage at T2's collector is very low and the PUT circuit is disabled.

As the T5 emitter falls to the negative supply rail potential, it creates, in conjunction with the associated 30uF capacitor, a differentiated pulse which is applied to the base of T6. This activates the relay in the collector circuit of T6. The 12K resistor in series with the base of T6 ensures that the relay will be held closed for a few seconds; long enough for the projector mechanism to engage and lock up for a complete cycle.

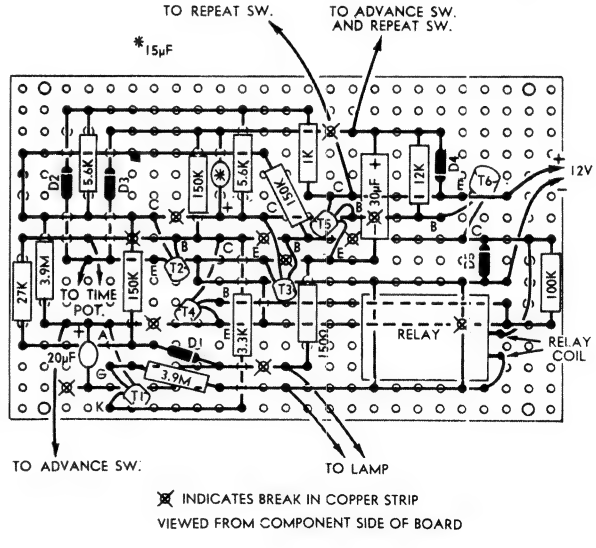
There are several diodes in the circuit, including a power diode across the relay winding to protect its switching transistor against high voltage transients. Depending upon switching speed, quite high voltages can be developed across an inductive load causing irreparable damage to the transistor.

Two other low power diodes are used in conjunction with the 15 and 30uF electrolytic capacitors. The diode connected to the 15uF capacitor ensures reliable multivibrator timing irrespective of the use of the advance button, while the other diode allows the relay to be operated a number

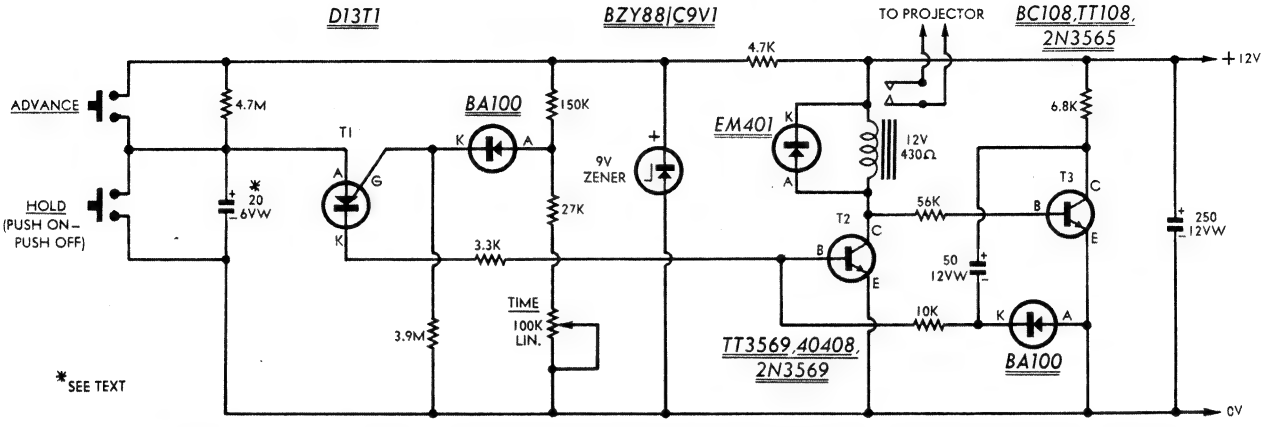


This shot of the Veroboard, removed from the box, clearly shows the positions of most of the components and associated leads.

The wiring diagram for the Veroboard, at right shows the positions and wiring of all the components mounted on the board. Also shown in the diagram are the various take off points for the leads to warning lamp, push buttons and potentiometer.



A SIMPLIFIED GENERAL-PURPOSE TIMING CIRCUIT



Shown above is the circuit diagram of a simplified timer produced by pruning the slide timer circuit. The simplified device is intended for general purpose timing, but will also function as a slide timer.

of times in succession, without having to wait for the 30uF capacitor to recover.

Essentially, the advance button is simply required to energise the relay and engage the changer mechanism. This could be easily done by connecting the resistor at the base of T6 to the negative supply rail via a suitable button. While this method would advance the projector it would not negate the timing cycle already in progress, so that the projector would again be activated when the timing cycle ended. What is required is that the relay should be closed and both timing circuits returned to their start-of-cycle conditions.

This has been arranged by reason of the advance button's position in the circuit and the inclusion of an additional transistor, T4. When the button is closed the 12K resistor at the base of T6 is connected to the PUT anode. Thus current is able to flow through the base-emitter junction of T6, turning it on and energising the relay. The same base current flows through the 12K resistor into the 20uF timing capacitor, charging it almost instantaneously and firing the PUT.

Once the PUT fires the capacitor is completely discharged, thus returning it to the start-of-cycle condition. However, to ensure that T2 is not turned on by the discharge current, so initiating the six-second timing period, a transistor is connected from the base of T2 to the negative rail. This transistor (T4) is switched into saturation at the instant the relay is energised because its base is connected to the collector of T6, via a 100K resistor.

If the timer happens to be in the six-second warning cycle T2 will have already been turned on, but the device will still advance the projector and return both timing circuits to their starting condition. When T4 is switched on, its saturation voltage is less than the base emitter voltage of T2, and T2 is simply switched off.

Thus, the projector can be instantaneously advanced at any part of the timing cycle without upsetting the following cycle or producing any anomalous effects. However, if the advance button is held on, the relay will remain activated and the projector will advance slides in rapid succession until the button is released.

Operation of the repeat button is somewhat simpler, circuit wise, simply inhibiting the switching pulse to T6 base. The button is actually wired from positive rail to the 12K resistor and 30uF capacitor junction. It will be noted that this junction point is common to both buttons, so if they were made remote from the unit only three wires would be required, rather than four, as might be expected.

When using the repeat button it is necessary to hold it closed until the 6-second warning lamp goes out, otherwise T6 will receive a normal pulse from T5 emitter and engage the relay. Once the lamp has gone out the timer will automatically commence another cycle, whether the button remains held down or not.

Although we have only shown one pair of normally open relay contacts, this being all that is required to operate automatic and semi-automatic projectors, we actually used a relay which had a two pole change-over set. The miniature relay, type number 240AFO, was a 12V 430 ohm unit manufactured by Standard Telephones and Cables.

The timer's current requirements will depend in the main, upon the warning lamp and relay, the rest of the circuit requiring only a few milliamps. However, operation of the lamp and relay is intermittent so the average power requirement will be quite modest.

For the prototype, we included a mains power supply using a small Ferguson transformer, type number PF2851. It has a 12.6V centre tapped winding which, when applied to a half wave rectifier, gives about 17V. A zener diode is then used to establish a 12V supply for the timer. Note that a 250uF capacitor across the zener diode is necessary for the correct operation of the unit.

With some later-generation projectors, the necessary low AC voltage could be obtained from the lamp transformer; this may vary between 12 and 24V depending upon the projector type. If 12V RMS is available the supply circuitry may be used, unaltered. But, for 24V RMS the 150 ohm 1 watt resistor should be increased to about 330 ohms with a 4 watt power rating. Also, the rating of the 200uF electrolytic should exceeed 34VW.

Alternatively, if low voltage is not available from the projector and a mains supply at the control point is considered inconvenient, the small power transformer could be mounted in the projector housing. A four-core cable between sequencer and projector, carrying low-voltage AC and the changing mechanism voltage, would obviate the need for a second cable. In some cases the low-voltage supply from the projector and changing mechanism voltage could be common, in which case it may be possible to use only three-core cable, but this will depend upon the particular projector.

The prototype sequencer was wired on a section of Veroboard, with the exception of power supply components which were wired on a tag strip. The miniature relay was attached to the board by two straps, made from 22-guage tinned copper wire, which also served as "jumpers" for the negative rail.

The completed board assembly was housed in a small die-cast metal box

(Continued on Page 141)

PARTS LIST

1 Metal box. (See text).
1 Miniature push button.
1 Miniature push-on push-off switch.
1 Speaker socket with plug.
1 Miniature relay, 12V 430 ohms (See text).

TRANSISTORS

1 Programmable unijunction, transistor, type D13T1.
1 BC108, TT108, 2N3565 or similar.
1 TT3569, 40408, 2N3569 or similar.

DIODES

1 BZY88/C9V1.
2 BA100, or similar low power silicon diode.
1 EM401, or similar power diode.

RESISTORS

1 100K potentiometer, linear taper.
1 4.7M, 1 x 3.9M, 1 x 150K, 1 x 56K, 1 x 27K, 1 x 10K, 1 x 6.8K, 1 x 4.7K, 1 x 3.3K.

CAPACITORS

1 250uF 12VW electrolytic.
1 50uF 12VW electroltic.
1 20uF 6VW tantalum electrolytic.

A TIMER FOR SLIDE PROJECTORS (From page 67)

measuring 4-5/8 x 3-5/8 x 2-1/8, manufactured by Eddystone. The interior assembly is shown in the accompanying photograph, giving a clear indication of the position of the transformer and other components. The potentiometer, push-buttons and warning lamp were mounted on the lid, the lamp being held firmly in place with a rubber grommet. A speaker plug-and-socket combination was used to connect the projector to the relay contacts.

After completion of the timer it was apparent that there would be more applications for a regenerative timer than just a slide-changer. In addition to intermittent operation of lights on Christmas trees and in display windows, a timer could be used in "time-lapse" photography and exposure timing. In such applications a warning lamp facility would probably not be required.

In order to fulfil some of these requirements we are presenting a second circuit which has been pruned from the design used in the slide timer. As it happens, this much-simplified circuit can be used as a slide timer without the full facility of the previous device.

It simply consists of the basic PUT timing circuit together with a monostable circuit incorporating a relay. The monostable circuit provides a time dealy to hold the relay closed for a few seconds, allowing time for associated mechanism to engage. The relay holding time may be increased, if required, simply by increasing the 10K-50uF time constant.

Again a diode is used with the time constant network, and a protection diode is wired across the relay winding. Also, the 20uF timing capacitors is a tantalum electrolytic while the 50uF capacitor may be a regular electrolytic. Again a 12V supply is required; the supply circuit shown is suitable.

On the circuit diagram we have shown two buttons labelled "advance" and "hold". In a similar manner to the previous circuit, the advance button charges the timing capacitor very rapidly causing the PUT to fire and activate the relay. However, the hold button simply shorts out the timing capacitor preventing the PUT discharging into the base of T2 and activating the relay.

The range of this timer is between 7 seconds and 1 minute 8 seconds, but this may be conveniently varied by altering the value of the charging capacitor proportionally. Increasing the capacitor will logically increase the maximum and minimum timing periods. However, to increase the overall range of variation, the 100K potentiometer may be increased in value, as determined by individual experiment.

If an electric clock with a sweep second hand is available it may be conveniently used to time the operation of both circuits. The only proviso is that the clock should start instantaneously without manual assistance. By connecting the clock in series with a set of normally closed relay contacts it can be operated as an electronic stop watch.

While we did not finish off the second timer in a completed form, we did mock it up on the bench. Conceivably it could be constructed in a similar fashion to the first circuit, using Veroboard and a small die-cast metal box. However, the ultimate presentation will be up to the individual constructor, and may be tailored to suit particular requirements. ■