



## A Battery-Operated Pilot Balloon Time-Signal Generator

RALPH H. MOLTZAU, JR.

**ABSTRACT:** Describes the design and construction of a 1-pound, battery-operated, time-signal transmitter, which is usable with portable radio or field telephone circuits for synchronizing multi-theodolite observation of pilot balloons.

Accurate above-the-surface wind measurements are necessary in studies of weather patterns related to critical fire danger. Such measurements require that the successive positions of a pilot balloon

(pibal) be determined precisely. Usually, simultaneous theodolite observations on the balloon are made at regular intervals from opposite ends of a known baseline from 500 to 5,000 feet long. The observations, taken at intervals of a fraction to a whole minute, must be synchronized carefully.

Observation time is usually signaled by synchronized stopwatches, by voice, or by a time-signal transmitter. Commercial time-signal transmitters are usable where 110-volt power is available. But a lightweight, battery-operated unit is necessary for use in mountain wind studies where communication on the baseline might be either by field telephone or by portable radio (fig. 1).

The unit described in this note has proved to be ideally suited for 1/2-minute double-theodolite pibal observations by a 2-man crew, using it with pack-set radio and tape recorders (fig. 2). A stopwatch at each station was used to keep track of total time elapsed. When the unit is used with either radio or telephone, normal communication is possible, except during actual signal transmission.

### Design

For mountain wind studies, a time-signal device should be economical, small, and rugged. It should be usable with standard Forest Service radios, without modification. When used with a radio, it should in no way affect its use or operation whether the timer is off or on. The timing interval should be accurate and adjustable. Battery life should be as long as possible. Construction and maintenance must be simple. And timer should be usable with a telephone circuit or as a direct source of audible signals.

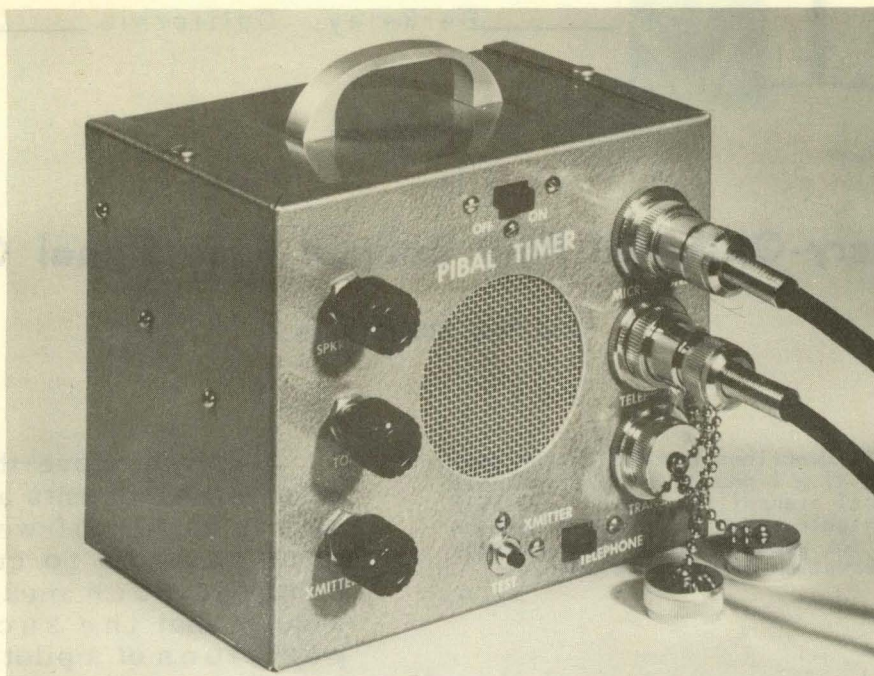


Figure 1.--Pibal time-signal generator. Normally, microphone and telephone would not be connected at the same time.

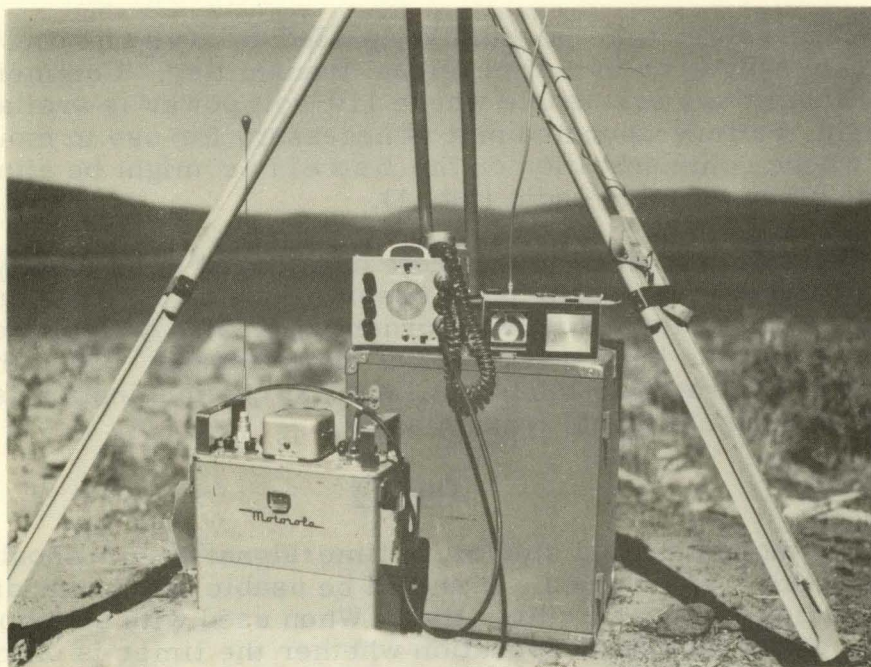


Figure 2.--Field view of timer in use with radio during double-theodolite observations. Observations were read into tape recorder at right of timer.

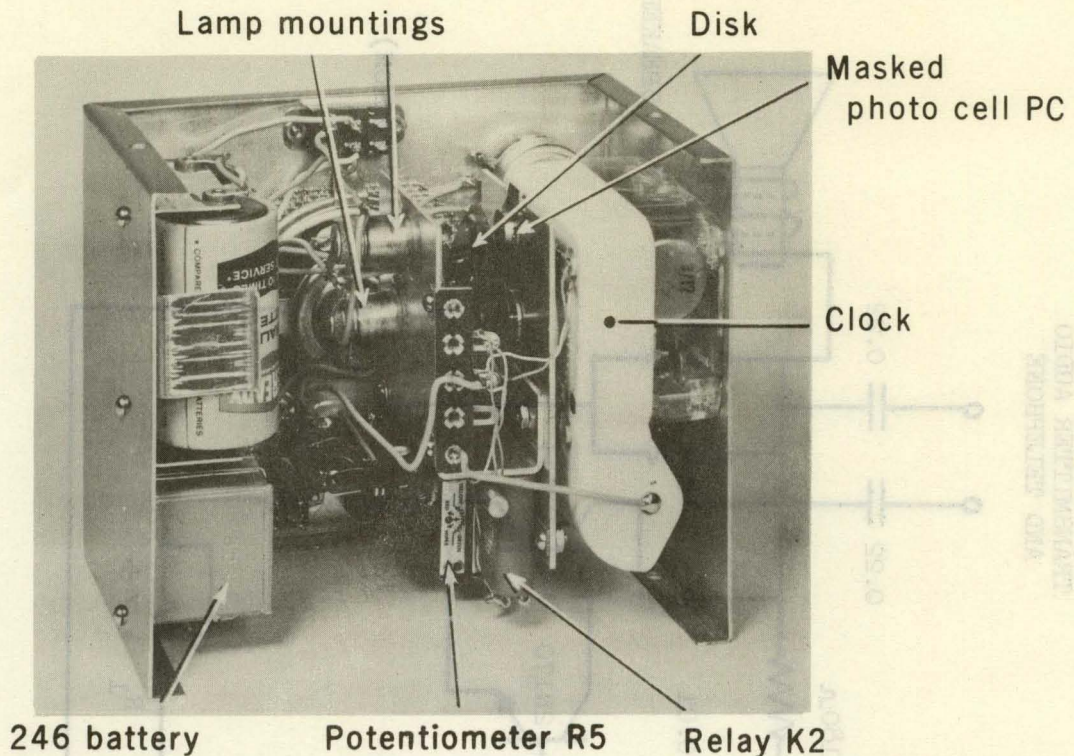


Figure 3.--Back view of timer.

The instrument described here satisfies all these requirements. Its heart is an electric motor-wound spring-driven clock that runs off a flashlight battery (fig. 3). The clock rotates a 2-1/2-inch opaque disc at 1 r.p.m. Windows in the disc permit light to pass to two photocells. One photocell controls an audio oscillator that supplies a signal tone; the other controls the keying of the radio transmitter if used (fig. 4).

Accurate timing depends on use of the lightest possible material for the disc. A heavier material will appreciably slow down the clock owing to the low torque exerted by the second hand pinion to which the disc is cemented. Several materials were tried, ranging from light brass shim stock to blackened 3- by 5-inch cards. Best results were given by a piece of developed, overexposed photographic film, despite its tendency to warp. Discs can be readily prepared photographically; however, the film should be painted with negative "opaque" to insure opacity. The warping seemed to have no appreciable effect on the operation or accuracy of the timer; total error amounted to about a 1-second lag in half an hour.

Timing and length of tone signals are determined by placement and length of holes or transparent windows in the opaque disc (fig. 5). Greatest care must be used in positioning the smaller time-signal windows, each of which is preceded by a distinctively longer warning-signal window. These oscillator control windows are placed near the edge of the disc to permit greater angular accuracy. The location of windows controlling activation of the radio transmitter is less critical; hence, they are located

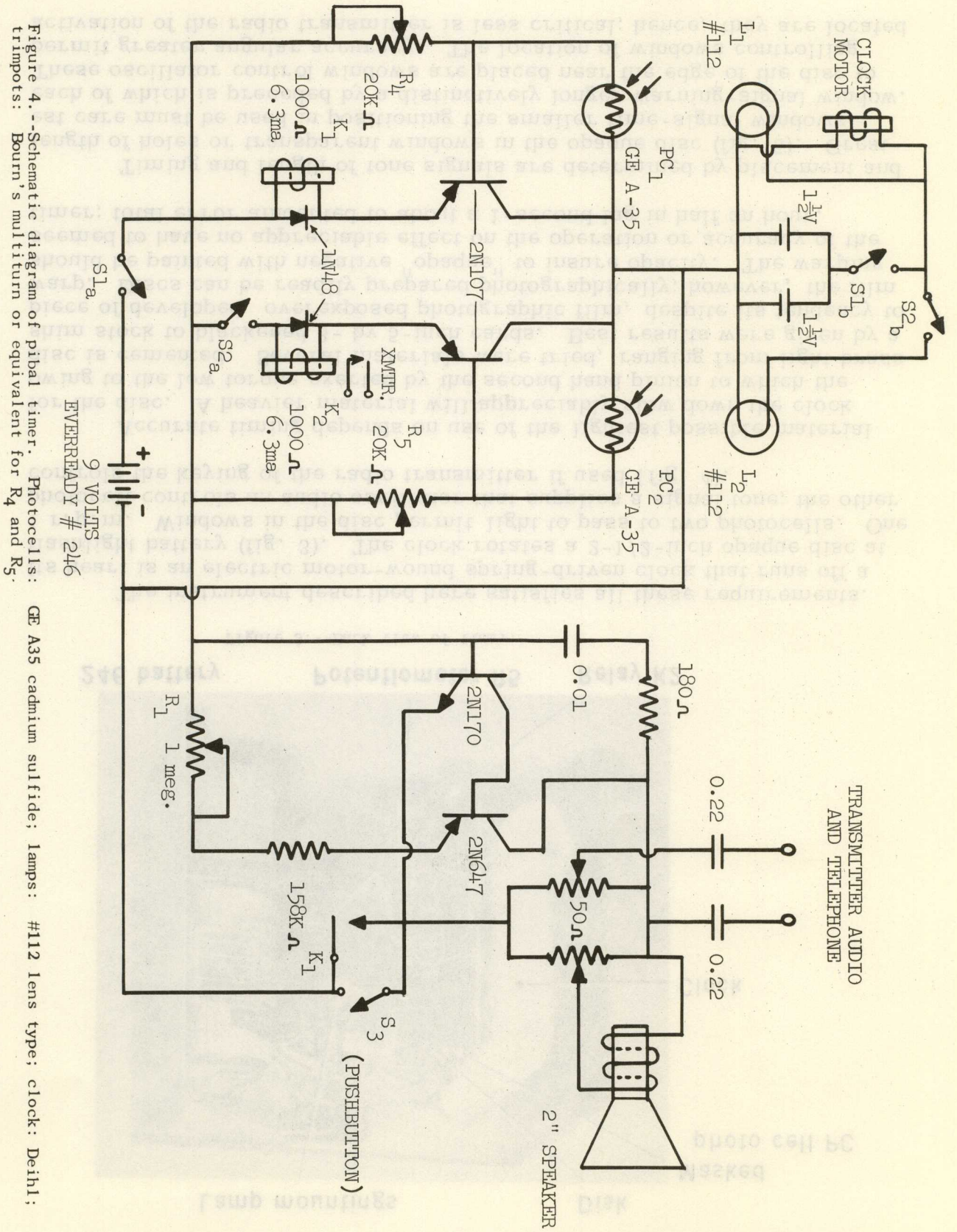


Figure 4.--Schematic diagram of Bourn's multivibrator. Photocells: GE A35 cadmium sulfide; lamps: #112 lens type; clock: Deihl; trimpots: Bourn's multivibrator or equivalent for R<sub>4</sub> and R<sub>5</sub>.

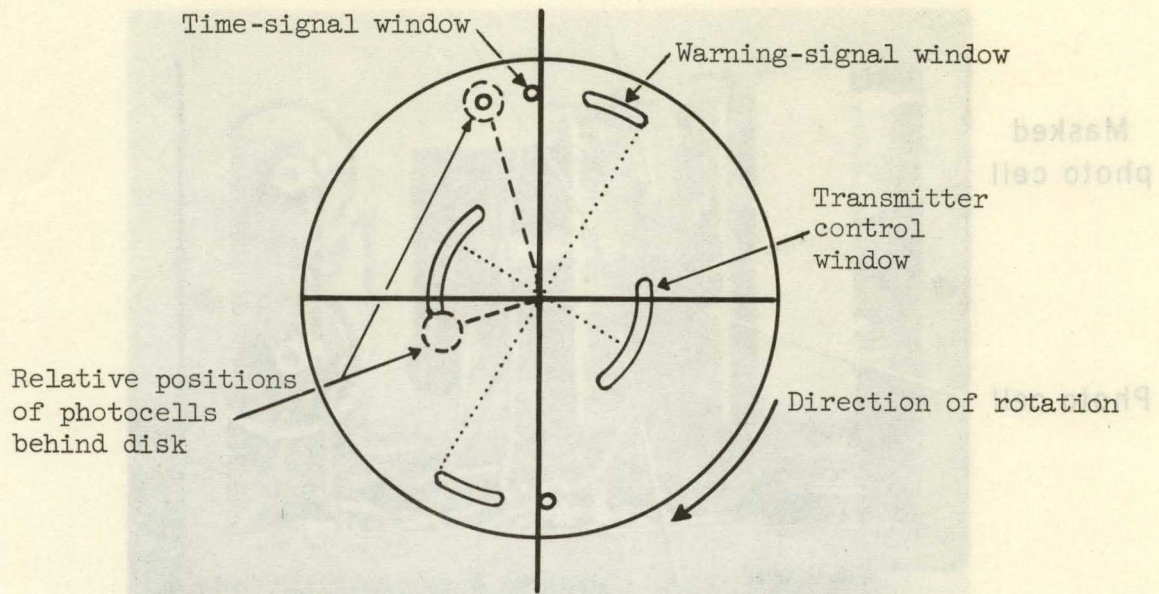


Figure 5.--Rotating disk for half-minute signals. Dashed lines show relative position of photocells; dotted lines show position of warning signal and transmitter turn on; and solid lines show the start of time signal and transmitter turnoff.

closer to the disc's center. They must, however, provide 3- to 5-second warmup time before the warning signal. Dimensions and placement of windows shown on the timer illustrated (fig. 5) are for producing a signal every 30 seconds. Intervals of 20 or 15 seconds may be provided by separate discs. Greater control of the tone signals is achieved by masking the photocell with black tape, leaving only a 1/16-inch-diameter hole over the cell center. This opening passes enough light with 1/2-inch spacing between light and photocell (fig. 6). The two photocells are placed 90° apart to minimize mutual interference and to simplify the location of timing windows in the disc.

A volume control enables separate adjustment of transmitter and speaker volumes. This separation is necessary because the remote station receives a transmitted signal while the master station is guided by the audible tone from the speaker. A tone control breaks the monotony of having the same tone all the time. A pushbutton "test" switch permits the tone to be checked at any time.

#### Alternative Features

A different tone can be provided for the "observe" signal by adding an additional photocell keyed circuit. Two tones during poor reception conditions offer a definite advantage. To provide a double warning tone at the half minute, the disc windows can be designed for this purpose.

Power is provided by two D-cells connected in parallel to operate the lamps and clock. The major source of current drain is the No. 112 lamps. Alkaline batteries will provide a much longer battery life than

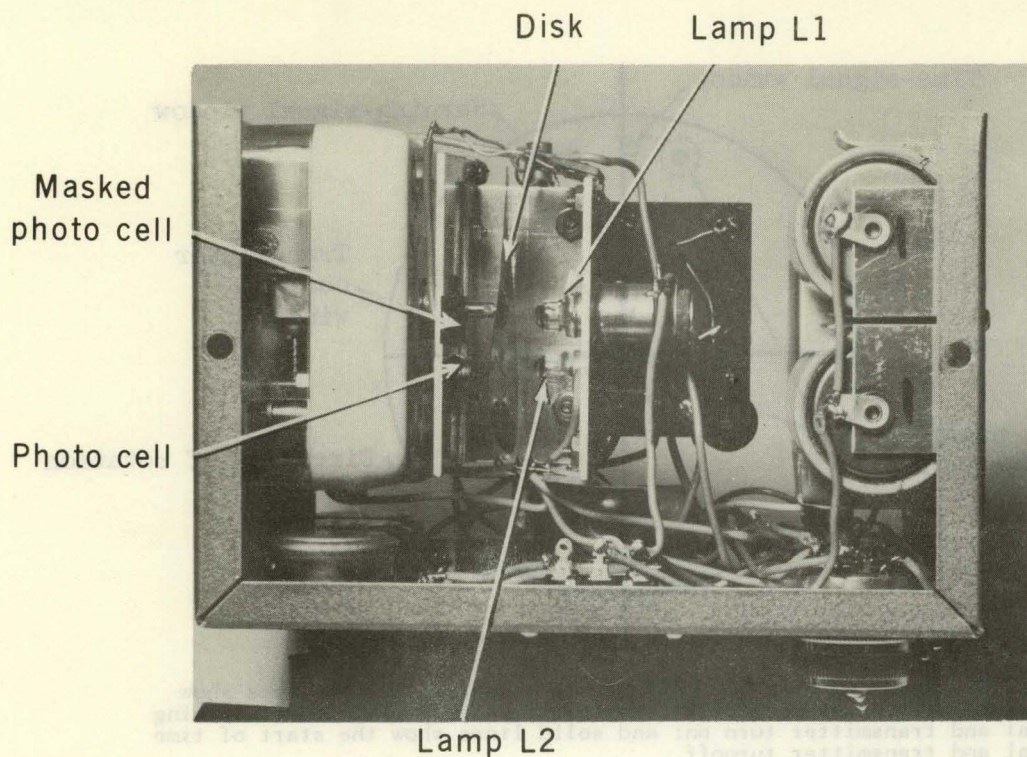
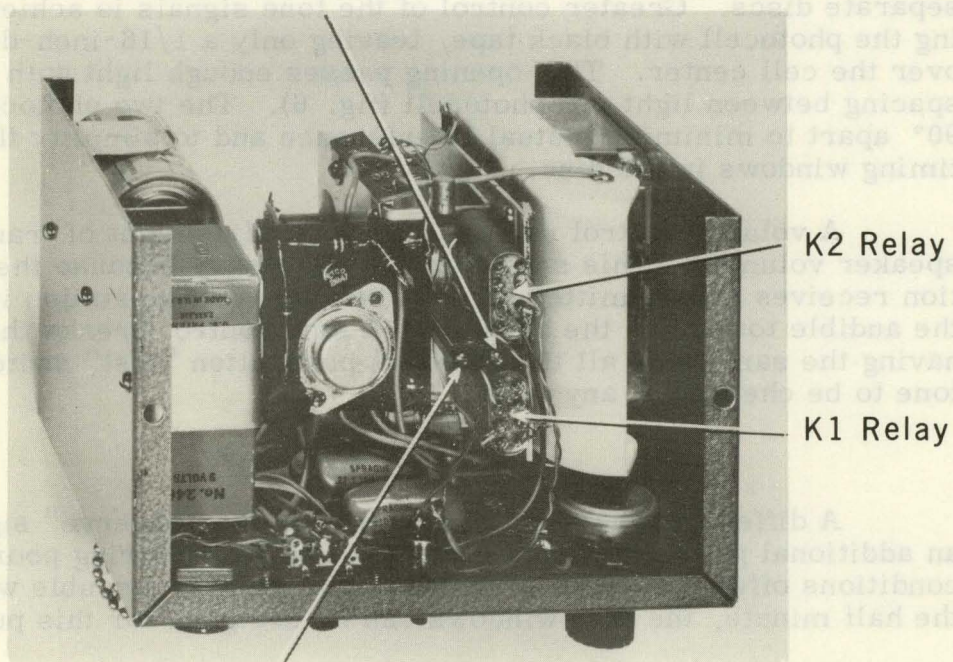


Figure 6.--Top view showing lamps and disc. L1 controls the tone signal oscillator; L2 controls the radio transmitter.

#### Potentiometer R4



#### Potentiometer R5

Figure 7.--Bottom view.

the standard cell. The rest of the circuit is powered by an Eveready<sup>1</sup> No. 256, 9-volt battery, the largest battery that would fit in the available space. The exact life of the batteries is not known, but their service life should be more than 50 hours if the unit uses two Alkaline D-cells in parallel and the 9-volt battery as specified. When the timer is used with a telephone line, a slide switch permits cutting out the transmitter keying circuit and one of the lamps to conserve battery life.

To assure greatest stability of operation under temperature extremes, replace the germanium transistors used in the prototype with silicon types of similar ratings. The 2N107 and 2N170 have maximum temperature ratings of 122° F. Such temperatures are often reached when the unit is left in the sun for extended periods.

The power output of the unit, though not known, appears to be more than adequate except possibly under the most severe noise conditions. When used as shown in the field, no problem was experienced in hearing the tone above the noise of a moderate wind blowing and logging trucks passing at a distance of about 100 feet.

Though the impedance match between the 50 ohm output of the timer and that of the telephone is not nearly as close as it could be, it does seem adequate for operational use with field telephones. The impedance, however, could definitely be better matched with only a minor increase in cost.

### Construction and Cost

Parts were put wherever there was room for them in a 4- by 5- by 6-inch Budd Minnibox (fig. 7). The microphone and transmitter connectors are of the same type used on the end of the microphone or hand-set cables of the radio transmitters. The connector for the microphone is wired so that the relay is in parallel with the "push to talk" switch on the microphone. When the timer is used with field telephones, the tone output is connected directly across the line terminals. Construction requires about 20 hours. Cost of components depends on the source of the parts, but in any case should be around \$50.

### Operation

Before placing the timer in operation, adjust the sensitivity controls ( $R_4$  and  $R_5$ ) (fig. 7). Shade the photocells to keep out stray light when this is being done. But first adjust the sensitivity of the oscillator control. Adjustment screw  $R_4$  should be turned until the tone remains on after the windows in the disc have passed by the photocell. Determine the direction of rotation by trial. Several complete turns of the screw may be necessary before any effect is evident. When the point is reached at which the tone remains on, back off the adjustment until the tone cuts off immediately when the window has passed the photocell. Make final adjustment with the cover on by using the access holes in the bottom of the case.

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<sup>1</sup>Mention of trade names and commercial products or enterprises is solely for necessary information. No endorsement by the U.S. Department of Agriculture is implied.

The same procedure applies to  $R_5$ , which controls transmitter keying sensitivity. This time, however, switching the transmitter on and off is the criterium used. The transmitter should be turned on several seconds before beginning transmission. Length of warmup time may vary with the kind of radio used. This adjustment is probably best made with two radios, one receiving while the other transmits the timer signal. The sensitivity controls will have to be adjusted from time to time as the batteries age.

When the timer is used with a radio, the radio's microphone or handset is plugged into the microphone connector. A jumper cable is used to join the "transmitter" connector to the microphone connector on the transmitter. The microphone can still be used in the normal manner for voice communication.

When the timer is used with field telephones, a line from the "telephone" connector is run to the telephone line. Place the "transmitter-telephone" switch in the "telephone" position to conserve the batteries.

#### The Author

RALPH H. MOLTZAU, JR., was formerly on the fire meteorology research staff of the Pacific Northwest Forest and Range Experiment Station, at Portland, Ore., where he carried on the work reported in this note. Since his departure for service with the U.S. Navy, responsibility for fire meteorology research west of the Cascade-Sierra Divide has been assigned to the Pacific Southwest Station.

#### Operation

Before placing the timer in operation, adjust the sensitivity control (R<sub>4</sub> and R<sub>5</sub>) (Fig. 7). Shade the photocell to keep out stray light when this is being done. But first adjust the sensitivity of the oscillator control. Adjustment screw R<sub>1</sub> should be turned until the tone remains on after the window in the disc has passed by the photocell. Determine the direction of rotation by trial. Several complete turns of the screw may be necessary before any effect is evident. When the point is reached at which the tone remains on, back off the adjustment until the tone cuts off immediately when the window has passed the photocell. Make final adjustment with the cover on by using the access holes in the bottom of the case.