and now —

THE TRANSISTORIZED PORTABLE SCOPE

Using almost no tubes, this industrial unit can be powered by an external ac or dc source, or it can use built-in batteries

By TOM JASKI

IT seems that we have been waiting a long time for the transistor to fulfill all our hopes and provide us with light, portable devices of all kinds. The portable transistor TV is with us, but not so easy to come by. Now Tektronix breaks another barrier by producing the all-transistor (well, nearly all) portable oscilloscope. "Nearly all" because there are two tubes in the scope, besides the CRT, to do jobs which transistors could not do well enough. One tube is the vertical input amplifier and the other is the high-voltage supply rectifier. However, these two tubes do not materially affect battery life and they certainly do not change the scope's portability.

As a result the scope can compete specification-wise with high-quality tube models. Bandwidth is dc to 5 mc with a rise time of .07 μsec. Deflection sensitivity is variable from 10 mv to 20 volts per division (cm) in 11 calibrated steps in a 1–2–5 (10 mv, 20 mv, 50 mv, . . .) sequence. Sweep ranges from 0.5 μsec per division to 0.5 second per division (5 seconds to sweep across the tube face). The sweep circuit has 19 calibrated steps, also in the 1–2–5 sequence. The scope incorporates a calibrator for precise voltage comparison, weighs 17 pounds complete with batteries and measures 8¾ x 5¾ x 16 inches. What more can you ask for!! The model 321 costs approximately $775 (not including batteries) and rechargeable batteries are available at extra cost. So is a charger, that can be built into the instrument. But 10 size-D flashlight cells will also operate the scope, as will 117 or 220 volts ac, 50 to 800 cycles. This means that the scope can be plugged directly into a 400-cycle aircraft supply. Also 11.5 and 35 volts dc can be used (you can plug the instrument into an automobile, boat, railway, or farm dc power system). Just about as versatile as can be.

This is, of course, part of the beauty of this scope. It can be used on practically any power source or *none at all*, making it useful where before no scope could be operated. Examples are: troubleshooting and repair jobs on boats, small planes, railway work, "on location" and experimental work in inaccessible or difficult places, all kinds of applications where a scope would ordinarily either require carrying a bulky converter or running a power cord for long distances. Let us see what it takes in the way of circuitry to get this kind of performance.

Circuitry

Fig. 1 shows the block diagram. Tektronix engineers did not get tricky; it is pretty conventional except for the oscillator low-voltage supply, which is built along the lines of the usual scope or portable TV high-voltage supply.

Vertical amplifier

Fig. 2 shows part of the vertical amplifier (and calibrator). This has first a standard attenuator, then the 5718 input amplifier, one of the two tubes used in the scope. This triode, used in a cathode-follower circuit, was used to obtain the high-impedance input, stability (stabilized heater supply) and wide-band response desired. After the 5718 the amplifier consists of alternate emitter followers and amplifiers, using a number of 0C170's. The 0C170 is a European transistor, used because of its high gain, low leakage and high voltage tolerance. It is a drift transistor.

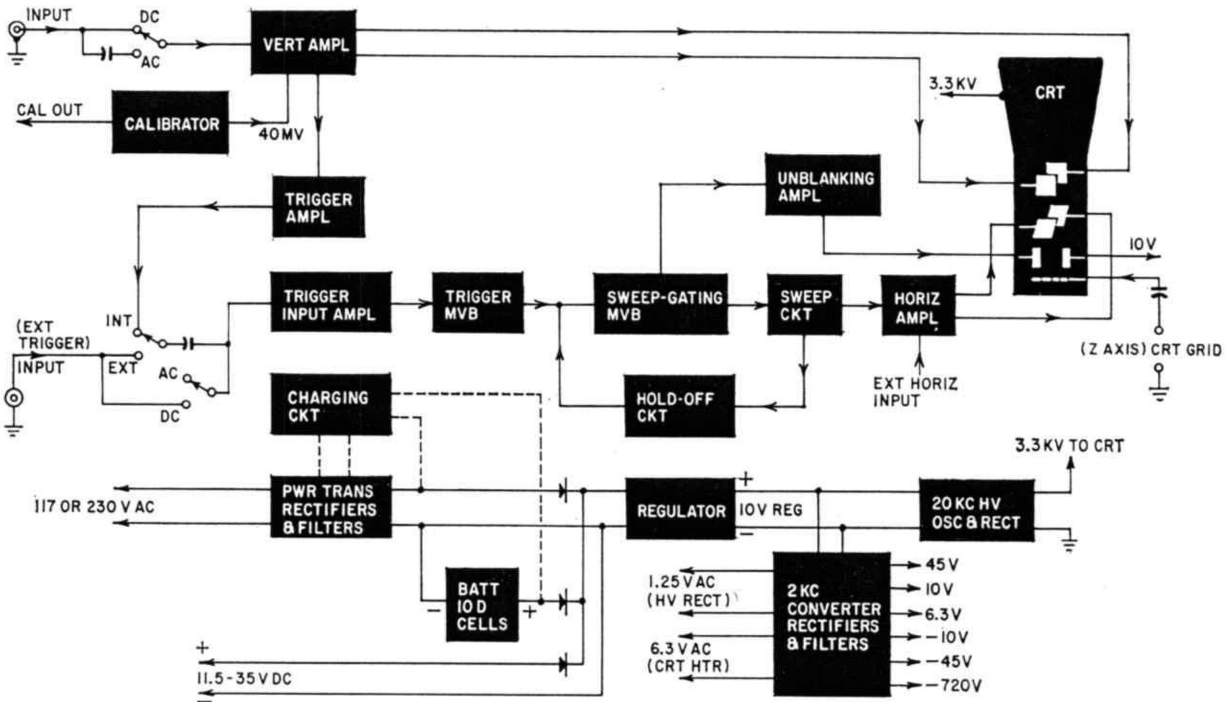


Fig. 1—Block diagram of Tektronix 321 oscilloscope.

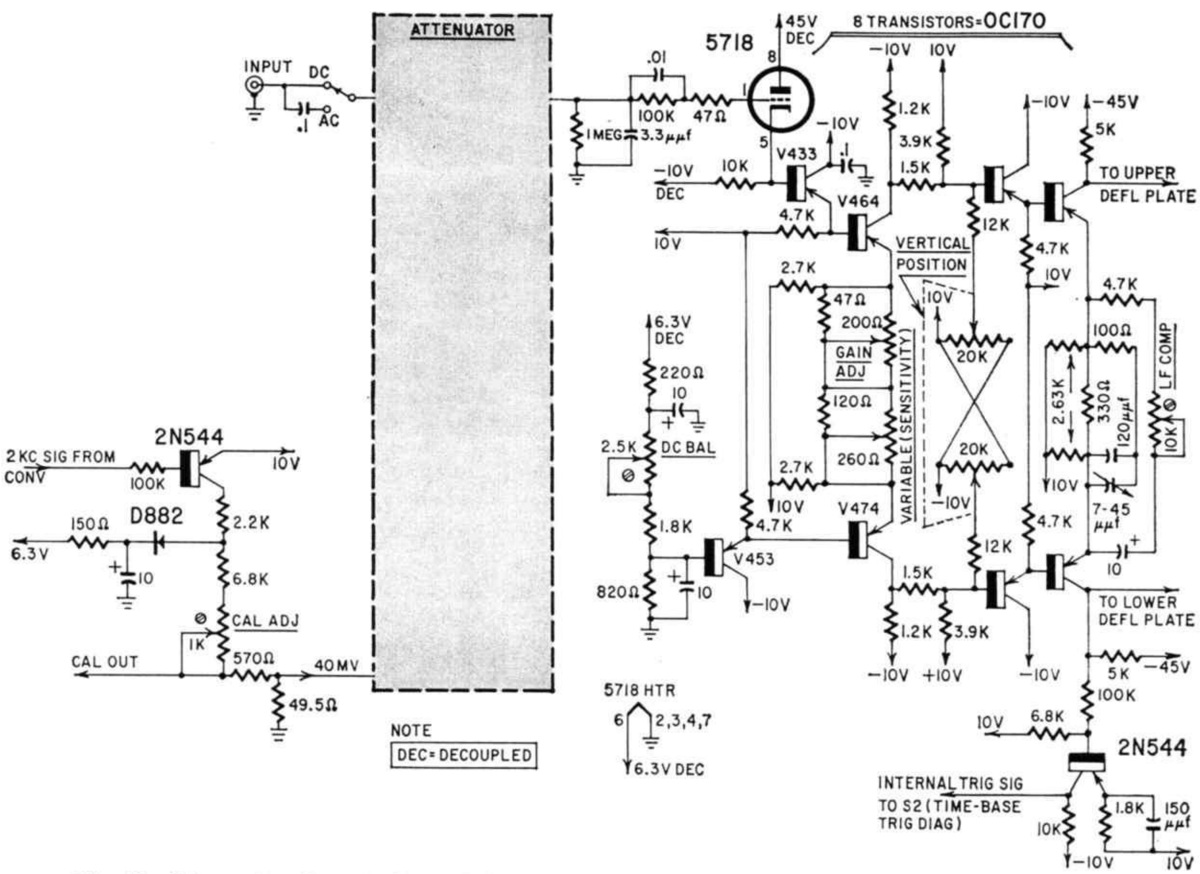


Fig. 2—Schematic of vertical amplifier and calibrator. Step type attenuator has 11 positions.

Because it has its own power supply, the scope may be used in servicing small-plane equipment.

The amplifier is completely balanced to minimize temperature effects and to obtain push-pull deflection. Vertical position is adjusted by changing the bias on the last set of emitter followers. V453 receives no signal. It serves to balance the bias on V474 against that on V464. These last two transistors form a common emitter resistor-coupled stage. The trigger takeoff amplifier is shown on the right, and on the left we see the calibrator. This is an overdriven amplifier which obtains the calibration signal (2 kc) from the converter in the low-voltage power supply.

Horizontal amplifier

The horizontal amplifier is not unusual. It consists of a set of emitter followers and a pair of amplifiers (somewhat similar to the output sections of the vertical amplifier). These are again balanced to obtain push-pull deflection and minimize temperature effects. Horizontal sensitivity is not great (1.5 volts per division maximum). In the emitter-bias circuit of the output stage a switch is used to obtain five-times-normal sweep width by effectively reducing the emitter series resistance.

The trigger amplifier (Fig. 3) is a balanced common-emitter amplifier. It can reverse trigger-signal polarity when desired. The trigger multivibrator, which shapes the trigger for the sweep circuit, is a transistor version of the well known Schmitt circuit. The trigger pulse is applied to the sweep-gating multivibrator (Fig. 4), which is also a Schmitt circuit but with a large voltage differential between the "on" and "off" triggers. This circuit holds the gate open (nonconducting) for the duration of the sweep. The "gate" is the normally conducting (closed) V153, which prevents the timing capacitor from charging.

Sweep circuit

Initially the timing capacitor (C160) is discharged, allowing a positive voltage at the base of emitter follower V163. A negative output from the Schmitt cuts down the conductivity of V153, allowing the capacitor to charge. This creates a voltage drop across the

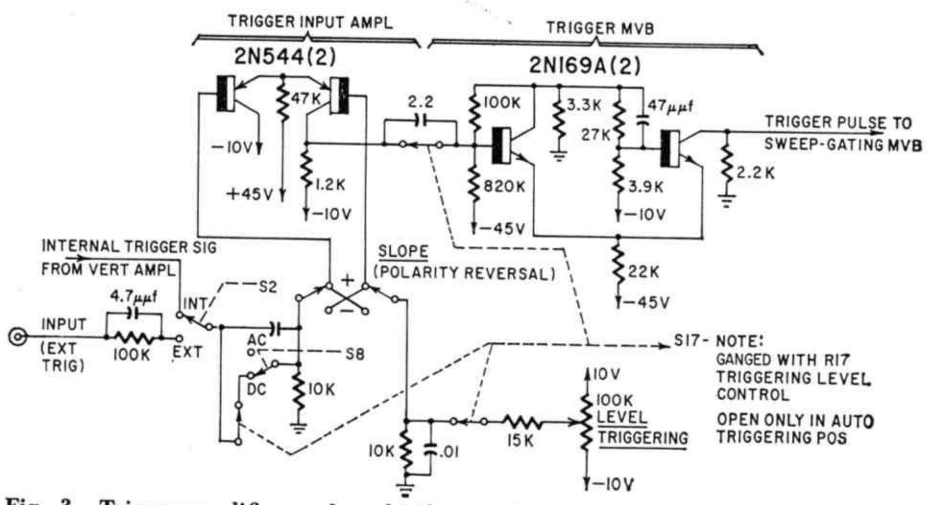


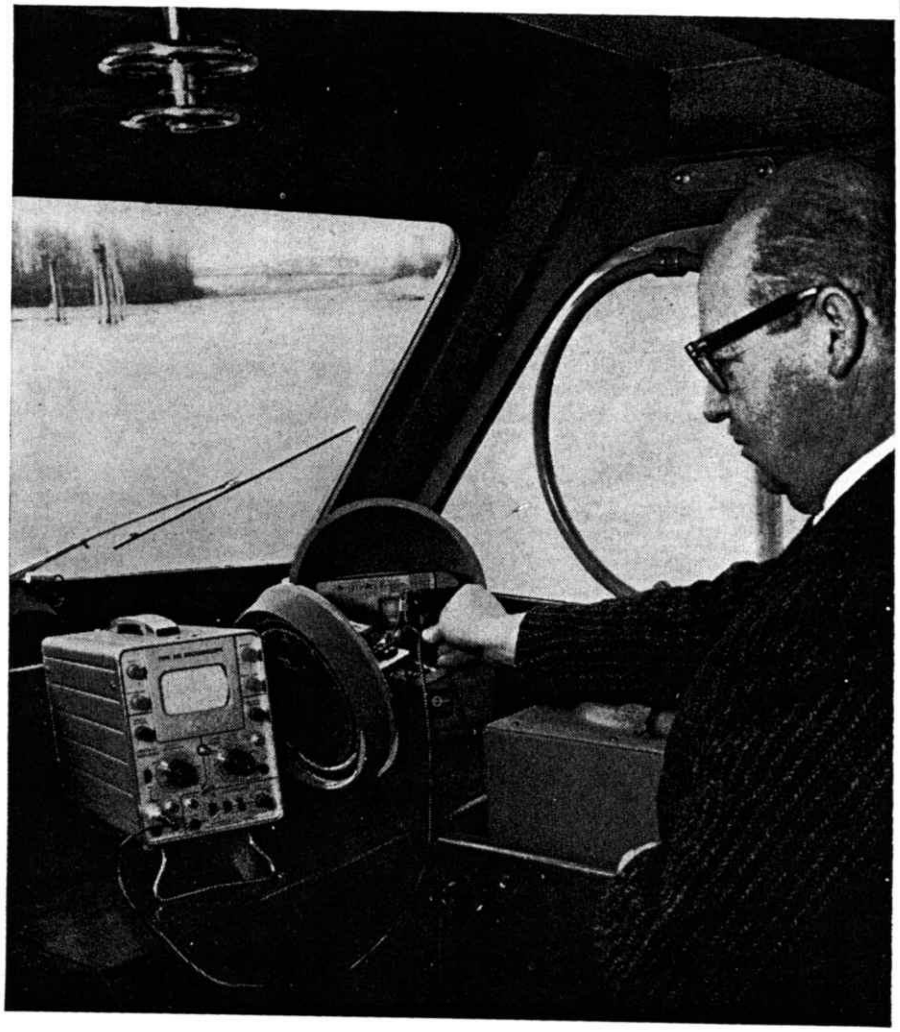
Fig. 3—Trigger-amplifier and multivibrator circuit.

timing resistor (R160), lowering the voltage on the base of V163. V161 amplifies this change in signal, and it is applied to the horizontal amplifier through another follower, V173. But the signal is also applied to the collector of V153 and, when the charging rate of the capacitor increases, V153 will conduct more heavily and thus reduce the charging rate. In this way charging of the capacitor is kept perfectly linear. S160 selects different values for R160 and C160 to get the desired sweep rate.

A portion of the sweep signal is also applied to the base of V183, the holdoff transistor. This transistor is normally conducting, holding C180 (holdoff timing capacitor) discharged. When the sweep signal is applied to V183, the capacitor begins to charge, raising the voltage on the base of V135. The Schmitt circuit changes state and once again can accept trigger pulses. When the gate closes (V153 conducts), timing capacitor C160 discharges through D153.

Unblanking

The cathode-ray tube in this instrument is a special type, containing a second set of horizontal deflection plates (above G1 in Fig. 5). One is connected to 10 volts, the other to the unblanking amplifier. Between sweeps, the unblanking plate is held at −20 volts. The beam is deflected off-screen and is not visible until a positive pulse voltage is applied to the unblanking deflection plate. A special overdriven blanking amplifier (V194, Fig. 4) provides the unblanking voltage with ultra-rapid rise time. V199 is a voltage regulator



Using scope to check out depth indicator.

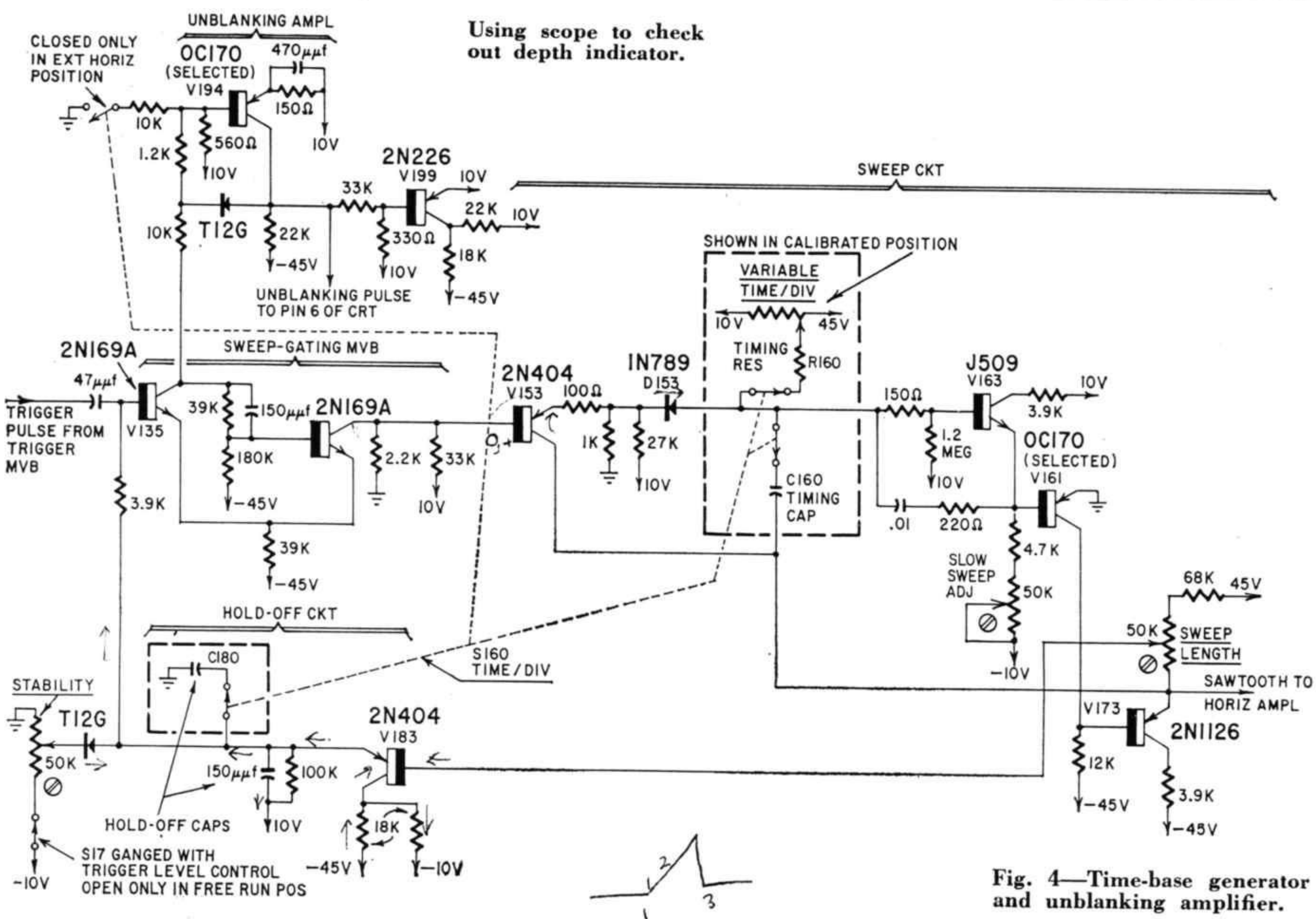


Fig. 4—Time-base generator and unblanking amplifier.

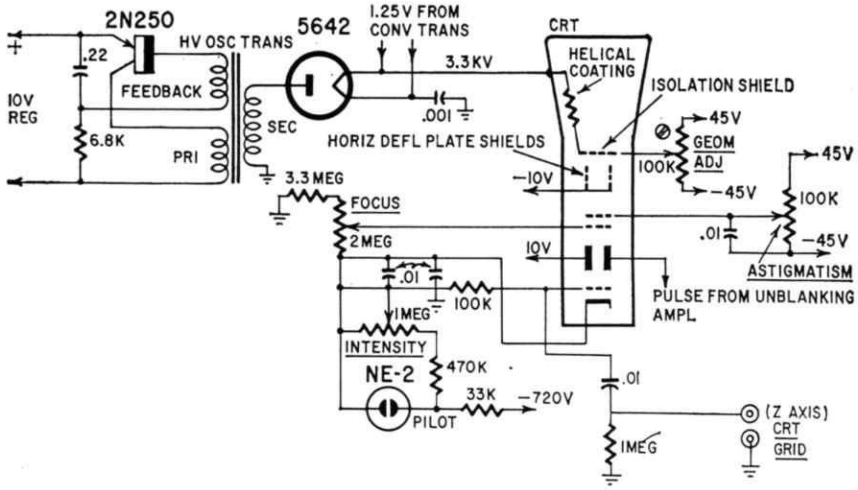


Fig. 5—Connections to cathode-ray tube. 20-kc oscillator and rectifier supplies high voltage. Standard deflection plates are not shown.

for the amplifier. The unblanking signal puts the beam back on the screen during scanning.

The low-voltage power converter is conventional and resembles the often published "transistor power supply." Operating frequency is 2 kc (the high-voltage supply operates at 20 kc). Note that voltage regulation takes place *before* the converter (Fig. 1). In this manner voltage supplied by the 117-volt ac circuits is regulated as well as the dc input voltages. In other words, whether the scope is being supplied from its own batteries, from an outside dc source or from the ac line, the converter and regulator are always operative. This makes for the least difference in the various modes of operation, as far as the amplifier and sweep circuits are concerned. The battery charger is optional. It has a current regulator with a temperature-sensing bridge. The temperature of the battery is proportional to the charging rate. Maintaining an even charging rate is important with the small rechargeable batteries used, and the regulator measures the temperature rise *above* ambient.

There you have it, a new instrument which, in spite of its price, is going to gain enormous popularity because of its portability, versatility and ease of operation. There is no sacrifice in performance for portability, and the 321 will do any job as well as most service type scopes, and perhaps a little better. It is no match for the very-high-performance types also made by Tektronix, but then it was never meant to be. And apart from the rather special CRT, the designers did not have to resort to tricks to get the response required, just good sensible design. This is a first in the scope business, and a step in the right direction to fulfill the promise of the transistor. END

PROTECT that Voltage Regulator

ALL voltage regulators and transistor versions in particular should be protected against overloads. After all, too much current through a regulator transistor and several dollars go down the drain. Some circuits recently appeared in a Texas Instruments *Application Note* (July, 1960) on using a backward diode to protect regulator circuits.

A basic circuit using a backward diode, an auxiliary transistor and two resistors to protect a voltage regulator (V2) is shown in Fig. 1. During normal regulator operation, the voltage across R1 keeps the diode from conducting and V1 operates in saturation. Thus the series control element—the collector-emitter element of V2—sees V1 as a low impedance. However, when load current becomes excessive, the diode starts to conduct in the reverse direction because of the additional voltage drop across R1. This reduces the base-emitter voltage of V1 which reduces collector current to a safe figure.

Fig. 2 is a working regulator using the protective circuit shown in Fig. 1. It demonstrates the current-limiting technique of overload protection. This circuit causes little deterioration in normal regulator performance although the saturation resistance of V1 and the resistance of R1 make the output resistance somewhat higher. Also, changes in operating temperature can shift the current level at which limiting occurs. Temperature effects can be reduced, however, by careful selection of components. Fig. 2 is set up with control R1 adjusted so current regulating starts whenever the load current exceeds 500 ma. As Fig. 3 indicates, current limiting with this circuit is very sharp once the maximum allowable load current is exceeded.

This circuit has one important disadvantage—V1 must withstand both the maximum load current and a voltage nearly equal to the unregulated input while a short-circuit load condition exists. This makes it necessary to limit the use of this circuit to low-voltage low-current regulators. But, as higher-voltage higher-power transistors become available, this same protective circuit will apply to higher-power regulators. Until then, cascade the protective circuits if the unregulated supply voltage is greater than the voltage rating of a single transistor. END

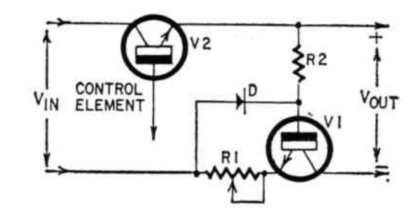


Figure 1.

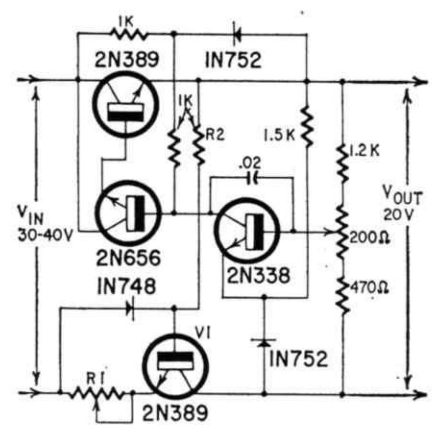


Figure 2.

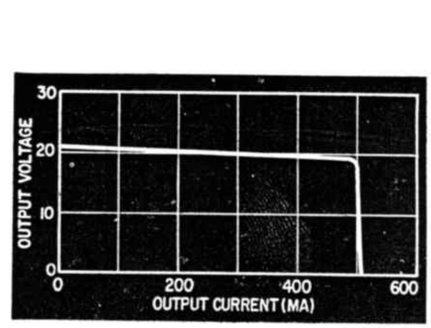


Figure 3.