UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY [Reports - Open file series]

A 500-Volt Pulse Transmitter for Ice Sounding

by

Charles J. Roubique

Open-file Report 78- 372

1978

A 500-Volt Pulse Transmitter for Ice Sounding

by

Charles J. Roubique

A high-voltage pulser developed by the U.S. Geological Survey for glacier soundings is a small battery-operated unit that weighs about one kg and was packaged in a case measuring 8.2 X 12 X 18.8 cm. It operates from an external 12 volt battery and supplies a 500-V pulse to a dipole antenna. The waveform changes shape only slightly for antenna impedances ranging from 20 ohms to thousands of ohms. Shunting a resistive load of 200 ohms with a capacitance of hundreds of pF causes only a very small rounding of the leading corner of the pulse. The pulse-rise time to the full voltage is about 100 nS and fall time to zero is about 150 nS. The 10 to 90-percent rise time is about 60 nS. The total pulse duration is adjustable from about 250 nS to about 1200 nS. Pulse-repetition rates range from 1000 to 10,000 pulses/sec. Maximum battery drain of 3 A occurs at the maximum repetition rate, and is less than 1 A at minimum-repetition rate.

The pulse is generated by a method similar to that used in digital switching at the output of TTL logic. An extremely-fast-switching power transistor connects the active terminal of the antenna to the source of pulse energy, a low inductance (disc ceramic) capacitor charged to 500 V. After a given pulse-duration interval, another similar transistor shunts the antenna terminals to stop the pulse; that is, it shorts the active terminal to the power common, which is the instrument case.

In the block diagram shown in Fig. 1, the RF chokes in the battery-power input terminals isolate the pulses from the battery so that they won't affect other instruments connected to the battery. The chokes are each 13 turns of

#22 enameled wire handwound in one layer on a 2 W carbon resistor, 10 k ohms or greater. The inductance is about 3 μH and self-resonance is at 24.8 MHz.

The relay is used to prevent damage by reverse polarity of battery connection without loss of battery voltage, as would be the case if a series power diode were used instead. Full output at the maximum repetition rate can thus be obtained until the battery voltage has dropped to 10.5 volts.

The pulse-repetition-rate generator is shown in detail in Fig. 2. The resistor connected to pin 6 should be placed near pin 6. If stability of the repetition rate is important, then the two 2 k ohm resistors and the 25 k ohm pot should be metal-film resistors and a Cermet or wire-wound pot. The 0.022 μF capacitor should be a polycarbonate, or a mylar capacitor if the other is not available.

The pulse-duration control circuitry is detailed in Fig. 3. The timing capacitors should be stable, such as dipped mica, or NPO ceramic. These are the 33, 82, and 150 pF capacitors. The 2.2 k, 4.33 k, and 7.5 k ohm timing resistors should be metal film, and the 25 k ohm pulse-duration pot should be a Cermet unit.* The 0.05 μF (or at least 0.01 μF) disc capacitors should be as close as possible to the one-shots (monostable multivibrators), and should connect between pins 7 and 14 to minimize cross-coupling through the inductance of power leads.

---

* Use of a specific brand name does not necessarily constitute endorsement of the product by the U.S. Geological Survey.

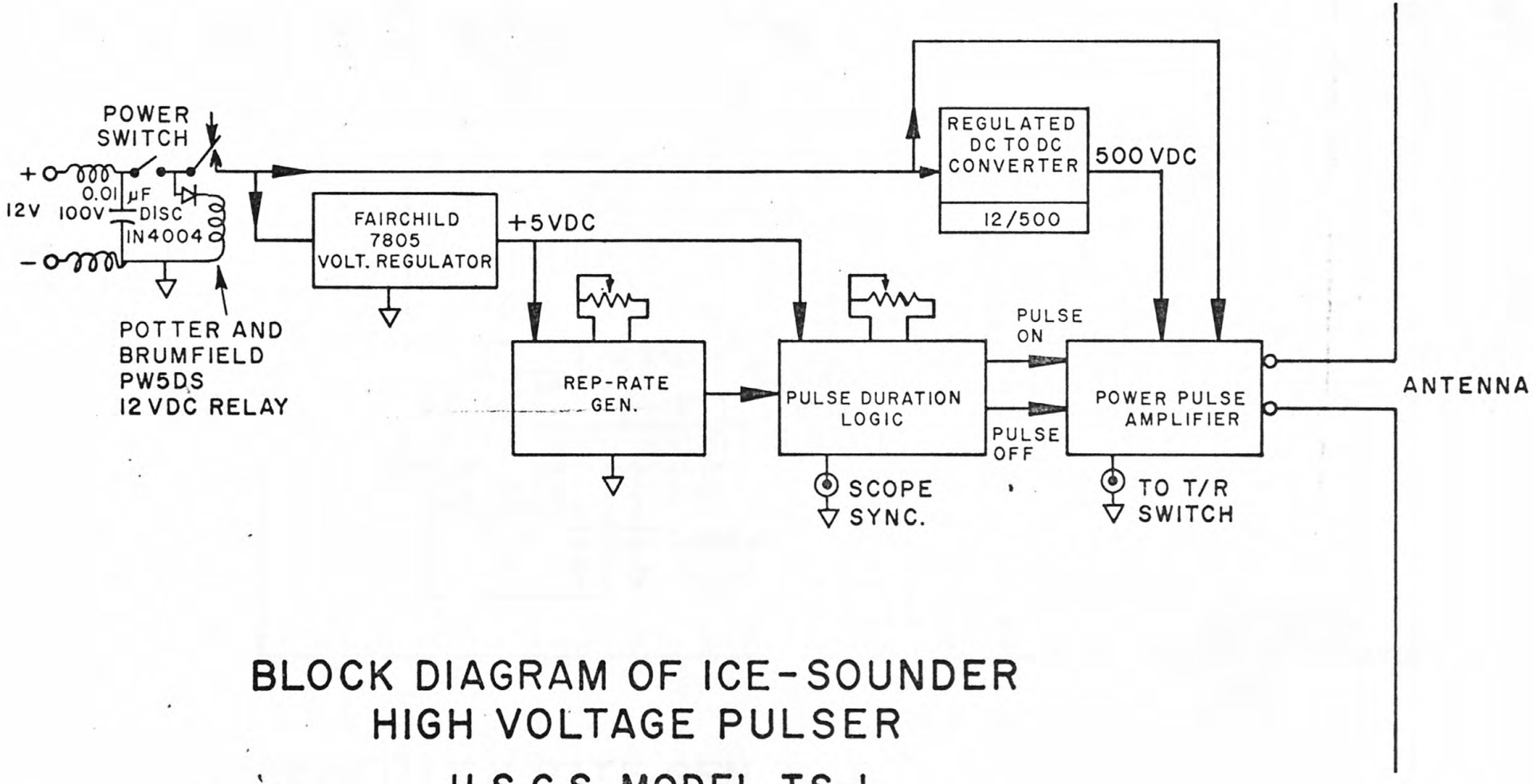
In Fig. 4, the inverter section generates a square wave which is rectified by a half-wave doubler at the transformer output. For no load, the 500 V can be produced by 5 VDC at the transformer center-tap. For an output of 500 V at 42 mA, the center-tap supply must be 10.5 V. To maintain a constant 500-V output with a varying load requires a regulator circuit. The stable resistor-divider (1 megohm and 10 kilohm metal film resistors) provides a small voltage proportional to output, which is compared to a stable, adjustable reference in a feedback loop, and controls a series regulator to keep the high-voltage output constant. A simple circuit consisting of an avalanche-diode-connected silicon transistor and a silicon diode in series (shown in lower left corner) can substitute for the more expensive temperature-compensated zener diode reference. Its temperature stability is good because the temperature coefficients of the reverse-breakdown base emitter diode and the silicon diode are almost equal, and opposite in polarity.

In adjusting the power supply, the voltage-adjust trimming potentiometer should be set so that the voltage at the wiper is a bit more than 4 V. This will produce an output less than 500 V. A clockwise rotation of the screw adjust should then decrease the 4 V and increase the output to the desired 500 V. This 500 V will produce a pulse amplitude of 480 to 490 V. If it is critical to have exactly 500 V pulses, then the supply output can be increased to a value sufficient to provide a measured 500- volt pulse amplitude.

In Fig. 5, the 0.02 μF energy storage capacitor, the current-limiting 3.9 k, 2 W carbon resistor and the 0.02 μF filter capacitor should be close to each other and as near the collector of the upper transistor as possible. The

lead between the emitter of the top transistor and collector of the lower transistor should be short to minimize inductance, as should the connecting lead to the antenna output terminal and the lower emitter lead to chassis.

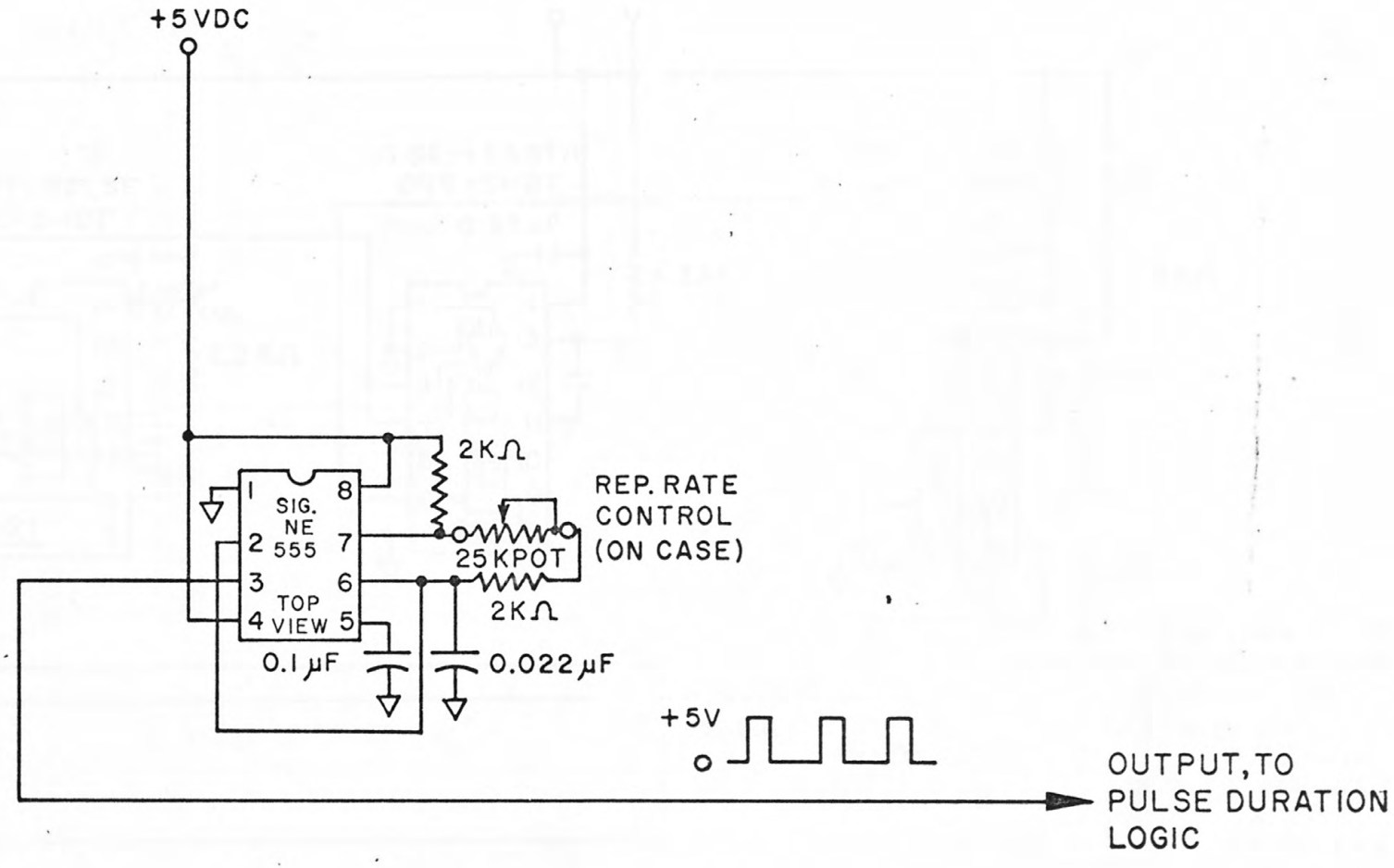
It is advisable to use sockets for the integrated circuits so that testing and repairs may be simplified. Sockets for the MJ10007 output transistors are recommended, since all units will not give equal output-pulse rise times. The lower-breakdown-voltage unit in the top position works best, because the fastest switching occurs when the transistor is triggered by the input pulse into an avalance mode of collector-emitter breakdown. If methods of measuring breakdown-voltage are not available, then one might obtain five of the output transistors and use the best performing pair of the possible 20 combinations.



BLOCK DIAGRAM OF ICE-SOUNDER HIGH VOLTAGE PULSER

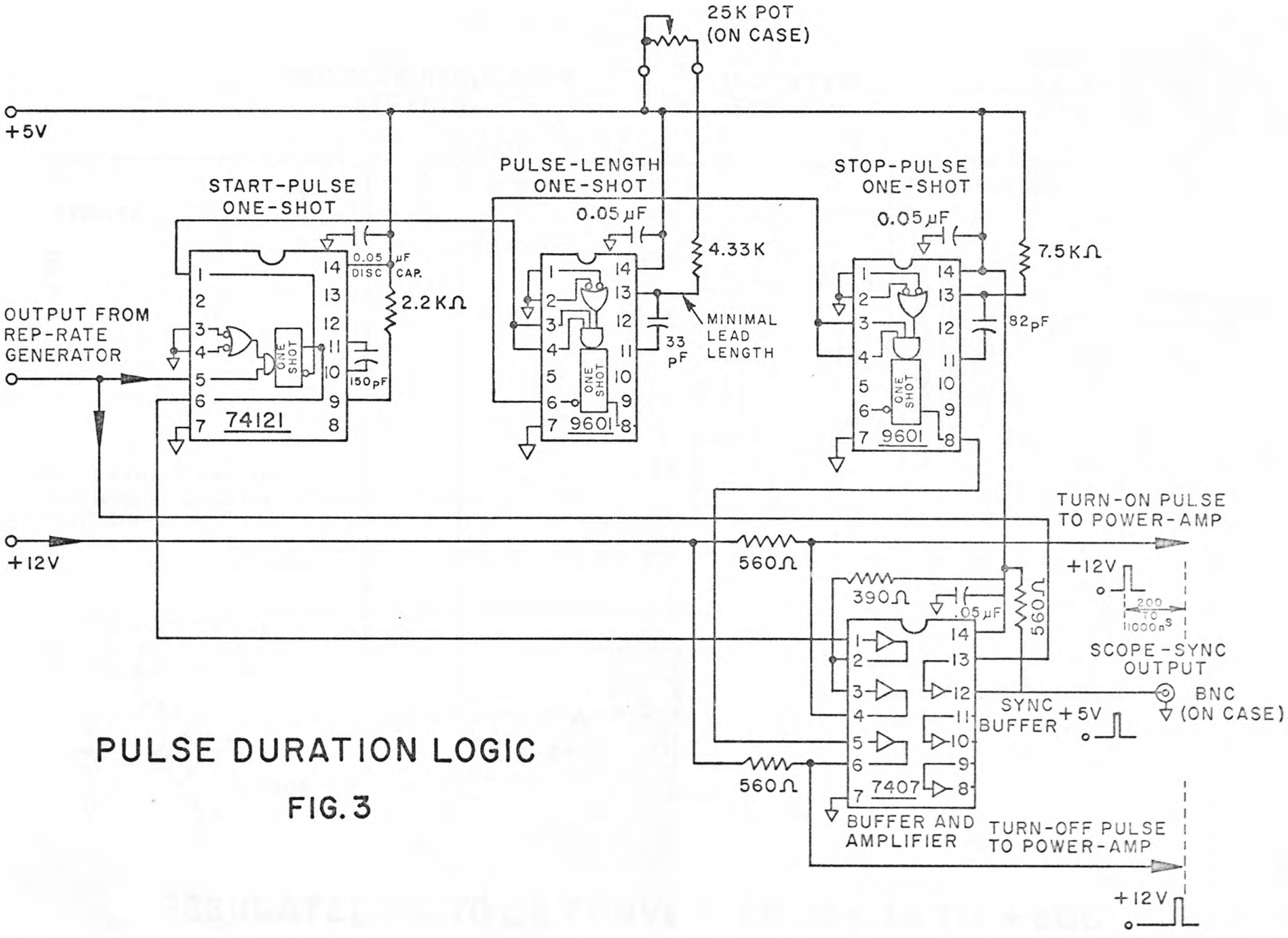
U.S.G.S. MODEL IS-1

FIG. 1



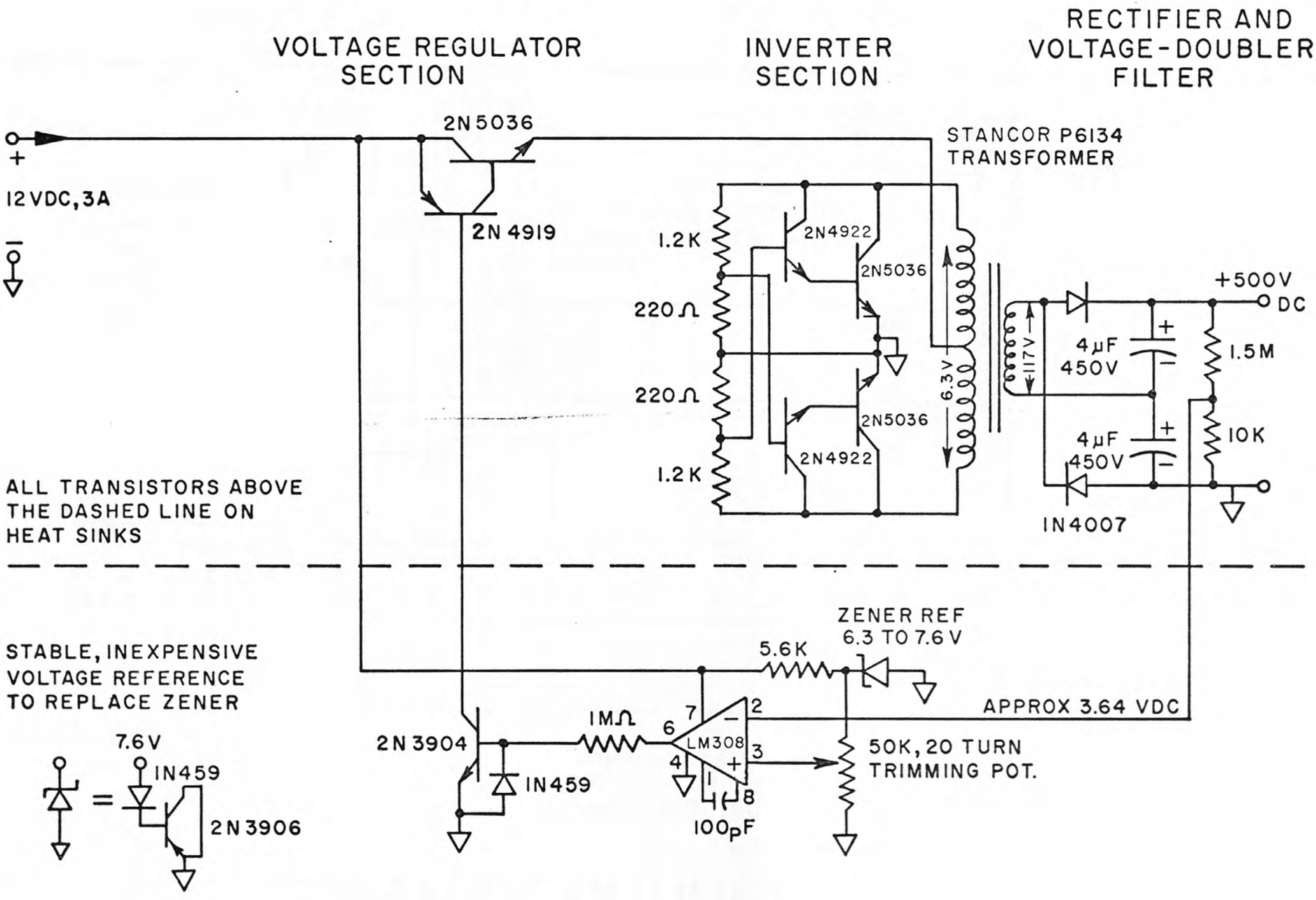
REPETITION RATE GENERATOR

FIG. 2

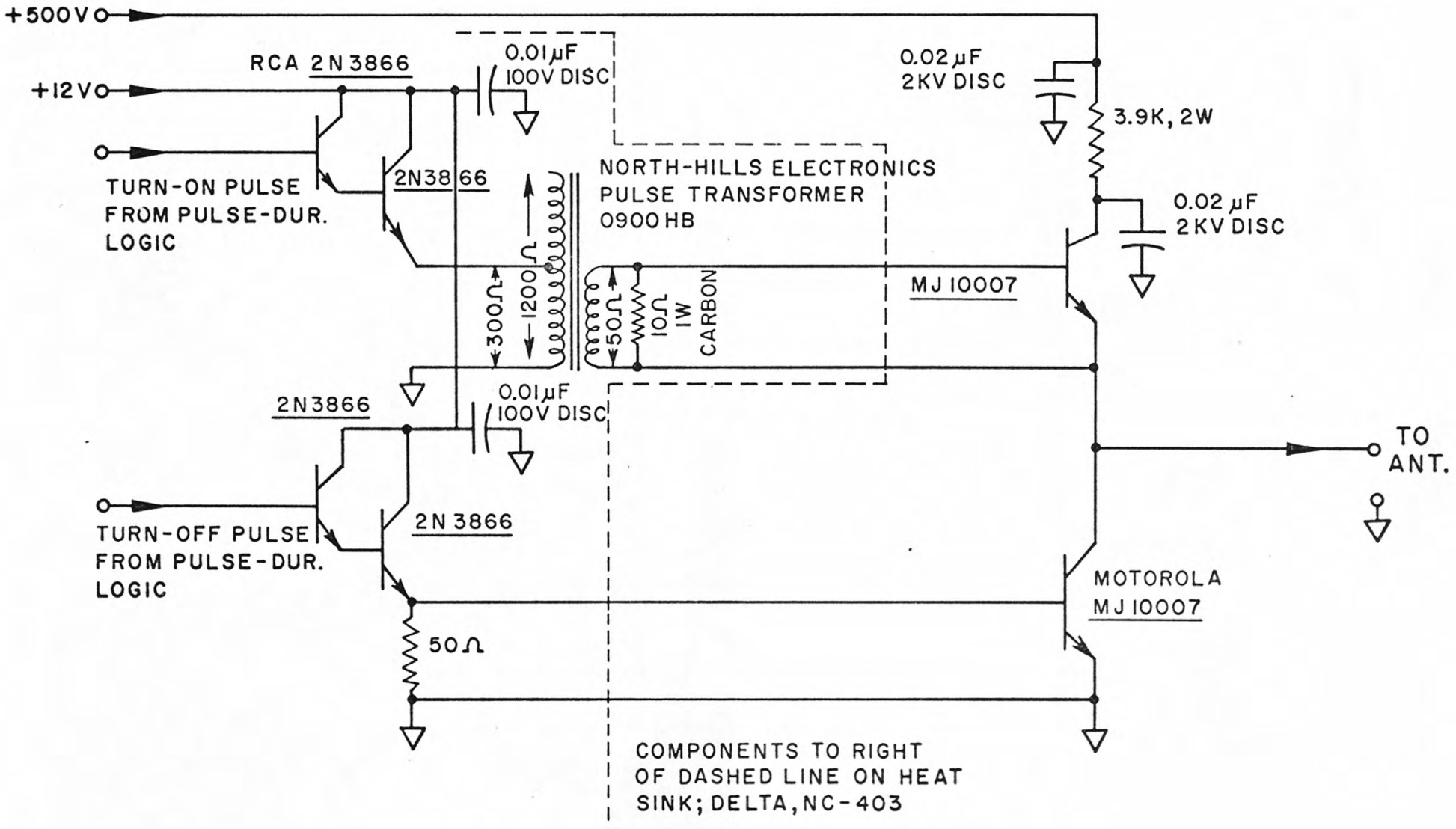


PULSE DURATION LOGIC

FIG. 3



REGULATED DC TO DC CONVERTER; 12V, 3A TO +500V, 42mA



POWER PULSE AMPLIFIER

FIG.5