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Title

APPARATUS FOR THE INVESTIGATION OF THE BIRESISTANCE STATE OF MATERIALS

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GODDARD SPACE FLIGHT CENTER,

GREENBELT, MD.

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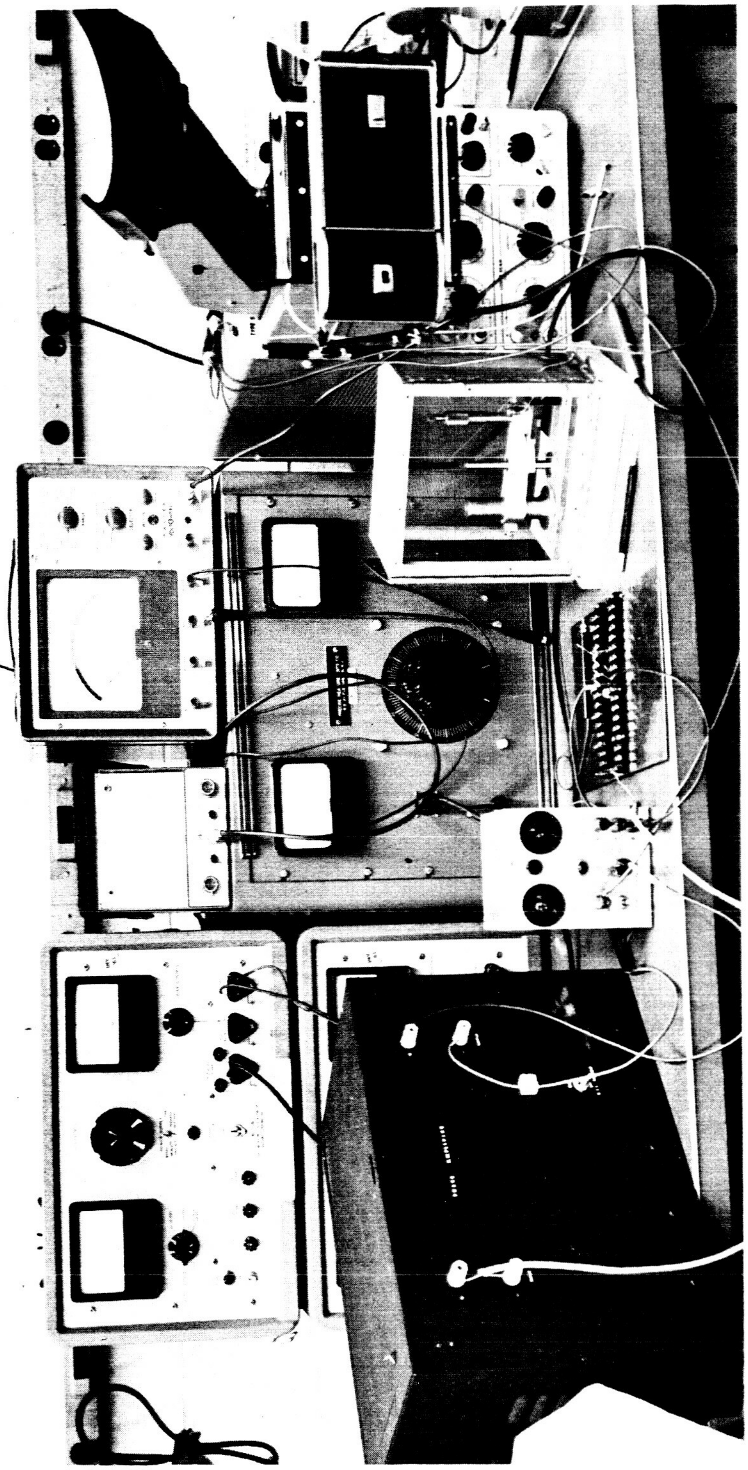

ABSTRACT

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A description is given of the experimental apparatus including a variable-amplitude, variable-time pulse generator designed and assembled for the research and development of materials exhibiting a dual resistant state when subjected to certain electrical conditioning.

Author

INTRODUCTION

Recently it has been found*† that both film and bulk semiconducting or dielectric material can be made to exhibit a dual electrical resistance when subjected to voltage pulses of brief duration. The specimen remains in either one of its resistance states indefinitely, without the aid of any holding potential. To investigate this effect more precisely it was necessary to design and construct a time-variable and amplitude-variable voltage supply capable of single, large magnitude, microsecond pulses. This note is primarily concerned with the specialized equipment developed and utilized to investigate the biresistant response. The detailed behavior of the various materials under study will be reported elsewhere.

EXPERIMENTATION

The initial investigation centered on the biresistant properties of NiO. Samples have been prepared in three ways: (1) pure nickel foil of various thickness was oxidized in air followed by fired-on gold or silver electrodes, (2) reagent grade NiO powder was hydraulically pressed into disc-shaped pellets of different thickness and density, fired in air and electrodes applied, (3) thin films were evaporated on metal substrates followed by an evaporated conductive overlay.

In the early phases of this investigation it was known that: (1) for relatively thick specimens, a voltage pulse of the order of 1500 V applied for several seconds was required to "prime" the specimen, i.e., allegedly to form a conductive path through the sample, (2) voltage pulses of anywhere from 200V to 800V D.C. for several microseconds were required to switch the primed sample from either high to low or low to high resistance. (Typical values in the high and low regions have been reported as several megohms and several hundred ohms,

*U.S. Patent 2,784,389, Mar. 5, 1957, M.J. Kelly, IBM Corp., N.Y.
†Trionics Corporation, Contract NAS 5-2019.

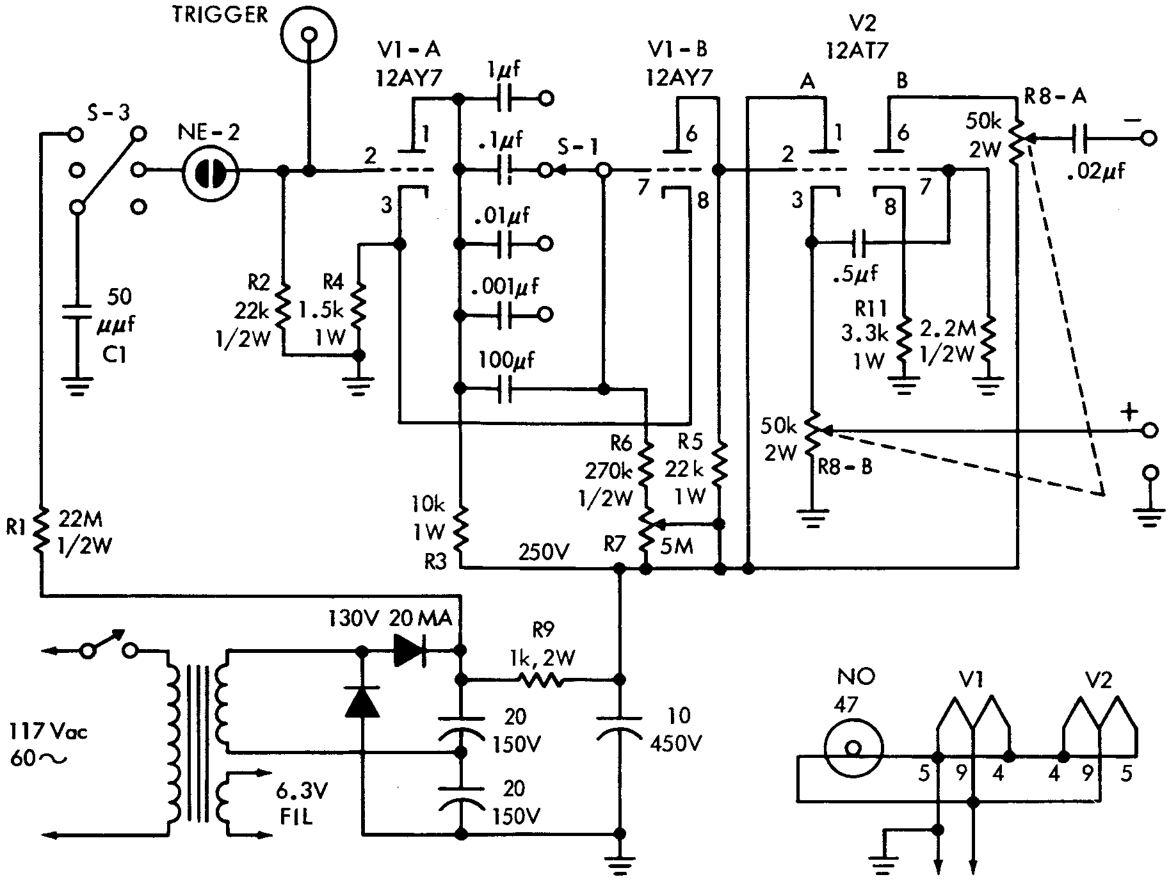

Figure 1—Single pulse generator. Pulse length 1/5 sec to 1 µsec, pulse amplitude 0 to 100V.

respectively), (3) A. C. as well as D. C. pulses of smaller magnitude also caused the specimen to switch, (4) pulse energies were somewhat critical for a successful switch.

In order to study the abovementioned phenomena, a pulse generator and amplifier designed for a single square wave-type output with variable voltage amplitude and pulse width was constructed. The generator circuit is shown in figure 1. The generator pulse width and pulse height are continuously controllable from 1.0 microsecond to 0.2 seconds and from 0 to ± 100 volts, respectively. The 50 µµf capacitor (C1) is continuously charged through the normally closed contact of switch (S3). Depressing the switch connects (C1) to the neon bulb (NE-2) in series with the 22K grid resistor (R2). The energy in the 50 $\mu\mu f$ capacitor is sufficient to fire the NE-2 only once, thereby placing a positive pulse on the first stage grid of the 12AY7, (V1-A). This trips the multivibrator which normally has the second stage (V1-B) conducting. The return of the multivibrator to the normal state is delayed by selecting time constants with switch (S1) and time control (R7) to control the width of the output pulse. The multivibrator pulse is applied to the grid of the 12AT7 cathode follower which prevents multivibrator loading and provides the final positive output. The pulse is also fed to the grid of the reversing amplifier (second half of the 12AT7) which then supplies the equivalent negative pulse.

The pulse amplifier, (figure 2) is essentially a two stage R. C. coupled amplifier employing transmitting type tubes capable of withstanding the necessary high voltages. The internal impedance is

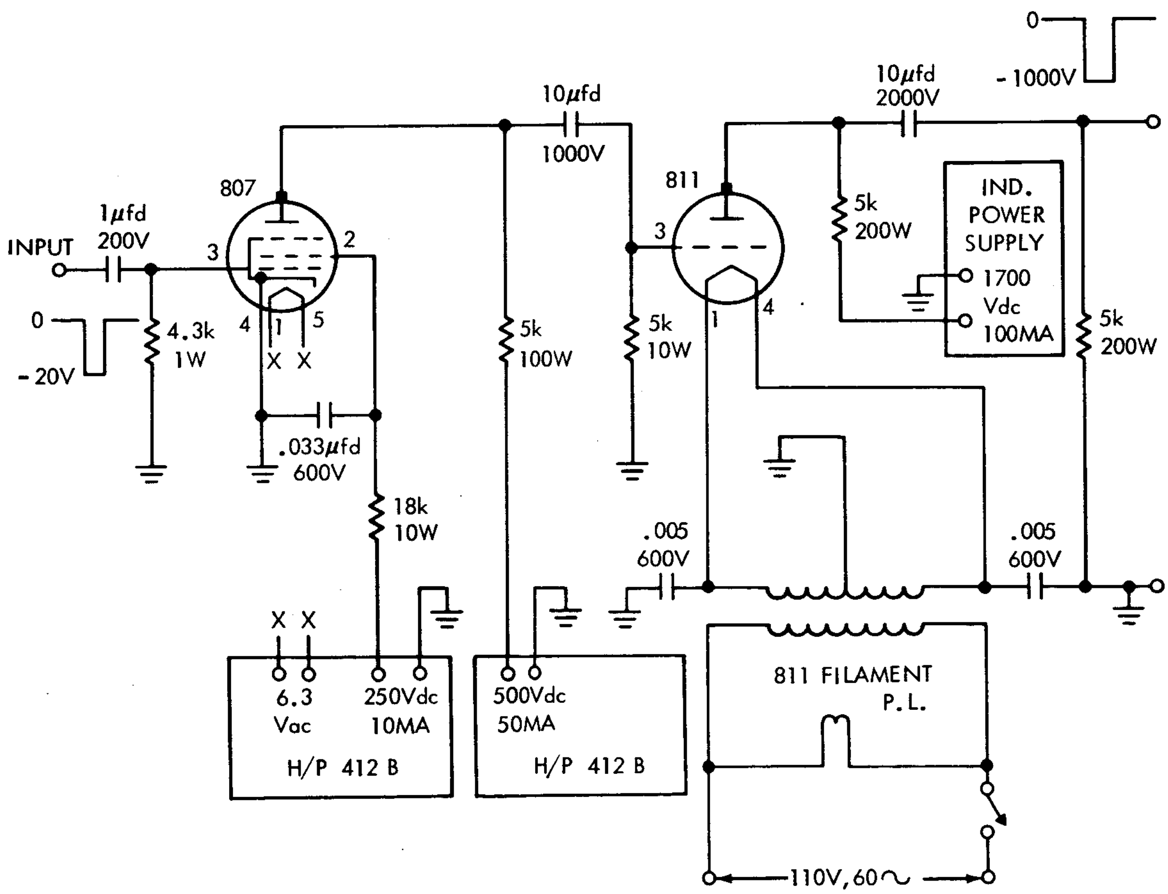

Figure 2-Pulse Amplifier

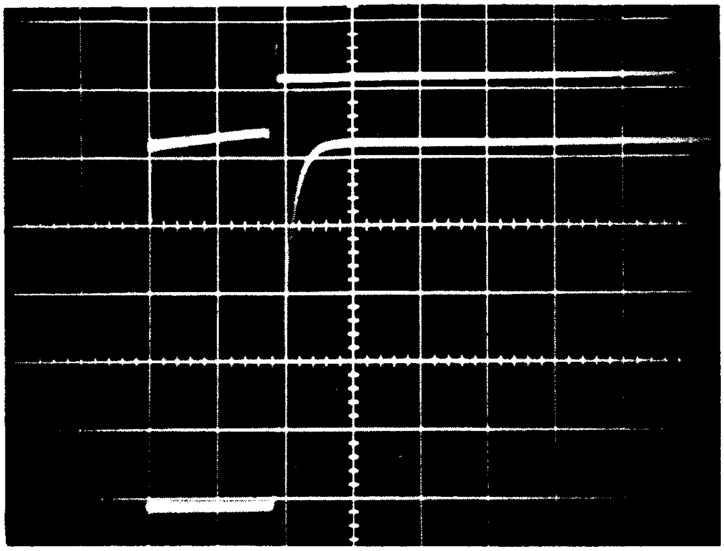

Figure 3—Upper trace: Vertical sensitivity = 20v/cm, horizontal = 20μ sec/cm lower trace: Vertical sensitivity = 200v/cm, horizontal = 20 μ sec/cm

approximately 2,000 ohms. Two Hewlett Packard Model 712B power supplies are used for the D.C. plate and screen voltages of the first stage and a Precise Measurements Company 0 to 3 KV, 0-500 ma power supply for the D.C. voltage to the second stage. At maximum drive conditions of -20 V input, and no load, 1,000 volt pulses with a rise and decay time of 0.8 microseconds can be obtained.

Figure 3 shows typical pulses available from the pulse generator and pulse amplifier. The upper trace shows the output of the pulse generator while the lower trace shows the output of the amplifier at maximum drive, no-load conditions.

The sample holder (figure 4) was designed to withstand the high voltage pulses and to establish a variable area pressure contact by means of interchangeable copper probe tips. The upper electrode (micrometer spindle) advances in the vertical direction without rotating with the shaft and places no undue strain on the material when making contact. The sample is then pulsed with the high voltage supply and then switched by using the pulse generator. The amplifier may be bypassed when lower switching voltages are used. The sample holder may be bypassed when solder-type contacts are used. Voltage and current waveforms are simultaneously displayed on the dual beam oscilloscope. The state of the sample is then non-destructively determined with the voltohmist. A second D.C. pulse in the same direction or a briefly-applied A.C. signal then switches the sample back to its original state. This procedure may be continued indefinitely.

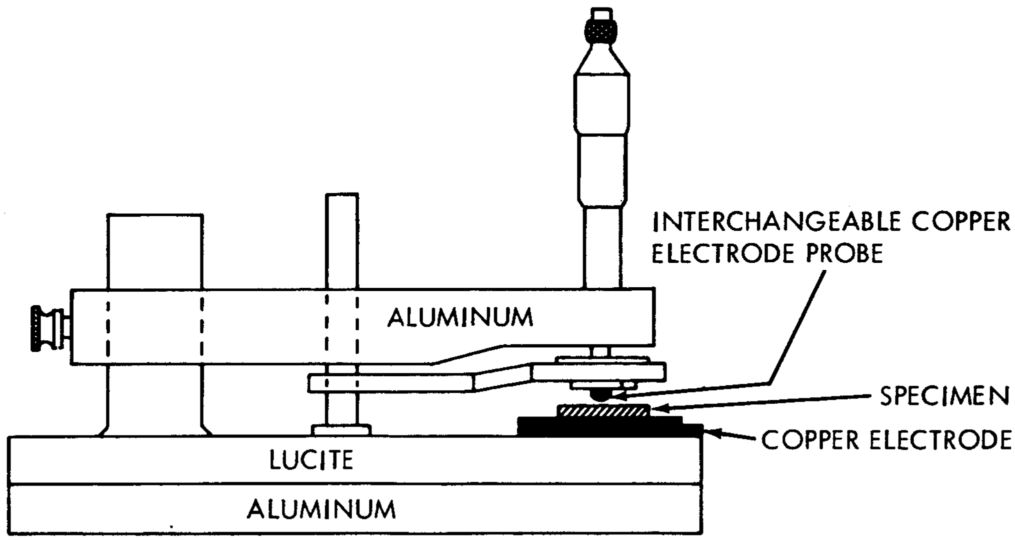

Figure 4—Sample holder

The block diagram of the entire test apparatus is shown infigure 5.

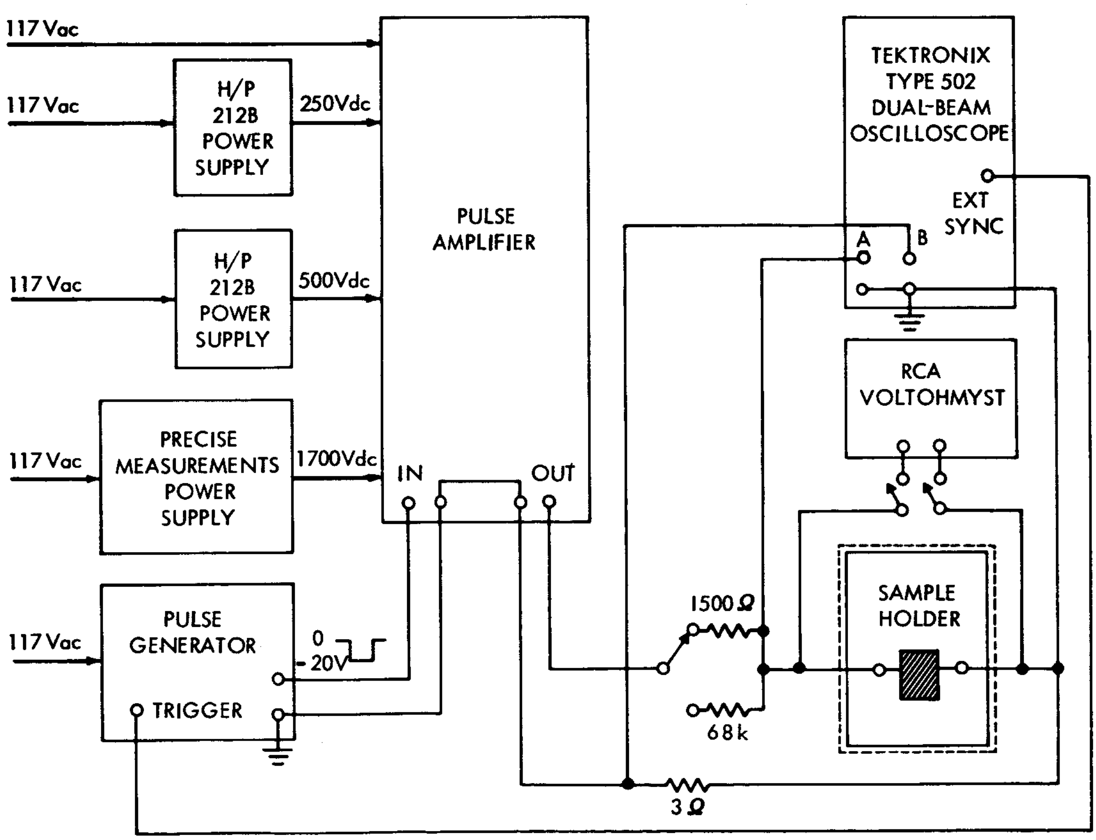

Figure 5—Block diagram of test set up

ACKNOWLEDGMENT

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