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OPERATIONS DIVISION

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TECHNICAL MEMORANDUM COVER SHEET

Title of Memorandum - Communication Between Electronic Circuitry and Mechanical or Electro-Mechanical Devices

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Description

A discussion of the means of communication used in the Task 13 machine between the electronic equipment and mechanical or electro-mechanical devices.

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XA-19742

12 December 1950

TECHNICAL MEMORANDUM NO. 15

COMMUNICATION BETWEEN ELECTRONIC CIRCUITRY AND MECHANICAL OR ELECTRO-MECHANICAL DEVICES

In the design of electronic computing equipment it is necessary to provide means of communication between the electronic equipment and mechanical or electro-mechanical devices. In the Task 13 equipment, such communication includes the following:

1. Manual Start.
2. Operation of relays as a result of pulse occurrence.
3. Producing relay contact pulses as a result of a very short pulse (0.1 usec).
4. Communicating with the output system.
5. Generation of system clock pulses for use on single step or "inch" operation.

The above problems will be taken up in order. It is recognized that there are many methods of accomplishing these results. The ones discussed have proved to be very reliable.

The standard pulses in the arithmetic and control systems vary between 0.1 and 0.2 usec in width and from 20 to 35 volts in amplitude. Pulse widths up to 0.5 usec may be tolerated with the standard circuitry. Advantage of this fact was taken in the development of the circuits discussed below.

1. Manual Start

This application calls for the generation of a single pulse as a result of a mechanical contact closure. This pulse must be coincident with a standard clock pulse.

This is accomplished in two steps. The first is the production of a single sharp pulse initiated by a contact closure. The second is the synchronizing of this signal with the standard clock pulses. For the first step, a self-extinguishing thyratron circuit was chosen because an output pulse of very short rise time may be easily obtained. Adjustment of circuit time constants eliminates spurious pulses due to contact bounce. This circuit is shown in Figure 1.

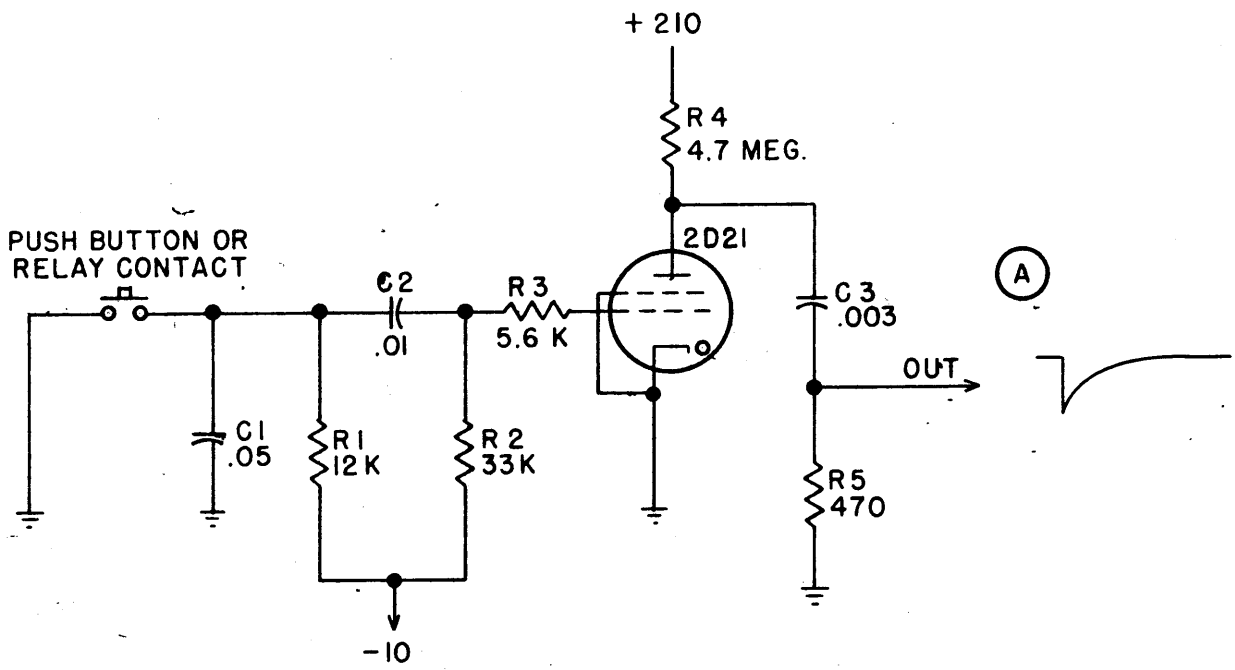

Figure 1 - Pulse-former

The thyratron is normally held off by the -10 volt bias. Capacitor C_3 is charged to +210 volts.

Capacitor C_1 serves the dual purpose of preventing firing due to cross-talk and eliminating much of the contact bounce signal.

Capacitor C_2 is initially discharged (-10 both sides). Closing the contact causes the grid to momentarily come to ground potential. The tube fires, producing a negative output at (A). Firing of the tube discharges C_3. The tube will go out when the plate reaches the extinction potential as C_3 discharges. The tube cannot fire again until C_3 charges through R_4 to the firing potential. By this time, however, the grid has regained its negative bias and the tube remains off.

The output pulse is several microseconds wide so must be shaped into a usable pulse. For this purpose the circuit of Figure 2 was used.

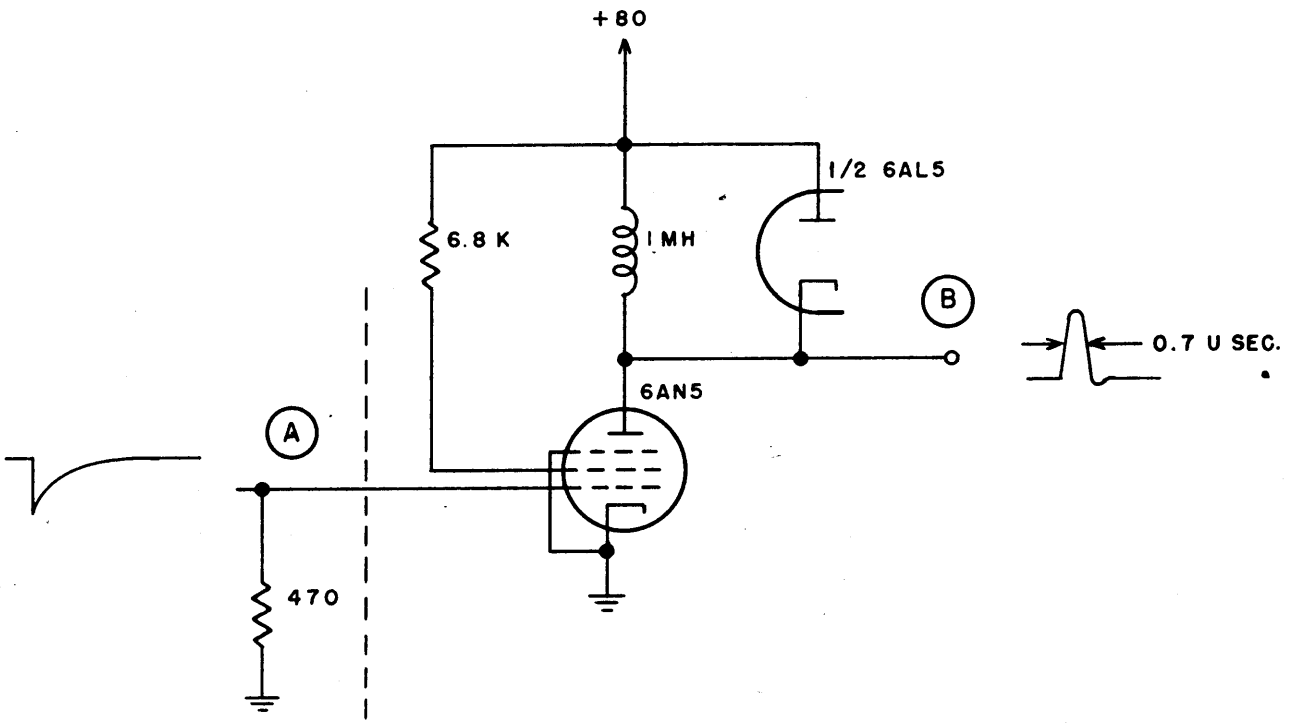

Figure 2 - Pulse Shaper

The 6AN5 is normally conducting. The pulse from the thyratron circuit cuts off the tube thereby interrupting the flow of current through the inductance. The potential at (B) will rise sharply, its limit being proportional to $L\left(\frac{di}{dt}\right)$. The circuit will attempt to oscillate, but is prevented from doing so by the damping diode. The output is essentially a half-sine wave of about 40 v amplitude and 0.7 usec duration.

One more stage is necessary to produce a pulse approximating the standard characteristics. Figure 3 shows the pulse amplifier used throughout the equipment.

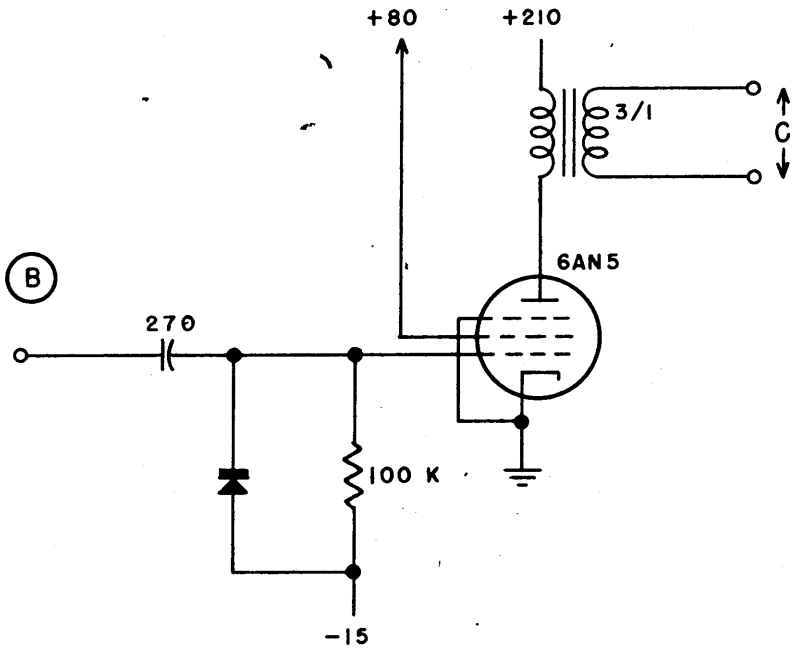

Figure 3 - Pulse Amplifier

When the signal from (B) of Figure 2 is applied to the input of Figure 3, an output will appear across C. Either polarity may be used. The circuit will deliver about a 35 v pulse into a 100 Ω load. When used with Figure 2, the width is about 0.4 usec.

Since these three circuits will be used throughout the discussion, it is convenient to assign names and symbols for them. (See Figure 4). The symbols from left to right represent the circuits of Figures 1, 2, and 3, respectively.

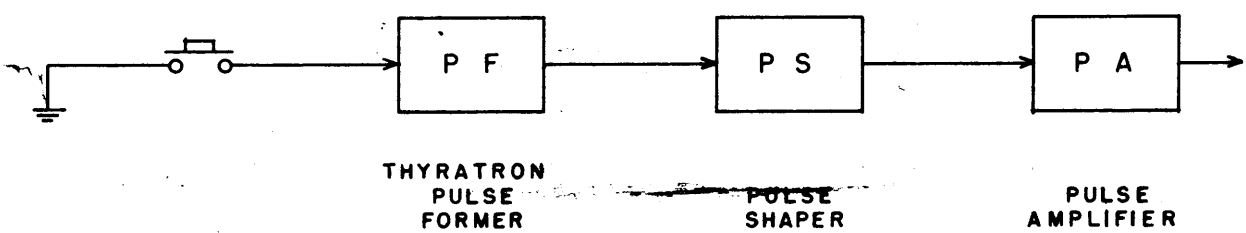

Figure 4 - Manually Initiated Pulse Former

The second step regarding manual start is the synchronizing of the manually initiated signal with the standard clock pulses.

The simplest method of accomplishing this would be the circuit of Figure 5.

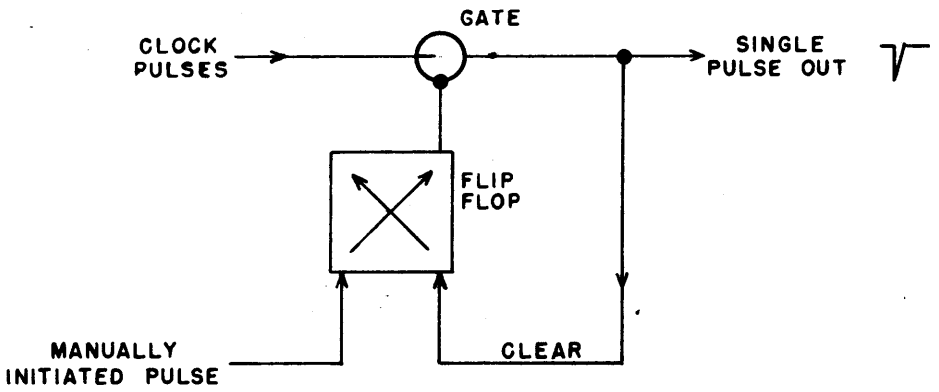

Figure 5 - Elementary Synchronizing Circuit

The gate is biased off by the flip-flop. The manually initiated pulse triggers the flip-flop; one clock pulse passes through the gate and returns the flip-flop to the normal condition.

With this circuit, however, there exists a possibility of producing as output a "runt" pulse. The initiating pulse may occur at any time with respect to the clock pulses; the gate may be only partially enabled when a clock pulse occurs. To eliminate this possibility, the arrangement of Figure 6 was used.

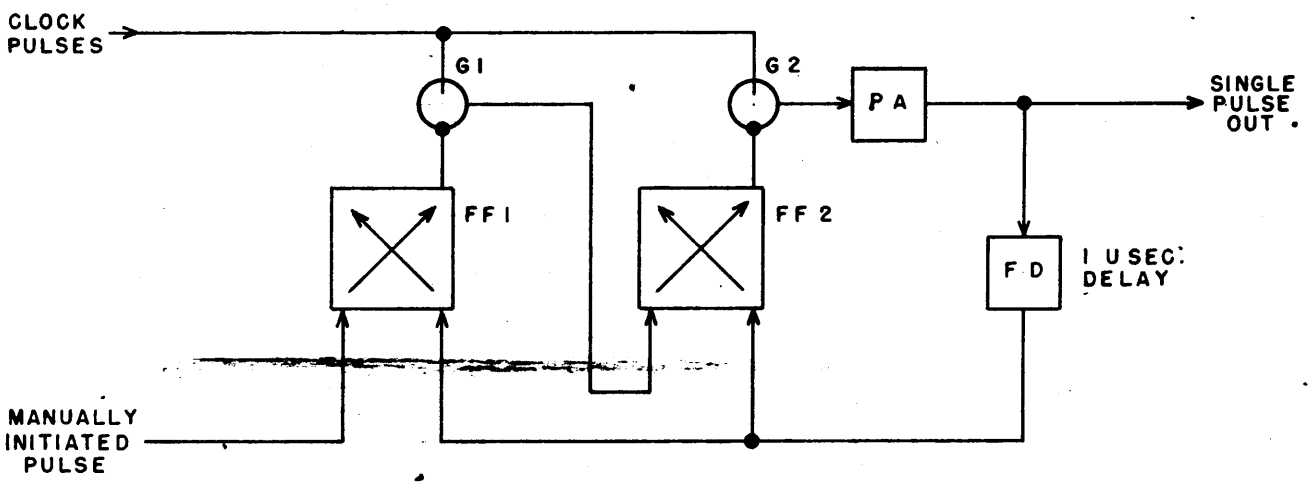

Figure 6 - Synchronizing Circuit

Now if a "runt" pulse is emitted from Gate 1 it will either trigger FF2 or it will not. If it does, FF2 has ample time to completely enable G2 before the next clock pulse occurs. If it does not, the next one will. The purpose of the delay in the clear line is to avoid the possibility of "confusing" FF2 by pulsing both sides simultaneously with signals of different amplitudes. (G1 is putting out a pulse simultaneously with that from G2).

The Task 13 standard flip-flop and gate circuits will not be discussed here as other material is available on the subject. The delay circuit of Figure 6 is shown schematically in Figure 7.

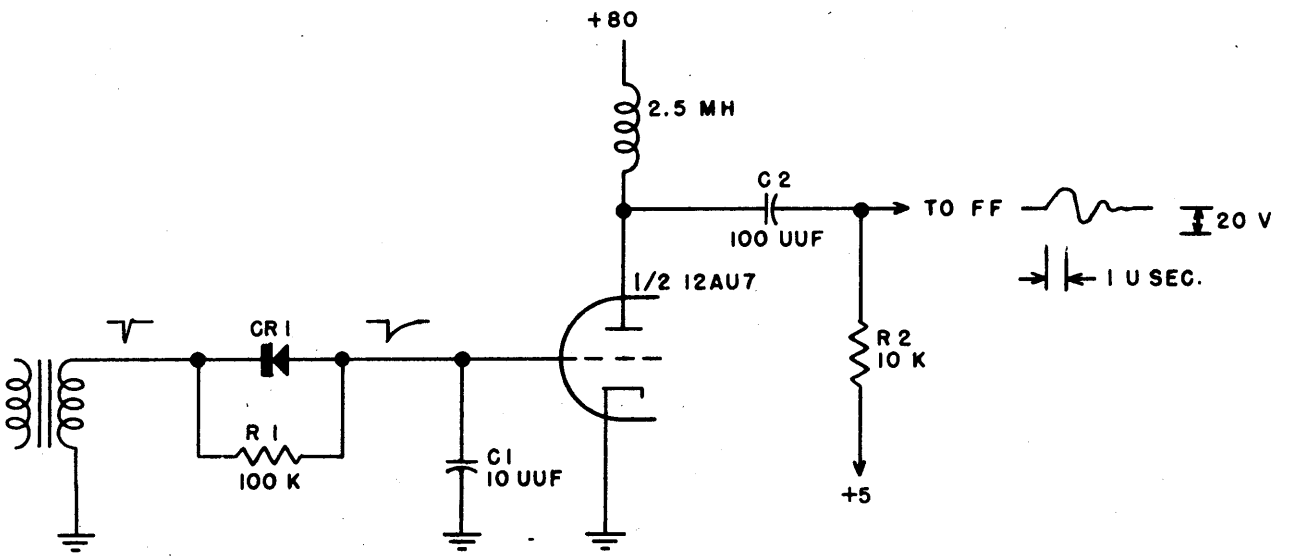

Figure 7 - One Microsecond Delay

The tube is normally conducting. The input pulse is a standard negative pulse of at least 20 v amplitude. This pulse charges C_1 through diode CR_1, cutting off the tube. The charge leaks off through R_1. The grid signal is therefore a "stretched" pulse which keeps the tube cut off for about 2 usec. When the plate current cuts off, an output is produced from the plate in the form of a damped sine wave. The signal is R-C coupled to the FF. The negative portion is used and provides a delay of about 1 usec from the initiating pulse.

2. Relay Operation as a Result of Pulse Occurrence

When certain pulses occur within the computer, it is necessary to operate relays to perform indicating and control functions. For this service the arrangement of Figure 8 was used. Considerable loss of emission can be tolerated in the 5687 tube before relay operation fails.

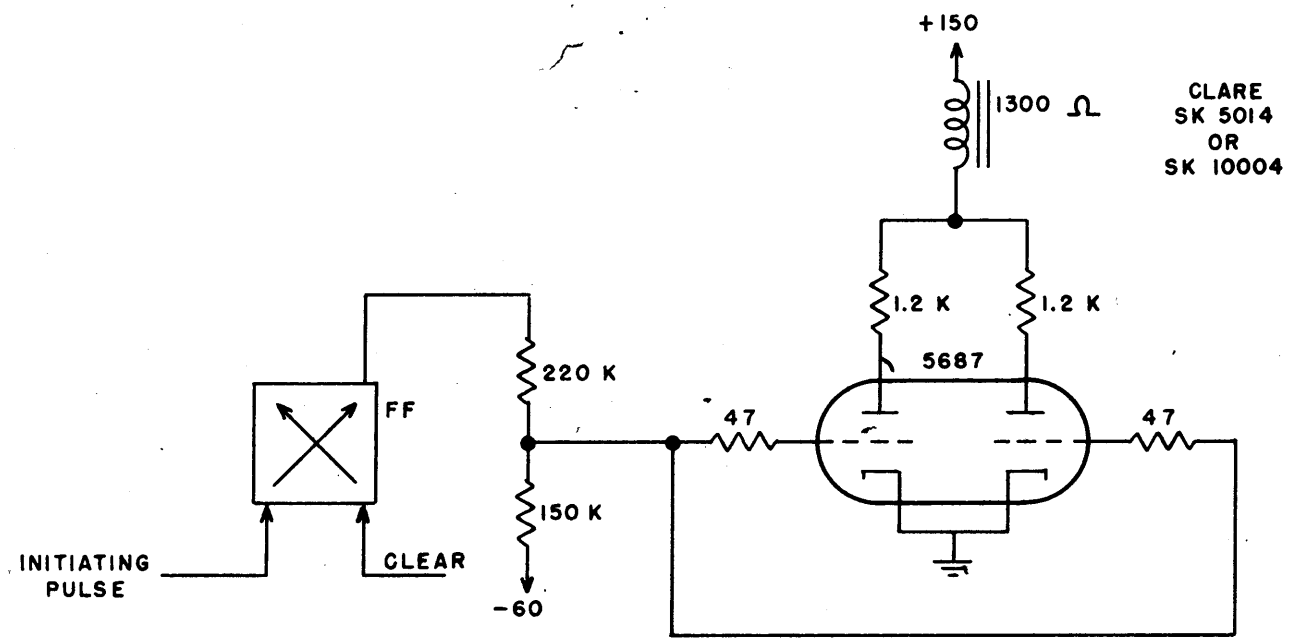

Figure 8 - Flip-flop and Relay Puller

3. Pulsed Relay Operation

Pulsed relays are needed for several control applications. Time of "energy-on" varies from 15 MS to 60 MS for different uses. A cathode coupled one-shot multivibrator was used combined with the relay puller of Figure 8. (See Figure 9).

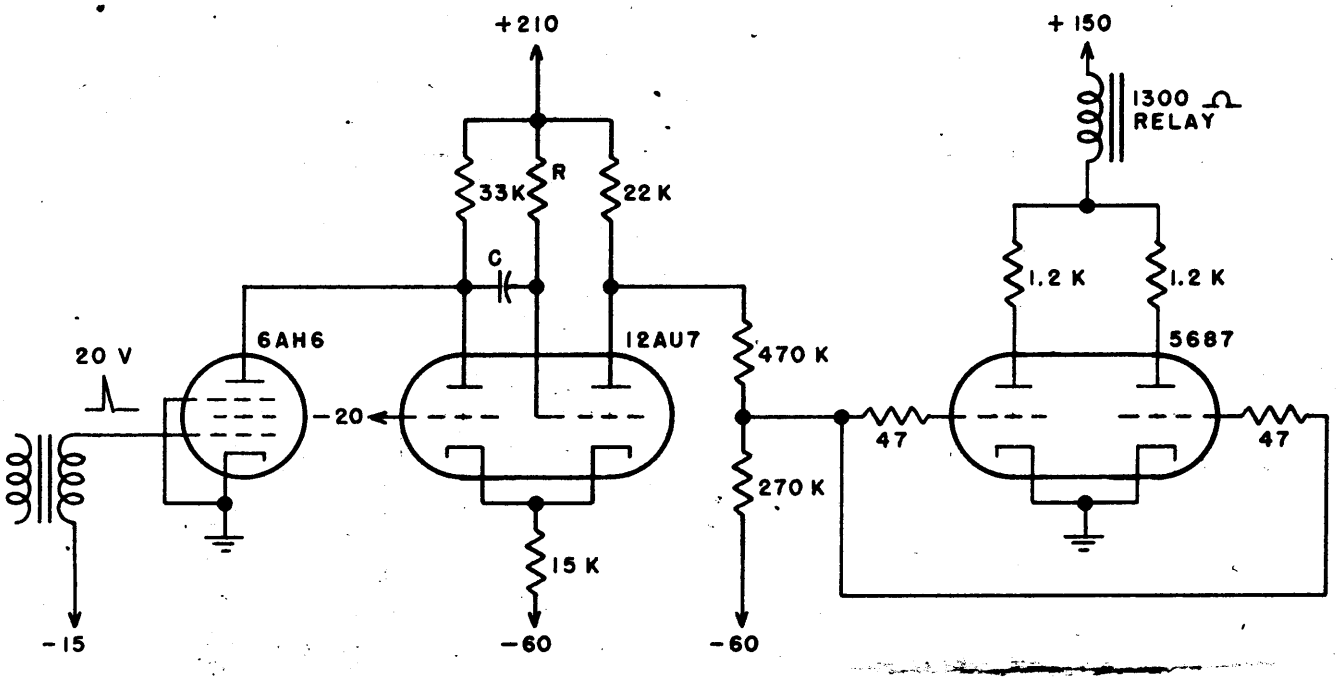

Figure 9 - One-Shot Multivibrator and Relay Puller

The pulse duration is equal to kRC; for this circuit k = .28 within the range used.

4. Providing Information to the Output System

It was required to print out a character corresponding to a six-digit binary number. The information was read out of storage to a thyratron-relay register. These relays energize the relay translator which selects the proper typewriter solenoid. Each element of the register has the circuit of Figure 10.

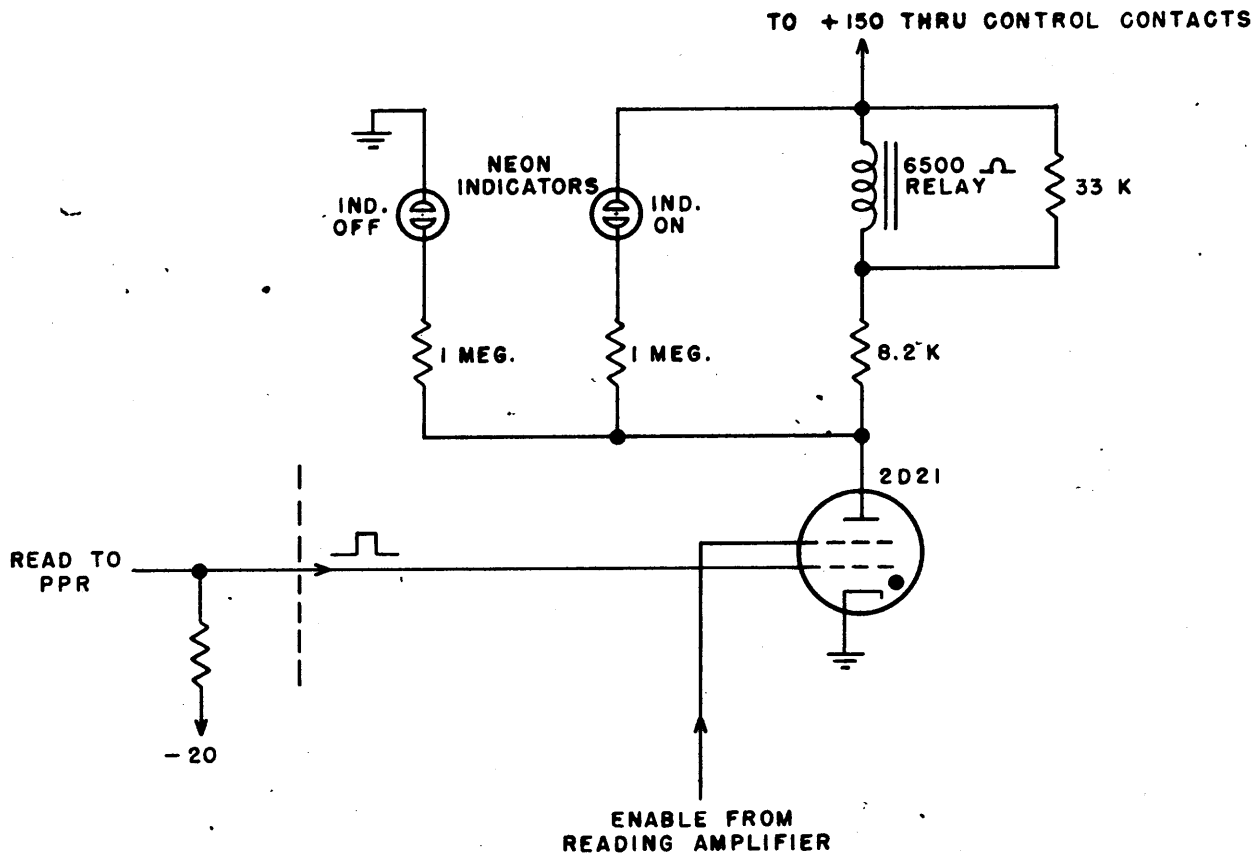

Figure 10 - Print-Punch Register Element

To initiate the print cycle, the circuit of Figure 11 was used.

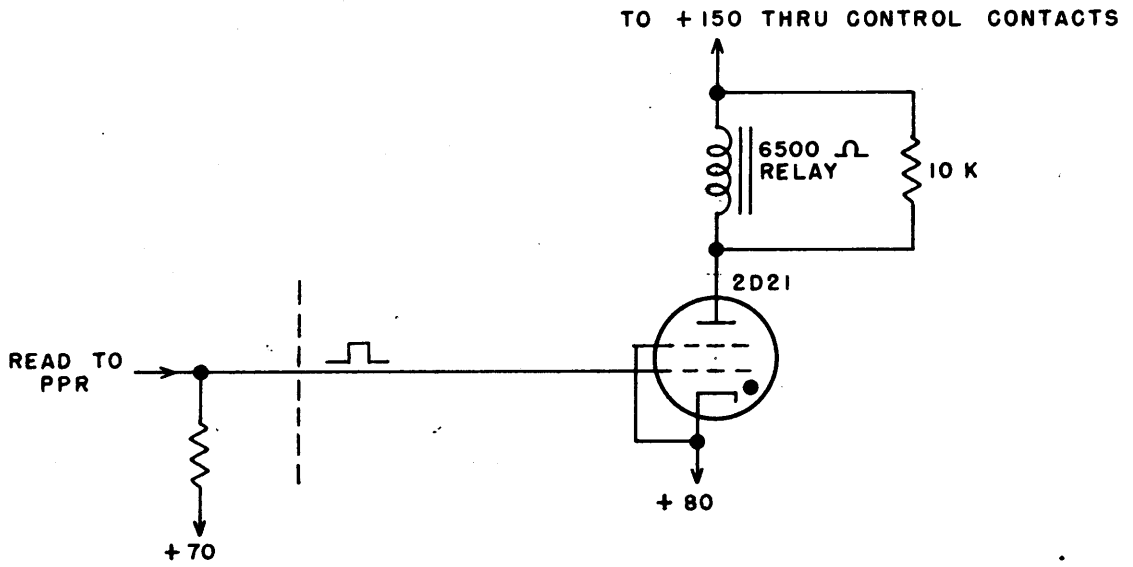

Figure 11 - Print Initiate Circuit

The purpose of the resistors paralleling the relays in both Figures 10 and 11 is to provide a resistive load to insure rapid ignition.

When the typewriter had printed it was necessary to produce an "acknowledge" signal to inform the electronic circuits of this fact. Figure 12 is a block diagram of the circuit.

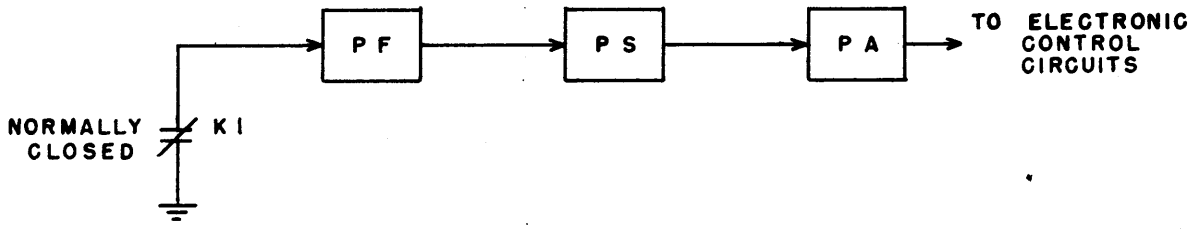

Figure 12 - Print Acknowledge

The relay contact K1 is normally closed; this relay is pulsed when the typewriter function is completed. A single shaped pulse is emitted from the amplifier.

5. Single Step Operation

For test purposes, the equipment is often operated in the "inch" condition. One clock pulse is produced for each closure of a push-button switch. These clock pulses must look exactly like the normal high speed pulses. For this reason, the shaping and output stages of the clock generator were common to all pulse rates. A block diagram of the circuit appears in Figure 13.

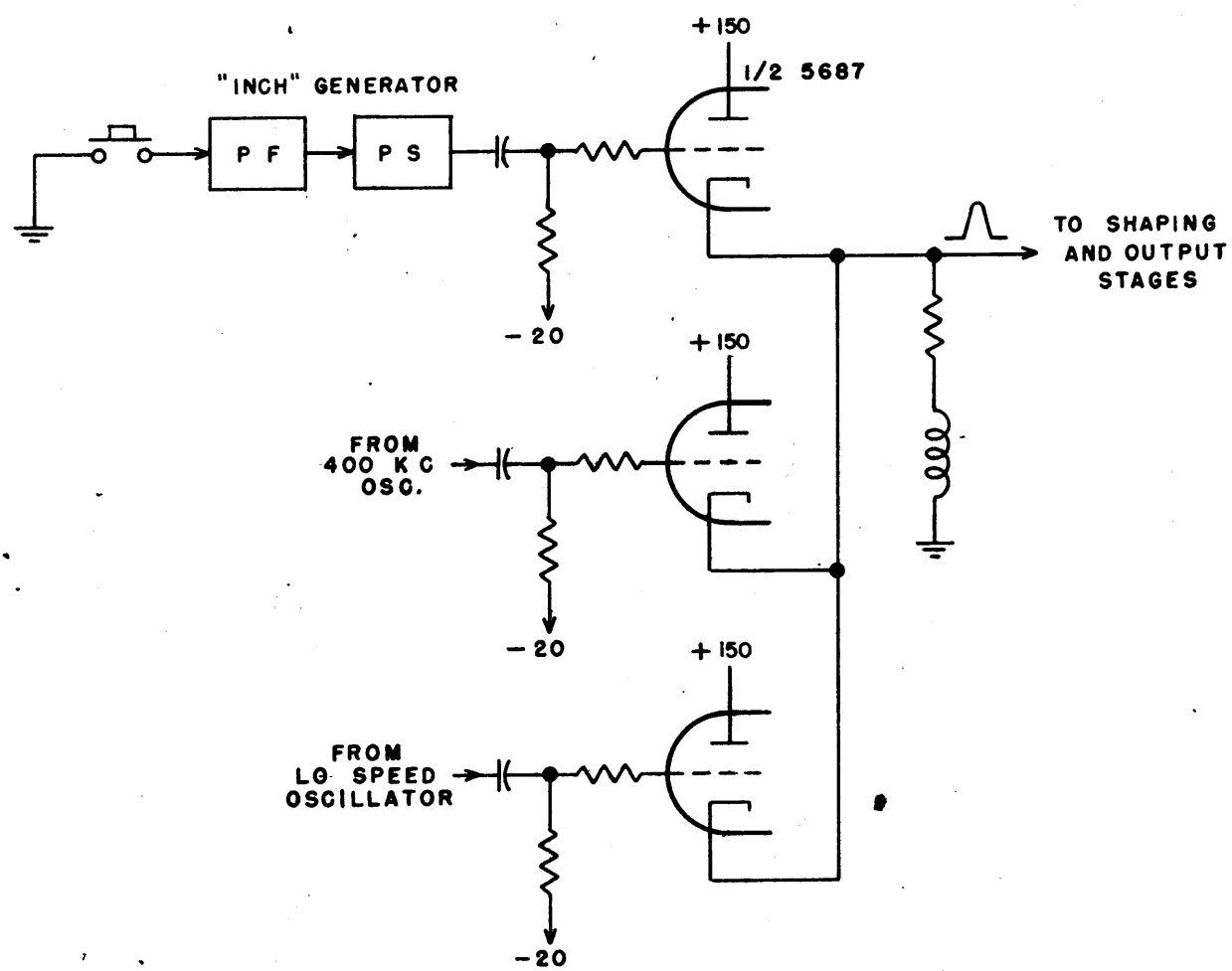

Figure 13 - Single Step Pulse Generator and Clock Pulse Mixing Circuit

SUMMARY:

For producing sharp pulses from contact closures, a self-extinguishing thyratron circuit is used in combination with a pulse shaper and pulse amplifier. The input circuit has an RC filter to avoid spurious pulses due to contact bounce.

To operate relays as a result of a pulse occurrence, either a flip-flop or a one-shot multivibrator is used in conjunction with a hard tube amplifier termed a "relay puller".

To transfer intelligence to the output system, a thyratron-relay register is used.

F. C. Mullaney

Reference: For a discussion of Task 13 standard circuits see Instruction Book CXMX equipment (Confidential) Section 3, "Detailed Theory".