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TRIGGER REQUIREMENTS FOR POSITRON OPERATION

I INTRODUCTION

The Positron operation imposes requirements for: 1) Trigger and Pre-Triggers, 2) a target position interlock, 3) special pre-trigger programming. This note describes a way to satisfy these requirements.

Somewhat different requirements are imposed by the "wheel" (continuous) and the "wand" (intermittent) targets. The "wheel" is a water-cooled disk which oscillates in a circular path. It will handle the full beam continuously. The "wand" is a small target on the end of a lever which is driven across the beam aperture on demand. It can handle but one or two beam pulses per second but intercepts the beam axis for about five pulses on each trip.

Special trigger signals are needed for phase shifters in Sectors 1 - 10, for klystrons 3A and 3C in Sector 11 and for the experimenter. Special pre-triggers are needed for the "wand" target and for experimental equipment such as a bubble chamber. An interlock circuit must inhibit the gun if the target is in a position to intercept a portion of the beam but is not yet properly located for positron operation. For operation with the wand target and/or bubble chamber, pre-triggers 10 - 40 milliseconds early must be generated and provision made for periodic operation at 1 or 2 pps.

II SPECIAL TRIGGERS AND PRE-TRIGGERS

A. GENERAL

A positron beam is programmed in the same manner as any other beam for the accelerator. Programming of the Injector, adjustment of pulse steering in Sector 30, and pulse magnet interlock programming in the beam switchyard are therefore handled in the same manner as they would be for any other beam.

B. SECTORS 1 - 10 (PHASE SHIFTER)

In Sectors 1 to 10 there is an 180° phase shifter at the input to the subbooster. (The subbooster for Sector 1 provides the RF for the injector.) The phase shifter is a pulsed ferrite device in which

a magnetic bias is switched from plus to minus to introduce the phase shift. The settling time of the switch is approximately 1.5 milliseconds. The switch will be operated each time the positron beam is required and will be reset for electron operation immediately after the beam pulse. The switch can, therefore, be operated by a standard pattern signal from the Pattern Generator in Central Control. For operation of the wand target, a single pattern pulse will switch the phase shifter when the positron beam is required; the switch will then be returned to its normal state for electrons. Using the wheel target, all beam pulses must be positron pulses. The phase shifter is nevertheless switched for positron 1.5 milliseconds before each programmed beam pulse and switched back, as if for electron operation, immediately after each pulse. Since the entire switch consists of solid state devices, the apparently-large number of switching operations will not effect its life.

A special pattern signal is sent via the trigger generator in each of Sectors 1 - 10 directly to the phase shifter switch.

C. SECTOR 11 - POSITRON SOURCE

A special trigger generator will be furnished. It will have provisions to trigger klystrons 3A and 3C at a rate and pattern different from those used for the remaining klystrons in Sector 11. It will have a pre-trigger channel for starting the drive mechanism for the wand target at any time in advance of the positron pulse. It will provide a scope trigger when positron pulses are expected. It can be expanded to provide additional trigger channels as required. The pattern signal from Central Control will operate 180° phase shifters at the inputs to klystrons 1B and 2B.

Provision must be made for local fine adjustment of the timing of the drive mechanism for the wand target. It will probably be necessary to make independent adjustment for alternate strokes of the target.

It may be noted that the rate and patterns of klystrons 3A and 3C will normally be the same as those of the rest of the Sector. The provision of special trigger channels allows them to be used only for Positrons if so desired. If they are used for accelerating both

electrons and positrons, however, their trigger pattern will be still independent of the pattern of the positron beam.

D. END STATIONS

It is anticipated that a trigger generator will be built up for each experiment. A trigger generator for a bubble chamber to be used with positron beams will have a normal trigger channel gated by the positron beam pattern which can be used to give the experimenter timing signals up to 25 μsec in advance of the positron beam. A special channel using the same pattern can give pre-trigger signals up to 1/360 sec. in advance of the positron beam. Earlier pre-triggers such as are required for bubble chamber expansion will be provided in an additional trigger channel using a separate pattern signal generated by the pattern generator in Central Control.

III TARGET INTERLOCK

To protect against discrepancies between anticipated and actual target positions, an interlock signal from the positron target is required. This signal will shut off the gun (in the same manner as does the pulse-magnet permissive interlock) whenever the target is in a position to intercept the beam but is not in the proper position for producing positrons. The gun should also be inhibited if the target is in position unless a positron pulse has actually been programmed. This signal will also be sent to Central Control and will provide sufficient information for the operator to adjust the delays appropriately.

IV PATTERN PROGRAMMING

A. WHEEL TARGET

Operation with the wheel target poses no pattern programming difficulties. Only positron beams will be programmed, electron beams will be shut off. If an electron beam is by accident programmed, the gun will be inhibited by the target interlock. Pre-trigger requirements will differ little from those for any other experiment.

B. WAND TARGET

Most of the special triggering requirements for the Intermittent Positron source (wand target) can be handled at the pattern generator in Central Control. It is contemplated that the pattern generator will provide a start signal to the bubble chamber and a start signal to the target actuator at independently variable times; it will blank out all electron pulses when the target is expected to intercept the beam and it will provide a single positron pulse when it is expected that the target is in position. This entire program may be initiated on demand by the experimenter or automatically at regular intervals from, say, 2/sec to 1/day.

The required signals will be generated by a set of pre-set counters of the type described in the Pattern Generator Design Criteria Report, ED-106-146-RO, January 22, 1965, K. B. Mallory. Briefly, these counters consist of plug-in control units and decade cards. The counters are normally driven by the 360 pps clock signal but may be driven by any other signal if desired. The counters count until they reach the number pre-set on the decade cards and then are immediately reset to zero. The counter may be instructed to start counting again immediately or to wait for an external start signal.

The counter has two output signals. The "counting" output exists for N intervals between clock pulses where N is the number set on the counter. The "end-of-count" output exists during the last of these intervals.

An experiment to run at two pulse per second and requiring a 35 millisecond pre-trigger for the wand target and requiring a 20 millisecond pre-trigger for bubble chamber experimentation might be programmed with the counters shown in Figure 1.

Figure 2 shows typical waveforms that might exist in the counters. Counter A counts the 360 pps clock (Fig. 2a). When it reaches 180, it initiates the positron pulse cycle, by starting counters B, C, D and F, (Fig. 2b). It resets itself and starts counting off the next 180 clock pulses, (Fig. 2c).

Counter F determines the total delay between the initiation of the cycle and the actual positron beam pulse, (Fig. 2d).

Counter B controls the delay between the initiation of the cycle and the bubble chamber pre-trigger. The difference between the delay in F and the delay in B is the actual pre-trigger interval which may be adjusted by changing the number pre-set in Counter B, (Fig. 2e).

Counter C provides a similar, independent adjustment of the pre-trigger interval for the drive mechanism of the wand target, (Fig. 2f).

Counter D and E are a luxury, which requests a "null" beam (no Injector, no acceleration). This inhibits all electron beams during the time the wand target is moving across the beam aperture. They thus provide a back-up for the target interlock circuit and also insure that target equipment for electron beams is not triggered on pulses for which it is known that the gun will be inhibited. The request for a "null" beam is in turn overriden by the positron beam request from Counter F.

Counter D is adjusted to start inhibiting beam pulses as soon as the target begins to intercept the beam (Fig. 2g) and Counter E continues this inhibition until the target is again clear, (Fig. 2h).

Figure 3 shows a proposed display which will allow the operator to make proper adjustments of the delays.

The scope display is triggered by the cycle start. Normal 360 clock pulses are indicated by small positive spikes, pulses on which the electron beams are inhibited are shown by small negative spikes and the positron pulse is represented by a larger positive spike. The target interlock signal from the wand is represented as a pedestal with a notch when the target is approximately in the correct position. The target drive delay (Counter C) is adjusted until the positron pulse is centered in the notch. The "null" beam request (Counters D and E) is adjusted so that only negative spikes show on the pedestal.

Changes of the bubble chamber pre-trigger interval would be made in steps of 1/360 sec. at the pattern generator by the operator. Finer adjustments will be made by the experimenter.

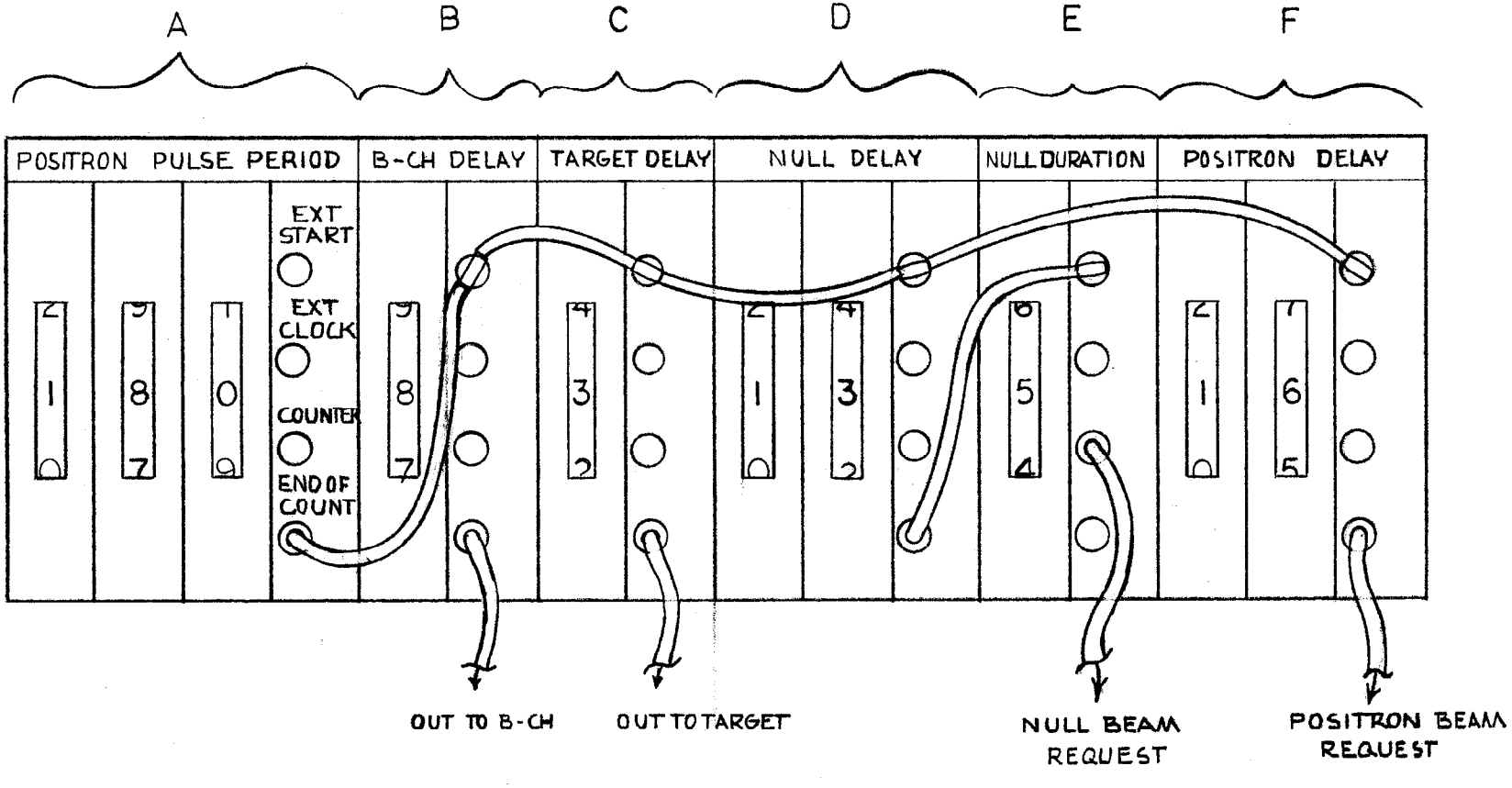

FIG. 1

SETUP FOR POSITRON PROGRAM

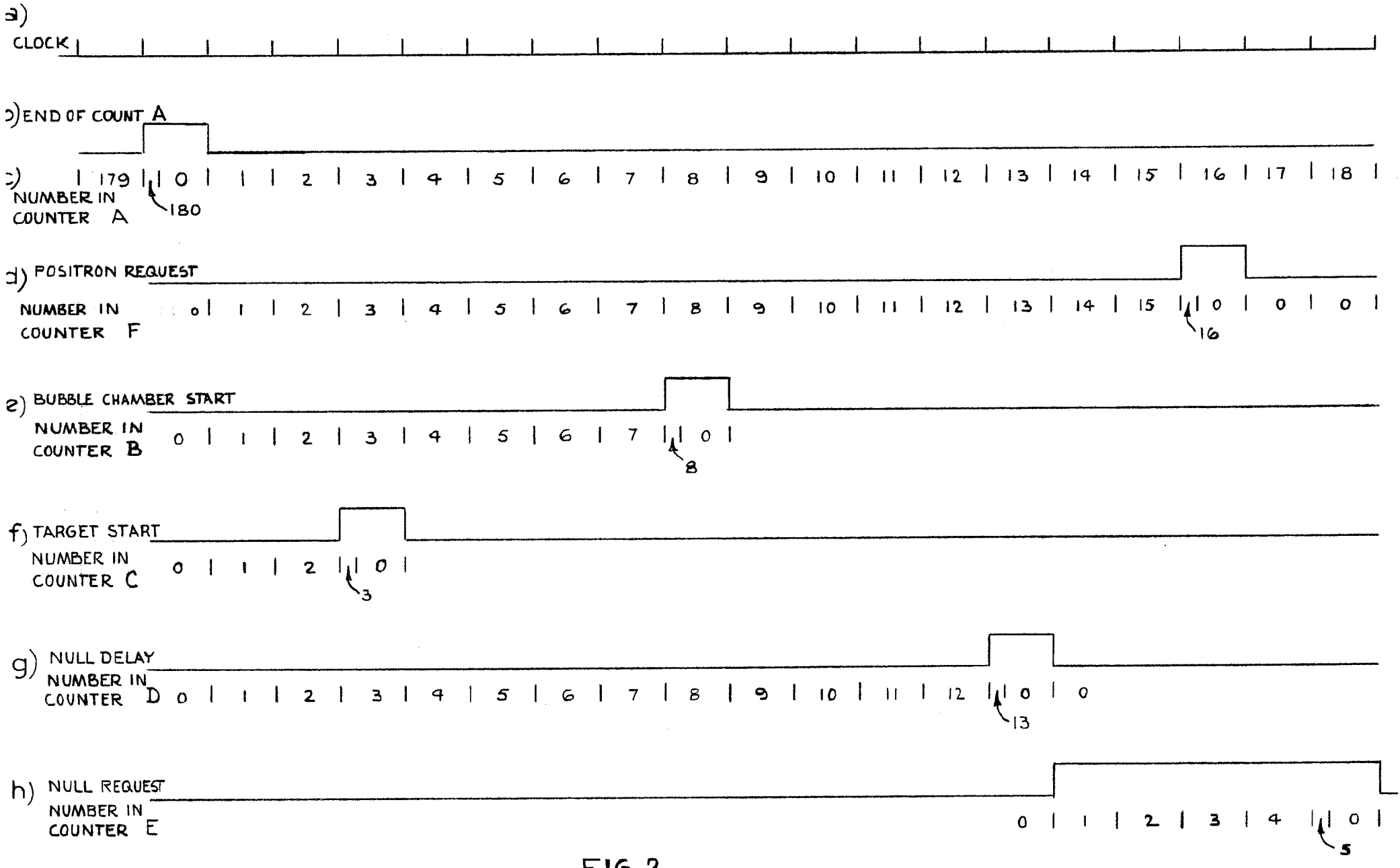

FIG. 2

WAVEFORMS IN COUNTERS

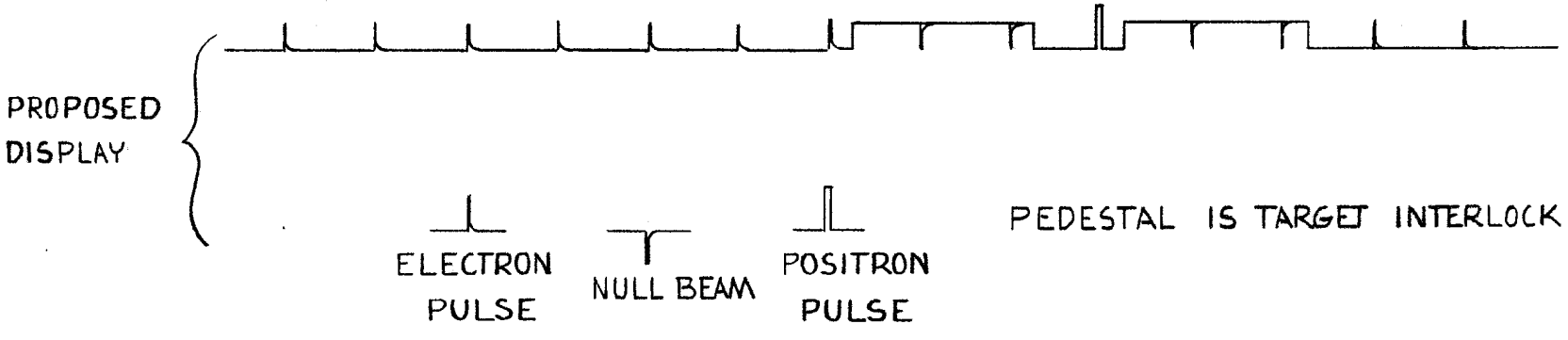

FIG. 3

CCR DISPLAY