INSTRUCTION BOOK

HVI-603

NANOSECOND PULSER FOR THE MODEL TANDEM VAN DE GRAAFF ACCELERATOR

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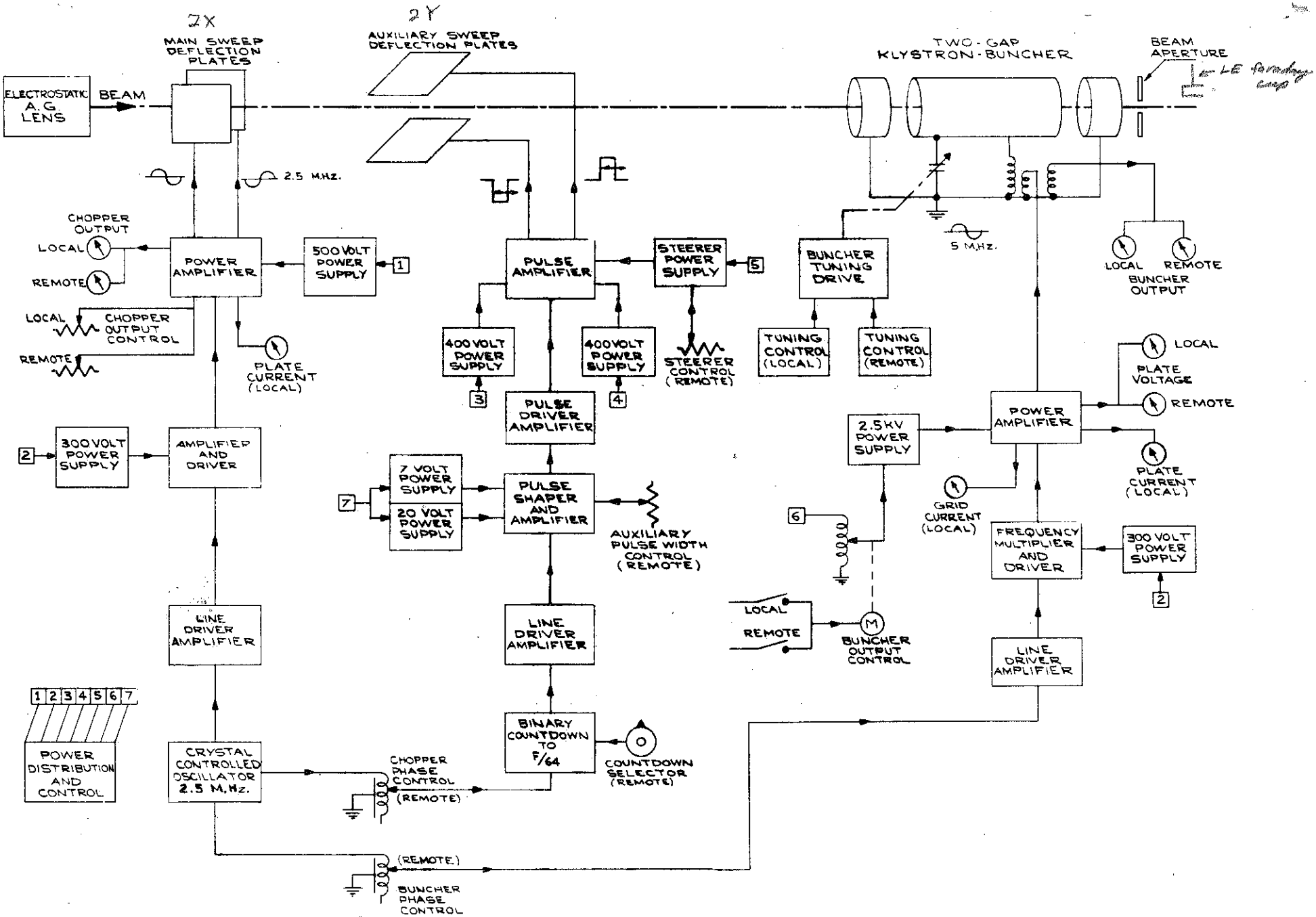

Klystron Buncher One Line Diagram (C-21967)

1. GENERAL

The nanosecond pulser for the Model Tandem Van de Graaff accelerators is designed to provide nanosecond pulses of short duration ($\leq$ 1 nanosecond) when used in conjunction with a diode source or an off-axis duoplasmatron source.

2. BASIC THEORY OF OPERATION

a. Deflection System

A continuous negative ion beam from the ion injector is swept across an aperture located at the accelerator object by a beam deflection system, located between the source and the aperture. The main deflection system is driven by a sinusoidal voltage and provides a basic chopped pulse width.

The auxiliary deflection system, synchronized with the main deflection system and operating in quadrature, provides retrace elimination such that only one burst per cycle of the main sweeping voltage is transmitted. A binary countdown system (Frequency-Selector) provides selection of pulse repetition rates with countdown factors of 1, 1/2, 1/4, 1/8, 1/16, 1/32 times the basic frequency.

b. Klystron Buncher

The Klystron Buncher, located between the deflection system and the low energy end of the Tandem accelerator, bunches the basic pulses to obtain pulses of less than one nanosecond duration at the high energy target.

The Klystron Buncher energy modulates the basic pulse in such a way that the leading edge of the pulse is slowed down, the middle of the pulse is not affected, and the trailing edge of the pulse is sped up so that all particles within the pulse arrive at the target at almost the same time. (See Figure 1.)

3. SYSTEMS COMPONENTS (See C-21967 - Klystron Buncher One-Line Diagram)

The Nanosecond Pulser is divided by function into five subsystems:

a. Frequency Selector System

b. Main Deflection System

c. Auxiliary Deflection System

d. Klystron Buncher System

e. Power Distribution and Control System

Each system is described in the following paragraphs and in the Maintenance Section.

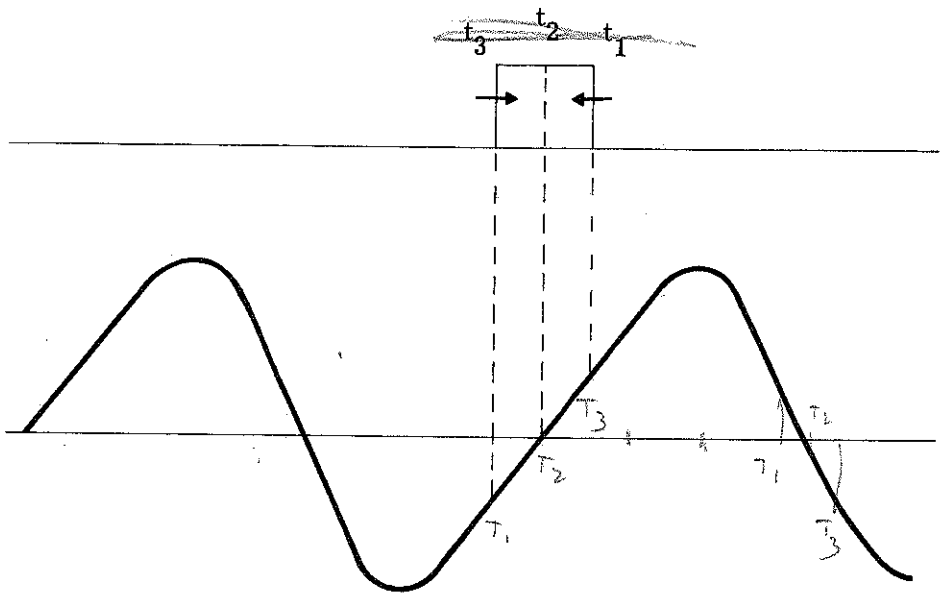

Figure 1. Buncher Voltage versus Pulse Relationship.

t_1 = Time for leading edge of pulse to pass through buncher gap. (Results in a velocity decrease to these particles.)

t_2 = Time for mid-portion of pulse to pass through buncher gap. (Results in zero velocity change to these particles.)

t_3 = Time for trailing edge of pulse to pass through buncher gap. (Results in a velocity increase to these particles.)

a. Frequency Selector System

The frequency selector is a solid state pulse generator with separate outputs for the deflection systems, the klystron buncher system and the post-acceleration chopper system (when used). Output pulses have an amplitude of -5 volts and a duration of approximately 100 nanoseconds. The pulses for the main deflection system, klystron buncher system and post-accelerator chopper system are fixed frequency pulses.

The pulses for the auxiliary deflection system are provided by a binary countdown with a countdown factor of 1, 1/2, 1/4, 1/8, 1/16, 1/32 times the basic frequency.

The timing of the pulses for the auxiliary deflection syste, the klystron buncher system and the post-acceleration chopper system can be varied by means of variable delay lines for proper time phasing with respect to the main deflection system.

b. Main Deflection System

The main deflection system consists of an R.F. amplifier stage, triggered and synchronized by pulses from the frequency selector, and an R.F. power amplifier,

the output of which is controlled by the "chopper output" control (local or remote). Two output voltages, phase shifted 180 ° with respect to each other are applied to two main sweep deflection plates. The relative output voltage on the deflection plates is indicated by a meter. In cases where D.C. steering is used, the R.F. deflection voltage is superimposed on the D.C. steering voltage.

c. Auxiliary Deflection System

The auxiliary deflection system is a unique fully transistorized high voltage chopper. A pulse-shaper circuit triggered by a pulse from the frequency selector countdown (1, 1/2, 1/4, 1/8, 1/16, 1/32 times the basic frequency), produces two pulses of fixed duration (see Figure 2). The time between these pulses can be varied by the auxiliary pulse width control.

The output pulses of the pulse shaper circuit are amplified by two-pulse driver amplifiers, each driving two sets of series-connected pulse transformers.

The output of the pulse transformers drives a high voltage chopper circuit (pulse amplifier) in such a way that the deflection plates which are normally maintained at a +400 volts and -400 volt potential, respectively, are discharged during the "ON" pulse, held at almost ground potential for a period determined by the setting of the auxiliary width control and charged up again during the "OFF" pulse. During the time the deflection voltage is zero, these deflection plates allow the main sweeping voltage to sweep the beam across the beam aperture. When the plates are charged to +400 volts and -400 volts (total deflection voltage, 800 volts), the beam is kept off the aperture hole and no pulses are produced.

In cases where D.C. steering is used, the pulses are superimposed on the D.C. steering voltage.

d. Klystron Buncher System

The klystron buncher system consists of an R.F. multiplier and/or amplifier stage-triggered and synchronized by pulses from the frequency selector.

The sinusoidal output voltage of this first stage is amplified by a driver-amplifier, the output of which can be set to the required driving level of the power-amplifier (grid-current). The output of the power amplifier is coupled into the tuned buncher circuit via a 50 ohm R.F. power cable and impedance matching network. Plate voltage and plate currents are indicated by meters as is the R.F. power level in the tuned circuit.

The voltage across the buncher tube will be proportional to the power input as the buncher tube is part of the total capacity of the tuned circuit. Variation of the power output of the amplifier is accomplished by a motor driven variable transformer controlling the plate and screen grid voltage of the power amplifier and tuning of the tuned buncher circuit is obtained by a selsyn driven variable capacitor. Both controls are local and remote as are the meters indicating voltage and power levels.

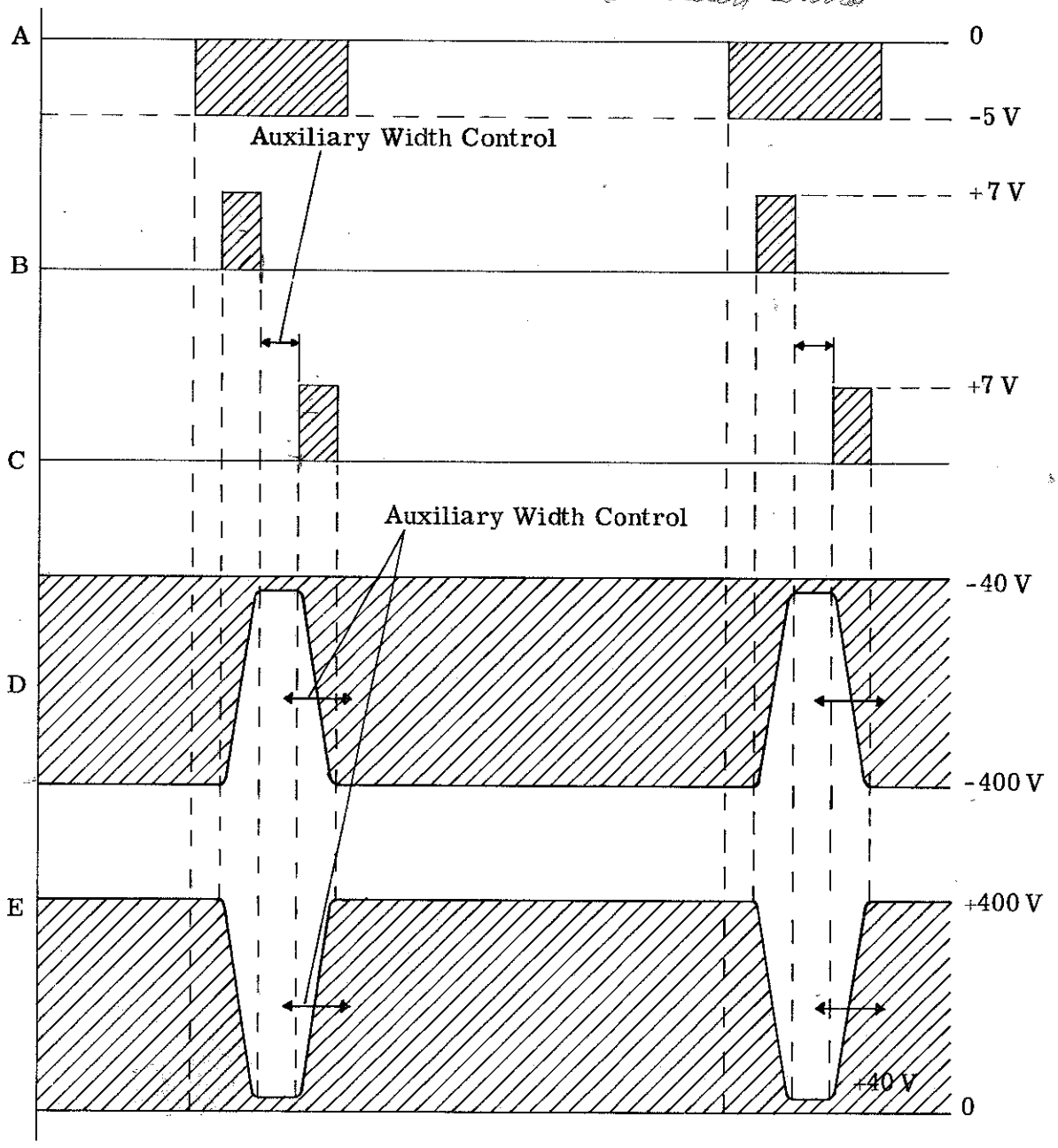

Figure 2. Pulse Relationship of the Auxiliary Deflection System

A = Trigger pulse from frequency selector.
B = "ON" pulse to pulse driver amplifier.
C = "OFF" pulse to pulse driver amplifier.
D = Positive output pulse on deflection plate.
E = Negative output pulse on deflection plate.