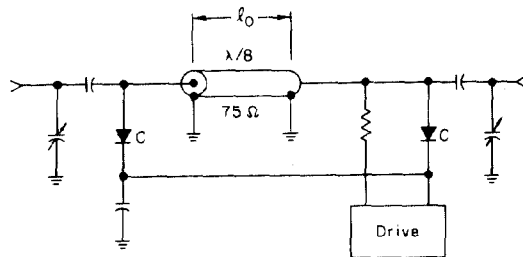


BASIC PHASE SHIFTER



VARICAP PHASE SHIFTER

Fig. 2. Phase Shifter.

Fig. 2 shows the Varicap version of this phase shifter design. Varicap diodes have a nonlinear capacity vs back voltage characteristic. To provide a linear phase vs input voltage function, a power series expansion linearizer as shown in Fig. 3 was designed to match the diode characteristic. The linearizer makes use of two analog multipliers to generate the function:

$$V_o = a + b V_i - c V_i^2 + d V_i^3$$

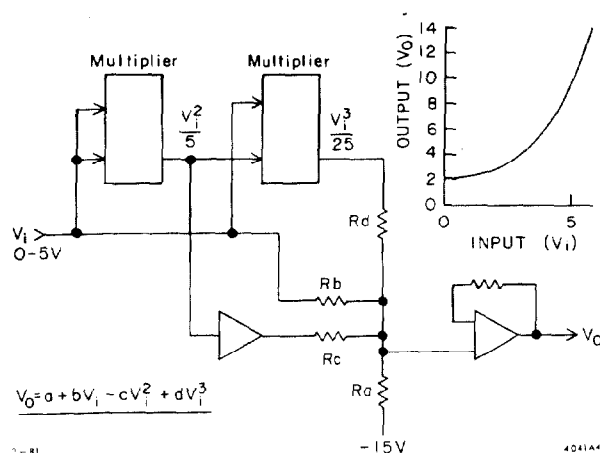


Fig. 3. Linearizer.

The phase shift as a function of Varicap reverse voltage is first experimentally plotted. Then, using a computer fitting routine, the values of a , b , c , and d are computed to provide the inverse characteristic necessary to linearize the phase shifter. For most fits, the value of the square term is negative, hence, an inverting amplifier is used in the linearizer design. V_i is driven from a DAC which allows direct computer control of the phase shifters. We have built these phase shifters with coax cable at 59.5 MHz, and with stripline techniques at 476 MHz.

The rf generation system shown has been developed to accommodate EL CID injector tests. When the collider with its damping ring come on-line, a new rf system based on the damping ring revolution frequency (8.5 MHz) will be necessary. The new countdown chain will produce 59.5 MHz for the laser gun, 8.5 MHz and 17 MHz for synchronized trigger generation, 119 MHz and/or 238 MHz

for new subharmonic bunchers, and 714 MHz for the damping ring rf drive.

Trigger Generation

The concept of the collider involves generating positrons and electrons in the linac, storing and cooling them in a pair of rings for one and two accelerator cycles respectively, and then accelerating both electron and positron bunches down the linac to the collider ring. These operations require precision timing within each accelerator pulse cycle, and because of the damping rings, precision timing from pulse-to-pulse. The accelerator PRF is normally locked to the sixth harmonic of the power line to minimize the effects of power supply ripple and other power line fields interacting with the beam. We want to preserve this feature in the collider system, but we must also provide the damping ring with rf locked triggers needed for injection and ejection of electrons and positrons into and out of the linac. Fig. 4 shows a block diagram of the proposed master trigger generator for the collider. The revolution frequency for the damping ring is 8.5 MHz and a half-period corresponds to the period of 17 MHz. Since there are two bunches of electrons or positrons in each ring, and they are loaded and ejected on alternate accelerator cycles, the accelerator PRF must be counted from the ring half-period. To keep the ac line lock under these conditions, 360 pulses are counted from the 17 MHz clock, and then the cycle counter transfers the retrigger to a 100 μsec default counter. During the default count, the line-lock sync module looks at the ac line locked 360 Hz phase-locked oscillator signal and sends a retrigger pulse to the PRF counter at the 17 MHz transition immediately following the 360 Hz zero crossing. If no zero crossing occurs in the 100 μsec gate, the default counter triggers the PRF counter. Since a default triggered PRF is at a rate slightly below 360 Hz, the system will precess into line-lock after several default retrigger cycles. The detailed design of the master trigger generator is still in progress.

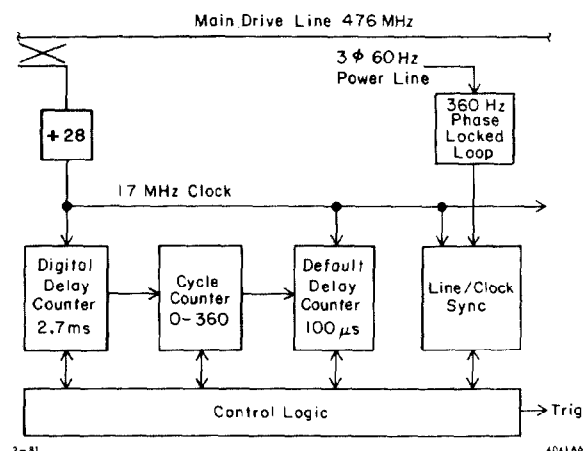


Fig. 4. Trigger Generator.

Thermionic Gun Development

The primary gun for the collider system is a laser-driven photocathode device that has the capability of high-peak current, short pulses, and possibly polarized electron output. The vacuum requirements to make this type of a gun work reliably are severe, and early in the collider injector planning, it was decided to develop a thermionic cathode gun of equivalent peak current output to act as a backup for the laser gun. This development is now well along; we have our first high-current

cathode-grid assemblies from EIMAC in-house,³ and fabrication of the rest of the gun is almost complete. Fig. 6 shows a cross section of the high-current gun.

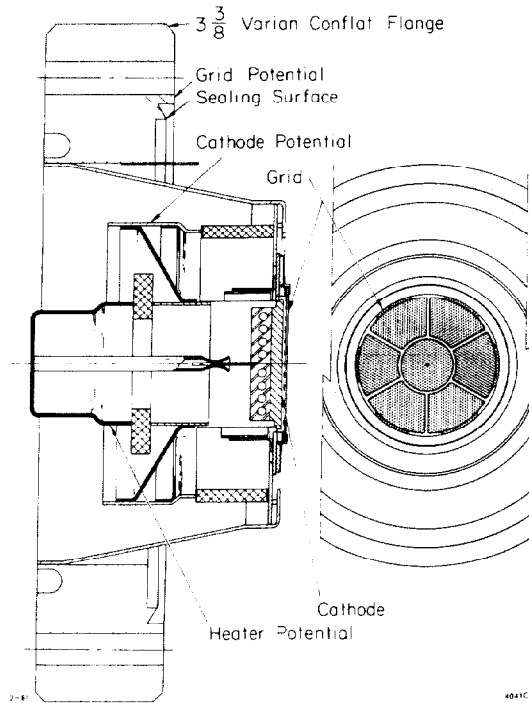


Fig. 5. Thermionic Gun Cathode-Grid.

Fig. 5 is a detail of the cathode-grid assembly supplied to us by EIMAC. This structure can produce up to 20 amps peak current with a +200 volt drive pulse. Cutoff on the cathode requires less than -100 volts on the grid. EIMAC achieves this high transconductance by using a planar mesh grid under tension placed only 150 μm from the planar cathode. Beam optics for this gun are shown

in Fig. 7 for 17 amps at 200 kV. Since the cathode is flat, and a large beam is desirable to minimize the space charge force in the bunching process, we attempted to design a nonconvergent gun. However, it was necessary to make the beam slightly convergent to counteract the divergent lens effect of the anode aperture. The calculated emittance is $3.0 \times 10^{-3} \pi \text{ m}_0\text{c-cm}$. We expect to have this gun and an appropriate pulser system operating by the end of May 1981.

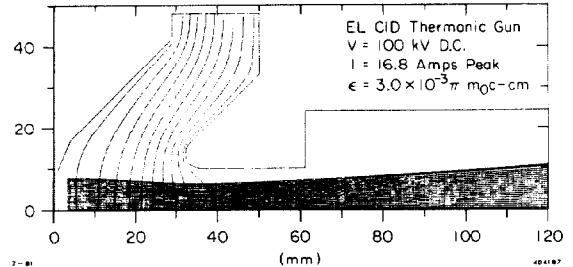


Fig. 7. Beam Optics.

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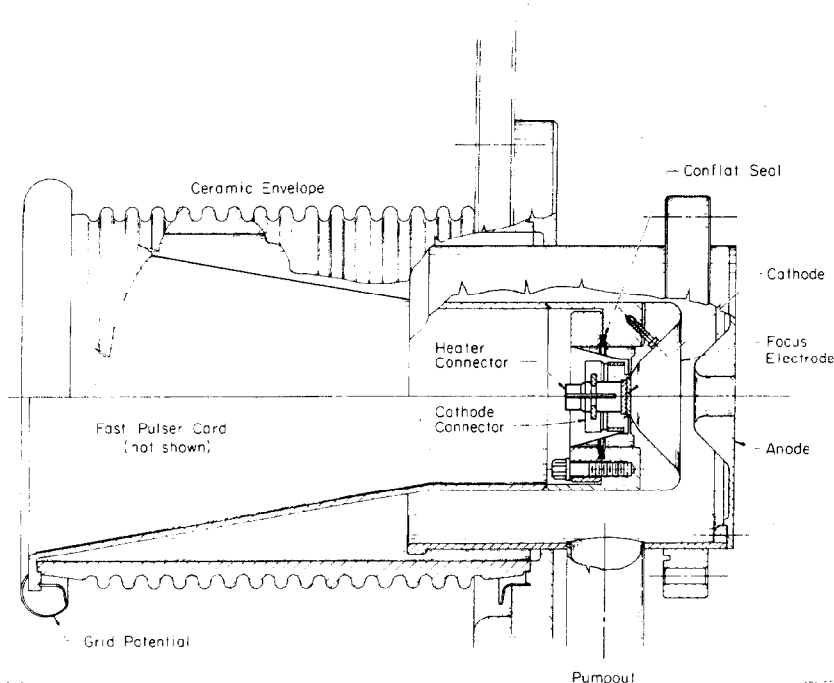


Fig. 6. Thermionic Gun Assembly