triggering of these circuits by the calibration step signal must be prevented.

Two 1809 OR gates, G8 and G9, placed just after the comparators, are used for blocking signals during the calibration step interval. These gates are disabled during the calibration interval by a signal from MV2 causing both comparator output signals to be blocked. Due to mechanical delay on pull-in and drop-out inherent in the relay, the calibration voltage step generated by the charge amplifier is not in exact time register with the control signal coming from MV2. Therefore, the turn off of MV2's control signal sent to gates G8 and G9 is extended in time beyond the signal turning off the relay so that the calibration voltage signal is removed before the OR gates are unblocked. Two 834 INVERTERS and a 2.3 μF capacitor form the pulse stretcher circuit. All of the above is illustrated in the traces shown in Figure 5.

Gated Oscillator

Two 832 NAND gates cross-coupled with 2000 pF capacitors form a free running multivibrator used for the gated oscillator. When any of the input pins 1, 2, and 4 are at logic LOW, the circuit will not oscillate and the output on pin 8 is at logic LOW. Pin 2 is used to disable the oscillator during standby using the logic state on gate G2. Pin 1 uses the signals from gate G6 to turn on the oscillator at the appropriate times. The signal from the PTB to pin 4 disables the oscillator at the end of the first pressure pulse in a sequence yet to be described.

If all of the input pins 1, 2, and 4 are HIGH, the circuit will oscillate at about 82 kHz with an approximately squarewave output. During a compressor firing, the oscillator is turned on three times as shown in Figure 5 by either MV1 or the Low Level Comparator.

Calibration Step Circuit

A mercury-wetted relay is used to apply the reference voltage signal to the calibration input terminal on the Charge Amplifier. Reference voltage level is adjusted using a 10-turn potentiometer and is passed through a voltage follower amplifier to prevent loading by the Charge Amplifier circuit.

The test switch tied to the collector of the 2N1613 transistor may be used to apply a static calibration signal to the oscilloscopes while making adjustments in the display. Generating a calibration signal in this way, or by using the test switch on the Charge Amplifier itself, will trigger both voltage comparators. During standby, signals from the comparators will pass through OR gates G8 and G9 but gate G10 and the 850 PTB are disabled by the logic state on G2 thereby preventing any unwanted operation of the oscillator or firing circuits.

Note that the output of the LL Comp goes directly to gate G6. During the calibration step interval, the output from the LL Comp passes through G6 to turn on the gated oscillator as seen in Figure 5. This action provides oscilloscope triggering for displaying the calibration step when the oscilloscopes are operated in the multiple sweep mode.

Voltage Comparator Circuits

Two Analog Devices Model AD351 voltage comparator integrated circuits are used. These comparators have an output that can be operated at a level compatible with the logic circuits used. The function of the LL Comp is to turn on the oscillator in response to the calibration and pressure signals from the Charge Amplifier. Triggering the spectrograph shutter and flashlamp high voltage firing circuits in response to the first pressure pulse is the function of the HL Comp.

When the pressure signal voltage on pin 2 of the LL Comp rises above the reference level on pin 13, the output on pin 10 changes state from HIGH to LOW. This corresponds to the time t_1 in Figure 4. For the best oscilloscope display, the reference voltage is set to about 0.10 V. The signal from the comparator turns on the oscillator and is passed through OR gate G8, is inverted and applied to the PTB on pin 6.

When the pressure signal falls below the reference voltage level, the LL Comp reverts to its initial logic state turning off the oscillator. At the same time, the turn-off level transition as applied to the PTB on pin 6, will trigger that circuit. Once triggered, the PTB will change output logic states and remain that way until reset at a later time by the signal to pin 13. Pin 3's output change from HIGH to LOW disables the gated oscillator and OR gate G10 via gate G7. Thus, triggering the PTB at the end of the first pressure pulse disables the oscillator to prevent further oscilloscope triggering. Disabling gate G10 prevents any possibility of retriggering the shutter or flashlamp circuits during subsequent pressure pulses. These results are also illustrated in Figure 5.

As explained earlier, the HL Comp operates on the pressure signal voltage to initiate spectrograph shutter and flashlamp firing at the desired time. Reference voltage for this comparator is obtained from a set of four thumbwheel switches acting as a Kelvin-Varley voltage divider on a stable 10 V source. A range of 0 to 9.999 V is covered with 1 mV resolution.

When the comparator changes output logic states, the signal is passed through OR gates G9 and G10 to gates G11 and G12. Gate G12 immediately changes state with its output going HIGH for a positive pulse to serve as a trigger signal for the spectrograph shutter high voltage firing circuit. This is shown as line E in Figure 4.