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JULY 16th NUCLEAR EXPLOSION: FAST ELECTRONIC TIMING SEQUENCE

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VERIFIED UNCLASSIFIED
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Abstract

The present report discusses the design and performance of the electronic equipment which was used at Trinity on July 10th to provide time signals during the last 100 milliseconds to an accuracy of ±1/2 ms, to fire the gadget and to provide certain signals related to the firing signal with an accuracy better than 0.1 microseconds.
Problem

In order to coordinate the functions of the cameras, spectroscopes, electronic measuring gear, etc., set up in the countryside around the test bomb at Trinity, a master timing system was required. Since observers were not allowed to be nearer to the gadget than the 6-mile shelters S10\(^4\), W10\(^4\) and N10\(^4\) (Fig.1), remote control of most field equipment was necessary and timing signals between the 3 main shelters were essential.

The functions required of a master timing system fall into 3 main categories:

1) Switching required in the period up to 60 seconds before the event. For example, turning on heaters of electronic equipment in the field, etc.

Such functions can be carried out satisfactorily by manual switching at the control station.

2) Switching required in the last 60 seconds which does not require time accuracy better than ± 50 milliseconds. Examples are application of B\(^+\) to field equipment, camera shutter excitation, etc.

Such switching can be readily achieved mechanically by means of a rotating drum system.

3) Operations required in the last 100 milliseconds with accuracies of ± 1/2 milliseconds or better. The equipment requiring such service will be described fully later and the present report discusses the design and performance of the electronic circuits built to meet the requirements.
The equipment for 1 and 2 above was designed and built by E. Marlowe and J. L. McKibben and is described elsewhere. The equipment under 3 is the subject of this report.

Electronic Method Used for Timing in the Interval \((t_0 = 0.1)\) sec to \(t_0\)

The block diagram of Fig. 2 indicates the elements of the method.

A long sawtooth, initiated by a relay closure at \((t_0 = .1)\) sec from McKibben's Drum System, rising linearly to 200 volts in 100 milliseconds, together with a second sawtooth of five times the slope started at \((t_0 = 20)\) m secs and rising linearly to 200 volts by \(t_0\) are the essentials.

A system of discriminators arranged to fire at preselected points on either the fast or slow sawtooth then allow pulses to be generated at any time within the given 100 m sec interval. The signals derived from the discriminator pulses were shaped and could be made to put either positive or negative signals onto the lines by means of the Mixer Line Driver.

A code of positive and negative signals could thus be transmitted over the lines to M10,000 or W10,000. The band-pass characteristics of these lines in order to give rise times at the receiving end of 1/2 ms or so will be seen to be about 2-3 KC. Standard Army-Navy twisted pair telephone line fulfilled the requirement and was used to convey the signals a little over 12 miles to M10,000 (a big loop around the gadget was necessary) and some 3 miles to W10,000 (Fig. 1).

The local \(t_0\) signal required accurately for equipment in the S10,000 shelter was tied in with the firing pulse to better than ±1/2 microseconds.

To carry the fast firing signal from S10,000 to the gadget a line of much greater band-pass was essential and 5 miles of RG54AU coaxial cable were laid.
Even then experiment showed that the rise time at the recording end was greater than 5 microseconds and to eliminate difficulties from the slow wave front, this pulse was sharpened at the gadget and the high-accuracy timing required for the Wilson and Rossi experiments was made with respect to this exceedingly steep wave-front.

Measurement of Time Intervals

In order to calibrate the saw-tooth generators and the over-all equipment a time measuring system was required. A scale of 2\(^10\) (1024) was provided for this purpose. Normally it was set up to "count" the cycles of a 16KC sine wave derived from a Hewlett-Packard RC oscillator type 200C. This oscillator was found to be very stable after a warm-up period but was adjusted to the exact frequency whenever necessary by scaling the 16KC down to 2KC and using this 2KC wave to form a Lissajous figure with a standard 1KC frequency from an electrically maintained tuning fork. A stationary pattern on the CRO indicated exact tuning to 16KC.

In order to measure time intervals the scaler unit was converted to a Counter Chronograph by the addition of a "gate" circuit. That is, the 16KC sine wave was applied to the scaler through an electronic circuit which, normally, prevented its passage. However, on receipt of a positive signal (the beginning of the interval to be timed) the circuit is "opened" and the scaler commences to count the cycles of the 16KC sine wave.

A second signal applied to the circuit, at the end of the interval to be timed, "closes" the gate and prevents the sine wave from reaching the scaler. The scaler, therefore, counts the number of cycles bracketed by the two signals and hence provides a measurement of the interval between them to 1 cycle or 1/16 millisecond.
Thus measurements of all signals including the \((t_0 - 0.1)\) sec with respect to the \(t_0\) signal could be accomplished.

**Statement of Requirements**

a) Slow timing, i.e., accuracy \(+1/2\) milliseconds

May 6th requirements 100-ton test

<table>
<thead>
<tr>
<th>Place</th>
<th>Instrument</th>
<th>Time and Tolerance Milliseconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (10^4)</td>
<td>B L Spectroscope</td>
<td>(-37 \pm 1)</td>
</tr>
<tr>
<td>W (10^4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N (10^5)</td>
<td>Hilger Spectroscope</td>
<td>(-16.5 \pm 1)</td>
</tr>
<tr>
<td>W (10^5)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**HOUGHTON + COON**

Time Required

<table>
<thead>
<tr>
<th>Place</th>
<th>Instrument</th>
<th>(t_0 \pm 1) millisecond</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (10^4)</td>
<td>Geophone Recorders</td>
<td></td>
</tr>
<tr>
<td>S (10^4)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**WALKER**

<table>
<thead>
<tr>
<th>Place</th>
<th>Instrument</th>
<th>(t_0 \pm 1) millisecond</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (10^5)</td>
<td>Piezo gauges</td>
<td></td>
</tr>
<tr>
<td>S (10^5)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**BARSCHALL**

<table>
<thead>
<tr>
<th>Place</th>
<th>Instrument</th>
<th>(t_0 \pm 1) millisecond</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (10^7)</td>
<td>Sound Velocity Measurement</td>
<td></td>
</tr>
<tr>
<td>S (10^7)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
These requirements reduce essentially to 3 signals

- 97 + 1 milliseconds
- 16.8 + 1 milliseconds
- to + 1 milliseconds

and for the 100-ton test were coded onto the lines as indicated in Fig.

For the July 16th test Mack's requested requirements changed to:

<table>
<thead>
<tr>
<th>Place</th>
<th>Instrument</th>
<th>Milliseconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>N 10°</td>
<td>B + L Spectroscope</td>
<td>to + 1</td>
</tr>
<tr>
<td>N 10°</td>
<td>Hilger Spectroscope</td>
<td>- 16.8 + 1/2</td>
</tr>
<tr>
<td>W 800</td>
<td>Marley Camera</td>
<td>- 40 + 1</td>
</tr>
<tr>
<td>W 10°</td>
<td>Photocell Drum Camera</td>
<td>- 40 ± 5</td>
</tr>
</tbody>
</table>

A coding as indicated in Fig. was therefore chosen and the receiving end equipment designed to decode this pulse series.

Before the final experiments these requirements were amended. The Marley Camera Expt. was abandoned and the B + L Spectroscope was moved forward as:

<table>
<thead>
<tr>
<th>Place</th>
<th>Instrument</th>
<th>Milliseconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>N 10°</td>
<td>B + L Spectroscope</td>
<td>- 40 + 1</td>
</tr>
<tr>
<td>N 10°</td>
<td>Photocell Drum Camera</td>
<td></td>
</tr>
<tr>
<td>N 10°</td>
<td>Hilger Spectroscope</td>
<td>- 16.8 + 1</td>
</tr>
</tbody>
</table>
Thus the same coding could be used but another decoding system was required.

6) Fast Timing, i.e. Accuracy ± 0.1 microsecond

For the Wilson-Rossi Experiments a pulse rising 300 volts in less than 0.1 microsecond and exactly related in time with respect to the firing pulse supplied to the gadget to ± 0.1 microsecond was required. Such a pulse was derived from the pulse sharpening circuit at the tower and was supplied over 1000 yds. of RG9U coaxial cable from the tower to the N 1000 revetment. This cable was correctly matched at the receiving end so that its input impedance was purely resistive and provided a suitable load for the pulse sharpening circuit.

SENDING END EQUIPMENT

1. Sawtooth Generators and Discriminators, Fig. 4, Dwg. 724.

A relay closure effected by the Rotating Drum system at (t₀ - 0.1) sec applied a.m.f. to the relay coil energizing S₁ and S₂.

Closure of S₁ throws the 8 µF condenser charged to 150V in series with the 4 µF condenser in the grid circuit of V₁. A transient pulse of -100V is applied to the grid of V₁ cutting off this tube. The transient condition finally gives way to the steady state value of grid voltage of -75V determined by resistors. As soon as V₁ ceases to conduct its plate potential, which had been caught at +10 volts by the diode V₁₅, leaps to a value equal to the product of the current in V₁ before cut off and the 25K resistor in the C.R. coupling to ground — i.e. a voltage step of 10 volts.

Thereafter the plate voltage of V₁ rises linearly through the standard "boot strap" feedback circuit including V₃ and V₆.
The slope of the linear sawtooth appearing at the cathode of V_3 can be varied by adjusting the variable 70K in the plate of V_1. The sawtooth at the cathode of V_3 is applied directly to the grid of V_4 which in conjunction with V_5 comprises an a.c. coupled discriminator circuit.

The grid potential of V_5 can be varied between some 10 — 160 volts by means of a linear wire around G.R. 100 K potentiometer. Suppose it is set at + 100v, then V_5 will be conducting and its cathode will be at some 105v (say).

Since the grid of V_4 is connected to the cathode of V_3 which in the static condition is at about 20V ground it follows that V_4 is cut off. When the sawtooth rises the grid of V_4 begins to carry current thereby applying a negative pulse to the grid of V_5. Cathode regeneration then provides a rapid change over of current from V_5 to V_4. The sawtooth is not distorted because the cathode of V_4 continues to follow up and grid current is not drawn. The positive voltage rise at the plate of V_5 is used as the output signal. The amplitude of this wave decreases the higher the grid voltage of V_5 but the circuit constants are chosen for its minimum value to be sufficient.

A constant output pulse can be obtained from this circuit by replacing the 150K cathode load by a constant current device — pentode or saturated diode but this was not deemed worth the extra complication.

The time at which the pulse is generated at the plate of V_6 is related to the closure of S1 according to the position of the G.R. pot and a 0-100 scale on this spot can be calibrated to read milliseconds directly by adjusting the SLOPE (70K plate circuit of V_1) and ZERO controls.

V_11, V_12, V_13, and V_14 are exactly similar discriminator circuits.
except that in these cases the slope and zero adjustments are both located on the potentiometer chain.

In practice the discriminator $V_4$ and $V_5$ is used to initiate a second sawtooth 80 milliseconds after the closure of $S_1$. The negative gate at the anode of $V_4$ cuts off $V_7$ which, together with $V_8$ and $V_6$, forms a fast sawtooth generator identical in principle with the slow one. To maintain $V_7$ permanently cut off the A.C. coupling from the plate of $V_4$ is insufficient and the input relay switches $S_2$ from position 1 to 2 which, through the diode $V_{17}$, eventually holds the grid of $V_7$ at -75 v RE ground.

The sawtooth rises 150 volts in some 20 milliseconds and by means of the slope and zero settings the potentiometer of the discriminator $V_9$, $V_{10}$, is calibrated to read 0-20 milliseconds directly.

The positive pulse generated at the anode of $V_{10}$ is used as the $t_0$ signal and occurs exactly 100 m secs after $S_1$ closes.

The second sawtooth was considered necessary to improve the accuracy of timing near to $t_0$ — the steeper sawtooth providing improved firing of circuits driven from it. Normally, the discriminators $V_{11}, V_{12}$ were operated from the slow sawtooth i.e. in the interval $(t_0 - 0.1)$ seconds to $(t_0 - 20)$ milliseconds and $V_{13}, V_{14}$ operated from the fast sawtooth to provide signals in the range $(t_0 - 20)$ ms to $t_0$. Provision is made to switch discriminators $V_{12}$ and $V_{13}$ to either the slow or fast sawtooth channels. The unit thus allows pulses to be generated in the 100 ms period before $t_0$, each pulse being phasable with respect to the $t_0$ pulse.
2. Four Channel Line Driver, Fig. 5, Dwg. 725

Three identical channels of this unit comprised pulse forming circuits, pulse amplifiers, pulse inverters and driver stages capable of mixing positive and negative signals and transmitting them over the twisted pair lines to the remote stations.

Two only of these channels were used, one to send to N10,000 and the other to send information to the N10,000 station. The third channel was a stand-by.

The drawing shows one of these channels. Discriminator pulses put in at sockets 1, 2, or 3 are mixed/\overline{V_1}, \overline{V_2}, \overline{V_3} which are normally cut off. A positive discriminator input pulse drives /\overline{V_1} into grid current, the input time constant determining the pulse duration (in this case about 1.5 milliseconds).

The wave appearing at the anode of /\overline{V_1} is a negative rectangular wave of amplitude 175\text{V} which is used to cut off \overline{V_{10}} providing a positive rectangular pulse of 300 volts amplitude at its anode. This positive pulse is applied to the line at low impedance through the cathode follower \overline{V_8}.

Insertion of the discriminator pulses in sockets 4, 5, 6 provides similar negative pulses at the anodes of \overline{V_4}, \overline{V_5}, and \overline{V_6} which are D.C. coupled to the inverter \overline{V_7} which is operating at $E_g = 0$. The negative pulse appearing at the grid of \overline{V_7} cuts it off completely providing a 200 volt positive pulse at the grid of \overline{V_9} which is driven into grid current and provides a negative pulse of amplitude about 250 volts to the line.
The twisted pair lines were not terminated at the receiving ends in order to take advantage of the voltage gain at the end of a line terminated in a resistance large compared with its characteristic impedance. These lines therefore behaved as capacitative loads on the driver circuits.

At the receiving end, after transmission over 12 miles of twisted pair, the peak amplitude of the pulse was about 110 volts rising in 1/2 ms. with circuits tripping at a 30-volt level and including the undetermined transmission time on the line -- about 150 microseconds -- the tie-in with the sending end was considerable better than 1/2 ms.

The fourth channel of the equipment provided to signals to measuring equipment in the same shelter (§10,000).

The output pulse from the discriminator was fed through a cathode follower $V_{11}$ to fire a 2050 thyatron $V_{12}$. The 250-volt fast positive cathode pulse was supplied to the detonator line driver and also to the pulse stretcher $V_{13}$. The lengthened pulse from $V_{13}$ was supplied to three cathode followers $V_{14}$, 15, 16 in parallel which provided the signal to the various customers over short lengths of twisted pair. Grid current limiting resistors were provided for $V_{13}$ and $V_{14}$.

$V_{17}$ is a pair of cathode followers convenient as buffers for feeding discriminator pulses to various points.

$V_{18}$ and $V_{19}$ are thyatron pulse sharpeners accepting a positive input pulse and providing exceedingly fast 300 v output pulses at the cathodes.

This unit, located at §10,000, accepts the local $t_o$ signal from the line driver unit and delivers a 1600 volt signal to the coaxial firing cable.
firing line. The pulse has a rise time of less than 0.1 microsecond and an exponential tail falling to 1/e in 2 milliseconds. The six miles of unterminated coaxial cable provides a capacitative cathode load but the anode storage condenser is chosen to be large in comparison to this so that practically the full voltage is developed across the line.

The pulse at the receiving end of the RG54AU cable had a peak amplitude of 700 volts and rose to peak in 5 microseconds i.e. is badly distorted by the line. Since this wavefront is too slow it was sharpened at the base of the tower and the resulting steep wave front used as a time datum.

The present 4035 circuit is self-quenching and a neon indicator enables an external check to be made of satisfactory firing and also that the peak output pulse exceeds a certain level. The tube has a peculiar characteristic in that, on firing, the grid initially leaps up to plate potential before taking up a mean potential in the plasma. This, coupled with the elevated cathode potential following on conduction, causes a strong, fast positive pulse to be fed back into the driving circuit which overdrives the local to cathode followers.

4. Counter Chronograph, Fig. 7, Deg. 719

The circuit employs a conventional scale-of-210 circuit embodying the 6SL7 unit. The pulses fed to the scaling circuit are shaped by the discriminator $V_1$ and $V_2$ which is set to "fire" on the positive slope of the positive slope of the positive half cycle of the sine wave. If the grids of $V_3$ are switched to ground a rectangular voltage wave is generated at the plate of $V_2$ every cycle and this wave is fed directly to the scaler unit.
$S_1$ which feeds $S_2$, etc. --- $S_{10}$. $S_{10}$ can be employed to drive $V_6$ which operates a mechanical counter.

A counter is not generally used, however, since interpolation on $N_1, N_2$ --- $N_{10}$ enables all intervals up to 100 ms to be measured directly. With the grids of $V_3$ unclamped from ground (switch open) the static grid voltage of $V_3$ is such that the cathode of $V_3$ elevates the grid of $V_2$ by a few volts.

The negative pulse appearing at the anode of $V_1$ per cycle of the sine wave looks into the low impedance of $V_3$ and is therefore heavily attenuated. The small positive pulse resulting at the anode of $V_2$ is then far below the level required to operate the first scaler $S_1$. The circuit is thus "clamped".

For free running (calibration, etc.) the circuit can be unclamped by closing the switch and maintaining the grids of $V_3$ at ground potential. $V_3$ is thus cut-off and the signal at the grid of $V_2$ is not affected by it.

Electronic unclamping and clamping are affected by means of tube $V_4$ and $V_5$.

A positive signal applied at input 1 causes the anode voltage of $V_4$ (1st half) to fall thereby cutting off $V_3$ and unclamping the discriminator. Meanwhile the fall in plate voltage of $V_4$ (1st half) and $V_5$ (1st half) triggers the univibrator $V_5$ and the plate of $V_4$ (1st half) is held down and hence the circuit is unclamped for a period depending on the a.c. coupling constants of the univibrator. This period is chosen to be 150 milliseconds i.e., greater than any interval to be measured. A.c.
coupling is used as a precaution against the circuit accidentally being tripped into a wrong stable condition.

A second (later) positive signal applied at input 2 reclamps the circuit as follows: - The tubes \( V_4 \) (2nd half) and \( V_5 \) (2nd half) conduct and their plate voltages fall. The univibrator is thus kicked back into its stable state, the plate voltage of \( V_4 \) and \( V_5 \) (1st halves) rise and \( V_3 \) is again brought into conduction to reclamp the discriminator \( V_1 \) and \( V_2 \).

**Receiving-End Equipment**

**General**

A code of positive and negative pulses appears at the receiving end of the lines. Usually a switching action is required on one only of these pulses. The method of approach is therefore to count the pulses of one sign and arrange for circuit operation on the appropriate count.

The completely general circuit would be able, by prearrangement, to initiate on any of the 1st, 2nd, 3rd ---- positive pulses or 1st, 2nd, 3rd ---- negative pulses. This would make the system completely flexible.

The counting can be achieved most readily by means of conventional scale-of-two circuits and an inverter makes positive and negative pulse acceptable. Switching is usually effected by means of a thyatron.

In the present case, since the operations to be performed were fixed and known in advance it was unnecessary to make the circuits completely flexible and thus much time was saved and more compact units achieved.

In what follows, however, the general principles of a flexible scheme are illustrated.
1. Bausch and Lomb Clutch Driver, Fig. 8, Dwgs. 645

The circuit is arranged to apply a.c. power to a relay which
throws in a mechanical clutch at a time related within ± 1/2 ms with t₂.
Closure of the clutch causes the velocity of the film flow through the
spectroscope to be reduced according to a 1/t² law thereby providing correct
exposure throughout the light flash. (See IAMS Report by Julian Mack).

The circuit has two functions according to the position of the
switches S₁ and S₂.

Switch Position 1

The first positive input pulse drives the grid of V₆ positive
through the cathode follower V₁. V₆ fires thereby closing the contacts
of the relay (Advance 204 AM or BM) in its anode circuit. One contact of
this relay completes the clutch power circuit but is insufficient to carry
the steady current. The other contact is therefore used to apply a.c. to
the coil of the Dunco IXBX relay. On closure this takes over the duty
of carrying the current (one pole) and meanwhile the other contact is
used to perpetuate current flow in its coil thereby maintaining it closed.
Meanwhile the 204AM relay opens when V₆ extinguishes.

The circuit is reset i.e. the IXBX relay opened by applying a
short circuit across the "Relay Reset" terminals thereby opening the
normally closed Dunco CRTX or IXBX relay momentarily.
Switch Position 2

In this position the first input positive pulse is cathode followed through $V_1$ inverted by $V_2$ and used to drive a single 6SN7 scaler stage (Fig. 9, pgs. 247). The negative pulse developed at the anode (pin 3) applied through the cathode follower $V_5$ is ineffective in firing $V_6$. However, on receipt of the second positive input pulse the rise of plate potential at pin 3 provides a positive pulse delivered through $V_5$ which fires $V_6$.

Thus the circuit operates on the second positive pulse. Before use the scaler unit has to be "reset" in order that it shall not accept the first positive pulse. This is achieved by allowing the point p8 to rise positively by opening the "reset" switch.

Indication of the unit being in its correct equilibrium position is given when the neon bulb connected from pin 3 to $B^+$ through $M_1$ is extinguished.

The time delay between the receipt of the firing pulse and the closure of the clutch circuit was checked using the counter chronograph and after manipulation of the 204 HM relay was reduced to 1.5 milliseconds.

Reproducibility of this delay was to $\pm 1/16$ millisecond and well within the requirements.

The three circuits (one $10^4$, one $10^5$ and the spare) were trimmed up to be identical and these delays were added in as constants in setting the discriminator circuit.

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2) Hilger Solenoid Operator, Fig. 10, Dwg. 619

This circuit has to reject positive pulses and accept the first negative pulse.

$V_1$ is a diode connected to the grid of $V_2$ which is a straight amplifier. The cathode of $V_1$ is biased to $-12$ volts to prevent the negative "tail" of a positive pulse from feeding through. The amplitude of such tails is kept low by maintaining the input time constant at a value large compared with pulse duration.

Capacity feed through $V_1$ is negligible since the input capacity of $V_2$ is large due to the Miller effect. Receipt of a negative pulse at the input drives the grid of $V_2$ negative, producing a positive pulse at its anode and hence at the grid of $V_3$. When fired, $V_3$ discharges 400 $\mu$F into the solenoid operating the shutter plunger (which is an inductive load in the cathode circuit) thereby providing fast operation. By allowing the plunger to close an electrical circuit the delay and consistency of operation were examined using the counter chronograph and were found to be 1 ms $\pm$ 1/16 ms.

Peak current limiting resistors were included in the plate circuit of $V_3$ which was self quenching.

3) Marley Camera Shutter Release, Fig. 11, Dwg. 641

These circuits are to be located at W800 and N800 had to be powered by batteries since no A.C. was available and therefore had to be remotely controlled by relays. Minimax batteries are used for B+ (applied at -1 min) and storage batteries for cathode heating (applied at -10 min).

The circuit fires on the first positive pulse and is self-explanatory.
4) Galvo Step Tare Timer, Fig. 12, Dwg. 616

In general at N10,000 the whole of the pulse sequence was put onto one recording channel of the Hailand Mechanical Oscillographs and hence all records were related with respect to the firing pulse.

At N10,000 the t₀ signal alone was supplied to all recorders to provide a time fiducial.

In one case at N10,000 a step wave was required on the record in known time relation to the t₀ signal.

The circuit of Dwg. 616 was built to provide this service. The first positive signal arriving at N10,000 fired the 2050 thereby closing the relay in the plate circuit which connected a 1 1/2v. cell in series with resistance across one galvanometer of the Hailand recorder. A step deflection was produced. The delay in closure of the relay was measured and hence the time relation of the step wave with respect to t₀ could be given to ± 1/2 ms.

5) Buffer Pulse Unit, Fig. 12, Dwg. 649

As discussed earlier the firing pulse arriving at the tower on the 54AU cable had an amplitude of 600 volts and rise time of 6 microseconds. The purpose of the present unit is to sharpen this wave front.

The incoming signal is used to fire the 4635 thyatron providing a 700 volt pulse at its cathode. This pulse rises in considerably less than 0.1 microsecond and is supplied over 100 ft. of cable to the Electric Detonator (so-called "Raytheon") unit on top of the tower which fires the bomb. A fraction (1/20) of the same positive pulse is carried over 1000 ft. of RG U cable, (Ω - ft) terminated correctly in the N1000 shelter. This
pulse was used to intensify the measuring scopes, start sweeps, etc. Since the delay in the detonator set, H.E. train, coaxial cables, etc., were known this pulse had a time relation known with respect to the nuclear explosion.

The 4035 in this unit was self-quenching and all a.c. supplies were 400 cycle from a generator operated at the base of the tower. The filament supply was turned on remotely at -10 minutes and the a.c. to the B+ transformer at -90 secs to allow 60 secs heating time for the 5U4 rectifier.

6) Time fiducial, Fig. 14, Dwg. 624

This unit, located at N1000, accepted the fast positive pulse from the Buffer pulse unit and supplied it through the cathode follower V1 to fire the thyratron V2. The 300 volt pulse appearing at the cathode of V2 was utilised to start sweep circuits meanwhile a fraction of the same pulse, delayed 1 microsecond in the delay line #12647, was applied to the y-axis deflector system of the C.R.O. to provide a time fiducial.

V3 and V4 utilise the termination of the delay line as a common cathode load and allow four further signals to be mixed together and presented on the y-axis deflector system of the scope. To prevent reflection of these signals from the input of the delay line the input, as well as output, is loaded with a resistance equal to the characteristic impedance of the line.
a) B & L Spectroscope
b) Hilger Spectroscope
c) to signal to all measurement gear.
Input from McKibben at \( (t_o - 1) \) sec.

**SENDING END LAYOUT**

**FIGURE 2**

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**FIGURE 3**

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**CALIBRATION CIRCUITS**

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"INPUT ON FIRING LINE FROM S10" AMPH. 80-C

"OUTPUT" AMPH. 80-C TO RAYTHEON UNIT ON TOP OF TOWER

OUTPUT ON 50Ω CABLE TERMINATED IN 500 OHMS AT N1000

400 CYCLE OPERATION ONLY

Fig. 13

DESIGNED BY TITTERTON GROUP G-4
DRAWN BY H.M.B. DATE 6/25/45

BUFFER PULSE UNIT
Fig 14

ALL CONNECTORS ARE AMPH. BO-G