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JULY 16TH NUCLEAR EXPLOSION: RELAY TIMING

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ABSTRACT

Relay timing equipment used July 16, 1945 at Trinity is described. Master timing equipment was at S 10,000 yards, and remote control equipment was located in the vicinity of zero and also at W 10,000 and N 10,000.

[redacted]

JULY 16TH NUCLEAR EXPLOSION; RELAY TIMING

Apparatus for observation of the nuclear-bomb explosion as listed in Tables 1 to 4 were turned on by means of the relay system described. The system was selected by E. W. Marlowe and much of it was basic equipment manufactured by Union Switch and Signaling Co. for railroad use. As will be more apparent later, this equipment did not handle timing involving less than .1 second; this was done by E. Titterton's group using electronic equipment and separate lines. The master control station was South 10,000. Remote-control stations were located at West 10,000, North 10,000, and West 900. The latter station was simply a box in the ground with lines running to the various points as shown on Table 4.

The remote stations were operated by a single twisted pair plus a spare to each station. None of the spares was needed on the nuclear-bomb test; however difficulty due to line failure was experienced by Titterton on the 100-ton test. Actually a 5 pair cable went to the W 900; this gives small cross talk if connected properly, and has about one-half the loop resistance of the twisted pair which is .1 ohm per loop yard. As it is easy to connect up (it requires no poles) it would seem that it merits wider use than it was given at Trinity.

The system works as follows: A sequence of signals is started by throwing five manual switches, making 22 microswitch closures on the drum system, and then throwing again five manual switches. Each operation reverses the current in the line, and each reversal causes a coding or a stepping relay chain to advance one step. On the 32nd step it held it for .2 second and returned to 0 position. In order to tell at S10,000 that a remote station was in position 0 or other than position 0 a resistance was cut in at step 0 reducing the current in the line from 15 to 7 mils.

[redacted]

As the code system is advanced through the various steps it operates a stick polar relay. These relays are four pole, double throw. Permanent magnets hold in either position quite firmly; in fact it takes quite a jar to operate the relay. Each relay has two independent coils, of 120 ohms each, having terminals marked +1, -1, +2, -2. The armature terminals are marked 1P, 2P, 3P, 4P and make contact with 1N, 2N, 3N, 4N, respectively, or with 1R, 2R, 3R, 4R, respectively. Connecting + side of coil to + voltage makes P-to-N contacts; reversing the connection makes P-to-R contacts. As we used it, P and N completed the customers' circuit so + 1 was connected to the terminal numbered the same sequence on coding unit. The circuit was broken by -2 being connected to the terminal numbered corresponding to turn off sequence. To save a few relays, certain circuits were completed by series or even parallel arrangements of the contacts.

The remote stations had lights to tell if they were working properly. The lights had the following meanings:

1. White light on for position 0;
2. Red light on for position other than 0;
3. Red light on for input line current off;
4. White lights on for customer circuits open.

These lights were 18-volt telephone lamps and were turned on by a toggle switch when desired. White lights showed the customer circuit open rather than on for safety reasons.

The customer circuit had a toggle switch in each to open for safety so that the remote station could be operated for circuits desired. Simple relay closures were furnished at the 10,000-yard stations. At W 900 all circuits were energized by 126 volts of storage batteries; this was desirable from the safety standpoint since a short in a twisted-pair line to the customer could not operate his circuit or the bomb. It was also a saving in batteries for the many customers. As the relay contacts are not rated for more than 1/2 ampere, protective resistance was placed in each circuit inside the box so even if the terminals were accidentally shorted the relay would not be damaged.

Care had to be taken that the customers' relay could be operated through the line resistance in his circuit as shown on Table 4; these relays were mounted in dust free boxes. BJX relays (begged from Brode's group) were furnished in two ratings, 28 volts (280 ohms) and 110 volts (3500 ohms). Also furnished were Allen Bradley Bulletin 20 relays in 32 volt (170 ohms) and 110 volt (2000 ohms) ratings. These latter relays were used for heavy-current circuits such as the inverter and the arming relays in the firing unit. Automatic electric mercury relays would have been good for this service but were not received in time.

In operation a remote station consisted of two input relays (biased polar) connected to coding unit (see accompanying diagram of W 10,000 station). The coding unit and output relays, lights and switchs, comprise the remainder of the station. For the nuclear-bomb test we mounted all this in one upright wooden box for the 10,000 yard stations, and in a horizontal box for W 900. Three storage batteries operate the stations. Care must be taken to connect the batteries with the proper polarity or some snubbing rectifiers in the coding unit will draw excessive current. Also the coding unit fails to work if the voltage drops below about 12 volts. The stick polar relays will operate as low as 4 volts so that they can be operated in series. The manufacturer recommends that they not be operated in semi-parallel, but may be operated in series-parallel if needed. The reason semi-parallel operation is bad is that the transformer action, if coils 1 in relays 1 and 2 are in parallel, then energizing coil 2 in relay 1, may cause relay 2 to operate likewise.

The reason for use of two input relays is to make for safer operation. The KP relays here are also of the biased polar type with 1070-ohm coils. Unlike the stick polar relays they return to P-to-R contact if the current is broken; this is done by not permitting the armature to get close enough to the permanent magnet on the N side to stick. Thus by hooking the input coils in opposing series one relay makes P-to-N contacts, the other P-to-R contacts if a current of more than about 2 mils flows. If no current flows then both relays are in R position. In the first test we used this latter to reset the station to step 0 by means of a thermal relay of about 1-minute delay as shown by the diagrams of coding units; this was purposely left out in the last shot as being unnecessary and a possible source of trouble if blast should break a line to a 10,000-yard station.

It is to be noted that the coding units were modified after being received from the factory. Diagrams for the connection before and after are included. The modification was necessary so that they would not drop back to step 0 if the input current to the biased polar relays was interrupted.

<u>Caution</u>. If the current is interrupted too soon (less than one second) on step 32, the unit does not return to step 0. If this happens it locks and it is necessary to interrupt the power to the unit momentarily. This difficulty occurs only on step 32 but did give trouble on the last shot on test work.

At S 10,000 was located the master equipment. This consisted of the drum timer, the locked box for output circuits, and a station for the local signals. The lines to the stations came into this box through knife switches, through a meter to indicate polarity and magnitude of current thereby checking reset, then through the resistors supplementing line resistance, through the reversing contacts on a common KP stick polar relay, and to a 115-volt supply of B batteries. Because on the 100-ton test people picked up these signals by cross-talk, we put on a 2-mfd condenser on the output side of the reversing relay and 100 series resistance. In addition lines were well isolated on the final shot. No complaints were made about this cross-talk difficulty in the nuclear-bomb test.

The switches on the control panel on the drum housing and the microswitches on the drum proper energized coils 1 and 2 on the stick polar reversing relay in sequence. Two additional microswitches on the carriage transferred the control of these relays from the toggle switches to the drum and back to the toggles when the carriage came to the end of its travel. Another microswitch operated a counter once each second for timing signals. As this did not seem enough on the first shot another wheel was installed which rang a gong at selected times as given on Table.1. This went out over the radio and the public-address system at the bomb test and was interpreted by S. K. Allison. The above drum was to be operated off constant frequency from a fork source, but since we did not get it into operation soon enough, it was ruled out on the bomb test. A dial plate on the end allows the time of blast to be determined to about one tenth of a second if WWV can be heard soon after the blast. Actually it could not be heard at the time of the bomb test. The drum was built by C. Turner.

In firing the bomb the following steps were taken:

1. Inverter turned on - 10 minutes. This heated thyratron and rectifier filaments. The inverter made 115-volt 400-cycle power out of 28 volts of storage batteries.

2. HV turned on - 1 minute. This charged the condensers in the firing set.

3. Close arming relays at -.1 second. This connected the

thyratron output to spark gap probes and spark gap output to detonators.

4. Gave Titterton the firing signal at -.1 second. At = 0.0 he sent a pulse out over a RG 54/A to cable which could have fired the thyratron. Since an accurate timing of the interval between detonation and the nuclear explosion was desired it was decided to renew this pulse at the base of the tower. There a 4C35 thyratron unit was set up also operating off of the inverter. The output of this unit fed one pulse to Sutton's timer and a pulse to the firing unit.

In order to guarantee safety further measures were taken. A separate line from S 10,000 operated contactor A in a locked box at the base of the tower. This was hooked in series between the 28-volt storage-battery supply and relay B (which was turned on at -10 minutes by W 900 remote station) and the inverter. Relay C operated at -1 minute to turn on inverter output to the HV transformers. Relay D connected the arming relays to the same 28 volt battery supply again through Relay A. The above relays were Allen Bradley Bulletin 20 with at least 2 contacts hooked in parallel. Through N.C. contacts these relays turned on lights on the locked box when in safe position.

For checking purposes a line went back to S 10,000 to indicate voltage on the condenser system and a second to indicate operation of arming. The first was merely a 0 to 1 milliameter mounted on the locked box at S 10,000. Trouble was experienced on an early test due to lightning surges being picked up and causing the thyratron in the firing unit to be fired prematurely. A condenser choke filter was installed at the top of the tower where our lines terminated in a box. The final shot was not made in a thunder storm so this seemed to be adequate. Arming was accomplished by 6 relays. In order to insure that all were safe a series connection was made tion on each must be broken. In order to transmit this information back to S 10,000 over a twisted pair the three output wires were connected into two KP biased polar relays in the locked box at the base of the tower. With both series and parallel connections made the line was connected to one polarity of a 22½-volt battery in the box, breaking the series connection broke the connection to the battery and breaking the parallel connection reversed the current in the line. To guarantee that the gadget did not get fired partially armed it was fixed so that the fully armed signal had to operate another biased polar relay in the station at S 10,000 and to indicate such failure by turning on a red light on the box. For protection of the arming party, lights on locked box at base of tower also indicated series and parallel connection when made.

The arming box for the 5# charge gave us a bit of trouble because we decided to use a fast relay for accurate timing. A KP biased polar was found to be best for this purpose as it is non-microphonic as well as fast. A normally closed contact by means of 6 volt battery lit a lamp when safe. The output knife switch was DPDT and shorted the line for safeing while 5# charge was being connected. The locked box, the inverter, an FM radio, and two telephones were in a small shack at the base of the tower. A private telephone proved quite useful also. Telephones were installed at S 10,000, W 900, W 800 for informer people who had a lot of test work to do, base of tower and top of tower. By leaving the telephone at the base of the tower connected to battery, operation of inverter could be heard as well as the 5 pound and 1/2 pound charge explosions used in the preliminary tests.

Each of the five lines going to S 10,000 in the 5 pair cable was protected at W 900 as well as S 10,000 by lightning arrestors. The negative

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side of the battery supply was grounded also to the well ground at W 900 and this was made common for all customer circuits from this station. Before the arming party left S 10,000 they saw that all stations were on code zero and lines to them were thrown to a battery in the box for holding and checking purposes. The safe line was opened and the firing coax line from Titterton which went through this box was opened and the output side shorted to its shield. All this was done by knife switches in the box. The box was locked and the keys were taken by the arming party.

The party then went to W 900 where all customer circuits were checked to be off (actually they had been off for some time so the cameras, etc., could be loaded) and various circuits were checked to be continuous by an ohmmeter. The box was relocked.

The 28-volt switch as well as switches to filaments and HV on the firing set and the pulse splitter and one to the informer battery supply were opened in the locked box at base of the tower. The cords between the output box and the firing unit were plugged in on the tower and the party upstairs left. Next the 5 pound charge was connected and the switches closed in the locked box. Next the switches at W 900 were closed checking of course that lights were showing safe. The party then retired to S 10,000 where the remaining switches were to be closed

Men were also stationed at W 10,000 and N 10,000 to insure that these stations were operating properly.

A more elaborate check-back system was purchased but not used for lack of time. This would have recorded by lights the fact that various lines were continuous and did operate satisfactorily. We did not believe that the extra trouble of setting up this carrier system was worth while, particularly as the above system worked and we might not get the elaborate system operating in time.

A movie record was taken of meters on the locked box at S 10,000 to prove that operation was satisfactory but results made it unecessary to examine this record. During the time between the charging of the HV condensers, Hornig watched the HV meter and was prepared to open contractor A by opening the knife switch to it in the box at S 10,000 if the HV showed any misbehavior. This would have prevented the arming relays from closing and since the fast timing system could get no signal, prevent the firing of the thyratron.

INTER-OFFICE MEMORANDUM

12 June 1945

To: All Concerned

From: J. L. McKibben

Subject: Electrical Arming Protection of Gadget and Auxiliary Charges

I. Protection of Gadget.

A.. To fire the gadget the following steps will be taken:

Inverter - 10

1. H. V. turned on at -1 minute. This heats the tubes and charges high voltage condensers;

2. Close arming relays at -.4 second. This connects thyratron output to spark gap probes and the spark gap output to detonators;

3. 4C35 thyratron is fired by a pulse from Titterton over a RG54/AU coax line from S 10,000 at t = 0. The output is coupled by transformer to the probes which initiate a spark in the gap connecting the high voltage condensers and the detonators.

B. Locked boxes to control these operations are located at the following positions:

1. S 10,000 - Master sequence station;

2. W 900 - O area sequence station;

3. Base of tower - Contactors to perform 1 and 2 above.

The inverter is turned on by two Allen Bradley 200 contactors in series in the locked box at base of tower. These are contactor A operated from S 10,000 by a direct line and contactor B operated from W 900 sequence station. Contactor C, also in this box, operates the arming relays and is operated by the W 900 station. The battery supplies that operate these contactors are located at the operated end so an accidental short will not close a contactor.

One set of contacts on contactor A will close the firing line between W 900 and the 5# charge of Barschall's located near W 50. There will be no electrical connection between this line and the inverter.

These contactors will be visible through a lucite window in the side of the box so contacts can be checked. If procurement permits, NC contacts will light 6 volt lamps for an additional check. Thus as long as the lamps are lit the contactors are in the safe positions.

As present plans call for the inverter and battery supply at the base of the tower, the following DPST switches are in the locked box:

1. Between (a) the contactors A and B and battery supply and (b), the inverter;

2. Between (a) the inverter output and (b) the firing set;

3. Between (a) the battery supply and contactor C and (b) the arming relays.

C. The W 900 sequence station is operated by one twisted pair of a 5 pair cable from S 10,000. The input relays of the sequence stations are two biased polar relays hooked in opposing series connection. When >5 mils current flows in the line if relay 1 is normal, relay 2 is reverse position; if the current reverses then relay 2 is normal and relay 1 is reverse; but if the current is zero both relays are reverse. The manufacturer has labeled these positions for their own reasons. To move the sequence station from one position to the next it is necessary to reverse the current in the line.

Lights are provided in the output box of the station which light only

1. When sequence station is in position zero;

2. When sequence station is not in position zero;

3. When line current is zero;

4. When customer's circuit is off. This light goes off when the customer is connected and vice versa. There is a light for each customer. Toggle switches are provided to inactivate customer's circuit which include contactors B and C. All arming and firing circuits are inactivated by opening the circuit.

D. At S 10,000 is located the master control station. Between the control switches and timing drum and the output lines is a locked box which contains switches to insure nonoperation of output stations while arming party is at work. Meters to indicate direction and magnitude of current in each line are mounted on this box. In detail it contains:

1. Switches in lines to remote station. These are DPDT.

One position is operate, the other connects the line to a battery in this box which indicates through the meter that the remote sequence stations are connected and on position zero by the amount of current to it. On all positions except zero a resistance in the remote station is cut out so that the current rises from 7 to 15 mils. The observer at S 10,000 can not only keep check on position of remote stations but also on line continuity;

2. Switch on line to contactor A. Meter on this circuit will indicate proper current when operated;

3. The coax from Titterton's fast timing circuit to the thyratron in firing set passes through this box. A SPDT switch opens the center conductor and shorts it on the firing set side to the shield;

4. Switch in line to Mack's large flash bombs.

E. The procedure for the arming party is as follows:

1. At S 10,000.

a. Check that sequence stations are in position 0 and connected to battery in box which will then indicate line continuity as well as station position;

b. Open and short Titterton's firing line;

c. Check that safe line conducts proper current and then open it;

d. Lock box and take all keys.

2. At W 900.

a. Check that sequence 0 light shows and sequence not 0 does not. Also that light indicating no line current does not show;

b. Check that all lights on customer's circuits show. These lights are operated by NC contacts on the output relays and these contacts will break when customer circuit operates;

c. Check that all customer circuits are inactive;

d. Lock door.

3. At base of tower.

a. Check that contactors are open;

b. Open two knife switches that connect inverter and arming relay to contactors and battery supply;

c. Open inverter to firing set line;

d. Lock box.

4. At base of tower after charges are all fused.

a. Repeat 3a;

b. Close knife switches;

c. Lock box.

5. At W 900 after charges are all fused.

a. Check by telephone to S 10,000;

b. Repeat 2a and 2b;

c. Activate all customer circuits;

d. Lock doors.

6. At S 10,000 after charges are all fused.

a. Connect all sequence stations to drum switch system;

b. Connect Titterton's line to firing set thyratron;

c. Operate contactor A noting that current is correct.

Operating sequence system will now fire the charges.

II. <u>Arming Protection on the 5# Sound Velocity Charge.</u>

It is assumed that the party that fuses the main charge fuses the 5# charge for Barschall. After step 3 of above the firing line between the W 900 sequence station and the 5# arming box is open by contactor A. The DPDT relay which fires this charge on closure lights a 6 volt lamp if in safe position. A 67 volt battery is supplied to fire the charge. An output knife switch protects while charge is being connected. Arming is affected by closure of relay A.

This charge will be fired at -3.0 seconds.

III. <u>Arming Protection on Mack's 48 1/2 Torpex Sources and 6 Primacords.</u>

These are operated by 54 latch on relays and local batteries. The 54 arming boxes are being manufactured by Mack's group. An output knife switch and 20 ft. of wire connects each arming box to its charge. This is long enough to be safe to fire charge.

These are hooked on 6 lines coming into a box at W 100 which

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contains a relay, 135 volts of heavy duty B batteries, an output DPST knife switch, and a 6 volt lamp that lights for normal relay psotion. After the 54 charges are connected, the output knife switch in this box is closed prior to the fusing of the main charge.

The location of this box is fixed by the necessity of having the battery supply at the junction of the six lines.

Latch on relays are made necessary by the requirement that they remain closed after W 100 is destroyed. These relays have electrical resets and these terminals will be brought out on the local boxes. After a dry run each box can be checked for closure and reset electrically by applying voltage to this pair of contacts.

These charges will be armed at -.4 seconds.

IV. Mack's Five Large Flash Bombs.

These have not been located as yet. Details for firing have not been worked out either as they normally fire 15 seconds after a firing pin is pulled upon release from plane. If fired by our group a stepping relay system will be used.

I. Protection of Gadget

A. To Fire the gadget the following steps will be taken

1. Inverter turned on -10 minutes to heat filaments. This is done by relay B at base of tower.
2. High voltage turned on -1 minute. This is done by relay C at base of tower.
3. Arming relays closed -4 sec. This is done by relay D at base of tower. Arming connects thyratron to spark gap probes and spark gap output to detonators.

4. Thyratron is fired by a pulse from Titterton over a RG54/AU coax line from S 10,000 at t = 0. This pulse is sharpened and split at the base of tower.

B. To indicate operation of firing unit.

1. A meter to read voltage is located on box at S 10,000.
2. A meter to indicate arming is located on same box. In addition unless all relays are in armed position no signal can be given to Titterton at -.1 second to start fast timing.

C. Safe line

1. A relay known as A is located in the box at base of tower and operated by a line from S 10,000 which controls the 28 volt supply. Unless this is operated neither the inverter can start nor can the arming relays be operated.

D. For operation of W 900 code station see June 12 memorandum

II. Check List

A. Sunday PM

1. Check all lines
2. Check all storage batteries placing fresh ones in service for inverter.

B. At S 10,000 before leaving with arming party

1. All lines are continuous and remote stations are on code 0.
2. Lock on code 0 all remote stations.
3. Check safe inverter line. The operator relay A which turns off 28 volts battery supply and line to fire Barschall 5# charge.
4. Mack's flash bomb line should already be off and left so.
5. Open and short Titterton firing coax.
6. Leave on voltmeter and arming signal back.
7. Lock box and take both sets of keys.

C. At Base of Tower

1. Open all knife switches.
2. Check that all relays are actually open.
3. Lock box

D. At W 900

1. Open all customer circuits.
2. Check with ohmmeter that they are still attached.
3. Check that code 0 light shows.
4. Check battery voltage again.
5. Lock box

E. At Tower

1. Arm Mack's 54 arming box. Check that the jumper to D contact is removed.
2. Check finally storage batteries for connection.
3. Check that relays A, B, C, D are open.
4. Connect arming check lead and note that both lights are on and the meters at S 10,000 reads to the left.
5. Connect voltmeter lead.
6. Connect arming, power, firing, and informer leads.
7. Connect and arm 5# charge.
8. Leave phone connected to hear inverter.
9. Close all knife switches in box and lock box.
10. Connect search lights to relay operation.
11. Turn on plane signal lights at S 100.

F. At W 900 on way out
1. Turn on lights and check.
2. Turn on all toggle switches.
3. Turn off lights and lock box.
4. Place on cover.
5. Plane signal lights on.

G. At S 10,000 on return

1. Check that all sequence station are in proper sequence.
   a. By observations of current.
   b. By word of Bailey and Treibel.
2. Close all switches in locked box.
3. Turn on all customer circuits in S 10,000 code station. Check that red light on arm signal back is off.
4. Check that drum is set and all microswitches work.
5. Check that gong and counter are properly set and turned on.
6. Camera and lights are set to take pictures.
7. Plane signal lights on.

	User	Service	Location	Signal	Terminal	Time in sec. On	Time in sec. Off	Sequence On	Sequence Off	Relay No.
1	Houghton	Heiland	Local	Relay Closure	1	-10	300	8	29	1
2	Walker	"	"	"	2	-10	300	8	29	
3	Barschall	"	"	"	3	-2.5	301	12	30	2
4	Moon	"	"	"	4	-1.0	10	14	28	3
5	Titterton	Start fast timing	"	"	5	-.1	1000	19	31	4
6		Buzzer	"	"	6	-45 -10 -1.0	-44.5 -9.5 -.7	5 8 14		5
	Mack	5 flash bombs			Line S6	every second				
	This line operates a 2500 position stepping relay which sets off flash bombs at					45 105 225 465 945				

Over the radio and public address system will go the sound of a counter every second starting at -45. In addition, a gong will sound on same at -40, -31, -30, -20, -10, -2, -1, 0, 10, 20, 29, 30, 40, 50, 58, 59, 60 and repeats the pattern every minute

Sequence times of operation of coding units.

0	Normal position	11	-3	22	0.5
1	-600	12	-2.5	23	1.0
2	-599	13	-2.0	24	1.75
3	-300	14	-1.0	25	3.0
4	-60	15	-0.7	26	4.0
5	-45	16	-0.5	27	5.0
6	-44.5	17	-0.4	28	10
7	-22	18	-.25	29	300
8	-10	19	-0.10	30	301
9	-9.5	20	-0.005	31	1000
10	-5	21	0.2	32	1001

TABLE III

W 10,000 Pittsburgh

Relay No.	User	Service	Location	Signal	Time in sec. On	Off	Sequence On	Sequence Off	Terminal
7	Mack	Slow Fastax	Local	Relay Closure	-2.0	-.7	13	15	1
5	Mack	16 mm Cine	"	"	-5	1000	10	31	2
5	Mack	Mitchel Camera	"	"	-5	1000	10	31	3
2	Mack	Aero Camera	"	"	-45	1001	5	32	4
3	Mack	Pinhole Camera	"	"	-10	1000	8	31	5
8	Mack	Gen. Radio Recorder	"	"	-1	4	14	26	6
1	Mack	Hilger Motor	"	"	-300	1	3	23	7
4	Mack	Hilger Pip Gen.	"	"	-9.5	5	9	27	8
3	Mack	B & L Spectrograph	"	"	-10	1000	8	31	9
6	Mack	B & L Spectrograph	"	"	-.25	1001	18	32	10
9	Mack	Color Temp. Camera	"	"	-1	10	14	28	11
1	Mack	Photo-Cell Motor	"	"	-300	1	3	23	12
2	Bright	Heiland	"	"	-45	1001	5	32	13
10	Titterton	Shutter	"	"	-.5	-.25	16	18	14
11		Buzzer	"	"	-45 -10 -1.0	-44.5 -9.5 -.7	5 8 14	6 9 15	 15 16
12	Mack	Fast Fastax	"	"	.7	1.75	15	24	16
6, 12	Mack	Photo-Cell Shutter	"	"	-.25	1.75	18	24	17

Over the radio and public address system will go the sound of a counter every second starting at -45. In addition, a gong will sound on same at -40, -31, -30, -20, -10, -2, -1, 0, 10, 20, 29, 30, 40, 50, 58, 59, 60, and repeats the pattern every minute.

13	Mack	Rec. Spectro	"	"	-.1	300	19	29	18

TABLE III

N 10,000 Abel

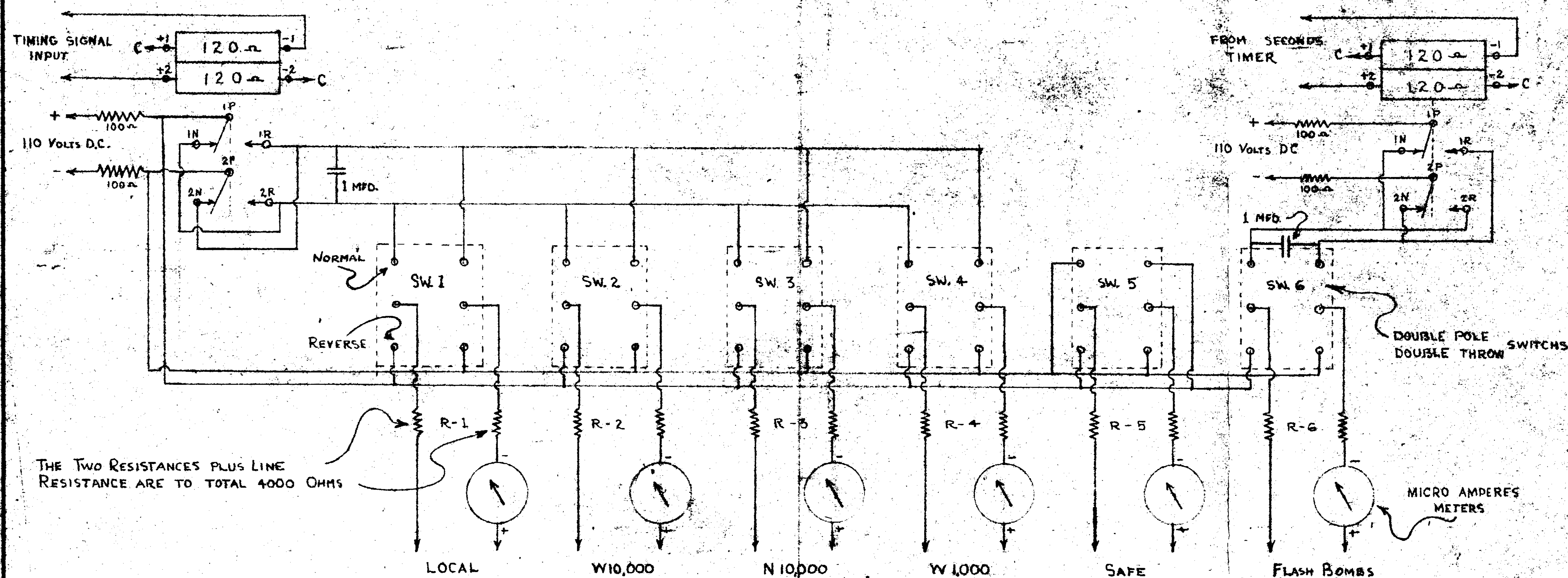
Relay No.	User	Service	Location	Signal	Time in Sec. On	Time in Sec. Off	Sequence On	Sequence Off	Terminal
9	Mack	Slow Fastax	Local	Relay Closure	-2.0	-0.7	13	15	7
7	"	16 mm Cine	"	"	-5	+1000	10	31	2
7	"	Mitchel Camera	"	"	-5	+1000	10	31	3
3	"	Aero Camera	"	"	-45	+1001	5	32	4
5	"	Pinhole Camera	"	"	-10	+1000	8	31	5
11	"	General Radio Recorder	"	"	-1.0	+4.0	14	26	6
7	"	Hilger Motor	"	"	-300	+1.0	3	23	7
6	"	Hilger Pip Generator	"	"	-9.5	+5.0	9	27	8
5	"	S and L Specto-graph	"	"	-10	+1000	8	31	9
13	"	"	"	"	-.25	1001	18	32	10
10	"	Color Temp Camera	"	"	-1.0	+10.0	14	28	11
8	Berschall	Heiland	"	"	-2.5	+301	12	30	12
4	Houghton	"	"	"	-10	+300	8	29	13
4	Walker	"	"	"	-10	+300	8	29	14
11	Moon	"	"	"	-1.0	+4.0	14	26	15
2	Leet	Seismograph	N 9000	"	-60	+301	4	30	19
2,7	"	"	"	"	-5	+301	10	30	17
		Buzzer	Local	"	-45	-44.5	5	5	18
					-10	-9.5	8	9	15
					-1.0	-.7	14	24	18
12	Mack	Fast Fastax	"	"	-.7	-.005	15	20	19
15	Mack	Rec. Spectro.	"	"	-.1	+3.0	19	25	20

W 900

Relay No.	User	Service	Location	Line	Res.	Line Res.	Volt. Sup.	Time in sec. On	Off	Sequence On	Sequence Off
8	Barschall	Fire 5# charge	W 30	S 10	150	90	126	-3.0	3	11	25
4	Hornig	H. V.	0	S 11	150	90	126	-60	2	4	24
14	"	Arm firing set	0	S 12	150	90	126	-.4	.5	19	22
13	Mack	Arm 54 flashes	W 100	S 14	150	80	126	-.4	3	17	25
10	Moon	Gamma cameras	S 275	S 15	300	100	126	-2.5	5	12	27*
10A	Richards	Neutron balloon	SW 460	S 16	300	50	126	-1.0	-.005	14	20
1	Segre	Gamma balloon	NW 600	S 17	300	50	126	-600	4	1	26
6	"	" "	NW 600	S 18	300	50	126	-22	4	7	26
7	Hornig	Inverter	0	S 19	150	90	126	-600	4	2	26
13	Titterton	Camera Shutter	W 800	S 20	300	10	126	-.4	3	17	25
6	Moon	Camera motor	S 150	S 21	300	100	126	-22	4	7	26
9	Mack	Slow Fastax	N 800	S 25	300	120	126	-2.0	1000	13	31
9	"	" "	W 800	S 26	300	10	126	-2.0	1000	13	31
11	"	Fast Fastax	N 800	S 27	300	120	126	-.7	1001	15	32
11	"	" "	W 800	S 28	300	10	126	-.7	1001	15	32
12	Wilson	Camera Shutter	N 1000	S 29	300	140	126	-.5	-.1	16	19
15	"	Test	N 1000	S 30	300	140	126	-.005	.2	20	21
7	Mack	Search lights	E 10,000	S 33	300	1000	126	-10	10	8	28*
		Marley motor turn off safing switch							.2		21

* Voltage will be maintained on lines S 15 and S 33 and will go off to operate equipment. This insures against failure due to broken line due to gadget. Line resistance is estimated. Protective resistance of value shown is wired into circuit in box. One side of each output line will be grounded at this station.

TRANSMISSION CIRCUIT



		APPROVED FOR CONST.		
		CHIEF ENG.		
		PROJ. ENG.		
		CHECKED		
		DRAWN	RTM	
GROUP REPR.	GROUP NO.	LAYOUT OR SKETCH		
			INITIALS	DATE

FINISHES: (A) GROUND, (B) SMOOTH MACHINE, (C) ROUGH MACHINE

TOLERANCE EXCEPT AS NOTED

FRACTIONAL	± 1/64
ANGLES	± 1/2°
SHEET METAL	± 1/32
DECIMALS	NOTED

CALC. WT. #

ACT. WT. #

SUPERSEDES

SUPERSEDED BY

REV. LET.	CHANGED ITEM WAS	DATE	BY

ADDITIONAL SHEETS

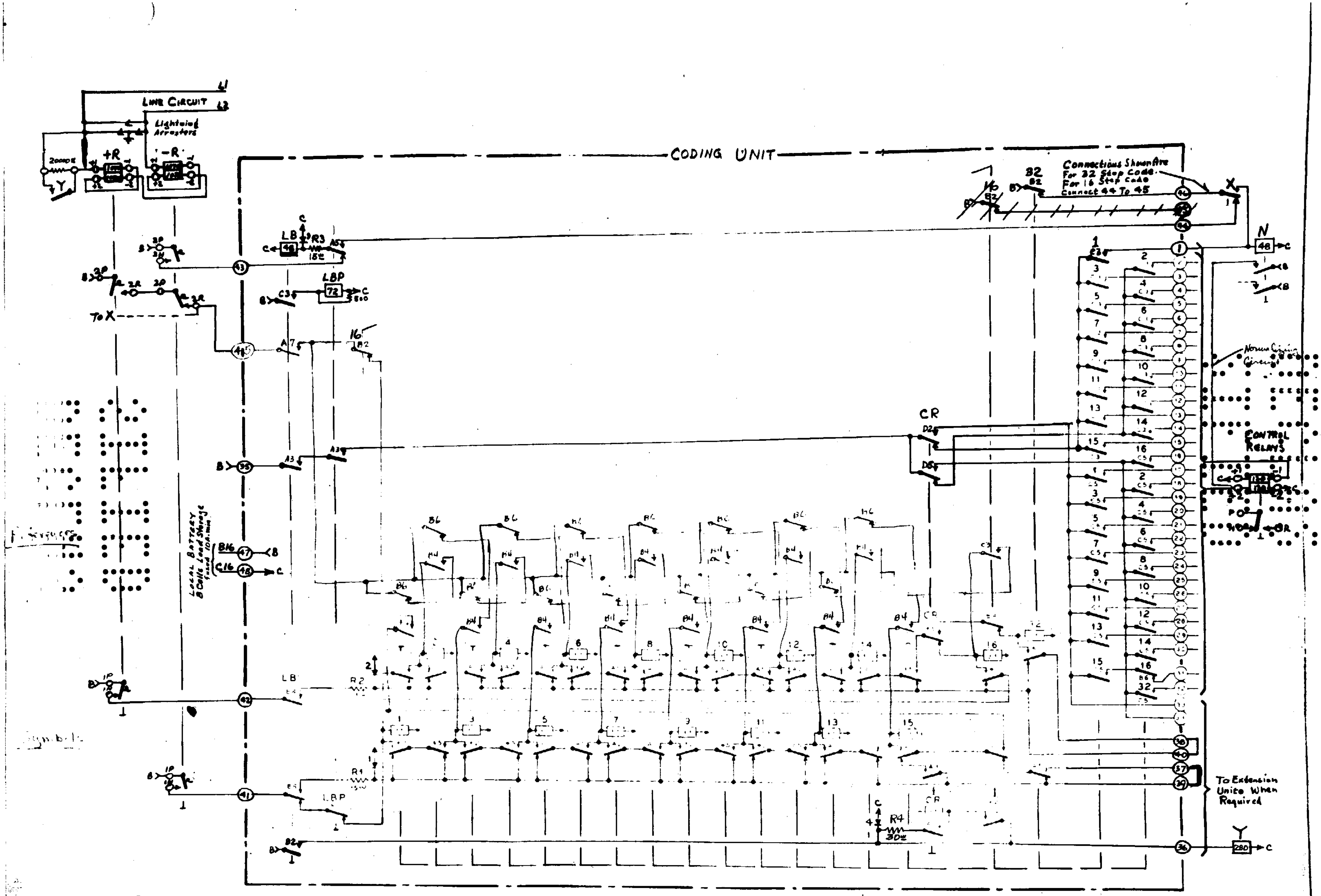
MODEL OR TITLE | DRAWING NO.

SHEET SIZE B

NO.

TOTAL

SCALE



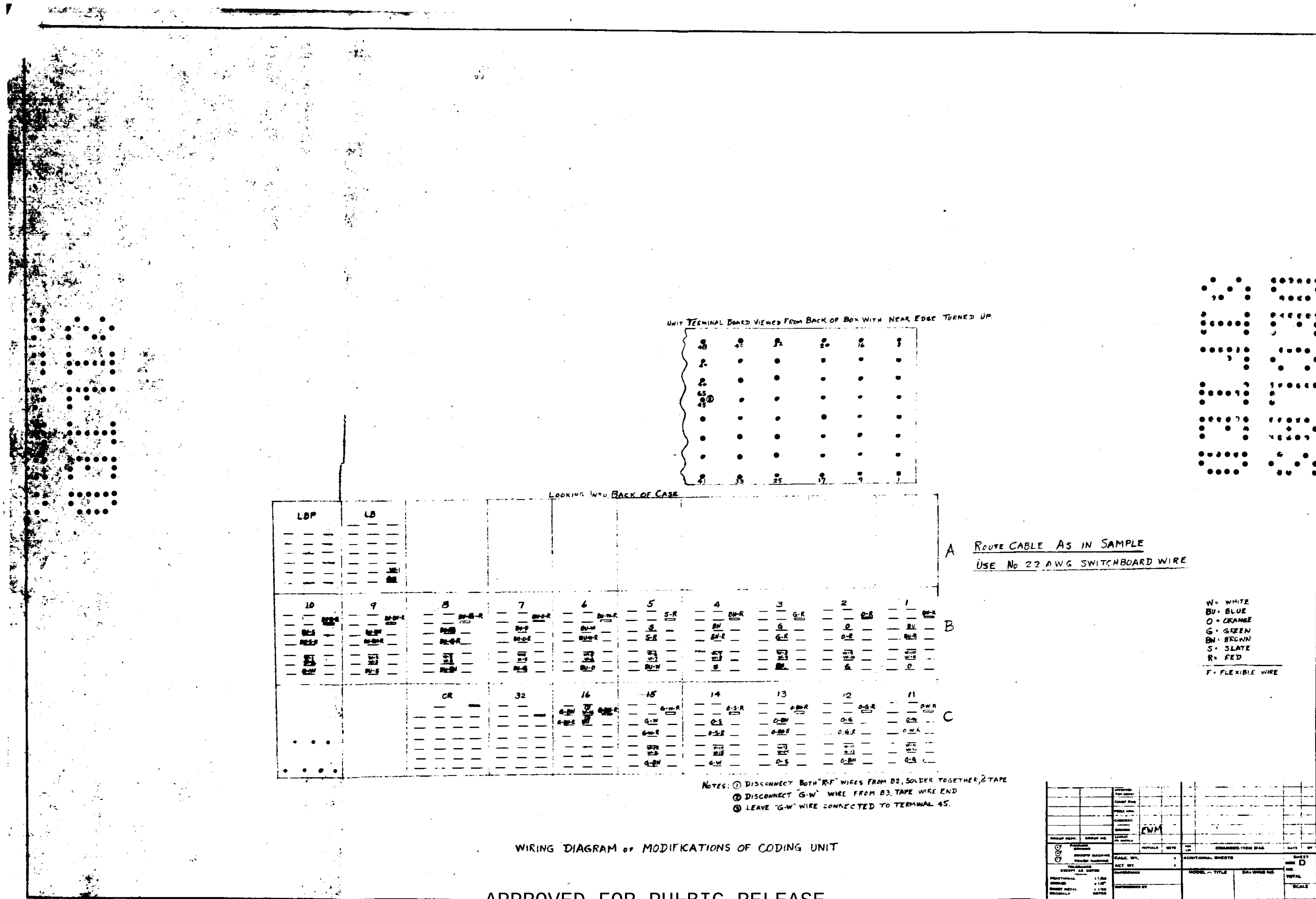
C9362-S61784

CIRCUIT DIAGRAM
32 FUNCTION CODE CONTROL SYSTEM
SPECIAL DESIGN FOR SEQUENCE OPERATION
U.S. ENGINEERING CORPS.
USQSCO SWISSVALE, PA

Drawn By AP Jackil 4/16/45

GO. 3060

SH. 1


UNIT TERMINAL BOARD VIEWED FROM BACK OF BOX WITH NEAR EDGE TURNED UP.
48 40 32 24 16 8
41 33 25 17 9 1
65
45
LOOKING INTO BACK OF CASE
LBP
LB
10 9 8 7 6 5 4 3 2 1
CR 32 16 15 14 13 12 11
A
B
C
ROUTE CABLE AS IN SAMPLE
USE No 22 A.W.G. SWITCHBOARD WIRE
W = WHITE
BU = BLUE
O = ORANGE
G = GREEN
BN = BROWN
S = SLATE
R = RED
F = FLEXIBLE WIRE
NOTES: ① DISCONNECT BOTH "R-F" WIRES FROM B2, SOLDER TOGETHER, & TAPE
② DISCONNECT "G-W" WIRE FROM B3, TAPE WIRE END
③ LEAVE "G-W" WIRE CONNECTED TO TERMINAL 45.
WIRING DIAGRAM OF MODIFICATIONS OF CODING UNIT
EWM
D