3-4-11 April 1958

AGENDA

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Thursday A.M.: A. Lab trip for TEM operation - 20 minutes brief demonstration - more detailed demonstrations later.

Thursday A.M. & Daily P.M.: B. TEM operation

1. Block diagram description
2. Electro-mechanical schematic
3. Wiring diagram
4. Principles of operation
5. Cutaway sketch
6. Test setup - line schematic & wiring diagram
7. 3 types of readout
   a. AC Scope
   b. DC Scope
   c. DC Pen
8. Discussion of last monthly report

C. TEM performance

1. Low temperature
   a. Solenoids
   b. Multivibrator
   c. Electrical
2. Watch contact
3. Command Pulse problems
4. Watch performance
5. Inertia

D. SAD

1. Principles of operation
   a. Blackboard development
2. Current status
   a. Watch & hack mechanism
   b. Switching arrangement
   c. Printed circuits - 1 on hand - 2 to be made here
   d. 2 Drawings (assembly and layout)
   e. Bistable multivibrator
   f. Future progress

E. Lab trip

1. Bistable multivibrator demonstration
2. More detailed demonstration of TEM readout
3. 1000 cycle oscillator demonstration
4. Solenoid Watch Demonstration

F. Contractual discussion

Friday A.M. & P.M.: G. Project 69

1. Discussion of difficulties
2. Spare parts and residual inventory

H. Discussion of Solenoid Watch

I. Discussion of TEM Decoder

a. Original proposal
b. Present systems
c. Customer desires
d. Cost

J. Discussion of Project 96

a. Residual Inventory
b. Recommendations

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4/3/58

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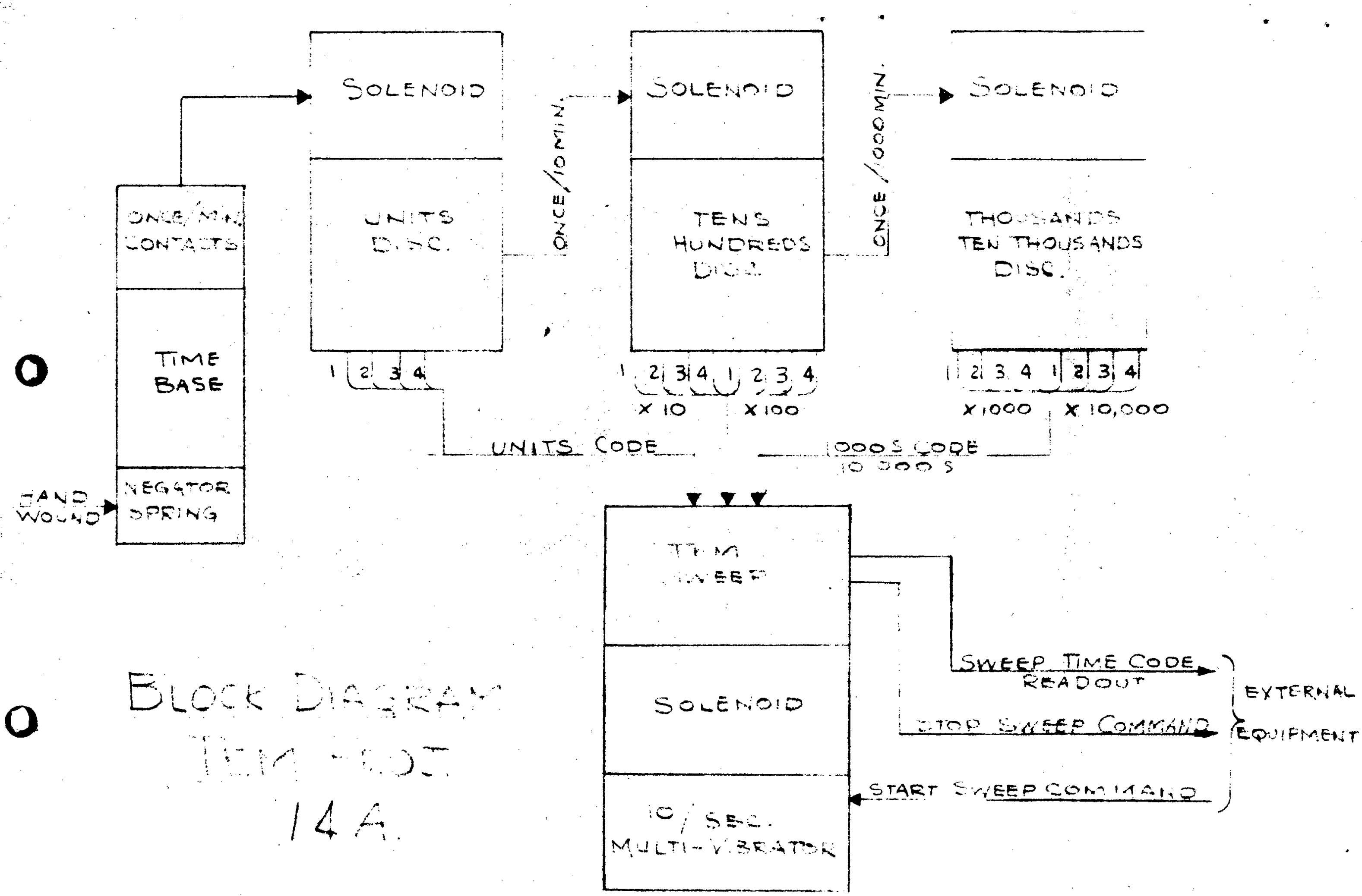
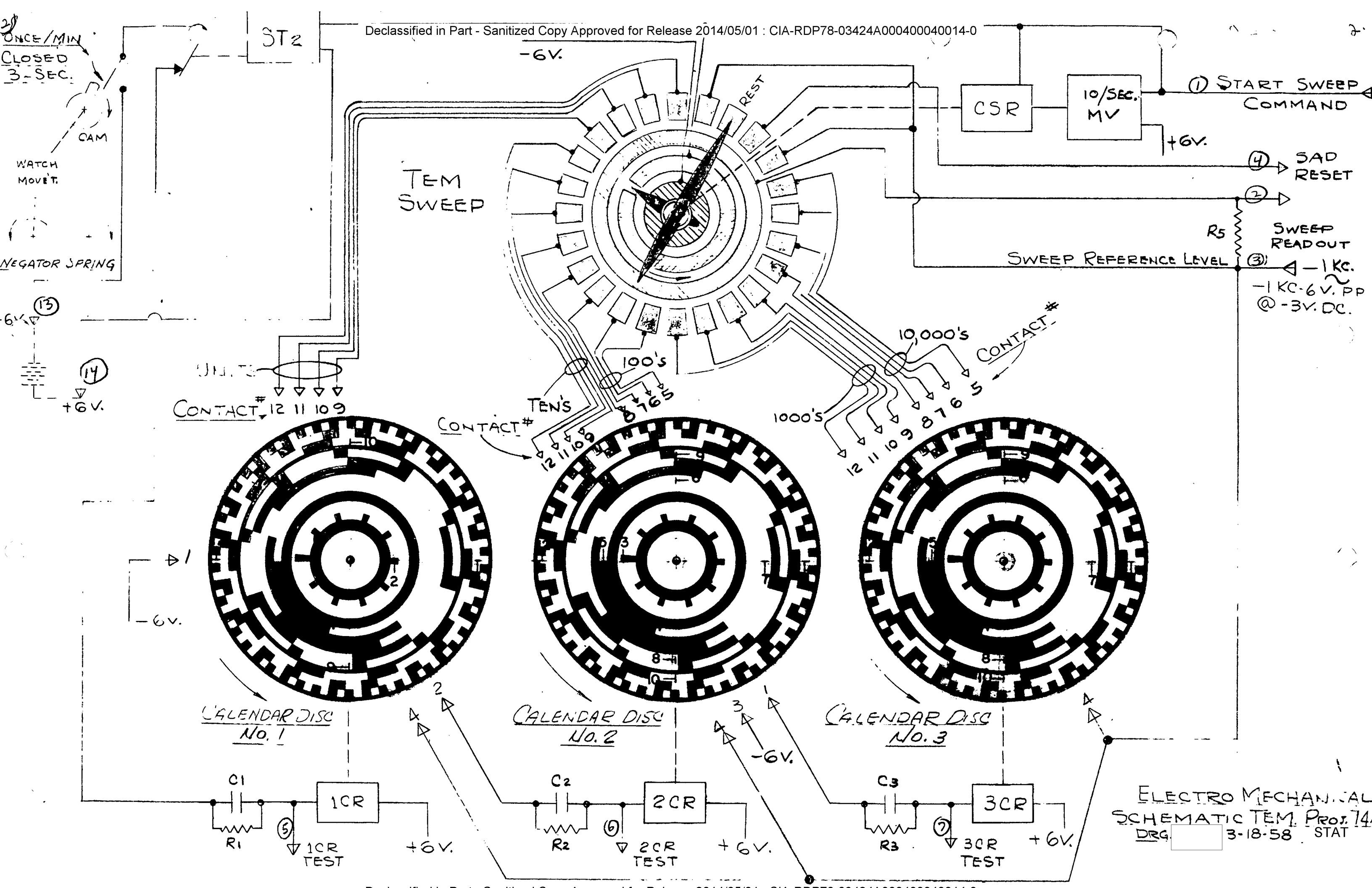


BLOCK DIAGRAM
TEM [illegible]
14A.


ONCE/MIN
CLOSED
3-SEC.
CAM
WATCH
MOVE'T.
NEGATOR SPRING
ST2
-6V.
TEM
SWEEP
REST
CSR
10/SEC.
MV
+6V.
(1) START SWEEP
COMMAND
(4) SAD
RESET
(2)
R5
SWEEP
READOUT
SWEEP REFERENCE LEVEL
(3) -1 KC.
-1 KC-6V. PP
@ -3V. DC.
(13)
(14)
+6V.
UNITS
CONTACT# 12 11 10 9
TEN'S
100's
8 7 6 5
CONTACT#
12 11 10 9
10,000's
CONTACT#
1000's
12 11 10 9 8 7 6 5
CALENDAR DISC
No. 1
CALENDAR DISC
No. 2
CALENDAR DISC
No. 3
-6V.
C1
R1
1CR
(5) 1CR
TEST
+6V.
C2
R2
2CR
(6) 2CR
TEST
+6V.
C3
R3
3CR
(7) 3CR
TEST
+6V.
ELECTRO MECHAN…AL
SCHEMATIC TEM. PROJ. 14…
DRG.
3-18-58
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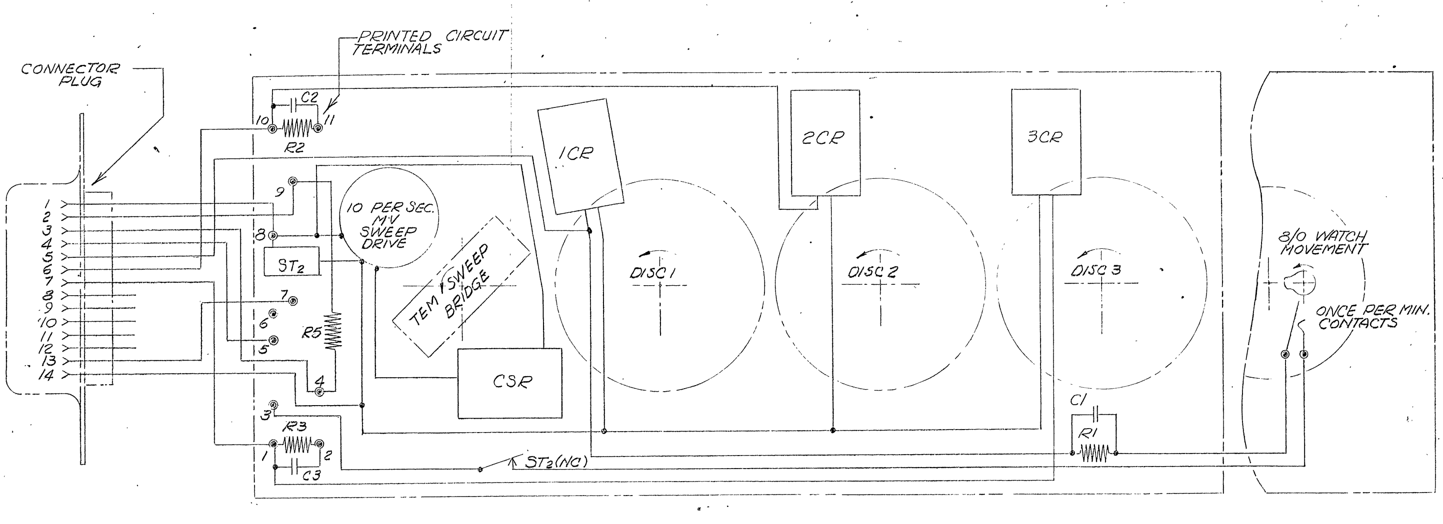

EXTERNAL PLUG CONNECTIONS

1. SWEEP COMMAND INPUT
2. SWEEP READOUT OUTPUT
3. -1 KC INPUT REFERENCE
4. SAD RESET OUTPUT
5. 1CR TEST INPUT
6. 2CR TEST INPUT
7. 3CR TEST INPUT
8. NO CONNECTION
9. NO CONNECTION
10. NO CONNECTION
11. NO CONNECTION
12. NO CONNECTION
13. -6 VOLT INPUT
14. +6 VOLT INPUT

PRINTED CIRCUIT PATHS (NOT SHOWN)

TERM. 1 NO CONNECTION
TERM. 2 TO WIPER ARM, CONTACT PATH 1, DISC 2.
TERM. 3 TO WIPER ARMS. CONTACT PATH 1, DISC 1, AND CONTACT PATH 3, DISC 2 ALSO TO TERM. 7.
TERM. 4 TO WIPER ARM. CONTACT PATH 4, DISCS 1, 2, 3 AND SWEEP REFERENCE LEVEL CONTACTS.
TERM 5 TO SAD RESET CONTACT.
TERM 6 TO SWEEP REST CONTACT SLIP RING.
TERM. 7 TO SWEEP CONTROL SLIP RING AND TERM 3.
TERM. 8 TO SWEEP CONTROL CONTACT RING.
TERM. 9 TO SWEEP OUTPUT SLIP RING.
TERM. 10 NO CONNECTION
TERM. 11 TO WIPER ARM, CONTACT PATH 2, DISC 1.

1CR CALENDAR RATCHET SOLENOID – DISC 1.
2CR " " " DISC 2.
3CR " " " DISC 3.
CSR CALENDAR SWEEP RATCHET SOLENOID
ST_2 SIGNAL TRANSFER RELAY (COINCIDENCE CKT.)

COMPONENT VALUES

R1 - 100 KΩ
R2 - 1.5 MΩ
R3 - 22 MΩ
R5 - 1 KΩ

C1 120 μfd
C2 180 μfd
C3 180 μfd

REFERENCE DRWG. NO'S.

PRINTED CIRCUIT BOARD -74A-13
PRINTED CIRCUIT DISC - CM74E18

ITEM NO.	NO. REQ.	DESCRIPTION	DWG. NO.
ITEM NO.	FINISH	NO. REQUIRED	
MATERIAL	HEAT TREAT	HARDNESS	

CHGE. LET.	REVISION	DATE	CH'D	APP'D
A	REDRAWN	3/26/58		

UNLESS OTHERWISE SPECIFIED
1—REMOVE ALL BURRS AND SHARP CORNERS.
2—TOLERANCES ON MACHINING DIMENSIONS ARE. FRACTIONAL ± .010: DECIMAL ± .003: ANGULAR ± 1/2°.
3—TOLERANCES ON DRILLED HOLES; WIRE GAGE DRILLS PLUS OR MINUS NEXT DRILL SIZE NOT TO EXCEED PLUS OR MINUS .002. LETTER AND FRACTIONAL DRILLS UP TO 1/4 DIA. PLUS .002 MINUS .001. OVER 1/4 DIA. PLUS .004 MINUS .002.
4—THREAD LENGTH DIMENSIONS ARE FOR FULL THREADS
5—DO NOT SCALE DRAWING.

TITLE: WIRING DIAGRAM

SCALE —	SHEET NO. OF SHEETS	
DWG. BY	DATE 3-26-58	DWG. NO. C 74A-01
CHECKED	DATE	
APP'D.	DATE	

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PRINCIPLES OF OPERATION AND DESCRIPTION OF TIME EVENT MARKER

I. Purpose of Equipment

This equipment measures elapsed time from a zero time reference in one minute intervals for 99,999 minutes. The elapsed time is continuously stored in binary-decimal combination and may be extracted (in coded electrical form) at will upon insertion of an electrical command pulse.

II. Principles of Operation (Refer to Electro-Mechanical Schematic, TEM, Project 74A)

A. Once-per-minute Time Base

1. The time base consists of a standard 8/0 watch movement powered by a Negator spring and started manually at t=o. A cam, mounted on the fourth wheel of the watch, closes a single pole normally open contact for three seconds each minute.

B. Calendar Coded Storage

1.a. Normal operation of the Calendar is controlled by the once-per-minute contacts. When these contacts close, solenoid 1CR is pulsed through R_1C_1, indexing Calendar Disc No. 1 through 3.6^o (1/100 part of a circle). This disc stores units information (minutes) on contact tracks #12, 11, 10 and 9, coded to represent one, two, four and eight, respectively, in a binary yes-no arrangement. As the disc indexes over the stationary contact fingers, these fingers touch either metal or plastic on the printed circuit calendar disc. If a given contact finger touches metal, its track is in "yes," (or closed) condition, and vice-versa. The points where contact fingers touch the discs are shown on the schematic by the intersections of the two lines of a "T." Thus, on disc No. 1, contact fingers #12, 11, 10 and 9 are all shown on plastic, so the units digit is zero. (The entire apparatus is shown reading 00,000 minutes.) After the disc indexes one division, #12 will go to "yes," all others staying "no." But #12 is the code for <u>one</u>, so one minute has gone by. Similarly, after another pulse, #12 goes to "no," #11 to "yes," and all others remain "no." But #11 corresponds to <u>two</u>, so two minutes have elapsed. After the next disc index, #12 goes to "yes," #11 remains "yes," #10 and #9 remain "no." #12 is <u>one</u>, #11 is <u>two</u>, so <u>one</u> plus <u>two</u> equals <u>three</u>, or three minutes have elapsed. The following table summarizes the decimal coding:

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On the tenth pulse, contact finger #2 makes contact with #1 through the disc. This pulses #2CR, which indexes Calendar disc #2 3.6°. Here contact tracks #12, 11, 10 and 9 correspond to tens of minutes exactly as minutes were stored on disc #1. Contact fingers 8, 7, 6 and 5, meanwhile, store 100's of minutes in an exactly analagous fashion. On the one-hundredth index of disc #2, or 1000 minutes after t=o, contact finger #1 becomes energized through finger #3 and pulses 3CR, which in turn, indexes disc #3 3.6°. Contact fingers #12, 11, 10 and 9 here, store 1000's of minutes, while fingers #8, 7, 6 and 5 store 10,000's of minutes.

To summarize, Solenoid 1CR indexes disc #1 3.6° every minute through the once-per-minute contact. Solenoid 2CR indexes disc #2 3.6° every ten minutes through contact track #2 on disc #1. Finally, Solenoid 3CR indexes disc #3 3.6° every 1000 minutes through contact track #3 on disc #2. So one revolution of disc

#1 occurs every 100 minutes, one revolution of disc #2 every 1000 minutes, and one revolution of disc #3 every 100,000 minutes.

1.b. When the respective control circuits are closed, the solenoids are pulsed through series capacitors (C_1, C_2, C_3) connected in parallel with high resistances (R_1, R_2, R_3). The capacitors charge rapidly, giving a pulse of current through the solenoids of about 20 MS duration, and thus limiting the overage operating currents to small values although the control circuits may remain closed for substantial times. When the control circuit opens, the capacitor discharges through the resistor at a rate which insures discharge in one-fifth of the time available before the circuit is reclosed for another solenoid pulse.

2. Provision is made for testing the solenoids and calendar disc index system. External test leads are brought from each solenoid which, when energized through a switch from the minus terminal of the 6 volt D.C. source, will index the respective calendar disc 3.6° for each closing of the switch, and will advance the coded elapsed time storage accordingly. CAUTION: When testing a solenoid, avoid leaving the test switch closed as solenoid heating (and possibly coil burnout) will result. Use of a "momentary" switch is advocated.

C. TEM Sweep

1. This assembly literally "sweeps" over the 20 contacts corresponding to the coded time storage outlined in B. above, and yields an electrical readout corresponding to the yes-no condition of the 20 successive contacts versus the sweep time base. The sweep also provides a reference yes contact just before, and another just after the 20 coded bits. Following the latter reference contact is another contact used for resetting auxiliary equipment. The 24th

and final position of the sweep is a rest position.

The sweep is driven by solenoid CSR which, in turn, is actuated at a 10 cps (nominal) rate by a 10 per second multivibrator. The sweep pickup arm, then, takes 2.4 seconds to make a complete revolution and return to rest, pausing 95 milliseconds on each contact and taking about 5 milliseconds to traverse the interspaces.

2. Sweep Start Circuit

The sweep start is initiated by the insertion of minus six volts at the START SWEEP COMMAND point for a duration of 40 milliseconds minimum, two seconds maximum. If a shorter command is given, the sweep may fail to start or a slow start may occur, so that the first reference bit may be longer than succeeding bits. If a longer command is given, the sweep may repeat.

The command voltage energizes the free-running multivibrator which, in turn, energizes CSR, indexing the sweep bridge 15°. Since the innermost (solid) sweep ring (connected always to -6 volts) is now connected via the short arm of the bridge to the broken ring (which is tied to the multivibrator input point) the command voltage may now be removed and the multivibrator continues operating, indexing the sweep bridge 15° ten times per second.

3. Sweep Readout

A. As the bridge indexes, each of the 24 outermost contacts is successively connected, via the long arm of the bridge, to the outermost solid ring. This is permanently connected to one end of R_5, across which the sweep readout occurs as a time function. The other end of R_5 is the sweep reference level, which is tied to the two sweep reference contacts (discussed in Paragraph II.C.1.), and also to contact finger #4 of each of the three calendar discs. The track for this contact is a solid ring having zero resistance to every "yes" position of contact tracks #12, 11, 10, 9, 8, 7, 6 and 5. Therefore, when the pickup arm of the sweep bridge moves onto any given one of the 20 coded sectors, R_5 is shorted out if that particular sector is in the "yes" condition, and unaffected if the sector is in the "no" condition.

B. Readout of the time code through the sweep may be accomplished by using a 1000 cycle A.C. voltage or a D.C. voltage. The result will be two levels of A.C. or D.C. depending upon the condition of the contacts. For example, an input of 1 KC alternating current at 6 volts peak to peak will show an output of approximately 3 volts representing zeros and 6 volts representing ones in the binary code.

Appendix II illustrates a system of readout using direct current excitation.

4. Sweep Stop Circuit

The sweep breaks its own energization at the completion of one revolution, when one end of the short sweep arm stops in the break of the broken sweep ring. This, the rest position, is the one shown in the electromechanical schematic of TEM.

5. Coincidence Circuit

Since the initiation of TEM sweep may occur at any time, a means of preventing calendar indexing while sweep is in progress, has been provided. (If calendar indexing occured during sweep readout, the coded readout could become meaningless.) A relay, ST_2, is connected in such a way that it is energized whenever the sweep 10 per second multivibrator is energized. A normally closed contact of this relay is in series with the once-per-minute watch contacts. Thus, during sweep, these relay contacts open and 1CR (and therefore, 2CR and 3 CR) cannot operate even if the once-per-minute contacts close. However, since this relay is energized for 2.4 seconds (sweep duration) and the once-per-minute contacts close for three seconds, calendar indexing (if blocked by ST_2) would occur immediately following completion of sweep operation. Thus, no time is lost by this coincidence "lock-out" circuit.

III. Description of Hardware

A. Once-per-minute Time Base

1. Negator Spring: This spring, located in the bottom plate assembly, powers the watch movement through a step-up gear, for a minimum of sixty days. The spring exhibits essentially a constant-torque characteristic over its entire travel.
2. Watch and once-per-minute Contact Assembly: This assembly is drawer mounted in the rear of the unit, just below the center plate. The balance wheel may be observed from below, and the entire assembly is accessible when the drawer is removed. Removal entails unsoldering the leads from the two feed through terminals at the outer bottom side of the drawer. CAUTION: When removing the watch drawer, the NEGATOR SPRING must be firmly HELD to avoid violent uncoiling with resultant damage to the unit. The contact assembly consists of gold-plated phosphor bronze contacts, insulated from the watch plate, and designed to reduce closing and opening bounce to less than 1 millisecond duration. These contacts are closed by the action of a cam on the 4th wheel of the watch movement. This wheel rotates once per minute.
3. Starting Watch: The watch is started (unhacked) by pushing <u>in</u> firmly on the rubber covered lever at the rear of the TEM unit.

The unit is supplied with the watch stopped (hacked), and once it has been unhacked, there is no provision for rehacking unless the unit is removed from its case and the hacking lever pulled <u>out</u> firmly.

B. Calendar Assembly

1. Solenoid drive and ratchet assembly: When the solenoid is energized, the plunger closes and the driving arm, being an extension of the plunger, advances the 100 tooth ratchet wheel a distance of one tooth. Overtravel is prevented by a stop pin located near the ratchet wheel, which pin squeezes the driving arm between itself and the ratchet wheel. At the completion of the stroke, a detent spring on the opposite side of the ratchet wheel falls into the root of the next tooth, preventing the ratchet wheel from backing up when the driving arm is withdrawn. When the solenoid is de-energized, a return spring (located at the front of the solenoid and mounted to the solenoid housing) pushes the plunger and driving arm back to the open position, where travel is stopped by a pin attached to the solenoid mounting. Another pin, running through the back of the plunger and affixed to the housing is used to prevent plunger rotation within the solenoid.
2. The ratchet wheel shaft turns in a jewelled bearing at its lower end (on the center plate) and has a shouldered bearing at its top end (upper plate). This shouldered bearing acts as a thrust bearing, since the calendar disc and hub assembly is mounted transversely on the top of the shaft and is pushed upward by the pressure of the printed circuit contact fingers. CAUTION: Removal of the calendar disc, or of the disc and hub assembly, entails a difficult re-alignment of the calendar ratchet assembly. **CAUTION:** The calendar

ratchet assembly should, under no circumstances, be turned backward (clockwise as viewed from the top of the TEM unit) as damage to delicate parts will result. It is advisable never to attempt to turn the discs manually, in view of the above.

3. Calendar disc and contact assembly: The calendar disc is a circular brass-backed printed circuit composed of rhodium plated copper, gold flashed, in a smooth, hard transparent plastic bed. The disc rides face down pressing against the contact fingers which are of Paliney #7 on disc 1 and of gold alloy [redacted] STAT on discs 2 and 3. These contacts are electrically connected to the circuitry of the printed circuit plate and mechanically fastened to the plastic body of the plate. This plate is of epoxy, with photoetched plated copper circuitry. (An improvement in the construction and material of this plate is anticipated for future units.) The disc is held to a hub with three screws visible from the top of the unit. The hub, in turn, is threaded down to the top of the ratchet shaft. This action draws the disc down to bear against the contact fingers.

C. TEM Sweep Assembly:

1. Solenoid drive and ratchet assembly: The sweep solenoid is electrically and mechanically identical to the calendar solenoids, with the exception that no series capacitance is used to operate the sweep solenoid

2. The sweep ratchet shaft mounts a large gear which drives the sweep bridge shaft through a speed up gear. All shafts are jewelled at the center plate bearings.

APPENDIX II

TIME EVENT MARKER SWEEP READOUT USING D.C. EXCITATION

Purpose: This test setup can be used for reading out the time stored in the TEM Calendar as a series of two level marks on an oscillograph tape. These marks can be readily decoded to show the time in minutes.

Equipment: Equipment used includes a pen type oscillographic recorder, (A brush type P-04 was used at [redacted] which can be operated by 6 volts D.C., a 6 volt D.C. supply and a 600 ohm resistor.

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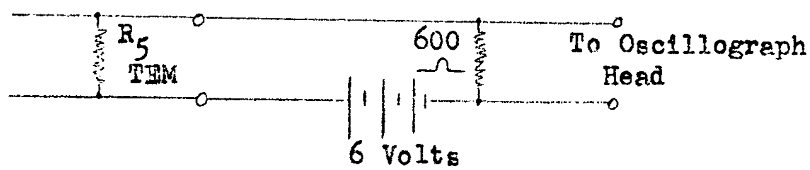
Circuit:



Operation: Operation of the time event marker sweep readout shorts and unshorts R_5. When a current is passed thru TEM from the 6 volt supply, the shorting allows more current to pass, giving a higher voltage across the 600 ohm resistor. The oscillograph pen circuit is set to operate on the differential between the two resulting voltages. The attached chart illustrates the result.

[redacted]

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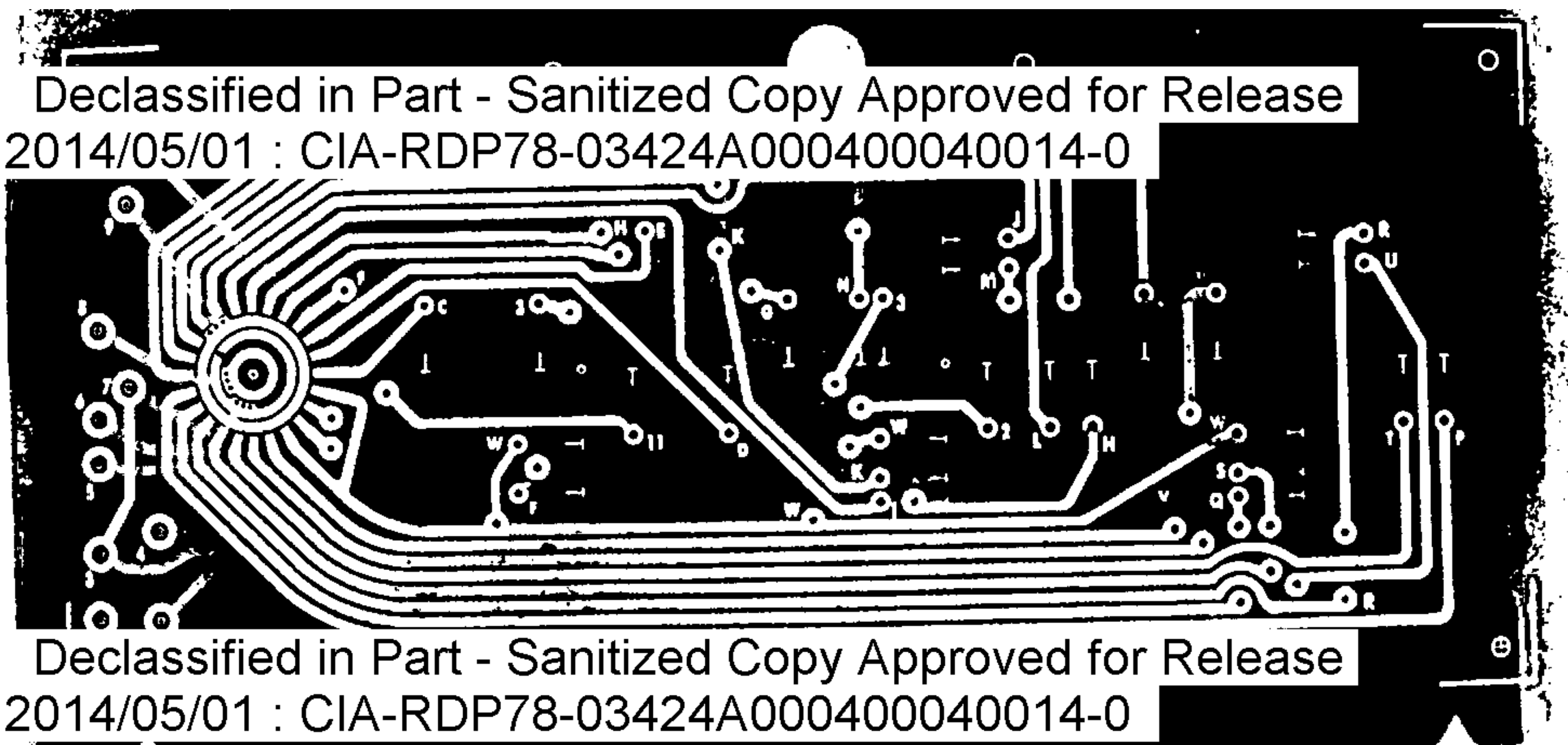

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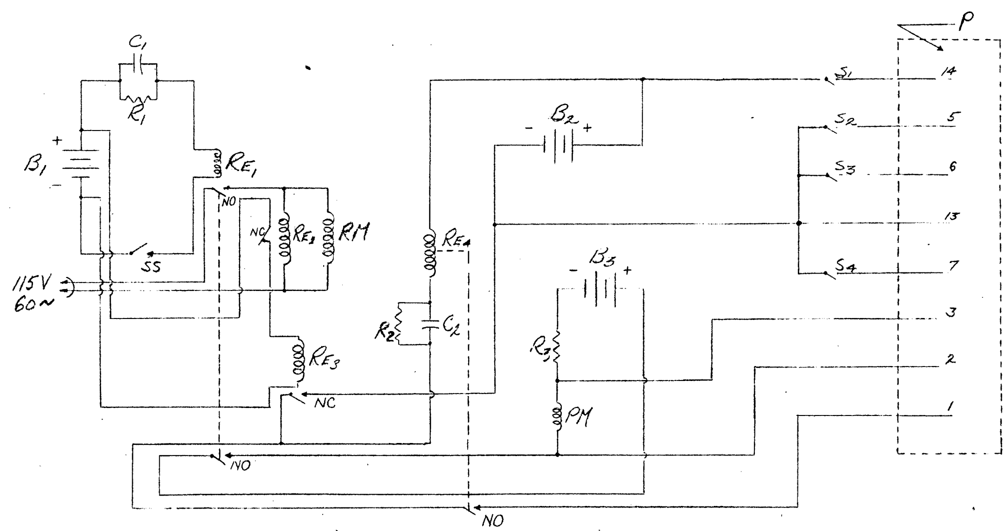

R_1 - 100K
R_2 - 10K
R_3 - 465
C_1 - 525 μfd
C_2 - 250 μfd
R_{E_1} - Elgin S.Y-2C-8000 (DPDT 28VDC)
R_{E_2} - Amperite 1 Sec Thermal
R_{E_3} - Allied Control RSH-30-6330 (SPDT 29V)
R_{E_4} - Elgin Neomite NM-1C-220 (SPDT 6-10V)
R_M - Recorder Motor
P_M - Pen Motor
S_1 - SPST Power
S_2 - SPST 1CR Test
S_3 - SPST 2CR Test
S_4 - SPST 3CR Test
B_1 - 24 V
B_2 - 6 V
B_3 - 12 V
P - Connector, Amphenol (on TEM)
SS - 1/10 Min. Timer (on 2 Min, Off 8)

ITEM NO.	NO. REQ.	DESCRIPTION	DWG. NO.

ITEM NO.	FINISH	NO. REQUIRED
MATERIAL	HEAT TREAT	HARDNESS

STAT

CHGE. LET.	REVISION	DATE	CH'D	APP'D

UNLESS OTHERWISE SPECIFIED
1—REMOVE ALL BURRS AND SHARP CORNERS.
2—TOLERANCES ON MACHINING DIMENSIONS ARE, FRACTIONAL ± .010; DECIMAL ± .003; ANGULAR ± ½°.
3—TOLERANCES ON DRILLED HOLES; WIRE GAGE DRILLS PLUS OR MINUS NEXT DRILL SIZE NOT TO EXCEED PLUS OR MINUS .002. LETTER AND FRACTIONAL DRILLS UP TO ⅜ DIA. PLUS .002 MINUS .001. OVER ⅜ DIA. PLUS .004 MINUS .002.
4—THREAD LENGTH DIMENSIONS ARE FOR FULL THREADS
5—DO NOT SCALE DRAWING.

TITLE
TEM TEST (74A)
Wiring Schematic

SCALE	SHEET NO.	OF	SHEETS
DWG. BY	DATE 3/28/58	DWG. NO.	
CHECKED	DATE 4/1/58	B	
APP'D.	DATE		

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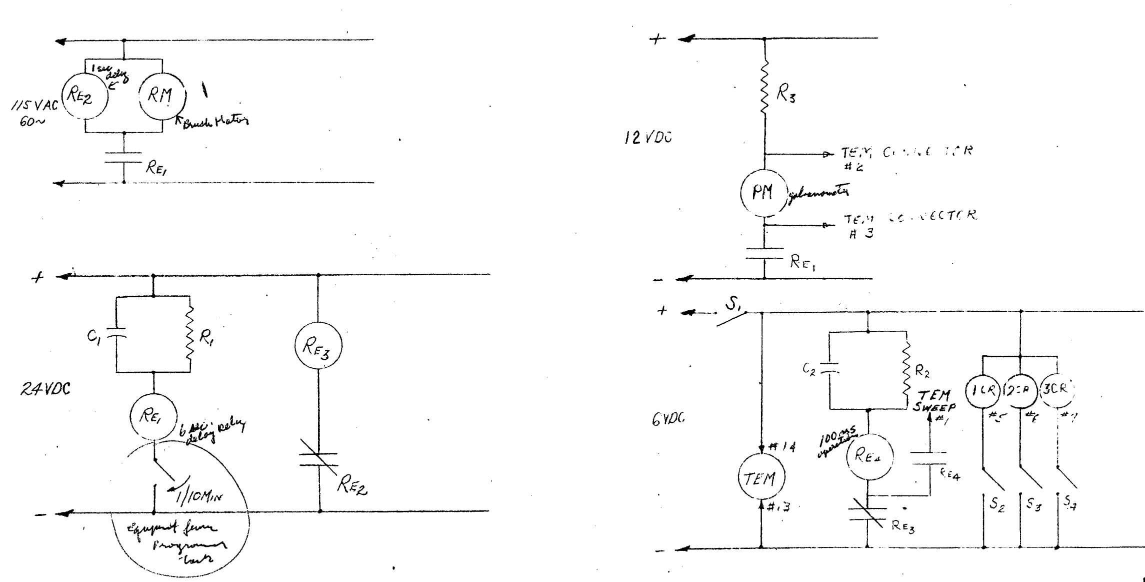

R_1	100 K
R_2	10 K
R_3	465 Ω
C_1	525 ufd
C_2	250 ufd
R_{E1}	Elgin CY-20-8??? DPDT 6V
R_{E2}	Amperite 1 Sec Thermal
R_{E3}	Allied Control RSH-3D-??? SPDT 24V
R_{E4}	Neomite NM-1C-22? SPDT 6V
RM	Recorder Motor
PM	Pen Motor
S_1	SPST Power
S_2	SPST 1CR Test
S_3	SPST 2CR Test
S_4	SPST 3CR Test
B_1	24V
B_2	6V
B_3	12V

ITEM NO.	NO. REQ.	DESCRIPTION	DWG. NO.

ITEM NO.	FINISH	NO. REQUIRED
MATERIAL	HEAT TREAT	HARDNESS

STAT

CHGE. LET.	REVISION	DATE	CH'D	APP'D

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4—THREAD LENGTH DIMENSIONS ARE FOR FULL THREADS
5—DO NOT SCALE DRAWING.

TITLE
TEM TEST ?7-A
Line Schematic

SCALE	SHEET NO.	OF	SHEETS
DWG. BY	DATE 3/28/53	DWG. NO.	STAT
CHECKED	DATE 4/1/53	B	
APP'D.	DATE		

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