113BR

WLETT-PACKARD COMPANY / OPERATING AND SERVICE MANUAL

113BR

FREQUENCY DIVIDER AND CLOCK

INCLUDING H02 113BR

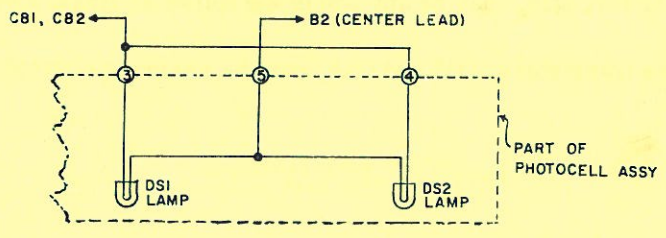
MANUAL CHANGES

MODEL 113BR

FREQUENCY DIVIDER AND CLOCK

Serials Prefixed: 107-
Manual Printed: 5/61

The following changes adapt this manual to instruments having the serial prefixes listed below:
(Ch. # = Change Number; Ser. Pre. = Serial Prefix)

Ch. #	Ser. Pre.	New Data
1	107-	Table 1-1, (Specifications) under PULSE OUTPUTS: Change line 3 (Rise Time) under Positive* 1-kc Pips to read: 2V/μsec min. Paragraph 2-12, Add: A capacitor must be added to instruments modified for operation from a positive supply (negative ground). Install a 1000 microfarad, 50 vdcw, fixed, electrolytic, (hp Stock No. 0180-0090) at the rear of the chassis near J10 (add a bracket). Connect negative terminal of capacitor to pin C of J10; connect positive terminal to pin D of J10. Figure 5-6, Transformer T11 should be labeled T10, and transformer T12 should be labeled T11. Figure 7-1, Change "1/4 RPH gear and ratchet" to "1 RPH gear and ratchet". Transistor types 2N1008, 2N1008A, or 2N1008B may be used for Q1 - Q11 and Q18. If the 2N1008 family is used in the frequency divider (Q1-Q8), mixer base resistors R16 and R46 must be 1000 ohms, 1/2 watt (hp Stock No. 0687-1021). Note: Transistors in the 100-kc to 10-kc divider (Q1-Q4) and in the 10-kc to 1-kc divider (Q5-Q8) should be restricted to either the 2N1008 family or the 2N1373 (as shown on schematic) and not mixed. Capacitor C93 on schematic diagram is shown with polarity reversed. Negative terminal of C93 should be connected to junction of R88-R89; positive terminal should be connected to J8 and pin A of J6.
2	110-	For instruments with Serials Prefixed: 110-, include the following changes: C20: Change to capacitor, fixed, mica, 330pf ±10%, 500 vdcw; hp Stock No. 0140-0043, Mfr., 76433. R13: Change to resistor, fixed, composition, 5600 ohms ±10% 1/2 W; hp Stock No. 0687-5621, Mfr., 01121.
3	110-00175 thru 110-0250	For instruments with Serials 110-00175 thru 110-0250, include the following changes: (1) Figure 8-2 and Table 9-1, change: R97 to 1500 ohms, stock no. 0727-0110. (2) Table 9-1, change: A1 to photocell assembly (includes DS1, DS2, V1), stock no. 113B-23B. (3) Table 9-1, add: lamp DS2, description and stock no. same as DS1. (4) Table 9-1, change: lamp support for DS1 to stock no. 113B-54A. (5) Figure 8-2, add: lamp DS2 in parallel with DS1 as shown below: 

12/20/61

Ser. Pre.	New Data

110-00175 thru 110-0250

(6) Paragraph 3-5d, add the following sentences: Readings normally vary between "6" and "9". Excessively high or low readings or a sudden change in readings indicates that a thorough maintenance check should be made (see table 6-2).

(7) Paragraph 5-27, change to read: ...from DS1 and DS2 to fall...

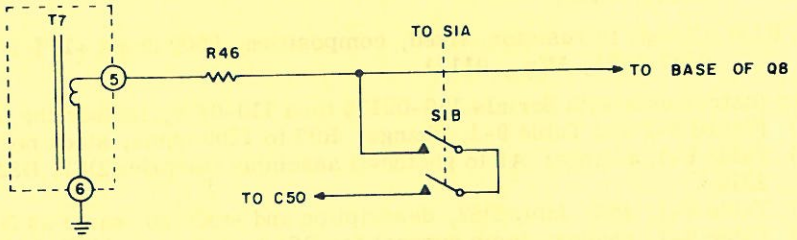
(8) Figure 5-6, add: lamp DS2 adjacent to lamp DS1.

(9) Add to Table 6-2:

CIRCUIT STATUS	METER READINGS				
	SUPPLY	100KC	10KC	1KC	CLOCK
Failure of either DS1 or DS2	6.5	7	7	7	6.5
Failure of both DS1 and DS2	6.5	7	7	7	4.5

(10) Delete Paragraph 7-4. Add the following:
7-4. PHOTOCELL AND LAMPS. Clock operation should be continued without interruption during removal of the photocell assembly and replacement of DS1, DS2, or V1. To remove the assembly (located at right side of clock mechanism) remove only the two large retaining screws (8-32 binding head) at the front of the assembly. Do not loosen the two smaller screws located to the rear of the retaining screws. The lamps and photocell can then be extracted individually after loosening the setscrews in the assembly housing. Disconnect defective component and install replacement component carefully using an insulated (ungrounded) soldering iron; do not short component leads to other wires or to the chassis.

Figure 8-1,
Connect S1B as follows:



4 132- This manual, including the above changes, applies.

5 All Regulator transistor, Q19, may be any one of the following types: 2N458A, 2N1905 or 2N297A.

Power amplifier transistors, Q12 and Q13, may be either type 2N458A or 2N297A.

OPERATING AND SERVICING MANUAL

MODEL 113BR

SERIALS PREFIXED: 107 -

AND

SPECIFICATION H02 113BR

FREQUENCY DIVIDER AND CLOCK

01044-1

Printed: MAY 1961

This manual has been carefully prepared to help you operate and maintain your equipment. Technical content follows the requirements of most military specifications including MIL-H-7960, MIL-M-9848, and MIL-M-16616; typography generally conforms to MIL-M-5474 and MIL-M-4410. We welcome suggestions for additions and corrections. Please address your comments to Publications Supervisor, Hewlett-Packard Co., 1501 Page Mill Road, Palo Alto, California.

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Table 1-1. Specifications

Characteristic	Pulse Outputs: Positive Tick	Negative Tick	Auxiliary Pulse	Positive * 1-kc Pips
Pulse Rate	1 pps	1 pps	1 pps	1000 pps
Amplitude	+10 v, min **	-10 v, min **	+4 v min open ckt +2 v min into 50 Ω	+4 v min
Rise Time	2 μsec, max	2 μsec, max	1 μsec, max	2 μsec, max
Duration	20 μsec, min	20 μsec, min	200 μsec	20 μsec, min
Jitter	1 μsec, max	1 μsec, max	1 μsec, max	1 μsec, max
Recommended Load Impedance	4700 Ω min shunted by 200 pf max	1M Ω min shunted by 100 pf max	50 Ω min shunted by 5000 pf max	1000 Ω min shunted by 1000 pf max
BNC Location	rear	front	rear	rear

* Negative pulses available on special order.
** For any load impedance higher than minimum recommended.

Auxiliary Output:
100, 10 and 1 kc sinusoidal, 0.25 volts rms, min. Source impedance 12,000 ohms nominal. Front panel BNC connectors.

Input Frequency:
100 kc for solar time, input bandwidth ± 300 cps.
100.3 kc for sidereal time, on special order.

Accuracy:
1) Accuracy of output pulse and sine-wave signals determined by accuracy of input frequency.
2) Time reference dial linearity ±10 μsec.

Input Voltage:
0.5 to 5 volts rms.

Input Impedance:
300 ohms nominal

Time Reference:
Continuously adjustable. Directly calibrated in 10 microsecond increments on dial and in milliseconds on mechanical counter.

Frequency Divider:
Manually starting, regenerative type fail-safe.

Effect of Transients:
Will not gain or lose time because of
1) ±300 volt step function on 100 kc input.
2) 0 to 50 volt pulses, 0 to 500 pps, 1 to 10 μsec duration on 100 kc input.
3) ±4 volt step in 26 vdc input.

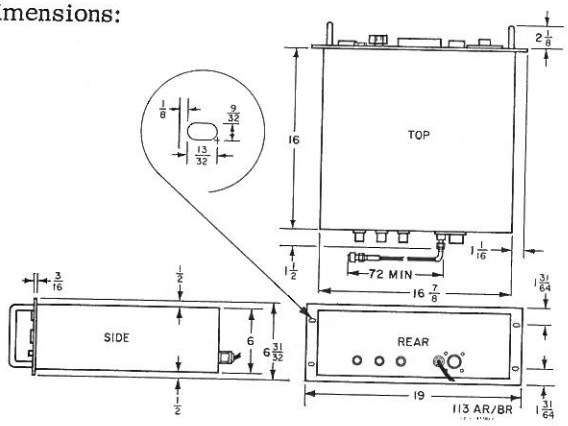
Clock Mechanism:
24-hour dial; minute hand adjustable in 1 minute steps; second hand continuously adjustable. Manual start. Front panel adjustment of clock hands does not affect tick output. (12-hour dial on special order.)

Monitor Meter:
Ruggedized meter and selector switch on front panel for checking supply voltage, divider operation (100 kc, 10 kc, 1 kc) and total clock current.

Power Required:
22-30 vdc, approximately 2 watts; recommended supply, hp 724BR or 725AR.

Power Connector: GS02-14S-2P-112

Dimensions:



Weight:
Net 35 lbs. shipping approximately 51 lbs.

Accessory Furnished:
113A-16E Cable, 6 feet long (connects 113BR to 724BR or 725AR Standby Power Supply).

Complementary Equipment:
hp 724BR Standby Power Supply, 16 ampere-hour standby capacity with batteries.
hp 725AR Standby Power Supply, 2 ampere-hour capacity.
hp 103AR Quartz Oscillator.
hp 120AR Oscilloscope.

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. This manual provides complete instructions on installation, operation, and maintenance of the Hewlett-Packard Model 113BR Frequency Divider and Clock (figure 1-1) and the Specification H02 113BR Frequency Divider and Clock. This manual applies directly to all instruments with serial numbers prefixed 107-. Serial number is stamped on rear of cabinet and on serial number tag on chassis inside cabinet.

1-3. DESCRIPTION.

1-4. The Model 113BR is a component instrument in the Hewlett-Packard frequency and time standard system (see paragraph 1-8). Instrument specifications are listed in table 1-1. The Model 113BR indicates time on a standard clock face and provides 1-pps output pulses or ticks whose phase can be manually adjusted using a calibrated front-panel control. In operation, the phasing control is adjusted to give time coincidence between the clock tick and a master timing tick. The time difference between two phase settings can be read directly from the phasing control and is used to compute system oscillator frequency.

1-5. The Specification H02 113BR is a standard Model 113BR which has been tuned for sideral time operation, using an input frequency of approximately 100.27379091 kc. The tuned circuits which are affected include T1 through T8.

1-6. In this manual, the Model 113BR Frequency Divider and Clock is referred to as the "clock".

1-7. The clock meets the performance requirements of military specification MIL-E-16400 and is suitable for mobile operation. Fail-safe operation is provided by using non-self-starting frequency dividers and a non-self-starting synchronous clock motor. The clock therefore either continues to operate without error or ceases operation completely in case of momentary failure of either the external power supply or the external frequency standard.

1-8. SYSTEM CONCEPT.

1-9. The general idea behind frequency determination by means of time comparisons is this: A precision oscillator drives a synchronous-motor clock (figure 1-2); if the oscillator frequency is exactly its nominal

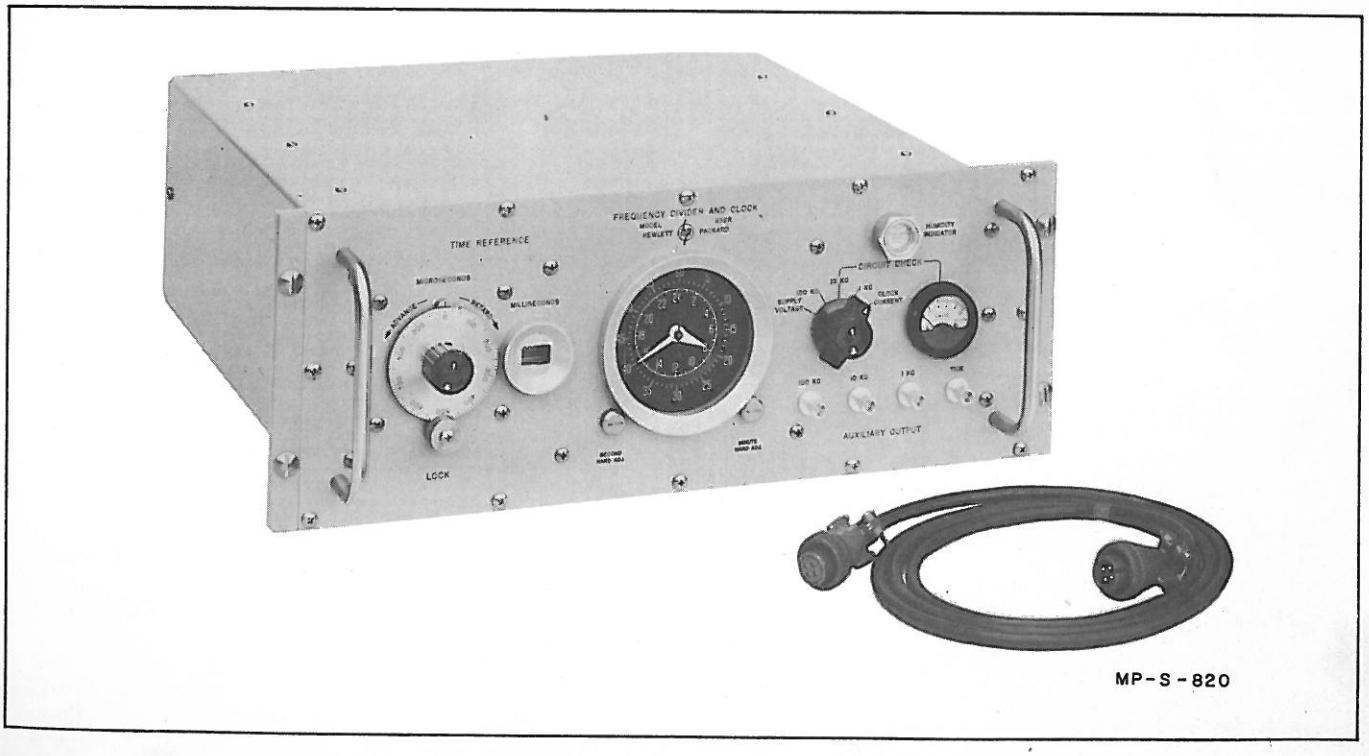


Figure 1-1. The ⓗⓟ Model 113BR Frequency Divider and Clock

value, the clock will keep correct time indefinitely; if the oscillator frequency is high, the clock will continuously gain time, and if the oscillator frequency is low, the clock will continuously lose time. The time error, expressed as a fraction, is equal to the average oscillator error during the measurement period.

1-10. As an example, if the clock apparently gains 2 milliseconds relative to a true time interval, taken from a master standard, of 1,000,000 seconds (approximately 12 days), the time error is $+2 \times 10^{-3}$ sec/10^{6} sec or $+2 \times 10^{-9}$ and the average oscillator frequency during the test interval is 2×10^{-9} higher than its nominal 100 kc frequency.

1-11. Refer to Hewlett-Packard Application Note 52, "Frequency and Time Standards" for a discussion of system operation and alternative methods of frequency and time control.

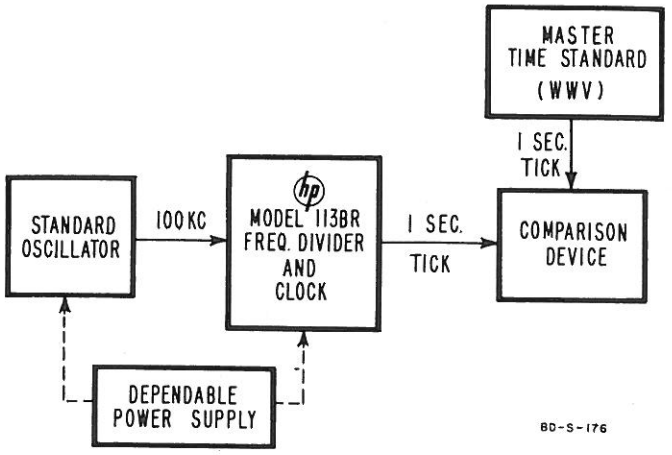


Figure 1-2. Relationship to Frequency and Time Standard System

CAUTION

STANDARD INSTRUMENTS ARE CONNECTED FOR OPERATION FROM A NEGATIVE 24-VOLT SUPPLY (POSITIVE GROUND). MODIFICATION INSTRUCTIONS FOR OPERATION FROM A POSITIVE SUPPLY (NEGATIVE GROUND) ARE GIVEN IN PARAGRAPH 2-12.

SECTION II
PREPARATION FOR USE

2-1. UNPACKING & MECHANICAL INSPECTION.

2-2. Inspect instrument for shipping damage as soon as it is unpacked. If reshipment is expected, save all packing materials to simplify repackaging. Check for broken knobs, meter faces, or connectors; inspect painted surfaces for scratches or abraided areas. If instrument is damaged in any way, notify the carrier immediately to report damage.

2-3. PACKING FOR STORAGE OR RESHIPMENT.

2-4. To properly protect valuable electronic equipment during storage or shipment always use the best packaging methods available. Your Hewlett-Packard sales office can provide packing material such as that used in original factory packaging. Contract packaging companies in many cities can provide dependable custom packaging on short notice. The following packaging methods are recommended for the clock:

a. ORIGINAL. Place instrument in original container. Replace all packing pads and fillers in the exact position which they originally occupied.

b. RUBBERIZED HAIR. Cover painted surfaces of instrument with protective wrapping paper. Pack instrument securely in strong corrugated container (350 lb/sq.in. bursting test) with 2-inch rubberized hair pads placed along all surfaces of the instrument. Insert fillers between pads and container to ensure a snug fit on all surfaces of the instrument.

c. EXCELSIOR. Cover painted surfaces of instrument with protective wrapping paper. Pack instrument in strong corrugated container (350 lb/sq.in. bursting test) with a layer of excelsior about 6 in. thick packed firmly against all surfaces of the instrument.

2-5. Environmental conditions during storage and shipment should normally be limited as follows:

a. Maximum altitude 20,000 feet (6,150 m).

b. Minimum temperature -80°F (-62°C).

c. Maximum temperature 167°F (75°C).

2-6. INSTALLATION.

2-7. Mount the clock in a standard rack. Ambient temperature in the rack during operation should not exceed a maximum of 122°F (50°C) or a minimum of 32°F (0°C).

2-8. Connect socket end of power cable (supplied with clock) to 24 VDC INPUT connector (J15) on rear of clock. Special power cables may be fabricated using a type MS3106E-14S-2S connector. The following supply polarity is required on all instruments: Negative to pin C, positive to pin D.

2-9. Connect pin end of power cable to Model 724BR or 725AR Standby Power Supply or equivalent.

CAUTION

Damage to equipment may result if improperly polarized or improperly grounded power supply is connected to power input connector J15 of clock. Standard instruments are connected for operation from a negative 24-volt supply (positive ground). Pin D of J15 is internally connected to chassis. If clock is to be operated from positive supply (negative ground), see paragraph 2-12 for clock modification details.

2-10. Connect shielded cable (BNC connectors) between 100 KC INPUT connector (J14) on rear of cabinet and "100-kc output" connector of Model 103AR or 104AR Quartz Oscillator or equivalent standard oscillator. Oscillator output should be within 300 cps of 100 kc. An alternative 100 kc input connector (J9) and power connector (J10) located on the chassis may be used for operation when the cabinet is removed.

2-11. The clock is now ready for operation. See paragraph 3-3 for starting instructions. Output connections from the clock (J1, J2, J3, J4, J11, J12, J13) to the time comparison device can be made at any time (during operation, if desired). Connection depends on individual system requirements: For operation with Model 114BR Time Comparator, connect BNC-to-BNC cable between TICK OUTPUT (J11) at rear of clock and MASTER TICK input at rear of Model 114BR; for operation with oscilloscope only, connect TICK AUXILIARY OUTPUT (J4) on front panel to horizontal input connector on oscilloscope. Refer to Application Note 52, "Frequency and Time Standards", for information on various system arrangements.

2-12. MODIFICATION FOR OPERATION FROM POSITIVE SUPPLY (NEGATIVE GROUND).

2-13. To operate the clock from a positive 24-volt supply (negative ground), modify standard wiring as follows:

a. Remove the 12 screws around the edge of the front panel. Do not loosen any other screws. Slide the chassis out of the cabinet.

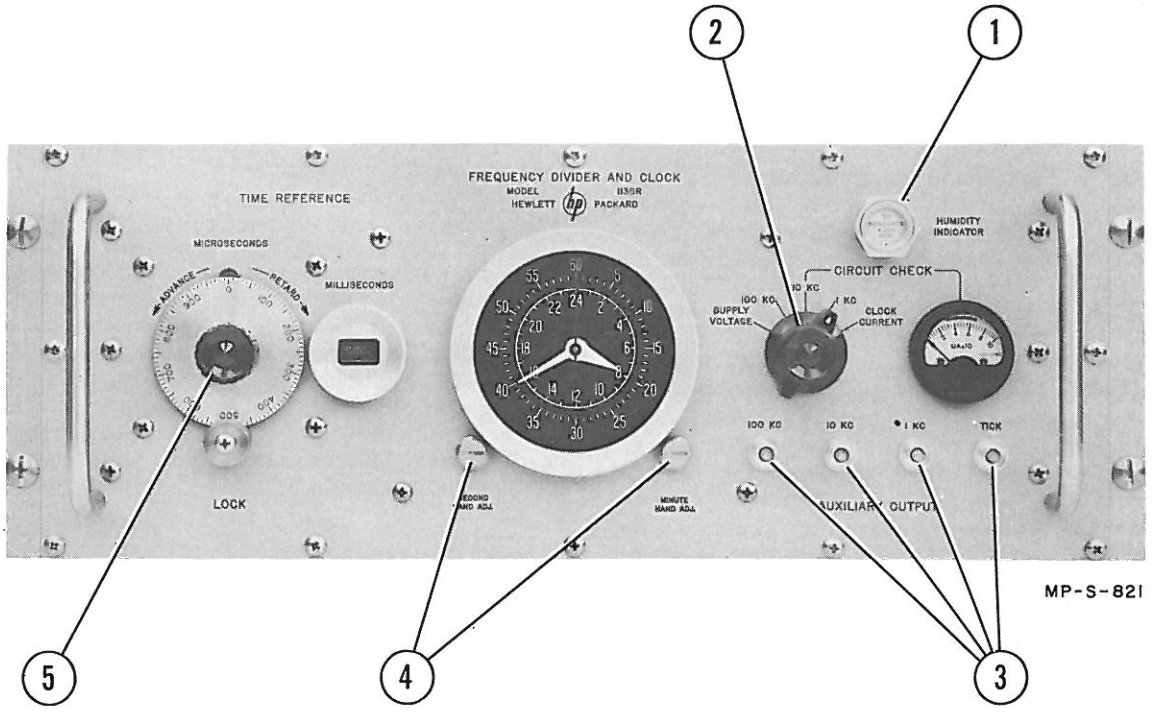
b. Remove cabinet grounding wire from pin D of J15.

c. Solder cabinet grounding wire to pin C of J15.

d. Remove cabinet grounding wire from one LOAD terminal of FL1.

e. Solder cabinet grounding wire to originally unused LOAD terminal of FL1.

f. Replace cabinet.



1. HUMIDITY INDICATOR should be blue in color. Reactivate desiccant if color becomes pink.

2. CIRCUIT CHECK switch and normalized meter.

   SUPPLY VOLTAGE position checks input voltage.

   100 KC, 10 KC, and 1 KC positions monitor currents within the frequency divider circuits.

   CLOCK CURRENT position monitors current supplied to clock motor, motor drive amplifier, and frequency divider circuits.

3. AUXILIARY OUTPUT provides 1-pps TICK for oscilloscope trigger and sine-wave signals at 100 KC, 10 KC and 1 KC.

4. SECOND HAND ADJ. and MINUTE HAND ADJ.: Screwdriver controls for clock hand position are located behind front-panel plugs.

5. TIME REFERENCE control shifts phase of the 1-pps TICK, AUXILIARY PULSE, and 1 KC pip outputs. These outputs are available at J11, J12, and J13 on rear of chassis cover and at J4 (TICK) on front panel.

   One full rotation of the MICROSECONDS dial, equivalent to a time shift of 1000 microseconds, will change the MILLISECONDS indicator by one count.

   Clockwise rotation (in the direction of the RETARD arrow) of the MICROSECONDS dial will shift the TICK, 1 KC, and 100 MS outputs ahead in time.

Figure 3-1. Front-Panel Controls

SECTION III
OPERATING INSTRUCTIONS

3-1. POWER SUPPLY.

3-2. Power is supplied continuously to the clock while the Model 724BR or 725AR Standby Power Supply or equivalent is connected. The clock is not equipped with a power on-off switch. To remove power from the instrument, disconnect the power connector from J15 at the rear of the cabinet or unplug P10 on the chassis (inside cabinet).

3-3. STARTING PROCEDURE.

3-4. The clock is ready for starting after the 100-kc input signal and 24-volt power supply are connected. Proceed as follows:

a. Remove the 12 screws around the edge of the front panel. Do not loosen any other screws. Slide the chassis partially out of the cabinet.

b. The START switch for the frequency divider circuits is located on a vertical panel directly behind the right edge of the clock mechanism (gear box). First operate the switch UP momentarily to start the 100-kc to 10-kc divider. Then operate the switch DOWN momentarily to start the 10-kc to 1-kc divider. You should be able to hear a slight 1000-cps whine after the 10-kc to 1-kc divider starts operating.

c. The motor starting knob is located on the rear of the clock motor. Spin the knob rapidly clockwise (as viewed from the front panel) using the right forefinger. The clock will start if the motor is spun at or above its synchronous speed. If the clock motor starts at a subsynchronous speed, indicated by high motor noise and slow movement of clock hands, spin the starting knob faster.

d. Slide the chassis into place and replace the 12 panel screws.

3-5. FRONT-PANEL CONTROLS. (See figure 3-1)

a. HUMIDITY INDICATOR normally is blue in color. A pink color indicates that relative humidity is higher than about 30%, requiring desiccant reactivation. If the cabinet is removed temporarily, atmospheric moisture may turn the indicator pin; allow about two hours for indicator color to return to normal after replacing the cabinet. Refer to paragraph 4-5 for desiccant reactivation instructions.

b. CIRCUIT CHECK meter readings should be recorded daily in the system log to provide maintenance information for future use.

c. AUXILIARY OUTPUT connectors provide 10-volt negative pulses at 1 pps and 0.25-volt (rms) sine-wave signals at 100 KC, 10 KC, and 1 KC. Accidental shorting of these connectors does not affect clock operation.

d. SECOND HAND ADJ. and MINUTE HAND ADJ. screwdriver controls are located behind front-panel plugs. Clock hands can be adjusted while the clock is running. Be sure to replace the plugs securely after hand adjustment to maintain the water-tight cabinet seal.

e. TIME REFERENCE control provides adjustment for the phase of the TICK, 1 KC and AUXILIARY PULSE outputs. A small division of the MICROSECONDS dial represents 10 microseconds. A full turn of the MICROSECONDS dial represents 1000 microseconds or one millisecond. Full turns of the MICROSECONDS dial are indicated on the MILLISECONDS shaft-rotation counter. To read the MILLISECONDS indicator if two numerals in a single column are visible when the MICROSECONDS dial is near "0", (1) use the smaller numeral if the MICROSECONDS dial reads between "950" and "0", (2) use the higher numeral if the MICROSECONDS dial reads between "0" and "50".

NOTE

Specific operating techniques vary widely depending on individual requirements. For additional information on operation and data interpretation, refer to Application Note 52, "Time and Frequency Standards".

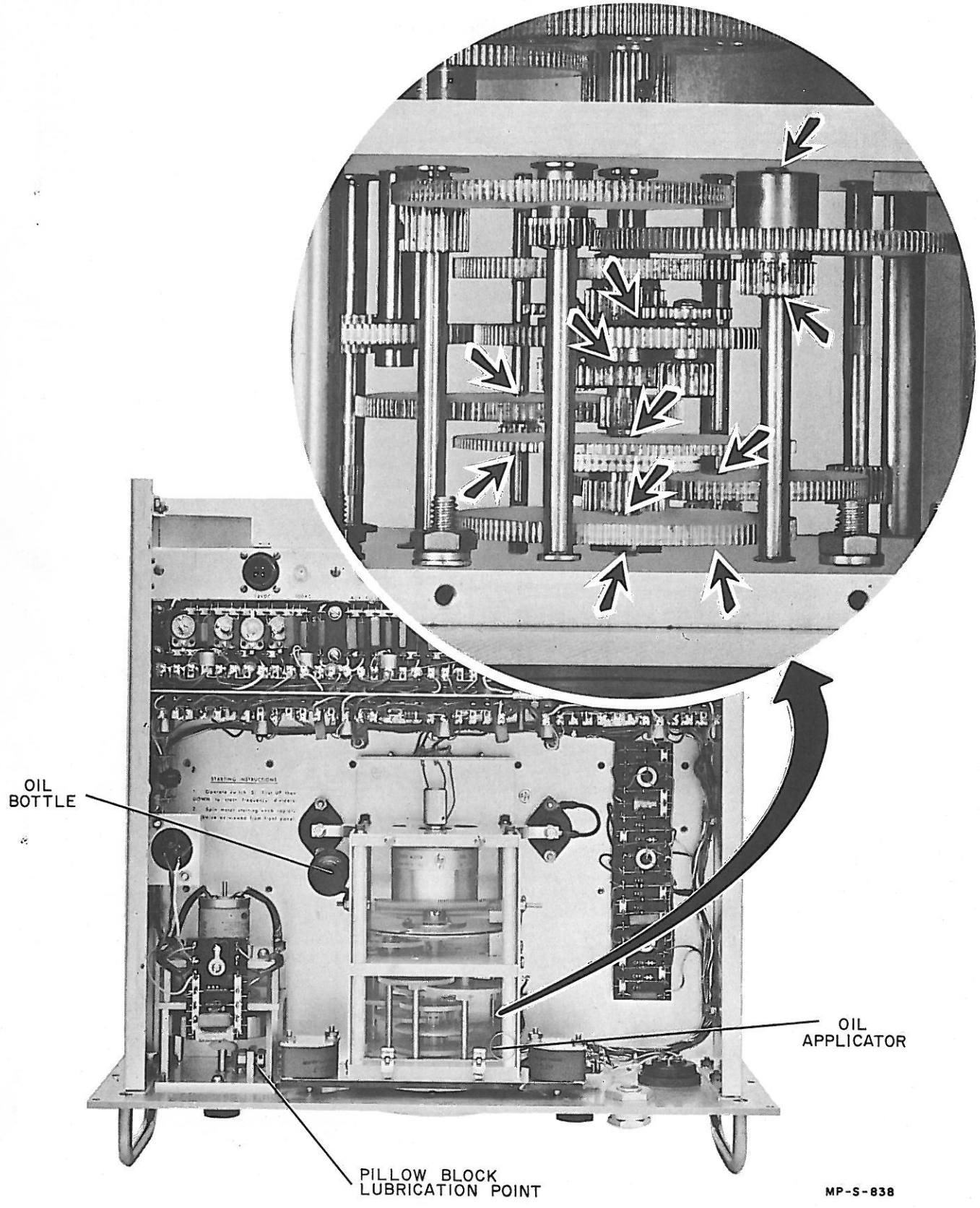


Figure 4-1. Lubrication Points

SECTION IV

PERIODIC INSPECTION AND MAINTENANCE

4-1. DAILY INSPECTION.

4-2. The following daily checks made by the operator help keep the clock functioning properly.

a. HUMIDITY INDICATOR should be blue in color. If color is white or pink, desiccant requires a reactivation. See paragraph 4-5.

b. CIRCUIT CHECK meter indication is normalized to give readings between 6 and 9 at each switch position. Departure from this range indicates either marginal operation or a circuit malfunction. Keep permanent record of CIRCUIT CHECK meter readings to simplify future maintenance.

4-3. BEARING LUBRICATION.

4-4. Lubricate clock bearings once every six months. The clock may be left running while the bearings are lubricated. Proceed as follows:

a. Remove instrument from cabinet. Instrument can be slid out after removing the 12 screws around the edge of the front panel. Do not loosen any other screws.

b. Remove the clear plastic cover from the clock gear box (remove two rear screws, loosen two front screws). A wire oil applicator is attached to the front screws of the plastic cover.

c. The oil bottle is located on the left side of the clock gear box. The oil supplied with the clock is a special lubricant and should be used exclusively on all lubrication points.

d. Apply one drop of oil to each of the lubrication points shown in figure 4-1. There are 11 points in the gear box and 1 point on a bearing behind the TIME REFERENCE indicator.

e. Replace the gear-box cover; slide instrument into cabinet and replace screws around edge of panel.

4-5. DESICCANT REACTIVATION.

4-6. Silica-gel desiccant is used within the clock to reduce the internal relative humidity. The normally blue color of the HUMIDITY INDICATOR turns pink if the relative humidity is greater than about 30%, indicating that it is necessary to remove and dry the desiccant.

4-7. Atmospheric moisture may turn the indicator pink if the instrument is removed from its cabinet. Allow about two hours for the humidity to return to normal after returning the instrument to the cabinet. If the indicator remains pink after about two hours, it is necessary to dry the desiccant.

4-8. If desired, two spare packages of dry 2-unit silica-gel desiccant can be used to replace the desiccant in the instrument. The desiccant compartments are located at the top-rear corners of the chassis.

4-9. To reactivate the desiccant removed from the clock, place the desiccant packages in an oven at 245-260°F (118-127°C) for at least 12 hours.

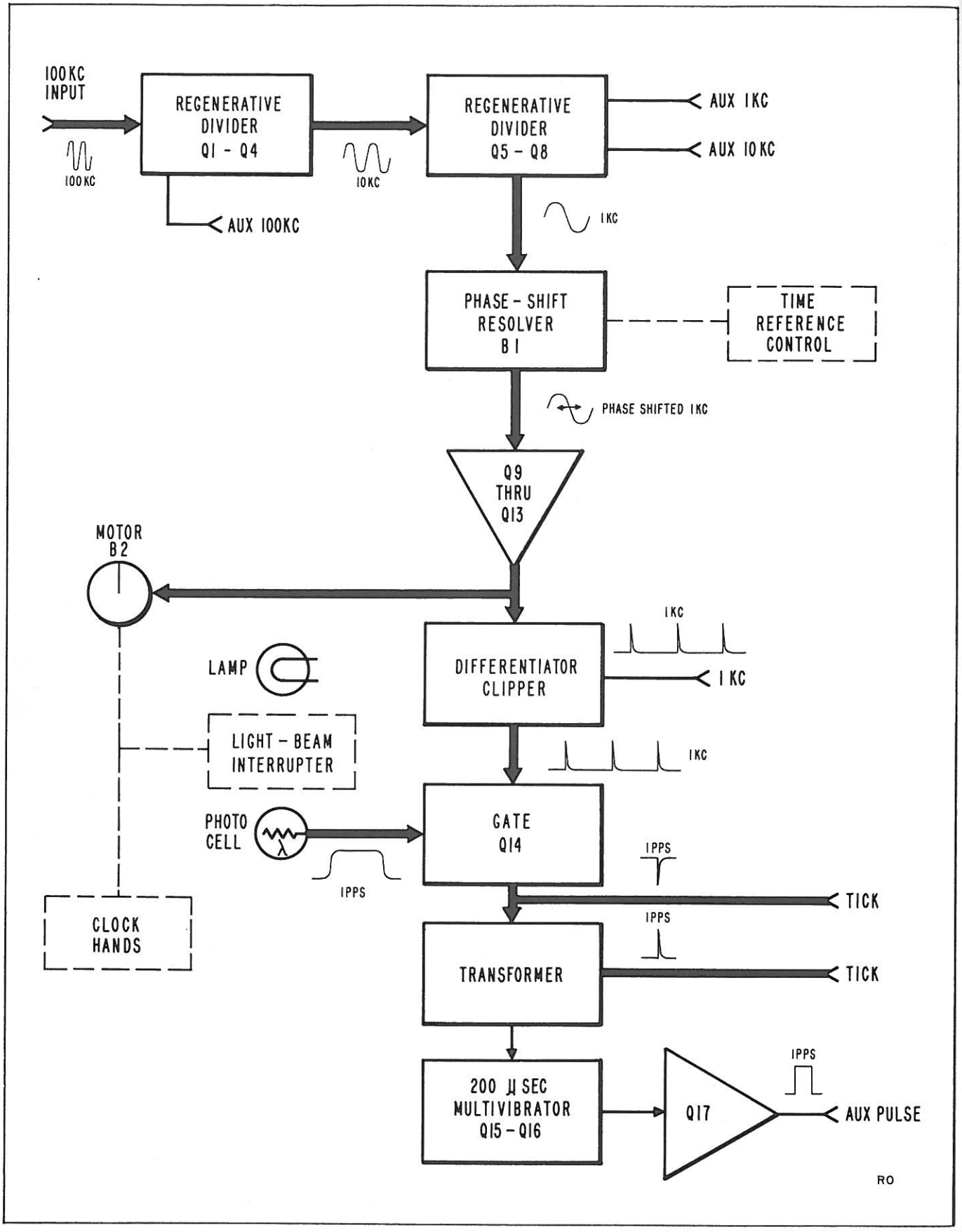


Figure 5-1. Block Diagram

SECTION V
PRINCIPLES OF OPERATION

5-1. INTRODUCTION.

5-2. The block diagram, figure 5-1, shows the main functional sections and signal flow within the clock.

5-3. DIVIDER. The 100-kc input is divided to a 1-kc sine wave by two 10:1 regenerative dividers. Neither divider is self-starting. In case of momentary interruption of either the 100-kc or 24-volt input, the dividers will stop working, halting clock operation. The regenerative frequency divider is discussed in detail in paragraph 5-6.

5-4. RESOLVER. The phase of the 1-kc divider output is continuously adjustable by turning the TIME REFERENCE control on the front panel. One full turn shifts the phase of the 1-kc motor-drive signal by 360° and changes clock hand position by one millisecond, which is the duration of one period of the 1-kc signal. The 1-pps TICK and 1-pps AUXILIARY PULSE outputs are simultaneously shifted by a like amount. The phase-shift resolver circuit is discussed in detail in paragraph 5-10.

5-5. TICK GATE. A mechanical light interrupter, driven by the clock motor, allows a light beam to fall on a photocell once per second. The photocell output pulse is used as one input to a gate circuit. Phase-shifted 1-kc pips provide the other input. One accurately phased pip is passed each second by the gate. The gate output provides the external TICK outputs and internally triggers the 200-microsecond multivibrator. Gate circuitry is discussed in detail in paragraph 5-24.

5-6. REGENERATIVE DIVIDER.

5-7. The frequency divider circuitry consists of two similar 10:1 regenerative dividers. The first divider reduces the 100-kc input to 10 kc, and the second divider reduces the 10-kc output of the first divider to 1 kc.

5-8. Normal operation of the 100-kc to 10-kc divider is shown in figure 5-2. Mixer Q4 combines a 90-kc signal (applied to Q4 base) and the 100-kc input (applied to Q4 emitter after amplification by Q1) to produce a 10-kc signal. The 10-kc signal is tripled to 30 kc by Q2 and again tripled by Q3 to 90 kc to provide the 90-kc mixer input. Since generation of the 90-kc mixer input depends upon the 10-kc mixer output, the frequency divider does not operate when power is first applied or if there is a momentary circuit failure from any cause (such as loss of power or loss of 100-kc input). Manual operation of START switch S1 produces a pulse containing a 90-kc component to initiate divider operation.

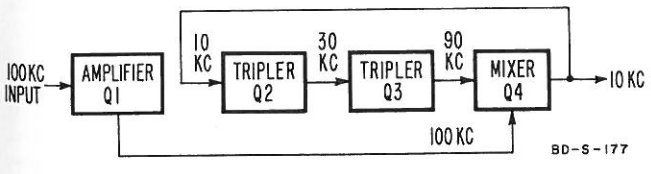


Figure 5-2. Regenerative Divider

5-9. The 10-kc to 1-kc divider (Q5 through Q8) operates as described above, except that mixer Q8 combines 10-kc and 9-kc signals to produce a 1-kc signal. The 1-kc mixer output is tripled to 3 kc by Q6 and triples again by Q7 to generate the 9-kc mixer input.

5-10. PHASE-SHIFT RESOLVER.

5-11. The phase of the 1-kc output of resolver B1 is adjusted with the TIME REFERENCE-MICROSECONDS dial. Turning the dial through a given angle shifts the phase of the resolver output by the same amount. For example, turning the dial 135° shifts resolver output phase by 135°.

5-12. The resolver (figure 5-3) is a transformer with a stationary secondary (stator) and a rotating primary (rotor) which has two windings whose fields are at right angles. The output of Q8 is applied to one rotor winding (rotor 1) and a voltage of equal amplitude whose phase leads the Q8 output by 90° is applied to the other rotor winding (rotor 2). The resolver output voltage is the vector sum of the voltages induced in the stator by each rotor winding.

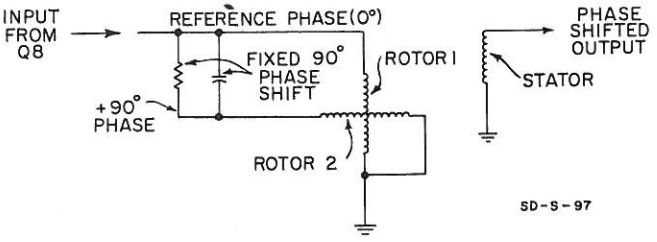


Figure 5-3. Phase-Shift Resolver

5-13. Figure 5-4A shows the resolver in the 0° or no-phase-shift position. Rotor 2 induces no voltage in the stator since the stator is perpendicular to rotor 2. Since rotor 1 is parallel to the stator, the voltage induced in the stator is in phase with the rotor 1 voltage (0°).

5-14. Figure 5-4B shows the resolver rotated 90°. Since rotor 1 is perpendicular to the stator and rotor 2 is parallel with the stator, the resolver output voltage is in phase with the rotor 2 voltage (+90°).

5-15. Figure 5-4C shows the resolver rotated 180°. There is maximum coupling between rotor 1 and the

stator since the windings are parallel, but the output is 180° out of phase with voltage applied to rotor 1, since rotor 1 is inverted.

5-16. Figure 5-4D shows the resolver in the 45° position. A portion of the voltage applied to each rotor winding is coupled to the stator. The resultant stator voltage is phased midway between the voltages applied to the rotors or 45°.

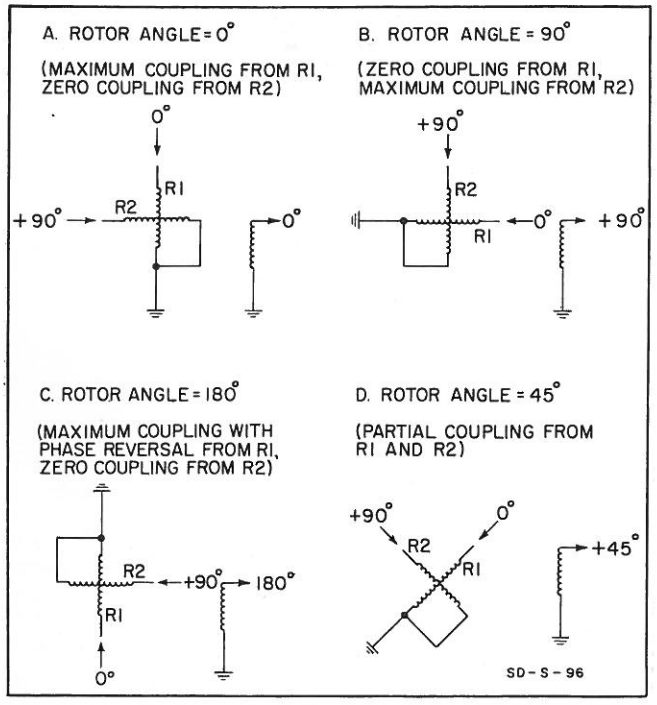


Figure 5-4. Resolver Operation

5-17. MOTOR AMPLIFIER.

5-18. The circuitry including Q9 through Q13 squares and amplifies the phase-shifted output of resolver B1 to provide (1) drive to clock motor B2 and (2) one input to the Q14 gate circuit. Refer to the schematic diagram, figure 8-5, during the following description.

5-19. AMPLIFIER AND LIMITER. The output of resolver B1 is amplified by Q9. Note that bias for Q9 is provided by the R61-CR2-R62 divider. Limiter CR3 and CR4 square the Q9 output, providing a square wave of about 1-volt amplitude to the Q10 input.

5-20. DRIVER. Drivers Q10 and Q11 are connected as an emitter-coupled paraphase amplifier. The Q11 base is returned to the junction of R61 and CR2 for dc bias.

5-21. POWER AMPLIFIER. Transformer T9 provides push-pull square-wave drive to bridge-connected power amplifiers Q12 and Q13.

5-22. Figure 5-5A shows the effective paths of electron flow when Q12 is conducting and Q13 is cut off. Capacitor C81 discharges; C82 charges; electron flow is from left to right through B2.

5-23. Figure 5-5B shows the effective path of electron flow when Q12 is cut off and Q13 is conducting. Capacitor C82 discharges; C81 charges; electron flow is from right to left through B2.

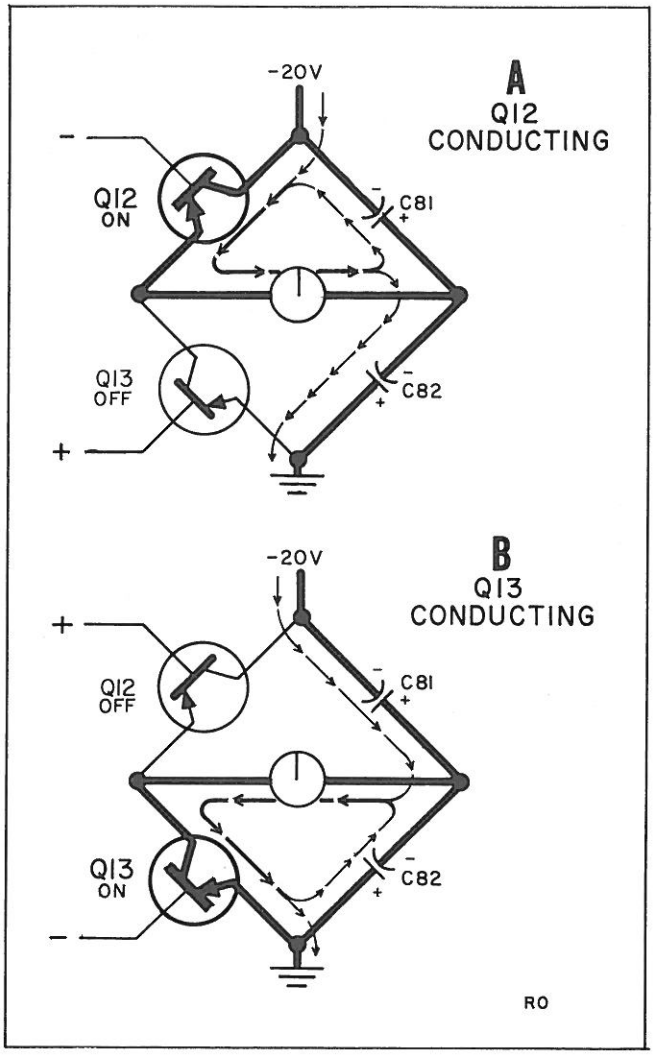


Figure 5-5. Power Amplifier Operation

5-24. GATE CIRCUITRY.

5-25. A gate circuit produces the 1-pps TICK outputs and the trigger for the 200-microsecond multivibrator. As shown in the schematic diagram, figure 8-5, a portion of the Q12-Q13 square-wave output drives T10. Capacitor C86 and the T10 primary differentiate the driving signal, and breakdown diode CR5 clips and limits the differentiated waveform to modify the T10 input to a positive-going 12-volt 1-kc pulse train.

5-26. The simplified schematic, figure 5-6, shows the essential details of gate circuit operation. Gate transistor Q14 is normally cut off (-14.2 volts applied to emitter, -20 volts applied to base). Although a continuous train of positive 1-kc pips is applied to the

Q14 base, normal pip amplitude is insufficient to cause conduction.

5-27. A positive-going pulse, one millisecond in duration, is generated once each second when the slotted disks in the clock mechanism coincide and permit a light beam from DS1 to fall on photocell V1. (Lamp filament voltage is provided from a tap on the B2 motor winding.) Limiter CR9 prevents the pulse from going more positive than -15 volts.

5-28. The 1-kc pip waveform and the photocell pulse are superimposed at the base of Q13. The combined amplitude of the photocell pulse and the single pip occurring during the photocell pulse drives Q14 into conduction and produces a negative pulse at the Q14 collector. This 1-pps negative pulse is supplied directly to the front-panel TICK connector and is inverted by T12 to provide (1) the positive TICK output at the rear of the chassis and (2) the positive trigger to the 200-microsecond one-shot multivibrator.

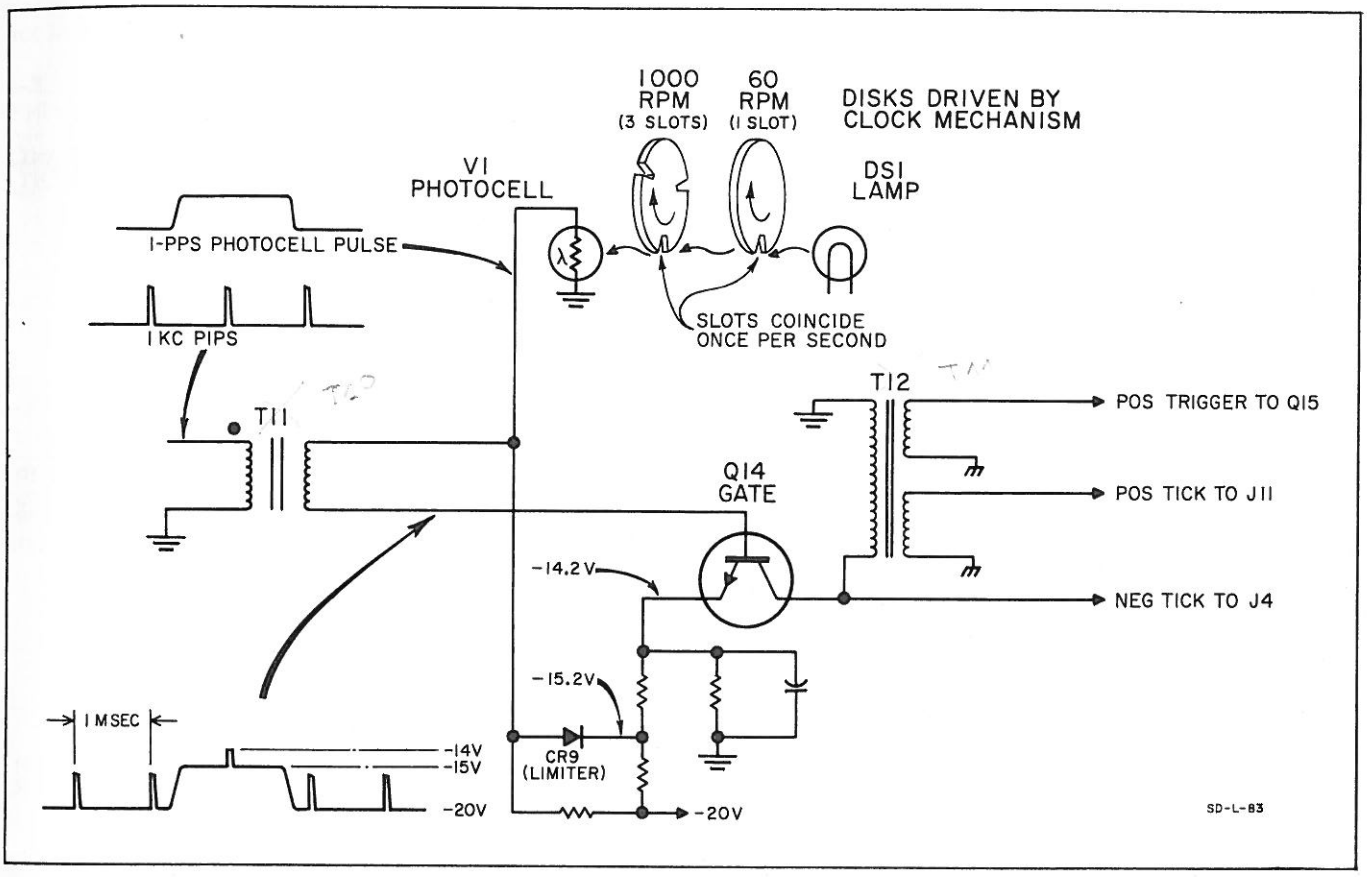


Figure 5-6. Tick Gate Operation

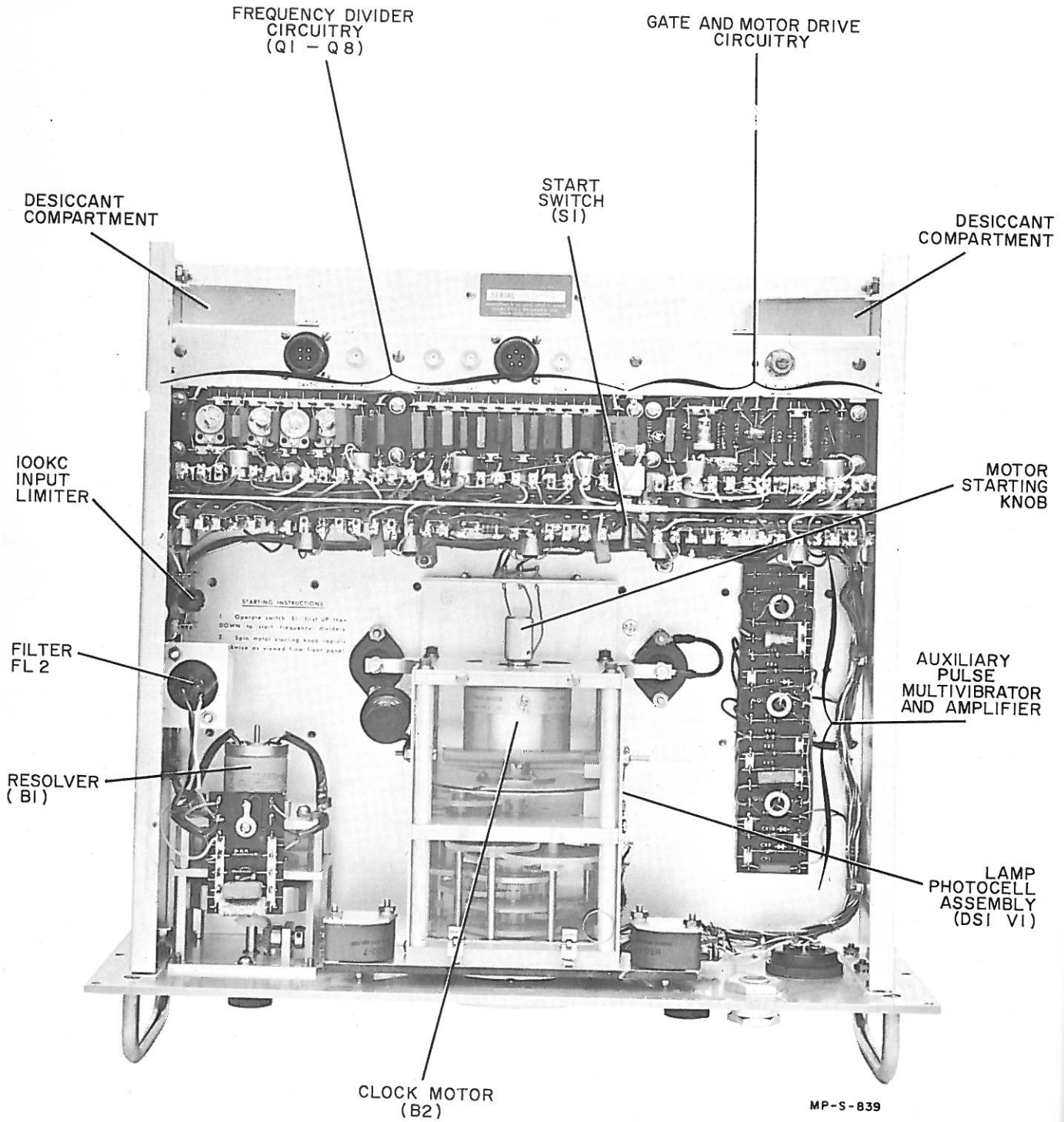


Figure 6-1. Component Location

SECTION VI
TROUBLESHOOTING

6-1. GENERAL INFORMATION.

6-2. CABINET REMOVAL. The clock can be slid partially out of its cabinet for routine inspection and maintenance while it is operating if the 12 screws around the edge of the front panel are removed. Do not loosen any other front-panel screws.

6-3. ELECTRICAL CONNECTIONS. Unplug P6 and P10 on the chassis to completely disconnect the clock from its cabinet. To continue operation of the instrument while it is removed from the cabinet, (1) connect a 100-kc signal to J9 (BNC connector) and (2) connect 24-volt supply to J10 using an MS3106E-14S-2S connector. The external connector which normally supplies power to J15 on the rear of the cabinet mates with J10 and can be used to supply power for out-of-cabinet operation.

6-4. DESICCANT. The silica-gel desiccant may absorb excessive atmospheric moisture while the instrument is out of its cabinet. If possible, do not leave the instrument out of the cabinet for more than about 15 minutes. If the instrument is out for longer periods of time, dry the desiccant as describes in paragraph 4-5.

6-5. TROUBLESHOOTING METHOD. In general, the following approach is recommended for finding circuit failures in the clock:

a. Sectionalize trouble by evaluating front-panel symptoms (paragraph 6-7).

b. Localize trouble by making voltage checks in the defective section (paragraph 6-9). Refer to figures 8-1 and 8-2 for schematic diagrams.

c. Check for failure of individual components by substitution, resistance measurements, etc.

6-6. TEST EQUIPMENT. Recommended test equipment for complete maintenance of the clock is listed in table 6-1.

6-7. SECTIONALIZATION.

6-8. Proceed as follows to determine the general location of a faulty circuit from CIRCUIT CHECK meter readings:

a. Check the SUPPLY VOLTAGE and 100 KC position of the CIRCUIT CHECK switch if the clock stops. Typical values for meter readings are shown in table 6-2.

Table 6-1. Recommended Test Equipment

Type	Application	Recommended Instruments	
		Commercial	Military
Electronic Voltmeter	General troubleshooting	℗ Models 410B, 412A	AN/PRM-16 TS-375A/U AN/USM-34 TS-487/U ME-25A/U TS-505/U ME-26/U TS-520/U
Oscilloscope (dual channel preferred)	General troubleshooting; tuned circuit alignment; resolver and motor alignment; photocell checking	℗ Models 122A, 150A with 152B plug-in, 160B with 162A plug-in	AN/USM-24 AN/USM-25 AN/USM-105A
Test Oscillator (1 kc to 100 kc range)	Alignment and troubleshooting of tuned circuits	℗ Models 200CD, 200T	AN/USM-30 SG-83(XC)/U TS-382E/U
Electronic Counter	Adjustment of AUX PULSE WIDTH (R79); monitoring test oscillator output	℗ Models 522B, 523B/C/D, 524B/C/D	AN/FRM-3 AN/USM-29 AN/URM-18 FR-4/U AN/URM-79 FR-5/U AN/URM-80 FR-38/U AN-USM-26 FR-47/U
Capacitor Substitution Box	Tuned circuit alignment	Cornell-Dubilier Model CDA-5	none
Resistor Substitution Box	Tuned circuit alignment	Cornell-Dubilier Model RDC	none

Table 6-2. Trouble Sectionalization with Circuit Check Meter

Circuit Status	Meter Readings				
	SUPPLY VOLTAGE	100 KC	10 KC	1 KC	CLOCK CURRENT
No 24-volt supply	0	0	0	0	0
No 100-kc input	6.5	0	2	2	3.7
All divider circuits inoperative	6.5	2	2	2	3.7
10-kc to 1-kc divider inoperative	6.5	7	7	2	3.8
No 1-kc drive to clock motor	6.5	7	7	2	3.8
All circuits normal and operating	6.5	7	7	7	8.5

b. If the 24-volt supply and the 100-kc inputs are correct, try starting the clock (see paragraph 3-3). The clock may have stopped because of momentary interruption of the supply voltage or the 100-kc input.

c. If the clock does not start, check each position of the CIRCUIT CHECK switch. Compare meter readings with table 6-2 and the system record sheets to determine location of defective circuitry.

6-9. LOCALIZATION.

6-10. After determining which section of the clock is defective, make dc voltage checks at the emitter, base, and collector terminals of each transistor in the defective section. Approximate dc voltages for each stage are shown in table 6-3.

6-11. Since the 100-kc to 10-kc divider (Q1-Q4) is very similar to the 10-kc to 1-kc divider (Q5-Q8), dc voltage checks between similar points on each divider can help localize troubles. It may be necessary to use a signal-injection system for troubleshooting the divider circuits. Follow the alignment procedure in paragraph 8-5; omit capacitor adjustment, but observe the output of each stage.

Table 6-3. Typical Emitter-Base-Collector Voltages

Transistor	Divider ON: Motor running			Divider OFF		
	Emitter	Base	Collector	Emitter	Base	Collector
Q1	-3.50 v	-3.60 v	-11.9 v	-3.50 v	-3.62 v	-11.9 v
Q2	-1.50	+0.710	-11.9	-0.413	-0.056	-11.9
Q3	-3.40	-0.875	-11.9	-0.809	-0.974	-11.9
Q4	-1.60	+0.143	-11.9	-0.605	+0.031	-11.9
Q5	-3.20	-2.40	-11.9	-3.01	-3.19	-11.9
Q6	-1.40	+0.600	-11.9	-0.410	-0.020	-11.9
Q7	-3.37	-0.950	-11.9	-0.924	-1.07	-11.9
Q8	-2.23	+0.170	-11.9	0	-0.017	-11.9
Q9	-3.08	-3.05	-11.4	-3.07	-3.23	-11.7
Q10	-3.12	-3.06	-18.8	-3.05	-3.16	-19.3
Q11	-3.12	-3.05	-18.8	-3.05	-3.23	-18.7
Q12	-9.40	-9.20	-19.2	-14.6	-14.6	-19.3
Q13	0	+0.200	-9.40	0	0	-14.3
Q14	-14.6	-19.0	0	-14.8	-19.2	0
Q15	-0.648	-0.800	-0.890	-0.650	-0.897	-0.803
Q16	-0.648	-0.164	-19.0	-0.650	-0.163	-19.3
Q17	-0.648	-0.289	-19.0	-0.650	-0.290	-19.3
Q18	-19.5	-19.6	-24.0	-19.5	-19.6	-24.1
Q19	-19.4	-19.5	-24.0	-19.4	-19.6	-24.2

Conditions: Supply voltage -24.0 volts; regulated voltage 11.9 volts (may be 12.0 ± 1 volt); all voltages referenced to the chassis.

SECTION VII
REPAIR

7-1. AREAS REQUIRING SPECIAL ATTENTION.

7-2. ADJUSTMENT AFTER REPAIR. Readjustment of certain circuits is required after repair. The required adjustments are listed in paragraph 8-3.

7-3. TRANSISTOR REPLACEMENT. When replacing transistors, liberally coat the transistor surface which is to contact its heat sink with special silicone compound (see miscellaneous parts list, table 9-2) to improve heat transfer. For power transistors, coat the anodized aluminum insulator wafer which is placed between the transistor and chassis with the silicone compound. For small transistors, place the silicone compound between the cap portion of the transistor and the cup in the heat sink. REMEMBER: REPLACEMENT ANODIZED INSULATOR WAFERS AND A SUPPLY OF SILICONE COMPOUND MUST BE AVAILABLE BEFORE REPLACING TRANSISTORS; refer to table 9-2 for stock numbers.

7-4. PHOTOCELL AND LAMP. To remove the photocell assembly (located on right side of clock mechanism) for replacement of either photocell V1 or lamp DS1, remove only the two large retaining screws (8-32 binding head) at the front of the assembly. Do not loosen the two small screws located to the rear of the retaining screws. The lamp and photocell can then be extracted individually after loosening the setscrews in the assembly housing.

7-5. MECHANICAL REPAIR. Replacement of components in the clock mechanism gear box and the resolver mechanism requires careful workmanship. Detailed instructions for repair of these mechanisms are given in paragraphs 7-6 through 7-14.

7-6. INTRODUCTION TO MECHANICAL REPAIR.

7-7. The clock mechanism and the resolver mechanism are precision devices which require special repair techniques. Replacement mechanisms are available to simplify maintenance. Disassembly should be necessary only to replace a defective resolver, a defective motor, damaged gears, or worn bearings. Note the following points before proceeding with repair.

a. Be sure to have the necessary tools and parts listed below:

(1) Tool kit (includes necessary special tools; see table 9-4).

(2) Spare minute hand and spare hour hand (necessary if front portion of clock mechanism is disassembled; see figure 9-1 and table 9-3).

(3) Silicone compound (if resolver mechanism is removed; see table 9-2).

b. Prepare a clean, hard-surfaced work table before commencing so that work can proceed without interruption.

c. Cleanliness is especially important during the entire procedure. Ball bearings, in particular, must be kept free from contamination.

d. Refer to the exploded views (figures 7-1 and 9-2) during both disassembly and reassembly for component identification and location. Lay out each part in the order removed so that the correct component can be quickly selected during reassembly.

e. Begin clock mechanism repair by removing the entire mechanism as outlined in paragraph 7-8. If repair area is to the rear of the center plate, proceed with disassembly and reassembly instructions given in paragraphs 7-9 and 7-10. If repair area is in front of the center plate, proceed with disassembly and reassembly instructions given in paragraphs 7-11 and 7-12. Installation is outlined in paragraph 7-13.

f. For resolver mechanism repair instructions, refer to paragraph 7-14.

CAUTION

DO NOT FORCE OR HAMMER ANY PORTION OF THE MECHANISM DURING DISASSEMBLY OR REASSEMBLY. Use gentle pressure only while separating or reassembling parts.

7-8. CLOCK MECHANISM REMOVAL.

a. Remove clear plastic guard (two nuts) from motor terminals at rear of mechanism.

b. Clip or unsolder motor input wires at rear of motor terminal board. Note position of wires so that they can later be returned to original position.

c. Remove the two retaining screws (8-32 binding head) at the front of the photocell assembly on the right side of the clock mechanism. Do not loosen the smaller screws located on the rear of the retaining screws. Carefully slide the photocell assembly away from the clock mechanism.

d. Remove the two screws (phillips head with sealing ring) and spacers from the front panel which hold the upper shock mounts of the clock mechanism.

e. Remove the two cap screws (allen socket head) which hold the rear corners of the mechanism to the rear shock mounts.

f. Carefully lift clock mechanism from chassis.

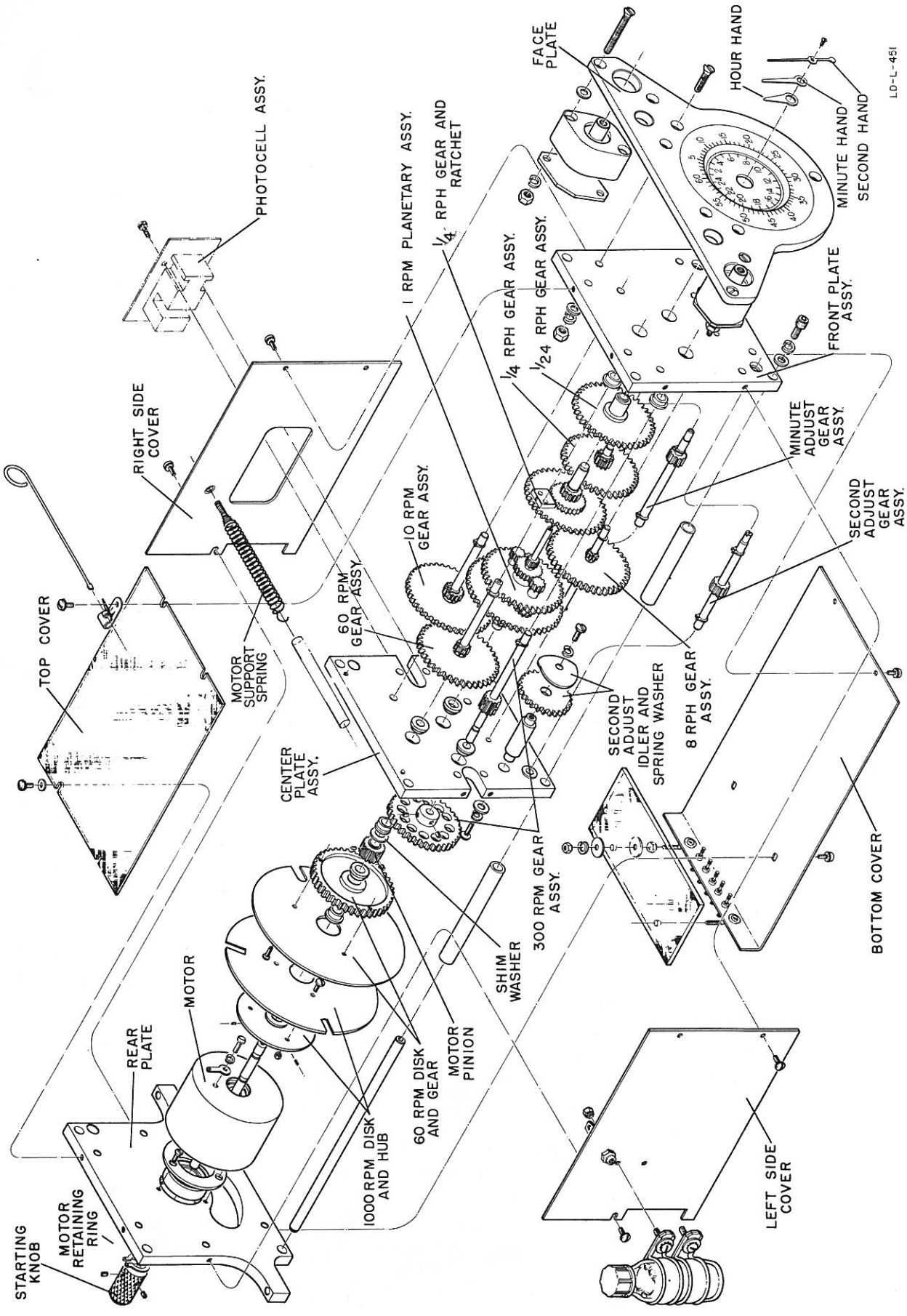


Figure 7-1. Exploded View of Clock Mechanism

7-9. CLOCK MECHANISM DISASSEMBLY (REAR).

a. Unsolder motor leads from terminals at rear of bottom cover (figure 7-1). Note position of leads so they can be returned to original position later.

b. Remove plastic top cover (four screws).

c. Unhook motor support spring from left side plate. Remove flexible plastic tube from inside of spring. Twist spring to remove from supporting lug on motor; leave spring attached to adjusting screw on right side plate.

d. Remove side covers (three screws each) and bottom cover (four screws).

e. The motor support spring may now be removed from the right side plate, if desired. Screw the adjusting screw through its support using a narrow-blade screwdriver, then separate spring and adjusting screw.

CAUTION

Support for spring-adjusting screw (looks like nut) is permanently attached to right side plate. Do not attempt to twist or turn screw support.

f. Remove starting knob from rear of motor shaft (two setscrews).

g. Remove the four capscrews (allen socket head) from the corners of the rear plate. Press the four aligning rods from which the capscrews were removed forward about 3/8 inch until they clear the rear plate.

h. Rotate the motor shaft to position the setscrews on the motor pinion (on motor shaft, immediately behind center plate) to the right side of the mechanism, away from the meshing gear.

i. Remove the rear plate and attached components by pulling smoothly to the rear.

CAUTION

Handle aluminum gating disks carefully to prevent accidental bending.

j. The 300 rpm gear at the rear of the center plate can now be removed (two setscrews) for replacement, if necessary.

k. Remove large retaining ring from rear of motor. Separate motor and rear plate by pushing rear of motor forward.

m. Remove motor pinion (two setscrews).

n. Slide front disk forward for removal from motor shaft. Note that this disk contains two ball bearings.

p. Remove rear disc (two setscrews).

7-10. CLOCK MECHANISM REASSEMBLY (REAR).

a. Inspect all parts for evidence of damage or excessive wear. Replace faulty parts. Clean the gears and shafts with a lintless wiping cloth moistened with a solvent (such as acetone) which leaves no deposit after drying.

CAUTION

Ball bearings are permanently lubricated. Do not permit solvent to come in contact with ball bearings.

b. Replace 300 rpm gear on shaft at rear of center plate (large gear forward) if it was removed in paragraph 7-9 step j. Rear of small gear should be about flush with end of shaft. Tighten setscrews.

c. Slide rear disk into place on motor shaft (flange toward motor). Do not tighten setscrews.

d. Slide front disk with its two ball bearings into place (gear at front).

e. Slide motor pinion into place (setscrews at front). Do not tighten setscrews.

f. Fit rear of motor into place in the rear plate. The side of the rear plate with the bearing retainer must be forward. Install large retaining ring on rear of motor (center of bowed portion should be to the rear, away from motor).

g. Rotate motor pinion gear so that its setscrews are to the right, away from meshing gear. Carefully slide rear plate and attached components into place. The motor shaft should slide smoothly into the ball bearing in the center plate, and the pinion gear and front disk gear should mesh smoothly with the 300 rpm gear.

h. Press the four aligning rods to the rear into place in the rear plate.

i. Install four capscrews (8-32 allen socket head) in aligning rods. One flat washer and one split lockwasher are required under each screw head. Tighten the screws to 20 inch-pounds torque.

j. Insert 0.002-inch shim between front of motor pinion and rear of ball bearing in center plate. Slide motor pinion firmly against shim and tighten setscrews. Remove shim.

NOTE

If setscrews contact edge of groove in shaft, indicated by slight movement of the motor pinion along the shaft when the setscrews are tightened, add one or more shim washers between the center-plate bearing and the motor pinion to space the pinion to the rear.

k. Insert disk alignment jig into slot in right side of center plate (figure 7-2). Rotate motor shaft to align slot in front disk with tongue of jig. Rotate rear disk

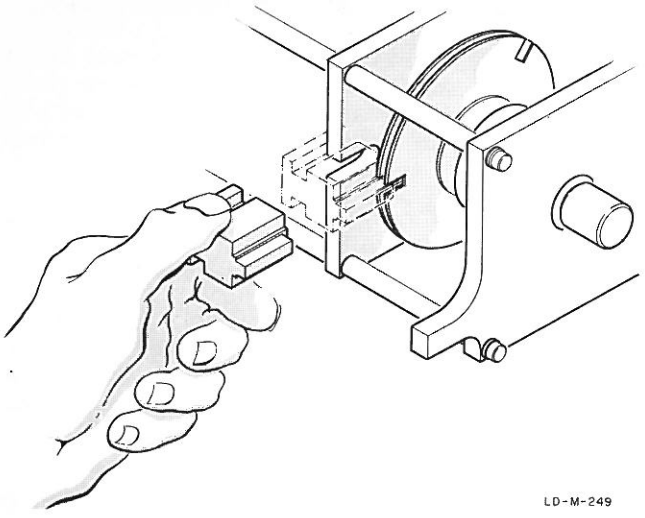


Figure 7-2. Disk Alignment

to align one slot with tongue of jig. Slide rear disk forward until it contacts the rear of the front disk. Tighten setscrews in rear disk. Remove alignment jig.

m. Attach motor starting knob (two setscrews).

n. If motor-support spring was removed in paragraph 7-9 step e, attach spring to right side plate with motor-adjusting screw (cone-shaped end of spring toward right side plate).

p. Center motor-adjusting screw in its support.

q. Install bottom cover (four screws) and side covers (three screws each).

r. Thread motor-support spring through lug on motor. Twist spring until lug is roughly centered on spring. Slide flexible plastic tube into spring. Hook spring into its support on left side plate. Motor lug should now be approximately centered (vertical).

s. Install plastic top cover (four screws).

t. Solder motor leads to original position on terminals at rear of bottom cover.

7-11. CLOCK MECHANISM DISASSEMBLY (FRONT).

a. Unsolder motor leads from terminals at rear of bottom cover (figure 7-1). Note position of leads so they can be returned to original position later.

b. Remove top cover (four screws), side covers (three screws each), and bottom cover (four screws).

c. Remove starting knob (two setscrews) from rear of motor shaft.

d. Loosen, but do not remove, the four capscrews (allen socket head) which hold the face plate and front plate assembly to the mechanism frame.

e. Place the mechanism in the assembly jig with the front (face) up.

f. Remove the second hand by unscrewing the small screw at the center of the hand.

g. Remove the minute and hour hands. Hands are pressed on their shafts and may be damaged during removal. Replace damaged hands with new hands during reassembly.

h. Remove the four screws loosened in step d above. Remove the split lockwasher and flat washer which are used under each screw head.

i. Press the four aligning rods from which the capscrews were removed to the rear at least 3/8 inch. Carefully lift the face plate and front plate assembly free. Work the front ends of the shafts out of the front plate assembly as it is removed.

j. Remove the 1/24 rph gear.

k. Remove minute adjust gear assembly.

m. Remove 1/4 rph gear and ratchet assembly.

n. Remove 1 rph gear and ratchet assembly.

p. Remove 8 rph gear assembly.

q. Remove second adjust gear assembly.

r. Remove retaining screw from second adjust idler gear. Remove lockwasher, spring washer, and idler gear.

s. Remove 1 rpm planetary gear assembly.

t. Remove 10 rpm gear assembly.

u. Rotate 300 rpm pinion to position its setscrews away from the meshing 60 rpm gear.

v. Remove the 60 rpm gear assembly.

w. The 300 rpm gear assembly may now be removed, if desired by first loosening the setscrews in the 300 rpm gear located immediately behind center plate; then slide the shaft forward while supporting the loose gear.

CAUTION

Do not further disassemble gear assemblies. If replacement of part of any assembly is necessary, replace entire assembly. Do not remove small retaining rings from shafts; do not attempt to remove or loosen gears within the assemblies, and do not remove the bronze bearings which are pressed into the front plate assembly and the center plate assembly.

7-12. CLOCK MECHANISM REASSEMBLY (FRONT).

a. Inspect gears, shafts, and bearings for damage or excessive wear. Replace faulty parts. Clean each part of the disassembles clock mechanism with a clean lintless cloth moistened with a solvent (such as acetone) which does not leave a residue after drying.

CAUTION

Ball bearings are permanently lubricated and should not be cleaned. Do not permit solvent to contact ball bearings.

b. Install 300 rpm gear assembly if it was removed in paragraph 7-11 step w. End of rear gear should be about flush with the end of its shaft.

c. Turn 300 rpm pinion gear to position its setscrews away from the position of the meshing 60 rpm gear. Install 60 rpm gear assembly.

d. Install 10 rpm gear assembly (meshes with 60 rpm gear).

e. Install 1 rpm planetary gear assembly (meshes with 10 rpm gear).

f. Place second adjust idler gear in position on its post. Apply a light coat of PML grease to the front surface of the gear. Add spring washer (convex side forward), split lockwasher, and screw (6-32 x 3/8 binding head). Tighten screw.

g. Install second adjust gear assembly (meshes with second adjust idler gear).

h. Install 8 rph gear assembly (meshes with front pinion of 1 rpm planetary gear assembly).

i. Lubricate front portion of shaft of 1 rpm planetary gear assembly with PML grease.

j. Install 1 rph gear and ratchet assembly (meshes with 8 rph gear).

k. Install 1/4 rph gear assembly (meshes with 1 rph gear and ratchet assembly).

m. Install minute adjust gear assembly (meshes with 1/4 rph gear assembly).

n. Lubricate front portion of 1 rph gear assembly with PML grease.

p. Install 1/24 rph gear (meshes with 1/4 rph gear).

q. Lubricate front portion of 1/24 rph gear assembly with PML grease.

r. Carefully fit front plate assembly into place. Make sure that all shafts are aligned with the proper holes or bearings in the front plate assembly. Do not force or tap front plate into place. Pull aligning rods into place in the front plate assembly by inserting a long 8-32 screw from the front, or push the rods into place from the rear while holding the clock mechanism together. Attach the front plate assembly and face plate with four capscrews (8-32 allen socket head), flat washers (against front plate assembly), and split lockwashers.

CAUTION: If front plate assembly and face plate have been separated, insert face centering pin in center holes during reassembly to assure proper alignment.

s. Press replacement hour hand in place. Hour hand must point to any exact hour.

t. Press replacement minute hand in place. Minute hand must point to hour 24 (straight up).

u. Attach second hand with small screw. Second hand must point to hour 24 (straight up).

v. If 300 rpm gear was removed (paragraph 7-11 step w), adjust disk alignment as described in paragraph 7-10 step k.

w. Install bottom cover (four screws), side covers (three screws each), and plastic top cover (four screws).

x. Solder motor leads to original position on terminals at rear of bottom cover.

7-13. CLOCK MECHANISM INSTALLATION.

a. Place clock mechanism in original position on chassis.

b. Install the two capscrews (allen socket head) which hold the lower rear corners of the mechanism to the rear shock mounts.

c. Install the two screws (phillips head) which hold the front shock mounts to the front panel using 1/8 inch spacers between the shock mounts and panel.

d. Carefully install the photocell assembly (two 8-32 binding-head screws).

e. Solder the motor input leads to their original positions on the terminal strip at rear of bottom cover.

f. Install plastic guard over motor input terminals.

g. Connect and start clock. If maintenance was performed on rear portion of mechanism or if 300 rpm gear was loosened, adjust motor alignment as described in paragraph 8-22.

7-14. RESOLVER MECHANISM.

7-15. Proceed as follows for removal, disassembly, reassembly, and installation (refer to figure 9-2):

a. Clip or unsolder the leads attached to the component board atop the resolver mechanism which connect the resolver circuitry to on-chassis circuitry. Note location of leads so that they can later be returned to original position.

b. Remove cable clamp from side of resolver mechanism.

c. Loosen, but do not remove, the MICROSECONDS knob (two setscrews) on the front panel.

d. While supporting the resolver mechanism from the rear, remove the four front-panel screws (phillips head) which hold the resolver assembly to the front panel. Hold the MICROSECONDS knob temporarily in place and withdraw resolver mechanism from rear.

e. Disassemble required portion of mechanism. Refer to the exploded view in figure 9-5.

f. Replace defective parts and reassemble mechanism in reverse order of disassembly. Add special silicone compound (see miscellaneous parts list, figure 9-2) to "0" ring seal where shaft passes through front panel; lubricate counter coupling shaft at pillow block with clock gear lubricant (attached to left cover of clock gear mechanism).

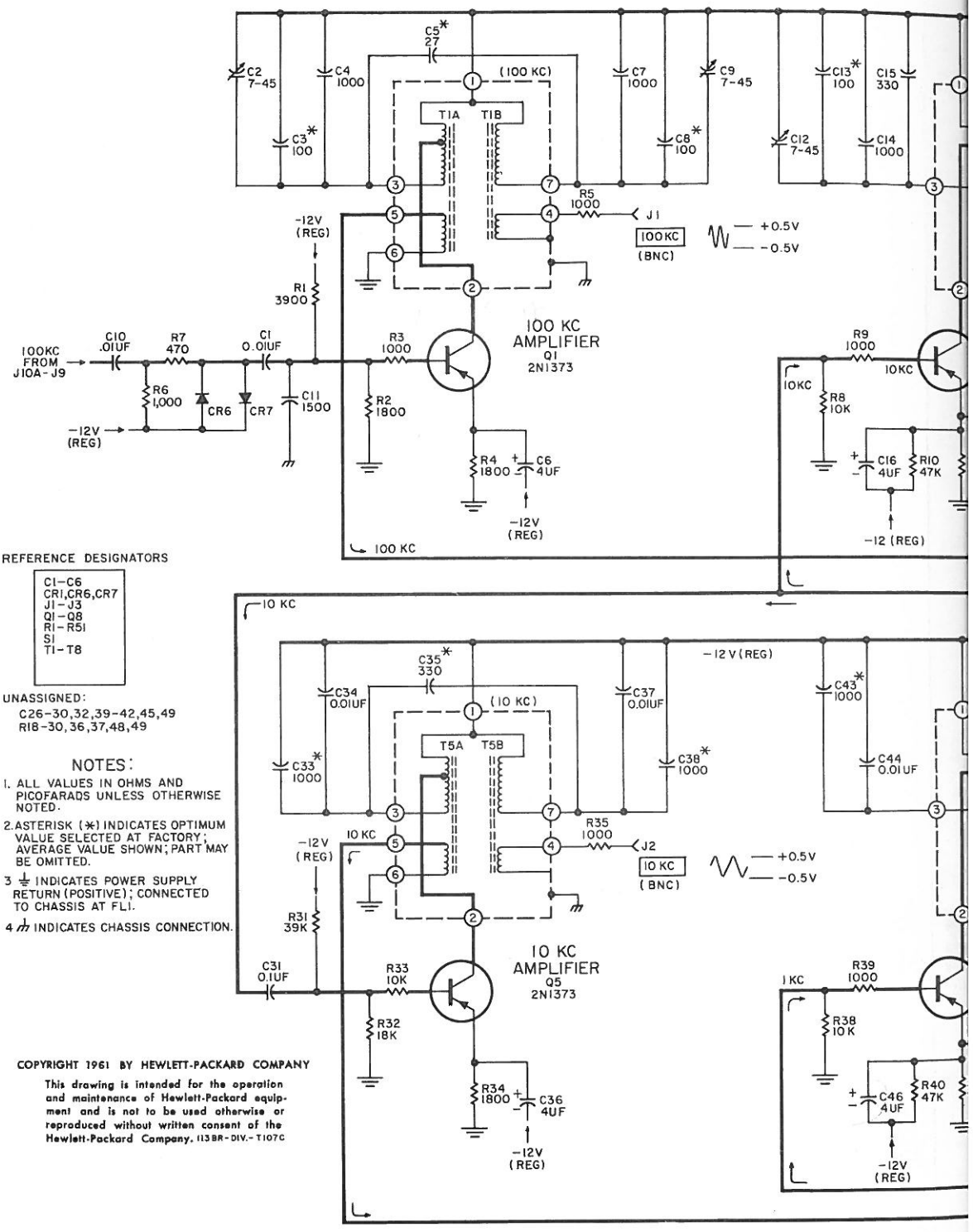
g. Proceed with mechanical and electrical alignment as outlined in paragraph 8-16.

Table 8-1. Tuned Circuit Alignment

Test Oscillator Frequency*	Signal Input to the Base of	Monitor Signal at	Substitute C values across	Average C value (pf)	Remarks
100 kc ±100 cps	Q1	T1 Pin 4	C2	100	C2 Mid Position
100 kc ±100 cps	Q1	T1 Pin 4	C9	100	C9 Mid Position
30 kc ± 30 cps	Q2	T2 Pin 5	C12	100	C12 Mid Position
90 kc ± 90 cps	Q3	T3 Pin 5	C17	100	C17 Mid Position
10 kc ± 10 cps	Q4	C24-C25 Junction	T4 Pins 3-1	1000	----
10 kc ± 10 cps	Q5	T5 Pin 7	T5 Pins 3-1	1000	----
10 kc ± 10 cps	Q5	T5 Pin 7	T5 Pins 7-1	1000	----
3 kc ± 3 cps	Q6	T6 Pin 3	T6 Pins 3-1	1000	----
9 kc ± 9 cps	Q7	T7 Pin 3	T7 Pins 3-1	1000	----
1 kc ± 1 cps	Q8	T8 Pin 7	T8 Pins 3-1	0.01 μf	----
1 kc ± 1 cps	Q8	T8 Pin 7	T8 Pins 7-1	0.01 μf	----

* Multiply by 1.003 for sidereal clocks.

NOTE: Tuned circuit pairs T1A and B, T5A and B, T8A and B interact.



REFERENCE DESIGNATORS

C1–C6
CR1,CR6,CR7
J1–J3
Q1–Q8
R1–R51
S1
T1–T8

UNASSIGNED:
C26–30,32,39–42,45,49
R18–30,36,37,48,49

NOTES:

1. ALL VALUES IN OHMS AND PICOFARADS UNLESS OTHERWISE NOTED.
2. ASTERISK (*) INDICATES OPTIMUM VALUE SELECTED AT FACTORY; AVERAGE VALUE SHOWN; PART MAY BE OMITTED.
3. ⏚ INDICATES POWER SUPPLY RETURN (POSITIVE); CONNECTED TO CHASSIS AT FL1.
4. ⏚ INDICATES CHASSIS CONNECTION.

Figure 8-1. Frequency D

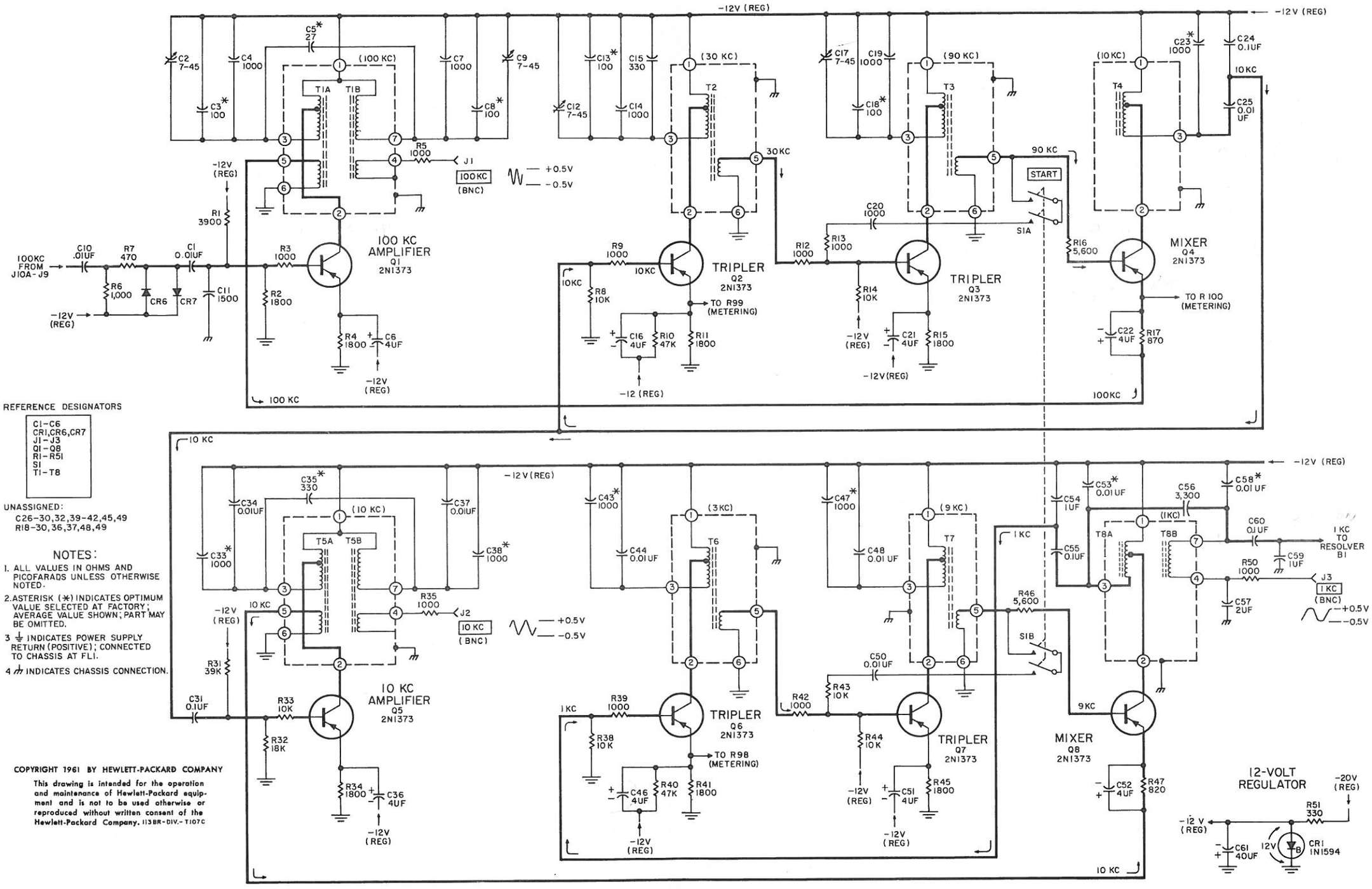


Figure 8-1. Frequency Divider Circuits

FIGURE 8-1
FREQUENCY DIVIDER CIRCUITS

NOTES:

1. ALL VALUES IN OHMS AND PICOFARADS UNLESS OTHERWISE NOTED.
2. ASTERISK (*) INDICATES OPTIMUM VALUE SELECTED AT FACTORY; AVERAGE VALUE SHOWN; PART MAY BE OMITTED.
3. ⏚ INDICATES POWER SUPPLY RETURN (POSITIVE); CONNECTED TO CHASSIS AT FL1.
4. ⏚ INDICATES CONNECTION TO CHASSIS OR CABINET.
5. GROUND WIRE CONNECTED AS SHOWN (HEAVY LINE) FOR STANDARD (POSITIVE GROUND) INSTRUMENTS; FOR NEGATIVE GROUND INSTRUMENTS, GROUND WIRE IS CONNECTED BETWEEN CHASSIS AND J15-PIN C AND THE P10-PIN C SIDE OF FL1.

REFERENCE DESIGNATORS

B1-B2
C70-C96
CR2-CR5, CR8-CR16
DS1
FL1
J4-J15
M1
P6-P10
Q9-Q19
R54-R101
T9-T11
V1

UNASSIGNED
C76-C80, C83, C87-C90
R56-R60, R67-R69, R75-R78, R90-R92

Figure 8-2. Indicator and Output Circuits

FIGURE 8-2
INDICATOR AND OUTPUT CIRCUITS

SECTION VIII
TESTING AND ADJUSTMENT

8-1. PERFORMANCE CHECK.

8-2. If the clock appears to be operating normally, indicated by clock-hand movement and regular occurrence of the 1-second tick (system oscilloscope trigger pulse), it can be assumed that all basic circuitry within the clock is operating properly. Because of the fail-safe circuit design in the clock, basic circuitry either operates properly or stops operating completely.

8-3. CIRCUITS REQUIRING ADJUSTMENT.

8-4. Adjustment is required after replacing components in certain circuits. Table 8-2 lists the adjustments which must be made after component replacement.

Table 8-2. Adjustment after Maintenance

Area of Repair	Adjustment Required	Paragraph Reference
Tuned circuits T1-T8	Tuning capacitor selection or adjustment	8-5
Resolver B1 or R54, R55, C70, C71	Resolver alignment	8-8
Clock mechanism (disassembly of rear portion or loosening of 300 rpm gear)	Motor alignment	8-12

8-5. TUNED CIRCUIT ALIGNMENT.

8-6. Selection of fixed tuning capacitor is required if components are replaced in the frequency divider tuned circuits (T1 through T8). The procedure outlined here, omitting capacitor selection, may be used as a signal-injection troubleshooting aid to localize frequency divider troubles.

8-7. Each tuned circuit is similarly aligned. Follow the outline given in table 8-1 and the following general instructions:

a. Disconnect the 10-kc output wire at the junction of C24 and C25 before tuning T2, T3, or T4. Disconnect the output wire at the junction of C54 and C55 before tuning T6, T7, or T8.

b. Set test oscillator (table 6-1) to the tuned circuit frequency. Monitor the test oscillator output with an electronic counter to assure accurate frequency setting.

c. Apply the test oscillator frequency (using dc blocking capacitor) to the base (green lead) of the transistor that drives the tuned circuit. Adjust test oscillator output amplitude to a level just below transistor saturation (distorted waveform at collector indicates saturation). The tripler circuits are operated as conventional amplifiers to drive their tuned circuits.

d. Monitor tuned circuit output with an oscilloscope.

e. Set variable trimmers (T1, T2, and T3 only) to mid-capacity.

f. Select a capacitor which maximizes the tuned circuit output when placed across the tuned circuit. The selected capacitor is shown for each tuned circuit on the schematic diagram and is marked with an asterisk. The value shown is the average value used. Vary the value of the capacitor in increments of roughly 10% of the average value. The correct value for this capacitor may be selected quickly by using a capacitor-substitution box connected across the tuned circuit. Solder the selected capacitor in place.

g. Adjust the trimmer capacitor (T1, T2, and T3 only) for maximum output.

h. Connect wires which were disconnected in step a.

8-8. RESOLVER ALIGNMENT.

8-9. Accurate mechanical alignment and component selection for R54 and C70 (electrical alignment) is required after resolver replacement to provide accurate TIME REFERENCE dial calibration. If a component is replaced in the phase-shift network (R54, R55, C70, C71), electrical alignment is required (paragraph 8-11). The frequency divider circuits must be operating during the following alignment procedures.

8-10. MECHANICAL ALIGNMENT. Proceed as follows to mechanically align the resolver and TIME REFERENCE indicators:

a. Loosen all setscrews (four) in the coupling attached to the resolver shaft. Leave an allen wrench in one of the setscrews during the alignment procedure so that the setscrews will remain in an easily accessible position.

b. Connect a dual-channel oscilloscope (table 6-1) to observe the resolver input (junction of C59 and C60) and output (base of Q9) simultaneously. Physically position the resolver rotor so that the input and output signals are in phase. Keep the resolver rotor in this position until mechanical alignment is completed.

c. Loosen the MICROSECONDS knob (two setscrews). Set the knob to "0" dial reading. Lock the knob in place. Do not tighten the knob setscrews.

d. Position the MILLISECONDS shaft-rotation counter so that the units digit is midway between numbers. This position will allow the MILLISECONDS indication to change just as the MICROSECONDS dial passes through zero.

e. Tighten the two setscrews in the MICROSECONDS knob. Tighten the four setscrews in the shaft coupling.

8-11. ELECTRICAL ALIGNMENT. Proceed as follows to select values for C70 and R54:

a. Trigger an oscilloscope with phase-shifted 1-kc pips from J5.

b. Observe the fixed-phase 10-kc output at J2. Adjust sweep speed so that one complete sine wave is visible in the CRT.

c. Set MICROSECONDS dial to "125".

d. Use oscilloscope positioning controls to place a sine-wave positive peak on the vertical centerline of the CRT.

e. Set MICROSECONDS dial to "375". Two and one-half "cycles" should move past the CRT vertical centerline as the dial is turned.

f. Substitute values for capacitor C70 until the sine-wave negative peak is precisely centered on the CRT centerline. Try capacitor values in increments at least as small as 100 pf. The process can be considerably simplified by using a capacitor-substitution box.

g. Repeat steps c to f, leaving the component selected in step f connected.

h. Set MICROSECONDS dial to "0".

i. Use oscilloscope controls to place a sine-wave positive peak on the CRT vertical centerline.

j. Set MICROSECONDS dial to "250". Two and one-half "cycles" should move past the CRT vertical centerline.

k. Substitute values for R54 until the sine-wave negative peak is precisely centered on the CRT centerline. Use a resistor-substitution box which permits selection of standard resistor values to simplify the process.

m. Repeat steps h to k, leaving the component selected in step k connected.

n. Move the oscilloscope probe to observe the 100-kc output at J1. With the MICROSECONDS dial set to "0", adjust the oscilloscope control to position a sine-wave positive peak on the CRT vertical centerline.

p. Turn MICROSECONDS dial, noting both oscilloscope presentation and the dial reading. One "cycle" should move past the CRT vertical centerline for each 10 microsecond dial division. You may further select values for C70 and R54 to improve the results of this test.

8-12. MOTOR ALIGNMENT.

8-13. Accurate physical positioning of motor B2 is required after mechanical repair of the clock mechanism (for motor or gear replacement, etc.). Proceed as follows:

a. Synchronize an oscilloscope with the signal at pin 5 of T10. Observe the waveform at the base of Q14 (with clock motor B2 running).

b. If the 1-pps photocell pulse is not centered on a positive 1-kc pip, turn the motor-adjusting screw (located on the right side of the clock mechanism) until the photocell pulse is centered (± 10%) under a 1-kc pip.

SECTION IX
REPLACEABLE PARTS

9-1. INTRODUCTION.

9-2. This section contains information for ordering tools and replaceable parts for the Model 113BR Frequency Divider and Clock. Parts descriptions are arranged as follows:

Table 9-1. Electrical Components
Table 9-2. Miscellaneous Components
Table 9-3. Clock Gear Mechanism Components
Table 9-4. Resolver Mechanism Components
Table 9-5. Tools

Figure 9-1. Clock Gear Mechanism, Exploded View
Figure 9-2. Resolver Mechanism, Exploded View

9-3. Each table includes the following information for each part:

a. Reference designation or item number, where applicable.

b. Description of part.

c. Five-digit code identification of manufacturer; refer to appendix for interpretation.

d. Hewlett-Packard stock number.

e. Total quantity used (TQ column).

f. Recommended spares for complete maintenance during one year of isolated service (RS column).

9-4. ORDERING INFORMATION.

9-5. Address inquiries regarding service or replaceable parts either to your Hewlett-Packard sales office or to

CUSTOMER SERVICE
Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California

or, in Western Europe

Hewlett-Packard S. A.
Rue du Vieux Billard No. 1
Geneva, Switzerland

9-6. When ordering a part include the following information:

a. Model number and serial number of instrument.

b. Hewlett-Packard stock number of part.

c. Complete description of part including circuit reference.

9-7. Parts which are not listed in the following tables can be ordered by giving complete description including function and location of part.

Table 9-1. Electrical Components (Sheet 1 of 10)

Ckt Ref.	Description	Mfr *	Stock No.	TQ*	RS*		
A1	Assembly, photocell (includes DS1, V1)	28480	113B-23A	1	0		
A2	Assembly, amplifier (includes C81, C82, C95, Q9 thru Q14, Q18, Q19, T10)	28480	113B-58A	1	0		
A3	Assembly, resistor board (includes C72 thru C74, CR2 thru CR4, R61 thru R64, R66)	28480	113B-75E	1	0		
A4	Assembly, resistor board (includes C75, C84, CR7, CR8, R65, R71 thru R74, T12)	28480	113B-75F	1	0		
A5	Assembly, resistor board (includes C91 thru C93, CR9 thru CR11, R80 thru R89)	28480	113B-75G	1	0		

* See introduction to this section

Table 9-1. Electrical Components (Sheet 2 of 10)

Ckt Ref.	Description	Mfr *	℗ Stock No.	TQ*	RS*		
A6	Assembly, resistor board (includes C85, C86, CR5, CR6, CR12, CR13, R70, R95, R96, T11)	28480	113B-75H	1	0		
A7	Assembly, resistor board (includes CR6, CR7, R7, T9)	28480	113B-75J	1	0		
A8	Assembly, Frequency Divider (includes A9 thru A11, C4 C19 C54 C60 C7 C24 C55 CR1 C11 C25 C57 Q1 thru Q8 C14 C34 C59 R51, S1 T1 thru T8)	28480	113A-42A	1	0		
A9	Assembly, resistor board (includes C16, C20, C21, C46, C48, C51, R8 thru R15, R38 thru R45)	28480	113A-75A	1	0		
A10	Assembly, resistor board (includes C6 R1 thru R5 C22 R16 C31 R17 C36 R31 thru R35 C50 R46 C52 R47 C61 R50)	28480	113A-75B	1	0		
A11	Assembly, resistor board (includes C2, C5, C9, C12, C17, C35, C56)	28480	113A-75C	1	0		
B1	Resolver	19315	3140-0018	1	0		
B2	Motor	28480	113B-97A	1	0		
C1	Capacitor: fixed, mica, 0.01 μf ±10%, 300 vdcw	76433	0140-0008	6	2		
C2	Capacitor: variable, ceramic, 7-45 pf, 500 vdcw	72982	0130-0001	4	1		
C3	Capacitor: fixed, mica, 100 pf ±5%, 500 vdcw Optimum value selected at factory Average value shown	76433	0140-0041	4	1		
C4	Capacitor: fixed, polystyrene, 1000 pf ±10%, 200 vdcw	56289	0170-0050	4	1		
C5	Capacitor: fixed, mica, 27 pf ±10%, 500 vdcw Optimum value selected at factory Average value shown	00853	0140-0005	1	1		

* See introduction to this section

Table 9-1. Electrical Components (Sheet 3 of 10)

Ckt Ref.	Description	Mfr *	ⓗp Stock No.	TQ*	RS*		
C6	Capacitor: fixed, electrolytic, 4 μf -15% +20%, 60 vdcw	10411	0180-0008	10	3		
C7	Same as C4						
C8	Same as C3						
C9	Same as C2						
C10	Same as C1						
C11	Capacitor: fixed, ceramic, 1500 pf ±20%, 500 vdcw	72982	0150-0020	1	1		
C12	Same as C2						
C13	Same as C3						
C14	Same as C4						
C15	Capacitor: fixed, mica, 330 pf ±10%, 500 vdcw	00853	0140-0043	2	1		
C16	Same as C6						
C17	Same as C2						
C18	Same as C3						
C19	Same as C4						
C20	Capacitor: fixed, mica, 1000 pf ±10%, 500 vdcw	76433	0140-0003	1	1		
C21, 22	Same as C6						
C23	Capacitor: fixed, mica, 1000 pf ±5%, 500 vdcw Optimum value selected at factory Average value shown	00853	0140-0018	5	2		
C24	Capacitor: fixed, polystyrene, 0.1 μf ±10%, 200 vdcw	56289	0170-0049	3	1		
C25	Capacitor: fixed, polystyrene, 0.01 μf ±10%, 200 vdcw	56289	0170-0048	4	1		
C26 thru C30	Not assigned						
C31	Capacitor: fixed, paper, 0.1 μf ±10%, 100 vdcw	56289	0160-0076	1	1		
C32	Not assigned						

* See introduction to this section

Table 9-1. Electrical Components (Sheet 4 of 10)

Ckt Ref.	Description	Mfr *	Stock No.	TQ*	RS*		
C33	Same as C23						
C34	Same as C25						
C35	Same as C15 Optimum value selected at factory Average value shown						
C36	Same as C6						
C37	Same as C25						
C38	Same as C23						
C39 thru C42	Not assigned						
C43	Same as C23						
C44	Same as C25						
C45	Not assigned						
C46	Same as C6						
C47	Same as C23						
C48	Same as C1						
C49	Not assigned						
C50	Same as C1						
C51, 52	Same as C6						
C53	Same as C1 Optimum value selected at factory Average value shown						
C54	Capacitor: fixed, paper, 1 μf ±10%, 200 vdcw	56289	0160-0075	3	1		
C55	Same as C24						
C56	Capacitor: fixed, mica, 3300 pf ±10%, 500 vdcw	76433	0140-0029	1	1		
C57	Capacitor: fixed, paper, 2 μf ±10%, 200 vdcw	56289	0160-0074	1	1		
C58	Same as C1 Optimum value selected at factory Average value shown						
C59	Same as C54						

* See introduction to this section

Table 9-1. Electrical Components (Sheet 5 of 10)

Ckt Ref.	Description	Mfr *	℗ Stock No.	TQ*	RS*		
C60	Same as C24						
C61	Capacitor: fixed, electrolytic, 40 μf -15% +50%, 30 vdcw	10411	0180-0071	3	1		
C62 thru C69	Not assigned						
C70	Same as C23						
C71	Capacitor: fixed, paper, 0.068 μf ±10%, 100 vdcw	56289	0160-0119	1	1		
C72 thru C74	Capacitor: fixed, electrolytic, 30 μf -15% +20%, 20 vdcw	10411	0180-0082	3	1		
C75	Same as C6						
C76	Capacitor: fixed, paper, 4 μf ±10%, 200 vdcw	56289	0160-0073	1	1		
C77	Same as C54						
C78 thru C80	Not assigned						
C81, 82	Capacitor: fixed, electrolytic, 1000 μf 50 vdcw	56289	0180-0090	2	1		
C83	Not assigned						
C84	Same as C6						
C85	Capacitor: fixed, mica, 820 pf ±10%, 500 vdcw	76433	0140-0010	2	1		
C86	Capacitor: fixed, polystyrene, 0.01 μf ±10%, 50 vdcw	56289	0170-0029	1	1		
C87 thru C90	Not assigned						
C91	Same as C85						
C92	Capacitor: fixed, mica, 4700 pf ±10%, 2500 vdcw	00853	0140-0019	1	1		
C93	Same as C61						
C94	Capacitor: fixed, mica, 470 pf ±10%, 300 vdcw	76433	0140-0139	1	1		
C95	Capacitor: fixed, paper, 1.0 μf ±20%, 200 vdcw	82376	0160-0029	1	1		
C96	Same as C61						

* See introduction to this section

Table 9-1. Electrical Components (Sheet 6 of 10)

Ckt Ref.	Description	Mfr *	℗ Stock No.	TQ*	RS*		
CR1	Diode, avalanche: 1N1594	75042	1902-0002	1	1		
CR2	Diode, germanium	73293	1910-0011	6	6		
CR3, 4	Diode, silicon	01295	1901-0022	5	5		
CR5	Diode, avalanche	04713	1902-0016	2	2		
CR6, 7	Same as CR3						
CR8 thru CR10	Same as CR2						
CR11	Same as CR5						
CR12, 13	Same as CR2						
CR14	Same as CR3						
CR15	Diode assembly	28480	113B-172A	1	1		
CR16	Diode assembly	28480	113B-172B	1	1		
DS1	Lamp, incandescent Attaching hardware: lamp support	71744 28480	2140-0016 113A-54A	1 1	1 0		
FL1	Filter, power line	56289	9110-0014	1	1		
J1 thru J4	Connector, female: BNC hermetic seal (UG-5944A)	91737	1250-0047	8	1		
J5	Connector, female: BNC (UG-1094/U)	91737	1250-0083	4	1		
J6	Connector, male: 5 pin	71468	1251-0111	1	1		
J7 thru J9	Same as J5						
J10	Connector, male: 4 pin	71468	1251-0110	2	1		
J11 thru J13	Same as J1						
J14	Same as J1						
J15	Same as J10						
M1	Meter: 0-100 μa	81030	1120-0083	1	1		
P1 thru P5	Not assigned						
P6	Connector, female: 5 pin	71468	1251-0126	1	1		
P7 thru P9	Not assigned						

* See introduction to this section

Table 9-1. Electrical Components (Sheet 7 of 10)

Ckt Ref.	Description	Mfr *	ⓗp Stock No.	TQ*	RS*		
P10	Connector, female: 4 pin	71468	1251-0108	1	1		
Q1 thru Q11	Transistor: 2N1373	77068	1850-0070	12	12		
Q12, 13	Transistor: 2N458A	01295	1850-0042	3	3		
Q14	Transistor: NPN	01295	1854-0001	1	1		
Q15 thru Q17	Transistor: PNP	94144	1850-0062	3	3		
Q18	Same as Q1						
Q19	Same as Q12						
R1	Resistor: fixed, composition, 3900 ohms ±10%, 1/2 W	01121	0687-3921	5	2		
R2	Resistor: fixed, composition, 1800 ohms ±10%, 1/2 W	01121	0687-1821	7	2		
R3	Resistor: fixed, composition, 1000 ohms ±10%, 1/2 W	01121	0687-1021	14	3		
R4	Same as R2						
R5, 6	Same as R3						
R7	Resistor: fixed, composition, 470 ohms ±10%, 1/2 W	01121	0687-4711	1	1		
R8	Resistor: fixed, composition, 10,000 ohms ±10%, 1/2 W	01121	0687-1031	8	2		
R9	Same as R3						
R10	Resistor: fixed, composition, 47,000 ohms ±10%, 1/2 W	01121	0687-4731	2	1		
R11	Resistor: fixed, deposited carbon, 1800 ohms ±1%, 1/2 W	19701	0727-0112	2	1		
R12, 13	Same as R3						
R14	Same as R8						
R15	Same as R2						
R16	Resistor: fixed, composition, 5600 ohms ±10%, 1/2 W	01121	0687-5621	2	1		
R17	Resistor: fixed, deposited carbon, 870 ohms ±1/2%, 1/2 W	19701	0727-0094	1	1		
R18 thru R30	Not assigned						

* See introduction to this section

Table 9-1. Electrical Components (Sheet 8 of 10)

Ckt Ref.	Description	Mfr *	℗ Stock No.	TQ*	RS*		
R31	Resistor: fixed, composition, 39,000 ohms ±10%, 1/2 W	01121	0687-3931	1	1		
R32	Resistor: fixed, composition, 18,000 ohms ±10%, 1/2 W	01121	0687-1831	1	1		
R33	Same as R8						
R34	Same as R2						
R35	Same as R3						
R36, 37	Not assigned						
R38	Same as R8						
R39	Same as R3						
R40	Same as R10						
R41	Same as R11						
R42	Same as R3						
R43, 44	Same as R8						
R45	Same as R2						
R46	Same as R16						
R47	Resistor: fixed, composition, 820 ohms ±10%, 1/2 W	01121	0687-8211	1	1		
R48, 49	Not assigned						
R50	Same as R3						
R51	Resistor: fixed, composition, 330 ohms ±10%, 1 W	01121	0690-3311	1	1		
R52, 53	Not assigned						
R54	Resistor: fixed, composition, 220,000 ohms ±10%, 1/2 W Optimum value selected at factory Average value shown	01121	0687-2241	1	1		
R55	Resistor: fixed, deposited carbon, 2900 ohms ±1%, 1/2 W	19701	0727-0123	1	1		
R56	Same as R3						
R57	Resistor: fixed, composition, 270 ohms ±10%, 1/2 W	01121	0687-2711	1	1		
R58	Resistor: fixed, composition, 220 ohms ±10%, 1/2 W Optimum value selected at factory Average value shown	01121	0687-2211	1	1		

* See introduction to this section

Table 9-1. Electrical Components (Sheet 9 of 10)

Ckt Ref.	Description	Mfr *	℗ Stock No.	TQ*	RS*		
R59	Resistor: variable, composition, 75 ohms ±10%, 2 W	01121	2100-0076	1	1		
R60	Resistor: fixed, composition, 56 ohms ±10%, 1/2 W	01121	0687-5601	1	1		
R61	Resistor: fixed, composition, 22,000 ohms ±10%, 1/2 W	01121	0687-2231	1	1		
R62 thru R64	Same as R1						
R65	Same as R8						
R66	Same as R3						
R67, 68	Resistor: fixed, deposited carbon, 20,400 ohms ±1%, 1/2 W Optimum value selected at factory Average value shown	19701	0727-0175	4	1		
R69	Resistor: fixed, deposited carbon, 312,000 ohms ±1%, 1/2 W	19701	0727-0232	2	1		
R70	Same as R3						
R71	Resistor: fixed, composition, 27,000 ohms ±10%, 1/2 W	01121	0687-2731	1	1		
R72	Resistor: fixed, composition, 680 ohms ±10%, 1/2 W	01121	0687-6811	1	1		
R73	Resistor: fixed, composition, 2200 ohms ±10%, 1/2 W	01121	0687-2221	3	1		
R74	Same as R8						
R75 thru R78	Not assigned						
R79	Resistor: variable, composition, linear taper, 20,000 ohms ±20%, 2 W	01121	2100-0060	1	1		
R80	Resistor: fixed, deposited carbon, 24,700 ohms ±1%, 1/2 W	19701	0727-0178	1	1		
R81	Resistor: fixed, composition, 3300 ohms ±10%, 1/2 W	01121	0687-3321	1	1		
R82	Same as R73						
R83	Same as R1						
R84	Same as R3						
R85	Same as R73						
R86	Same as R2						

* See introduction to this section

Table 9-1. Electrical Components (Sheet 10 of 10)

Ckt Ref.	Description	Mfr *	ⓗ Stock No.	TQ*	RS*		
R87	Same as R3						
R88	Resistor: fixed, composition, 82 ohms ±10%, 1/2 W	01121	0687-8201	1	1		
R89	Resistor: fixed, composition, 220 ohms ±10%, 1/2 W	01121	0687-2211	1	1		
R90 thru R92	Not assigned						
R93, 94	Resistor: fixed, wirewound, 1 ohm ±1%, 5 W	91637	0811-0040	2	1		
R95	Same as R2						
R96	Resistor: fixed, wirewound, 2 ohms ±1%, 5 W	91637	0811-0043	1	1		
R97	Resistor: fixed, deposited carbon, 860 ohms ±1%, 1/2 W Optimum value selected at factory Average value shown	19701	0727-0092	1	1		
R98	Resistor: fixed, deposited carbon, 18,000 ohms ±1% 1/2 W Optimum value selected at factory Average value shown	19701	0727-0170	1	1		
R99, 100	Same as R67 Optimum value selected at factory Average value shown						
R101	Same as R69						
S1	Switch, toggle: DPDT, momentary action	88140	3101-0020	1	1		
S2	Switch, rotary: 1 section, 5 position	76854	3100-0267	1	1		
T1	Transformer: 100 kc	28480	113A-60A	1	1		
T2	Transformer: 30 kc	28480	113A-60B	1	1		
T3	Transformer: 90 kc	28480	113A-60C	1	1		
T4	Transformer: 10 kc	28480	113A-60D	1	1		
T5	Transformer: 10 kc	28480	113A-60E	1	1		
T6	Transformer: 3 kc	28480	113A-60F	1	1		
T7	Transformer: 9 kc	28480	113A-60G	1	1		
T8/L1	Transformer/inductor assembly: 1 kc	28480	113A-60H	1	1		
T9	Transformer: audio	28480	9120-0061	1	1		
T10	Transformer: pulse, 4:2:1	01961	9130-0012	1	1		
T11	Transformer: pulse, 1:1:1	01961	9130-0013	1	1		
V1	Cell, photosensitive: 1N2175	01295	1970-0007	1	1		

* See introduction to this section

Table 9-2. Miscellaneous Components (Sheet 1 of 1)

Description	Mfr *	Stock No.	TQ*	RS*		
Coiled cord, 3 conductor, 12 turns	85660	8120-0058	1	1		
Coiled cord, 5 conductor, 16 turns	85660	8120-0059	1	1		
Desiccant, 2-unit packet	85474	9240-0001	2	2		
Humidity Indicator	00334	9240-0005	1	1		
Insulator wafer: anodized aluminum (pwr transistors)	76530	1200-0043	3	3		
Insulator insert (for power transistors)	83298	1410-0001	6	3		
Kit, gear lubrication	28480	113A-95A	1	0		
Knob, CIRCUIT CHECK	28480	G-74N	1	0		
Knob and dial, TIME REFERENCE MICROSECONDS	28480	113A-40A	1	0		
Power cable, 6 ft. (connects 113BR to power supply)	28480	113A-16E	1	1		
Chassis glide	28480	0403-0017	2	2		
Connector, 4 socket, MS3106E-14S-2S (mates with J14 on 113BR)	71468	1251-0108	1	0		
Connector, 4 pin, MS3106E-14S-2P (mates with J3 on power supply)	71468	1251-0127	1	0		
(Abbreviation BHMS=binding head machine screw)						
BHMS, 6-32 x 7/16, stainless steel, sealing		2390-0011	6	2		
BHMS, 8-32 x 1, stainless steel, sealing		2550-0002	2	2		
BHMS, 8-32 x 1/2, stainless steel, sealing		2550-0004	6	2		
BHMS, Phillips, 8-32 x 1/2, stainless steel, sealing		2550-0001	12	4		
BHMS, Phillips, 8-32 x 3/4, stainless steel, sealing		2550-0003	2	2		
BHMS, 4-40 x 5/16, stainless steel, sealing		2230-0001	9	5		
BHMS, 4-40 x 1/2, stainless steel, sealing		2230-0002	4	2		
Silicone compound: 8 oz tube (for transistor heat sink and panel-shaft seal lubrication)	71984	8500-0059	1	1		
Threaded plug (for clock hand adjustment access)	28480	113A-99F	2	1		
"O" ring: 3-1/2 ID	02280	0900-0019	1	1		
"O" ring: 15/16 ID	02286	0900-0020	2	2		
"O" ring: 3/4 ID		0900-0021	1	1		
"O" ring: 3/8 ID	02286	0900-0022	2	2		
"O" ring: 1/4 ID	02286	0900-0023	1	1		
"O" ring: 5/32 ID	02286	0900-0024	2	2		
Panel mounting strap	28480	113A-12D	2	2		
Transistor, heat sink	28480	113A-11A	13	3		
Spacer, heat sink	28480	113A-47A	13	3		
Cap, heat sink	28480	113A-57A	13	3		
Bushing, insulator	28480	0340-0019	13	3		
Window, clock face	28480	113A-99B	1	1		
Window, MILLISECONDS indicator	28480	113A-99C	1	1		

* See introduction to this section

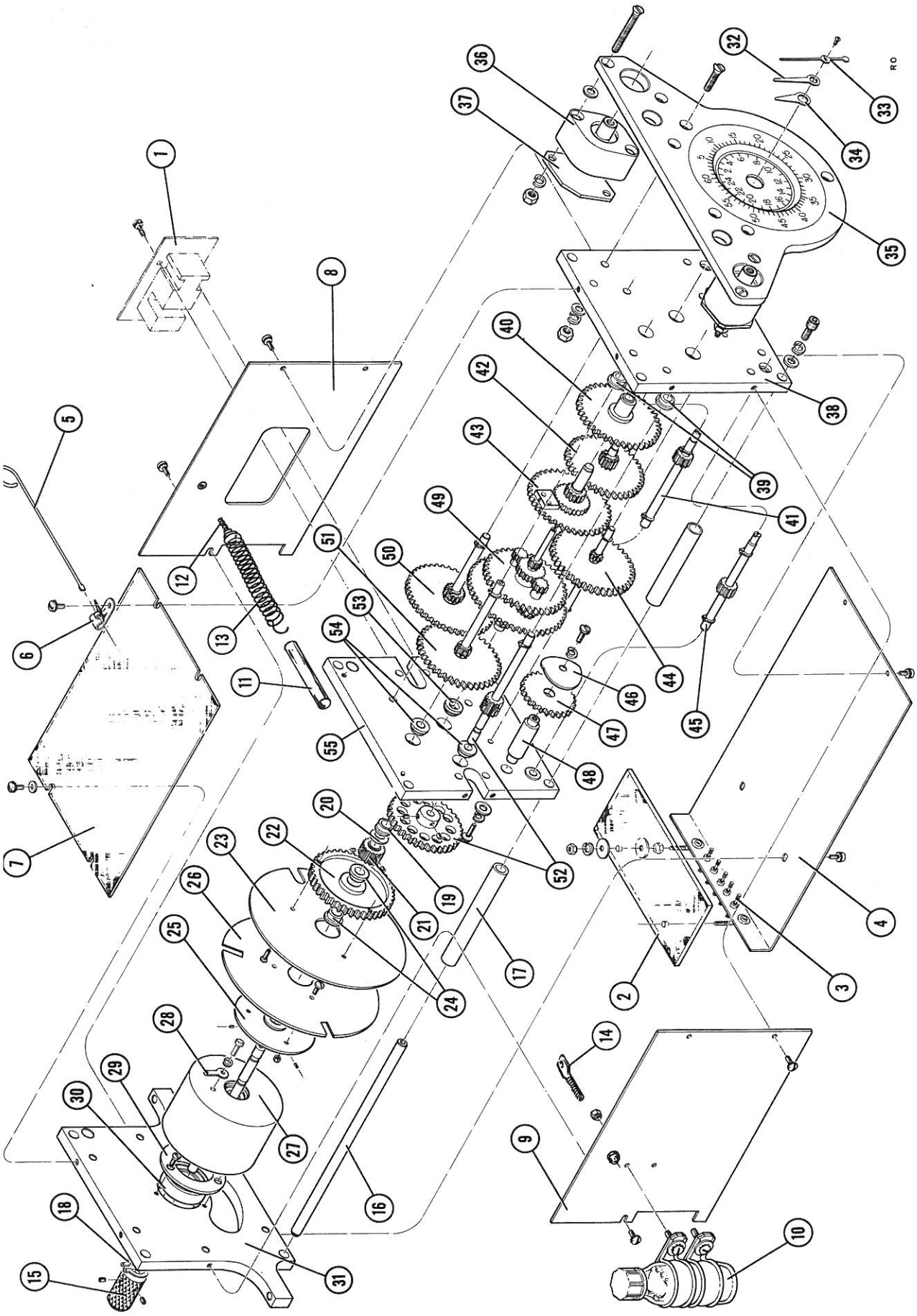


Figure 9-1. Clock Gear Mechanism Exploded View

Table 9-3. Clock Gear Mechanism Components (Sheet 1 of 3)

Item Figure 9-1	Description	Mfr *	Stock No.	TQ*	RS*		
	(Abbreviations: BHMS = binding head machine screw FHMS = flat head machine screw						
	Assembly, clock gear, complete (includes motor B2, gears, light beam gating disks, clock face and hands)	28480	113B-36A	1	1		
1	Photocell Assembly (see A1, table 9-1)						
	attaching hardware: BHMS, 8-32 x 3/8, stainless steel, with lockwasher		2550-0007	2	2		
2	Guard plate	28480	113A-41F	1	0		
	attaching hardware: Flat washer, #6		3050-0016	4	4		
	Lockwasher, split, #6		2190-0006	2	2		
	Nut, 6-32, stainless steel		2420-0003	4	4		
3	Tie point, feed-through	01255	0340-0015	5	1		
	Insulator bushing for above	01255	0340-0011	5	1		
4	Bottom cover	28480	113A-1B	1	0		
	attaching hardware: BHMS, 6-32 x 5/16, stainless steel, with lockwasher		2390-0007	4	4		
5	Oil applicator	0000N	8710-0001	1	0		
6	Clip, Fahnstock	79963	1400-0043	2	0		
7	Top plate	28480	113A-41E	1	0		
	attaching hardware: BHMS with lockwasher, 6-32 x 5/16, stainless steel		2390-0007	4	4		
	Flatwasher, #6		3050-0100	2	2		
8	Right side plate	28480	order by description	1	0		
	attaching hardware: BHMS with lockwasher, 6-32 x 5/16, stainless steel		2390-0007				
9	Left side plate	28480	order by description	1	0		
	attaching hardware: BHMS with lockwasher, 6-32 x 5/16, stainless steel						
10	Lubricant (1 oz bottle)	28480	113A-95A	1	0		
	attaching hardware: clamp, 1 inch	95987	1400-0002	2	0		
	BHMS with lockwasher, 6-32 x 1/2, stainless steel		2390-0001	2	0		
	flatwasher, #6		3050-0100	2	0		
	nut with lockwasher, 6-32	28480	2420-0001	2	0		
11	Plastic tubing, 3 in. length of 0890-0006		order by description				
12	Adjusting screw	28480	113B-13A	1	0		
13	Spring, tension, 0.291 in. ID x 1-1/2 in.	05006	1460-0089	1	1		
14	Spade lug, 6-32 x 1/2	79251	0560-0003	1	0		
15	Knob, motor starting	28480	113A-74C	1	0		

* See introduction to this section

Table 9-3. Clock Gear Mechanism Components (Sheet 2 of 3)

Item igure 9-1	Description	Mfr *	hp Stock No.	TQ*	RS*		
16	Aligning pin	28480	113A-101A	4	0		
	attaching hardware:						
	cap screw, Allen-socket, 8-32 x 3/8		3030-0019	8	4		
	lockwasher, split, #8		2190-0017	8	4		
	washer, flat, #8, stainless steel		3050-0139	8	4		
17	Rear spacer	28480	113A-47E	4	0		
18	Retaining ring	90970	0510-0081	1	0		
19	Ball bearing	40920	1410-0057	1	0		
20	Shim washer (optional)	78471	3050-0017	1	0		
21	Motor pinion	28480	113A-24B	1	0		
	attaching hardware:						
	setscrew, Allen, 6-32 x 1/8		3030-0022	2	0		
22	Gear, 60 rpm disk	28480	113A-24A	1	0		
23	Disk, 60 rpm	28480	113A-36A-5	1	0		
	attaching hardware:						
	BHMS, 2-56 x 3/16, stainless steel		0520-0024	3	0		
24	Ball bearing	40920	1410-0057	2	0		
25	Hub, 1000 rpm disk	28480	113B-36A-2	1	0		
	attaching hardware:						
	setscrew, Allen, 8-32 x 1/8		3030-0022				
26	Disk, 1000 rpm	28480	113A-36A-3	1	0		
	attaching hardware:						
	BHMS, 2-56 x 3/16, stainless steel		0520-0024	3	0		
	nut, 2-56, stainless steel		0610-0001	3	0		
27	Motor (refer to B2, table 9-1)						
28	Lug, straight #6	79963	0360-0005	1	0		
	attaching hardware:						
	Fillister head machine screw, 6-32 x 1/4, stainless steel		2380-0001	1	0		
	lockwasher, split, #6		2190-0006	1	0		
	flat washer, #6		3050-0016				
29	Bearing retainer	28480	113A-17G	1	0		
	attaching hardware:						
	FHMS, 4-40 x 1/4, stainless steel		2210-0002	3	0		
30	Ball bearing	21335	1410-0066	1	0		
31	Rear plate	28480	113A-17D	1	0		
32	Second hand	74455	1490-0020	1	1		
33	Minute hand, white	0000P	1490-0029	1	1		
34	Hour hand, white	0000P	1490-0028	1	1		
35	Face plate, black	28480	113A-40C	1	0		
	attaching hardware:						
	FHMS, 8-32 x 7/8, stainless steel		2530-0005	5	0		
	flat washer, #8, stainless steel		3050-0139	5	0		
	lockwasher, split, #8		2190-0017	5	0		
	nut, 8-32, stainless steel		2580-0004	5	0		

* See introduction to this section

Table 9-3. Clock Gear Mechanism Components (Sheet 3 of 3)

Item Figure 9-1	Description	Mfr *	℗ Stock No.	TQ*	RS*		
36	Shock absorber (2 each required on mechanism, 2 each required on chassis)	76005	1520-0009	4	2		
37	Plate, shock mount retainer	28480	113A-12J	2	0		
	attaching hardware:						
	FHMS, 8-32 x 1-3/8, stainless steel		2530-0002	4	4		
	lockwasher, split, #8		2190-0017	4	4		
	nut, 8-32, stainless steel		2580-0004	4	4		
38	Assembly, front plate	28480	113A-95C	1	0		
39	Ball bearing	40920	1410-0055	2	0		
40	Gear, 1/24 rph	28480	113A-24G	1	0		
41	Assembly, gear, minute adjust	28480	113A-95H	1	0		
42	Assembly, gear, 1/4 rph	28480	113A-95M	1	0		
43	Assembly, gear and ratchet, 1 rph	28480	113A-95L	1	0		
44	Assembly, gear, 8 rph	28480	113A-95K	1	0		
45	Assembly, gear, second adjust	28480	113A-95J	1	0		
46	Spring washer	28480	113A-91C	1	0		
47	Gear, second adjust idler	28480	113A-24S	1	0		
	attaching hardware:						
	BHMS, 6-32 x 3/8, stainless steel		2390-0008	1	0		
	lockwasher, split, #6		2190-0006	1	0		
48	Bearing post	28480	113A-37H	1	0		
	attaching hardware:						
	BHMS, 6-32 x 3/8, stainless steel		2390-0008	1	0		
	lockwasher, split, #6		2190-0006	1	0		
	flat washer, #6		3050-0100	1	0		
49	Assembly, planetary gear, 1 rpm	28480	113A-95G	1	0		
50	Assembly, gear, 10 rpm	28480	113A-95F	1	0		
51	Assembly, gear, 60 rpm	28480	113A-95E	1	0		
52	Assembly, gear, 300 rpm	28480	113A-95D	1	0		
53	Ball bearing	40920	1410-0057	1	0		
54	Ball bearing	40920	1410-0055	2	0		
55	Assembly, center plate	28480	113A-95B	1	0		

* See introduction to this section

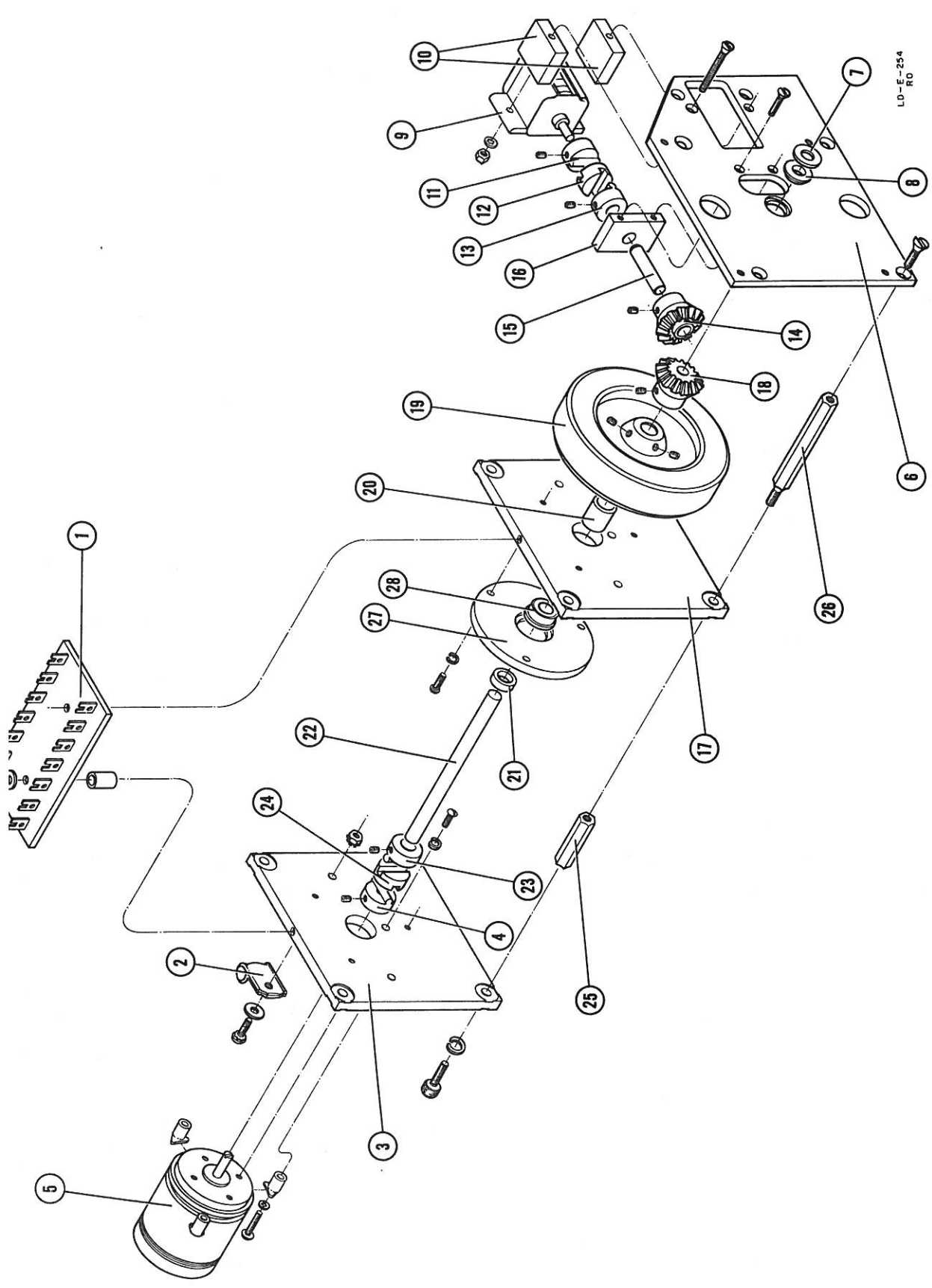


Figure 9-2. Resolver Mechanism Exploded View

01044-1

Table 9-4. Resolver Mechanism Components (Sheet 1 of 2)

em re 9-2	Description	Mfr *	Stock No.	TQ*	RS*		
	Assembly, resolver mechanism, complete (includes resolver B1, flywheel, gears, MILLISECONDS shaft revolution counter)	28480	113A-14A	1	1		
	Resistor board (see A6)						
	Clamp, 3/16 inch	95987	1400-0053	2	0		
	attaching hardware:						
	BHMS with lockwasher, 8-32 x 1/2, stainless steel		2550-0009	2	0		
	flat washer, #8		3050-0063	2	0		
	nut with lockwasher, 8-32		2580-0003	2	0		
	Resolver plate	28480	113A-17A	2	0		
	attaching hardware:						
	cap screw, Allen drive, 8-32 x 3/8, cadmium plated steel		3030-0019	4	0		
	lockwasher, split #8		2190-0017	4	0		
	Coupler hub, 0.120 ID	99934	1500-0008	1	0		
	attaching hardware:						
	setscrew, Allen head, 4-40 x 1/8, cadmium plated steel		3030-0007	2	0		
	Resolver (see B1)						
	attaching hardware:						
	clamp	19315	1400-0073	3	0		
	BHMS, 3-56 x 1/2, stainless steel		0525-0003	3	0		
	lockwasher, internal #3		2190-0031	3	0		
	RHMS, 4-40 x 5/16		2280-0002	1	0		
	lockwasher, internal #4		2190-0004	1	0		
	Front bearing plate	28480	113A-17F	1	0		
	attaching hardware:						
	FHMS, 8-32 x 1/2, stainless steel		2530-0003	4	0		
	Washer, bearing retainer	28480	113A-88C	1	0		
	Ball bearing	40920	1410-0057	1	0		
	Revolution counter	79142	1140-0001	1	0		
	attaching hardware:						
	FHMS, 4-40 x 1		2290-0004	2	0		
	nut, 4-40, stainless steel		2260-0001	2	0		
	lockwasher, internal #4		2190-0004	2	0		
	Spacing block	28480	113A-47J	2	0		
	Coupler hub, 1/8 ID	99934	1500-0007	1	0		
	attaching hardware:						
	setscrew, Allen head, 4-40 x 1/8, cadmium plated steel		3030-0007	2	0		
	Coupler insert	99934	1500-0004	1	0		
	Coupler hub, 1/4 ID	99934	1500-0005	1	0		
	attaching hardware:						
	setscrew, Allen head, 6-32 x 1/8, cadmium plated steel		3030-0022	2	0		

* See introduction to this section

Table 9-4. Resolver Mechanism Components (Sheet 2 of 2)

Item Figure 9-2	Description	Mfr *	Stock No.	TQ*	RS*		
14	Bevel gear (metal)	28480	624A-36A-3	1	0		
	attaching hardware: setscrew, Allen head, 8-32 x 1/8, cadmium plated steel		3030-0005	2	0		
15	Shaft, counter coupling	28480	113A-37J	1	0		
16	Pillow block	28480	113A-47K	1	0		
	attaching hardware: FHMS, 4-40 x 5/8		2290-0003	2	0		
17	(same as item 3)						
18	Bevel gear (plastic)	28480	113A-24W	1	0		
	attaching hardware: setscrew, Allen head, 8-32 x 1/8 cadmium plated steel		3030-0005	2	0		
19	Flywheel	28480	113A-104A	1	0		
	attaching hardware: setscrew, Allen head, 8-32 x 1/8, cadmium plated steel		3030-0005	2	0		
20	Spacer, flywheel	28480	113A-47L	1	0		
21	Spacer, hub	28480	113A-47M	1	0		
22	Shaft, resolver	28480	2-2494-SS-3-1/8	1	0		
23	Coupler hub, 1/4 ID	99934	1500-0005	1	0		
	attaching hardware: setscrew, Allen head, 6-32 x 1/8, cadmium plated steel		3030-0022	2	0		
24	Coupler insert	99934	1500-0004	1	0		
25	Rear spacer	28480	113A-47G	4	0		
26	Front spacer	28480	113A-47H	4	2		
27	Plate, bearing retainer	28480	113A-17E	1	0		
	attaching hardware: RHMS, 3-56 x 3/8, stainless steel		0525-0002	3	0		
	lockwasher, internal #3		2190-0031	3	0		
28	Ball bearing	40920	1410-0056	1	0		

* See introduction to this section

Table 9-5. Tools (Sheet 1 of 1)

Description	Mfr *	℗ Stock No.	TQ*	RS*		
Hand installer, ℗ tool 12578	28480	none		1		
Clock Mechanism Tool Kit (includes 1 each of the following items)	28480	113A-95N		0		
Lubricant, PML grease (tube)	26992	6040-0024				
Tweezers	28480	8710-0007				
Pliers, Truarc #2 straight nose	90970	8710-0009				
Wrench set, Allen, 0.050; 1/16; 5/64; 3/32; 1/8; 5/32	84396	8720-0019				
Wrench, Allen, 0.035 (for 2-56 setscrew)	84396	1470-0008				
Torque screwdriver, cal-30 roto torque	28480	8730-0012				
1/8 Allen driver insert bit	03705	8830-0015				
5/32 Allen driver insert bit	03705	8830-0014				
1/4 slotted screwdriver insert bit	03705	8830-0013				
Bit holder	03705	8830-0016				
Screwdriver (Stanley #25 - 4")	76210	8730-0001				
Screwdriver (Stanley #1010)	84396	8730-0008				
Face centering pin ℗ tool #8754	28480	113A-95N-1				
Assembly fixture ℗ tool #8758	28480	113A-95N-2				
Disk alignment jig ℗ tool #8759	28480	113A-95N-3				

* See introduction to this section

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

CODE NO.	MANUFACTURER	ADDRESS
00334	Humidial Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00853	Sangamo Electric Co., Cap. Div.	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	Pacific Semiconductors, Inc.	Culver City, Calif.
01295	Texas Instruments, Inc. Semiconductor Components Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04404	Dymec Inc.	Palo Alto, Calif.
04651	Special Tube Operations of Sylvania Electronic Systems	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Division	Culver City, Calif.
04777	Automatic Electric Sales Corp.	Northlake, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05624	Barber Colman Co.	Rockford, Ill.
05783	Stewart Engineering Co.	Soquel, Calif.
06004	The Bassick Co.	Bridgeport, Conn.
06812	Torrington Mfg. Co., West. Div.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08718	Cannon Electric Co. Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.
09134	Texas Capacitor Co.	Houston, Texas
09250	Electro Assemblies, Inc.	Chicago, Ill.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
12697	Clarostat Mfg. Co.	Dover, N.H.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
15909	The Daven Co.	Livingston, N.J.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G. E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G. E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C. A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Mfg. Co.	Waltham, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.
62119	Universal Electric Co.	Owosso, Mich.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66346	Wollensak Optical Co.	Rochester, N.Y.
70119	Advance Electric and Relay Co.	Burbank, Calif.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71450	Chicago Telephone Supply Co.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C. P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A. O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Div. of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	Industrial Products Co.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Mfg. Co., Inc.	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littelfuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C. W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Chicago, Ill.
77068	Bendix Corp., Bendix Pacific Div.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77342	Potter and Brumfield, Inc.	Princeton, Ind.

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APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

CODE NO.	MANUFACTURER	ADDRESS
77630	Radio Condenser Co.	Camden, N.J.
77634	Radio Essentials Inc.	Mt. Vernon, N.Y.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
78283	Signal Indicator Corp.	New York, N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78790	Transformer Engineers	Pasadena, Calif.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association Any brand tube meeting EIA standards	Washington, D.C.
80248	Oxford Electric Corp.	Chicago, Ill.
80411	Acro Manufacturing Co.	Columbus, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Tube Division	Quincy, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Texas Instruments, Inc., Metals and Controls Div., Spencer Products	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82893	Vector Electronic Co.	Glendale, Calif.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85474	R. M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers, Inc.	Attleboro, Mass.
91637	Dale Products, Inc.	Columbus, Neb.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Micro-Switch Div. of Minneapolis Honeywell Regulator Co.	Freeport, Ill.
92196	Universal Metal Products, Inc.	Bassett Puente, Calif.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94144	Raytheon Mfg. Co., Receiving Tube Div.	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div.	Newton, Mass.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	Carlstadt, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95265	National Coil Co.	Sheridan, Wyo.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	New Rochelle, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99821	North Hills Electric Co.	Great Neck, L.I., N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics, Corp.	Evanston, Ill.
99957	Technology Instruments Corp. of Calif.	No. Hollywood, Calif.

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

0000C	Connor Spring Mfg. Co.	San Francisco, Calif.
0000D	Connex Corp.	Oakland, Calif.
0000E	Fisher Switches, Inc.	San Francisco, Calif.
0000F	Malco Tool and Die	Los Angeles, Calif.
0000G	Microwave Engineering Co.	Palo Alto, Calif.
0000H	Philco Corp. (Lansdale Division)	Lansdale, Pa.
0000I	Telefunken (c/o American Elite)	New York, N.Y.
0000L	Winchester Electronics, Inc.	Santa Monica, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000R	Metro Cap. Div., Metropolitan Telecommunications Corp.	Brooklyn, N.Y.
0000S	Moulton Electronics	San Carlos, Calif.

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WARRANTY

All our products are warranted against defects in materials and workmanship for one year from the date of shipment. Our obligation is limited to repairing or replacing products (except tubes) which prove to be defective during the warranty period. We are not liable for consequential damages.

For assistance of any kind, including help with instruments under warranty, contact your authorized hp Sales Representative for instructions. Give full details of the difficulty and include the instrument model and serial numbers. Service data or shipping instructions will be promptly sent to you. There will be no charge for repair of instruments under warranty, *except transportation charges*. Estimates of charges for non-warranty or other service work will always be supplied, if requested, before work begins.

CLAIM FOR DAMAGE IN SHIPMENT

Your instrument should be inspected and tested as soon as it is received. The instrument is insured for safe delivery. If the instrument is damaged in any way or fails to operate properly, file a claim with the carrier or, if insured separately, with the insurance company.

SHIPPING

On receipt of shipping instructions, forward the instrument prepaid to the destination indicated. You may use the original shipping carton or any strong container. Wrap the instrument in heavy paper or a plastic bag and surround it with three or four inches of shock-absorbing material to cushion it firmly and prevent movement inside the container.

GENERAL

Your authorized hp Sales Representative is ready to assist you in any situation, and you are always welcome to get directly in touch with Hewlett-Packard service departments:

CUSTOMER SERVICE

Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California, U.S.A.
Telephone: DAvenport 6-1755
Direct Dial Area Code 415
TWX No. PAL AL 117-U
Cable: "HEWPACK"

OR (In Western Europe)

Hewlett-Packard S.A.
Rue du Vieux Billard No. 1
Geneva, Switzerland
Telephone: (022) 26. 43. 36
Cable: "HEWPACKSA"