OPERATION AND SERVICE MANUAL

FOR

MODEL CD624

DIGITAL CLOCK

Model CD624

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SPECIFICATIONS

Table 1-1. Specifications

Display	Six-digit nixie tube display indicating hours, minutes, and seconds
Alarm	Programmable time of day, audible alert from internal speaker
1 pulse per second (1 PPS) output (0.4 volt into 50 ohms)	BNC connector, 30 volts into 1 megohm
Time base (selectable)	
Internal	Ovenized quartz crystal oscillator, 36 kc
AC line input	60 cps only
Accuracy	
Internal time base	Less than ±0.5 second per month
AC line operation	Line frequency dependent, ±7 seconds typical
Aging rate	Less than 2 parts in 10^7 per week at time of shipment
Power requirements	105 - 130 volts, 50-1500 cps, 40 watts
Fuse	1-ampere cartridge fuse
Size	15" wide x 9" high x 12" deep
Weight	35 lbs

SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION

The CD624 Digital Clock is an accurate and reliable time of day clock featuring a 24-hour display and programmable audible alarm. Time is maintained independent of the AC power line frequency using a quartz crystal oscillator exhibiting superb accuracy. By employing the latest in cold cathode tube technology, the clock's power consumption is reduced to less than 40 watts, an efficiency unrivaled by other instruments of its kind. Further outstanding characteristics of this clock are its high resilience to radiation, high reliability, compact size, and bright, easy to read nixie tube readout.

With its distinctive features, the CD624 will find use in a host of military and industrial applications including laboratories, bunkers, radio rooms, and fallout shelters.

1-2. SUPPLIED ACCESSORIES

POWER CABLE
The three conductor power cable supplied with this instrument is terminated in a three prong male connector. The third contact is a retractable round pin, affixed to a standard two-blade connector, which grounds the instrument chassis when used with the appropriate receptacle. To use this connector in a standard two-contact receptacle, the third contact may be rotated aside, allowing the connector blades to engage the receptacle normally.

MODEL DS-36 TUNING TOOL
A tuning tool is included with the clock, held in a clip located on the rear inside wall of the cabinet. The insulated tool has a specially shaped driver at each end, one for the coarse frequency adjustment, and the other for the fine frequency adjustment. To prevent damage to the tuning screws, all adjustments should be made with the tool provided.

SECTION II
OPERATING INSTRUCTIONS

2-1. CONTROLS AND CONNECTORS

J1
AC power input circular connector accessible from the cabinet rear. Apply 105 - 130 volts, 50-1500 cps, using the supplied power cable.

F1
Power input fuse accessible from the cabinet rear. Replace with a 1-ampere cartridge fuse. The fuse holder illuminates if the fuse is blown.

SET/ALARM TIME ROTARY SWITCHES
Used in conjunction with the TIME SET pushbutton to set the clock's time, or to set the alarm time when the alarm is in use.

TIME SET PUSHBUTTON
Used in conjunction with the rotary switches during the initial setting of the clock. Inhibits counting while depressed.

ALARM ON
Enables the audible alarm.

REF LINE/XTAL
Selects either the internal crystal controlled oscillator, or the AC power line frequency as the source of timing for the clock.

OSC ON/OFF
Turns the power supply to the internal crystal oscillator on or off.

1 PPS OUT CONNECTOR
Provides a once-per-second voltage pulse synchronous with the seconds display.

OVEN ON/OFF - INTERNAL SWITCH (S1)
Located on the top side of the clock chassis. Turns power to the crystal oven heater on or off.

COARSE FREQUENCY ADJUST - INTERNAL CAPACITOR (C5)
Located on the top side of the clock chassis; used to make large adjustments to the internal oscillator frequency. Full tuning range in 180 degrees of rotation.

FINE FREQUENCY ADJUST - INTERNAL CAPACITOR (C6)
Located on the top side of the clock chassis; used to make small adjustments to the internal oscillator frequency. This is a multi-turn capacitor; one full revolution of the screw corresponds to approximately 7 parts in 10^7 change in frequency.

2-2. OPERATION

2-3. INITIAL INSTALLATION
When the instrument is first put into operation, the following procedure should be observed:

a. Make sure the crystal oven and all tubes are firmly in their sockets.

b. Plug the power cord into a 115 volt, 50 - 1500 cycle power supply. Upon initial power-on, the clock display will show random digits, with some digits possibly not illuminated at all. Even though it takes approximately 12 hours of warm-up for the crystal oven to heat to the proper temperature and for the frequency of the internal oscillator to stabilize, the clock may now be set to the approximate time. See SETTING TIME.

c. For maximum accuracy and stability, the clock should be placed in a location free from air drafts and large temperature fluctuations, with an ambient temperature in the range of 10 to 40 degrees C.

2-4. SETTING TIME
Setting the time of the CD624 involves synchronizing the clock with a reference clock known to be accurate. Examples of reference clocks include WWV radio signals provided by the National Bureau of Standards, the telephone Time of Day service, Western Union clocks, and the time services provided by some observatories.

Place the four HOURS and MINUTES rotary switches in positions corresponding to a time one or two minutes ahead of the reference clock. As the reference clock time approaches the time set on the switches, depress and hold the set button. This action pre-sets the hours and minutes, resets the seconds and 10ths of seconds to zero, and suspends the clock's counting. At the instant the reference clock time is identical to the CD624 display, release the pushbutton. The CD624 time, and its 1 PPS output, are now in synchronism with the reference clock.

NOTE:
Do not press the TIME SET pushbutton more than once in a 10 second period. The capacitive circuit requires time to recharge.

The method of setting the clock just described is an approximate one. To obtain a more precise time setting, refer to the techniques described in the section FREQUENCY ADJUSTMENT OF THE INTERNAL CRYSTAL OSCILLATOR.

2-5. USING THE ALARM

To set the time of day alarm, place the four HOURS and MINUTES rotary switches in positions corresponding to the desired alarm time. Place the ALARM switch in the ON position. The alarm will sound when the clock's HOURS and MINUTES display matches the time set on the switches. Once the alarm sounds, it will continue to do so until the ALARM switch is returned to the OFF position. The alarm will immediately sound again if the ALARM switch is turned back ON while the HOURS and MINUTES displays still correspond to the alarm time. It is necessary therefore, to wait at least one minute before re-arming the alarm to sound again at the same time the following day.

2-6. TIMING REFERENCE

Either the internal crystal oscillator, or the 60 cycle power line may be selected as the timing reference for the clock. Place the REF LINE/XTAL switch in the XTAL position to select the internal crystal oscillator, or the LINE position to select the AC power line frequency as the reference.

Note that while the clock is capable of operating on a 115 volt source of any frequency between 50 and 1500 cycles, it will only be accurate in LINE reference mode when using standard 60 cycle power.

Deciding which reference source is optimum for a particular application requires detailed knowledge of the frequency stability of the local power source, the stability of the internal crystal oscillator, and the accuracy required by the application.

General guidelines:
The internal oscillator will provide better short-term accuracy than the power line, but requires periodic recalibration to keep the clock within a given window of time error.

Using the 60 cycle power line as a reference has the advantage of the clock not needing periodic recalibration, but comes at the expense of poorer short term stability.

2-7. OSCILLATOR POWER ON/OFF

When long-term operation of the clock using the power line frequency as a reference is contemplated, the crystal oscillator may be switched off to extend the life of oscillator components To turn the oscillator off, place the OSC ON/OFF switch in the OFF position. Although not necessary, power to the crystal oven would typically be turned off in this mode of operation. Refer to the section, OVEN ON/OFF - INTERNAL SWITCH (S1).

2-8. 1 PULSE PER SECOND (1 PPS) OUTPUT

To facilitate measurement of the clock's timing, or to synchronize external devices, a high-impedance, once-per-second pulse is provided at the 1 PPS OUT BNC jack on the front panel.

Amplitude of the 1 PPS signal is 30 volts into one megohm, or 400 millivolts into 50 ohms, with the rising edge of the signal being synchronous with the seconds counting of the clock. The pulse width is approximately 10 microseconds.

2-9. OVEN POWER - INTERNAL SWITCH (S1)

The crystal oven switch, S1, located on the top side of the chassis, may be switched off to extend oven life and reduce heating inside the clock cabinet. This would typically be the case when operating in the power line reference mode. To turn the crystal oven off, move the handle of the switch away from the "ON" legend (handle toward the front panel of the clock). Operating the clock on the internal crystal reference with the OVEN OFF is also possible, but not recommended unless the operation is taking place in an exceptionally stable thermal environment.

2-10. FREQUENCY ADJUSTMENT OF THE INTERNAL CRYSTAL OSCILLATOR

The need to adjust the crystal oscillator frequency is indicated when the clock is gaining or losing time at a rate greater than permissible by the application.

Accurate determination of the oscillator frequency is usually accomplished by comparing the timing of the clock's 1 PPS output to the time of arrival of radio time signals. There are many ways to make these measurements depending upon what equipment is available. Some examples can be found in the publication "General Radio Experimenter", Vol. 32, No. 13, June 1958.

However, if a WWV radio receiver and a triggered-sweep oscilloscope are available, you may proceed as follows:

Connect the audio output of the WWV receiver to the vertical input of the oscilloscope. Connect the 1 PPS output of the clock to the sweep trigger input and adjust the oscilloscope gain controls such that one sweep of the receiver audio signal can be seen on the CRT each second.

For best results the clock time should be 50 to 100 milliseconds ahead of standard time. This may be accomplished by setting the clock more than 100 milliseconds fast, and then retarding the clock phase in small increments by momentarily switching the REF LINE/XTAL switch to LINE and then back to XTAL. Due to the contact actuation time of the switch, several 60 cps cycles are lost each time the switch is thrown. Using the reference switch in this manner works best when the clock is powered from a 60 cycle input.

Once the clock time and oscilloscope have been set correctly, the WWV tick, and its timing with respect to the clock's time may be observed. The top-of-second WWV tick is 5 cycles of 1000 cps audio. Compare the clock with standard time, and after an appreciable interval (say 24 hours or some multiple thereof) perform the comparison again. The amount by which the reading differs is a measure of the offset of the oscillator frequency from its nominal value. To determine the average relative frequency over any time interval, divide the time drift during that interval by the length of the interval in seconds.

Once the clock has been found to be running fast or slow as compared to a reference clock, the frequency of the crystal oscillator may be adjusted to compensate for the error. There are two frequency adjustments on the top of the clock chassis, one coarse (C5) and one fine (C6). Large changes in frequency are made by C5, with C6 used as a trimming adjustment. Turn either adjusting screw counter-clockwise to increase the oscillator frequency (clock runs faster), or clockwise to decrease frequency (clock runs slower). One full revolution of the fine frequency adjustment (C6) corresponds to approximately 7 parts in 10^7 change in frequency.

Example:

Suppose the clock is compared with standard time and is found to be 55 milliseconds early. The next day, 24 hours (86400 seconds) later, the clock is found to be 35 milliseconds early; the clock is running slow (oscillator frequency is low).

$$\text{relative frequency} = \frac{\text{time drift}}{\text{observation interval}}$$

$$= \frac{(0.055 - 0.035)}{86400} = 2.3\text{x}10^{-7}$$

One full revolution of the fine frequency adjustment (C6) corresponds to approximately 7 parts in 10^7 change in frequency, therefore C6 needs to be turned counter-clockwise approximately 1/3 turn to raise the frequency by 2.3 parts in 10^7.

SECTION III
PRINCIPLES OF OPERATION

3-1. GENERAL

Arrangement of the circuit is shown in block diagram form in Figure 3-1 at then end of this section, and in detail on the schematic diagram pages at the end of this manual.

3-2. CIRCUIT DESCRIPTIONS

3-3. OSCILLATOR/FREQUENCY DIVIDER

V7 is an electron-coupled crystal oscillator operating at 36 kc. The crystal, Y1, is contained in an oven held at a constant temperature of approximately 50 degrees C to minimize frequency variations due to changes in ambient temperature. Switch, S1 allows switching off the oven heater when desired.

The oscillator frequency is adjustable over a narrow range by coarse tuning capacitor C5, and fine tuning capacitor C6.

The output of V7 is input to the grid of V8, a cathode-coupled, locked-oscillator frequency divider which divides the 36 kc by 6 to generate 6 kc. The tank circuit consisting of L2, C17, and C14 is tuned to approximately 6 kc, and with no input, V8 operates as a cathode-coupled oscillator at this frequency. With a 36 kc signal present at pin 7, the oscillator locks to it, producing exactly one cycle of 6 kc for every 6 cycles of 36 kc (divide by 6).

V9 operates in the same manner, except that it divides 6 kc by 10 to generate 600 cps.

V10 is a triode-connected pentode amplifier to raise the output voltage of the frequency divider to the approximately 100 volts peak-to-peak necessary to drive V11, a high speed argon dekatron which divides 600 cps down to 60 cps.

3-4. REFERENCE FREQUENCY SELECT

Switch S2 selects either the 60 cps output from V11, or the 60 cps from the AC power line as the frequency source driving the remaining frequency dividers. Power line 60 cps comes from the voltage divider and filter network, R2, R3, and C1, in the power supply section.

3-5. 60 CPS TO 1 PPS FREQUENCY DIVIDERS

Trigger tube V12 fires on each positive half cycle of the 60 cycle signal, an action that generates negative-going pulses of about 100 volts peak across R43. The pulse is applied in-phase to gate-1 of dekatron V13, and to gate-2 slightly delayed by the phase shift network consisting of R45 and C29. On each negative pulse, the count of V13 advances by one. Counting continues until cathode-6 of the dekatron ignites, producing a voltage across R47 of approximately 25 volts. This positive-going voltage is coupled through C31 to the gate of trigger tube V14, igniting the tube and sending a negative pulse back to cathode-0 of V13, resetting it to to a count of zero. The cycle of counting continues, with the result being that for every six cycles of 60 cps, one pulse is produced at the plate of V14, a divide by 6 function.

Dekatron V15 functions in a similar manner, with the exception that reset pulse feedback is not required because V15 is dividing by 10, which it does inherently.

3-6. 1 PPS FRONT PANEL OUTPUT

V16 serves to provide both a buffered 1 PPS signal of about 30 volts peak to the front panel BNC jack, and once-per-second pulses to the seconds counters.

3-7. HOURS, MINUTES, AND SECONDS COUNTERS

Each seconds, minutes, and hours digit of the clock has a corresponding dekatron that performs the counting for that digit. These trigger-tube/dekatron circuits operate in a manner similar to that described for V13 in the frequency divider section above. The ones-of-minutes, and ones-of-seconds counters simply count

0, 1, 2, ..., 9, 0, 1, ..., therefore special reset circuitry is not required for these stages.

The tens-of-minutes and tens-of-seconds counters each count from zero to five and then reset back to zero, thus each of these counters has a trigger tube that fires when the count reaches 6. This pulse both resets the dekatron to zero, and carries a pulse forward to the next stage.

V64 serves to reset both the tens-of-hours and ones-of-hours counters to zero when the count reaches "24", and its operation deserves some additional description. V64 has two inputs to its gate: H10-2, a positive signal when the tens-of-hours count is "2", and H1-4, a capacitively-coupled positive-going signal when the ones-of-hours digit changes from "3" to "4". The H10-2 signal biases the gate of V64 positive, but not enough to ignite the tube. At the instant H1-4 goes positive (the clock time attempts to advance from 23:59:59 to 24:00:00), the positive pulse coupled through C55 fires V64, sending a reset pulse to the cathode-0 of both V61 and V63, the hours counters. The result is a clock time display that advances from 23:59:59 to 00:00:00.

3-8. NIXIE TUBE DISPLAY CIRCUITS

Each nixie tube cathode that plays a role in the display of the clock's time, (some numerals in some of the tubes are not used) has a trigger tube associated with it that fires when the corresponding dekatron cathode is lit. Once any trigger tube fires, it remains in the conducting state until it is reset by the voltage across it falling below the sustaining value. Because the nixe/trigger tube circuits are powered from a full-wave rectified, but unfiltered, supply, +420V-P, this reset occurs every half cycle of the AC power line.

The voltage divider networks across each nixie tube, R76, R77, and R78 for example, set a bias voltage at the connection point between the nixie cathode and trigger tube, ensuring consistent ignition of both tubes when there is a proper drive signal at the gate of the trigger tube.

3-9. TIME SET

The front panel rotary switches S5-S8 are used both for setting the clock time and for setting the alarm time. For time-setting, the switches connect the selected hours and minutes dekatron cathodes to the time-set diodes, V80–V86. When pushbutton S4 is depressed, the diode side of C58 momentarily drops from +55 volts to -145 volts, turning on the diodes and setting the dekatrons to the desired state.

Diodes V84, V85, and V86, connected to cathode-0 of the tens-of-seconds, seconds, and tenths-of-seconds dekatrons, reset those counters to zero when the time is set.

As long as the pushbutton is depressed, S4B interrupts the 60 cps clock in the frequency divider section, preventing the time from advancing.

3-10. ALARM

The rotary switches also route the selected dekatron cathodes to a logical coincidence circuit consisting of diodes V87-V90. When the clock time matches the time set on the switches, the voltage on the gate of trigger tube V91 rises from approximately 53 volts to 68 volts, firing the tube and turning on relay K1. V91 cannot fire unless the alarm is enabled by turning S9 on. K1 supplies power to the 2-tone relaxation oscillator V92-V94. V91 remain and K1 remain active until their power is removed by opening S9. Transformer T2 transforms the low impedance at the terminals of speaker SP1 to a value high enough such that the relaxation oscillator is not excessively loaded.

3-11. POWER SUPPLY

The power supply provides the following DC and AC voltages to the clock circuits:

Table 3-1. Power supply Voltages

Voltage	Circuits supplied
+450V; regulated	Dekatron tube anodes
+420V-P; pulsating DC	Nixie tube anodes
+200V; regulated	Trigger tube anodes
+150V; regulated	V7-V10 plates
+55V; unregulated	Dekatron and trigger tube bias
6 VAC #1	V1, V2, V6 filaments
6 VAC #2	V7-V10 filaments

The secondary windings of power transformer T1 supply power to all clock circuits except the crystal oven heater, which is powered directly from the 115 volt AC input. An auxiliary winding on T1, terminals 6 and 7, may be connected in series with the main primary winding to accommodate line voltages higher or lower than nominal. Connecting pin 6 to pin 2 and pin 7 to the other side of the line (buck winding) raises the input voltage rating from 115 nominal to 121, while reversing the connections to pins 6 and 7 (boost winding) lowers the input voltage rating from 115 nominal to 109.

T1 has two 6 volt filament windings. The first is for the power supply tubes and the second winding supplies all other filamentary tubes, which are located in the oscillator/frequency divider section. Resistor R1 helps to extend the life of the oscillator tubes by slightly reducing their filament voltage.

Current for the high voltage supply is rectified by dual diode V1, filtered by C2 and C3, and regulated by regulator tubes V3, V4, and V5. Three voltages are available from the regulator tubes: 450 volts, 300 volts, and 150 volts. Cathode follower V6 provides a regulated, adjustable 200 volt output.

Switch S3 allows powering down the crystal oscillator, and the portion of the divider circuits that divide 36 kc down to 60 cps. Normally these circuits would be turned off only when operating the clock using the 60 cycle power line as a reference. S3B disables the oscillator/divider by removing filament voltage to tubes V7-V10. S3A removes anode voltage from V11, by way of relay K2, to prevent the cathode poisoning that would eventually occur when V11 is powered, but not driven, and the glow sits on one cathode for a long time.

The coil of K2, and resistors R39 and R40, serve an additional function: they draw a load current from the 150 volt supply when the oscillator is off. This current is designed to be equal to the current drawn by the oscillator when it is on, thereby presenting a constant load to the regulated supply, and constant dissipation in the regulator tubes. Without this load, the distribution of current among the three regulator tubes would become unbalanced, increasing their power dissipation and reducing their life.

A second high voltage rectifier, V2, provides an unfiltered pulsating DC source, +420V-P, required by the nixie tubes as detailed in the section "NIXIE TUBE DISPLAY CIRCUITS".

The +55 volt bias supply is slightly unusual. It merely sinks current to ground from higher-voltage sources, rather than source current from its own positive supply. Furthermore, the current returned to ground is fairly constant, therefore the simple circuit consisting of R14, R17, and C4, is sufficient to satisfy the +55 volt requirements.

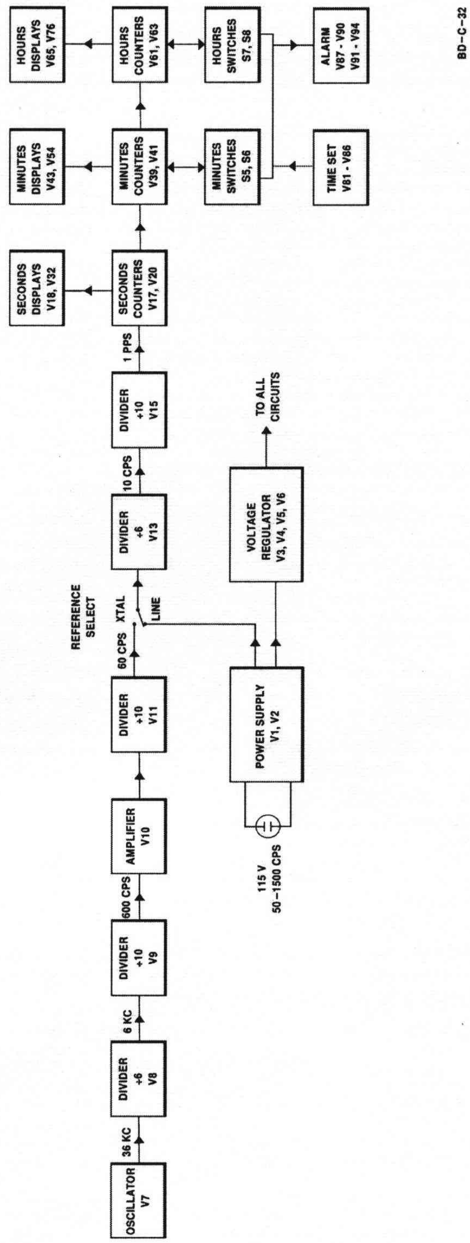

Figure 3-1. CD624 Block Diagram

SECTION IV
TROUBLESHOOTING

4-1. GENERAL

To assist in troubleshooting, Table 4-1 has been prepared which lists various trouble symptoms, and possible causes and/or remedies. If the cause of the trouble is of a more obscure nature than can be covered by the chart, then the next step in troubleshooting is always to perform a thorough visual inspection of the unit, followed by voltage and resistance checks. Some faults such as burned-out resistors, defective tubes, and shorted transformers can often be located by sight, smell, and hearing. While making voltage checks, refer to Table 4-2 as well as the typical voltage readings noted on the schematic.

For aid in locating key components and test points, refer to the chassis top and bottom views at the end of Section V.

4-2. TEST EQUIPMENT

The following test equipment, or its equivalent, is required for troubleshooting or making adjustments to the clock:

a. Vacuum Tube Voltmeter: Voltage range 0 to 1000 volts, such as HP 410B or RCA VoltOhmyst.

b. Oscilloscope: Triggered-sweep, such as Tektronix 511 or HP 150A.

4-3. TROUBLESHOOTING CHART

Table 4-1. Troubleshooting Chart

SYMPTOM	POSSIBLE CAUSE AND/OR REMEDY
Nixie and dekatron tubes are dark.	Fuse blown - replace. If fuse blows again, check for a short circuit or defective tube or component in the power supply and/or heater circuits. Line cord defective. If filaments are lit, no high voltage – check V1.
Nixie tubes are dark, dekatrons are lit.	V2 defective
Clock time does not advance in either internal crystal or external line frequency reference modes.	Problem in reference divider section V12 - V16. A weak tube or defective component - check component values and replace tubes or components as necessary. Also check S2 and S4 for continuity.

Table 4-1. Troubleshooting Chart – continued

SYMPTOM	POSSIBLE CAUSE AND/OR REMEDY
Clock time does not advance in internal crystal mode. Power line reference mode works normally.	Problem in reference divider section V7 - V11. A weak tube or defective component - check component values and replace tubes or components as necessary. Also check S2 and S4 for continuity.
Clock time is in error.	Re-set time per operating instructions.
Clock runs either slow or fast while using internal crystal oscillator.	Oscillator is off frequency - adjust coarse and/or fine frequency adjust capacitors (C5 and C6). One of the frequency divider stages is out of adjustment or slipping cycles - adjust associated frequency divider capacitor (C14 and C19).
Internal crystal oscillator is off frequency and coarse frequency adjustment is way off or at the end of its range.	Crystal oven turned off or defective - turn oven on or replace. Defective crystal - replace. Crystal or component aging - replace crystal or change value of C5, C6, or C10.
Clock loses time in 1 second steps, signal at 1 PPS output connector is also missing pulses.	V16 weak, or component aging in the vicinity of V16/V15 - check component values. Replace V16 and/or V15.
Clock gains or loses time in 1.67 millisecond steps.	Frequency divider stage V9 is out of adjustment or slipping cycles - adjust frequency divider capacitor C19.
Clock gains or loses time in 167 microsecond steps.	Frequency divider stage V8 is out of adjustment or slipping cycles - adjust frequency divider capacitor C14.
Clock gains or loses time in 27.8 microsecond steps.	36 kc oscillator or divider problem - adjust frequency divider capacitor C14. Replace V7 and/or V8.
Operation of TIME SET pushbutton is erratic or display time does not match rotary switch settings after depressing pushbutton.	Pushbutton being depressed too often, not allowing adequate re-charge time for C58 - see operating instructions. A tube in the range V81 - V86 may be defective. All seven tubes should ignite briefly when pushbutton is depressed. Replace defective tubes if necessary.

Table 4-1. Troubleshooting Chart – continued

SYMPTOM	POSSIBLE CAUSE AND/OR REMEDY
Alarm fails to sound at time set.	A problem with tubes V87 – V90, or alarm tube V91- Replace defective tubes as necessary. Aging of resistors R255, R256, or R257 - Check values and replace as necessary. Relay K1 defective - replace K1.
Clock time fails to roll over from 23:59:59 to 00:00:00.	Power line voltage below 105 volts or weak rectifier tube V1 - correct line voltage problem or replace V1. V64 weak or defective, or R241 drifted high in value - replace V64 or R241.

4-4. VOLTAGE CHECKS

All voltages measured relative to chassis ground unless otherwise specified.

Table 4-2. Voltage Checks

TEST POINT	NORMAL RANGE
TP1, +450V	Should be between +430 volts and +460 volts
TP2, +150V	+150 volts, ±5 volts
TP3, +200V	+200 volts, ±5 volts
TP4, +55V	+55 volts, ±1.5 volts
Voltage across R8, R10, and R12	Should be between 5 millivolts and 25 millivolts
C2 or C3	Varies with line voltage, 530 volts typical
V7 control grid (pin 1)	-1 volt typical
V8 cathodes (pins 4 and 5)	9 volts typical
V8 plate (pin 8)	130 volts typical
V9 cathodes (pins 4 and 5)	11 volts typical
V9 plate (pin 8)	130 volts typical
V10 control grid (pin 1)	-10 volts typical
V10 plate (TP10)	100 volts typical
A101 dekatron cathodes	Cathode off: +55 volts, cathode lit: +80 volts
A101 dekatron guide electrodes	70 volts typical

SECTION V
MAINTENANCE AND ADJUSTMENTS

5-1. GENERAL

Many measures have been included to assure for the clock the high order of reliability that the purpose of the instrument demands. Under normal circumstances, no maintenance or adjustments to the clock should be required, except for occasional inspection and cleaning, and the adjustment of the internal crystal oscillator frequency when needed.

The more intricate adjustment procedures described in this section are provided for those who have the necessary skill and test equipment. When qualified personnel and test facilities are not available, it is suggested that adjustments not be made in the field.

Refer to the chassis top and bottom views at the end of this section for aid in locating the test and adjustment points.

5-2. CASE REMOVAL

The front panel and chassis assembly are fastened to the front of the case with six thumbscrews. To remove the case, first remove the power cord at J1, then loosen the six screws and slide the chassis assembly to the front and out of the case.

5-3. INSPECTION AND CLEANING

Inspect the case and front panel for damage and accumulations of dust and dirt. The front panel, nixie display filter, and dekatron tubes may be cleaned with an ammonia solution, and wiped dry with a lint-free cloth.

Inside the clock, inspect the front panel and chassis for accumulations of dust and dirt. Use a clean, dry, lint-free cloth or a dry brush for cleaning. If available, dry compressed air at a line pressure not exceeding 40 pounds per square inch may be used to remove dust from inaccessible places. Be careful however, damage from air blast may result.

Make sure the crystal oven and all tubes are firmly in their sockets.

Tubes may be cleaned with a rag dampened with an ammonia solution.

If necessary, parts may be cleaned with a brush or rag soaked in TCE or benzene.

Clean electrical contacts with a cloth or brush moistened with carbon tetrachloride, then wipe them dry with a cloth.

Inspect the chassis top and bottom for broken or burnt components, leaking capacitors and transformers, and signs of overheating.

5-4. TEST EQUIPMENT

The following test equipment or its equivalent is required for trouble shooting or making adjustments to the clock:

a. Vacuum Tube Voltmeter: Voltage range 0 to 1000 volts, such as HP 410B or RCA VoltOhmyst.

b. Oscilloscope: Triggered-sweep, such as Tektronix 511 or HP 150A.

5-5. TUBE REPLACEMENT

Any tube in the clock may be replaced with a tube having corresponding RETMA characteristics. However, for the utmost reliability, it is recommended that whenever a tube is replaced, Table 5-1 be consulted and the specified adjustment checked.

Table 5-1. Tube Replacement

TUBE	FUNCTION	CIRCUIT ADJUSTMENT
V3 - 0A2	Power supply regulator	Check +450 volts
V4 - 0A2	Power supply regulator	Check +300 volts, adjust +200 volts (R11)
V5 - 0A2	Power supply regulator	Check +150 volts
V7 - 5840	Oscillator	Check oscillator frequency, adjust frequency (C6, C5)
V8 - 6111	36 kc to 6 kc frequency divider	Check frequency divider lock, adjust divider (C14)
V9 - 6111	6 kc to 600 cps frequency divider	Check frequency divider lock, adjust divider (C19)
V10	Amplifier	Check drive to V11, adjust drive level (R28)
V1,V2 - 6X4	Power supply high voltage rectifier	Visual - Confirm proper clock operation, no adjustments necessary
V6 - 5965	Power supply series regulator	Check +200 volts, adjust +200 volts (R11)
Dekatron - A101/OG3	Counters/frequency dividers	Visual - Confirm proper clock operation, no adjustments necessary
Nixie - IN-12	Display	Visual - Confirm proper clock operation, no adjustments necessary

5-6. ADJUSTMENTS

5-7. +55 VOLT SUPPLY

a. Connect the VTVM to TP4 and chassis.

b. Adjust R14 so that the DC voltage is exactly 55 volts.

5-8. +200 VOLT SUPPLY

a. Connect the VTVM to TP3 and chassis.

b. Adjust R11 so that the DC voltage is exactly 200 volts.

5-9. CRYSTAL OSCILLATOR FREQUENCY

a. Refer to the instructions given in Section II.

5-10. FREQUENCY DIVIDER V8 (divide by 6, 36 kc to 6 kc)

a. Connect the oscilloscope trigger input to TP7 (6 kc) and chassis.

b. Connect the oscilloscope vertical input to TP6 (36 kc) and chassis.

c. Adjust the oscilloscope time base to 50 microseconds per division.

d. Adjust the oscilloscope vertical sensitivity and trigger levels to obtain a stable and stationary 36 kc pattern on the CRT. If a stable pattern is not possible, the divider may be unlocked. Confirm that a 36 kc signal of about 6 volts peak-to-peak is present at TP6, and a 6 kc signal of about 25 volts peak-to-peak is present at TP7.

e. Slowly turn C14 clockwise until the 36 kc pattern on the CRT becomes unstable (divider unlocked); then turn C14 back slightly to the point where the pattern becomes stable (divider locked) again. Choose one of the peaks in the pattern near the center of the display and make note of the peak's horizontal position on the graticule. This is "position 1".

f. Slowly turn C14 counter-clockwise, observing the motion of the pattern and following the chosen peak on the CRT as the capacitor is rotated. Keep slowly turning C14 until the pattern becomes unstable; then turn C14 back slightly to the point where the pattern becomes stable again. Make note of the peak's new horizontal position on the graticule. This is "position 2".

g. Slowly turn C14 clockwise again until the chosen peak is centered horizontally between "position 1" and "position 2".

h. C14 is now adjusted to the optimum value to maintain divider lock over a range of varying environmental and electrical conditions.

5-11. FREQUENCY DIVIDER V9 (divide by 10, 6 kc to 600 cps)

a. Connect the oscilloscope trigger input to TP9 (600 cps) and chassis.

b. Connect the oscilloscope vertical input to TP7 (6 kc) and chassis.

c. Adjust the oscilloscope time base to 10 microseconds per division.

d. Adjust the oscilloscope vertical sensitivity and trigger levels to obtain a stable and stationary 6 kc pattern on the CRT. If a stable pattern is not possible, the divider may be unlocked. Confirm that a 6 kc signal of about 25 volts peak-to-peak is present at TP7, and a 600 cps signal of about 30 volts peak-to-peak is present at TP9.

e. Slowly turn C19 clockwise until the 6 kc pattern on the CRT becomes unstable (divider unlocked); then turn C19 back slightly to the point where the pattern becomes stable (divider locked) again. Choose one of the peaks in the pattern near the center of the display and make note of the peak's horizontal position on the graticule. This is "position 1".

f. Slowly turn C19 counter-clockwise, observing the motion of the pattern and following the chosen peak on the CRT as the capacitor is rotated. Keep slowly turning C19 until the pattern becomes unstable; then turn C19 back slightly to the point where the pattern becomes stable again. Make note of the peak's new horizontal position on the graticule. This is "position 2".

g. Slowly turn C19 clockwise again until the chosen peak is centered horizontally between "position 1" and "position 2".

h. C19 is now adjusted to the optimum value to maintain divider lock over a range of varying environmental and electrical conditions.

5-12. V11 INPUT DRIVE

a. Connect the oscilloscope vertical input to TP10 (600 cps) and chassis.

b. Adjust the oscilloscope time base to 1 millisecond per division.

c. Adjust the oscilloscope vertical sensitivity and trigger levels to obtain a stable and stationary 600 cps pattern on the CRT.

d. Adjust R28 for maximum peak-to-peak signal amplitude and the most square-looking waveform possible. The pattern should have relatively flat tops and bottoms, steep rise and fall times, and an amplitude of about 100 volts peak-to-peak.

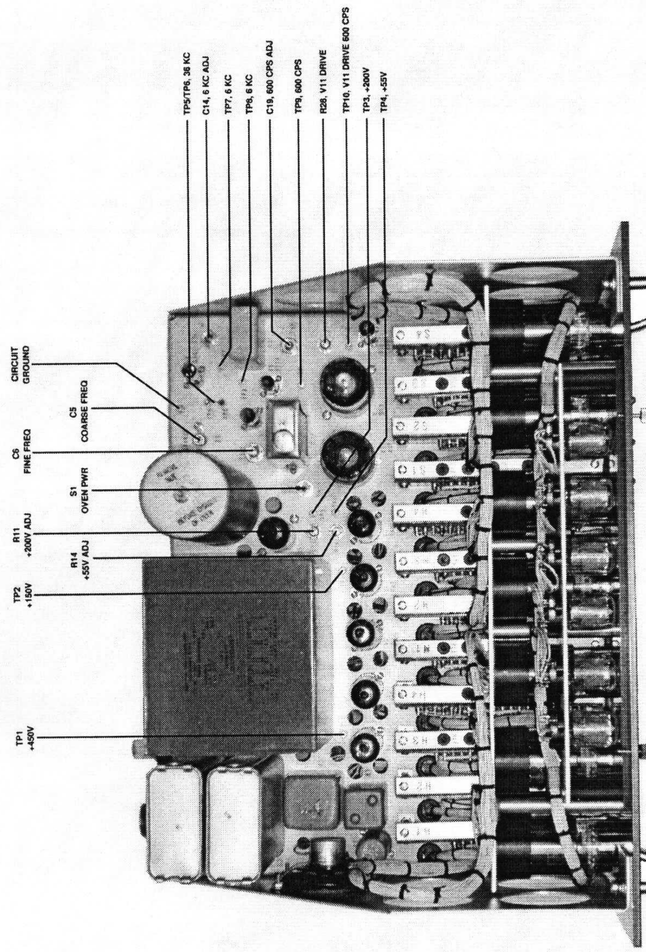

Figure 5-1. Model CD624 Chassis Top View

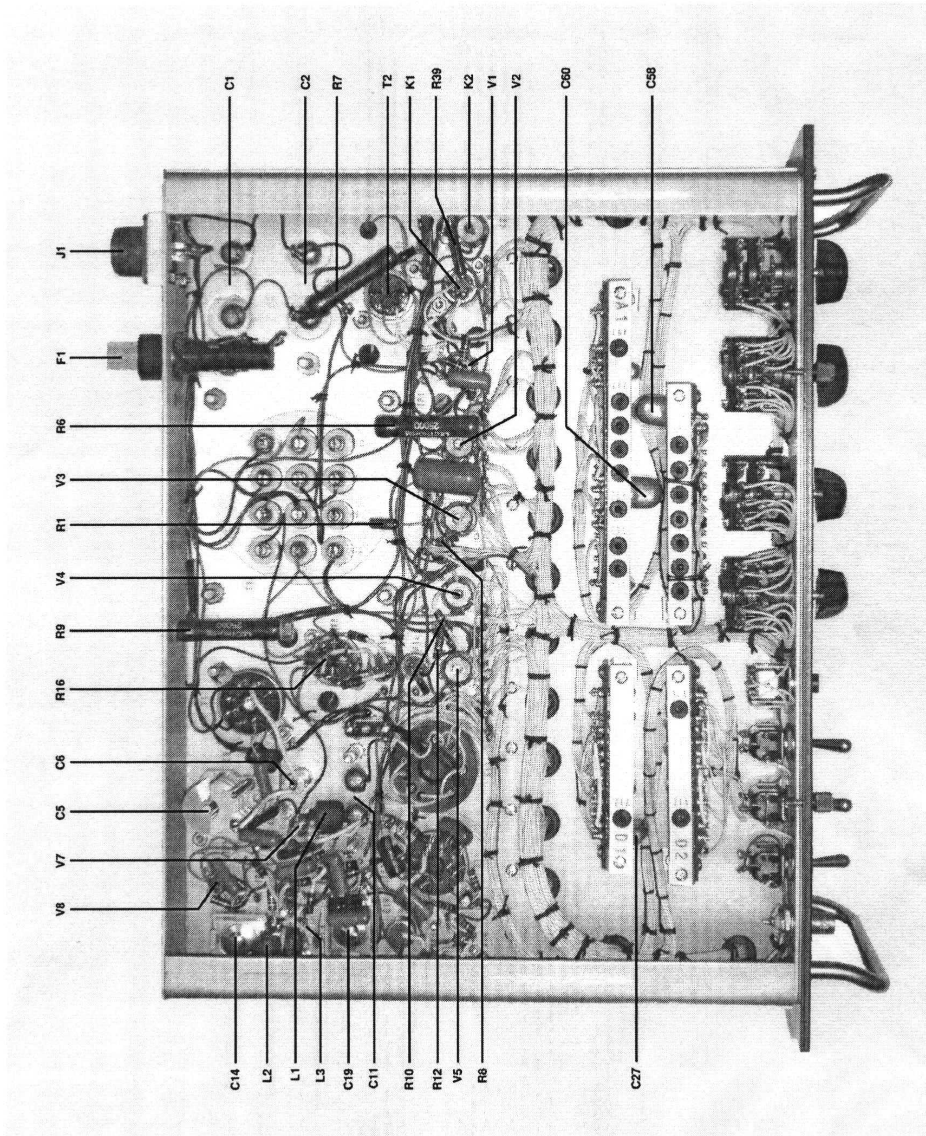

Figure 5-2. Model CD624 Chassis Bottom View

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SECTION VI
DEMOLITION OF CLOCK TO PREVENT ENEMY USE

6-1. DEMOLITION OF CLOCK TO PREVENT ENEMY USE

When capture or abandonment of the clock to an enemy is imminent, the responsible operator must make the decision to destroy the clock and associated equipment. Whatever method of demolition is employed, it is essential to destroy the same vital parts of all equipment and all corresponding repair parts.

<u>METHODS OF DESTRUCTION</u>

Use any or all of the following methods to destroy the equipment:

a. Smash. Smash the tubes, crystals, switches, capacitors, terminal boards, and transformers using sledges, axes, handaxes, pickaxes, hammers, or any heavy tool.

b. Cut. Cut cords and wiring, using axes, handaxes, or machetes.

c. Burn. Burn cords, resistors, capacitors, wiring, and technical manuals, using gasoline, diesel fuel, kerosene, oil, flame throwers, or incendiary grenades.

d. Bend. Bend panels, cabinet, and chassis.

e. Explosives. If explosives are necessary, use firearms, grenades, or TNT.

f. Disposal. Bury or scatter the destroyed parts in trenches, wells, ravines, or other holes, or throw them into streams.

g. Destroy Everything.