Model 241
ARCADE ANALYZER
INSTRUCTION MANUAL

PUBLICATION NO. 2490-737

The Hickok Electrical Instrument Company

10514 DUPONT AVENUE • CLEVELAND, OHIO 44108 • (216) 541-8060 • TWX: 810-421-8286

HICKOK

LIMITED WARRANTY

IMPORTANT

The following warranty shall be void if the registration card is not properly completed and returned to the Hickok factory, post marked within ten days after date of purchase.

The Hickok Electrical Instrument Co. warrants this instrument of its manufacture to be free from defects in material and workmanship for a period of one year (12 months) from the date of original purchase, subject to the following conditions.

Any instrument found to be defective during the first twelve month period after date of purchase may be returned, transportation prepaid, to the factory for repair or, at our option, replacement without charge.

This warranty does not apply to any of our products which have been repaired or altered by unauthorized persons, or which have been subject to misuse, negligence, or accident, or which have had the serial number altered, effaced, or removed. Neither shall the warranty apply where a warranty registration card has not been properly completed and returned to us promptly after purchase. This warranty is in lieu of all other warranties whether expressed or implied.

RETURNING EQUIPMENT FOR REPAIR

Before returning any equipment for service, the factory must first be contacted, giving the nature of the trouble. Instructions will then be given for either correcting the trouble or returning the equipment. Upon authorization, this equipment should be forwarded directly to:

Hickok Electrical Instrument Co.
1714 Carrollton Avenue
Greenwood, Mississippi 38930

or to a designated service station in your locality.

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GENERAL

The Model 241 ARCADE ANALYZER is an instrument specifically designed to efficiently service the major down time causes in coin operated video games. Monitor and control failures represent over 80% of all problems encountered with video arcade games. The Model 241 addresses these two failure elements in a single highly portable package specifically developed for field use yet quite at home on the bench.

The instrument incorporates two primary capabilities. The generator portion of the instrument provides all the signals needed to troubleshoot and align both raster scan and X-Y monitors used with video arcade games. The generator handles both color and black and white monitors. The VARI-TRAKER is a unique volt/ohmmeter that not only can be used to measure but also is superb at identifying intermittents and discontinuous controls.

The patterns available on the 241 are largely those used by the monitor manufacturers in their service literature and also include several patterns that improve serviceability. In addition, the brightness of all patterns, except the calibrated X-Y Gray Scale, is front panel adjustable. An X-Y picture size control that is calibrated at two positions and can be used for gain adjustments also allows sizing of the patterns to the most convenient size for convergence and other adjustments. The generator is supplied with an 8 foot cable and 4 prewired adapters which mate to nearly all Electrohome and Wells Gardner monitors. At this time these monitors represent over 90% of all monitors in use in video arcade games. Additionally two connectors are supplied which can be used to wire special adapters for other monitors.

The VARI-TRAKER is a new concept in a volt/ohmmeter required to troubleshoot common video games problems. The VARI-TRAKER uses a continuously variable audio tone to indicate the value of the parameter it is measuring. A short use period will allow the user to identify voltages and resistances by the sound of the tone. What is particularly important about the VARI-TRAKER is that it not only allows value measurements but the use of sound instead of meters or digits has the unique property of identifying intermittents, the presence of small amounts of AC ripple on DC voltages, discontinuities in potentiometers and a whole host of similar common, but hard to find, problems.

The Model 241 ARCADE ANALYZER is a real contribution to the maintenance technology of video arcade games. It also has uses in other electronic devices which use video monitors as an integral element of their interface with people. The 241 contains all the measurement and signal generation capabilities needed to efficiently service the major fault problems of these devices as well.

SECTION I

SPECIFICATIONS AND REFERENCE DATA

GENERATOR

DISPLAY PATTERNS

RASTER SCAN MONITORS (262 line progressive scan)

Solid Raster

Single Crosshatch; intersecting at center of screen

Fine Crosshatch
15 lines vertical (0.25 μsec)
15 lines horizontal (1 scan line)

Bold Crosshatch
8 lines vertical (4 μsec)
8 lines horizontal (16 scan lines)

Single Dot
One dot at center of screen

X-Y MONITORS

Single Crosshatch — intersecting at center of screen — See **X-Y SIZE** control

Diagonal Crosshatch — fine line crosshatch — See **X-Y SIZE** control

Full Screen Lined Raster (X is a maximum writing rate sawtooth sweep, Y is a maximum writing rate triangle sweep) — See **X-Y SIZE** control

Gray Scale Staircase — 4 level staircase, black level =+1V, each succeeding level +1V higher

OUTPUT SIGNALS

FOR RASTER SCAN MONITORS

SYNC OUTPUTS — 0 to 5V TTL Compatible

		FREQUENCY	WIDTH
H	Horizontal	15.625 KHz	4μS
$\overline{H}$	Horizontal Inverted	15.625 KHz	4μS
V	Vertical	61.0 Hz	1.0 msec
$\overline{V}$	Vertical Inverted	61.0 Hz	1.0 msec

Minimum monitor input impedances on these signal lines 1KΩ

GUN OUTPUTS — 0 to 4V TTL Compatible – High level adjustable 0 to 4V using **BRIGHTNESS** control

R	Red	Each signal may be turned on or off using **GUN CONTROL** pushbuttons
G	Green	
B	Blue	

Minimum monitor input impedances on these signal lines 150Ω

FOR X-Y MONITORS

SIGNAL OUTPUTS

X — Adjustable to ±4V to ±10V using **X-Y SIZE** control. Minimum monitor input resistance 150Ω

Y — Adjustable to ±3V to ±7.5V using **X-Y SIZE** control. Minimum monitor input resistance 150Ω

GUN OUTPUT — 0 to +4V TTL Compatible – High level adjustable 0 to +4V using **BRIGHTNESS** control except (Gray Scale)

R	Red	Each signal may be turned on or off using **GUN CONTROL** pushbuttons
G	Green	
B	Blue	

Minimum monitor input impedances on these signal lines 150Ω

EXTENDER CABLE

8 foot, extends output connector to convenient length – connects to MONITOR ADAPTERS.

MONITOR ADAPTERS

Four (4) supplied (see **ADAPTERS** section for connections).

A — Mates to most WELLS GARDNER and ELECTROHOME RASTER SCAN monitors (6 pin Molex 09-50-7061).

B — Mates to most ELECTROHOME COLOR X-Y monitors (6 pin Molex 09-50-7061).

C — Mates to many WELLS GARDNER and ELECTROHOME B/W X-Y monitors.

D — Mates to most WELLS GARDNER COLOR X-Y monitors.

OUTPUT CONNECTOR

Located on rear panel. All signals are present simultaneously depending on **SCAN MODE.** Location of signal pins shown on diagram on rear panel. Mating connector Molex Part No. 03-09-3092. Pins Molex Part No. 02-09-2116 (2 extras supplied).

VARI-TRAKER

FUNCTIONS

AC and DC VOLTS, OHMS

RANGE

DC VOLTS

0 to 50V continuously varying tone that begins at approximately 200mV and changes frequency up to approximately 50 volts input.

DC voltage will sound as a clear single frequency tone.

AC VOLTS

0 to 200V continuously varying tone that begins at approximately 1V and changes frequency up to approximately 200 volts RMS input. The tone will have a warbling sound. The base frequency of warble depends on frequency of signal being tested.

MAXIMUM INPUT	250V DC or RMS
INPUT IMPEDANCE	10MΩ

OHMS

LO

Frequency varies from silent with approximately 300Ω at the terminals to shrill pitch at 0Ω. Resistances to 0.4Ω are discernible as a tone difference.

OPEN CIRCUIT VOLTAGE
15V

MAX OUTPUT CURRENT
16mA

HI

Frequency varies from silent with approximately 2MΩ at the terminals to shrill pitch at 500Ω. Resistances to 1KΩ are discernible as tone difference.

OPEN CIRCUIT VOLTAGE
0.7V

MAX OUTPUT CURRENT
3μA

PROTECTION	250V DC or RMS
VOLTAGE ISOLATION	Generator to VARI-TRAKER — 300V max

GENERAL

VOLTAGE ISOLATION	500V max to earth ground
POWER REQUIREMENT	105 to 130V RMS, 50/60 Hz 2.5W max
TEMPERATURE	Operating 0° to 50°C Storage -40° to 75°C
SHOCK & VIBRATION	Meets MIL-T-28800 specifications
HUMIDITY	Up to 95% (noncondensing)

DIMENSIONS	2.2 x 6.7 x 6 in. (5.6 x 17 x 15.2 cm)
WEIGHT	
CASE MATERIAL	High impact, fire retardant, ABS plastic
ACCESSORIES SUPPLIED	Soft vinyl carrying case Four (4) prewired monitor adapters Two (2) output mating connectors and pins for user made special cables

SECTION II

DESCRIPTION OF CONTROLS

X-Y SIZE

The **X-Y SIZE** control is used in **X-Y SCAN MODE** only. The control allows size adjustment of all patterns when in X-Y operation. The two marks at the operating extremes of the control represent positions in which the X and Y output signals are calibrated values. The mark at minimum adjustment sets the X and Y output signals at X=±4V and Y=±3V. The mark at maximum adjustment sets the X and Y output signals at X=±10V and Y=±7.5V.

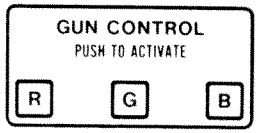
BRIGHTNESS

The **BRIGHTNESS** control is used to adjust the level of the gun output signals in order to adjust brightness of the pattern on the monitor screen. The control has no effect on  Gray Scale since this is a calibrated signal used to adjust the brightness of X-Y monitors. Minimum adjustment represents "0" volts output on the gun controls. Maximum adjustment is approximately +4 volts on the gun controls.

TEST PATTERNS

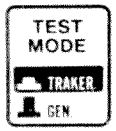
Mutually interlocked pushbutton switches used to select the specific pattern desired. The upper row of patterns are for use with X-Y monitors and signals creating these patterns are outputed when the **SCAN MODE** pushbutton is "depressed" in **X-Y**. The lower row of patterns are for use with raster scan monitors and signals creating these patterns are outputed when the **SCAN MODE** pushbutton is in the "out" position, **RASTER**.

Single push-push pushbutton used to select signal appropriate for either raster scan or X-Y monitors.



Single push-push pushbutton switches used to turn on or turn off the **R,G,B** signals in either X-Y or raster scan operation. When the button is pushed in, the associated signal is present at the output connector on the rear of the instrument.

Single push-push pushbutton switch used to turn the instrument on or off. When turned on, an LED is used to backlight the center portion of the block indicating the instrument is on.



Single push-push pushbutton switch used to select either Generator operation or VARI-TRAKER operation of the instrument. When VARI-TRAKER is selected the generator portion is turned off and vice versa. The two capabilities of the instrument will not operate simultaneously.

VARI-TRAKER MODE SELECT

Slide switch used to select the measurement mode of the VARI-TRAKER. For the two "Ω" positions of the switch the mode selected is indicated by the line associated with the mode being visible. In the **VOLTS** mode neither "Ω" line will be visible. Note that the **TEST MODE** switch must be in **TRAKER** for the VARI-TRAKER to operate.

VARI-TRAKER SIGNAL INPUT

Standard safety banana jacks. The "+" lead indicates plus inputs for DC volts as well as output signal for ohms measurements. Note that if "0" volts or a negative DC voltage is applied to the VARI-TRAKER the tone will be silent.

OUTPUT CONNECTOR

Located in a recessed compartment on the rear panel. Also identified on the rear panel are the signals present on each pin of the connector. Note that the signals will depend on the **SCAN MODE** selected. For instance in **X-Y** mode the signal on the **H/X** will be "X." In **RASTER** mode the signal on the **H/X** pin will be "H."

SECTION III

OPERATING INSTRUCTIONS

PRELIMINARY

When the instrument is unpacked inspect it for visual damage. The following accessories should be contained in the package:

1. Carrying/storage case
2. Line cord
3. 8 foot extender cable with connectors at both ends
4. Four adapter cables labeled A,B,C,D. Each is labeled on the strain relief of the connector which mates with the connector on the 8 foot cable.
5. Two connector shells
6. Eighteen pins which fit in connector shells
7. Red and black test lead set for use with VARI-TRAKER

GENERAL

To prepare for use, plug the line cord into the mating connector on the rear panel and the plug into a standard 120V outlet. Plug the proper end of extender cable into the connector on the rear panel or the red/black test lead set into the VARI-TRAKER input jacks located on the right side of the instrument depending on the intended use.

Set the **TEST MODE** switch to either **TRAKER** or **GEN**. as appropriate.

IF USING AS A GENERATOR

1. Select the adapter cable appropriate to the monitor to be tested. See the **ADAPTER** section of this manual.
2. Be sure the **PWR** is turned off and connect the adapter cable to the extender cable and to the monitor.
3. Set the **SCAN MODE** to the type of monitor to be serviced.
4. Turn on the **PWR.** The back lighted indicator should illuminate.
5. Proceed with testing.

IF USING AS A VARI-TRAKER

1. Select the type of measurement desired using the **VARI-TRAKER MODE SELECT**. Note that the line showing indicates **LOΩ** or **HIΩ** selected and no line showing indicates you have selected **VOLTS**.

2. Proceed with tests.

VARI-TRAKER INSTRUCTIONS

The VARI-TRAKER section of the instrument provides 10MΩ input impedance volt/ohmmeter measurement capability.

The reading is presented as a variable frequency audio tone. Obviously super precise measurements cannot be made with this method but for field applications usually only approximate measurements suffice and other advantages of the tone more than outweigh its limitations. With a brief learning, time measurements to ±5% accuracy are easily achievable. The VARI-TRAKER has some other significant ADVANTAGES which make it more valuable than a normal volt/ohmmeter. Some of the advantages are:

1. Eyes-off measurements – you can keep your concentration on the points being probed.

2. When measuring controls any little discontinuity in the operation is immediately identifiable.

3. Extremely fast continuity tests and switch closure tests. Noise or bouncing in switches show up immediately.

4. Unwanted ripple on DC voltages is identifiable by the sound of the tone.

5. See **GETTING THE MOST OUT OF VARI-TRAKER** for many more uses and ideas.

VOLTS MEASUREMENTS

The VARI-TRAKER **VOLTS** mode is used to measure both AC and DC voltages. For DC voltages, only voltages with plus connected to the "+" jack will cause the tone. Less than 0.2 volts or negative voltages will be silent. The range of sound frequency change with voltage change occurs from 0.2V to approximately 50V DC.

AC voltages will have a "warble" associated with the tone of the VARI-TRAKER. The range audio frequency change with voltage magnitude of the VARI-TRAKER for AC voltages is 1V to approximately 200V.

OHMS MEASUREMENTS

Two ranges of ohms measurements are provided. The **LOΩ** mode is intended for continuity and very low resistance value measurements.

The **HIΩ** mode is intended for resistances from 500Ω to above 2MΩ. In ohms mode the higher the resistance the lower the tone. An open circuit will have no sound where as a short circuit will be a shrill pitch. **HIΩ** mode should be selected for most measurements in circuit or when checking for isolation. Resistances into the high hundred KΩ range will have distinctive identifiable tones associated with them. The sound will turn off at resistances above approximately 3MΩ.

Using the **LOΩ** range resistances as low as 0.5Ω can easily be detected as being different from "0" ohms. Resistances up to about 300Ω will have a distinctly characteristic sound. Above 300Ω the tone turns off. For resistances that make no sound on the **LOΩ** mode the **HIΩ** mode should be used.

GETTING THE MOST OUT OF VARI-TRAKER

DETECTING RIPPLE OR NOISE ON POWER SUPPLY LINES

VARI-TRAKER as a troubleshooting tool can be extremely valuable when measuring DC volts in a variety of circuits, particularly in power supplies where a ripple may be of some concern. If the ripple becomes significant, say more than 2% of the DC voltage, a 60 cycle warble will begin to appear. This is a good indication that there is a substantial amount of ripple on the supply and tests for failed filter capacitors or regulators should be performed.

LOCATING INTERMITTENT PROBLEMS

VARI-TRAKER is designed for quick response. For this reason it can be a very useful tool when looking for an intermittent either in voltage or ohms. For example, consider a situation in which you are attempting to find intermittent continuity somewhere in a game. Set the VARI-TRAKER to the **LOΩ** mode and connect it between the two suspected points. VARI-TRAKER will present a tone associated with the impedance between the two points. Then move wires, vibrate, and otherwise attempt to make the intermittent occur. A change or interruption of audio tone will instantly alert you if there is, in fact, an intermittent connection. The fast response of the VARI-TRAKER output allows you to detect intermittence that would not be detected with an ordinary digital or analog meter.

TROUBLESHOOTING BY CHARACTERISTIC OR "SIGNATURE" SOUNDS

In repetitive troubleshooting or similar systems, certain signals will often produce characteristic and distinctive sounds from the VARI-TRAKER output, depending on the frequency and amplitudes associated with the signal.

Once these characteristic sounds are learned, troubleshooting of many circuits can be performed by simply touching the probe to the various points and listening to see if the characteristic sounds are there. The human ear is particularly adept at noticing the differences in sound which will occur as signals change. It is fortunate that the human ear is particularly sensitive to small changes of a frequency and is particularly sensitive to harmonics added to a base frequency. For these reasons the VARI-TRAKER can be an extremely useful tool for detecting small differences in reading or characteristic sounds associated with particular signals. In many of these cases the VARI-TRAKER allows the ARCADE ANALYZER to replace a variety of additional test equipment including an oscilloscope in many applications.

CAPACITOR CHECKING

VARI-TRAKER can be used for detection of capacitors in circuits. When there are capacitors present, there will be time associated with charging of the capacitors. It is possible to approximate the value of the capacitor by counting the seconds that it takes to charge the capacitor until the sound stops changing.

AS AN ANALOG METER FOR PEAKING AND NULLING

The VARI-TRAKER output of the ARCADE ANALYZER provides an analog response similar to an analog meter. An analog response is often more suitable than a digital reading for detecting trends (increasing or decreasing) in measurements. The VARI-TRAKER analog response fills this need for trend indication in a variety of adjustment applications. For example, consider making a calibration adjustment which calls for adjusting to maximum voltage. Using the VARI-TRAKER simply adjust for the highest frequency tone. Typical adjustments of this type can be achieved within 1/2% of the true peak voltage very quickly with VARI-TRAKER.

ADDITIONAL VARI-TRAKER APPLICATIONS

This has been a brief sampling of ways to use VARI-TRAKER to advantage. There are many more ways; there simply isn't room to describe.

AC

Distinguish between 60 Hz and 400 Hz line
Trace 100 to 400 Hz audio through audio circuits
Trace line voltages
Distinguish between 110 and 220V AC
Detect operation of line chopper circuits
Detect full wave vs half wave rectification
Check SCR control outputs

DC

Detect 2% ripple on power supply
Check power bus voltages
Use for peaking or nulling
Monitor pulse width modulated circuits
Identify voltage polarity
Check AGC circuit operation
Detect low frequency instabilities in amplifiers (motor boating)
Check power supply regulations
Check power supply transient response

OHMS

Fast continuity check — test cables, point to point connections, chassis interconnects, ground connections, coax wiring
Detect faulty connections
Check pots for wiper contact over full travel
Remote contact closure detections
Check potentiometer taper
Check for brush bounce

GENERAL

Detect intermittents on volts, ohms, or current by listening for audio discontinuities
Use an annunciator — monitor relays for closure, etc. Audio will appear
"A-B" comparisons when troubleshooting between good and bad units
Signature sound analysis of test points

DIODE CHECK

Eyes off go-no go diode check
Distinguish between silicon and germanium (or Schottky) semiconductor junctions
Check LED's, infra-red emitters, and optical coupler inputs

GENERATOR OPERATION

GENERAL

The Generator section of the Model 241 ARCADE ANALYZER provides signals for servicing and aligning color and black and white raster scan and X-Y monitors. The patterns available were selected to be compatible with those used in the service literature provided by the monitor manufacturers. Before beginning to service a monitor, a copy of the manufacturer's service instructions should be consulted.

IMPORTANT

Elsewhere in this manual brief generalized instructions for use of patterns and other features of the 241 in servicing monitors is presented; however, often adjustments are interacting and the manufacturers have prescribed an order of adjustment which simplifies these adjustments.

Four adapters which mate to most of the monitors currently supplied by Electrohome and Wells Gardner are provided with the Model 241. Before connecting to the monitor, the manufacturer's input configuration should be compared to the adapter wiring detailed in the **ADAPTER** section of this manual. If none of the adapters match both connector type and pin-out of signals then the operator must make an adapter. Several extra connectors have been provided for this purpose. If additional connectors are needed, refer to the FIELD REPLACEABLE PARTS LIST in the rear of this manual and to the **ADAPTER** section.

In some cases power for the monitor is supplied through the same connector as the signals. The Model 241 does not supply power to the monitor. In cases where power and signals are on the same connector a "Y" adapter is used which plugs into the monitor input, the 241 output and the game output. The power connections are made through the connectors from game output to monitor input and the Model 241 signals are "inserted" into the monitor signal input pins.

There are several steps and precautions which should be taken when working on any Arcade game. They are:

IMPORTANT

1. Be sure the Model 241 **PWR** and the monitor powers are turned OFF before connecting to or disconnecting from the monitor.

WARNING

2. Many monitors have circuit ground connected to one side of the power line. The Model 241 is entirely insulated but the monitor itself can provide a shock hazard. When servicing such a monitor an isolating transformer should be used.

3. Be sure both the connector and the pin-out of the Model 241 adapter matches the monitor you are servicing. If there is any difficulty plugging in the adapter, check the connector match and for bent pins in either the monitor or instrument connector.

4. If at first no patterns can be obtained, check **PWR** mode and **SCAN MODE** buttons on the Model 241 for proper selection. Then check the **R,G,B** buttons to be sure they are activated. Recheck the adapter connections (diagrams in the **ADAPTER** section).

SECTION IV

RASTER SCAN MONITOR SERVICING

IMPORTANT

Be sure the **GENERATOR OPERATION** section of this manual has been reviewed.

GENERAL

The Model 241 RASTER Scan outputs provide separate horizontal and vertical sync signals 0 to +5 volts (TTL compatible). Both plus going (V, H) and negative going ($\overline{V}$, $\overline{H}$) signals are provided simultaneously. The R,G and B signals are separate 0 to +4 volts (TTL compatible) signals which can be turned on or off using the front panel **R,G, B** pushbuttons. The signal amplitude can be adjusted from 0 to +4 volts to control the pattern brightness using the front panel **BRIGHTNESS** control. For black and white monitors only one gun signal is required but which signal (R,G or B) depends on the monitor connections. It is best to activate all **GUN CONTROL** buttons.

RASTER SCAN SETUP

1. Follow the instructions in the **GENERATOR OPERATION** section of the **OPERATING INSTRUCTIONS** section of this manual for preparing to service a raster scan monitor.

2. Set the **SCAN MODE** pushbutton to **RASTER** and turn the **BRIGHTNESS** control to minimum.

3. Activate all of the **GUN CONTROL** switches.

4. Select the  (Bold Crosshatch) pattern.

5. Set **PWR** to ON.

6. Turn up the **BRIGHTNESS** control until the pattern appears at a normal brightness. Do not set the brightness too high as it can cause defocusing of the CRT.

ADJUSTMENTS SPECIFIC TO RASTER SCAN MONITORS

Adjustment procedures for monitors will vary from monitor to monitor often even with monitors from the same manufacturer. It is advisable always to use the manufacturer's Service Instructions when performing adjustments to monitors. Presented here is a generalized review of adjustments normally

SECTION V

X-Y MONITOR SERVICING

GENERAL

The Model 241 X-Y Scan outputs provide separate X and Y signals which are adjustable from X=±4 volts, Y=±3 volts to X=±10 volts, Y=±7.5 volts using the **X-Y SIZE** control. At the control extremes are calibration marks. When the control is set to these marks, the X and Y signals are calibrated voltages. See **SPECIFICATIONS** for details. The R,G and B signals (Z) are separate 0 to +4 volts (TTL compatible) signals which can be turned on or off using the front panel **R,G, B** pushbuttons. The signal amplitude can be adjusted from 0 to +4 volts to control the pattern brightness on all patterns except the  (Gray Scale) using the front panel **BRIGHTNESS** control.

The  (Gray Scale) pattern is a calibrated 1V/step pattern used to adjust black level on the monitor. For black and white monitors only one gun signal is required but which signal (R,G or B) depends on the monitor connections. It is best to activate all **GUN CONTROL** buttons.

X-Y SETUP

1. Follow the instructions in the **GENERATOR OPERATION** section of the **OPERATING INSTRUCTIONS** section of this manual for preparing to service an X-Y monitor.

2. Set the **SCAN MODE** pushbutton to **X-Y** and turn the **BRIGHTNESS** and **X-Y SIZE** controls to minimum.

3. Activate all of the **GUN CONTROL** switches.

4. Select the  (Diagonal Crosshatch) pattern.

5. Set **PWR** to ON.

6. Turn up the **BRIGHTNESS** control until the pattern appears at normal brightness. Do not set the brightness too high as it can cause defocusing of the CRT.

7. Adjust the **X-Y SIZE** control until the pattern covers all but about a 1/2" border around the outside of the CRT. Do NOT adjust the size beyond the edges of the CRT because some monitors contain protective fuses or circuitry to prevent overdrive and these devices may trip if the monitor is overdriven.

performed on raster scan monitors and the recommended patterns associated with each. PURITY, STATIC CONVERGENCE, DYNAMIC CONVERGENCE and major centering adjustments are common to Raster Scan and X-Y Monitors and are presented separately.

DISPLAY PATTERN USES

The following table lists some of the monitor adjustments for which the various display patterns are used.

ADJUSTMENT FOR	PATTERNS
1. Centering or positioning	Single Crossbar
2. Height, width, linearity, and pin cushion effect, focus	Crosshatch (Bold and Fine)
3. Static convergence	Single Crossbar, Single Dot
4. Dynamic convergence	Fine Crosshatch

DEFLECTION SYSTEM TESTS

Many abnormalities in a monitor deflection system will show up in a simple check of the monitor scanning. Always refer to the manufacturer's recommendations when evaluating the results of these tests.

OVERSCAN

1. Set display selector to the Fine Crosshatch pattern.
2. Adjust the monitor contrast and brightness to display sharp, thin lines against a black background.
3. Note the number of vertical and horizontal lines. The monitor should display 15 vertical and 15 horizontal lines.

CENTERING, SIZE, AND LINEARITY

The Crosshatch pattern provides a stable display of evenly spaced lines to make these adjustments. With this pattern displayed, abnormal conditions such as deflection non-linearity, pin cushion distortion, and excessive 60 Hz hum are easily detected.

Vertical size and linearity should be adjusted to produce even spacing between all horizontal lines. If the adjustments will not permit this, then there may be a vertical deflection problem.

Pin cushion distortion is most common on large screen monitors. The correct amount of compensation should make the vertical and horizontal crosshatch lines appear as straight and parallel as possible. If 60 Hz hum is entering the circuitry, it will produce a horizontal bar rolling through the pattern or apparent moving waves through the pattern.

Generally the following control type adjustments are present on raster scan monitors:

Focus
Vertical Size
Vertical Video Position (often a jumper on PC board)
Focus
Horizontal Hold
Horizontal Video Position
Horizontal Width

Each of the adjustments are intended for small amounts of correction on the picture. If major corrections are needed they generally involve moving the CRT Yoke Assembly.

ADJUSTMENTS SPECIFIC TO X-Y MONITORS

Adjustment procedures for monitors will vary from monitor to monitor often even with monitors from the same manufacturer. It is advisable always to use the manufacturer's Service Instructions when performing adjustments to monitors. Presented here is a generalized review of adjustments normally performed on monitors and the recommended patterns associated with each. PURITY, STATIC CONVERGENCE, DYNAMIC CONVERGENCE and major centering adjustments are common to Raster Scan and X-Y monitors and are presented separately.

DISPLAY PATTERN USES

The following table lists some of the monitor adjustments for which the various display patterns are used.

ADJUSTMENT FOR	PATTERNS
1. Centering and positioning	Diagonal Crosshatch, or Single Crosshatch
2. Height, width, linearity	Diagonal Crosshatch, or Single Crosshatch
3. Static convergence	Single Crosshatch, or Diagonal Crosshatch
4. Dynamic convergence	Diagonal Crosshatch, and Raster
5. Black level	Gray Scale Staircase
6. Black and white tracking (Gray Scale adjustment)	Gray Scale Staircase

CENTERING AND POSITIONING

Most monitors contain screwdriver type controls for adjusting centering and positioning. These controls are generally intended for fine tuning of these parameters. If gross adjustments must be made, it generally involves movement of the yoke assembly which can be accomplished in conjunction with PURITY and CONVERGENCE adjustments.

For centering and positioning set the generator to the  (Single Crosshatch) pattern and adjust the **X-Y SIZE** for a convenient picture size. Refer to the manufacturer's literature for adjustment location and adjust for the lines to cross in the center of the CRT.

HEIGHT, WIDTH, LINEARITY

If the X and Y deflection sensitivity is known for the monitor size then the Diagonal Crosshatch or Single Crosshatch pattern size can be determined using the equations presented below. If the deflection sensitivity is not known, then the monitor can be set up to produce a pattern with the typical aspect ratio of 4:3 (X:Y) and final sensitivity adjusted when reconnected to the game.

Proceed as follows:

1. Set generator output to Diagonal Crosshatch pattern. Adjust brightness as required.

2. Set **SIZE** control to minimum **CAL** position. The Diagonal Crosshatch pattern now has a calibrated output of X=±4V, Y=±3V.

   A) If the monitor specifications call for X=±4V and Y=±3V simply adjust the monitor **SIZE** controls for a picture which just covers the screen. Typical lengths on a 19" screen are X=14.5" and Y=10.5".

   B) If the monitor specifications call for X=±10V and Y=±7.5V adjust the **X-Y SIZE** control to the upper **CAL** mark. Adjust the monitor size controls for a picture which just covers the screen. Typical lengths on a 19" screen are X=14.5" and Y=10.5".

3. If the monitor specifications call for sensitivities other than X=±4V, Y=±3V or X=±10V, Y=±7.5V the proper sensitivity can be set with the help of the deflection size equations below. To calibrate a monitor using the equations proceed as follows.

   A) Set the **X-Y SIZE** control to the minimum **CAL** mark (X=±4V, Y=±3V). The signals producing the Diagonal Crosshatch and Single Crosshatch are calibrated signals of X=±4V and Y=±3V.

   B) Determine the desired deflection sensitivity from the manufacturer's literature. Measure the "X" and "Y" dimensions of the CRT using a ruler. Dimensions on a 19" screen are X=14.5" and Y=10.5".

   C) To find the length of the "X" size of the pattern fill in the blanks and perform the arithmetic.

$$\text{X length} = \frac{\text{Measured width of screen ("B" above)} \times \text{Mfr spec'd sens. ("B" above)}}{4}$$

Using the monitor X size adjustment, adjust the "X" line on the screen to the "X length" determined above.

D) To find the length of the "Y" size of the pattern fill in the blanks and do the arithmetic.

$$\text{Y length} = \frac{\text{Measured height of screen ("B" above)} \times \text{Mfr spec'd sens. ("B" above)}}{3}$$

Using the monitor Y size adjustment, adjust the "Y" line on the screen to the "Y length" determined above.

E) Set the Model 241 to  (Diagonal Crosshatch) and note that the pattern is square on the screen and that its overall size is the same as the "X" and "Y" settings from C) and D) above.

GRAY SCALE TRACKING (WHITE BALANCE)

To adjust the gray scale tracking of an X-Y monitor, the Model 241 has the  (Gray Scale) pattern. This pattern is a calibrated brightness pattern and is not adjustable by the **BRIGHTNESS** control. The pattern signal is a series of 1 volt step changes in the R,G and B output signals beginning with "black" (+1V) signal and progressing in 1 volt steps to "white" (+4V). The manufacturer's literature should be consulted to be sure this signal is suitable for the monitor being serviced; however, at this writing, all known monitors use this standard.

Normal procedure is to set the drive controls at the center of their rotation, the cutoff and common screen control to minimum. Turn up the common screen control until the left hand (black) bar is just visible then back off until the bar is black again. The cutoff control of whatever color appeared in the black is left at minimum. Next turn up the other two cutoff controls similar to what was done with the common screen control. Finally adjust the drive controls for a neutral white on the "white" (right hand) bar.

SECTION VI

GENERAL CONVERGENCE PROCEDURE (RASTER SCAN AND X-Y MONITORS)

GENERAL

Due to the magnetic sensitivity of color monitors, it is desirable to make color and alignment adjustments at the site of the permanent location of the receiver. The light weight and portability of the Model 241 lends itself particularly to "on location" use although it may also be used in the shop. It is usually desirable to give the receiver a final touch-up at its permanent location, if it has been serviced elsewhere.

The service technician who establishes a routine sequence in his testing saves himself a great deal of work and time. He is less apt to follow false leads. Frequently a slight touch-up is all that is required. The following sequence of procedure is recommended.

DEGAUSSING

To remove unwanted stray magnetism from the color monitor, degauss it at the beginning of all testing or adjusting. To do this, place a degaussing coil on the floor about ten feet in front of the monitor. Energize it. Lift the coil to the level of the monitor and hold it in a plane parallel to the face of the TV tube. Move the coil to within a couple of inches of the face of the tube, maintaining the parallel plane between coil and tube. In a circular motion, pass the coil over the face of the tube a half dozen times. In a similar manner move the coil around the sides, top and (if possible) the bottom of the monitor, always maintaining the plane of the coil parallel to the top, sides, and bottom. Return the coil to the face of the monitor and, for good measure, pass the coil over the face of the tube a few times.

Maintaining the parallel plane, move the coil away from the face of the tube a distance of about ten feet. Turn the coil 90 degrees to the face of the tube and de-energize the coil.

COLOR PURITY

The purpose of purity adjustment is to compensate for misalignment that may exist between the position of the three electronic gun beams and the center of deflection of the tri-color picture tube.

The direction of displacement of the beams is controlled by rotation of the purity magnet, while the amount of displacement is controlled by the strength of the magnetic field. It might be convenient to think of purity

adjustments as repositioning of the entire three gun structure with respect to the neck, screen mask, and the phosphor screen in the color picture tube. Proper positioning will permit each of the beams to strike its respective phosphor dots.

Purity adjustments are made with only one gun in operation, while the other two guns are biased to cut-off. In this way we can determine if the correct beam is striking the proper phosphor dots to produce a pure color field. When adjusting, use the red beam. Impurities are more readily observed on the red screen than either the blue or green screens. A portion of the red beam, falling on blue or green phosphor dots, will illuminate them and contaminate the red field. If this condition occurs, color impurity results. A pure red raster is obtained by adjustment of the static convergence magnets on the convergence yoke assembly, the purity magnet adjustment tabs, the deflection tabs, and the deflection yoke. Before beginning purity or convergence adjustments, make sure that all picture centering, size, linearity, and focus adjustments are properly set.

STATIC CONVERGENCE

This adjustment is usually accomplished using one or more pairs of ring magnets located on the neck of the CRT. The rings are adjusted to converge the red, green, and blue beams in the center portion of the CRT screen. This is most easily performed using the  Single Crosshatch or  Single Dot.

Each manufacturer has their own method of adjusting purity and since it is a sensitive adjustment, often involving movement of the yoke, the manufacturer's literature is the only safe way of assuring good results. For this reason any general procedure we might give could be misleading.

DYNAMIC CONVERGENCE

This adjustment converges the red, green, and blue beams around the outer portion of the CRT screen. On most arcade game monitors this is performed by adjusting the tilt of the yoke with respect to the CRT neck and fixing it in position by means of rubber wedges.

Manufacturers have very specific procedures for these adjustments so no attempt will be made in this manual to offer a general procedure.

SECTION VII

ADAPTERS

SUPPLIED ADAPTERS

Four adapter harnesses are supplied with the Model 241 ARCADE ANALYZER. These adapters are compatible with nearly all Electrohome and Wells Gardner and a number of other manufacturers' X-Y and Raster Scan monitors used in arcade games.

The Model 241 supplies only signals to the monitor under test. It does not supply operating power. Most raster scan monitors have separate signal and power connectors and therefore only a single connector to match the signal input connector of the monitor is required. A number of X-Y monitors, however, use the same connector for both signals and power. The adapter therefore must connect power from the game and allow signals to be inserted from the Model 241. The adapters for these monitors need 3 connectors (1 to the game, 1 to the monitor, 1 to the Model 241).

The following table lists the particulars on the four adapters supplied with the Model 241 along with a partial list of the monitors it is compatible with.

ADAPTER A

Used on raster scan monitors only.

Monitor Connector: 6 terminal Molex

*PIN OF MOLEX CONNECTOR	WELLS GARDNER SCHEMATIC NUMBERING	SIGNAL
1	6	Horizontal Sync (H)
2	5	Vertical Sync (V)
3	4	GND
4	3	Blue Gun
5	2	Green Gun
6	1	Red Gun

*On manufacturer's schematic, pin numbering is reverse of numbers molded on the Molex connector.

Typical Monitors using Adapter A

Wells Gardner 19K4901, 19K4906, 19K4951, 19K4956
Electrohome G07 Series Monitors

ADAPTER B

Used on color X-Y monitors.

Monitor Connector: 6 pin Molex

*PIN OF MOLEX CONNECTOR	WELLS GARDNER SCHEMATIC NUMBERING	SIGNAL
1	6	Blue Gun
2	5	Green Gun
3	4	Red Gun
4	3	GND
5	2	Vertical (Y)
6	1	Horizontal (X)

*On manufacturer's schematic, pin numbering is reverse of numbers molded on the Molex connector.

Typical Monitors using Adapter B
Electrohome G08 Series Monitors

ADAPTER C

Used on black and white X-Y monitors only.

Game/Monitor Connectors: 12 pin AMP "Mate and Lock"

PIN OF AMP CONNECTOR	SIGNAL
1	Z (Red Gun)
2	Vertical (Y)
3	Horizontal (X)
4	Power Ground
5	Signal Ground
6	Signal Ground
7	Power
8	Signal Ground
9	Power
10	Power
11	Power Ground
12	Power

Typical Monitors using Adapter C
Wells Gardner 19V2000
Electrohome G05 Series Monitors

ADAPTER D

For use with color X-Y monitors.

Game/Monitor Connectors: Amp "Mate and Lock" 15 pins

PIN OF AMP CONNECTOR	SIGNAL
1	Red Gun (R)
2	Green Gun (G)
3	Blue Gun (B)
4	Signal Ground
5	N.C.
6	N.C.
7	Horizontal (X)
8	Vertical (Y)
9	N.C.
10	N.C.
11	N.C.
12	N.C.
13	Power
14	Power Ground
15	Power

Typical Monitors using Adapter D
Wells Gardner Color X-Y Model 19K6103

SECTION VIII

MAKING YOUR OWN ADAPTERS

The adapters provided with the Model 241 cover most of the monitors in service in arcade games today. If, however, it is necessary to service a game containing a monitor other than one of those compatible with the supplied adapters, it is not difficult to make your own adapter. The Model 241 is supplied with 2 extra connectors compatible with the output plug on the instrument and extender cable.

The key to successful adapter construction is some initial care to be sure you are connecting the correct signal to the correct pin of the monitor connector. We suggest you use the chart below and fill in the blanks, then make the cable according to the chart.

On many X-Y monitors, both signal and power are supplied to the monitor through the same connector. The Model 241 does NOT supply power so it will be necessary to make a cable that plugs into both the monitor and the game output connector (to the monitor) as well as the Model 241. The objective is to supply monitor power from the game and signals to the monitor from the Model 241 so a "Y" kind of adapter that plugs into all three connections will be necessary. Most raster scan monitors have signal and power connections separated into two different connectors so it is only necessary to connect into the signal connector.

Step By Step Procedure:

1. Fill out the chart below.

2. Obtain the proper connectors and compatible terminals. The parts list in this manual contains a list of connectors typically used in arcade games and most are readily available from arcade game service parts suppliers.

3. Using stranded #18 to #22 insulated wire, make the connections called for in the chart.

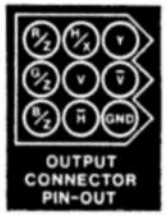
4. Check your work then plug it in and service the game.

NUMBER REQ'D	DESCRIPTION
1	9 Pin Connector for connection to Model 241
6	Terminals for connector
1	Connector for connection to Monitor
____	Terminals for connector
	IF REQUIRED FOR POWER
1	Connector for connection to Game
____	Terminals for connector

MODEL 241 9 PIN CONNECTOR

PIN	SIGNAL	DESCRIPTION
1	Y	Vertical (X-Y)
2	$\overline{V}$	Inverted Vertical Sync
3	GND	Ground
4	H/X	Horizontal Sync (raster scan) Horizontal (X-Y)
5	V	Normal Vertical Sync
6	$\overline{H}$	Inverted Horizontal Sync
7	R/Z	Red Gun
8	G/Z	Green Gun
9	B/Z	Blue Gun

VIEWED FROM REAR OF INSTRUMENT



VORK CHART

MANUFACTURER AND PART NUMBER

Molex #03-09-2092 Hickok #3475-457
Molex #02-09-2118 Hickok #20340-180

MONITOR CONNECTOR [SIGNALS FROM 241, POWER FROM GAME CONNECTOR (IF REQUIRED)]

GAME CONNECTOR [POWER TO MONITOR (IF REQUIRED)]

WIRE COLOR	PIN	POWER DESC.	WIRE COLOR	PIN

SECTION IX

MAINTENANCE AND CALIBRATION

Your Model 241 ARCADE ANALYZER has been constructed using the latest components and techniques that the electronic technology has to offer. It has been designed for long reliable service as indicated by our one (1) year warranty.

Should difficulty be encountered with your instrument, The Hickok Electrical Instrument Co. maintains complete facilities for reliable and timely service of our products.

A troubleshooting procedure is not presented in this manual. The experienced electronic technician can easily interpret the Schematic and Parts Location diagrams for routine troubleshooting.

Special effort has been made to design the instrument around components that are readily available in electronic distribution. In addition, the calibration of the unit has been developed using general purpose test equipment commonly found in most repair facilities. For these reasons your Model 241 can easily be checked or repaired by competent service personnel.

CAUTION

There is exposed power line voltage present inside the Model 241 whenever the unit is plugged in regardless of the ON-OFF switch position. Always unplug the unit from the power source when disassembling or repairing the unit.

To calibrate the Model 241 you will need:

Digital Multimeter – AC accuracy ±1%
15 MHz Oscilloscope
200mV DC Voltage Source

To accomplish the calibration, perform the following steps: (Locations of adjustments are in the Parts Location Diagram at the rear of this Manual.)

1. Plug the unit into 115 volt ±10%, 60 Hz power source and turn it on.

2. Set the front panel controls as follows:
   TEST MODE – **GEN.**
   SCAN MODE – **X-Y**
   X-Y SIZE – Minimum **CAL** position
   TEST PATTERN – Diagonal Crosshatch
   GUN CONTROL – All activated
   BRIGHTNESS – Maximum

3. Using the digital multimeter, set to AC volts monitor from Pin 3 (GND) of the OUTPUT connector to Pin 4 (X).

4. Adjust the X cal (R336) for 2.22±0.01V AC.

5. Monitor from Pin 3 (GND) of the OUTPUT connector to Pin 1 (Y).

6. Adjust the Y cal (R230) for 1.65±0.01V AC.

7. Set the **X-Y SIZE** control to the maximum **CAL** position.

8. Again monitor from Pin 3 to Pin 4.

9. Adjust the X max cal (R229) for 5.55±0.01V AC.

10. Monitor from Pin 3 to Pin 1.

11. Adjust the Y max cal (R233) for 4.17±0.01V AC.

12. Select the Gray Scale pattern.

13. Connect the oscilloscope to Pin 3 (GND) and Pin 7 (R/Z) of the OUTPUT connector.

14. Adjust the White Level pot (R128) to obtain 4.00V±0.05V for the highest step on the staircase signal.

15. Adjust the Black Level pot (R127) to obtain 1.00V±0.05V for the lowest step on the staircase.

16. Repeat steps 14 and 15 (since they interact) until the voltages are within tolerance.

17. Set the front panel controls as follows:
    TEST MODE – TRAKER
    VARI-TRAKER MODE SELECT – VOLTS

18. Apply 200mV DC plus to the "+" jack of the VARI-TRAKER input jacks.

19. Adjust the SOUND CAL (R204) so that a slow ticking sound is emitted by the VARI-TRAKER.

This completes calibration of the instrument.

SECTION X

PARTS LIST

When ordering parts be sure to give the reference designation, description, and the Hickok part number as listed in the following table. Unless otherwise indicated in the DESCRIPTION column, parts listed are applicable to all models. Also include the model and serial number of the equipment. Minimum billing is $50.00. Orders for less than $50.00 will be accepted and shipped prepaid if accompanied by a check for the full amount plus $3.50 postage and handling.

DESCRIPTION	HICKOK PART NO.
CONNECTORS	
CONNECTOR, PLUG: housing 9 pin, Molex #03-09-2092 . . . . . mates with output connector of Model 241 and Adapter Cable	3475-457
TERMINALS: for use with 3475-457 (typically 6 required)	20340-180
CONNECTOR: 6 pin Molex #09-50-7061	3475-458
TERMINALS: for use with 3475-458 (typically 6 required)	20340-181
CONNECTOR: 12 pin plug AMP #1-480708-0	3475-460
TERMINALS: for use with 3475-460 (typically 12 required)	20340-183
CONNECTOR: 15 pin plug AMP #1-480710-0	3475-462
TERMINALS: for use with 3475-462 (typically 15 required)	20340-183
CONNECTOR: 12 pin socket AMP #1-480709-0	3475-459
TERMINALS: for use with 3475-459 (typically 8 required)	20340-182
CONNECTOR: 15 pin socket AMP #1-480711-0	3475-461
TERMINALS: for use with 3475-461 (typically 6 required)	20340-182
FIELD REPLACEABLE PARTS	
CAP: decorator, molded	3075-92
CABLE ASSEMBLY: extender	3030-291
CABLE ASSEMBLY: adapter "A"	3030-292
CABLE ASSEMBLY: adapter "B"	3030-293
CABLE ASSEMBLY: adapter "C"	3030-294
CABLE ASSEMBLY: adapter "D"	3030-295
CASE: molded, top	3140-220
CASE: molded, bottom	3140-221
CASE: carrying, vinyl (CC-6)	3145-774
CORD: line	3675-68
KNOB: round	11505-266
KNOB: square	11505-312
LEAD SET: banana plug to prod	12450-494
NAMEPLATE: front panel, upper right	14103-106
NAMEPLATE: front panel, lower	14103-107
NAMEPLATE: front panel, upper left	14103-127
PANEL: front	16025-711
PANEL: upper left	16025-714
PANEL ASSEMBLY: side (includes jacks)	16026-962
PANEL ASSEMBLY: rear	16026-963

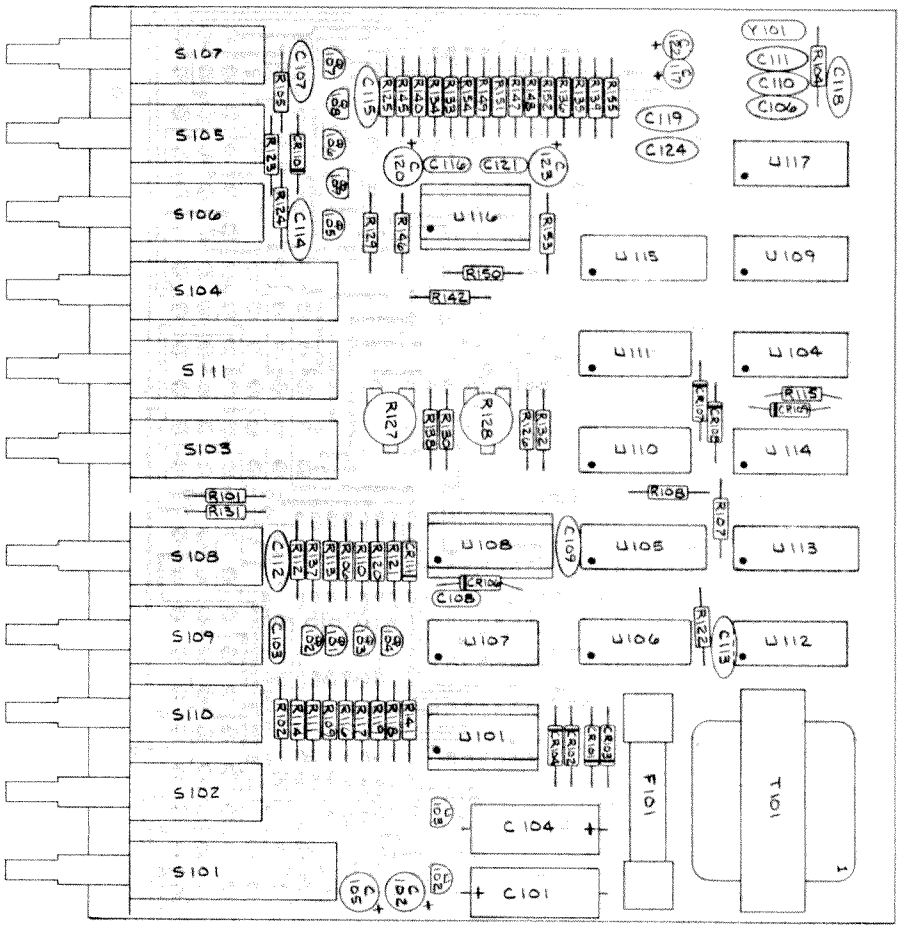
REF. DESIG.	NOTES	DESCRIPTION	HICKOK PART No.
		SERVICE PARTS	
C101		CAPACITOR, FIXED, ALUMINUM ELECTROLYTIC: 100 µf, 35 volts	3085-592
C102		CAPACITOR, FIXED, ALUMINUM ELECTROLYTIC: 10 µf, 35 volts	3085-580
C103		CAPACITOR, FIXED, CERAMIC: disc type, 0.1 µf, 50 volts	3110-371
C104		Same as C101	
C105		Same as C102	
C106		CAPACITOR, FIXED, CERAMIC: disc type, 33 pf	3111-513
C107		CAPACITOR, FIXED, CERAMIC: disc type, 100 pf	3111-516
C108		Same as C103	
C109		Same as C103	
C110		CAPACITOR, FIXED, CERAMIC: disc type, 22 pf	3111-512
C111		CAPACITOR, FIXED, CERAMIC: disc type, 68 pf	3111-515
C112		CAPACITOR, FIXED, CERAMIC: disc type, 47 pf	3111-514
C113		CAPACITOR, FIXED, CERAMIC: disc type, 0.01 µf, 25 volts	3110-332
C114		CAPACITOR, FIXED, CERAMIC: disc type, 2200 pf	3111-524
C115		CAPACITOR, FIXED, CERAMIC: disc type, 220 pf	3111-518
C116		CAPACITOR, FIXED, POLYESTER FILM: 0.0047 µf, 100 volts	3103-187
C117		CAPACITOR, FIXED, ALUMINUM ELECTROLYTIC: 1 µf, 50 volts	3085-577
C118		Same as C107	
C119		Same as C103	
C120		Same as C102	
C121		Same as C116	
C122		Same as C117	
C123		Same as C102	
C124		Same as C103	
C201		CAPACITOR, FIXED, ALUMINUM ELECTROLYTIC: 47 µf, 10 volts	3085-582
C202		CAPACITOR, FIXED, POLYESTER FILM: 0.01 µf, 100 volts	3103-184
C203		Same as C202	
C204		Same as C113	
CR101		SEMICONDUCTOR DEVICE: silicon diode 1N4001, 1 amp, 50 volts	3870-229
CR102 thru CR104		Same as CR101	
CR105		Not used	

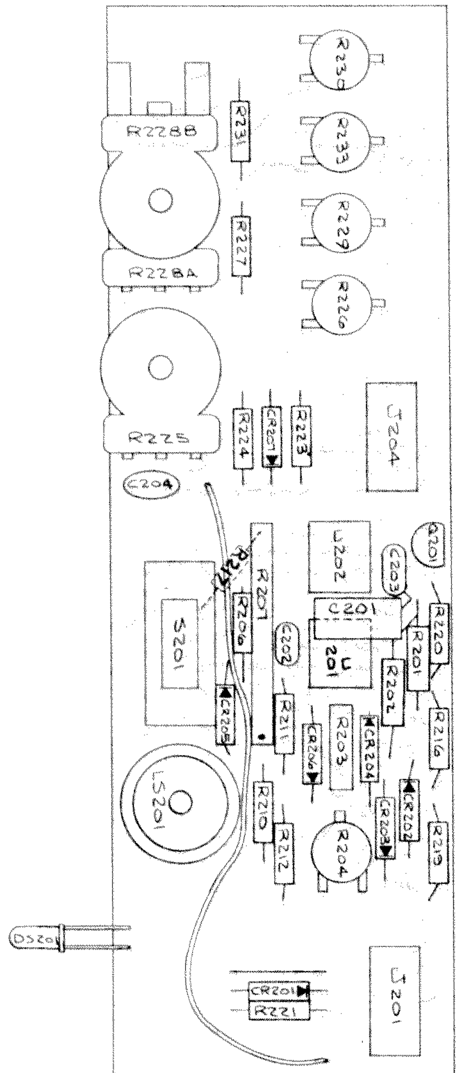
REF. DESIG.	NOTES	DESCRIPTION	HICKOK PART NO.
CR106		SEMICONDUCTOR DEVICE: diode 1N4148 or 1N914	3870-289
CR107 thru CR111		Same as CR106	
CR201		Same as CR101	
CR202		SEMICONDUCTOR DEVICE: zener diode 1N5729B, 5.1 volts	3870-320
CR203		Same as CR202	
CR204		SEMICONDUCTOR DEVICE: diode 1N4004	3870-300
CR205		Same as CR106	
CR206		Same as CR106	
CR207		Same as CR202	
DS101		LAMP, LED: red diffused	12270-163
F101		FUSE: SLO-BLO, 1/4 amp, 250 volts	6900-78
J101		CONNECTOR: receptacle, 9 pin	3475-463
J201		CONNECTOR: 6 pin	3475-464
J202		JACK: machined	10300-138
J203		Same as J202	
J204		Same as J201	
Q101		TRANSISTOR: silicon 2N3904	20861-141
Q102 thru Q105		Same as Q101	
Q106		TRANSISTOR: silicon 2N3906	20861-319
Q107		Same as Q101	
Q108		Same as Q106	
Q109		Same as Q101	
Q201		Same as Q106	
R101		RESISTOR, FIXED, DEPOSITED CARBON: 30K ohms, 5%, 1/4 watt	18470-303
R102		RESISTOR, FIXED, DEPOSITED CARBON: 15K ohms, 5%, 1/4 watt	18470-153
R103		Not used	
R104		RESISTOR, FIXED, COMPOSITION: 10 megohms, 5%, 1/4 watt	18456-101
R105		Same as R102	
R106		RESISTOR, FIXED, DEPOSITED CARBON: 75 ohms, 5%, 1/4 watt	18470-750
R107		RESISTOR, FIXED, DEPOSITED CARBON: 10K ohms, 5%, 1/4 watt	18470-103
R108		Same as R107	
R109		RESISTOR, FIXED, DEPOSITED CARBON: 100 ohms, 5%, 1/4 watt	18470-101
R110		Same as R107	
R111		RESISTOR, FIXED, DEPOSITED CARBON: 1K ohms, 5%, 1/4 watt	18470-102
R112		Same as R109	
R113		Same as R107	
R114		Same as R111	
R115		Same as R107	
R116		Same as R109	
R117		Same as R111	

REF. DESIG.	NOTES	DESCRIPTION	HICKOK PART NO.
R119		Same as R111	
R120		Same as R101	
R121		Same as R101	
R122		RESISTOR, FIXED, DEPOSITED CARBON: 1 megohm, 5%, 1/4 watt	18470-105
R123		Same as R107	
R124		RESISTOR, FIXED, DEPOSITED CARBON: 100K ohms, 5%, 1/4 watt	18470-104
R125		Same as R124	
R126		RESISTOR, FIXED, DEPOSITED CARBON: 22K ohms, 5%, 1/4 watt	18470-223
R127		RESISTOR, VARIABLE: horizontal mounting, 10K ohms, 20%	16925-820
R128		RESISTOR, VARIABLE: horizontal mounting, 1K ohm, 20%	16925-819
R129		RESISTOR, FIXED, DEPOSITED CARBON: 270K ohms, 5%, 1/4 watt	18470-274
R130		RESISTOR, FIXED, DEPOSITED CARBON: 39K ohms, 5%, 1/4 watt	18470-393
R131		RESISTOR, FIXED, DEPOSITED CARBON: 3.6K ohms, 5%, 1/4 watt	18470-362
R132		RESISTOR, FIXED, DEPOSITED CARBON: 43K ohms, 5%, 1/4 watt	18470-433
R133		RESISTOR, FIXED, DEPOSITED CARBON: 390K ohms, 5%, 1/4 watt	18470-394
R134		RESISTOR, FIXED, DEPOSITED CARBON: 75K ohms, 5%, 1/4 watt	18470-753
R135		Same as R101	
R136		Same as R131	
R137		Same as R122	
R138		RESISTOR, FIXED, DEPOSITED CARBON: 560K ohms, 5%, 1/4 watt	18470-564
R139		Same as R101	
R140		Same as R107	
R141		Same as R134	
R142		RESISTOR, FIXED, DEPOSITED CARBON: 47K ohms, 5%, 1/4 watt	18470-473
R143		Not used	
R144		Not used	
R145		Same as R107	
R146 thru R149		Same as R134	
R150		Same as R142	
R151		Same as R101	
R152		Same as R131	
R153		Same as R124	
R154		Same as R134	
R155		RESISTOR, FIXED, DEPOSITED CARBON: 150K ohms, 5%, 1/4 watt	18470-154
R201		RESISTOR, FIXED, COMPOSITION: 510 ohms 5%, 1/2 watt	18411-511

REF. DESIG.	NOTES	DESCRIPTION	HICKOK PART NO.
R202		Same as R201	
R203		RESISTOR, PTC: high voltage current limiter, 1K ohms, 40% at 25°C positive temperature coefficient	18682-69
R204		RESISTOR, VARIABLE: linear taper, 25K ohms, 20%	16925-965
R205		Not used	
R206		RESISTOR, FIXED, DEPOSITED CARBON: 430K ohms, 5%, 1/4 watt	18470-434
R207 A-H		RESISTOR NETWORK: thick film	16950-29
R208		Not used	
R209		Not used	
R210		Same as R104	
R211		Same as R122	
R212		RESISTOR, FIXED, DEPOSITED CARBON: 200K ohms, 5%, 1/4 watt	18470-204
R213 thru R215		Not used	
R216		RESISTOR, FIXED, DEPOSITED CARBON: 62K ohms, 5%, 1/4 watt	18470-623
R217		Same as R124	
R218		Not used	
R219		Same as R107	
R220		Same as R109	
R221		RESISTOR, FIXED, DEPOSITED CARBON: 1.3K ohms, 5%, 1/4 watt	18470-132
R222		Not used	
R223		RESISTOR, FIXED, DEPOSITED CARBON: 6.8K ohms, 5%, 1/4 watt	18470-682
R224		RESISTOR, FIXED, DEPOSITED CARBON: 2.7K ohms, 5%, 1/4 watt	18470-272
R225		RESISTOR, VARIABLE: horizontal mounting, 25K ohms, 20%	16925-847
R226		RESISTOR, VARIABLE: horizontal mounting, 50K ohms, 20%, 0.1 watt	16925-788
R227		RESISTOR, FIXED, DEPOSITED CARBON: 9.1K ohms, 5%, 1/4 watt	18470-912
R228A		RESISTOR, VARIABLE: linear taper dual, 25K ohms, 20%	16925-964
R228B		Same as R228A	
R229		RESISTOR VARIABLE: horizontal mounting, 5K ohms, 20%	16925-846
R230		Same as R226	
R231		Same as R227	
R232		Not used	
R233		Same as R229	
S101		SWITCH: pushbutton, 5 station	19910-297
S102		Same as S101	
S108 thru S110		Same as S101	

REF. DESIG.	NOTES	DESCRIPTION	HICKOK PART NO.
S103		SWITCH: pushbutton, 6 station	19910-296
S104 thru S107		Same as S103	
S111		Same as S103	
S201		SWITCH: slide, 4p 3t	19911-232
T101		TRANSFORMER: power, 115VAC	20800-521
U101		INTEGRATED CIRCUIT: LM324N	9800-270
U102		INTEGRATED CIRCUIT: MC78L15CP, ... 15 volts, 100mA, voltage regulator	9800-265
U103		INTEGRATED CIRCUIT: MC79L15CP, ... -15 volts, 100mA, voltage regulator	9800-194
U104		INTEGRATED CIRCUIT: MC14069UBCP, . . . hex inverter	9800-246
U105		INTEGRATED CIRCUIT: MC14520BCP, ... CMOS, dual binary up counter	9800-281
U106		INTEGRATED CIRCUIT: MC14012BCP, ... CMOS, dual 4-input NAND gate	9800-236
U107		INTEGRATED CIRCUIT: MC14001BCP, ... CMOS, quad 2-input NOR gate	9800-96
U108		INTEGRATED CIRCUIT: MC14049UBCP, . . . CMOS, hex inverter buffer	9800-162
U109		INTEGRATED CIRCUIT: MC14011BCP, ... CMOS, quad NAND	9800-131
U110		Same as U106	
U111		Same as U104	
U112		INTEGRATED CIRCUIT: MC14070BCP, ... CMOS, quad 2-input exclusive OR gate	9800-226
U113		Same as U105	
U114		Same as U106	
U115		INTEGRATED CIRCUIT: MC140161BCP, ... CMOS, syn prog., 4-bit count binary	9800-268
U116		INTEGRATED CIRCUIT: TL084CN, ... quad bifet OP-AMP	9800-296
U117		INTEGRATED CIRCUIT: MC14013BCP, ... CMOS, dual D flip flop	9800-111
U201		INTEGRATED CIRCUIT: 1CL7611CPA, ... CMOS, low power operational amplifier single supply	9800-245
U202		INTEGRATED CIRCUIT: ICM75551PA, ... low power timer	9800-254
Y101		CRYSTAL: 4 MHz	3800-447




R230
R233
R229
R226
R231
R227
R228B
R228A
R225
R224
CR207
R223
J204
C204
R207
R206
S201
C202
J202
C203
C201
U 201
Q201
R220
R201
R202
R216
CR205
R211
CR206
R203
CR204
CR202
CR203
R210
R212
R204
R219
LS201
CR201
R221
J201