1967

ULTRA-HIGH REGULATION

POWER SUPPLY

OPERATING AND MAINTENANCE MANUAL

Models UHR-220, UHR-220R, UHR-230R

MODEL UHR-220

SERIAL NO.

KROHN-HITE CORPORATION

580 Massachusetts Ave., Cambridge 39, Mass., U.S.A.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

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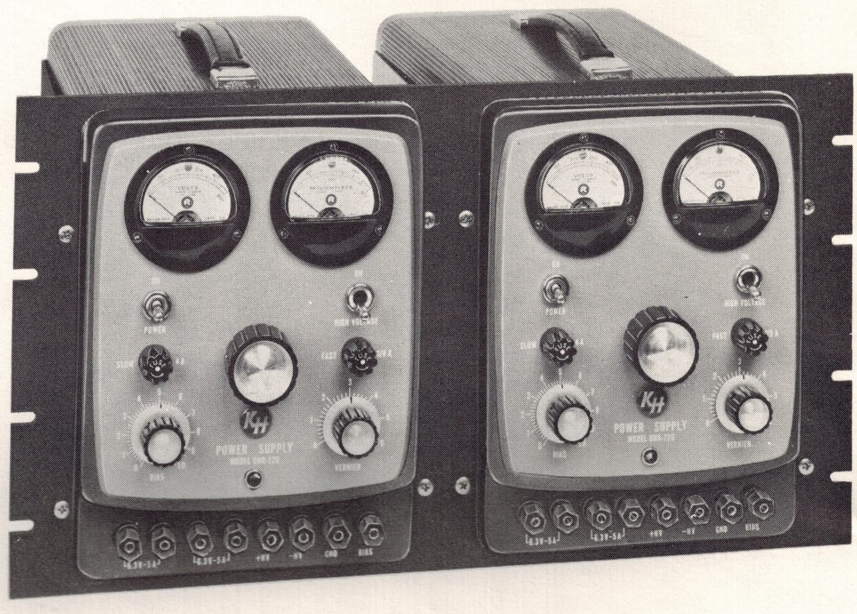
MODEL UHR-220 Power Supply



▶
MODEL UHR-230R Dual Power Supply
(Two Models UHR-220 Rack Mounted)

FIGURE 1 – Models UHR-220 and UHR-230R
Ultra-High Regulation Power Supplies

SECTION I - GENERAL DESCRIPTION

1. Technical Summary

MAIN DC OUTPUT:

VOLTAGE: Zero to 500 volts (continuously adjustable without switching).

CURRENT: Zero to 200 milliamperes at any voltage setting and at any line voltage within the operating range. (See Fig. 2)

*REGULATION (no load to full load): Less than 0.001% plus 0.002 volt.

LINE VOLTAGE STABILIZATION (for a line voltage change of ±10% within the operating range): Less than 0.003% plus 0.003 volt.

TEN HOUR DRIFT (any 10 hour continuous operation): Typical ±(300 ppm plus 20 millivolts), maximum ±(1,200 ppm plus 75 millivolts).

ONE HUNDRED HOUR DRIFT (any 100 hour continuous or interrupted operation): Typical ±(1,000 ppm plus 70 millivolts), maximum ±(3,000 ppm plus 200 millivolts).

*OUTPUT IMPEDANCE (at any load):
DC: less than (0.01 + 0.00005 x output volts) ohm.
AC: (See Fig. 1) under 0.1 ohm plus 0.1 microhenry (4" of wire).

TRANSIENT RESPONSE TIME (after rapid load current change): 0.001 millisecond.

*RIPPLE: Less than 0.1 millivolt rms.

POLARITY: Either positive or negative terminal may be grounded.

DC BIAS OUTPUT:

VOLTAGE: Zero to minus 150 volts (continuously adjustable).

CURRENT: Zero to 5 milliamperes.

REGULATION (no load to full load at maximum output voltage): Less than 1%.

LINE VOLTAGE STABILIZATION (for a line voltage change of ±10% within the operating range): Less than 0.05%.

OUTPUT IMPEDANCE: Zero to 12,000 ohms depending on setting of BIAS control.

RIPPLE: Less than 0.002% at any setting of the BIAS control.

POLARITY: Positive output connected internally to negative terminal of the Main DC Output (-HV).

1. Technical Summary (cont'd)

**TWO INDEPENDENT AC OUTPUTS (unregulated, isolated and ungrounded): May be used separately, in series or in parallel; each having a nominal 6.3 volt output at the rated load current of 5 amperes.

METERS: 2 1/2" voltmeter, scale 0-500 volts; 2 1/2" milliammeter, scale 0-200 milliamperes.

AMBIENT TEMPERATURE AND DUTY CYCLE: Continuous duty at full load up to 50°C (122°F) ambient.

CONTROLS:

DC Output Voltage control.
VERNIER control.
BIAS control.
HIGH VOLTAGE OFF-ON switch.
POWER OFF-ON switch.

TERMINALS: Output voltages available from eight multi-purpose binding posts on the front panel and from a Jones type S-308 connector on the rear of the chassis.

POWER REQUIREMENTS:

105-125 volts, single phase.
60 cycles only (50 cycle model available on special order; this Model cannot be furnished for 400 cycle operation).
300 watts with 150 watt load.

FUSE PROTECTION:

Line: 4 ampere slow-blow.
DC Output: 0.2 ampere slow-blow.
AC Outputs: (each) 5 ampere slow-blow.

TUBE COMPLEMENT (furnished with instrument): 1-5R4-GYA, 1-12AX7, 1-0G3/85A2, 1-6SN7-GTA, 2-6AS7-GA, 2-6U8-A, 1-0A2.

FORM: Furnished in an attractively styled perforated steel cabinet with a cast aluminum front panel and frame. Front panel finished in gray enamel; frame and cabinet in blue enamel. Other finishes available on special order. Overall dimensions Model UHR-220: 7 1/2" wide, 10" high, 15" deep. Weight 50 lbs. net, 54 lbs. shipping. Can be rack mounted by means of accessory hardware available separately. Overall dimensions Model UHR-220R: 19" wide, 10 1/2" high, 15" deep. Weight 62 lbs. net, 67 lbs. shipping.

NOTE:
*These specifications apply to the front panel terminals only; the regulation, output impedance and ripple of the Main DC Output from the rear Jones connector may be approximately twice the above specifications.
**This specification is based on an input of 115 volts, 60 cycles.

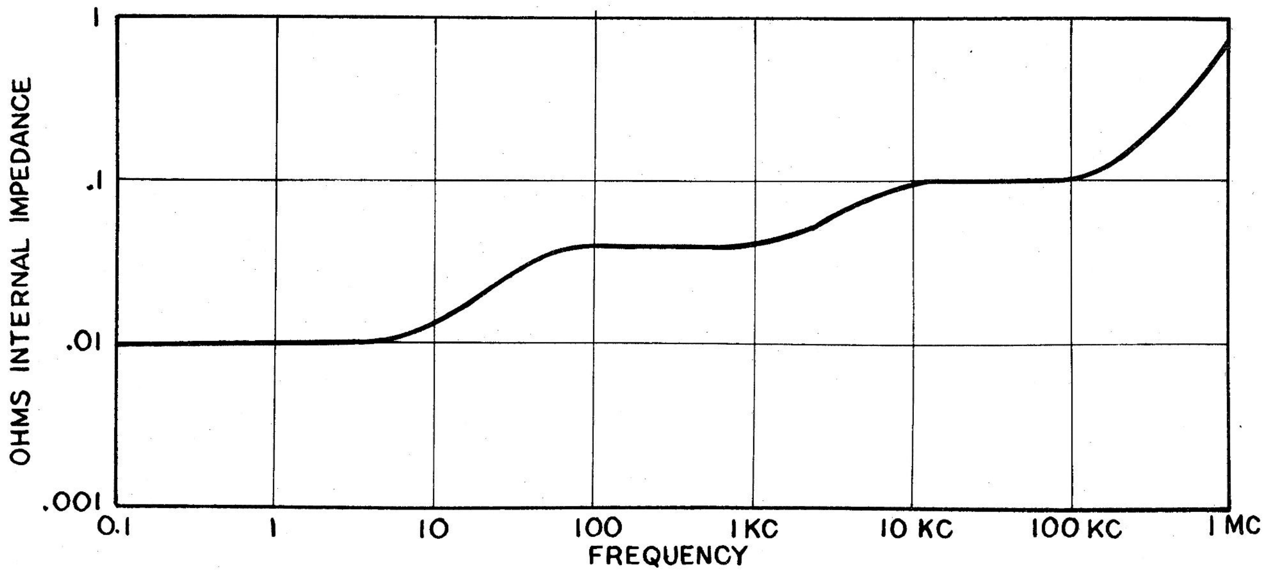


Fig. 2 - Models UHR-220, UHR-220R, UHR-230R IMPEDANCE vs. FREQUENCY

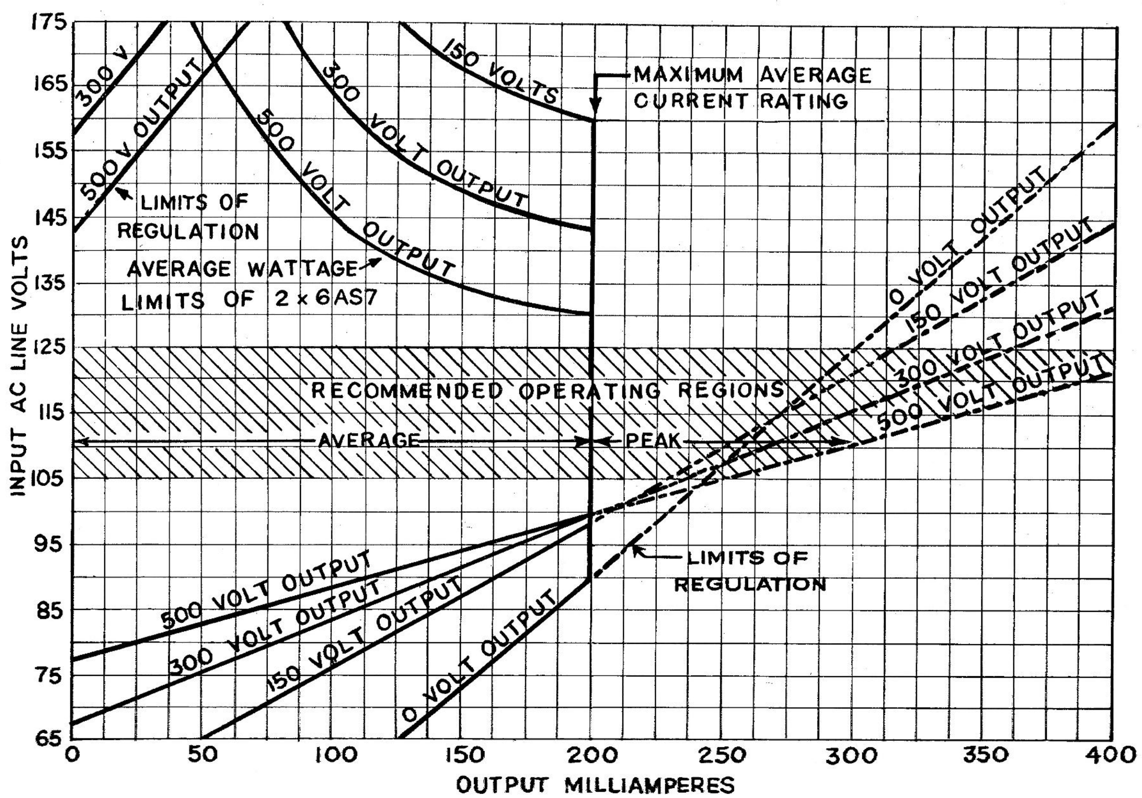


Fig. 3 - Model UHR-220, UHR-220R, UHR-230R PERFORMANCE LIMITS

2. DESCRIPTION

The Krohn-Hite Models UHR-220 and UHR-230R, shown in Figure 1, are portable Power Supplies, designed for applications requiring a combination of ultra-high regulation and very low ripple with additional stabilization* versus line voltage for improved stability in the range from 500 down to zero volts. There is an internal stabilizing transformer, which provides stabilized heaters on the internal amplifier to maintain less than three millivolts variation of output voltage for ±10% line voltage change at the low output voltages, and less than 0.003% variation at high output voltages. The use of an amplifier with 100 db gain provides a regulation from no load to full load of 0.001% plus 0.002 volt over the entire operating range. To obtain this regulation, it is necessary that the line supply voltage remain within 5% when the power supply is loaded from no load to full load.

The zero to -150 volt bias supply is stabilized both by the stabilizing transformer and by a voltage reference tube to obtain a variation of less than 0.05% for ±10% line voltage change at any setting of the logarithmic output bias control potentiometer. This potentiometer is connected directly across the voltage regulator tube and attenuates the ripple at reduced voltages to maintain less than 0.002% ripple at any output voltage. This bias supply is regulated for load changes at the maximum output setting only, since the internal impedance varies with the bias control setting.

The internal impedance of the high voltage output of the Model UHR-220, shown in Figure 2, is less than 0.1 ohm for frequencies as high as 100 kc. At higher frequencies the impedance is equivalent to 0.1 ohm in series with 0.1 microhenry (4 inches of wire). The low frequency and dc impedance is less than (0.01 + 0.00005 x output volts) ohm, which gives 0.01 ohm for minimum output voltage and 0.035 ohm for maximum output voltage. A circuit connection, which eliminates the milliammeter impedance, is employed.

The high degree of voltage stability is obtained by the use of drift-cancelling differential amplifiers with stabilized heaters, a new high stability voltage reference tube and low-temperature-coefficient wire-wound resistors.

The Ultra-High Regulation is obtained over the entire operating range. The UHR-220 requires no "derating" at maximum voltage and current output. Full rated maximum current can be drawn with 100% duty cycle at

*The changes in the output d-c voltage of a regulated power supply due to a fixed percentage fluctuation in the line supply voltage is often called the line regulation as differentiated from the load regulation which is the output d-c voltage change from no load to full load. In accordance with the I.R.E. Standards On Methods Of Measurements Of Electronically Regulated Power Supplies, as reported in the January, 1951 Proceedings of the I.R.E., Volume 39, No. 1, the accepted terminology for changes in the output d-c voltage for fluctuations in the line supply voltage is referred to as the "Output Voltage Stabilization".

any output voltage and any line voltage from 105 to 125 volts. The capacity of the regulated supply in excess of ratings is shown in Figure 3.

The 105 to 125 line voltage limits insure correct tube heater voltage and longer tube life. The supply will regulate over the wider limits shown in Figure 3. This insures undisturbed operation during severe and prolonged line voltage transients.

There are two independent 6.3 volt a-c heater windings of 5 ampere capacity, each protected by a 5 ampere slow-blow fuse. They may be used separately or connected in series to obtain 12.6 volts at the individual current rating, or in parallel to provide 6.3 volts at twice the individual current rating. C A U T I O N ! See Section II below on operation before paralleling the a-c heaters.

SECTION II - OPERATION

1. OPERATION

The Power Supplies are checked carefully in final test to insure that they meet all our specifications. They are aged under full load and again tested prior to shipment to be sure that they are ready for use. The Model UHR-220 is shipped complete and after unpacking is ready to be turned on and used.

In the Model UHR-220 there are three front panel controls in addition to the POWER and HIGH VOLTAGE OFF-ON toggle switches. The POWER OFF-ON switch should be turned on at least 15 seconds before the HIGH VOLTAGE OFF-ON switch to preheat the heaters of the tubes. When turning the power supply off, it is recommended that the HIGH VOLTAGE OFF-ON switch be turned off first and then the POWER OFF-ON switch. When the POWER OFF-ON switch is switched to the ON position, the HEATER outputs and BIAS output are activated and remain so in either position of the HIGH VOLTAGE OFF-ON switch.

The large center knob is the coarse adjustment of the high voltage output and operates a precision wire-wound potentiometer ganged with a variac. Occasionally the center arm of this potentiometer may produce abnormally high noise on the high voltage output by making intermittent contact with turns on the potentiometer card adjacent to the point of contact. A slight movement of the coarse high voltage control will readily eliminate this noise. A VERNIER control provides additional coverage of 8 volts anywhere in the operating range of the high voltage output. The BIAS control adjusts the bias output to any voltage from zero to -150 volts. The load on the bias output should not exceed 5 milliamperes.

There are two independent 6.3 volt a-c heater windings of 5 ampere capacity, each protected by a 5 ampere slow-blow fuse. They may be used separately or connected in series to obtain 12.6 volts at the individual current rating, or in parallel to provide 6.3 volts at twice the individual current rating. The proper series and parallel connections of the Model UHR-220 are shown in Figure 4.

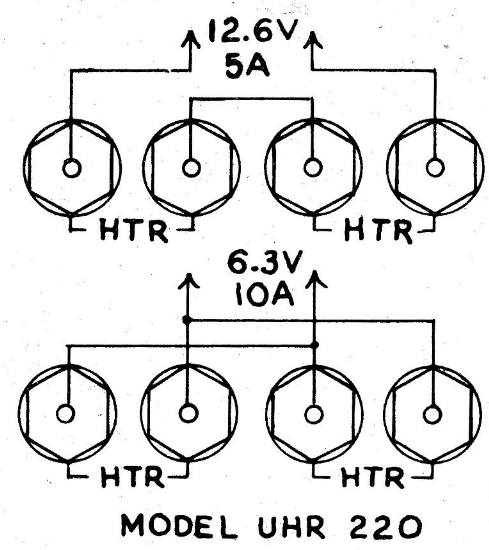


Fig. 4 - SERIES AND PARALLEL HEATER CONNECTIONS

All of the d-c and a-c output voltages are isolated from the chassis and from each other except the positive of the bias supply which is connected internally to the negative of the high voltage output. The positive of the high voltage output appears on the terminal marked +HV and the negative of the high voltage output appears on the terminal marked -HV. Either of these terminals may be connected to the terminal marked GND which is connected internally to the chassis and cabinet of the power supply. For minimum hum and noise, this GND terminal should be connected to the +HV or -HV terminals, whichever is grounded. A maximum of 1000 volts between the chassis, heater and high voltage outputs is permissible. Two Model UHR-220 supplies may therefore be connected in series to obtain a maximum output of 1000 volts at 200 milliamperes. With this connection, either the +HV or -HV terminals of either one of the supplies may be grounded.

All of the front panel outputs are available on a Jones socket at the rear of the chassis. The heater voltages, the bias voltage and the regulated high voltage are brought to an 8 pin connector Jones type S-308. The specifications given in the Technical Summary apply to the front panel terminals only. The regulation, output impedance and hum of the regulated High Voltage output at the rear Jones socket may be approximately twice these specifications.

For parallel operation of the a-c heater windings at the rear Jones socket of the Model UHR-220, jumper pin 1 to pin 4 and pin 2 to pin 3. For series operation, jumper pins 1 and 2 to obtain 12.6 volts at 5 amperes across pins 3 and 4. If the front and rear a-c heaters are used simultaneously, the combined output of any one heater should not exceed its specified rating.

The milliammeter on the front panel which indicates the external load current has a residual reading of from 0 to 7 MA (depending on the high voltage output setting) due to the current drawn through it by internal precision resistors. The voltmeter indicates the high voltage output.

The Model UHR-220R is the same as the UHR-220 except that the UHR-220R is provided with additional hardware for converting to relay rack mounting. Any model UHR-220 can be converted to a rack mounted unit by procuring the necessary additional hardware. Since the relay rack mounting hardware is shipped separately even when a Model UHR-220R is ordered, the following procedure is included to facilitate the assembly.

1. Model UHR-220

   a) Remove four rubber bumpers on bottom of instrument and only one of the two screws in back of cabinet.

   b) Fasten one of the brackets to the bottom of the instrument, on the slide from which the screw was removed using the enclosed 8-32 x 1/4" undercut flat-head screws.

   c) Replace the screw in the back of the instrument and then remove the other screw. Fasten other bracket in a similar manner.

   d) Mount instrument with attached brackets to front panel with enclosed hardware.

   e) Additional hardware consisting of machine screws, cupped washers and protecting fibre washers are enclosed for relay rack mounting.

2. Model UHR-230R

   The Model UHR-230R consists of two identical Model UHR-220's rack mounted side by side on one standard panel ($10\frac{1}{2}$" x 19"). The assembly procedure is similar to that of the Model UHR-220.

SECTION IV - THEORY OF OPERATION

The regulated high voltage supply of the Model UHR-220 is a conventional series type degenerative regulator employing an unusually high gain amplifier. The simplified basic circuit of a series type degenerative regulator is shown in Figure 5.

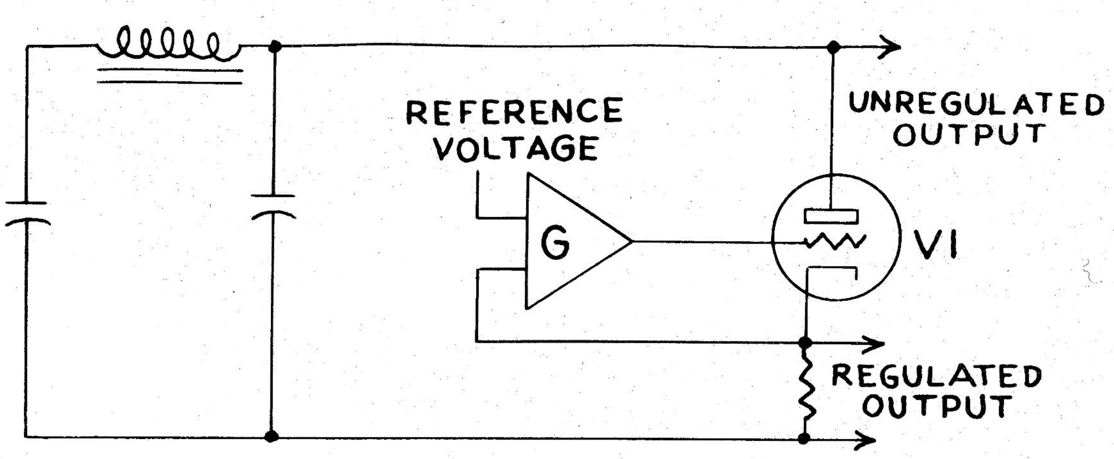


Fig. 5 - SIMPLIFIED BASIC CIRCUIT OF DEGENERATIVE REGULATOR

It consists basically of a series tube, V1, acting as a cathode follower whose plate supply potential is the unregulated output of a power supply. The regulated output is obtained from the cathode of the cathode follower. One of the inputs of the balanced amplifier, G, direct-couples the cathode of V1 back degeneratively to its grid. This circuit multiplies the transconductance, g_m, of V1 by the gain G. The other input of the amplifier establishes a reference potential.

The internal impedance of the cathode follower, V1, is approximately $1/(G \times g_m)$. If an internal impedance of 0.01 ohms is required using two parallel 6AS7 series tubes, the gain G of the amplifier can be readily determined. The realistic total transconductance of two 6AS7's operating at small plate current and reduced filament voltage may be as low as 1000 micromhos. To obtain an impedance of 0.01 ohms an amplifier with a gain of 100 db is required.

The impedance of most regulated power supplies is lowest at audio frequencies where the gain lost in the voltage determining resistors and interstage coupling resistors can be restored by bypass capacitors. The regulation for load changes is sometimes improved by using a form of current feedback. The stabilization against line voltage changes is sometimes improved by using the variation in the unregulated d-c voltage to furnish an additional correction voltage to the series tube. Since these methods involve a number of components and tubes (including the series tube, whose gain varies widely with voltage and current), it is impossible to obtain good load regulation and good line voltage stabilization under all operating conditions.

The Model UHR-220 power supply uses circuits which overcome these difficulties. Two of the stages of the amplifier section, V4 and V6, are separately regenerated at the low frequencies so that each, individually, has high gain. It has been found that with normal variations in the tube and its components, each of these stages will reliably contribute appreciable gain increase. The combination of two such stages, in the otherwise high gain amplifier, gives a great improvement in both the load regulation and the line voltage stabilization under all operating conditions.

To maintain low impedance at high frequencies, wide band amplifier stages are used and the signal is fed forward around the less wide band sections. Local feedback is employed to permit high gain in the main feedback loop without oscillation at high frequencies.

With the very high gain in the amplifier at low frequencies, the changes in the unregulated d-c voltage from the output of the rectifier cause negligible change in the regulated output. The remaining variables which cause variations in the regulated output are, the voltage determining resistors, the voltage reference, and contact potential in the amplifier. To reduce drift due to these variables the main output voltage control potentiometer and associated fixed resistors are low-temperature-coefficient wire-wound units. The voltage reference tube is the new type OG3 whose performance improves with aging. Each of the first three stages in the amplifier has heater voltage regulation and employs a double tube, connected to give drift cancellation.

SECTION IV - THEORY OF OPERATION

The high gain amplifier makes the ripple from the unregulated d-c voltage negligibly small at the regulated output. The remaining sources of hum are electrostatic and magnetic pickup in the amplifier stages. Electrostatic pickup is kept very low by the use of low impedance circuits adequately spaced or shielded from sources of hum. Magnetic pickup is overcome by routing the wiring so that the area of potential flux loops in the critical circuits is made as small as possible.

SECTION V - CIRCUIT DESCRIPTION

The Model UHR-220 consists of three basic units, an unregulated high voltage supply, a regulated high voltage supply, and a stabilized bias and reference supply.

1. UNREGULATED HIGH VOLTAGE SUPPLY

The unregulated high voltage supply uses a full wave rectifier tube, V1, whose output is filtered by a capacitor input single section pi filter consisting of C101 and L101. The choke is tuned by C102 to suppress the second harmonic of the line frequency.

One primary lead of the plate transformer, T102, is connected directly to the center arm of the Variac, T101, to provide a continuous variation of the unregulated output voltage as the high voltage regulated output is changed. The other primary lead is connected to a tap on the primary of the filament transformer, T201, to supply the required unregulated voltage when the regulated high voltage supply is set to zero. This circuit permits the use of the complete arc of the variac track and resistance card of the output voltage determining potentiometer, P101.

2. REGULATED HIGH VOLTAGE SUPPLY

The regulated high voltage supply is a conventional series type degenerative regulator employing an unusually high gain amplifier. Two type 6AS7 series tubes (V2 and V3) are used. A four stage amplifier consisting of V4, V5, V6 and V7 provides the necessary gain to maintain the regulation, stabilization, impedance and hum within specifications.

The balanced differential input stage V7 compares the high voltage output which appears, after attenuation through the voltage control precision potentiometer, P101, on the grid of V7 (pin #2), with the stabilized reference voltage which is applied to the other grid of V7 (pin #7). The plate supply of -85 volts for V7 is derived from the voltage reference tube, V9. The heaters of V7 and those of V5 and V6 are powered by the stabilizing transformer, T202.

The push-pull output of V7 is direct coupled to a second balanced amplifier, V6, whose single ended output is connected to the grid (pin #2) of a third balanced amplifier, V5. Additional gain by the use of regeneration is obtained in V6 by direct coupling the output of V6 to the opposite grid (pin #9) through R227. The d-c level at the grid (pin #9) of V5 is derived from the cathode of V6 through R222. A suitable amount of the a-c component of the unregulated output is also applied to the grid (pin #9) of V5 via C103, C206 and C207 to provide the proper gain and phase margin in the four stage amplifier.

The push-pull output of V5 is direct coupled to the balanced amplifier, V4 whose single ended output from the plate (pin #5) is direct coupled to the control grids of the series regulator tubes, V2 and V3. Additional gain by use of regeneration is obtained in V4 by coupling both plates to opposite grids through R205 and R211.

3. STABILIZED BIAS AND REFERENCE SUPPLY

The stabilized bias and reference voltage supply uses a stabilizing transformer, T202, which stabilizes the bias and reference voltage against line fluctuation and provides a stabilized heater supply for V5, V6 and V7. A half wave selenium rectifier, SR501, is used, whose output is filtered by a capacitor input three section RC filter consisting of C501, R501 and R503. Additional stabilization against line variation is obtained by using a portion of the unregulated voltage, of the correct phase and amplitude, to buck out the rated fluctuations in the high voltage secondary of T202. This bucking voltage, which is in series with the high voltage secondary of T202, is obtained from the secondary of T201. Additional stabilization is obtained by use of the first voltage regulator tube, V8, which provides the -150 volt bias output. The -150 volt output is further stabilized by the second voltage regulator tube V9 which supplies the reference and plate supply voltage for V7. A voltage doubler circuit consisting of three selenium rectifiers, SR502, SR503, SR504 and capacitor, C502, are used to develop a -600 plate supply voltage for V4.

SECTION VI - MAINTENANCE

If the Power Supply is not functioning properly and requires maintenance, the following procedure in the order described may facilitate locating the source of trouble. The chassis and attached front panel and frame can be pulled out through the front of the cabinet after the two screws in the rear of the cabinet are removed.

1. FUSE FAILURE

There are two fuses, marked LINE and LOAD, on the front panel of the Model UHR-220. The 4 ampere slow-blow LINE fuse is used in the primary circuits of the transformers to protect the power supply components from short circuits. A 0.2 ampere LOAD fuse in the Model UHR-220 is used to protect the power supply components from external overloads of the high voltage output. When the LOAD fuse blows, the high voltage output will be slightly negative, as indicated by the voltmeter. Two additional 5 ampere slow-blow fuses, located on the inside rear apron of the chassis, protect each 6.3 volt ac heater output. The rating of these fuses was selected for the proper protection of the instrument and they should be replaced with the same type and rating.

If a LINE fuse failure is detected, the following procedure is recommended before turning the supply on after replacing the fuse:

(a) Remove the 5R4 rectifier tube in the Model UHR-220. Disconnect the a-c line cord and measure the resistance across the contacts of the line cord plug with the HIGH VOLTAGE and POWER controls in the ON position and the coarse voltage control knob at maximum clockwise. The resistance of the Model UHR-220 should be 1.4 ohms. A lower resistance probably indicates a shorted primary in just one of the transformers, since all of the transformers are essentially connected in parallel.

(b) Connect the power and then check the primary and secondary voltages of all the transformers as indicated in the schematic diagram shown in Fig. 6. If the voltages are correct, the transformers are functioning properly and the fuse failure is probably due to either a faulty rectifier tube, a shorted filter capacitor, C101, C501 or C502, or a short circuit in the regulated high voltage and bias supply outputs.

(c) Prior to inserting a new rectifier tube, disconnect the line cord and check the filter capacitors C101, C501 and C502. A shorted capacitor can be detected by connecting an ohmmeter (low range) across it directly. C101 is a dual 7MFD oil capacitor with the center terminal common. C501 is a three section and C502 is a two section electrolytic capacitor.

If these capacitors are not shorted, check for shorts at the regulated high voltage output, -150 volt bias supply and -600 volt negative supply. The regulated high voltage and bias outputs are readily accessible at the output terminals and -600 volts can be located at the negative terminal of C502.

(d) If the above procedure has not uncovered any faulty components or short circuits, the rectifier tube may be the cause of the trouble and should be replaced. In most cases, the above procedure will uncover the cause of a fuse failure. However, occasions arise when unusual defects occur like intermittent shorts in components and tubes. These, unfortunately, are beyond the scope of this maintenance procedure.

2. TUBE COMPLEMENT CHECK

Before any detailed maintenance procedure, turn on the power supply and then check to make certain that the correct tubes are inserted properly in their respective sockets. The type number of each tube is marked on the chassis adjacent to the tube. At the same time note if the filaments of all the tubes are lighted and replace any that fail to light.

If the above procedure produces no results, the likeliest source of failure is the vacuum tubes since they have an inherently shorter life. Obtain appropriate new tubes and then one at a time, substitute the new tube in each position in the power supply where it is used. A 5651 voltage regulator tube may be substituted for an OG3 with some reduction in performance.

In most cases the above procedure will eliminate the cause of failure and restore the power supply to proper operation. If changing tubes fails to remedy the difficulty, a detailed point to point evaluation, as described in the following paragraphs, will be necessary.

3. STABILIZED BIAS AND REFERENCE SUPPLY

The stabilized bias and reference voltage supply uses a stabilizing transformer, T202, which stabilizes the bias and reference voltage against line fluctuation. Additional stabilization against line variations is obtained by using a portion of the unregulated line voltage of the correct phase and amplitude, to buck out the rated fluctuation in the high voltage secondary of T202. This bucking voltage, which is in series with the high voltage secondary of T202, is obtained from the secondary of T201 and is adjusted at the factory to minimize the change in the output of the bias supply against line voltage fluctuation. The correct high voltage secondary waveform of T202 is shown adjacent to the winding in the schematic of Figure 6.

A half wave selenium rectifier, SR501, is used whose output is filtered by a capacitor input three section RC filter consisting of C501, R501 and R503. The d-c output of the filter furnishes the required voltage for the -150 volt regulator tube, V8, which provides the bias voltage. A series dropping resistor, R504, limits the current in V8.

If the OA2 voltage regulator tube, V8, fails to light or there is insufficient voltage across it, check if SR501, C501, R501, R503 or R504 are defective.

The -150 volt output is further stabilized by the second voltage regulator tube, V9, which supplies the reference and plate supply voltage for the input amplifier, V7. If the OG3 voltage regulator tube, V9, fails to light, check if the series dropping resistor, R405, is defective.

A voltage-doubler circuit consisting of three selenium rectifiers, SR502-SR504, and capacitor, C502, is used to develop a -600 volt plate supply voltage for V4. The other half of the voltage-doubler is the output of the half wave selenium rectifier, SR501. If the voltage-doubler fails to put out -600 volts, which can be located at the negative terminal of C502 (purple wire), check for a defective selenium rectifier, SR502-SR504, or capacitor, C502.

4. UNREGULATED HIGH VOLTAGE SUPPLY

When functioning properly, the unregulated high voltage supply at normal line voltage and no output current should furnish from approximately +280 to +930 volts d-c as the coarse regulated high voltage control is varied from minimum to maximum clockwise position. The positive unregulated high voltage can be located at pin #2 and pin #5 of all the type 6AS7 series tubes and the negative is connected to the -HV output terminal.

If the unregulated high voltage supply is not providing the proper voltage, check the primary and secondary voltages of the plate supply transformer, as the coarse regulated high voltage control is varied. Check the high voltage output before and after the LC filter and the series dropping resistor, R102.

5. REGULATED HIGH VOLTAGE SUPPLY

When the regulated high voltage supply is not regulating properly, the voltage and resistance chart, as shown in the schematic diagram of Figure 6, should be referred to. Before any detailed point to point trouble shooting, make certain that all the knobs are in the maximum counter-clockwise position and the high voltage and power off-on switches are in the ON position. The power supply should be powered but not loaded.

When the coarse and vernier controls are in the maximum counter-clockwise position, the regulated high voltage output should be slightly negative as indicated by the voltmeter. Since the meter also indicates a negative reading when the LOAD fuse blows, it is advisable to check this fuse before proceeding. To simplify the discussion, we will assume that the correct regulated output voltage, when the coarse and vernier controls are in the maximum counter-clockwise position, is zero rather than slightly negative. This can be achieved easily in practice by advancing the vernier control. The voltages in the following discussion should be measured with a vacuum tube voltmeter between pins of each socket and -HV (grounded).

The potential at the grid (pin #7) of V7 is stabilized at -48 volts by the reference supply. Any appreciable discrepancy in this voltage could result from defective resistors consisting of R406, R407, R408, R304 and R306 as shown in Fig. 6. When the regulated high voltage output is appreciably more positive* or negative than zero, when the coarse and vernier controls are in the maximum counter-clockwise position, the potential at the grid (pin #2) of V7 should be appreciably less negative or more negative respectively than the correct voltage which is -48 volts. If it is not, all the components, consisting of R112, R113, S101C, P101 (potentiometer ganged with variac), P301 (vernier), R310, R311, R309, R312 and R313, as shown in Fig. 6, should be checked.

If the grid (pin #2) of V7 is appreciably less negative or more negative than normal, the potential at the plate (pin #1) of V7 should be slightly more negative or less negative respectively than its normal -12.5 volts and the potential at the plate (pin #6) of V7 should be appreciably less negative or more negative respectively than its normal -12.5 volts. If the plate potentials of V7 are not unbalanced as described, V7 is not functioning properly and its components, wiring and voltage and resistance readings to ground should be checked.

If the plate potentials of V7 are unbalanced properly, the grids of V6 should be unbalanced in the same direction and the potential at the plate (pin #6) of V6 should be appreciably less negative or more negative

*The underlined words in the following paragraphs correspond to the condition where the regulated high voltage output is more positive than the correct value, which is zero.

respectively than its normal -55 volts. If the potential at the plate (pin #6) of V6 is not appreciably less negative or more negative respectively than normal, V6 is not functioning properly and its components, wiring and voltage and resistance readings to ground should be checked.

Summarizing the results briefly at this point, we find that if the regulated high voltage is appreciably more positive than zero when the coarse voltage control is maximum counter-clockwise, the potential at the plate (pin #6) of V6 should be appreciably less negative than its normal -55 volts if V6 and V7 and related components are not defective. If the regulated high voltage is appreciably less negative than zero under the same conditions, the potential at the plate (pin #6) of V6 should be appreciably more negative than the normal -55 volts, if V6 and V7 and related components are not defective.

If the potential at the plate (pin #6) of V6 deviates from its normal value in the manner described above, the grid (pin #2) of V5 should be appreciably less negative or more negative respectively than its normal value of -150 volts. The potential at the plate (pin #6) of V5 should be appreciably more negative or less negative respectively than its normal -65 volts and the potential at the plate (pin #1) of V5 should be appreciably less negative or more negative respectively than its normal -60 volts. If the plate potentials of V5 are not unbalanced as described, V5 is not functioning properly and its components, wiring and voltage and resistance readings to ground should be checked.

If the plate potentials of V5 are unbalanced properly, the grids of V4 should be unbalanced in the same direction and the potential at the plate (pin #5) of V4 should be appreciably more negative or less negative respectively than its normal -200 volts and the plate (pin #2) of V4 should be appreciably less negative or more negative respectively than its normal -90 volts. If the plate potentials of V4 are not unbalanced as described, V4 is not functioning properly and its components, wiring and voltage and resistance readings to ground should be checked.

The output from the plate (pin #5) of V4 is direct coupled to the control grids of all the type 6AS7 series tubes through parasitic suppressor resistors. When the regulated high voltage output is appreciably greater than zero, the potential at the plate (pin #5) of V4 should be appreciably more negative than normal. This drives the series tubes toward cut-off which should decrease the regulated high voltage output to its correct voltage by increasing the voltage across the series tubes. When the regulated high voltage output is appreciably less than zero, the plate (pin #5) of V4 should be appreciably less negative than normal. This drives the series tubes toward increased conduction which should increase the regulated high voltage output to its correct voltage. If the grids of the series tubes are being driven in the correct manner and the regulated high voltage output is incorrect, the series tubes are defective and should be replaced.

SECTION VII - TEST PROCEDURE

The main d-c output of the Krohn-Hite UHR Series Power Supplies has unusually low figures for load regulation, line voltage stabilization, impedance and ripple. Because of this, testing of these Power Supplies is extremely difficult and precautions must be taken which can be neglected when testing ordinary regulated power supplies. Most of the commercially available power supply test equipment is not suitable for testing the Krohn-Hite UHR Series Power Supplies.

The procedure outlined below follows the basic methods of measurement and definitions given in the I.R.E. Standards On Methods Of Measurements Of Electronically Regulated Power Supplies presented in the Proceedings of the I.R.E., Volume 39, No. 1 (January, 1951).

The test procedure is prefaced by a series of precautions which should be studied carefully before any testing is attempted. Reference to particular precautions will be made for each test outlined.

Equipment required to make the following tests:

1. D-C millivoltmeter 10 mv FS sensitivity (see Precaution G)
2. A-C millivoltmeter 1 mv FS sensitivity (see Precaution G)
3. Reference voltage source (see Precaution E)
4. Audio oscillator (100 MW minimum output)
5. Load - passive or dynamic
6. Variable auto-transformer for adjusting power supply line voltage
7. A-C voltmeter for checking line voltage

PRECAUTIONS

A. For these tests the cabinet (GND Terminal) must always be connected either to the +HV or -HV terminal, whichever is operated at ground potential. The cabinet and chassis act as an electrostatic shield for the tubes and components, and also provide a path for leakage currents.

B. If the load is controlled by a switch, the switch must be located at least five feet from the Power Supply and the other test equipment to reduce the effect of spark interference.

C. The voltage measuring circuit must be connected separately and directly to the +HV and -HV terminals. Under no circumstances should any load current flow through any impedance which is common to the voltage measuring circuit. (The resistance of two one-foot lengths of number 16 copper wire is comparable to the Power Supply impedance. Also, contact resistance at the Power Supply terminals is a problem if separate leads are not used.)

D. Poor line voltage regulation can cause an erroneous load regulation measurement. If the line voltage changes appreciably due to the change in power drawn by the Power Supply as its load is varied, there may be a change in output voltage due to the change in line voltage. The degree of precision of the load regulation measurement determines the amount of line voltage change which can be tolerated - refer to the Power Supply STABILIZATION specification. Control of the Power Supply input line voltage is strongly recommended, but most constant voltage regulators and transformers introduce waveform distortion and are not suitable. Most suitable line voltage control is achieved by the use of a manual or automatic variable auto-transformer type of regulator.

E. The reference potential may be obtained from a separate well-regulated power supply provided that it is more stable than the supply under test and is isolated from line voltage changes. It is strongly recommended that the reference potential be obtained from batteries since measurement difficulties are frequently caused by variation of the reference potential.

F. Since even a slight drift in any part of the test set-up can affect the accuracy of the measurements, it is suggested that the necessary data be obtained as quickly as possible.

G. If a line-operated millivoltmeter or oscilloscope is used, there can be an error due to the effect of varying line voltage on this equipment.

1. LOAD REGULATION

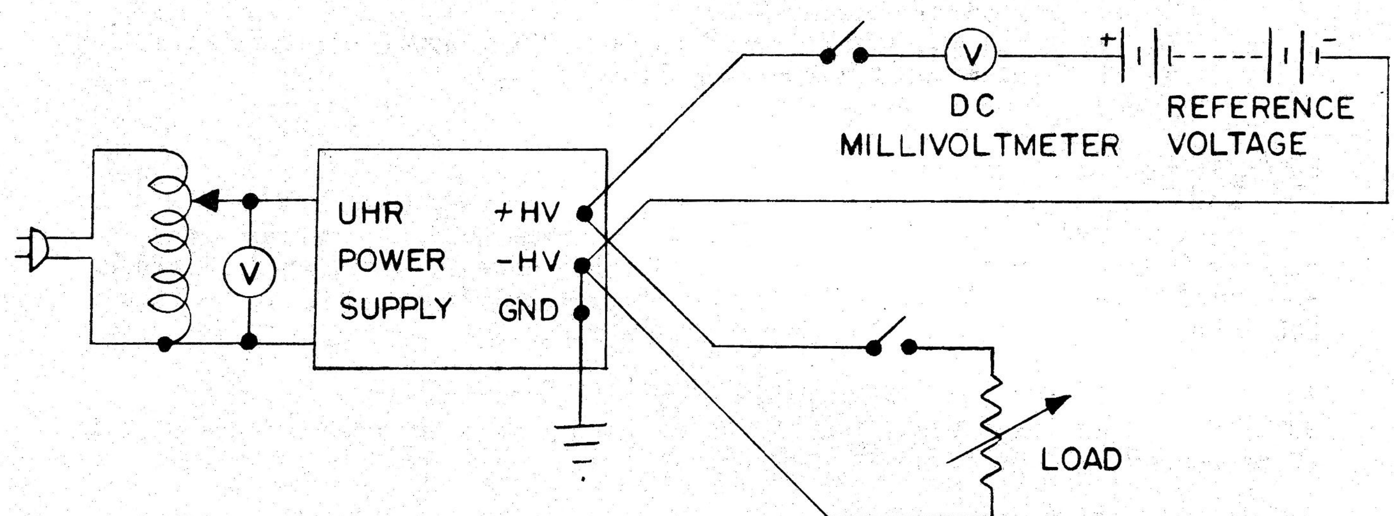


Fig. 7 - LOAD REGULATION TEST BLOCK DIAGRAM

Load regulation is determined by measuring the change in output voltage as the load current is varied from zero to maximum. The ideal load is one which can be turned on and off electronically by controlling grid bias. The Power Supply input voltage must be held constant for all values of load. The precautions noted above all apply to this measurement.

2. LINE STABILIZATION

Line stabilization is determined with the same set-up as load regulation. In this case the input line voltage is varied and the load current is constant. Measure the change in output voltage as the line voltage is varied from 105 to 125 volts. The precautions A, E, F and G noted above apply to this measurement.

3. D-C OUTPUT IMPEDANCE

The effective d-c output impedance is calculated from the load regulation measurement.

$$\text{D-C Output Impedance} = \frac{\text{Change in output voltage}}{\text{Change in load current}}$$

4. A-C OUTPUT IMPEDANCE

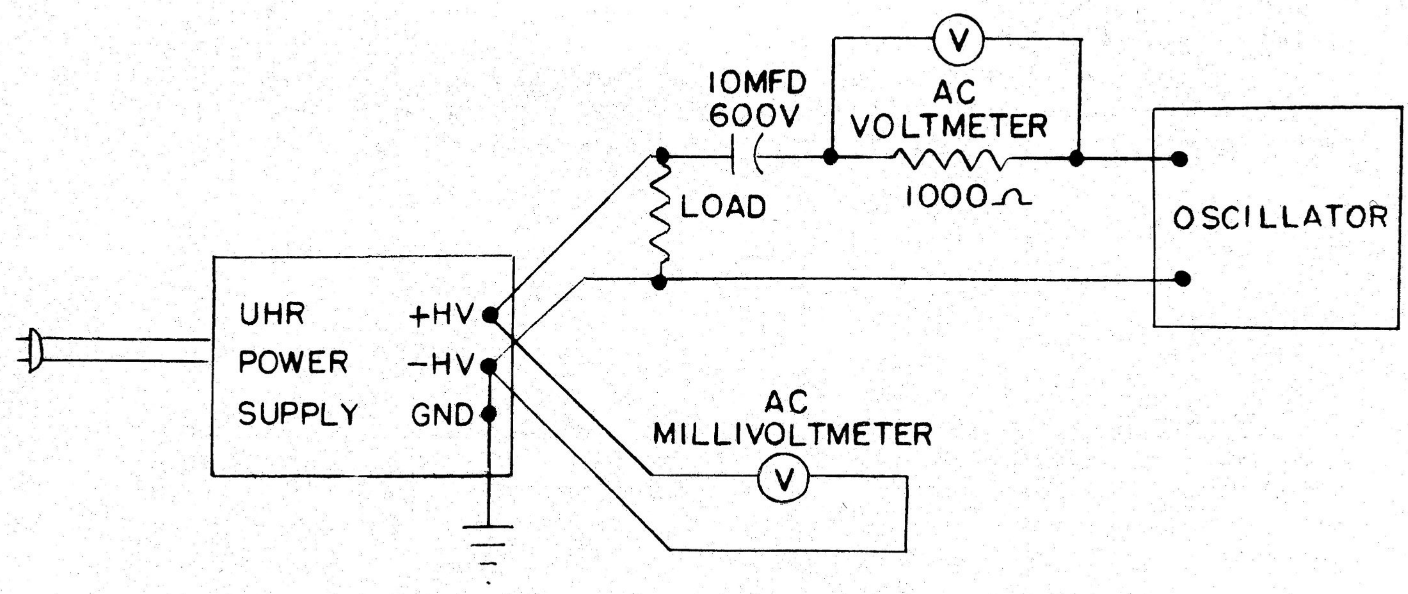


Fig. 8 - A-C OUTPUT IMPEDANCE TEST BLOCK DIAGRAM

Using the set-up shown, adjust the power supply load to any convenient value. Adjust the oscillator output until the voltmeter across the 1,000 ohm resistor reads exactly 10 volts. A current of 10 milliamperes at the oscillator frequency is now flowing through the Power Supply output impedance. Divide the voltage read across the Power Supply output terminals by 0.01 amperes to determine the output impedance at any frequency. Be sure to recheck the voltage across the 1,000 ohm resistor each time the oscillator frequency is changed. The precautions A, C, D and G noted above apply. Care must be exercised below 10 kc because the oscillator voltage developed across the Power Supply output terminals is low and may be masked by the output ripple voltage.

5. DRIFT

Drift measurements require approximately the same set-up as load regulation measurements. The millivoltmeter is replaced by a recorder of adequate stability and sensitivity. Precautions A, C, D. E and G apply, with special attention to the stability of the reference potential. For this measurement it is desirable to use standard cells in a temperature controlled oven. A lower voltage reference can be used in conjunction with a resistance divider to divide down the Power Supply output voltage. The divider must be made up of very stable low temperature coefficient wire wound resistors and it must be kept in a temperature controlled oven.

6. RIPPLE

The ripple can be measured most conveniently by a sensitive true RMS millivolt meter connected directly to the Power Supply terminals. Leads to the meter must be twisted because hum picked-up from magnetic fields on these leads can be greater than the Power Supply ripple. Interference from nearby radio stations can also cause an erroneous reading. With the Power Supply turned OFF, short the +HV and -HV terminals with a very low impedance such as a screw-driver blade. Note the residual meter reading, and subtract this reading from the reading obtained with the Power Supply operating. Be sure that the meter used in this measurement is rated for use with a much higher d-c input potential than is applied during the measurement. Leakage in the meter input coupling circuit can lead to erroneous readings.

SECTION VIII - SERVICE AND WARRANTY

KROHN-HITE instruments are designed and manufactured in accordance with sound engineering practices and should give long trouble-free service under normal operating conditions. If your Power Supply fails to provide satisfactory service and you are unable to locate the source of trouble, write to our Service Department giving all the information available concerning the failure.

Do not return the instrument without our written authorization for in most cases we will be able to supply you with the information necessary to repair the Power Supply and thus avoid the transportation problems and costs. When it becomes necessary to return the instrument to our factory, kindly pack it carefully and ship it to us via express, prepaid.

KROHN-HITE instruments are conservatively designed to provide continuous reliable service under normal laboratory conditions. The material and workmanship in every instrument is guaranteed for one year from the date of purchase. Any instrument developing defects during this period will be repaired or defective parts will be replaced without charge when the failure is the result of defective material or workmanship. Our warranty does not apply to vacuum tubes.

KROHN-HITE CORPORATION reserves the right to make design changes at any time without incurring any obligation to incorporate these changes in instruments previously purchased.

Voltage values are measured from the pins of each socket to the MINUS HV terminal with the MINUS HV terminal connected to the GND terminal for safety reasons; NO LOAD on the instrument; POWER and HIGH VOLTAGE switches ON; the instrument connected to a source of 115V 60 cycle ac power and the voltage control knob in the maximum CCW position.

All dc voltage readings were taken with a VTVM having an input resistance of 11 megohms.

Resistance values are measured from the pins of each socket to the output terminals with the PLUS HV and MINUS HV terminals connected together; the line cord disconnected from the power line; POWER and HIGH VOLTAGE switches ON and the voltage control knob in the maximum CCW position. C502 should be shorted while resistance readings are being taken.

		PIN NUMBER								
TUBE No.		1	2	3	4	5	6	7	8	9
V1	V	--	280	--	205 ac	--	205 ac	--	280	--
	R	--	750K	--	60	--	60	--	750K	--
V2	V	-200	275	-1 to -11	-200	275	0 to -10	0 to -10	0 to -10	--
	R	150K	700K	600	150K	700K	600	600	600	--
V3	V	-200	275	0 to -10	-200	275	0 to -10	0 to -10	0 to -10	--
	R	150K	700K	600	150K	700K	600	600	600	--
V4	V	*	-90	-340	-330	-200	-340	-450	-450	
	R	850K	50K	94K	450K	150K	94K	62K	62K	
V5	V	-60	-150	-60	-150	-150	-65	-145	-145	*
	R	25K	210K	25K	150K	150K	25K	34K	34K	1.5M
V6	V	0	*	0	-150	-150	-55	105	105	*
	R	0	3.4M	0	150K	150K	15K	30K	30K	3.0M
V7	V	-12.5	-48	-47	-150	-150	-12	-48	-47	-150
	R	75K	270K	1.8M	150K	150K	600K	320K	1.8M	150K
V8	V	0	-150	--	-150	0	--	-150	--	--
	R	0	25K	--	25K	0	--	25K	--	--
V9	V	0	-85	--	-85	0	--	-85	--	--
	R	0	28K	--	28K	0	--	28K	--	--

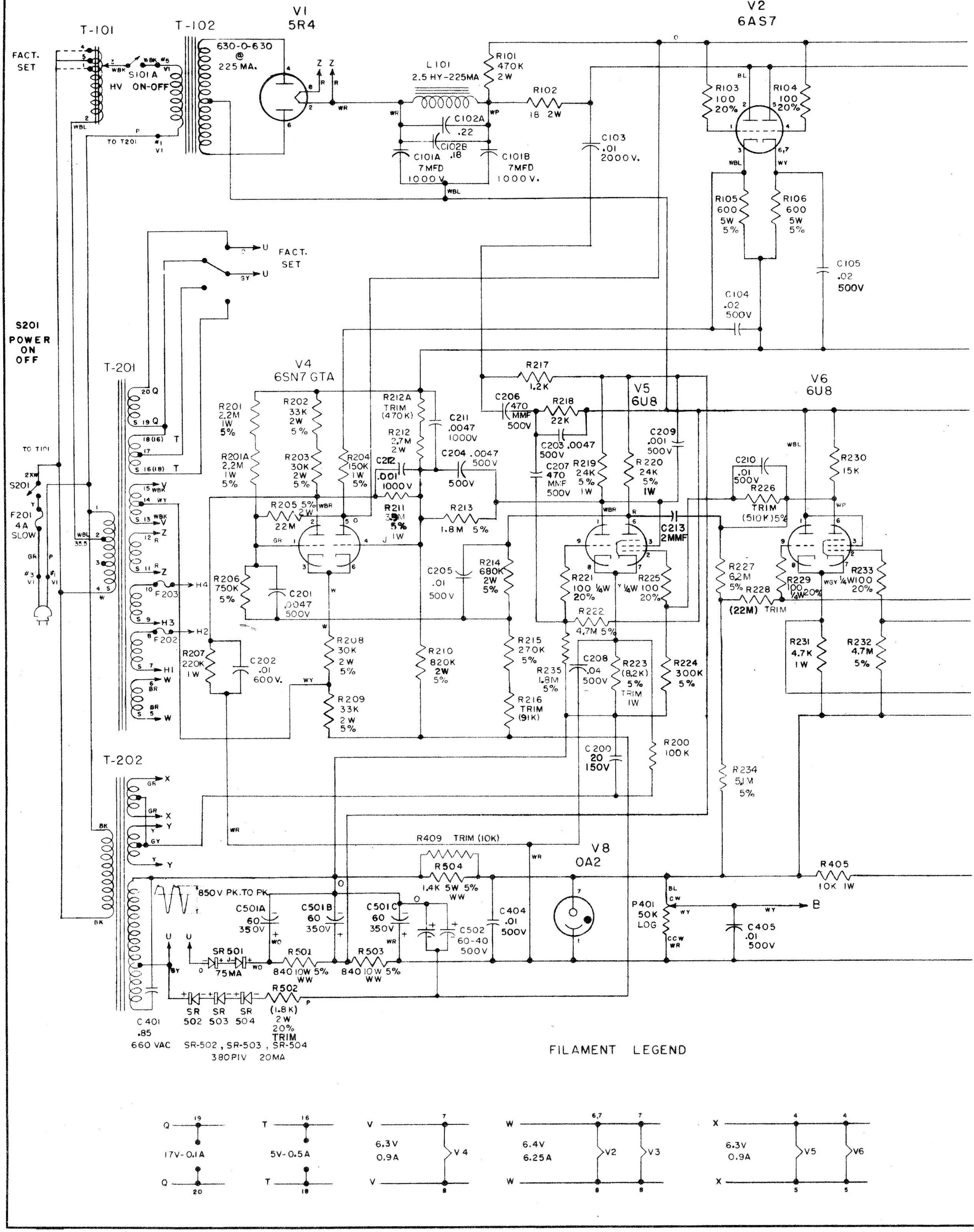
Figure 8 - Model UHR-220 TABLE OF VOLTAGE AND RESISTANCE MEASUREMENTS

NOTE: All resistance values in OHMS. K = 1,000 M = 1,000,000.

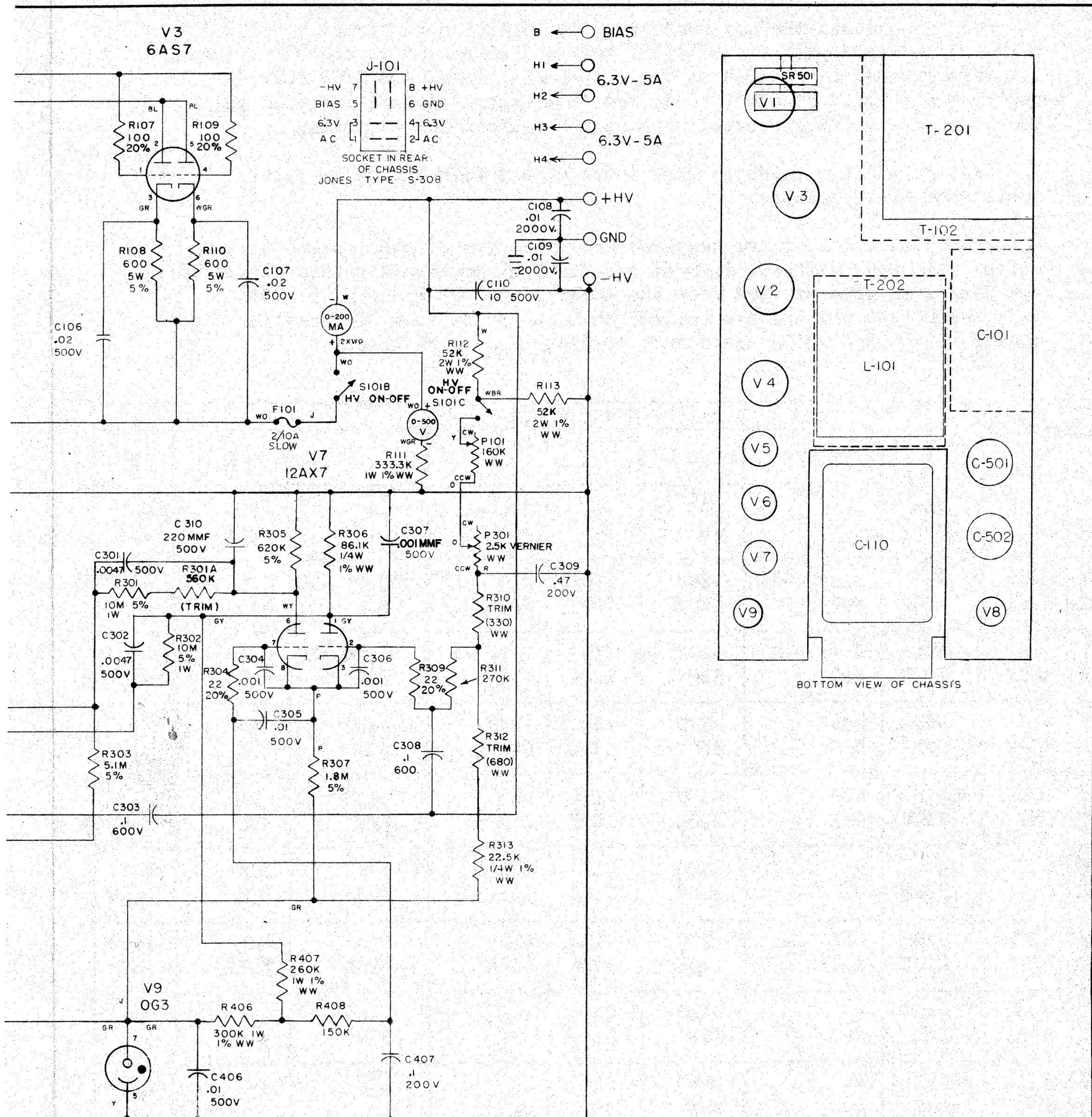
* High impedance point where voltmeter loading causes large error.

The normal resistance measured between the PLUS HV and the MINUS HV terminals is 50,000 ohms.

Variations of up to ±20% in all readings can be expected.

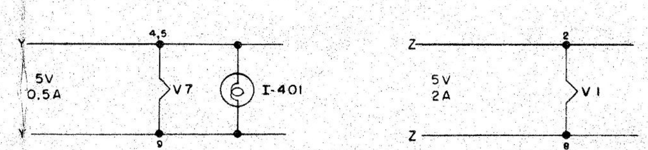


T-101
T-102
V1
5R4
V2
6AS7
FACT. SET
S101A
HV ON-OFF
630-0-630
@
225 MA.
L101
2.5 HY-225MA
R101
470K
2W
R102
18 2W
C102A
.22
C102B
.18
C101A
7MFD
1000V
C101B
7MFD
1000V.
C103
.01
2000V.
TO T201
R103
100
20%
R104
100
20%
R105
600
5W
5%
R106
600
5W
5%
C105
.02
500V
C104
.02
500V
FACT. SET
S201
POWER
ON
OFF
T-201
V4
6SN7 GTA
R201
2.2M
1W
5%
R201A
2.2M
1W
5%
R202
33K
2W
5%
R203
30K
2W
5%
R204
150K
1W
5%
R212A
TRIM
(470K)
R212
2.7M
2W
C211
.0047
1000V
C212
.001
1000V
C204 .0047
500V
R205 5%
22M
R211
3.9M
5%
1W
R213
1.8M 5%
R217
1.2K
C206
470
MMF
500V
R218
22K
C203 .0047
500V
C207
470
MMF
500V
R219
24K
5%
1W
R220
24K
5%
1W
C209
.001
500V
V5
6U8
V6
6U8
R230
15K
C210
.01
500V
R226
TRIM
(510K) 5%
C213
2MMF
R206
750K
5%
C201
.0047
500V
C205
.01
500V
R214
680K
2W
5%
R221
100 1/4W
20%
R225
1/4W 100
20%
R222
4.7M 5%
R227
6.2M
5%
R228
(22M) TRIM
R229
100
1/4W 20%
R233
1/4W 100
20%
TO T101
S201
F201
4A
SLOW
R207
220K
1W
C202
.01
600V.
R208
30K
2W
5%
R209
33K
2W
5%
R210
820K
2W
5%
R215
270K
5%
R216
TRIM
(91K)
R235
1.8M
5%
C208
.04
500V
R223
(8.2K)
5%
TRIM
1W
R224
300K
5%
R231
4.7K
1W
R232
4.7M
5%
R200
100K
C200
20
150V
R234
5.1M
5%
T-202
R409 TRIM (10K)
V8
OA2
R504
1.4K 5W 5%
WW
R405
10K 1W
850V PK. TO PK.
C501A
60
350V
C501B
60
350V
C501C
60
350V
C502
60-40
500V
C404
.01
500V
P401
50K
LOG
C405
.01
500V
SR501
75MA
R501
840 10W 5%
WW
R503
840 10W 5%
WW
R502
(1.8K)
2W
20%
TRIM
SR 502
SR 503
SR 504
C401
.85
660 VAC
SR-502, SR-503, SR-504
380PIV 20MA
FILAMENT LEGEND
17V-0.1A
5V-0.5A
6.3V
0.9A
V4
6.4V
6.25A
V2
V3
6.3V
0.9A
V5
V6



NOTES
T101 AND P101 ARE GANGED.
ALL COMPONENTS LABELED TRIM ARE FACTORY ADJUSTMENTS.
F-202 AND F-203 ARE 5 AMP SLOW BLOW FUSES.
THE SECONDARY VOLTAGE OF T-102 WAS MEASURED WITH 115V PRIMARY.

ALL RESISTORS 1/2W 10%, IN OHMS
ALL CAPACITORS 20%, 400V, IN MFD
UNLESS OTHERWISE SPECIFIED



MODEL UHR-220	
SCALE: DATE: 11/19/54	APPROVED BY FIGURE 6	DRAWN BY / REVISED 1-25-60
POWER SUPPLY	
KROHN-HITE CORPORATION CAMBRIDGE 39, MASSACHUSETTS	DRAWING NUMBER UHR 220-2