INSTRUCTION MANUAL

for

AUTO-LEVEL

HARKINS RADIO, INC.
4444 East Washington
Phoenix, Arizona

HARKINS AUTO-LEVEL

TECHNICAL DATA

POWER REQUIRED
100 - 130 VAC, 50/60 cps
60 watts

INPUT IMPEDANCE
500 ohms, balanced

OUTPUT IMPEDANCE
500 ohms, balanced

GAIN - MAXIMUM BELOW THRESHOLD OF COMPRESSION
60 db.

FREQUENCY RESPONSE
± 1 db. - 30 to 15,000 cps

NOISE LEVEL
-70 db., below 25 dbm output

HARMONIC DISTORTION
Less than 1.5% RMS, 30 - 15,000 cps, with 25 db compression

INPUT LEVEL
-50 dbm to +10 dbm

MAXIMUM OUTPUT
+25 dbm

COMPRESSION RATIO
Up to 6:1

TIME CONSTANTS
Attach Time -25 milliseconds
Recovery Time -2 seconds for 63% recovery
9 seconds for 90% recovery

SPECIAL FEATURES
Continuous variable input and output controls
Upward indicating compression metering circuit

"AUTO-LEVEL"
OPERATING INSTRUCTIONS

DESCRIPTION

The "Auto-Level" is designed for use in any audio system where it is desired to automatically control the level differences between two or more program sources or to maintain a constant output level from a varying source of audio. Additional uses are contained in this operation manual.

The self-contained unit fits a standard 19" equipment rack and occupies 5 1/4" vertical rack space. The controls for regulating the input and output levels are on the front panel.

The "Auto-Level" is capable of maintaining automatically a nearly uniform average output level over a wide range of variation of input levels. The output level is more than adequate to drive existing transmitters and other devices encountered in the broadcast and recording field.

Input and output balanced lines are connected to the rear of the unit. Also available are terminals to connect to an external meter for an indication of the amount of gain reduction taking place.

INSTALLATION

The "Auto-Level" may be mounted in a standard equipment rack and has been designed for operation in the presence of strong R.F. fields. Due to the high gain of the circuit, extreme care should be exercised in the shielding of the input connections. The use of shielded twisted pair wire for both input and output circuits is desired. Standard practice of grounding the shield at one end only is also desirable. The use of shielded wire that is also covered with a sheath of insulation will help reduce pickup of noise and crosstalk.

If signals from the output leads are allowed to couple into the input leads, feedback oscillation can occur due to the gain of the amplifier.

The peak input voltages applied to the input terminals should not exceed plus 10 DBM otherwise excessive distortion will occur and the input transformer could be damaged. If the source of audio feeding the "Auto-Level" is higher than plus 10 DBM, an external fixed H pad should be inserted in the input line prior to the input terminals. Suggested values are shown elsewhere in this manual.

Terminals are provided for the connection of a meter that can be located at any distance from the unit convenient for the particular operation. A D.C. meter having a movement of 0-1 Ma. or more sensitive may be used.

CIRCUITRY

Operation of this unit revolves around the variable gain stage using the G.E. 6386 tube. This remote cutoff dual triode has almost complete linear amplification over the entire portion of its characteristic curve. Besides high gain, low noise and low distortion, this tube offers variable gain over a wide range that is directly controlled by the applied negative grid bias. The bias may be varied over a wide range without causing distortion.

Referring to the block diagram, it will be seen that the input audio passes through an input transformer and dual input level control to the grids of the 6386. The output of this variable gain stage is applied to a 12AT7 voltage amplifier whose output in turn is fed to the push pull parallel 12AU7 output tubes.

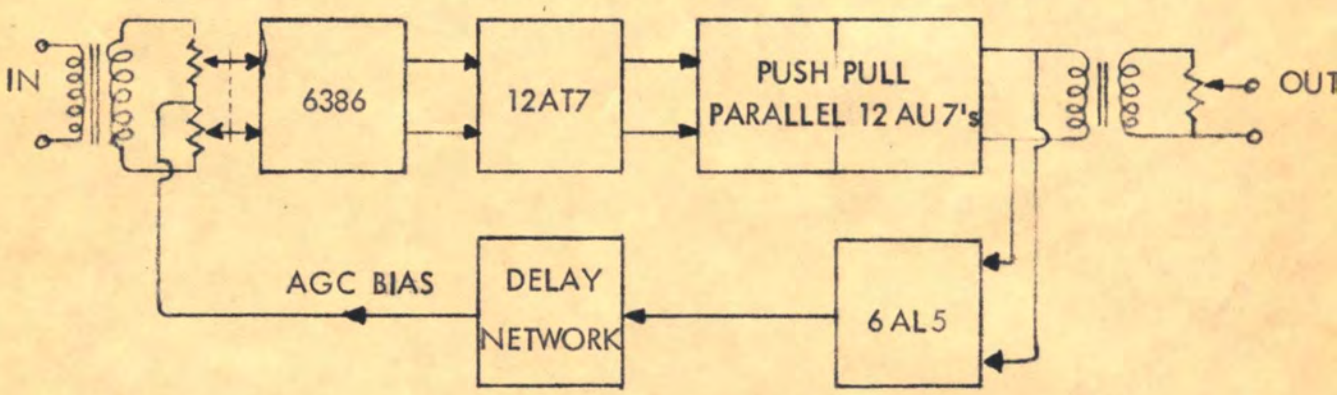


FIG. 1

The output voltage appearing at the plates of the push pull parallel 12AU7's is applied to the cathodes of a 6AL5 which in turn develops the D.C. gain control bias. A fixed positive voltage is also applied to the 6AL5 cathodes so that recticiation of the applied audio voltage does not occur until it rises to a level above the applied "bucking" voltage.

After the output voltage of the 12AU7's rises above the "threshold" to permit rectification, the resultant negative voltage is fed through a resistance-capacitance filter network to the control grids of the variable gain 6386. The design of this filter permits almost instantaneous charging time and a slow discharge rate. As the rectified output voltage increases, the applied negative bias causes the gain of the 6386 to drop. As long as the input signal is sufficient to drive the output

voltage over the "threshold", the gain will be automatically regulated by this closed loop arrangement. The output will remain at a nearly constant level once the input signal rises above the threshold level.

If the input level is kept below the "threshold", the amplifier functions in a linear manner with the output level being directly proportional to the input level. This mode of operation can be ob ained at all times merely by unplugging the 6AL5 tube.

Fig. 2 shows the operating characteristics of the "Auto-Level". As the input level is increased beyond the "threshold", the output level rises only a small percertage of the increase in input. This gain controlling function is best described as the "compression ratio". If, for example, the input level is raised by 10 db and the output increases 2 db, the compression ratio would be 5:1.

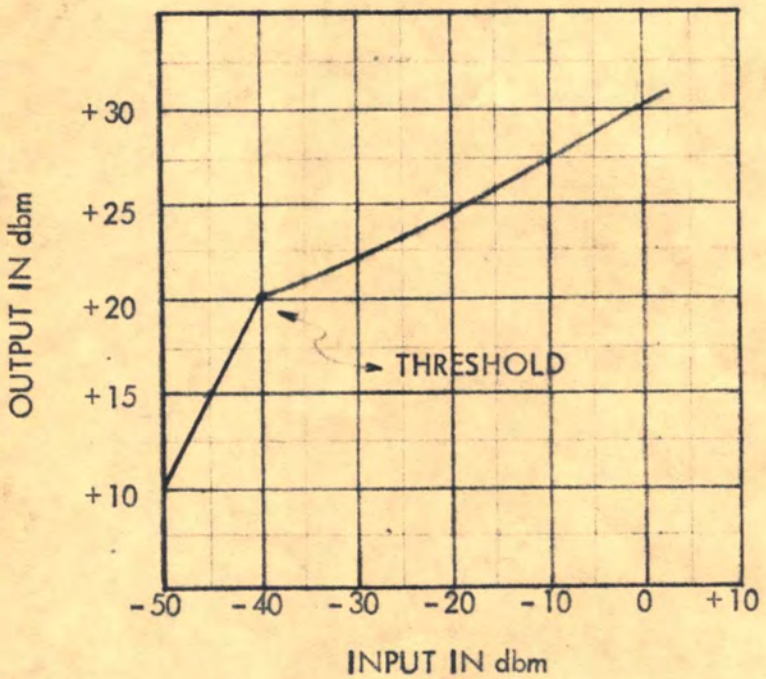


FIG. 2

Both the input and output gain controls are wide open and the levels measured at the input and output terminals for this graph.

For optimum results, the input levels should be kept between -40 dbm to -20 dbm points on the curve. As the following chart of values shows, the distortion rises as the limiting action increases. Although usuable for many applications, limiting above an amount of 20 db is not advised for broadcast application such as AM, FM or TV aural.

INPUT	OUTPUT	COMPRESSION	DISTORTION
- 50 dbm	+ 10 dbm	0 db	.8 %
- 45 dbm	+ 15 dbm	0 db	.8 %
- 40 dbm	+ 20 dbm	0 db	.8 %
- 35 dbm	+ 21 dbm	4 db	.8 %
- 30 dbm	+ 22 dbm	8 db	.4 %
- 25 dbm	+ 23 dbm	12 db	.45 %
- 20 dbm	+ 24.5 dbm	15.5 db	.55 %
- 15 dbm	+ 26 dbm	19 db	.9 %
- 10 dbm	+ 27 dbm	23 db	1.3 %
- 5 dbm	+ 29 dbm	26 db	2.6 %
0 dbm	+ 30 dbm	30 db	5.0 %

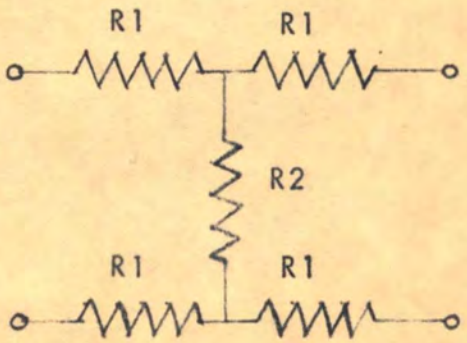
All of the above measurements are taken with both input and output gain controls at full maximum.

Under actual use, input levels of as much as plus 10 dbm can be applied to the input terminals and the input gain control used to deliver the equivalent of a - 20 dbm signal to the control grids.

The importance of setting up the proper input levels is apparent and if the audio voltages feeding the unit are of higher peaks than plus 10 dbm, it is suggested that an external fixed "H" pad be used in order to prevent distortion within the input transformer.

Balanced "H" Loss Pads
using standard resistors
$\bar{Z}$ in = $\bar{Z}$ out = 500 Ω
Use of these values will result
in not over a 10% mismatch

Loss in db	R1	R2	Actual Measured Loss
5	68	680	5.5
10	150	470	10.5
15	150	150	15
20	220	100	21.5
25	270	27	24.7
Min. loss isolation (2 db)	15	1000	2



Above chart shows design of several pads from standard resistors.

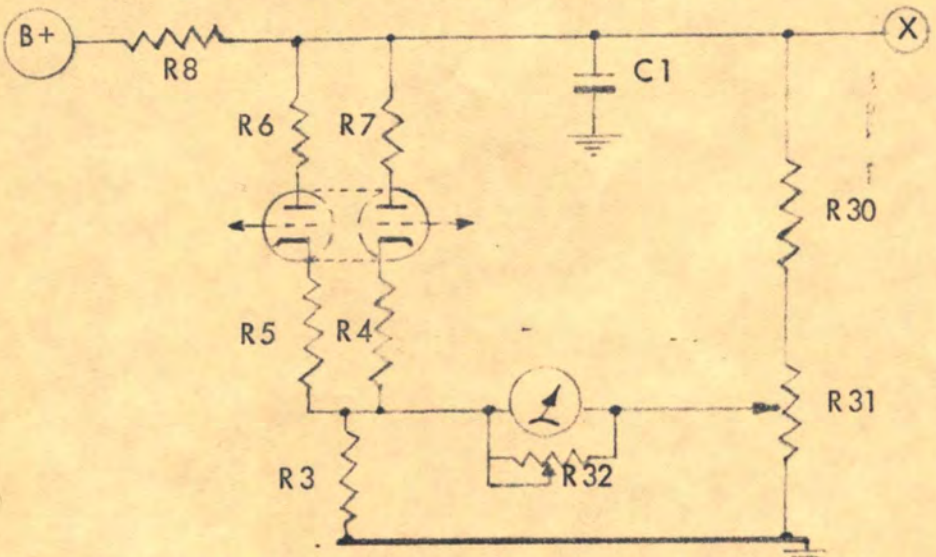
The input control is used for the actual adjustments of the input levels and unless the inputs are exceeding plus 10 dbm, no external input pads are required.

The output control enables any degree of attenuation desired. The unit delivers ample voltage to drive standard audio equipment such as peak limiters, tape recorders, AM and FM transmitters, etc.

It may be desirable to install a fixed pad in the output leads so that the panel control operates near maximum during normal operation. "H" pads may be designed from the same chart as shown for input pads. This has the advantage of preventing accidental overdrive of the unit being driven.

INDICATING METER CIRCUIT

Terminals are provided to connect a 0-1 D.C. Milliameter or any meter having a movement of higher sensitivity. This is in a "bridge" type of circuit so that it reads upwards from zero as limiting action takes place.



In the above schematic it is shown that the meter is balanced between the reference voltage divider and the cathodes of the 6386 tube. With no signal applied to the "Auto-Level", R31 is adjusted so the meter reads zero. As bias is applied to the 6386 grids, thus lowering its gain, the supply voltage for the reference will raise and the cathode voltage will lower thus unbalancing the bridge and causing the meter to read upward.

By adjusting the shunt resistance R32 the full scale reading can be adjusted to read the value desired. Using a 0-1 Ma. meter, the full scale reading at maximum sensitivity will be 16 db limiting. This occurs with R32 set a full 500 Ω.

The meter may be remotely located such as near the audio console for maximum utility.

The sensitivity control is usually adjusted so that full scale indications are the maximum amount of limiting to be used. This degree of maximum limiting is usually dictated by the amount of noise that will become apparent in the absence of program audio. Room noise, film hiss, preamplifier hum and the like will all become apparent as the "Auto-Level" gain recovers in the absence of program material.

As an aid to calibrating the meter, a VTVM may be connected to point "Y" to measure the negative bias that is produced to control the gain of the 6386 tubes. From the following chart, the indicating meter may be calibrated as follows:

Limiting	Volts at point "Y"
6 db	- 2.8
10 db	- 5.6
15 db	- 17
20 db	- 24
25 db	- 36

FREQUENCY RESPONSE

A family of curves is shown to relate the response characteristics under various contions of limiting.

THRESHOLD LEVEL

The compression ratio is a function of the threshold level. The rectifier delay bias obtained from the voltage divider R29 determines the point at which control bias can be delivered to the 6386 gain reduction tubes. As supplied, the compression ratio is in the 5:1 range. Resistor R29 may be increased to place a larger delay bias on the 6AL5 to gain a larger compression ratio. Values above 47K Ω to obtain a 7:1 ratio are not recommended as the distortion increases. R29 may be reduced to obtain a smaller compression ratio is desired.

R 29	Ratio
47K Ω	7:1
39K Ω	6:1
27K Ω	5:1 **

R 29	Ratio
22K Ω	3:1
15K Ω	2:1

** factory choice

TIME CONSTANTS

R23 and C10 determines the attack time of 25 milliseconds. The recovery time is controlled by the dual circuit consisting of R24 and C10 which functions on short audio peaks and C11 and R25 which charge up on sustained peaks. As shipped from the factory, R23 is 3.3 Meg. which causes 2 seconds for 63% recovery of gain, and 9 seconds for 90% recovery.

This action is most desirable for complex program material and permits the full advantage of the unit to be realized without aural awareness of the smooth gain changes.

Considerable variation in the recovery time constants can be made by juggling the values of R23, R24, C10 and C11. However, for practical purposes, most operating conditions can be satisfied by changing R23. The following table gives the timing for several values of R23.

R 23	63% Recovery	90% Recovery
6.8 Meg.	7.5 seconds	22 seconds
4.7 Meg.	5 seconds	15 seconds
* 3.3 Meg.	2 seconds	9 seconds
1.5 Meg.	1 second	4 seconds

* our choice

NOISE MEASUREMENTS

With both the input and output controls fully advanced, apply sufficient tone to the input terminals to obtain a calibrate level of plus 25 dbm.

Remove all wires from the input terminals (to prevent stray pickup) and measure the noise that remains. This should be at least 70 db below the plus 25 dbm calibrate level. Since this unit has high gain, the importance of proper balance and shielding of the input cable is very apparent when making the noise measurement.

MAINTENANCE

Designed for long tube life, the best maintenance is to know the tube socket voltages for normal operation. The following chart of voltages are typical under conditions when no signal is on the input.

VOLTAGE CHART

No Input - Input control full shut - CCW
Output control full open - CW
Meter balanced for zero

Pin	1	2	3	4	5	6	7	8	9
6386 V1	6.3 AC	.9	0	45	.1	45	0	.9	-
12AT7 V2	150	0	2	6.3AC	6.3AC	150	0	2	6.3AC
12AU7 V3	250	0	8	6.3AC	6.3AC	250	0	8	0
12AU7 V4	250	0	8	6.3AC	6.3AC	250	0	8	0
6AL5 V5	28	0	0	6.3AC	28	0	0	-	-
5Y3 V6	-	330*	-	300AC	-	300AC	-	330*	-
5VAC between Pins 2 & 8 - 5Y3									

The audio levels throughout can also be checked with an Audio VTVM such as Heathkit AV-3.

For this purpose apply a 1000 cycle tone so that the output with output control fully advanced is plus 25 dbm (14 volts rms). With the input control also fully advanced, an output of -20 dbm (.078 rms) should cause this condition which also indicates 15 db of limiting.

With the above conditions, the audio signal voltage at the socket pins will be as follows (considerable variation permitted due to normal component tolerances.)

Audio Voltage - + 25 dbm output - 14 VRMS
- 20 dbm input - 7.8 VRM
15 db of limiting

Pin / Tube	1	2	3	4	5	6	7	8	9
6386 V1	-	.008	.34	.46	-	.46	.34	.008	-
12AT7 V2	2.5	.38	.3	-	-	2.5	.38	.3	-
12AU7 V3	27	2.5	.42	-	-	27	2.5	.42	-
12AU7 V4	27	2.5	.42	-	-	27	2.5	.42	-

As measured with 1000 cps -20 dbm input and both input and output controls at full maximum.

TYPICAL APPLICATIONS

The "Auto-Level" is valuable for use between the audio console and the line feeding the transmitter. This insures the proper operating level is feeding the telephone line at all times.

It makes an ideal companion to an automatic peak limiting amplifier for maximum A.M. transmitter coverage. In this application, it is suggested to be used just ahead of the peak limiter.

The "Auto-Level" will function as an automatic fader on a multiple input console. If the microphone level is adjusted higher than the turntables, opening the mike will cause the music to fade to the background automatically and the music will return to normal level after the announcement.

For background music services, it insures uniform reproduction volume regardless of changes in tape or record changer levels. Excellent for feeding 'phone lines.

For television audio purposes, it is needed for use with reproduction of sound on film where high variations are often encountered between reels and commercials. It is also of extreme advantage for use in live "interview" type shows where sudden changes in audio cannot be anticipated.

Some stations have found an extra "Auto-Level" to be useful in the handling of remote pickup lines. The individual incoming remote is "patched" into the input of the "Auto-Level" while the output feeds the remote channel of the console. This application is most desirable for sport broadcasts and similar "gainriding"headaches.

CLAIM FOR DAMAGE IN SHIPMENT

The unit should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier.

WARRANTY

Harkins Radio, Inc. warrants equipment manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any unit returned to the factory for that purpose and to replace any defective parts thereof. Tubes as well as fuses and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the unit is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

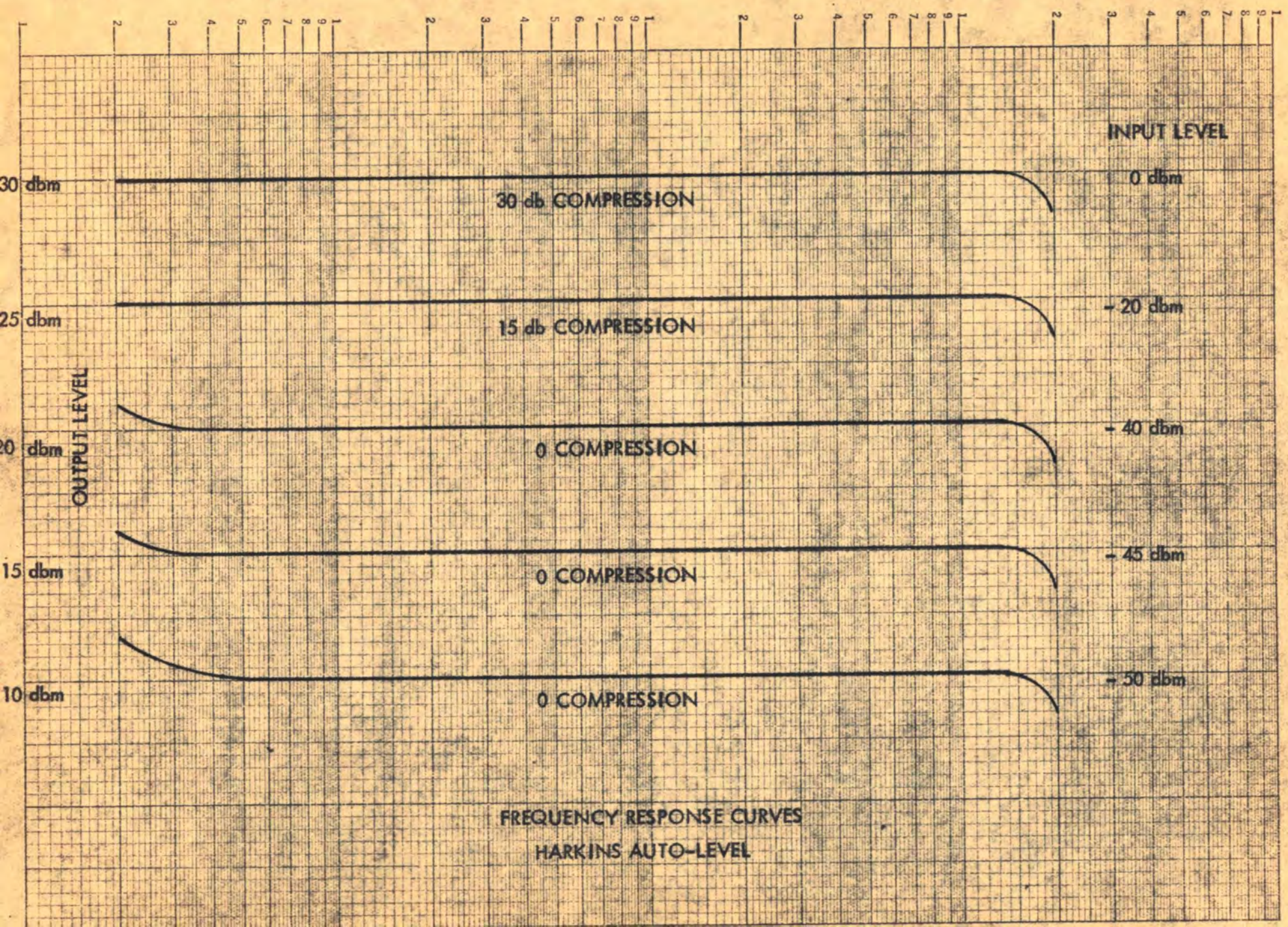
1. Notify us, giving full details of the difficulty, and include the model number and serial number. On receipt of this information, we will give you service data or shipping instructions.
2. On receipt of shipping instructions, forward the unit prepaid to the factory. If requested, an estimate of the charges will be made before the work begins provided the unit is not covered by the warranty.

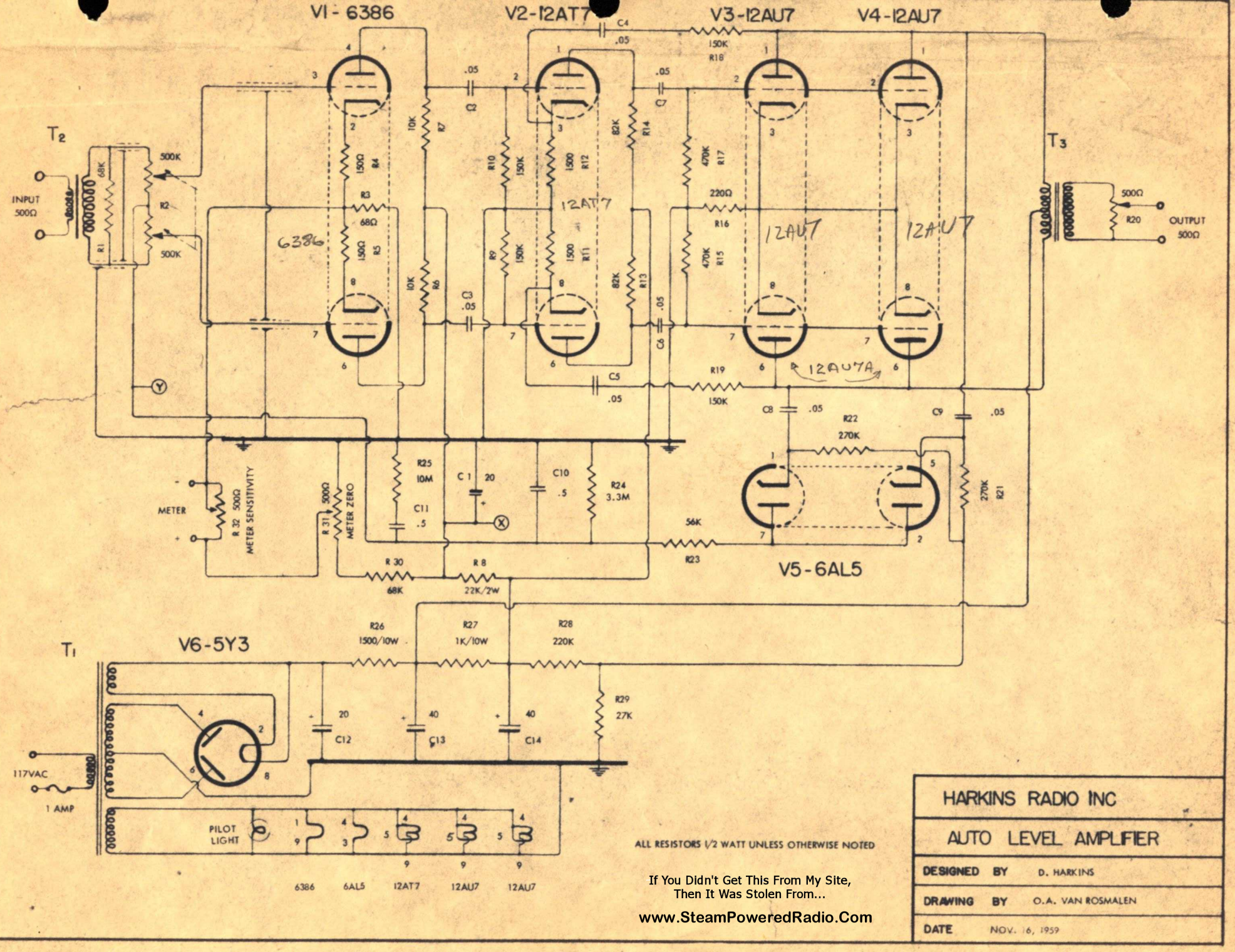
SHIPPING

All shipments to Harkins Radio, Inc. should be made via Truck or Railway Express. The unit should be packed in a strong exterior container and surrounded by two or three inches of excelsior or similar shock-absorbing material.

DO NOT HESITATE TO CALL ON US

HARKINS RADIO, INC.
4444 E. Washington Street
Phoenix, Arizona
Phone BRidge 5-6224





ALL RESISTORS 1/2 WATT UNLESS OTHERWISE NOTED

HARKINS RADIO INC	
AUTO LEVEL AMPLIFIER	
DESIGNED BY	D. HARKINS
DRAWING BY	O.A. VAN ROSMALEN
DATE	NOV. 16, 1959