BEFORE PROCEEDING WITH COMPLETE UNPACKING AND SETUP, CONSULT UNPACKING AND INSPECTION INSTRUCTIONS ON PAGE

model LA-2A

LEVELING AMPLIFIER

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*** NOTICE TO PURCHASER ***
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This product, manufactured by UREI a division of Harman Electronics, in 1992 is identical in all essential respects to the Teletronix LA-2A Leveling Amplifiers which went out of regular production in 1969.

The LA-2A was originally born as the LA-2, a product of Teletronix Engineering Company, Pasadena, California. It soon achieved wide acclaim in professional audio applications, because its unique, patented Electro-Optical Attenuator obtained a smooth, unobtrusive compression/limiting action not possible with any other available technology.

Teletronix Engineering Company became a division of Babcock Electronics Corporation, Costa Mesa, California in 1965. The assets of that division, including the Electro-Optical Attenuator patent, were acquired in 1967 by Studio Electronics Corporation/UREI, and we continued production of the LA-2A until 1969, when the solid-state LA-3A was introduced.

This Instruction Manual has been reproduced without change from the original artwork, as acquired with the product in 1967, except for the addition of reference to the protective circuitry which has been installed to remove all hazardous voltages when the hinged front panel is opened for servicing or inspection. This circuitry must be deliberately defeated to operate the unit with the interior of the chassis exposed for servicing. In the era of low voltage solid state circuitry, it is easy to become complacent in poking about active electric components.

THIS LA-2A UTILIZES VACUUM TUBES. VOLTAGES AS HIGH AS 350V ARE PRESENT. BE CAREFUL! UREI ASSUMES NO RESPONSIBILITY FOR POSSIBLE INJURY FROM ELECTRIC SHOCK WHILE SERVICING THIS PRODUCT OR OPERATING IT WITH THE FRONT PANEL OPEN.

This Instruction Book was reprinted from text composed by the original manufacturer (complete with errors and exaggerations). We feel the specification for attack time should have been in milliseconds, rather than microseconds. Production test of your unit was accomplished with virtually identical instrumentation and the same procedures employed in the original LA-2A manufacture. Your LA2-A conforms in all performance respects to LA-2A's made before 1969.

Your new LA-2A is warranted for one year under UREI's standard warranty, except for vacuum tubes and pilot lamps. We recommend that the unit be returned to the factory for any required service.

The heart of the LA-2A (and its first successor, the solid-state LA-3A) is the T4B Electro-Optical Attenuator. This plug-in assembly utilizes an Electro-Luminescent light source, which will deteriorate with usage. Replacements are readily available at modest cost. When significant changes are noticed in PEAK REDUCTION control settings to achieve a certain amount of gain reduction (based on previous experience) the T4B is probably due for replacement. In normal daily usage, this should not occur sooner than 3 or 4 years.

A great deal of care has been taken by UREI to make your new LA-2A conform as closely as possible to the best of the originally produced units. We hope you will enjoy its use, and that the "LA-2A Magic" will bring great success to your end product. Certain parts in this device were very difficult to obtain in 1992. It is doubtful that genuine LA-2A's can ever be manufactured again. Treat yours with care; it may become a prized relic of the vacuum-tube era.

OPERATING INSTRUCTIONS

TELETRONIX MODEL LA-2A LEVELING AMPLIFIER

INTRODUCTION

The Teletronix Leveling Amplifier will automatically reduce audio peaks which might otherwise over drive broadcast or recording equipment.

Automatic gain reduction is accomplished by the use of an electro-optical variable attenuator, which is placed ahead of the first amplifier stage. The attenuation is controlled by the amplitude of the LA-2A input signal.

This system permits up to 40 DB of instantaneous gain reduction, yet causes no wave form or harmonic distortion. The amplifier provides sufficient gain and output level (10 DBM nominal) to be used as a line or program amplifier, or for direct connection to the transmitter in the case of radio or TV operation.

Provisions are made for interconnection of the optical attenuators to provide equal gain reduction in both channels when two of the LA-2A Leveling Amplifiers are used for FM stereo broadcasting.

SPECIFICATIONS

1.	Gain Reduction:	up to 40 DB
2.	Distortion:	less than 0.35% total harmonics at +10 DBM, and less than 0.75% total harmonics at +16 DBM output
3.	Response:	±0.1 DB, 30 cycles to 15 KC
4.	Noise:	75 DB below +10 DBM output level
5.	Gain:	40 ±1 DB
6.	Output Level:	+10 DBM nominal +16 DBM maximum peaks
7.	Input Level:	+16 DBM maximum
8.	Attack Time:	essentially instantaneous (10 usec)
9.	Release Time:	approximately 0.06 seconds for 50% release, 0.5 to 5 seconds for complete release depending upon amount of previous reduction

10.	Input Impedance:	50, 150, 250, and 600 ohms, balanced or unbalanced
11.	Output Impedance:	50, 150, 250, and 600 ohms, balanced or unbalanced
12.	Output Source Impedance:	approximately 150 ohms, at 800 CPS
13.	Panel Size:	standard 19" x 5-1/4"
14.	Depth Behind Panel:	7-1/4"
15.	Panel Controls:	Gain (input level), Peak Reduction and Meter Selector Switch
16.	Meter:	DB Gain Reduction and DB Output
17.	Power Requirements:	115/230 volts 50-60 cycle 35 watts
18.	Tube Complement:	(2) 12AX7A (1) 12BH7A (1) 6AQ5
19.	Fuse:	3AG, 3/8 AMP Slow Blow for 115V; 3AG 15/100 AMP Slow Blow for 230V

CIRCUIT DESCRIPTION

The LA-2A Leveling Amplifier will produce essentially instantaneous gain reduction of over 40 DB with no increase in harmonic distortion.

A typical gain reduction curve for this system is illustrated on Figure 1. Compressor action occurs from the breakaway point at -30 DB input and up to -20 DB, at which point the curve becomes horizontal to exhibit limiting action. The input increases an additional 20 DB, but the output increases less than 1 DB. The leveling amplifier thus combines the characteristics of a compressor and limiter. A reasonable amount of care in gain riding will restrict normal operation to the compression region, but uncontrolled output levels will be prevented by the limited action.

The heart of the leveling amplifier is the electro-optical attenuator which is placed ahead of the first amplifier stage. The actual stage gains and tube operating parameters are not varied, permitting the tubes to operate at optimum conditions regardless of the amount of gain reduction.

The optical attenuator consists of a photo-conductive cell, which is optically coupled to an electro-luminescent light source. The electro-luminescent device provides a light intensity which is proportional to the audio voltage applied to its terminals. Not unlike a capacitor in construction, the electro-luminescent lamp consists of a plate of glass or plastic coated with a clear conducting material on one side and a thin layer of phosphor on the other side. A metallic plate contacts the phosphor coating. As alternating current is applied to the conducting plates the phosphors are excited by the voltage across the dielectric and light is produced. The amount of light depends upon the applied voltage and frequency. The gain or level controlling element is the photo-conductive cell. The resistance of the cell decreases with an increase in the impinging light. Since the light is produced directly from the audio voltage, the response is instantaneous. Rectification and filtering of the audio to produce a control signal are not necessary as in the case of conventional limiters. This system results in automatic level control whose speed of operation is limited only by the response of the variable resistance photo cell used.

A cell is selected which provides minimum attack time, and a release time which requires about 60 milliseconds for 50% release, and then a gradual release over a period of 1 to 15 seconds to the point of complete release.

Referring to Figure 2, the functional block diagram, the input signal is applied directly to the optical attenuator from the high impedance winding of the input transformer. The amount of attenuation introduced by the optical attenuator is controlled by the audio voltage applied to it by the 6AQ5 (V4), which is the luminescent driver amplifier. The amount of signal applied to the 12AX7 (V1) voltage amplifier is also controlled by the manual gain control. The voltage amplifier stage provides a gain of 40 DB. Overall amplifier feedback of approximately 20 DB provides low distortion, flat response, and gain stability.

The output stage is somewhat unconventional in that a totem pole or double cathode follower is used. This output stage can tolerate great amounts of output impedance mismatch, but retains low distortion and flat frequency response.

For stereo broadcasting applications, a portion of the input signal is fed through the gain reduction control to the 12AX7 control amplifier (V3). The output at this stage is applied to the stereo balance control and is also brought out to a terminal on the chassis. For stereo operation, this terminal is connected to the same terminal on an identical amplifier and control voltage becomes common to both units. A gain-reduction control voltage generated in either amplifier will cause equal gain reduction in both units. The control voltage is applied through the stereo balance control R3 to the 6AQ5 driver amplifier. This stage provides the necessary voltage to operate the electro-luminescent light source.

OPERATION

The LA-2A Leveling Amplifier is designed to prevent an increase in output level beyond a pre-determined point, and due to its unique design, functions as a combined compressor and limiter. The effect is illustrated in Figure 1. The point at which the compressed curve breaks away from the straight "No-Gain Reduction" line is determined by the setting of the "Peak Reduction" control. It can be seen from the curve that compression occurs and gradually increases over the first 10 DB of input level rise. The slope of the curve then becomes horizontal, preventing an increase of output level regardless of input increase.

CONTROL SETTINGS

It is recommended that the "Peak Reduction" control be set to prevent increase in output level beyond the 100% modulation point. This setting should be made on typical program material.

Setting of the "Gain" and "Peak Reduction" controls are independent. However, the "Gain" control should be set to provide sufficient output after the "Peak Reduction" control has been adjusted.

The "Peak Reduction" control should be set for the desired amount of gain reduction as indicated by the meter. Continuous extreme reduction, such as 20 or 30 DB, does tend to reduce the dynamic range of music. Maximum benefit is obtained by running 4 to 8 DB of compression continuously. This will usually cause full limiting to occur when 100% modulation is approached.

For ease of control and to prevent overload of the input transformer, sufficient fixed pad should be placed ahead of the LA-2A to allow normal output at approximately 50% setting of the gain control.

VU METER

The VU Meter serves two functions; it indicates output level as well as gain reduction directly in DB. When the meter selector switch is placed in the "output" position, the meter will indicate output level across the 600 ohm terminals. The meter is calibrated to read 0 VU or 100% when the amplifier output is +10 DBM or +4 DBM, depending upon the switch position.

The position marked "Gain Reduction" permits the meter to indicate the amount of gain reduction or peak limiting directly in DB. During periods of no gain reduction the pointer will return to 0 VU on the meter scale. The pointer is initially set to this position by means of the screw driver adjusted control located on the left end of the front panel.

STEREO

If two LA-2A Leveling Amplifiers are to be used in tandem for stereo, the gain reduction of each amplifier can be made equal, regardless of which channel is instigating the limiting. This is accomplished by interconnecting terminals 6 and 7 of the LA-2A Leveling Amplifiers. The interconnecting wire should not be over two feet in length and should be shielded, the ends of the shield being connected to the #7 terminals (ground).

Stereo "set-up" is as follows:

1. Connect the input terminals of the left and right channel LA-2A to an audio oscillator. Make certain that the amplifiers are connected in phase to the generator.

A generator frequency of 400 or 1000 cps is satisfactory. Generator output level should be set to the average level to be applied in operation.

2. Place the meter selector switches in the +10 or +4 position and adjust the LA-2A "Gain" controls for equal output. The "Peak Reduction" controls must be set to full counterclockwise or off.

3. Make certain that the screw driver adjustment (R3) on the rear of each unit are "full on" (clockwise). Place each meter selector switch in the "Gain Reduction" position.

4. Advance the "Gain Reduction" control on the left channel amplifier until approximately 5 DB of reduction is indicated on the meters. Note which channel is indicating the most gain reduction. Reduce the setting of R3 on this unit until both meters show equal reduction.

5. The "Gain Reduction" controls can now be placed at any desired setting, keeping both knob settings equal. Gain Reduction will now be equal on both channels.

GAIN REDUCTION FREQUENCY RESPONSE CONTROL

FM broadcasting and TV aural transmission systems use audio pre-emphasis in the transmitter. The standard is 17 DB increase in response at 15 KC, the exact curve being the result of a 75 microsecond network. The program frequencies in the vicinity of 15 KC will modulate the carrier 17 DB more than frequencies below 1 KC. Thus, if the program material contains a large amount of high frequencies, over-modulation may occur if the levels had been previously adjusted for program material with less high frequency content.

An attempt to alleviate this problem has been made by others in the form of level controlled high frequency cutoff filters and high end peak clippers. Because the amount of control over the remainder of the spectrum is limited and because of the high distortion created, such devices have found only limited application.

The Teletronix Leveling Amplifiers are capable of at least 30 DB of gain reduction or limiting with less than 0.5% harmonic distortion. For most applications, such as AM broadcasting and recording, the amount of gain reduction is a function of input level and is independent of frequency.

By increasing the gain reduction at the higher frequencies, the over-modulation caused by the pre-emphasis can be greatly reduced or eliminated. While it is possible to increase the gain reduction sensitivity on an inverse of the pre-emphasis curve, this usually results in an insufficient leveling on the low frequencies. The actual amount of the limiter pre-emphasis must be determined according to the amount of high frequency content in the program material.

Adjustment of the gain reduction frequency response is accomplished by control R37 which is located on the rear of the LA-2A. Increasing the resistance of R37 reduces the amplitude of the low frequency voltage applied to the Peak Reduction control, R2. The high frequency components are not affected because of the low reactance of C12. Thus, if the control is set to the "flat" position the LA-2A will provide equal gain reduction on all frequencies. If the control is moved away from the "flat" position, the leveling will be greater on the high frequencies. The actual setting can be best determined on program material for a compromise between low and high frequency limiting. Maximum high frequency response will provide approximately 10 DB more reduction at 15 KC than at frequencies below 1 KC.

230 VOLT INPUT

The LA-2A is set for a power line voltage of 115V when shipped. In order to change this for 230 volts, open the front panel and make the following changes: Locate the vertical solder terminal strip at the right hand end of the chassis. Terminal 1 is connected to 2, and 3 is connected to 4 for 115V operation. Remove these jumper wires and connect terminal 2 to 3. This will allow operation on 230 volts ±10%, 50/60 cycles.

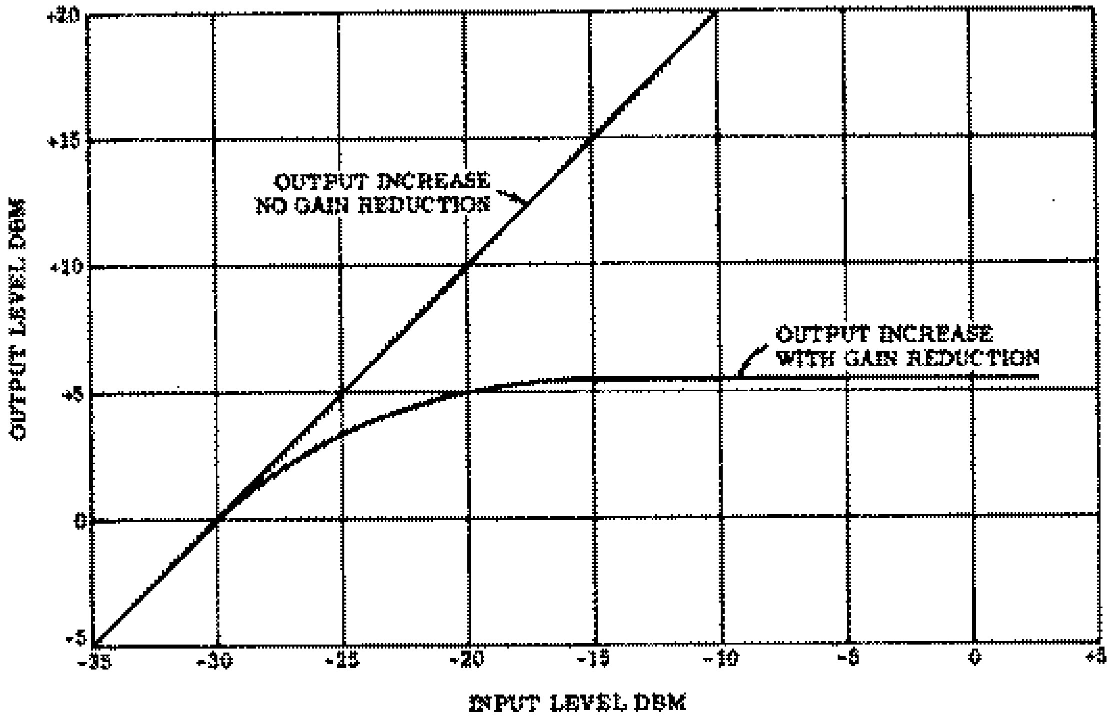

Figure 1. Typical Gain Reduction Plot for Model LA-2A Leveling Amplifier

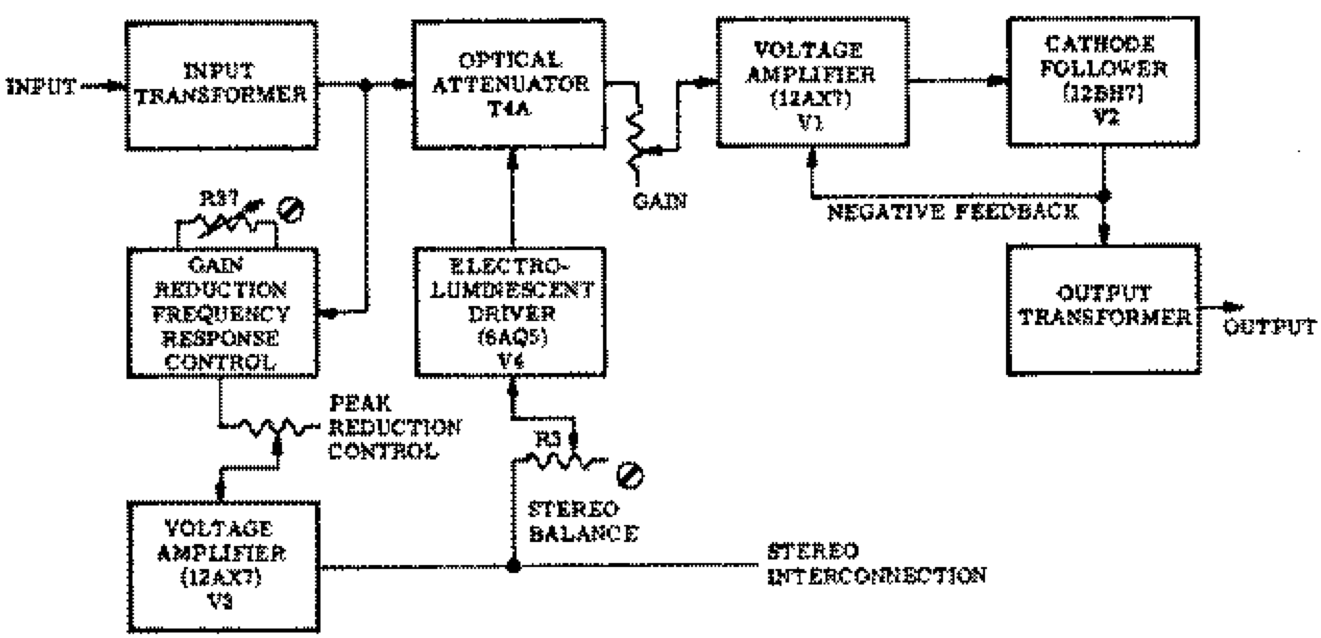

Figure 2. Limiter Block Diagram

ADDENDUM - LA-2A INSTRUCTION MANUAL

All LA-2A Leveling Amplifiers after serial number 572 incorporate a leveling slope control switch. The purpose of this switch is to allow selection of either limiter or compressor action in the LA-2A.

Referring to Figure 1, page 8, the typical gain reduction curve is illustrated for limiter operation. Beyond the break away point the output does not increase with an increase of input level, producing a plot which is horizontal. When the switch is set for compressor operation, the output will increase slightly with increasing input level. The resulting curve will have a slope of approximately 3:1, which means that an increase of input level of 100% will cause an output increase of 30%.

This switch is located on the chassis adjacent to the optical attenuator (T4A) socket.

An Improved Method of Audio Level Control for Broadcasting and Recording

By JAMES F. LAWRENCE, JR.

An improved audio compressor-limiter system has been developed by making use of a new linear optical attenuator. The shortcomings of earlier systems are overcome by producing light instantly and in direct proportion to audio level through the use of electroluminescence. The light controls amplifier input level by means of a photoconductive cell. There is no distortion due to limiting, and the attack time for the system is 10 microseconds.

The volume compressor or limiter is commonly used in broadcasting and recording studios to prevent distortion and over-modulation from sudden audio peaks or loud program passages. Such a device is usually used to supplement or assist the operator in holding levels within predetermined limits.

Constant improvement of audio equipment together with higher standards of broadcasting and recording are more than ever emphasizing the shortcomings of the conventional compressor or limiter. When used as a link in a quality audio chain it is a never-ending source of irritation to the quality-conscious engineer. The advent of stereo broadcasting as well as a long-standing need for a low-distortion method of automatic gain control instigated the development of a device which very closely approaches the ideal. Before describing this device, the operation of compressors and limiters is reviewed.

As illustrated on Fig. 1, if the amplifier input level is plotted horizontally, and the output level plotted vertically on equal db scales, a straight line will be obtained, making an angle of 45° with the horizontal. This indicates that the output is proportional to the input. If the amplifier exhibits the properties of a compressor or limiter, the 45° line will suddenly bend toward the horizontal when compression begins. The point at which the line bends away from 45° (1:1) is called the "breakaway point" or point of "commencement of compression."

The difference between the actual output when compression is taking place and the output that would be obtained if there was no compression is the amount of compression in db. In the example, the reduction due to compression is 21.5 db at the point where the input increased 30 db and the output only 8.5 db. It can be seen that the slope of the line is approximately 4:1. The slope is called the compression ratio.

An ideal limiter or compressor should provide a maximum of 30 to 40 db of limiting or gain reduction with no increase in waveform distortion, and have an attack and release time which will provide a smooth inaudible transition between the limiting and nonlimiting condition.

Conventional limiters control the amplifier gain by applying a variable-control grid bias voltage to the amplifier stages in order to cause a reduction of the stage gain. This shift of the operating bias from optimum causes a rapid increase in distortion as the amount of limiting or gain reduction increases. Distortion values of 2 to 10% are common for conventional limiters operating at 10 to 15 db of gain reduction. Since negative feedback loops are usually not practical around variable-gain stages, the nonlimiting distortion figures are high and tube aging and operating parameters become a maintenance problem if low distortion is to be retained.

The leveling amplifier system described here will produce essentially instantaneous gain reduction of over 40 db with no increase in harmonic distortion.

A typical gain reduction curve for this system is illustrated on Fig. 2. It is interesting to note that a somewhat mild compressor action occurs from the breakaway point at −30 db input and up to −20 db, at which point the curve becomes horizontal to exhibit limiting action. The input increases an additional 20 db, but the output increases less than 1 db.

The leveling amplifier thus combines the characteristics of a compressor and limiter. A reasonable amount of care in gain riding will restrict normal operation to the compressor region, but uncontrolled levels will be prevented by the limiter action.

The heart of the leveling amplifier is the electrooptical attenuator which is placed ahead of the first amplifier stage. The actual stage gains and tube operat-

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(This paper, first received on March 9, 1964; and in final form on July 24, 1964.)

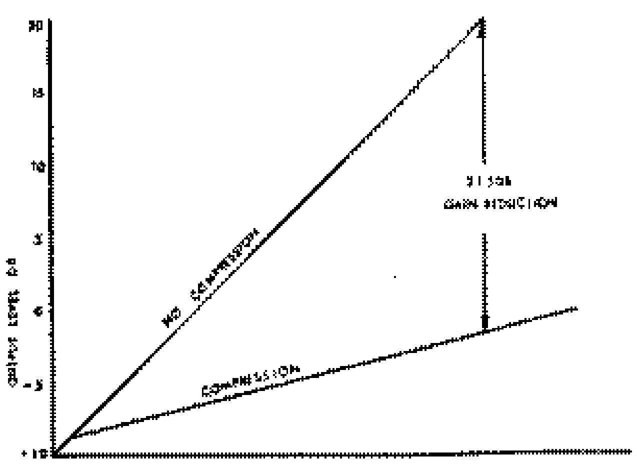


Fig. 1. Typical compressor curve.

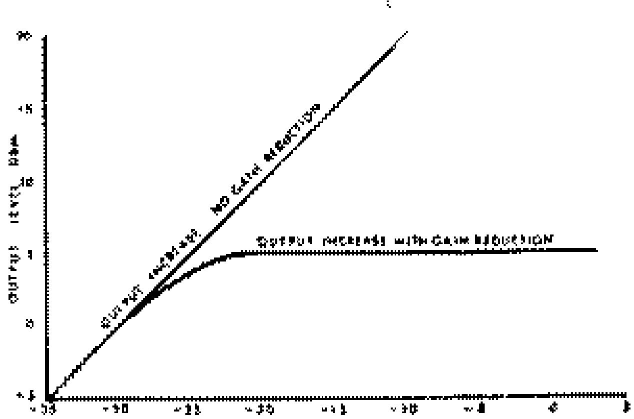


Fig. 2. Typical gain-reduction plot for model LA-2 leveling amplifiers.

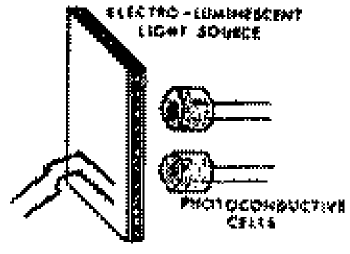


Fig. 3. Optical attenuator.

ing parameters are not varied, permitting the tubes to operate at optimum conditions regardless of the amount of gain reduction.

Referring to Fig. 3, the optical attenuator consists of a photoconductive cell which is optically coupled to an electroluminescent light source. The electroluminescent device provides a light intensity which is proportional to the audio voltage applied to its terminals.

For those not familiar with the phenomenon of electroluminescence, it is a method of producing light by the passage of current through a thin layer of phosphor. Not unlike a capacitor in construction the electroluminescent lamp consists of a plate of glass or plastic coated with a clear conducting material on one side and a thin layer of phosphor on the other side. A metallic plate contacts the phosphor coating. As alternating current is applied to the conducting plates the phosphors are excited by the voltage across the dielectric and light is produced. The amount of light depends upon the applied voltage and frequency.

The gain- or level-controlling element is the photoconductive cell. The resistance of the cell decreases with an increase in the impinging light. The photosensitive resistor has been used by others[1] for the purpose of audio gain control and peak limiting. All of these systems have utilized neon or incandescent lamps as the source of control light. These systems were investigated during the early development phases of the equipment described here, but were discarded for several reasons. A light source was desired which would produce light output immediately upon application of audio voltage, that is, instantaneous response. This precluded the use of a filament-type lamp, because of the thermal inertia of the filament. The light output should be proportional to the applied audio voltage. This eliminated the use of the neon lamp.

After experimenting with several cathode-ray types of light sources, the electroluminescence light source was selected. Since the light is produced directly from the audio voltage the response is instantaneous. Rectification and filtering of the audio to produce a control signal are not necessary as in the case of conventional limiters. This new system results in automatic level control whose speed of operation is limited only by the response of the variable-resistance photocell used.

A cell is selected which provides minimum attack time, and a release time which requires about 60 milliseconds for 50% release, and then a gradual release over a period of 1 to 15 seconds to the point of complete release.

The photoconductive cell has a "memory" that provides a more rapid reduction of resistance when gain reduction has occurred within the past 20 or 30 seconds. Measured attack time for the system is 10 microseconds for 50% of full gain reduction when the cell has been active within the previous 30 seconds; and approximately 50 to 100 microseconds, if no previous gain reduction has occurred.

The photoconductive cell depends on the energy received from light to reduce the adherence of outer orbit electrons in the atoms which make up the cadmium sulfide crystals. The electrons actually detach themselves and become free to cause electrical conduction. Conductivity depends on the amount or intensity of light striking the crystals. The decrease in resistance from dark to light is much more rapid than return to the dark value. After light is removed the electrons do not recombine immediately. Return to dark condition is much slower when large numbers of electrons have been released or after high light intensity has occurred. The return to dark conductivity when resistance is plotted as a function of time approximates a log function. This interesting and useful feature of the variable-resistance cell used in the attenuator provides a release time that is dependent upon the amount of gain reduction just prior to release. Five or six db of limiting will permit full release in about 2 seconds, while 20 or 30 db of limiting will require a release time of 5 to 10 seconds; 50% release in either case occurs in less than 1 second. This characteristic, together with the fast and smooth attack provides a system which is free of thump and the usual working sounds peculiar to limiters and compressors.

Other types of cells such as the cadmium selenide can be used in place of the cadmium sulfide unit used here to produce very fast release times in the order of 0.1 to 1.5 seconds.

Referring to Fig. 4, a functional block diagram, the input signal is applied directly to the optical attenuator from the high-impedance winding of the input transformer. As explained previously, the amount of attenuation introduced by the optical attenuator is controlled by the audio voltage applied by the 6AQ5 luminescent driver amplifier. The amount of signal applied to the 12AX7 voltage amplifier is also controlled by the manual gain control. The voltage amplifier stage provides a gain of 40 db. Overall voltage amplifier feedback of approximately 20 db provides low distortion, flat response, and gain stability.

The output stage is somewhat unconventional in that a totem pole or double cathode follower* is used. An output stage was desired which would tolerate great amounts of output impedance mismatch, but retain low distortion and flat frequency response. The totem pole cathode follower was selected because its output admittance

$$y_o = \frac{\mu + 1}{r_p + R_1} + \frac{1 + \frac{\mu(\mu + 1)}{1 + r_p/R_1}}{r_p}$$

$$\approx \mu g_m, \text{ or } Z_o \approx \frac{1}{\mu g_m}.$$

For the conventional cathode follower

$$y_o = \frac{1 + \mu}{r_p}, \text{ or } Z_o \approx \frac{1}{g_m}.$$

Thus it can be seen that the totem pole circuit will provide an output impedance which is a twentieth that of a conventional cathode follower when a tube having a μ of 20 is used in both cases.

A portion of the input is fed through the gain reduction control to the 12AX7 control amplifier. The output of this stage is applied to the stereo balance control and is also brought out to a terminal on the chassis. For stereo operation this terminal is connected to the

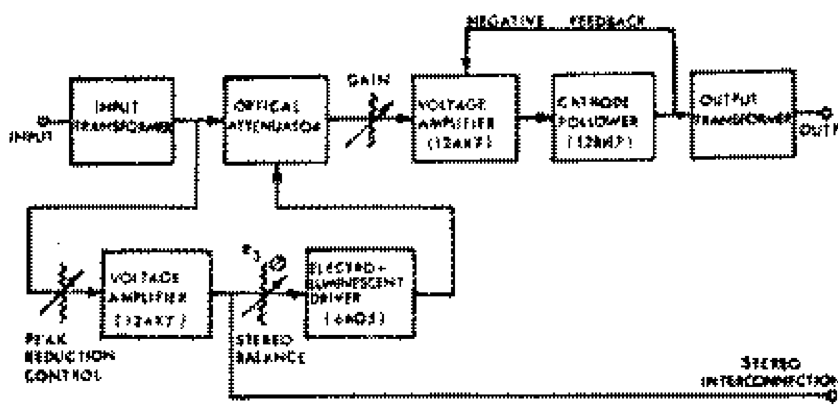
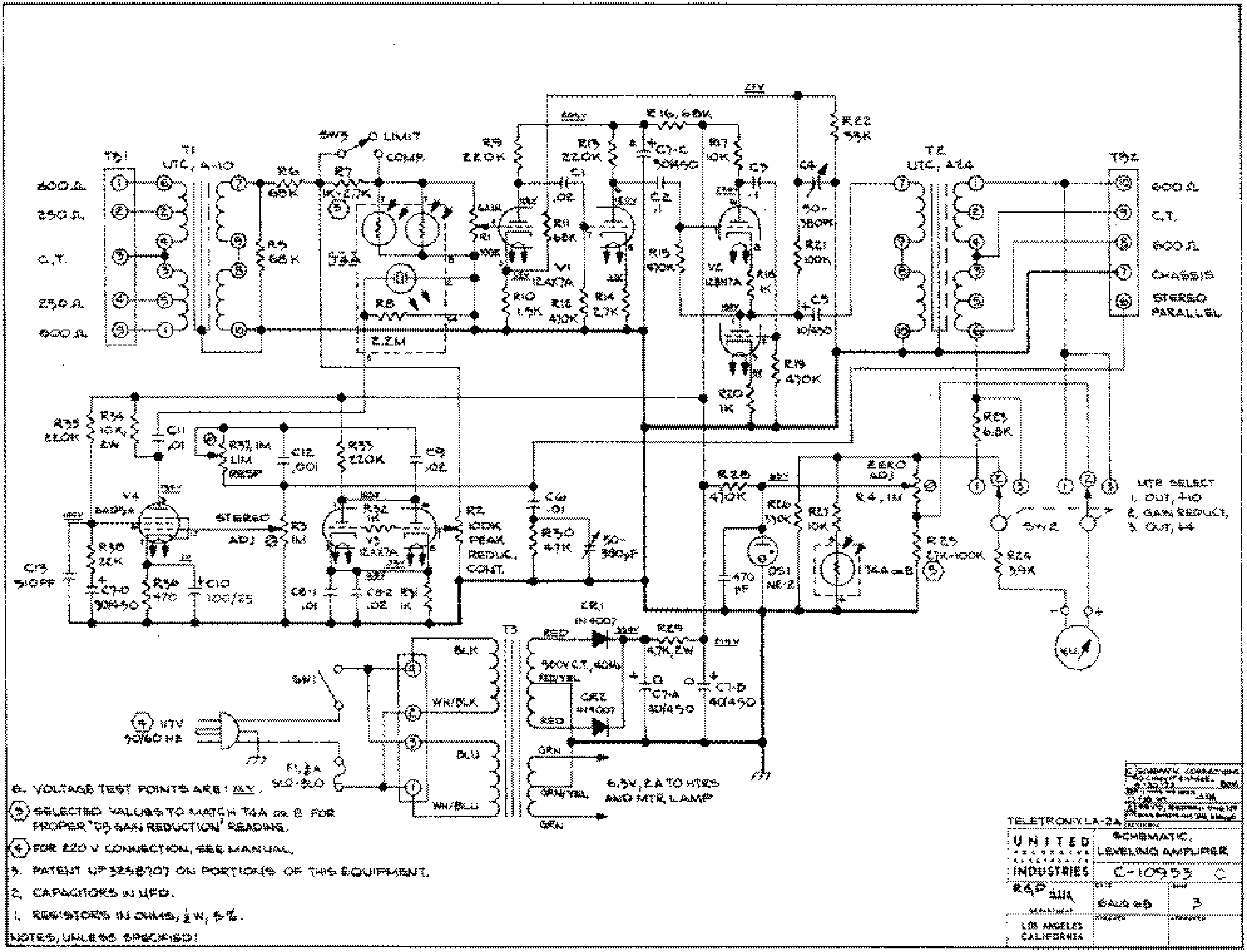


Fig. 4. Limiter block diagram.



6. VOLTAGE TEST POINTS ARE: XXV.

(5) SELECTED VALUES TO MATCH T4A or B FOR PROPER "DB GAIN REDUCTION" READING.

(4) FOR 220 V CONNECTION, SEE MANUAL.

3. PATENT UP3258707 ON PORTIONS OF THIS EQUIPMENT.

2. CAPACITORS IN UFD.

1. RESISTORS IN OHMS, ½ W, 5%.

NOTES, UNLESS SPECIFIED:

TELETRONIX LA-2A

UNITED RECORDING ELECTRONICS INDUSTRIES

SCHEMATIC, LEVELING AMPLIFIER

C-10953 C

LOS ANGELES CALIFORNIA