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The ACOUSTAT SERVO-CHARGE AMPLIFIER

Service and Owner's Manual

ACOUSTAT
SERVO-CHARGE AMPLIFIER
SERVICE MANUAL

Contents:

INTRODUCTION

The Servo-Charge Amplifier Service and Owner's Manual has been written as part of an effort to minimize the service problems encountered by our dealers and customers. We have found that many of these problems are the result of a failure to understand the principles of operation of the circuitry of the Servo-Charge amplifier and that this situation has been complicated by a lack of ducumentation of the physical layout of the printed circuit board.

We have also determined that many systems fail to function at their full potential because of deficiencies in the initial set-up. Therefore, a section has been included outlining the preferred procedure for the placement and connection of a newly installed system.

The acoustics of the room will play a major role in the ultimate performance of the speaker system and we have found that it is far more rewarding, in terms of the quality of results obtained, to tune the speakers to the room than to add line equalization. A solid, reflective, and unobstructed wall should be directly behind the speakers and any required tuning of the room can normally be accomplished with slight changes in the placement of drapes or other wall hangings.

SET-UP INSTRUCTIONS FOR ACOUSTAT ELECTROSTATIC SPEAKER SYSTEMS

The set-up procedure, exclusive of assembly, is the same for all Acoustat electrostatic speaker systems. We have been able to make the Monitor series speaker systems more tolerant than the Acoustat X systems for small aberations in the set-up and room tuning; but we still advise that the preferred procedure should be followed fully to obtain the best possible performance from the system.

Some of the principal considerations which will determine the performance potential of the speaker system as installed are:

The Wall Behind the Speakers:

This wall should be hard, reflective, and sufficiently rigid that it will not rattle--sliding glass doors are a "No-No".

The Orientation of the Speaker System Within the Room:

Unless there is an overriding consideration to the contrary, the speakers should project sound along the longer axis of the room. This can be considered a universal rule of stereo speaker systems and is in no way peculiar to Acoustat products.

The Grounding of the System:

It is essential that the power supply ground be connected to prevent any buildup of charges in the Servo-Charge amplifier power supplies. THE THIRD WIRE GROUND MUST BE CONNECTED.

While the system may function reasonably well with only the power supply ground, this leaves the main signal ground floating. THERE MUST BE ONLY ONE SIGNAL GROUND IN THE SYSTEM and this should normally be provided at the input of the preamplifier.

Electric Feedback:

Electrostatic loudspeakers produce a strong electric field which can influence the operation of any low level electronic circuitry in close proximity and can result in feedback at frequencies well above the audio spectrum--this has the effect of high power dissapation and decreased headroom in the system. The tone arm of the turntable and the input of the preamplifier should be kept at least six to eight feet from the nearest speaker to ensure that no feedback can occur.

Phasing:

Acoustat speaker systems are designed to preserve correct absolute phase throughout the system including the final coupling of the signal to the air. This ensures that vocalists and instruments will sound as natural as possible. Therefore, make sure that the connections from the speakers to the amplifiers are correctly oriented: the wires should enter the three prong Pomono plug from above.

The Area Between the Speakers:

This area should be kept clear of major obstructions to airflow if optimum imaging is to be achieved. The size and shape of objects placed between the speakers will determine the extent of any deleterious effect on the imaging--objects such as record cabitets or equipment racks between the speakers should be avoided.

Tiltback:

The tiltback of the speakers has the combined effect of improving the vertical dispersion of the system and of breaking up standing waves in the room. Two or three degrees of tilt is typical and is a good initial setting--this corresponds to about three inches of rearward displacement of the top of the speaker.

Toe-in:

This setting is possibly the least critical. However, if the speakers are toed in too much, a soloist will appear to be singing from a position somewhere beyond the rear wall.

Distance from the Wall:

If the speakers are placed too close to the rear wall of the room, a soloist will tend to sound "muffled", and if the speakers are placed too far from the wall, a soloist will sound "hollow".

For purposes of setting up the system, we recomend that the speakers be auditioned using a solo female vocalist of reference quality. We have found that the human ear more sensitive to anomalies in the human voice than in instrumental music and, since "imaging" is most discernable in the mid-range, we recomend that a female vocalist be selected.

Once the system has been assembled and connected, the orientation within the room determined, the initial settings of tiltback and toe-in made, and the amplifier controls set (nine o'clock for the gain controls and twelve o'clock for the HF Balance control of the Monitor--eleven o'clock for the Acoustat X and Monitor Three would be typical); the audition may begin with the speakers placed too close to the wall. At this point, the speakers should sound muffled. By moving the speakers out from the wall a little at a time, a point should be reached at which "you could reach out and touch the soloist." When this has been accomplished, the tiltback, toe-in, HF Balance, and gain balance to center the preamplifier control can be fine-tuned by experimentation.

SHIELDING AND GROUNDING OF AUDIO SYSTEMS

The purpose of this section is not to make the reader an expert on the subject of shielding and grounding; but, rather, to provide simple guidelines for the reduction of environmental noise in the signal paths typically used in high fidelity audio systems. In this application, the use of single conductor coaxial cables between single ended outputs and inputs is nearly universal and the RCA "phono plug" is the most common connector in use. Therefore, we will confine our discussion to this type of feed.

While it should be obvious that proper grounding is always important, it is all the more important with this type of feed where extraneous shield currents are so easily injected into the audio. Thus, it is quite important that a single grounding point for the system be selected so that the ground and "neutral" currents of the power wiring in the building in which the system is installed will not be conducted through the shields of the connecting cables. The degree to which a single well chosen grounding point can be selected and the degree to which ground "loops" can be eliminated will be the principal determinant of the degree to which inductively coupled and resistively coupled environmental noise can be isolated from the system. Thus, for example, the two cables of a stereo feed from a stereo preamplifier to a stereo power amplifier should be of equal length and use adjacent routing. Deviation from this principal can result in the cable shields acting as a loop antenna.

It should be pointed out that power line noise can never be totally eliminated as some noise will be fed in through the power supplies of the equipment involved in addition to the internal noise generated within the high fidelity audio equipment. While it is certainly true that the internal noise situation is improved with each advance of the "state of the art", the problem can never be completely eliminated!

Normally, the system grounding point chosen will be the lowest level signal input of the system and when a tuner is not in use, this will usually be the phono preamp input. If a tuner is present, it is often preferable to use the low side of the antenna input as the system ground.

Shielded cable should always be used from any source to the input of an amplifier and the connections, especially of the shields, must be excellent so that the resistance of the connection will be trivial. Thus, the connectors must be clean and must mate securely and the atachment of the connectors to the cables must be properly executed.

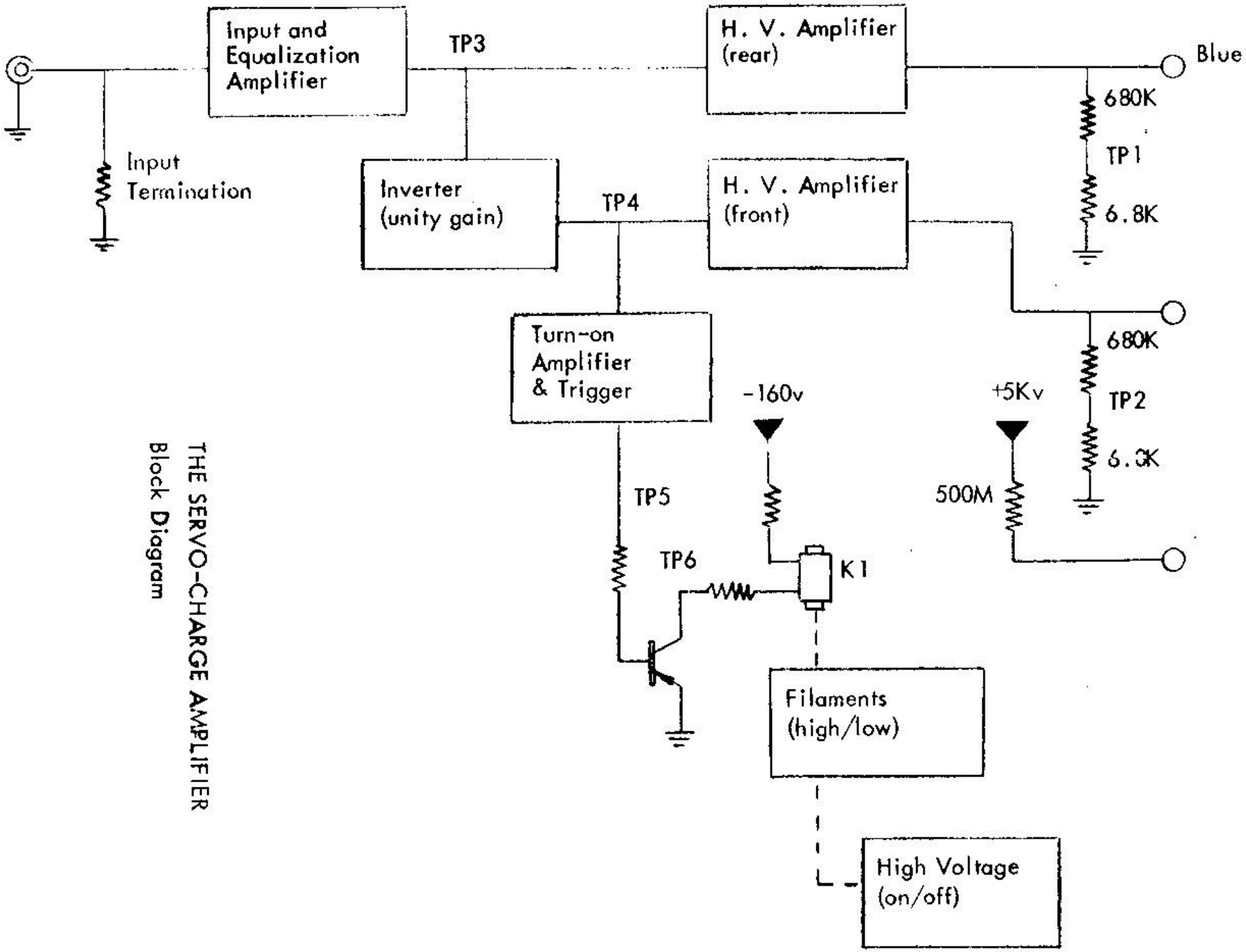
DESCRIPTION

The Acoustat Servo-Charge amplifier is a hybrid solid state and vacuum tube device specifically designed to drive the electrostatic transducer panels of the Acoustat X and Acoustat Monitor loudspeaker systems.

In order to eliminate the requirement for power amplifier switching cables from the preamplifier, the Servo-Charge amplifier is designed to turn itself on at the first presence of an input signal and to turn itself off after the signal has been absent for a period of approximately five minutes. To accomplish these goals, the solid state portion of the circuitry operates at all times. When the amplifier is in its "off" state, the high voltage supply for the output vacuum tubes is inoperative and the vacuum tube filament supplies are reduced to one half of their operating voltage.

The input section of the amplifier is based on a premium quality quad integrated circuit operational amplifier used for signal amplification, active equalization, phase inversion, and control of the automatic turn-on/turn-off functions.

The output sections of the amplifier are two hybrid discrete operational amplifiers which drive the "plates" of the electrostatic transducer panels in a push-pull format. The output vacuum tubes operate at the working voltage of the electrostatic panels so that transformer "matching" is not used.

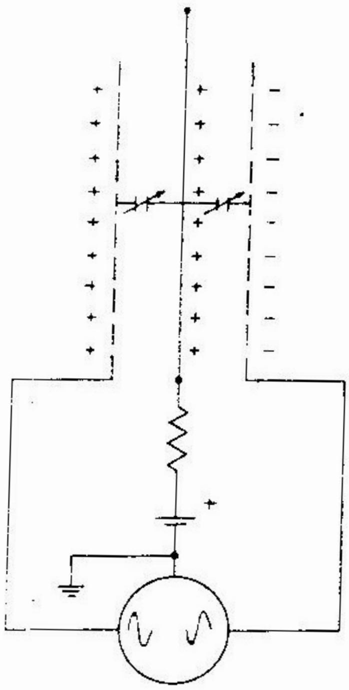


THE SERVO-CHARGE AMPLIFIER
Block Diagram

THEORY OF OPERATION

In order to understand the operation of the Servo-Charge amplifier, it is very usefull to have at least a rudimentary understanding of the load which it was designed to drive.

Acoustat uses what are referred to as <u>constant charge</u> electrostatic transducer panels in which the electrostatic "plates" are driven in a push-pull format and the driven diaphram is biased in such a manner that its electrostatic charge remains constant despite the application of high voltage audio signals to the electrostatic plates.



$C = q/V$

$J = CV^2/2$

$\vec{F} = \vec{E}q$

Where:
- C capacitance in farads
- V voltage in volts
- J energy in joules
- F force in newtons
- E electric field in newtons per coulomb *
- q charge in coulombs

newtons per coulomb and volts per meter are alternate units of measure of electric field

While we admit that the physics is not "obvious at a glance" we will, for the purposes of this amplifier service manual, simply state the electrical requirements to drive the electrostatic loudspeaker panels that we use at Acoustat Corporation and not dwell on the physics of electrostatic loudspeaker design.

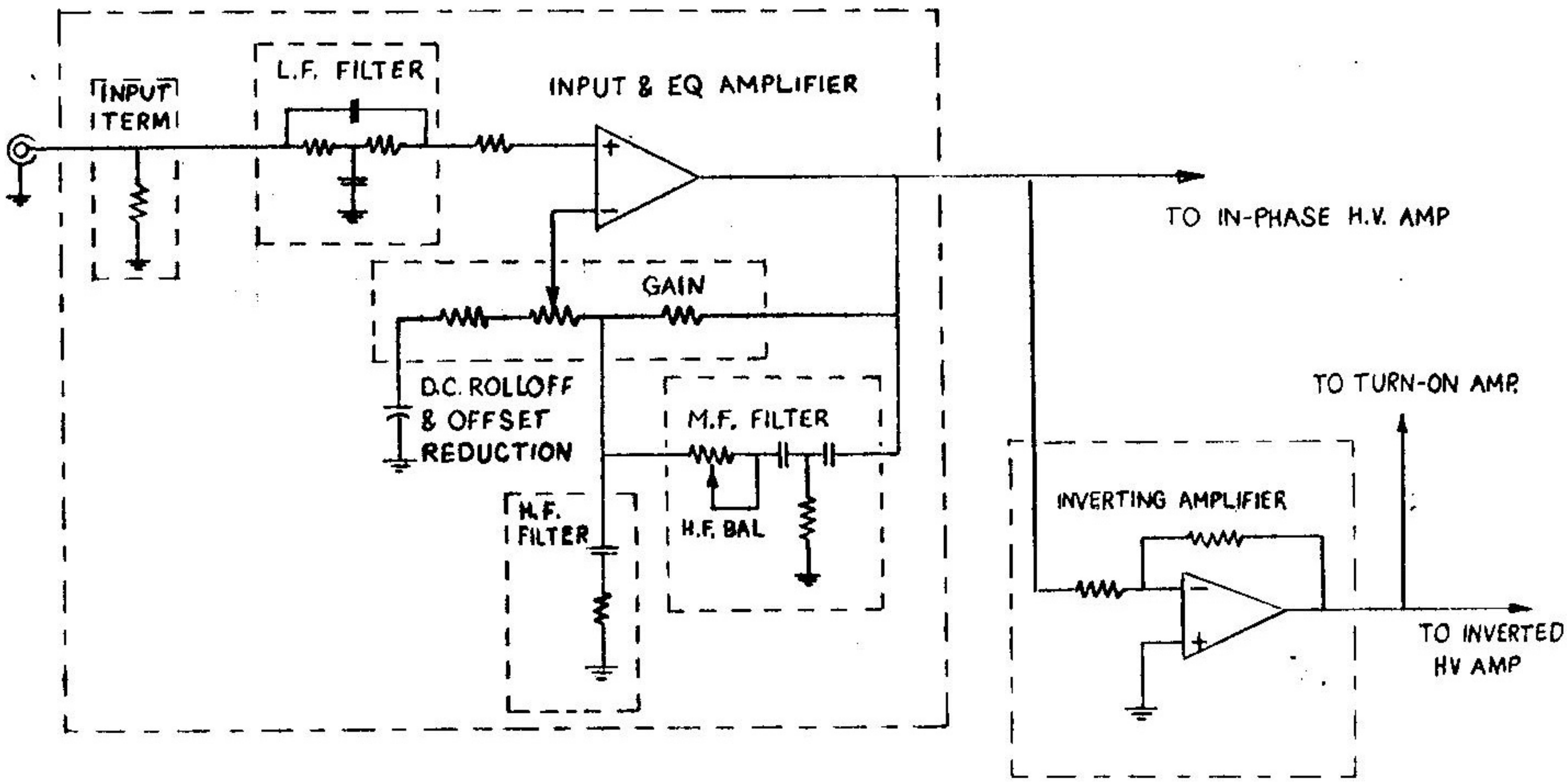
In order for the charge on the driven diaphram to remain constant despite its own physical excursions (it is the moving element used to excite the air and is analogous to the cone in a conventional speaker) and the electrical excursions of the electrostatic "plates" (we use insulated wire bonded to a plastic grid rather than perforated and insulated sheet metal for reasons of reliability and acoustic openness) it must be biased through a sufficiently high resistance that its charging time constant will be long compared to the period of the lowest audio frequency used and the DC offset of both plates must be nearly the same and sufficiently removed from the potential of the diaphram for proper biasing of the system to exist.

Within the Servo-Charge amplifier, we bias the diaphram through a 500 megohm resister to provide the proper time constant and capacitively couple the drive to the electrostatic plates so that their DC offset can be controled to near ground potential by the use of a resistor which is tapped to also act as a low voltage measuring point for testing purposes.

The above biasing situation results in a DC voltage differential of 4000 to 4500 volts between the diaphram and the plates. The plates are in turn driven with a maximum AC signal amplitude of 4000 to 4500 volts peak to peak. The front and rear plates, being operated in a push-pull format, are driven with equal amplitude but 180 degrees out of phase.

The use of constant charge transducer panels eliminates the second order (or square law) functions from the force equations so that the waveform used to drive the electrostatic plates is nearly identical to the waveform at the output of the first stages of the amplifier except for amplitude and is also nearly identical to the waveform at the input of the amplifier (from the preamplifier or tuner) except for amplitude and the equalization necessary for flat acoustic frequency response. The panels are also equipped with felt dampers on their rear sides to broaden and reduce the amplitude of the diaphram resonant peak so that it can be used in a controlled manner to improve the bass frequency response of the system.

The theory of operation of each specific portion of the Servo-Charge amplifier is as follows:


INPUT TERM
L.F. FILTER
INPUT & EQ AMPLIFIER
+
−
TO IN-PHASE H.V. AMP
GAIN
D.C. ROLLOFF & OFFSET REDUCTION
M.F. FILTER
H.F. BAL
H.F. FILTER
TO TURN-ON AMP.
INVERTING AMPLIFIER
−
+
TO INVERTED HV AMP

INPUT AND EQUALIZATION AMPLIFIER

This is the first stage of the Servo-Charge amplifier and is in operation in both the operating and standby modes of the amplifier. This stage amplifies and processes the signal from the preamplifier other audio source and drives the phase inverter and in-phase (rear plates of the speaker) high voltage amplifier.

The Input and Equalization Amplifier provides approximately 20 dB of gain at typical settings of the Gain control and includes the equalization networks and the HF Balance control.

R5 acts as the input termination and sets the input impedance of the amplifier.

R9, R10, C12, and C13 comprise the "wall effect" equalization network to smooth the base response of the dipole output of the speakers in the presence of an acoustically reflective rear wall. If the speakers are to be operated a considerable distance from a wall, or in "free air", this network can be effectively bypassed by the addition of 1/2 megohm resistor in parallel with C12.

C18, C19, and R18 comprise the midrange equalization network.

R15 and C17 comprise the high frequency equalization.

R16, R16A, and R17 comprise the High Frequency Balance control network and determine the relative contributions of the midrange and high frequency equalization networks.

R12, R13, and R14 comprise the overall gain control network and C15 acts to limit the DC offset of the stage by reducing the DC gain to unity.

In addition, on amplifiers prior to serial number 1700, a higher level input was provided which was designed to be driven by the speaker outputs of any tuner/amplifier on which a preamplifier was not provided. This provision was seldom utilized and was eliminated in the process of changing the main input provision from a DIN (RCA phono) jack to a 1/4 inch diameter telephone jack. This is a two conductor (mono) jack with only tip and sleeve connections.

If required in individual cases, the "receiver input" provision may be substituted for the preamplifier input on the later amplifiers by moving the tip connector lead from the telephone jack to the printed circuit board so that the input to the amplifier is the junction of R6, R7, and R8 rather than the junction of R5, R9, and C12--after installing R6, R7, R8, and C11 on the printed circuit board (R6 is substituted for the factory installed wire jumper in this procedure).

PHASE INVERTER

This stage is driven by the Input and Equalization Amplifier and is used to drive the Rectifier (or Turn-On) Amplifier and the inverted-phase (front plates of the speaker) high voltage amplifier.

This is a unity gain stage without equalization and should very seldom be the cause of any technical difficulty. The signal at pin 8 of the op-amp should be equal to, but out of phase with, the signal at pin 7 (output of the Input and Equalization Amplifier).

RECTIFIER (TURN-ON) AMPLIFIER

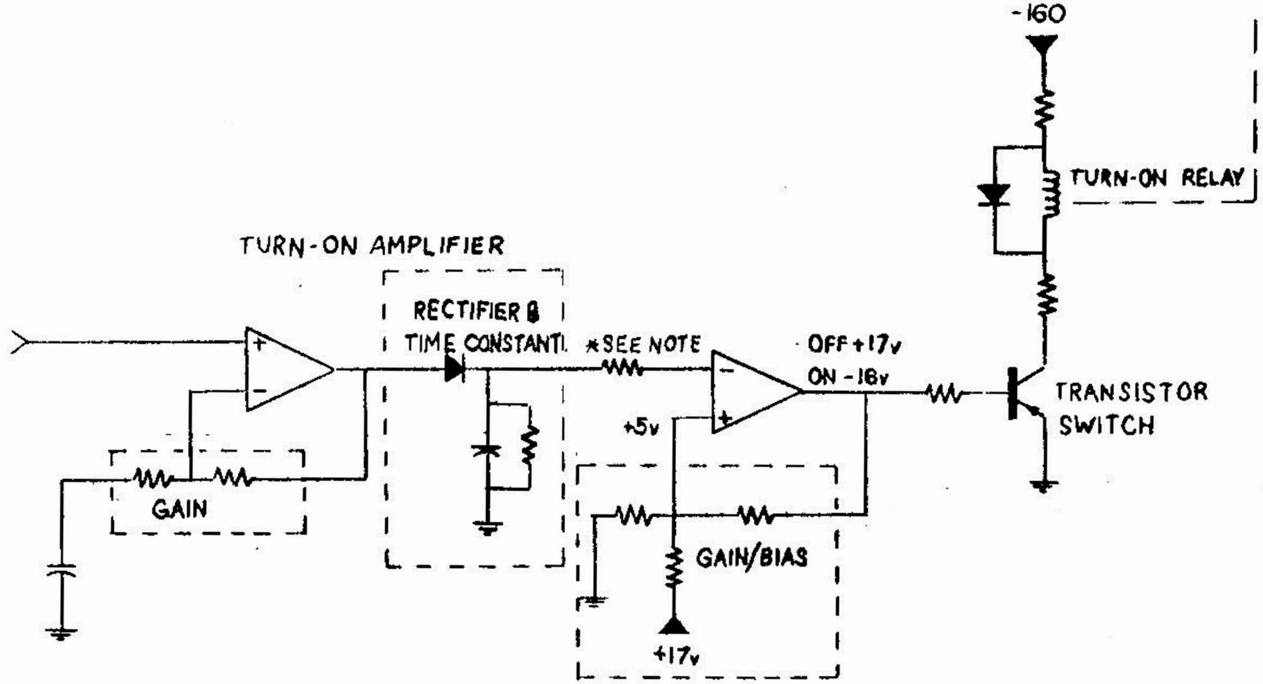
This is the first stage of the automatic "instant-on" circuitry and is driven by the Phase Inverter.

This stage provides up to 40 dB of gain throughout the audio range diminishing sharply to unity gain at DC for offset control. The full gain is available only for low signal levels since the stage is driven to clipping during moderate to loud passages; but the full gain must be available for small signals so that the amplifier will not tend to "turn-off" (or resume its stand-by mode) during quiet passages in musical selections.

Rectifier diode CR14 provides a DC signal to operate the Trigger Amplifier and the signal storage network composed of R26 and C21 provides a sufficiently long time constant to maintain the amplifier in its operating mode for 3 to 6 minutes (averaging about 5 minutes) after the cessation of moderate to high signal levels.

After amplifier serial number 1700, R25 is included in the circuit to slow the charging rate of the signal storage network to reduce the probability of "falsing" or turn-on due to a single transient pulse.

While difficulties involving this stage are not common, assembly errors have occurred and a complaint of premature turn-off (or turn-off during quiet passages in music) should lead first to a visual inspection of R23 and R24 for their correct values.



NOTE: INPUT PROTECTION FOR OP-AMP PREVENTS DAMAGE
DURING POWER FAILURE OR WHEN UNPLUGGED

TRIGGER AMPLIFIER

This is the switching portion of the automatic turn-on circuitry and is used to operate relay K1. Relay K1 is part of the power supply and controls the filament supplies and, through one of the filament supplies and a triac, the high voltage supply.

The Trigger Amplifier operates as a voltage comparitor and is referenced to the positive low voltage supply rail such as to cause an "off", or stand-by, state of the Servo-Charge amplifier. The amplitude of the reference bias is such that approximately five volts (positive) is required from the Rectifier Amplifier to force an "on" condition.

The gain of the system is such that approximately -15 dBv at the main input should result in an "on" condition when the Gain control of the Servo-Charge amplifier is at approximately the "nine o'clock" position.

DIAPHRAM BIAS

The diaphram (or diaphrams) of the Acoustat loudspeaker is biased from the high voltage supply through a 500 megohm resistor. Thus, the speakers are only biased when the Servo-Charge amplifier is "on".

OUTPUT AMPLIFIER

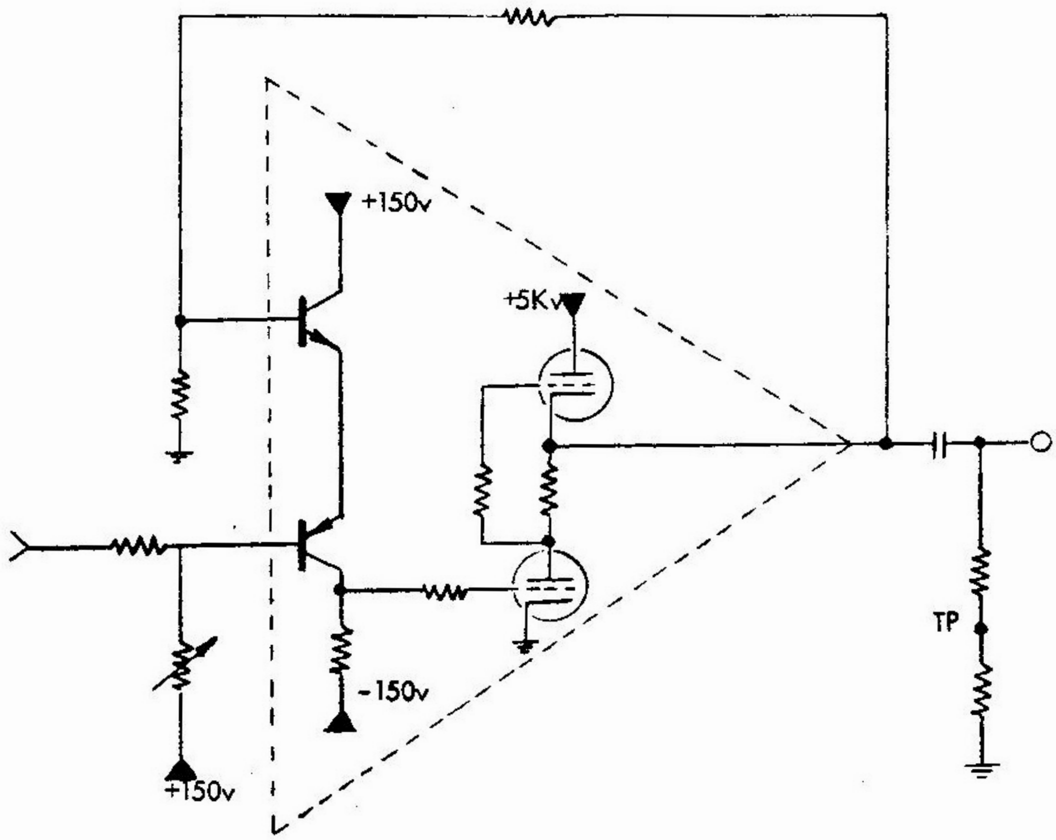
There are two Output Amplifiers which operate 180° out of phase so that the electrostatic plates of the Acoustat speaker are driven "push-pull". Each of the Output Amplifiers is a discrete hybrid op-amp operated with a gain of approximately 45 dB.

With the Gain control set at the "nine o'clock" position, a 7.5v RMS input signal at 1KHz will result in 4500v peak to peak signals at the electrostatic plates of the speaker.

The high voltage portions of the output amplifiers operate only when the Servo-Charge amplifier is in the "on" condition.

SIMPLIFIED SCHEMATIC

Discrete High Voltage Amplifier



POWER SUPPLIES

The power supply of the Servo-Charge amplifier can be thought of as having been divided into two principle parts. The 17 volt supplies and the 150 volt supplies operate at all times. The 5000 volt supply operates only in the "on" condition of the amplifier and the filament supplies are switched between two levels of operation--6 volts in the "on" condition and 3 volts in the "off" or stand-by condition.

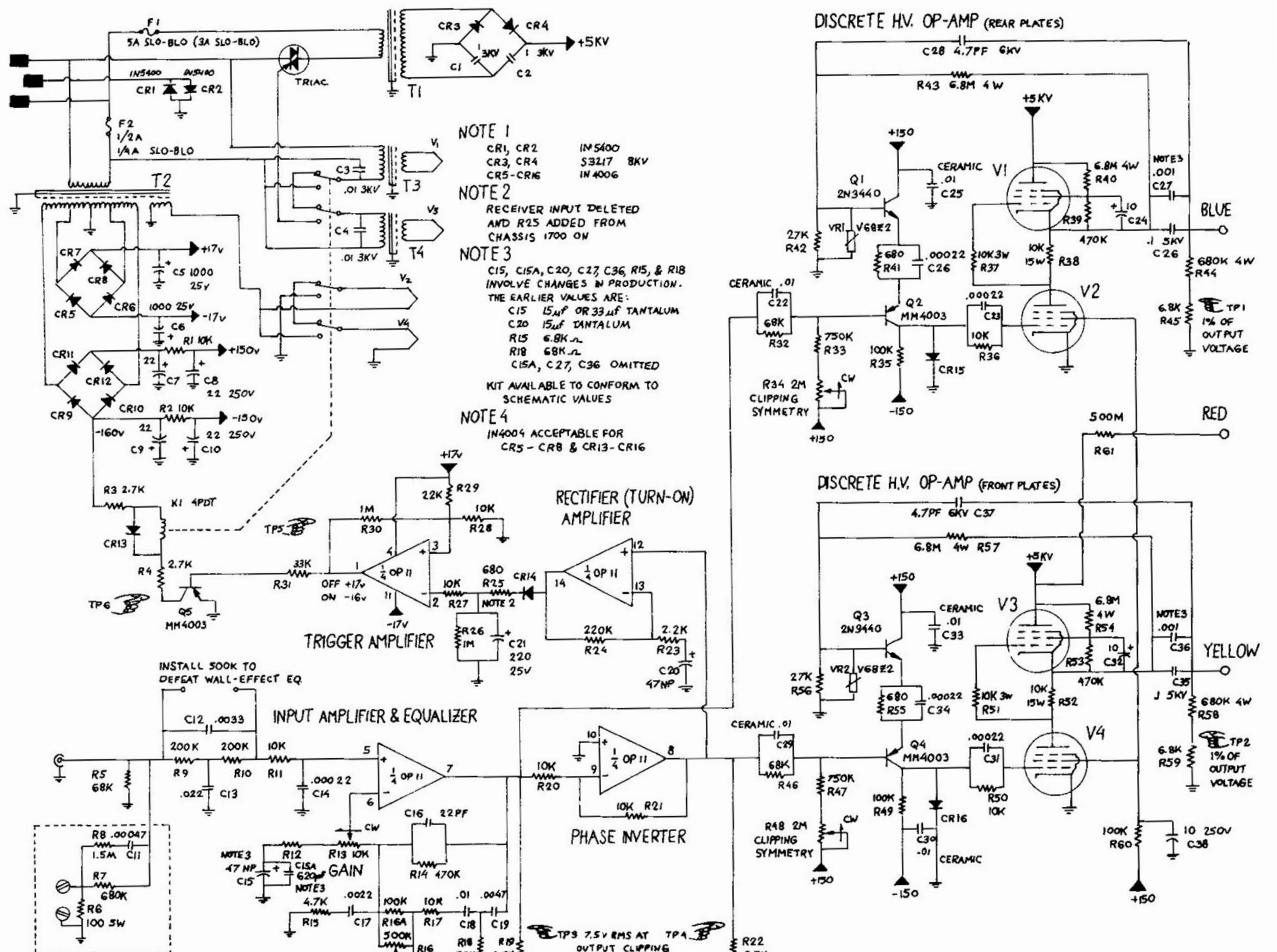
The positive and negative 17 volt supplies, the positive and negative 150 volt supplies, and the filament supplies for the two "lower" vacuum tubes are all powered by a single transformer with appropriately tapped secondary windings. The term "lower" vacuum tubes, in this case, maens the tubes with grounded cathode connections. The filament portion of this part of the power supply is switched between series and parallel operation for the "off" and "on" conditions of the amplifier, respectively.

Two separate filament transformers are used to provide the necessary cathode heater isolation for the two "upper" vacuum tubes and the primary windings of these two transformers are switched between series and parallel operation for the "off" and "on" conditions of the amplifier. In the "on" condition, the primary winding of the high voltage transformer is also supplied with power through the triac.

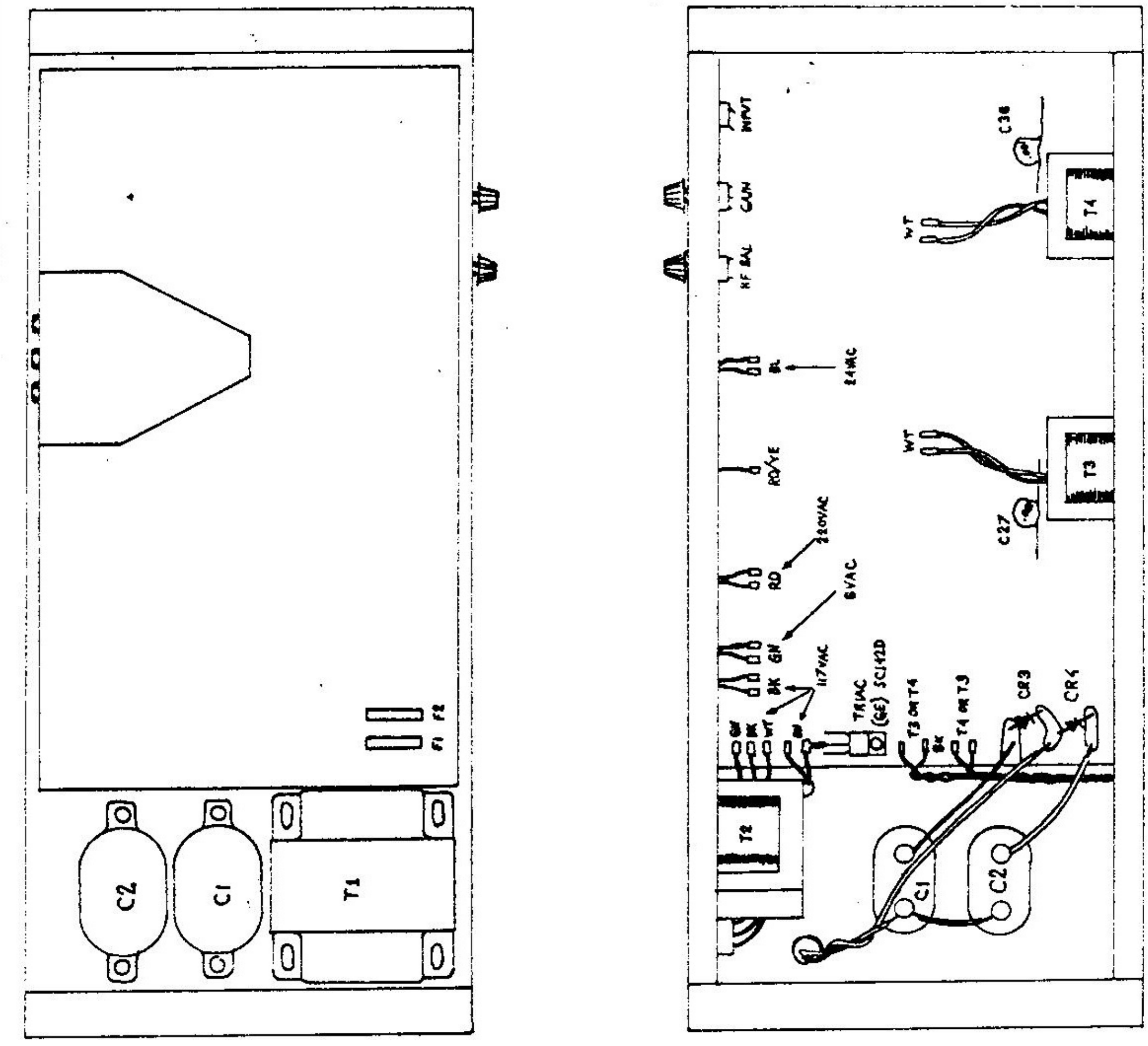
GROUNDING

To permit a solid connection between the chassis of the Servo-Charge amplifier and the chassis of the preamplifier or tuner, the Servo-Charge amplifier is "floated" away from power line ground by the use of two silicon diodes. These provide for an isolation of up to six tenths of a volt and preclude the occurance of the hums and buzzes which result from the slight potential difference between the various power outlets within a room.

It is essential, however, that the power supply ground also be used to prevent any buildup of static charges in the power supplies. Thus, THE THIRD WIRE GROUND MUST BE CONNECTED.



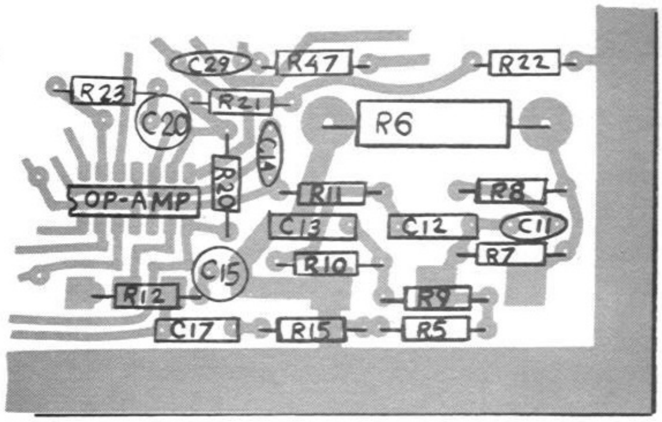
SCHEMATIC SC-X3 FEBRUARY 1979



CHASSIS ASSEMBLY CA-X3 FEBRUARY 1979

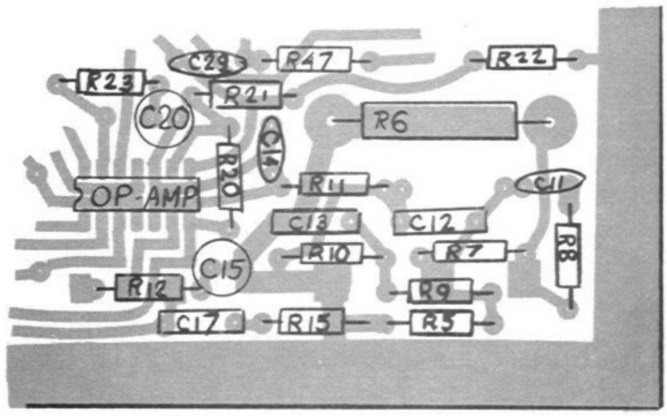
Input area of Printed Circuit

Thru s.n. 1699

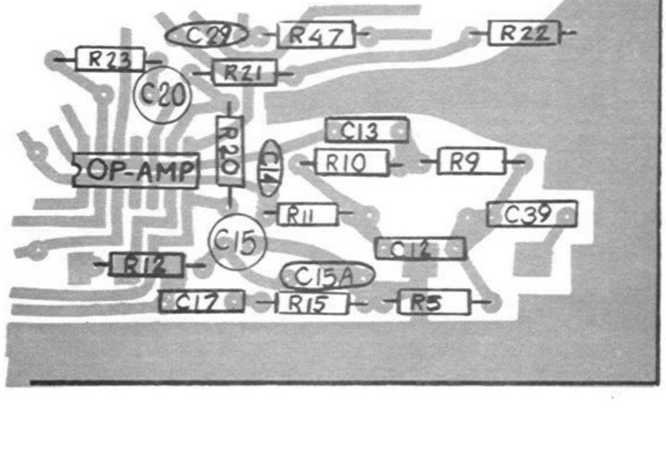


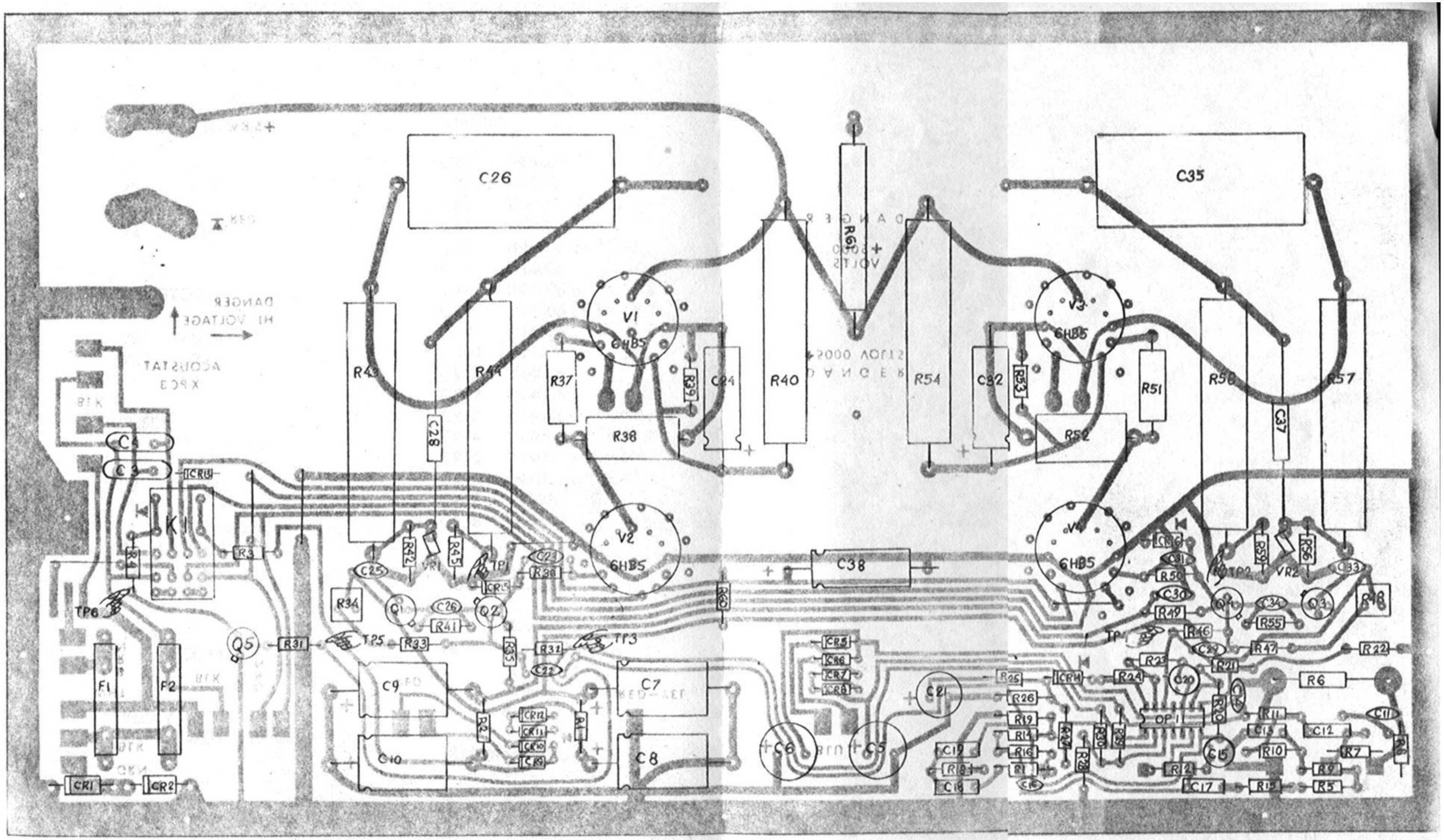
Thru s.n. 1899

R7, R8, C11 omitted and R6 jumpered as delivered by factory



From s.n. 1900





PRINTED CIRCUIT ASSEMBLY PC-X3 FEBRUARY 1979

PARTS LIST

VACUUM TUBES

V1	6HB5
V2	6HB5
V3	6HB5
V4	6HB5

VARISTORS

VR1	68Z2
VR2	68Z2

FUSES

	110v models
F1	5A Slo-Blo
F2	1/2A
	240v models
F1	3A Slo-Blo
F2	1/4A

TRIAC

SC142D

RELAY

K1	4PDT 120vdc

DIODES

CR1	1N5400
CR2	1N5400
CR3	S3217 8Kv/150ma
CR4	S3217
CR5	1N4006 or 1N4004
CR6	1N4006 or 1N4004
CR7	1N4006 or 1N4004
CR8	1N4006 or 1N4004
CR9	1N4006
CR10	1N4006
CR11	1N4006
CR12	1N4006
CR13	1N4006 or 1N4004
CR14	1N4006 or 1N4004
CR15	1N4006 or 1N4004
CR16	1N4006 or 1N4004
CR17	1N5384 150v zener
CR18	1N5384

TRANSFORMERS

T1	2Kv
T2	6.3v, 20v C.T., & 220v C.T.
T3	6.3v
T4	6.3v

TRANSISTORS

Q1	2N3440
Q2	MM4003
Q3	2N3440
Q4	MM4003
Q5	MM4003

CAPACITORS

C1	1 3Kv Oil filled
C2	1 3Kv Oil filled
C3	.01 3Kv Ceramic
C4	.01 3Kv Ceramic
C5	1000 25v
C6	1000 25v
C7	22 250v
C8	22 250v
C9	22 250v
C10	22 250v
C11	470pf
C12	.0033
C13	.022
C14	220pf
C15	47 Non-polar formerly 33 Tantalum, or 15 Tantalum
C15A	620pf Mica
C16	22pf
C17	.0022
C18	.01
C19	.0047
C20	47 Non-polar formerly 15 Tantalum
C21	220 25v
C22	.01 Ceramic
C23	220pf
C24	10 250v
C25	.01 Ceramic
C26	.1 5Kv
C27	.0001 6Kv
C28	4.7pf 6Kv
C29	.01 Ceramic
C30	.01 Ceramic
C31	220pf
C32	10 250v
C33	.01 Ceramic
C34	220pf
C35	.1 5Kv
C36	.0001 6Kv
C37	4.7pf 6Kv
C38	10 250v

RESISTORS

R1	10K
R2	10K
R3	2.7K
R4	2.7K
R5	68K
R6	100 5W
R7	680K
R8	1.5M
R9	200K
R10	200K
R11	10K
R12	4.75K
R13	10K Pot
R14	470K
R15	4.02K
R16	500K Pot
R17	10K
R18	56K
R19	2.7K
R20	10K
R21	10K
R22	2.7K
R23	2.2K
R24	220K
R25	680
R26	1M
R27	10K
R28	10K
R29	22K
R30	1M
R31	33K
R32	68K
R33	750K
R34	2M Pot
R35	100K
R36	10K
R37	10K 3W
R38	10K 15W
R39	470K
R40	6.8M 4W
R41	680
R42	27K
R43	6.8M 4W
R44	680K 4W
R45	6.8K
R46	68K
R47	750K
R48	2M Pot
R49	100K
R50	10K
R51	10K 3W
R52	10K 15W
R53	470K
R54	6.8M 4W
R55	680
R56	27K
R57	6.8M 4W
R58	680K 4W
R59	6.8K
R60	100K
R61	500M 2W

COMPONENT CHANGES IN THE SERVO-CHARGE AMPLIFIER

	CURRENT	FORMERLY	REASON
CR9 - CR12	1N4006	1N4004	Mandatory for adiquate PIV for all conditions
C22	.01 Ceramic	.01 Mylar	Transient response
C25	.01 Ceramic	.01 Mylar	
C29	.01 Ceramic	.01 Mylar	
C30	.01 Ceramic	.01 Mylar	
C33	.01 Ceramic	.01 Mylar	
C27	.001 6Kv	Omitted	
C36	.001 6Kv	Omitted	
R25	680 ohms	Omitted	Slower turn-on to reduce falsing
C15	47 Non-polar	15 or 33	Mandatory due to deformation
C15A	620 pf	Omitted	of Tantalum capacitors
C20	47 Non-polar	15	
R18	56K ohms	68K ohms	Increase "warmth"
R15	4.02K ohms	6.8K, 4.75K	Increase "air"
IC	uA 774	OP-11 TL-084 HA-4741-5 LF 347	

Some or all of the above are installed on nearly all amplifiers currently in service and all are available for installation on all amplifiers.

R6	Jumper	100 5W	Receiver input deleted
R7	Deleted	680K	after SN 1700
R8	Deleted	1.5M	
C11	Deleted	470 pf	

From SN 1700 through SN 1895, although an amplifier can not have both standard and receiver inputs, in can be converted to have a high level (receiver) input instead of the standard line level input.

TROUBLESHOOTING

Section 1

The Acoustat Servo-Charge Amplifier is designed for years of trouble-free operation. To insure continued reliability the following suggestions are made:

1. Connection or disconnection of audio cables within the system must always be made prior to connection of the amplifiers to the AC outlet. This will prevent possible thermal runaway of the vacuum tubes.
2. Do Not, under any circumstance, exceed the rating of either fuse should replacement become necessary.
3. Do read the section on proper grounding of the audio system.
4. Tubes should be replaced after about one, to one and one half years of average use. Exceeding this life expectancy will most likely result in decreased sonic properties and degradation of high frequency response. A weak tube could fail completely and cause overheating of the grid biasing resistors. The sound will be distorted accompanied by a drop in volume and a tube will usually glow bright red. Zener diode protection has been employed to guard this condition. Should this occur, AC power should be removed as quickly as possible. Refer to Section 2.

Section 2

The purpose of this section is to assist the user/technician in determining the cause of a malfunction and eliminating it. When using the troubleshooting charts, it may be necessary to refer to the schematic and parts layout diagrams. The Acoustat Technical Staff is available to answer questions pertaining to service and to assist in obtaining replacement parts. The AC line cord should be disconnected to prevent dangerous electrical shock, when attempting repairs to the amplifier. All transistors, the integrated circuit device, relay, and 10k 15watt resistors have been installed in sockets to simplify replacement.

SYMPTOMS	CAUSE	CURE
VI or V3 glows red. Sound is distorted, weakened. or Tube explodes or cracks. also 5 amp fuse may be blown.	A tube has failed, usually V2 or V4, causing the "good" tube in the pair to pull full current and glow red.	Replace both VI and V2 or V3 and V4 Replace the 10k 5w resistor (R37 or R51) and 10k 15w resistor (R38 or R52) closest to the bad tube, or check with an ohmeter. The zener diode, if used, should also be checked/replaced. Check the 5 amp fuse and replace if necessary.
5 amp fuse blows	Shorted high voltage transformer or Shorted high voltage diode	Remove AC power: You are about to operate on the high voltage section! Determine if the transformer is shorted by disconnecting the red secondary lead from the circuit board. Place a piece of tape over the exposed end of the wire. Install a fresh 5 amp fuse, connect to AC outlet, and apply input signal for turn on. If fuse blows at this time, replacement of the high voltage transformer is indicated. If the fuse does not blow, check or replace the high voltage diodes (located under the circuit board) observing correct polarity, reinstall a new 5 amp fuse, and reconnect the red wire to the circuit board.
1/2 amp fuse blows	Shorted diode in 150 volt bridge	Check/Replace CR9, CR10, CR11, CR12. Replace 1/2 amp fuse--Do not overfuse, as this will cause the small power transformer to burn up under shorted conditions.

SYMPTOMS	CAUSE	CURE
Unit shuts down to standby, but comes back on immediately. or Unit will not shut down to standby mode. or Unit will not turn on from standby.	Defective I.C. or Arcing tube Defective I.C., Q5 Transistor or bad Relay	A defective integrated circuit can cause this problem. The OP-II device was found to be particularly prone to this rare problem. An arcing tube can also affect proper operation of the turn on circuitry. The offending tube will usually arc at the shutdown to standby point and bring back the amplifier to the full on condition. This tube can sometimes be spotted in a darkened room. The simplest solution is to replace all four tubes.
White noise in background below level of music	Leaky 2N3440 (QI,Q3)	Be sure the noise isn't originating upline in the preamp or elsewhere by removing the input to the servo charge amplifier. If noise persists replace QI or Q3.
Amp distorts, weakened output sometimes accompanied by a low level hum.	Defective Q2,Q4, QI or Q3 transistor	Check/Replace defective transistor.
Intermittent drop in volume, about 50%, accompanied by low level hum.	Intermittently open junction mm4003 transistor(2N5416 on later units)	Replace Q2 and Q4
Unit turns on from standby due to AC line surges-sometimes induced by an air conditioner,flourescent lights etc.		Earlier production amplifiers are sometimes found to do this. Eliminate the problem by installing a 680 ohm resistor in series with the cathode (banded end) of CRI4. This resistor is factory installed beginning with s/n 1700.

SYMPTOMS	CAUSE	CURE
Amp shuts down to standby mode after 10-15 minutes of play. Input signal is still present.	Defective CR14 Diode opens when heated by nearby tube V4.	Replace CR14 (In4004 or In4006)
Loud intermittent hum	Bad connection at input strip	Check for clean, tight ground connection at input jack of the amplifier and at the output jacks of the preamplifier. A poorly soldered plug on an input cable will also cause this problem.
Constant or intermittent hum		Check and resolder bad connection on C5 or C6 1000 uf @ 25 v (3300 uf on later units)
Violent purple arcing inside V1 or V3	Intermittently shorted filament transformer T3 or T4	Replace the filament transformer associated with the arcing tube.
Waveshapes o.k. at test points 1 and 2, When amp is connected to speaker output is very weak.	Open R61 500 megohm resistor	Check or replace R61 500 megohm resistor
Popping Crackling	Arcing tube or Defective R43, R57	Bad tube will usually show visual arc. If popping occurs after considerable on time, replace R43 and R57 6.8 megohm resistors.