TANDBERG TAPE RECORDER
MODEL 5
Service Manual
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MODEL 5

1. TECHNICAL DATA

MODEL 5 STEREO QUADRIPEL

**Line Voltage:** 110 — 125 — 145 — 200 — 220 — 245 volts, 50 c/s (60 c/s).

**Power Input:** 75 watts.

**Tubes:**
2 x 6PD6, 2 x ECC81, 2 x EL84, 6BH7 and Selenium Rectifier 100 mA, 250 volts. 2 low voltage Selenium Rectifiers.

**Recording Tape:** Red oxide tape. Maximum reel diameter is 7".

**Tape Speeds:**
- 7 1/2", 3 3/4" and 1 1/2" per sec.
- The recording amplifier as well as the playback amplifiers are individually equalized, so that for all 3 speeds the equalizer corrections will conform to the NAB/F standard. (The Recorder may also be equipped with an amplifier correction up to the CEC standard.) This allows the Recorder to play back stereo tape recorded on 3 3/4" and 1 1/2" per sec.
- Speed changer: 1/5 or for all speeds at correct line frequency and voltage 50 c/s 220 V (60 c/s 110 V).

**Heads:**
- Quadriple erase head: 2 x 80 mm. quadruple.
- Record-playback head: Spectral made in line stereo quadruple.
- Head gap: .0086 inch.
- The Recorder will play back four track and two track stereo and monaural tapes as well as tapes recorded according to the former European Standard. The in-line alignment of the heads is such that when playing both tracks, one may use both heads.
- The Recorder can record four track and two track monaural, and also two track according to the former European Standard. In combination with the Stereo Record Amplifier for Model 6 the Recorder can record two track and four track stereo.

**Playing Time:**
Four track recording on 1200 ft. of tape gives the following playing times:
- Tape speed of 7 1/2": 2 x 32 min. stereophonic 4 x 32 min. monaural.
- Tape speed of 3 3/4": 2 x 44 min. a 4 x 44 min. a
- Tape speed of 1 1/2": 3 x 128 min. a 4 x 128 min. a

**Path of Tape:**
The tape moves from left to right. The heads are positioned with the gaps towards the front. Recording takes place on track 1 and track 3.

**Fast Forwarding:**
- Takes about 3 min. in either direction, without wearing the heads.

**Controls:**
- Combination playback and record-level control. Double potentiometer with a double knob with mutual friction and dial which makes it possible to regulate the two amplifiers simultaneously or individually.
- Speed Change Switch 7 1/2", 3 3/4", 1 1/2".
- Mono-Stereo Switch.
- Bas Switch equals both amplifiers simultaneously in playback position only. Mode Switch for recording, playback and push-wide.

3
Lever Control for start, stop, forward and rewind.

As an extra equipment recorder for 110V 60Hz are equipped with a Ceramic Full-

wave Power Output Switch which makes it possible to bypass the power output stage

when using external power amplifiers. Stereo Monaural Switch (located under the

level control knob) gives the following possibilities:

1. Mono Switch in pos. RECORD:

   a) Pos. STEREO: The upper track amplifier operates as a normal recording
      amplifier. The lower track amplifier is disconnected. The arm head gets
      same current as both head thieves and will erase track 1 and 2 (or 4 and 2).
      Simultaneously, this combination of switch positions may therefore be
      used when recording stereo.

      Stereo recording is only possible when plugging in the Stereo Record Amplifier.

      In the setup the lower part of the record-playback head will get less current
      through contact in the plug, signal current from the Stereo Record Amplifier
      and the Recorder will record 4 track stereo. The program on track 1 (or 4)
      comes from the inputs on the Recorder itself and is controlled by the potenti-
      meter connected to the large knob on the gain control. The program on track
      3 (or 2) comes from the input on the Stereo Record Amplifier and is controlled
      by the gate control at the Stereo Record Amplifier.

      The magic eye on the Recorder acts as a recording level indicator for track
      1 (or 4), the magic eye at the Stereo Record Amplifier acts as a record level
      indicator for track 3 (or 2). When recording stereo, please remember that
      according to the standard the left hand program shall be recorded on the upper
      track. Also check that the speed selectors on the Stereo Record Amplifier and
      the Recorder are placed in the same position. The Recorder is in combination
      with the Stereo Record Amplifier is capable of recording 4 track stereo at
      7 τ, 8 τ, 9 τ, 10 τ and 11 τ, up to with the same quality as described for monaural
      recordings.

   b) Pos. MONAUR: The upper track amplifier operates as a normal recording
      amplifier for track 1 (or 4). The gate is controlled by the potentiometer con-
      nected to the large knob. The lower track amplifier is connected as a power
      amplifier for the recorded program. The gate is in the extra amplifier is con-
      trolled by the potentiometer connected to the small knob.

   c) Pos. EXTRAV: The upper track amplifier operates as a normal recording
      amplifier for track 3 (or 2). The gate is controlled by the potentiometer con-
      nected to the large knob. The lower track amplifier is connected as a power
      amplifier for the recorded program. The gate in the extra amplifier is con-
      trolled by the potentiometer connected to the small knob.

2. Mono Switch in pos. PLAYBACK:

   a) Pos. STEREO: Each amplifier is connected to the individual two head thieves,
      ready for playing back stereo tapes, two tracks or quadraphile. The level control
      simultaneously or individually controls both amplifiers.

      The double-potentiometer is adjusted so that the amplification in the two
      amplifiers never deviate more than 2 dB from each other. Differences in
      tape, external amplifiers or loudspeakers can be compensated by turning the
      large knob relative to the small knob.

   b) Pos. MONAUR: Both amplifiers coupled to track 1 (or 4) and the gain of
      the two amplifiers may be controlled individually or simultaneously.
c) Pana-EXTRA: Both amplifiers coupled to track 3 (or 2) and the gate of the two amplifiers may be controlled individually or simultaneously.

2. Mode switch is in pos. PUBLICATION.

a) Pana-STEREO: The two amplifiers are connected to the stereo pick-up inputs. The sensitivity across the stereo input is approx. 13 mV for 3.5 watts across the output transformer. The frequency response flat.

b and c) Pana-MONO/4 and EXTRA: Both amplifiers connected to the ordinary inputs and the gate of the amplifiers may be controlled individually or simultaneously.

| Frequency Response of Record-Playback | Flat within ± 2 db from 20 to 16 000 c/s, from 40 to 10 000 c/s and from 70 to 5 000 c/s for the 7-1/2, 3-1/2, and 1-1/2 speed respectively.
| Distortion and Noise Level: |
| Wow: | Better than 0.15 % at 7-1/2 ips tape speed.
| | Better than 0.2 % at 3-1/2 ips tape speed.
| | Better than 0.5 % at 1-1/2 ips tape speed.
| | Wow is defined as the r.m.s. value of frequency deviation to one side in percent of the signal frequency, when a constant signal is recorded and played back. The peak to peak value is 2.8 times greater.
| Input: |
| Microphone 5 Megohms. |
| Because of the high impedance input, the loss due to the input impedance is below 3 db at 20 cycles when using the Tandberg TMD microphone. Sensitivity of microphone — 1.5 millivolt, for maximum recording level at 1000 cycles.
| Phone or radio input (5 Megohm) with provision for simultaneous use of two inputs for mixing.
| Phone or radio sensitivity — 75 millivolts.
| Input for stereo plug-in. Sensitivity when used as stereo disc amplifier 15 mV for full power output (2 ± 3.5 watts).
| Microphone: |
| Crystal microphone-insulated for rugged use. Response — 20 to 13 000 cycles ± 3 db.
| Noise and Bias Frequency: |
| Even harmonic distortion in high frequency bias current is below 0.5 %.
| Record Amplifier: |
| Distortion at maximum recording level — below 1 %. The electronic magic eye maintains its sensitivity corresponding to recording current to 10 000 cycles (with sodium rectifier and damped backward movement). Electronic eye take range is 36 db, plus overload.
| Record Level Indicator: |
| Distortion at maximum recording level — below 1 %. The electronic magic eye maintains its sensitivity corresponding to recording current to 10 000 cycles (with sodium rectifier and damped backward movement). Electronic eye take range is 36 db, plus overload.
| Playback Amplifiers, Frequency Response: |
| Two identical playback amplifiers, matched to the heads give a frequency response when playing back a NABTEB standard tape to within ± 2 db at all recorded frequencies. |
### Playback Amplifier

**Gain:**
The double potentiometer and its gain of the amplifiers are matched to give a maximum difference in output voltage when playing back full track tape of 2 dB in the range from 5 to 25 kHz.

<table>
<thead>
<tr>
<th>Playback Amplifiers</th>
<th>Output &amp; Distortion</th>
<th>Distortion below 1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>At 1000 cycles:</td>
<td>1.6 watts (3.5 volts)</td>
<td>Distortion below 1%</td>
</tr>
<tr>
<td></td>
<td>2.5 watts (3.5 volts)</td>
<td>Distortion below 1%</td>
</tr>
<tr>
<td>At 50 cycles:</td>
<td>1 watt (2 watts)</td>
<td>Distortion below 1%</td>
</tr>
<tr>
<td></td>
<td>1.5 watts (3.5 volts)</td>
<td>Distortion below 1%</td>
</tr>
</tbody>
</table>

Effective source impedance of playback amplifiers is less than 1 ohm, negative feedback about 15 dB. (Matched load impedance — 4 ohms.)

Because of low output impedance and high degree of negative feedback with corresponding low distortion, the output can be fed into any Hi-Fi amplifier, regardless of input impedance, with no loss in frequency response or quality.

Frequency response when used as PA amplifier — ± 2 dB, 40 to 30,000 cycles.

**Monitor Speaker:** Goodness, 5 in. or 7 in.
The monitor speaker may be switched to the upper track amplifier, the lower track amplifier or neither.

**Clock-Counter:**
(Similar to an ordinary clock dial), Each hour (by hour-hand) shows 100 revolutions of tape speed; each minute (by minute-hand) shows 5% revolutions. Location and length of recording is designated as time on a clock (e.g., 2:12 to 2:15).

**Automatic Stop:**
Possible on tape which has the necessary metal coating at beginning and end of the reel.

**Stereo Recording:**
Equipped with connectors for SStereo Record Amplifier for Model 5a.

**Dimensions:**
Rise grain mahogany cabinet, 15 1/4" long, 11 1/2" wide, 6 1/2" high.

**Weight:**
Instrument alone 27 lbs., with carrying case 32 lbs.
2. ALTERATIONS COMPARED WITH MODEL 3 STEREO

The tape transport is exactly like the tape transport in the Model 3 Stereo. The alterations therefore are limited to the heads and the electrical circuitry. This description is based on the Service Manual, Model 3 Stereo, and references to this are abbreviated to 5MA.

<table>
<thead>
<tr>
<th>TRACK</th>
<th>DIMENSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 1.

3.1 The Quadraphonic Track Standard.

Fig. 2 shows the quadraphonic track standard, seen from the head. The double track head makes contact with tracks 1 and 3. By turning the knob over, the track 4 and 2 will come in contact with the head. By means of the STEREO — MONOaural — EXTRA — switch, the desired track (or tracks) is selected. The record-playback head gaps are .0012" and .0016". The width of the record-playback head corresponds to the track width, and the inductance of each head half is approx. 4—1 nH.

The erase head is also a double head and the STEREO — MONOaural — EXTRA — switch also selects the erase head so in all positions of the switch the contact track (or tracks) is erased. The depth of the erase head is .002". The gap, .012", and in the index track, approx. 15—35 nH.

3.2 Alterations in the Electrical Circuitry.

3.2.1 The Bias and Error Current Circuits.

The introduction of the quadraphonic standard with its possibilities for four track monaural and stereo recording has made some changes in the oscillator circuit. The EL34 in the upper track amplifier is an electron-coupled oscillator with the tank circuit L3—C7 and the plate circuit L2—C9 tuned to 66 kHz. See 5MA, sec. 4.2.1.

The bias and error circuitry is, however, completely changed. From the plate circuit the H.F. current is fed to contact 53 in the stereo switch via condenser C20—100 µfd and the second harmonic suppressor circuit L4—C22. From contact 53 in the stereo switch, the H.F. voltage is fed to the two erase heads via contacts 53 and 54 dependent on the position of the stereo switch. Because of the switching between, the upper and lower erase heads, it is not possible to obtain the band-filter coupling used in the former models. The erase heads here is a resonant frequency slightly above the erase frequency. In stereo position the two heads are coupled in parallel directly across the plate circuit (C20) and the combination of the two erase heads and plate circuit is tuned by the erase by the condenser L6 in L3. Disconnected one head will slightly distort the circuit, but at the same time the head will decrease, the result being opposite, the erase voltage across the erase head. This voltage should be 160—215 volts.

The fact that it is not possible to maintain the band-filter coupling in this model will increase the second harmonic distortion in the erasing and bias voltage. To avoid this, a second harmonic suppressor circuit is inserted, which brings the second harmonic distortion well below 1% in all combinations of erase heads connections. To adjust this, it is necessary to have a tuned variable meter set at the second harmonic (132 kHz) and have the circuit to erase, second harmonic voltage.

The H.F. recording bias for each track is taken from the corresponding erase head via C10 and C110. The wiring for the bias and signal currents is as follows:

1. Upper head in position MONOaural and STEREO.

From the upper erase head through C10—100000 µfd and R21 to contact 53 in the stereo switch R21 is a variable resistance potentiometer and should be adjusted to give 4 to 4.5 mV bias current (4 to 4.5 volt across 1000 ohms in series with the upper head). With the stereo switch in position STEREO and MONOaural, contact 53 makes contact with 522 and at this point the signal current from the recording amplifier in the
tape recorder is injected. The bias and the signal are then fed to the upper head via contacts R3L, R3L, in the mode switch and contacts 514—513 in the stereo switch. In position EXTRA the bias route to the upper head is broken at external points, and the contact 511 is grounded via 514—513 and 515. This is done to avoid leakage of bias current to the upper head in this position.

2. Lower head in position EXTRA.

From the lower inner head the bias current goes through C180—001233, J1 and J11 to contact 511 in the stereo switch. R18 is a variable potentiometer and should be adjusted to give 4 to 45 mA bias current (4 to 45 volts across 1000 ohms in series with the lower head). With stereo switch in position EXTRA 511 makes contact with 523 and at this point the signal current from the built in record amplifier is injected. The bias and the signal current is then fed to the lower head via contacts R3L, R3L, in the mode switch and 514—513 in the stereo switch. In position MONORAURAL the bias routes for the lower head is broken at different points and the contact 511 is grounded via 514—513 and 515 for the same reason as expounded above.

3. Lower head in position STEREO.

From the lower inner head the bias current goes through C198 (90221, 2) and R113 (90—100 KQ) to contact 2 in socket in the rear trim cover R113, is a fixed resistor and adjusted to give 4 to 5 mA bias current through lower head. The adjustment of the bias current for the lower head had to be done separately in STEREO position because the capacitance of the head differs considerably from the head impedance in position EXTRA. When the plug from the external record amplifier is inserted in the socket, the contacts 1—3 are shorted, and simultaneously the signal current from the external record amplifier is injected. From contact 3 in the socket the bias current together with the signal current is fed to the lower head via contacts 517—513 in stereo switch.

2.2 The Recoupling of the Record Playback Heads.

The switching of the record playback head in RECORD position is completed in the stereo sec. (if playback the mode switch is in its mid position and the connections between head and tube are again determined by the stereo switch.

a) STEREO position: The upper head is connected to the EBD4 in the upper track amplifier via contacts 513—514 in the stereo switch, and contact R3L, R3L, and R3L, R3L, in the mode switch. At contact R3L, the equalization switch is connected. This switch couples condensers across each head to give a moment peak which compensates for the playback losses at 1/3 ips and 3/4 ip. There is no condenser at 1/3 ip because the resonant frequency of the head and the wiring capacity gives the proper compensation at 1/3 ip. Contact R3L, is grounded to reduce cross talk and to increase the stability of the amplifiers. The lower head is connected to the EBD4 in the lower track amplifier via contacts 517—513 in the stereo switch, and contacts R3L, R3L, in the socket at the rear trim cover. These socket contacts are shorted when the plug from the external record amplifier is not inserted. At the grid of EBD4 the equalization switch is connected and works in the same manner as described for the upper head.

b) Position MONORAURAL. The upper head is connected to the EBD4 in the same way as in position STEREO. The connection between the lower head and the EBD4 in the lower track amplifier is broken by 517—513 and the grid of EBD4 is grounded by 517—513 via 844—844 (each 10 ohms).

c) Position EXTRA. The upper head is disconnected from the EBD4 in the upper track amplifier because 513—514 is opened. The lower head is connected to the EBD4 in the upper track amplifier via contacts 517—514 in the stereo switch and contacts R3L, R3L, and R3L, R3L, in the mode switch. The lower head takes then the place of the upper head and uses the equalization circuits of the upper track amplifier.

The interconnections between the two amplifiers in PLAYBACK — RECORD and PUP ADD, work in the same manner as in the Model 3 Stereo. In PLAYBACK both amplifiers are connected to the same track in MONORAURAL and EXTRA.

When recording in MONORAURAL and EXTRA position, the lower track amplifier works as a monitor amplifier for the recorded program. In PUP ADD both amplifiers are connected to...
the inputs in MONO/STereo and EXTRAN. In PUB, AUDOR and STEREO see sec. 2.2.5 Stereo Amplifier Input.

The switching between the two amplifiers is done after the two potentiometers. It is therefore possible to regulate the output of the two amplifiers individually in all combinations. The coupling lends the the plate of 50öY in the upper track amplifier with two 5 Meh potentiometers in parallel in both RECORD and PLAYBACK position in MONO/STereo and EXTRAN, while in STEREO it is loaded with only one potentiometer. This means that the frequency response in record-playback differs approx. +0 db at 3.5 kHz for STEREO in MONO/STereo — EXTRAN. The equalization is therefore adjusted to give approx. — 3 db at 30 kHz in STEREO position.

2.2.3 Equalization Curves.

The decrease in gap width has made it possible to change to 100 l.s playback equalization curve at 3½ ips and 200 l.s at 7½ ips and yet increase the frequency response. The rederiving of the lead together with the two potentiometers 921 and 921B has reduced the Q value of the head and decreased the resonance peak both in playback and recording. The decrease in Q value is wanted in playback because the reduced gap reduces the playback level. To obtain correct reproduction in recording position, a resonant circuit (C3—C2) is placed in the cathode of the first electrode of ECC83 and is tuned to approximate 9,000 c/s at 7½ ips, 6,000 c/s at 3½ ips, and 3,000 c/s at 1½ ips respectively. By means of the ears in LS mixers connected at the high frequency response can be made. Fig. 3 and 4 show the frequency response of the record and playback amplifiers at different speeds. Fig. 5 shows the total frequency response of the Recorder.

2.2.4 Muting Switch.

In NEUTRAL and in both FAST WINDING positions the amplifiers are muted by grounding the tops of the potentiometers. These groundings are made by the muting switch situated underneath the upper recording plate. The muting takes place in the following manner: The plate of the EF84 tube in the lower track amplifier is grounded after G6 via contacts M4—M4 in muting switch and mutes the amplifier in the STEREO position. This plate is already muted via contacts M2—M2 in the mode switch and contacts SQL—SQL in the stereo switch in positions MONO/Stereo and EXTRAN and extra 4NIs. The muting of the upper track amplifier in position STEREO and both amplifiers in positions MONO/Stereo and EXTRAN is done by contacts M4—M4 in the muting switch and contacts L1—L1 in the mode switch. In positions RECORD and PUB/AUDOR the muting switch has no effect whatsoever.

On the first version the muting of the upper track amplifier was done directly on the head via contacts H1—H1, in the mode switch and contacts M4—M4 in the muting switch. On those recorders the upper track amplifiers are more noisy when muted, because noise generated in the first tuba, is present. These recorders may not be changed because the muting of the plate of EF84 in the upper track amplifier requires changing of the mode switch.

2.2.5 Stereo Amplifier Input.

To permit playback of stereo discs through the two amplifiers or to use the recorder as a stereo power amplifier for other program sources, a stereo amplifier input is introduced. With the mode switch in position PUB/AUDOR and the stereo switch in position STEREO the potentiometer in the upper track amplifier is connected to the socket marked Stereo Amplifier Input via contacts S16—S19 in the stereo switch and contacts L1—L0 in the mode switch. The potentiometer in the lower track amplifier is connected to the socket via contacts L0—L1 in the mode switch and contacts S18—S19 in the stereo switch. The potentiometer in the lower track amplifier is connected to the grid of the ECC83 tube in the lower track amplifier via contact 1—1, in the mode switch. The gain of the two amplifiers from the top of the potentiometers is approx. 250 times or 46 db. For full amplifier output (2 X 3 watts) it is necessary to have 15 mV in the Stereo Amplifier input socket.

2.3.6 Power Output — Cathode Follower Switch.

On special request some of the Model S have been equipped with a Power Output — Cathode Follower Switch. This switch makes it possible to bypass the two EF84 and the output transformer, when extra power amplifiers are used. The lower for the switch is situated on the rear left of the recorder in
the slit between the top plate and the wooden case. It functions as follows:

1. In position Power Output the two amplifiers function as described in S.M.

2. In position Cathode Follower the shorting of 1N68 and 6N8 P in the cathode of the second triode of the ECC87 tube is open at contact PO—CF 17—18 and contact PO—CF 6—7. Simultaneously, 1N7 and 56A are shorted by contact CF—PO 23—25 and 8—10. The opening of 1N68 and shorting of 1N7 in the upper track amplifier are, when the mode switch is in position RECORD, prevented by contacts IV—V, V—IV and IV—III, in the mode switch, and the operation of the PO—CF switch will not affect the operating functions of the upper track amplifier. The switch will, however, reselect the amplifiers in all other positions of the meter and the mode switch. When placing the PO—CF switch in cathode follower position, the cathodes of the second triodes of ECC87 will be connected to the output terminals for each track, via C2—PO25—7 and contacts C1—PO 11—15 for the upper track amplifier, and C4—PO 22—5 and contacts C5—PO 1—2 for the lower track amplifier. Simultaneously, the two output transformers are disconnected from the output terminals by contacts CF—PO 13—14 and CF—PO 2—3. The feedback loops in the two amplifiers are also disconnected by C1—PO 15—19 and C5—PO 2—3.

3.3.7 Miscellaneous Improvements. To improve the hum level dc heating is introduced on the two ECC87 tubes. The raterifier is changed to 350—1000, and C4 is increased to 400 pF. A loop is inserted in the cathode of BE64 in the lower track amplifier. This loop should be bent to give minimum hum.

3. MECHANICAL CHECK UP

The instructions in S.M. sec. 5 goes also for the Model 5.

4. INSTRUCTIONS FOR ELECTRICAL CHECK UP

For complete measurements, the following equipment is needed: Universal voltage and current instrument, audio signal generator, vacuum tube voltmeter with a frequency range from 50 c/s to 100 kHz and a voltage range from 75 and to 200 volts, c.c., electromagnet, output meter, distortion meter, wow meter and a standard alignment tape. (National Standard Alignment Tape for 7½ ips.) Wow is defined as the effective value of frequency deviation from a signal of constant frequency recorded and played back taken as a percentage of the signal frequency. The electrical check up falls into two parts, introductory and final checking.

4.1 Introductory Check Up of the Oscillator.

1. Adjust the oscillator frequency. A radio receiver tuned to 200 kHz is used as an indicator. The antennas input terminals must be supplied with a signal of 500 kHz (visible on a crystal oscillator) and the oscillator coil L2 (22,1) of the tape recorder, see circuit diagram Fig. 4 and late S.M. Fig. 21, is adjusted to its third harmonic of 66 kHz tuned with the 200 kHz signal.

2. Adjust the oscillator frequency reed circuit L1 (717). See photographs S.M. Fig. 17 and 18 and schematic 3.6 A, Fig. 5. The V.T.V.M. is attached to point P in schematic 3.6 A, Fig. 20 and should indicate about 5 volts when the circuit is adjusted for minimum.

3. Adjust the plate circuit L3 (383) to measure with the dress switch in STEREO position, see photographs S.M. Fig. 21 and schematic 3.6 A, Fig. 5. As an indicator use a V.T.V.M. across one of the access heads. It should be about 200 volts across the access head. Check that the earphone volume is zero, the same regardless of whether one or two heads are connected.

4. Adjust the bias current through the upper head in position MONO-0M, and through the lower head in position EXTRA to 0.4 mA. (4 volts across 1000 ohms in series with the head). The adjustments are done by the unremovable potentiometer R21 and R23 located on the plate circuit board (28.3). Set the dress switch in position STEREO and check that the bias current through the upper head is zero, the same, insert the plug from the Deneo Record Amplifier and measure the bias current through the lower head. This should be 0.4 to 0.5 mA. If necessary, adjust this current by changing R21, which is also located on the plate circuit board.
5. Tune the second harmonic rejaeter circuit C4 located on the plate circuit balance board to mini. second harmonic (133; kHz) in the bias current. To do this it is necessary to have a frequency selective V.T.V.M. The second harmonic in the bias current shall be below 3%.  

4.3 Introductory Adjustment of the Amplifiers in Recording Position.  
This test is performed without the tube EL34 in the upper track amplifier. The mode switch 192 and the operating lever 39.14 are put in position for recording. The input terminals are supplied with a voltage from the audio signal generator. The V.T.V.M. is attached to measure the voltage over 1000 ohms in series with the upper track record head.

1. Sensitivity of the indicator.  
The audio signal generator should supply a signal enough to drive the tape to its maximum recording level, indicated by the eye-gage. The recording current through the head should then be between 90–110 microamperes at a voltage of 100–110 mV across the series resistor. If the current does not check with the value given, the centervariable potentiometer 930 should be adjusted.

2. The frequency response curve of the recording amplifier. In the position for recording, the frequency response of the upper track amplifier is changed by changing the speed. Drive the amplifier with a voltage corresponding to 20 dB below maximum recording level. The response curve should be as shown in Fig. 3, curves 1, 2, 3, and 3. The response is checked at all three speeds. The sensitivity of 1000 T c should be between 100 and 200 mV across the input terminals in both of the recorder, when the voltage across 1000 ohms in series with the head is 90 to 110 mV and the volume is set to max.

3. The lower track amplifier during recording. Check that the lower track amplifier is connected to the recorded program in both position MONOURAL and EXTRA of the stereo switch and that the output may be regulated by the VTS knob. The frequency response measured across the output terminals of the amplifier is shown in S.M. Fig. 24. It should be noted that the interconnection between the two amplifiers is broken on position STEREO. The cross talk in this position shall be better than — 55 db.

4.3 Introductory Check Up of the Amplifiers in Playback Position.  
1. Put the tube EL34 in its socket in the upper track amplifier. Connect generator to 1000 ohms in series with the head for the lower track and the Vacuum Tube Voltmeter to the output terminals of the lower track amplifier. Adjust the generator to 250 c/s and set the volume control of the tape recorder to max. The generator voltage is adjusted to give 2–3 volts across the output terminals of the lower track amplifier. (This corresponds to a generator voltage of approx. 6.2–9 mV. If necessary, use a voltage divider on the generator terminals to obtain half.) The volume control for the lower track amplifier is regulated down 4 db. Check that the output of the lower track amplifier is cut out when the stereo-monitor lever 39.8 is set in position MONOURAL, but is present in position STEREO and EXTRA. Also check that the built-in loudspeaker is connected to the lower track amplifier when the loudspeaker switch 39.7 is set in the right position and is disconnected in middle and left position. Check that the upper track amplifier is connected to the lower head in position EXTRA. Connect the generator to 1000 ohms in series with the upper track head without changing either volume control on the tape recorder or the generator voltage. By means of the centervariable potentiometer R5 (see S.M. Fig. 27) the gain of the upper track amplifier is adjusted similarly to that outlined above for the lower track amplifier. (The final adjustment is done when playing the alignment tape see set 4 point G). The loudspeaker switch 39.7 has to be set in the middle position during the gain adjustment. (Both amplifiers unloaded). Check that the loudspeaker switch 39.7 connects the built-in loudspeaker to the upper track amplifier in the left position and disconnects the loudspeaker in the two other positions. Further check that with the stereo switch in position MONOURAL; the lower track amplifier is connected and disconnected in position STEREO and that both amplifiers are connected in position EXTRA.
2. The frequency response of the two amplifiers is checked at all three speeds. The response should correspond to the curves in Fig. 1. During these measurements the generator is connected across 1000 ohms in series with the heads and the V.T.V.M. across the corresponding output terminals. The generator voltage is regulated so that the output voltage does not exceed 3 volts at frequencies with max. gain (50–60 db). The dummy-mass switch is set to STEREO position and the loudspeaker switch (S7) in the middle position. The gain at 1000 ohms is with the volume control at max. is approx. 67.5 db (4500 times) at 7 1/2 ips, approx. 79 db (5150 times) at 3 1/2 ips, and approx. 73.5 db (4750 times) at 1 1/2 ips, measured from the head to the output terminals. Also check that the output voltage increases 10–12 db at 1000 ohms when the bass switch is set in position BASS in both amplifiers and at all speeds.


1. Alignment: The heads, tape guides, pressure wheel assembly and the adjustable tape guides must be repositioned by means of a powerful ac magnet.

2. The procedure in S.M. sec. 3.9 point 1 to 4 has to be followed.

3. Adjustment of the tape height. This adjustment is made by sight and the gap of the amplifiers needs no adjustment. By means of the adjustable tape guide the tape path is adjusted so that the upper edge of the tape runs exactly even with the upper edge of the record/playback head. Then check that the tape runs equidistant from the flanges of the adjustable tape guide. If not, the height of the fixed tape guides should be adjusted by means of washers to allow this. If a rather large adjustment of the tape path is necessary, the arm alignment of the head gaps should be rechecked.

4. After the correction of the tape path has been done, the stereo switch is set in position STEREO. Both potentiometers are set to zero, and the large knob is fastened by means of the locking screw in such a position that the marked dat between the two knobs is in mid position. Pay back a 250 c/s steady tone recorded at full track and regulate the potentiometers until the lower amplifier gain is approx. 4 db below maximum. In this position the gain of the upper track amplifier is adjusted by means of the semi-variable potentiometer P40 to give exactly the same output as the lower track amplifier.

5. The height of the erase head. The height of the erase head is rather critical with respect to unwanted erasing. Adjust the height of the erase head by changing the little rod underneath the head mounting plate in such a way that the upper edge of the tape runs 0.25 mm (0.01") below the edge of the erase head. Then record a steady 400 c/s tone on track 1 and 3 on the same portion of the tape. Turn the reels and erase in position EXTRA (track 2) interferent 10 sec. erasing and 10 sec. no erasing. Be sure that the erasure takes place at the same portion where the tape has been recorded. Turn the reels again and play back in position STEREO with output meters across the terminals of the two amplifiers. It should not be possible to measure any erasure effect whatsoever on the tracks 1 and 3 on the portion of the tape where track 2 has been erased.

If so, the height of the erase head has to be adjusted. Any moving of the upper track (track 1) indicates that the erase head sands too low, and moving on the lower track (track 2) that the erase head sands too high. Adjust the head if necessary several times until the correct height of the erase head is secured. A final and real critical check one should regard in position EXTRA (track 3) and turn the reels and erase the tape in position STEREO (track 2 and 4), turn the reels once more and measure the erasing of track 3. This should be below 3 db. If the erasing effect is more than 1 db, minor corrections of the height of the erase head should be done.

6. Frequency response during playback.

The standard alignment tape with full track recording is played back at 7 1/2 ips. The stereo switch in position STEREO and the bass switch in position NORMAL. The frequency response of the playback should be within ± 2 db for both amplifiers, and the deviation between the two outputs should not exceed 3 db at any frequency during this measurement. The volume controls should be adjusted to the same output at 250 c/s. If necessary, small corrections in frequency response can be done by varying R5 and R53.
7. Frequency response curves, distortion and noise level. The procedure is the same for all tape speeds. The numbers in parentheses refer to the lower speeds.

In position MONAURAL, record a 1000 c/s signal of about 0.5 volt across the input terminals and adjust the volume control for about 30 dB below closing of the magic eye. At this input and volume control position one records 45 c/s, 100 c/s, 1000 c/s, 5000 c/s (3000 c/s), 10,000 c/s (100,000 c/s), 15,000 c/s (8000 c/s), 40,000 c/s and 16,000 c/s (10,000 c/s, 4000 c/s). Then record a 400 c/s signal at zero recording level. Pull out the generator leads. Put them back in place after a while and record 400 c/s at half of maximum recording level (10 db down).

Rewind tape and play back. The 1000 c/s signal frequencies recorded should give signal output within ± 2 db relative to the zero level.

Next play back the piece of tape containing the 400 c/s signal at max. recording level and measure distortion at 2.5 volt output. There should be less than 5% distortion. Where nothing is recorded, record off the noise level. Leave the volume control unchanged. With a straight line voltmeter the noise voltage should be less than 3 mv or about 55 db below maximum signal level. The last thing to be checked is the distortion at 10 db signal level. An output voltage of 1 volt with the distortion should be less than 1.3%.

Note: Check for wow. Speed should be less than 0.5% at 17.71 ips, 0.2% at 14.45, 0.5% at 12.85, RMS. If a wow meter is not available, a program recorded on a tape recorder having 1000 c/s can be played back through the unit, and the judgement done by ear. A program of piano music with some long notes will easily detect wow if the error is present.

All points with exception of the wow is then measured in position EXTRA and STEREO, with the signal fed through the built in amplifier. If a stereo record amplifier is used, the program is repeated in stereo on lower track through stereo record amplifier. Be aware of the difference of the box and between the frequency response in MONAURAL and STEREO.

8. Cross talk. With the volume control set to zero a part of the tape is erased. The two tape reels are turned upside and changed from left is right terminal and vice versa. A 1000 c/s signal is recorded at maximum recording level on track 1. (Eye just closed.) Rewind the tape and play back the 1000 c/s signal (signal on upper track), set the stereo switch in position MONAURAL, and regulate the volume control to give 3 db across the output terminals of the lower track amplifier, with the built in loudspeaker connected. Set the stereo switch in position STEREO, and check that the signal is barely heard in the loudspeaker (opposite, 60 db cross talk damping).

Record in position EXTRA and measure the cross talk heard through the upper track amplifier in position STEREO. The tape is turned upside down again (signal on track 2), connect the loudspeaker to the upper track amplifier. With the same volume control setting (3 db across the terminals of the lower track) and the stereo switch in position MONAURAL, and then in position EXTRA, the signal should barely be heard. The cross talk in these positions should also be approx. — 60 db.

If correct measurement of the cross talk is wanted, it is necessary to use a wave analyzer because the cross talk signal will be masked by the noise when using a straight voltmeter.

9. Erasing. Record a 1000 c/s noise at maximum recording level in MONAURAL and EXTRA and erase in STEREO, MONAURAL, and EXTRA. The erasing should be better than 60 db in STEREO and better than 70 db in MONAURAL and EXTRA.

10. Seal all adjusting screws with lacquer.

5. COMMENTS ON THE QUADRIPLIPE SYSTEM

The quality of a tape recorder is of course mainly dependent on the make and design. In this section the Model 5 will be compared with our former Model 5 Series. The advantages of the Model 5 is mainly twice as long playing time. In view of this doubling of playing time is apparently wanted because it often the possibility of recording at double volume is larger as former is measured, thus playing stereo without rewinding the tape. In addition the air gap of the playback head is reduced from approx. 0.02 to 0.01, (0.5023 approx., 0.492). This will reduce the playback losses due to air gap effect form approx. 0.1 to 0.05 at 10,000 c/s and 0.1 to 0.02 at 5000 c/s and 1/4 ips. This reduction has made it possible to use a 100 db playback equalization curve instead of 200 db at 3/4 ips and still meet the frequency response specification of 10,000 c/s. At the same time the playback equali-
1. Tape noise. The track width of the Model 5 is almost 1⁄2 of the track width of the Model 3 Stereo. The virgin tape noise as well as the noise arising from erase and play current is mainly dependent on the geometrical size and design of the magnetic layer of the tape and will be uncorrelated. i.e. the phase of the noise components will vary along the track width. The noise effect of an uncorrelated tape noise will be proportional to the track width. The signal on the tape will however be correlated (i.e., along the whole track width) and the signal voltage will be proportional to the track width. By reducing the track width by one half, the noise will be reduced 3 dB and the signal by 6 dB, resulting in a 3 dB poorer signal to noise ratio. This relative increase in noise will be inherent on the tape and it is therefore impossible to restore the signal to noise ratio by improved design of tape or amplifiers. The overall tape noise, of course, be improved by better tape and perhaps by better erase methods, but the relation between the two track widths will be the same. Fortunately, other and often more important noise factors will not vary in the same manner.

2. Program source and recording amplifier noise. All noise generated in the system before the recording head will be recorded on the tape and therefore be correlated. The noise voltage will therefore vary in accordance to the signal voltage and the track width will have no effect whatsoever on the signal to noise factor referring to this special noise. This fact is especially important when playing pre-recorded tape, where the recorded noise generally is much higher than the tape noise. Because of the number of copying processes from the original, see S.M. sec. 4.7. Consequently there will be no audible difference when playing back pre-recorded tape on either 2 tracks or quadripole heads.

3. Noise in playback amplifier. The noise in the playback amplifier consists mainly of tube and resistor noise. At a good amplifier, this noise will be constant and the signal to noise ratio will be dependent on the signal at the input i.e. the signal voltage from the head. With the same numbers of turns and the same iron construction, the head sensitivity will decrease both with decreasing track width and gap width. It has however been possible to design the quadripole head with equal, or even better, sensitivity than the former Model 5 Stereo head. The main difference in design being that the additional air gap is in the recorder. This will increase the danger of accidental d.c. magnetizing of the head, but experience has shown that this danger in the Model 5 is almost eliminated. The loss in signal to noise ratio in the playback amplifier is therefore not more than 1—2 dB and will generally not be detectable because the tape noise and recorded noise will be dominating.

4. Hum. The hum level is determined by the hum induced in the head and the hum generated in the playback amplifier. The hum induced in the head is the difference of the induced hum voltage in the two windings of the head and will generally not be affected by alternation in the front and rear gap. The hum from the head will however be dependent on the physical size of the head and will normally decrease with decreasing size. The sensitivity of the head is therefore, the same in the Model 3 Stereo as in the Model 5, whereas the hum from the head is lower in the Model 5 and there will be an improvement in hum level from the head in the Model 5 compared to the Model 3 Stereo. At the same time, i.e., the head has been improved in the two ECC83s in the Model 5 which reduces hum generated in the playback amplifier. The Model 5 has therefore a lower hum level than the Model 3 stereo. In both models, different hum compensating devices are used and the hum may therefore differ from recorder to recorder, but the overall hum level will be 3—6 dB lower in the Model 5. The conclusions of the comparison in noise level between the Model 3 stereo and the Model 5 are:

1. When recording programs where the noise from the program source is small compared
with the tape noise there will be a loss of 3 dB in signal to tape noise ratio.

2. When playing back prerecorded tape there will be no audible difference.

3. The hum level has been reduced in the Model 5 with the result that it has been possible to obtain the same measured overall signal to noise ratio (noise and hum) in the Model 3 as in the Model 5 Stereo, even when recording programs from sources with negligible noise.

The above comparisons apply to the 7½ ips speed since the equalization curves at this speed are unchanged. At 3½ ips and 1½ ips a much greater improvement in noise level is obtained by changing the playback equalization curves. As will be seen from Fig. 3 this improvement has to a certain extent increased the risk of overloading the tape at the higher frequencies. One disadvantage with the Model 3 compared with the Model 5 Stereo is that the Model 5 requires a better adjustment of the tape path, and therefore faults may be caused by improper tape transport. A further difficulty is the absence in STEREO position. There is a rather critical balance between sufficient output and unwanted noise of the track in between. To avoid unwanted noise it has been necessary to feed the two head files in opposite phase. This will reduce the unwanted effect in STEREO because the field from one head will counteract the other. This reduction limits the output to 68-66 dB in STEREO position, while in MONO/PHILAL and EXTRA the output is better than 70 dB.

A point which was taken into consideration when changing to the quadraphonic track standard, was the compatibility between the new standard and the former two track standard. All monaural recorded tape may be played at a quadraphonic recorder with the same quality. Prerecorded stereo tape has a track width of 1" whereas the upper edge of the lower head in quadraphonic standard is 1½ inches above the lower edge of the tape. When playing prerecorded two track stereo tape on a Model 5, 0.01" of the lower head will extend above the track, the result being a drop in output voltage of approx. 3 dB. This unbalance may however easily be rectified by adjusting the paralelometers. The result being when playing prerecorded two track tapes, a loss of approx. 3 dB in playback amplifier gain, and a slightly increased noise level on the lower track.

6. ELECTRICAL TROUBLE — CAUSE AND REMEDY

Any amplifier not operating

Metal shield between power in mode switch or stereo switch is grounding rivets for contacts clips. Any blown fuse. Missing switch not open in the playback mode. Adjust switch arm for proper operation.

The upper track amplifier clicking in playback mode

Too high resistance in 63 volt base on power transformer. Occurring only in the first series of Model 5-62 or. Replace base or recreate wiring B plus supply for EL34 corresponding to the schematic diagram No. 226.

Hum caused by false grounding.

Shaded wires from the amplifiers to the record/playback heads are ground underneath the top cover. Metal shield in wafer switch touching contact clip or rivet. Move the two 10 ohm resistors in front of the stereo switch.

Hum compensation in the upper track amplifier.

Locate inaudible shield in front of the playback head for minimum hum level.

Hum compensation in the lower track amplifier.

Stereophonic switch in position STEREO. Bend brown wire loop at the front end of the lower track amplifier to reduce the hum level.
7. ADDITIONAL PARTS LIST FOR MODEL S

A number of parts have been changed in the Model S from the Model 3 Stereo, from example Mode Switch, Stereo Switch, Double Panometer and many others. For these parts which are substitutes for parts existing in the Model 3 Stereo, one

7.5 Mechanical Parts.

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>06.1</td>
<td>Female plug for power connection Stereo Record Amplifier</td>
</tr>
<tr>
<td>19.6</td>
<td>Socket for head connection Stereo Record Amplifier</td>
</tr>
<tr>
<td>30.33</td>
<td>P.O. — C.F. Switch</td>
</tr>
<tr>
<td>30.34</td>
<td>Making Switch</td>
</tr>
<tr>
<td>30.35</td>
<td>Bracket for Making Switch</td>
</tr>
<tr>
<td>30.36</td>
<td>Actuator for Making Switch</td>
</tr>
<tr>
<td>30.37</td>
<td>Shaft for Making Switch</td>
</tr>
<tr>
<td>30.38</td>
<td>Socket head connection from Stereo Record Amplifier</td>
</tr>
<tr>
<td>30.39</td>
<td>Female plug (for power connection Stereo Record Amplifier)</td>
</tr>
<tr>
<td>33.15</td>
<td>Socket for Stereo Amplifier input, with turbo plate</td>
</tr>
<tr>
<td>19.3</td>
<td>P.O. — C.F. Switch, wired</td>
</tr>
<tr>
<td>39.4</td>
<td>Making Switch, wired</td>
</tr>
</tbody>
</table>

7.2 Electrical Parts.

There may be some minor alterations in the value or type of electrical components. Simultaneously there are some new components. When ordering electrical spare parts for the Model S, please state component number, value and Model S.
STEREO RECORD AMPLIFIER FOR MODEL 5

9. TECHNICAL DATA FOR STEREO RECORD AMPLIFIER FOR MODEL 5

9.1. TUBE SPECIFICATIONS

- Tube Type: EPB94, ECC83, EM71
- Power Consumption: 7 watts
- Control: Record level control
- Equalization Switch: Changes the recording equalization to 7, 3, and 1.5 kHz curves
- Frequency Response: 20 Hz to 18 kHz
- Distortion: Less than 0.1% at max. recording current
- Input: Microphone 50 mV, sensitivity 0.5 mV
- Recording Level Indicator: Magic eye with selenium rectifier and damped backward movement
- Connections: Plug with leads for connections to lower head on the Model 5
- Dimensions: All metal case 2 ¼" wide, 8 ½" deep and 5 ¾" high (57 x 22 x 12.5 cm) without leads and vents
- Weight: 23 lbs (10 kg)

The power supply for the Amplifier is taken from the Recorder. The check-up corresponds to the procedure in sec. 4.2. One has to connect the Stereo Record Amplifier for Model 5 to the Recorder and set the Stereo Switch on the Recorder in position STEREO and the Mode Switch in position RECORD. All head measurements are then done at the lower head on the Recorder.

Fig. 6 shows the wiring diagram for Stereo Record Amplifier for Model 5. To obtain a correct recording equalization, a resonant circuit is inserted in the feedback loop in the first cathode circuit of ECC83 as described in sec. 3.2.3.

The frequency response of the Record Amplifier for Model 5 is shown in Fig. 3 for the different speeds.
### 10. PARTS LIST FOR STEREO RECORD AMPLIFIER FOR MODEL S

#### 10.1 Mechanical Parts

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Name</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>02.2</td>
<td>Conical base with plug</td>
<td></td>
</tr>
<tr>
<td>17.3</td>
<td>Bushing strip</td>
<td></td>
</tr>
<tr>
<td>18.1</td>
<td>Equalization coil</td>
<td></td>
</tr>
<tr>
<td>18.7</td>
<td>Main balance board</td>
<td></td>
</tr>
<tr>
<td>27.1</td>
<td>Suppressor coil</td>
<td></td>
</tr>
<tr>
<td>27.2</td>
<td>Board for suppressor circuit</td>
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</tr>
<tr>
<td>30.9</td>
<td>Pot, meter 0.5 M frame</td>
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</tr>
<tr>
<td>30.40</td>
<td>Equalization switch</td>
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<tr>
<td>31.1</td>
<td>Socket for EMT7, wired</td>
<td></td>
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<tr>
<td>45.1</td>
<td>Microphone jack, wired</td>
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<tr>
<td>70.55</td>
<td>Front cover</td>
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<tr>
<td>70.56</td>
<td>Polyethylene washer</td>
<td></td>
</tr>
<tr>
<td>70.57</td>
<td>Speaker for test prongs contact</td>
<td></td>
</tr>
<tr>
<td>70.58</td>
<td>Rubber mounting</td>
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</tr>
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#### 10.2 Electrical Parts

##### 10.2.1 Resistors

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<tr>
<td>R101</td>
<td>.51 Mohm — 1/2 W Type 580</td>
<td>— 10 %</td>
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<tr>
<td>R102</td>
<td>10000 ohm — 1/2 W e e</td>
<td>— 10 %</td>
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<tr>
<td>R103</td>
<td>5.1 Mohm — 1/2 W e e</td>
<td>— 10 %</td>
</tr>
<tr>
<td>R104</td>
<td>3000 ohm — 1/2 W e SC101</td>
<td>— 5 %</td>
</tr>
<tr>
<td>R105</td>
<td>2 Mohm — 1/2 W e e</td>
<td>— 10 %</td>
</tr>
<tr>
<td>R106</td>
<td>1  e — 1/2 W e e</td>
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<td>R107</td>
<td>5  e — Pot. T 150BB E82</td>
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<tr>
<td>R108</td>
<td>390 ohm — 1/2 W</td>
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<tr>
<td>R109</td>
<td>31 000  e — 1/2 W Type ABT</td>
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<td>R110</td>
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<tr>
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<td>1  e — 1/2 W e SB7</td>
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<td>R113</td>
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<td>R114</td>
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<tr>
<td>R115</td>
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<td>2 Mohm — 1/2 W e BD7</td>
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<tr>
<td>R122</td>
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<tr>
<td>R123</td>
<td>5.1 Mohm — 1/2 W e e</td>
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### 10.3.2 Capacitors

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<tr>
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<td>C103</td>
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<tr>
<td>C107</td>
<td>10,000 µF</td>
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<tr>
<td>C108</td>
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<td>C110</td>
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<tr>
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<td>10,000 µF</td>
<td>–</td>
</tr>
<tr>
<td>C115</td>
<td>10 µF</td>
<td>–</td>
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<tr>
<td>C116</td>
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<td>Electrolytic</td>
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