TANDBERG TAPE-RECORDER

MODEL 3 STEREO, MODEL 3B, MODEL 3BF

Service Manual

Tandberg

TANDBERGS RADIOFABRIKK A/S · OSLO · NORWAY

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MODEL 3 STEREO

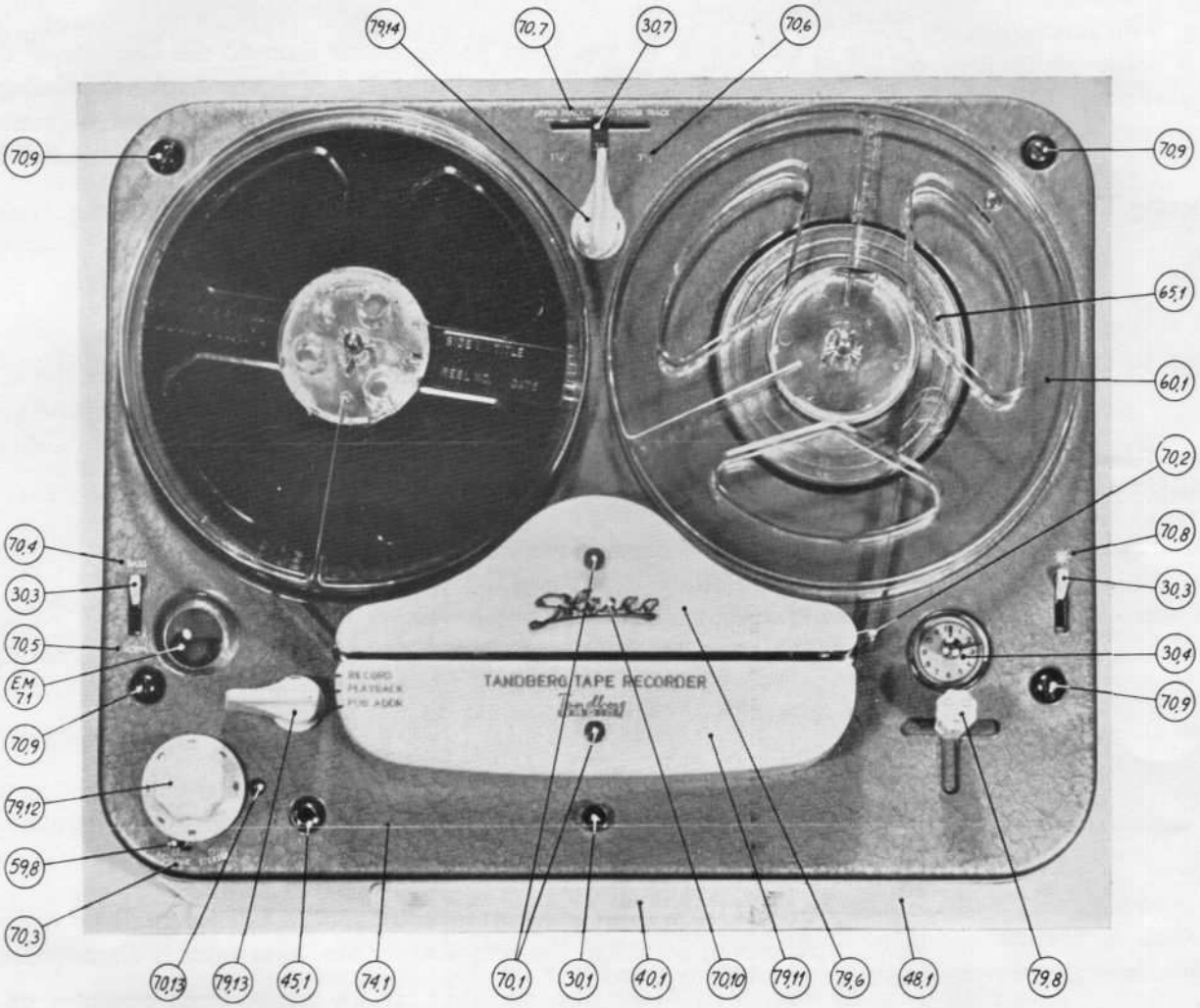


Fig. 1. Top View.

1. TECHNICAL DATA MODEL 3 STEREO

Line Voltage:	110 — 125 — 145 — 200 — 220 — 245 volts, 50 c/s (60 c/s).
Power Input:	75 watts.
Tubes:	2 EF804, 2 ECC83, 2 EL84, EM71 and Selenium Rectifier 100 mA, 250 volts, 2 low voltage Selenium Rectifiers.
Recording Tape:	Red oxide tape. Maximum Reel Diameter is 7" and 1200 ft. (366 m) or 1800 ft. (550 m) of Tape.
Tape Speeds:	7 1/2", 3 3/4" and 1 7/8 per sec. By help of the equalization switch, the recording amplifier as well as both playback amplifiers are re-coupled, so that for all speeds the amplifier corrections will be up to the NARTB standard. (The Recorder may also be supplied with amplifier corrections up to the CCIR standard). This involves that the Recorder being capable of playing back stereophonic tapes recorded on 3 3/4" and 1 7/8" per sec. if actual. Speed tolerance: ± 1 % for all speeds at correct line frequency and voltage 50 c/s 220 V (60 c/s 110 V).

Heads:

Half track erase head.
Record-playback head: Special made in line stereo.
Head gap: .00025 inch.
Cross-talk between the two head halves better than 60 dB. Because of the high cross-talk quality, the Recorder will record and play back normal single half-track tape without any reduction of quality. The co-linear alignment is so good that one may play back a fulltrack tape using both head halves.

Playing Time:

Two Track Recording and 1200 ft. of Tape give the following Playing Times:
Tape Speed of $7\,1/2$ ips: 2×32 min.
Tape Speed of $3\,3/4$ ips: 2×64 min.
Tape Speed of $1\,7/8$ ips: 2×128 min.

Path of Tape:

The Tape moves from left to right. The heads are positioned with the slits towards the front. Recording takes place on the upper half of the tape.

Fast Forward- and Rewinding:

Takes about 2 min. in either direction, without wearing the heads.

Controls:

Joint playback and record-level control.
Speed change switch $7\,1/2$", $3\,3/4$", $1\,7/8$".
Monitor speaker switch.
Bass switch equalizes both amplifiers simultaneously in playback position only.)
Mode switch for recording, playback and pub.addr.
Lever control for start, stop, forward and rewind.
Stereo monaural switch (located under the level control knob) giving the following possibilities:

1. Mode switch in pos. RECORD.
   a) Pos. STEREO: The amplifier for the upper track operates as a normal recording amplifier. The amplifier for the lower track is disconnected.
   b) Pos. MONAUR.: The amplifier for the upper track operates as a normal recording amplifier. The amplifier for the lower track is connected as a power amplifier for the recorded program. The gain in the extra amplifier is matched to give full output at maximum recording level.
2. Mode switch in pos. PLAYBACK:
   a) Pos. STEREO: Each amplifier connected to the individual two head-halves, ready for playing back stereo tape.
   The level control simultaneously engages both amplifiers.
   The double-potentiometer adjusted so that the amplification in the two amplifiers mutually never deviate more than 2 dB.
   b) Pos. MONAUR.: Both amplifiers coupled to the upper track across the same potentiometer.
3. Mode switch in pos. PUB.ADDR.:
   a) Pos. STEREO: The amplifier for the upper track connected to the microphone input (as for Model 3 Speed Hi-Fi). The amplifier for the lower track disconnected.
   b) Pos. MONAUR.: Both amplifiers connected to the microphone input across the same potentiometer.

Frequency Response at record-playback.

Flat within ± 2 dB from 40 to 16 000 c/s, from 50 to 9 000 c/s and from 70 to 4 500 c/s for the 7 1/2 ips, 3 3/4 ips and 1 7/8 ips speed respectively.

Distortion and Noise Level:

The tape recorded to the maximum level by a 400 c/s signal will give less than 5 % distortion when played back. A recording level 10 dB below the maximum level results in less than 1 % distortion of the 400 c/s signal when played back. The noise level is 55 dB below the signal level when the tape is driven to the maximum level.

Wow:

Better than 0.15 % at 7 1/2 ips tape speed.
Better than 0.2 % at 3 3/4 ips tape speed.
Better than 0.3 % at 1 7/8 ips tape speed.
Wow is then defined as the r.m.s. value of frequency deviation to one side in percent of the signal frequency, when a constant signal frequency 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 TM-2 microphone. Sensitivity of mike input — 1.5 millivolt, for maximum recording level at 1000 cycles.
Phono or radio input (0.5 Megohm) with provision for simultaneous use of both inputs for mixing.
Phono or radio sensitivity — 75 millivolts.

Microphone:

Crystal mike shock-insulated for rugged use. Response — 20 to 13 000 cycles ± 3 dB.

Erase and Bias Frequency:

66 2/3 kc/s.
Even harmonic distortion in high frequency bias current is below 0.5 %.

Record Amplifier, Recording 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 selenium rectifier and damped backward movement). Electronic Eye tube range is 26 dB, plus overload.

Playback Amplifiers, Frequency Response.

Two identical playback amplifiers, matched to the heads to give a frequency response when playing back a CCIR (NARTB) standard tape within ± 2 dB at all recorded frequencies.

Playback Amplifier Gain.

The double potentiometer and the 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 damping range from 0 to 25 dB.

Playback Amplifiers Output & Distortion:

At 1000 cycles . . .

2 watts (2.8 volts)	Distortion below 1 %
3.3 watts (3.6 volts)	Distortion below 5 %

At 50 cycles . . . .

1 watt (2 volts)	Distortion below 1 %
1.5 watts (2.5 volts)	Distortion below 5 %

Effective source impedance of playback amplifier is less than 1 ohm; negative feedback about 15 dB. (Matched load impedance — 4 ohms).
Because of the low output impedance and high degree of negative feedback with corresponding low distortion, the Playback 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 20000 cycles.

Monitor Speaker: Goodman, Heavy-duty, 5 in. × 7 in.
The monitor speaker may by help of the loudspeaker switch be connected to the amplifier for the upper track, the amplifier for the lower track, or no connection at all.

Clock-Counter: (Identical to an ordinary clock dial). Each hour (by hour-hand) shows 150 revolutions of tape spool, each minute (by minute-hand) shows 2 1/2 revolutions. Location and length of recording is designated as time on a clock (e.g. 2 : 12 to 3 : 15).

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

Dimensions: Fine grain mahogany cabinet, 15" long 11 5/8" wide, 6 5/8" high.

Weight: Instrument alone-27 lbs., with carrying case-32 lbs.

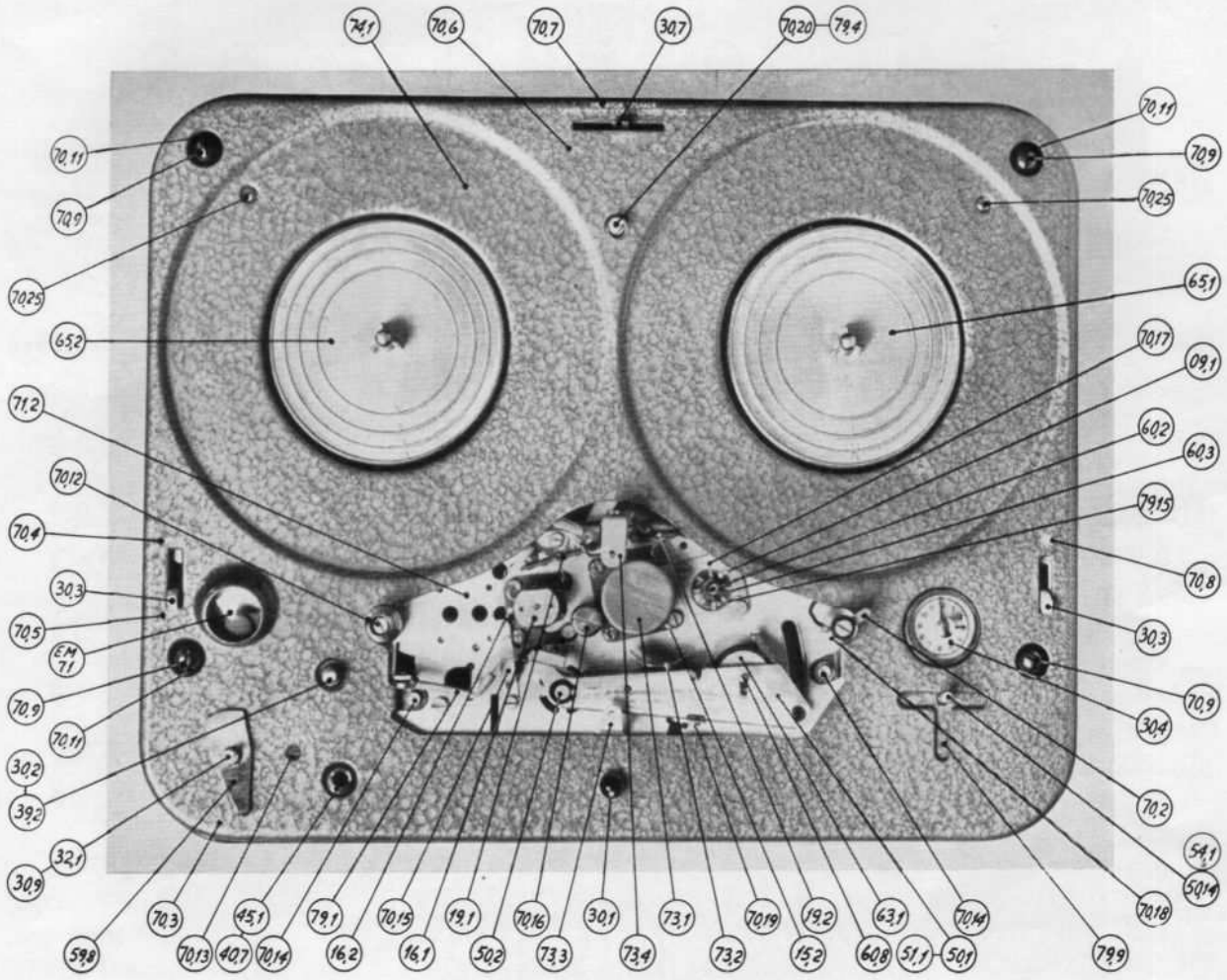


Fig. 2. Top View without Trim Covers and Knobs.

2. THE MECHANICAL FUNCTION

The driving mechanism has three main functions, namely normal forward drive, fast forward winding and fast reverse winding. The operating lever has one neutral or stop position and three operation positions which are as follows: Normal forward drive when the operating lever is pulled toward the front, fast forward and reverse winding when the operating lever is in the position to the right or to the left of the neutral position respectively.

Fig. 2 is a top view of the tape recorder, the knobs and trim covers removed. The operating lever (50.14) is in the position neutral. The speed selector shaft (7020) with its three positions for $7\,1/2$ ips, $3\,3/4$ ips and $1\,7/8$ ips is located between the turntables towards the rear. Speed selection is accomplished by turning the knob (79.14) to the marked position for the wanted speed. The path of the tape, the erase head (16.1) and the record head (15.1) are also shown in the picture, the record head with its mu metal shielding (73.1). Recording takes place on the upper half of the tape, according to the International Standard (CCIR).

The top plate can be removed without taking the unit out of the mounting cabinet, the four screws marked (2×70.25, 2×70.14) have been removed in before hand. (Do not lose the turbax washer (40.2) that insulate the microphone jack from the top cover, and make sure that washers and screws are replaced in their proper positions when reassembling).

In Fig. 3 the top cover is removed and part of the mechanism is seen. The motor pulley (62.1) is seen in the middle. It has two grooves for coupling the belt (70.29) to the two pulley discs (61.1) located underneath the turntables. The supply turntable is pulled out of its bearing so

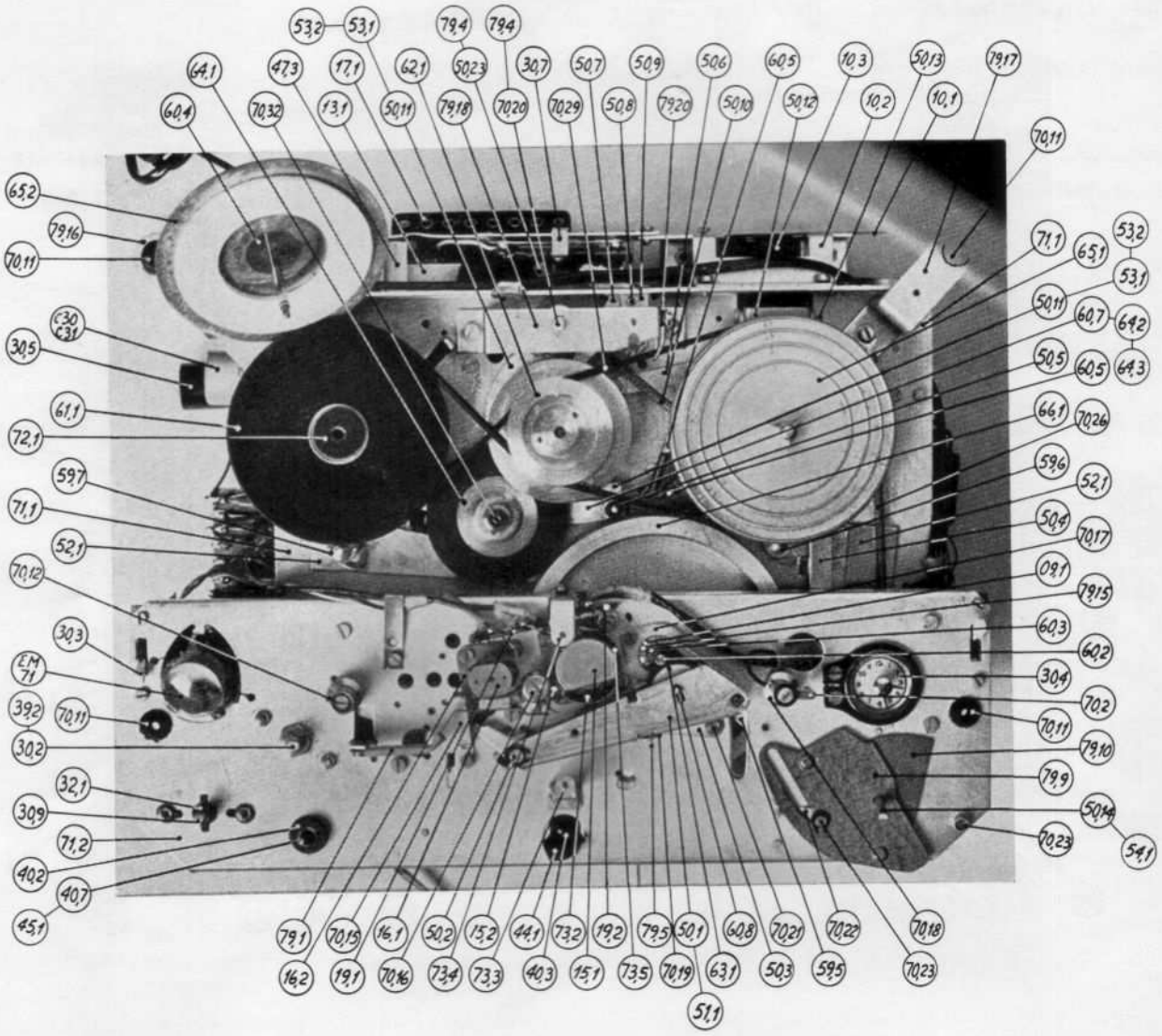


Fig. 3. Top View, Top Plate Removed.

that the left hand pulley disc (61.1) is clearly visible. Detailed descriptions of the pulley discs are given later.

The pulley discs are permanently coupled to the motor pulley (62.1) by means of the rubber drive belt (70.29) and start turning as soon as the motor is switched on.

In addition to the two V-shaped grooves on the motor pulley there are three peripherad tracks of unequal diameters. These tracks, in conjunction with the speed transfer wheel (64.1) give the correct speeds to the flywheel (66.1) and capstan (60.2) and consequently to the recording tape at either 7 1/2, 3 3/4 or 1 7/8 ips. Operating the speed selector disengages the speed transfer wheel by turning its mounting arm (5011) which raises or lowers the arm to switch the speed transfer wheel from one track to the other. The cam disc (50.23) see Fig. 14, provides for three accurate height positions for the transfer wheel mounting arm corresponding to 7 1/2, 3 3/4 and 1 7/8 ips. Two springs (60.5) attached to the mounting arm for the speed transfer wheel keep the wheel engaged. Details concerning the speed transfer wheel are taken up later.

The whole mechanical operation is actuated by means of the operating lever (50.14). In the neutral position the motor is turned off. Any other position of the operating lever switches the motor on, and starts the pulley discs.

The automatic stop functions only when tapes having metal coating at both ends are used. This metal coating will make contact between

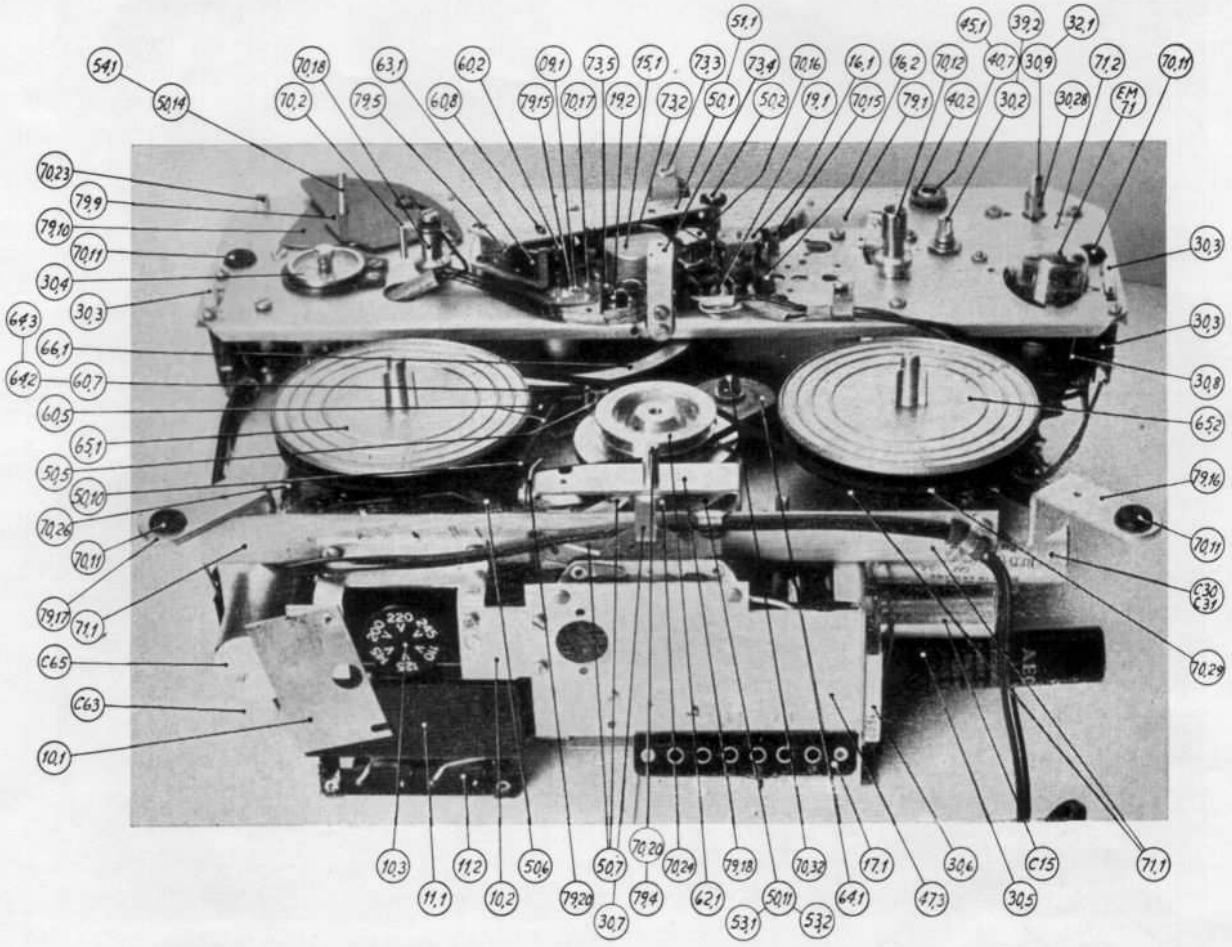


Fig. 4. Rear View.

the right tape guide (70.18) and the contact (70.2). The stop magnet mounted on the operating lever bracket is actuated and cuts the motor current by means of the switch otherwise operated by the operating lever.

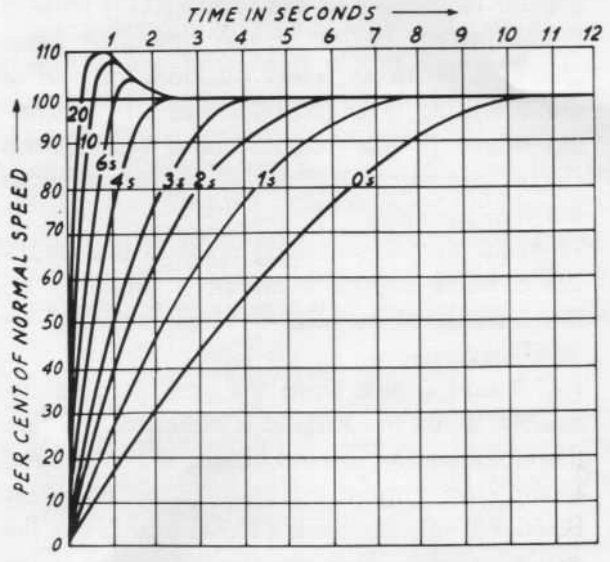


Fig. 4 B. The Speed of the Recorder During the Start Period in Percentage of the Normal Speed, given for Different Time Intervals with the Operating Lever in its Half-way position.

3. DETAILED DESCRIPTION AND INSTRUCTIONS FOR ADJUSTING THE MECHANISM

3.1 Operating Lever with the Micro Switch for the Motor.

When the operating lever (50.14) is in the position for normal forward drive, the pressure wheel (63.1) is pressed against the capstan (60.2). To the pressure wheel assembly (50.1) is attached a roller (50.20) that slides along the contour of an eccentric segment (59.5) Fig. 29 which is the connecting link between the operating lever (50.14) and the pressure wheel assembly (50.1). Just about in the middle of the contour is an indentation that marks the half way position of the pressure wheel. At this point the driving mechanism has started. Holding the operating lever in this position for about 3 to 4 seconds gives the motor sufficient time to get up to full speed. If the operating lever (50.14) is now pulled all the way down, the tape starts at normal speed instantaneously. Fig. 4b shows the speed of the recorder in percentage of the normal speed as function of the time in seconds during the start period. The numbers quoted on the curves

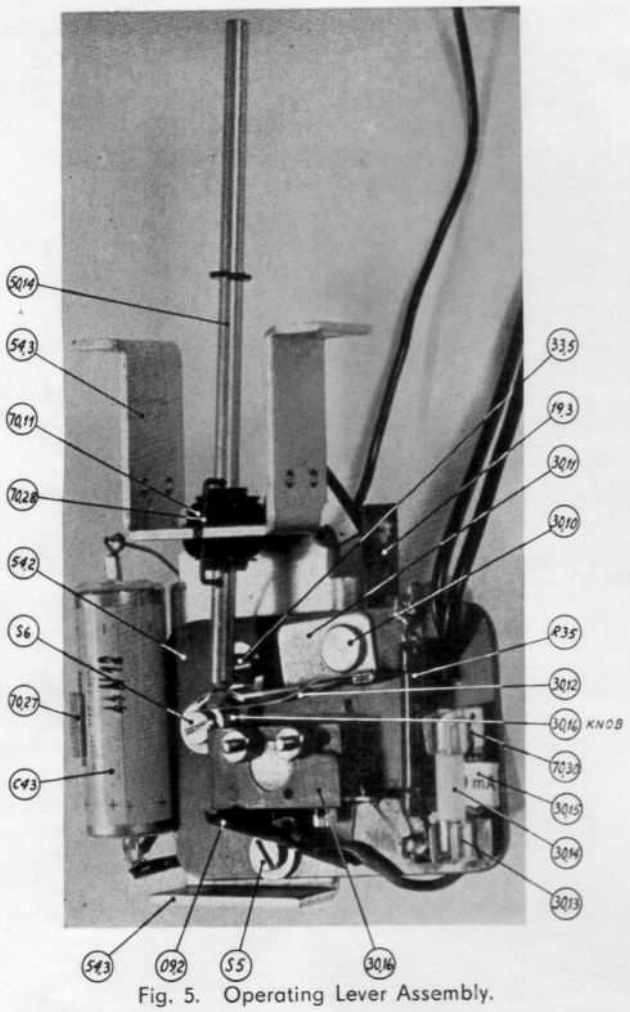


Fig. 5. Operating Lever Assembly.

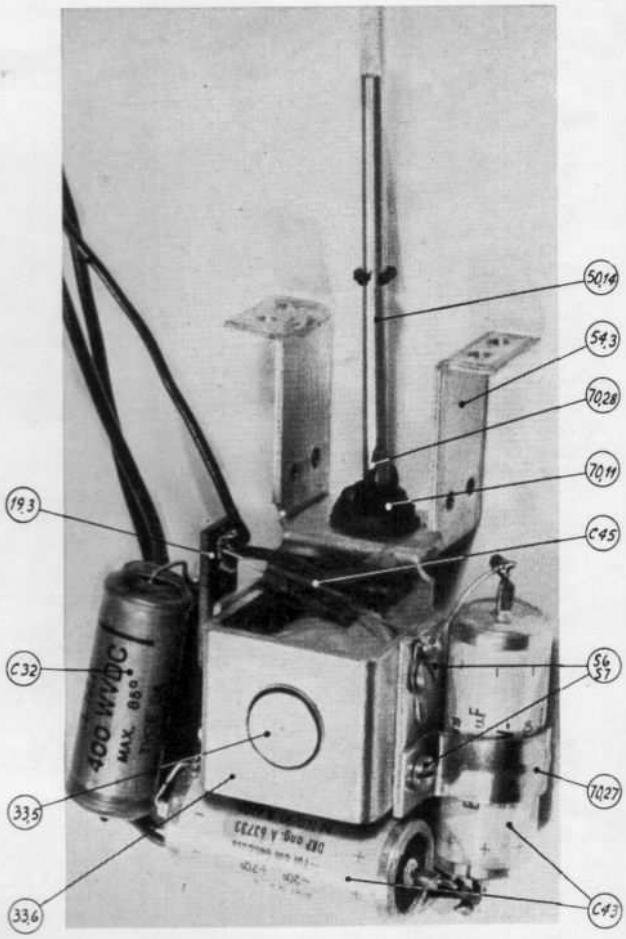


Fig. 6. Operating Lever Assembly.

correspond to the time in seconds the operating lever (50.14) has been kept in the halfway position. The turntables (65.1, 65.2) are put into motion by the operating lever in this way: the rotating pulley discs (61.1) are raised or lowered depending upon the position of the trip bar (52.1). The pulley discs (61.1) engage or disengage the turntables (65.1, 65.2). Detailed description of the function assembly is found under the next heading. In normal forward drive position the take-up turntable (65.1) is coupled to its pulley disc (61.1) with sufficient take-up friction, while the supply turntable (65.2) runs with only the bearing friction. The pulley disc (61.1) engages the take up turntable (65.1) with max. friction in the position for fast forward winding, while the supply turntable (65.2) runs with just bearing friction. In the position for fast reverse winding the frictions as described above are interchanged.

In Fig. 5 and 6 is a close up of the operating lever assembly. The actuator of the micro switch is located underneath the actuator lever for microswitch (30.11) which keeps the microswitch (30.16) in the «off» position while the operating lever (50.14) is in the neutral position as shown. The micro switch (30.16) used has very little overtravel and a preset plate spring for micro switch (30.12) is inserted between the actuator lever (30.11) and the operating knob on the switch. This spring (30.12) allows a greater movement on the lever (30.11) making the adjusting easier. If the operating lever (50.14) is set to any other position, the end of the operating lever (50.14) slides off the sloping edges of the actuator lever (30.11) and causes the micro switch (30.16) to switch to the «on» position.

To avoid electric switching noise in the amplifier a noise supressor circuit is mounted on the bakelite strip, C32 — .1 μF and R35 — 50 ohms.

Fig. 5 and 6 also show the stop magnet assembly. When the magnet is actuated (through the metal coating on the tape) the conical end of the stop magnet armature (33.5) will press down the actuator lever (30.11) and break the motor current. Pushing the operating lever (50.14) in neutral position, the armature will move back again. The energy required of

the stop magnet is delivered by the condenser C 43. This condenser is charged from the H.T. through R 41 — .2 Mohm. The charging time is approx. 10 sec.

3.2 Adjusting of the Operating Lever, Stop Magnet and Micro Switch.

The switching of the motor current takes place when the operating lever (50.14) is about half way between the NEUTRAL and any other position. Adjustment of this operating point when going to the fast winding positions, is obtained by loosening the two screws S.5, S.6 fig. 5 and displacing the bakelite mounting plate for micro switch (54.2) sidewards until the actuator lever for micro switch (30.11) becomes symmetrical with the tip of the operating lever (50.14). Thereupon the bakelite mounting plate (54.2) is moved upwards until the switching takes place at the proper position. The operating point, when moving the operating lever (50.14) towards record or playback position, is adjusted by bending the tip of the actuator lever (30.11).

After the bakelite mounting plate (54.2) with the micro switch (30.16) is fastened in its proper position with respect to the operating lever (50.14), the stop magnet assembly is adjusted. The location of the armature (33.5) is determined by the hole in the rear plate for stop magnet (33.6). The holes for the screws holding this plate are oblong, allowing necessary movement. When the armature (33.5) is correctly adjusted and operated, the cylindrical part of the brass end of the armature (33.5) should enter the actuator lever (30.11). In this position the actuator lever (30.11) has just operated the micro swich (30.16). One has to make sure that the actuator lever (30.11) is not pressed so far down that the plate spring for micro switch (30.12) is actuated, else the power required is too great and the automatic stop will not work correctly.

3.3 The Turntables.

The clutch assembly of the two turntables is constructed as shown in Fig. 7 in which the various parts of the assembly are layed out. The whole assembly is built around the housing of the turntable bearing (70.36). The housing is riveted to the lower mounting plate (71.1). Assembling is done as follows: Place the compression spring (61.2 or 61.3) over the housing (70.36), one end going into one of the holes in the lower mounting plate (71.1). Next place the pulley disc (61.1) with its cartridge (60.11) over the housing (70.36) while guiding the compression spring (61.2 or 61.3) into its cylindrical groove in the cartridge (60.11). The tags of the cartridge (60.11) should then lie on a line perpendicular to the front of the mounting plate (71.1). Press down on the pulley disc (61.1) till the tags have passed through the notches in the clutch levers (59.6 and 50.12 or 59.7). Then turn the cartridge (60.11) 90 degrees (clockwise for the take-up clutch assembly and counter clockwise for the supply clutch assembly) so that the two tags are locked in position by the catches

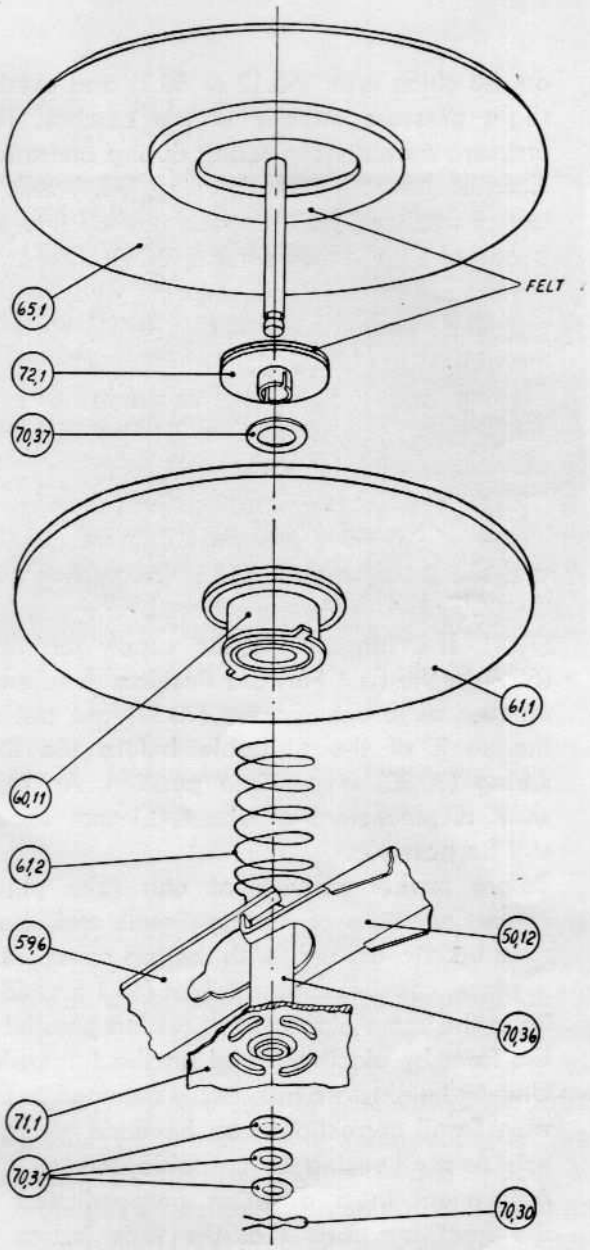


Fig. 7. Clutch Assembly of Take-up Turntable Exploded View.

on the cluch lever (50.12 or 59.7) and exert a slight pressure on one of the catches. This pressure prevents chattering during operation. Now the flange for the housing (72.1) with its turbax washer (70.37) ca nbe pushed into the upper end of the housing (70.36). The turntable shaft goes into its bearing and the felt ring underneath the turntable (61.1) rests on the pully disc (65.1 or 65.2).

Exerting pressure on the turntable (65.1 or 65.2) causes the pulley disc (61.1) to displace and the turntable is stopped by the flange (72.1) mounted in the housing. Push the operating lever (50.14) to the Fast Reverse Position and the pulley disc (61.1) is lowered so that the take-up turntable (65.1) rests on the flange (72.1). This happens to the supply turntable (65.2) in the Fast Forward Position. A suitable number of turbax-spacers (70.31) are put on the shaft of the turntable before the lock spring (70.30) is put into position. An axial shaft displacement of about 0.1 mm should still be possible.

Before further adjustment can take place, correct positions of the tape reels and shafts must be ascertained. With the top cover (74.1) in place, see that the turntables (65.1 and 65.2) lie in the same plane in a direction parallel to the front by placing a reel on the turntables. Uneven heights are also easily detected in this way. Small corrections can be done giving a twist to the housing for turntable bearing.

Adjustment in a direction perpendicular to the front are such that the tape leaves or enters the tape reel without touching the flanges of the tape reel. With an empty tape reel on the turntable sight across and see that the track in the tape guide (70.12 and 70.18) lies equidistant from the flanges of the tape reel. (This checking should be done with the operating lever (50.14) in the neutral position). If not, correction is done in two different ways: The housing for the turntable bearing can be twisted a little towards or away from the tape guides (70.12 and 70.18) or the height adjusted by adding or subtracting turbax washers (70.37) underneath the flange (72.1) in the housing for the turntable bearing. See Fig. 7. Which procedure to follow depends upon how the tape runs relative to the top cover and the reel. Secure sufficient clearance between the tape reel and the top cover (74.1).

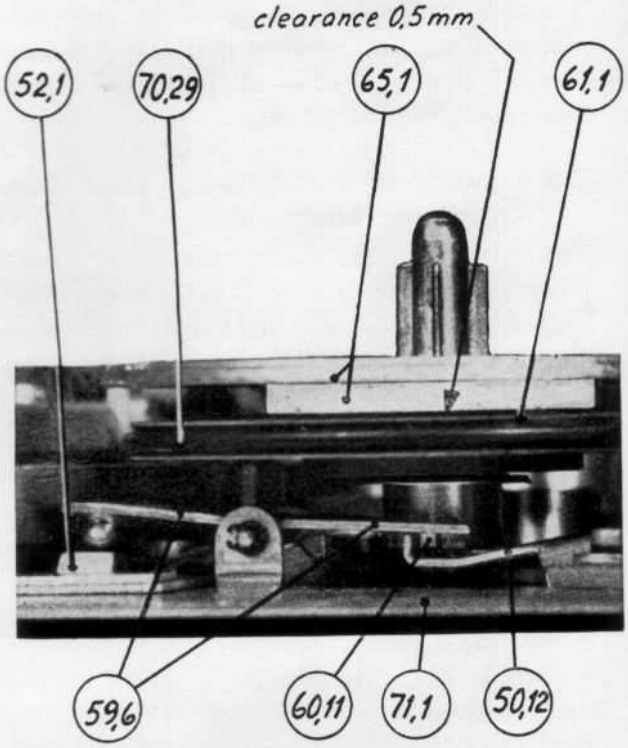


Fig. 8. Take-up Turntable, Fast Reverse Position.

3.4 Pulley Disc for the Take-up Turntable.

Operating Lever (50.14) in the Fast Reverse Position (Fig. 8): The upper clutch lever for take up pulley disc (59.6) is adjusted in this position. The trip bar (52.1) is then in such a position that the steel ball on which the clutch lever (59.6) rests is in its highest position. The other end of the upper clutch lever (59.6) pushes down the tags on the cartridge (60.11) and lowers the pulley disc (61.1) together with the lower clutch lever for take up pulley disc (50.12). In this position there must be about 0.5 mm clearance between felt ring and the pulley disc (61.1). This clearance can be adjusted by bending the clutch lever (59.6) slightly, at all times make sure that the clutch lever (59.6) touches the two tags on the cartridge (60.11) simultaneously.

The Operating Lever (50.14) in the Normal Forward Drive Position (Fig. 9). In this position the take-up turntable (65.1) must be given a suitable friction torque by the pulley disc (61.1) to wind up the tape during recording or playback. This friction torque should be from 10 to 14 grams measured at the end of a spoke in the empty tape reel or about 120 gram centimeters. From Fig. 9 it may be seen that the tags on the cartridge

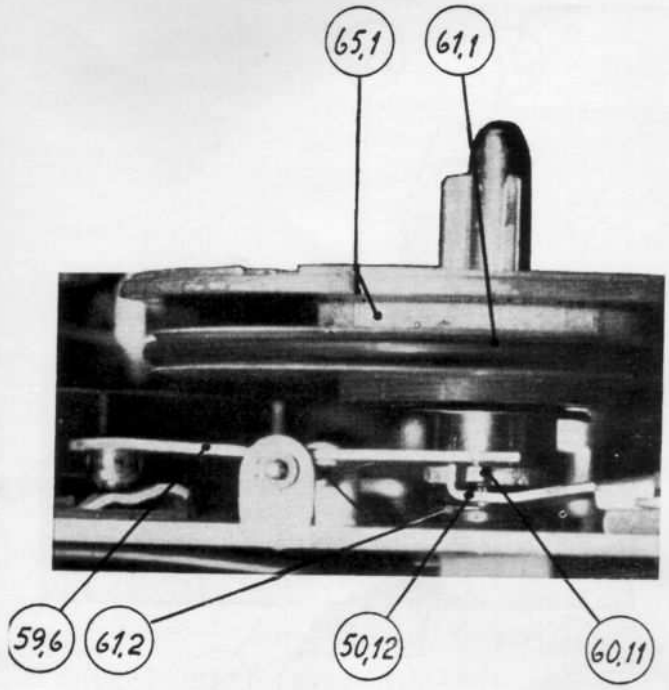


Fig. 9. Take-up Turntable, Normal Forward Drive.

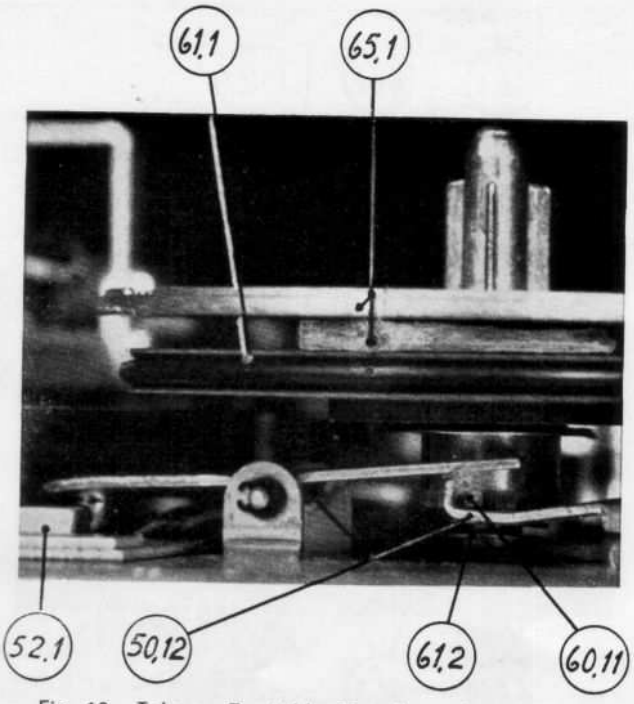


Fig. 10. Take-up Turntable, Fast Forward and Neutral Position.

(60.11) are midway between the upper (59.6) and lower (50.12) clutch levers. The upper clutch lever (59.6) is positioned with its steel ball in the middle position which releases the pressure from the lower clutch lever (50.12) on the tags. The pulley disc (61.1) is pressed against the felt ring on the turntable (65.1) with the compressive force of the helical compression spring for take up pully disc (61.2) only. The compressive force of the spring (61.2) must be adjusted so it gives the above mentioned friction torque. Because the felt gradually wears down, the clearance between the tag on the cartridge (60.11) and the upper clutch lever (59.6) should be about 0.5 to 1 mm. To guard unwanted extra upward pressure by the lower clutch lever (50.12), there should be about 0.5 mm clearance underneath the tag.

Operating Lever in the Fast Forward and Neutral Positions (Fig. 10): The operating lever (50.14) is now in a position such that the steel ball on which the clutch lever (59.6) rests is in its lowest possible position, i.e. the other end of the lever (59.6) is as high as possible. The spacing between the upper clutch lever (59.6) and the catches on the lower one (50.12) should be about 0.5 mm. The lower lever (50.12) exerts pressure on the tags of the cartridge (60.11) and engages the clutch by means of a forceful spring (60.10). In the fast forward position it is of importance to ascertain a high friction torque. This is accomplished by means of a helical spring (61.2) and an additional spring underneath the lower clutch (60.10). The friction torque should be about 50 grams acting on an arm of 8 cm or the equivalent of 400 gram centimeters. The friction torque is mainly supplied by the lower clutch lever (50.12) and this spring tension must be adjusted if the torque is too low.

3.5 Pulley Disc for the Supply Turntable.

Operating Lever in the Fast Forward and Normal Forward Drive Positions (Fig. 11): The pulley disc (61.1) is in the same position for fast forward and normal forward drive. The steel ball of the clutch lever for supply pulley disc (59.7) is at its highest position on the trip bar (52.1). The clutch lever (59.7) acts on the tags of the cartridge (60.11) and disengages the clutch.
Felt to pulley disc clearance should be 0.5 to 1 mm. Clearance is adjusted by bending the clutch lever (59.7).

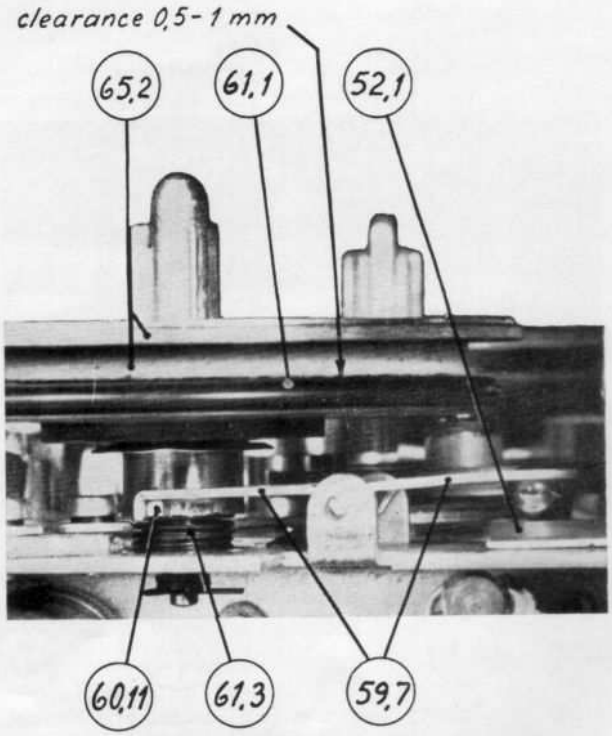


Fig. 11. Supply Turntable, Fast Forward and Normal Forward Drive Position.

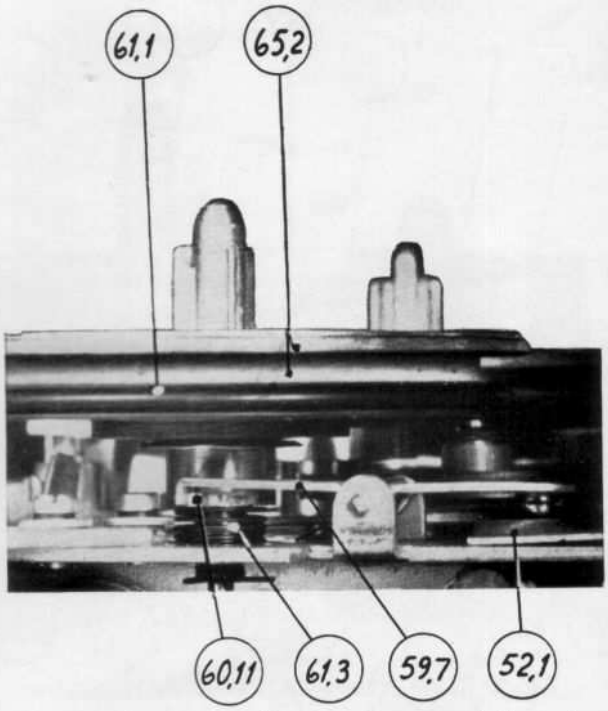


Fig. 12. Supply Turntable, Fast Reverse and Neutral Position.

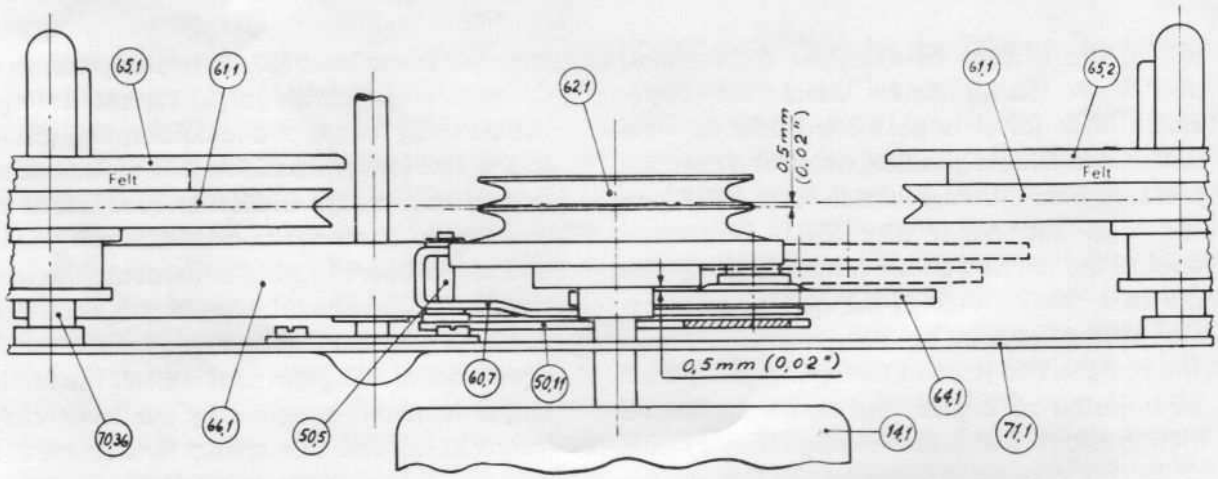


Fig. 13 Driving Mechanism.

Operating Lever in Fast Reverse and Neutral Positions (Fig. 12): The steel ball is lowered as much as possible and the clutch lever (59.7) raised to obtain clearance between the lever (59.7) and the tags on the cartridge (60.11): The helical compression spring for supply pulley disc (61.3) supplies the necessary clutch friction. This spring (61.3) has considerably higher tension than the corresponding one (61.2) in the right hand clutch assembly and supplies all the friction torque itself. The friction torque should be 50 grams acting on 8 cm or about 400 gram centimeters.

3.6 Motor Pulley, Speed Transfer Wheel and Speed Change.

A side view of the driving mechanism with the transfer wheel (64.1) in $1\,^7/_8$ ips position is shown in Fig. 13. The speed transfer wheel (64.1), has three different positions, corresponding to the three speeds. In the two lowest positions ($1\,^7/_8$ and $3\,^3/_4$ ips) the spacing between the upper edge of the speed transfer wheel (64.1), and motor pulley (62.1) shall be 0.5 mm. In upper position ($7\,^1/_2$ ips) the upper edge of the speed transfer wheel (64.1) should be below the upper edge of the flywheel (66.1).

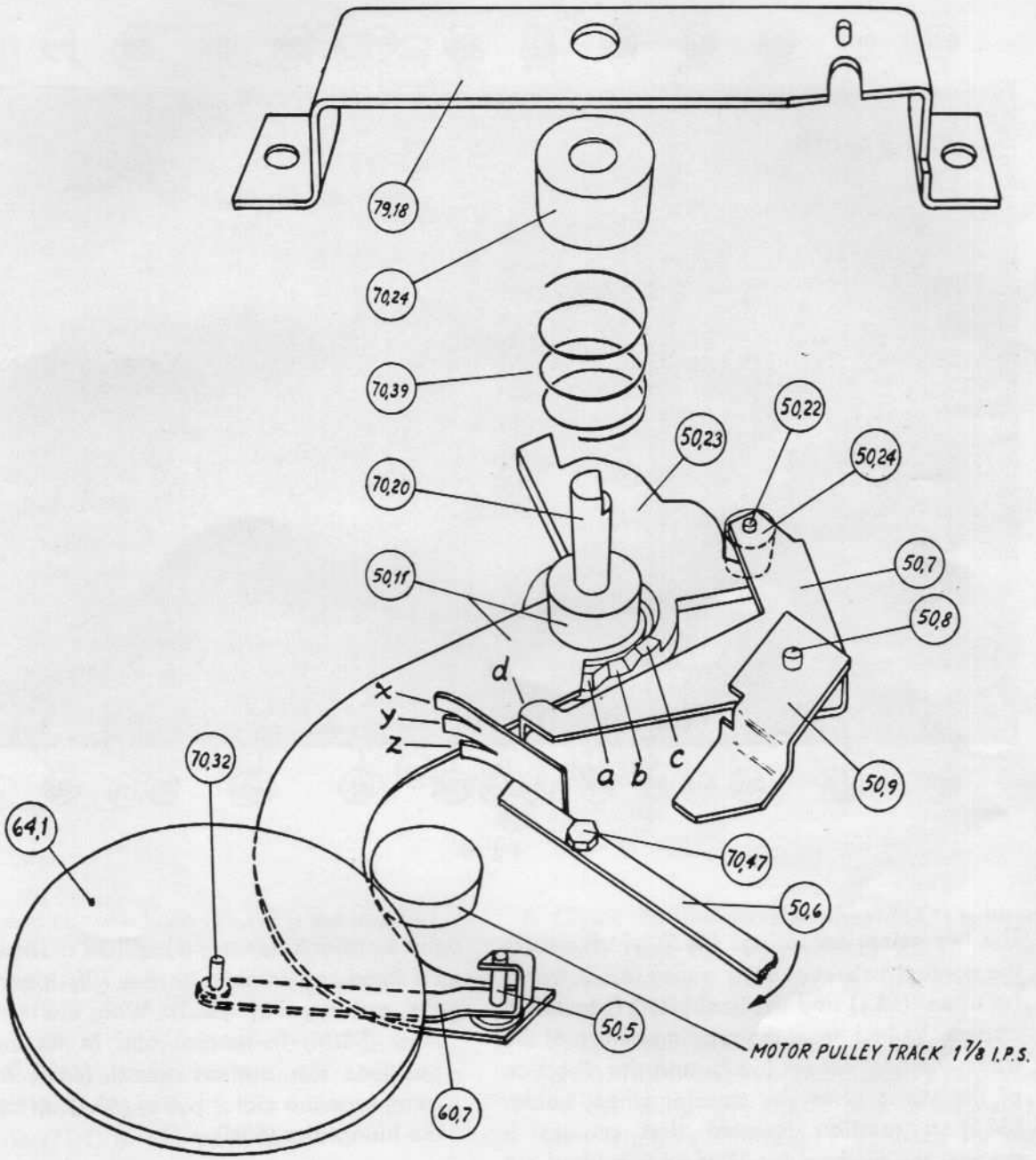


Fig. 14. Speed Change Mechanism.

The speed change mechanism is shown on Fig. 14. The key part is the cam disc (50.23) which determines the position of the transfer wheel arm (50.11) and also takes care of the elevation. The manner of operation is as follows: In $1\,^{7}/_{8}$ ips position the transfer wheel arm (50.11) is pressed against the lowest level of the cam disc (50.23). When turning the speed selector knob (79.14) towards $3\,^{3}/_{4}$ ips position, the transfer wheel (64.1) is first lifted away from the motor pulley (62.1) and the flywheel (66.1) by the cam disc arm (50.7), which rests with a little roller (50.24) against the curvature of the cam disc (50.23). The transfer wheel (64.1) is lifted so far that it can easily be lifted to the track for $3\,^{3}/_{4}$ ips. This lifting is done by the slope of the cam disc (50.23) which is pushed underneath the transfer wheel arm (50.11). See Fig. 14, 15, 16.

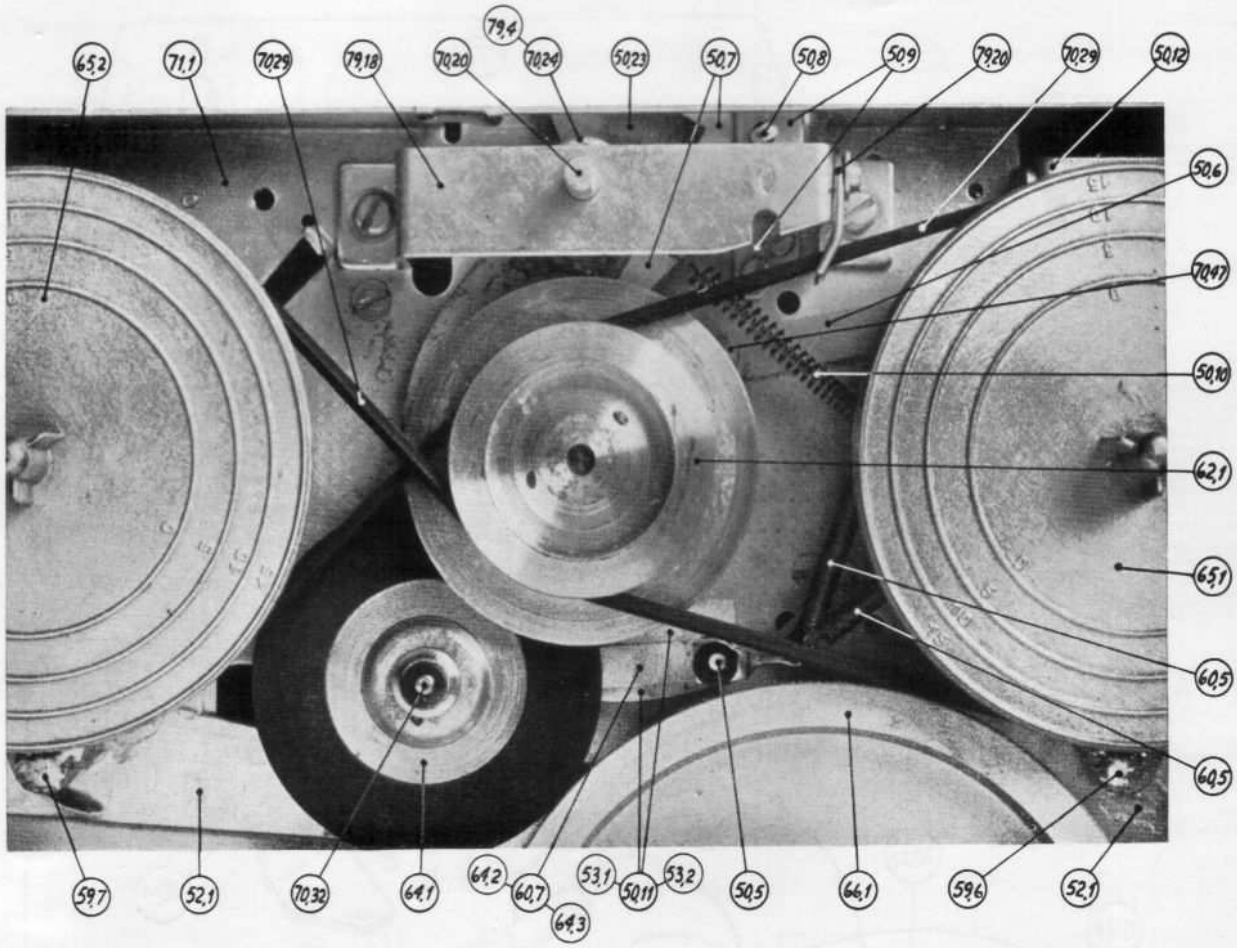


Fig. 15.

The two extension springs (60.5) which secure the contact between motor pulley (62.1), transfer wheel (64.1) and flywheel (66.1) is fastened approx. $^1/_2$ inch from the rotating centre of the transfer wheel holder (60.7), and the direction of the stress gives the transfer wheel holder (64.3) a rotation moment that presses it against the flywheel (66.1) when it is lifted out of contact.

This rotation moment secures that the transfer wheel (64.1) will not be jammed under the motor pulley (62.1) during the elevation. When the speed selector knob (79.14) has reached the $3\,^3/_4$ position, the cam disc arm (50.7) will move backwards again and allow the transfer wheel (64.1) to go into contact with the motor pulley (62.1) and flywheel (66.1), but now with the track for $3\,^3/_4$ ips on the motor pulley (62.1). This backwards movement is obtained at the moment the roller (50.24) slips into the marking slot for $3\,^3/_4$ ips. When turning the speed change knob (79.14) further to $7\,^1/_2$ ips position the transfer wheel (64.1) will in a similar way be lifted to contact with the $7\,^1/_2$ ips track on the motor pulley (62.1). With the operating lever (50.14) in neutral and in fast winding positions the transfer wheel (64.1) is lifted away from the motor pulley (62.1) by means of the lifting arm (50.6).

3.7 Mounting and Adjustment of Motor Pulley, Transfer Wheel and Speed Change. Fig. 13, 14, 15 and 16.

1. Check that the turntables (65.1 and 65.2) are correctly adjusted according to part 3.3.
2. Operating lever (50.14) is set in neutral position, and the motor pulley (62.1) is fastened in such a position that the dividing rib of the motor pulley (62.1) is 0.5 mm (0.02") below an imaginary connection line between the bottoms of the V-shaped grooves in the pulley discs (61.1). See Fig. 13.

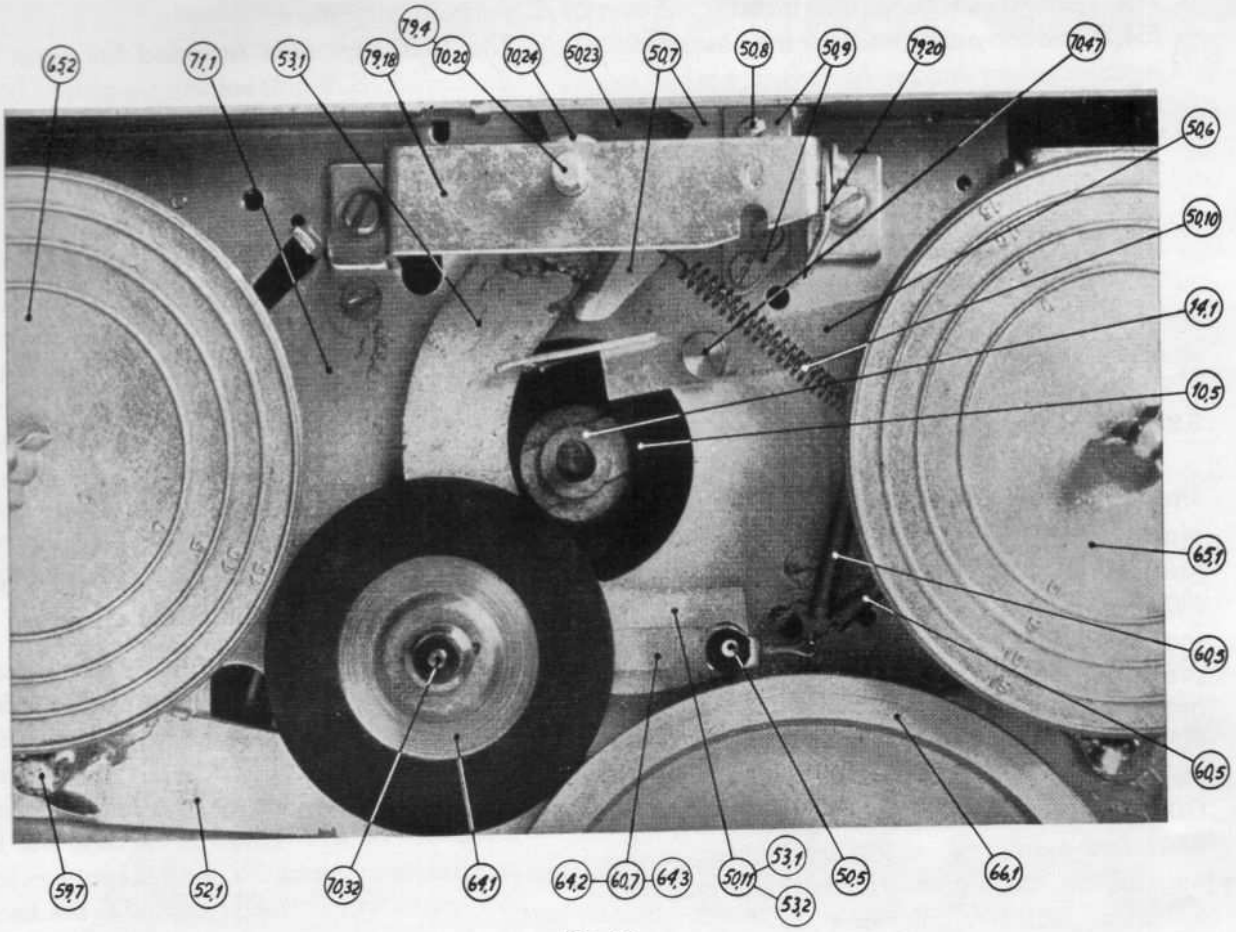


Fig. 16.

3. Speed change knob (79.14) is set to 1 $^{7}/_{8}$ ips position. The speed selector bracket (79.18) is adjusted until the transfer wheel arm (50.11) is parallel with the lower mounting plate (71.1) (approx. 1 mm (0.04") distance). It is checked that the transfer wheel arm (50.11) does not touch the lower mounting plate (71.1) in any position.

4. Speed transfer wheel (64.1) is mounted on the shaft for speed transfer wheel (70.32). Check that the cam disc arm (50.7) moves the transfer wheel (64.1) safely away from the next track on the motor pulley (62.1), before the slope on the cam disc (50.23) starts the elevation. In the working positions the spacing between the cam disc arm (50.7) and transfer wheel arm (50.11) at point d shall be 0.5 mm (0.02"). If necessary, the spacing is adjusted bye bending the nose on cam disc arm (50.7) see Fig. 14. When doing this adjustment the motor pulley (62.1) has to be removed.

5. Check that the transfer wheel (64.1) is lifted away from the motor pulley (62.1) in the three working positions of speed change knob (79.14), when the operating lever (50.14) is in neutral and fast winding positions. This lifting is accomplished by transfer wheel lifting arm (50.6), and if necessary, the lifting is individually adjusted for the three speeds by bending the three split ends x, y, z (Fig. 14) of the lifting arm (50.6). The lifting shall take place by a relative little movement towards neutral positions of the operating lever (50.14). The lifting should have taken place before the motor current is broken by the micro switch (30.16).
On the other hand, when moving the operating lever (50.14) from neutral to playback-record position, the transfer wheel (64.1) shall have come into action before the operating lever (50.14) has come to its marked position for instantaneous start. To make this adjustment the motor pulley (62.1) has to be taken off.

6. The spacing between the transfer wheel (64.1) and the pulley track for the next speed is adjusted by means of turbax washer to 0.5 mm (0.02"). During this adjustment the motor pulley (62.1) has to be in its correct position, see above 3.7 point 2. Check that the upper edge of the transfer wheel (64.1) is below the upper rim of the flywheel (66.1) in 7 1/2 ips position. If necessary, the flywheel (66.1) is lifted by an extra steel washer in the lower flywheel bearing.

3.8 Path of the Tape and Correct Positioning of the Heads.

The tape path is from the left to the right in playback and recording position. One adjustable (70.16) and two fixed tape guides (70.12 and 70.18) provide the proper path of the tape, but correct contact between the pressure pad (79.1) and erase head (16.1) together with uniform pressure of pressure wheel (63.1) against capstan (60.2) are of great importance, see Fig. 3. The adjustable tape guide (70.16) is inserted as a gurantee for momentary unwanted movement of the tape and should normally not make press against the tape. This will cause excessive noise and sometimes drop the high frequency response. In correct position the heads (15.1, 16.1) should make good contact to the tape at the gapzone, and the gaps should stand in a right angle to the motion of the tape.

3.9 Adjustment of the Path of the Tape and Head Position.

A Standard Alignment Tape, and an output-meter are required to make this adjustment.

1. The adjustable tape guide (70.16) is removed, the tape is put in position and the speed change knob (79.14) is set to 7 1/2 ips. The adjustable latch (70.19) on the pressure wheel assembly (50.1) is adjusted until the pressure wheel (63.1) runs with shaft (60.8) parallel to the capstan (60.2) and with an even pressure. The pressure pad (79.1) is adjusted so that the tape has no tendency to vertical movement. Approx. 100 grams force is correct for the pressure pad (79.1).
2. The adjustable tape guide (70.16) is inserted and adjusted in such a way that the tape runs equidistant from its flanges.
3. Azimuth alignment.
   The 10 000 c/s note recorded full track on the Standard Alignment Tape is played back and the azimuth alignment of the play back heads (15.1) is done by the two screws on the left side of the head mounting plate (15.2). The output meter is first coupled across the output terminals of the amplifier for upper track. Thereupon it is checked that the head for lower track also is correctly adjusted. It may happen that the maximum output from the two heads does not occur for exactly the same position of the screws. The reason is that besides the azimuth alignment the two screws have also some effect on the height of the head. The azimuth alignment screws are therefore adjusted to maximum sum of the outputs.
4. Control of contact between playback head and tape. By means of a stud of a none magnetic material the contact angle between the tape and head (15.1) is momentarily increased. First on the left side and thereafter on the right side. It shall not be possible to increase the head output by such manipulations. If this is possible, the head (15.1) has to be turned to give a better contact between gap and tape. A final check of the contact is done by lifting the pressure pad (79.1) momentarily away from the tape. The output voltage of 10 000 c/s shall then not decrease more than 4 dB on either track.
5. Adjustment of the tape path height.
   To make this adjustment it is necessary that the two amplifiers' amplifications are adjusted according to part 6.3.1. The potentiometer should be set to the exact position where the amplifications are adjusted.
   Set the stereo switch in position STEREO and play back the 250 c/s note on the Standard Alignment Tape. (Full track). By means of the adjustable tape guide (70.16) the tape path is adjusted to give exactly the same output across the output terminals of the two amplifiers. Afterwards check that the tape runs equidistant from the flanges of the adjustable tape guide (70.16). If not so, the height of the fixed tape guides (70.12 and 70.18) is adjusted by means of washer to secure this point. If a rather great adjustment of the tape path is necessary, the

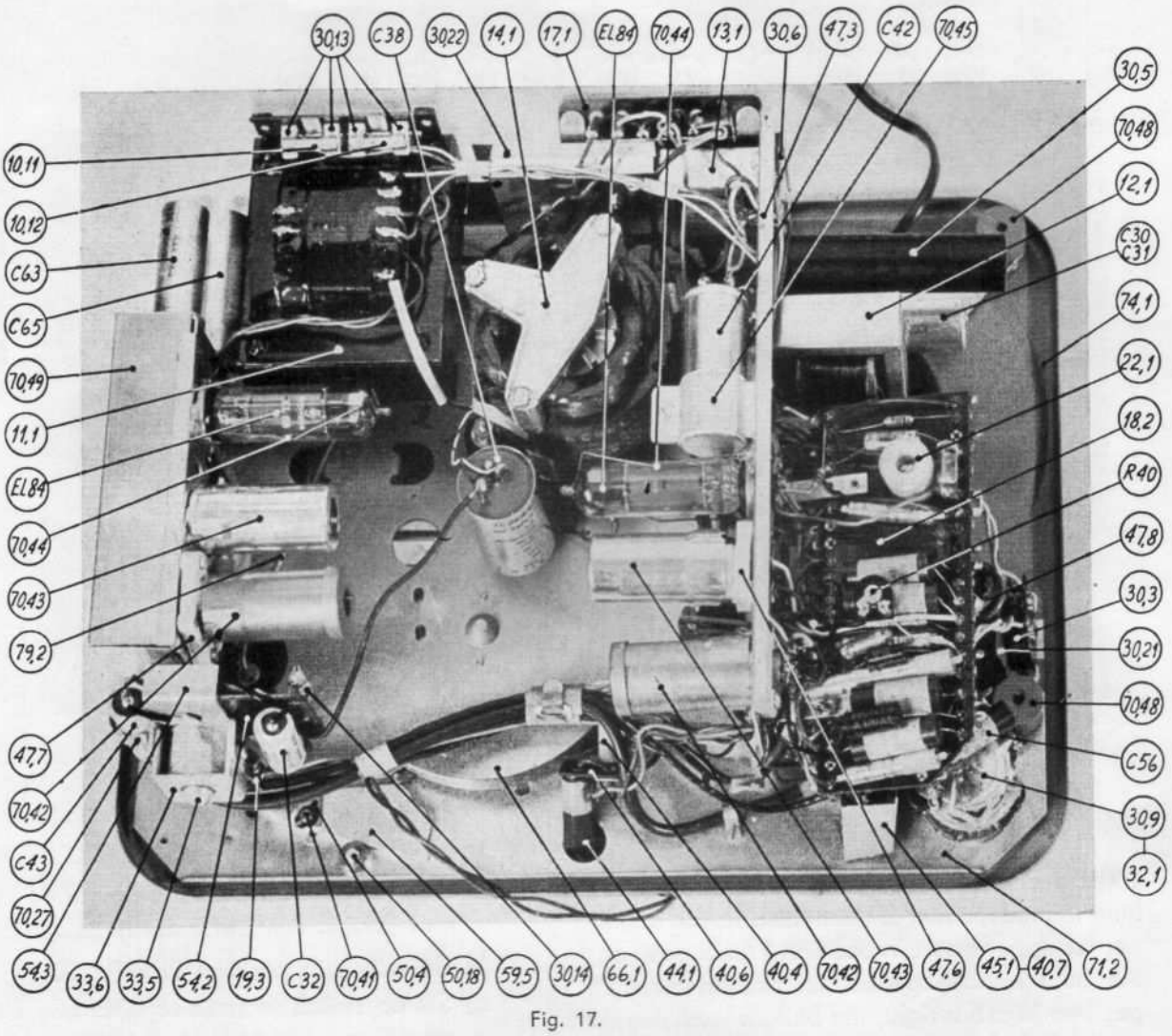


Fig. 17.

azimuth alignment of the head gap has to be rechecked.

6. The height of the erase head (16.1) is adjusted by means of the dimensions on the rod underneath the head mounting plate (16.2) in such a way that the upper edge of the tape runs 0.1 mm (0.005") below edge of the erase head (16.1).

4. DESCRIPTION OF THE ELECTRONIC UNIT

4.1 Operating Controls.

The electronic unit has the following operating controls: Mode switch (79.13) (Record- playback- pub.addr. switch), speed selector switch (79.14), loudspeaker switch (30.7), volume control (79.12), bass switch (30.3) and stereo switch (59.8). The location of the operating knobs is shown in Fig. 1.

The mode switch is mechanically coupled to the operating lever (50.14). The switch is held in position PLAYBACK by means of a spring (50.21). The knob (79.13) is turned counter clockwise to position RECORD for recording. The switch is locked in this position when the operating lever (50.14) is set to normal forward drive. Push the operating lever (50.14) back to its neutral position when recording is finished, and the mode switch releases automatically. Turned clockwise, the switch is set to position PUB. ADDR. in which the unit operates as a public address system. The necessary mechanical and electrical switching when changing tape speeds is done by the equalization switch (30.25). Location of the equalization switch (30.25) is shown in Fig. 17 and without shield in Fig. 18. The loudspeaker switch (30.7) has three positions. In position

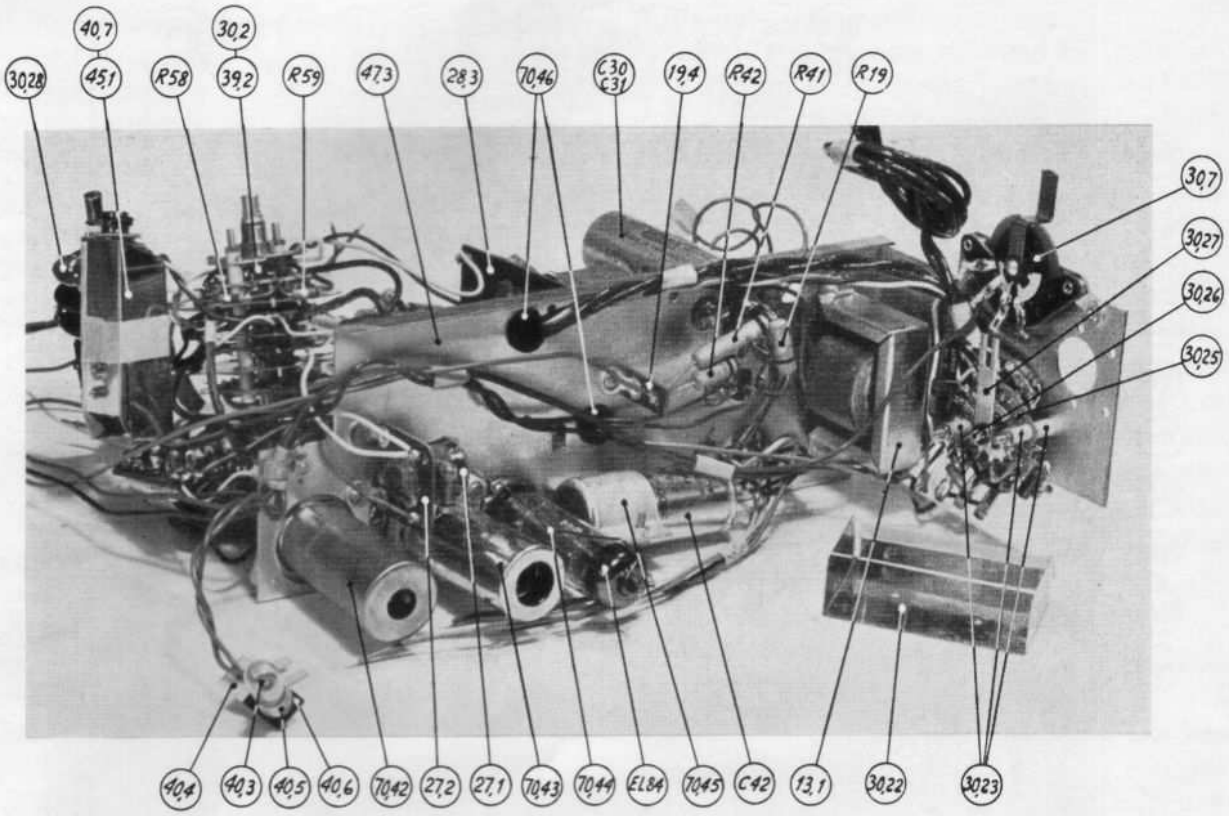
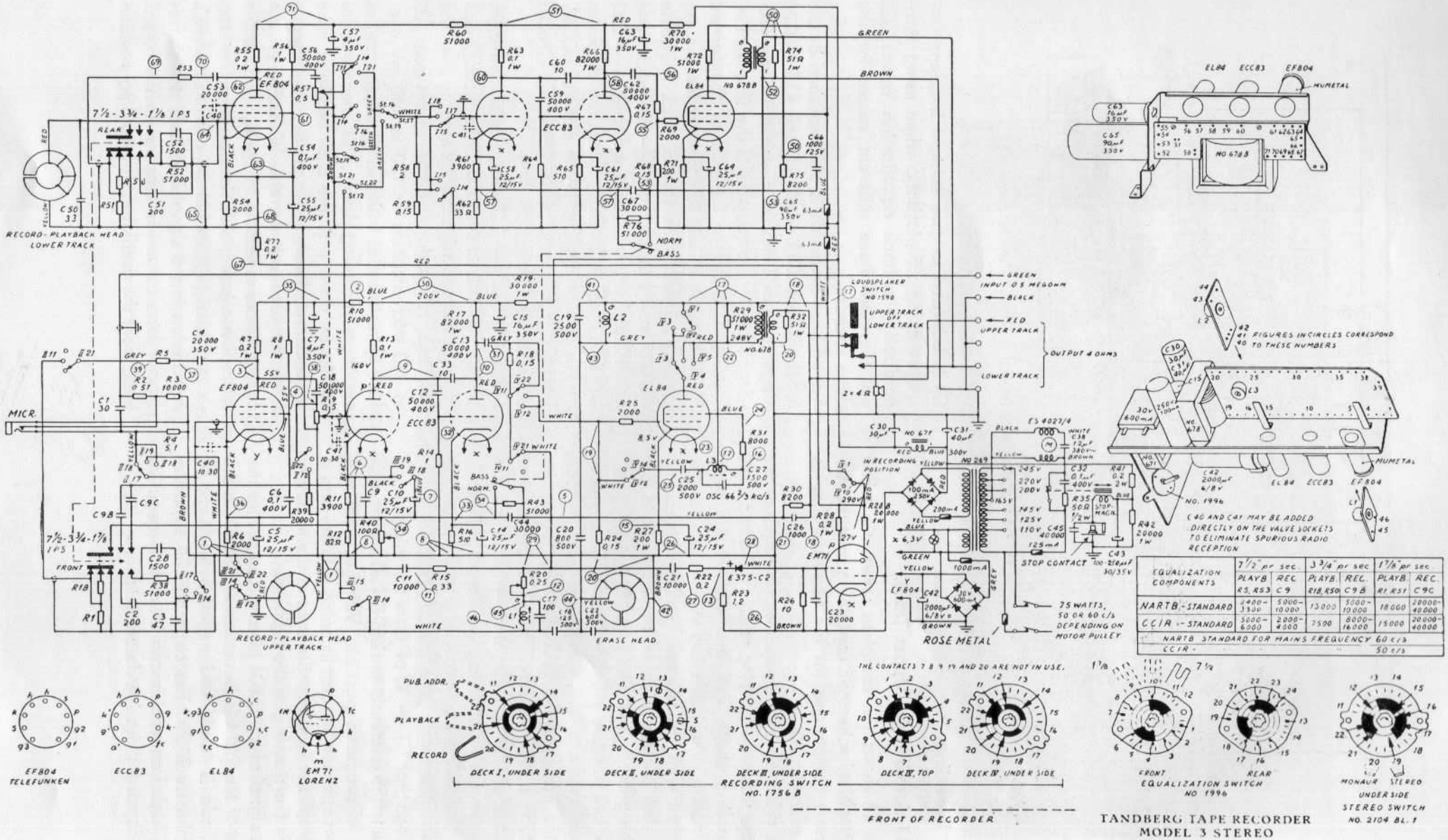


Fig. 18. Amplifier for Upper Track.

1 (to the left, seen from recorder front) the built in loudspeaker is connected to the amplifier for upper track. In position 2 (mid position) the built in loudspeaker is disconnected. In position 3 (to the right) the built in loudspeaker is connected to the amplifier for lower track. The stereo monaural switch gives the following possibilities:

1) Mode switch in position RECORD.
   a) Stereo switch in position STEREO. The amplifier for upper track is working as a a normal recording amplifier for upper track. The amplifier for lower track is disconnected.
   b) Stereo switch in position MONAUR. The amlifier for upper track is working as a normal recording amplifier for upper track. The amplifier for lover track is working as power amplifier for the recorded program, getting this from the first tube of the recording amplifier. The amplification in both amplifiers is regulated simultaneously by the upper half of the double potentiometer, and the power output of the amplifier for lower track is approx. 2.5 watts at max recording current (magic eye just closed).
2) Mode switch in position PLAYBACK.
   a) Stereo switch in position STEREO. Each amplifier is connected as normal playback amplifier for each of the two tracks, ready for stereophonic play-back.
   The output is regulated by a double potentiometer. This is specially made and the max. deviation between the amplification in the two amplifiers is below 2 dB in the range from 0 to 25 dB damping.
   b) Stereo switch in position MONAUR. Both amplifiers are connected to the head for upper track through the upper half of the double potentiometer.
3) Mode switch in position PUB.ADDR.
   a) Stereo switch in position STEREO. The amplifier for upper track is connected to the input of the recorder. The amplifier for lower track is disconnected.
   b) Stereo switch in position MONAUR. Both amplifiers are connected to the input of the recorder over the upper half of the double potentiometer.



EQUALIZATION COMPONENTS	7½" pr sec. PLAYB. R5, R53	7½" pr sec. REC. C9	3¾" pr sec PLAYB. R18, R50	3¾" pr sec REC. C9B	1⅞" pr. sec. PLAYB. R1, R51	1⅞" pr. sec. REC. C9C
NARTB - STANDARD	4400 - 3300	5000 - 10000	13000	5000 - 10000	18000	20000 - 40000
CCIR - STANDARD	5000 - 6000	2000 - 4000	7500	6000 - 16000	15000	20000 - 40000

NARTB STANDARD FOR MAINS FREQUENCY 60 c/s
CCIR - 50 c/s

TANDBERG TAPE RECORDER
MODEL 3 STEREO

DRAWING NO 2143

Fig. 19.

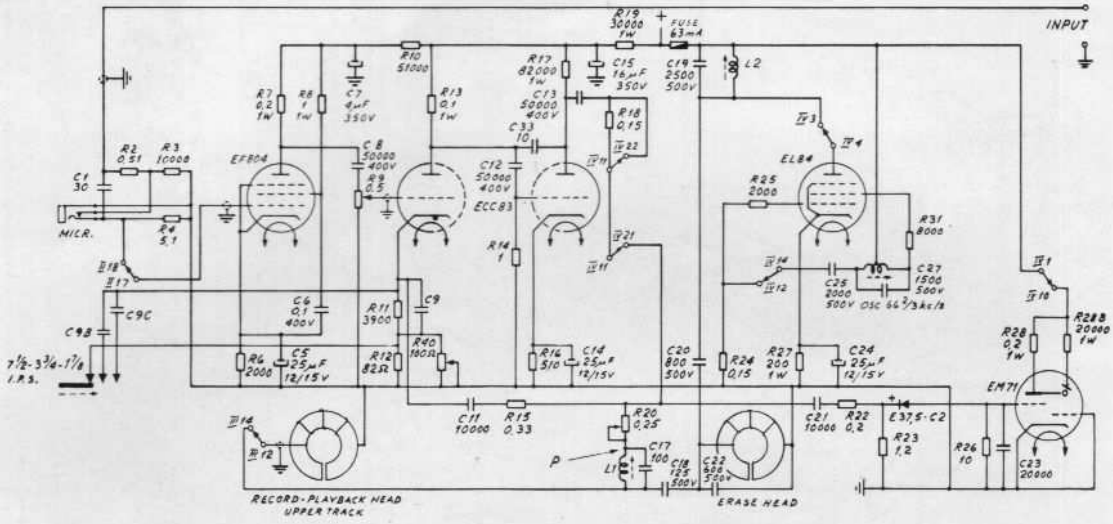


Fig. 20. Simplified Diagram of Amplifier for Upper Track in Record Position.

4.2 Recording.

4.2.1 Amplifier for Upper Track.

Fig. 19 shows the complete schematic, while a simplified schematic containing only the necessary components for the understanding is given in Fig. 20.

The tubes operate, as follows, in amplifier for upper track in recording position: Preamplifier, recording stage, oscillator and record level indicator. Switching points in the amplifier are marked with roman and regular numbers to indicate the locations of the contacts in the three gang switch. See Fig. 19.

The unit has two input terminals. One is over the microphone jack, bringing the total voltage to the first amplifier grid, the other is via the terminals marked INPUT which incorporate a voltage divider 0.51 megohm — 10 Kohms that reduces the input voltage in the ratio 50 to 1, thereby giving the signals from radio or phono pickup the correct voltage level.

A capacitor C1 — 30 pF from the microphone jack to the terminals marked INPUT makes mixing of programs possible. Voltages from a 4 ohms speaker (regular listening volume) and a microphone held at a distance of about 20 cm. from the mouth give the right level.

The signal of the EF804 plate circuit excites the grid of the first triode section of ECC83. In the cathode is introduced negative feedback to emphasize highs. The capasitor C9 bypasses the high frequencies and introduces negative feedback for the low frequencies.

C9 is adjusted to give straight frequency response at record-playback, when using standardized play-back equalization curves. C9 will therefore have different values for the three speeds.

A smal bass emphasis is accomplished by the feedback loop C11 — .01 μF and R15 — 0.33 megohm from the plate of second triode section ECC83 to the cathode of the first section. The signal is fed to the grid of the second triode section ECC83 which supplies the recording current to the record head. The plate circuit consists of the record — playback head and a bias frequency rejector circuit L1 — C17 tuned to 66 $^2/_3$ kc/s, that prevent the oscillator frequency from getting to the plate of ECC83. The voltage measured at point P in Fig. 20 must be less than 5 volts.

The resistor R20 — 0.25 megohm semivariable potentiometer is in series with the record head to keep the record current constant over the frequency range. A recording current from 120 to 140 microamperes or 120 to 140 mV over 1000 ohms in series with the head is normal at maximum recording level. This measurement should be done with the EL84 oscillator tube removed from its socket to prevent interference from the oscillator current. With the volume control set to maximum, a 2 mV signal at the microphone jack is sufficient to drive the tape to saturation (120 to 140 mV over 1000 ohms). In addition to the signal frequency a high frequency bias current is supplied to the record head from the oscillator. In recording position

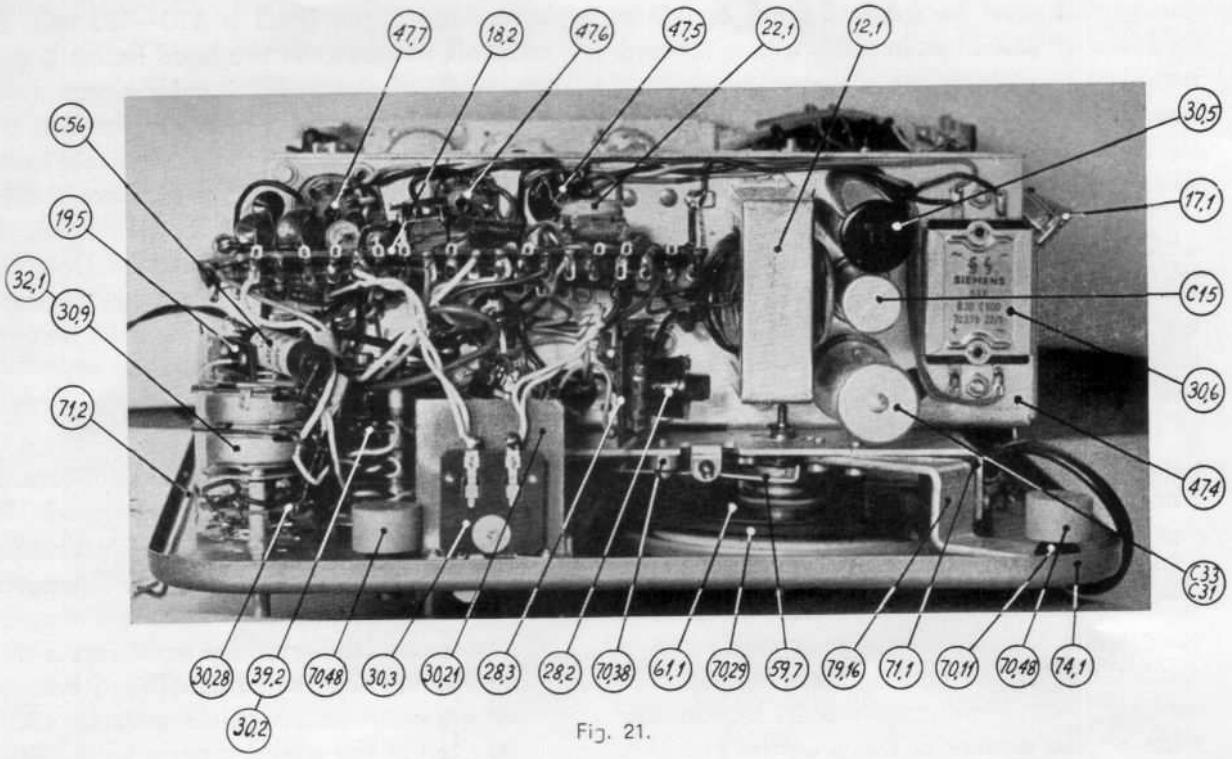


Fig. 21.

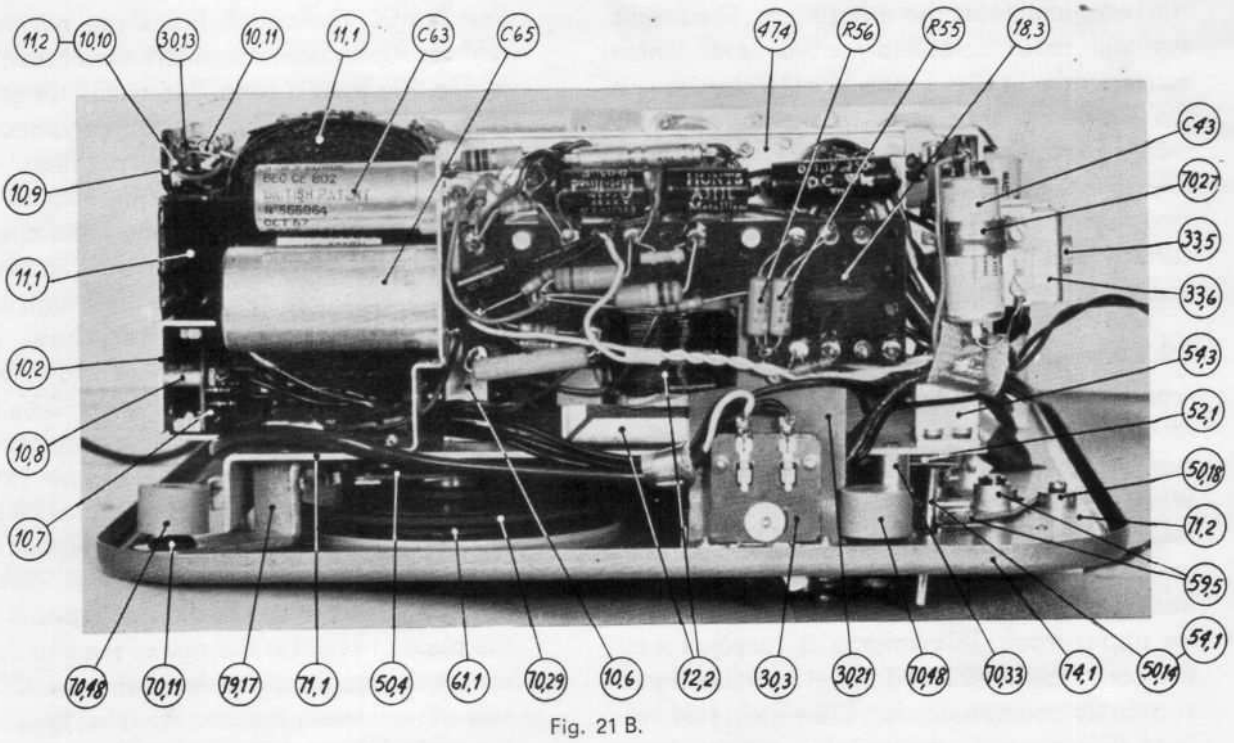


Fig. 21 B.

of the mode switch, the output tube EL84 works as an electron-coupled oscillator with the tank circuit L3 — C27 tuned to 66 $^2/_3$ kc/s. The plate is tuned to the same frequency by means of L2 — C19. R31 in the oscillator circuit controls the oscillator so that the least amount of harmonics are present in the oscillator voltage.

Erase current is fed from the plate through the erase head which itself is tuned to 66 $^2/_3$ kc/s with a capacitor of 600 pF. Erase voltage over the erase head must be 170 to 190 volts. Location of tubes, tuned circuits and switches is shown in Figs. 17, 18 and 21. The record head receives its bias current via capacitor C18 and the recording switch gang III marked 14/12

The current must be 0.5 to 0.6 mA or 0.5 to 0.6 volt over 1000 ohms in series with the record head.
The record level indicator EM71 receives its signal voltage over the voltage divider R22 — R23.

4.2.2 The Magic Eye.

The magic eye EM71 receives its signal voltage over the voltage divider R22 — R23. In the grid circuit of the magic eye a rectifier E 37.5 — C2 has been introduced. This charges the .02 μF condenser C23. The discharge of the condenser takes place through R26 — 10 megohms, parallel with the non-conducting direction of the rectifier, in which the impedance is more than 20 megohms. The charging of C23 is done rapidly through R22 — 0.2 megohm, while the discharge goes slowly. As a result the return of the magic eye indication is very sluggish. The magic eye indication will «ride on the peaks» of the program and this markedly facilitates the adjustment. The magic eye will close completely at a level which corresponds to 3—4 per cent distortion on the tape. The magic eye maintains its sensitivity over the whole frequency range from 30—15 000 c/s. The adjustment of the magic eye sensitivity with regard to the recording current is done by means of R20 which is connected in series with the recording head.

4.2.3 Amplifier for Lower Track.

Amplifier for lower track can, when the tape recorder is in record position, be used as a monitor amplifier for the recorded program. When the stereo switch is placed in position MONAUR. the first grid of the ECC83 tube in amplifier for lowert rack gets signal voltage from the top of the potentiometer in amplifier for upper track. This voltage is received over the contacts 12—22 and 19—17 in the stereo switch via voltage divider R58—R59. This voltage divider gives approx. full output when the recorder for upper track gives maximum recording current (Tape loaded to approx. 4 % distortion). The upper half of the double potentiometer is regulating both amplifiers. When the stereo switch is set to position STEREO the interconnection between the two amplifiers is broken.
In record position the bias magnetizing voltage across the upper head is 110—130 volt. The crosstalk between the two head halves is approx. — 60 dB, but still it is a HF-signal across the lower head which is fed to the first grid in the amplifier for lower track. To avoid further amplification of this voltage which would cause overloading and cross talk difficulties, the first tube is biased beyond cut off. This bias is obtained by a positive voltage of approx. 3 volts on the cathode, taken from the main HT via R77 — 0.2 megohm.

4.3 Playback.

1) In position STEREO the two amplifiers are connected to each of the two heads. The amplifiers are two normal audio amplifiers with the standard equalizations. This equalization is different for the different speeds and the recoupling of the amplifiers is done by the equalization switch. This is actuated by the equalization switch actuator (30.20) inserted in the speed change shaft (70.20). See fig. 22 The switch has three positions and recouples both amplifiers simultaneously. Fig. 23 shows a simplified circuit diagram containing only the necessary components for the understanding of the operation.
All equalizations are done in connection with the first tube EF804. In the head circuit are inserted condensers which, combined with the head, give a rise at the high frequency end. These condensers have the values 47 μμF, 47 μμF + 200 μμF and 47 μμF + 200 μμF + 1500 μμF at 7½ ips, 3¾ ips and 1⅞ ips respectively. These condensers boost the high frequencies with the same amount as the high frequency losses in the playback head, (gap losses and eddy current losses). The boost is approx. 4 dB at 15 kc/s, 8 kc/s and 4 kc/s for the different speeds. In the plate of EF804 is the rest of the standard playback equalization. According to CCIR resommendations the frequency response of the reproducing channel should correspond with the impedance of RC series-combination with time constans of 100 μs, 200 μs and 400 μs for the tape speeds 7½ ips, 3¾ ips and 1⅞ ips. In U.S.A. a time constant of 50 μs is mostly used at 7½ ips and as a consequence all tape recorders made for 60 c/s are equipped with this equalization. The changing of the time

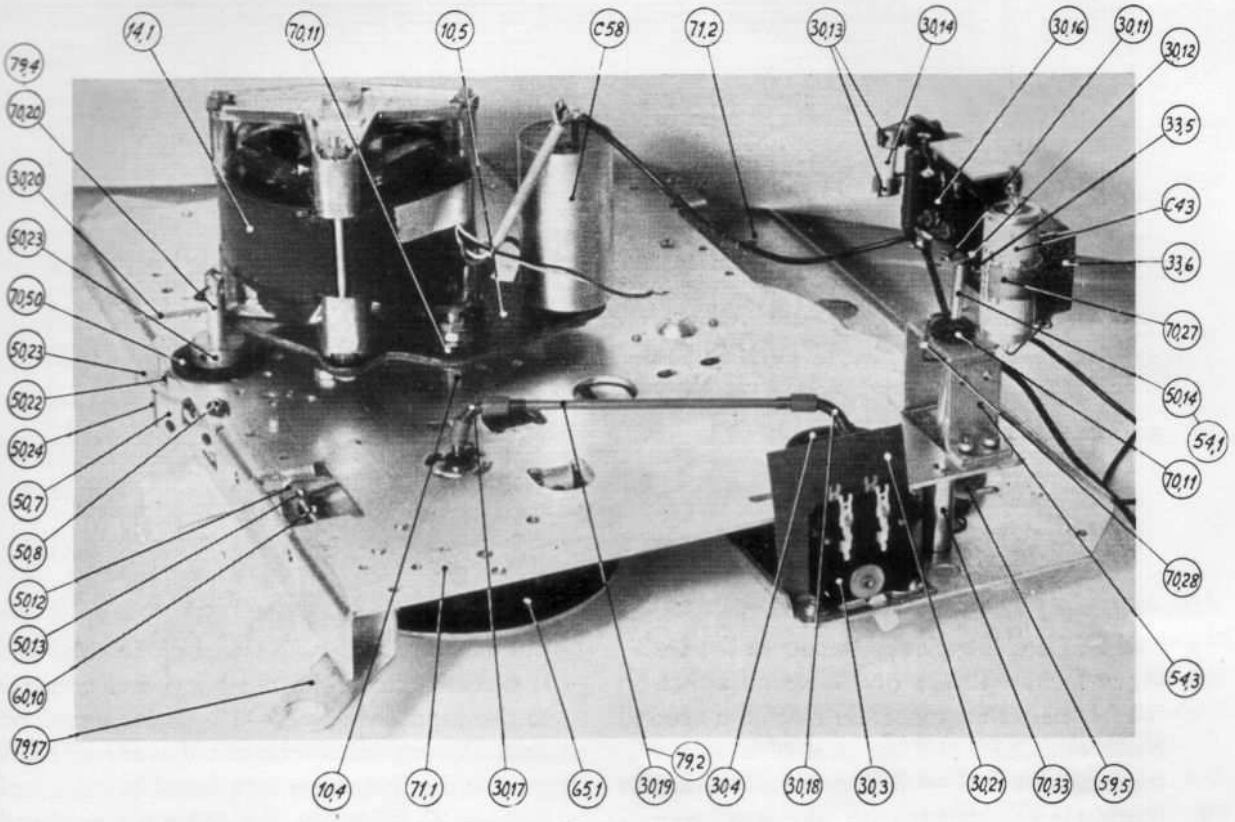


Fig. 22.

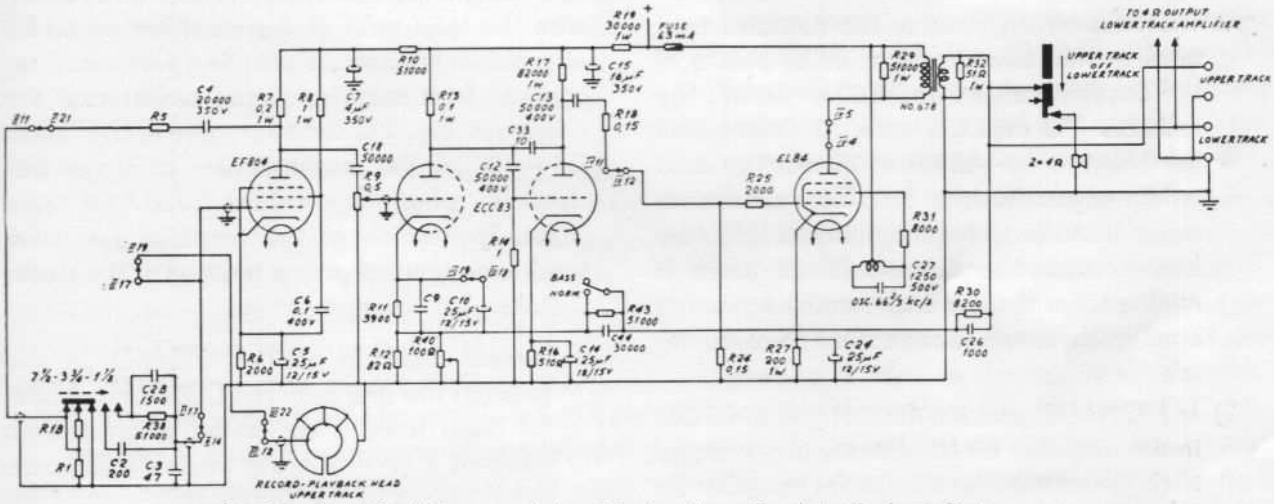


Fig. 23. Simplified Diagram of Amplifier for Upper Track in Playback Position.

constants is done by changing the resistor and using the same condenser. Further details about the equalization is given in part 4.5.

From the top of the potentiometer both amplifiers have a straight frequency response with the bass switch in normal. The negative feedback is approx. 15 dB. The treble boost in the amplifier for upper track in recording positions is removed by an electrolytic condenser C10 — 25 μF, and the corresponding bass boost by cancelling the feedback from the 2. plate of ECC83.

In playback position the negative feed back takes place from the secondary of the output transformer to the first cathode of ECC83 over R30 — C26 to R12 — R40 in amplifier for upper track and via R75 — C66 to R62 in amplifier for lower track. R40 is a semivariable linear potentiometer and is regulated until the amplifications in the two amplifiers are exactly like. The condensers C26

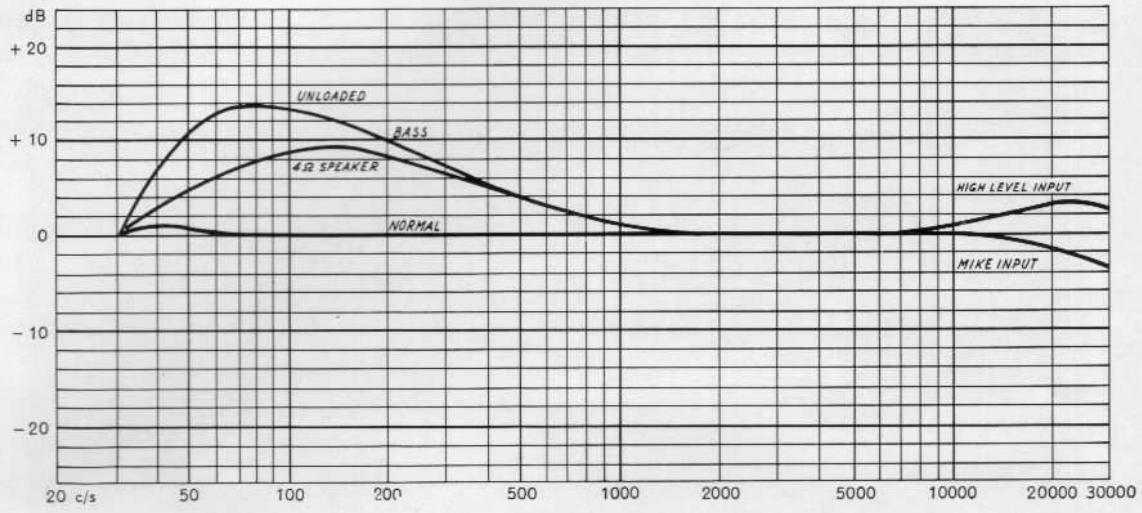


Fig. 24. Frequency Responses in Pub.Address.

and C66 are introduced to secure the stability of the amplifiers and have no effect on the frequency response. Between the second plate of ECC83 and the grid of EL84 a voltage divider R18 — R24 and R67 — R68 is introduced to remove an unwanted amplification.

The bass switch reduces the negative feed back at the lower frequencies by means of the condensers C44 and C67 at .03 μF. The resistors R43 and R76 each 51 Kohms limit the boost to 10—12 dB at 70 c/s. The bass switch effects the two amplifiers simultaneously. In order to reduce the hum level, the heater current to the two EF804 tubes is rectified. For the same reason the screening cans on these two tubes are made of mumetal.

2) In MONAUR. position the first grid of ECC83 in the amplifier for lower track is connected to the potentiometer arm in the amplifier for upper track via the contacts 12—22 and 19—17 in the stereo switch. Thus the first grids of the two ECC83 tubes are directly connected, and when playing back monaural tapes, it is possible to utilize the total output power of the tape recorder. The bass switch works in the same manner as in position STEREO.

4.4 Public Address.

With the mode switch in PUB. ADDR. position the amplifier for upper track works as a straight audio amplifier from the input to the output of the recorder. The grid of the tube EF804 is disconnected from the head and connected to the inputs via II 17—18, as in record position. The equalizations are disconnected. The gain in the first stage is reduced by introducing R39 — 20 kohms in the plate via contacts II 22—12. This gain reduction is desirable, otherwise the total gain of the amplifier would be unsuitable for normal use. The frequency responses from mike input and radio input are shown in Fig. 24. Because of the condenser C1 — 30 pF the response rises at higher frequencies, when the amplifier is fed from radio input. The action of the amplifier for lower track is dependent on the position of the stereo switch.

1) Stereo switch in position STEREO. In this position the first grid of ECC83 in amplifier for lower track is connected to ground via contacts I 17—18 in the mode switch, contacts 17—16 in the stereo switch and contacts I 16—14 in the mode switch.

2) Stereo switch in position MONAUR. The first grid of ECC83 in amplifier for lower track is connected to the first grid of amplifier for upper track via contacts I 17—18 in the mode switch and 22—12 in the stereo switch. This interconnection between the two amplifiers offers possibilities for utilizing the full output power of the recorder and also connecting and disconnecting a loudspeaker (or loudspeaker group) without any influence on the other.

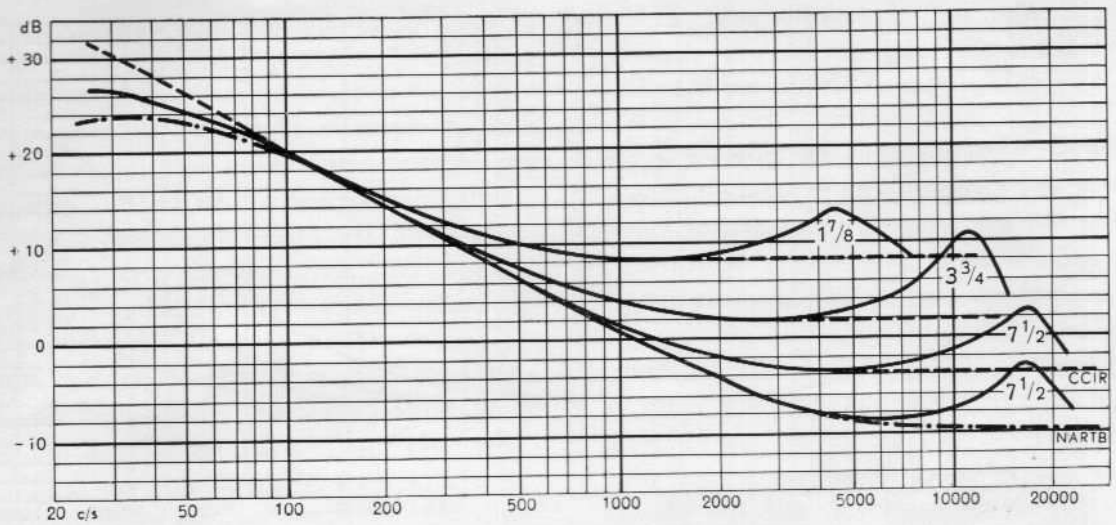


Fig. 25. Frequency Responses of Playback Amplifiers.

4.5 The Frequency Responses of the Amplifiers.

1) The CCIR (Comité Consultative International de Radio Communications) has in the Recommendation No. 209 specified the frequency response of the reproducing channels corresponding with the impedance of RC seriescombinations with time constants of 100 and 200 μs for the tape speeds 7 1/2 and 3 3/4 ips. The same standard has been specified by IEC (International Electrotechnical Commision). In addition the reproducing amplifier should boost the higher frequencies corresponding to the play back head losses. These losses consist mainly of gap loss and eddy current losses in the play back head and will, with effective gap width of approx. 6/1000 mm (0.00023") and head- laminations thickness of 0.12 mm (0.005"), amount to approx. 4 dB at 15 kc/s, 8 000 kc/s and 4 000 kc/s at 7 1/2 ips, 3 3/4 ips and 1 7/8 ips, varying somewhat depending on the insulation of the lamination and effective gap width. The reason for this standard is that tapes recorded on one tape recorder can be played back on others with a correct result. At 1 7/8 ips there is no standard. The response curve at this speed is chosen 400 μs. In U.S.A. and other countries with a main power supply of 60 c/s, the CCIR standars are not mainly accepted. Usually the reproducing channel specified in the NARTB recommendation for 15 ips, is used. This has a 50 μs response. In addition the NARTB limits the boost on the lower frequencies corresponding to a RC parallel combination with a time constant of 3180 μs. In these countries there are no standard responses, and tape recorders made for such countries are equipped with reproducing channels corresponding to 50 μs, 200 μs and 400 μs for the speeds 7 1/2 ips, 3 3/4 ips and 1 7/8 ips. Also NARTB counts with an additional boost on the higher frequencies to eliminate the high frequency losses in the play back head. Fig. 25 shows the actual frequency responses for the reproducing channels. Checking and adjustment of the reproducing channels are described in sec. 6.3 point 2 and 6.4 point 3.
2) The recording amplifier frequency respons will as a consequence of the standardisation of the reproducing amplifier, be different for the different speeds. The recoupling of the amplifier is done by the equalization switch, and the condensers C9, C9B and C9C adjust the boost at the higher frequencies. Fig. 26 shows the different recording amplifier responses. These may vary quite a bit from recorder to recorder owing to differences in bias current and recording head efficiency. Checking and adjusting of the recording amplifier frequency responses is described in sec. 6.2 point 2.

4.6 Hum and Noise.

1) Hum. As a consequence of the standardisation of the reproducing amplifier it is not possible to boost the lower frequencies in the recording amplifier. This makes it very difficult to obtain a reasonable hum level.

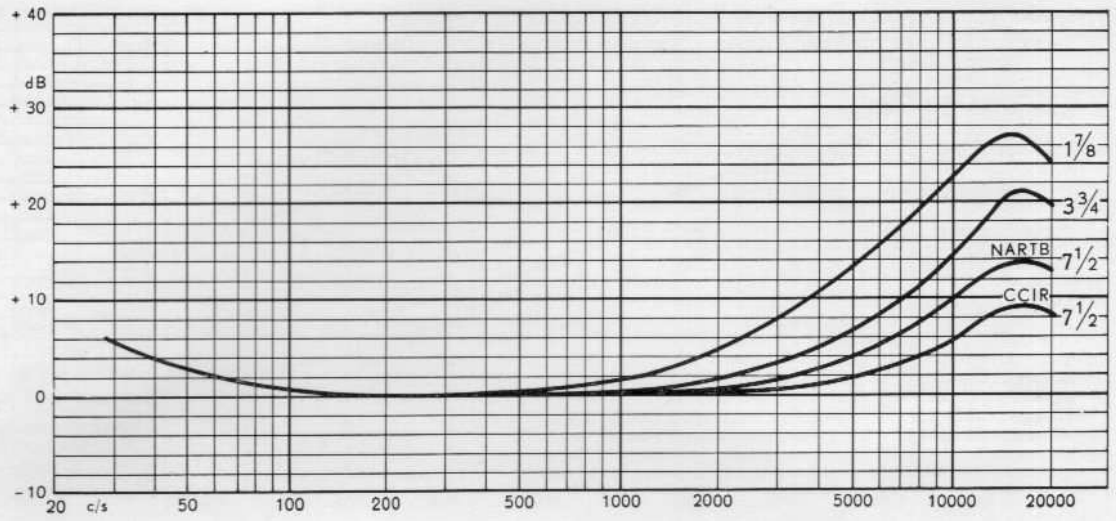


Fig. 26. Frequency Responses of Recording Amplifier.

At 50 c/s (60 c/s) the gain of the reproducing amplifier with the volume control at max. is approx. 92 dB (40 000 times). A 50 c/s (60 c/s) hum component of 20 mV across the output terminals, corresponds to 0.5 μV at the grid of EF804. Good input tubes as EF804 guarantee 5 μV on this point. It has therefore been necessary to use dc heating of these tubes and make the screening can of mumetal. The dominating hum cause is now the stray fields from the power transformer, and all wiring and position of parts are very sensitive to displacement. In Faults, Causes and Remedies some of these critical points are mentioned. At a too great hum level these points have to be checked first. The resulting hum is mainly caused by the head and EF804. In spite of the mumetal screening of these parts stray field may affect them, and in some cases the hum level may be annoying even if everything in the wiring and positioning of the parts is correct. In these cases an improvement in hum level is only possible by introducing a hum component in opposite phase with the original hum. Such compensations will generally be present even in ordinary recorders and often a theoretic improvement in the wiring will increase the hum. On the other hand a more or less accidential movement of wires or components may result in an improvement of the hum level without any reasonable cause. This more causal improvement should not involve any danger since the stray fields in the tape recorder are rather constant and in general much greater than accidental hum fields, and the improvement in the special recorder will therefore be lasting. One may however not think that such accidental improvement on one recorder involves an improvement when transferred to others. The stray fields being constant in time in one recorder, can vary consederably from recorder to recorder. The best way is therefore to reduce the hum as far as possible, in the theoretical best way. Common earth connection in the same circuit, no earthloop, twisted wires etc. This is done in the production. If the hum level still is not satisfactory, an adjustable compensation is inserted in form of a humbucking coil. Because the dominating hum sources are the head and EF804 which both are before the volume control in the circuit diagram, the humbucking coil had also to be placed before volume control, to obtain a good compensation independent of the potentiometer setting. Likewise the humbucking coil should only act with the mode switch in the play back position, because it is in this position the hum is most annoying and a compensation for the hum for all the three positions of the mode switch is impossible. The convenient place for the humbucking coil is therefore in the ground wire of the head. A coil with an inductance of 15—20 mHy is inserted and turned until the recorder shows minimum hum level. At this adjustment the mode switch has to be set in play-

back position and the operating lever in normal forward drive position. To obtain a good result one has to listen to the output through a big loudspeaker and with the bass switch in position bass. Generally the hum will be masked by the noise when using a linear output meter. The best result is reached by using a wave analyzer and compensate for the third harmonic in the hum 150 c/s (180 c/s). The value of this component with the volume control at max. should be below 1 mV. The volume of the first harmonic of the hum 50 c/s (60 c/s) will even when using a wave analyzer with 2 c/s band width be masked by the low frequency noise components, but will be below 8 mV.

2) Tube and random noise will as a consequence of the frequency response of the reproducing amplifier mainly consist of lower frequencies when measured with a straight outputmeter. This noise may often be mistaken for hum but generally be recognized by the fluttering of the meter. The dominating of the lower frequencies is accentuated by the fact that the tube noise even on a straight amplifier has its maximum at the lower frequencies owing to flicker and shot effect. When searching for causes of hum, one has to take into account that it may be a noisy EF804. An other cause of noise may be the resistors R7 and R8 in amplifier for upper track. More seldom also R6 and R5. Such noisy resistors also generally have their dominating noise effect in the lower region of the frequency spectrum and may be mistaken for hum. The minimum of total noise voltage measured across output terminals with a straight output meter and with the volume control at max. will be between 12 and 25 mV. The variation is generally caused by differences in the amplification caused by tolerances on tubes and other components. This noise figure corresponds to a signal to noise factor of approx. 57 dB when the tape is loaded to 5 % third harmonic distortion.
At such noise voltage the different hum components will not be measurable, and the noise voltage will be dominated by the noise components in the lower end of the frequency spectrum. Owing to the sensitivity of the ear they will not dominate during listening. When therefore, the tape is played back, an increasing of the noise will be heard but not measured.

4.7 Comments on Tape Recorder Ouality.

The quality of a tape recorder depends on many various factors, some of which to a certain extent are working against each other. Some of these factors can be expressed in figures which are reproducable, and give a good indication of the quality on these points, as other quality limiting factors are not measurable, or the results can not be given such a form that they are comparable. The decisive quality test must therefore always rely on the ear.
On account of the Hi-Fi publicity the judge of the quality among the public is one-sided relying on the total frequency response. A frequency response is only telling a little about the quality of a tape recorder, and will, without comments, be almost worthless. It is not difficult to obtain a good frequency response, when this is done on the expense of signal to noise ratio and cleanness of the program. Much simplified the decrease in the signal to noise ratio can be explained as follows: If one, on a certain speed, will increase the frequency range, the gap must be decreased. Simultaneously one boost often more on the high frequency end in playback amplifier. Both remedies will increase the noise. The magnetic layer of the tape consists of innumerable magnetic particles with a max. size 1 μ (1/1000 mm). The magnetic field induced in the head is dependant on the total resulting magnetizing of all the particles which in every moment are in the gapzone, and the reason why the noise is arising, is that the renewal of these particles is taking place with definitive amounts, so that the total magnetizing in the gapzone is fluctuating, also without program. This fluctuation is only dependant on the difference between the particles which are coming in and the ones which are going out of the gapzone, and will therefore not decrease by narrower gap. This is however, the case with the signal voltage, as several of the power lines will connect themselves across the play back gap, as the magnetic resistance of this will decrease, and not go through the head and induce voltage in the head coil. With the gaps used in modern

tape recorders, the sensibility will be almost proportional with the gap width. The result will be an inferior signal to noise ratio when the gaps are reduced. Simultaneously the amplifier noise will be relatively stronger. This noise is also independant of the gap width, and when the voltage is decreased, the signal to noise ratio will also decrease. That the noise will increase by increasing the play back amplification on the high frequencies is evident. An increase of the frequency range will also, when the other conditions are the same, increase the noise, as more noise frequencies will contribute to the total noise.

This increase of background noise can be expressed in figures, but the audible impression is normally greater than these are showing. The noise measured across the output terminals of a tape recorder will consist of the sum of amplifier noise and tape noise. Both have their greatest components in the very low frequency range (below 100 c/s).

An increase in high frequency noise components will therefore not contribute much to the measured value, whereas they are heard very distinctly, because they are falling within the field where the sensitivity of the ear is great. The low components, which decide the amount of noise voltage, will not be heard, on account of the decrease of the ear's sensitivity on low frequencies. The video recorders for T.V. recording is an example on such a decrease of the signal to noise ratio by increase of the frequency range. These have a frequency range in kc/s almost like 10 times the tape speed in ips (approx. 3.5 Mc/s by tape speed approx. 360 ips). The signal to noise ratio is about 25—30 dB. A head constructed according to these principles would have a frequency range of 18—19 kc/s by $1^7/_8$ ips, and would on this point fully satisfy the demand to Hi-Fi reproduction, but the noise would be destructive.

The increase of modulation noise will be still more harmful for the reproduction than the increase of background noise due to too great extention of the frequency range. This increase can, simplified, be expressed as follows: The tape consists of small permanent magnets, fully magnetized. (The fact that each grain also may contain more such magnets does not change the fundamental operation manner). The magnetic pattern on the tape arises as these magnets are orientated by the recording field. The magnetic recording will therefore never take place continuously, but as a step function. The shorter the wavelength on the tape is, the fewer small magnets will there be which build up patterns, and the more marked will the irregularities and also the noise be. These irregularities will cause the note sound fuzzy. If one is analyzing such a note played back from a tape, one will see that the notes stick out above a noise «grass» which is spreading out over the whole audible range. As one goes up in frequency, this noise behind the signal will be more and more annoying, at first because its absolute value is increasing, secondly because the signal is weakened as the sensitivity of the tape is decreasing according to the decrease of the wave length, and thirdly because the note will be heared more faintly, as the sentisitvity of the ear is decreasing at high frequencies, whereas an essential part of the noise components will be in a range where the sensitivity of the ear is greatest. One will get the most extreme example by recording a note which is higher than the ear can hear. When playing back, one will only hear a marked increase in noise.

The third factor to take into consideration in determining the frequency response is the intermodulation at the higher frequencies. This intermodulation is dependant on the recorded wavelength on the tape and is due to a distortion which occurs when the recording field changes its direction during the time interval a cross section of the tape moves through the recording field, set up by the recording gap. The harmonic distortion will not be measurable because these frequencies will be above the frequency range which the system is capable to reproduce, but simultaneously with the harmonic distortion there will occur intermodulation products within the frequency range of the system when two high notes are recorded simultaneously. This special distortion is rather annoying when recording string quartets which have a rather high contents of higher harmonics in critial balance. The reproduction sounds harsh and unpleasant. By measuring these intermodulation products it is wise to record two notes f_1 and f_2 with a constant frequency difference of 400 c/s and at same recording

current. By playback, measure the magnitude of the frequency 2 f_1—f_2 in persentage of f_1. (It is the cubic distortion which is dominating). At a certain frequency of f_1—f_2 a rather steep increase in intermodulation will start. With rather good recording head this increase will start at a frequency corresponding to a recorded wavelength of 10—15 μ. The intermodulation is dependent of the recording current and can of course be reduced by reducing the high frequency boost in the recording amplifier, but this will require more boost on the high frequencies in the playback amplifier, which will increase the playback noise, and also be against the standard.

The tendency to extend the frequency range for a certain speed is due to the desire to save tape. As it will be seen, such saving of tape by reducing the speed will be made at the expense of the signal to noise ratio and the clearness of the tone if the frequency range is kept constant. Another obvious method to save tape is to increase the number of tracks on the tape. This will involve a decrease of the track width, but the head gap and the equalization curves will be the same. Such a decrease of the track width will however, also involve a reduction of the signal to noise ratio, and this will have the following reason: The noise energy will be almost proportional with the track width, i.e. the noise voltage is proportional with the square root of the track width. The signal voltage is, on the other hand, directly proportional with the track width. A reduction of the track width to the half will thus reduce the signal to noise ratio with 3 dB. Simultaneously the sensitivity of the head will be reduced, whereas the noise voltage from the amplifier is the same. With the same head construction the signal to noise ratio of the amplifier is reduced with 6 dB.

While thus the background noise by reducing the track width will increase relatively, the modulation noise will probably not increase in the same ratio. The wavelength on a certain frequency will be the same, and the building of the magnetizing patterns will take place during a corresponding distance. If one with a certain frequency response wants to increase the playing time for a tape, and for instance can choose between recording two tracks at $3\,^3/_4$ ips, and four tracks at $7\,^1/_2$ ips, it is difficult to say what solution will give the most favourable result, but one thing is sure — by both solutions the result will be inferior to the quality one obtains by 2 tracks at $7\,^1/_2$ ips. A saving of tape will always cost something.

As to the construction, it will not involve special difficulties to produce tape recorders with a frequency range much greater than what will be practical. The manufacturers must therefore make a choice to the best of their judgment what the optimal compromise is. On account of the press for wider frequency range, one can take it for certain that the frequency response will not lose anything by this compromise. The frequency response is easy measurable and can be expressed in figures that look well in the advertising. We will however, point out that w h e n the choice has been made as to gap width and amplifier equalizations, the signal to noise ratio can not be restored by tone control on the playback side, most of the noise increasing factors will still be working.

From the above one must not make the conclusion that a tape recorder with a smaller frequency range automatically has a better signal to noise ratio than one with a greater frequency range. Here will of course the quality of the individual model and the factory's technical standard count. By a good and favourable construction essential improvements may be obtained. The right conclusion is that a certain tape recorder gets a better signal to noise ratio if head and amplifiers were constructed for a smaller frequency range.

It is not right to close an orientation about the signal to noise ratio without touching the prerecorded tapes. On these one must be still more careful with a one-sided extention of the frequency range. These tapes are never original records, but are first, second or third copies. Some tapes can indicate that they are copies still far out in the range. On these tapes the above mentioned factors will come in 2, 3 or 4 times, and the result will often be a bad signal to noise ratio. Simultaneously the recordings must be done by lower level, because the distortion on the various copies will add. Usually it is not fair to judge the quality of a tape recorder from such tapes. Here the tape is the quality limiting factor. By playing back pre-recorded tapes it is essential that the tape

recorder's speed and track width are designed to give low noise. In these cases there are little quality reserves.

5. INSTRUCTIONS FOR MECHANICAL CHECK UP

After repair, a mechanical check up should be performed. While repairing, the top cover (74.1) has most probably been removed and some of the checking ought to be done before replacing the top cover (74.1). One should make sure that the prescribed tolerances are maintained and that the drive mechanism works satisfactorily. In case of dubious operation look up the points in the detailed description and ascertain perfect operation.

5.1 Fast Winding.

A real of tape (1200 feet) should be wound forward or reverse in 1 3/4 minute. Make sure that start of fast winding can take place even when the supply reel is almost empty. Also make sure that levers and pulley discs are correctly adjusted as shown in the photographs. Observe that the tape reels do not rub on the top cover. Ascertain sufficient clearance.

5.2 Normal Forward Drive.

The speed transfer wheel (64.1) must run freely without any throw or vibration. In the position for the two lower speeds there must be sufficient clearance between speed transfer wheel (64.1) and motor pulley (62.1).

There must be sufficient friction in the speed transfer system. It should be possible to stop the motor by holding the fly wheel (66.1) at all three speeds. Check that the transfer wheel (64.1) is lifted away from the motor pulley (62.1) at all speeds when the operating lever (50.14) is set to neutral and fast forward positions. Both pulley discs (61.1) should be checked and the levers (59.6, 59.7 and 50.12) be as prescribed in the detailed description. The takeup torque of the right hand reel should preferably be measured. It should be 10 to 14 grams measured at the spoke as close to the perifery as possible. The tape should not move with the operating lever (50.14) in the middle position when the right hand reel is almost empty. This will happen if the takeup torque is too high.

Start by means of the on-off switch should be possible with a line voltage 15 % below the voltage selector setting. The path of the tape should be carefully tried out. When the tape is stretched out between the tape guides (70.12, 70.18), the upper lamination of the erase head 16.1) should stick out 0.1 mm. over the edge of the tape. The adjustable tape guide (70.16) must then be in such a position that the tape does not rub against either the upper or lower flanges. Make sure that there is good clearance between the tape and the mu metal shield (73.1, 73.2) on both sides of the record-playback head when the pressure wheel is in position for forward drive. The pressure spring with felt pad (79.1) should exert a force of 100 grams against the erase head (16.1) and must not give rise to «climbing». The presure wheel assembly must be adjusted so that the stud in front of the pressure wheel is flush with the edge of the rear trim cover (79.6).

Make sure that the stud on the pressure wheel assembly (50.1), the pressure wheel (63.1) and the pressure pad (79.1) do not prevent the tape from dropping in when inserted into the slit between the trim covers (79.6, 79.11). The pressure wheel shaft (60.8) must be parallel to the capstan (60.2). If not try a careful adjustment of the spring equalization latch (70.19) on the pressure wheel assembly (50.1). Do not correct the path of the tape by adjustment of this latch (70.19). Incorrect path of the tape has usually other causes and will not be corrected by such an adjustment. The pressure of the pressure wheel spring (79.5) holding the pressure wheel (63.1) should be about 0.7 kg. This pressure influences the tape speed and its pressure should not be changed without a tape speed test. If necessary a complete adjustment of the tape path and head alignment is carried out according to sec. 3.9.

5.3 Tape Speed Test.

This test is performed using a marked section of the tape 1144 cm (450 ins.) long (start and end markers). This predetermined length should pass by the recording head (15.1) in the course of one minute at 7 1/2 inches per second tape speed. Measure the time with a stop watch. Deviation should be less than ± 1% or ± 0.6 sec. out of one minute. During test, the line vol-

tage must be 220 volts (110 c 60 c/s) and the frequency 50 c/s (60 c/s).
One should not be tempted to reduce the pressure of the pressure wheel too much to increase the tape speed. If the tape speed is too low, the cause is most probably too much friction somewhere else in the drive mechanism. When replacing the top cover (74.1) ascertain that screws and washers are put back in their proper positions. After the top cover (74.1) has been put back in place, recheck the mechanical funtions for proper operation. The spacing between tape reels and top cover (74.1) must be checked to be sufficient for all positions of the operating lever (50.14).

6. 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 kc/s and a voltage range from 70 mV to 200 volts, a.c. electromagnet, output meter, distortion meter, wow meter and a standard alignment tape. (Ampex Standard Alignment Tape for 7 1/2 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 electric check up falls into two parts, introductory and final checking.

6.1 Introductory Check up of Oscillator.

1. Adjust the oscillator frequency. A radio receiver tuned to 200 kc/s is used as an indicator. The antenna input terminals must be supplied with a signal of 200 kc/s (Droitwich or a crystal oscillator) and the oscillator coil L3 (22.1) of the tape recorder, see circuit diagram Fig. 19 and foto Fig. 21, is adjusted so its 3. harmonic of 66 2/3 kc/s beats with the 200 kc/s signal.
2. Adjust the plate circuit L2 (28.2) to maximum, see photograph Fig. 21 and schematic Fig. 19. As an indicator is used a vacuum tube voltmeter measuring the voltage over 100 ohms in series with the erase head.
3. Adjust the oscillator frequency rejector circuit L1 (27.1). See photographs Fig. 17 and 18 and schematic Fig. 19. The V.T.V.M. is attached to point P in schematic Fig. 20 and should indicate about 5 volts when the circuit is adjusted for minimum.
4. Measure the erase voltage. It should be 160—190 volts across the erase head.
5. Measure the high frequency recording bias voltage. Its value should be 100—130 volts across the recording head.

6.2 Introductory Adjustment of the Amplifiers in Recording Position.

The test is performed without the tube EL84. Mode switch (39.2) and operating lever (50.14) are put in position for recording. The input terminals are supplied with a voltage from the audiosignal generator. The V. T. V. M. is attached to measure the voltage over 1000 ohms in series with the record head.

1. Sensitivity of the indicator. From the audio signal generator is supplied a signal strong enough to drive the tape to its maximum recording level, indicated by the magic eye. The recording current through the head should then be between 140—160 microamperes or a voltage of 140—160 mV across the series resistor. If the current does not check with the value given, adjust the semivariable potentiometer R20.

2. The frequency response curve of the recording amplifier. In the position for recording the frequency response of the recording amplifier (amplifier for upper track) is changed by changing the speed. Supply the amplifier with a voltage corresponding to half of maximum recording level. The response curves should be as shown in Fig. 26 curves 7 1/2, 3 3/4 and 1 7/8. The response is checked on all three speeds. The sensitivity at 1000 c/s should be from 100 to 200 mV across the input terminals in back of the recorder when the voltage across 1000 ohms in series with the head is 140 to 160 mV and the volume control is set to max.

3. Amplifier for lower track during recording.
Check that the amplifier for lower track is connected to the recorded program when the stereo switch is set to position MONAUR.

and that the output is not overloaded when the magic eye is closed. The frequency response measured across the output terminals of the amplifier is shown in Fig. 24. It is checked that the interconnection between the two amplifiers is broken in position STEREO. The cross talk in this position shall be better than — 55 dB.

6.3 Introductory Checkup of the Amplifiers in Playback Positions.

1. Put the tube EL84 in its socket in amplifier for upper track. 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 amplifier for lower track. 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 amplifier for lower track. (This corresponds to a generator voltage of approx. 0.6 — 0.9 mV, and if necessary use a voltage divider on the generator terminals to avoid hum). The volume control on the recorder is regulated down 4 dB. It is checked that the output of the amplifier for lower track disappears when the stereo-monaur. lever (59.8) is set in position MONAUR. Further it is checked that the built in loudspeaker is connected to amplifier for lower track when the loudspeaker switch (30.7) is set in the right position and is disconnected in middle and left position. Connect the generator to 1000 ohms in series with the head for upper track without changing either volume control on the tape recorder or the generator voltage. By means of the semivariable potentiometer R40 see Fig. 17 the gain of the amplifier for upper track is adjusted exactly like the gain of the amplifier for lower track. The loudspeaker switch (30.7) has to be set in the middle position during the gain adjustment. (Both amplifiers unloaded). It is checked that the loudspeaker switch (30.7) connects the built in loudspeaker to amplifier for upper track in left position and disconnects the loudspeaker in the two other positions. Further check that with the stereo-monaur. switch in position MONAUR. the amplifier for lower track is connected, and disconnected in position STEREO.
2. The frequency responses of the two amplifiers is checked at all three speeds. These responses should correspond to the curves in Fig. 25. 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 surpass 3 volts at frequencies with max. gain (30—60 c/s). The stereo-monaur. switch is set to STEREO position and the loudspeaker switch (30.7) in the middle position.
   The gain at 1000 c/s with the volume control at max. is approx. 67.5 dB (2400 times) at $7\,1/2$ ips, approx. 70 dB (3150 times) at $3\,3/4$ ips and approx. 73.5 dB (4 750 times) at $1\,7/8$ ips, measured from the head to the output terminals. It is further checked that the output voltage increase 10—12 dB at 100 c/s when the bass switch is set in position BASS in both amplifiers and at all speeds.

6.4 Final Check Up.

1. Demagnetization. The heads, tape guides, pressure wheel assembly and the adjustable tape guide must be demagnetized by means of a powerful a.c. magnet.
2. The tape path and placement of heads are adjusted according to the procedure in sec. 3.9.
3. Frequency response during play-back. The standard alignment tape with full track recording is played back at $7\,1/2$ ips. The stereo switch in position STEREO and bass switch in position NORM. The frequency response of the play back should be within $\pm$ 2 dB in both amplifiers, and the deviation between the two outputs should not extend 3 dB at any frequency during this measurement. The volume control should stand in exactly the same position as during the gain adjustment described in sec. 6.3 point 1. If necessary, small corrections in frequency response can be done by varying R5 and R53.

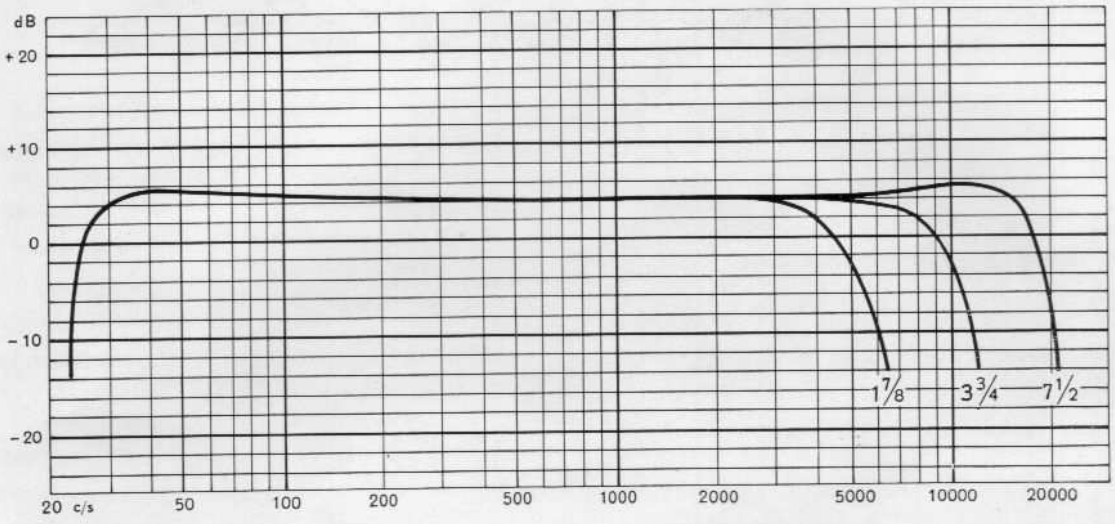


Fig. 27. Frequency Responses for the Different Speeds.

4. Frequency response curve, distortion and noise level. The procedure is the same for all tape speeds. The numbers in paranthesis refer to the lower speeds.
   Record a 1000 c/s signal of about 0.5 volt across the input terminals and adjust the volume control for about 20 dB below closing of the magic eye.
   At this input and volume control position one records: 40 c/s, 100 c/s, 1000 c/s, 5000 c/s (3000 c/s, 2000 c/s), 10 000 c/s (5000 c/s, 3000 c/s), 15 000 c/s (7000 c/s, 3500 c/s) and 16 000 c/s (8 000 c/s, 4000 c/s), Then record a 400 c/s signal at max. 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 first recorded supplies the 0 dB level. The other frequencies recorded should give signal outputs 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 volts output. There must be less than 5 % distortion. Where nothing is recorded, read off the noise level. Leave the volume control unchanged. With a straight line voltmeter the noise voltage should be less than 8 mV or about 55 dB below maximum signal level. The last thing to be checked is the distortion at — 10 dB signal level (half of max. recording level). At an output voltage of 2.5 volts the distortion should be less than 1.5 %.
   Next check for wow. Wow should be less than 0.15 % at 7 1/2 ips, 0.2 % at 3 3/4, 0.3 % at 1 7/8 RMS. If a wow meter is not available a program recorded on a tape recorder having little wow 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 this error is present.
5. 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 to right turntable and vice versa. A 1000 c/s signal is recorded at maximum recording level. (Eye just closed). Rewind the tape and play back the 1000 c/s signal (signal on upper track), set the stereo switch in position MONAUR. and regulate the volume control to give 3 volts across the output terminals of the amplifier for lower track, with the built in loudspeaker connected. Set the stereo switch in position STEREO, and check that the signal is hardly heard in the amplifier (approx. 60 dB cross talk damping). The tape is turned upside down again (signal on lower track), connect the loudspeaker to amplifier for upper track. With the same volume control setting (3 volts across the terminals of lower track) and the stereo switch in position MONAUR., the signal should hardly be heard. The cross talk in this position should

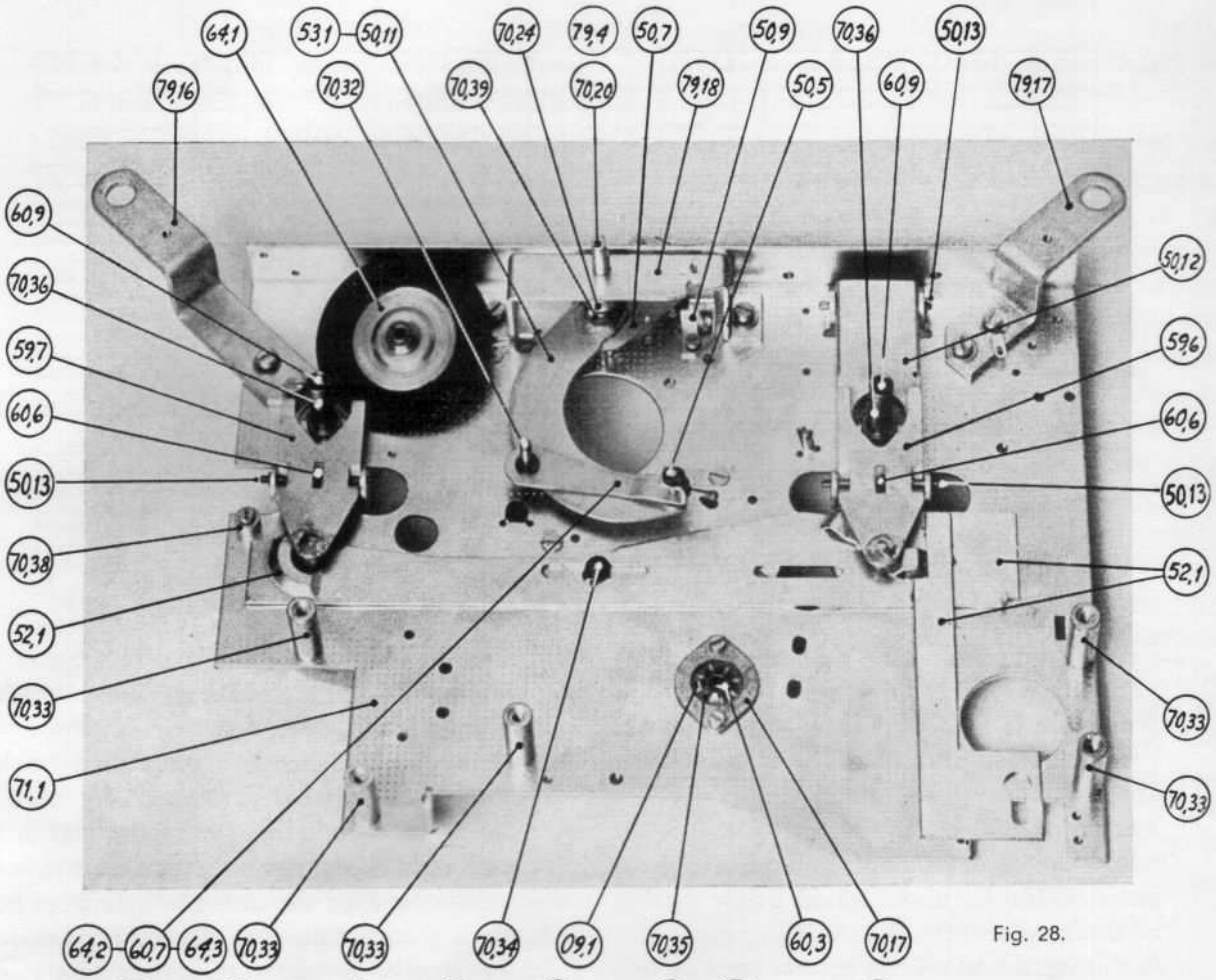


Fig. 28.

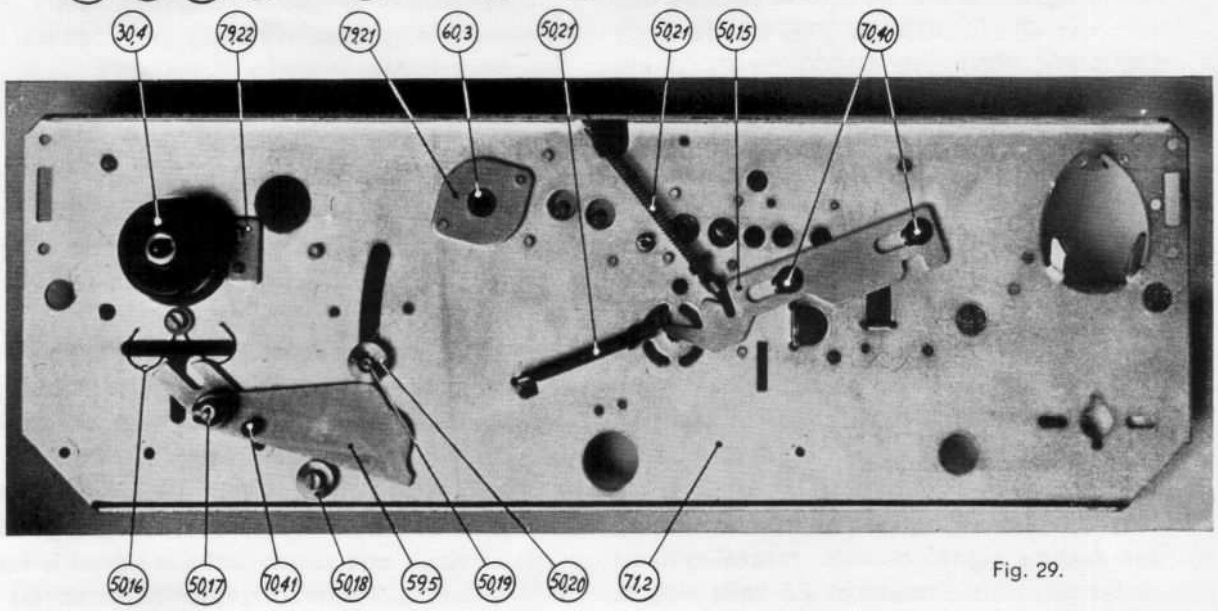


Fig. 29.

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.

6. Microphone test and erasing. Record speech at maximum recording level and beyond this level. Next check the speech. Erase the recording done at the highest levels. When played back, nothing should be heard even with the volume control at maximum.

7. Seal all adjusting screws with lacquer.

MODEL 3 B

7. TECHNICAL DATA MODEL 3 B AND 3 BF

Line Voltage:	110 — 125 — 145 — 200 — 220 — 245 volts, 50 c/s (60 c/s).
Power Input:	55 watts.
Tubes:	1 EF804, 1 ECC83, 1 EL84, EM71 and Selenium Rectifier 70 mA, 250 volts, 2 low voltage Selenium Rectifiers.
Recording Tape:	Red oxide tape. Maximum Reel Diameter is 7" and 1200 ft. (366 m) or 1800 ft. (550 m) of Tape.
Tape Speeds:	7 1/2", 3 3/4" and 1 7/8" per sec. By help of the equalization switch, the recording amplifier as well as the playback amplifier is re-coupled, so that for all speeds the amplifier corrections will be up to the NARTB standard. (The Recorder may also be supplied with amplifier corrections up to the CCIR standard).
Heads:	Half track erase head. Half track record-playback head. Gap width .00025 inch.
Playing Time:	Twin Track Recording and 1200 ft. of Tape give the following Playing Times: Tape Speed of 7 1/2 ips: 2 × 32 min. Tape Speed of 3 3/4 ips: 2 × 64 min. Tape Speed of 1 7/8 ips: 2 × 128 min.
Path of Tape:	The Tape moves from left to right. The heads are positioned with the gaps towards the front. Recording takes place on the upper half of the tape.
Fast Forward- and Rewinding:	Takes about 2 min. in either direction, without wearing the heads.
Controls:	Joint playback and record-level control. Speed change switch 7 1/2", 3 3/4", 1 7/8". Output switch. Bass switch. Mode switch for recording, playback and pub.addr. Lever control for start, stop, forward and rewind.
Frequency Response at Record-playback:	Flat within ± 2 hB from 40 to 16 000 c/s, from 50 to 9 000 c/s and from 70 to 4 500 c/s for the 7 1/2 ips, 3 3/4 ips and 1 7/8 ips speeds respectively.
Distortion and Noise Level:	The tape recorded to the maximum level by a 400 c/s signal will give less than 5 % distortion when played back. A recording level 10 dB below the maximum level results in less than 1 % distortion of the 400 c/s signal when played back. The noise level is 55 dB below the signal level when the tape is driven to the maximum level.
Wow:	Better than 0.15 % at 7 1/2 ips. tape speed. Better than 0.2 % at 3 3/4 ips. tape speed. Better than 0.3 % at 1 7/8 ips. tape speed. Wow is then defined as the r.m.s. value of frequency deviation to one side in percent of the signal frequency, when a constant signal frequency 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 TM-2 microphone. Sensitivity of mike input — 1.5 millivolt, for maximum recording level at 1000 cycles. Phono or radio input (0.5 Megohm) with provision for simultaneous use of both inputs for mixing. Phono or radio sensitivity — 75 millivolts.
Microphone:	Crystal mike shock-insulated for rugged use. Response — 20 to 13 000 cycles ± 3 dB.
Erase and Bias Frequency:	66 2/3 kc/s. Even harmonic distortion in high frequency bias current is below 0.5 %.
Record Amplifier, Recording 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 selenium rectifier and damped backward movement). Electronic Eye tube range is 26 dB, plus overload.
Playback Amplifier Output & Distortion:	At 1000 cycles . . . 2 watts (2.8 volts) . . . . . Distortion below 1 % 3.3 watts (3.6 volts) . . . . . Distortion below 5 % At 50 cycles . . . . 1 watt (2 volts) . . . . . Distortion below 1 % 1.5 watts (2.5 volts) . . . . . Distortion below 5 % Effective source impedance of playback amplifier is less than 1 ohm; negative feedback about 15 dB. (Matched load impedance — 4 ohms). Because of the low output impedance and high degree of negative feedback with corresponding low distortion, the Playback 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 Pub.Addr. amplifier — ± 2 dB, 40 to 20 000 cycles.
Speaker:	Goodman, Heavy-duty type, 5 in. × 7 in. By means of the output switch the output can be connected to monitor speaker, to the output terminals, or to both simultaneously.
Clock-Counter:	(Identical with ordinary clock dial). Each hour (by hour-hand) shows 150 revolutions of tape spool, each minute (by minute-hand) shows 2 1/2 revolutions. Location and length of recording is designated as time on a clock (e.g. 2 : 12 to 3 : 15).
Automatic Stop:	Possible on tape which has the necessary metal coating at beginning and end of the reel.
Dimensions:	Fine grain mahogany cabinet, 15" long 11 5/8" wide, 6 5/8" high.
Weight:	Instrument alone-22 lbs.; with carrying case-27 lbs.

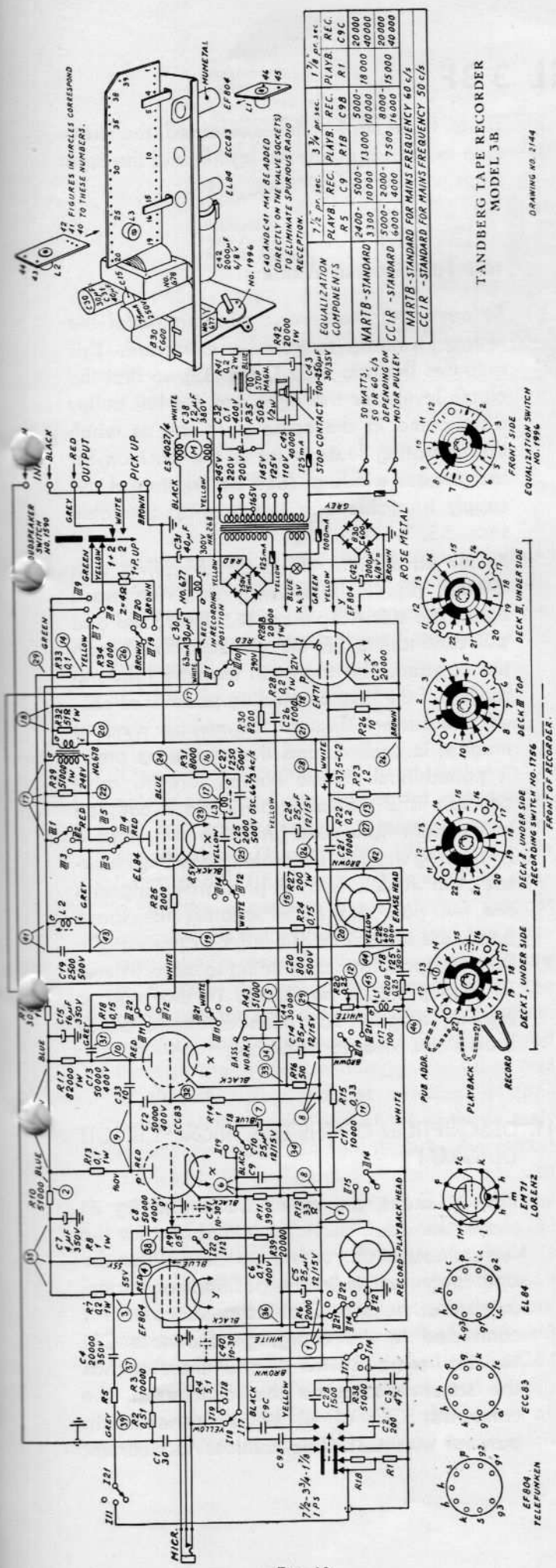


Fig. 30.

8. ADDITIONAL DESCRIPTION OF MODEL 3 B.

The driving mechanism of model 3 B is identical with the mechanism of model 3 Stereo. Fig. 30 shows the circuit diagram of model 3 B. The amplifier is almost identical with the amplifier for upper track in model 3 Stereo with exeption of the special features which are necessary in connection with the stereo — monaurel switch. The electrical description of the amplifier for upper track therefore also goes for model 3 B, with exeption of the two following points.

1. The output switch connects in the left position (seen from front of the recorder) the output transformer to both the output terminals and the monitor speaker. In the mid position the output transformer is only connected to the output terminals. In the right position the output transformer is connected to the monitor speaker, while the terminals marked P.U. are connected to the output terminals. This is done to ease the use when both the tape recorder and a record-player are intended to be played back through the same external amplifier (or radio set). To do this, one connects the output from the record-player to the terminals marked P.U. and the output terminals to the input of the external amplifier. When playing tape recordings, the output switch is placed in mid position (or in the left position if it is desired to listen simultaneously to the monitor speaker). When playing records, the output switch is placed in the right position.

2. In the record position the loudspeaker and and output transformer are disconnected from the output terminals and these get signal from the second plate of the ECC83 via a voltage divider R_{33}—R_{34} (.1 Mohm—10 Kohms), thus giving opportunity to monitor the recorded program through headphones or an external amplifier. The output impedance is 10 Kohms. Because of the great value of R_{33} the output terminals can be shorted without affecting the recorded program.

MODEL 3 BF

9. INTRODUCTION

Model F is equipped for the additional attachment of a remote control for start stop and fast reverse winding. The amplifier section, the frequency response and the recording and erasing heads are identical with those of the ordinary model. When the remote control is not attached, the model F works exactly like the ordinary model. The remote control is attached to the Tape Recorder by means of a three-pin plug, and will only work when the operating lever is in the normal forward drive position. In the positions neutral, fast forward winding and fast reverse winding the current is disconnected from the remote control, and therefore the model F works like the ordinary model in these positions.

10. FUNCTION AND OPERATION OF MODEL F WITH PEDAL

10.1 Start Stop.

The Tape Recorder is connected to the line, and the operating lever is set in the position for normal forward drive. The tape will be stationary if the pedal is connected. An electro-magnet, the start-stop magnet, is energized via the pedal and lifts the pressure roller away from the flywheel shaft (capstan) by means of a mechanical linkage. In this position the flywheel continues running at normal speed, and the winding friction on the right hand spool is connected. The spring which presses the tape against the erase head does, however, brake the tape so much that the right hand spool is unable to pull the tape forward, and will only hold it tight As soon as the start pedal is operated, the current to the start-stop magnet is broken, and the pressure roller presses against the capstan in the normal manner. As the flywheel has been running all the time with normal speed, the tape will start with full speed. For reasons to be explained later, a condenser C37, of 10 μF capacity is connected in parallel with the stop magnet. This condenser will discharge through the magnet winding. This gives a delay of about .5—1 seconds from the time the pedal is operated to the time the tape starts. If the start pedal is released, the start-stop magnet is energized again, and the tape stops with no delay.

10.2 Fast Reverse Winding.

By operating the reverse winding pedal the reverse winding magnet is energized. This actuates the arm I (52.1, Fig. 33), so that the clutch levers for the right and the left pulley discs come in the same positions as when the operating lever is set to the position for fast reverse winding. (See description of the supply turntable and the take-up turntable secs. 3.3, 3.4 and 3.5.)

At the same time the pressure spring with the felt pad is lifted away from the erase head. The start-stop magnet is energized and will continue to lift the pressure roller from the capstan. The tape will then be rewound rapidly. If the reverse winding pedal is released, the current through the reverse winding magnet is broken, and the operating arm I is pulled back to the normal forward drive position, and the take-up friction is coupled to the right hand side turntable and stops it by braking action. This braking action is, however, too weak. When the pressure spring with the felt pad is pressed against the erase head, the tape stops. In order to prevent the take-up spool from continuing to move, whereby a loop would be formed in the tape, a braking magnet has been arranged which brakes the take-up turntable.

11. DESCRIPTION OF THE ELECTRICAL CIRCUIT DIAGRAM

Fig. 30 shows the main circuit and fig 31 shows the additional circuit diagram for the remote control unit with the pedals. When the operating lever is in the position for normal forward drive, point C of the pedal contact is connected to the charging condencer C31 via the micro switch I and therefor has the same voltage as this condenser. The condenser C35 of 40 μF is connected in parallel with C31. This reduces the current

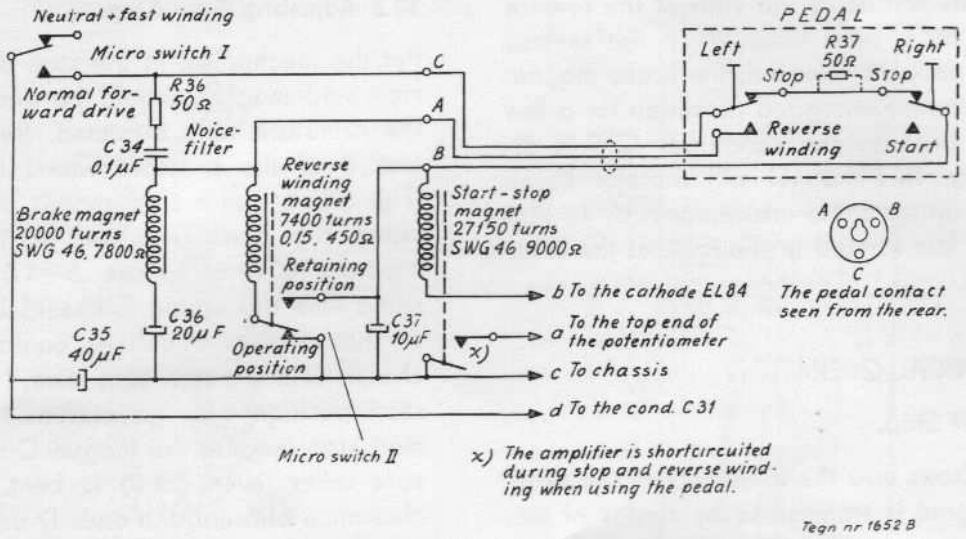


Fig. 31.

shocks to which the rectifier would otherwise be subject, and these condensers will also supply most of the energy when the low impedance reverse winding magnet is connected.

11.1 Start Stop.

If the pedal is connected, the start-stop magnet is energized via the pedal contacts in the left hand and right hand pedal from condensers C31 and C35. When the right hand pedal (the start-stop pedal) is operated, the current to the start-stop magnet is broken by the pedal contact, and the pressure roller presses against the capstan. There is a delay between the operating of the pedal and the time when the magnet releases, because the condenser C37 is discharged through the magnet windings. The other end of the start-stop magnet winding is connected to the upper end of the cathode resistance for tube EL84 (point 15 in the circuit diagram). In the playback position this will reduce the current through the EL84 when the magnet is connected. The magnet draws 30 mA, while the current through the EL84 is reduced by 17 mA so that the actual increase is 13 mA. Both the transformer and the rectifier can stand this increase without becoming overloaded. In the recording position the EL84 draws considerably less current, and in this manner the load is kept at a safe level in all cases. A spring contact attached to the start-stop magnet shorts the top end of the potentiometer in the stop position.

11.2 Fast Reverse Winding.

If the left pedal is operated for reverse winding, the reverse winding magnet is energized from C31 and C35 via the pedal contact. This magnet has a low impedance winding and at the moment when it is connected it draws approx. .7 A (or about 200 watts). This power is mainly supplied by the condensers C31 and C35. When the armature is fully attracted, only a small fraction of this power is needed to hold the armature in place. By means of a contact the reverse winding magnet will connect itself in series with the start-stop magnet, whereby the current through the two magnets will be reduced to approx. 30 mA. The start-stop magnet is disconnected from the H.T. at the moment when the reverse winding pedal is operated, but by means of the discharge current from the condenser C37 the armature is held until the magnet is again energized by current flowing in series through the reverse winding magnet. If the reverse winding magnet is released, the current through the reverse winding magnet is broken, but the start-stop magnet is once again connected directly to H.T. and will therefore continue to be attracted.
When the reverse winding pedal is operated, the condenser C36, 20 μF, is charged and this gives the brake magnet a current im-

pulse. This will delay the start of the reverse winding for a brief time. When the reverse winding pedal is released, the brake magnet will stay in the energized condition for a few seconds because the condenser C36 is discharging. This magnet will therefor brake the take-up turntable instantaneously so that no loops are formed in the tape at the take-up spool.

12. MECHANICAL OPERATION

12.1 Start Stop.

Fig. 32 shows how the movement of the start-stop magnet is transferred by means of two levers to the pressure roller. The magnet is a pushing magnet. When the magnet is energized, point A at the bottom of the lever for start-stop, (59.3), will be pushed away from the magnet by means of the screw, (33.8). This screw is connected to the magnet armature and is fixed by means of two nuts in an oblong hole in the lever, (59.3). The lever, (59.3), pushes the long lever for the pressure wheel, (59.9). This lever will pull the pressure wheel axis, (60.8), with the pressure wheel, (63.1), away from the capstan, (60.2). This stops the tape. At the same time the spring E (33.14) makes contact with the chassis over the lever, (59.3), whereby the upper end of the potentiometer is connected to chassis.
When the current to the start-stop magnet is broken, the pressure roller will again be pressed against the capstan, and the tape will run.

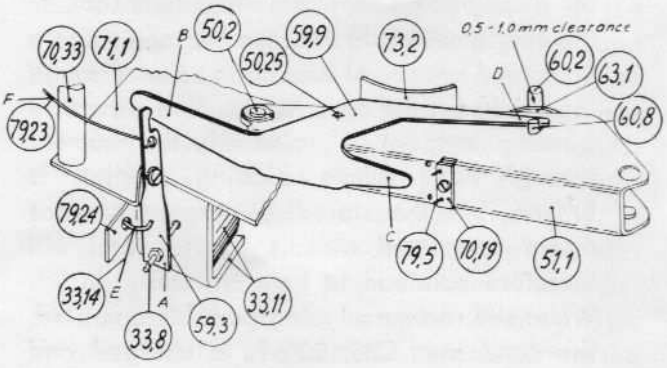


Fig. 32.

12.2 Adjusting Start Stop.

Put the mechanism in the stop position. The start-stop magnet should be energized and the armature fully attracted. Bend the flat end B of the pressure wheel lever, (59.9) (Fig. 32) so that a clearance is obtained between the pressure wheel (63.1), and the capstan, (60.2) of approx. .5—1.0 mm. At the same time the spring E should be adjusted so that it gives a definite contact with the chassis over the start-stop lever, (59.3). In the start position with no current through the start-stop magnet the tongue C of the pressure roller lever, (59.9) is bent, so that a clearance between the ends D and the pressure wheel axis (60.8) of approx. 1 mm is obtained. The pressure wheel lever, (59.9) should move very smoothly when it is not loaded, and should have a secure grip at the ends of the pressure wheel axis.
In the start position one should check that the spring F (79.23) pushes the lever (59.3) all the way back, and it should also be checked that the spring E does not shortsircuit the potentiometer in this position.

12.3 Fast Reverse Winding.

Fig. 33 shows the mechanical linkages from the reverse winding magnet and also shows how this magnet is placed. The sketch is drawn with the operating lever in the normal forward drive position and with de-energized magnets. Micro switch I is closed and thereby connecting the pedal contacts to + H.T. When the operating lever is moved to the positions neutral, fast forward winding or fast reverse winding, the reverse winding magnet arm, (50.26), will open the micro switch I as shown in the electrical circuit diagram, whereby the pedal contacts are disconnected from H.T. In the normal forward drive position and when the left hand pedal, the reverse winding pedal, is operated, the reverse winding magnet will be energized and will attract the armature, (3032). In the fully attracted position the armature will operate micro switch II by means of the reverse winding magnet arm, (50.26) ,and the reverse winding magnet will connect itself in series with the start-stop magnet as shown above under

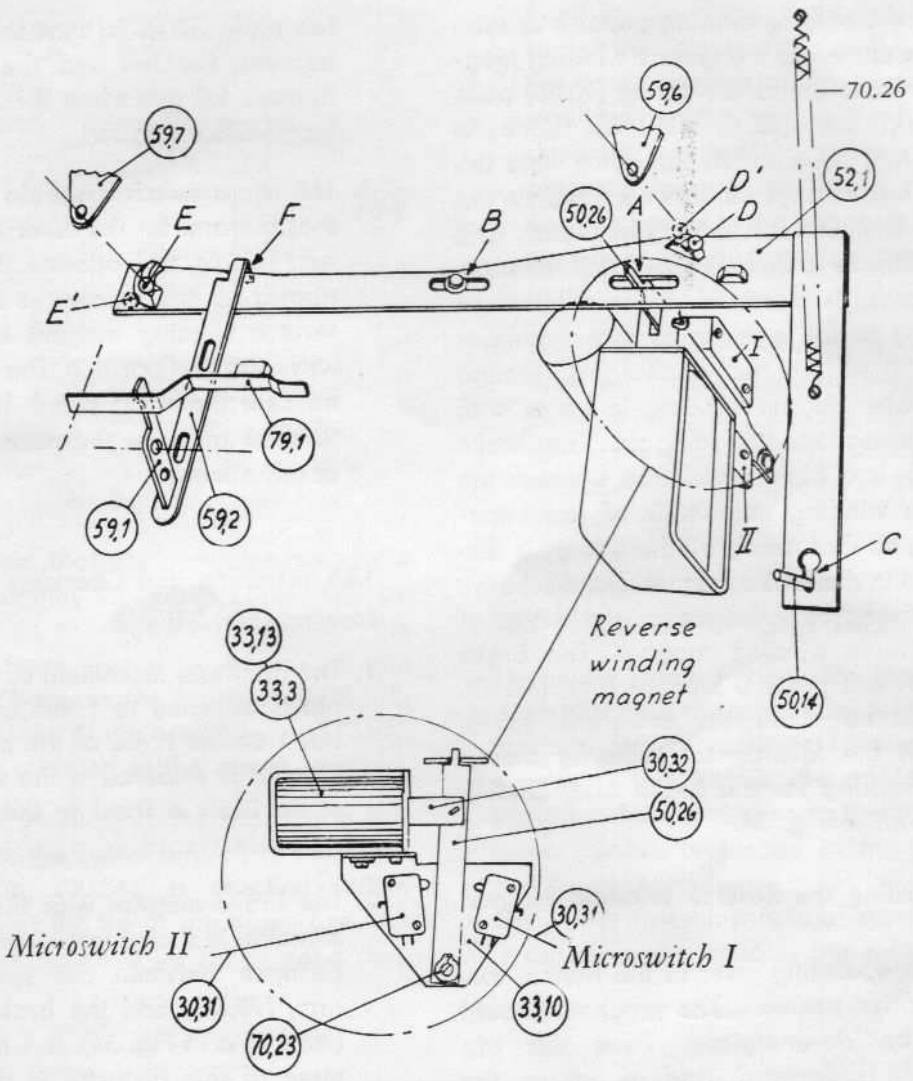


Fig. 33.

the description of the electrical circuit diagram. The trip bar, (52.1), can swing around point B, while at point C it can slide, guided by the operating lever, (50.14). When the reverse winding magnet is energized, the following happens:

1. The ball in the clutch lever for the right pulley disc, (59.6), Fig. 33, will move from D to D' and will thereby remove the pulley disc from the take-up turntable.
2. The ball in the clutch lever for the left pulley disc, (59.7) will move from E to E' and the pulley disc will be pressed with the full spring force against the supply turntable, and this will start pulling with the full reverse winding torque.
3. The trip bar, (52.1) will pull the coupling arm for the felt pad, (59.2) at point F. This is connected with the lever for the felt pad, (59.1) which lifts the pressure spring with felt pad, (79.1) away from erase head.
4. At the same time, as explained during the discussion of the electric circuit diagram, the start-stop magnet will be energized so that the pressure wheel, (63.1), Fig. 32, is lifted away from the capstan, (60.2). According to paragraphs 1—2 the pulley discs will stay in the same positions as during a fast reverse winding.
   Because of 3 and 4 all braking of the tape has been removed at the same time, and the tape will therefore be rewound as long as the reverse winding pedal is operated.

When the reverse winding pedal is released, the current to the reverse winding magnet is broken, and the spring (70.26) pulls the trip bar (52.1), Fig. 33, back to the initial position. At the same time the start-stop magnet will be energized via the contacts in the left and right pedals and will continue to be energized until the start-stop pedal is operated. When the reverse winding pedal is released, the condenser C36—20 μF will be discharged through the brake magnet winding in series with the reverse winding magnet. The brake magnet is of high impedance, whereas the reverse winding magnet is of low impedance, so that nearly all the energy is dissipated in the brake magnet. The discharge current has no influence on the action of the reverse winding magnet. The brake magnet will press the brake arm, (59.10), via the nut I on the armature, (33.9), against the take-up turntable by means of the spring for the brake arm, (70.54), as shown in Fig. 34.

12.4 Adjusting the Reverse Winding Magnet (Fig. 33).

1. Put the operating lever in the normal forward drive position. The magnets should both be de-energized. Push the trip bar, (52.1), forward, and as far as the armature of the reverse winding magnet permits. Check that the trip bar moves smoothly without any tendency to stic, and that the spring (70.26) will positively pull the trip bar back. Check this several times.
2. With the operating lever in the position for normal forward drive operation, and with the reverse winding magnet energized, the reverse winding magnet itself is moved (it is fixed in oblong holes) until the ball of the clutch lever for the supply pulley disc has just descended on to the flat portion of the trip bar at point E'. At the same time one should check that the ball of the clutch lever for the take-up pulley disc has moved right up to the highest point of the knob D'.
3. When the reverse winding magnet has been placed in the correct position, the lever for felt pad, (59.1), is bent until the distance between the felt and the erase head is approx. 1.0 mm when the reverse winding magnet is energized.
4. The micro switch II should be adjusted so that the arm for the reverse winding magnet, (50.26), will operate the micro switch approx. .5 mm before the armature of the reverse winding magnet has reached its fully attracted position. The upper fastening hole for the micro switch II is oblong and therefor provides the necessary possibility of adjustment.

12.5 Installing and Checking the Brake Magnet (Fig. 34).

1. The armature movement of the brake magnet is adjusted to 1 mm by means of the nut 1 on the screw of the armature, (33.9). The nut is soldered to the screw, while the screw itself is fixed to the armature with adhesive.
2. The brake magnet with the brake arm is mounted in such a fashion that the greatest distance between the spring for brake arm, (70.54), and the brake arm, (59.10), (marked a in Fig. 34), is 1 mm. The adjustment of this distance is done by means of the armature screw nut, (70.53).
3. The guide plate for the brake arm, (70.52), is hooked on the brake arm and is screwed to the brake magnet when the armature is in its natural resting position. (De-energized).
4. The brake magnet is fastened to the lower mounting plate, (71.1), with the brake arm between the take-up turntable and the pulley disc.
5. By means of the armature screw nut, (70.53), the brake arm, (59.10), is finally adjusted until approx. .5 mm clearance is obtained between the brake arm and the take-up turntable, when this is rotating in its lower position (operating lever in position for fast reverse winding). By pressing the armature of the brake magnet all the way in by means of a finger,

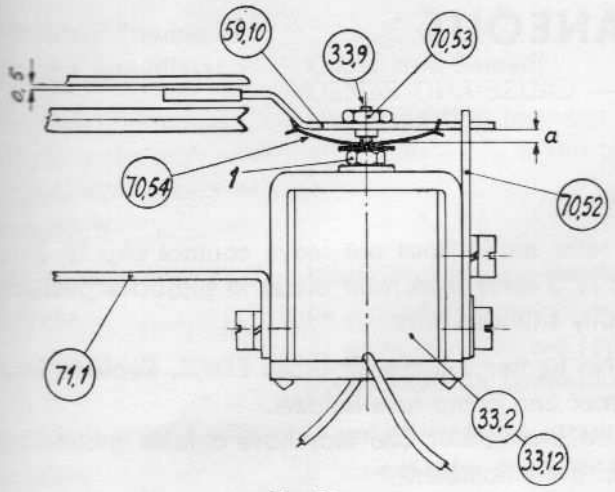


Fig. 34.

it is checked that the armature movement is so great that the brake spring will be deflected. In the bottom position of the armature there should be approx. .5 mm clearance between the brake arm, (59.10), and the flange of the armature nut (70.53). The nut is soldered to the armature screw.

6. When the position of the brake arm has been fixed, the initial tension of the brake arm spring, (70.54), is checked. When measured at the tip of the brake arm this initial tension should be 350 to 400 grams.
7. Plug in the Tape Recorder in the line socket and connect the pedal. Check that the brake magnet armature moves oll the way in when the reverse winding pedal is released, so that the same clearance is obtained between the brake arm, (59.10), and the flange of the armature nut, (70.53), as when the armature is pressed in by hand.
8. The fast reverse winding is tested using tape and pedal. When the reverse winding pedal is released, no loops should be formed in the tape at the take-up turntable, irrespective of the division of tape between the two spools.

12.6 Adjustment of Micro Switch I. (Fig. 33).

The micro switch I should be placed in such a position that the arm of the reverse winding magnet, (50.26), actuates the micro switch approx. 1 mm before the arm reaches the position which is obtained when the operating lever, (50.14), is placed in the position for fast forward winding.
The upper fastening hole of the micro switch is oblong and facilitates this adjustment.

MISCELLANEOUS

13. ELECTRICAL TROUBLE — CAUSE AND REMEDY

Electrical Trouble in Playback Amplifiers:	**Cause and Remedy:** See circuit diagram Fig. 19.
Upper track amplifier not operating.	Defect tube. Mode switch rotor blade does not leave contact clip IV 3 in playback position. Turn clip IV 3 away from rotor blade in playback position of the mode switch. Any faulty shielded wire.
Any amplifier not operating.	Any faulty shielded wire. No heater voltage on tubes EF804. Replace fuse 1000 mA on power transformer and crimp fuse holders. Defect tube. For the lower track amplifier C56 may have a false grounding at the underside of the dual potentiometer.
Muffled sound, low output, in any amplifier.	The tape is not running correctly. Dirt on playback head, or defects in same. Use a liquid head cleaner or alcohol. Use an alignment tape for correct azimuth adjustment of playback head.
Motorboating in any amplifier.	Low capacity in coupling capacitors .05 μF in the plate circuits for tubes ECC83. Replace capacitor.
Motorboating in both amplifiers simultaneously.	Broken wire to common grounding point on dual potentiometer. Put in a longer wire between potentiometer and shielded wire coming from the tube ECC83 in the upper track amplifier.
Noise in any amplifier, with volume control turned down.	Replace the tube ECC83 in the noisy amplifier.
Noise in any amplifier, with volume control turned up.	Noisy resistors in plate and/or screen grid circuits for the tubes EF804. Replace noisy resistors with carbon film types.
Hum, in any amplifier.	Open ground connection to any shielded wire. Relocate mumetal shield in front of playback head for minimum hum level. Hum induced in the playback head may be cancelled out by inserting humbucking coils in ground leads from the playback heads. Locate humbucking coils for minimum hum level. Black wire from tape stop solenoid running too close to resistor R53. Relocate this black wire. Location of black wire from cathode point of the tube socket EF804 also very critical in both amplifiers. Soldering tags in recorder touching foil inside the wooden case. Foil not grounded, due to missing grounding spring for the left front mounting screw. Connect a wire directly from foil to chassis of the recorder. Shielded wires from equalization switch must be twisted in pairs to each amplifier.
Too low output level in the lower track amplifier.	Check capacitor C54 .1 μF for short or leakage.
Distortion and noise in the lower track amplifier.	Check capacitors C59 and C62 for short or leakage.
Oscillations in the lower track amplifier.	Red wire from plate of EL84 to output transformer running close to components for the tube ECC83. Relocate the wire.
The two amplifiers out of balance.	Readjust balance by means of the variable resistor R40 (se text for the proper procedure).

Electrical Trouble in Record Amplifiers:	**Cause and Remedy:**
Recording squeezed up, from the high level input, with excess of sensitivity.	No connection between leaves in the microphone jack, so that the voltage divider R_2 — R_3 is out of operation. Adjust jack leaves.
Noisy recording, oscillations.	White and black wires from points 33 and 34 on the terminal board have to be placed close together and pressed against the terminal board. EL84 defect or generating at too low level. Check tube EL84. Open erase head. Check erase head for continuity.
Insufficient or no erasure.	Open erase head circuit. Incorrect tape path. Tube EL84 not oscillating due to defect tube or shorted C27.
Automatic tape end stop not functioning.	Adjust solenoid operation. Low capacity C43.
Voltage crackling.	Loose spring clips on fuse holder on operating lever. Crimp fuse holders to assure tight contact with fuse.

14. MECHANICAL TROUBLE — CAUSE AND REMEDY

Mechanical Trouble:	**Cause and Remedy:**
Slow acceleration of flywheel and wow is encountered.	Too little friction between motor pulley (62.1) and the speed transfer wheel (64.1). Clean motor pulley, speed transfer wheel and flywheel (66.1) with alcohol. Check clearance to the transfer wheel lifting arm (50.6).
The machine will not run after transportation.	Caused by the speed transfer wheel which slipped over the flywheel. Remove the rear trim cover (79.6) and push the speed transfer wheel off the flywheel. Ship the recorder in $1\,^7/_8$ ips position.
Too much friction in speed selector mechanism.	Dismount the speed selector bracket (79.18), and lift the transfer wheel mounting arm (53.2) off the speed selector shaft. Clean the brass bushing and the shaft, and lubricate the bearing before reassembling.
Crunching sound from turntables.	The noise will disappear when top of shaft is depressed. Replace and/or lubricate turbax washers (70.31) at the bottom end of the shaft. Check the lock spring (70.30) for evenness.
Mechanical noise.	The ball bearings in the pulley discs make noise. Replace pulley discs.
Does not operate in any position of the operating lever.	Motor fuse (30.14) blown or loose in the clips. Microswitch (30.16) does not make contact. The microswitch should break the motor current in the neutral position of the lever and make contact when the lever is brought half-way out to any other position. If necessary, adjust the switch positioning. The belt has jumped out of its groove in the motor pulley. Remove the top cover and put the belt back in place. The belt runs from the lower groove in back of the motor pulley on to the right pulley disc and from here to the upper groove in front of the motor pulley. The belt crossover is to the left of the motor pulley. The height position of the motor pulley should be checked. The grooves of the pulley discs should be cleaned for rubber granuals, possible excessive glue etc. The motor stalls. Reseat the armature, or replace motor and adjust the motor pulley.

Mechanical Trouble:	Cause and Remedy:
Does not operate in the position for normal forward drive.	The roller (50.20) on the pressure wheel monting arm has fallen off. Put the roller in place but lock with a new retainer ring. The retainer ring must not be stretched too far when put into place. Special pliers should be used. The extention spring (60.5) for the speed transfer wheel does not exert enough force. Shorten the spring till it pulls with 110 to 130 grams in the position $3\,^3/_4$" per sec. Too much friction in the supply turntable (65.2), which may be caused by incomplete disengagement of the pulley disc. Adjust pulley disc according to instructions in sec. 3.5. Too much friction between supply turntable and flange (72.1) mounted in the housing of the bearing. See Fig. 7. Put a drop of oil on the green felt on the flange. The take-up clutch friction is too high so it loads the motor. The take-up clutch friction is adjusted as described in sec. 3.4. Do not put any oil on the felt as it will come on to the pulley disc after a while and damage the same. The pulley discs load the motor too heavily because of too high bearing friction. Replace pulley discs.
Pulls unsatisfactorily in the position fast forward.	Too high running friction in the left turntable. Check that the pulley disc runs free of the turntable. Put a drop of oil on the green felt on the flange. Insufficient torque at the right pulley disc. The felt ring underneath the turntable is too thin so that the pulley disc does not press against the felt. Replace the turntable. The tag of the pulley disc cartridge (60.11) rests on the upper clutch lever. Adjust the clutch lever. See sec. 3.4. Insufficient spring pressure on the lower clutch lever. Adjust the spring tension (60.10).
The tape reels rub on the top cover.	The turntables are out of position. See instructions for adjustment of the turntables in sec. 3.3.
Tape path unnormal. Tape «climbs».	The felt pad (79.1) is pressed unevenly against the erase head. Twist the pad spring a little until pressure is evenly exerted on the tape with a nominal value of 100 grams. See sec. 3.8 and 3.9.
The tape stops in the guiding mechanism.	The adjustable tape guide (70.16) has loosened. The split cylinder into which the tape guide is screwed must be tightened a little. The pressure wheel (63.1) exerts uneven pressure on the capstan. A slight correction of the latch (70.19) on mounting arm will correct this. Tape splicing has been done with undue care. The splice is too wide. Cut the tape slightly narrower than its standard width at the splice. The tape is wider than the international standard 6.35 mm. Glue or the like in the groove of the tape guide. Clean with alcohol.

15. FAULTS — CAUSES AND REMEDIES, F EQUIPMENT

Fault:	Cause:	Remedy:
Reverse winding magnet gives a loud knock (like a machine gun) when the operating lever is moved slightly towards the normal forward drive position, even when the pedal is not connected.	C34 shortcircuited.	Replace C34.
Tape Recorder runs with the operating lever in normal forward drive position and with the pedal attached, but without operating the start-stop pedal. The start-stop magnet is not energized, and the armature does not move.	Open circuit in the start-stop magnet winding. Short circuit to chassis in the start-stop magnet winding. C37 shortcircuited. Micro switch I incorrectly adjusted, so that the start-stop magnet is not energized. Micro switch I does not operate properly (sticks).	Replace magnet. Replace magnet. Replace condenser. Adjust micro switch I according to the description, sec. 12.6. Replace and adjust micro switch I.
Tape Recorder works with the operating lever in the normal forward drive position, with the pedal connected, without operating the start-stop pedal. The start-stop magnet is energized. The pressure roller is not lifted away from the capstan.	The long lever for the pressure roller, (59.9), is incorrectly adjusted. The lever does not lift the pressure roller or lifts it too much. The screw for the start-stop armature, (33.8), has become loose, whereby the pressure roller is lifted too much.	The long lever for the pressure roller, (59.9), must be adjusted as described in sec. 12.2. Tighten the screw, (33.8).
Especially when the take up spool is nearly empty, the tape moves with a jerking motion when the pedals are not operated. The pressure roller is lifted away from the capstan.	Too powerful take up torque. Too weak spring pressure against the erasing head.	Adjust take up torque, should be approx. 100 gram.-cm. Adjust spring pressure, should be approx. 100 grams.

Fault:	Cause:	Remedy:
Tape Recorder does not run when the start-stop pedal is operated.	Pedal contact is not operating properly or is incorrectly adjusted.	Replace and/or adjust pedal contact.
Tape Recorder runs forward when the reverse winding pedal is operated.		
a. Reverse winding magnet is not energized, armature does not react.	Open circuit in the reverse magnet winding.	Replace magnet.
b. Reverse winding magnet is energized and the armature is attracted.	Short circuit to ground in the magnet winding.	Replace magnet.
	Micro switch II is not operated or is faulty.	Replace and/or adjust micro switch II. See description sec. 12.4 paragraph 4.
Reverse winding magnet is noisy (like a machine gun) when reverse winding pedal is operated.	Micro switch II is operated prematurely.	Micro switch II should be adjusted, see description sec. 12.4 paragraph 4.
	Open circuit in start-stop magnet.	Replace start-stop magnet.
No action when the reverse winding pedal is operated.	Pedal contact faulty or incorrectly adjusted.	Replace and/or adjust micro switch in left hand pedal.
	Micro switch II gives faulty operation (sticks).	Replace micro switch II.
	Faulty operation of micro switch I.	Replace micro switch I.
Take-up torque disappears after use of reverse winding pedal.	The spring G on the trip bar (52.1), is too weak, or the trip bar (52.1) moves with too much friction.	Remove possible additional friction and/or tighten the spring. It should be seen that the spring is not so tight that the reverse winding magnet is unable to pull the armature in.
When the reverse winding magnet is released, great loops of tape are formed at the take-up turntable.	Winding open circuited in the brake magnet.	Replace magnet.
	Short circuit to chassis in the brake magnet.	Replace magnet.
	Armature of brake magnet moves sluggishly.	Replace magnet.
	Defective condenser C36.	Replace condenser.
	Incorrectly adjusted brake magnet.	Adjust brake magnet, see description sec. 12.5.

16. PARTS LIST

Important when ordering parts!

This part list is based upon Tandberg Model 3 STEREO, but can also be used for all Tandberg models, because corresponding parts in the other models have the same part no. This does not mean, however, that corresponding parts are exactly like. When ordering it is therefore necessary to **state model as well.**
Also it may be important to state voltage and frequency for correct execution of a part.
For example:

1 only no. 53.2 Transfer wheel mounting arm for Model 3 Stereo, 60 c/s 110 volts.

16.1 Mechanical Parts.

Part no.:	Name:	Shown in Fig.:
02,1	Shielded interconnection wire	
09,1	Feltring for flywheel bearing	2, 3, 4, 28
09,2	Switch insulation	5
10,1	Lid for voltage coupler	3, 4
10,2	Power transformer bracket	3, 4, 21B
10,3	Voltage coupler	3, 4
10,4	Spacer for motor	22
10,5	Bakelite motor mounting plate	16, 22
10,6	Leg for power transformer	21B
10,7	Contact strip for voltage coupler	21B
10,8	Spacer for voltage coupler	21B
10,9	Fuse strip bracket	21B
10,10	Fuse strip I	21B
10,11	1000 mA fuse	17, 21B
10,12	500 mA fuse	17
11,1	Power transformer	4, 17, 21B
11,2	Bakelite fuse strip I	4, 21B
11,3	Bakelite fuse strip III	
12,1	Output transformer for upper track	17, 21
12,2	Output transformer for lower track	21B
13,1	Choke	3, 17, 18
14,1	Motor, Engel 165 v, 50—60 c/s. ES-4027/40	13, 16, 17, 22
15,1	Record-playback head	3, 4
15,2	Mounting plate record-play back head	2, 3
16,1	Erase head	2, 3, 4
16,2	Mounting plate erase head	2, 3, 4
17,1	Output terminal strip	3, 4, 17, 21
18,2	Bakelite mounting board	17, 21
18,3	Bakelite coupling board for amplifier lower track	21B
19,1	Head terminal strip I	2, 3, 4
19,2	Head terminal strip II	2, 3, 4
19,3	Bakelite strip	5, 6, 17
19,4	Bakelite strip	18
19,5	Bakelite strip	21
22,1	Oscillator coil	17, 21

Part no.:	Name:	Shown in Fig.:
27,1	Supressor coil	18
27,2	Board for supressing circuit	18
28,1	Plate circuit mounted	
28.2	Plate coil	21
28.3	Plate circuit bakelite board	18, 21
30.1	Pilot lamp cover	1, 2
30.2	Mode switch	2, 3, 4, 18, 21
30.3	On-off switch. (Bass switch)	1, 2, 3, 4, 17, 21, 21B, 22
30.4	Revolution counter	1, 2, 3, 4, 22, 29
30.5	Selenium rectifier 100 mA	3, 4, 17, 21
30.6	Selenium rectifier 600 mA	4, 17, 21
30.7	Monitor speaker switch	1, 2, 3, 4, 18
30.8	Spring for magic eye EM 71	4
30.9	Double potentiometer	2, 3, 4, 17, 21
30.10	Axis for the actuator lever for micro switch	5
30.11	Actuator lever for micro switch	5, 22
30.12	Plate spring for micro switch	5, 22
30.13	Fuse holder	5, 17, 21B, 22
30.14	Motor fuse	5, 17, 22
30.15	Motor fuse label	5
30.16	Micro switch	5, 22
30.17	Spring I for transfer axis for revolution counter	22
30.18	Spring II for transfer axis for revolution counter	22
30.19	Transfer axis for revolution counter	22
30.20	Equalization switch actuator	22
30.21	Insulation for on-off switch (Bass switch)	17, 21, 21B, 22
30.22	Shield for equalization switch	17, 18
30.23	Spacer for equalization switch	18
30.25	Deck for equalization switch	18
30.26	Shaft for equalization switch	18
30.27	Actuator lever for equalization switch	18
30.28	Stereo switch	4, 18, 21
32.1	Double potentiometer R9 + R57 with stereo switch	2, 3, 4, 17, 21
33.4	Mounting board for micro switch	
33.5	Armature for automatic stop magnet	5, 6, 17, 21B, 22
33.6	Rear plate for stop magnet	6, 17, 21B, 22
33.7	Coil for automatic stop	
39.1	Equalization switch	
39.2	Mode switch, wired	2, 3, 4, 18, 21
40.1	Monitor speaker frame	1
40.2	Bakelite washer for mic-jack	3, 4
40.3	Pilot lamp	3, 18
40.4	Pilot lamp bracket	17, 18
40.5	Pilot lamp socket	18
40.6	Bakelite strip for pilot lamp	17, 18
40.7	Microphone jack	2, 3, 4, 17, 18
40.8	Microphone plug	
44.1	Pilot lamp shield	3, 17
45.1	Microphone jack, wired	1, 2, 3, 4, 17, 18
47.1	Amplifier for upper track, wired	

When ordering parts always state model.

Part no.:	Name:	Shown in Fig.:
47.2	Amplifier for lower track, wired	
47.3	Amplifier for upper track	3, 4, 17, 18
47.4	Amplifier for lower track	21, 21B
47.5	Tube socket EL84	21
47.6	Tube socket ECC83	17, 21
47.7	Tube socket EF804	17, 21
47.8	Tube socket EM71	17
48.1	Wooden case	1
50.1	Pressure wheel bracket	2, 3, 4
50.2	Shaft for pressure wheel bracket	2, 3, 4, 32
50.3	Pressure spring bar	3
50.4	Linkage I for transfer wheel lifting	3, 17, 21B
50.5	Shaft for transfer wheel holder	3, 4, 13, 14, 15, 16, 28
50.6	Transfer wheel lifting arm	3, 4, 14, 15, 16
50.7	Cam disk arm	3, 4, 14, 15, 16, 22, 28
50.8	Shaft for cam disk arm	3, 14, 15, 16, 22
50.9	Bracket for shaft for cam disk arm	3, 14, 15, 16, 28
50.10	Extension spring for cam disk arm	3, 4, 15, 16
50.11	Transfer wheel mounting arm (only)	3, 4, 13, 14, 15, 16, 28
50.12	Lower clutch lever for take up pulley disk	3, 7, 8, 9, 10, 15, 22, 28
50.13	Shaft for lower clutch lever right pulley disk	3, 22, 28
50.14	Operating lever	2, 3, 4, 5, 6, 21B, 22, 33
50.15	Linkage for mode switch	29
50.16	Arresting spring for operating lever	29
50.17	Axis for eccentric segment	29
50.18	Movement limiter for eccentric segment	17, 21B, 29
50.19	Axis for roller for pressure wheel bracket	29
50.20	Roller for pressure wheel bracket	29
50.21	Spring for linkage for mode-switch and spring for pressure wheel bracket	29
50.22	Axis for cam disk arm roller	14, 22
50.23	Cam disk	3, 14, 15, 16, 22
50.24	Roller for cam disk arm	14, 22
51.1	Pressure wheel bracket assembly (mounted)	2, 3, 4, 32
52.1	Trip bar	3, 8, 10, 11, 12, 15, 16, 21B, 28, 33
53.1	Transfer wheel mounting arm	3, 4, 15, 16, 28
53.2	Transfer wheel mounting arm assembly	3, 4, 15, 16
54.1	Operating lever, mounted	2, 3, 4, 21B, 22
54.2	Bakelite mounting plate for micro switch	5, 17
54.3	Bracket for operating lever	5, 6, 17, 21B, 22
59.4	Linkage for transfer wheel lifting mounted	
59.5	Eccentric segment	3, 17, 21B, 22, 29
59.6	Upper clutch lever for take up pulley disk	3, 7, 8, 9, 15, 28, 33
59.7	Clutch lever for supply pulley disc.	3, 11, 12, 15, 16, 21, 28, 33
59.8	Stereo-monaur. lever	1, 2
60.1	Empty reel	1
60.2	Capstan	2, 3, 4, 32
60.3	Bushing for flywheel bearing	2, 3, 28, 29

When ordering parts always state model.

Part no.:	Name:	Shown in Fig.:
60.4	Turbax washer for turntables	3
60.5	Spring for transfer wheel	3, 4, 15, 16
60.6	Spring for clutch lever	28
60.7	Transfer wheel holder only	3, 4, 13, 14, 15, 16, 28
60.8	Pressure wheel axis	2, 3, 4, 32
60.9	Bushing for turntable bearing	28
60.10	Spring for right lower clutch lever	22
60.11	Pulley disc cartridge	7, 8, 9, 10, 11, 12
61.1	Pulley disc.	3, 7, 8, 9, 10, 11, 12, 13, 21, 21B
61.2	Helical compression spring for take up pulley disk	7, 9, 10
61.3	Helical compression spring for supply pulley disk	11, 12
62.1	Motor pulley	3, 4, 13, 15
63.1	Pressure wheel	2, 3, 4, 32
64.1	Transfer wheel	3, 4, 13, 14, 15, 16, 28
64.2	Transfer wheel holder with shaft	3, 4, 15, 16, 28
64.3	Transfer wheel holder, mounted with transfer wheel	3, 4, 15, 16, 28
65.1	Right turntable with felt	1, 2, 3, 4, 7, 8, 9, 10 13, 15, 16, 22
65.2	Left turntable with felt	2, 3, 4, 11, 12, 13, 15, 16
66.1	Flywheel	3, 4, 13, 15, 16, 17
70.1	Screw for trim cover	1
70.2	Stop contact	1, 2, 3, 4
70.3	Decal «STEREO-MONAUR»	1, 2
70.4	Decal «BASS»	1, 2
70.5	Decal «NORM»	1, 2
70.6	Decal «1 7/8 — 3 3/4 — 7 1/2»	1, 2
70.7	Decal «MONITOR SPEAKER»	1, 2
70.8	Decal «ON — OFF»	1, 2
70.9	Mounting screws	1, 2
70.10	Stereo emblem	1
70.11	Rubber mounting, washer for mounting screws	2, 3, 4, 5, 6, 21, 21B, 22
70.12	Left tape guide	2, 3, 4
70.13	Marker for pot.meter	1, 2
70.14	Top cover mounting screws	2
70.15	Tape guide bracket	2, 3, 4
70.16	Adjustable tape guide	2, 3, 4
70.17	Latch for flywheel bearing	2, 3, 4, 28
70.18	Right tape guide	2, 3, 4
70.19	Spring equalization latch	2, 3, 32
70.20	Speed selector shaft	2, 3, 4, 14, 15, 16, 22, 28
70.21	Axis for pressure spring bar	3
70.22	Spring for cower plate I	3
70.23	Stud for plates. (Extension stud)	3, 4, 33
70.24	Cup for speed selector spring	4, 14, 15, 16, 28
70.25	Top cover mounting screws	2

When ordering parts always state model.

Part no.:	Name:	Shown in Fig.:
70.26	Extension spring for trip bar	3, 4, 33
70.27	Clamp for C43	5, 6, 17, 21B, 22
70.28	Operating lever guide spring	5, 6, 22
70.29	Rubber drive belt	3, 4, 8, 15, 21, 21B
70.30	Spring (for fuse holder)	5, 7
70.31	Turbax washer	7
70.32	Shaft for transfer wheel. (Transfer wheel axis)	3, 4, 14, 15, 16, 28
70.33	Spacer	21B, 22, 28, 32
70.34	Stud	28
70.35	Spring for lower flywheel bearing	28
70.36	Housing for turntable bearing	7, 13, 28
70.37	Turbax washer	7
70.38	Guiding stud for trip bar	21, 28
70.39	Speed selector spring	14, 28
70.40	Stud	29
70.41	Stud	17, 29
70.42	Mumetal tube shield	17, 18
70.43	Aluminium tube shield	17, 18
70.44	Spring for EL84	17, 18
70.45	Clamp for C42	17, 18
70.46	Rubber mounting	18
70.47	Stud for lifting arm	14, 15, 16
70.48	Rubber mounting	17, 21, 21B
70.49	Shield for amplifier for lower track	17
70.50	Seeger ring	22
70.51	Flat spring for operating lever knop	
71.1	Lower mounting plate	3, 4, 7, 8, 13, 15, 16, 21, 21B, 22, 28, 32, 34
71.2	Upper mounting plate	2, 3, 4, 17, 21, 21B, 22, 29
72.1	Flange for turntable housing	3, 7
73.1	Head mumetal shield (226°) with top	2
73.2	Head mumetal shield (100°)	2, 3, 4, 32
73.3	Front trim cover bracket	2, 3, 4
73.4	Rear trim cover bracket	2, 3, 4
73.5	Mumetal shield base	3, 4
74.1	Top cover	1, 2, 17, 21, 21B
79.1	Pressure spring with felt pad	2, 3, 4, 33
79.2	Transfer axis for revolution counter with springs and rubber	17, 22
79.4	Shaft for speed selector with parts	2, 3, 4, 15, 16, 22, 28
79.5	Pressure wheel spring	3, 4, 32
79.6	Rear trim cover	1
79.8	Operating lever knob	1
79.9	Cover plate I	2, 3, 4
79.10	Cover plate II	3, 4
79.11	Front trim cover	1
79.12	Volume control knob	1
79.13	Mode switch knob	1
79.14	Speed selector knob	1
79.15	Spring for upper flywheel bearing	2, 3, 4

When ordering parts always state model.

Part no.:	Name:	Shown in Fig.:
79.16	Left rear mounting bracket	3, 4, 21, 28
79.17	Right rear mounting bracket	3, 4, 21B, 22, 28
79.18	Speed selector bracket	3, 4, 14, 15, 16, 28
79.20	Rubber drive belt guide	3, 4, 15, 16
79.21	Flywheel bearing mounting latch	29
79.22	Latch for revolution counter	29

16.2 Electrical Parts.

16.2.1 Resistors.

Part no.:	Name:								Remarks:
R1	15 000	ohm	—	1/2	W	Type	SBT	— 5 %	CCIR
R1	18 000	«	—	«	«	«	«	— 5 %	NARTB
R1B	7 500	«	—	«	«	«	«	— 5 %	CCIR
R1B	13 000	«	—	«	«	«	«	— 5 %	NARTB
R2	.51	M.ohm	—	«	«	«	«	— 10 %	
R3	10 000	ohm	—	«	«	«	«	— 10 %	
R4	5.1	M.ohm	—	«	«	«	«	— 10 %	
R5	5 100	ohm	—	«	«	«	«	— 5 %	CCIR
R5	3 300	«	—	«	«	«	«	— 10 %	NARTB
R5B	15 000	«	—	«	«	«	«	— 10 %	NARTB
R6	2 000	«	—	1	«	«	SCD1	— 5 %	
R7	.2	M.ohm	—	1	«	«	ABT	— 10 %	
R8	1	«	—	1	«	«	«	— 10 %	
R9 + R57	2 × .5	«	—	Double pot.meter					
R10	51 000	ohm	—	1/2	W	Type	SBT	— 10 %	
R11	3 900	«	—	«	«	«	«	— 10 %	
R12	82	«	—	«	«	«	«	— 10 %	
R13	.1	M.ohm	—	1	«	«	ABT	— 10 %	
R14	1	«	—	1/2	«	«	SBT	— 10 %	
R15	.33	«	—	«	«	«	«	— 10 %	
R16	510	ohm	—	«	«	«	«	— 5 %	
R17	82 000	«	—	1	«	«	ABT	— 10 %	
R18	.15	M.ohm	—	1/2	«	«	SBT	— 10 %	
R19	30 000	ohm	—	1	«	«	ABT	— 10 %	
R20	.25	M.ohm	—	Pot. type 57 TR, Elap					Lin.
R22	.2	«	—	1/2	W	Type	SBT	— 10 %	
R23	1.2	«	—	«	«	«	«	— 10 1/2	
R24	.15	«	—	«	«	«	«	— 10 %	
R25	2 000	ohm	—	«	«	«	«	— 10 %	
R26	10	M.ohm	—	«	«	«	«	— 10 %	
R27	200	ohm	—	1	«	«	ABT	— 5 %	
R28	.2	M.ohm	—	1	«	«	«	— 10 %	
R28B	20 000	ohm	—	1	«	«	«	— 10 %	
R29	51 000	«	—	1	«	«	«	— 10 %	
R30	8 200	«	—	1/2	«	«	SBT	— 10 %	
R31	8 000	«	—	«	«	«	12h	— 10 %	
R32	51	«	—	1	«	«	BW1	— 10 %	
R35	50	«	—	1/2	«	«	12h	— 20 %	
R38	51 000	«	—	«	«	«	SBT	— 10 %	
R39	20 000	«	—	«	«	«	«	— 10 %	

Part no.:	Name:							Remarks:
R40	100	ohm	— Pot. Type 57 TR, Elap					Lin.
R41	.2	M.ohm	— 2 W Type BBT				— 10 %	
R42	20 000	ohm	— 1 «	«	«		— 10 %	
R43	51 000	«	— ½ «	«	SBT		— 10 %	
R50	7 500	«	— « «	«	«		— 5 %	CCIR
R50	13 000	«	— « «	«	«		— 5 %	NARTB
R51	15 000	«	— « «	«	«		— 5 %	CCIR
R51	18 000	«	— « «	«	«		— 5 %	NARTB
R52	51 000	«	— « «	«	«		— 10 %	
R53	5 100	«	— « «	«	«		— 5 %	CCIR
R53	3 300	«	— « «	«	«		— 10 %	NARTB
R53B	15 000	«	— « «	«	«		— 10 %	NARTB
R54	2 000	«	— 1 «	«	SCD1		— 5 %	
R55	.2	M.ohm	— 1 «	«	«		— 10 %	
R56	1	«	— 1 «	«	«		— 10 %	
R58	2	«	— ½ «	«	SBT		— 10 %	
R59	.15	«	— « «	«	«		— 10 %	
R60	51 000	ohm	— « «	«	«		— 10 %	
R61	3 900	«	— « «	«	«		— 10 %	
R62	33	«	— « «	«	«		— 5 %	
R63	.1	M.ohm	— 1 «	«	ABT		— 10 %	
R64	1	«	— ½ «	«	SBT		— 10 %	
R65	510	ohm	— « «	«	«		— 5 %	
R66	82 000	«	— 1 «	«	ABT		— 10 %	
R67	.15	M.ohm	— ½ «	«	SBT		— 10 %	
R68	.15	«	— ½ «	«	«		— 10 %	
R69	2 000	ohm	— « «	«	«		— 10 %	
R70	30 000	«	— 1 «	«	ABT		— 10 %	
R71	200	«	— 1 «	«	«		— 5 %	
R72	51 000	«	— 1 «	«	«		— 10 %	
R74	51	«	— 1 «	«	BW1		— 10 %	
R75	8 200	«	— ½ «	«	SBT		— 10 %	
R76	51 000	«	— « «	«	«		— 10 %	
R77	.2	M.ohm	— 1 «	«	ABT		— 10 %	

16.2.2 Capacitors

Part no.:	Name:							Remarks:
C1	30	μμF	— Styroflex		— 10 %		125 V	
C2	200	«	— «		— 10 %		125 V	
C2B	.0015	μF	— Paper W99		— 10 %		150 V	
C3	47	μμF	— Styroflex		— 5 %		350 V	
C4	.02	μF	— Paper W48		— 5 %		350 V	
C5	25	«	— Electrolytic		—		12/15 V	
C6	.1	«	— Paper A51		— 20 %		400 V	
C7	4	«	— Electrolytic		—		350/385 V	
C8	.05	«	— Paper A50		— 20 %		400 V	
C9	.005	«	— «	W99	— 10 %	(20)	150 V	CCIR
C9	.008	«	— «	W99	— 10 %	(20)	150 V	NARTB
C9B	.008	«	— «	W99	— 10 %	(20)	150 V	NARTB

Part no.:	Name:						Remarks:
C9B	.01	µF	— Paper W99	— 10 % (20)	150 V		CCIR
C9C	.02	«	— « W99	— 10 % (20)	150 V		
C10	25	«	— Electrolytic	—	12/15 V		
C11	.01	«	— Paper W99	— 20 %	150 V		
C12	.50	«	— « A50	— 20 %	400 V		
C13	.50	«	— « A50	— 20 %	400 V		
C14	25	«	— Electrolytic	—	12/15 V		
C15	16	«	— «	—	350 V		
C17	100	µµF	— Styroflex	— 10 %	500 V		
C18	125	«	— «	— 5 %	500 V		
C19	.0025	µF	— «	— 2,5 %	500 V		
C20	800	µµF	— «	— 10 %	500 V		
C21	.01	µF	— Paper W99	— 20 %	150 V		
C22	600	µµF	— Styroflex	— 2,5 %	500 V		
C23	.02	µF	— Paper W99	— 10 % (20)	150 V		
C24	25	«	— Electrolytic	—	12/15 V		
C25	.002	«	— Styroflex	— 20 %	500 V		
C26	.001	«	— «	— 10 %	125 V		
C27	.0015	«	— «	— 5 % (10)	500 V		
C30—C31	40 + 20 + 10	µF	— Hunt Electrolytic	—	350 V		
32	.1	µF	— Paper CA	— 20 %	350 V		
C33	10	µµF	— Ceramic	— 5 %	500 V		
C38	1.2	µF	— Oilpaper	—	380/570 V		
C40	10	µµF	— Ceramic	—			
C41	10	«	— «	—			
C42	2 000	µF	— T.I.K. (EAL) Electrolytic		6/8 V		
C43	100	«	— N 100/30B 4101 Electrolytic		30/35 V		
C44	.03	«	— Paper W99	— 10 % (20)	150 V		
C45	.04	«	— « W99	— 20 %	150 V		
C50	33	µµF	— Styroflex	— 5 %	125 V		
C51	200	«	— «	— 10 %	125 V		
C52	.0015	µF	— Paper W99	— 10 %	150 V		
C53	.02	«	— « W48	— 5 %	350 V		
C54	.1	«	— « A51	— 20 %	400 V		
C55	25	«	— Electrolytic	—	12/15 V		
C56	.05	«	— Paper A50	— 20 %	400 V		
C57	4	«	— Electrolytic	—	350/385 V		
C58	25	«	— «	—	12/15 V		
C59	.05	«	— Paper A50	— 20 %	400 V		
C60	10	µµF	— Geramic	— 5 %	500 V		
C61	25	µF	— Electrolytic	—	12/15 V		
C62	.05	«	— Paper A50	— 20 %	400 V		
C63	16	«	— Electrolytic	— CE802	350 V		
C64	25	«	— «	—	12/15 V		
C65	90	«	— Siemens 30 × 60 El.lyt.		350/385 V		
C66	.001	«	— Styroflex	— 20 %	125 V		
C67	.03	«	— Paper W99	— 10 % (20)	150 V		

16.2.3 Tubes

V1	EF 804	Telefunken
V2	ECC 83	
V3	EL 84	
V4	EM 71	Lorenz
V5	EF 804	Telefunken
V6	ECC 83	
V7	EL 84	

16.2.4 Rectifiers

Simens SSF B30 C600
AEG B250 C100
Siemens E37,5 — C2

16.3 Additional Parts for F-model.

Part no.:	Name:	Shown in Fig.:
10,13	200 mA fuse	
30,31	Micro switch	33
30,32	Reverse winding magnet armature	33
33,1	Stop magnet (complete assembled)	(32)
33,2	Brake magnet (complete assembled)	34
33,3	Reverse winding magnet (complete assembled)	33
33,8	Stop magnet armature with screw	32
33,9	Brake magnet armature	34
33,10	Bracket for reverse winding magnet	33
33,11	Stop magnet without armature	32
33,12	Brake magnet without armature	34
33,13	Reverse winding magnet without armature	33
33,14	Contact spring	32
50,25	Shaft for pressure wheel lever	32
50,26	Arm for reverse winding magnet	33
59,1	Lever for felt pad	33
59,2	Coupling arm for felt pad	33
59,3	Start stop lever	32
59,9	Pressure wheel lever	32
59,10	Arm for brake magnet	34
70,52	Guide plate for brake arm	34
70,53	Armature screw nut	34
70,54	Spring for brake arm	34
79,23	Spring for start stop lever	32
79,24	Bakelite strip	32

When ordering parts always state model.

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