POPPY
RECORDS

ARCHIVAL
DISC PLAYER

HANDBOOK

Dec 2025

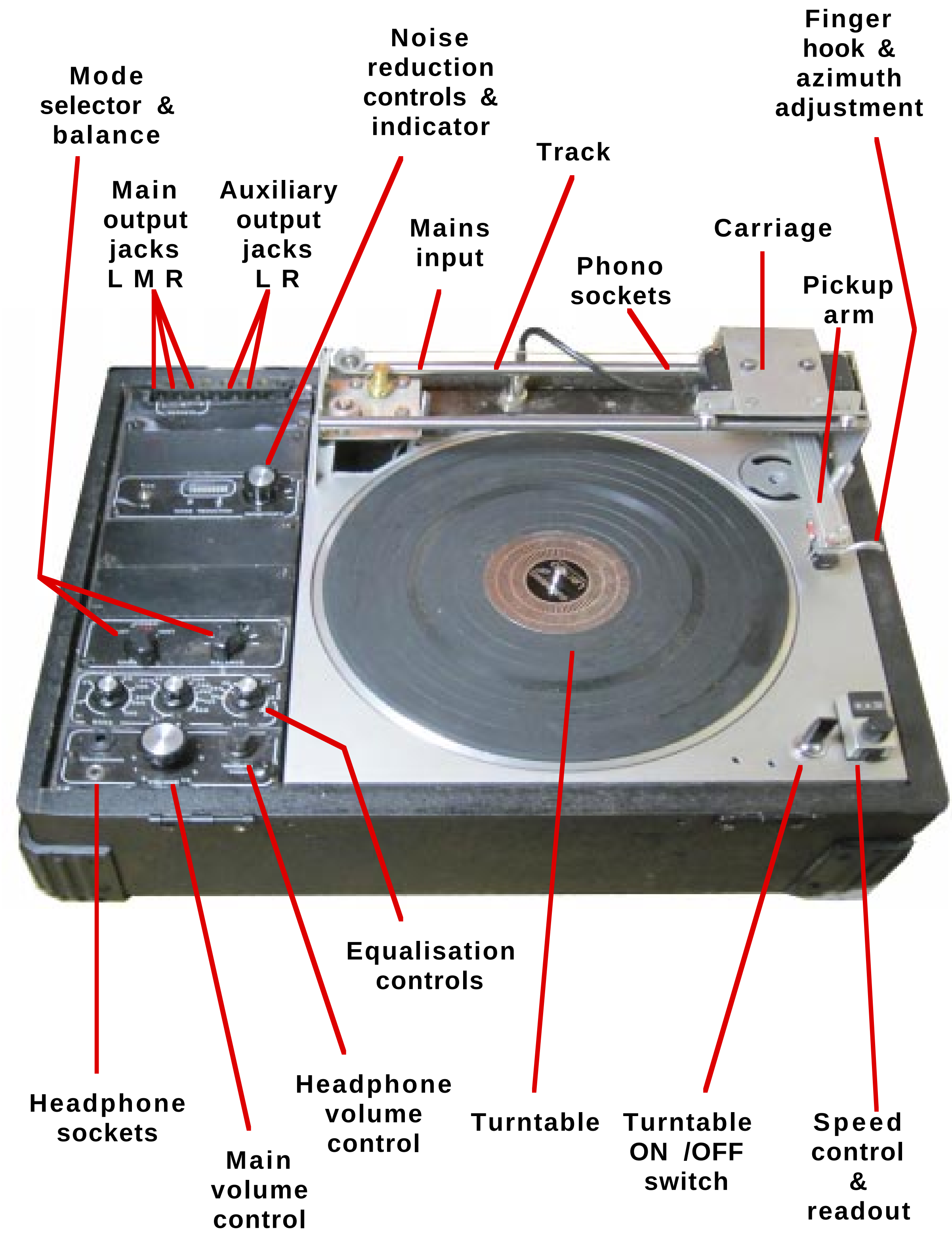

Fig 1 — The Disc Player

ARCHIVAL DISC PLAYER

CONTENTS

ARCHIVAL DISC PLAYER

INTRODUCTION

This is a versatile portable unit with facilities for playing the many formats in which historic disc recordings may be found. The equipment consists of:

a) Gramophone Turntable

For playing discs up to 12.5 inches in diameter at any speed from 25 to 120 r.p.m. Clockwise rotation (when viewed from above). Continuous speed adjustment with accurate readout from a ‘cyclometer’ dial.

b) Pickup Arm

A lightweight parallel-tracking pickup arm with a servo-controlled drive that ensures minimal sideways loading on the stylus. Manually-operated lift and lower for rapid operation by means of a finger hook.

c) Cartridge

A Shure 44M moving-magnet cartridge is mounted on the pickup arm. It has an interchangeable stylus assembly which allows the use of a wide selection of styli to suit various groove profiles. The cartridge may be rotated to suit discs with “azimuth error” (i.e. recorded with the modulation misaligned on the two groove walls due to a skewed cutter). Lateral, vertical or stereo modulation can be selected electronically without the need for cartridge or wiring alterations.

d) Pre-amplifiers

These are mounted inside the parallel-tracking carriage so as to give the shortest possible wiring from the cartridge. They use a virtual impedance input circuit for the lowest possible noise level. Output signals at cartridge level are made available through “RCA phono” connectors to allow the use of an independent amplifier if desired.

e) Selector and Equaliser

A selector switch caters for monophonic records with lateral or vertical modulation and 45/45 stereo recordings. In the monophonic positions of the selector switch, a comprehensive set of equalisation characteristics with sufficient range to equalise most monophonic electrical recordings, is available. In the stereo position, R.I.A.A. equalisation is automatically applied to both channels.

f) Noise Reduction

An analogue computer for noise reduction is built-in. The sensitivity of this can be adjusted by a single knob and it can be by-passed completely for comparison purposes. It only operates in the lateral monophonic position of the selector switch.

g) Main Outputs

Unbalanced left, right and mono output signals are available from a Gauge ‘B’ jackfield at nominally 0 dBu signal level. The level can be controlled by means of a volume control knob. In addition, unbalanced left and right unequalised signals are available for operating an external X-Y oscilloscope at a fixed level of approximately -10 dBu.

h) Headphone Outputs

A quarter-inch Gauge ‘A’ stereo jack and a 2.5mm stereo jack are provided for the connection of stereophonic headphones. High or low impedance headphones are equally suitable. The headphone volume level can be controlled independently of the main output level.

TECHNICAL DATA

2.1 Dimensions
(approximate)

Width	..	..	..	21″	515mm
Depth	..	..	..	16″	405mm
Height	..	..	..	9″	2304mm
Weight	..	..	..	40 lb	18.5Kg

2.2 Power Supply
Voltage range: 200 - 250 volts
Frequency range: 50c/s - 60 c/s
Power consumption: <100 Watts
Mains connector: I.E.C.'C13'
This equipment must be earthed.

2.3 Turntable
Diameter: 12″ (300mm)
Clearance radius: 6.25″ (160mm)
Rotation: clockwise (seen from above)
Speed range: 25 to 120 rpm
Speed accuracy: + or - 0.5 rpm

2.4 Pickup arm
Lightweight alloy extrusion
Swivel mounting for cartridge
Fnger hook control
Parallel tracking

2.5 Cartridge
Type: Shure 44m stereo moving magnet
Tracking weight: 4.5g

2.6 Modulation type
Horizontal (lateral)
Stereo 45°/45°
Vertical (hill and dale)
Channel balance adjustable from zero output to +6dB

2.7 Equalisation

L.F rolloff:. 25 - 300 c/s
Mid turnover: 170 - 2000 c/s
H.F. rolloff: 2 - 20 Kc/s

2.8 Frequency response

With equalisation controls set to ‘flat’
With or without noise reduction
20c/s - 20 Kc/s ± 1.5db

2.9 Noise level

With equalisation controls set to ‘flat’
Noise reduction switched off
Measurement bandwidth 20c/s - 20 Kc/s
System noise at least 65 dB below average modulation.

2.10 Outputs

Main outputs
Left channel
Right channel
Mono (equal-weighted L+R)
(With the Selector switch in either of the mono positions, all three outputs are identical)
BBC Gauge‘B’ jacks (for P.O. 315 plugs)
Source impedance 600 ohms unbalanced
Variable output level from 0 to approx 10v rms (+20 dBu)
Variable equalisation and noise reduction

Auxiliary outputs
Left and Right channels unequalised (for X-Y oscilloscope)
BBC Gauge‘B’ jacks (for P.O. 315 plugs)
Source impedance 600 ohms unbalanced
Signal level: nominally -10 dBu

Headphone outputs
1/4-inch stereo jack socket
3.5 mm stereo jack socket
Output impedance approx 50 ohms unbalanced
Variable output level from 0 to approx 10v rms (+20 dBu)

Pickup output
Left and right channels from “RCA phono” sockets
Source impedance 600 ohms unbalanced
Signal level = cartridge output level (nominally 5mV).

OPERATION

3.1 Location

The apparatus should be installed in a clean dry location with temperatures in the range 0°C to 30°C.

Sound and other vibrations can be transmitted to the disc and pickup through resonant floors or furniture. A heavy solid base, mounted directly on the walls or the foundations, is preferred but if this is not available, a resilient pad, such as a cushion, may be placed underneath the apparatus. Monitoring loudspeakers should be placed where their airborne sound does not impinge directly on the equipment and mounted so that their cabinet vibrations cannot be transmitted by contact with other structures.

Ideally, a work surface should be arranged immediately adjacent to the equipment so that discs can be handled without risk of breakage. Good lighting is desirable but lamps which emit heat should not be positioned where they might overheat the discs.

3.2 Unpacking & Packing

Ensure the box is standing the correct way up (the carrying handle is attached to the lower section of the box). The side with the two toggle latches should be facing away from the operator. Lift up the levers on the toggle latches, swing the latch bars clear and lift the lid gently. As the lid is swung back, the hinges will release and it can be removed altogether Caution: the lid is heavy! The lid contains a kit of connecting leads and spare parts, so it should be stored in a safe and easily-accessible place.

Before replacing the lid, check that the stylus has been removed and is stored in the box provided for the purpose. The pickup should be on its rest stud, with the parallel-tracking carriage at the right hand end of its travel. No discs should be left on the turntable. The spares compartment should be securely bolted shut and the bolt lever must lie flat. With the lid in an upright position, engage the two hinges, then swing the lid down to the closed position checking that the hinges remain correctly engaged. If any resistance is met, stop immediately and check to see if anything is misplaced and trapped. Raise the levers of the toggle latches and swing the latch bars upwards onto the top part of each latch, then lower the levers and check that the latch bars have pulled down firmly into a position where they retain the lid securely closed.

3.3 Power

Plug an IEC connector lead into the mains connector behind the L.H. end of the parallel-tracking rails. Ensure the side of the pickup arm is against the pillar at the RH end of its travel and is resting on the projecting stud. Check that the parallel-tracking carriage is correctly seated on its rails before switching on the supply. Upon switching on, there may be a brief flash from the noise reduction indicator or the parallel-tracking carriage may jump slightly. To test that the power is connected correctly, switch on the turntable and check that it begins rotating.

3.4 Turntable Speed

Rotate the Speed knob until the correct speed for the record to be played is shown on the cyclometer-type dial. Between 20 and 100 rpm the display shows the speed directly in rpm with one decimal place. For speeds above 100 rpm the dial will indicate speeds from 0 to 20 rpm, so an additional 100 should be added to the display reading to get the actual speed.

3.5 Stylus

Select an appropriate stylus for the records to be played. When changing the stylus assembly it may be helpful to temporarily disconnect the power to prevent unwanted movement of the parallel-tracking carriage. The stylus assembly is inserted, brass tube first and stylus downwards, into the diamond-shaped hole at the front bottom edge of the cartridge. Extreme care must be taken when inserting the stylus assembly, as both the brass tube and the pole-pieces inside the cartridge hole can be easily damaged if force is applied whilst they are misaligned.

3.6 Parallel Tracking & Azimuth

The unexpected movement of the parallel-tracking mechanism can be a little disconcerting to operators who have never used one before. In fact it is operated exactly like a manual pickup, with the user lifting, locating and lowering the pickup arm by means of the finger hook; the carriage will follow the pickup movements automatically. Never place a finger on top of the hook or attempt to press the pickup down onto the record.

The cartridge can be swivelled by gently turning the finger hook. The screw on the top of the pickup adjusts the friction, it is delicate and should not be overtightened. Normally the cartridge should be in line with the pickup but some records, which were recorded incorrectly, may benefit from playing with the cartridge at an angle. This adjustment is particularly important when using the noise reduction system and is dealt with in more detail in section 3.12.

3.7 Mode Selector

The MODE selector switch can be used to select one of the three different modulation systems found on the majority of discs:

MONO LATERAL	The sum of the two channels is selected. This suits laterally-modulated discs (the most common type)
STEREO	Both channels are processed independently
MONO VERTICAL	The difference of the two channels is selected. This suits vertically-modulated discs (hill & dale) such as Edison and Pathé

The stereo channels are equalised to the R.I.A.A. response curve which has been standard for all microgroove mono and stereo records since 1955. In either mono position, the equalisation can be varied to suit the recording characteristic of the disc. (See section 3.9) The mono R.I.A.A. settings are marked with red spots on the variable controls.

3.8 Balance Control

The BALANCE control alters the gain of each channel relative to the other. In stereo mode this is useful for centring the stereo image. In either of the mono modes, it can be adjusted to obtain the maximum reduction of distortion and scratch; simply leaving it in the central position may be adequate for casual listening.

For critical work, to obtain the optimum setting of the BALANCE control in a chosen mono mode, switch temporarily to the opposite mono MODE and adjust the BALANCE control for the minimum sound, then switch back to the chosen mode.

Some records may have been damaged along one groove wall, The unwanted noise and distortion that this causes may be reduced by more drastic adjustment of the BALANCE control to reduce or completely suppress the sound from the damaged groove wall.

The setting of the BALANCE control is more critical when the noise reduction system is in use, this is dealt with in greater detail in Section 3.12.

3.9 Variable Equalisation

These controls are provided so as to correctly equalise the response curve of electrically-recorded records made before the R.I.A.A. curve became standard, They operate in the Lateral and Vertical positions of the MODE switch, but not in the Stereo mode. The subject of pre-R.I.A.A. equalisation is a complex and specialised one, beyond the scope of this manual. In some cases, historic research has revealed the correct settings for these recordings but in other cases the information is not available and the controls must be adjusted by ear and informed guesswork.

As a very rough guide, start by setting the BASS control fully anticlockwise and the TOP control fully clockwise. If the recording was made in America or on continental Europe, set the MID control to 500. If the recording was made in England before 1945, set the MID control to 300. If you are unsure, adjust this control until the recording sounds neither too boomy nor too ‘thin’.

If scratch is a problem or if the recording sounds shrill, reduce the setting of the TOP control to give a satisfactory sound. If rumble or excessive low bass is a problem, increase the setting of the BASS control.

Acoustic recordings will have to be equalised by ear. Start by setting the MID control to around 1Kc/s and then adjust all three controls for the best compromise.

If a flat frequency response (without any equalisation) is required, set both the BASS and the MID control to 200 and rotate the TOP control fully clockwise.

3.10 Output Connectors

Three jacks are provided for the main output, giving Left, Mono and Right signals respectively. The signal levels are nominally 0dBm and are unbalanced with a source impedance of 600 ohms. Only Gauge ‘B’ plugs should be inserted in these jacks, Gauge ‘A’ plugs may cause damage.

The signal levels are suitable for feeding most types of self-amplified loudspeaker and the line inputs of most professional amplifiers and mixing desks. When feeding domestic equipment the levels may have to be reduced by about 12dB to avoid overloading; this can be done by means of the volume control setting or by inserting a 12dB attenuator in the connecting lead.

Two auxiliary outputs are available for feeding an X-Y oscilloscope with unequalised left and right signals at about -10 dBv unbalanced. This is useful for analysing the types of recording, checking for record damage and checking that the stylus fits the groove profile.

3.11 Output Levels

The VOLUME control sets the level at the three main output jacks and can be used to fade out the sound completely. The HEADPHONE VOLUME control sets the level at the headphone jacks and is independent of the main VOLUME control.

3.12 Noise Reduction

This system only works with monophonic lateral recordings, it cannot work with stereo or vertical modulation. It is critically dependent on the stylus fitting the groove correctly and not being obstructed by a build-up of dirt.

A built-in analogue computer analyses the stylus movement to identify unwanted sounds caused by groove-wall roughness (crackle) and record damage (clicks), and remove them. The miniscule gaps left by removal of the unwanted sounds are filled with a synthesised waveform that approximates the sound occurring before each gap, thus avoiding any audible discontinuity.

The waveforms on the two groove walls are compared and any discrepancy may indicate crackle or clicks. For this reason it is important to have the points of contact of the stylus with the two groove walls accurately synchronised and this azimuth alignment cannot be maintained if the playback arm is swinging about a pivot. For this reason, parallel tracking is a necessity with a noise reduction system of this type.

With the noise reduction system switched on, the sensitivity of the system to crackle can be adjusted by means of the SENSITIVITY control until a satisfactory result is obtained. Excessive sensitivity may cause distortion and insufficient sensitivity will allow some unwanted noises to escape detection. The degree of sensitivity required will vary from disc to disc and is also dependent on stylus fit and geometry. The LED indicator strip shows the extent to which the computer is processing each octave of the audio spectrum.

The effectiveness of the system depends to a great extent on having the correct fit of the stylus in the groove. A truncated elliptical stylus which contacts each groove wall at 45 degrees is ideal; the correct fit is less critical with ‘V’ grooved records than with ‘U’ groove records.

The settings of the channel balance and azimuth must be correct for optimum noise reduction. If the results are disappointing and the stylus is clean, these two settings should immediately be suspected.

SETTING BALANCE AND AZIMUTH
Switch the MODE switch to the vertical modulation position and, if necessary, increase the volume so that the crackle and any breakthrough of the lateral modulation can be heard clearly. Play loud and soft selections of the relevant record and adjust the BALANCE control for minimum breakthrough. If this position is not sharply defined, the stylus azimuth may be incorrect for

that record.

By means of the finger hook, turn the azimuth angle of the cartridge a few degrees and repeat the balance test to check if there has been any improvement or worsening. Keep repeating this sequence: adjusting the cartridge azimuth until an angle is found which gives the sharpest balance null.

If the breakthrough cannot be reduced to a satisfactory level by any combination of azimuth and balance settings, the problem may be caused by record damage or a badly-fitting stylus. Check that the stylus really is clean (some deposits can be amazingly tenacious) and, if it is, fit a larger or smaller stylus and repeat the adjustments to see if there is any improvement.

If all the above measures fail, the problem is probably caused by record damage. Switching the noise reduction on and off will allow comparison between the direct and the processed sound and may reveal the source of the unwanted noises.

For more rapid adjustment and an in-depth analysis of record playing problems, the use of an X-Y oscilloscope is strongly recommended. This displays the stylus movement on an oscilloscope screen and will show up many types of unsuspected misbehaviours, some of which may have been inherent in the recording process.

AUDIO CIRCUIT DESCRIPTION

4.1 Gain Distribution

The gain of each stage is carefully controlled so as to give the maximum possible headroom without compromising the signal-to-noise ratio. The voltage gain expressed as dB is noted above each stage in bold figures, with the nominal signal level in dBu shown in normal type.

4.2 Component nomenclature

Where two identical circuits are shown for the two channels of the stereo signal, the components are suffixed ‘a’ and ‘b’ to indicate one or other channel. In the description below they will be referred to by their numbers alone, and the description will apply to either channel.

4.3 Optical Pickup & Pre-amplifier (100 prefix)

The optical pickup inside the pre-amplifier box generates a signal corresponding to the angle of the pickup arm relative to the pre-amplifier box which forms part of the parallel-tracking carriage. An LED D101 generates two similar light beams, of 450nm wavelength, which fall in two photo diodes D102 & D103. A lightweight metal shutter, mounted on the pickup arm bearing, interrupts approximately 50% of each light beam when the arm is in the central position (at 90 degrees to the carriage track). If the angle changes, the shutter moves so that one photo diode receives more light and the other receives less. This results in an unbalance in the voltage at the centre point of the two diodes, which is fed to the servo amplifier and controls the parallel-tracking drive motor in such a way as to correct the angular error.

The pickup input stages are designed to present a 47k load to the cartridge in parallel with 390pf (C101). This is achieved by current feedback through R105, which avoids the losses and thermal noise of the more common arrangement of a 47k loading resistor in parallel with the input signal. The voltage gain of Ic1 is determined by the ratio of R106 to R107. C103 allows maximum negative feedback to D.C. thereby minimising any unwanted offset voltage. C102 ensures stability of the amplifier. The optical and pre-amplifier assembly is connected to the main unit by a flexible cable and 7-pin pug and socket. This plug must not be connected or disconnected with the power supplies switched on.

4.4 Parallel-tracking servo (200 prefix)

The angle signal from the optical system is buffered by Ic201, with unity gain determined by the ratio of R201 and R204. An offset voltage derived from Rv201, C201, R202 and R203 may be fed into the non-inverting input of Ic201 but this facility is not currently used and the non-inverting input terminal is earthed.

The angle signal is fed into Ic202 (configured as an integrator) and Ic203 (configured as a differentiator). C203 and R207 perform the integration, with R205 limiting the high frequency amplification. R206 and C202 perform the differentiation with Ic203 acting as a unity-gain buffer. If the signal across D201 or D202 exceeds 0.6v, the relevant diode conducts and rapidly charges C202 so that the integrating action is over-ridden and new conditions rapidly established. This is helpful to permit the parallel-tracking carriage to rapidly move to a new position in response to large movements of the pickup.

The integrated and differentiated signals are recombined by the circuit around Ic204. The integration gain is set by Rv202 and the ratio of R208 to R210 and the differentiation gain is set by Rv203 and the ratio of R209 to R210. The variable resistors are adjusted to give a response to rapid changes with sufficient damping to prevent overshoots - and accurate correction of slow errors without too much gain which would cause instability.

If the output signal from Ic204 remains consistently high or consistently low for significantly longer than would be necessary for the carriage to traverse the full length of the rails, this indicates that there is a mechanical fault in the system. As continued running of the motor in one direction might cause excessive wear to the motor, gearbox or drive cord, the motor signal is inhibited after a period of time determined by R213 and C204. Ic204 acts as a unity gain buffer for the voltage on C204 and communicates this through diodes D203 or D204 to the circuit around Ic206.

Under normal conditions R214 and R215 hold the inverting input to Ic206 at about -5v. R216 and R217 hold the non-inveting input of Ic206 at about +5v. Under these conditions the output of Ic206 will be about +15v. Under fault condition which result in a positive voltage on C204, the output of IC205 will gradually rise and, through D204, will eventually pull the voltage on the inverting input of Ic206 above +5v. At that point the output of Ic206 will switch from +15v to -15v. Similarly, under fault condition which result in a negative voltage on C204, the output of IC205 will gradually fall and, through D203, will eventually pull the voltage on the non-inverting input of Ic206 below -5v. At that point the output of Ic206 will switch from +15v to -15v. Removal of the sustained fault signal will result in the circuit conditions returning to normal after about 1 second.

The purpose of Ic210 is to disconnect the drive to the servo motor under fault conditions. It is implemented in CMOS and is unable to tolerate the full + to - 15v signals which are found in the rest of the circuit. Accordingly all signals into it must be attenuated to prevent ‘latch-up’ and a lower power supply voltage is necessary. The +ve supply is reduced by R232 and R234, smoothed by C205. The -ve supply is reduced by R235 and R236, smoothed by C206. The incoming analogue signal is reduced by R211 and R212. The incoming switching signal is reduced by R218 and R219. When the switching signal from Ic206 goes negative, the CMOS switch will open and disconnect the drive signal to the motor amplifier.

The motor diver Ic207 combines several signals to give the required drive voltage to the power amplifiers: Tr201 and Tr 202 for the positive drive and Tr203 and Tr 204 for the negative drive. Tr201 and Tr203 compare the output voltage from Ic207 with the voltage fed to the ‘live’ side of the servo motor. If the error exceeds 0.6v, one of other of these transistors turns on its associated ‘helper’ transistor (Tr202 or Tr204) to feed a large enough current into the motor.to restore the correct voltage. R222 (15k) acts as part of a feedback network in conjunction with the source impedance of the motor amplifier drive voltage, which is derived from R211 and 212 when the CMOS switch is closed. The source impedance is equivalent to R211 and R212 in parallel; as these are both 15k resistors, the source impedance is 7.5k. The ratio of the source impedance to the feedback impedance around Ic207 is therefore 1:2, so the voltage gain of the stage is x2, which exactly compensates for the reduction in the drive signal voltage due to the divider action of R211 and R212. C208 limits the high frequency response of Ic207 and ensures stability.

The motor current returns to the earth rail through R225, where it develops a voltage proportional to the motor current. This is applied to the inverting input of Ic209 through R224. Feedback is applied through R223 and the ratio of R224 to R223 ensures that this stage accurately divides the voltage by 8.2 and inverts it. C209 reduces the gain still further at motor commutation frequencies and C211 by-passes any other interference which may result from motor commutation. The output voltage of Ic209, which corresponds to slightly less than the voltage drop in the 8-ohm motor windings, is now fed into Ic207 as positive feedback. This gives the effect of driving the motor from a negative impedance which is numerically only slightly less than the positive value of the motor winding resistance, so that the motor rotational speed is mostly dependent on the back-emf and is hardly affected by mechanical loading; stalling and ‘cogging’ are thereby avoided.

The components shown connected to T202 and T203 are not currently included. Instead T202 is linked directly to T203.

The +15v and -15v supplies to the motor driving stage, the optical pickup and the cartridge pre-amps are derived from 22v supplies by Ic209 and Ic 210, decoupled by C216, C217,C218 & C219 and smoothed by C 214 & C215. Additional smoothing for the pre-amps is provided by R231, R232, C212 & C213, which are mounted on a separate board near the parallel-tracking flexible lead connector.

4.5 Phono outputs & Balance Control, (300 prefix)

The signals from each pre-amplifier are fed into screened cables through R310a, which matches the characteristic impedance of the cable and prevents direct capacitive loading of the pre-amp which might lead to instability. The signal is attenuated by R302 and R303, a ratio of 30:1, which nullifies the gain of the pre-amp and brings it back to the level at which it left the cartridge. This is fed into an “RCA phono” socket from a source impedance of 600 ohms.

The ratio of R304 to part of the balance control Rv301 determines the signal level fed into Ic301. By varying the position of the earthed wiper of Rv301, the signals in the two channels can be balanced in amplitude or one of them can be muted altogether. The attenuation of this stage with the wiper in the mid position is 6dB in each channel.

4.6 Auxiliary Outputs (300 prefix)

The unequalised signals from each side of the balance control are buffered by Ic301 and fed via R305 to output jacks, which allows them to be displayed on an X-Y oscilloscope. The buffered signals are also fed to the stereo and mono equalising stages.

4.7 Stereo R.I.A.A. Equalisers (300 prefix)

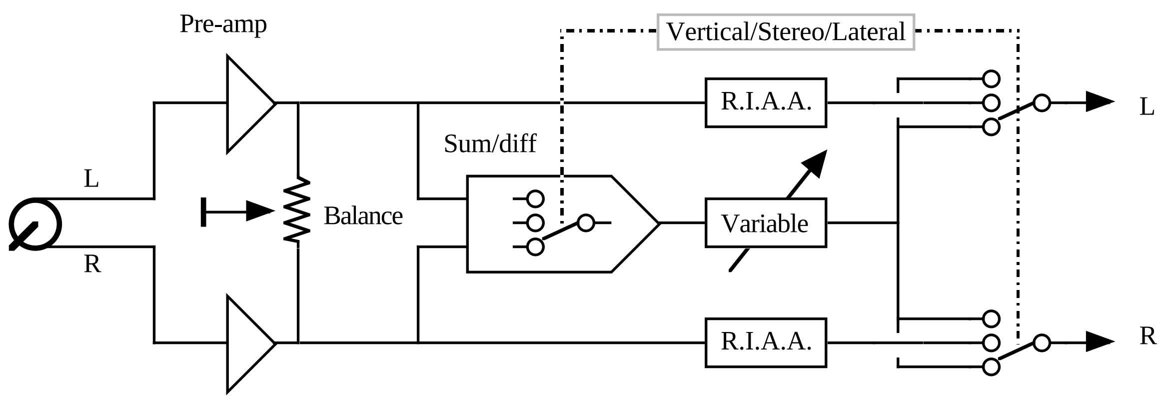

Fig 2 — Block diagram of equaliser stages

For stereo R.I.A.A. equalising the signal is first fed through the combination R232 and C206, which performs the high frequency roll-off function of the equalisation curve. R323 and R324 determine the gain of Ic309, which acts as an isolating buffer between the aforesaid high frequency components and the low frequency correction C207 and R325. The mid frequency turnover is achieved by the feedback network around Ic310, which has a time constant determined by the parallel combination of C208 and C209 and R326. Below the turnover point, the gain of the stage rises with falling frequency until R327 limits the ultimate maximum gain.

4.8 Mono Vertical or Lateral Selection (300 prefix)

The choice of lateral or vertical modulation is determined by respectively taking the sum or the difference of the two channels.

The left channel is fed into Ic302 through R305 and the right channel through R308, r307 sets the gain of Ic 302 to unity for each input, so the combined output will be the sum of the left and right channels and will correspond to horizontal movement of the stylus.

The left channel is fed into the inverting input of Ic303 through R309; in the absence of any other signals the output will be the inverse of this input multiplied by the ratio of R309 to R310, which is unity. The right signal is fed into the non-inverting input of Ic303 through an attenuator formed from R311 and R312 which are of equal value. This halves the signal into the non-inverting input but R309 and R310 effectively form a divider which increases the gain of this stage to non-inverting signals by a factor of two, so the output contributed by this signal will be equal to the input. Thus the combined output will be the difference between the left and right channel and will correspond to vertical movement of the stylus.

A three-position switch feeds the mono horizontal or the mono vertical channel into the variable equaliser stage. In the stereo position, the switch earths the equaliser input to prevent it picking up spurious signals. Two more sections of this switch select the signals from the outputs of the stereo equaliser or the mono equaliser to be fed as left and right channels to the noise reduction and output stages.

4.9 Mono Variable Equalising (300 prefix)

The high frequency turnover of the equalisation curve is determined by the resistance of R313 plus the variable resistor Rv102 in combination with C201. The signal is buffered by Ic304 with unity gain and fed to the low frequency turnover components: C202 in combination with R315 and variable resistor

Rv303. Ic304 acts as a unity gain buffer which feeds the signal into the mid-frequency turnover stage.

The mid frequency turnover is determined by combining the direct signal with a proportion of the same signal after integration and polarity-inversion The time constant of the integrator Ic307 is determined by the combination R313 and C305, with R319 limiting the sub-audio gain. R317 and R320 feed the direct and integrated signals respectively into Ic308, with the gain set by R321. At high frequencies the output from the integrator is negligible, but as the frequency falls, the integrated output increases in amplitude until it is larger than the direct signal. As the frequency falls further, the combined output signal rises at 6dB per octave, exactly compensating the recording characteristics.

The frequency at which the direct and integrated signals are the same amplitude is designated the turnover frequency and this can be controlled by the gain in the integrator signal path. This gain is set by the ratio of the sum of the fixed resistor R315 and the variable resistor Rv304 to R316 around Ic306, which also inverts the signal to give the correct polarity after the integrator. C203 and C204 block any DC offset signals from entering the integrator.

4.10 Main Output stage (400 prefix)

The signal at about -10dBu is fed into the VOLUME CONTROL Rv401. The ratio of the two sections of this control potentiometer is one factor controlling the gain of the stage. The other factor is the ratio of R401 to R402, which sets the maximum gain available from Ic401. At the RH end of the control track, the stage gain is determined entirely by the control and is zero; at the LH end of the control the gain is determined entirely by R401 and R402 and is +20dB. The linear control obeys an approximately logarithmic law over the central part of the range.

The signal is fed to the output jack through R403, which gives an output impedance of 600 ohms. C401 and C402 block any DC which might appear on the output and R404 prevents any build up of voltage due to leakage currents.

The mono signal is derived by combining the left and right signals in equal quantity through R405 and R406. It is buffered by unity-gain buffer Tc402 and fed to the output jack through R407, which gives an output impedance of 600 ohms. C403 and C404 block any DC which might appear on the output and R408 prevents any build up of voltage due to leakage currents.

Power to the stage is supplied through R409 and R410, which act as burn-out resistors in the event of a fault. C405 and C406 decouple the supplies

4.11 Headphone Output stage (400 prefix)

The signal at about -10dBu is fed into the HEADPHONE VOLUME CONTROL Rv402. The ratio of the two sections of this control potentiometer is one factor controlling the gain of the stage. The other factor is the ratio of R411 to R412, which sets the maximum gain available from Ic403. At the RH end of the control track, the stage gain is determined entirely by the control and is zero; at the LH end of the control the gain is determined entirely by R411 and R412 and is +20dB. The linear control obeys an approximately logarithmic law over the central part of the range.

The gain of the headphone driver stage is set to unity by the ratio of R413 to R415, with C407 blocking any DC offset. The quiescent current through the output transistors 'mirrors' the current flowing through R414, D401, D402 & R416 and is arranged to give Class 'A' operation over most of the output voltage swing. Ic404 drives the output stage through D401 and D402 with any non-linearity being reduced by feedback through R415. C408 reduces the gain if Ic404 at high frequencies to ensure stability. The output impedance of the stage, seen from the output jack is equivalent to R417 and R418 in parallel, i.e. approximately 50 ohms. The output transistors remain within their safe operating area even when driving a short circuited load, so low impedance headphones can be driven satisfactorily.

Power to the stage is supplied through R419 and R420, which act as burn-out resistors in the event of a fault. C409 and C410 decouple the supplies

4.12 Power Supply (500 prefix)

The earth conductor of the mains supply is connected directly to the exposed metal panels and other parts for reasons of safety. To prevent earth loops whilst maintaining screening from spurious external electrostatic fields, the internal 'earth' line of the amplifier is connected to the chassis by C509, with R501 acting as a bleed resistor to prevent any build-up of static charges.

The live and neutral mains supply is connected to L501 and L502 of the mains transformer. These windings are connected in series for supplies from 200 to 250 volts rms. The transformer secondary windings, L503 and L504, are connected in series to give a centre-tapped supply of approximately 18v rms. This is full-wave rectified by D501 to D504 to give a 22v positive supply across C501 and a 22v negative supply across C502. These unregulated supplies are fed to the servo motor control board (Prefix 200) where they are stabilised.

The output from L503 and 504 of the mains transformer is also fed to D505 to D508 to give a separate unregulated supply of 22v positive across C503 and 22v negative across C505. These supplies are regulated by Ic501 and Ic502 respectively to give +15v and -15v for the audio stages (Prefix 300 & 400). C505, C506, C507 and C508 ensure stability of the regulators.

NOISE REDUCTION CIRCUIT DESCRIPTION

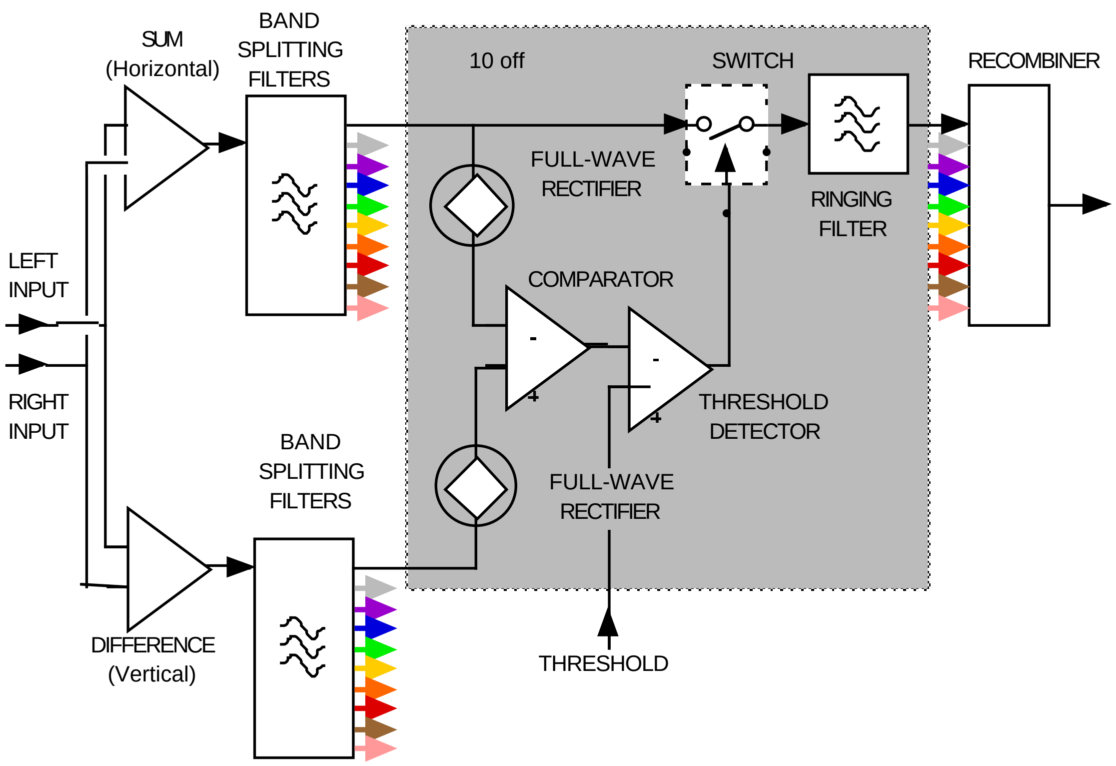

Fig 3 —Block diagram

5.1 General principle

Monophonic sound can be recovered from a mono record by adding together the left and right channels from a stereo pickup. If the groove walls are rough or damaged, this will result in noisy disturbances known as crackles and clicks being added to the sound of the horizontally-modulated waveform which was originally recorded. If the left and right channels are subtracted, the recorded waveform cancels out, as it does not (or should not) contain a vertical component but the crackles and clicks will still be heard as they are the result of angular displacement of the stylus.

In this equipment he left and right channels are added to give the horizontal sound plus noise and subtracted to give the noise component without the horizontal sound. The noise cannot simply be subtracted from the sound because the relative polarity of the signals is unknown.

The audio spectrum of the vertical and horizontal waveforms is split into octave bands by a chain of filters whose high and low-pass outputs are complimentary and can be recombined without phase or amplitude errors. Within each octave, the absolute amplitudes (regardless of polarity) of the vertical and horizontal signals are compared. If the vertical signal corresponds to a significant proportion of the horizontal signal, this identifies a vectorial stylus movement which corresponds to a portion of a crackle or a click.

The threshold at which the disturbance is detected as a click can be varied in two ways: a user-operated panel control marked SENSITIVITY varies the gain of the vertical channel and an automatically-generated threshold voltage inhibits operation on very loud passages where spurious operation may cause distortion.

When a click is detected, a CMOS switch opens to prevent it from being passed on. The switch is followed by a filter which ‘rings’ when its input is disconnected, so it continues to produce a waveform of approximately the same amplitude, phase and frequency as the waveform before the click. This has the effect of considerably reducing the disturbances caused by operation of the switch, most of which lie outside the passband of the filter. In this equipment the audio spectrum is split into 10 octave bands so that the second harmonic of each switching module lies outside the bandwidth of its own ringing filter.

Because the outputs of the ringing filters and the original band-splitting filters are both complimentary, the resulting signals can be recombined with a simple resistive network, giving equal weighting to each octave. The resulting output signal is rectified and smoothed to give the variable threshold voltage previously mentioned.

5.2 Power supply (600 prefix)

Because the circuit contains CMOS components, the power supply rails and signals to the analogue computer section must never exceed 15v in total. For this reason, these circuits have their own power separate supply of +7.5v and -7.5v. The op-amps also run off this supply, so they cannot feed damaging voltages into the CMOS circuits.

The mains transformer L601, L602, L603, L604 supplies + and - 12v AC to the diode bridge D601 to D604. A positive supply of 16v unstabilised is generated across C601 and a negative supply of -16v is generated across C602. Ic601 stabilises the negative supply to -7.5v referred to the earth rail (0v) Ic602 stabilises the positive supply to +15v referred to the negative rail, so the positive rail is +7.5v indirectly referred to earth. The voltage of Ic601 is set by a select-on-test resistor in its earth connection, this many not be exactly the correct value but the voltage between the positive and negative rails cannot exceed 15v, even if a mistake is made in selecting the resistor.

C605 and C606 ensure stability of Ic601 and C603 by-passes any signal voltages across R601. C604 acts as a reservoir capacitor for the negative supply rail. C607 and C608 ensure stability of Ic602 and C609 acts as a reservoir capacitor for the positive supply rail.

5.3 Input buffers & matrix (600 prefix)

The left and right signals are taken from the ends of the balance control (Section 4.5 Prefix 300) at a level of approximately -24dBu. The gain of 3.5dB around Ic603 is set by the ratio of R602 to R603. The resistors R604 and R606 add the left and right signals into Ic604 with a gain determined by R605. The resistors R607 and R609 feed the left and right signals into the inverting and non-inverting inputs of Ic605 which is configured to produces difference signal with the gain determined by R608 and the input balanced by R610.

The vertical signal is fed via the SENSITIVITY control into the vertical splitting filter. (Section 5.4)

5.4 Splitting filters (700 prefix)

The audio spectrum is split into 8 bands, each 1 octave wide. In addition there are two more bands covering all signals above 8 Kc/s and all signals below 62 c/s. The filters are of a type known as ‘state variable’, which give high-pass, band-pass and low-pass outputs simultaneously. They have the useful property that their outputs are ‘complimentary’ i.e. combining the high and low-pass outputs restores the originsl signal without phase or amplitude errors at the crossover points. By cascading the filters, the complimentary properties of each filter’s outputs are retained across all of the outputs, thereby allowing all the bands to be recombined without error.

Two of these cascades are required, one for the vertical and one for the horizontal channel. this ensures that the delays caused by the filters are the same in each pair of channels and do not cause spurious difference signals when they are compared.

The basic circuit of each filter, built around Ic701, Ic702 & Ic703, is the same, with the differences being confined to the component values listed in the table. Filter 8 at the start of the vertical cascade, is the exception to this rule: it has higher values for the negative feedback resistors R702 and R703 to increase the gain in that channel. The positive feedback resistors R704, R705, & R706 are identical in every case and are chosen to give the correct amount of damping to the filter.

5.5 Rectifiers, switching & ringing filter (800 prefix)

The 10 channels from the horizontal splitting filter chain are paired up with the 10 channels from the vertical splitting filter chain in 10 individual circuits. These are constructed with two on each printed circuit board, giving 5 boards in total.

Because the signal is to be precision full-wave rectified, any DC offset in either the positive or negative direction must be avoided, otherwise the output half-cycles will be asymmetric. Capacitor C801 performs this function but it must be large enough that it causes no significant phase shift within the filter band. The value of C801 for each channel is shown as ‘C’ in the table of values.

This precision full-wave rectifier circuit is more complex than some similar circuits but it avoids saturating the amplifier on alternate half-cycle and the problem this causes because of the finite recovery time of the amplifier. When the signal to Ic802 through R801 is positive-going, the output of Ic802 will swing to +0.6v, at which point D802 will begin to conduct and feed current through R802 into the inverting input. The positive output swing will thereafter be just sufficient to maintain a voltage at the junction of D802 and R802 which is the precise inverse of the input signal. When the signal is negative-going, the output of Ic802 will swing 0.6v positive, back biassing D802 and feeding current directly into the inverting input through D801. No further positive swing will take place, so Ic802 will not saturate and there will be no effect on the output signal as D802 is back-biassed.

The input signal is inverted by Ic801 in conjunction with R803 and R804 and applied to a second precision rectifier circuit around Ic803. The output of this circuit exactly mimics that of the previous circuit except that the negative-going swings appear on the opposite half-cycles of the input signal. With one rectifier following one half-cycle and the other following the opposite half-cycle, the combined output is an accurate full-wave-rectified replica of the input.

The precision full-wave rectifier connected to the vertical signal behaves in exactly the same way except that the diodes are reversed, so that the output signal is positive-going.

By summing the positive-rectified and negative-rectified waveforms through R807 and R808, Ic804 responds to the difference between them. The choice of resistor values gives greater sensitivity to the vertical signal, which is normally the weaker of the two. The gain of Ic804 is set by R809 and the amplified difference signal fed to Ic805 through R810. When the difference signal is more positive then the threshold voltage, the output of Ic805 swings negative and is clamped at about -6v by the zenering action of Dz801. When the difference signal is negative, the output of Ic805 swings positive and is clamped at +0.6v by Dz801 behaving as an ordinary diode. The switching signal to Ic810 swings between two states with respect to the earth (0v) rail i.e. -6v and +0.6v. However the CMOS logic switching signals to Ic810 are taken with reference to the -ve supply rail, so these voltages will appear to be +1.5v and +8.1v respective to the logical inputs of Ic810. These voltages are sufficient to be unambiguously recognised as Logical 0 and Logical 1 by Ic810.

In normal operation, horizontal signals are fed into the filter (Ic806, Ic807 & Ic808) through the closed switch of Ic 810 and R811. The filter is tuned to mid-band using the same component values as the splitting filter which supplied the signals to that particular channel (See Section 5.4), so it has no detrimental effect on in-band signals. When Ic810 receives a Logical 1 signal the switch in the signal path opens and the horizontal signal is disconnected from R811. The filter continues to ring in a moderately-damped manner until the switch re-connects the horizontal signal. The filter then resumes normal operation at a speed which minimises out-of-band signals

The output of Ic809 snaps to the positive supply rail when the the output of Ic805 swings positive. The signal from Ic809 is connected vis R817, which limits the current, to LED display on the control panel that shows the user which channel switches are operating at any moment. D805 prevents reverse voltage from damaging the LED.

5.6 Recombiner & threshold generator (900 prefix)

Signals from the 10 ringing filters are combined by a network of parallel resistors R901 connected to the virtual earth input of a buffer amplifier Ic901. R902 sets the gain of the buffer amplifier and is chosen so that the output voltage amplitude exactly matches the amplitude of the original signals entering the system.

R903 and C901 form a high pass network which, in conjunction with Rv901 causes the gain of Ic902 to increase at higher frequencies. The signal from Ic902 is fed into Ic904 which, in conjunction with D901 rectifies one half cycle of the waveform. The signal is also fed through the unity-gain inverting stage consisting of Ic903 R904 & R905 to Ic904 and D902, which rectify the opposite half cycle.

A variable positive voltage from Rv902 is applied to a voltage divider consisting of R907 & R908 to give a threshold voltage of a few millivolts, which is sufficient to prevent the click detectors from triggering spuriously. On load signals, especially those containing high frequencies, the ‘pinch effect” or record damage can cause spurious signals to break through on the vertical signal. To prevent these causing false triggering of the switches, the threshold is momentarily raised by a current through R906, derived from the rectified signal at the junction of D901 & D902. C902 smooths the threshold variations.

REPLACING THE DRIVE CORD

The drive cord can be made from any reasonably strong hard-wearing flexible cord; woven shark-fishing line is preferred; monofilament lines or frayable cotton thread should not be used except in emergency.

Disconnect the mains supply and remove the stylus to avoid damage. Disconect the ‘pop’ fastener from the carriage, lift the carriage off the track and place it where it will not be damaged.

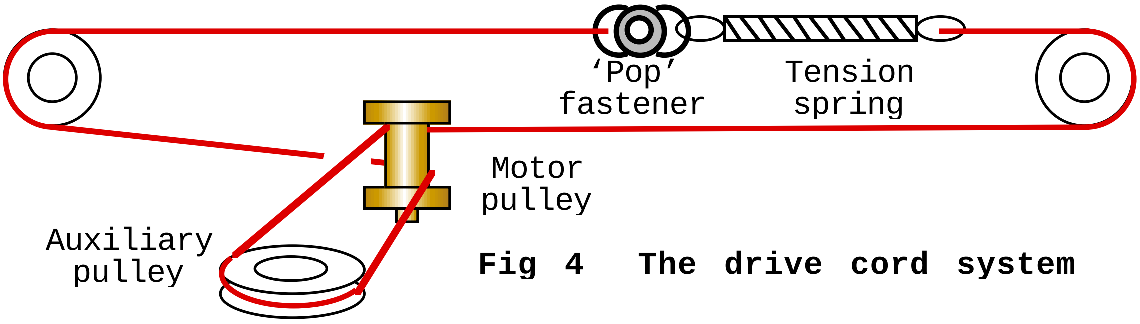

Fig 4 The drive cord system

Ensure that one end of the tension spring is hooked around a wire ‘eye’ on one side of the ‘pop’ fastener. Cut a length of cord approximately 30″ (800mm) long and tie one end to the free end of the tension spring with a double or triple knot. Feed the cord onto the top of the right-hand pulley and clockwise around it for half a turn. Draw the cord horizontally to the left until it reaches the motor pulley. Take the cord a small part of a turn anticlockwise around the motor pulley, then half a turn anticlockwise around the auxiliary pulley. Return the cord to the motor pulley, making sure it passes underneath the previous horizontal run and take it anticlockwise for a small part of a turn. Continue to draw the cord leftwards to the bottom of the left-hand pulley and pass it half a turn clockwise around this pulley, so as to emerge at the top.

Take the cord rightwards to the ‘pop’ fastener and pass it twice through the unused eye. Gently pull the cord until the tension spring has stretched about 0.5″ (12mm) from its resting length, then pinch the cord at the eye and tie it off in this position.

Replace the carriage on the rails and reconnect the ‘pop’ fastener to the back LH end of the carriage. Check that the cord lies in two parallel runs and is not hooked around any part of the carriage. The tension spring should be hidden underneath the carriage canopy.

Check that the system operates correctly. If the carriage persistently runs to one end of the track when the cartridge is resting on the turntable mat, suspect that the cord is wrapped the wrong way around the motor pulley.

ADJUSTING THE TURNTABLE SPEED

Fot this you will need a stroboscope with markings for 33.1/3 rpm and 78 rpm and a source of light which contains an accurate 100 c/s flicker component. Many modern LED fittings are unsuitable but a tungsten lamp or a fluorescent strip lamp with choke ballast is usually satisfactory. A small screwdriver will be necessary to adjust the variable resistors through the holes in the deck on the LHS of the turntable ON-OFF SWITCH. The “33” adjuster is on the left and the “78” adjuster is on the right.

Set the turntable speed dial to 333 + 3 small divisions and adjust the “33” potentiometer until the bars on the stroboscope appear stationary. Set the turntable speed dial to 779 + 2 small divisions and adjust the “78” potentiometer until the bars on the stroboscope appear stationary.

Repeat the two above adjustments until no further inprovement can be made, the calibration of the dial should now be accurate to within 1% between those two speeds. If a 45 rpm stroboscope is available, a further check could be made at that speed.

If no suitable light source or stroboscope is available, a small piece of white paper can be temporarily attached to the turntable and the rotational speed timed with the seconds sweep hand of an analogue watch or a stopwatch.

POPPY
RECORDS

88, Mount Road
Southdown
Bath
BA2 1LH

01225 335974