Modern turntable technology

Here we look at the requirements of the modern record player and discuss how advanced electronics can provide 'the ultimate' in this branch of hi-fi. We also consider the products of the major manufacturers and some of the special facilities offered in high quality decks.

Brian Dance

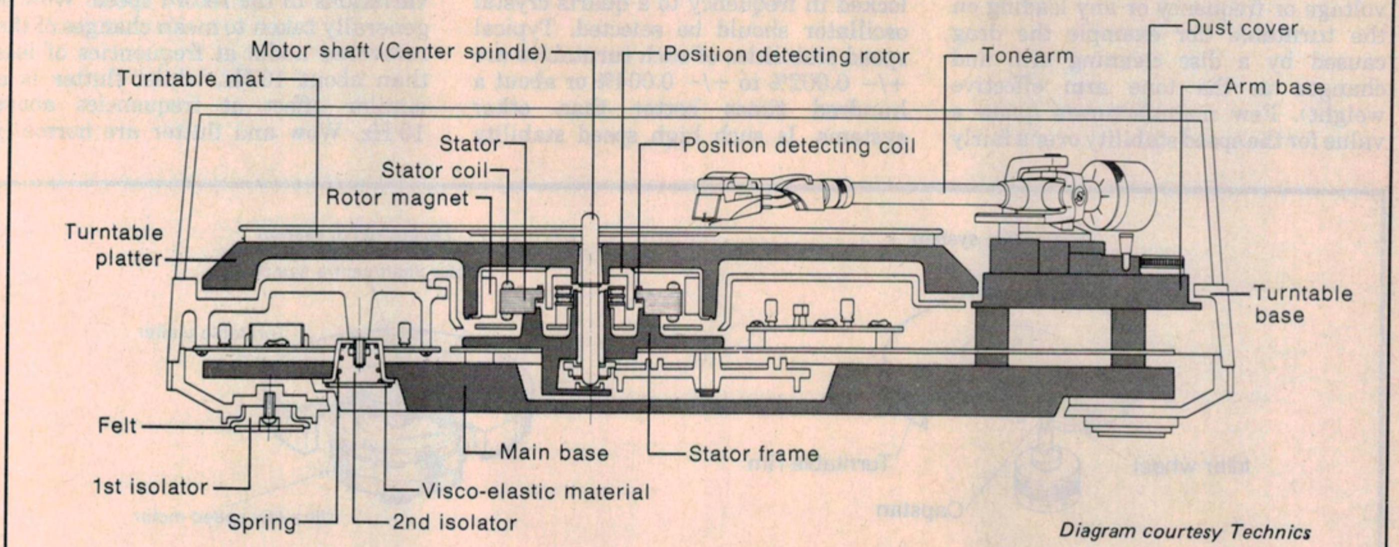


Diagram courtesy Technics

THE BASIC REQUIREMENT of any record player assembly is that the turntable shall rotate noiselessly, at the required speed without any short-term or long-term variations in this speed. This sounds a simple enough requirement, yet sophisticated, modern players contain quite complex circuitry with large numbers of integrated circuits and discrete components; indeed, the circuitry is too complex for us to reproduce in full for any of the latest players mentioned in this article!

Turntable mechanisms have evolved a very long way from the purely mechanical gramophones of about fifty years ago where one had to wind up a spring motor with a handle. All of the audio power came from the mechanical interaction of a large steel needle with the surface of the revolving record; the steel needle moved a mica diaphragm at the narrow end of a flexible horn which provided suitable acoustic coupling to the air. The weight of the moving arm part of the horn seemed almost enough to push the needle through the record! However, it is this old type of gramophone which has set the pattern for the modern record player of today.

Turntable speed

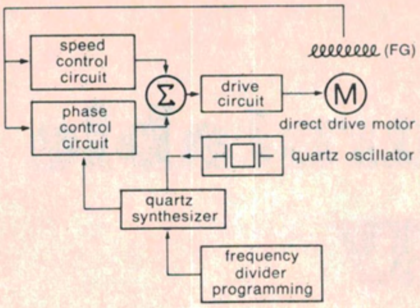
The rate of rotation of the turntable directly controls the frequency of the audio signal reproduced from the record track. Any slight increase or decrease in the rate of rotation will produce a proportionate increase or decrease in the pitch of the recovered audio signal. Most modern recordings are made for use at either 33⅓ or 45 revolutions per minute. How accurately must the player match these speeds of rotation in order to be acceptable? This is not a question to which one can give a definite answer, since so much depends on one's hearing, on the listening experience one has had previously and on the amount of hard cash one is willing to spend in order to obtain a constant rate of revolution. (See April 1980 ETI, p.108.) (One might even add that it could even depend on how much one is willing to spend to be able to praise one's equipment to one's friends and neighbours!)

Most of the fairly economical turntables employ a strobing system which enables the rate of rotation of the turntable to be set quite accurately to the required speed. The cheapest strobing system employs a lamp (normally a light emitting diode) which flashes at the mains frequency of 50 Hz. However, if one uses the mains frequency as one's standard, any ▶

changes in the mains frequency will produce errors. This problem can be avoided by driving the lamp from an astable multivibrator circuit which is operated from a stabilised supply voltage.

In the simplest systems the lamp may be placed under the edge of the turntable so that light passes through a pattern of bars on the edge; the speed is correct when the bar pattern for that speed remains stationary as the turntable rotates.

To stabilise rotation speed a tachometer and an F/V converter can be used to give a voltage proportional to rotation rate. The difference between this and a reference voltage is used to adjust the speed of rotation so that the error voltage is reduced almost to zero. The use of such a system minimises speed variations due to changes in the mains voltage or frequency or any loading on the turntable (for example the drag caused by a disc cleaning arm and changes in the tone arm effective weight). Few manufacturers quote a value for the speed stability over a fairly



Block diagram of a quartz stabilised turntable drive circuit, as devised by Technics.

long period for such equipment, but generally a few tenths per cent speed variation is reasonable.

Quartz stabilised

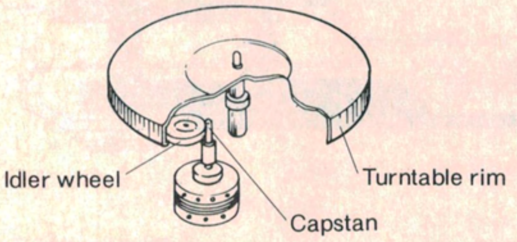
If one requires much more closely controlled speed stability, a turntable locked in frequency to a quartz crystal oscillator should be selected. Typical speed stabilities of such turntables are +/− 0.002% to +/− 0.004% or about a hundred times better than other systems. Is such high speed stability necessary? Only you, the user, can answer this question after prolonged listening to both quartz stabilised and other equipment.

In some quartz stabilised equipment one cannot vary the turntable speed at all without switching the quartz control out of use. In others the crystal reference frequency is divided by different factors to enable the speed of rotation of the turntable to be varied without losing the advantages of quartz control. Some manufacturers of top quality decks offer quartz control systems with a digital display of the platter speed. Changes in speed of a quartz controlled system with temperature can be as low as 0.2 parts per million per centigrade degree.

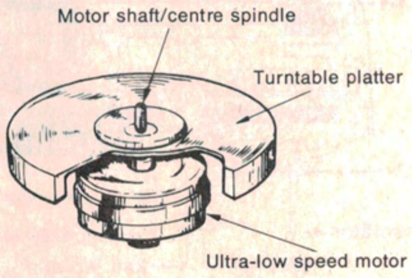
Wow and Flutter

Wow and flutter are short term variations in the record speed. Wow is generally taken to mean changes of the recovered audio at frequencies of less than about 10 Hz, whilst flutter is a similar effect at frequencies above 10 Hz. Wow and flutter are normally

Rim drive system

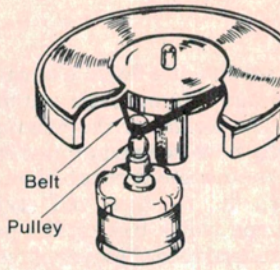


Direct drive system



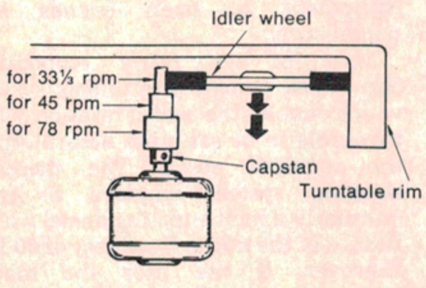
Rim Drive
In this system the motive power provided by the drive motor is applied to the inner or outer edge (rim) of the turntable by means of a capstan on the shaft of the motor. Since a high speed motor is used, one or more idler wheels are inserted between the capstan and the rim to reduce the speed and achieve the desired ratio to obtain the correct platter speed. (This system is also known as 'idler drive'). The rim drive system is relatively low in cost, permits the use of a low torque motor and allows mechanically simple speed changing. Its main disadvantage is rotational instability due to slippage occurring between the capstan, idler and rim.

Belt drive system



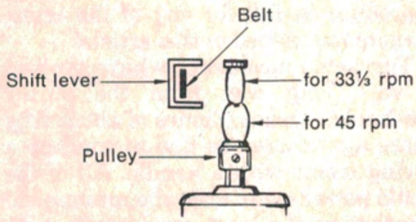
Direct Drive
As the name implies, this system uses no speed reduction devices to transfer the motive power from the motor to the turntable platter. Rather, the shaft of the platter is set in the centre of the motor itself and is driven directly. The motor rotates at exactly the required speeds (33 1/3 or 45 rpm) and its rotational accuracy is maintained by any one of a variety of electronic servo mechanisms. The slower rotational speeds and very high rotational accuracy of this system have brought both rumble and wow and flutter specs to levels seldom if ever before achieved. Since the introduction of the first direct drive turntable by Technics in 1970, this system has rapidly become very popular and many manufacturers have entered the market with their own models.

Speed change of rim drive



Belt Drive
This is a very common drive system like the rim drive. A relatively high speed motor is used and coupled to the turntable platter by a compliant belt. By moving the belt up or down over different diameter sections of the motor shaft pulley, speed changes may be effected. One of the big advantages of this system is that the belt serves to dampen motor vibrations, thereby reducing noise and rumble. Polyurethane is the preferred belt material because of its resistance to heat, humidity and oil and its low elasticity. The problems encountered with belt drive are instability due to belt slippage and a relatively large amount of vibration due to the high rotational speed of the motor.

Speed change of belt drive



measured together as a total percentage, but a form of weighting network is often used which attempts to take account of the degree of annoyance to the listener so that wow and flutter of particularly annoying types produces a larger contribution to the percentage figure than a similar amount of other types.

Wow and flutter can be measured in various ways. If one uses a test record, replay cartridge and tone arm, one will usually obtain a higher percentage figure than if one measures the fluctuations of speed in the turntable more directly with a tachogenerator. Many of the Japanese manufacturers employ the tachogenerator technique to obtain a percentage figure for wow and flutter expressed as a WRMS figure (weighted root mean square). The German standard DIN (Deutsche Industrie Normal) is a peak weighted figure expressed as a percentage which is a *third* figure to catch the unwary.

It has been agreed that DIN peak weighted wow and flutter percentages of less than about 0.1% are probably undetectable in normal listening. However it has recently been shown that intermodulation products which can be generated by pitch fluctuations can impair the recovered audio signals, so it is wise to select a system with the minimum wow and flutter percentage figures you can afford. The percentage figures quoted are normally in the range 0.01% to 0.1%. (See also, April 1978 ET, p.108).

Table 1 shows wow and flutter percentage figures for the Philips AF877/AF977 and AF677/AF777 turntables measured in various ways for comparative purposes. The lower values obtained for the AF877 and AF977 are due to improved control circuitry and differences in the mass of the turntable.

Cogging

Most turntable motors are dc electric motors which employ Hall Effect cells for commutation instead of the conventional brushes and copper commutator ring. Brush sparking can generate much noise; the use of Hall Effect cells for detecting the changes of magnetic field and for generating the switching pulses eliminates brush noise.

However, the problem remains that the energy is given to the motor in small discrete pulses as each coil passes through one of the magnetic fields. The uneven running due to this effect is known as 'cogging'; it can result in appreciable rumble combined with wow and flutter. Technics have developed a 20-pole, 30-slot brushless dc motor to minimise the effects of cogging. Hitachi employ their 'Unitorque' motor which incorporates a 200-pole rotary magnet. The coils are arranged 22.5° physically or 90° electrically out of phase with each other. The torque produced by a single coil fluctuates in a linear mode between a maximum value and zero. When the coils are out of phase at a given rotor angle, the sum of the torque produced is equal to the maximum torque of a single coil. This results in a motor action which has a uniform torque which is completely free from cogging.

Other effects

Various other effects can cause minor variations in turntable rotation. One of these is 'platter wobble' in which the turntable wobbles on its axis. It may be reduced by the use of a large diameter centre shaft, but Pioneer employ a hanging rotor system in which the main bearing is placed at the centre of gravity of the rotating system at the top of a *fixed* motorshaft. This provides a kind of gyrostatic action, increasing the stability and allowing the platter and the attached 'hanging cup rotor' to glide without any wobbling.

The actual recorded groove can cause small fluctuations in the speed of rotation of the platter. Figure 1 shows a stylus tip following a heavily modulated signal. It can be seen that the pressure of the stylus on the one wall of the groove acts as a variable braking effect on the rotation of the turntable. This problem can be reduced by using a turntable of high moment of inertia, but in turn this involves the use of a high torque motor which can bring the turntable up to its correct speed reasonably quickly.

AF877-AF977	AF677-AF777	Measurement technique
0.05	0.08	% DIN using test record, cartridge and tone arm.
0.03	0.05	% WRMS using test record, cartridge and tone arm.
0.02	0.04	% WRMS measured directly at output of tachogenerator (thus eliminating effects due to the test record, cartridge and tone arm).

Table 1. Wow and flutter figures for Philips turntables measured in three ways.

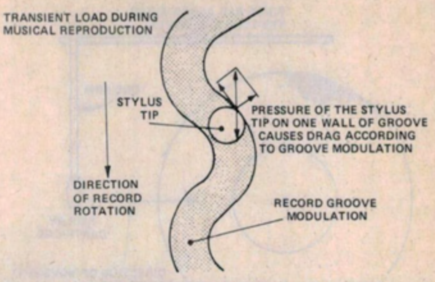


Figure 1. **The groove modulation can apply a variable braking effect on turntable rotation.**

Vibrations from the motor, transformer and acoustic waves from the speakers can also affect the rotational stability of the platter.

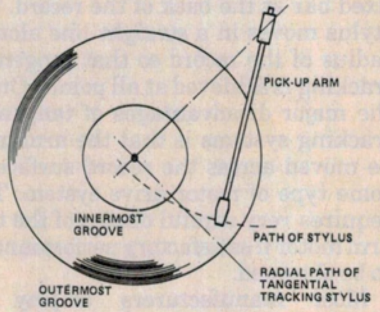


Figure 2. **The path a conventional tone arm traces across the record is different to the path taken by the cutting arm of the original disc cutter. Thus, the stylus is not always tangent to the groove. Tangential tracking arms were devised to overcome this.**

Tangential tracking

The conventional tone-arm moves across the record in an arc of a circle so that the path of the stylus is as shown in Figure 2. When a record is being cut, however, the cutting arm moves inwards along a radius towards the centre of the record. Thus the cutting path is a straight line unlike the arc of the replaying stylus. This leads to the important point that the direction of the motion of the recording head relative to the record surface is a tangent to the recording groove at all times. A conventional stylus cannot move at a tangent to the record groove at more than two places. At all other points there will be a small angle between the direction of relative movement and a tangent to the groove.

Many people feel that a stylus which follows the path of the cutting head across the disc as accurately as possible is likely to achieve a more faithful reproduction of exactly what is on the disc than a stylus which moves at an angle to the direction of movement of the cutting head. A few record decks are now coming onto the market in which 'tangential' or 'parallel' tracking is achieved. ▶

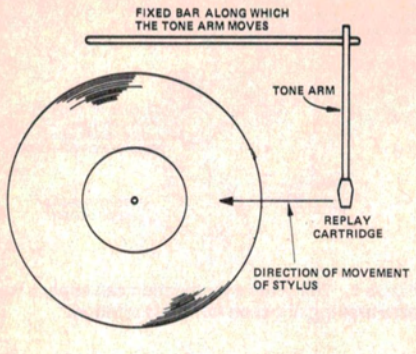


Figure 3. **The basic arrangement of a tangential tracking turntable system.**

The basic idea of the tangential tracking system is shown in Figure 3. The tone arm does not swing in an arc, but moves from right to left along a fixed bar at the back of the record. The stylus moves in a straight line along a radius of the record so that tangential tracking is achieved at all points. One of the major disadvantages of tangential tracking systems is that the arm must be moved across the record surface by some type of motor drive system. This requires very careful design of the tone arm motor if satisfactory performance is to be obtained.

Most manufacturers employ an optical feedback system to control the tone arm motor. In the normal or equilibrium position a beam of light from a lamp is blocked off by a shutter on the tone arm so that it cannot reach a photo-resistive cell. If the record now rotates so that the stylus is closer to the centre of the record, the position of the tone arm will be changed by a small amount so that the shutter no longer prevents the beam of light from reaching the photoconductive cell. The current through this cell activates the tone arm motor which moves the arm inwards towards the centre of the record until the shutter again blocks the beam of light.

A successful optical system of this type must be very accurate, since the record grooves are very small and close together. The tone arm motor system must also be carefully designed to prevent 'hunting' in which excessive or inadequate movement of the tone arm takes place and the system hunts for the correct position.

Tangential tracking systems generally provide tracking angles to within a few tenths of a degree of the desired angle, whereas conventional systems may have angles of up to a few degrees at some point on the record. But what is the practical effect? Tracking error angles tend to introduce second harmonic distortion which, whilst obviously undesirable, is not nearly so objectionable as third harmonic distortion. There seems to be some controversy as to exactly how much distortion is introduced by such tracking angle errors. Pioneer state that reduction of crosstalk between channels can be achieved by the use of tangential tracking.

In a tangential tracking system the effective arm length can be relatively short and the equivalent mass low even if strong materials are used to obtain a highly rigid arm. This can bring the advantages of minimum vibrational levels and small resonance patterns and hence of cleaner reproduction.

In spite of their important advantages, tangential tracking decks must be very carefully designed if they are to be better than conventional systems. Designers have not yet had extensive experience with linear tracking, so the intending purchaser would be well advised to try any linear tracking equipment very thoroughly before committing himself to purchase. However, it may well be the system of the future for top-of-the-market systems.

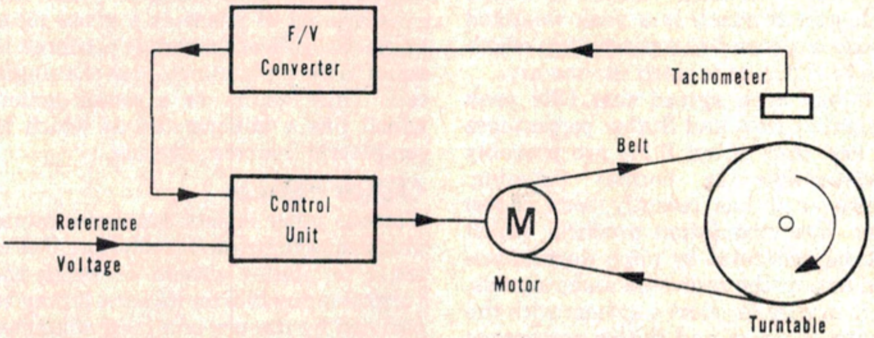


Figure 4. **The Philips 'direct control' system employs belt drive for the platter and servo feedback to the motor control circuitry via a tachometer sensing the platter speed.**

The pickup arm of a conventional system will tend to 'skate' towards the centre of a record unless the correct amount of bias compensation is applied. If no bias or an incorrect bias is applied, the inner groove is likely to receive more force from the stylus which will result in signals of an unequal amplitude in the two channels and which is likely to cause the inner groove to wear at an increased rate. These problems are said not to arise in tangential tracking systems, whereas in conventional systems the application of bias is only a compromise, since the required bias varies with the position of the tone arm on the record and with the modulation levels.

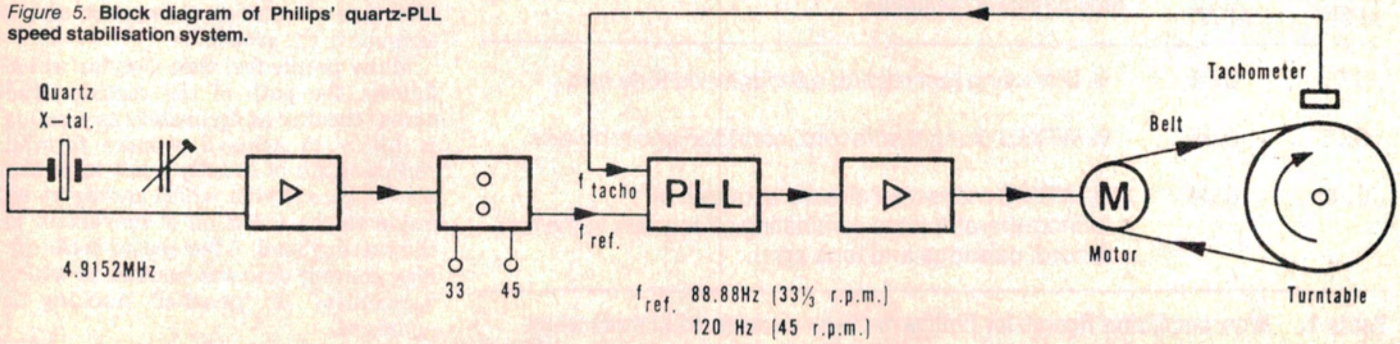
TURNTABLE SURVEY

We will now review various turntables and will stop to examine any unusual features offered in specific types. As the Japanese seem well ahead in this market, most of the models considered are Japanese.

Philips turntables

The Philips AF685 turntable is at the low-price end of the market and has electronic speed control with belt drive. The AF677 features 'direct control' and has about half the wow and flutter level of the AF685. The AF777 is rather similar to the AF677, but has automatic record diameter selection and arm

Figure 5. **Block diagram of Philips' quartz-PLL speed stabilisation system.**



positioning, variable pitch controls with a LED speed display, etc. The AF877 offers lower wow and flutter (see Table 1) and completely silent operation is achieved by the use of touch control switches; at the end of each disc, a photo-electronic sensor detects the acceleration of the arm as it follows the run-out groove and the arm is automatically returned to its rest. The AF977 employs a quartz stabilised speed system.

Let us look at the Philips 'direct control' belt drive system which is said to provide similar specifications to direct drive systems without the expensive constructional techniques required in direct drive systems to avoid rumble, etc. The direct control system is shown in Figure 4. Unlike servo control systems, in direct control the feedback signal is obtained from the turntable itself and not from the motor. Thus, stabilisation is related to the speed of the turntable itself — which is what matters most of all. Any slackness in the belt will have a much smaller effect than if the tachometer were connected to the motor. Fine control of the turntable speed is effected by varying the reference voltage with which the fed-back voltage is compared.

The AF977 deck employs a quartz stabilised circuit of the type shown in Figure 5. The 4.9152 MHz signal from the crystal controlled oscillator is divided by a suitable factor, the value of which depends on whether one requires the 33⅓ or 45 rpm speed. The resulting reference frequency is fed to a phase-locked loop (PLL) circuit together with the speed frequency fed back from the tachometer. The output from the loop is used to control the motor speed. Thus, the phase of the tachometer generated signal is continually compared with that of the reference frequency and very high stability is obtained.

Trio-Kenwood Turntables

Japanese manufacturer Trio-Kenwood produces the KD-600/650/750/850 range of quartz/phase-locked loop stabilised turntables and the electronically speed controlled types KD-3100 and KD-4100. This manufacturer emphasises the importance of using a turntable of a high moment of intertia to prevent transient changes of speed due to load variations. The turntable bases have been developed from a limestone-resin-concrete mixture to reduce low frequency resonance problems to a minimum. Brushless 20-pole, 30-slot dc motors are employed to minimise cogging and to provide DIN weighted rumble levels of −75 dB. Electronic braking is employed to minimise resonance effects. The tone arm wiring

Philips' AF977 turntable features 'state of the art' specifications, digital speed indication, automatic operation and direct readout of the adjustable stylus force.

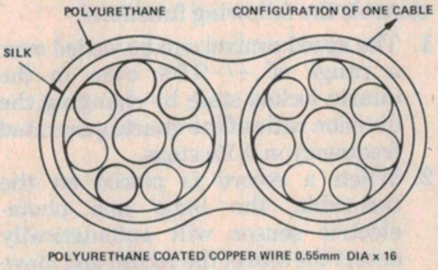


Figure 6. **The Trio-Kenwood low capacitance tone arm wire.**

in these models consists of 'Penta-Litze' wire of the cross section shown in Figure 6; this has a very low capacitance and therefore signal losses and cross talk are minimised.

The model KD-850 has a fully automatic tone arm controlled by a digital-optical electronic system; it is both completely silent and error proof even if the arm is operated manually whilst set for automatic operation. ▶

The Trio-Kenwood KD-850 fully automatic direct drive turntable.

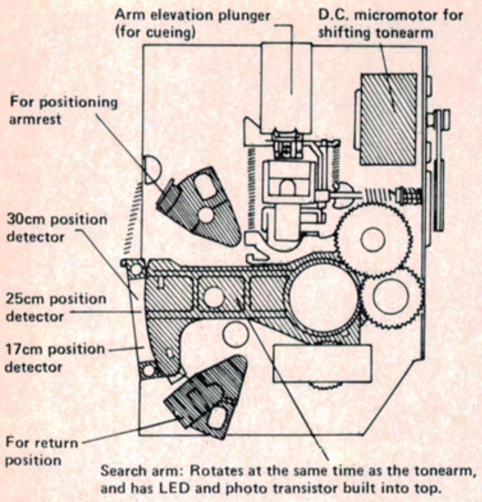


Figure 7 (a). **The automatic mechanism of Trio-Kenwood's model KD-850 turntable.**

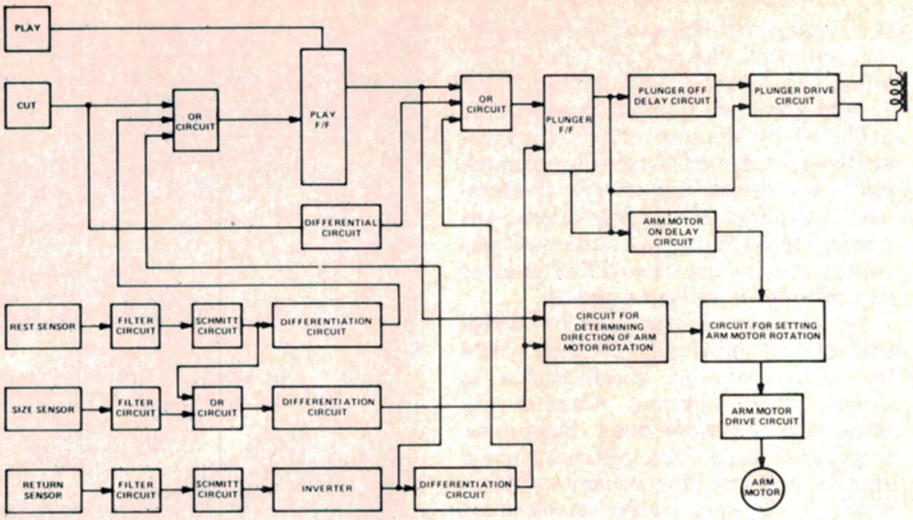


Figure 7 (b). **Block diagram of the logic system employed for automatic operation in the Trio-Kenwood KD-850.**

The automatic mechanism is shown in Figure 7. A photo-sensing system automatically selects the record size for the tone arm by sending a light beam to any of the prism slots in the platter not covered by records so that the information is signalled back to the disc size selector. The KD-4100 also employs an electronic system for automatic tone arm control, but the turntable is not locked in frequency to a quartz oscillator circuit.

Hitachi Turntables

Hitachi manufacture a range of turntables, including the HT324 and HT354, with electronic speed control, the HT356, HT353, HT550Q (semi-automatic) and the HT463 and HT660 (fully automatic) quartz crystal stabilised types. Perhaps the most interesting model, however, is the new HT-860 microcomputer controlled, quartz stabilised, fully automatic turntable.

The microcomputer control system (shown in block form in Figure 8) controls the following functions:

1. The speed control can be varied over a range of +/−9.9% even in the quartz locked state by changing the division ratio of the quartz generated frequency in 0.1% steps.
2. When a record is placed on the turntable, the lamp and photo-electric sensor will automatically detect the size of the record and move the tone arm into the correct position.
3. The speed is automatically set on detection of the record size, except in the case of 300 mm, 45 rpm and 170 mm, 33⅓ rpm records.
4. Optical sensors are used for moving the tone-arm in this fully automatic deck.
5. A repeat function allows the automatic replaying of any record up to nine times.
6. The tone-arm can be swung to any position by front panel button operation.
7. A safety mechanism prevents damage to the stylus under error conditions (such as operating the start button with no record on the turntable).
8. A fluorescent tube display indicates the turntable speed, any pitch variation, the record size and the number of repeat cycles.

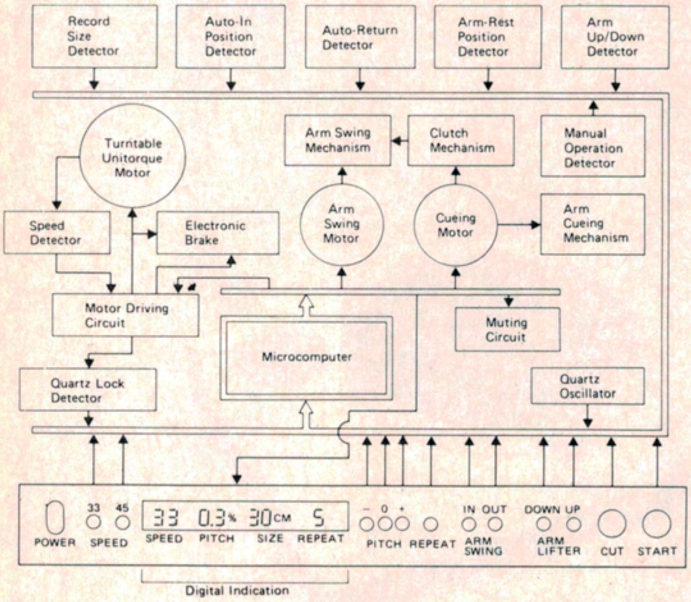


Figure 8. **Block diagram of Hitachi's HT-860 microcomputer controlled deck.**

The Hitachi HT660 quartz locked, fully automatic deck features optical sensing for the tone arm return and electronic platter braking.

Sharp Optonica Turntables

Sharp Optonica produce three types of turntable. The RP-5100 is a fully automatic, direct-drive type with stroboscopic indication, the RP-7100 is a quartz locked unit with an Auto Programme Locate Device (APLD) and the RP-9100 has all of these features plus remote control, digital speed display, etc. One may note that the RP-9100 employs some 40 integrated circuits, 40 transistors, 22 diodes, two Hall cells and two quartz crystals, so it is quite complex! The integrated circuits include a Z-80 microprocessor, an EPROM, 256 x 4-bit random access memories and a host of other logic devices.

The quartz locked motor systems of the models RP-7100 and RP-9100 are similar. A frequency generator comprising a 160-pole magnet and a multigap head having 80 pairs of pole teeth and coils is connected to the motor and generates a 44.44 Hz sine wave signal, when the motor is rotating at 33⅓ rpm and a 60 Hz sine wave signal when the motor is rotating at 45 rpm.

The signal from the generator is fed to an operational amplifier and then to an astable circuit which produces a rectangular waveform of 50% duty cycle. This frequency is compared with a reference frequency generated from a crystal oscillator in the following way.

The crystal oscillator frequency of 9.3312 MHz is divided first by four and then by 972. The resulting frequency is then divided by either 27 (for 33⅓ rpm) or by 20 (for 45 rpm) and finally by a factor of two to produce the reference frequency of either 44.44 Hz or 60 Hz.

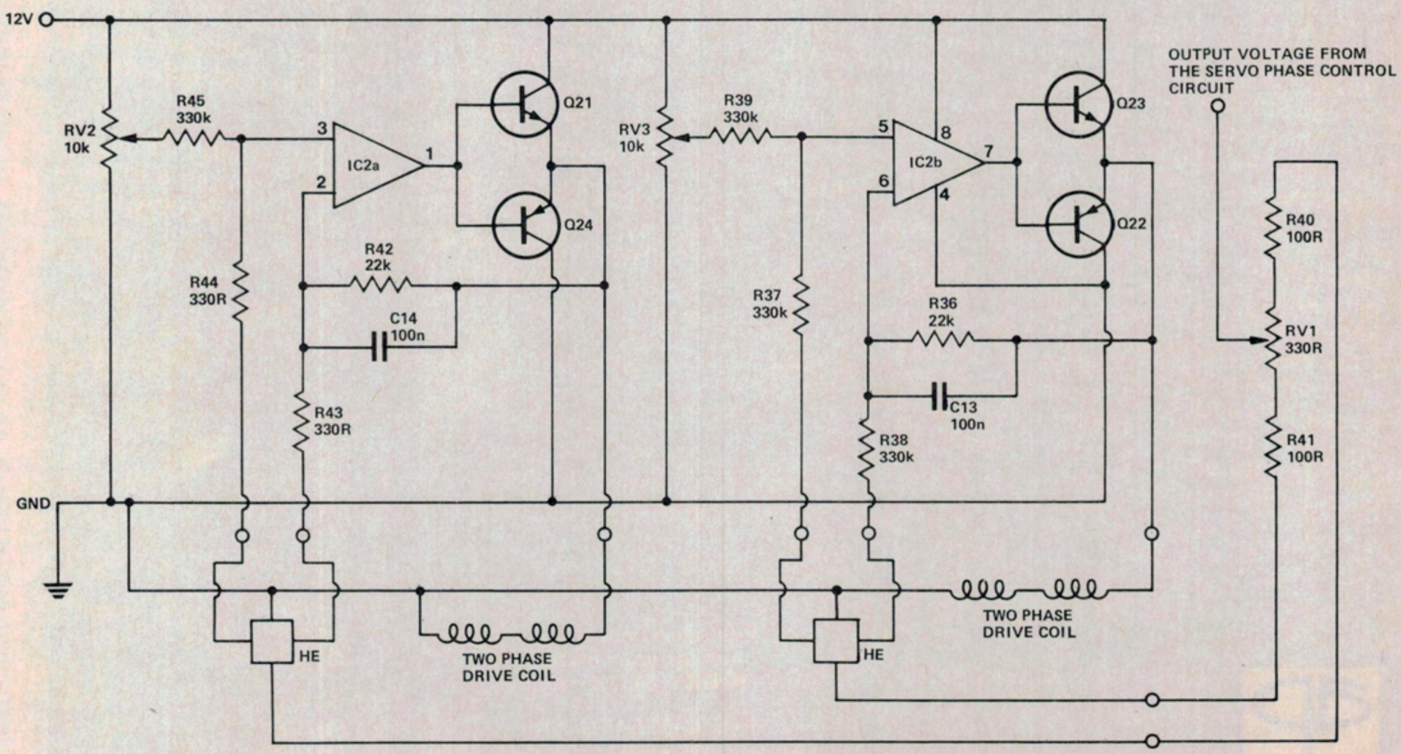
The operation of the direct drive motor circuit with its Hall effect commutating devices is well illustrated in Figure 9. The outputs of each of the two Hall Effect cells (marked HE) are fed to the inputs of operational amplifiers. The output of each operational amplifier drives a pair of complementary transistors which in turn control the current in the motor drive coils. The Hall cells detect the position of the rotor magnets and cause the currents in the motor drive coils to be phased accordingly. In addition, the voltage applied across the Hall cells is controlled by the servo phase control circuits and alters the switching times of the motor drive coil current so that the motor rotates at the desired speed.

The automatic programme locate

– to page 128.▶

The Optonica RP-7100 turntable features a special 'Auto Programme Locating Device' (APLD).

Figure 9. **Basic circuit diagram of the Sharp Optonica motor drive system.**



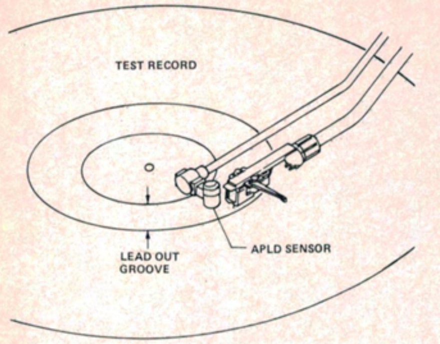
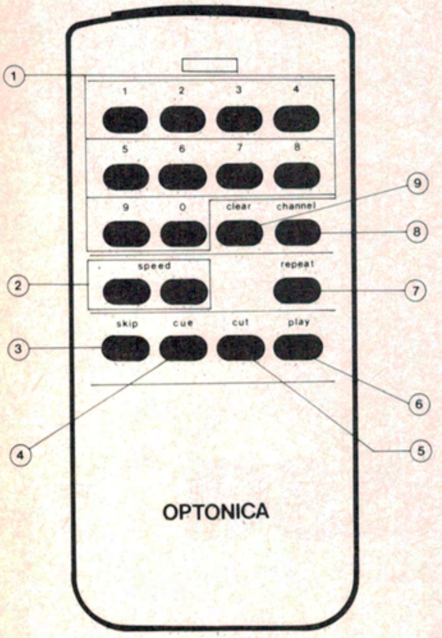
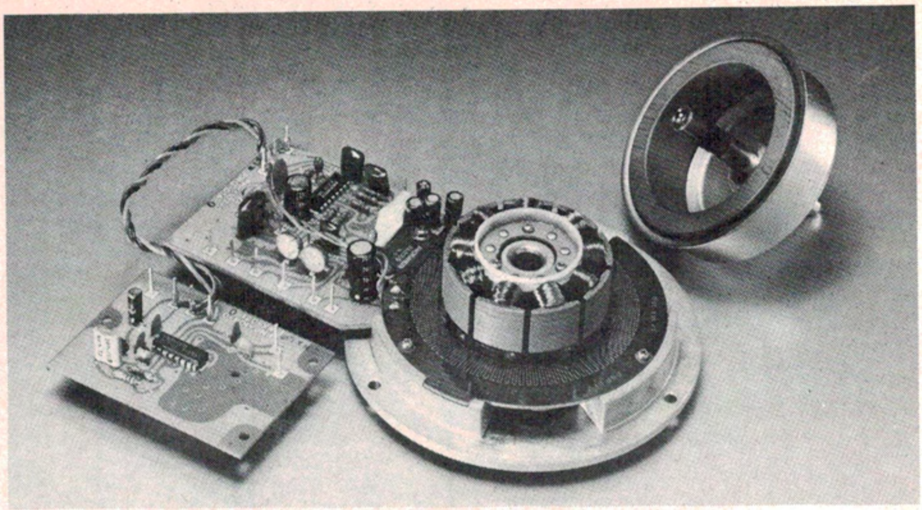


Figure 10. **The Sharp Optonica 'APLD' sensor system is mounted on a separate arm adjacent to the tone arm.**



1 APMS NUMBERED INPUT BUTTONS
2 TURNTABLE SPEED SELECTOR BUTTONS
3 SKIP BUTTON
4 CUEING BUTTON
5 CUT/CLEAR MEMORY BUTTON
6 PLAY START BUTTON
7 REPEAT PLAY BUTTON
8 CHANNEL BUTTON
9 CLEAR BUTTON

Figure 12. **Configuration and functions of the remote control unit for the Sharp Optonica RP-9100 turntable.**



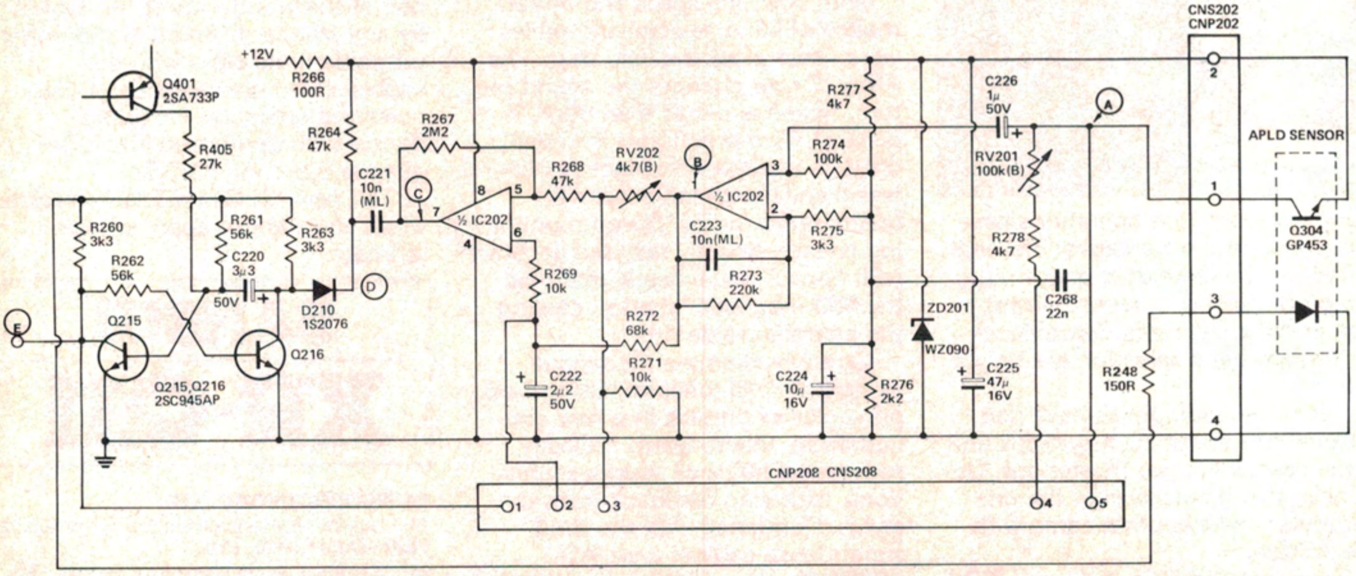
The Hall Effect dc drive motor and control electronics from Pioneer's model PL-560 turntable.

device (APLD) is carried on an arm separate from the tone arm, as shown in Figure 10, so that it does not alter the stylus force. This device utilises the difference in the reflection factor for infra-red radiation of sound modulated grooves and unmodulated grooves to detect the spaces between parts of the recorded material. When using the RP-7100, the user can push any APLD button, from one to seven, to select, for example, any song on a record. In the case of the RP-9100, the unit can be programmed to play up to 10 songs (with any specific songs repeated, if desired) in any order and to repeat the entire programme up to four times or indefinitely. A digital indicator displays the number of songs remaining.

The circuitry of the APLD sensor is shown in Figure 11. When the sensor reaches an unmodulated groove, positive-going pulses of some 20 to 40 mV in amplitude appear at the collector of the sensor device. This is amplified to a level of 1 V to 3 V by the operational amplifier whose output is at B. The second amplifier shapes the pulses into square waves of 7 V amplitude at point C, after which they are differentiated by C221 and R264 to form sharp pulses which are used to trigger the monostable circuit of Q215 and Q216. The output pulses from this circuit are of constant amplitude and duration and are fed to the complex logic circuitry of this record player.

The remote control unit of the RP-9100 turntable is shown in Figure 12. The keys provide for the 10 song locations of the microprocessor controlled automatic programmable music selector to be entered into the turntable memory by means of infra-red radiation carrying the data from the remote control unit to the turntable itself. Speed selector buttons and other controls are also provided. – *to page 130.* ▶

Figure 11. **Basic circuitry of the Sharp Optonica APLD sensor system discussed here.**



– from p.128.

Technics turntables

Technics is an associate of the well-known Matsushita Electric Company of Japan. They produce a wide range of turntables from the SL-200 and SL-B2 semi-automatic servo types to the SL-Q2 fixed speed, quartz locked, the SL-5200 fixed speed with quartz lock or manually variable speed without quartz locking and the SL-150Mk2, the SL-1300Mk2, the SL-1400Mk2 and the SL-1500Mk2 which all offer +/−9.9% variation of speed with quartz locking and digital display of speed. Perhaps most remarkable is the SL10 which has tangential tracking and is extremely compact.

The SL10 has a record clamp built-in and the tracking force is applied by means of a fine spring, so this remarkable turntable can be used in any position, including on its side or even inverted! The arm runs along a pair of guide bars and is driven by a coreless electric motor. The motor is controlled by an optical system mounted in the shorter of the two arms near the tip of the stylus.

The SL10 will accept only the special moving coil cartridge with which it is supplied. The low output cartridge can be used with a step-up head amplifier which may be switched in and out of the circuit. However, this turntable is most remarkable for its portability.

Technics' SL-1500Mk2 turntable features direct drive, which the company pioneered, digital speed display and quartz-locked speed variation of nearly +/− 10%.

Revox turntables

The Revox Company (based in Switzerland) offer two turntables which both have the same type of tangential tracking system. The B790 has been available for over a year and incorporates a quartz controlled direct-drive system with a manual speed variation facility of +/−7% and digital indication of the speed to two decimal places by a four digit display. The B795 is a more economical turntable which has the same general performance, but without the speed variation facility and without the digital display. The stopping time of the platter is longer with the B795 than with the B790.

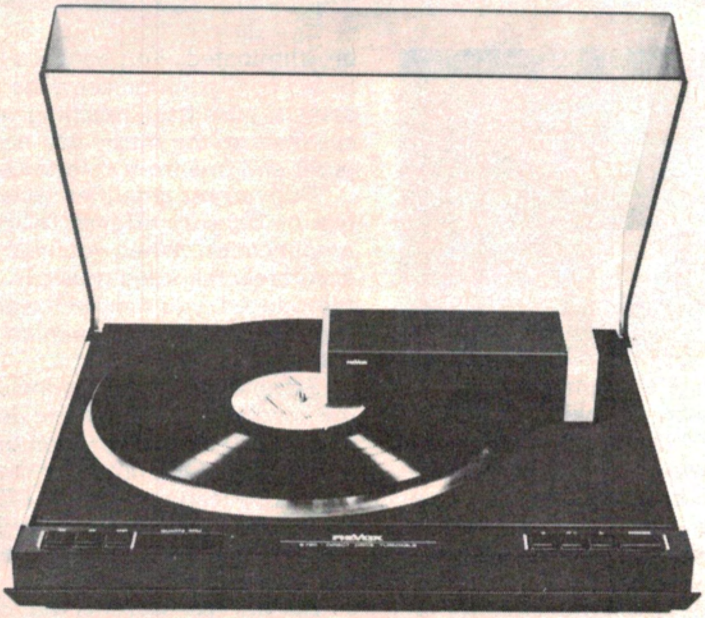
A servo-controlled motor is employed to achieve tracking together with a cord and pulley system which move a headset along horizontal parallel bars. The whole of the tracking system assembly is mounted in a rectangular shaped housing of substantial size on the right hand side of the turntable. This housing gives these turntables an unusual appearance and it can be swung forwards through 90° (or even through 180° to the right) when changing records. The shuttle carrying the cartridge moves in a straight line from the right hand edge of the record towards the centre during the playing time. The shuttle is driven by two horizontal pulleys, one at each end of the parallel bars, and a nylon cord.

An infra-red sensor containing a diode emitter and a pair of photodiodes in a symmetrical circuit is used to detect any tracking error. Any displacement of the head from the tangential position causes a movement of the slot through which the infra-red beam passes and the photodiodes become unequally energised. This operates the control circuit and a small motor operates one of the pulleys so that the nylon cord moves the shuttle just far enough to restore the symmetry of the circuit. The sensing circuit has an accuracy such that the lateral tracking error cannot exceed half a degree.

The shuttle has some free vertical movement to enable the cartridge to be raised and lowered. A solenoid-controlled lifting arm can hold the cartridge clear of the record or allow it to descend. The damping mechanism ensures that the stylus descends onto the record slowly and a muting circuit ensures that there is no audio output until the cartridge has been completely

– to page 132.▶

The Revox B790 turntable is another tangential tracking unit, shown here with the tangential tracking assembly in the playing position.



– from p.130.
lowered onto the record. The amount of movement is limited so that it is impossible for the stylus to touch the rubber mat on the platter if there is no record on the turntable.

Three touch switches on the left hand side of the B790 set the speed to 33⅓ or 45 rpm or to the variable speed which is controlled by a small thumbwheel. Two of the buttons on the right hand side control the rapid movement of the shuttle inwards or outwards whilst the pick up is raised. When the third button on the right hand side is touched the cartridge will descend, whilst pressing this button again will raise the cartridge.

When a 300 mm diameter record is to be played, the cartridge will automatically position itself at the start of the record, but the position of the cartridge must be adjusted manually for playing records of a smaller diameter. The shuttle control buttons will move the stylus by about one groove when touched momentarily, but when a button is held down, the stylus takes some seconds to move from one end of the track to the other. At the end of a record, the widely spaced groove near the centre moves the stylus so that the optical system produces a signal which causes the stylus to be lifted off the record and the shuttle is returned to its rest position.

A particular advantage of these turntables is that it is almost impossible to damage the stylus, even if over-enthusiastic children operate the equipment. Any slight movement of the carriage immediately causes the stylus to be lifted off the record; for example, if the carriage is swung out whilst a record is playing, the mechanism will lift the stylus extremely rapidly.

Wow and flutter of both Revox decks are quoted as being better than 0.05% weighted. Speed accuracy is +/−0.01% — more than adequate, although lower than that quoted for many quartz controlled decks. The length of the tone arm is only 15 mm and this minimises any problems with resonances.

Pioneer

The Pioneer Company of Japan's PL-L1000 turntable (reviewed Feb. '80 ETI) features tangential tracking using an ingenious linear motor to drive the arm. Two speeds are provided by a dc motor stabilised with a quartz oscillator, but no fine speed adjustment is possible. A small red lamp glows when the speed has become locked to the quartz frequency standard.

Perhaps the most unusual feature of the PL-L1000 is the use of a linear motor to drive the tone-arm. Although the principle of the linear motor is not new, this is probably the first time a linear motor has been used in the hi-fi field. The uses of linear motors are few, although there is interest in their possible use for high speed rail transport; in the Pioneer deck the stylus must be transported along a rail. The coil of the motor is linear and magnets placed on either side of this coil move in a straight line under the influence of the magnetic fields.

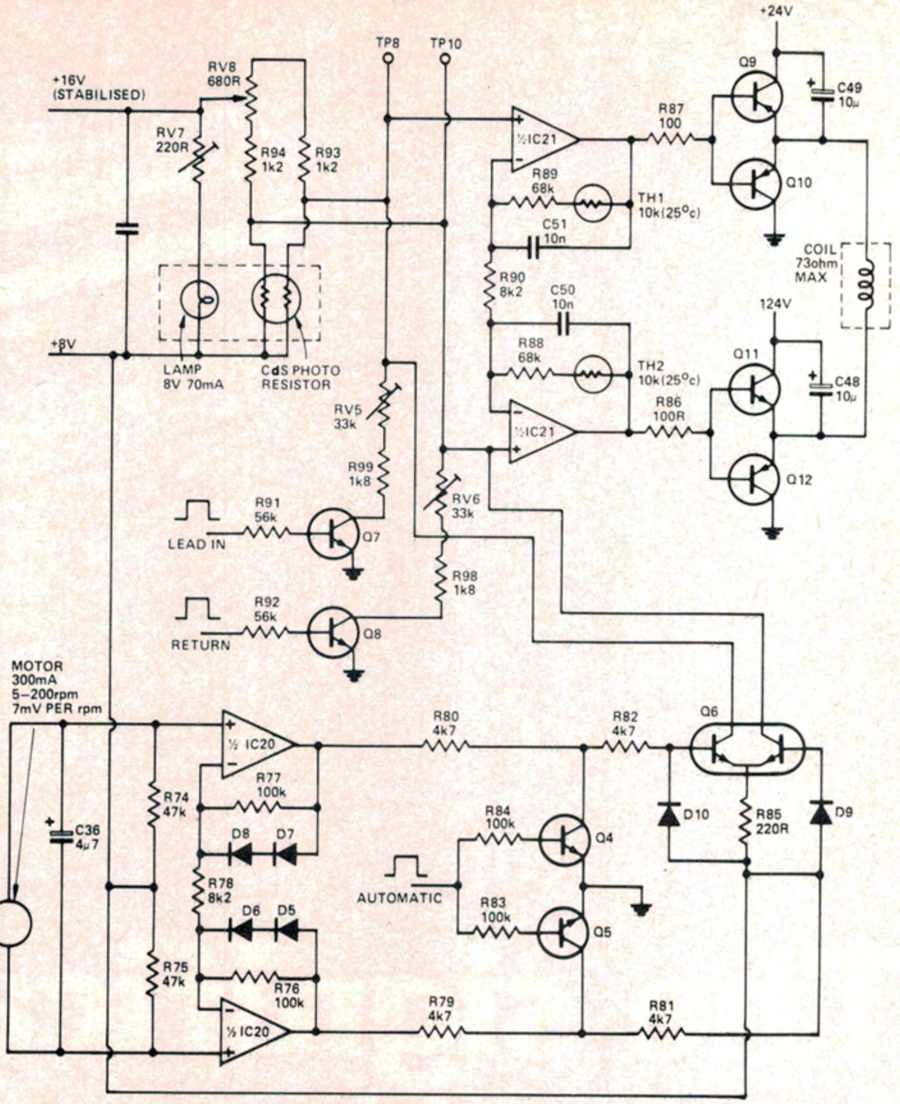


Figure 13. **The Pioneer PL-L1000 turntable has a tangential tracking tone arm employing an optical tracking system. This is the optical sensor circuitry.**

The PL-L1000 employs an optical tracking sensor for its tangential tracking system which is sensitive to 0.2 degrees of deflection. See Figure 13. When the stylus is positioned exactly at right angles to the carrier, the beam from a miniature lamp illuminates both sections of a twin photoresistor which, together with R93, R94 and RV8, forms a Wheatstone bridge, RV8 being adjusted so that there is no potential difference between TP8 and TP10 when the stylus is accurately located at right angles to the stylus carrier.

If the stylus happens to move either to the right or to the left, the amount of light striking each section of the photoresistive cell will change so that the bridge becomes unbalanced and a potential difference appears between TP8 and TP10. This potential is amplified by the differential amplifier stage comprising the two parts of IC21 which drive the twin complementary output stages Q9 to Q12 inclusive. These output stages form a push-pull bridge circuit which can drive a current of up to 300 mA in either direction through the 73 ohm motor coil. The tracking motor moves to return the bridge back to the balanced state, whereupon the potential at TP8 becomes equal to that at TP10.

When a record is about to be played, a current is fed to the base of Q7; the collector of this transistor therefore takes a current through R99, RV5 and R93 and the potential drop across R93 causes the stylus carrier to move to the left so that the stylus is above the record. The speed of movement is controlled by the setting of RV5. Similarly, after a record has been played, Q8 is made to conduct so that the potential difference between TP8 and TP10 causes the stylus carrier to return to its rest position on the right hand side at a rate determined by the setting of RV6.

During the automatic modes (lead-in, return or repeat), Q4 and Q5 are turned on and the resulting currents flowing through D9 and D10 turn Q6 off so that the groove locating function is inhibited. During manual operation, the differential amplifier IC20 is activated and this causes one side of Q6 to be turned on, the side being determined by the rotation direction of the dial. A voltage drop therefore occurs across R93 or R94 which, after amplification, causes a current to be passed through the coil to move the stylus carrier. This linear motor system has the advantages of being gearless and without mechanical linkages, the tone arm running on rails along the rear of the deck. The equipment will operate only if the turntable is accurately levelled and a spirit level is provided for this purpose; any tilting will probably result in the stylus carrier moving along its rails. The tone arm is 190 mm long and (unlike most conventional decks) the equipment can accurately track records which are off-centred.

The Pioneer PL-L1000 features a tangential tracking tone arm driven by a unique linear motor system. It employs an optical tracking sensor to maintain the arm position to within 0.2° of deflection.

Pioneer's hanging rotor system (already mentioned) is employed. Wow and flutter figures of 0.025% and 0.013% WRMS (depending on the measurement technique) are quoted. Speed drift is less than 0.8 parts per million per hour and less than 0.3 parts per million per centigrade degree at 33⅓ rpm.

Conclusion

Modern electronic circuitry has enabled record decks to be made which offer a standard of performance and a level of automation which would have been out of the question just a few short years ago. ●