the underside of the arm to fit over the spike. In an advanced design described by Percy Wilson (THE GRAMOPHONE, September and October 1963) the vertical member itself rests on a tube filled with grease and containing an air bubble. The compliance of the latter helps to isolate the arm from spurious mechanical shocks on the motorboard. Mr Wilson's design has the recessed pivot bearing at the base of a novel stabiliser, which resembles an upturned beaker with a thickened, heavy rim. Besides improving stability, this avoids side thrust difficulties (see below) since the frictional drag of the record is automatically opposed by the gravitational restoring force.

A unipivot gives low friction bearing in both the horizontal and vertical planes. It also tells you immediately if it is properly balanced—any imbalance will cause it to rub. Other types of pivot must contain a separate ball, knife edge or twin point bearing to permit freedom of up and down motion. In this case, an important requirement is that the vertical and horizontal pivots should be vertically in line with each other, to avoid severe side-thrust if tilting takes place.

**Side-thrust**

As we have seen, it follows from the practice of mounting pickup arms with the stylus overhanging the centre spindle that the axial line of the arm is not tangential to the groove. As a result, the frictional drag on the stylus has a component which tends always to pull the pickup towards the centre of the record. To some degree this inherent side-thrust or bias is a good thing since part of it serves to overcome the horizontal pivot friction which we have just discussed. Nevertheless, the residual bias introduces a slightly greater force against the inner wall of the groove than against the outer (right hand) wall and this can lead to distortion or even skating of the pickup. The amount of the distortion is admittedly small, but assumes importance as other types of distortion are gradually being suppressed.

The better class pickup arms, which we may assume are being used with relatively distortion-free catridges, amplifiers, etc., therefore tend nowadays to incorporate some means of opposing or compensating for this side-thrust. In the most popular approach, a small weight is dangled on a nylon thread which is attached to the arm at a point behind the pivot. This thread is taken over a bracket to the left of the arm and so applies an outward force to the pickup which, when correctly adjusted, will just cancel the inward force due to side-thrust. (Note that when J. Crabbe first put forward this idea—*Wireless World* May 1960—he attached the thread on the right hand side *in front of* the pivot, which had the same effect, and recommended Luron No. 2 fishing line!)

**Magnetic compensation**

An alternative type of bias compensator is offered by Decca, which incorporates magnetic materials to produce the desired adjustable counterclockwise torque. The idea is also developed in the Audio & Design pickup arm, which has the further novelty of requiring no lead-out wires. Although not mentioned in the section above on pivot friction, the wires which carry the electrical output from the cartridge are a common cause of unwanted mechanical resistance. With lightweight pickups particularly, these wires must be very carefully looped at the point where they emerge from the rear end of the arm so that they in no way impede the movement of the arm as it tracks across the record.

The Audio & Design arm has its internal wires terminated in four probes which are lowered into tiny baths of mercury. Thus a proper electrical connection is made for the twin stereo outputs but the possibility of undesirable forces from twisting wires is eliminated.

**Playing weight adjustment**

Most pickup arms, except those designed for a specific integral cartridge, include some means of adjusting the playing weight. This adjustment is made necessary by the varying recommended playing weights of cartridges on the market and the fact that the cartridges themselves have widely varying physical weights. (Just to quote two contrasting examples, the Pickering V-15 cartridge weighs 5 grams and should be played at 2 to 5 grams, whereas the Ortofon S15-T weighs 18½ grams and has a recommended playing weight of 1 to 2 grams.) In the usual see-saw like construction, the weight of the cartridge (and shell, if any) and the major length of the arm are opposed behind the pivot by a shorter extension of the arm and a relatively heavy counterbalance weight.

As a first step, it is usual to slide the counterweight to and fro until a position is found which exactly balances the pickup so that the cartridge will swing over the record without touching it. Then the required playing weight is applied by such means as moving the counterweight forward by specified amounts, sliding auxiliary weights forward, or increasing the tension on a spring which bears on the arm in front of the pivot.

Notice that all these techniques are setting the so-called longitudinal balance of the arm. In most cases, however, due for example to the cranking of the arm or the shell mounting to give the necessary offset angle, the weight of the arm is not equally distributed laterally on either side of its centre long axis. For this reason, certain arms have some means of achieving lateral as well as longitudinal balance. The SME arm has its auxiliary playing weight counterbalance on an L-shaped shaft at the right of the arm: this produces a clockwise torque when viewed from the front which can be adjusted to balance out the torque due to offset. Another way of achieving the same result is to use a counterweight which is itself offset: that is the hole by which it is slid on to the arm is off centre. Then, once it has been set at the correct fore-and-aft position for longitudinal balance, one can orientate it for proper lateral balance too.

**Raise and lower devices**

The human hand (and brain?) finds it easier to lift and put down with precision something relatively heavy like a pencil than something as light as a feather. For this reason, ultra-light gramophone pickups are difficult to handle and most pickup arms incorporate a raise and lower device. This can be a simple lever which pushes up on the arm at some point in front of the pivot (or down on the arm behind the pivot): or it can be the quite complex result of applied ergonomics (design for operational simplicity).

In the best designs, the rate of lowering is taken out of the hands of the operator and safely controlled by a hydraulic piston. Also, the raising and lowering should be precisely vertical so that, if we want to, we can continue playing a record from the groove at which we stopped. It is also useful on occasion to be able to cue into a record at a pre-selected spot. This requires an indicator scale of some sort and, though omitted from most arms, can be added in the shape of the Auriol Pickup Control. This clever accessory gives precise cueing and adjustable lowering speed (and is available in a version with raised scale divisions for blind users).

Now, after all this theorising, I expect many readers will want to get down to brass tacks and the proper methods to use when mounting a cartridge in its shell and the shell/arm combination on the turntable. These practical matters will be covered in the next instalment.

# TECHNICAL REPORTS

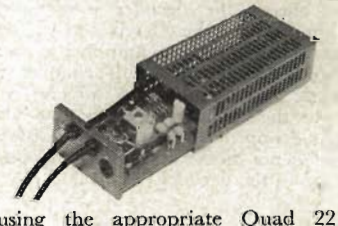
**Quad Multiplex Decoder.** Price: £16. Manufactured by The Acoustical Manufacturing Co. Ltd., Huntingdon, Hunts.

**Makers' Specification:**
*De-emphasis:* 50 micro-seconds European standard; 75 micro-seconds North American standard. *Output voltage:* 100mV (nominal for 30% modulation) into 100K. *Crosstalk:* Better than 30 dB at 1 Kc/s. *Suppression:* 19 Kc/s Pilot tone better than 36 dB; 38 Kc/s switching tone better than 40 dB. *Power Requirements:* 330V DC, 8mA mono plus 9mA stereo. *Size:* 6⅝ x 3⅜ x 2 *in. Weight:* 1 lb. 3 oz.

The Quad stereo decoder is primarily designed for use with the Quad FM tuner, the unit being fixed to the back of the tuner by two adjustable length straps which pick up the two long screws that secure the tuner to the mounting panel. The Quad team of designers, anticipating that pilot-tone multiplex broadcasting would be adopted by the BBC, have incorporated a switch in tuners manufactured after Serial No. 19062 which cuts out the normal de-emphasis components and transfers the de-emphasis function to the decoder unit. In earlier tuners it is necessary to modify them in accordance with the instructions given in the Quad decoder instruction book—a simple operation for a service engineer or knowledgeable amateur.

Normally the tuner unit obtains its power supply from a socket on the Quad 22 pre-amplifier but, with the decoder in position, the tuner power supply is obtained from a socket on the decoder, two other leads on the decoder going to the pre-amplifier. The audio lead from the tuner is also plugged into the decoder, and separate left and right channel leads taken to the pre-amplifier. With the later tuners and Quad 22, the installation can be completed easily in 30 minutes, no adjustments of any kind being necessary.

Although it is possible to use the Quad decoder with other makes of FM tuner, it would be necessary to provide the correct DC voltage, audio signal level and the necessary switching for mono and stereo transmissions. With the Quad combination, the selection of either mono or stereo programme is achieved



by using the appropriate Quad 22 press buttons. For mono transmissions, the programme can be heard only on one channel by pressing the 'mono' button, or on both channels by pressing both the 'mono' and 'stereo' press buttons (as for discs). Under the first condition, when the transmission changes to stereo no signal is heard. However with both buttons depressed, the programme continues in twin channel mono. To receive the programme in stereo, only the stereo button is depressed.

The testing of stereo multiplex decoders requires considerable specialized test apparatus and in particular a stereo multiplex generator. The type used for THE GRAMOPHONE measurements has been standardized on the Danish Radiometer generator. For portable

purposes where, for example, one wishes to test a decoder on site, the compact but efficient Loewe-Opta is used. The Radiometer generator enables one to test the decoder alone or when it is connected to the associated FM tuner. Basically it consists of a 19 Kc/s, crystal controlled oscillator which can be modulated externally or by audio tones of 80, 1,000 or 5,000 c/s either mono, left or right channels separately, or together. Also built-in is a metered RF generator operating at 100 Mc/s followed by an attenuator which reduces the signal in steps of 20 dB to −80 dB below 100 mV.

The Quad Multiplex Decoder was measured in association with a recent Quad FM tuner, Quad 22 Control unit and two Quad power amplifiers. Past experience in measuring continental decoders indicated that separate measuring instruments should be used for each channel instead of switching instruments from channel to channel. One also learned, the hard way, that the measuring valve voltmeters, and oscillographs must be identical in performance and loading.

The Quad circuit arrangement is of considerable interest. For example, it anticipates that many users will wish to make tape recordings of stereo transmissions and hence special care has been taken to prevent the 20 Kc/s BBC transmitter tone, or the 19 Kc/s and 38 Kc/s tones reaching the audio output stage where they could beat with the bias oscillator of the tape recorder. The Quad decoder is fully transistorized and the audio signal from the tuner is fed to a high impedance input stage (OC44). A word of warning should be given on the audio connecting lead. This appears to be several inches longer than is necessary, to connect the tuner to the decoder, and one might be inclined to shorten it. However, the self-capacity of the co-axial cable forms part of the de-emphasis circuit and the given length must not be changed. Between the emitter output of the first transistor and a four-diode ring demodulator is a 55 Kc/s low pass filter which effectively kills any 57 Kc/s sub-carrier (third harmonic of the 19 Kc/s pilot tone). In the collector circuit is a transformer tuned to precisely 19 Kc/s, which drives an OC81 amplifier with a further tuned transformer in its collector circuit. The secondary winding feeds a pair of push-push diodes, thus generating a 38 Kc/s signal which is used for switching the diode ring modulator, and to produce the bias potential necessary to switch to stereo. The power supply is applied to the decoder only when the Quad 22 'radio' press button is depressed and then this supply voltage biasses the decoder into the mono condition. When the stereo button only is depressed, the pilot tone amplifier is switched on (together with the right channel power amplifier). To maintain a precise voltage supply to the decoder, the nominal 300 HT supply is dropped by appropriate resistors and a pair of Zener diodes used to ensure constancy of voltage to the decoder circuits.

### Performance tests

For all practical purposes the Quad decoder met its makers' specification, the cross-talk from left to right channels being 29 dB and right to left 30 dB. Frequency response was within 1 dB from 40-15,000 c/s, these being the limits of the current BBC transmissions. Output voltage without visible distortion on the oscillograph trace considerably exceeded that required to load the Quad 22.

As is usual with Quad instruction booklets, very full alignment details are given, but they should never be required as each unit is fully aligned at the factory. To prove the accuracy of the alignment procedure I purposely moved the tuning slugs in the inductors in random directions, and then attempted to re-align the decoder, possibly to a higher standard than its original tuning. This is an exercise not to be undertaken lightly but, as all the necessary test apparatus was to hand, it was an instructive and fascinating exercise. As some of the transformers are not in screening cans, the unit must be aligned inside its perforated screening container, the slugs of the coils being accessible through the perforations. In the alignment procedure, certain voltages have to be measured, components short-circuited, etc., and undoubtedly at the works they have test jigs for this purpose. Therefore some time was spent in making up suitable probes but, after some four hours, I could not improve on the original measurements. At least I had established that the alignment instructions were accurate and could be repeated.

Sensitive as the Quad FM tuner is, it does deserve a good aerial signal and, in south-west London some 30 miles from Wrotham, an external aerial with one director is adequate. Tests were made with several indoor aerials which gave a reasonable signal on mono FM but the background noise became noticeable on stereo FM. Immediately the external aerial was used, the background noise disappeared; but on occasion one became conscious of hum on some of the BBC microphone circuits. When the broadcast switched to tape or gramophone records the hum disappeared. It is interesting during a stereo transmission to depress the mono button in addition to the stereo button, thus producing a twin mono signal and allowing one to compare stereo directly with mono. Press the mono and one hears at once how lifeless mono sounds in comparison with stereo. I do not know a better demonstration of the comparative advantages.

The Quad stereo decoder was the first British unit to be placed on the market and it is difficult to fault it, particularly when used with the associated Quad tuner and amplifiers. If one leaves the control unit in the single mono position, nothing is heard when a stereo signal is transmitted and it takes some 20 seconds for the second power amplifier to warm up. Hence it is wise to leave the control unit press buttons in the twin mono position for listening to mono radio as then both channels are immediately available when a stereo transmission starts up. If there is one additional feature I would appreciate on this decoder it would be some form of indicator which shows whether mono or stereo is being radiated. I know it only requires a moment to press a button, or to look at the *Radio Times*—but perhaps I am lazy.

Many other decoders are about to reach the UK market but they will require a great deal of technical skill and development to improve on the high quality established by the Quad decoder.

JOHN GILBERT.

**Akai Model X-355 Tape Recorder.** Price: £250 19s. Manufactured by Akai Electric Co., Japan. U.K. Distributors, Pullin Photographic Ltd., 11 Aintree Road, Perivale, Middlesex.

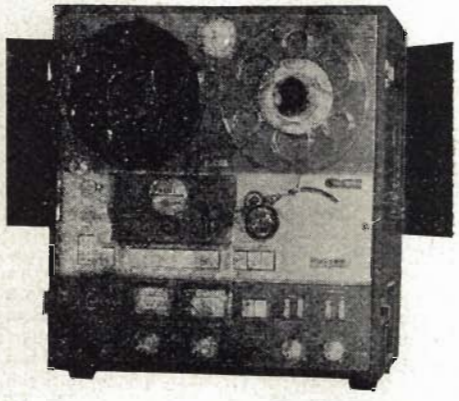
**Makers' Specification:**

*Tape Speed:* 3-3/4 and 7-1/2 ips (15 ips adaptor mainly for high-speed tape duplication). *Frequency response:* 30 to 24,000 c/s ± 3 dB at 7-1/2 ips, 30 to 18,000 c/s ± 3 dB at 3-3/4 ips. *Signal to noise:* Better than 47 dB at normal play. (Better than 45 dB at reverse play). *Wow and flutter:* Less than 0·08% rms at 7-1/2 ips. Less than 0.14% rms at 3-3/4 ips. *Equalization:* NAB. *Cross talk:* Less than −82 dB (monaural). Less than −45 dB (stereo). *Bias frequency:* 90 kc. *Distortion:* Within 4.0% 1,000 c/s 0 VU at 10 Watts (total harmonic). *Timing accuracy:* ± 0.3% at all tape speeds. *Recording sensitivity:* 0·5 mV in microphones jack. 50 mV in line input jack. *Power output:* 25 Watts Music Power maximum on each channel, total 50 Watts. 20 Watts Undistorted maximum on each channel, total 40 Watts.

*Fast forward and rewind time:* 45 seconds for either operation using 1,200 feet tape. *Loudspeakers:* 6-1/2 in. round, wide range speaker, one each on both channels. *Power requirements:* AC 100 to 240 volts, 50-60 cps, 60VA (at non signal) to 170 VA (at maximum output) *Weight:* 62 lb. *Dimensions:* 17-3/8 x 16 x 12 in.

The packing of the Akai X-355 instrument is amongst the best I have come across. The instrument itself measures 17⅜ by 16 by 12⅛ inches, and weighs 63 lb., yet by an unbelievable piece of oriental cunning, no handles are fitted. Not being a Samurai, it was as much as I could do to lift the recorder on to the test bench.

The Akai X-355 is designed for either vertical or horizontal operation and to this end substantial rubber feet are fitted to the base



and back. Also on the back are four clips around which the captive mains cord can be wound for stowage and, whilst the clearance is adequate for American type flat plugs, it is insufficient for normal English 5 Amp or 13 Amp three pin plugs. Also fitted to the back is a switch varying the tension of the take-up spool motor for 7 inch and 10½ inch spools. The latter can be used only with 'outriggers' which are an optional extra.

At the bottom of the cabinet is an inspection panel allowing access to the amplifier systems. The various amplifiers, with the exception of the power amplifier, are mounted on individual printed circuits, and are easily removable by virtue of an edge connector.

The front face of the recorder follows current American practice, being finished in silver and grey. The tape transport mechanism consists of a synchronous motor driving the capstan flywheel via an elastic endless belt. Being synchronous, its speed is dependent only on mains frequency and stepped pulleys are fitted to accommodate either 50 or 60 c/s mains. Tape speed switching 7½/3¾ ips is accomplished by altering the number of effective poles. The capstan diameter is 0.2364 in. and it revolves at 666 rpm at 7½ ips. It did not appear to be hardened, lapped or polished. The oxide coating of the tape is in contact with the capstan and at the end of twelve hours' operation there was a heavy coating of oxide on the capstan. It should be noted that there is a fair amount of mechanical noise from the capstan, especially at 7½ ips, which can be annoying if the instrument is situated in the same room used for recording and playback. Separate induction motors are provided for the feed and take-up spools. These are of adequate power and the claimed fast forward and rewind speed of 45 seconds for 1200 feet of tape was in fact met; but at the end of the rewind the full spool spun madly for about thirty seconds, tearing the end of the leader to shreds.

The tape is taken from the feed spool via a spring loaded guide roller and inertia wheel past the tape heads to the capstan on to another guide roller and tension arm to the take-up