feet of a low-pass filter. Typical values for 4-wire cable, measured between conductors, and the shield and conductors are:
1 wire and shield, 33.4 pF per foot.
2 wires, connected in parallel at one end only, and shield, 52 pF per foot.
2 wires, no shield, 21.3 pF per foot.

16.51 What is the relationship of frequency to wavelength for a given recording diameter? This relationship is shown graphically in Fig. 16-27B.

16.52 How may pickup-arm tangent error be minimized? Tangent error may be minimized by use of either an offset or curved arm which progressively reduces the tangent error as the arm moves across the face of the record.

The conventional pickup arm is generally mounted in a swivel bearing at the rear and to one side of the turntable. With such a mounting, the pickup can be tangent to the groove at only one point in the recorded area, the center. In the early design of pickup arms, the arm was straight and it was not uncommon to find tangent errors of 14 to 30 degrees at the inner and outer diameters of a 12-inch record. The use of this type mounting tears out the side wall of the record groove. Tangent errors may be reduced by increasing the length of the arm, but this too far becomes impractical. Modern pickup arms employing an offset have on the order of 1-degree tracking error.

A precision arm, manufactured by SME of England, is shown in Fig. 16-52A, with its essential components indicated. At A are two knife-edge bearings having a pivot with friction less than 20 milligrams in both vertical and horizontal directions. The arm B is of stainless steel, screwed to place the resonant frequency well below the reproducing range. Weight C is used to statically balance the arm longitudinally and laterally. Rider weight D adjusts the tracking force 1/2 to 5 grams, in 1/4 increments. Alignment is obtained by the use of a sliding horn E through a 1-inch area, with alignment in the vertical plane to 1/4 inch. These latter adjustments permit the arm to be raised to the proper height, length, offset, and overhang. A small, weight F provides a bias adjustment to prevent the arm from skating across the face of the record. Lever G provides a slow motion lock-down for the pickup. Connections for the pickup cartridge are provided in the head I, with external connections at plug J. Tangent error is reduced to less than 1 percent by the use of an offset in the arm back of the pickup cartridge mount, and the arm placement at the rear of the turntable.

A turntable and pickup developed by Marantz Co., Inc., designed to solve the tangent error, is shown in Fig. 16-32B. The pickup unit is guided across the face of the record in a straight line, so that the pickup is always tangent to the record groove, therefore the tangent error is zero. The turntable is belt driven by a hysteretic-asynchronous motor. The turntable weighs 12 pounds, and is supported by a tungsten-carbide thrust bearing. Push buttons control the starting, stopping, and the dropping of the pickup on the record. The pickup employs an elliptical diamond stylus, with a compliance of 30 × 10⁻⁶ cm/ dynes. The rumble is said to be 132 dB below a reference level of 7 nanometers per second. Two speeds are provided, 78 and 45 rpm. An interior view, showing the driving mechanism for guiding the pickup across the record, appears in Fig. 16-32C.

16.53 What is the procedure for mounting a pickup arm? Generally the manufacturer of the arm supplies a template and mounting instructions for a knock-down arm. However, in the absence of such information, the pickup arm is mounted in such a manner that the tangent error is at a minimum. One method of mounting the arm is shown in Fig. 16-53. A template is platted to facilitate the inner and outer areas of medication, and the arm so placed for a minimum tangent error. The procedure is the same for any length arm and diameter platen. It will be found, regardless of where the arm is placed, tangent error cannot be eliminated entirely. Several excellent methods of mounting arms are discussed in the references.

16.54 What is overhang? The distance the stylus projects beyond the center pin of the turntable when the pickup arm is in such a position that a line joining the pickup stylus tip and the lateral-arm pivot passes through the turntable center pin.

16.55 In what frequency range should the resonant frequency of a pickup arm fall? The design should be such that resonance at 30 Hz is avoided, as this is the rumble frequency for a four-pole motor. As a rule, the resonant frequency of a pickup arm on a record changer occurs between 30 and 40 Hz. Reproducing equipment for broadcast and other professional use is designed to place the resonant frequency of the arm, below 10 Hz. For a number of commercial arms, resonant frequency is around 2 Hz.

16.56 What is the effect of the magnetic structure in a pickup cause a drop on the turntable? The attraction of the magnetic structure of a pickup to a steel turntable can increase the stylus pressure and could cause the turntable to run slightly slow if the attraction is strong enough. The attraction of the pickup can be reduced by placing a pad between the pickup and turntable. In modern design, the attrac-
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