If the peaks are not symmetrical, undesired couplings are probably responsible. All traces of regeneration must be removed and, because the stability requirements are more severe than usual, unusual effects are liable to be uncovered. For example, regeneration may occur due to coupling between a loop formed by the generator input leads and the output of the i-f amplifier (twisting generator leads will cure this) or coupling may occur between first and second i-f transformers within the steel chassis. When this happens, rotating one or both transformers will probably give cancellation but leave production receivers susceptible to the trouble. Additional spacing between transformers is advisable with each primary and secondary wired for minimum regenerative coupling.

The switch used for the tertiary winding should preferably be of the " break before make " variety. A " make before break " switch momentarily short circuits the tertiary winding during switching, giving a sudden reduction and increase in sensitivity which can be heard as a click.

Even after a satisfactory i-f selectivity curve has been obtained, the over-all curve may be too narrow if a r-f stage is used in the receiver. In such cases the r-f stage should also be expanded [Chapter 35 Sect. 5(iii)].

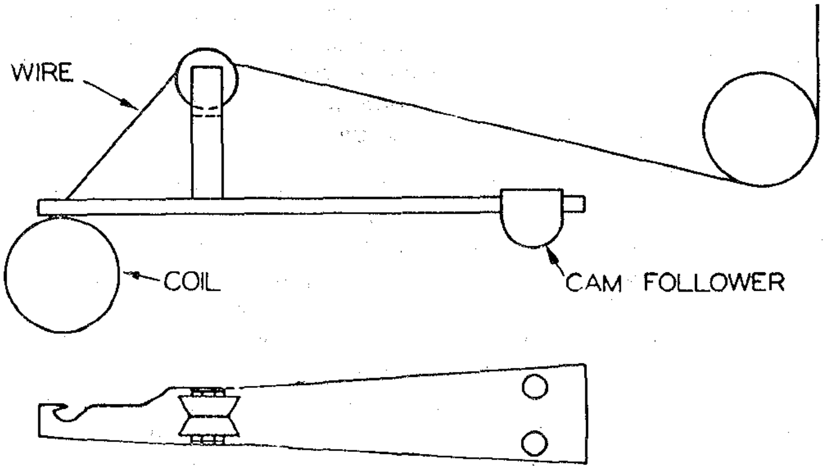

FIG. 11.4

Fig. 11.4. *Type of finger recommended for universal winding.*

(iv) Calculation of gear ratios for universal coils

To obtain electrical consistency between universal coils in production runs it is essential to wind the coils with good mechanical stability. For this, machines must be adjusted correctly, but a suitable gear ratio is of equal importance.

The method of gear ratio calculation given below has been used successfully for production coils, and gives a straight pattern on the side of each coil.

The instructions make provision for a spacing between centres of adjacent wires of 8/7 of the wire diameter. This diameter should be measured, and the required spacing depends on the type of winding finger used. The most satisfactory types, and the ones for which the spacing factor will be found suitable, are those in which the wire passes to the bottom side of the finger before being placed in position on the coil. Fig. 11.4 shows such a finger, and it will be seen that the tension on the wire pulls the finger down to the face of the coil.

Fingers in which the wire passes through a groove on the top and then takes up its own position on the surface of the coil may require more spacing than that specified. Other factors may also affect the spacing required, but a small amount of experiment will decide this. It will be noticed that some types of litz wire tend to spread when wound, and so need more spacing than would be expected from measurement.

Symbols

d = former diameter (inches)
c = cam throw (inches)
n = nominal number of crossovers per turn (see Table 1)
q = number of crossovers per winding cycle, i.e. before wire lies alongside preceding wire (see Table 1).
v = nominal number of turns per winding cycle (see Table 1)
R = gear ratio = former gear/cam gear
w = modified wire diameter (inches)—see Note below
$P = qc/(w + x)$ = an integer
x = smallest amount necessary to make $(P + 1)/v$ an integer (inches).

Note. For fabric covered wire, w = (measured diameter of covered wire) × 8/7. If the wire is enamelled only, the same formula is used but the bare wire diameter is multiplied by 8/7.

Procedure

(A) From $n \ngtr (2d/3c)$ determine the largest convenient value for n. Do not use values of n less than 2 for bare enamelled wire. Obtain values of q and v from Table 1 below for the value of n chosen.

TABLE 1

n	4	2	1	2/3	½	1/3	¼
q	4	2	2	2	2	2	2
v	1	1	2	3	4	6	8

(B) Determine w from information given in the note above.

(C) Calculate P from $P = qc/(w + x)$.

(D) Obtain R from $R = \frac{1}{2}n(P + 1)/P$.

Example 1

Given $d = \frac{1}{2}$ in. and $c = 0.1$ in. determine the gears to wind a coil with 42 S.W.G. enamelled wire.

(A) $(2d/3c) = 1.0/0.3$. Take $n = 2$, giving $q = 2$ and $v = 1$ from the table.

(B) The diameter of bare 42 S.W.G. wire is 0.004 in., so $w = 0.004\,57$ in.

(C) $P = qc/(w + x)$ and $(P + 1)/v$ must be an integer, i.e. P must be an integer since $v = 1$.

$qc/w = 200/4.57 = 43.7$.
But $P = qc/(w + x)$ = an integer.
Therefore $P = 43$.
(D) $R = \frac{1}{2}n(P + 1)/P = \frac{1}{2} \times 2(43 + 1)/43 = 44/43$.

Example 2

Given $d = \frac{1}{4}$ in. and $c = \frac{1}{4}$ in. determine the gears to wind a coil with 0.016 in. litz wire.

(A) $2d/3c = 2/3$. Take $n = 2/3$, giving $q = 2$ and $v = 3$.
(B) $w = 0.016$ in. $\times 8/7 = 0.0183$ in.
(C) $qc/w = 500/18.3 = 27.3$.
But $(P + 1)/v$ = an integer.
Therefore $P = 26$.
(D) $R = \frac{1}{2}n(P + 1)/P = 1/3 \times 27/26$.
To obtain suitable gears :—
$R = 2/3 \times \frac{1}{2} \times 27/26 = (28/42) \times (27/52)$.

When it is known that n will be 2, as is the case with the majority of coils, the method reduces to dividing the modified wire diameter into twice the cam throw (ignoring any fractions in the answer). This gives P and the required ratio is $(P + 1)/P$.

For further information on universal coil winding see Refs. I 1 to I 8.

(v) Miscellaneous considerations

(A) Direction of windings

Although the coupling between primary and secondary is assumed to be due to mutual inductance, the capacitive coupling is appreciable. Depending upon the direction of connection of the windings, the capacitive coupling can aid or oppose the inductive coupling. When the two types are in opposition and of the same order a slight change in one—the capacitive coupling is particularly liable to random variation—gives a much larger percentage variation in the effective coupling. In a bad case, production sensitivity variations from this cause may be quite uncontrollable.

To avoid the trouble, i-f transformers are usually connected for aiding capacitive and inductive coupling. This is done by connecting the i-f amplifier plate to the beginning of one winding and the following grid to the end of the other winding when the two coils are wound in the same direction. Other connections to give the same winding sense will give the same result.

Even with aiding couplings it is desirable to reduce capacitive coupling to a minimum to obtain a symmetrical response curve and care should be taken in the placing of tuning capacitors and with details such as keeping the grid wire of the secondary winding well away from the plate wire or the plate side of the primary winding.

(B) Amount of coupling

An undesirable feature, from a production point of view, of i-f transformers in which the coupling is less than critical, is that receiver sensitivity becomes more dependent on i-f coil spacing. For a transformer with approximately critical coupling a spacing difference of 1/32 inch makes no appreciable difference to sensitivity in a typical case. However if the transformer were under-coupled the sensitivity change would be noticeable.

Transformers which are slightly over-coupled can be aligned for symmetrical response curves without undue trouble by detuning each winding (say with an additional capacitor of the same size as the tuning capacitor) while the other winding of the transformer is aligned for maximum sensitivity. Symmetry is of course dependent on the absence of regeneration.

(C) Losses

Unless care is taken, the sum of a number of apparently negligible losses may result in appreciable reduction in Q. Many artificial coverings have greater losses than silk, but this is usually obvious when a sample coil is wound. Less obvious losses may occur in details such as the material used to seal the end of a winding or in the placing of shunt capacitors or even coil lugs close to the actual i-f winding. An assembly of straight parallel wires between top and bottom of the i-f can may cause appreciable decrease in Q, particularly if large blobs of solder are placed close to the windings.

To eliminate such losses it is advisable to check the Q of a winding, sealed with low-loss material and baked to remove all moisture, when suspended well away from any substances which will introduce losses. The mechanical structure of the complete i-f assembly can then be added, one section at a time, and the Q read at each stage, a final reading being taken when the coil is mounted in the receiver.

(D) F-M i-f transformers

For details of F-M i-f construction and other i-f information of practical interest see Chapter 26 Sect. 4(vi).

(E) Other ferromagnetic materials

The development of a non-metallic ferromagnetic material named **Ferroxcube** has been announced by Philips (Refs. A28, A29, A30, A31, A32, A33).

Several grades of Ferroxcube are manufactured. They have in common a high specific resistance of 10^2 to 10^8 ohm cm. and a high initial permeability of from 50 to 3000 depending on the type. Ferroxcube IV, which is useful to 40 Mc/s, has a permeability of 50, and Ferroxcube III with an upper frequency limit of about 0.5 Mc/s has a minimum permeability of 800.

Because of the closeness of the Curie point to room temperature (the Curie point of Ferroxcube III is 110°—160°C) some change of permeability occurs with changing temperature. For instance the permeability of Ferroxcube III can be almost halved by an increase in temperature from 20°C to 80°C. However, the permeability of Ferroxcube V is decreased less than 10% by a similar temperature change under the same conditions. Between 10° and 40°C the change in permeability averages 0.15% per 1°C for the various types of Ferroxcube.

In cases in which the magnetic circuit is normally completely enclosed, the high permeability of Ferroxcube can be used to minimize losses by means of an air gap. If the gap is such as to reduce the effective permeability to one tenth of its original value (which could still be high), losses and the effect of heat on effective permeability will also be reduced in the same proportion.

The properties of Ferroxcube allow considerable reductions to be made in the size of such items as i-f transformers or carrier-frequency filters, and it is an excellent material for magnetic screens or for permeability tuning. However its saturation point is rather low and it is not used for power transformer or output transformer cores.

Ref. A27 describes research on **ferromagnetic spinels** by the Radio Corporation of America. These spinels are ceramic-like ferromagnetic materials characterized by high permeability (up to greater than 1200), high electric resistivity (up to 10^8 ohm cm), and low losses at radio frequencies. Wide ranges in these and other properties are obtainable by varying the component ingredients and methods of synthesis.

Ferrospinels are being used increasingly in electronic equipment operating in the frequency range of 10 to 5000 Kc/s. At power and low audio frequencies the ferrospinels are not competitive with laminated ferromagnetic materials, and at very high frequencies the losses in ferrospinels are excessive when high permeability is required. It is possible however to produce a ferrospinel, with low permeability, useful at frequencies in the order of 100 Mc/s. The application of ferrospinels as core bodies in the deflection yoke, horizontal deflection transformer and high voltage transformer for television receivers is now finding wide acceptance. The ferrospinels are especially suited to television video frequencies as their use in these components results in improved performance at lower cost and with smaller space.

In the standard broadcast receiver, the ferrospinels are expected to be used in the radio frequency circuits as " trimmers " and as permeability tuning cores. With a properly designed coil it is possible to tune a circuit, by the movement of a ferrospinel rod, from 500 to 3000 Kc/s, or to cover the standard American broadcast band (540 to 1730 Kc/s) with only three eighths of an inch movement of the rod.

By using a ferrospinel with a high electric resistivity as the core body for radio frequency inductances, the wire body may be placed on the ferrospinel without additional insulation. In fact, the conductor may be affixed by the printed circuit technique for some applications.

SECTION 4 : MEDIUM WAVE-BAND COILS

(*i*) *Air-cored coils* (*ii*) *Iron-cored coils* (*iii*) *Permeability tuning* (*iv*) *Matching.*

(i) Air-cored coils

With large diameter formers reasonable Q can be obtained on the broadcast band with air-cored solenoids. However in limited spaces, coils are wound with two or more pies or by progressive universal winding when high Q is required. The progressive winding has the advantage of being less susceptible to inductance variation through careless handling or winding, and from the production point of view it is desirable because it can be wound without stopping.

Although high Q is not necessary for broadcast band oscillator coils, it is desirable. Low Q tuned circuits need larger reaction windings which in turn give increased