The Mystery of the Receiver

An Old Subject from a New Angle

(By "Pentode")

WHEN an electric current is passed through a wire, magnetic lines of force are set up about the wire, creating a magnetic field. The intensity of this field depends upon the amount of current flowing through the wire and also the distance from the wire. This is dealing with a straight piece of wire, and an example of this can be seen in the precautions taken in arranging land lines used in telegraphic communication. When run between poles the wires are zig-zagged and run to different insulators on adjacent poles. Conversations on one wire which runs parallel to a second wire for any distance would interrupt communication on the second line.

If a wire through which a current is flowing is wound in the shape of a coil, the field is considerably increased. In the plain solonoid coil, that is, a single coil with open ends, the field is most intense along the axis, and lines of force spread out, round the coil from end to end.

This field exists round coils through which current, either direct or alternating, is flowing. In the case of alternating current, the direction of flow is constantly changing, and the polarity of either end changes with the alternations. The speed at which these alternations occur is called the frequency, usually denoted as so many cycles per second. High frequency or wireless waves have a frequency of many million per second, while audio frequency currents vary from 30 to 20,000 cycles or alternations per second. It can be seen then that wireless or high-frequency current differs from low frequency current only in the number of alternations that occur per second, and in both cases a field will be produced if either of these currents pass through wire in the form of a coil.

In the case of audio frequency work, an iron core is introduced to further increase this field. Unless this iron core is magnetically saturated it will absorb the magnetic energy produced in the coil and being in most cases a shell type transformer, serve as a medium through which these lines of force travel from one end of the coil to the other, at the same time confining this field within itself.

Radio Frequency Transformers.

AS it is more with radio frequency coils that we are interested, we can assume a receiver, employing two high frequency stages, is constructed with coils lying a few inches apart and all in the same plane. Small radio frequency currents are set up in the aerial coil when in tune to a station. These currents are amplified by the valve producing similar currents in the second coil, only much more amplified.

The second valve amplifies these alternations still further. As the field of a coil depends on the current flowing, the last coil will have quite an appreciable field, and if visible, the lines of force would be seen to be cutting the lines of force of the first and second coils. When the output of a valve is fed back by accident or design, to the input, that valve commences to oscillate, and if the oscillations are uncontrollable, the circuit is out of control and refuses to amplify.

It is to the suppresison of these oscillations that radio engineers have devoted so much time during the last few years.

Controlling Interaction.

VARIOUS methods have been devised. The first, and most obvious, is to separate the coils so that the field from one does not reach the preceding coil. This is impracticable as the field increases as amplification proceeds, and coils would have, on occasions, to stand yards apart. An arrangement known as the Hazeltine circuit surmounted the difficulty to some extent by arranging the coils at such an angle that the lines of force from one coil cuts those from the other at right angles, thus producing no coupling.

A further, and to the writer's mind an improved method of reducing this back coupling effect, is to reduce the field of each coil by an arrangement of winding.

Straight cylindrical coils with open ends are known as solonoid coils. If this coil was bent in the middle so that two halves lie side by side with the previous opposite ends brought together, the coil is known as a binocular. In the electrical properties concerning inductance, etc., the solonoid and binocular are practically identical. In the case of the latter, however, the field is restricted and considerably reduced.

The torridal coil is very similar, being merely a solonoid coil bent round instead of being bent sharply in the middle as in the binocular. When these field restricted coils are used in a receiver they can be placed comparatively close to each other without sufficient coupling existing to set the valve oscillating. Yet another method adopted by many commercial manufacturers is the introduction of damping into the circuit in the form of resistance.

Why a Valve Oscillates.

WHEN a tuning system, say a coil and condenser are tuned to a given station, small oscillations which continue as long as the station feeds minute amounts of energy to keep them going, are set up in that coil. If the station stops, then these minute oscillations also stop. These small impulses of current are fed to the grid of a three-electrode valve, in the plate circuit of which is a coil which can be adjusted with respect to the first coil.

These impulses of current appear in this plate coil in an amplified form. As the current takes practically no time to travel through the valve between the two coils, the two sets of oscillations can be assumed to be in phase. Now we come to an interesting point.

It has been stated that oscillation in the first or grid coil are kept in motion by the incoming oscillations from the station to which the system is tuned. By gradually increasing the coupling between the plate and grid coils energy is given by the plate coil in the form of oscillations exactly in phase with those of the grid coil and in turn with those of the station. "Every little helps," says the grid coil, and it oscillates with renewed vigour. This is desirable from a point of reception, as enormous amplification, far in excess of that of the amplification of the valve itself, is obtained. There comes the natural question. Why not increase this feed back still further and obtain all the amplification that is desired. Well, let us see just what would happen.

Controlling Feed Back.

ASSUMING this coupling to be gradually increased, there comes a time when the valve would generate oscillations itself, still at the same frequency as that of the station, but absolutely uncontrollable by the transmitting station. If the station stops altogether, the valve would still oscillate, and as it is the station the operator is listening to and not one's oscillating receiver (which is very often decidedly not the case), whatever the station is broadcasting will be entirely marred by one's own generated oscillations. Also, as has been stated before, a valve will not amplify when oscillating itself.

The amount of back coupling necessary to produce these oscillations depends on a number of factors. The chief one being the resistance of the grid coil. If of a high resistance, then more coupling and more energy will have to be imparted to start this state of self oscillation. In the average broadcast receiver, these coils are of a fairly low resistance and it needs only a little feed back to produce this undesirable effect. Assuming that these various coils are not of the binocular or similar types, and no arrangement is made whereby lines of force cut at right angles, then the feed back can be utilised in overcoming the resistance of the grid coil by placing additional resistances in one of the leads. This explains then how some commercial manufacturers keep the valves below oscillating point by damping one, or each of the tuning systems.

Effect of Screening.

THERE is still the best method of all to be considered, and that is the screened stages. By this is meant the total isolation of each stage, comprising usually coil and condenser, by a metal screen. To be quite successful this has to be an absolutely tight compartment and made of a metal with a good electrical conductivity. It is out of the question to make one of pure gold, which is one of the best known conductors. Running down the list we soon come to copper, which is quite the best practical material to use. Aluminium follows close behind and there is very little to choose between the two.

When magnetic lines of force, or rather we should say, alternating magnetic lines of force, come in contact with the conductor, a current drains away through that conductor. This energy then, passing through space, is converted to an electric current when in contact with a conductor. As an example, the outside aerial receives the wireless waves which are resolved into a flow of electricity down the lead into the set.

Let us consider again the screening between successive stages. These small currents produced leak away and are known as eddy currents. Having leaked away, they cannot come in contact with the coil, from which they are screened, and no feed back is produced.

Suggestions for Screening.

A few remarks regarding screening will, perhaps, not be out of place, and if mentioned here, will, perhaps, be more readily understood.

It has been stated that reaction or feed back reduces the resistance of the grid coil. In a receiver employing reaction intentionally, the construction, guage of wire and spacing, etc., of the grid coil is of little importance. This is a statement which numerous readers will, no doubt, question, but when looked on from the theoretical aspect, it will at once be realised that to bring the grid coil to maximum efficiency, simply needs the addition of more reaction. But this is beside the point.

If a screened receiver is built to reduce all chances of a feed back occurring with no reaction, then the grid coil of all the valves will have to be designed to be of as low a resistance as possible. Thick wire well spaced is indicated, and the coil kept as far from the sides of the screening box as possible. Condensers will have to be of good quality, and all insulation to be very thorough.

This article has dealt entirely with the coupling existing between coils. In a later number, the writer intends to consider the other path, through which