BEGINNERS start here... 7

An Instructional Series for the Newcomer to Electronics

Shown here are a number of small inductors and transformers such as are commonly used in transistorised equipment.

The components in the rear half of the photograph are, reading from left to right, as follows: ferrite aerial as used in portable transistor radios; intermediate frequency (i.f.) transformer with iron dust core, and its screening can; audio frequency (a.f.) transformer with laminated iron core; and another i.f. transformer.

In the foreground, left to right are the following: radio frequency (r.f.) inductor or "choke" having an inductance value of about 2.5 millihenrys; miniature a.f. transformer with laminated iron core; r.f. choke of about 20 millihenrys—this form of construction with sectional windings is used to minimise self-capacitance effects; and finally a ferrite ring with single winding, this is used in computer "memory" circuits.

So far in this series we have met the resistor and the capacitor. It will be recalled that these are the names for components or parts which are designed to make use of the properties of *resistance* and *capacitance*, respectively. There remains one other basic electrical property, this is *inductance*. In fact there are two kinds of inductance, self-inductance and mutual inductance, and both occur through the action of magnetic fields produced when an electric current passes through a wire or other conductor.

The component that makes use of self-inductance is called an *inductor*. It may be a simple coil of wire, or it may be wound in a certain peculiar fashion, and may or may not have an iron core.

The component that utilises the mutual induction effect is called a *transformer*. Again, this may be simple or complex in construction, but essentially it consists of two (or more) windings in close proximity to each other.

ELECTRO-MAGNETISM

Surely it is remarkable, but just as surely taken for granted nowadays, that the flow of electric current produces a magnetic field; and that a *moving* magnetic field, in turn, makes current flow in nearby conductors.

The first effect was noticed by accident, but the reverse effect was carefully thought out, and tested by experiments, by the scientist M. Faraday back in the last century.

The experiments to be described later will enable you to study the formation of an electric current by moving magnets to and fro. Notice that no current is obtained if the magnetic field is steady.

Of course, instead of the permanent magnet, the field can be produced by a current flowing in a coil. This current can then produce a further current in a separate coil nearby, see Fig. 7.1.

Coiling the conductor concentrates the magnetism from each turn, and forms a strong field. Also, using an iron bar or magnetic core makes a strong increase in the magnetic effect—in an analogous way to the dielectric increasing the electric field in a capacitor.

The "induced" current in the second coil only flows when a *moving* field links with the turns of wire, but it is not necessary to move the first coil, as in the case of the magnet, because if the current in it is turned on and off, then the field builds up and collapses in sympathy—in other words moves. Thus currents flow in the second coil in sympathy.

Obviously you will see already the importance of alternating current in electronic devices—it is changing rapidly all the time.

The above linking of circuits with a magnetic field is called *mutual induction*, and the circuits are said to be magnetically coupled. Mutual induction is used in transformers; it is also used in induction heating, where the strong, rapidly changing fields round a coil induce currents into a nearby metal so that it becomes red- or white-hot. This is useful when the metal part to be heated is inside a vacuum tube, see Fig. 7.2.

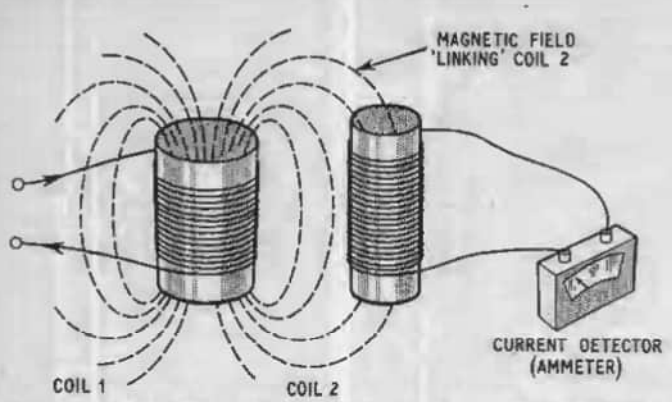

Fig. 7.1. The "lines of force" representing the field produced by the current in the first coil, link with the second coil. If the field moves relative to this coil then currents are set up in it. The amount of linking of the field is called the degree of coupling between the coils

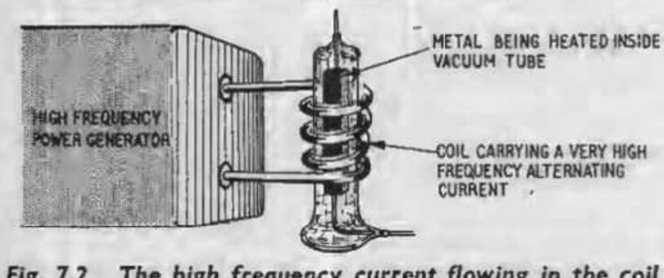

Fig. 7.2. The high frequency current flowing in the coil produces a rapidly changing magnetic field, which causes large currents to flow in the metal placed in the centre of the coil and these "eddy currents" as they are called, make the metal hot

This induction effect is also used in the "magnetic memory matrix" units in some computers. These consist of a large number of tiny rings of a magnetic material called a "ferrite" in which the magnetic field can go round, as it were, in a clockwise direction or an anticlockwise one. Conductors link these rings as shown in Fig. 7.3. Pulses of current sent in at the

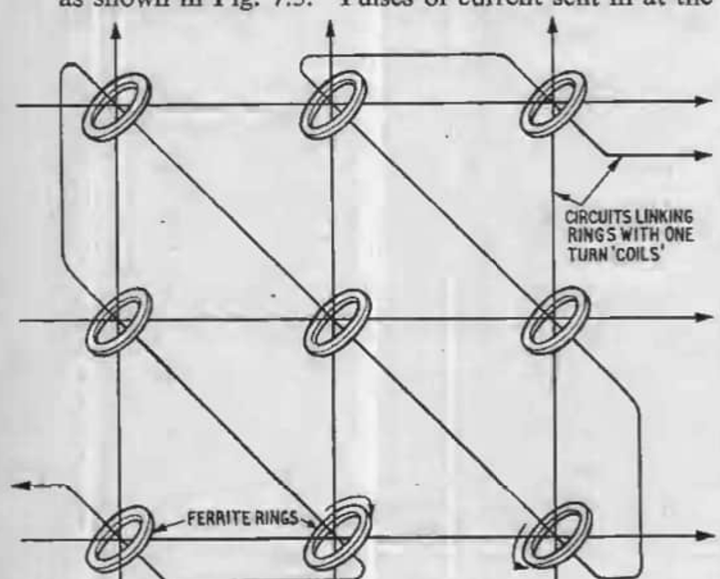

Fig. 7.3. The leads linking the ferrite rings are one turn coils, and when a pulse of current passes through both a horizontal and vertical wire at the same time, the field is switched in the appropriate ring. The field can be in one of the two directions indicated by the arrows. The diagonal wire is the "readout" circuit. It conveys a pulse to the computer whenever a ring has its field direction changed

right points set the magnetic fields in the rings into a pattern of clockwise and anticlockwise circulation. Clockwise would correspond to "0" and the other way to "1". Computers usually count up to "1", i.e. the *Binary System*, so here is a whole pattern of information held for an indefinite time, and ready to be extracted later by currents induced into conductors (when the fields are made to change over to the other direction).

AN INDISPENSABLE EFFECT!

Consider all the rows of tiny magnets—all varying in strength—which are on the surface of a piece of magnetic recording tape with "signals" on it. As the tape moves past the "playback" head, the magnetic field variations induce small currents in the coil on the head.

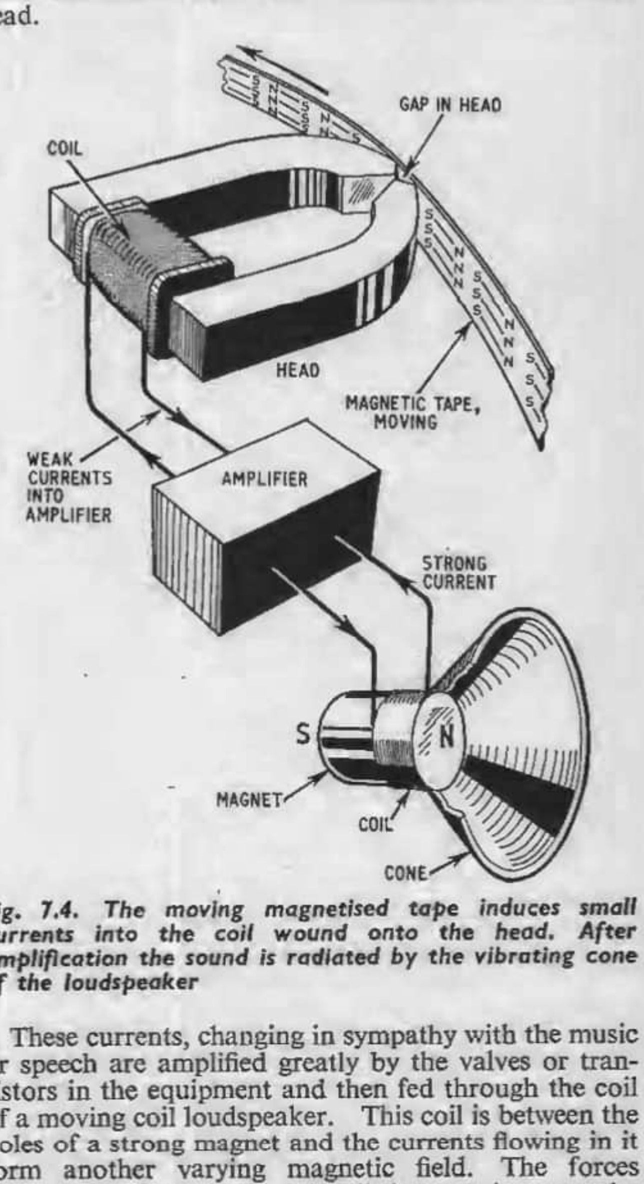

Fig. 7.4. The moving magnetised tape induces small currents into the coil wound onto the head. After amplification the sound is radiated by the vibrating cone of the loudspeaker

These currents, changing in sympathy with the music or speech are amplified greatly by the valves or transistors in the equipment and then fed through the coil of a moving coil loudspeaker. This coil is between the poles of a strong magnet and the currents flowing in it form another varying magnetic field. The forces between the fields push and pull the cone in sympathy with the music or speech variations—and sound waves are radiated to our ears. This chain of events is illustrated in Fig. 7.4.

We could go on listing the vast number of devices using effects similar to the above! But, may we encourage you, the reader, to think about the operation of these other things—the principles are all the same; for instance the small magnet moved by the stylus of a magnetic gramophone pick-up. . . .