APPLICATIONS OF CATHODE RAY TUBES I

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An early use of cathode ray tubes was in the study of alternating electric potentials. In comparison with mechanical oscillographs, such as the loop oscillograph, the cathode ray tube has the advantage that the beam of electrons has practically no inertia, and that therefore very high frequencies and phenomena of very short duration can be made visible. The rising technique of radio communication immediately seized upon the cathode ray tube as a welcome instrument of investigation. Due to the presence of two sets of deflection plates the beam of electrons can be deflected in two mutually perpendicular directions; this offers the possibility of examining the behaviour of a voltage as a function of the time in a very simple way, or of examining the relation between two voltages. In the first case the set of plates for horizontal deflection obtains its voltage from a "linear time-base", that is, a potential which increases linearly with the time for the whole period, and then falls back to its initial value again. In the second case one of the two voltages is applied to each set of deflection plates. If for instance the two alternating voltages are sinusoidal with an integral ratio between their frequencies, so-called Lissajous figures result.

The voltage necessary to obtain good deflection of the beam is about 20 to 60 volts, the load on the source of potential is then nearly zero, since a capacity of a few \(\mu F\) only is present as loading impedance between the deflection plates. It is obvious that this will sometimes be an important advantage, especially in working with high frequencies.

One very good feature of the newer cathode ray tubes is the fact that the fluorescence image on the screen is sufficiently brilliant to be observed in fairly light surroundings, thanks to its great brilliancy, so that photography is unnecessary unless it is desired to record a particular result. The direct observation of the fluorescence image is obviously of great advantage, since, as in the investigation of particular circuits, the result of changes in the circuit may be seen immediately on the screen of the cathode ray tube.

The technical development of cathode ray oscillographs has taken these possibilities into consideration. In addition to large permanent set-ups of oscillographs with complete photographic equipment, more and more small portable equipments have recently come into use. In these smaller sets the cathode ray tube with its power supply, amplifier and time-base generator and synchroniser is built as a compact unit \(^1\), so that it becomes very simple to transport the oscillograph to the place where the phenomenon to be investigated is taking place. This is one of the factors which have led to the more general use of the cathode ray tube as a measuring instrument in the investigation of innumerable phenomena. In a series of short articles we shall discuss some of the applications. The articles will be illustrated by photographs of the oscillograms \(^2\) which may be observed on the screen of the cathode ray tube.

Oscillograms of power mains

The most obvious oscillograms of alternating currents or voltages are the curves recorded for power mains. The oscillograms of figs. 1 and 2 offer little that is new to the electrical engineer. Upon careful consideration it will be seen that the curve of fig. 1 is slightly more angular than that of fig. 2. Such differences may be of influence on the calibration, of voltmeters or wattmeters. Although the two curves in this case were obtained from two different mains, the same mains can also give different curves according to the nature of the load. It is sometimes important to know whether or not a given load on the mains, added to the circuit at a point far from the power station, will cause a distortion of the voltage curve, and to know the extent of such deformation. In such cases a convenient portable oscillograph offers great practical advantages. A rapid demonstration on the spot in the form of an oscillogram can obviate long discussions.

Although upon comparison of fig. 1 and 2 the latter appears the least deformed, it is not permissible to conclude immediately that the latter source of voltage will in every case give less departure from normal behaviour. If the voltage to be investigated is not connected directly but through a simple RC circuit (fig. 3) with the cathode ray oscillograph, the main frequency may be very much suppressed with respect to harmonics of

\(^1\) Such an apparatus was described fully in Philips techn. Rev. 1, 147, 1936. The cathode ray tube of the type DG 9-3 with a screen diameter of 9 cm is used. The following oscillograms were recorded with this apparatus.

\(^2\) The photographic recording of oscillograms is usually very simple. The photographs in this article were made with a very simple box camera and an extra lens; time of exposure about \(1/5\) sec.
much higher order. Afterwards these harmonics which have been filtered out may be amplified until they give a clearly visible amplitude on the cathode ray tube. In this way a new oscillogram

It will have been noticed that the general character of the curve in fig. 4 differs very much from that of figs. 1 and 2. The horizontal deflection is in this case not obtained from a linear time-base,

but from the 50 cycle alternating voltage of the mains. Since the filter does not completely suppress the fundamental frequency, an alternating voltage of 50 c/s is also present on the other set of deflection plates. The frequency of the latter is shifted in phase with respect to the mains voltage, and thus gives rise to the elliptical figure. This device is used in this case in order to make sure immediately without careful adjustment that the time-base is accurately synchronized with the mains voltage. This is important for the purpose of deciding whether the fine indentations have their source in the mains themselves or are due to an external source of interference. In the latter case the ripple will never be completely stationary, but will run more or less rapidly along the ellipse.

Finally a practical example will show how quickly it is possible to work with the cathode ray oscillograph. As was mentioned, an RC filter was necessary to obtain the curve of fig. 4. The resist-

![Fig. 3. A simple filter is connected between the mains and the deflection plates of the cathode ray tube in order to decrease the intensity of the fundamental frequency of the alternating voltage between the plates.](image)

![Fig. 5. Practical construction of the filter circuit represented in fig. 3.](image)
ance was here formed by the input potentiometer of the built-in amplifier, while the capacity was formed by winding an insulated wire connected to the input terminal of the amplifier several times loosely around the unearthed power mains cable (fig. 5).

Phenomena such as that illustrated by fig. 4 led to the construction of "standard mains" with an artificial interference by overtones. In the Philips Laboratory such mains of 50 c/s with 3 per cent overtones of 500 cycles are used for testing radio receivers. The oscillogram of these mains is given in fig. 6.

The oscillograms of direct current mains also may sometimes be important. When the mains are not fed from an accumulator battery a ripple will usually be observed superposed on the straight line which represents the direct voltage. Figs. 7, 8 and 9 give examples of what may be encountered in practice. Fig. 7 is the oscillogram of 130 volt mains from a source of 40 kW, used in connection with various small motors. The ripple, which is due in general to the dynamo, can scarcely be distinguished. At night, instead of the 40 kW dynamo, a 6 phase rectifier of lower power is used. This makes no difference to the running of the machines connected with the mains. On the oscillogram, however, the successive crests of the sine curves of the six alternating current phases can be very clearly distinguished. The short oscillation of much higher frequency at the end of each crest is typical. It is from such an oscillation that interference may be expected. We shall return in a following article to give an example of this.

A third example of direct current mains is the oscillogram in fig. 9 of a 5 kW motor generator. With this smaller machine the ripple is much larger than in the cases of the more powerful machine.

If it is desired to examine the ripple of direct current mains in more detail, the same device may be employed as that with which fig. 4 was obtained, but in this case of course using a normal linear time-base.