## FACSIMILE TELEGRAPHY

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## PART I

### INTRODUCTION

Facsimile telegraphy refers to the transmission and reception of pictures, documents, maps or diagrams.

Phototelegraphy is that branch of facsimile telegraphy which concerns the transmission and reproduction of as near as possible a correct tone range. Documentary facsimile telegraphy however is only concerned with the reproduction of a very limited tone range near the two extremes of black and white.  Both these systems are in daily use, the former by the Post Office (E.T.E.) and newspaper offices;  the latter by the Post Office, the Services, and many private firms.

Facsimile telegraphy transmits only still pictures, each of which requires several minutes for transmission, and should not be confused with television which transmits twenty-five pictures per second, so creating the illusion of motion.

The general principle is for the transmitting apparatus to traverse, or "scan" the original picture (or document etc.) as a series of lines, and by photoelectric means to produce an electric current which is proportional to the intensity of light reflected from each section of the picture.

At the receiving end a recording blank is scanned by some marking device in the same manner that the original was scanned at the transmitter.  The recording blank can be light sensitive (such as photographic film) in which case it is scanned by a light beam - or it may be a specially made paper capable of being marked directly by means of a scanning stylus.  The intensity of the light beam on the stylus voltage is controlled by the received current, the magnitude of which corresponds to the intensity of light and shade of the transmitted picture.

If a film is used it is then developed and processed in a similar manner to a normal photograph, but if the copy is directly recorded on special paper no further processing is required.

To preserve a correct tone range as is usually necessary in phototelegraphy, transmitted currents must be proportional to the "whiteness" of the picture at any instant during the scanning process.  Film or bromide paper is then used at the receiver;  the former providing a negative, the latter a positive copy.  If only a very limited tone range is required - as is normally the case with documentary facsimile work, special direct recording papers providing an immediate positive copy are satisfactory and the transmitted currents need not be proportional to the scanned message whiteness.

## BASIC PRINCIPLES

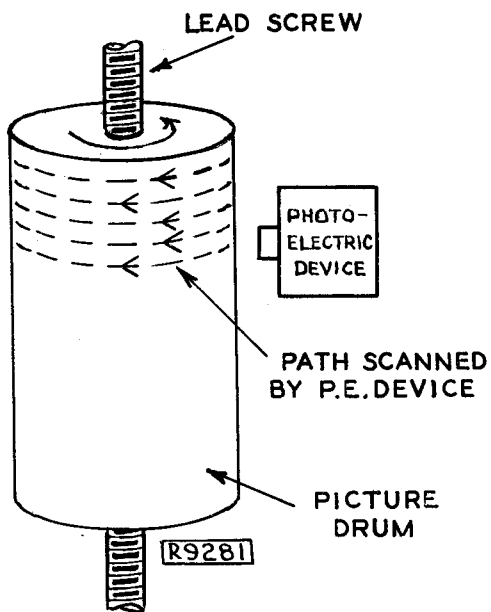### Scanning and frequency response



Fig. 1

The method most frequently used to scan the subject being transmitted is to mount it on a drum controlled by a lead screw; thus, as the drum rotates it advances by a distance proportional to the pitch of the screw for every revolution. In this manner all parts of the subject are brought consecutively (in the form of a spiral) under the aperture in the photo-electric device as shown in Fig. 1. The means by which this device scans the drum surface is more clearly shown in Fig. 2.
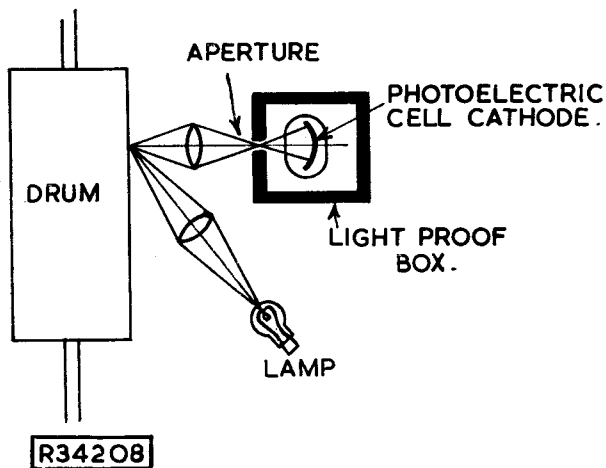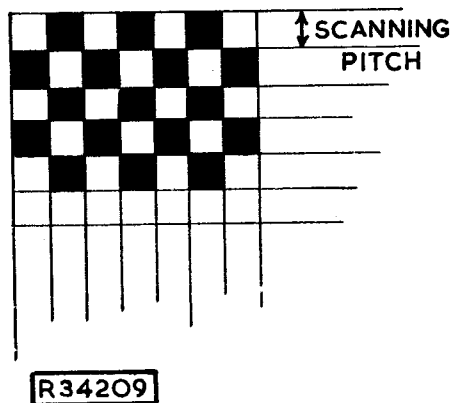


Fig. 2



Fig. 3

The lamp beam is focussed by a lens to produce a small intensely illuminated area on the drum surface. A second lens then focusses light reflected from this illuminated area into the scanning aperture. A small portion of the reflected

light passes through the aperture and strikes the photo-electric cell cathode, the aperture itself being situated in one side of a light tight box enclosing the cell.

The output from the photo-electric cell consists of frequencies ranging from zero to a maximum determined by the definition required and the speed of scanning. The definition in one direction is fixed by the scanning pitch and under normal conditions it is assumed that the same degree of definition is required in a direction at right angles to this. The subject to be scanned may therefore be considered as being made up of elemental squares each having a side of length equal to the scanning pitch as shown in Fig. 3. The maximum frequency that will be produced at the cell output can be represented by the condition that exists when the picture consists of alternate black and white picture elements.

In order to determine the band-width required for a phototelegraph transmission a typical example will now be taken.

The drum used on a phototelegraph transmitter is 88 mm in diameter (27.6 cm circumference) and is rotated at 60 r.p.m. The pitch of the lead screw and associated gearing is such that the drum makes 40 revolutions in advancing a distance of 1 cm, i.e. each line is $1/40$ cm wide. Assuming that the transmitting photo-electric device is capable of resolving an element of the picture $1/40$ cm square, then the maximum frequency it is required to transmit will be given when the picture consists of alternate black and white picture elements.

Number of black and white picture elements per line $= 27.6 \times 40$

$\therefore$ Number of picture elements per second $= \dfrac{27.6 \times 40 \times 60}{60}$

$= 1104$

Considering each pair of black and white elements as representing one cycle, then the maximum frequency transmitted $= \dfrac{1104}{2}$ c/s

$= \underline{552}$ c/s

The minimum frequency it is required to transmit will be given when the picture is of a uniform shade i.e. the current to line is not varying. Hence for the particular system discussed it is necessary to transmit a band of frequencies ranging from zero to 552 c/s at least, in order to obtain perfect reproduction. A still wider band would be required if it were necessary to reduce the time taken to transmit the particular picture, or to provide a higher definition.

Normal line limitations and problems of d.c. amplification prevent the direct transmission of this range of frequencies from the transmitter to the receiver. Therefore, in all cases a carrier frequency is employed and is modulated by the photo-electric cell signals. Amplitude or frequency modulation can be used, and it is usually termed sub-carrier amplitude (or frequency) modulation to distinguish it from the normal telephone land line or radio carrier frequencies. The sub-carrier frequency is chosen to be near the centre of the pass range of the average telephone speech circuit; 1900 c/s is the frequency recommended by the C.C.I.T. This permits the transmission of a maximum photocell frequency of approximately 1000 c/s, representing 1900 ± 1000 c/s to line. For high quality work, however the maximum is usually limited to 500 c/s to avoid phase distortion that can cause trouble with frequencies too far removed from the centre of the pass range of the transmission path.

The photocell signals are recovered at the receiver by demodulation and are then used to operate the marking device.

## Index of Co-operation

To ensure that, within practical limits, an exact facsimile of the original will be reproduced at the receiver, two basic conditions must apply:, (i) The transmitter and receiver drums must rotate at the same speed and (ii) the recorded copy must possess the same aspect ratio as that transmitted. The aspect ratio - or ratio of the lengths of the two sides of the copy (assuming it is scanned in lines parallel with one of these sides) is stated in terms of the index of co-operation.

The index of co-operation, M, is defined by the formula

$$M = \frac{D}{P} = DF$$

Where D is the diameter of the drum

P is the pitch of the helix formed by a series of scanning lines.

F is the scanning density (lines per unit length).

Applying this formula to the previous example

$$D = 88 \text{ mm}$$

$$P = \tfrac{1}{4} \text{ mm (per line)}$$

$$\text{or } F = 4 \text{ lines per mm}$$

$$\text{Then } M = \frac{88}{\tfrac{1}{4}} = 88 \times 4 = 352$$

If both transmit and receive machines have the same index of co-operation the received copy will have the same height to width ratio as the transmitted copy although the actual size may be different.

Maintenance of the correct index is important in phototelegraphy where high quality pictures are to be transmitted, but in some cases with documentary facsimile telegraph work it is advantageous to enlarge the copy in the scanning direction. In this case the transmitter index is smaller than that at the receiver but it is still necessary to maintain the same drum speed.

## Transmitting Devices

### Early methods

Early equipment employed various means of converting the tones of the picture into equivalent electric currents. These were, in the main, based on the use of a sheet of metallic (copper) foil covered by some insulating compound, such as wax or gum bichromate. The picture was then printed on this sheet using a process that removed the insulating covering at all points corresponding to black in the picture. A pin-point metallic contact was then used to scan the foil surface. With suitable circuit arrangements a current was made to flow between this contact and the foil

when the two made contact on the black parts of the picture. At other points the foil was insulated and current could not flow. This system did not transmit a tone range and was therefore only suitable for the transmission of prints, diagrams and similar documentary material.

Development of the selenium cell permitted the direct control of an electric current by the intensity of a light beam. One form of selenium cell consists of two separate wires wound round a flat plate of glass or slate, in such a manner as to form a close mesh having two separate electrical conductors. A thin layer of selenium is deposited on the mesh and, after suitable heat treatment, forms a conducting path between the two mesh connexions whose resistance varies according to the intensity of light reaching its surface.

A great disadvantage of the selenium cell is that there is an appreciable time lag between a change in light intensity and the corresponding change in resistance, and for this reason as far as facsimile is concerned it has been superseded by the photo-electric cell.

## Modern Methods

The photo-electric cell, in one form or another, is used for scanning on practically all modern facsimile equipment. The operation depends upon the action of light on an electrode enclosed within an evacuated or gas-filled glass envelope. This electrode is termed the cathode and is covered with an extremely thin deposit of caesium-silver or similar photo-sensitive material. When light strikes the caesium-silver surface electrons are emitted at a rate proportional to the intensity of the incident light. Another electrode, the anode, is held at a positive potential with respect to the cathode. It is constructed so as not to unduly obstruct the light striking the cathode but attracts the emitted electrons thus causing a current to flow in the external anode-cathode circuit. A load resistor is included in this circuit to provide a source of voltage directly related to the current and hence proportional to the intensity of light reaching the cathode. In a completely evacuated photo-cell, above a certain value of polarizing voltage, the current is proportional to the light intensity only. Some forms of photo-cell, however, contain traces of argon or other inert gas in order to increase the sensitivity by utilizing the ionization characteristic; the current in these types is proportional to the polarizing voltage as well as the light intensity. The voltage used is of the order of 150 volts depending upon the type of photocell employed; where gas-filled cells are used the voltage must not be so high as to cause ionization glow to occur and the working point is about 10 volts below this point.

The photocell does not suffer from any appreciable time lag, the measured value being better than $3 \times 10^{-9}$ second, but in view of the very low current produced (of the order of $10^{-8}$ amp) a valve amplifier is necessary and care must be taken to keep out any stray e.m.f.s by careful screening of the components.

The sensitivity of a typical gas-filled cell is 130 milliamps per lumen under given conditions.

A photoelectric cell of increasing importance in facsimile work nowadays is the multiplier type. This is a vacuum type photocell in which advantage is taken of secondary electron emission to achieve amplification within the cell. Photo-electrons emitted by the cathode are directed towards an auxiliary electrode, termed

the "dynode" which is maintained at a positive potential with respect to the cathode. The bombardment of the dynode causes it to emit a greater number of secondary electrons than the number of primary electrons initiating the secondary emission. An anode maintained at a positive potential with respect to the dynode collects the secondary electrons, but it is usual to have several dynodes within the same cell, each at a higher positive potential than the previous one and each contributing its quota of amplification. A load resistor is connected in the final anode circuit and provides a source of voltage proportional to the light incident on the photocell cathode.

One type of nine-stage multiplier photocell in common use provides a gain of $10^6$ and a sensitivity of the order of 10 amps per lumen with a maximum anode current of 1 milliamp.

## Receiving Devices

### General

At the receiving end of the system, the picture blank is scanned in the same manner as the picture at the transmitter and the image is built up line by line in accordance with the received currents.

Recording methods can be divided into two basic groups:

In the first group photographic film, or bromide paper, is used as the recording blank and it is exposed during the scanning process to a light beam controlled by the received signals. The recorded copy must undergo normal photographic development before the latent image becomes visible. By this method high quality photographs having an excellent tone range can be reproduced.

The second group comprises recorders that provide a visible copy suitable for immediate use without further processing. These machines use either an electro-thermal, electrolytic or percussion process.

In the electrothermal method a high voltage (a.c. or d.c.) is applied, by means of a metal stylus, to a light coloured varnish on the surface of a special recording paper having a metallic backing. This metallic base is in contact with the earthed drum (or platen) and provides the return path for an arc current which burns through the varnished surface. Between the varnished surface and the metallic backing, the paper fibres are impregnated with carbon and when the arc vapourizes the surface coating, the carbon becomes visible thus providing a black copy. When a "white" signal is received the voltage is not applied and the original varnish provides the white background.

The electrolytic process depends upon the production of a black dye when current flows through a damp paper containing certain chemicals. The recorded copy although slightly damp, very quickly dries and is suitable for immediate use.

Plain paper and normal ink are used in a percussion recorder. The ink is carried either on a small wheel or in a pen which is mechanically connected to the armature of an electromagnetic unit. When receiving a "black" signal the unit is energized so as to cause the wheel (or pen) to strike the paper and thereby provide a black mark. The wheel (or pen) is lifted off the paper when receiving a "white" signal.

The second group of recording methods is mostly used for documentary work. The copy generally provides a very limited tone range although in some cases under suitable conditions fair photographic results can be obtained.

## Methods of Light Control

There are several methods of producing the controlled beam of light necessary at the phototelegraph receiver. Early systems included the glow discharge lamp, the vibrating-tape light-shutter and the Kerr cell.

Present day phototelegraphy systems employ either an oscillograph or crater lamp method of light control.

The Oscillograph - The received current is amplified and rectified electronically and the rectified current is passed through an oscillograph consisting of a coil of wire placed in a strong magnetic field. A small mirror is mounted on the coil, the coil supports and inertia of the system as a whole being so arranged that it can respond to rapid changes in current; the angular movement of the coil and the mirror is proportional to the strength of the current. Light from a fixed lamp is projected on the mirror and the reflected rays are passed through a specially shaped aperture, after which they are focused as a spot on the film drum by a system of lenses. The aperture is so arranged that the intensity of the light spot varies with the amount of deflexion of the coil and is adjusted to give the correct relationship between received current and light intensity to suit the photographic requirements of the film.

The crater lamp - This lamp is a development of the neon or rare gas filled tube and produces what can be considered as a point source of comparatively high intensity light. The light intensity is proportional to the current flow through the tube and the lag in its response can be ignored at frequencies up to about 1000 c/s.

## Synchronization

In order to build up the received picture correctly it is essential that the scanning systems at the transmitting and receiving ends operate in synchronism and the problem of synchronizing the two equipments has been tackled in a number of ways. The usual arrangement is to provide some form of frequency standard at both ends and use these to control the driving motors. Clocks have been used in this way, but most systems use tuning forks although some modern equipment makes use of crystal control.

Tuning forks have been used for some years and still provide the simplest form of standard frequency source for this purpose. The most direct method of fork control is by use of the phonic motor. This device is very similar in principle to the synchronous motor used in the synchroscope and consists of a stator which is fed with alternating current at a suitable frequency together with a polarizing direct current in such a manner as to set up a rotating magnetic field. A toothed soft-iron rotor moves inside the stator and if the rotor is run up to a speed such that it moves forward one tooth for each cycle, it will fall into step and run synchronously. One common form of this motor, has 51 rotor teeth and runs at 20 revolutions per second when fed with 1020 c/s the synchronizing frequency standardized by the C.C.I.T.

Another method of synchronizing a machine consists of providing a d.c. motor driving an alternator which, at synchronous speed, generates the same frequency as the controlling frequency standard. The output of the alternator is fed into the anode circuit of a valve, and the control frequency to the grid. If the two frequencies are in synchronism, the valve will present a constant load to the alternator. Any change in mechanical load on the motor will change the phase of the alternator output, and consequently the phase relation between the grid control voltage and the anode voltage from the alternator. This will alter the load on the alternator in such a direction as to tend to maintain synchronism.

Control methods of the type described above are used whether the frequency standard is a tuning fork or a crystal and even in cases where the synchronizing frequency is transmitted over the system. In the case of crystals, a frequency divider has to be introduced to bring the frequency to a suitable value for operating the control, the frequencies used for this purpose in recent years being between 500 and 2,000 c/s.

Recent development of simple documentary facsimile equipment has necessitated the introduction of a less complicated means of synchronization. This has been achieved by driving the equipment by motors synchronized with the 50 c/s a.c. mains and provides reliable results throughout the grid-controlled mains network.

## Phasing

Having established that the transmitting and receiving mechanisms are synchronized it is also necessary to ensure that the scanning devices occupy the same relative positions with regard to the picture and the picture blank. If this operation, known as "phasing", were not performed, there would be every possibility that the received picture would not fall completely on the picture blank i.e. the joint in the film would occur in the picture. The method of phasing varies with the system, of which there are, broadly speaking, three classes. In the first class, the picture drum at the sending end may be started off from a definite position by means of a mechanical or electromagnetic clutch, together with the simultaneous transmission of a starting signal which operates a similar clutch at the receiving end, thus starting the receiving drum from the same relative position. Such a signal may be given by the interruption of the picture carrier current at the sending end. In the case of the second class of system, the driving mechanisms at the two ends of the circuit are in continuous operation and the demountable picture drums engage the driving shafts in one position only. Phasing in this case is carried out by mounting a neon lamp on the shaft at the receiving end such that it rotates with the shaft, the neon lamp being energized once per revolution by a phasing signal from the sending end. This signal may be from a contact on the transmitter shaft or alternatively a white line may be painted on the transmitter shaft in such a position that it is scanned by the transmitting device, thus causing picture carrier to be sent to line which in turn is used to energize the neon lamp at the receiving end. Since the two shafts are in synchronism, the neon flash will always occur at the same point on its path of rotation and the phasing of the receiving equipment is then altered until the flash occurs at some pre-determined position where the two shafts are in phase. The change in phasing of the receive equipment may be carried out by putting the machine out of synchronism until the phasing is correct or by turning the stator of the control alternator where this is used.

The third class covers a method introduced to simplify automatic phasing where unattended operation of the receiver is desired. This, of course, only applies to direct recording systems. There, one machine is made to run several percent faster or slower than the other. Contacts fitted on both instruments operate at the picture blank, or 'clip' position and eventually, due to the speed difference between the machines these operate simultaneously. A condition is then set up to restore the machine which is running off-speed (fast or slow) to its normal synchronizing speed thus setting both equipments to the same relative positions.

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PART III

SYSTEMS IN USE

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A brief description of two systems is given below in order to show the build up and special features of facsimile telegraph systems.

The Muirhead-Jarvis System
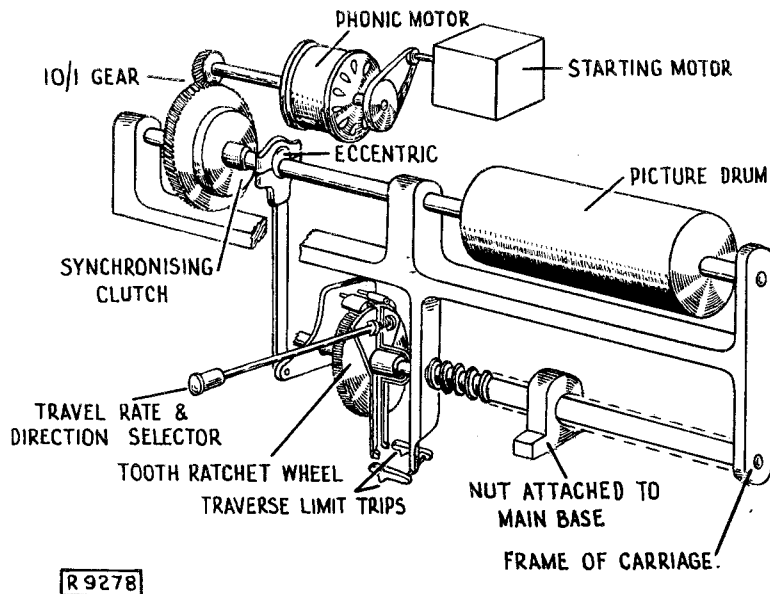


The equipment in this system is entirely mains operated and arranged for use in full daylight, a dark room being necessary only for loading the drum and developing the received picture. In both transmitter and receiver, the picture drum and the phonic motor which drives it, are mounted, together with a lead screw of $\frac{1}{2}$ in. pitch, on the carriage, which runs on a slide formed on the main bed of the machine.

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Fig. 4

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The lead screw runs in a nut which is fixed to this bed such that if the lead screw is turned, the carriage moves forward. The drum spindle carries an eccentric which works a rooker arm bearing a pawl. This pawl engages with a 150 tooth gear wheel attached to the lead screw, and, for each revolution of the drum spindle, feeds it round by a certain number of teeth and thus moves the carriage. The number of teeth which the pawl is allowed to feed on is determined by a sector plate over which it runs, and which keeps it clear of the ratchet wheel. It is only when it runs over the edge of the sector plate that the pawl can engage with the ratchet wheel and by altering the position of this sector plate, the pawl can be made to feed 0, 2 or 3 teeth per revolution of the drum. 0 corresponds to neutral, 2 gives 150 lines of scanning per inch and 3 gives 100 lines per inch. Actually, as will

be seen from Fig. 4, two pawls are provided, back to back, and two separate sector plates. When one pawl is in operation, the other is lifted clear by its sector plate and vice versa thus giving two directions of traverse, enabling positive prints or negatives to be obtained. Two drum speeds are provided, one of 1 r.p.s. and the other of 2 r.p.s., the changeover from one to the other being effected by using 1020 c/s direct from the synchronizing tuning fork for the 2 r.p.s. and half this figure for the 1 r.p.s. speed.
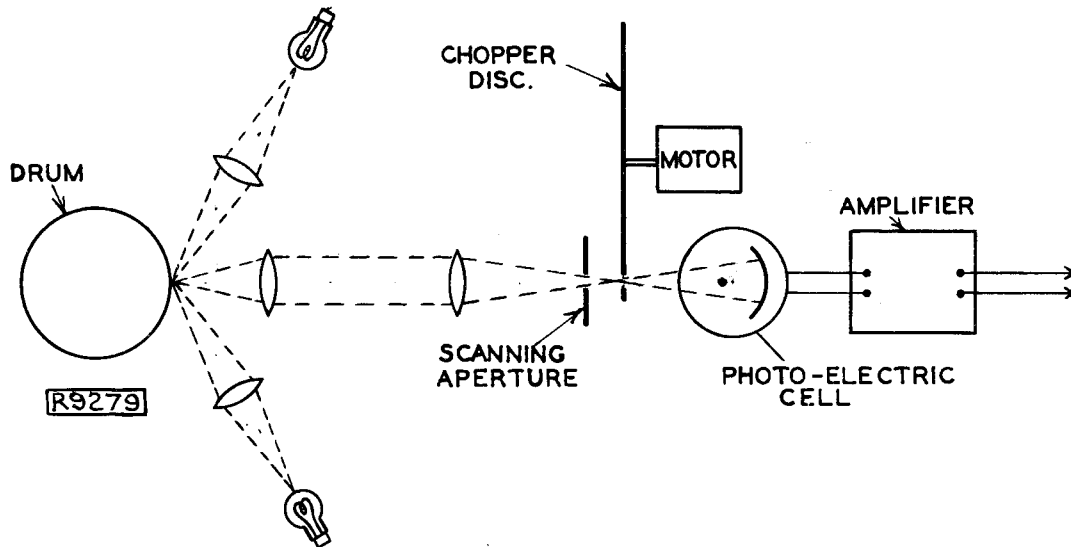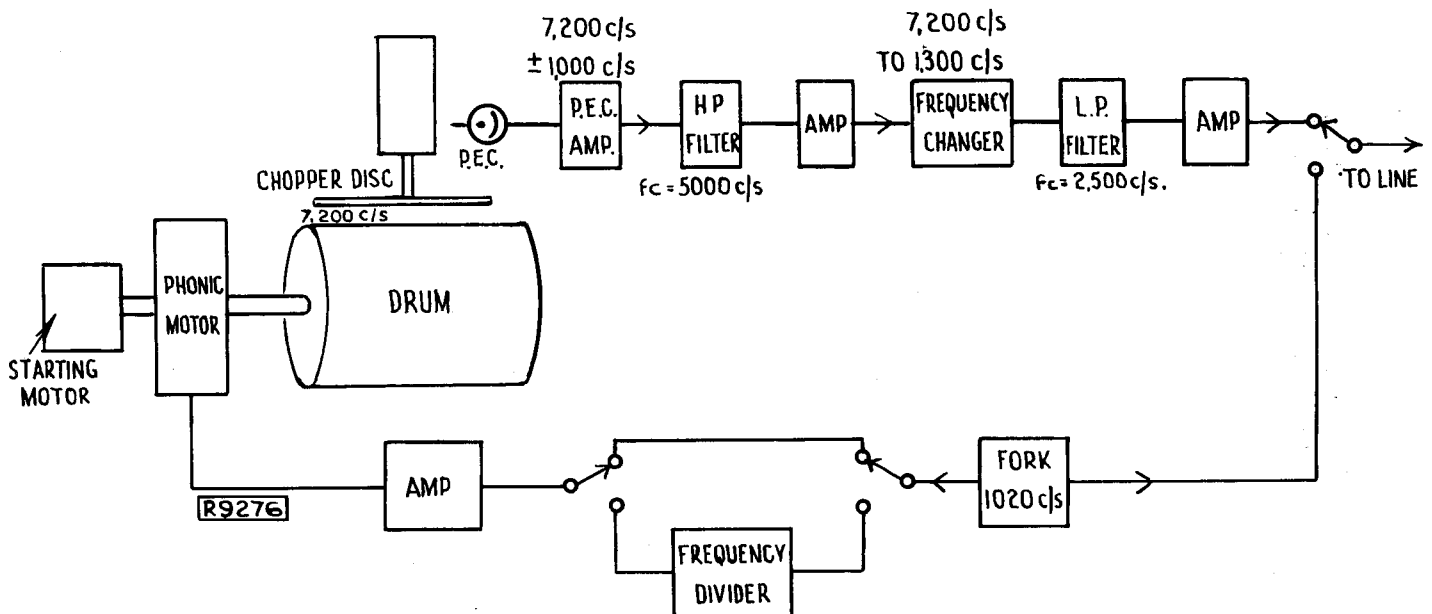


Fig. 5



Fig. 6

Fig. 5 shows the optical system employed at the transmitter whilst Fig. 6 shows the block schematic of the complete transmitter. Light reflected from the picture on the drum reaches the photocell via a chopper disc which interrupts it

7,200 times a second.   The output from the photocell, after amplification, is
passed through a high pass filter having a cut-off at 5000 c/s where the actual
picture frequencies of 0-1000 c/s are removed, and a carrier of 7,200 c/s modulated
with the picture signal 0-1000 c/s, is left.   After further amplification this
modulated signal is fed into a frequency changer with an oscillator frequency of
5,900 c/s.   This delivers a carrier of 1,300 c/s modulated with the picture signal
which is selected by means of the low pass filter, the 5,900, 7,200 c/s and unwanted
modulation products being suppressed.   The 1,300 c/s modulated carrier undergoes
further amplification before transmission to line.

The receiver optical system and block schematic are shown in Figs. 7 and 8
respectively.   The incoming signal is amplified in two stages, the first being a
normal amplifier whilst the second is non-linear to provide some measure of
compensation for the non-linear photographic characteristic of the film or paper.
From this point the signal passes to a demodulator and low pass filter, at the
output of which appears the actual picture signal of 0-1000 c/s.   This is fed into
the Duddell oscillograph unit, and the mirror on the oscillograph deflects a beam
of light across an aperture thus regulating the amount of light reaching the photo-
graphic material on the receiving drum.

Synchronization between the transmitter and receiver is obtained by providing
a tuning fork at each end controlling the phonic motor driving the scanning system.
The frequency of the tuning fork may be adjusted over a range of $\pm$ 2 parts in $10^4$
by rotating a magnet in the region of the tuning fork driving coils.   A change in
amplitude also takes place which is corrected by means of a potential divider ganged
on the same spindle as the magnet adjustment.   The two forks are synchronized by
observation of a cathode-ray tube pattern, the transmitting fork tone being sent
down the line for initial adjustment.   The receiving fork tone is fed to the
deflector plates of the cathode-ray tube through a phase splitting circuit, similar
to the one used in the T.D.M.S., producing a circular trace.   The transmitting
fork tone is then applied to the grid of the tube and causes the electron beam to
be cut off during a portion of the cycle.   This gives a figure on the tube which
is shaped like a horse-shoe and which, if the forks are exactly the same frequency,
is stationary.   To ensure correct phasing, the procedure adopted is to start the
transmitting drum by operating a switch which trips a magnetic clutch between the
phonic motor drive and the drum.   This clutch has only one tooth and so the trans-
mitting drum always starts in the same phase relationship to the drive.   A contact
on this drive makes once each revolution, and this sends the phasing signal down
the line to operate a magnetic clutch on the receiver.   This clutch consists of a
single pawl, bearing a fixed angular relationship to the start of the paper on the
drum, which is made to engage with a 100 tooth ratchet wheel on the drive.   Thus
the maximum phase error is not more than 3.6 degrees.

Some idea of the time taken for a picture transmission may be gained from the
following:   a picture measuring 10" x 8" requires 6 minutes 40 seconds when the
drum speed is 2 rev. per second and the scanning density is 100 lines per inch.
The same picture requires 20 minutes at a drum speed of 1 rev. per second and 150
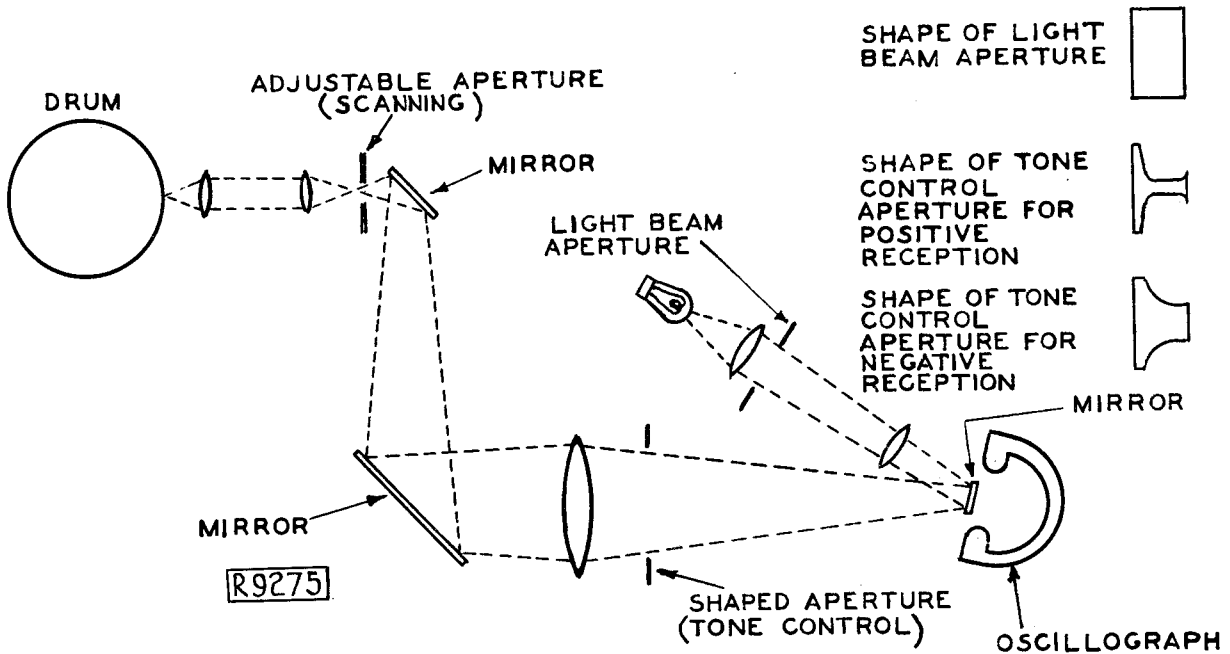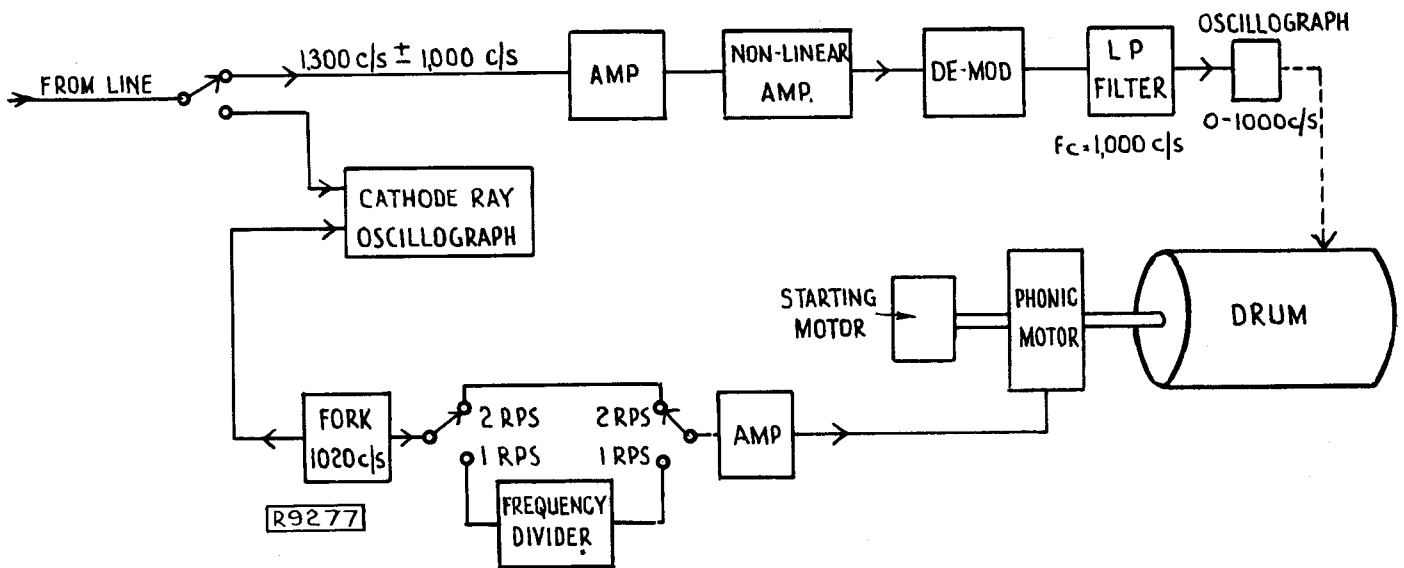lines per inch.

Fig. 7



Fig. 8

## Post Office Cable and Wireless System

The second system was designed at the Post Office Research Station on behalf of Cable and Wireless Ltd. and is again mains operated but uses crystal instead of fork control. The motor drive frequency source is a 108 kc/s crystal oscillator, the output of which is fed to a regenerative frequency divider producing 10.8 kc/s, which in turn drives a second frequency divider to produce 1,800 c/s. The 1,800 c/s voltage is used to feed a push-pull amplifier, using beam tetrode output valves, which drives a 1,800 r.p.m. synchronous motor. The picture drum is mounted on a hollow shaft rotated at 60 r.p.m. by the synchronous motor, whilst the lead screw runs inside the hollow shaft and is driven at a different rate by suitable gearing. The hollow shaft has a longitudinal slot for the lead screw

follower which slides the picture drum along the shaft.    Since the lead screw is
driven at a different rate to the picture drum shaft, the drum slides along the
shaft, its rate being determined by the difference in speeds.    Thus if the lead
screw rotates at 54 r.p.m. or 66 r.p.m. the effective speed difference is 6 r.p.m.
and with a pitch corresponding to 10 turns per inch on the lead screw, the drum
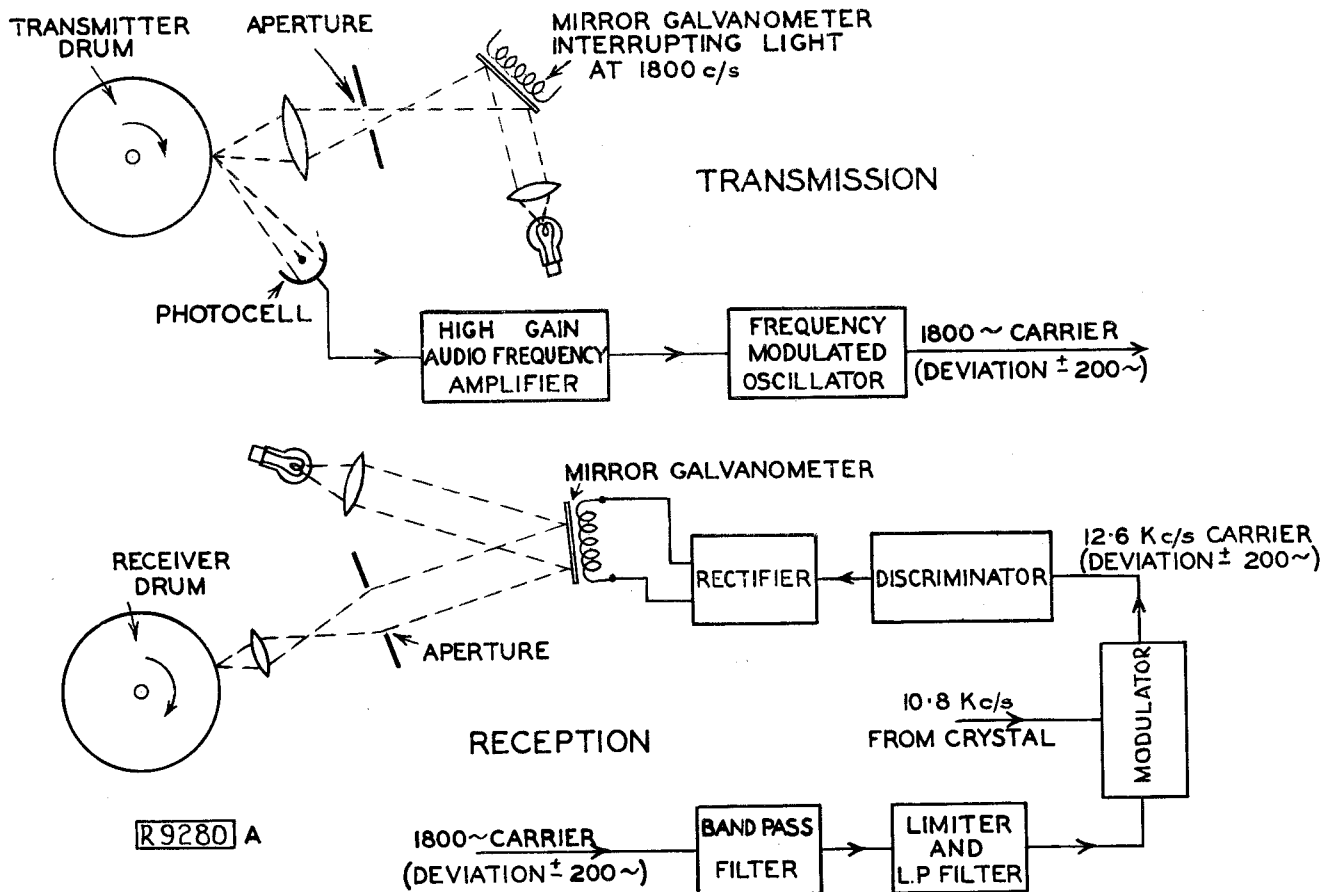will advance approximately 1/100 inch per revolution.



Fig. 9

At the transmitting end the scanning light spot is obtained from a lamp via a
mirror galvanometer and aperture (see Fig. 9).    The aperture determines the
ultimate shape and size of the light spot.    The mirror galvanometer has its
deflecting coil energized from the 1,800 c/s drive source thus interrupting the
light source at an audio frequency and simplifying the amplification of the
resultant photocell output, since a normal A.F. amplifier can then be used instead
of a d.c. amplifier.    The output signal from the photocell amplifier will consist
of a 1,800 c/s carrier modulated in amplitude by the picture intelligence which is
then rectified and the resultant d.c. is used to frequency modulate an oscillator.

When there is no output from the photocell i.e. black, the oscillator frequency is 1,600 c/s whilst full modulation, corresponding to white, shifts the oscillator frequency to 2000 c/s. The transmitted signal corresponds therefore, to a frequency modulated carrier of 1,800 c/s having a deviation of $\pm$ 200 c/s, frequency modulation having the advantages of improved signal to noise ratio and greater freedom from distortion as compared with the more normal amplitude modulation.

At the receiving end of the system it is necessary to reconvert the frequency modulated signals back into amplitude modulated signals in order to operate the oscillograph. This is done by what is known as a discriminator, which gives an output voltage proportional in amplitude to the frequency of the input voltage, provided the latter does not vary in amplitude as well. Unfortunately, it is difficult to design a discriminator to work at frequencies of the order of 2 kc/s so it is first of all necessary to shift the incoming frequencies to a higher portion of the spectrum.

The received signal is first filtered by a band-pass filter (pass band 800 c/s to 2,800 c/s) to remove noise and harmonic distortion components, it is then limited in amplitude by a push-pull valve limiter stage and subsequently passed through a low-pass filter to remove harmonics introduced by the limiting action. The carrier frequency is now raised to 12,600 c/s by modulating a 10,800 c/s frequency derived from the 108 kc/s crystal. After modulation, a band-pass filter selects the new carrier of 12,600 c/s with the $\pm$ 200 c/s deviation and this is applied to the discriminator. The demodulated signal is rectified and applied as a d.c. voltage to the mirror galvanometer, thus modulating the light beam and varying the amount of light falling on the film drum. The same optical system is used as for transmission except that in this case the rectified picture signal is applied to the mirror galvanometer coils instead of the 1,800 c/s chopping frequency.

## Portable Phototelegraph Equipment

A set of portable phototelegraph equipment is at present undergoing tests in Telegraph Branch. Details of the apparatus will be included in later issues of this pamphlet when more information is available.

## Documentary Facsimile Telegraph Equipment

Direct recording systems are frequently used for short distance transmission of written or typed matter. The equipment is usually designed to scan and re-produce the information contained in an area of from 20 to 40 square inches and to complete the transmission within 2 to 3 minutes. An exception to this is the transmission of large (18 inches square) weather maps by the Meteorological office; a service which is being expanded in this country and abroad. A brief description of the main points concerning direct recording is now given.

The equipment is operated and synchronized by the mains. A standard mechanical rotating drum and fixed speed lead screw provide the scanning. This method is quite satisfactory for the transmitter as an operator will always be present to load the drum with the message, and to start the transmission. At the receiver it is advantageous to avoid the need for continuous attention by an operator. Hence some equipments have receivers in which a continuous roll of recording paper is fed between recording electrodes. The received messages can then be recorded one after another (as on a page printing teleprinter) and torn off as required.