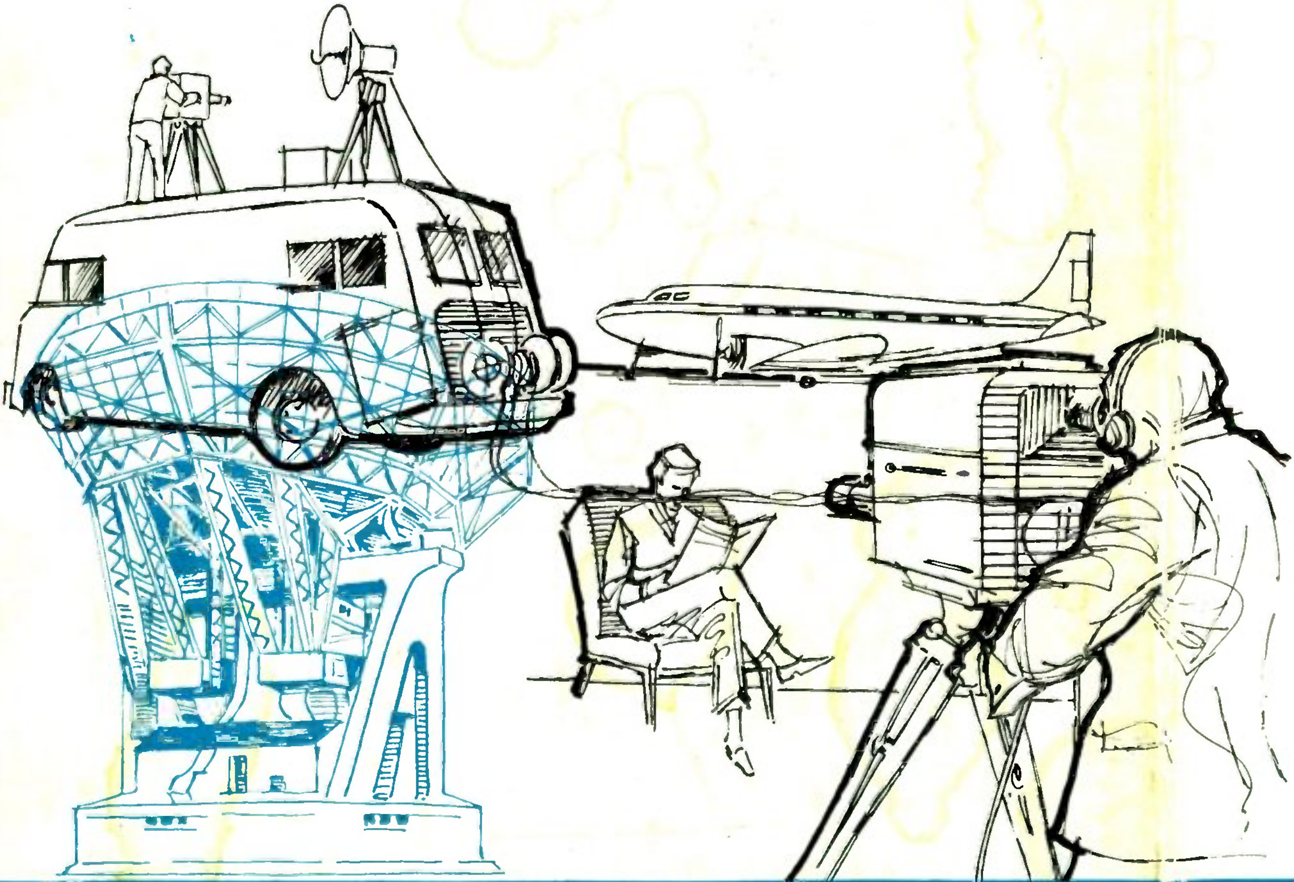
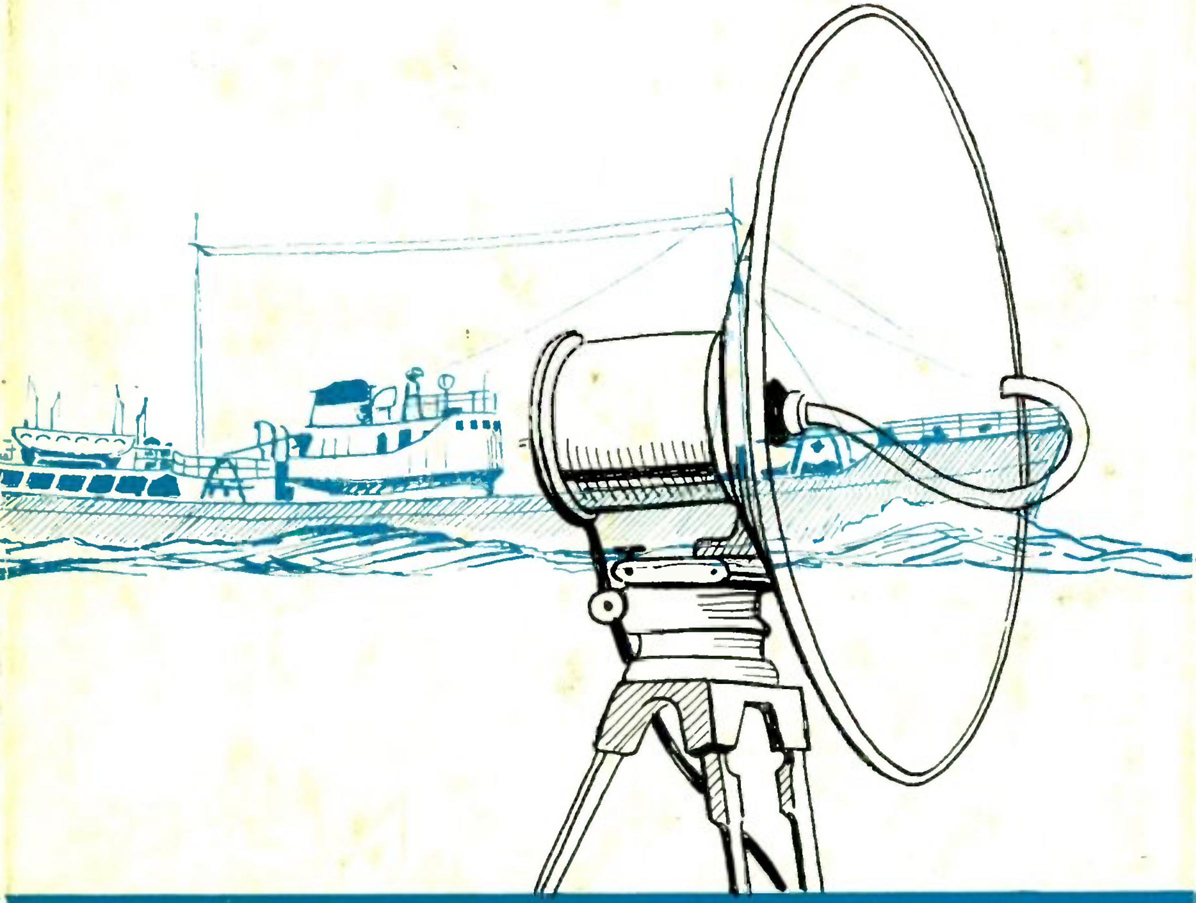
RADIO & TELEVISION



FREDERICK ROBERTS

KNOWING AND DOING



How is a television programme put on the air? What is a boom microphone? What happens when broadcasts are received by Telstar? These are just a few of the questions answered by this book, which is both informative and practical. As well as explaining how a radio studio is organised, it tells you how to set up a simple one yourself, gives suggestions for scriptwriting and production, and shows how a variety of interesting effects can be made. A number of experiments help readers to understand the techniques of television production from design and planning to camera control.

Mr Roberts treats his subject in such a way that no one is left standing on the touchlines of broadcasting; every reader will be caught up in its methods and purposes.

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Radio and Television

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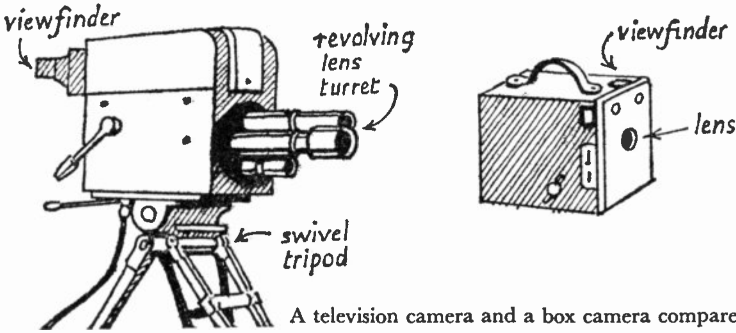
HOW A TELEVISION PROGRAMME IS PUT ON

When you are looking at television, you are seeing events happening in some place far distant from your home. This place may be a studio, where a play is being acted, or a football field where a match is in progress, or inside an aircraft in flight.

But you are not actually seeing the events themselves, for what would be impossible, even with the most powerful telescope. You are seeing *pictures* of the events, taken by a television camera. The TV camera is the 'eye' of television. We see on our screen only what this camera 'sees'.

The television camera

Let's take a look at a television camera. It is much larger than an ordinary camera used for taking photographs. It resembles such a camera, however, in several ways. For example, the TV camera has a viewfinder through which the cameraman can see what he is taking. It also has a lens in front, through which the actual picture is taken. The more expensive cameras for photographs and some cine cameras have lenses which can be changed; one lens for close-up objects, another for objects at medium dis-

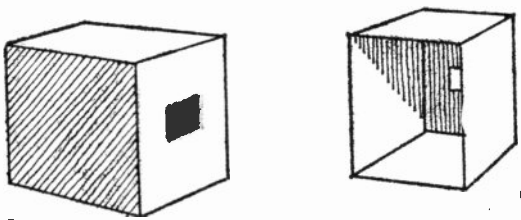


A television camera and a box camera compared

tance, and another for far distant objects. The TV camera usually has such a set of lenses mounted on a swivel or turret. The TV cameraman can thus easily select the lens he requires.

The large, heavy TV camera is mounted on a tripod, or a wheeled pedestal which may have a seat for the cameraman. The cameraman can turn his camera, or tilt it up and down to cover the scene he is taking. If the camera is on a wheeled pedestal, usually called a 'dolly', it can move about in any direction. Sometimes, when looking at television, you may see a small figure seated in a chair in the centre of a room. This figure gradually comes closer and closer until the person's face fills the screen of your set. This effect is achieved by moving the camera towards the sitter.

You can get a fair idea of what the cameraman sees when he is taking a scene if you make a simple model with a cardboard box. The picture shows you how to


Cardboard-box viewfinder

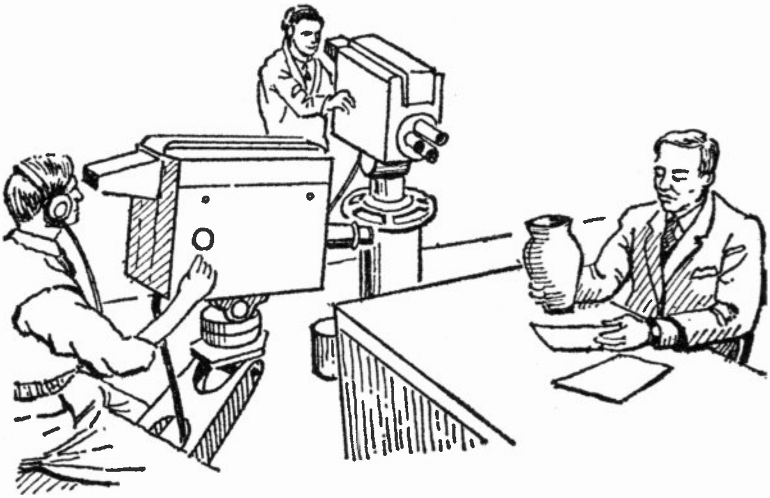
Long shot, medium shot and close-up

make it. Look through your camera at the scene in the room. Now turn the camera on its axis. This turning action is called 'panning'. Tilt the camera up and down, watching the picture all the time. Both panning and tilting must be done very slowly and smoothly, in practice, lest the viewers should be made to feel dizzy!

Now look at some object at a distance, such as a clock at the other end of the room. The clock appears very small in the picture. The cameraman calls this view a 'long shot'. Pick up the camera by its base and walk forwards until the clock is about half the picture space in size. This view is called a 'medium shot'. Finally, approach near enough for the picture to be filled by the clock-face or only part of it. This shot would be called a 'close-up'. You can see that changing shots would be easier if you and the camera were on wheels!

Sometimes during a television interview with some well-known person, the picture may suddenly change from a front view of the person's face to a side view. The change is far too rapid however for the camera to have moved round from the front to the side of the person. How is it brought about? The answer is that two cameras are used. We have changed from one showing the front view to the other showing the side view.

A single camera is usually sufficient for televising a



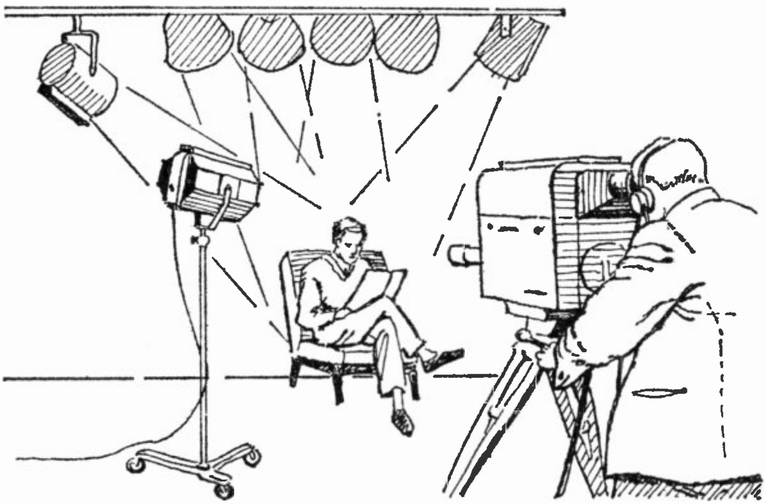
Using two cameras

single person talking, or the newsreader giving the news. To see a whole play, however, through the eye of just one camera might be exceedingly boring. Several cameras are therefore used when plays or concerts are being televised. The producer—that is the person who directs the actors and the cameramen—makes the arrangements for switching from one camera to another. Suppose that an actor has to go down a flight of stairs in the play. One camera might take him approaching the top of the stairs, coming towards the camera. Another camera might take him going down. A third at the bottom might now take him coming to the foot of the stairs. The next time you see stairs in a television play, try to work out how the cameras are being used when people are shown ascending or descending.

If we were televising a 'do-it-yourself' programme, like the Barry Bucknell series, two or three cameras might be grouped around the person who is showing how a particular job is done. To look down on something, the camera and cameraman have to be lifted up. A special mobile pedestal called a 'boom dolly', is used for this purpose. The boom carrying the camera and cameraman can be raised or lowered.

Lighting

Television in day-time out of doors has the advantage that the light is nearly always sufficient for the cameras. Indoors the situation is very different. Artificial light is rarely as strong as daylight, and is nearly always concentrated where the lamps are situated. You can see this effect in the sitting-room in the evening when the lights are on. Under the lights objects are brightly lit. To be able to read in some other parts of the room, however, an extra reading lamp is often necessary. To take an ordinary photograph indoors usually requires extra light-



Lighting in the studio

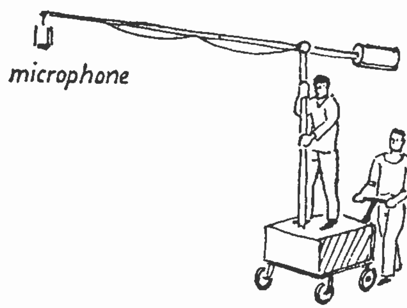
ing too. For this purpose powerful 'photo-flood' lamps are used, or, for a snapshot, a bright flash from an electric flashgun.

In the television studio, very powerful lighting is necessary. People who have to sit still whilst being interviewed in the studio often find this strong light very trying, and the heat from the lamps uncomfortable. The spot lights and floodlights are mounted on stands or fixed on walls and the ceiling overhead. As different parts of a scene in the studio need lighting differently, the lamps have to be arranged in suitable groups, able to be separately switched on or off as required.

Television sound

When we are looking at television we can usually hear what is going on, because sound, as well as pictures, is being broadcast. The 'ears' of television are microphones. These microphones are similar to those used in radio. In the studio, great trouble is taken to avoid the microphones being seen by the TV cameras. This is so that the studio scenes should seem as natural as possible. People do not normally go about their daily lives speaking into microphones.

The microphone at the end of a boom



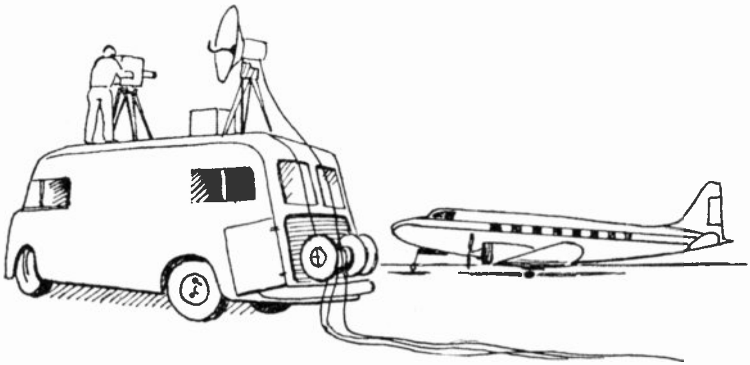
The studio microphones are attached to the end of long rods called booms. The booms are telescopic, which means that they can be lengthened or shortened, and are attached to stands which may be moved about. The microphone at the end of its boom is suspended above the people who are talking, so that it is out-of-sight of the camera.

At television interviews which are indoors, but in some place other than in the studio, you may see the interviewer and the person interviewed wearing black cords round their necks leading to something concealed inside their clothing. This 'something' is a small microphone. When several people are joining in a discussion each of them may be provided with a separate microphone in this way.

The interviewer in the street, however, uses a hand microphone, which, as you have often seen, he points at the people with whom he is speaking. The difficulty with microphones is that they have to be used fairly close to the sounds which are to be picked up.

Television scenes out of doors

Two methods of televising scenes out of doors are used. The first method is to make a movie film of the event, and then to let a TV camera 'see' this film. The advantage of this method is that the broadcast can be made *after* the event has taken place. 'Live' television out of doors necessitates taking the actual television cameras to the spot where the event is to take place. This creates some fuss and bother because television cameras have to be accompanied by a great deal of apparatus. They also have to be connected in some way with the television broadcasting station.



The mobile van on the airfield

Supposing that it has been decided to make a 'live' television broadcast of some Very Important Person arriving at an airport, and to get him to speak to the viewers. A mobile van would be despatched to the scene, with one or more camera crews. From the van instructions can be telephoned to the cameramen (you will nearly always see cameramen wearing earphones).

Sometimes in an outside broadcast, like the one we have just mentioned, a TV camera will be perched up on top of a van. Another may be stood on a tripod in front of the crowd and others further away still.

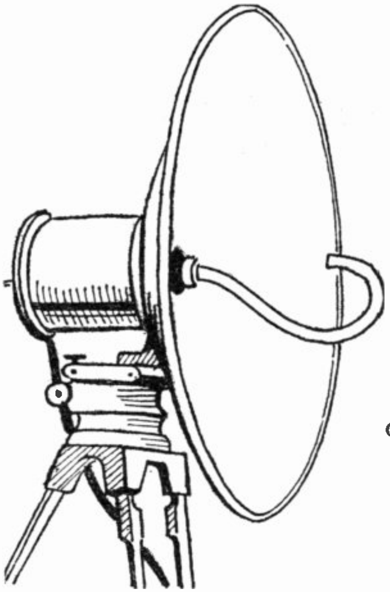
Let us follow what is going on at the airport. The plane has not yet arrived, but is due any moment now. Whilst we are waiting, a commentator speaks into a microphone and tells us about the weather, the crowds gathering, and the excitement. He interviews one or two people in the crowd and asks them what particular reason they have for coming to see the arrival. One of the television cameras will be working with the interviewer, taking pictures of him and the people he is speaking to.

The VIP arrives

The camera on the van also roves round the scene, letting us see the crowd, the waiting reporters and the airport buildings.

Suddenly we hear the sound of a plane coming in, picked up by microphones out near the runway. Then a television camera near the runway picks up the plane coming in to land. In a moment another camera shows us the gangway being run out. Now the great man appears and begins to descend. We get a close-up of him and the television interviewer, the latter pointing his microphone and asking questions.

You may ask how it was possible for the outside broadcast producer to switch from one camera to the other at exactly the right moment. The answer is that inside the mobile control van are a number of 'monitors', which are like small TV sets. The cameras are all 'on' together. The producer or control engineer can see on the monitors' screens what each camera is seeing. He can select the one which he wants to be broadcast at any particular moment. He can also speak to the individual cameramen,



One of the aerials used in the 'radio-link' between mobile van and TV station

to ask them to get closer or further away from the object they are taking.

How are the van and its camera at the airport connected to the television broadcasting station? This can be done by using a number of telephone lines, that is the wires of the ordinary GPO telephone. It can also be done by fitting the control van with its own wireless transmitter which can send the pictures 'through the air' back to the television broadcasting station.

In the case of televising the Boat Race, the television launch carrying the cameras and following the Oxford and Cambridge crews must have a wireless transmitter. It could hardly trail miles of telephone cable behind it in the river as it went along!

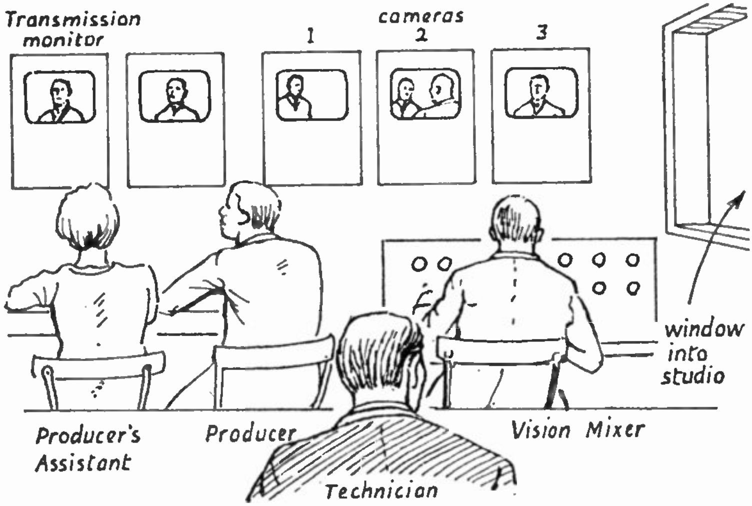
When a football match is being televised the cameramen in the stands try to keep the ball in view all the time. If you try this with binoculars, at an actual match, you will find how difficult it is. On your televising screen at home you will most probably be following the match through the 'eye' of a television camera which is equipped with a 'zoom' lens. Such a lens can change its focus like a telescope, so that the players can be seen close-up wherever they are on the field.

The studio

Imagine you are in a large room, like a school hall, or a room in a factory. From the ceiling and the walls spot lights and groups of flood lights blaze down. In one part of the room there appears to be what looks like part of a village street. Actors are moving about in the street. Microphones on long booms reach out over them to pick up what they are saying. TV cameras move about among wires and cables on the floor, following the movements of the actors. Behind the cameras are the camera crews and sound crews, all wearing headphones through which they can receive the instructions of the producer. The producer is directing the play from the control gallery, a room with a window looking into the studio.

In the control gallery also are the producer's assistants and other people concerned with the play. One of these, called the 'vision-mixer', operates a control panel covered with buttons and coloured lights. At the producer's bidding the vision-mixer presses buttons to select which of the cameras in the studio is to be 'on the air'. The control gallery is in semi-darkness, unlit except for the lights of the studio which can be seen through the window. The producer and his staff, however, are not looking through the window. Instead they are watching the

The studio control-gallery and its monitors

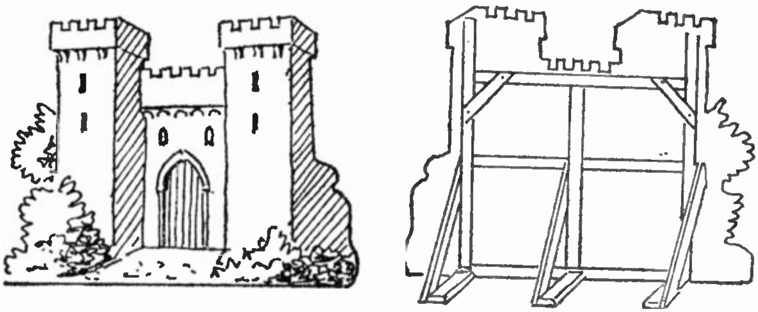


play on several monitors in the control gallery. Each of up to perhaps eight monitors is connected to a separate camera in the studio. One special monitor called the transmission monitor shows the picture actually being put 'on the air'. The producer can say 'on number two camera', the vision-mixer presses the right button, and the picture appearing on number two camera's monitor also appears on the transmission monitor.

Combining two cameras

If the producer so wishes, the pictures of two or more cameras can be mixed together. All kinds of tricks can also be performed by the vision-mixer and his control panel. Half of one camera's picture and half of another camera's picture can be fitted together and sent out as one picture. You may have noticed this effect on your screen; it is called 'inlay'. Pictures can also be made to fade away, and they can even be turned upside down.

The scenery for a play, like the village street we have just mentioned, is cleverly made from timber, hardboard, canvas and other materials. Although television pictures are normally only in black, white and grey, the studio scenery is painted in colour, so as to seem more natural to the actors. Attached to the studio there are workshops where this scenery—called 'flats'—is made and painted.



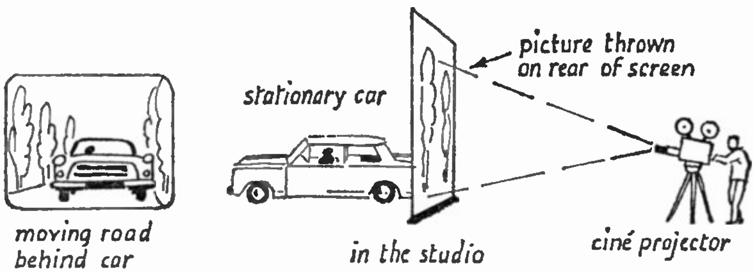
Studio scenery 'flats'

A less elaborate studio is required for the news. The newsreader sits in front of a single camera. A table may be provided for the typescripts of his bulletins, but this will probably be out of sight of the camera. Scenes from the news, that is of events during the day, will be shown to the viewers by means of cine films of the events. These films have been taken earlier on by cameramen on the spot, and have been sent by road, rail or air to the television centre in time for the broadcast.

Films in television

Ordinary cinema films are sometimes seen in television programmes. 'Laramie' and 'Wagon Train' are films specially made for television. Programmes like 'Panorama' often combine interviews in the studio with films of events of topical interest. Sometimes film is used as well as live actors in a television play. For example, in the 'Inspector Maigret' plays, the scenes in the police station (Maigret's office), the court, Maigret's home, etc., are taken with actors in the studio. The street scenes in French towns are films actually taken in France.

Short extracts of films are sometimes shown in the studio as part of the 'scenery' of a play. A film of the sea or the sea shore can be shown on a screen behind the players. See if you can notice when this is being done. The method used is to project the film pictures on to the back of the screen, so that they show through the



Back projection

screen to the side where the actors are performing. A trick employed to make a stationary car in the studio seem to be speeding along is to 'back project' behind it a film of a road actually taken from a moving car.

Finally, by using sound film, it is possible for an actor to be seen on the television screen apparently having a conversation with himself, or singing a duet with himself. How is this done? The answer is, by 'inlay'. Half the picture is a film of the actor, the other half is the live actor himself in the studio. You may think that effects like this are 'cheating', but they can often be very entertaining.

2

HOW A RADIO PROGRAMME IS PUT ON

Six pips and a voice saying 'Here is the News' is the well-known beginning of the news on sound radio. Every day the news is heard by millions of people in cities and in the country, by people on remote islands or on ships at sea. In spite of the coming of television, sound radio still performs a very useful service, especially in areas which television cannot yet reach. Radio also has the advantage that since we do not need to watch it, we can carry on working whilst listening. We can enjoy a programme whilst we are out of doors, or whilst travelling in a car. A radio set can be made small enough to go into a pocket. There is already a transistor radio which is smaller than a matchbox. Radio therefore can be always with us, by day or night, provided that programmes are being broadcast.

Radio news

The newsreader sits in a little room which has been made as nearly as possible soundproof. In front of him is the microphone; on his table are typed sheets of paper containing the news items he is about to read. He has been trained to read distinctly, without hesitation, and not to rustle his papers. He must watch for signals which are given to him when tape recordings are switched on to give 'on the spot' reports of items in the news.

The newsreader

In France news broadcasts are sometimes called 'The spoken newspaper'. Just as a newspaper employs reporters and editors, so does the BBC News. Reporters in all parts of the country send in accounts of events which have taken place. Other reports come in from places abroad, from the United Nations, from 'trouble spots', or from anywhere where something interesting has happened. Reports may be sent in to news headquarters by telephone or wireless, or by teleprinter, a machine which prints messages on paper tape. Just as newspaper editors select the news which is to be printed, so the editors of radio news decide which of the reports they receive are to be included in the programmes. They also decide which items are the most important, and how much time 'on the air' can be given to each. Finally, they arrange how the tape recordings they have received can be fitted in to the broadcast.

'Outside' broadcasts

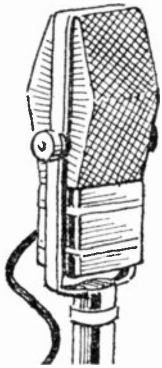
If you have heard a broadcast of a football match or a horse race you know how exciting it sounds. Because you cannot see what is happening, the commentator tells you all about it. How quickly he has to speak if events are happening rapidly, as when someone is scoring a goal, or horses are flashing by the winning post! His voice is almost drowned by the noise of the crowds. As in the case of television, live broadcasts outside the studio need a great deal of organising. The microphones being used have to be connected in some way, either by telephone line or by wireless, to the broadcasting station.

We should not forget that radio is sometimes the only means by which human beings in certain situations can communicate with each other. For example, explorers, crews of ships and aircraft, soldiers in tanks, policemen in patrol cars, all depend on radio for sending and receiving messages. Sometimes in a broadcast programme these messages are relayed to us, as in the case of the first cosmonauts circling the earth. This means that the signals are picked up by a special radio receiver, and then sent to the broadcasting station to be re-broadcast.

A great deal of 'outside broadcasting' comes to us through recording, so that we hear the events some time

A tape recorder

A studio microphone



after they have taken place. Tape recordings are used, as in the case of news items. BBC recording engineers usually employ special 'high-fidelity' tape recording machines when making records of concerts in places away from the studio. For recording interviews, either in the street or in people's homes, they may use small, portable, battery-driven tape recorders.

The microphone

The microphone is the 'ear' of radio, and of sound recording. The music and speech we hear coming out of a loudspeaker has been 'picked up' by a microphone, or several microphones as the case may be.

To broadcast or record someone speaking we need only a microphone placed near him. There are important differences between the microphone and the human ear, however. If the person speaking moves a short distance away from the microphone, his voice will sound a long way off to the listeners. The results of using only one microphone with a large orchestra would be that the instruments in the back row would hardly be heard.

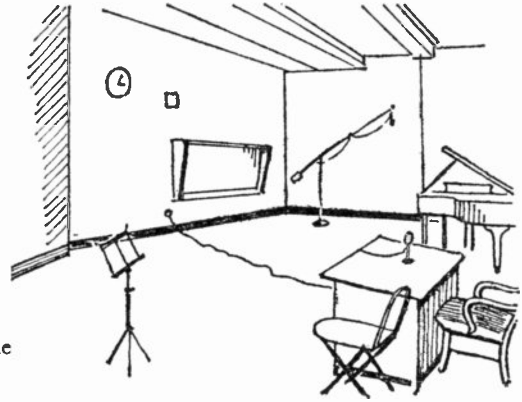
Therefore several microphones, spaced apart, are used for choirs, bands and orchestras. If you visit a hall from which a concert is being broadcast you will notice the microphones on stands, or strung on wires overhead.

Because we have two ears, we are able to tell the direction from which sounds are coming. Shut your eyes, and get someone to make a sound somewhere near you. You will quite easily be able to tell where the sound has come from. Now close your eyes, but stop up one ear, and have the sound repeated from a different position. You will find the sound more difficult to locate this time. Our brains are able to compare the loudness of the sound heard by one ear with that heard by the other. When the ear on one side hears the sound more loudly than the other ear we know that the sound is coming from that side. If both ears hear the sound equally we know it is coming from directly in front or behind.

In the case of a wireless set, all the sound comes to us from a small loudspeaker. We cannot tell, therefore, whether people in a radio play are on the right or the left of each other. We can only tell whether they are near to, or far from the microphone. A 'stereo' gramophone seems much more realistic because you can tell the direction from which the sounds of instruments or voices are coming. Stereo-broadcasting is, however, still in an experimental stage. The producer of a radio play has therefore to make us imagine distance and direction. In this, however, he often succeeds very well.

The sound studio

Some broadcasting studios are small: just large enough to accommodate one person, such as the announcer or some-



A sound studio. Note the producer's window and the microphone on the table

one giving a talk. Others are large, like concert halls, and can hold an orchestra and an audience. At Broadcasting House, the BBC headquarters in London, there are many studios in one building.

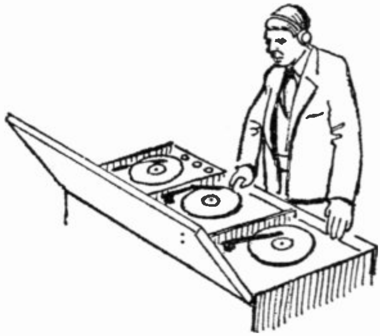
The difference between a studio and an ordinary room is that the studio must be sound-insulated. This means that the walls, floors and ceilings must be constructed so that sound will not pass through them. Noises from traffic, trains, low-flying aircraft, ships' sirens, and from neighbouring studios must be kept from interfering with the programme being broadcast. It has sometimes happened that workmen inside the building have interrupted the broadcast with their hammering. This kind of noise is especially difficult to keep out of a studio.

Normal doors and windows would easily let sound pass through them, as would chimneys and ventilators. Studio doors and windows are therefore specially made. The doors are very solidly built, and designed to seal up completely the opening when they are closed. A special arrangement is made to prevent them from slamming.

The windows are usually made of two or three sheets of plate glass, spaced apart, and are kept shut. You may wonder how anyone breathes in such a room. The answer is that 'air conditioning' is used, and that this too is insulated, so that the sound of the ventilating fans is not heard.

Too strong an echo in a room or hall can make voices or music indistinct. The studio-builder takes care to cause all echoes to be kept under control. The amount of echo can be reduced by hanging heavy curtains across part of the room, or increased by bringing in screens which reflect sound.

Record-playing desks and tape recorders are used in both television and sound radio. The person who broadcasts a programme of gramophone records is sometimes nicknamed a 'disc jockey'. Let us take a look at a well-known broadcast feature called 'Desert Island Discs'. 'Discs' here means gramophone records. In this particular programme a well-known person is asked to choose those records that he would like to have with him if he were shipwrecked (with a gramophone) on a desert island. The interviewer sits in the studio near the microphone with the well-known person who is the 'guest' of the programme. He introduces the guest, and asks him which record he has first chosen. The guest gives the title of a piece of music and perhaps the name of the person playing it on the recording. In another studio sits an engineer by the side of what looks like a gramophone with two or more turntables. The first record is already on the turntable. At a signal, usually a light which flashes on, the engineer starts the record. The microphone used by the commentator and his guest is switched off immediately the record starts.



The sound effects department

The control desk

As in the case of television, the person in charge of the arrangements for putting on a programme is called the producer. He has the duty of rehearsing the programme, seeing that the microphones are in the right places, and that they are each switched on or off at the right moment. A control cubicle (cubicle means a small room) is built next door to the studio, or just inside it. The people in the cubicle can see through a large window into the studio. The cubicle contains, amongst other apparatus, a control desk, at which the producer or engineer may sit.

Whilst the broadcast is on, the person at the control

The producer at his control desk

desk can listen to what is going on in the studio. He can 'mix' what is coming from the microphones with music from records, so that listeners hear a musical background added to the voices on the programme. He can regulate the loudness of anything being broadcast. He can also switch from one microphone to another, and send flashing light signals to people in the studio to tell them when they are 'on'. The cubicle also has telephones connected with the engineers in other parts of the building.

The script

Apart from the news reports, almost every radio programme is carefully rehearsed beforehand. The words you hear, the titles of music and particulars of sound effects are written down in a document called a script. Most talks are actually read by the person giving the talk.

The script for a talk is quite simple, consisting of the talk itself, typed out. If the talk is to be illustrated by gramophone or tape recordings, the script will be marked to show where the speaker must pause for the recording to come in. The producer in the control cubicle follows a copy of the script as he listens and watches what is going on in the studio. The notes on the script saying 'music' or 'sound recording' are called 'cues'. As he reaches such a cue in the script the producer turns knobs on his control panel to fade in or out the gramophones or tape recorders. The engineer in charge of these instruments will also be working from a copy of the script marked with cues.

The script for a play is also marked with cues for the entrance and exit of players, and for sound effects such as the opening and closing of doors, footsteps, motor-car noises, wind and rain. The producer has to ensure that the movements of the actors, and the switching on of the sound effects will take place at exactly the right moment.

Sound effects

Sound effects are as important to a radio programme as scenery is to a stage or television play. But it is obvious that we cannot always use the real sounds required. For a car crash, or a bridge falling down, for example, we must either use a recording of such an event, or else make a sound which the listeners will take for the real thing.

Thousands of recordings of sound effects can be obtained, some on gramophone records, others on tapes. They range from records of ordinary everyday sounds, such as people walking, doors opening, wood being chopped, crowds cheering, to less usual sounds such as an elephant trumpeting, or someone snoring.

A recording of a motor-car noise will probably begin with the car door slamming. Next, the engine starts, first gear is engaged, the engine speeds up and the car moves off. The driver changes gear again, until finally the car is moving at speed. The sound of braking and of the hooter will probably be included in the record for completeness. The engineer can use the whole, or any part of the sound effects, as he wishes.

Sometimes sound recordings are played on a machine in the studio, or through a studio loudspeaker, so that the actors can hear them. The listeners hear the sounds picked up by the studio microphones. At other times the recordings are played in the control cubicle, so that the actors do not hear them. In either case, correct 'cueing' of the sound effects is very important. The loudness of the sounds must also appear correct to the listeners.

If there are several sound effects on one record, a special attachment is used on the gramophone which can be set to lower the needle on to the record at exactly the right spot at the right moment.

Sound recordings are expensive. To cover all the needs of sound broadcasting a large library of such recordings would be needed. Some sounds, which can actually be made in the studio, are often better than recordings. These also have the advantage that they can be exactly timed with the speech or actions of the players. For example, real cups and saucers can be rattled, and a real door banged in the studio. One kind of whistle can be blown for a whistling kettle, another for a police whistle. A real door which squeaks as it opens can be used in a thriller, and a starting pistol can be fired for an assassination.

3

PRODUCE YOUR OWN RADIO PLAY

'Repeats' of broadcast programmes are generally tape recordings of the original broadcast. So good are modern tape recordings that listeners cannot tell the difference between them and live broadcasts.

It can be fun making a tape recording of a play, either at home or in the classroom. By doing so, we can also learn a great deal about putting on radio plays. Let's make the attempt, first to write and rehearse a short play, and then to record it.

The script

Let us imagine that we have thought of an idea for a play. We first write down the story in as few words as possible. This is the 'synopsis' of the play. Next the script is prepared. In it the words spoken by each actor are written out in full. It also contains the directions for the actors' movements, and for other sound effects which are going to be used during the performance.

Producer and actors

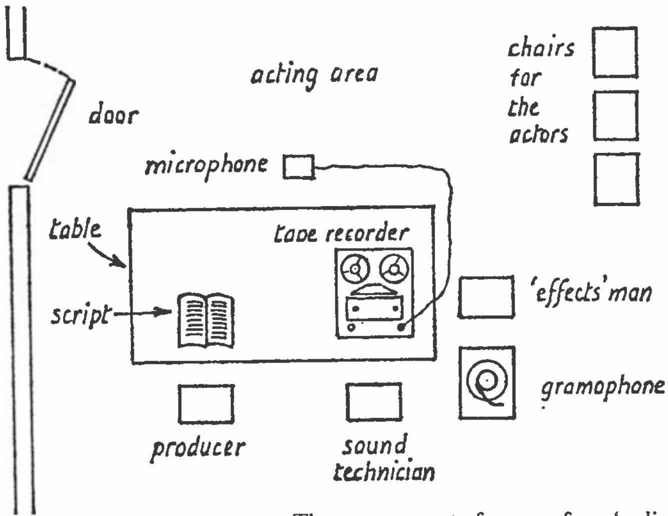
Choose someone to be the producer. He or she should have read the play and formed some idea of how it should be acted. The producer should choose the actors. Each actor will need a copy of the script. (A good way to obtain several copies is to have carbon copies made with a typewriter.) The producer now sets about rehearsing the play. He takes note of the movements of the actors and writes these as 'cues' on his script. He also makes notes about the sound effects, what these are to be and when they will be required. When, after two or three rehearsals, the players are beginning to know their parts, trial recordings can be made.

Apparatus

To record the play, we shall need a tape recorder, a tape and a microphone. The tape must be long enough to run while the play lasts. A gramophone and records, or a piano and a pianist will be useful if musical sound effects are needed. For other sound effects, some apparatus can be made which will be described later on in this chapter.

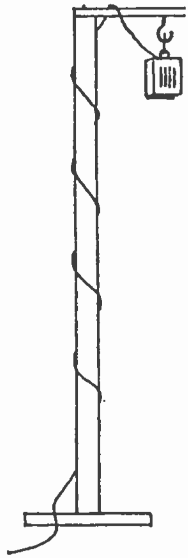
Arranging the 'studio'

The best place for the tape recorder is on a table where it will not be jolted or disturbed by people moving about. At this table will sit the recording engineer, who must be someone who has had practice in working the machine.



The arrangement of a room for a 'radio' play

Stand for the microphone



He will be given his cue when to switch on by the producer. During the recording he will watch the 'sound level' indicator on the tape recorder, and operate the volume control on the machine when necessary.

The microphone is attached by a lead to the tape recorder. It is a good idea to hang the microphone on to some form of stand or support so that it need not be handled by the actors. A piece of wood can be attached to the table, or to the back of a chair for this purpose. Screw a hook into the wood and suspend the microphone from it by a strong piece of elastic. Make sure that the microphone is at the right height for the players.

Acting will take place directly in front of the microphone. The players must be able, quickly and quietly, to take each other's place at the microphone. A chalk line on the floor will help them to speak at the right distance from it. All noise of moving about except that which the listeners need to hear must be avoided. So, if the floor is a hard one, put down a mat or carpet, or get the actors to wear slippers.

The producer should sit where the actors can see him. The effects man needs a place for his gramophone and sound effects fairly near to the microphone. Write out two large notices: one, 'Recording session, keep out!' is to hang outside the door of the room to prevent anyone from rushing in and spoiling the recording; the other, 'Quiet please' is for the producer to hold up once recording has started. Do not forget that the slightest sound in the room will be picked up by the microphone. Close the windows if there is noise outside.

Actors at the microphone

Practice beforehand

Before trying to make a trial recording of the whole play, the actors, sound effects man and recording engineer should each practise their jobs a little. The actors should get used to the microphone. A good way to do this is for each player to say or read a few of his lines whilst standing in the right position. If two or more people are supposed to be having a conversation, they must all stand together, quite close to the microphone. Movements can be practised too. The sound of someone entering a room may be difficult to record if the door is too far away from the microphone. In this case, get someone else to open the door, making as much noise with the knob as possible. The actor will sound as if he has come in if he speaks just a few feet away from the microphone. The right way to deal with many problems like this can only be found by experiment. That is why practice is so useful.

The effects man can also try recording his effects, particularly to find out how loud they must be, and how far from the microphone they must take place. Music is better 'faded' in and out, rather than switched on or off suddenly. This can be achieved with a gramophone by turning the volume control up or down gradually.

The recording engineer would do well to get used to starting the tape and stopping it, and operating the recording level control. Finally, all taking part must do as they are told by the producer and learn to follow the cues he gives them.

The play

We now come to consider the play itself. It is better that a radio play should not have too many characters in it. Five or six players acting together before the microphone is a 'crowd', difficult to manage. Apart from this, the listeners may get confused by too many different voices, since they cannot see who is speaking.

Here is a short extract from a play about children. It has only three characters, two boys and a girl. To the script should be added the radio producer's special instructions. These we shall refer to later.

The play is entitled *The Old Mill.* The story, up to the beginning of this extract, is as follows: Peter is spending a holiday with his cousin, Norman, who lives in the country. The two boys and Mary, one of Norman's school friends, decide to visit an old water-mill. In this scene, the children have just reached the mill.

Extract from *The Old Mill*

PETER Falling down a bit, isn't it?

NORMAN So would you be, if you were that old! Come on, let's get in.

PETER In? How?

NORMAN Through the door, daft! Round the other side. Come on!

MARY It's full of rats. I'm not going in, I'll stay here.

NORMAN Why—you're not afraid of rats?

MARY Well—but it's cold and dark in there. If I go in, I don't want to stay there long.

PETER (*Calls, from some way off*) I've found the door, it's open, I'm going in!

NORMAN (*Calls to Peter*) Wait for me—it's not safe! (*To Mary*) Come on Mary—he'll get into trouble.

(*Norman and Mary follow Peter into the mill*)

PETER What a lovely creepy place!

NORMAN Nobody's used it for years.

MARY My grandad says he remembers it working. The wheel used to go round. People used to bring sacks of flour here.

NORMAN Take them *away* from here you mean. They used to grind wheat into flour. The sacks of flour were stored up there.

PETER Where? Let's take a look.

MARY You can't. The ladder's broken.

PETER I'll soon get up there. It looks easy to me. What about it Norman?

NORMAN There are a few rungs out, the rest are rotten. Watch your step!

PETER Right. I'm going up. (*Begins to climb ladder*)

NORMAN Don't tread on the middle of the rungs. Keep your feet to the sides. Come on Mary. You go up next. I'll follow to see you don't fall. (*Both climb ladder*) Phew! it's dusty up here! Dry though. (*All walk across floor*) That's the hoist, they used it to lower the sacks on to carts below. It still works, I think (*Rattles chain*)

PETER What was that? (*Sound of bird flying away*)

MARY Only a bird in the roof, we startled it.

NORMAN There are bats up there as well, I've seen them!

MARY Oh, I hate bats.

NORMAN They won't come out in daylight—they're all asleep now. Be careful there Peter, don't you fall out! That timber is pretty rotten.

PETER I can see the river. Wait a minute, there's someone coming along the bank.

NORMAN Who?

PETER Two men, one carrying a bag, it looks like.

MARY Let me see! Coo—I don't know who they are. They're coming this way.

NORMAN Where? Oh yes, I see them. No, I don't know who *they* are. Complete strangers round here, I reckon. Hey, they're coming in below—at least, I think—yes! Keep quiet!

(*Door opens and bangs below. Muffled voices*)

PETER (*Whispers*) What do you think they are?

NORMAN (*Whispers*) Don't know, let's listen. No, I can't make anything out. (*Muffled*

	voices) Don't move or they'll hear us.
MARY	(*Whispers*) I heard one say the ladder is broken.
	(*Door bangs below*)
PETER	(*Whispers*) They're going out again. Wait, I can see them now.
NORMAN	Keep your heads down. They might look back!
PETER	Hey! They've not got the bag with them!

There we must leave Peter, Norman and Mary and their mill. You could try to finish this story yourself. Let us look back at the extract, however, to see how it would be produced in our home or classroom studio.

Production of *The Old Mill* extract

The play opens with the three actors grouped round the microphone, speaking in turn as in conversation. Each time the script has some 'stage directions' (words in brackets), however, the actors must move or perform some action. The first example is where Peter speaks for the third time. The words in brackets say, 'calls, from some way off'. To get this effect Peter moves away from the microphone to the back of the studio before he calls out his lines. He must be given a cue to move to his position in good time before he has to speak. Norman remains with Mary at the microphone. Next we have the direction: 'Norman and Mary follow Peter into the mill'. To do this they walk away from the microphone, and then return. Peter slips quietly back with them. Then all three are 'in the mill'—back at the microphone!

Now follows a sound effect. Peter 'begins to climb ladder'. The sound of climbing a ladder can be imitated by Peter standing on the rung of a wooden chair and 'marking time' on it. 'Both climb ladder' means that Mary and Norman each stand on a rung of the chair and begin 'climbing'. 'All walk across floor' sound effect can be imitated by the players walking about on two or three upturned wooden boxes placed on the floor. The hoist chain can be suggested by shaking a length of chain close to the microphone. 'Sound of bird flying away' requires an exercise book, or a booklet of similar size with fairly stiff covers. Hold the booklet by one corner near the back and flap it backwards and forwards to imitate the beating of a bird's wings.

When Peter says, 'I can see the river . . .' he should be standing two or three yards away from the microphone to give the effect that he is peering out, some distance from the others. Mary and Norman must do the same when it comes to their turn to look out.

'Door opens and bangs below' requires someone to bang the door of the next room to the Studio. For 'muffled voices' the trick is for someone to speak into a thick cardboard or wooden box through a hole in the lid, the box being held a little away from the microphone.

The playback

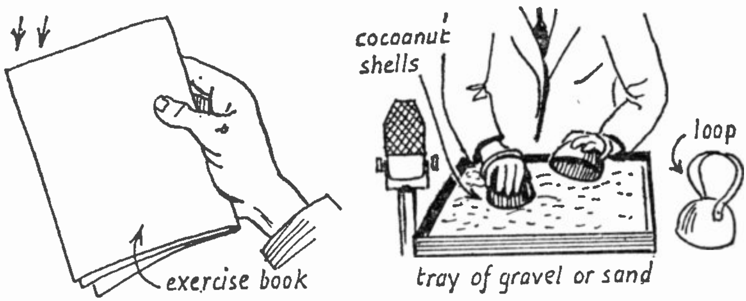
When our play is recorded, there comes the excitement of listening to the result. Undoubtedly we shall find we have made mistakes, and that the effect is not so realistic as we might have expected. Remember, however, that 'practice makes perfect'! What we are trying to create is a picture in sound, and, just as making any other kind of picture, some skill is required. Write your own play, practise it, record it, listen to it, and then do it again, until you have improved it as much as you can.

Just one tip about playing your tape to an audience: arrange the chairs so that people can sit comfortably, just as they would for a real radio programme. Hide the tape recorder. Put it behind a curtain or somewhere where it can be heard well but cannot be seen. This will make your play seem much more real. The sound can also be much improved by connecting a loud speaker to the tape recorder.

More sound effects

Here is a list of some 'do it yourself' sound effects. Try these with your tape recorder. Most of them are to be carried out as close as possible to the microphone, but experiment with them at different distances. Also try inventing your own effects. It can be great fun!

Sound effects: 'bird flying away' and 'horses hooves'



Chopping wood

Strike a piece of wood, or a tree branch with a heavy table knife.

Splintering wood

Crush a matchbox.

Squeaking or creaking wood

Twist a wooden peg in a hole in a piece of wood.

Fire crackling

Screw up a piece of cellophane in the hands.

Distant explosion

Put a few small ball bearings or lead shot into a balloon or football bladder, inflate and tie up. Shake for an explosion.

Crash

Partly fill a wooden box with stones, nails, broken glass, dry earth. Nail on the lid. For a crash turn the box over suddenly.

Window breaking

Put a piece of glass on some soft cloth at the bottom of a box. Drop a heavy weight to smash the glass. Hold microphone close to the box.

Splash

Fill a plastic bucket with water. Drop a piece of wood into the water.

Ice breaking

Twist an inflated toy balloon in the hands.

Horses' hooves

Use two half coconut shells, one in each hand. Strike with the open ends of these on to a wooden tray filled with sand or gravel.

Echo

Speak inside a large box held over the microphone.

Ghostly voice

Speak into a glass tumbler, or a large cardboard postal tube.

Car door slams

Slam refrigerator door.

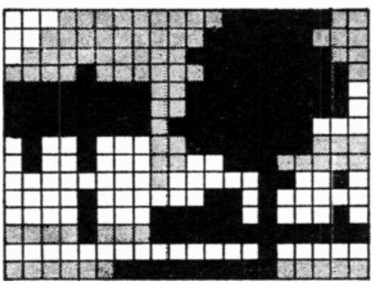
For some effects the real sound is better. Use real cups and saucers and other crockery when recording people at table. The same applies to washing-up. For a door opening and closing use the door of the room. A squeaky door is very useful for eerie effects in a mystery story. If you are lucky enough to be able to use a portable tape recorder, you can make a collection of 'real effects', like birds singing, motor-cars, ships' sirens. You can then use these in your plays.

4

HOW TELEVISION WORKS

Here is a simple game you can play which helps you to understand how a picture is sent by television. All you need is a sheet of squared paper and two pencils, one black and the other grey. We are going to 'send' the picture on this page. Notice that it is made up of black, grey and white squares. One person with this picture in front of him acts as the 'transmitter'. Another, seated some distance away, equipped with the paper and pencils, is the 'receiver'.

The 'transmitter' calls out the colours of the squares in the picture, beginning with the top line, first square. So his message runs like this 'white, white, white, grey . . .' At the end of each line he calls out, 'next line', and continues. The 'receiver' colours in the squares as quickly as he can and so the picture is gradually built up until it is completed. Transmitter and receiver in our game need not be in the same room. They could equally well be many miles apart, the one sending and the other receiving the message by telephone. The message could even be sent hundreds of miles, or be transmitted by wireless.



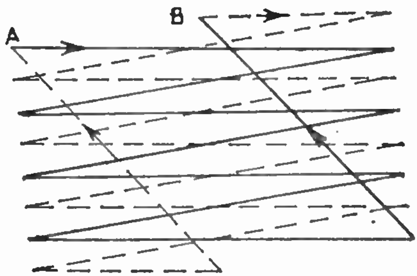
'Sending' a picture in strips

The television camera

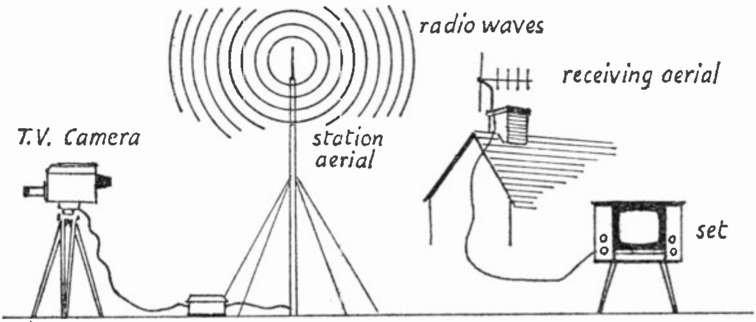
In real television exactly the same process takes place as in our game. The television camera also divides the picture in front of it into thin horizontal lines. In running over these lines it sends a message along its cable stating the shade, in terms of light and dark, of each small portion of the line. Make a hole in a piece of card with a knitting needle, pass this hole over the picture used in our game. All you see is a spot changing colour. This is what the television camera 'sees'. The action of running over the picture or scene in lines zig-zagging from top to bottom is called scanning. The television camera scans one complete picture in 405 or 625 lines from top to bottom, and takes only 1/25 second to do so.

The camera cable can be connected to a television receiver in the same room. What the camera sees will then be shown on the television set. The camera cable may be connected by telephone line to a television set many miles away; or it may be connected to a radio transmitting station, so that the camera's message goes through the air.

A television camera divides up a picture; the television set puts the pieces together again. The links in the television chain of events are camera, wire, receiver, or alternatively camera, radio waves, receiver. We shall deal with the 'radio-link' in the next chapter.



'Scanning'. The TV camera runs over a picture line by line. When it reaches the bottom it starts all over again. One complete picture is called a 'frame'. In modern television each picture is scanned twice, the line from A being one scanning, that from B the next



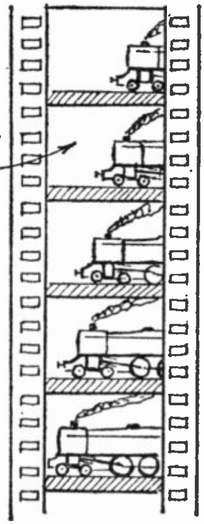
Links in the chain between TV station and TV set

The television receiver

The receiver also 'scans', exactly in step with the television camera. On your set screen you are really looking at a tiny point of light which zig-zags from top to bottom of the screen. This light is bright at each point where the picture is white, dim where it is grey, and 'out' altogether where it is black. So you can imagine the little spot of light changing in brightness as it speeds along the lines.

Why do we see a picture, and not simply a moving spot of light? The reason is that our eyes have a kind of 'memory' for light. Look directly at a bright light, such as an electric lamp, and then look away. You will seem to go on seeing the light for a brief instant. Shine a spot of light from a torch on to a wall or ceiling. Now wave the torch rapidly backwards and forwards. Because your eye continues to see the spot after it has moved, you will see a line of light, instead of a moving spot.

The spot on your television screen moves so quickly that you go on seeing it all the way along its zig-zag path to the bottom of the screen. Your eye, therefore, seems to see a complete picture. In fact, your 'eye memory' lasts for more than one picture.

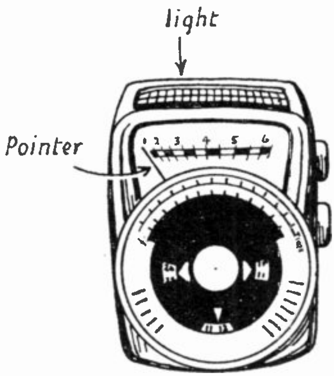


The cine film

Moving pictures

So far we have been considering the televising of a 'still' picture, like a drawing or a photograph. We come now to the televising of scenes of real life in which there is movement. The method employed is similar to that used in cinema films. A large number of pictures of the scene are taken by the television camera. As in the case of a film, each picture shows a slight change in the scene. The pictures are shown to the viewers rapidly, one after the other. Due to 'eye memory', the viewer thinks he is seeing one picture, in which things are moving. The separate pictures are called 'frames'. In home movies the rate at which the pictures change places on the screen is 16 frames a second. In the cinema, it is 24, and in television 25 frames in each second.

Remember then, when you are looking at television, that you are looking at a large number of pictures, built up at the rate of 25 in each second. The little spot of light scans each picture, then flies back to the top of the screen and begins the next. So that in one second the spot has covered 405 lines 25 times in the case of BBC 1 or ITV, or 625 lines 25 times in the case of BBC 2.

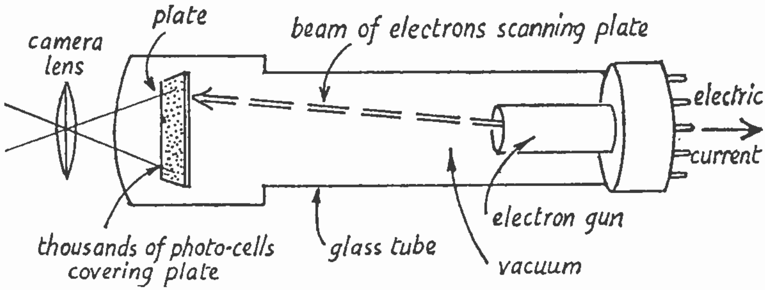


An exposure meter. The stronger the light, the further to the right the pointer moves

The camera tube

Now let us take the lid off the television camera and look at the works. These remind us in some ways of the inside of a television set. The main part is a glass cathode ray tube, although this tube is shaped differently from the one used in a set. Inside the camera tube is a flat plate of metal which takes the place of the film in a photographic camera. This plate is very different from a film however. When a picture is focused on it by the camera lens, it becomes charged with electricity.

To understand how this happens, let us look at a photographer's exposure meter (sometimes called a light meter). Inside the exposure meter is a photo-electric cell, a small electric battery, which generates electricity when light shines on it. The electricity works a pointer on a scale. The stronger the light, the more electricity is made, and the further the pointer moves. Try using the exposure meter to measure the brightness of light falling on objects. Hold it up to something white. Notice how far the pointer moves. Now try something grey, and something black. For grey the pointer will not move so far, for black it will move hardly at all.

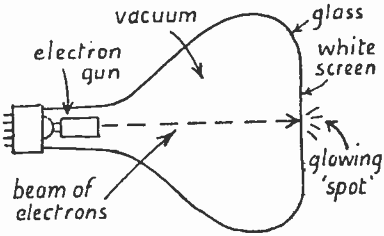


The TV camera tube

The plate of a television camera tube is covered with thousands of minute photo-electric cells, packed together closely like the grains of fine emery paper. When a picture is focused on this plate by the camera lens, each tiny cell gets charged-up with electricity. The cells in the light parts of the picture get charged-up most, those in the dark parts least.

Each cell in the plate is now made to discharge its electricity in the form of an electric current. Clearly this cannot be achieved by attaching wires to each cell, for the cells are too small. Instead, each cell is touched in turn by a ray, which is in some ways like a fine beam of light except that it is invisible. The ray scans the plate. The electricity from each cell forms a current which flows from the camera. This current, because it comes from differently charged cells, keeps continually changing as the ray goes on scanning.

The ray, which is called a cathode ray, is a stream of electrons. We shall deal further with cathode rays later on in the chapter. The diagram on this page shows a camera tube simplified. Notice how the cathode ray beam shoots out of the 'gun' to strike the plate. The cells on the plate have been charged up by the picture focused upon them. Where the beam touches the plate the cells are discharging their electricity.



The TV receiver tube

The chain of events in the camera is therefore:

1 Picture is focused on plate.
2 Photo-electric cells become charged.
3 Scanning ray discharges each cell.
4 Electric current flows from camera.

The receiver tube

The cathode ray tube in a television set is like a large glass bottle with a flat end and a narrow neck. The flat end is coated on the inside with a screen on which the picture appears. Wires enter the narrow neck to carry electricity to work the tube. Other wires bring in the electric current coming from the television camera. Let us look inside this receiver cathode ray tube to see how it works.

Like the camera tube, the receiver tube has a 'gun' which shoots a beam of invisible cathode rays at the screen. Where this beam touches the screen, a tiny point of light appears. This is because the screen is made of a coating of 'fluorescent' material which glows when cathode rays shine on it. When the tube is switched on, the beam begins to scan the screen. If no television signals are coming into the tube, all we see is a blank rectangle of glowing white screen. If we look closely we can see the lines of which it is made.

When the 'message' from the television camera enters the receiver tube, a change takes place. The cathode ray beam starts to become stronger or weaker at every instant while it is scanning. The moving spot glows brighter or dimmer as a result, and our picture appears.

Keeping in step

If our receiver spot of light did not move exactly in step with the scanning beam of the camera, we should see some very queer effects. For example, the picture might begin half-way down the set screen. In this case we should see two half-pictures together. The camera, however, sends out a strong burst (pulse) of current every 1/25 second, at the exact instant that each new picture is beginning. This 'signal' of electric current makes the receiver tube start its scanning at the right moment. It is called, therefore, a 'synchronising signal'.

The chain of events in the television receiver can be summed up as follows:

1 Current from the camera enters the receiver.

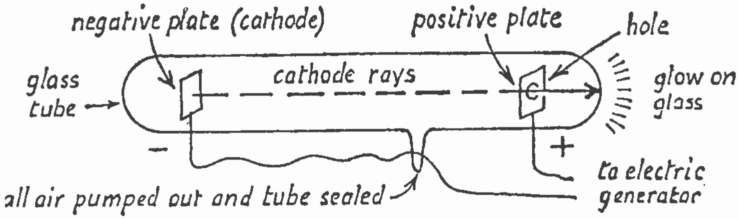
2 The cathode ray beam changes in intensity as it scans.

3 The spot glows with varied brightness as it moves.

4 Because of 'eye memory' we seem to see a picture on the screen.

Cathode rays

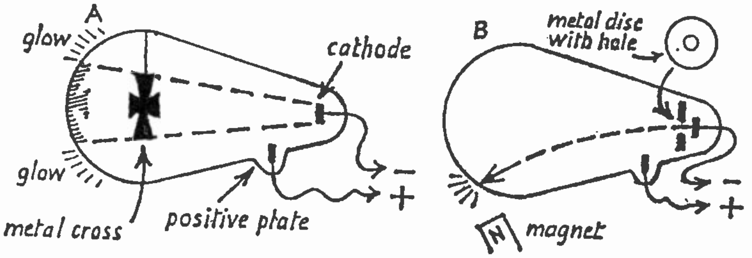
Both the television camera and the television receiving set depend on cathode ray tubes for their operation. To complete this chapter on how television works, let us



Cathode rays (1)

briefly consider cathode rays themselves, and how they are made.

When we think of an electric current, we usually imagine it running along a wire, or something which conducts electricity. With electricity of several thousand volts, however, a current can leap a gap between two conductors. The effect of this in the air is an electric spark. This spark is really the air being heated up by a stream of electrons rushing through it. An electric current of very high voltage can also travel through a vacuum—that is, empty space where there is no air or gas. The picture shows a sealed-up glass tube, from which all the air has been pumped. Wires going through the glass at each end lead to small metal plates. One metal plate has a hole in its centre. A supply of electricity of several thousand volts is connected to the plates. The plate with the hole is made positive. The other, called the 'cathode', is made negative. A strange thing happens when the electricity is switched on. At the opposite end to the cathode, on the glass behind the hole in the metal plate, appears a faint greenish spot of light. This spot is due to an electric current travelling through the vacuum. The current, which, like all electric currents, is a stream of electrons, leaves the cathode and strikes the other plate. It is called a cathode ray in consequence.



Cathode rays (2)

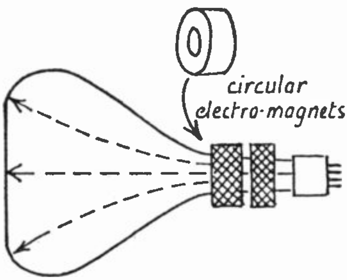
A. Cathode rays throw a shadow of a cross on the tube

B. A magnet attracts the rays

Some electrons go through the plate and hit the glass, making it glow.

What we have just described is the simplest form of cathode ray tube. In the picture above the two plates in the tube are arranged with the positive plate to the side of the cathode. The ray shoots out from the cathode in a straight line, misses the second plate and strikes the glass, which glows greenish at the end. A shadow of a little metal cross can be thrown on to the glass, since the rays will not go through metal. This shadow clearly shows that the rays travel in straight lines.

The cathode ray beam can be made more intense by turning on more electricity, that is, increasing the voltage. This gives us a means of making the 'spot' brighter or dimmer. A magnet brought near the tube will pull

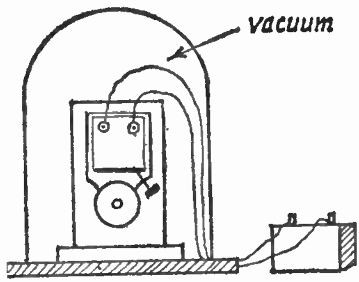


TV receiver tube. Circular electro magnets are used to make the beam scan the beam towards itself. The spot will then move in the direction of the magnet. An electro-magnet can be switched on and off. Let us imagine one electro-magnet placed above the tube, and another one underneath. By switching these magnets on and off alternatively the spot will be made to move up and down. Another pair of electro-magnets can move the spot horizontally from one side of the screen to the other. Both sets of magnets can be employed together to make the beam scan. In both camera and receiver there is apparatus which controls the electro-magnets so that the scanning goes on automatically.

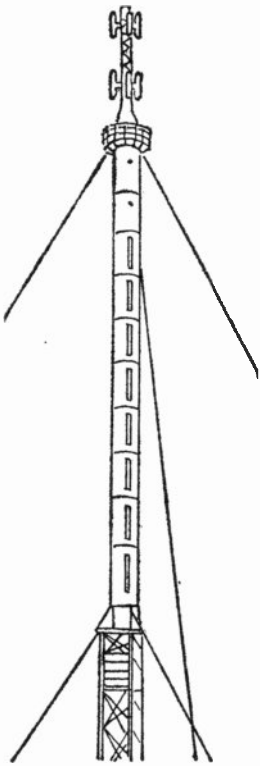
5

HOW RADIO WORKS

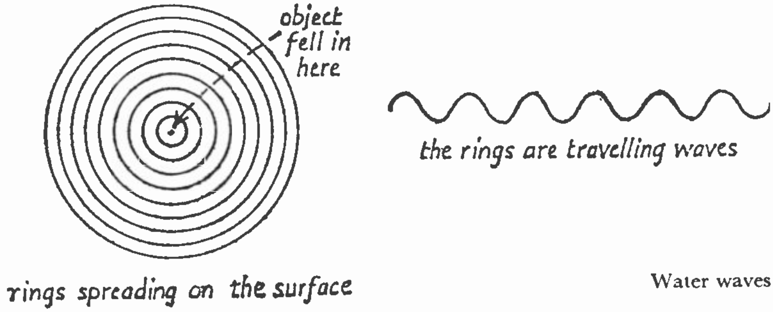
Radio was first used for sending out telegraph messages in the morse code. The system was then called 'wireless telegraphy' because no wires were needed along which to send the messages. Later on came 'wireless telephony' in which sound, like that of the human voice, was sent without using telephone wires. Today, radio is used for sending messages, for broadcasting news and entertainment, and for conveying television.



No sound can be heard from an electric bell ringing in a vacuum



The top of a 750-foot-high aerial of a TV station



Water waves

Radio works on the same principle whether it is being used for carrying morse code, sound or vision. In this chapter we shall describe sound radio, as an example of how radio works.

Sound

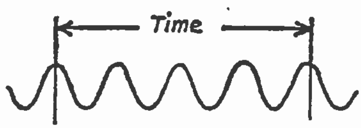
First, a few words about sound itself. We know that sound is caused in hundreds of different ways. For example, it can be caused by dropping a brick, plucking a guitar string, using one's voice or blowing a bugle. It is obvious that sound travels since you can hear something happening some distance away from you. It is a fact, however, that sound needs something to travel through. It cannot travel in empty space. This fact can be proved by trying to make an electric bell work inside a glass case from which all the air is removed. You can see the bell ringing, but you can hear nothing. The moment that air is let inside the case however, you hear the sound of the bell.

How then does sound travel? The answer is that sound is a movement of the air itself. We cannot see this movement, but we can form an idea of it by comparing what happens when we drop a stone into a pool of water. Ripples spread out in rings from where the stone fell in. These ripples are small waves. When they reach a floating object they make it bob up and down. When they reach the bank, they strike it one after another. A big bang is a 'splash' in the air. It causes a large number of 'waves' which spread rapidly. When these air waves strike an object, they make it shake. When these waves reach our ears, we can feel them.

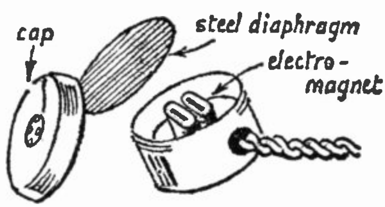
This 'feeling' we call hearing. Our ears can tell the difference between big and small waves. These we know as 'loud' and 'soft' sounds. We can also tell whether a small or a large number of waves reach our ears in a given time. If thirty-two waves arrive in a second, we call the sound a 'low pitched' sound. If several thousand waves arrive in a second, we call the sound 'high pitched'. A guitar string plucked to play the note 'middle C' vibrates 261 times a second and makes 261 sound waves in the air each second. The number of waves each second is called the frequency of the sound.

The telephone

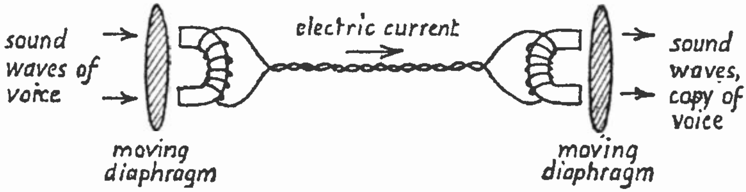
The mouthpiece of a telephone is a microphone. The earpiece is a small loudspeaker. Thus two people telephoning each have a microphone and a loudspeaker. On the next page the mouthpiece (microphone) of one telephone is shown connected by the telephone wires to the earpiece (speaker) of the other telephone.



Frequency: the number of waves in a second



The telephone earpiece



A simple telephone system

Underneath the cap of both earpiece and mouthpiece of a telephone is a thin circular steel plate, called the diaphragm. This plate, being springy, vibrates when sounds are made near it. On the other hand, if it is bent and let go, it vibrates and makes a sound.

The microphone generates an electric current when its diaphragm is made to vibrate. The earpiece is the microphone in reverse: when it receives an electric current its diaphragm vibrates. Let's now see what happens when Mary speaks to her friend John on the telephone.

The following is the sequence of events:

1 Mary's voice travels through the air as sound waves.

2 Sound waves make microphone diaphragm vibrate.

3 Microphone sends electric current along the wires to earpiece.

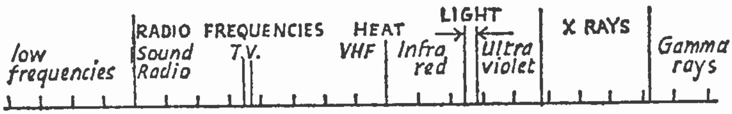
4 Earpiece makes its diaphragm vibrate.

5 Vibrating diaphragm creates sound waves which travel to John's ear.

These sound waves are copies of the sound waves of Mary's voice. If they are as good copies as is usual with modern telephones, John imagines he is hearing Mary's actual voice.

The radio-telephone

Police patrolmen like those you have seen in 'Z Cars' can keep in touch with their headquarters through telephones installed in their cars. Passengers on liners at sea can send telephone messages to the land. An astronaut circling the earth in a space satellite can speak with people on the ground. No wires can possibly link microphones and earpieces in these cases. How, then, does the electric current travel from one to the other? It is something made by this electric current which does the travelling. This something consists of waves in space, given the scientific name of 'electro magnetic waves'.



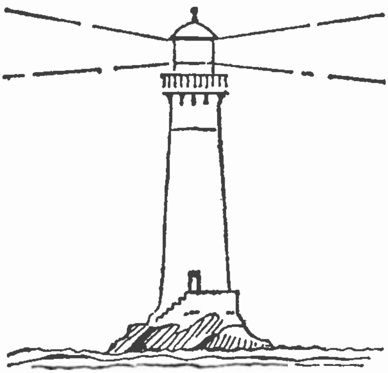
The scale of the electro-magnetic waves in order of frequency

Radio waves

You may have seen a 'silent' dog whistle. It is called silent because although the dog can hear it, human beings cannot. Just as there exists 'sound' too high or low for us to hear, there is also 'light' we cannot see. This 'invisible' light consists of gamma rays, X rays, ultra violet rays, infra-red rays, heat rays and radio waves. All of these, including the light we can see, are electro-magnetic waves. Above you can see them arranged on a scale, getting higher and higher in frequency as you go to the right.

All electro-magnetic waves are created by the flow of an electric current. For example, an electric current can make light, as in an electric lamp, or heat, as in an electric fire. It can also make radio waves. Instead of a lamp for light, or an electric fire for heat, an aerial is used for sending out radio waves. Broadcasting station aerials are wires attached to tall masts. Some other radio aerials look like the reflectors of electric fires, on a huge scale. All of these send out this 'invisible light' we call radio waves.

Let us imagine, therefore, that the tall aerial of the broadcasting station is a 'lighthouse', sending out radio waves in all directions. Unlike light these waves will go through 'solid' objects like brick walls, concrete, slates. They are stopped, however, by metal. A piece of wire is therefore attached to the chimney of a house, or inside the case of a radio receiver. This wire is called a receiving aerial. It stops some of the wireless waves. They cause a small electric current to flow in the wire. Thus an electric current causes radio waves to spread out from the radio station aerial. These waves are then turned back into electric current in the receiving aerial. A radio receiving set is a piece of apparatus in which the electric current from the aerial is made to work a loudspeaker.

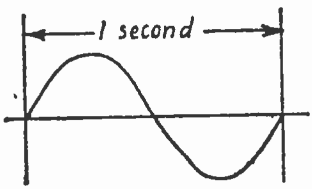


A lighthouse

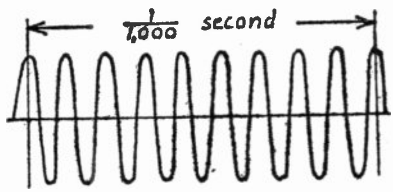
The radio transmitter

Let us go to the broadcasting station and follow the whole process in more detail. At the broadcasting station, the studio is linked to the transmitter, which is linked with the tall broadcasting aerial. We have already talked about the studio. The transmitter is contained in a building which may also house electric generators for supplying the electric current required.

Let us look at the transmitter itself. The main part of it is a large radio valve, which has some resemblance to an electric lamp, but may be two or three feet tall. Since it gets very hot when working, this large transmitting valve is usually water cooled. A valve resembles a cathode ray tube, in having a vacuum inside its glass tube. Suspended in this vacuum is a filament, like that of a lamp, and a metal plate. As in the case of the cathode ray tube a current of electrons passes through the vacuum. It flows from the hot filament to the plate and from the plate out of the valve. This current is sent to the station aerial.



Graph of an electric current rising and falling in strength



An electric current changing in strength ten times in one thousandth of a second

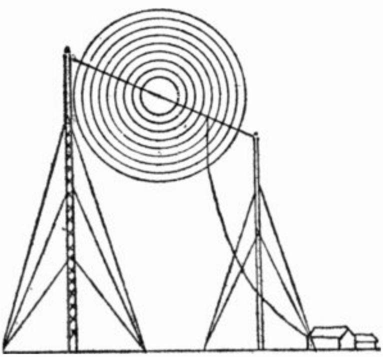
Radio waves are made when an electric current in a wire changes in strength very rapidly, rising and falling thousands of times in each second. Above, on the left, is a drawing to represent a current growing and then dying away all in one second. On the right is a current repeating this rising and falling ten times in a second. It would be difficult to make a drawing to show a thousand changes in a second, so you must imagine what it would look like.

The number of changes of the current in each second is called its frequency. Each change causes a radio wave so that radio waves have a frequency too. The frequency of the BBC Home Service is nearly one million waves per second. The technical expression for 'waves per second' is 'cycles per second'. 1000 cycles equal 1 kilocycle.

The purpose of the transmitting valve is to make a current rise and fall at a sufficiently high frequency to create radio waves. When the station is 'on the air' these radio waves leave its aerial wire just as rays of light shine out from a lighthouse. So far no programme is being sent out.

The microphone, however, is connected to the transmitter so that it controls the working of the transmitting valve. Just as someone's foot on the accelerator of a car makes the engine go more quickly or slowly, so the microphone current makes the transmitter produce stronger or weaker radio waves.

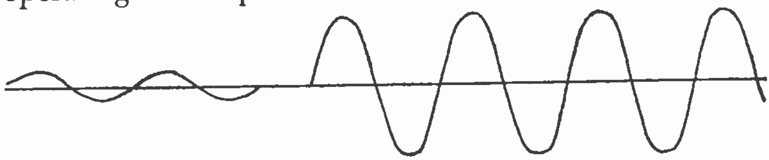
You can thus imagine our radio 'lighthouse' flickering—its radio waves changing in strength all the time that someone is speaking or playing music in the studio. These changing radio waves arrive at the receiving aerial on someone's chimney, or the tiny aerial inside a transistor set. Let's see what happens to them there.



Invisible waves spread out from the aerial of a radio station

The radio receiver

The receiver aerial is a piece of wire or a metal rod. Radio waves striking it cause an electric current in it. This electric current is very weak, however, particularly if the receiving set is tens or even hundreds of miles away from the transmitter. Electric current is measured in amperes, and the ordinary torch bulb fed from a small battery takes about one-fifth of an ampere. The current in a radio aerial may be as low as one-millionth of an ampere. This current is far too weak to be of any use in operating a loudspeaker.

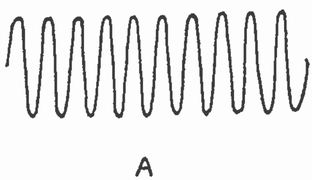


Magnification—a small change in an electric current becomes a large one

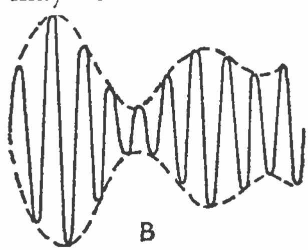
The radio set therefore has something inside it which can magnify the aerial current. This magnifier, called an amplifier, contains receiving valves or transistors. It is driven either by electricity from the mains, or by batteries. Valves or transistors have a current flowing through them which eventually works the loudspeaker. The weak aerial current controls the stronger valve or transistor current.

The tiny current in the aerial may be drawn like this.

A. The current in the aerial with the microphone off



A



B

B. The aerial current being varied in strength by the microphone

On the left no one is speaking into the microphone. The current therefore is a steady even stream of 'ups and downs' at a frequency of hundreds of thousands of times each second. Notice that the 'ups and downs' are all equal. On the right, however, someone is speaking into the microphone. The 'ups and downs' are now no longer all equal. The microphone is making the radio waves change in 'height', that is, in strength. The loudspeaker cannot follow changes of current taking place hundreds of thousands of times a second, because it is unable to move quickly enough. But it can follow the slower changes in strength caused by the microphone. This is perhaps like a boat, which is not moved by the small ripples created by the wind. Longer, slower waves from the wash of a steamer, however, rock it up and down.

The loudspeaker, therefore, moves as the microphone diaphragm moves. Thus, as in the case of the telephone earpiece, it makes copies of the original soundwaves.

Now let us go back to the broadcasting station, where the announcer is just going to speak.

Leaving out the details, this is what happens:

1 Transmitter is on the air sending out even radio waves.

2 Announcer speaks into microphone.

3 Radio waves change in size following the movements of the microphone.

4 Radio waves strike the receiving aerial.

5 Radio set magnifies aerial current.

6 Loudspeaker follows the changes of the aerial current.

7 Thus we hear the announcer speaking.

Do not forget, however, that we are not really hearing the sounds he actually made, but those made by the loudspeaker, which is imitating his voice.

Tuning

You can listen with your radio to the Home Service, the Light Programme, the Third Programme, or to dozens of other stations all over Europe. These stations are often all on at the same time. How, then, are we prevented from hearing a jumble of them all coming out of a loud-speaker? The answer is—by tuning. We select the station we want by turning a pointer on the set's scale to the name of the station, or to a number.

The word 'tuning' is borrowed from something connected with sound, such as 'tuning a piano'. A tuning fork which sounds 'middle C' vibrates at a frequency of 261 vibrations per second. When the piano is tuned, its middle C string is tightened until it also vibrates 261 times per second. The string and the tuning fork are then said to be 'in tune', for they sound exactly the same note.

If you have a tuning fork, try this experiment. Make it sound over the open mouth of an empty milk bottle. Now, very gradually, fill the milk bottle with water from a jug, whilst keeping on sounding the tuning fork near the mouth of the bottle. Presently, and quite suddenly, you should hear the tuning fork sound much louder, as if the bottle were answering back. The reason is that the air in the bottle is now vibrating in step with the tuning fork. Notice that if you pour in still more water this effect ceases. Only with one definite amount of water in the bottle is the air left inside 'in tune' with the tuning fork.

Now try an experiment with a bicycle pump. First make a note by blowing across the hole where the connection screws in. Now, try again with the pump handle pulled out at various distances. The note changes. You are varying the tuning of the pump by altering the length of the air column inside. Different lengths correspond to different sound frequencies.

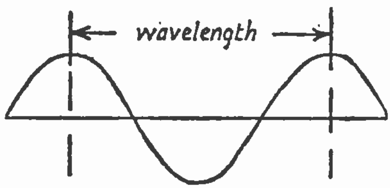
In the same way, you can vary the lengths of coils of wire or the distance between metal plates to correspond with the different frequencies of radio waves. Inside your radio set is an arrangement of metal plates which can be altered by turning the 'tuning' knob. This also moves a pointer on a scale. So the tuning of the set is altered.

Each radio station has a similar arrangement of coils of wire and metal plates which is fixed to correspond with a definite radio frequency. So, for example, one of the stations broadcasting the Light Programme has a frequency of 200 kilocycles per second. If you want to listen to that particular station you tune your set to 200 kilocycles per second.

Wavelength

The word 'wavelength' is often used instead of frequency when speaking about the tuning of radio stations and receivers. 'Wavelength' is the length in metres between the separate radio waves as they leave the transmitter aerial. All radio waves travel at the same speed, so that

Wavelength: the distance in metres between successive waves



the more waves there are in a second, the closer together they must be.

Very high frequency waves (VHF) are thus called 'short waves', because there are millions of waves each second. Lower frequencies of only a few hundred thousand waves each second are called 'long waves'.

The speed with which radio waves move is the speed of light, 300,000 metres per second, or about 186,000 miles a second. At this tremendous speed a radio signal could go right round the world about seven times while you are counting 'one'!

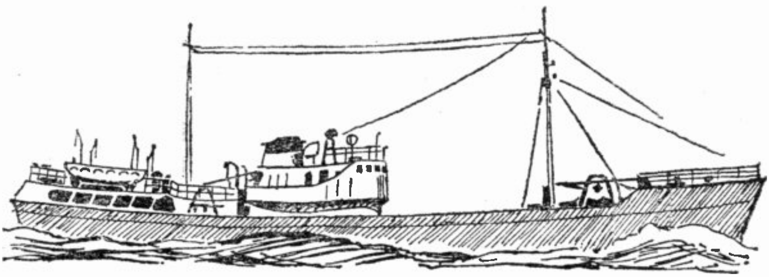
6

RADIO ROUND THE WORLD AND IN SPACE

Were it not for radio, all broadcasting, whether of sound or television, would have to be sent along wires. Moving vehicles, aeroplanes and ships would not be able to receive the programmes, nor would the parts of the world where the wires cannot reach. Without radio, aeroplanes, ships, police cars and military vehicles would have to rely on visible signals such as flashing lights, or flags, for sending messages. Messages from far distant places would have to be sent by telephone, and if there were no telephone lines, by letter. As it is, even the most remote parts of the world can keep in touch with the rest. Radio has made the world smaller.

Radio at sea

All modern ocean-going ships of any size carry wireless.



The wireless aerials on a trawler

Very large vessels have on board a radio transmitter which can cover distances of hundreds or even thousands of miles. The ships are also equipped with receivers sensitive enough to be able to receive signals from a great distance.

The morse code is still very much used for radio messages at sea. It has the advantage that a message in it can still be understood even if the signal is very weak, or if there is a great deal of 'interference' on the radio. Radio interference at sea is frequently caused by electric disturbances in the upper atmosphere, and takes the form of loud crackles called 'static' or 'atmospherics'.

The ship's radio officer has the duty of sending and receiving messages in morse and by telephony. He receives weather forecasts from the nearest weather station. He sends and receives messages for the captain. He and other officers also keep a twenty-four hour 'radio watch', listening for messages from other vessels. This is very important in case a vessel in distress is sending an 'S O S' for help.

Distress signals

S O S does not mean 'Save Our Souls'! The letters S and O were chosen for distress signals because S, · · · in morse, and O, – – – in morse, are not likely to be mixed up with any other letters in the code. A ship requiring help urgently therefore sends the S O S signal, which is understood by ships of all nationalities. There is not much point, however, in merely sending out S O S by itself, for this merely means 'Help!'. The ship in trouble will radio its name, its position and what the trouble is.

The message will run like this:

S O S
Steam Ship Ruritania
Latitude 54° N Longitude 4° W
Fire in engine room.

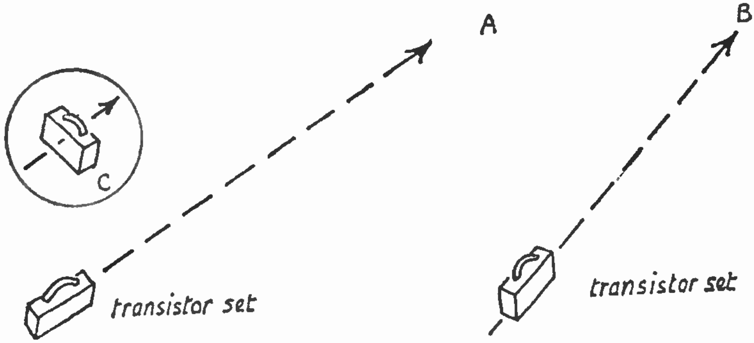
(You can easily plot the position of this ship in an atlas.) Ships receiving the message will alter course to give help, or if they are far away from the distressed vessel will make sure that a ship closer at hand goes to the rescue.

But supposing that the ship has sunk, leaving lonely lifeboats and rafts afloat—how will these be found? If the ship had sent out a call giving its position before sinking, help would be on the way from ships who had heard the S O S. But if the ship had gone down before its distress signals had been picked up, the survivors might be in great danger, especially if they were in stormy seas far out in the ocean. To meet such a possibility, lifeboats, rafts and even 'Mae West' life jackets are nowadays often fitted with automatic radio transmitters. Such transmitters go on sending out distress signals until the survivors are picked up. The position of the lifeboats and rafts can be found by the rescuing ships through 'radio direction finding'.

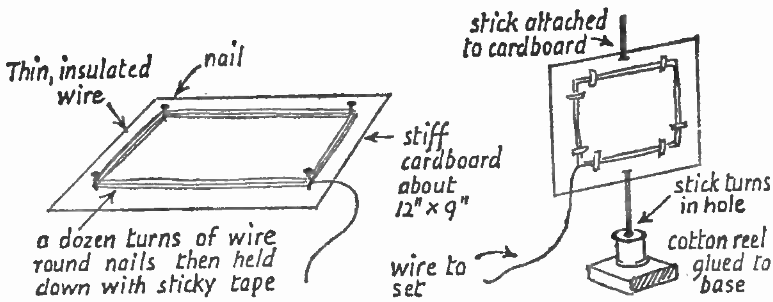
Direction finding by radio

This is called DF for short. It is a method of finding the direction from which radio signals are coming. Many portable transistor sets are 'directional', that is, they work best when they are pointing in the direction of the broadcasting station. Try the following experiment with a portable transistor set. Tune the set to some station which

A portable transistor set can show the direction of a radio station. The second set is a few miles away from the position of the first. The station's position is where the two lines A and B meet. (Alternatively the set can be turned to give the *least* volume from the station, as shown at C)



gives good reception in your area. Now lift the set up and turn it slowly round. If the set is directional, the volume will be loudest when the case is pointing in a certain direction. Stand the set down, pointing in this direction. Look along the longer edge of the top. The radio station is somewhere on a line running straight in front of you or behind you. To tell in which of these two positions the station is located you would need to repeat the experiment at some place a few miles from where you first tried it. The drawing shows you that the radio station is at the spot where the two direction lines cross.

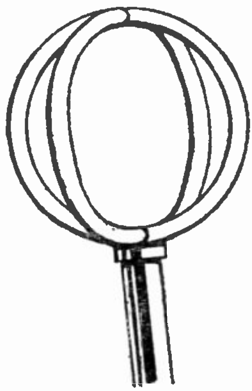


Direction-finding by radio: making a frame aerial

You can do some interesting experiments in direction finding with a frame aerial. The drawing shows you how to make one. Attach the wire from the frame aerial to the aerial terminal of a radio set. Get a fairly large map of Europe, and a compass. Place the map so that its north is facing north as shown by the compass. Stand the frame aerial so that its base is over the place where you live. Now tune the set to stations such as Luxembourg, Hilversum, Paris, London. In each case turn your frame aerial to the direction shown by the map. Try locating other stations you can pick up.

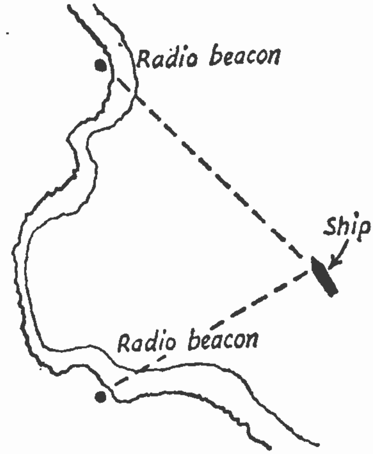
The direction finding frame aerial on a ship has two circular loops of wire at right angles to each other, each enclosed in tubes. By means of this aerial the ship can locate other ships who are sending messages, and radio stations on the land.

DF aerial
on a ship



Radio beacons

Certain radio stations have been built on the coasts of almost every country to help ships to find their way. These stations are called radio beacons. Formerly only lighthouses existed to warn navigators of dangerous rocks and narrow channels, and to help them steer their way



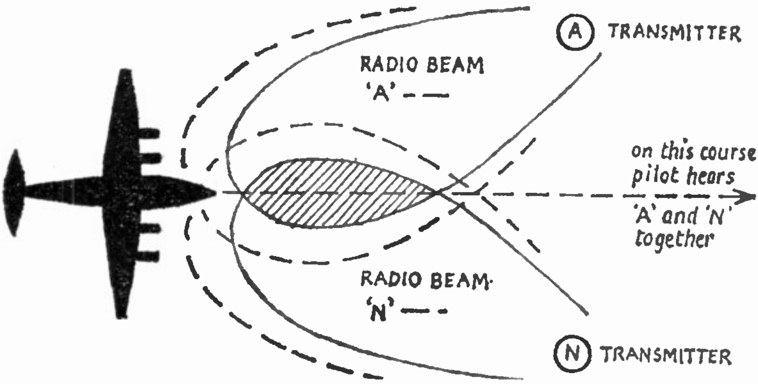
How radio beacons help a ship to find its position on the chart

in difficult places. Lighthouses still serve this useful purpose but nowadays most of them are also equipped with a radio beacon. These beacons have the advantage that ships can receive them in a fog or at a distance from which a light would not be visible.

Each lighthouse flashes its light in a different way, so that seamen can identify the lighthouse. In the same way each radio beacon sends out a special signal of its own which distinguishes the beacon from others. Radio beacons usually operate within frequencies of 255 to 415 kilocycles per second. If your set is able to tune to this frequency, you should be able to pick one up. Each one has an automatic transmitter which repeats a call sign in morse followed by a long dash. The call sign is for identification, the long dash is for direction finding purposes.

Radio in the air

Radio is of tremendous assistance to modern aircraft. It helps them to find their way over vast distances, and to



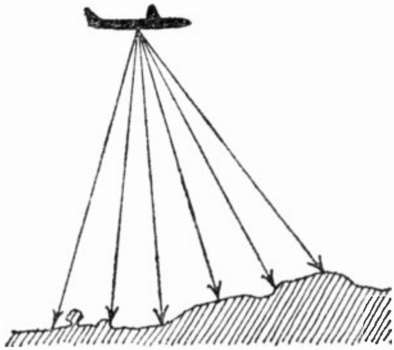
Radio helping an aircraft to find its way to the airport

take-off and land at crowded airports. By means of it the pilot can receive weather reports, send messages, if he is in difficulties, and keep in communication with the control tower when he is on or near the airfield. It helps him perform the difficult operation of landing, particularly at night, or in bad weather conditions.

Here is just one of the ways in which radio helps the pilot to find his way. In this case it is a way in which he is guided to the airport. Two radio transmitters are placed one at each side of the approach to the runway. One, on the left, continuously sends out the morse letter A, · – The other, to the right, sends out the letter N, – · The pilot approaching the airport listens to both these stations. If he is on course, flying exactly in between them, he hears both call stations together at equal strength. Morse 'A' and 'N' heard together make one long continuous note ————. If the pilot goes off-course to the left he begins to hear letter A, if to the right, N. He therefore steers so that he always hears a continuous note.

Radar

One of the most important radio aids to navigation at sea or in the air is known as radar. The word is short for 'radio detection and ranging' and it stands for a method of locating objects by radio and measuring their position.



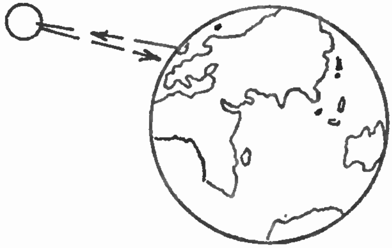
An aeroplane receiving a picture of the ground through its radar

If you bounce a ball against a wall you will find that the further you stand back the longer the ball takes to return to your hand. Radar works by sending radio-waves to strike an object and be reflected back. Obviously the further away the object the longer the time the radio waves will take. Since radio waves always travel at the same speed, this time taken to go and return will tell us the distance of the object. Radar thus provides us with information by using 'echoes' of radio signals.

A radar system consists of:

1 A suitable transmitter.
2 A receiver.
3 A device to measure the time between sending out the signal and receiving its 'echo'.

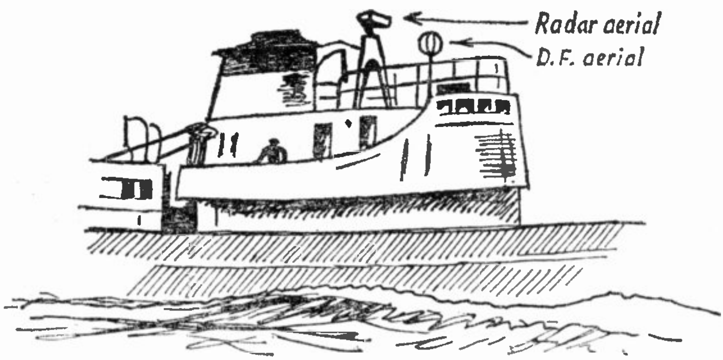
Suppose that you want to use radar to measure how far



Bouncing radio waves
off the moon

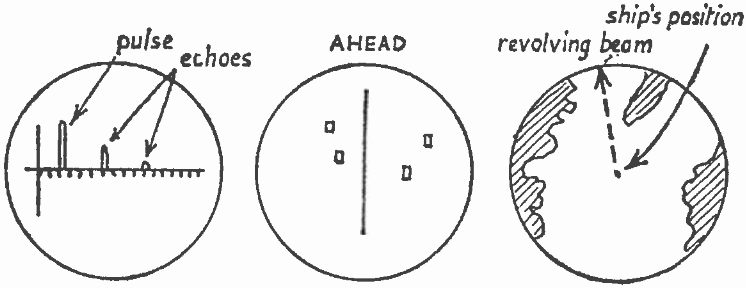
the moon is from the earth. You would need to send a 'pulse' of radio waves to the moon and to time how long it is before you hear the echo. The difficulty would be to measure this time interval accurately enough to give a correct answer. A radio wave would take about 2.6 seconds to reach the moon and return to earth. Light travels at about 186,000 miles each second. In 2.6 seconds it would have travelled 483,000 miles. Therefore this would be the distance to the moon and back. From this it appears that the moon is about 241,500 miles from the earth. (The mean distance in fact 238,840 miles.)

The aerial of a radar installation frequently takes the form of a metal box which turns round and round on its axis. You can usually find one of these above the bridge



The bridge of the trawler shown on page 67. Radar and DF aerials help with the navigation of the ship of a ship. As this aerial turns round it does two things. It shoots out pulses of radio signals, and it collects them when they are bounced back by the objects they strike. This action resembles that of someone making a loud sound and listening for the echo.

The radar receiver uses a cathode ray tube. On one form of screen the navigator can see a mark representing the pulse going out, and another one representing the pulse returning. The distance between the two can be measured by a scale of divisions on the cathode ray tube screen. The drawing at (A) shows the pulse and the echo.



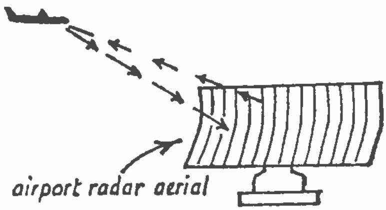
A. A radar screen showing the radio pulse and its echo. The *range* is the distance between pulse and echo
B. A radar screen showing echoes as bright spots. *Range* and *direction* are shown on this screen
C. P.P.I. (Plan Position Indicator) on this radar screen the revolving beam shows a plan of the harbour and the movement of the ship

All that this particular radar screen tells the navigator, however, is that there is some object at a certain range from the ship. It does not tell him in which direction the object lies.

The drawing at (B) shows a radar screen which gives the navigator both range and direction. The upright line on the screen corresponds to the ship's course. The square marks are bright spots appearing on the screen corresponding to echoes from objects. The direction and distance from the ship of each object is thus shown.

At (c) is shown a third type of radar screen, called the plan position indicator, P.P.I. for short. The position of the ship's radar aerial is at the centre of the screen. As this aerial rotates and sends out its radio pulses, the echoes form a map of the surroundings of the ship. The movement of the ship can be seen on this screen. P.P.I. is particularly useful for guiding a ship into harbour.

Many forms of radar are used by both aircraft and airports. Some of these resemble those used by ships and harbours, others are designed to suit the special problems of the air and the great speeds of flight.



The airport 'sees' an approaching aircraft by means of radar

Radio astronomy

It has been mentioned that the moon's distance can be measured by using radar. The distance of the planets can be measured in a similar manner. It has been discovered that just as light comes to us from the stars, so also we receive radio waves from outer space. These waves appear to be caused by matter in certain parts of the universe sending out radio frequency waves as well as, or instead of, light. Radio astronomers use so-called radio telescopes to receive these waves, and find where they are coming from. The huge Jodrell Bank radio telescope is a radio reflector which can pick up and focus radio waves coming from immense distances. It can also

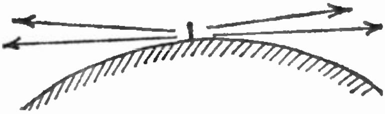
The radio telescope
at Jodrell Bank

'track' any star or planet, or even space satellite. The exploration of space by radio astronomy has only begun in recent years. It is already telling us interesting facts about the universe.

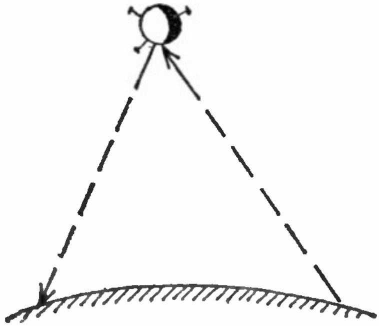
Telstar

This is the name given to a special space satellite which circles the earth from west to east at a distance of a few thousand miles. The purpose of the satellite is to reflect down to the earth radio waves which have been sent up to it.

High frequency radio waves such as those used for television travel in almost straight lines. Since the earth is round, waves from such a television station travel out into space a short distance from the station aerial, and if you are more than about thirty miles from a TV station you cannot receive it properly because its waves are travelling high up above you. The drawing shows how such waves reach the circling satellite and are sent down again.



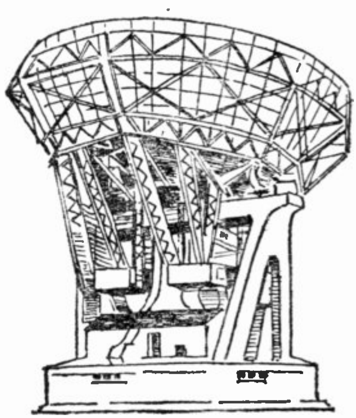
Very high frequency waves travel in straight lines. After a short distance these rays leave the earth and pass into space



Bouncing radio waves off Telstar

The satellite does not merely reflect radio waves. Inside it there is a receiver, an amplifier, and a transmitter. The signals are very weak by the time they reach the satellite. Its receiver picks them up and passes them to the amplifier. This magnifies them greatly and sends them to the transmitter which sends them back to the earth.

A television station in America or Japan can therefore aim its signals at the satellite. If the satellite is in the right position it can send these signals down to Britain. Our television stations can pick up these signals and send them to us in the ordinary way. We can thus receive the



The reflector aerial at Goonhilly Down, used for picking up Telstar

Japanese programme. The length of time we can do so depends on the height of the satellite and the speed it is moving.

Radio control

You may have seen model boats being steered on a lake by radio 'remote control'. On the shore someone has a small radio transmitter. With this he sends signals to a receiver on the model boat. Instead of working a loud-speaker the receiver operates the motor and the steering. The boat can be made to turn and return to its owner, or execute fascinating manoeuvres.

Radio is used in this manner to control the flight of rockets as they leave the ground. Pilotless aircraft have been made to take off, fly and land by the same means.

This brings us to the end of this chapter and of this book. There are many other interesting things to learn about television and radio. Read about them in other books and try further experiments.

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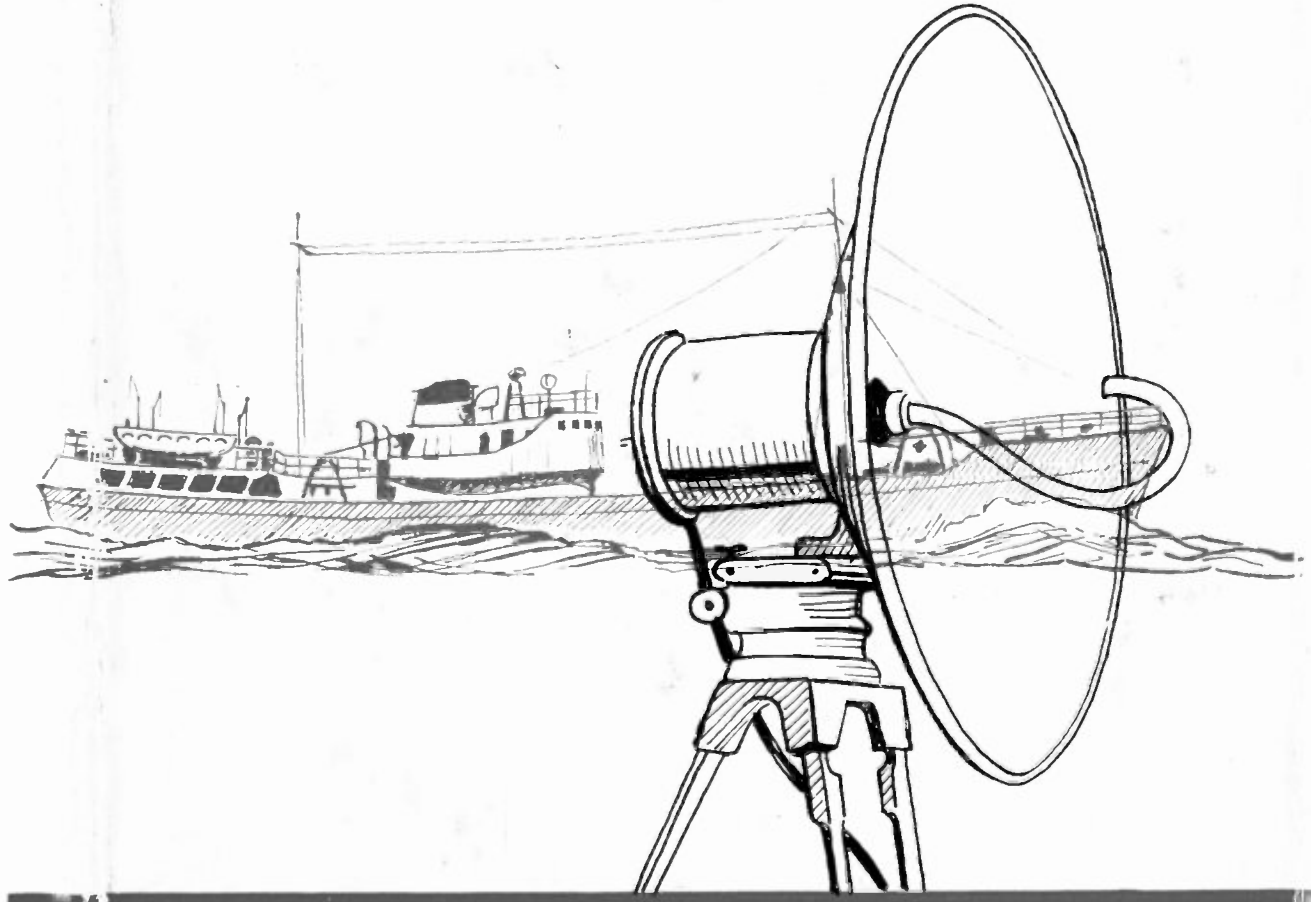

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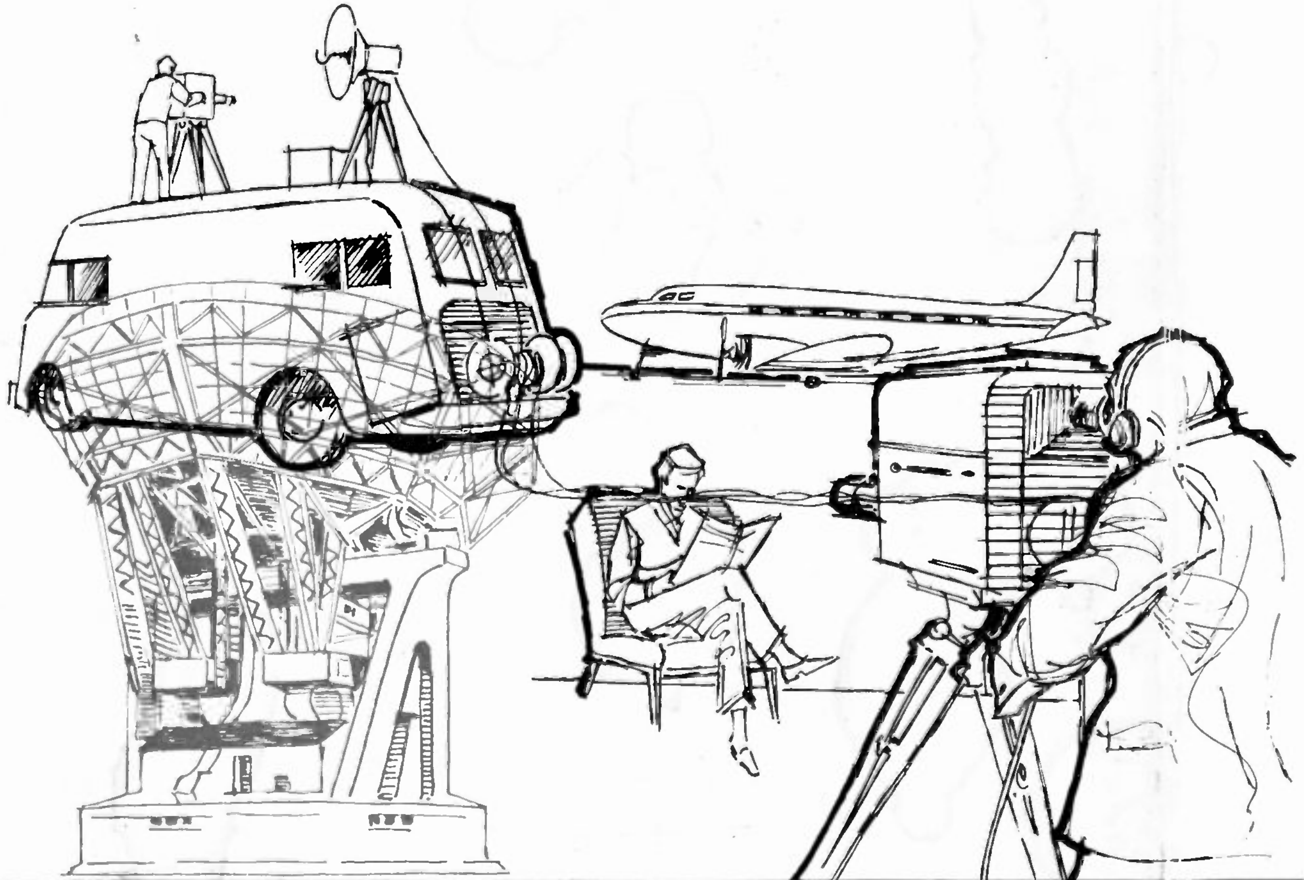

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Mr Roberts treats his subject in such a way that no one is left standing on the touchlines of broadcasting; every reader will be caught up in its methods and purposes.

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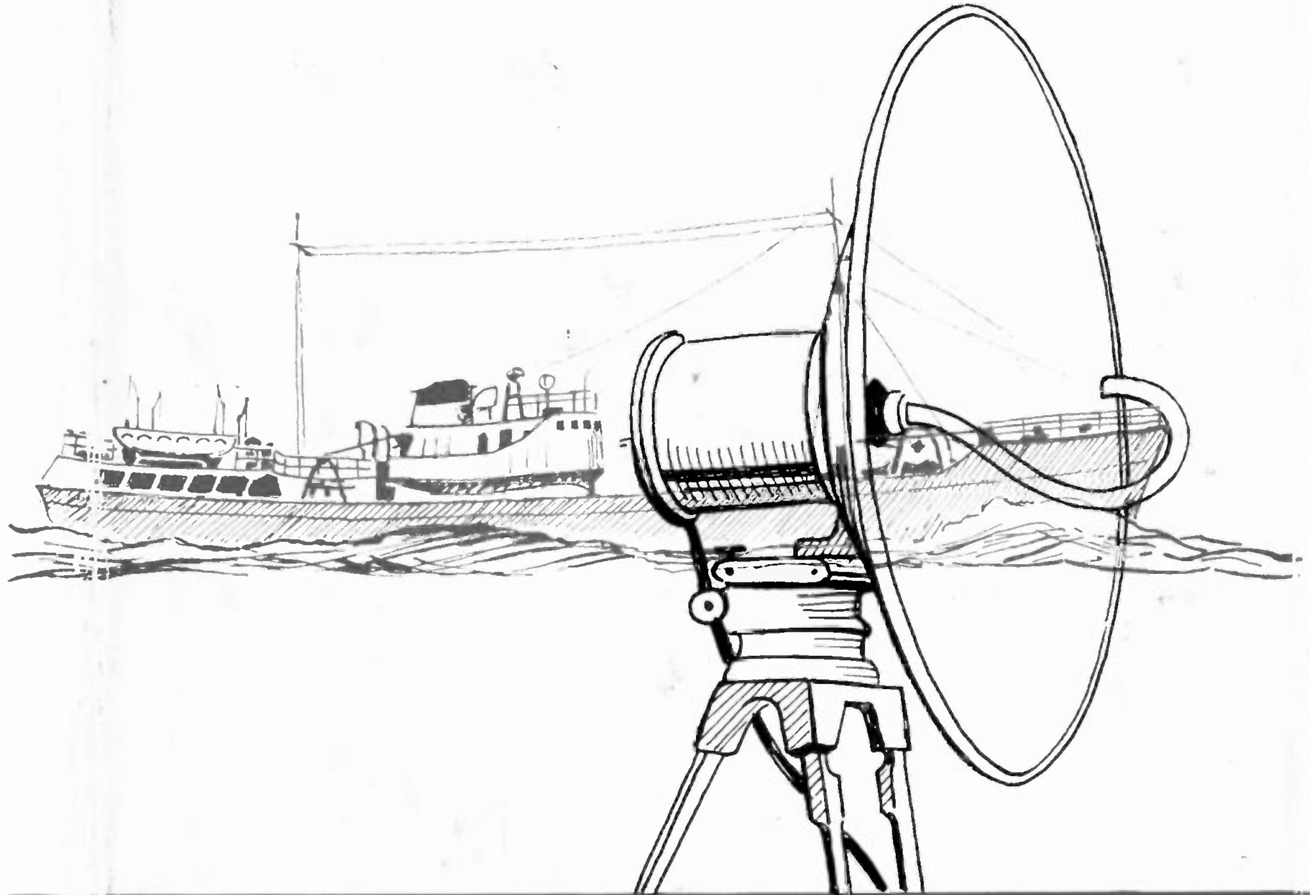

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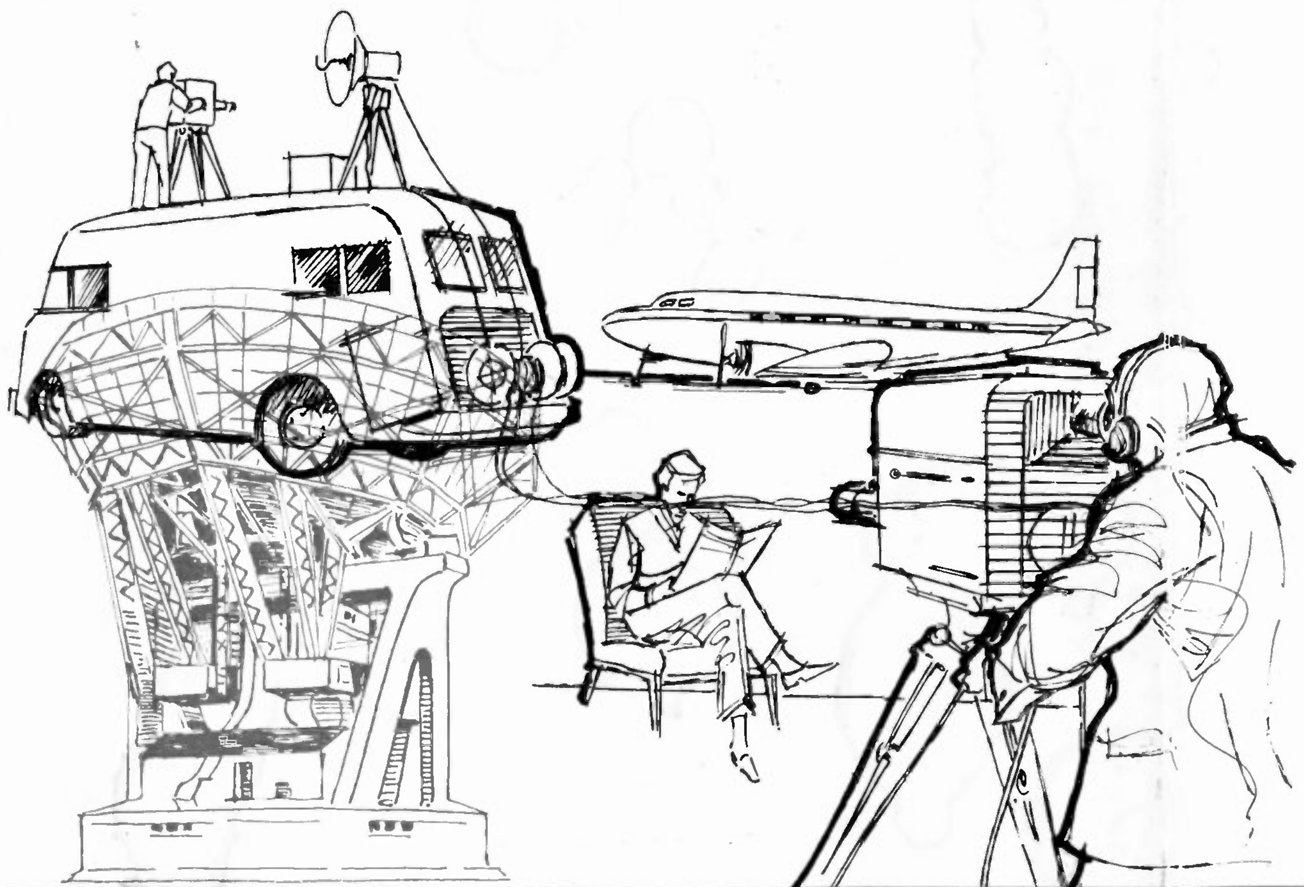

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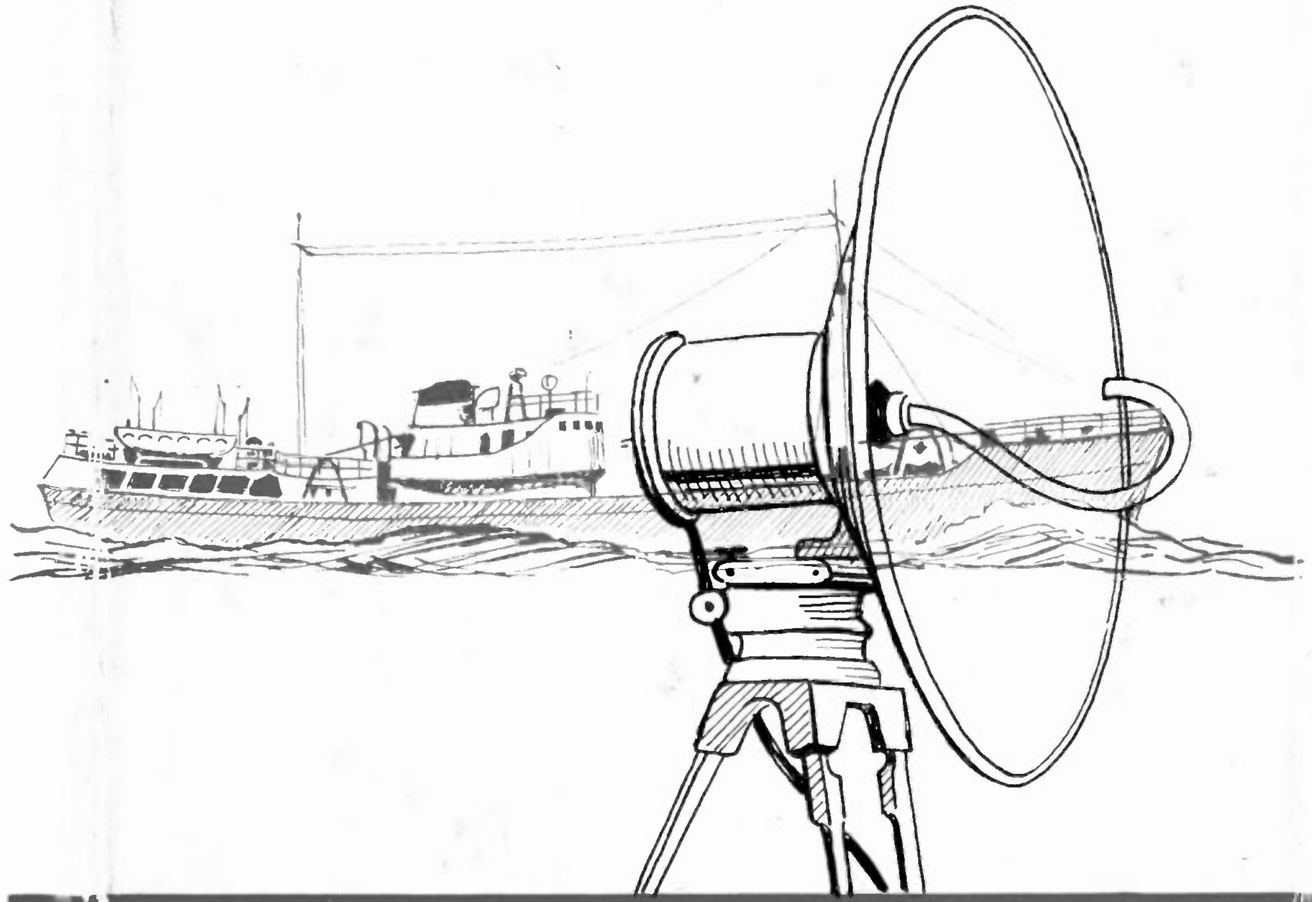

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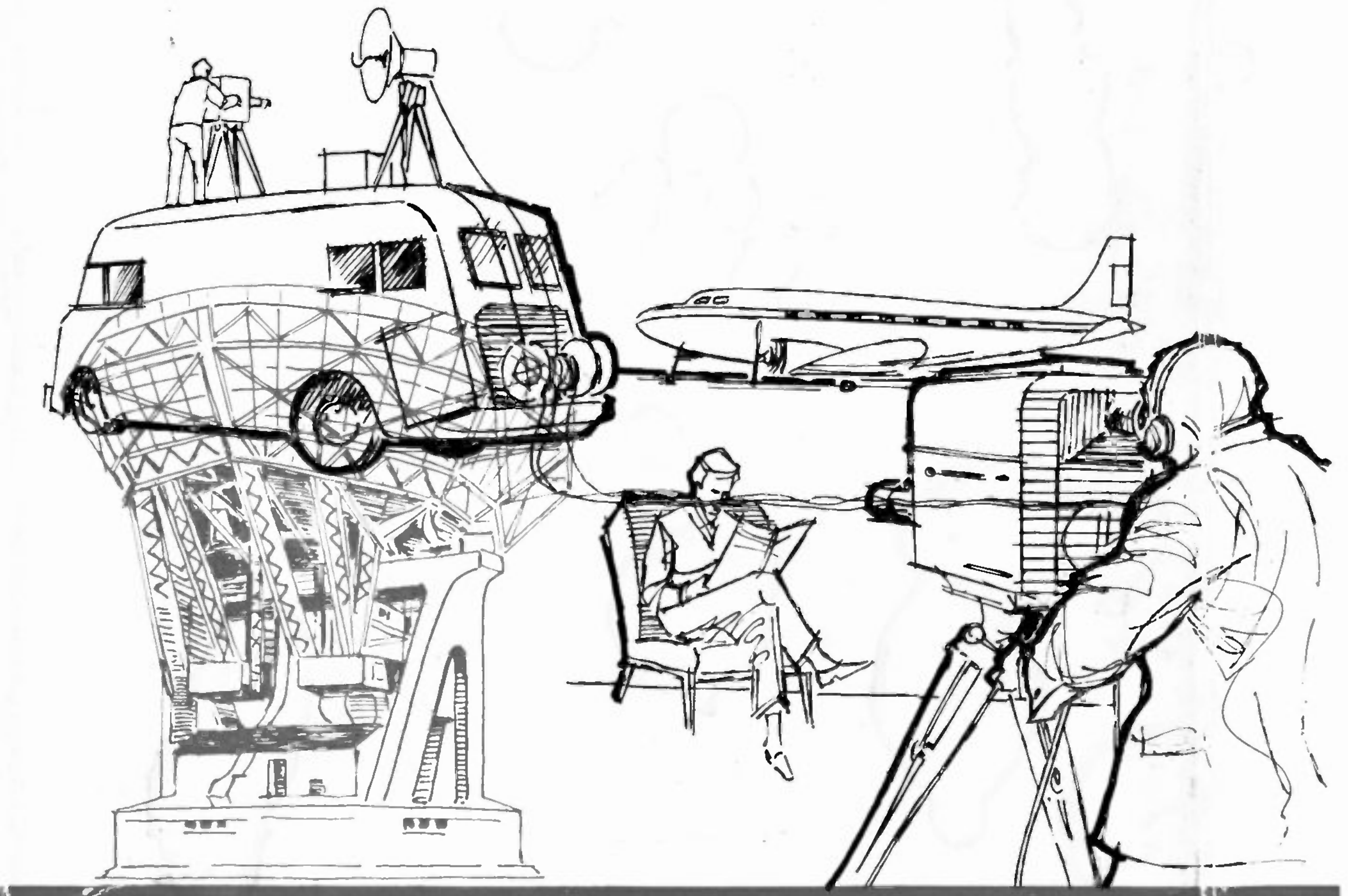

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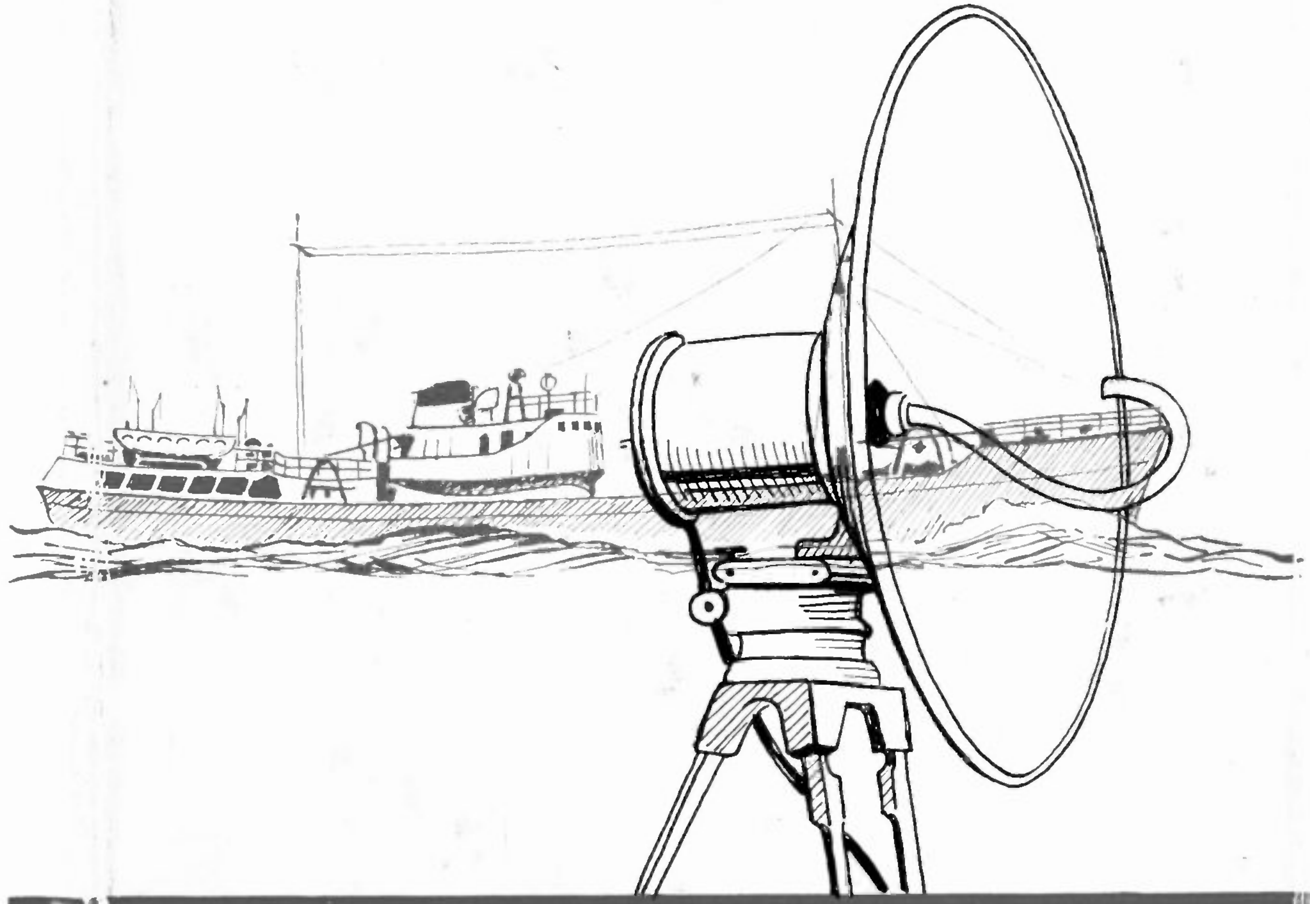

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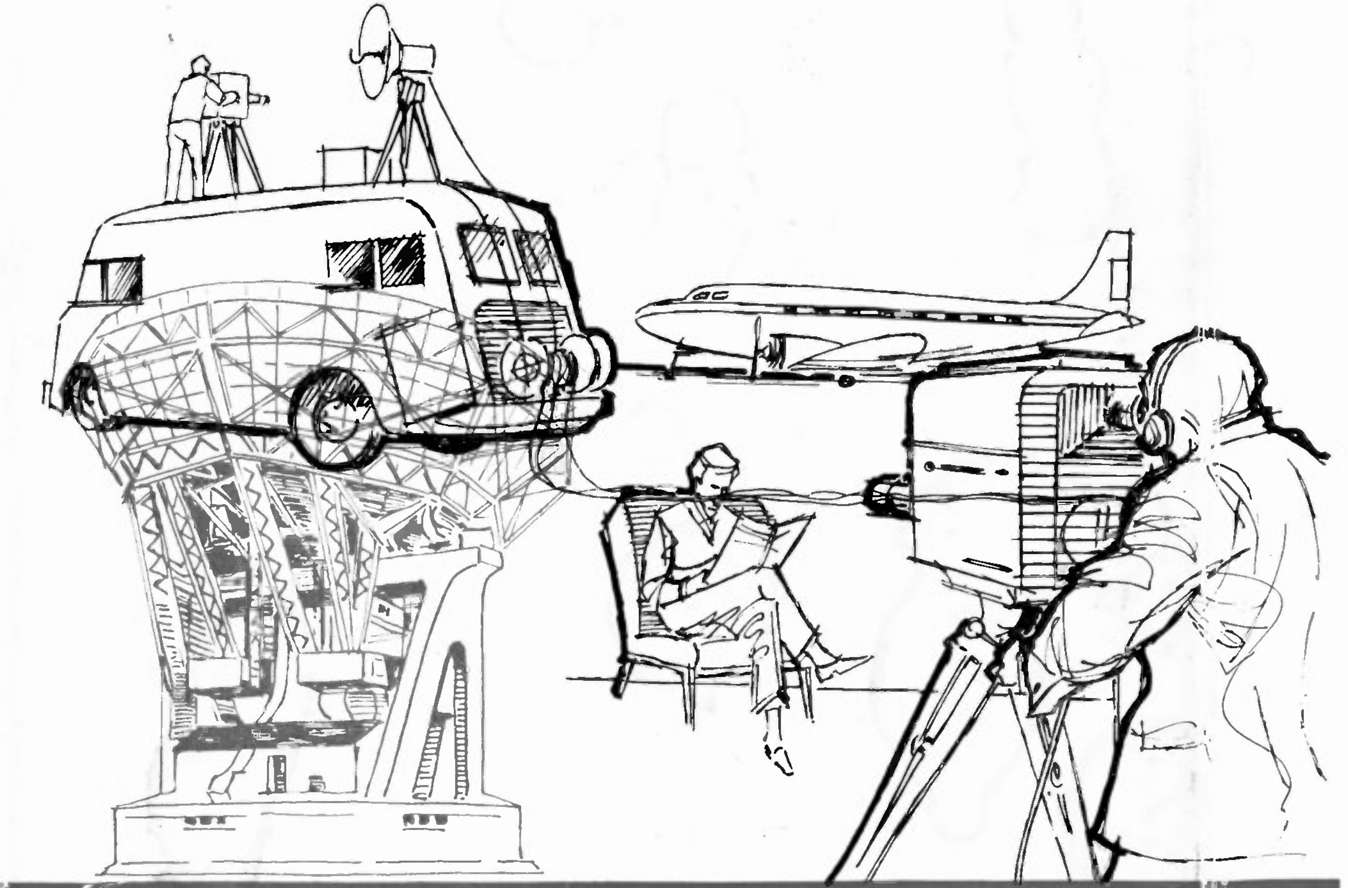

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Radio and Television

FREDERICK ROBERTS

Line drawings by the author

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CONTENTS

1

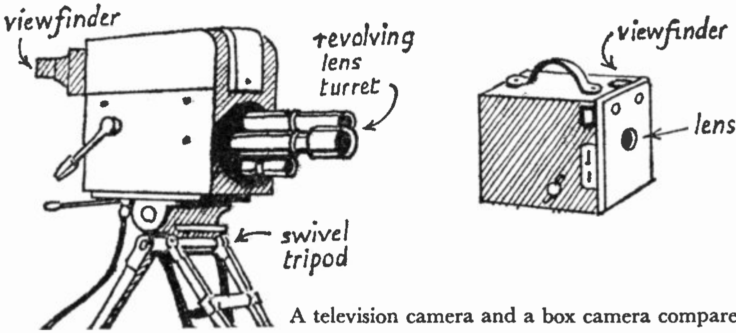
HOW A TELEVISION PROGRAMME IS PUT ON

When you are looking at television, you are seeing events happening in some place far distant from your home. This place may be a studio, where a play is being acted, or a football field where a match is in progress, or inside an aircraft in flight.

But you are not actually seeing the events themselves, for what would be impossible, even with the most powerful telescope. You are seeing *pictures* of the events, taken by a television camera. The TV camera is the 'eye' of television. We see on our screen only what this camera 'sees'.

The television camera

Let's take a look at a television camera. It is much larger than an ordinary camera used for taking photographs. It resembles such a camera, however, in several ways. For example, the TV camera has a viewfinder through which the cameraman can see what he is taking. It also has a lens in front, through which the actual picture is taken. The more expensive cameras for photographs and some cine cameras have lenses which can be changed; one lens for close-up objects, another for objects at medium dis-

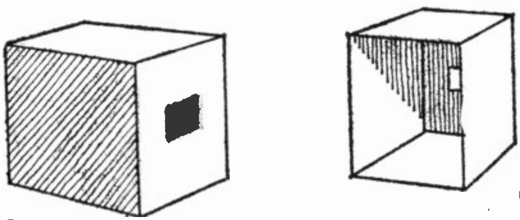


A television camera and a box camera compared

tance, and another for far distant objects. The TV camera usually has such a set of lenses mounted on a swivel or turret. The TV cameraman can thus easily select the lens he requires.

The large, heavy TV camera is mounted on a tripod, or a wheeled pedestal which may have a seat for the cameraman. The cameraman can turn his camera, or tilt it up and down to cover the scene he is taking. If the camera is on a wheeled pedestal, usually called a 'dolly', it can move about in any direction. Sometimes, when looking at television, you may see a small figure seated in a chair in the centre of a room. This figure gradually comes closer and closer until the person's face fills the screen of your set. This effect is achieved by moving the camera towards the sitter.

You can get a fair idea of what the cameraman sees when he is taking a scene if you make a simple model with a cardboard box. The picture shows you how to



Cardboard-box viewfinder

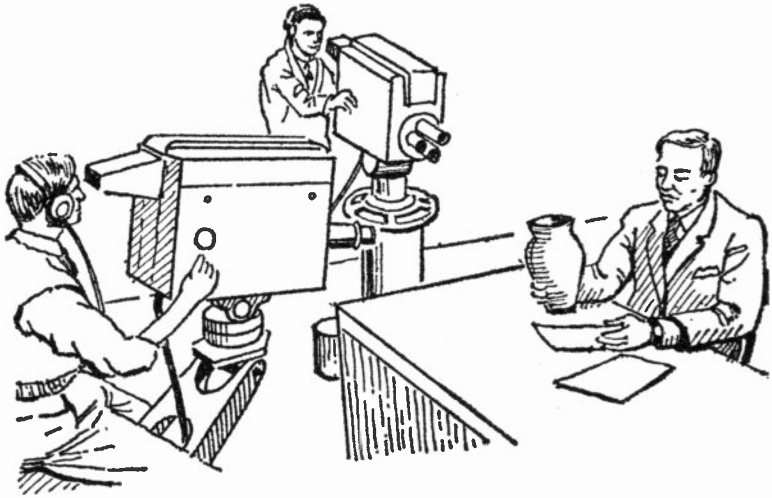
Long shot, medium shot and close-up

make it. Look through your camera at the scene in the room. Now turn the camera on its axis. This turning action is called 'panning'. Tilt the camera up and down, watching the picture all the time. Both panning and tilting must be done very slowly and smoothly, in practice, lest the viewers should be made to feel dizzy!

Now look at some object at a distance, such as a clock at the other end of the room. The clock appears very small in the picture. The cameraman calls this view a 'long shot'. Pick up the camera by its base and walk forwards until the clock is about half the picture space in size. This view is called a 'medium shot'. Finally, approach near enough for the picture to be filled by the clock-face or only part of it. This shot would be called a 'close-up'. You can see that changing shots would be easier if you and the camera were on wheels!

Sometimes during a television interview with some well-known person, the picture may suddenly change from a front view of the person's face to a side view. The change is far too rapid however for the camera to have moved round from the front to the side of the person. How is it brought about? The answer is that two cameras are used. We have changed from one showing the front view to the other showing the side view.

A single camera is usually sufficient for televising a



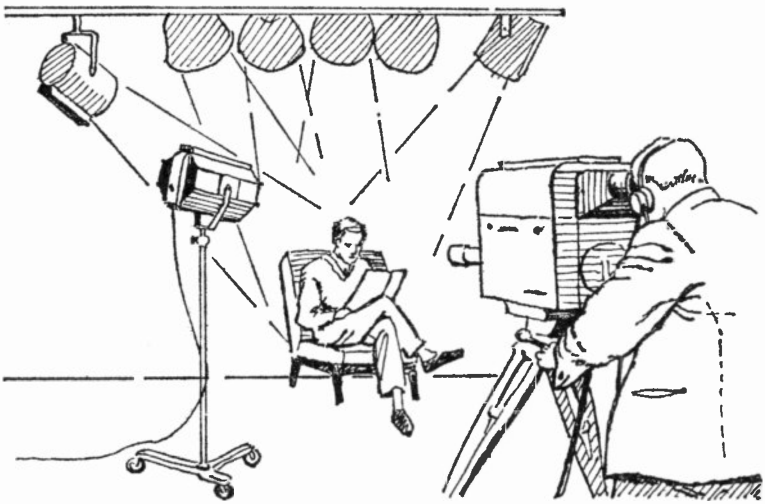
Using two cameras

single person talking, or the newsreader giving the news. To see a whole play, however, through the eye of just one camera might be exceedingly boring. Several cameras are therefore used when plays or concerts are being televised. The producer—that is the person who directs the actors and the cameramen—makes the arrangements for switching from one camera to another. Suppose that an actor has to go down a flight of stairs in the play. One camera might take him approaching the top of the stairs, coming towards the camera. Another camera might take him going down. A third at the bottom might now take him coming to the foot of the stairs. The next time you see stairs in a television play, try to work out how the cameras are being used when people are shown ascending or descending.

If we were televising a 'do-it-yourself' programme, like the Barry Bucknell series, two or three cameras might be grouped around the person who is showing how a particular job is done. To look down on something, the camera and cameraman have to be lifted up. A special mobile pedestal called a 'boom dolly', is used for this purpose. The boom carrying the camera and cameraman can be raised or lowered.

Lighting

Television in day-time out of doors has the advantage that the light is nearly always sufficient for the cameras. Indoors the situation is very different. Artificial light is rarely as strong as daylight, and is nearly always concentrated where the lamps are situated. You can see this effect in the sitting-room in the evening when the lights are on. Under the lights objects are brightly lit. To be able to read in some other parts of the room, however, an extra reading lamp is often necessary. To take an ordinary photograph indoors usually requires extra light-



Lighting in the studio

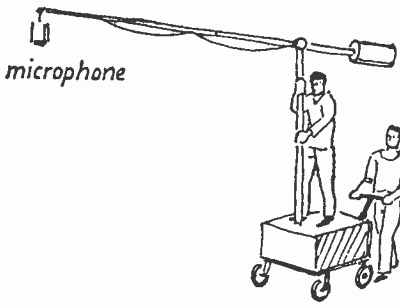
ing too. For this purpose powerful 'photo-flood' lamps are used, or, for a snapshot, a bright flash from an electric flashgun.

In the television studio, very powerful lighting is necessary. People who have to sit still whilst being interviewed in the studio often find this strong light very trying, and the heat from the lamps uncomfortable. The spot lights and floodlights are mounted on stands or fixed on walls and the ceiling overhead. As different parts of a scene in the studio need lighting differently, the lamps have to be arranged in suitable groups, able to be separately switched on or off as required.

Television sound

When we are looking at television we can usually hear what is going on, because sound, as well as pictures, is being broadcast. The 'ears' of television are microphones. These microphones are similar to those used in radio. In the studio, great trouble is taken to avoid the microphones being seen by the TV cameras. This is so that the studio scenes should seem as natural as possible. People do not normally go about their daily lives speaking into microphones.

The microphone at the end of a boom



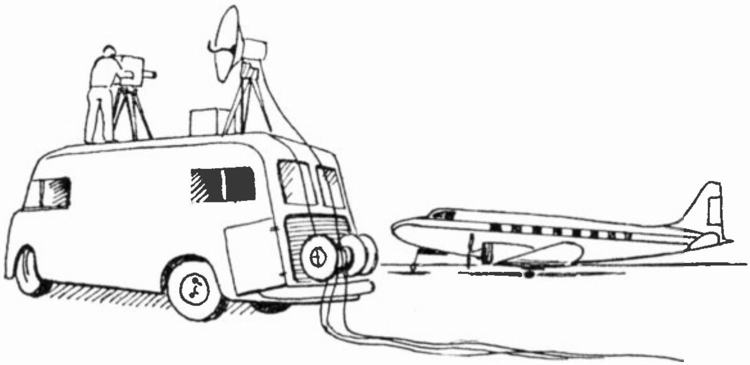
The studio microphones are attached to the end of long rods called booms. The booms are telescopic, which means that they can be lengthened or shortened, and are attached to stands which may be moved about. The microphone at the end of its boom is suspended above the people who are talking, so that it is out-of-sight of the camera.

At television interviews which are indoors, but in some place other than in the studio, you may see the interviewer and the person interviewed wearing black cords round their necks leading to something concealed inside their clothing. This 'something' is a small microphone. When several people are joining in a discussion each of them may be provided with a separate microphone in this way.

The interviewer in the street, however, uses a hand microphone, which, as you have often seen, he points at the people with whom he is speaking. The difficulty with microphones is that they have to be used fairly close to the sounds which are to be picked up.

Television scenes out of doors

Two methods of televising scenes out of doors are used. The first method is to make a movie film of the event, and then to let a TV camera 'see' this film. The advantage of this method is that the broadcast can be made *after* the event has taken place. 'Live' television out of doors necessitates taking the actual television cameras to the spot where the event is to take place. This creates some fuss and bother because television cameras have to be accompanied by a great deal of apparatus. They also have to be connected in some way with the television broadcasting station.



The mobile van on the airfield

Supposing that it has been decided to make a 'live' television broadcast of some Very Important Person arriving at an airport, and to get him to speak to the viewers. A mobile van would be despatched to the scene, with one or more camera crews. From the van instructions can be telephoned to the cameramen (you will nearly always see cameramen wearing earphones).

Sometimes in an outside broadcast, like the one we have just mentioned, a TV camera will be perched up on top of a van. Another may be stood on a tripod in front of the crowd and others further away still.

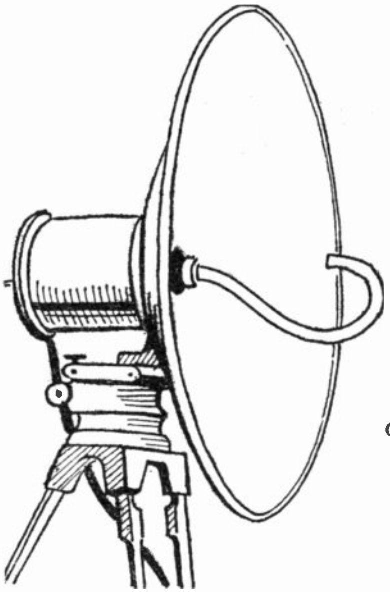
Let us follow what is going on at the airport. The plane has not yet arrived, but is due any moment now. Whilst we are waiting, a commentator speaks into a microphone and tells us about the weather, the crowds gathering, and the excitement. He interviews one or two people in the crowd and asks them what particular reason they have for coming to see the arrival. One of the television cameras will be working with the interviewer, taking pictures of him and the people he is speaking to.

The VIP arrives

The camera on the van also roves round the scene, letting us see the crowd, the waiting reporters and the airport buildings.

Suddenly we hear the sound of a plane coming in, picked up by microphones out near the runway. Then a television camera near the runway picks up the plane coming in to land. In a moment another camera shows us the gangway being run out. Now the great man appears and begins to descend. We get a close-up of him and the television interviewer, the latter pointing his microphone and asking questions.

You may ask how it was possible for the outside broadcast producer to switch from one camera to the other at exactly the right moment. The answer is that inside the mobile control van are a number of 'monitors', which are like small TV sets. The cameras are all 'on' together. The producer or control engineer can see on the monitors' screens what each camera is seeing. He can select the one which he wants to be broadcast at any particular moment. He can also speak to the individual cameramen,



One of the aerials used in the 'radio-link' between mobile van and TV station

to ask them to get closer or further away from the object they are taking.

How are the van and its camera at the airport connected to the television broadcasting station? This can be done by using a number of telephone lines, that is the wires of the ordinary GPO telephone. It can also be done by fitting the control van with its own wireless transmitter which can send the pictures 'through the air' back to the television broadcasting station.

In the case of televising the Boat Race, the television launch carrying the cameras and following the Oxford and Cambridge crews must have a wireless transmitter. It could hardly trail miles of telephone cable behind it in the river as it went along!

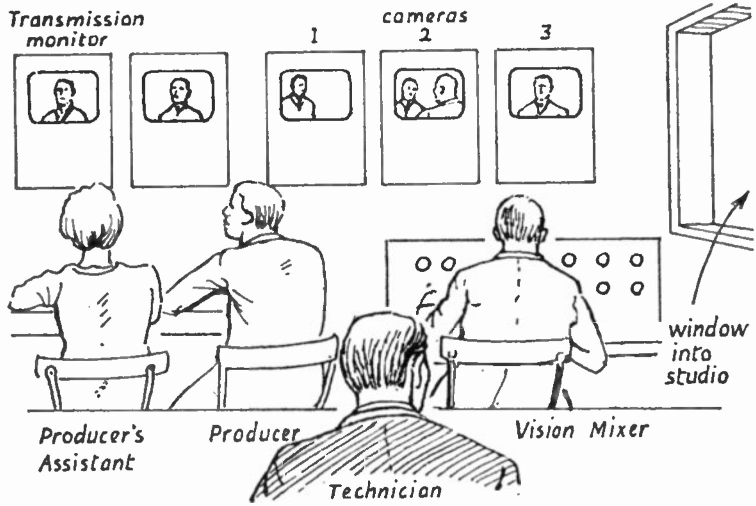
When a football match is being televised the cameramen in the stands try to keep the ball in view all the time. If you try this with binoculars, at an actual match, you will find how difficult it is. On your televising screen at home you will most probably be following the match through the 'eye' of a television camera which is equipped with a 'zoom' lens. Such a lens can change its focus like a telescope, so that the players can be seen close-up wherever they are on the field.

The studio

Imagine you are in a large room, like a school hall, or a room in a factory. From the ceiling and the walls spot lights and groups of flood lights blaze down. In one part of the room there appears to be what looks like part of a village street. Actors are moving about in the street. Microphones on long booms reach out over them to pick up what they are saying. TV cameras move about among wires and cables on the floor, following the movements of the actors. Behind the cameras are the camera crews and sound crews, all wearing headphones through which they can receive the instructions of the producer. The producer is directing the play from the control gallery, a room with a window looking into the studio.

In the control gallery also are the producer's assistants and other people concerned with the play. One of these, called the 'vision-mixer', operates a control panel covered with buttons and coloured lights. At the producer's bidding the vision-mixer presses buttons to select which of the cameras in the studio is to be 'on the air'. The control gallery is in semi-darkness, unlit except for the lights of the studio which can be seen through the window. The producer and his staff, however, are not looking through the window. Instead they are watching the

The studio control-gallery and its monitors

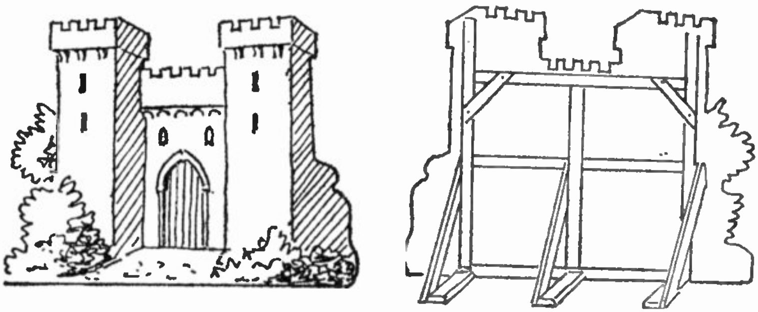


play on several monitors in the control gallery. Each of up to perhaps eight monitors is connected to a separate camera in the studio. One special monitor called the transmission monitor shows the picture actually being put 'on the air'. The producer can say 'on number two camera', the vision-mixer presses the right button, and the picture appearing on number two camera's monitor also appears on the transmission monitor.

Combining two cameras

If the producer so wishes, the pictures of two or more cameras can be mixed together. All kinds of tricks can also be performed by the vision-mixer and his control panel. Half of one camera's picture and half of another camera's picture can be fitted together and sent out as one picture. You may have noticed this effect on your screen; it is called 'inlay'. Pictures can also be made to fade away, and they can even be turned upside down.

The scenery for a play, like the village street we have just mentioned, is cleverly made from timber, hardboard, canvas and other materials. Although television pictures are normally only in black, white and grey, the studio scenery is painted in colour, so as to seem more natural to the actors. Attached to the studio there are workshops where this scenery—called 'flats'—is made and painted.



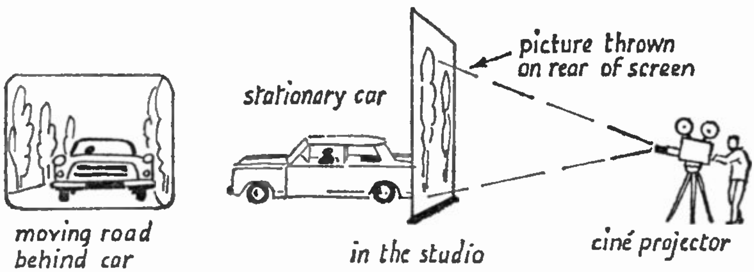
Studio scenery 'flats'

A less elaborate studio is required for the news. The newsreader sits in front of a single camera. A table may be provided for the typescripts of his bulletins, but this will probably be out of sight of the camera. Scenes from the news, that is of events during the day, will be shown to the viewers by means of cine films of the events. These films have been taken earlier on by cameramen on the spot, and have been sent by road, rail or air to the television centre in time for the broadcast.

Films in television

Ordinary cinema films are sometimes seen in television programmes. 'Laramie' and 'Wagon Train' are films specially made for television. Programmes like 'Panorama' often combine interviews in the studio with films of events of topical interest. Sometimes film is used as well as live actors in a television play. For example, in the 'Inspector Maigret' plays, the scenes in the police station (Maigret's office), the court, Maigret's home, etc., are taken with actors in the studio. The street scenes in French towns are films actually taken in France.

Short extracts of films are sometimes shown in the studio as part of the 'scenery' of a play. A film of the sea or the sea shore can be shown on a screen behind the players. See if you can notice when this is being done. The method used is to project the film pictures on to the back of the screen, so that they show through the



Back projection

screen to the side where the actors are performing. A trick employed to make a stationary car in the studio seem to be speeding along is to 'back project' behind it a film of a road actually taken from a moving car.

Finally, by using sound film, it is possible for an actor to be seen on the television screen apparently having a conversation with himself, or singing a duet with himself. How is this done? The answer is, by 'inlay'. Half the picture is a film of the actor, the other half is the live actor himself in the studio. You may think that effects like this are 'cheating', but they can often be very entertaining.

2

HOW A RADIO PROGRAMME IS PUT ON

Six pips and a voice saying 'Here is the News' is the well-known beginning of the news on sound radio. Every day the news is heard by millions of people in cities and in the country, by people on remote islands or on ships at sea. In spite of the coming of television, sound radio still performs a very useful service, especially in areas which television cannot yet reach. Radio also has the advantage that since we do not need to watch it, we can carry on working whilst listening. We can enjoy a programme whilst we are out of doors, or whilst travelling in a car. A radio set can be made small enough to go into a pocket. There is already a transistor radio which is smaller than a matchbox. Radio therefore can be always with us, by day or night, provided that programmes are being broadcast.

Radio news

The newsreader sits in a little room which has been made as nearly as possible soundproof. In front of him is the microphone; on his table are typed sheets of paper containing the news items he is about to read. He has been trained to read distinctly, without hesitation, and not to rustle his papers. He must watch for signals which are given to him when tape recordings are switched on to give 'on the spot' reports of items in the news.

The newsreader

In France news broadcasts are sometimes called 'The spoken newspaper'. Just as a newspaper employs reporters and editors, so does the BBC News. Reporters in all parts of the country send in accounts of events which have taken place. Other reports come in from places abroad, from the United Nations, from 'trouble spots', or from anywhere where something interesting has happened. Reports may be sent in to news headquarters by telephone or wireless, or by teleprinter, a machine which prints messages on paper tape. Just as newspaper editors select the news which is to be printed, so the editors of radio news decide which of the reports they receive are to be included in the programmes. They also decide which items are the most important, and how much time 'on the air' can be given to each. Finally, they arrange how the tape recordings they have received can be fitted in to the broadcast.

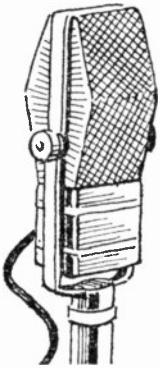
'Outside' broadcasts

If you have heard a broadcast of a football match or a horse race you know how exciting it sounds. Because you cannot see what is happening, the commentator tells you all about it. How quickly he has to speak if events are happening rapidly, as when someone is scoring a goal, or horses are flashing by the winning post! His voice is almost drowned by the noise of the crowds. As in the case of television, live broadcasts outside the studio need a great deal of organising. The microphones being used have to be connected in some way, either by telephone line or by wireless, to the broadcasting station.

We should not forget that radio is sometimes the only means by which human beings in certain situations can communicate with each other. For example, explorers, crews of ships and aircraft, soldiers in tanks, policemen in patrol cars, all depend on radio for sending and receiving messages. Sometimes in a broadcast programme these messages are relayed to us, as in the case of the first cosmonauts circling the earth. This means that the signals are picked up by a special radio receiver, and then sent to the broadcasting station to be re-broadcast.

A great deal of 'outside broadcasting' comes to us through recording, so that we hear the events some time

A tape recorder



A studio microphone

after they have taken place. Tape recordings are used, as in the case of news items. BBC recording engineers usually employ special 'high-fidelity' tape recording machines when making records of concerts in places away from the studio. For recording interviews, either in the street or in people's homes, they may use small, portable, battery-driven tape recorders.

The microphone

The microphone is the 'ear' of radio, and of sound recording. The music and speech we hear coming out of a loudspeaker has been 'picked up' by a microphone, or several microphones as the case may be.

To broadcast or record someone speaking we need only a microphone placed near him. There are important differences between the microphone and the human ear, however. If the person speaking moves a short distance away from the microphone, his voice will sound a long way off to the listeners. The results of using only one microphone with a large orchestra would be that the instruments in the back row would hardly be heard.

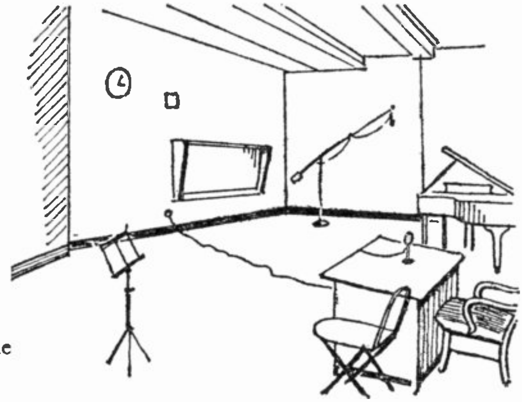
Therefore several microphones, spaced apart, are used for choirs, bands and orchestras. If you visit a hall from which a concert is being broadcast you will notice the microphones on stands, or strung on wires overhead.

Because we have two ears, we are able to tell the direction from which sounds are coming. Shut your eyes, and get someone to make a sound somewhere near you. You will quite easily be able to tell where the sound has come from. Now close your eyes, but stop up one ear, and have the sound repeated from a different position. You will find the sound more difficult to locate this time. Our brains are able to compare the loudness of the sound heard by one ear with that heard by the other. When the ear on one side hears the sound more loudly than the other ear we know that the sound is coming from that side. If both ears hear the sound equally we know it is coming from directly in front or behind.

In the case of a wireless set, all the sound comes to us from a small loudspeaker. We cannot tell, therefore, whether people in a radio play are on the right or the left of each other. We can only tell whether they are near to, or far from the microphone. A 'stereo' gramophone seems much more realistic because you can tell the direction from which the sounds of instruments or voices are coming. Stereo-broadcasting is, however, still in an experimental stage. The producer of a radio play has therefore to make us imagine distance and direction. In this, however, he often succeeds very well.

The sound studio

Some broadcasting studios are small: just large enough to accommodate one person, such as the announcer or some-



A sound studio. Note the producer's window and the microphone on the table

one giving a talk. Others are large, like concert halls, and can hold an orchestra and an audience. At Broadcasting House, the BBC headquarters in London, there are many studios in one building.

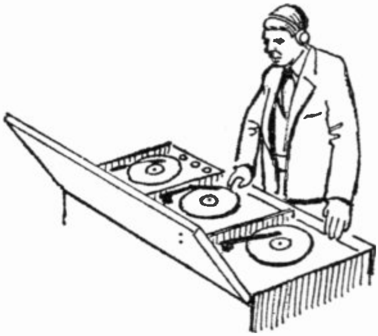
The difference between a studio and an ordinary room is that the studio must be sound-insulated. This means that the walls, floors and ceilings must be constructed so that sound will not pass through them. Noises from traffic, trains, low-flying aircraft, ships' sirens, and from neighbouring studios must be kept from interfering with the programme being broadcast. It has sometimes happened that workmen inside the building have interrupted the broadcast with their hammering. This kind of noise is especially difficult to keep out of a studio.

Normal doors and windows would easily let sound pass through them, as would chimneys and ventilators. Studio doors and windows are therefore specially made. The doors are very solidly built, and designed to seal up completely the opening when they are closed. A special arrangement is made to prevent them from slamming.

The windows are usually made of two or three sheets of plate glass, spaced apart, and are kept shut. You may wonder how anyone breathes in such a room. The answer is that 'air conditioning' is used, and that this too is insulated, so that the sound of the ventilating fans is not heard.

Too strong an echo in a room or hall can make voices or music indistinct. The studio-builder takes care to cause all echoes to be kept under control. The amount of echo can be reduced by hanging heavy curtains across part of the room, or increased by bringing in screens which reflect sound.

Record-playing desks and tape recorders are used in both television and sound radio. The person who broadcasts a programme of gramophone records is sometimes nicknamed a 'disc jockey'. Let us take a look at a well-known broadcast feature called 'Desert Island Discs'. 'Discs' here means gramophone records. In this particular programme a well-known person is asked to choose those records that he would like to have with him if he were shipwrecked (with a gramophone) on a desert island. The interviewer sits in the studio near the microphone with the well-known person who is the 'guest' of the programme. He introduces the guest, and asks him which record he has first chosen. The guest gives the title of a piece of music and perhaps the name of the person playing it on the recording. In another studio sits an engineer by the side of what looks like a gramophone with two or more turntables. The first record is already on the turntable. At a signal, usually a light which flashes on, the engineer starts the record. The microphone used by the commentator and his guest is switched off immediately the record starts.



The sound effects department

The control desk

As in the case of television, the person in charge of the arrangements for putting on a programme is called the producer. He has the duty of rehearsing the programme, seeing that the microphones are in the right places, and that they are each switched on or off at the right moment. A control cubicle (cubicle means a small room) is built next door to the studio, or just inside it. The people in the cubicle can see through a large window into the studio. The cubicle contains, amongst other apparatus, a control desk, at which the producer or engineer may sit.

Whilst the broadcast is on, the person at the control

The producer at his control desk

desk can listen to what is going on in the studio. He can 'mix' what is coming from the microphones with music from records, so that listeners hear a musical background added to the voices on the programme. He can regulate the loudness of anything being broadcast. He can also switch from one microphone to another, and send flashing light signals to people in the studio to tell them when they are 'on'. The cubicle also has telephones connected with the engineers in other parts of the building.

The script

Apart from the news reports, almost every radio programme is carefully rehearsed beforehand. The words you hear, the titles of music and particulars of sound effects are written down in a document called a script. Most talks are actually read by the person giving the talk.

The script for a talk is quite simple, consisting of the talk itself, typed out. If the talk is to be illustrated by gramophone or tape recordings, the script will be marked to show where the speaker must pause for the recording to come in. The producer in the control cubicle follows a copy of the script as he listens and watches what is going on in the studio. The notes on the script saying 'music' or 'sound recording' are called 'cues'. As he reaches such a cue in the script the producer turns knobs on his control panel to fade in or out the gramophones or tape recorders. The engineer in charge of these instruments will also be working from a copy of the script marked with cues.

The script for a play is also marked with cues for the entrance and exit of players, and for sound effects such as the opening and closing of doors, footsteps, motor-car noises, wind and rain. The producer has to ensure that the movements of the actors, and the switching on of the sound effects will take place at exactly the right moment.

Sound effects

Sound effects are as important to a radio programme as scenery is to a stage or television play. But it is obvious that we cannot always use the real sounds required. For a car crash, or a bridge falling down, for example, we must either use a recording of such an event, or else make a sound which the listeners will take for the real thing.

Thousands of recordings of sound effects can be obtained, some on gramophone records, others on tapes. They range from records of ordinary everyday sounds, such as people walking, doors opening, wood being chopped, crowds cheering, to less usual sounds such as an elephant trumpeting, or someone snoring.

A recording of a motor-car noise will probably begin with the car door slamming. Next, the engine starts, first gear is engaged, the engine speeds up and the car moves off. The driver changes gear again, until finally the car is moving at speed. The sound of braking and of the hooter will probably be included in the record for completeness. The engineer can use the whole, or any part of the sound effects, as he wishes.

Sometimes sound recordings are played on a machine in the studio, or through a studio loudspeaker, so that the actors can hear them. The listeners hear the sounds picked up by the studio microphones. At other times the recordings are played in the control cubicle, so that the actors do not hear them. In either case, correct 'cueing' of the sound effects is very important. The loudness of the sounds must also appear correct to the listeners.

If there are several sound effects on one record, a special attachment is used on the gramophone which can be set to lower the needle on to the record at exactly the right spot at the right moment.

Sound recordings are expensive. To cover all the needs of sound broadcasting a large library of such recordings would be needed. Some sounds, which can actually be made in the studio, are often better than recordings. These also have the advantage that they can be exactly timed with the speech or actions of the players. For example, real cups and saucers can be rattled, and a real door banged in the studio. One kind of whistle can be blown for a whistling kettle, another for a police whistle. A real door which squeaks as it opens can be used in a thriller, and a starting pistol can be fired for an assassination.

3

PRODUCE YOUR OWN RADIO PLAY

'Repeats' of broadcast programmes are generally tape recordings of the original broadcast. So good are modern tape recordings that listeners cannot tell the difference between them and live broadcasts.

It can be fun making a tape recording of a play, either at home or in the classroom. By doing so, we can also learn a great deal about putting on radio plays. Let's make the attempt, first to write and rehearse a short play, and then to record it.

The script

Let us imagine that we have thought of an idea for a play. We first write down the story in as few words as possible. This is the 'synopsis' of the play. Next the script is prepared. In it the words spoken by each actor are written out in full. It also contains the directions for the actors' movements, and for other sound effects which are going to be used during the performance.

Producer and actors

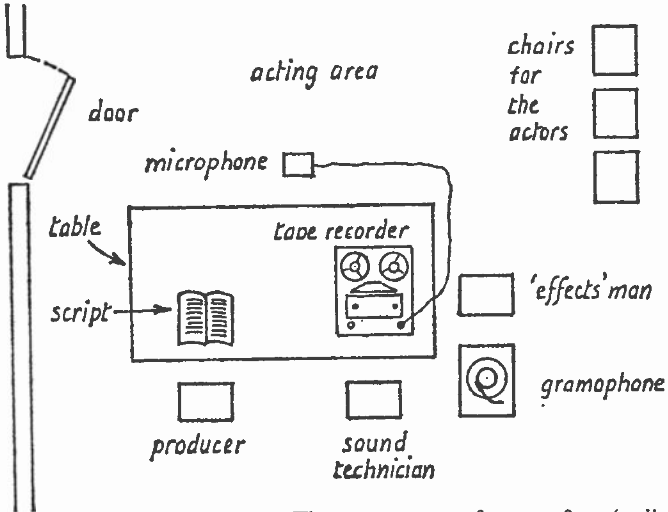
Choose someone to be the producer. He or she should have read the play and formed some idea of how it should be acted. The producer should choose the actors. Each actor will need a copy of the script. (A good way to obtain several copies is to have carbon copies made with a typewriter.) The producer now sets about rehearsing the play. He takes note of the movements of the actors and writes these as 'cues' on his script. He also makes notes about the sound effects, what these are to be and when they will be required. When, after two or three rehearsals, the players are beginning to know their parts, trial recordings can be made.

Apparatus

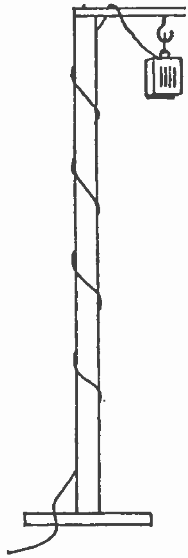
To record the play, we shall need a tape recorder, a tape and a microphone. The tape must be long enough to run while the play lasts. A gramophone and records, or a piano and a pianist will be useful if musical sound effects are needed. For other sound effects, some apparatus can be made which will be described later on in this chapter.

Arranging the 'studio'

The best place for the tape recorder is on a table where it will not be jolted or disturbed by people moving about. At this table will sit the recording engineer, who must be someone who has had practice in working the machine.



The arrangement of a room for a 'radio' play



Stand for the microphone

He will be given his cue when to switch on by the producer. During the recording he will watch the 'sound level' indicator on the tape recorder, and operate the volume control on the machine when necessary.

The microphone is attached by a lead to the tape recorder. It is a good idea to hang the microphone on to some form of stand or support so that it need not be handled by the actors. A piece of wood can be attached to the table, or to the back of a chair for this purpose. Screw a hook into the wood and suspend the microphone from it by a strong piece of elastic. Make sure that the microphone is at the right height for the players.

Acting will take place directly in front of the microphone. The players must be able, quickly and quietly, to take each other's place at the microphone. A chalk line on the floor will help them to speak at the right distance from it. All noise of moving about except that which the listeners need to hear must be avoided. So, if the floor is a hard one, put down a mat or carpet, or get the actors to wear slippers.

The producer should sit where the actors can see him. The effects man needs a place for his gramophone and sound effects fairly near to the microphone. Write out two large notices: one, 'Recording session, keep out!' is to hang outside the door of the room to prevent anyone from rushing in and spoiling the recording; the other, 'Quiet please' is for the producer to hold up once recording has started. Do not forget that the slightest sound in the room will be picked up by the microphone. Close the windows if there is noise outside.

Actors at the microphone

Practice beforehand

Before trying to make a trial recording of the whole play, the actors, sound effects man and recording engineer should each practise their jobs a little. The actors should get used to the microphone. A good way to do this is for each player to say or read a few of his lines whilst standing in the right position. If two or more people are supposed to be having a conversation, they must all stand together, quite close to the microphone. Movements can be practised too. The sound of someone entering a room may be difficult to record if the door is too far away from the microphone. In this case, get someone else to open the door, making as much noise with the knob as possible. The actor will sound as if he has come in if he speaks just a few feet away from the microphone. The right way to deal with many problems like this can only be found by experiment. That is why practice is so useful.

The effects man can also try recording his effects, particularly to find out how loud they must be, and how far from the microphone they must take place. Music is better 'faded' in and out, rather than switched on or off suddenly. This can be achieved with a gramophone by turning the volume control up or down gradually.

The recording engineer would do well to get used to starting the tape and stopping it, and operating the recording level control. Finally, all taking part must do as they are told by the producer and learn to follow the cues he gives them.

The play

We now come to consider the play itself. It is better that a radio play should not have too many characters in it. Five or six players acting together before the microphone is a 'crowd', difficult to manage. Apart from this, the listeners may get confused by too many different voices, since they cannot see who is speaking.

Here is a short extract from a play about children. It has only three characters, two boys and a girl. To the script should be added the radio producer's special instructions. These we shall refer to later.

The play is entitled *The Old Mill.* The story, up to the beginning of this extract, is as follows: Peter is spending a holiday with his cousin, Norman, who lives in the country. The two boys and Mary, one of Norman's school friends, decide to visit an old water-mill. In this scene, the children have just reached the mill.

Extract from *The Old Mill*

PETER Falling down a bit, isn't it?

NORMAN So would you be, if you were that old! Come on, let's get in.

PETER In? How?

NORMAN Through the door, daft! Round the other side. Come on!

MARY It's full of rats. I'm not going in, I'll stay here.

NORMAN Why—you're not afraid of rats?

MARY Well—but it's cold and dark in there. If I go in, I don't want to stay there long.

PETER (*Calls, from some way off*) I've found the door, it's open, I'm going in!

NORMAN (*Calls to Peter*) Wait for me—it's not safe! (*To Mary*) Come on Mary—he'll get into trouble.

(*Norman and Mary follow Peter into the mill*)

PETER What a lovely creepy place!

NORMAN Nobody's used it for years.

MARY My grandad says he remembers it working. The wheel used to go round. People used to bring sacks of flour here.

NORMAN Take them *away* from here you mean. They used to grind wheat into flour. The sacks of flour were stored up there.

PETER Where? Let's take a look.

MARY You can't. The ladder's broken.

PETER I'll soon get up there. It looks easy to me. What about it Norman?

NORMAN There are a few rungs out, the rest are rotten. Watch your step!

PETER Right. I'm going up. (*Begins to climb ladder*)

NORMAN Don't tread on the middle of the rungs. Keep your feet to the sides. Come on Mary. You go up next. I'll follow to see you don't fall. (*Both climb ladder*) Phew! it's dusty up here! Dry though. (*All walk across floor*) That's the hoist, they used it to lower the sacks on to carts below. It still works, I think (*Rattles chain*)

PETER What was that? (*Sound of bird flying away*)

MARY Only a bird in the roof, we startled it.

NORMAN There are bats up there as well, I've seen them!

MARY Oh, I hate bats.

NORMAN They won't come out in daylight—they're all asleep now. Be careful there Peter, don't you fall out! That timber is pretty rotten.

PETER I can see the river. Wait a minute, there's someone coming along the bank.

NORMAN Who?

PETER Two men, one carrying a bag, it looks like.

MARY Let me see! Coo—I don't know who they are. They're coming this way.

NORMAN Where? Oh yes, I see them. No, I don't know who *they* are. Complete strangers round here, I reckon. Hey, they're coming in below—at least, I think—yes! Keep quiet!

(*Door opens and bangs below. Muffled voices*)

PETER (*Whispers*) What do you think they are?

NORMAN (*Whispers*) Don't know, let's listen. No, I can't make anything out. (*Muffled* *voices*) Don't move or they'll hear us.

MARY (*Whispers*) I heard one say the ladder is broken.

(*Door bangs below*)

PETER (*Whispers*) They're going out again. Wait, I can see them now.

NORMAN Keep your heads down. They might look back!

PETER Hey! They've not got the bag with them!

There we must leave Peter, Norman and Mary and their mill. You could try to finish this story yourself. Let us look back at the extract, however, to see how it would be produced in our home or classroom studio.

Production of *The Old Mill* extract

The play opens with the three actors grouped round the microphone, speaking in turn as in conversation. Each time the script has some 'stage directions' (words in brackets), however, the actors must move or perform some action. The first example is where Peter speaks for the third time. The words in brackets say, 'calls, from some way off'. To get this effect Peter moves away from the microphone to the back of the studio before he calls out his lines. He must be given a cue to move to his position in good time before he has to speak. Norman remains with Mary at the microphone. Next we have the direction: 'Norman and Mary follow Peter into the mill'. To do this they walk away from the microphone, and then return. Peter slips quietly back with them. Then all three are 'in the mill'—back at the microphone!

Now follows a sound effect. Peter 'begins to climb ladder'. The sound of climbing a ladder can be imitated by Peter standing on the rung of a wooden chair and 'marking time' on it. 'Both climb ladder' means that Mary and Norman each stand on a rung of the chair and begin 'climbing'. 'All walk across floor' sound effect can be imitated by the players walking about on two or three upturned wooden boxes placed on the floor. The hoist chain can be suggested by shaking a length of chain close to the microphone. 'Sound of bird flying away' requires an exercise book, or a booklet of similar size with fairly stiff covers. Hold the booklet by one corner near the back and flap it backwards and forwards to imitate the beating of a bird's wings.

When Peter says, 'I can see the river . . .' he should be standing two or three yards away from the microphone to give the effect that he is peering out, some distance from the others. Mary and Norman must do the same when it comes to their turn to look out.

'Door opens and bangs below' requires someone to bang the door of the next room to the Studio. For 'muffled voices' the trick is for someone to speak into a thick cardboard or wooden box through a hole in the lid, the box being held a little away from the microphone.

The playback

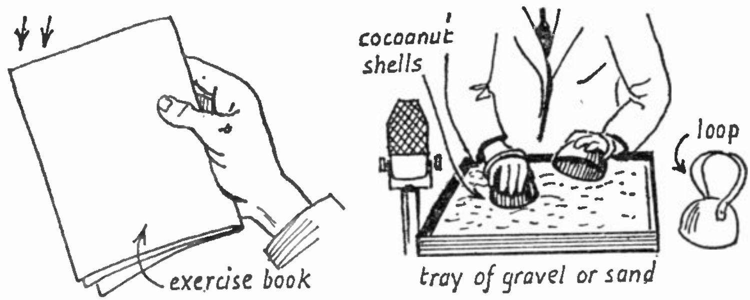
When our play is recorded, there comes the excitement of listening to the result. Undoubtedly we shall find we have made mistakes, and that the effect is not so realistic as we might have expected. Remember, however, that 'practice makes perfect'! What we are trying to create is a picture in sound, and, just as making any other kind of picture, some skill is required. Write your own play, practise it, record it, listen to it, and then do it again, until you have improved it as much as you can.

Just one tip about playing your tape to an audience: arrange the chairs so that people can sit comfortably, just as they would for a real radio programme. Hide the tape recorder. Put it behind a curtain or somewhere where it can be heard well but cannot be seen. This will make your play seem much more real. The sound can also be much improved by connecting a loud speaker to the tape recorder.

More sound effects

Here is a list of some 'do it yourself' sound effects. Try these with your tape recorder. Most of them are to be carried out as close as possible to the microphone, but experiment with them at different distances. Also try inventing your own effects. It can be great fun!

Sound effects: 'bird flying away' and 'horses hooves'



Chopping wood

Strike a piece of wood, or a tree branch with a heavy table knife.

Splintering wood

Crush a matchbox.

Squeaking or creaking wood

Twist a wooden peg in a hole in a piece of wood.

Fire crackling

Screw up a piece of cellophane in the hands.

Distant explosion

Put a few small ball bearings or lead shot into a balloon or football bladder, inflate and tie up. Shake for an explosion.

Crash

Partly fill a wooden box with stones, nails, broken glass, dry earth. Nail on the lid. For a crash turn the box over suddenly.

Window breaking

Put a piece of glass on some soft cloth at the bottom of a box. Drop a heavy weight to smash the glass. Hold microphone close to the box.

Splash

Fill a plastic bucket with water. Drop a piece of wood into the water.

Ice breaking

Twist an inflated toy balloon in the hands.

Horses' hooves

Use two half coconut shells, one in each hand. Strike with the open ends of these on to a wooden tray filled with sand or gravel.

Echo

Speak inside a large box held over the microphone.

Ghostly voice

Speak into a glass tumbler, or a large cardboard postal tube.

Car door slams

Slam refrigerator door.

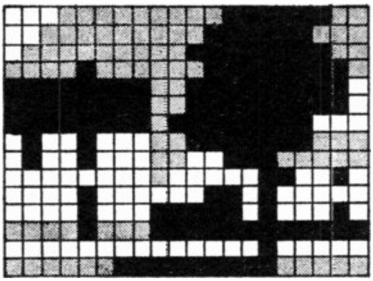
For some effects the real sound is better. Use real cups and saucers and other crockery when recording people at table. The same applies to washing-up. For a door opening and closing use the door of the room. A squeaky door is very useful for eerie effects in a mystery story. If you are lucky enough to be able to use a portable tape recorder, you can make a collection of 'real effects', like birds singing, motor-cars, ships' sirens. You can then use these in your plays.

4

HOW TELEVISION WORKS

Here is a simple game you can play which helps you to understand how a picture is sent by television. All you need is a sheet of squared paper and two pencils, one black and the other grey. We are going to 'send' the picture on this page. Notice that it is made up of black, grey and white squares. One person with this picture in front of him acts as the 'transmitter'. Another, seated some distance away, equipped with the paper and pencils, is the 'receiver'.

The 'transmitter' calls out the colours of the squares in the picture, beginning with the top line, first square. So his message runs like this 'white, white, white, grey . . .' At the end of each line he calls out, 'next line', and continues. The 'receiver' colours in the squares as quickly as he can and so the picture is gradually built up until it is completed. Transmitter and receiver in our game need not be in the same room. They could equally well be many miles apart, the one sending and the other receiving the message by telephone. The message could even be sent hundreds of miles, or be transmitted by wireless.



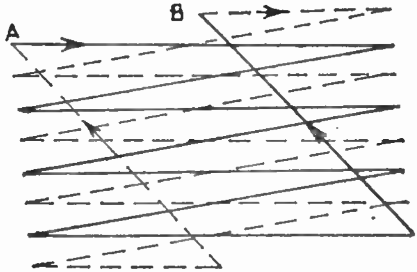
'Sending' a picture in strips

The television camera

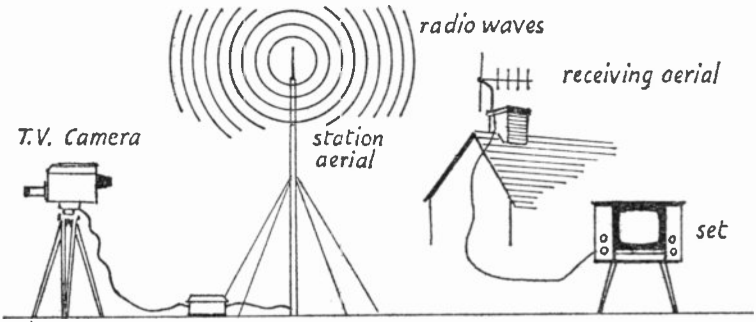
In real television exactly the same process takes place as in our game. The television camera also divides the picture in front of it into thin horizontal lines. In running over these lines it sends a message along its cable stating the shade, in terms of light and dark, of each small portion of the line. Make a hole in a piece of card with a knitting needle, pass this hole over the picture used in our game. All you see is a spot changing colour. This is what the television camera 'sees'. The action of running over the picture or scene in lines zig-zagging from top to bottom is called scanning. The television camera scans one complete picture in 405 or 625 lines from top to bottom, and takes only 1/25 second to do so.

The camera cable can be connected to a television receiver in the same room. What the camera sees will then be shown on the television set. The camera cable may be connected by telephone line to a television set many miles away; or it may be connected to a radio transmitting station, so that the camera's message goes through the air.

A television camera divides up a picture; the television set puts the pieces together again. The links in the television chain of events are camera, wire, receiver, or alternatively camera, radio waves, receiver. We shall deal with the 'radio-link' in the next chapter.



'Scanning'. The TV camera runs over a picture line by line. When it reaches the bottom it starts all over again. One complete picture is called a 'frame'. In modern television each picture is scanned twice, the line from A being one scanning, that from B the next



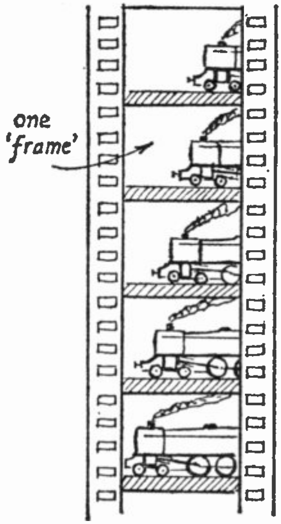
Links in the chain between TV station and TV set

The television receiver

The receiver also 'scans', exactly in step with the television camera. On your set screen you are really looking at a tiny point of light which zig-zags from top to bottom of the screen. This light is bright at each point where the picture is white, dim where it is grey, and 'out' altogether where it is black. So you can imagine the little spot of light changing in brightness as it speeds along the lines.

Why do we see a picture, and not simply a moving spot of light? The reason is that our eyes have a kind of 'memory' for light. Look directly at a bright light, such as an electric lamp, and then look away. You will seem to go on seeing the light for a brief instant. Shine a spot of light from a torch on to a wall or ceiling. Now wave the torch rapidly backwards and forwards. Because your eye continues to see the spot after it has moved, you will see a line of light, instead of a moving spot.

The spot on your television screen moves so quickly that you go on seeing it all the way along its zig-zag path to the bottom of the screen. Your eye, therefore, seems to see a complete picture. In fact, your 'eye memory' lasts for more than one picture.

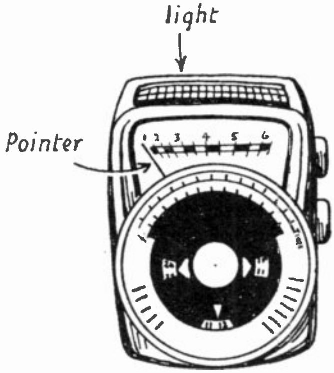


The cine film

Moving pictures

So far we have been considering the televising of a 'still' picture, like a drawing or a photograph. We come now to the televising of scenes of real life in which there is movement. The method employed is similar to that used in cinema films. A large number of pictures of the scene are taken by the television camera. As in the case of a film, each picture shows a slight change in the scene. The pictures are shown to the viewers rapidly, one after the other. Due to 'eye memory', the viewer thinks he is seeing one picture, in which things are moving. The separate pictures are called 'frames'. In home movies the rate at which the pictures change places on the screen is 16 frames a second. In the cinema, it is 24, and in television 25 frames in each second.

Remember then, when you are looking at television, that you are looking at a large number of pictures, built up at the rate of 25 in each second. The little spot of light scans each picture, then flies back to the top of the screen and begins the next. So that in one second the spot has covered 405 lines 25 times in the case of BBC 1 or ITV, or 625 lines 25 times in the case of BBC 2.

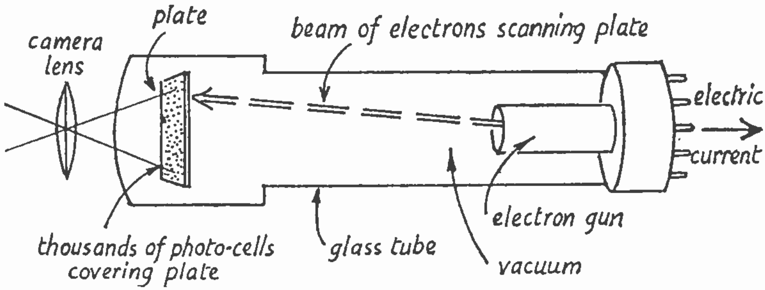


An exposure meter. The stronger the light, the further to the right the pointer moves

The camera tube

Now let us take the lid off the television camera and look at the works. These remind us in some ways of the inside of a television set. The main part is a glass cathode ray tube, although this tube is shaped differently from the one used in a set. Inside the camera tube is a flat plate of metal which takes the place of the film in a photographic camera. This plate is very different from a film however. When a picture is focused on it by the camera lens, it becomes charged with electricity.

To understand how this happens, let us look at a photographer's exposure meter (sometimes called a light meter). Inside the exposure meter is a photo-electric cell, a small electric battery, which generates electricity when light shines on it. The electricity works a pointer on a scale. The stronger the light, the more electricity is made, and the further the pointer moves. Try using the exposure meter to measure the brightness of light falling on objects. Hold it up to something white. Notice how far the pointer moves. Now try something grey, and something black. For grey the pointer will not move so far, for black it will move hardly at all.

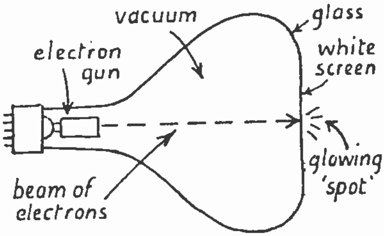


The TV camera tube

The plate of a television camera tube is covered with thousands of minute photo-electric cells, packed together closely like the grains of fine emery paper. When a picture is focused on this plate by the camera lens, each tiny cell gets charged-up with electricity. The cells in the light parts of the picture get charged-up most, those in the dark parts least.

Each cell in the plate is now made to discharge its electricity in the form of an electric current. Clearly this cannot be achieved by attaching wires to each cell, for the cells are too small. Instead, each cell is touched in turn by a ray, which is in some ways like a fine beam of light except that it is invisible. The ray scans the plate. The electricity from each cell forms a current which flows from the camera. This current, because it comes from differently charged cells, keeps continually changing as the ray goes on scanning.

The ray, which is called a cathode ray, is a stream of electrons. We shall deal further with cathode rays later on in the chapter. The diagram on this page shows a camera tube simplified. Notice how the cathode ray beam shoots out of the 'gun' to strike the plate. The cells on the plate have been charged up by the picture focused upon them. Where the beam touches the plate the cells are discharging their electricity.



The TV receiver tube

The chain of events in the camera is therefore:

1 Picture is focused on plate.
2 Photo-electric cells become charged.
3 Scanning ray discharges each cell.
4 Electric current flows from camera.

The receiver tube

The cathode ray tube in a television set is like a large glass bottle with a flat end and a narrow neck. The flat end is coated on the inside with a screen on which the picture appears. Wires enter the narrow neck to carry electricity to work the tube. Other wires bring in the electric current coming from the television camera. Let us look inside this receiver cathode ray tube to see how it works.

Like the camera tube, the receiver tube has a 'gun' which shoots a beam of invisible cathode rays at the screen. Where this beam touches the screen, a tiny point of light appears. This is because the screen is made of a coating of 'fluorescent' material which glows when cathode rays shine on it. When the tube is switched on, the beam begins to scan the screen. If no television signals are coming into the tube, all we see is a blank rectangle of glowing white screen. If we look closely we can see the lines of which it is made.

When the 'message' from the television camera enters the receiver tube, a change takes place. The cathode ray beam starts to become stronger or weaker at every instant while it is scanning. The moving spot glows brighter or dimmer as a result, and our picture appears.

Keeping in step

If our receiver spot of light did not move exactly in step with the scanning beam of the camera, we should see some very queer effects. For example, the picture might begin half-way down the set screen. In this case we should see two half-pictures together. The camera, however, sends out a strong burst (pulse) of current every 1/25 second, at the exact instant that each new picture is beginning. This 'signal' of electric current makes the receiver tube start its scanning at the right moment. It is called, therefore, a 'synchronising signal'.

The chain of events in the television receiver can be summed up as follows:

1 Current from the camera enters the receiver.

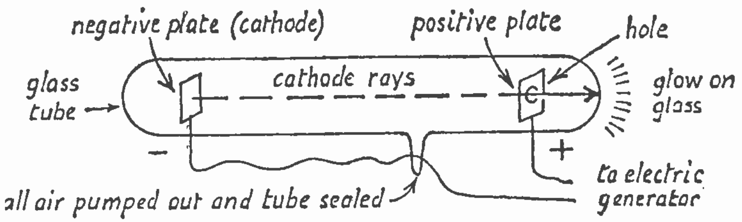
2 The cathode ray beam changes in intensity as it scans.

3 The spot glows with varied brightness as it moves.

4 Because of 'eye memory' we seem to see a picture on the screen.

Cathode rays

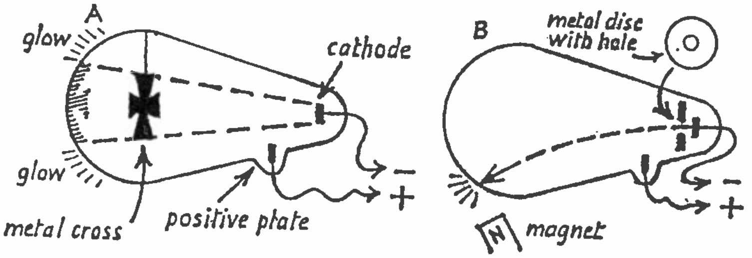
Both the television camera and the television receiving set depend on cathode ray tubes for their operation. To complete this chapter on how television works, let us



Cathode rays (1)

briefly consider cathode rays themselves, and how they are made.

When we think of an electric current, we usually imagine it running along a wire, or something which conducts electricity. With electricity of several thousand volts, however, a current can leap a gap between two conductors. The effect of this in the air is an electric spark. This spark is really the air being heated up by a stream of electrons rushing through it. An electric current of very high voltage can also travel through a vacuum—that is, empty space where there is no air or gas. The picture shows a sealed-up glass tube, from which all the air has been pumped. Wires going through the glass at each end lead to small metal plates. One metal plate has a hole in its centre. A supply of electricity of several thousand volts is connected to the plates. The plate with the hole is made positive. The other, called the 'cathode', is made negative. A strange thing happens when the electricity is switched on. At the opposite end to the cathode, on the glass behind the hole in the metal plate, appears a faint greenish spot of light. This spot is due to an electric current travelling through the vacuum. The current, which, like all electric currents, is a stream of electrons, leaves the cathode and strikes the other plate. It is called a cathode ray in consequence.



Cathode rays (2)

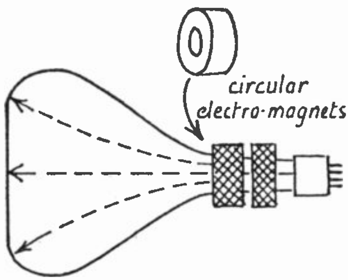
A. Cathode rays throw a shadow of a cross on the tube

B. A magnet attracts the rays

Some electrons go through the plate and hit the glass, making it glow.

What we have just described is the simplest form of cathode ray tube. In the picture above the two plates in the tube are arranged with the positive plate to the side of the cathode. The ray shoots out from the cathode in a straight line, misses the second plate and strikes the glass, which glows greenish at the end. A shadow of a little metal cross can be thrown on to the glass, since the rays will not go through metal. This shadow clearly shows that the rays travel in straight lines.

The cathode ray beam can be made more intense by turning on more electricity, that is, increasing the voltage. This gives us a means of making the 'spot' brighter or dimmer. A magnet brought near the tube will pull

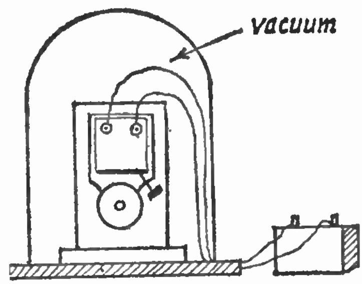


TV receiver tube. Circular electro magnets are used to make the beam scan the beam towards itself. The spot will then move in the direction of the magnet. An electro-magnet can be switched on and off. Let us imagine one electro-magnet placed above the tube, and another one underneath. By switching these magnets on and off alternatively the spot will be made to move up and down. Another pair of electro-magnets can move the spot horizontally from one side of the screen to the other. Both sets of magnets can be employed together to make the beam scan. In both camera and receiver there is apparatus which controls the electro-magnets so that the scanning goes on automatically.

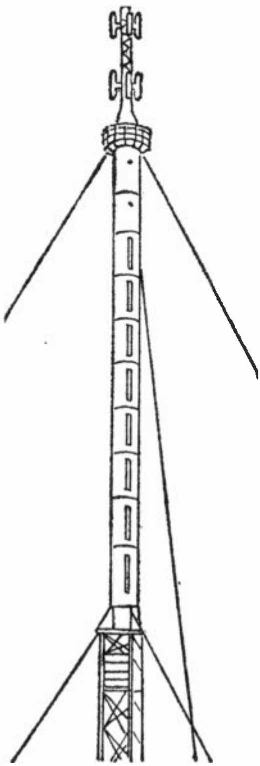
5

HOW RADIO WORKS

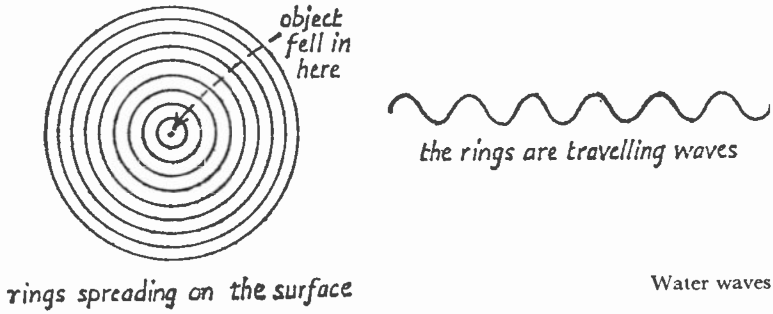
Radio was first used for sending out telegraph messages in the morse code. The system was then called 'wireless telegraphy' because no wires were needed along which to send the messages. Later on came 'wireless telephony' in which sound, like that of the human voice, was sent without using telephone wires. Today, radio is used for sending messages, for broadcasting news and entertainment, and for conveying television.



No sound can be heard from an electric bell ringing in a vacuum



The top of a 750-foot-high aerial of a TV station



Water waves

Radio works on the same principle whether it is being used for carrying morse code, sound or vision. In this chapter we shall describe sound radio, as an example of how radio works.

Sound

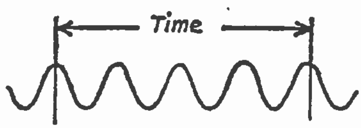
First, a few words about sound itself. We know that sound is caused in hundreds of different ways. For example, it can be caused by dropping a brick, plucking a guitar string, using one's voice or blowing a bugle. It is obvious that sound travels since you can hear something happening some distance away from you. It is a fact, however, that sound needs something to travel through. It cannot travel in empty space. This fact can be proved by trying to make an electric bell work inside a glass case from which all the air is removed. You can see the bell ringing, but you can hear nothing. The moment that air is let inside the case however, you hear the sound of the bell.

How then does sound travel? The answer is that sound is a movement of the air itself. We cannot see this movement, but we can form an idea of it by comparing what happens when we drop a stone into a pool of water. Ripples spread out in rings from where the stone fell in. These ripples are small waves. When they reach a floating object they make it bob up and down. When they reach the bank, they strike it one after another. A big bang is a 'splash' in the air. It causes a large number of 'waves' which spread rapidly. When these air waves strike an object, they make it shake. When these waves reach our ears, we can feel them.

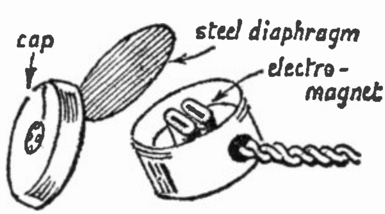
This 'feeling' we call hearing. Our ears can tell the difference between big and small waves. These we know as 'loud' and 'soft' sounds. We can also tell whether a small or a large number of waves reach our ears in a given time. If thirty-two waves arrive in a second, we call the sound a 'low pitched' sound. If several thousand waves arrive in a second, we call the sound 'high pitched'. A guitar string plucked to play the note 'middle C' vibrates 261 times a second and makes 261 sound waves in the air each second. The number of waves each second is called the frequency of the sound.

The telephone

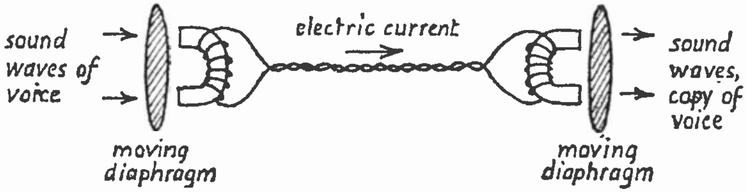
The mouthpiece of a telephone is a microphone. The earpiece is a small loudspeaker. Thus two people telephoning each have a microphone and a loudspeaker. On the next page the mouthpiece (microphone) of one telephone is shown connected by the telephone wires to the earpiece (speaker) of the other telephone.



Frequency: the number of waves in a second



The telephone earpiece



A simple telephone system

Underneath the cap of both earpiece and mouthpiece of a telephone is a thin circular steel plate, called the diaphragm. This plate, being springy, vibrates when sounds are made near it. On the other hand, if it is bent and let go, it vibrates and makes a sound.

The microphone generates an electric current when its diaphragm is made to vibrate. The earpiece is the microphone in reverse: when it receives an electric current its diaphragm vibrates. Let's now see what happens when Mary speaks to her friend John on the telephone.

The following is the sequence of events:

1 Mary's voice travels through the air as sound waves.

2 Sound waves make microphone diaphragm vibrate.

3 Microphone sends electric current along the wires to earpiece.

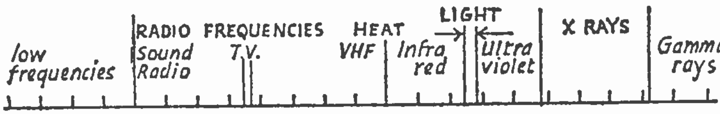
4 Earpiece makes its diaphragm vibrate.

5 Vibrating diaphragm creates sound waves which travel to John's ear.

These sound waves are copies of the sound waves of Mary's voice. If they are as good copies as is usual with modern telephones, John imagines he is hearing Mary's actual voice.

The radio-telephone

Police patrolmen like those you have seen in 'Z Cars' can keep in touch with their headquarters through telephones installed in their cars. Passengers on liners at sea can send telephone messages to the land. An astronaut circling the earth in a space satellite can speak with people on the ground. No wires can possibly link microphones and earpieces in these cases. How, then, does the electric current travel from one to the other? It is something made by this electric current which does the travelling. This something consists of waves in space, given the scientific name of 'electro magnetic waves'.



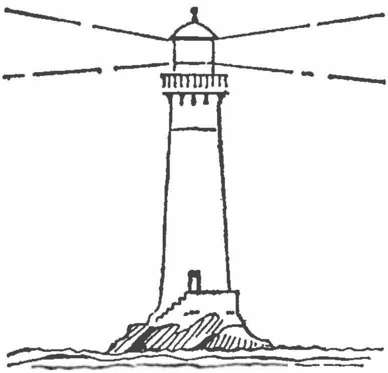
The scale of the electro-magnetic waves in order of frequency

Radio waves

You may have seen a 'silent' dog whistle. It is called silent because although the dog can hear it, human beings cannot. Just as there exists 'sound' too high or low for us to hear, there is also 'light' we cannot see. This 'invisible' light consists of gamma rays, X rays, ultra violet rays, infra-red rays, heat rays and radio waves. All of these, including the light we can see, are electro-magnetic waves. Above you can see them arranged on a scale, getting higher and higher in frequency as you go to the right.

All electro-magnetic waves are created by the flow of an electric current. For example, an electric current can make light, as in an electric lamp, or heat, as in an electric fire. It can also make radio waves. Instead of a lamp for light, or an electric fire for heat, an aerial is used for sending out radio waves. Broadcasting station aerials are wires attached to tall masts. Some other radio aerials look like the reflectors of electric fires, on a huge scale. All of these send out this 'invisible light' we call radio waves.

Let us imagine, therefore, that the tall aerial of the broadcasting station is a 'lighthouse', sending out radio waves in all directions. Unlike light these waves will go through 'solid' objects like brick walls, concrete, slates. They are stopped, however, by metal. A piece of wire is therefore attached to the chimney of a house, or inside the case of a radio receiver. This wire is called a receiving aerial. It stops some of the wireless waves. They cause a small electric current to flow in the wire. Thus an electric current causes radio waves to spread out from the radio station aerial. These waves are then turned back into electric current in the receiving aerial. A radio receiving set is a piece of apparatus in which the electric current from the aerial is made to work a loudspeaker.

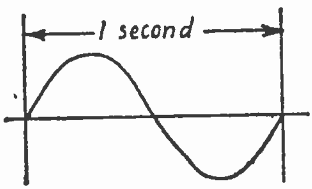


A lighthouse

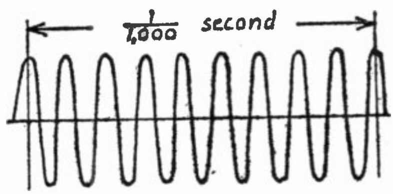
The radio transmitter

Let us go to the broadcasting station and follow the whole process in more detail. At the broadcasting station, the studio is linked to the transmitter, which is linked with the tall broadcasting aerial. We have already talked about the studio. The transmitter is contained in a building which may also house electric generators for supplying the electric current required.

Let us look at the transmitter itself. The main part of it is a large radio valve, which has some resemblance to an electric lamp, but may be two or three feet tall. Since it gets very hot when working, this large transmitting valve is usually water cooled. A valve resembles a cathode ray tube, in having a vacuum inside its glass tube. Suspended in this vacuum is a filament, like that of a lamp, and a metal plate. As in the case of the cathode ray tube a current of electrons passes through the vacuum. It flows from the hot filament to the plate and from the plate out of the valve. This current is sent to the station aerial.



Graph of an electric current rising and falling in strength



An electric current changing in strength ten times in one thousandth of a second

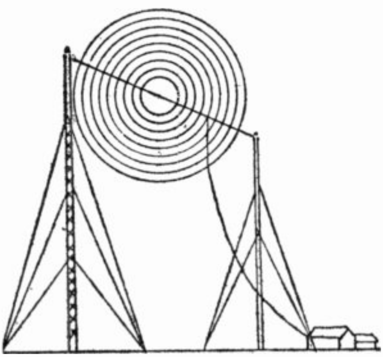
Radio waves are made when an electric current in a wire changes in strength very rapidly, rising and falling thousands of times in each second. Above, on the left, is a drawing to represent a current growing and then dying away all in one second. On the right is a current repeating this rising and falling ten times in a second. It would be difficult to make a drawing to show a thousand changes in a second, so you must imagine what it would look like.

The number of changes of the current in each second is called its frequency. Each change causes a radio wave so that radio waves have a frequency too. The frequency of the BBC Home Service is nearly one million waves per second. The technical expression for 'waves per second' is 'cycles per second'. 1000 cycles equal 1 kilocycle.

The purpose of the transmitting valve is to make a current rise and fall at a sufficiently high frequency to create radio waves. When the station is 'on the air' these radio waves leave its aerial wire just as rays of light shine out from a lighthouse. So far no programme is being sent out.

The microphone, however, is connected to the transmitter so that it controls the working of the transmitting valve. Just as someone's foot on the accelerator of a car makes the engine go more quickly or slowly, so the microphone current makes the transmitter produce stronger or weaker radio waves.

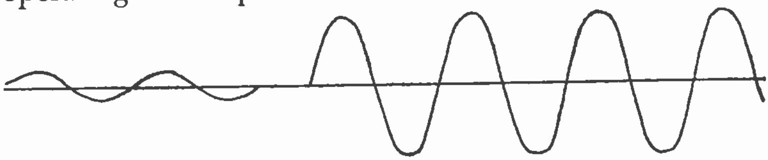
You can thus imagine our radio 'lighthouse' flickering—its radio waves changing in strength all the time that someone is speaking or playing music in the studio. These changing radio waves arrive at the receiving aerial on someone's chimney, or the tiny aerial inside a transistor set. Let's see what happens to them there.



Invisible waves spread out from the aerial of a radio station

The radio receiver

The receiver aerial is a piece of wire or a metal rod. Radio waves striking it cause an electric current in it. This electric current is very weak, however, particularly if the receiving set is tens or even hundreds of miles away from the transmitter. Electric current is measured in amperes, and the ordinary torch bulb fed from a small battery takes about one-fifth of an ampere. The current in a radio aerial may be as low as one-millionth of an ampere. This current is far too weak to be of any use in operating a loudspeaker.

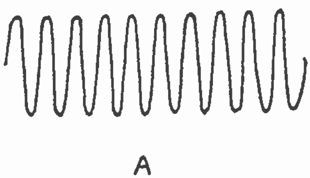


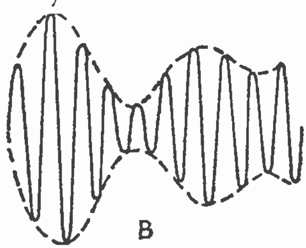
Magnification—a small change in an electric current becomes a large one

The radio set therefore has something inside it which can magnify the aerial current. This magnifier, called an amplifier, contains receiving valves or transistors. It is driven either by electricity from the mains, or by batteries. Valves or transistors have a current flowing through them which eventually works the loudspeaker. The weak aerial current controls the stronger valve or transistor current.

The tiny current in the aerial may be drawn like this.

A. The current in the aerial with the microphone off





B. The aerial current being varied in strength by the microphone

On the left no one is speaking into the microphone. The current therefore is a steady even stream of 'ups and downs' at a frequency of hundreds of thousands of times each second. Notice that the 'ups and downs' are all equal. On the right, however, someone is speaking into the microphone. The 'ups and downs' are now no longer all equal. The microphone is making the radio waves change in 'height', that is, in strength. The loudspeaker cannot follow changes of current taking place hundreds of thousands of times a second, because it is unable to move quickly enough. But it can follow the slower changes in strength caused by the microphone. This is perhaps like a boat, which is not moved by the small ripples created by the wind. Longer, slower waves from the wash of a steamer, however, rock it up and down.

The loudspeaker, therefore, moves as the microphone diaphragm moves. Thus, as in the case of the telephone earpiece, it makes copies of the original soundwaves.

Now let us go back to the broadcasting station, where the announcer is just going to speak.

Leaving out the details, this is what happens:

1 Transmitter is on the air sending out even radio waves.

2 Announcer speaks into microphone.

3 Radio waves change in size following the movements of the microphone.

4 Radio waves strike the receiving aerial.

5 Radio set magnifies aerial current.

6 Loudspeaker follows the changes of the aerial current.

7 Thus we hear the announcer speaking.

Do not forget, however, that we are not really hearing the sounds he actually made, but those made by the loudspeaker, which is imitating his voice.

Tuning

You can listen with your radio to the Home Service, the Light Programme, the Third Programme, or to dozens of other stations all over Europe. These stations are often all on at the same time. How, then, are we prevented from hearing a jumble of them all coming out of a loudspeaker? The answer is—by tuning. We select the station we want by turning a pointer on the set's scale to the name of the station, or to a number.

The word 'tuning' is borrowed from something connected with sound, such as 'tuning a piano'. A tuning fork which sounds 'middle C' vibrates at a frequency of 261 vibrations per second. When the piano is tuned, its middle C string is tightened until it also vibrates 261 times per second. The string and the tuning fork are then said to be 'in tune', for they sound exactly the same note.

If you have a tuning fork, try this experiment. Make it sound over the open mouth of an empty milk bottle. Now, very gradually, fill the milk bottle with water from a jug, whilst keeping on sounding the tuning fork near the mouth of the bottle. Presently, and quite suddenly, you should hear the tuning fork sound much louder, as if the bottle were answering back. The reason is that the air in the bottle is now vibrating in step with the tuning fork. Notice that if you pour in still more water this effect ceases. Only with one definite amount of water in the bottle is the air left inside 'in tune' with the tuning fork.

Now try an experiment with a bicycle pump. First make a note by blowing across the hole where the connection screws in. Now, try again with the pump handle pulled out at various distances. The note changes. You are varying the tuning of the pump by altering the length of the air column inside. Different lengths correspond to different sound frequencies.

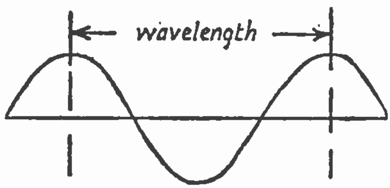
In the same way, you can vary the lengths of coils of wire or the distance between metal plates to correspond with the different frequencies of radio waves. Inside your radio set is an arrangement of metal plates which can be altered by turning the 'tuning' knob. This also moves a pointer on a scale. So the tuning of the set is altered.

Each radio station has a similar arrangement of coils of wire and metal plates which is fixed to correspond with a definite radio frequency. So, for example, one of the stations broadcasting the Light Programme has a frequency of 200 kilocycles per second. If you want to listen to that particular station you tune your set to 200 kilocycles per second.

Wavelength

The word 'wavelength' is often used instead of frequency when speaking about the tuning of radio stations and receivers. 'Wavelength' is the length in metres between the separate radio waves as they leave the transmitter aerial. All radio waves travel at the same speed, so that

Wavelength: the distance in metres between successive waves



the more waves there are in a second, the closer together they must be.

Very high frequency waves (VHF) are thus called 'short waves', because there are millions of waves each second. Lower frequencies of only a few hundred thousand waves each second are called 'long waves'.

The speed with which radio waves move is the speed of light, 300,000 metres per second, or about 186,000 miles a second. At this tremendous speed a radio signal could go right round the world about seven times while you are counting 'one'!

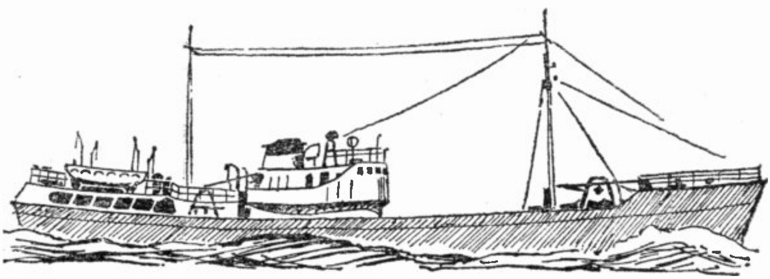
6

RADIO ROUND THE WORLD AND IN SPACE

Were it not for radio, all broadcasting, whether of sound or television, would have to be sent along wires. Moving vehicles, aeroplanes and ships would not be able to receive the programmes, nor would the parts of the world where the wires cannot reach. Without radio, aeroplanes, ships, police cars and military vehicles would have to rely on visible signals such as flashing lights, or flags, for sending messages. Messages from far distant places would have to be sent by telephone, and if there were no telephone lines, by letter. As it is, even the most remote parts of the world can keep in touch with the rest. Radio has made the world smaller.

Radio at sea

All modern ocean-going ships of any size carry wireless.



The wireless aerials on a trawler

Very large vessels have on board a radio transmitter which can cover distances of hundreds or even thousands of miles. The ships are also equipped with receivers sensitive enough to be able to receive signals from a great distance.

The morse code is still very much used for radio messages at sea. It has the advantage that a message in it can still be understood even if the signal is very weak, or if there is a great deal of 'interference' on the radio. Radio interference at sea is frequently caused by electric disturbances in the upper atmosphere, and takes the form of loud crackles called 'static' or 'atmospherics'.

The ship's radio officer has the duty of sending and receiving messages in morse and by telephony. He receives weather forecasts from the nearest weather station. He sends and receives messages for the captain. He and other officers also keep a twenty-four hour 'radio watch', listening for messages from other vessels. This is very important in case a vessel in distress is sending an 'S O S' for help.

Distress signals

S O S does not mean 'Save Our Souls'! The letters S and O were chosen for distress signals because S, · · · in morse, and O, – – – in morse, are not likely to be mixed up with any other letters in the code. A ship requiring help urgently therefore sends the S O S signal, which is understood by ships of all nationalities. There is not much point, however, in merely sending out S O S by itself, for this merely means 'Help!'. The ship in trouble will radio its name, its position and what the trouble is.

The message will run like this:

S O S
Steam Ship Ruritania
Latitude 54° N Longitude 4° W
Fire in engine room.

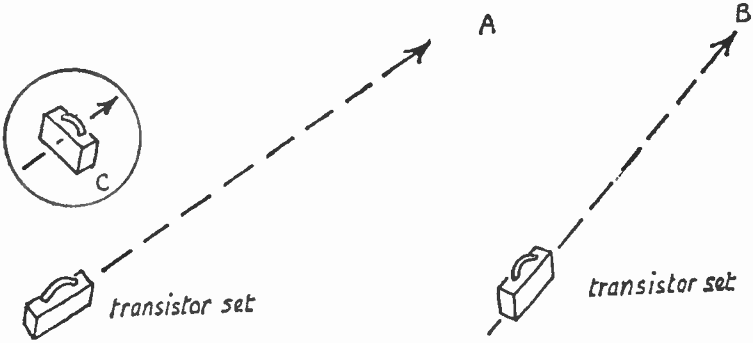
(You can easily plot the position of this ship in an atlas.) Ships receiving the message will alter course to give help, or if they are far away from the distressed vessel will make sure that a ship closer at hand goes to the rescue.

But supposing that the ship has sunk, leaving lonely lifeboats and rafts afloat—how will these be found? If the ship had sent out a call giving its position before sinking, help would be on the way from ships who had heard the S O S. But if the ship had gone down before its distress signals had been picked up, the survivors might be in great danger, especially if they were in stormy seas far out in the ocean. To meet such a possibility, lifeboats, rafts and even 'Mae West' life jackets are nowadays often fitted with automatic radio transmitters. Such transmitters go on sending out distress signals until the survivors are picked up. The position of the lifeboats and rafts can be found by the rescuing ships through 'radio direction finding'.

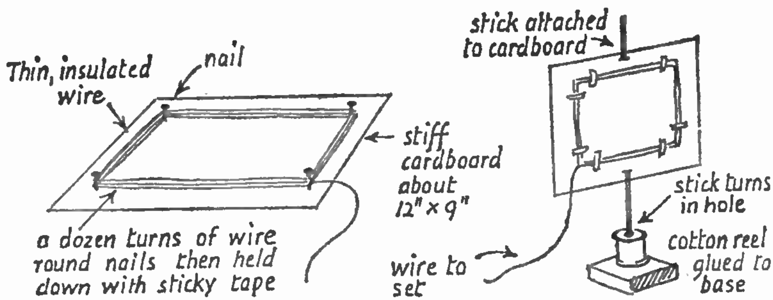
Direction finding by radio

This is called DF for short. It is a method of finding the direction from which radio signals are coming. Many portable transistor sets are 'directional', that is, they work best when they are pointing in the direction of the broadcasting station. Try the following experiment with a portable transistor set. Tune the set to some station which

A portable transistor set can show the direction of a radio station. The second set is a few miles away from the position of the first. The station's position is where the two lines A and B meet. (Alternatively the set can be turned to give the *least* volume from the station, as shown at C)



gives good reception in your area. Now lift the set up and turn it slowly round. If the set is directional, the volume will be loudest when the case is pointing in a certain direction. Stand the set down, pointing in this direction. Look along the longer edge of the top. The radio station is somewhere on a line running straight in front of you or behind you. To tell in which of these two positions the station is located you would need to repeat the experiment at some place a few miles from where you first tried it. The drawing shows you that the radio station is at the spot where the two direction lines cross.

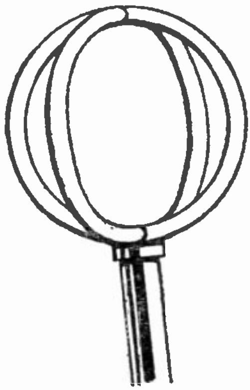


Direction-finding by radio: making a frame aerial

You can do some interesting experiments in direction finding with a frame aerial. The drawing shows you how to make one. Attach the wire from the frame aerial to the aerial terminal of a radio set. Get a fairly large map of Europe, and a compass. Place the map so that its north is facing north as shown by the compass. Stand the frame aerial so that its base is over the place where you live. Now tune the set to stations such as Luxembourg, Hilversum, Paris, London. In each case turn your frame aerial to the direction shown by the map. Try locating other stations you can pick up.

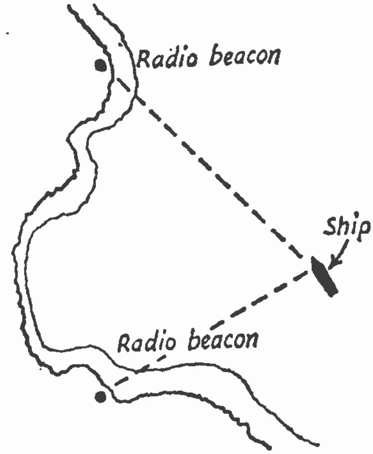
The direction finding frame aerial on a ship has two circular loops of wire at right angles to each other, each enclosed in tubes. By means of this aerial the ship can locate other ships who are sending messages, and radio stations on the land.

DF aerial
on a ship



Radio beacons

Certain radio stations have been built on the coasts of almost every country to help ships to find their way. These stations are called radio beacons. Formerly only lighthouses existed to warn navigators of dangerous rocks and narrow channels, and to help them steer their way



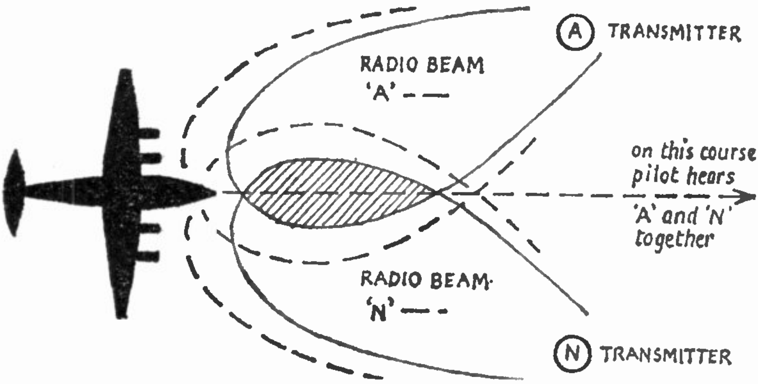
How radio beacons help a ship to find its position on the chart

in difficult places. Lighthouses still serve this useful purpose but nowadays most of them are also equipped with a radio beacon. These beacons have the advantage that ships can receive them in a fog or at a distance from which a light would not be visible.

Each lighthouse flashes its light in a different way, so that seamen can identify the lighthouse. In the same way each radio beacon sends out a special signal of its own which distinguishes the beacon from others. Radio beacons usually operate within frequencies of 255 to 415 kilocycles per second. If your set is able to tune to this frequency, you should be able to pick one up. Each one has an automatic transmitter which repeats a call sign in morse followed by a long dash. The call sign is for identification, the long dash is for direction finding purposes.

Radio in the air

Radio is of tremendous assistance to modern aircraft. It helps them to find their way over vast distances, and to



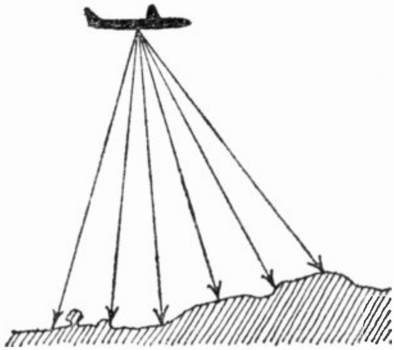
Radio helping an aircraft to find its way to the airport

take-off and land at crowded airports. By means of it the pilot can receive weather reports, send messages, if he is in difficulties, and keep in communication with the control tower when he is on or near the airfield. It helps him perform the difficult operation of landing, particularly at night, or in bad weather conditions.

Here is just one of the ways in which radio helps the pilot to find his way. In this case it is a way in which he is guided to the airport. Two radio transmitters are placed one at each side of the approach to the runway. One, on the left, continuously sends out the morse letter A, · — The other, to the right, sends out the letter N, — · The pilot approaching the airport listens to both these stations. If he is on course, flying exactly in between them, he hears both call stations together at equal strength. Morse 'A' and 'N' heard together make one long continuous note ————. If the pilot goes off-course to the left he begins to hear letter A, if to the right, N. He therefore steers so that he always hears a continuous note.

Radar

One of the most important radio aids to navigation at sea or in the air is known as radar. The word is short for 'radio detection and ranging' and it stands for a method of locating objects by radio and measuring their position.



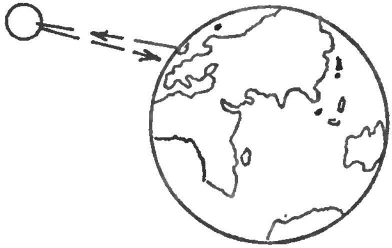
An aeroplane receiving a picture of the ground through its radar

If you bounce a ball against a wall you will find that the further you stand back the longer the ball takes to return to your hand. Radar works by sending radio-waves to strike an object and be reflected back. Obviously the further away the object the longer the time the radio waves will take. Since radio waves always travel at the same speed, this time taken to go and return will tell us the distance of the object. Radar thus provides us with information by using 'echoes' of radio signals.

A radar system consists of:

1 A suitable transmitter.
2 A receiver.
3 A device to measure the time between sending out the signal and receiving its 'echo'.

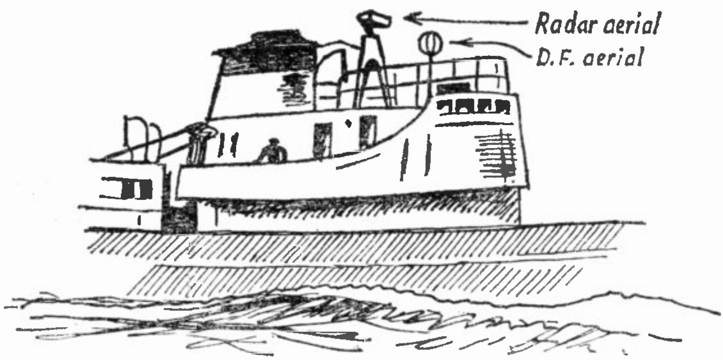
Suppose that you want to use radar to measure how far



Bouncing radio waves
off the moon

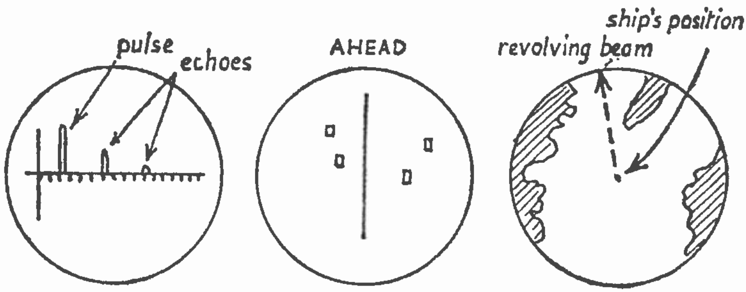
the moon is from the earth. You would need to send a 'pulse' of radio waves to the moon and to time how long it is before you hear the echo. The difficulty would be to measure this time interval accurately enough to give a correct answer. A radio wave would take about 2.6 seconds to reach the moon and return to earth. Light travels at about 186,000 miles each second. In 2.6 seconds it would have travelled 483,000 miles. Therefore this would be the distance to the moon and back. From this it appears that the moon is about 241,500 miles from the earth. (The mean distance in fact 238,840 miles.)

The aerial of a radar installation frequently takes the form of a metal box which turns round and round on its axis. You can usually find one of these above the bridge



The bridge of the trawler shown on page 67. Radar and DF aerials help with the navigation of the ship of a ship. As this aerial turns round it does two things. It shoots out pulses of radio signals, and it collects them when they are bounced back by the objects they strike. This action resembles that of someone making a loud sound and listening for the echo.

The radar receiver uses a cathode ray tube. On one form of screen the navigator can see a mark representing the pulse going out, and another one representing the pulse returning. The distance between the two can be measured by a scale of divisions on the cathode ray tube screen. The drawing at (A) shows the pulse and the echo.



A. A radar screen showing the radio pulse and its echo. The *range* is the distance between pulse and echo
B. A radar screen showing echoes as bright spots. *Range* and *direction* are shown on this screen
C. P.P.I. (Plan Position Indicator) on this radar screen the revolving beam shows a plan of the harbour and the movement of the ship

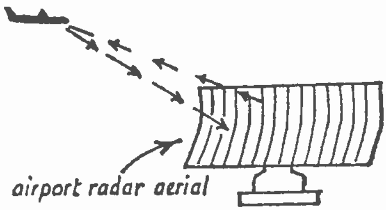
All that this particular radar screen tells the navigator, however, is that there is some object at a certain range from the ship. It does not tell him in which direction the object lies.

The drawing at (B) shows a radar screen which gives the navigator both range and direction. The upright line on the screen corresponds to the ship's course. The square marks are bright spots appearing on the screen corresponding to echoes from objects. The direction and distance from the ship of each object is thus shown.

At (c) is shown a third type of radar screen, called the plan position indicator, P.P.I. for short. The position of the ship's radar aerial is at the centre of the screen. As this aerial rotates and sends out its radio pulses, the echoes form a map of the surroundings of the ship. The movement of the ship can be seen on this screen. P.P.I. is particularly useful for guiding a ship into harbour.

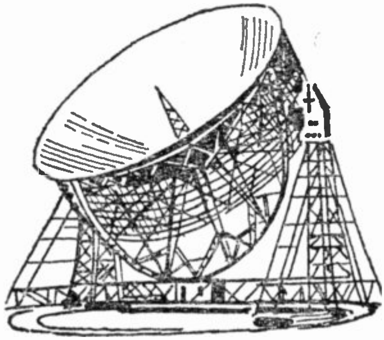
Many forms of radar are used by both aircraft and airports. Some of these resemble those used by ships and harbours, others are designed to suit the special problems of the air and the great speeds of flight.

The airport 'sees' an approaching aircraft by means of radar



Radio astronomy

It has been mentioned that the moon's distance can be measured by using radar. The distance of the planets can be measured in a similar manner. It has been discovered that just as light comes to us from the stars, so also we receive radio waves from outer space. These waves appear to be caused by matter in certain parts of the universe sending out radio frequency waves as well as, or instead of, light. Radio astronomers use so-called radio telescopes to receive these waves, and find where they are coming from. The huge Jodrell Bank radio telescope is a radio reflector which can pick up and focus radio waves coming from immense distances. It can also



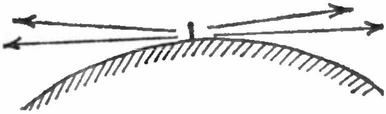
The radio telescope at Jodrell Bank

'track' any star or planet, or even space satellite. The exploration of space by radio astronomy has only begun in recent years. It is already telling us interesting facts about the universe.

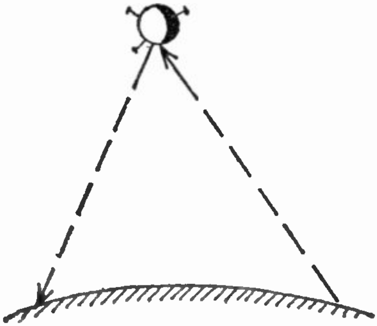
Telstar

This is the name given to a special space satellite which circles the earth from west to east at a distance of a few thousand miles. The purpose of the satellite is to reflect down to the earth radio waves which have been sent up to it.

High frequency radio waves such as those used for television travel in almost straight lines. Since the earth is round, waves from such a television station travel out into space a short distance from the station aerial, and if you are more than about thirty miles from a TV station you cannot receive it properly because its waves are travelling high up above you. The drawing shows how such waves reach the circling satellite and are sent down again.



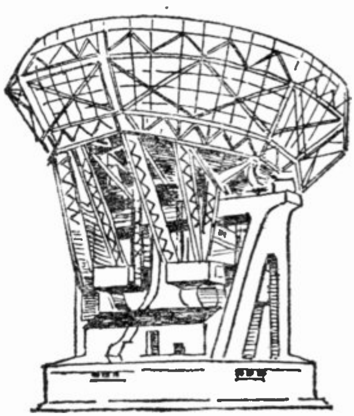
Very high frequency waves travel in straight lines. After a short distance these rays leave the earth and pass into space



Bouncing radio waves off Telstar

The satellite does not merely reflect radio waves. Inside it there is a receiver, an amplifier, and a transmitter. The signals are very weak by the time they reach the satellite. Its receiver picks them up and passes them to the amplifier. This magnifies them greatly and sends them to the transmitter which sends them back to the earth.

A television station in America or Japan can therefore aim its signals at the satellite. If the satellite is in the right position it can send these signals down to Britain. Our television stations can pick up these signals and send them to us in the ordinary way. We can thus receive the



The reflector aerial at Goonhilly Down, used for picking up Telstar

Japanese programme. The length of time we can do so depends on the height of the satellite and the speed it is moving.

Radio control

You may have seen model boats being steered on a lake by radio 'remote control'. On the shore someone has a small radio transmitter. With this he sends signals to a receiver on the model boat. Instead of working a loud-speaker the receiver operates the motor and the steering. The boat can be made to turn and return to its owner, or execute fascinating manoeuvres.

Radio is used in this manner to control the flight of rockets as they leave the ground. Pilotless aircraft have been made to take off, fly and land by the same means.

This brings us to the end of this chapter and of this book. There are many other interesting things to learn about television and radio. Read about them in other books and try further experiments.