TELEVISION
HOW IT WORKS

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DESIGNED AND ILLUSTRATED BY
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THE MAGIC OF TELEVISION
Bringing the world into the home
Imagine. Sunil Gavaskar broken down into thousands of small bits of electricity as he takes an outswinger and pushes it to silly mid-on. Rushed through the air at the phenomenal speed of light. Down your antenna. Through the wires. And into your receiving set. To be seen exactly as he is on that cricket field thousands and thousands of kilometres away in the West Indies!

Imagine. But you don’t have to. For, the magic of television does it for you every day. It breaks up every picture into thousands of small charges of electricity and sends them through the air as electromagnetic carrier waves at nearly 300,000 kms. per second, to be picked up by the antenna on your roof-top and conducted into your receiving set where they are amplified and converted back into a picture.
Television takes you places indeed. You can go down to the bottom of the sea or right up into space as you sit munching wafers before your TV set.

Time was when grandmother gathered her grandchildren around her to tell them stories about the man in the moon. Now, both grandmother and grandchild sit glued to the TV set as they watch and listen to the man on the moon.

The first 'waves'

It began with sound broadcasting, in the early 1920's, after Alexander Graham Bell had invented the telephone and Guglielmo Marconi had made wireless transmissions across the Atlantic: “If we can use waves to transmit speech,” said some “can we not also use them to transmit moving pictures?”

This set John Logie Baird, a Scotsman, thinking. One day, while in his bedroom, he pulled out some odd pieces of equipment which included two cycle lamp lenses, a torch, an old electric motor, parts of an old radio, string, wire, glue and sealing wax. Then he set about his task. The results, though not immediate, were dramatic. On January 27, 1926 he finally proved to the world that television was indeed a reality.

It was, of course, a combination of several discoveries that helped Baird to demonstrate how moving pictures could be
German, Paul Nipkow and the cathode-ray tube had been developed also by a German, Karl Braun in 1897. Some years later in Russia, Professor Boris Rosing recognised that the cathode-ray tube could be used to display television pictures. Later still, it was proved that variations of impulses in an electric circuit could be transformed into electromagnetic waves, as it is in sound broadcasting.

In 1930, Baird who had opened a studio in London, persuaded one of Britain’s most popular singers, Gracie Fields, to put in an appearance on his tiny, blurred screen. As he had not yet devised a system to transmit sound and pictures simultaneously, people first saw Gracie’s face and a few minutes later heard her voice as the screen turned blank. Funny though it sounds, it was a momentous occasion. It was the first programme that could be seen and heard a long way away exactly as it was happening at the studio.
During the war

People did not take to television overnight. TV sets were expensive and not many could afford to buy them. Besides, people had to be convinced that television was worth their money.

And convinced they were in 1936, when the British Broadcasting Corporation (B.B.C.) set up the first regular television service in the world. In the next couple of years television did grow in popularity and would have caught on in a big way, had the second world war not broken out.

This is, of course, not to suggest that people abandoned television thereafter. It was, in fact, during this time that some scientists considered using television for many purposes, for instance, to develop a bomb. The idea was to fit a small TV camera and transmitter to the flying bomb so that its course could be followed by the plane which had launched it. In this way the bomb would be guided nearer and nearer to its target. However, this was an idea that never really took shape.

The Germans, meanwhile, introduced a picture telegraph system for security reasons. This system used the same principles as television. Words in messages were projected as images to the other end so that they could be read and understood easily.

While Europe was at war, engineers in America threw themselves into establishing a regular television service. Numerous stations were opened at many of the large cities and a national network of cable and radio links, or what is more familiarly known as a 'national hook-up', was set up.
Mickey's gala premiere

After the war television spread. And perhaps it was Mickey Mouse who made it popular! For, the friendly little mouse endeared himself as much to people then as he does today. The last transmission made by the B.B.C. on September 1, 1939 just before the war, was a cartoon called, 'Mickey's Gala Premiere', and on June 7, 1946, to everyone's delight, the first programme televised after the war was the same cartoon!

Initially pictures could be transmitted only over a limited distance. One transmitter could not serve people living beyond a radius of about 160 kms. To send a programme across the Atlantic was out of the question.

With the launching of space satellites, this was made possible. On July 11, 1962 the first transatlantic transmission took place from Andover, U.S.A., via the satellite Telstar 1, to Pleumeur, France. Baird's dream had at last come true. Television had by now become an accomplished fact in many countries.
Doordarshan

In India television was introduced in 1959. Known as 'Doordarshan', the programmes initially were entirely educational. The first general service on a regular basis was started from Delhi in August 1965.

Now, besides having gone colour, television has reached practically every corner of the country. This offers us tremendous prospects for development. TV has great potential in the field of education, particularly basic education, and in other vital spheres such as transforming the social environment, bringing us culturally nearer and generating a science consciousness. Television has placed us in the unique position of being able to 'experience simultaneously the same environment.'

In 1963, people who had their TV sets on, in the United States, saw Jack Ruby kill President John Kennedy's presumed assassin, Lee Harvey Oswald, in the basement of Dallas Police headquarters as it happened. Within hours the rest of the world also saw it — thanks to the Satellite Telstar.
From sea to space

Today, television is shrinking the world. In fact, it has gone far beyond the stage of simply being one of the communication media. TV has extended itself to many complex and intricate areas — from underground pipes to spacecraft, from supermarkets to operation theatres, and from police stations to your front door. It can go places where man perhaps cannot.

It was a television camera that showed the world the first pictures of the moon long before Neil Armstrong set foot on it.

With possibilities of 3-D television taking shape, it may not be long before you can see your favourite star reaching out towards you as it were!

In a closed circuit TV system the signals from the camera are not broadcast to all, but are transmitted through cables to selected receivers. It helps students watch the surgeon perform his delicate task without crowding into the operation theatre. Similarly it helps the police to regulate traffic and spot thieves in supermarkets. And if you place one of these cameras outside your front door, you can even check who is calling!
The camera

The camera comes first in our bag of television equipment. In this case, we take a black and white one. Remember this is a TV camera and not an ordinary one that you may use to take photographs.

Several cameras are normally used for an outside telecast, as in a studio transmission. You have a team of people operating the equipment.

One camera is so arranged that it takes in the entire picture. Another camera shows close-ups of the scene, and others are positioned elsewhere to give different views of the same scene.

The producer positions the cameras suitably before the shooting is done. The overall effect is observed on a monitor which is placed before the producer. He can switch from one camera to another during the broadcast, in order to get the best possible coverage.

The inside of a black and white TV camera
The image-maker

The TV camera does not have a film as in the ordinary camera. The subject on which it focuses—a monkey, let us say, throws an image on a plate inside the camera. This is known as the signal plate. It is made up of thousands of tiny dots of a special material. These dots are actually photo-cells. When light falls on them, an electric charge is generated on each cell. The stronger the light, the stronger the electrical charge. There are actually two images on the signal plate. One is visible, being formed by the scene in front of the camera—in this case the monkey. The other is an invisible electrical ‘image’. This image has strong electrical charges where the scene before the camera is bright, and weaker electrical charges where the scene is less bright. In places where the scene is dark, there is no charge.

Television microscopes are used for biological research. With ultra-violet light the microscope magnifies the object being studied more than a thousand times.
The control room—a close-up
1. Monitors 2. Control panel

Shooting in a TV studio
The scene reproduced on your TV screen
1. Antenna (on rooftop) 2. Cathode-ray tube 3. Picture appears in a series of lines 4. The lines make up the picture
Dot by dot

What exactly happens to this invisible image? Just as sound is recorded, images are recorded on magnetic tapes. In order to facilitate this, the image has first to be turned into a stream of electrical signals. This process is known as scanning.

Scanning is done by an electron beam. In the TV camera there is a device called an electron gun which shoots out a high-speed beam of electrons. This beam moves rapidly across the signal plate in a fixed pattern. By this process each image is sliced into 625 lines. Each line is broken up into dots. Each dot on every line has a varying charge depending on whether it is black, white or grey. That seems easy, doesn’t it? Well, here is the difficult part.

Each dot is positively charged. The electron beam, however, has a negative charge. When the negative beam strikes a positive dot, it cancels out the charges and whoosh, the beam wipes out the electrical image!

As the charge is removed from each dot of the signal plate, it flows into a wire connected to the plate. The current coming from the plate varies in strength from moment to moment, according to the charges on the dots which vary according to the visible image. These varying charges are then recorded on a magnetic tape. A high current indicates ‘white’, a low current stands for ‘grey’, and no current for a ‘black’ spot.

In 1984, 2,500 million people the world over — the greatest number of viewers for a televised event — watched the 23rd Olympic Games as they were being played in Los Angeles, U.S.A.
The sound effect

While the TV camera picks up the picture of the monkey, there must be some way in which the sounds that the monkey makes and the commentator's remarks can be picked up and converted into electrical charges.

First, let us understand sound. All sounds are the result of vibrations that travel in waves through the air. If there was no air we would not hear any sound. You can prove this by placing an alarm clock under a jar. You will be able to hear the alarm when it goes off. Now, if you draw the air out of the jar by a suction pump, you will find that you cannot hear the alarm ring. Astronauts, when in space, have to speak to each other by radio. This is because in space there is no air.

Sound-waves can travel only a certain distance. A loud noise causing powerful waves will travel farther than a soft noise.

Even a very powerful sound will not travel far enough for us to hear a noise if we are a long way away. The normal human ear can hear vibrations from about 16 per second to about 16,000 per second.

Just as water moves in ripples when you throw a stone in a pond, sound-waves too travel like ripples.

Electromagnetic waves, however, do not need air to carry them. In fact, they travel better without.
The electric ear

We have seen that sound travels by vibrations. If your ear is in the path of the sound-wave, the latter sets your ear-drum vibrating, and you can hear the sound.

The sound effects in a television programme are picked up by a microphone. This is a kind of electric ear which has a thin metal plate, called a diaphragm, in it. This vibrates whenever any sound reaches it and changes the mechanical vibration into an electric one.

Different kinds of microphones are used today. The principle behind all of them is the same, that is, they pick up sound-waves and turn them into electrical charges.

Just as a picture has different shades, sounds too vary in strength and frequency. The microphone alternates its voltage according to the frequency and strength of the original sound.

So, we have the picture of the monkey, its chatter and the remarks made by the commentator recorded in the form of electrical variations on magnetic tapes. These variations can be re-converted into electrical impulses which are then broadcast as sound and vision to all the homes waiting to receive them. How does this happen?
The carrier

The transmission of pictures and sound almost instantly and over great distances was made possible with the discovery of electromagnetic radio waves.

At the television studio the recordings on magnetic tapes are fed into the transmitter by electrical impulses. In the transmitter these impulses are changed into electromagnetic energy which moves along the transmitting aerial in the form of waves.

These waves radiate from the aerial out into space at the speed of light and it is on these waves that the vision and sound signals are carried to your homes.

Brilliant, isn’t it? And to think that they were ordinary human beings like you and me who made these fantastic discoveries! Or perhaps we should call them superhuman beings!

Electromagnetic waves produced by transmitting aerials spread in all directions.

As these waves die over fairly short distances, they have to be kept going by some means. It is for this reason that relay stations are set up. Here the waves are re-generated in order to cover longer distances.
**Modulation**

Electromagnetic carrier waves, as we have seen, have a continuous flow of waves of the same strength or amplitude. However, the sound and vision that they carry vary in strength. A loud sound at the microphone, for instance, will cause a big variation and a soft sound a small variation in the strength of the carrier wave. Similarly the electron gun in the TV camera will cause variations in the current emitted by the light dots.

When these varying currents mix with the carrier wave, it is known as modulation. The variations in strength according to the sound and vision being broadcast is known as amplitude modulation.

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It is no longer necessary for human divers to risk their lives in the depths of the sea. As early as 1951, the submarine 'Affray', which sank to the bottom of the English Channel, was recovered by special TV cameras designed for salvage work.

Similarly in 1985, the wreckage of the Air India Jumbo 'Kanishka' was recovered from the Atlantic Ocean by extremely sophisticated TV cameras. The focuses of these cameras are remotely controlled and water-tight lamps are fitted to arms extending from the frame so as to illuminate the objects on the ocean bed. The camera can also indicate the size of the object and its distance away.
How a TV set receives sound

As electromagnetic waves radiate from the aerial of the TV station, they travel outwards. In order to catch these, receiving aerials have to be placed in their path.

The receiving antenna is connected to your TV set. In order to catch the waves radiated from the transmitting tower, your TV set has to be tuned to the same frequency. Then a voltage similarly modulated will be created in the antenna and fed down a special cable to your TV receiver.

The job of the sound equipment in a TV set is to extract from the high frequency carrier wave the original sound variations.

In your TV set is a one-way rectifier. This rectifier chops the electromagnetic wave in half and passes on the half which is a replica of the original sound produced by the microphone. This signal is then passed through smoothing circuits to an amplifying
circuit which produces an electrical output at the original frequency. This is then fed to a loudspeaker. The loudspeaker has a cone which vibrates according to the variations of the electrical current fed to it. The vibrations of the cone send out sound-waves which in turn strike our ear-drums. The sound we hear is the sound that went into the microphone many kilometres away.

How the picture comes alive

Like the sound, the waves carrying the pictures also pass through a rectifier. The rectifier once again chops the wave in half and passes on the half which is carrying the original picture as it is produced by the TV camera, to an amplifier. The amplifier helps to give the pulses greater strength and feed them into a tube in the TV set, known as the cathode-ray tube.

The cathode-ray tube has an electron gun similar to the one in the television camera. At the other end of this tube is a fluorescent screen — the screen on which we see the picture. It is known as fluorescent because the inside is coated with a special material which gives off light when the electron gun shoots electrons on to it. This material is made up of tiny particles, each of which gives off a speck of light.

The brightness of the light depends on the strength of electrons that reach it. The
Would you believe it?

The picture that you see on your television set is not really there! No, this is not a joke. It is absolutely true. For, if you were to slow everything down sufficiently, you would find that at any given second there is only one tiny speck on the screen. That would be the speck of fluorescent material being hit by the electron from the cathode-ray tube at that instant. It is only because the electron beam scans the screen at such a fantastic speed, together with something known as the ‘persistence of vision’ that we see what appears to be a complete picture.

Persistence of vision is a normal feature of human eyesight. This means — at least as far as television is concerned — that although the specks of light are going on and off continuously, our eyes are not able to detect the split second intervals, and that is how we see the picture as a whole and not broken up in dots.

electron gun scans the picture in the same way as the camera’s gun had scanned it.

Strong charges in current produce stronger electrons which give a brighter light speck. Weak charges in current produce weaker electrons which give a duller light speck on the screen. As the electrons strike the tiny specks of material they glow for an instant. This process exactly reverses what the camera does.

In the camera the dots of light from the picture cause varying charges of current, whereas in the TV set the varying charges of current form dots of light to create the picture on the screen. So, dot for dot, the monkey is faithfully reproduced on the TV screen.
**Colour TV**

As if black and white television was not fascinating enough, we have colour television in many countries.

It was Sir Isaac Newton who, in 1666, showed that when light is passed through a prism, it is split into several colours. The three principal colours of the spectrum, as it is called, are red, green and blue. If these colours are mixed, they will give white light again. Colour television was made possible with these discoveries.

Like in a black and white TV camera, light from the picture is focused on the colour TV camera by a lens. When the light reaches the camera, it is split into three beams by a set of special mirrors. Each beam of light is then passed through a filter to produce three separate beams of red, green and blue light. These beams are then directed to three separate camera tubes which produce signals for each of these colours. These are further processed to produce signals defining the brightness, line and saturation of the scene. These three signals are eventually broadcast on one carrier wave.

At the receiving set the three signals are separated and processed to reproduce the signals for the red, green and blue. These are then sent through three guns in one
cathode-ray tube. The screen in this tube is made up of thousands of phosphoric dots, one-third of which emit red light, one-third blue light and the remaining third green light.

The dots are arranged in groups of three — one of each colour. Between the screen and the dots is a perforated metal mask. The perforations are exactly aligned with the centres of each triangular group of three dots. This ensures that the red gun fires at the dots emitting red light, the blue gun at the dots emitting blue light, and the green gun at the dots emitting green light. With this, not only do the red, blue and green parts come out clearly, but where the red overlaps the green you get yellow and so on. The mixing rules for lights are quite different from mixing paints. So, don’t try your hand at that. What you could try, when you are older, is inventing even superior television techniques.
Just the first step

For, when the first television broadcast was made we thought we had reached the ultimate in technology. Today it seems pretty certain that that was just the first step. With satellites beaming programmes directly from foreign countries to the antennae on your roof-top, television has more up its tube than you can imagine.

Viewdata, for instance, can get you practically any information you want within seconds. This is a system that links a household television set with a central computer via the telephone line. All you do is use a key-pad containing numbers from 0 to 9 and call up any information you require provided it is listed in the computer.

Perhaps a day will come when you will not have to step out shopping, go to the bank, to your travel agent or to work! Television will be able to do all this for you while you sit at home and let your thoughts soar. For, in the decades to follow the only limit to television seems to be your imagination.
This book, one of a series of information books, introduces the child to the magic of television—how it works and how it has developed.

Others in this series include:

- The Motor Car
- The Aeroplane
- The Telephone
- The Clock
- The Ship
- The Railway Train
- The Computer

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