Mrs Goodman

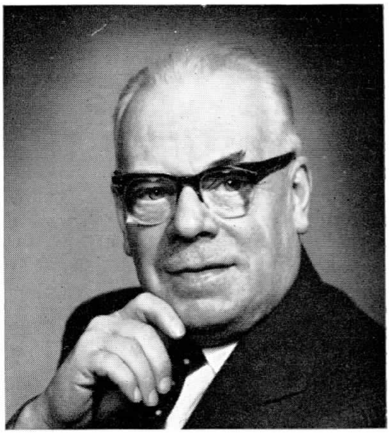
POST OFFICE

tele communications

JOURNAL

ONE SHILLING AND SIXPENCE

AUTUMN 1962



Captain C. F. Booth, Deputy Engineer-in-Chief. He is in charge of the Satellite Communications project for the British Post Office.

BEFORE

IN THIS ARTICLE THE AUTHOR TELLS OF THE POST OFFICE STUDIES INTO SATELLITE COMMUNICATIONS SYSTEMS, DESCRIBES THE TWO TYPES OF SATELLITES AND THE ORBITS IN WHICH THEY CAN BE USED AND DISCUSSES THE POSSIBLE DEVELOPMENT OF AN INTER-CONTINENTAL SATELLITE COMMUNICATION SYSTEM OF THE FUTURE

AS *Telstar* triumphantly circles the earth and Britain takes the first steps into the space age of inter-continental communications by satellites let us, for a moment, look back.

Some two years or more ago the Post Office Engineering Department, in collaboration with the Ministry of Aviation and other Government departments, began a study of the potentialities of satellite communication systems providing "line-of-sight" paths between ground stations and satellites for which radio waves in the spectrum 1,000 to 10,000 Mc/s can be used for long-distance communications.

The transmission of these waves is independent of the ionosphere and of solar activity so that they are not subject to the fading and distortion frequently observed on long-distance radio circuits operating in the high frequency range, 3-30 Mc/s. In fact, frequencies between 1,000 and 10,000 Mc/s are used for conventional microwave radio relay systems in which signals are relayed from hilltop to hilltop, the relay stations being some 30 miles apart.

In a satellite communication system the relay point would be several hundreds, or even thousands, of miles above the earth, the signals spanning a correspondingly longer path between ground stations. To cover these long distances a very high power ground station and a highly directive aerial which is steered to track the satellites would be needed and the ground station receiver would have to be very sensitive and associated with a similar aerial to that used at the transmitter.

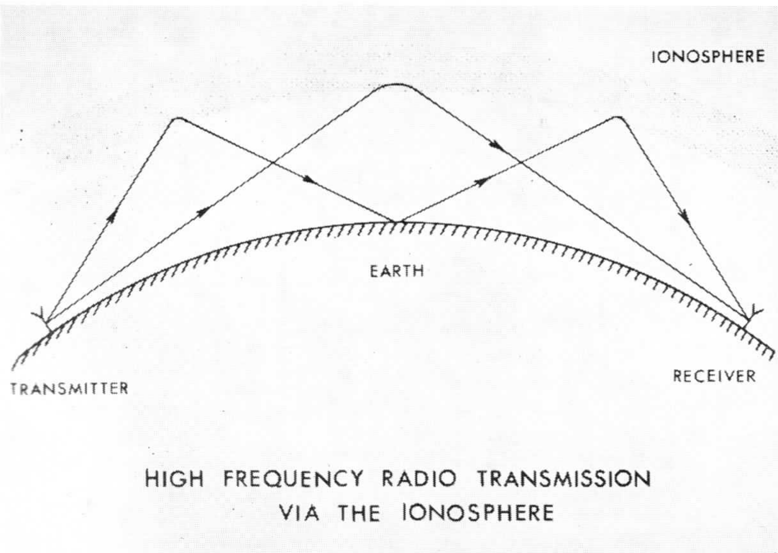
and AFTER TELSTAR

By CAPTAIN C. F. BOOTH, C.B.E.

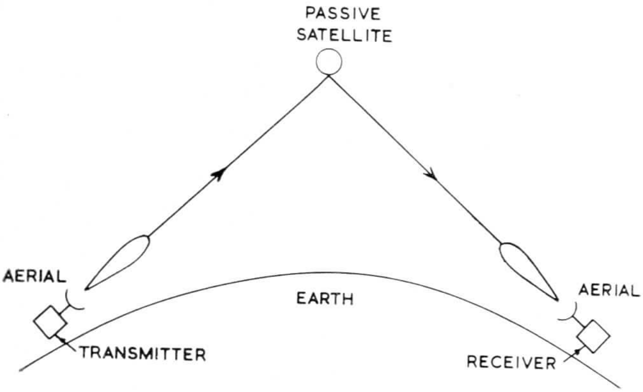
A visit to the United States in 1960 confirmed the conclusion of the preliminary studies that a global system to provide several hundred telephone and telegraph circuits and a television channel was technically feasible and that the large potential capacity and flexibility of satellite communications might be of considerable value in meeting the increasing demand for world-wide communications. It was also concluded that it would be necessary to use active, rather than passive, satellites. An active satellite, like *Telstar* which was launched by the United States National Aeronautics and Space Administration (NASA) on 10 July last, contains electronic equipment which receives signals from the ground station, amplifies and re-transmits them to the distant ground receiving station. A passive satellite acts merely as a reflector of incident signals.

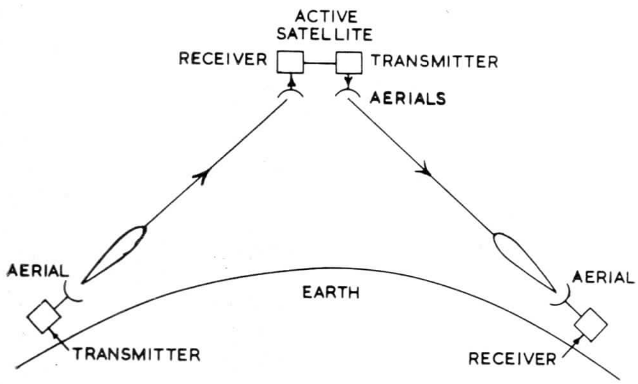
One example of a passive satellite is the metallised balloon, 100-ft. in diameter, launched by the Americans in Project *Echo* in August, 1960, into an orbit inclined to the equator and at a height of some 900 miles. Signals from a ground station

OVER



This diagram shows how high-frequency radio signals are bounced back from the ionosphere. Over long distances, however, high-frequency circuits suffer from fading and distortion because the ionosphere is affected by solar activity.





These two drawings illustrate the differences between an active and a passive satellite. The passive type merely reflects signals. The active satellite, fitted with a receiver and transmitter, picks up signals from a ground station, amplifies and re-transmits them.

transmitter on the eastern seaboard of the United States were bounced off the balloon when it was over mid-Atlantic and received at Malvern, England, on 19 August, 1960, by a team of Post Office and Royal Radar Establishment experts. The balloon is still circling the earth and can sometimes be seen at night, looking like a first-magnitude star.

The United States is also experimenting with another system of passive satellites in the form of a multitude of very fine metal needles, about half an inch long and as thick as a human hair, which will be sent up into the sky to act as a reflector, or artificial ionosphere, to incident microwave signals. The needles will be contained in a small canister and the material holding them together will volatilise when they reach orbital height, allowing them to scatter in a continuous belt around the earth. The first attempt to do this—Project *Westfall*—failed, but another is to be made. Some scientists have questioned the use of such belts of needles on the grounds that they may interfere with the work being done by optical, radio and radar astronomers.

The terminal station for an active satellite system in which a number of satellites move across the heavens would, like the one at Goonhilly, be on flat ground with an unobscured horizon. Information from an electronic computer would be fed with details of a satellite's orbit and converted into steering signals to operate the aerial control motors. As a satellite came into view of the two terminals of an inter-continental link the aerials would be steered automatically to point at it and follow it, signals being exchanged between the two ground stations through the satellite. Just before the satellite disappeared from view another would appear and a second aerial at each side would be directed on to it and would take over the circuit.

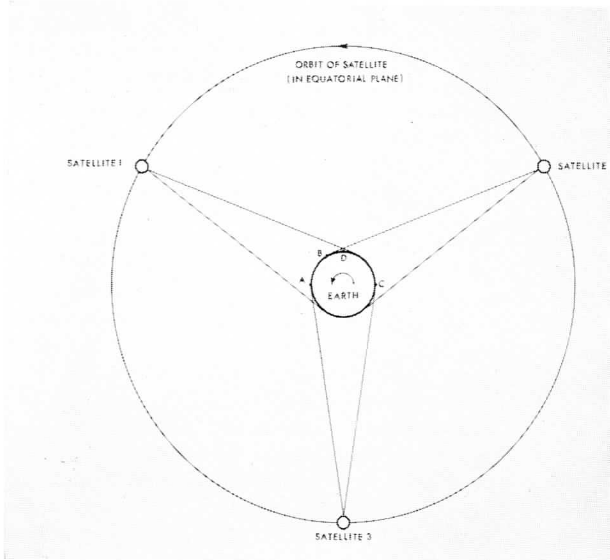
The type of orbit selected for the satellites decides the design and form of the system. There is a wide variety to choose from, including circular and elliptical orbits, in planes varying from polar to equatorial, and many have been suggested for use. It is thought that a system using a number of satellites in the equatorial plane would have many long-term advantages.

A special case is the circular orbit in the equatorial plane with the satellite some 22,300 miles above the earth and travelling in the same direction as the earth's rotation. The orbital period would be 24 hours so that the satellite would appear to hang stationary in the sky. It would "see" a large area of the earth and the ground station aerials would not need to be steered. If three such satellites were positioned at 120 degrees, one or other would be seen from most of the earth's surface, except the polar regions. Correction of the orbit and adjustment of the satellites' position in orbit would be necessary to ensure that they hung stationary. However, such a system might have serious disadvantages for multi-channel telephony because of the relatively long transmission time—more than half a second—from the ground station to the satellite and back. Tests have shown that this delay would cause difficulties for an appreciable number of telephone users but that it would not be troublesome for television and telegraph users.

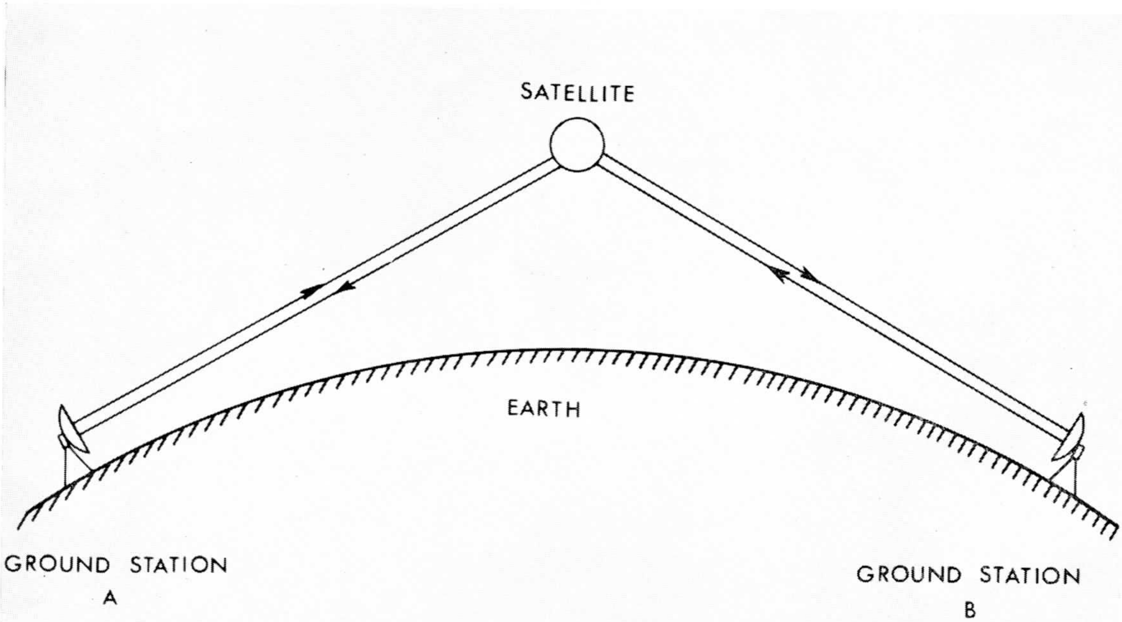
The time delay problem would be sensibly removed, however, by reducing the altitude of the satellites, for example from 22,300 to 8,600 statute miles, for which the orbital period would be 12 hours. In this system it would be necessary to increase the number of satellites from three to about 12 to achieve near-world coverage on a 24-hour basis. Each of the 12 satellites would have to be position and attitude stabilised, the latter probably requiring the satellites to have auxiliary jets to increase or decrease their speed. Each satellite

OVER

The system using three satellites in a 24-hour circular equatorial orbit. Each satellite would be 22,300 miles above the earth.



Signals can be exchanged between ground stations only when the satellite is visible to both.

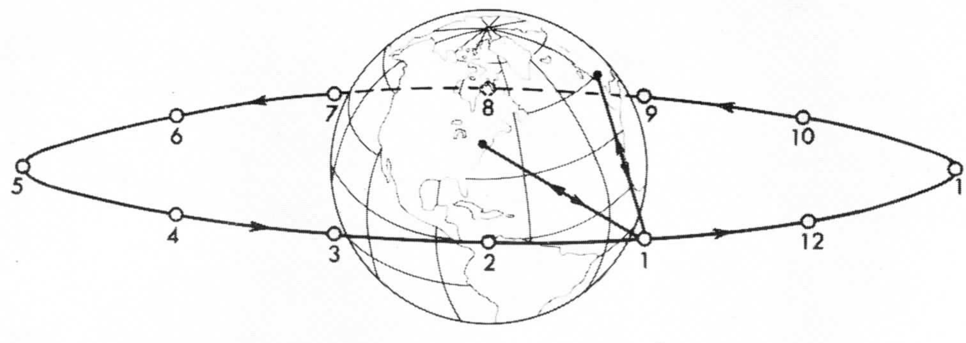


would be mutually visible to at least two ground stations in an inter-continental link and ground stations would track one for an hour and then switch to the next so that all 12 would be used each 12 hours. In this way continuous world-wide communications could be achieved from Latitude 57 North to Latitude 57 South and a system can be visualised which would provide 1,000 or more telephone circuits and two television channels.

It is not possible at present to specify the preferred type of system since more studies and the results of experimental tests are necessary. The British studies do, however, indicate that a system of active satellites, position and attitude stabilised and operating in circular orbits in the equatorial plane at a height of 8,600 miles may be a desirable objective, though many technical problems, some of them major ones, would have to be solved before it could be brought into being.

The early accumulation of experimental information on the performance of communication satellites is of extreme importance to the designers of a system for commercial use. To this end, in February, 1961, Britain and the United States reached a Memorandum of Understanding on collaboration between the British Post Office and NASA on the testing of experimental satellites launched by the latter for communication purposes. The first phase of the tests involve *Telstar* and *Relay*—both active satellites—and the next phase will cover Project *Rebound* (a passive satellite) and others. The understanding with the United States includes the interchange of technical information, makes clear that collaboration is in respect of experimental tests only and is not concerned with commercial exploitation. It does not preclude the use of the Post Office experimental ground station at Goonhilly for tests outside the co-operative projects outlined above. Similar agreements between the United States, France, the Federal Republic of Germany, Italy and Brazil have been approved.

The results achieved with *Telstar* have confirmed the technical feasibility of a global communication system to provide several hundred telephone and telegraph channels and one or two television

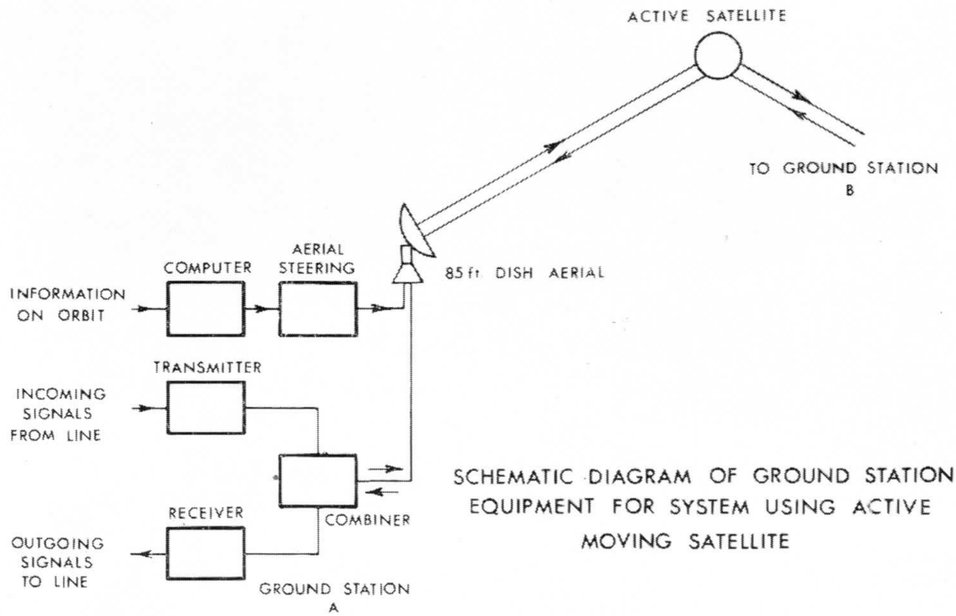


SYSTEM USING 12 EQUI-SPACED SATELLITES IN A CIRCULAR EQUATORIAL ORBIT, 7500 MILES

In this system, which solves the time delay problem, the 12 satellites would orbit the earth once every 12 hours and give near-world coverage. They would need to be position and attitude stabilised.

channels, using active earth satellites as relays. Engineers on both sides of the Atlantic are now busily engaged in testing the performance of *Telstar* and are looking forward to similar tests with *Relay*, which will be launched in the early autumn, and with others. The information they gain will be invaluable to them in their task of designing an operational system.

Much valuable experimental information has already been obtained but much more is needed before anyone can say with certainty what part a satellite system will eventually play. Nevertheless, there are grounds for hoping that within the present decade satellites will provide a complementary means of reliable long-distance communications to that already given by submarine repeatered cables.



ABOVE: *A simple diagrammatic layout of the Goonhilly station.* BELOW: *The proposed communication links in a system of 12 equi-spaced satellites travelling in an equatorial orbit at a height of about 7,500 miles.*