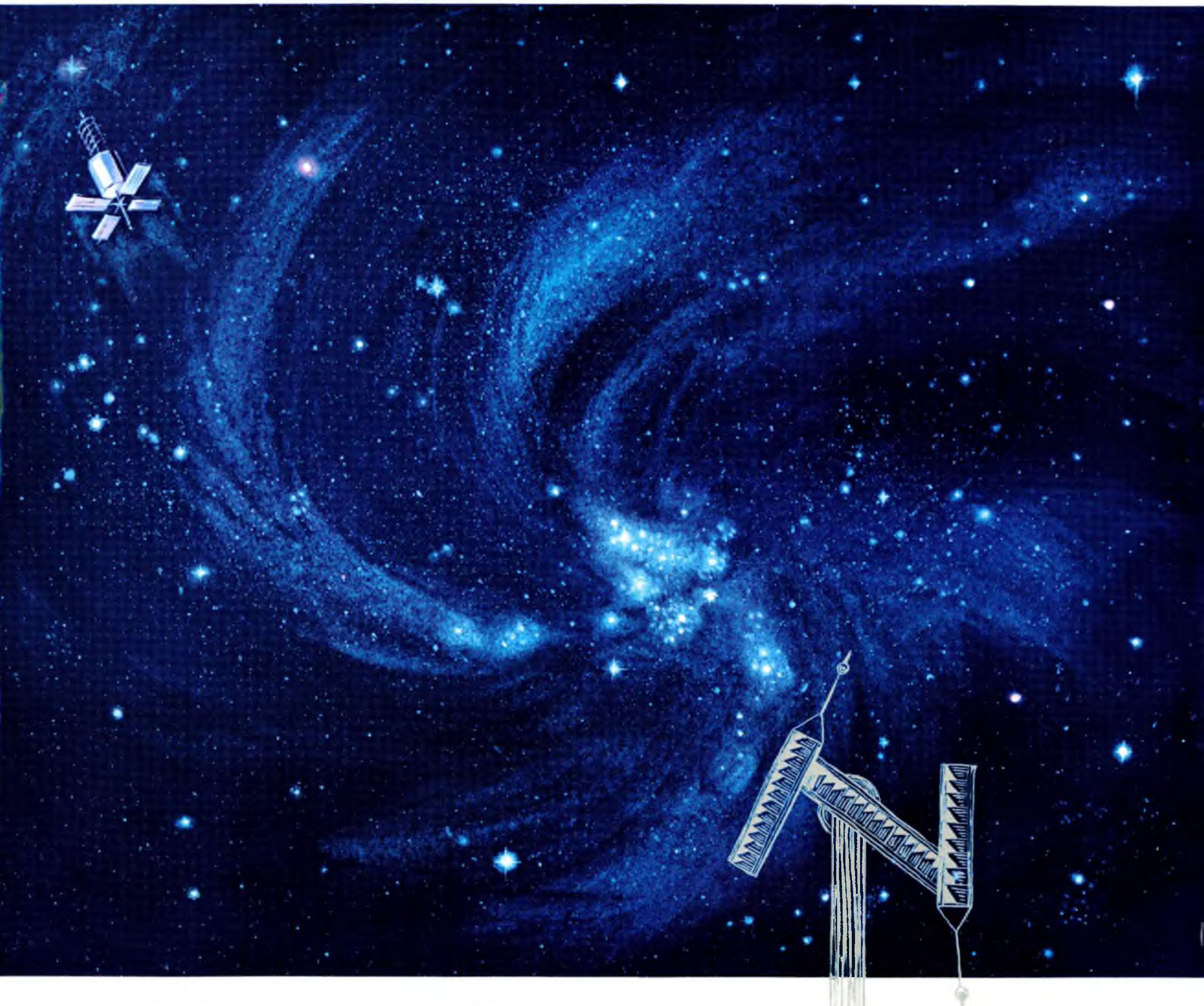
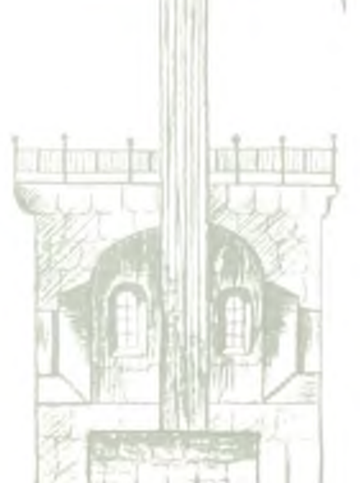
From Semaphore to Satellite





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1865-1965

Published by the International Telecommunication Union on the Occasion of its Centenary

Geneva 1965

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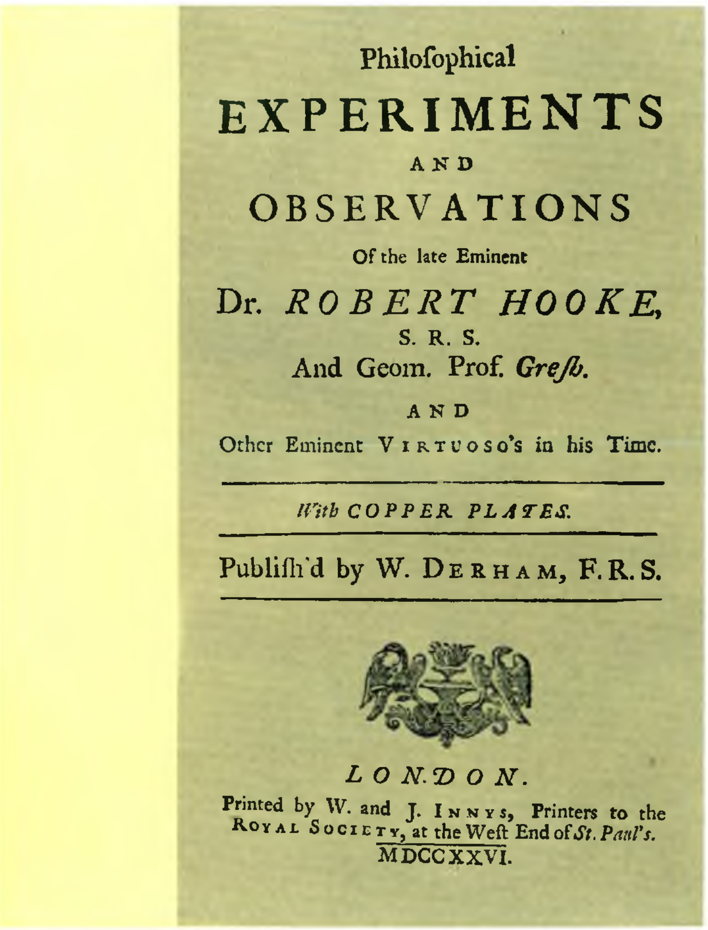

Philoſophical

EXPERIMENTS

AND

OBSERVATIONS

Of the late Eminent

Dr. *ROBERT HOOKE*,

S. R. S.

And Geom. Prof. *Greſh.*

AND

Other Eminent VIRTUOSO's in his Time.

With COPPER PLATES.

Publiſh'd by W. DERHAM, F.R.S.

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1-3 Robert Hooke's suggestion for optical telegraphy, as published in 1726. Individual letters and code signs were to be suspended from the wooden framework. As far as is known, these suggestions were never carried out in practice.

Foreword

To look back on a hundred years of successful international co-operation, as the International Telecommunication Union can do, is a unique achievement. The Union is the oldest of the intergovernmental organizations which now form the specialized agencies of the United Nations.

Yet a hundred years is but the briefest interval in the recorded history of man. Of the earth's own aeons it is a microscopic part. But in this last century there has occurred such a change for mankind that all previous discovery and progress are almost insignificant.

Probably the most remarkable advance of the last hundred years lies in the speed and variety of our communications. First the telegraph and the telephone, then radio, including broadcasting and television, all tremendously expanded through the electronic revolution, and now space communications, these are all an integral part of the exponential growth of science which may well astonish even our grandchildren.

But this ever-increasing rate of scientific invention has led to another equally astonishing growth, namely an ever closer working together across natural and man-made frontiers. Without the one, the other could never have altered the very texture of our life so deeply, intimately and so permanently. And that is the theme of our present book.

International co-operation in telecommunications started from small beginnings in Paris on May 17, 1865, when the International Telegraph Union was founded. To mark the 100th anniversary of this historic event the International Telecommunication Union is publishing this centenary volume.

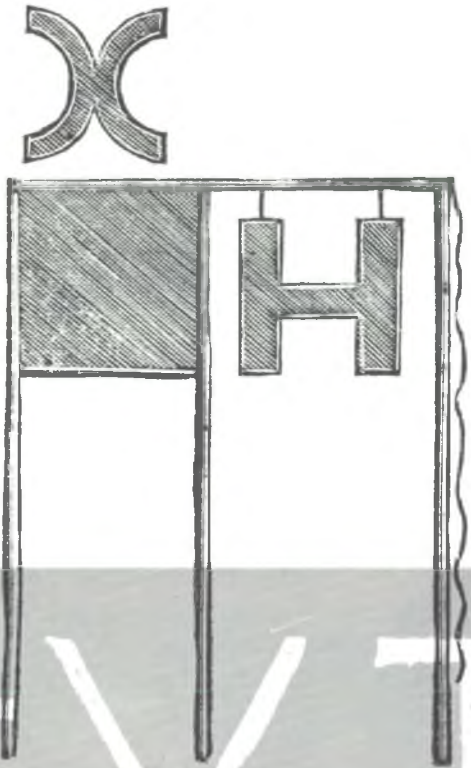
The decision to publish this Volume was taken by the ITU Administrative Council at its 1963 session. The text was written by Dr. Anthony R. Michaelis of London and the illustrations were mostly provided by ITU Member Governments, additional pictorial material being assembled from many sources by Dr. Michaelis. The design is by Claude Humbert and the book was printed by Henri Studer S.A. of Geneva.

Any opinions expressed in this Volume are those of the author and do not in any way commit the International Telecommunication Union.

Gerald C. Gross

Gerald C. GROSS
Secretary-General
International Telecommunication Union

Geneva, January 1965



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The Preface

Stand anywhere in the quiet countryside, away from crowded cities, ploughed fields, or other signs of man's many activities. Then your picture may well be the same as that of your forefathers, hundreds or even thousands of years ago. And yet, during the last few decades, a subtle change has occurred, which none of our senses can register. Radio waves, bearing messages in many tongues, flow ceaselessly around us, through us and above us. We can only hear and see them if we convert them to other waves to which our ears and eyes are receptive.

Perhaps that is the major reason why we take radio for granted. The moment wires are used to convey intelligence we become conscious of the means, although we are still ignorant of the ends. Yet, about 150 years ago, when the arms of the optical telegraph were waving in the air, anyone who knew their code could read the signals, simply by looking at them. From such simple beginnings then, the semaphores, to the satellites orbiting our planet, and acting as relay stations for our messages, has grown the subject which we now call telecommunications. It is defined as any transmission, emission or reception of signs, signals, writing, images, sounds, or intelligence of any nature, by wire, radio, optical or other electromagnetic systems.

Yet our book is not primarily concerned with a scientific history of these means of telecommunications. Its subject is the international co-operation which has occurred in this field during more than 100 years. Working together, across man-made and across natural frontiers, became an imperative necessity as soon as the technical means had been perfected to send messages over long distances. Small groups of countries first joined together to draft acceptable agreements, and then, on May 17, 1865, twenty delegations from different European countries signed in Paris the first convention of the International Telegraph Union. To-day there are over 120 members of the International Telecommunication Union, covering all the corners of the earth. These hundred years of successful, uninterrupted progress in international co-operation are the subject of our book.

But it proved impossible to tell this exciting story without explaining at the same time the scientific progress that was constantly made in the techniques of telecommunications. Neither the means, nor the international co-operation by themselves would have told the full story of success. Only by weaving the one into the other, telling once again how the telegraph, telephone and radio, as well as radar, broadcasting and television came about, and how each new invention demanded new efforts in international co-operation, could this cloth unfold which contains the threads of untold thousands of scientists, engineers and administrators. All had but one aim, to extend international co-operation in all fields of telecommunications, although it often took decades to achieve a single step towards it. After a hundred years, their success is assured. It can be seen in the pages of this book, and it contains many lessons which other workers in other fields might well find of value.

It is our sincere hope that you will find in this book more than dry historical facts. This achievement of successfully working together for a hundred years has so far remained unique. (The Universal Postal Union held a preliminary meeting in Paris in 1863, but their first formal conference only took place in Berne in 1874.) That so many different countries can work together for a hundred years in a field of communications is eloquent proof that international co-operation is feasible, that it is profitable, and that in the successful development of scientific inventions it is absolutely essential. To-day in the space age the world has great need for such a proof, and if the reader can absorb this spirit from the following pages, the purpose of this history will have been fulfilled.

To bring forth this spirit, both from the scientific and from the international developments, has meant that many interesting details had to be left aside. Fortunately, there is now a great literature available for anyone anxious to pursue the two subjects in greater depth than was possible in this book and a number of useful publications are listed in an appendix.

No book is ever the work of a single author. His thoughts are influenced by those that have written before him, who have given of their personal experience, and who have pointed out to the author relevant sources, both textual and pictorial. To all of these, whether members of the International Telecommunication Union, members of national Administrations, or personal friends and colleagues, the author would like to express here his sincere thanks.

Think then for a moment of what has been achieved in the past. It is but the first step, although it covers the apparently lengthy period of a hundred years. It is a testimony of what can be done, and with this proof to hand, the next step, infinitely greater and extending far into space, can be confidently taken. If this modest book has given you some small encouragement to make the next move forward in international collaboration be it in telecommunications, in other scientific fields or even broader human activities, then this book will not have failed.

Part I — The Telegraph and the Telephone

From 1793 to 1932

The Precursors

We would probably still live in a cave to-day, if men—and women—had not learnt to use speech and gesture to communicate their thoughts to their neighbours. This would be even more likely, if they had not used these skills to pass on to their children the knowledge they had gained in their short and dangerous lives. Once writing had been discovered it became possible to communicate over a distance, both in space and time, and to-day we would know but little of our early ancestors, if they had not left their inscriptions in stone, clay and metal, wood, paper and silk.

But such communications, which alone render true social life possible, remained for millennia the privilege of scholars and rulers. For Communications mean organisation. For the scholar it is the ordering and the increase of knowledge, for the ruler the maintenance of law and order. And for millennia the speed of communications remained that of the swiftest runner or the fastest horse, perhaps a distance of 15 km in an hour. Greek and Roman signal fires, African tom-toms and an occasional pidgeon carrier were of course somewhat faster. Only when the laws of optics became understood, and made the telescope possible was there any hope of communicating more swiftly over long distances.

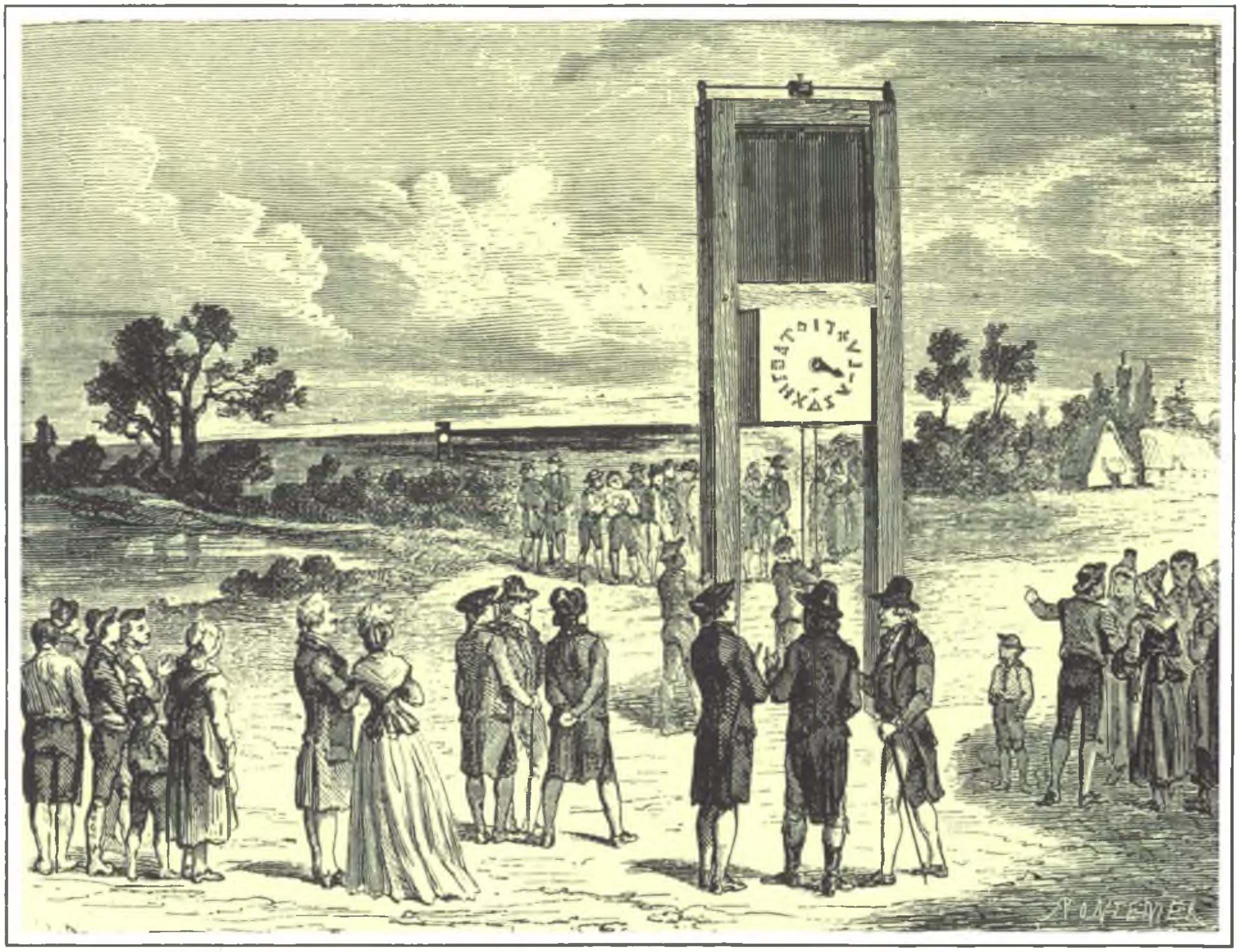
It was apparently the great English physicist and chemist Robert Hooke (1635-1703), who first gave a vivid and comprehensive outline of visual telegraphy in a discourse to the Royal Society in 1684; in it he referred to many practical details, but his system was never tried out in practice. Over a hundred years later, a brilliant French engineer, Claude Chappe (1763-1805), took up the challenge again. He succeeded and produced a practical system which could send messages all over France; when in 1852 the Chappe system was finally superseded by electrical telegraphy, France was covered by a network of 556 semaphore stations stretching over a total distance of 4800 kilometers.

There was a desperate need for swift and reliable communications in France during the period of 1790-1795. It was the height of the revolution, and France was surrounded by the allied force of Britain, Holland, Prussia, Austria and Spain. The cities of Marseilles and Lyons were in revolt, and the British Fleet held Toulon. In this hopeless position one of the most favourable circumstances for the French was the lack of co-operation between the allied forces, due to their inadequate lines of communication.

Claude Chappe and his brothers in the summer of 1790 set about to devise a system of communications that would allow the central government to receive intelligence and to transmit orders in the shortest possible time. Chappe carried out his experiments during the next two years, and on two occasions

4 *The first experiments by Chappe were made with an optical telegraph on 2 March 1791. A pointer was rotated, and in the distance a similar optical telegraph can be seen. Note the similarity of Hooke's and Chappe's symbols.*

5 *Dutch optical telegraphs in the beginning of the nineteenth century.*



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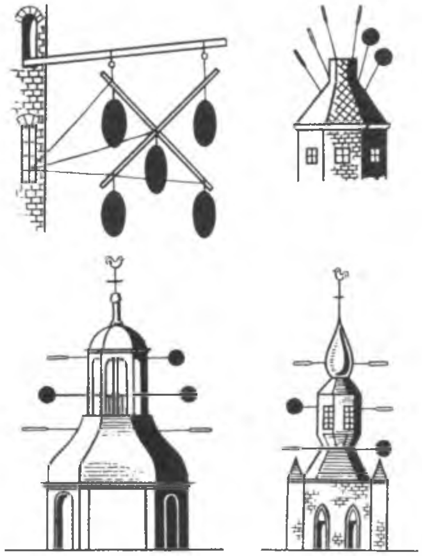

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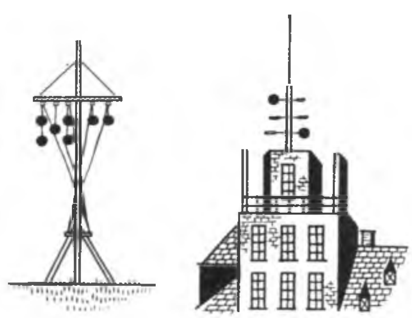
his apparatus at the Etoile in Paris was destroyed by the furious mob who thought that he was communicating with the imprisoned King, Louis XVI. Recognition came to him in the summer of 1793, when he was appointed *Ingénieur-Télégraphiste* and ordered to establish a line of telegraph stations between Paris and Lille, a distance of 230 kilometers.

His stations were simply towers, either constructed for this purpose, or existing ones; on their roofs there was a vertical wooden extension, and pivoted to this was a wooden horizontal beam, which could be swung into various angles by means of ropes. At the end of the horizontal beam, there were two further vertical arms, which were also movable. Thus a large number of possible configurations could be achieved, and these could be read by means of a telescope from the next tower. A coding of messages was therefore inherent even in the forerunner of all usable telegraphs. The first message which passed over Chappe's semaphore telegraph between Lille and Paris was that of 15 August, 1794, announcing to the government that their forces had retaken Le Quesnoy. A fortnight later, another message was joyfully received in Paris, telling of the recapture of Condé.

No wonder then that the telegraph was extended throughout France. Paris to Strasbourg with 50 stations was the next line and others followed soon, but, as each station had to be within sight of the next one, the cost of administration and the wages of the staff were a continuous source of financial difficulties; only when the telegraph was linked with a lottery did they cease. Chappe probably took his own life, in 1805, when the strain and anxiety became too great for him to bear.

The reports of Chappe's telegraph reached England in the autumn of 1794, and stimulated Lord George Murray (1761-1803), to propose a system of visual telegraphy to the British Admiralty. He employed a large wooden board atop his towers. Each board had six large circular holes which could be closed by wooden shutters. A chain of these stations, 15 in all, was erected for the Admiralty between London and Deal at a cost of nearly £4000; others followed to Portsmouth, Yarmouth and Plymouth. The line to Portsmouth was not finally closed down until 1847, and it is interesting to note that some of the prominences on which the towers were built are still to-day known as "Telegraph Hill".

In the United States, the first visual telegraph on the semaphore principle was built in 1800 by Jonathan Grout. It was a line of 104 km connecting Martha's Vineyard with Boston, and its purpose was to



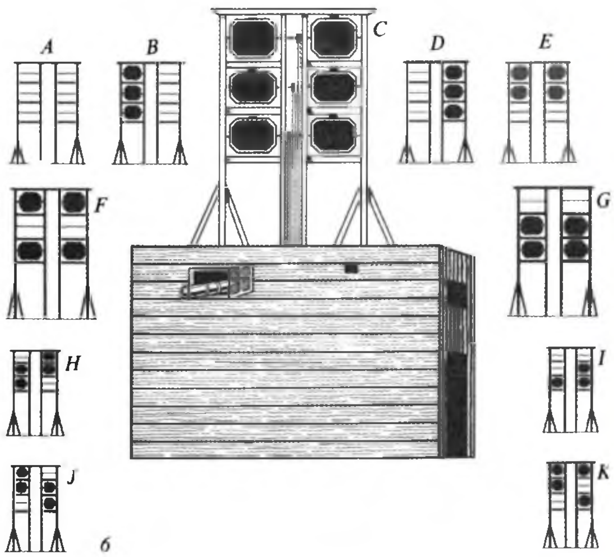
6 Lord Murray's optical telegraph consisted of six shutters which could either be in the horizontal or vertical position. Various letters of the alphabet could thus be spelt out in code.

Explanation of the Telegraph

When it appears as at Letter A, the Ports all open, it is not at Work; when the Ports are all shut, as at Letter C, it denotes it's going to work, and a Signal for the next Telegraph to look out in order to answer.

Sentences explained

When the order is Communicated to the Port Admiral in the Downs only, the Telegraph appears as at E, with the two lower Ports open. For the Port Admiral at Portsmouth,



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the two middle Ports open as at F, and for the Port Admiral at Plymouth, the two upper Ports open as at G. Commanders of Fleets, Squadrons and Cruisers have each a different Signal for example H, for the Commander of the Channel Fleet, J, the Commander of the North Sea Fleet, K, the Commander of the West India Fleet or Convoy, and L, for the Cruisers in such a port signified, etc.

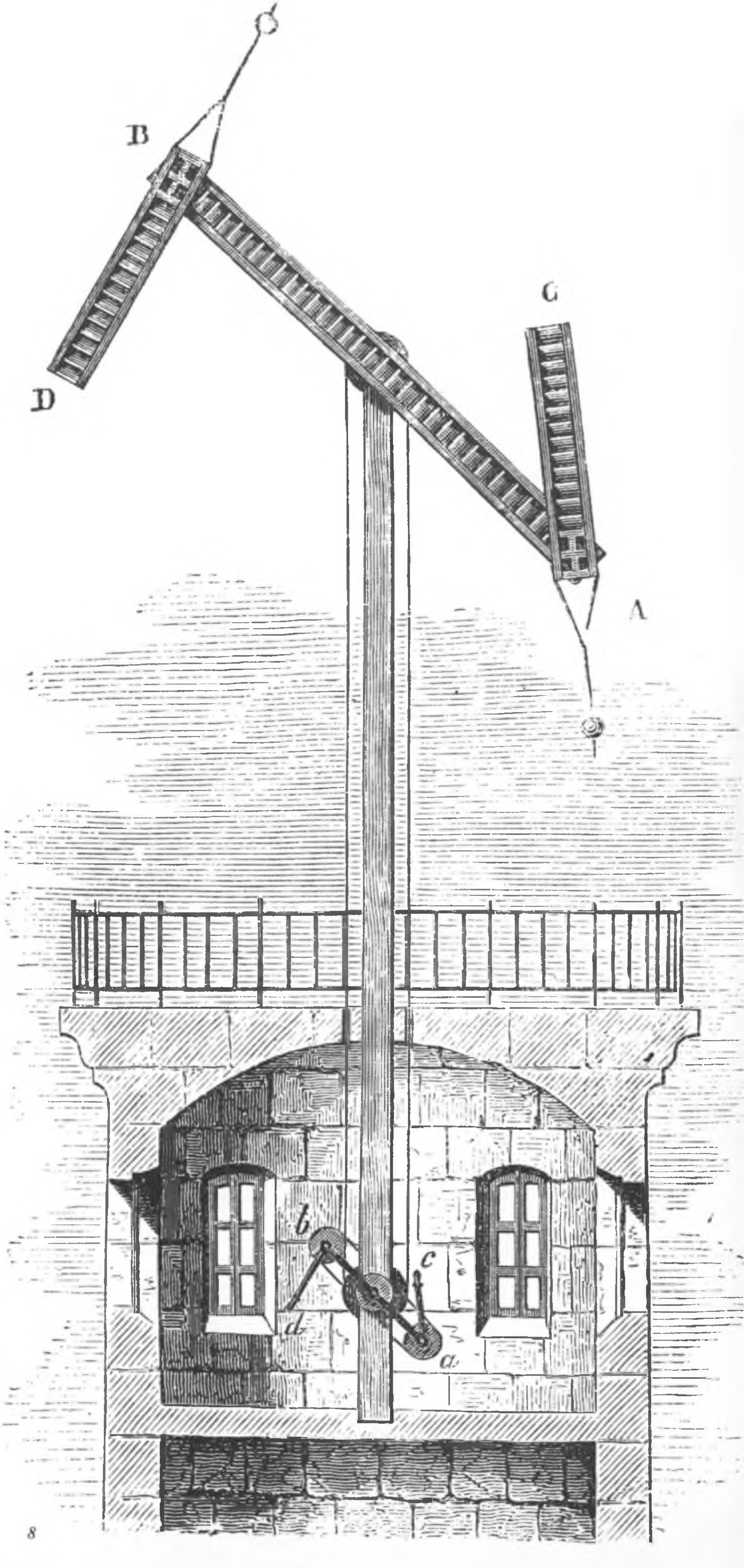
The Alphabet explained

When the Telegraph appears as at C, with the Ports all shut, the opening of the First denotes the letter a, the Second b, the Third c, and Fourth d, the Fifth e, the Sixth f—which is termed the first course. The second course of the Telegraph appears as at A, with the Ports all open, the shutting of either denotes a letter as they are Marked, this course contains the letters g, h, i, k, l, m; these are termed the second course. The third course appears as at B, then opening of either that are shut, denotes the letters n, o, p, q, r, s. The fourth course the Telegraph appears as at D, the opening or shutting denotes the letters t, u, v, w, x, y, z.

7

7 *Apparently the first illustration of telecommunications in the United States of America, in 1838. On the left the semaphore station of Staten Island in New York Bay. This was an intermediate between Sandy Hook and Merchants' Exchange in Manhattan, New York.*

8 *The top of a typical optical telegraph as designed by Chappe, showing the movable arms and the handles to operate them.*



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9 *Chappe's optical telegraph was used perhaps longest in Northern Africa, where it was not replaced by the electrical telegraph until 1859. Here is a typical installation in Algeria.*

transmit news about shipping. In Prussia, the Bergsträsser and the Watson-Pistor system was used, and some other European countries had similar installations, as we shall see later.

There can be no doubt that the visual telegraph was the fastest means of communication at the time. To quote from a contemporary description: "A single signal has been transmitted to Plymouth and back (London) in three minutes, which by the telegraph route, is at least 500 miles. In this instance, however, notice had been given to make ready and every captain was at his post to receive and return the signals. The progress was at the rate of 170 miles in a minute, or three miles per second, or three seconds at each station; a rapidity, truly wonderful!" But there were many disadvantages, as the system was wasteful in manpower and not accessible to the general public; its expenses could therefore only be justified as "defence needs". Worst of all, night and adverse weather brought the telegraph to a halt. "The Station on Putney Heath, communicating with Chelsea, is generally rendered useless during easterly winds by the smoke of London which fills the valley of the Thames."

Semaphore signalling is still in use to-day between ships, sailors using flags and holding them in different positions with their extended arms. But Chappe's brilliant invention had its longest success on the railway, where the semaphore arm of the signals, to transmit information to the engine men, is only now, a century and a half later, being slowly replaced by coloured electrical lights.

In telegraphy, however, electricity superseded visual signalling at a much more rapid pace. The history of the electric telegraph is generally considered to begin on February 17, 1753, when a remarkable letter, signed by a certain C. M., was published in the *Scots Magazine;* his identity has never been established. Briefly he proposed that "a set of wires equal in number to the letters of the alphabet, be extended horizontally between two given places, parallel to one another and each of them about an inch distant from the next to it." The letter goes on to explain in detail how the wires are to be connected to the conductor of an electrostatic machine when it is desired to signal a particular letter. On the receiving side "let a ball be suspended from every wire, and about one sixth to one eighth of an inch below the balls, place the letters of the alphabet, marked on bits of paper...".

It was of course known since very early times that electrostatic forces would attract small pieces of paper, and by the middle of the 18th century simple frictional machines to produce electrostatic energy were fairly common. They mostly consisted of a glass cylinder, rotated rapidly by hand, against which

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a leather cushion was pressed. C. M. then proposed to use the electricity from such a machine, channel it through one of his wires, and let it attract on the receiving side the corresponding pieces of paper with its letter of the alphabet. All the principal elements of electric telegraphy are present: A source of electricity, its manipulation to handle the information to be transmitted, the wire conductors, and the mechanism on the receiving end to read the information transmitted.

But 1753 was hardly the date at which practical and economical conditions were ripe for electrical telegraphy. Static electricity was then more often used to entertain the "philosophical" friends of the owner of a frictional machine. For example it was common then to transmit an electric shock through a circle of twenty or thirty persons, each holding hands with the next; all experienced the shock simultaneously. This experiment was repeated on a really grand scale by the Abbé Nollet (1700-1770), when a shock was passed round a circle, more than 1½ kilometers in circumference, in which 200 Carthusian monks were linked together by lengths of iron wire.

Evidently, then, the speed of transmission of electricity was very high, but in the year 1753, when in Potsdam Voltaire was discussing philosophy with Frederick of Prussia, and when Carolus Linnaeus, the great Swedish botanist, was elected into the fellowship of the Royal Society of London, electrical telegraphy was not taken really seriously.

As early as 1787, Betancourt, a Spaniard, carried out experiments with Leyden jars and static electricity to send telegraphic messages between Madrid and Aranjuez. Two other proposals for electrostatic telegraphy deserve, also, brief mention. One was by Don Francisco Salvá of Barcelona, who put forward a scheme in 1795 to use the discharge of Leyden jars together with multi-wire transmission to give electric shocks to the operators on the receiving end. There is a report that three years later, a modification of his scheme, using only a single wire, was actually constructed between Madrid and Aranjuez, a distance of 42 km. Apparently, private messages were sent to the Spanish Royal Family.

The other experimenter was Sir Francis Ronalds (1788-1873), an English merchant. When he began to enquire into static electricity, in 1816, he lived in a house in Hammersmith, a London suburb by the river Thames. He had a garden, 200 meters long, and in order to demonstrate the speed of electrical transmission he erected two large wooden frames and suspended between them a total length of almost 13 km of wire. To one end he connected a frictional machine, to the other a pair of pith balls, which

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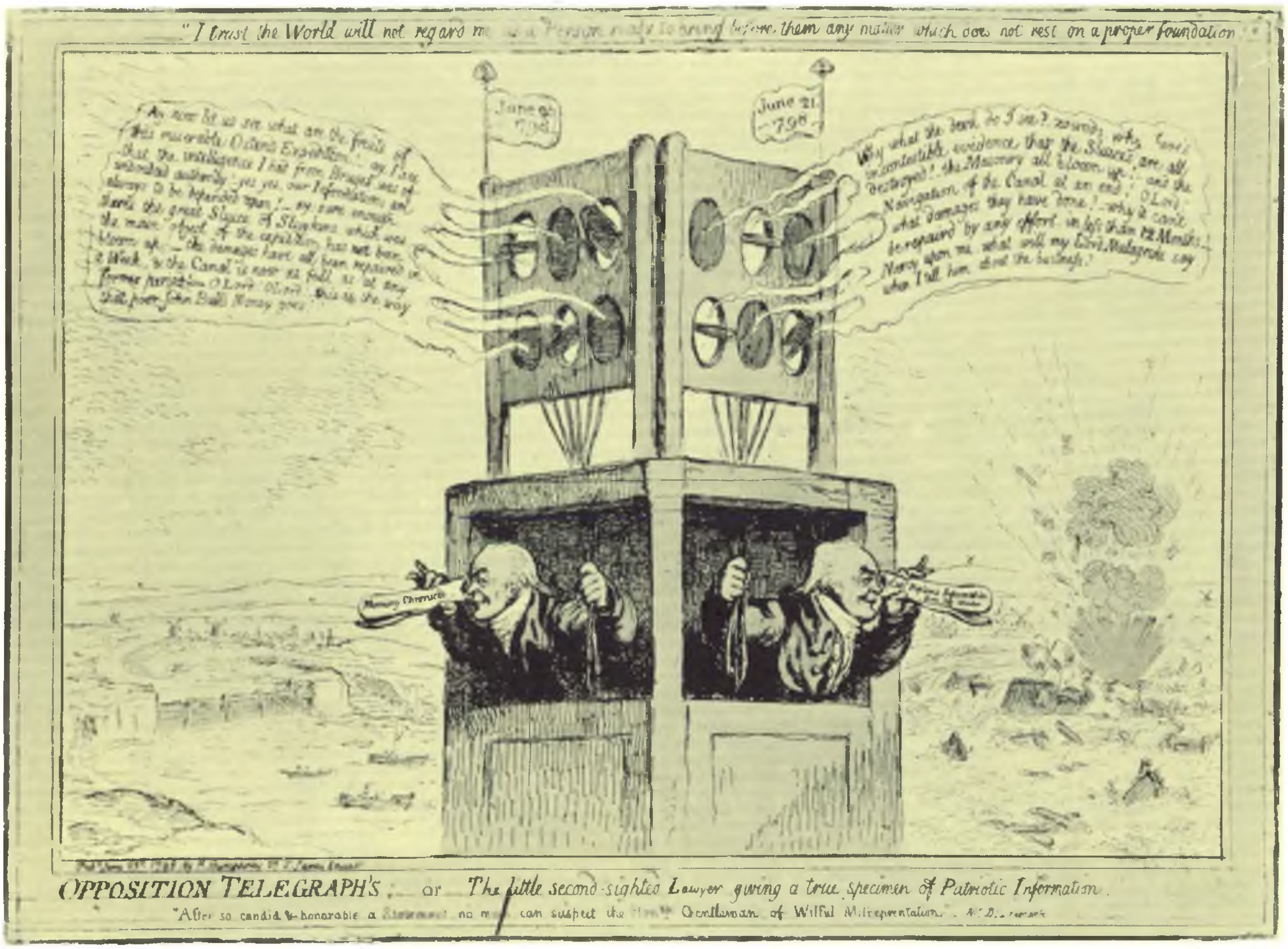
10 *Network of Chappe's optical telegraph lines in France in the beginning of the nineteenth century.*

11 *Optical telegraph line in Prussia between Berlin and Coblenz, 750 km long, installed by Postmaster Pistor and Major O'Etzel in 1832/34.*
One telegraphic signal could be transmitted in about 1½ minutes. The line was replaced in 1848 by an electric one.

12 *A cartoon of 1798 of the optical telegraph as invented by Lord Murray and used in England. Two contradictory messages were received about an English naval expedition to Ostend.*



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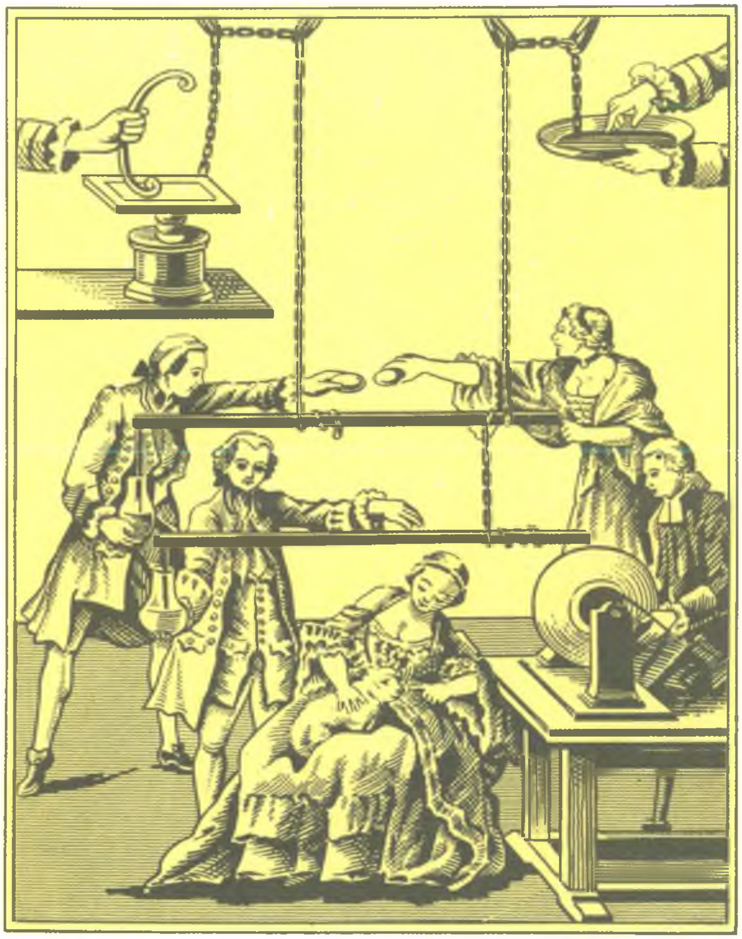
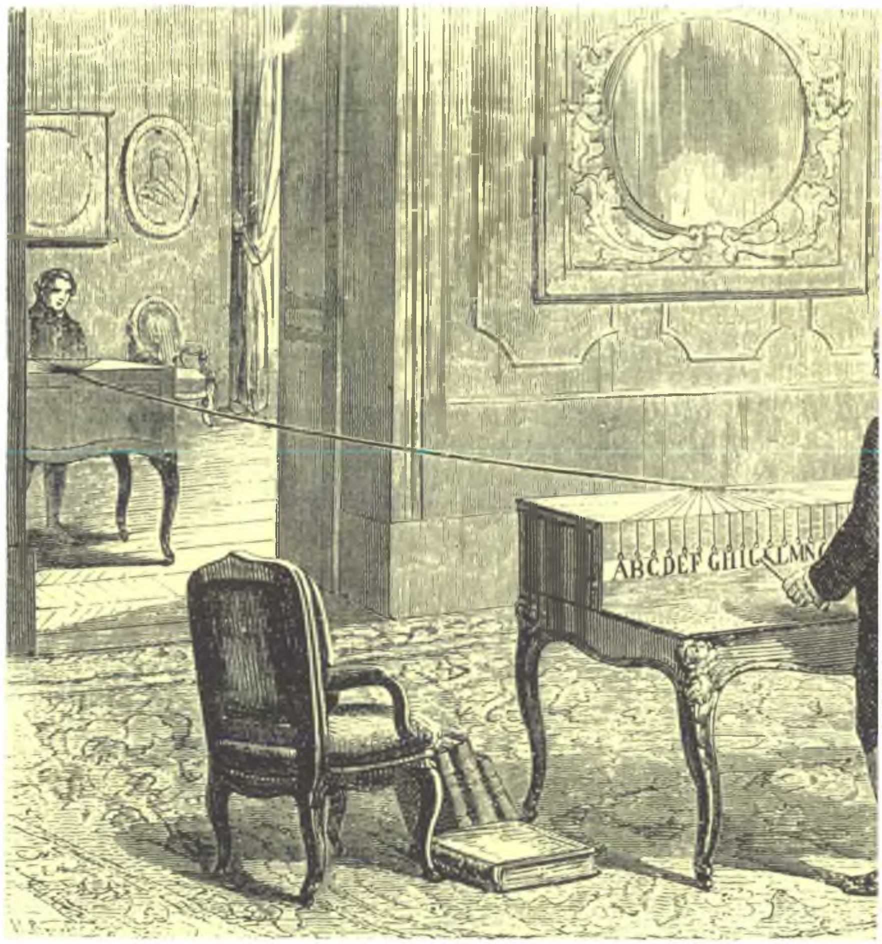
13 *By the middle of the 18th century simple frictional machines to produce electrostatic energy were fairly common. These were mainly used for amusement, and here the electricity generated by the friction on the glass sphere on the right is conducted to the suspended equipment by means of chains. Abbé Nollet is working the frictional machine on the right.*

14 *One of the first electric telegraphs was constructed by Georges Lesage in Geneva, in 1774, using a single wire for each letter of the alphabet.*





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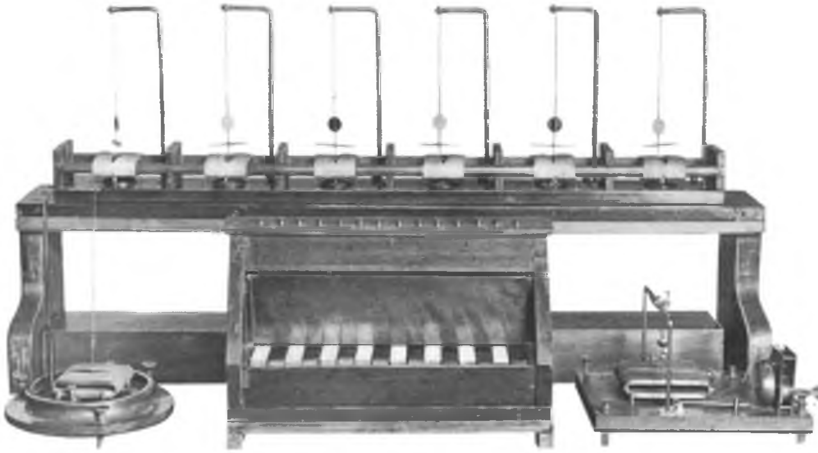
15 *An early electromagnetic telegraph apparatus devised by the Russian Scientist Pavel Lvovitch Schilling in 1832.*

16 *Telegraph of Professor Karl A. Steinheil of the Bavarian Academy of Sciences, 1836.*



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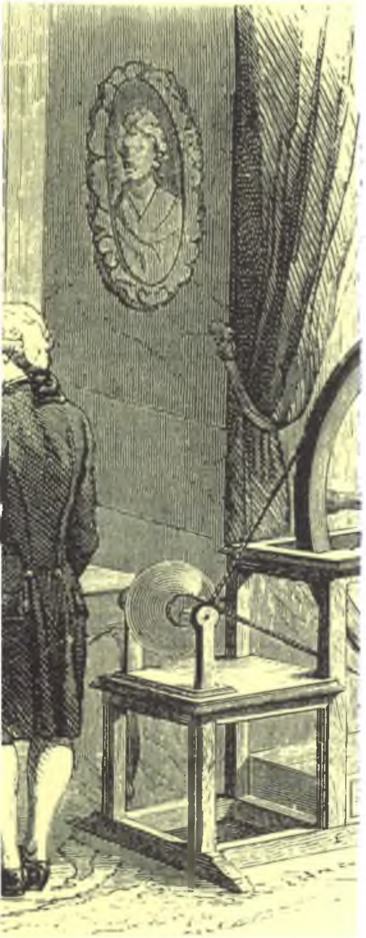

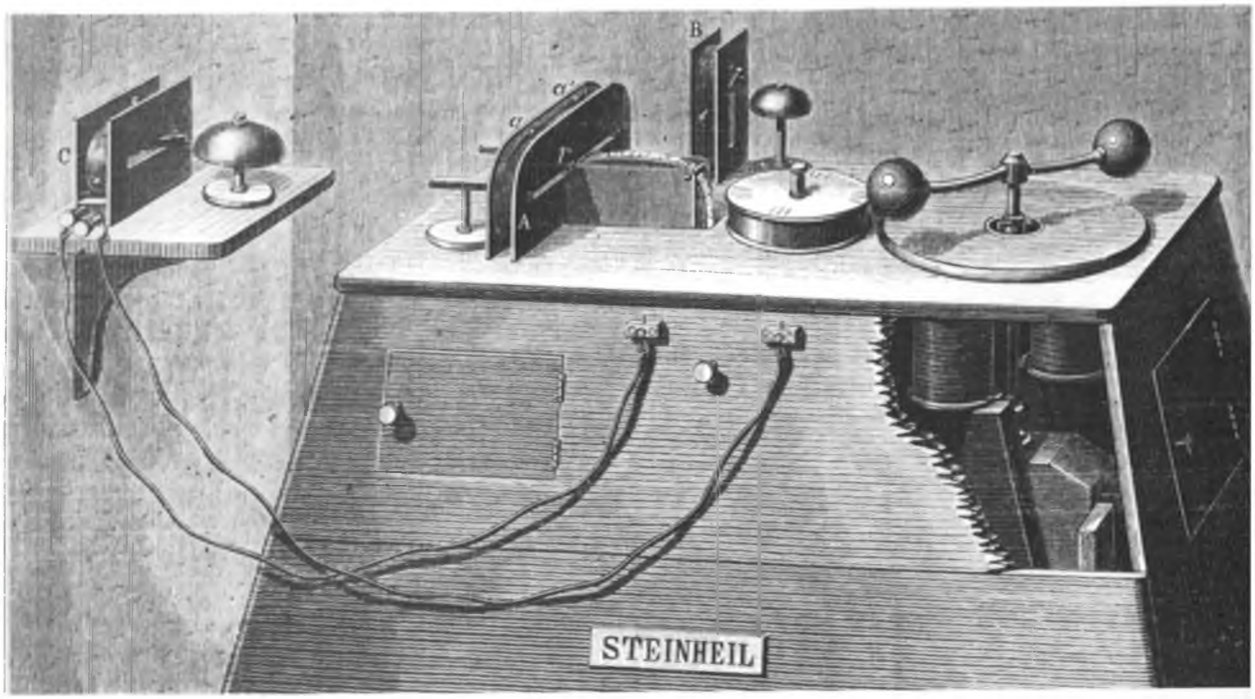

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diverged when the line was charged. At the sending station Sir Francis provided a rotating dial with the letters of the alphabet on it, driven by clockwork and running synchronously with a similar dial at the receiving station.

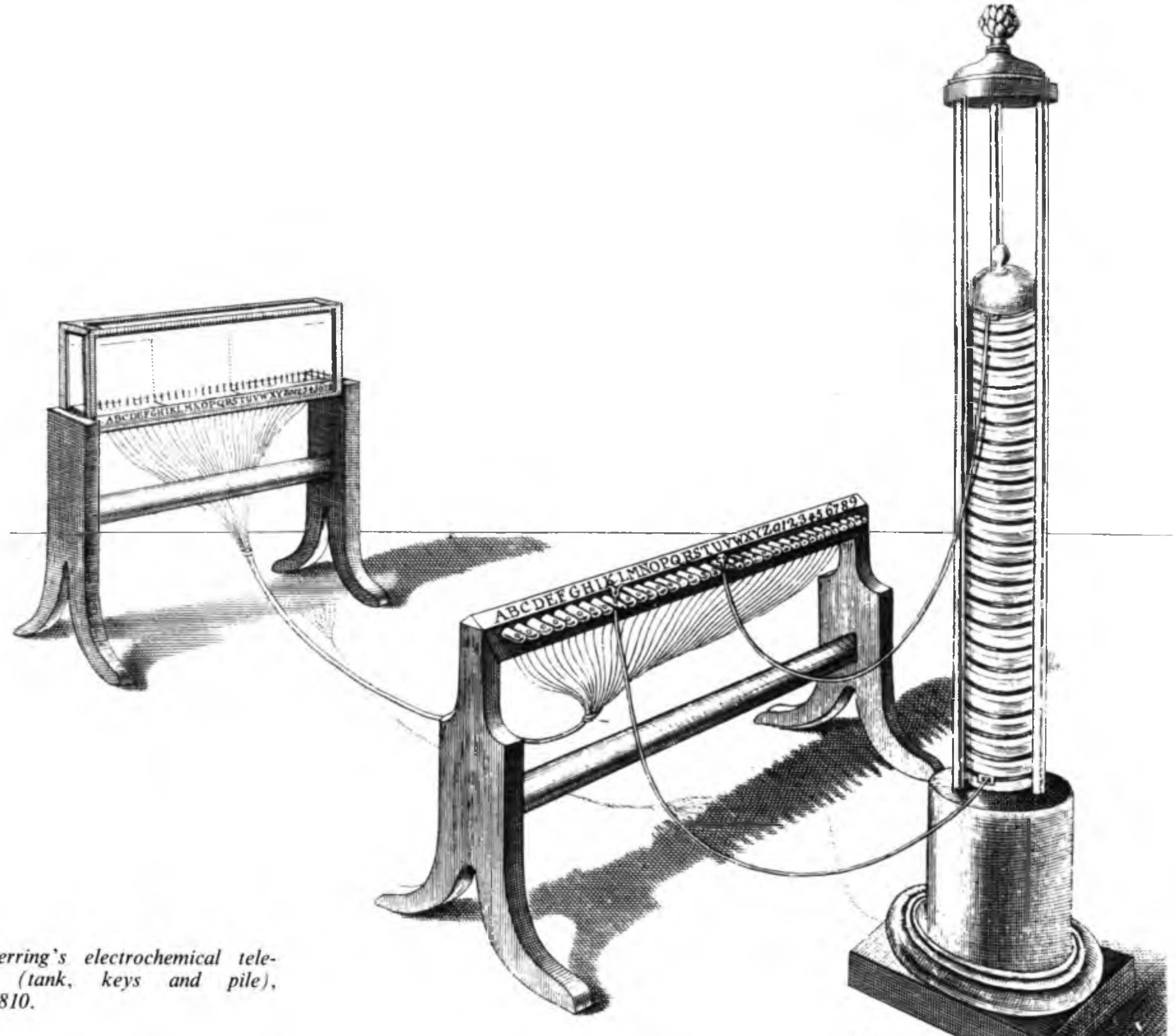
The line was charged continuously, but was discharged by the operator, when the desired letter became visible on his dial; on the receiving end, the other operator would see the pith balls of his dial indicator collapse as the same letter came into view. No doubt it was a highly ingenious system and it worked, which is more than can be said of the other schemes which have been mentioned.

It certainly deserved serious official consideration, but when it was submitted to the Admiralty, Sir Francis was informed that "telegraphs of any kind are now wholly unnecessary and no other than the one now in use will be adopted". No doubt Lord Murray had better friends at the British Admiralty than Sir Francis.

But whatever the British Admiralty thought about the necessity or otherwise of telegraphy during the beginning of the 19th century, the basic scientific experiments which were to make the electric telegraph such an outstanding success in the years to come had already been carried out by Alessandro Volta (1745-1827) and by Luigi Galvani (1737-1798) in Italy. Theirs was a new kind of electricity, of much lower pressure. It was to prove of vastly greater practical importance than the shock-giving electricity from the frictional machine. Theirs was to prove as copious and as tractable as the supply of static electricity had been elusive and capricious.

One of the first phenomena to be observed with "voltaic" electricity in 1800 was the electrolytic decomposition of water into its two constituent gases, hydrogen and oxygen, and it was only four years later that the ingenious Salvá in Barcelona proposed to use the rise of hydrogen bubbles on the negative electrode as an indicator in a new telegraph; but this scheme of his had as little practical success as his previous one which gave operators "alphabetical" shocks.

S. T. von Sœmmerring (1755-1830) described an electrochemical telegraph to the Munich Academy of Science in the summer of 1809 and gave many demonstrations to his friends. One of them was Baron Schilling, an attaché to the Russian Embassy in Munich, who, after seeing Sœmmerring's work, devoted much time and effort to the construction of his own electromagnetic telegraph.



17 Sœmmerring's electrochemical telegraph (tank, keys and pile), 1809-1810.

17

Schilling in turn influenced Cooke, one of the real pioneers of electrical telegraphy. Like Salvá's telegraph, a voltaic pile provided the current in Sœmmerring's apparatus and according to which of the 35 wires were used to close the circuit, hydrogen bubbles appeared on one of the 35 electrodes immersed in water at the receiving end; he used one wire for each letter and an additional 10 for the numbers.

A slight improvement was the telegraph of the American physicist Dyer, who only employed one wire, and used litmus paper as an indicator for his signals; his telegraph operated in 1828 over a 10 kilometer distance on a race-course in Long Island, but because he used electrostatic electricity his apparatus did not last longer than two years.

This brief history of the precursors of the electric telegraph is a fascinating demonstration of a basic truth in the whole history of technology: An inventor needs both to develop and exploit his schemes before he can either expect acknowledgment or reward. And if his ideas are too far ahead of the technical capabilities of his age, then all he can hope for is an honourable mention in the history books of his science. It is only on very rare occasions, as we have already hinted at above, and as we shall now discuss in some detail, that the unsuccessful ideas of one man can be directly traced down to the pioneer who brought them to fruition.

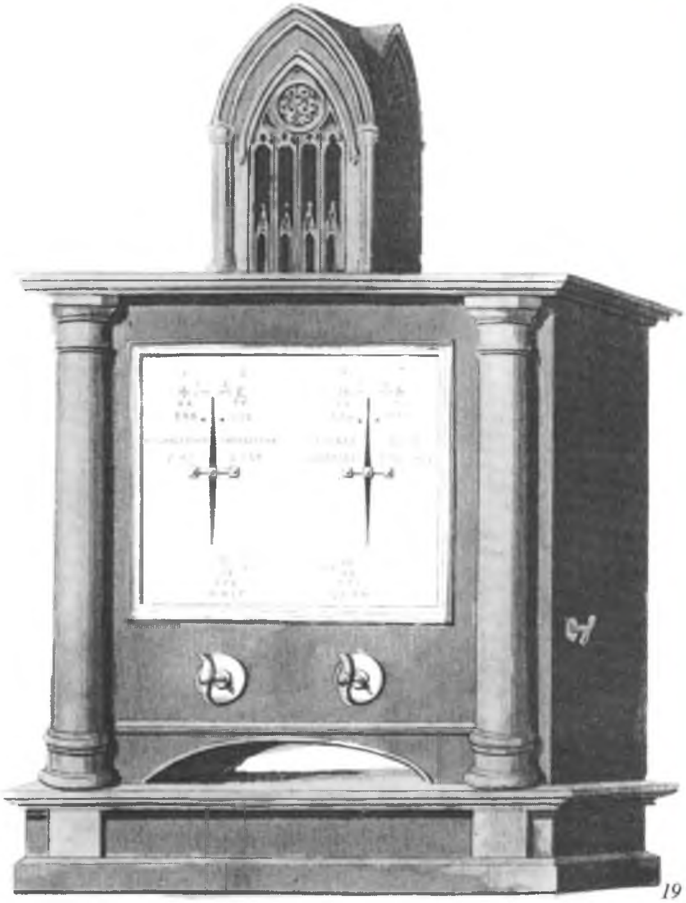
18

The Pioneers of the Telegraph

The steam railroad which "trailed smoothly away, upon its mighty course of civilisation and improvement" as Charles Dickens described it, was the first of the striking and revolutionary inventions of the 19th century. When the first public railway was opened in 1830 between Liverpool and Manchester in England, reaching a speed of 45 km an hour, it ushered in an age of speedy human communications which was to have deep effects on political and economic life all over the world. The first steam boat was even a little ahead of mechanical land transport, and in 1819 the American built *Savannah* crossed the Atlantic Ocean, driven by paddle-wheels and helped by her sails. By the middle of that century, a network of railways had spread all over Europe, and by 1858 the giant *Great Eastern* had been laboriously launched, broadside on, upon the Thames; her iron hull weighed 6250 tons, her engines developed 6600 horsepower, and she reached a speed of 14 knots. Both, the railways and the *Great Eastern*, were to have a decisive influence on the history of the electric telegraph.

We have already seen how the Russian diplomat, Baron Schilling, was stimulated to start experiments with electrical transmission of messages; his great contribution in 1832 was the use for telegraphy of the deflection of a compass needle when an electric current flowed around it. That this phenomenon occurred had first been observed by H. C. Oersted (1777-1851) professor of physics at the University of Copenhagen, and had been published by him, in Latin, in 1820. Schilling used this deflection of a needle, the galvanometer principle, in his indicator at the receiving end of his telegraph models. However, he died in 1837, the year when the Emperor Nicholas I of Russia had appointed a commission to advise on the installation of a Schilling telegraph between St. Petersburg and the imperial palace at Peterhof. In 1833 Professor Carl Friedrich Gauss and Professor Wilhelm Weber at Göttingen constructed the first electromagnetic needle telegraph for practical operations. It was used for the transmission of scientific information between the Physical Laboratory of the University and the Astronomical Observatory, a distance of 1 km, and it remained in use up to 1838. The principle of the Gauss-Weber telegraph with four elementary signal units was similar to the "Navy Galvanometer" developed as an operational instrument for long submarine cables in 1858 by Sir William Thomson.

During March of 1836, a copy of Schilling's telegraph was seen by a young Englishman who had just been invalided out of the East India Army, William Fothergill Cooke (1806-1879). Returning to England during the next month, he constructed several forms of telegraph, one of which was intended



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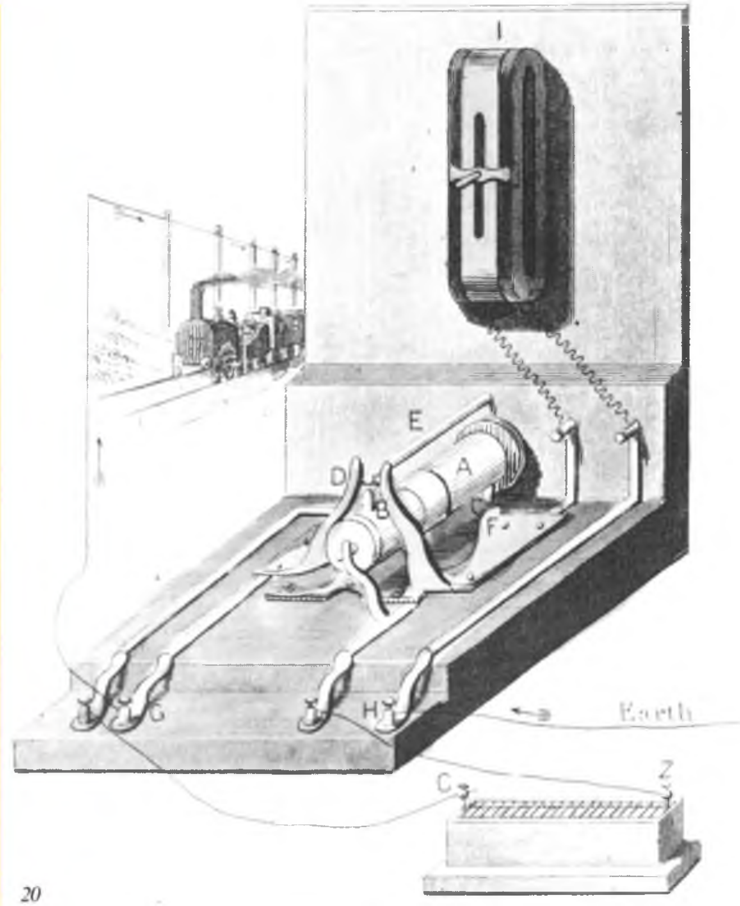

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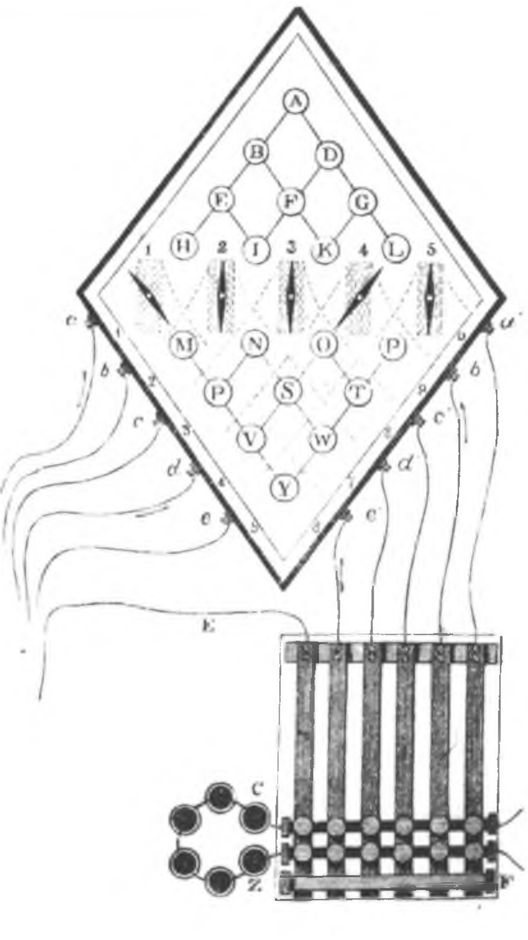

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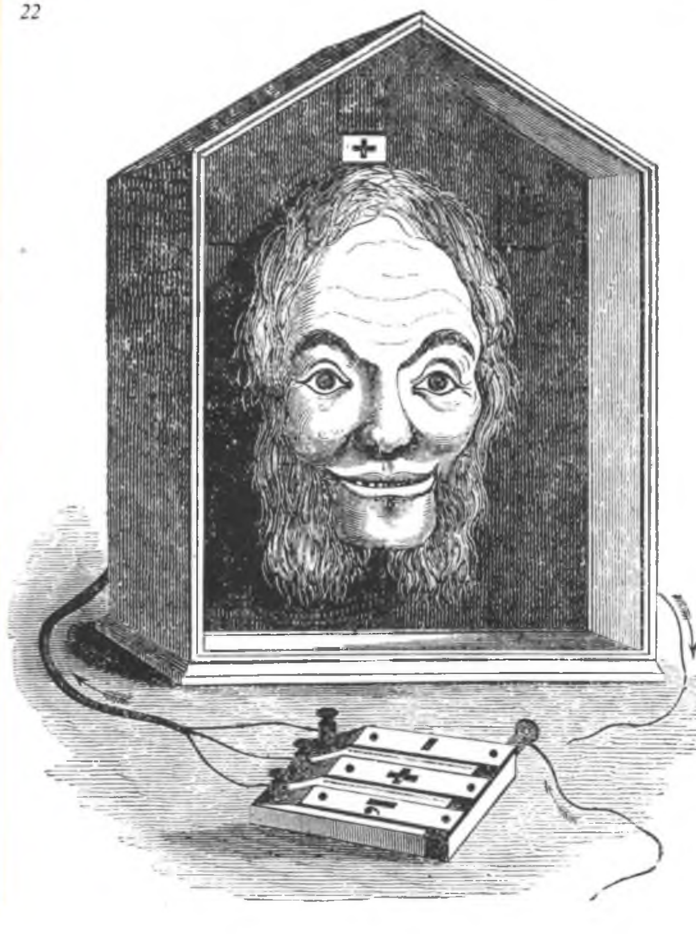


18 *Wheatstone's electric telegraph was used on the Croydon Railway in 1845.*

19-20 *Wheatstone's telegraph and its connection with the railways. On the left an engraving from the front and on the right the back view of the telegraph connected to the line running alongside the railway.*

21 *The way in which the five needles of Wheatstone's telegraph spelt out 20 alphabet letters. In the illustration the letter " V" is being sent, being the only point of intersection between two needles.*

to be installed on the Liverpool-Manchester Railway. As, however, he met with many difficulties, he called on Charles Wheatstone (1802-1875) the Professor of Natural Philosophy at Kings College, London, and asked for his help. They formed a partnership, and received in June 1837 their first patent; in July of that year, they demonstrated their five-needle telegraph to the directors of the new London-Birmingham Railway. It worked between Euston and Camden Town, a distance of about 1½ kilometers, but the directors were not convinced. It worked by deflecting any two out of the five compass needles, so that the two intersections of the needles pointed to one of ten possible letters above, or ten below their axis.

However, the directors of the Great Western Railway were more progressive. They commissioned Cooke and Wheatstone to instal a telegraph between Paddington Station, the London terminus of their line, and West Drayton, a distance of 21 kilometers; it began working on July 9, 1839 and was extended along the same railway line to Slough in 1843. This later model only used the deflection of two needles, and in order to send a message over it a pre-arranged code had to be used.

Other railway lines followed, and by 1845 substantial royalties were paid to these two pioneers by their satisfied customers. But that the range of potential customers of the telegraph might be much larger than railway officials, was dramatically proved on 1 January, 1845, when the operator at Paddington Station received a telegram from Slough. It informed him that a murder had been committed, and that the suspect had boarded the 7.42 train to Paddington, sitting in the last compartment of the second first class carriage. Policemen waited for him at Paddington Station, and when John Tawell, the murderer, was later hanged, the telegraph had indeed become the talk of London. It had proved to the public that even the "great" speed of their railways could be surpassed, and that transmission of electricity, as the Abbé Nollet had already shown with his 200 Carthusian monks, could be "as swift as light". (Both electricity and light travel at the speed of 300,000 km per second.)

Cooke and Wheatstone continued to improve their telegraph, finally reducing the number of needles to a single one; their system survived for a remarkably long time on British Railways, and in isolated instances right into the 20th century. In 1846 they formed the Electric Telegraph Company and by 1852 it was estimated that there were in England some 6500 km of telegraph lines. Queen Victoria knighted both Cooke and Wheatstone for their achievements and both Sir William and Sir Charles will always be remembered as two of the great pioneers of telegraphy.

22 *A " comic electric telegraph" was invented by G. R. Smith and shown at the Great Exhibition in London in 1851. Bent iron bars attached to the eyes and mouth of the comic face could be magnetised and thus produce distortions of the face. In addition, a code composed of —, +, and /, could be operated, spelling out the alphabet and appearing above the face in the box.*

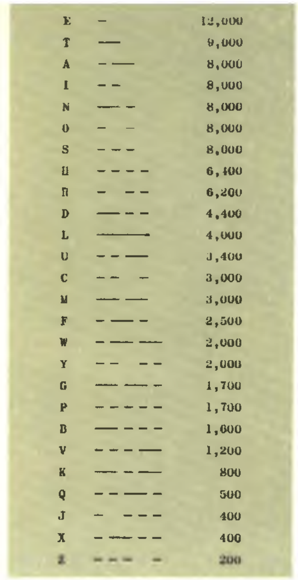
23

The other two great pioneers are Samuel Finley Breeze Morse (1791-1872) and Alfred Vail, his partner. Morse was an American painter of historical scenes of some distinction and in 1835 he was appointed Professor of the Literature of Arts and Design at the New University of New York. It was during a return voyage from Europe in 1832, where he had gone to study art, that he became interested in electromagnets; their properties were demonstrated to him by a fellow-passenger during his voyage. To Morse, this was a new and ingenious device and his mind became engrossed with the idea of using an electromagnet as the operative element in an electrical telegraph.

The essence of Morse's idea was to use the passage of an electric current through an electromagnet to deflect a pen or pencil in such a way that they could mark a strip of paper passing underneath them. The permanent recording of telegraphic messages onto paper was certainly a distinct new contribution and in 1835 his appointment to the University allowed him sufficient time to construct during that year his first, though still crude, telegraph. Much remained to be done before it could become of real practical use and only when in 1837 the mechanical abilities of Alfred Vail were joined with the persistent advocacy of Samuel Morse was the way opened to success.

The mechanical working of the telegraph was gradually improved, and the famous Morse code was devised by assigning the simplest signs to those letters of the alphabet which were most frequently found in the type cases of the local printer. After an earlier but unsuccessful attempt to obtain Congressional funds and patents in Europe, Morse finally obtained $30,000 in 1843 for a telegraph line from Washington to Baltimore; it was opened on 1 January, 1845. It is said that the first message sent by Morse was the phrase "What hath God wrought". With these very same words President Kennedy finished the first telephone conversation over a SYNCOM satellite on 23 August, 1963. He was speaking to the Nigerian Prime Minister, and their voices travelled over a distance of about 72,000 kilometers.

The development of the telegraph in the United States did not proceed as smoothly as in Europe, where the telegraph services were in the hands of the national Governments. The Washington-Baltimore line was sold to private interests by Congress in 1847, and not until the many other private companies which had sprung up were consolidated in 1865 by Hiram Sibley as the Western Union Telegraph Company was there any real and rapid expansion. By 1866 the Western Union owned 2250 offices and their original wires had expanded from 900 km to 120,000 km; one great contributory factor in this expansion



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was the development of a telegraphic news service for the New York Newspapers, led by the Associated Press.

Also in Europe, the Newspapers were amongst the first and best customers of the telegraph, once it had left the railways and became open to the public. Julius Reuter (1816-1899) will always be remembered as one of the most imaginative users of the new medium of communication, and for a time in 1850, when there was a 150 kilometer gap between the Paris-Brussels line and the Berlin-Aachen one, he bridged it by pigeon post; just after Christmas 1850, the gap was closed, Berlin was linked by electric telegraph with Paris, and Reuter left for London. There, for nearly half a century, he based his fame and fortune on the distribution of political, financial and economic news by "Reuter's Telegrams".

Collection and distribution of news across the Continent of Europe had become perfectly possible by the middle of the 19th century. The first telegraph line was completed in France in 1845 and in Austria-Hungary and in Belgium in 1846; the first line on the Italian Peninsula was constructed in 1847, the optical telegraph line Berlin-Cologne was electrified in 1849, the first in Switzerland in 1852, and the first in Russia in 1853. Although there was always an inevitable gap between the construction of the first lines, mostly for internal railway usage, and their opening up to the public, as for example in France from 1845 to 1850, once this had been done, three major customers brought about a continued and rapid growth.

The State saw in it an efficient means of establishing central control and government, the railways ensured by its use the safe and rapid functioning of their trains, and commercial users, as for example the newspapers, soon realised that rapid news of financial quotations from a foreign bourse, or of political events, meant profits to them. Many of the new countries who gained their political independence during the middle of the 20th century are appreciating again the very same factor. Without rapid and reliable communications, now of course by wire and wireless, neither state, transport nor industry can grow.

But there still remained in 1850 one obstacle, which neither the semaphores of the visual telegraph, nor the new electrical telegraph had yet overcome: the Sea. To lay a telegraph cable below the sea meant insulation, and until in 1847 satisfactory machines had been developed by Werner Siemens and others to apply gutta percha to copper wires for the insulation of underground cables for cities, submarine cables

23 *Morse alphabet.*

24 *Morse's original code, showing relation to quantities of type found by him in a printer's office. The modern International Code shows a similar appreciation of this statistical aspect of coding.*


25

were out of the question. So for example the telegraph line from London to Dover, opened in 1846, had to terminate there. Although Wheatstone had proposed a cable to link France and England and although Morse had laid a short length from Castle Garden to Governor's Island in the harbour of New York, it fell to the brothers John and Jacob Brett to lay the first submarine cable in the open sea between Cap Gris-Nez in France and Cape Southerland in England.

It was paid out from the tug *Goliath* on 28 August, 1850, but only a few messages passed. A fisherman took a part of the cable up in his trawl, cut off a piece and showed it in triumph as a specimen of a rare seaweed, with its centre filled with gold. A second cable, laid the following year, was more successful. It consisted of four separate copper wires, each of 1.65 mm diameter and each separately covered with two layers of gutta percha. The four insulated wires were then laid together and covered with tarred hemp and a protective armour of ten galvanized iron wires, each of 7 mm diameter. Such a cable was certainly proof against fishermen and it remained in operation for many years.

Once it had been shown that submarine telegraph cables were possible and economically profitable, there was a veritable rush of them. In 1852, both Wales and Scotland were linked with Ireland, and a cable across the North Sea linked England with Belgium and Denmark in the next year. In the Mediterranean, to mention only a few, cables linked Italy with Corsica and from there to Sardinia in 1854. In 1857, Ceylon could send telegrams to India over two submarine cables, and in 1859 there was a submarine cable between Tasmania and the Australian mainland. In 1860 a telegraphic cable connection existed between London and the Indian Continent, the last submarine links having been laid during that year via Suez, Kosseir, Souakim, Aden, Hallania, Mascate and on to Karachi. The fifteen years which had elapsed, 1845 to 1860, since the description of a murderer had been telegraphed over a railway wire, had indeed made the electric telegraph international and an instrument of Government.

There remained however the most important cable yet to be laid, the one to span the Atlantic Ocean. This story is indeed an epic of courage, enterprise and perseverance, the like has rarely been told in the history of telecommunications; its main protagonist was the great American citizen Cyrus W. Field (1819-1892), whose untiring efforts provided the impetus throughout. The construction of the first Atlantic cable differed materially from earlier cables. Its central conductor was stranded, consisting of seven pure copper wires, laid together to form a single conductor. It was covered with three layers

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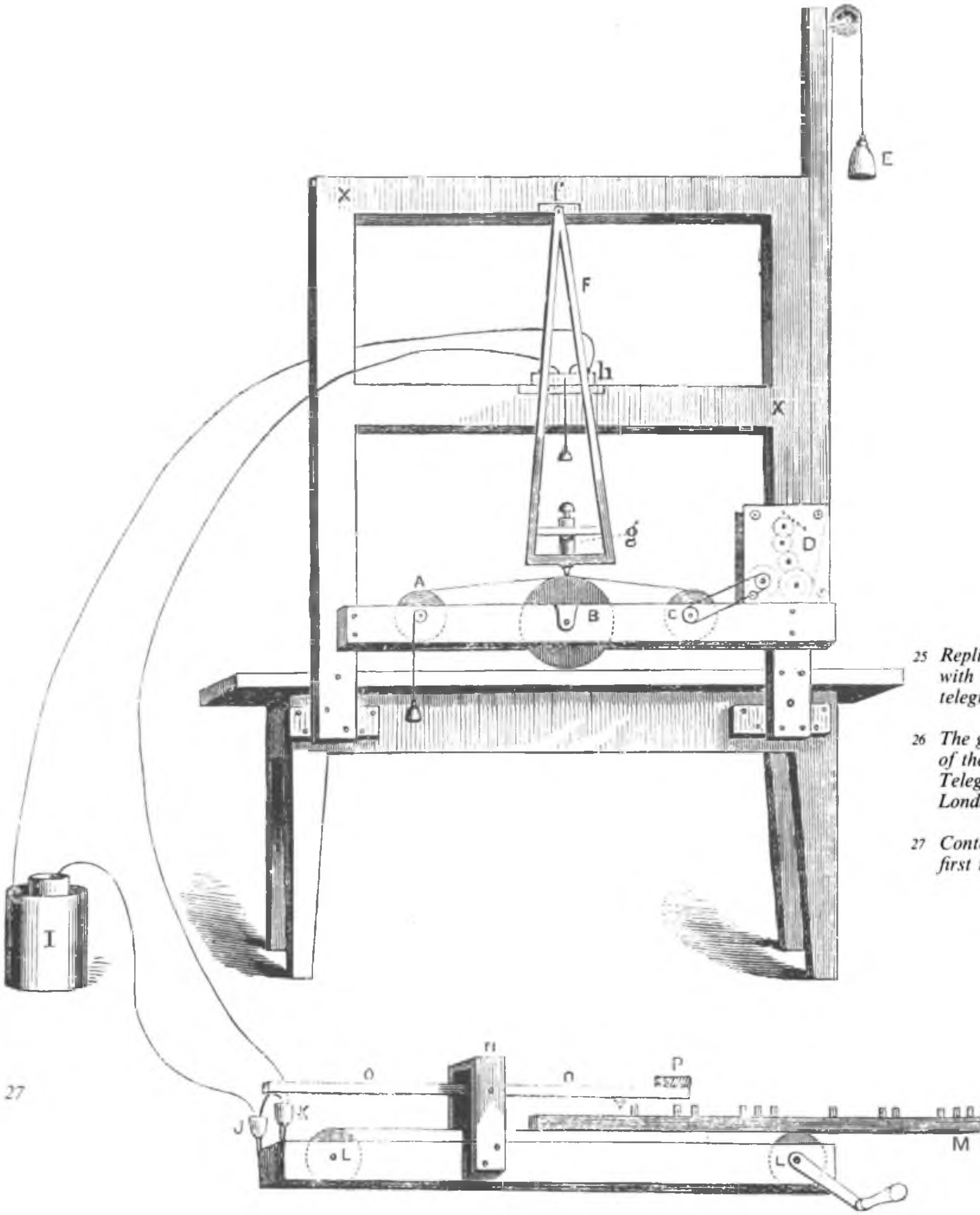

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25 *Replica of the instrument with which Morse sent the first public telegraph message on May 24th, 1844.*

26 *The great telegraph room at the new offices of the Electric and International Telegraph Company, Bell Alley, Moorgate, London, 1859.*

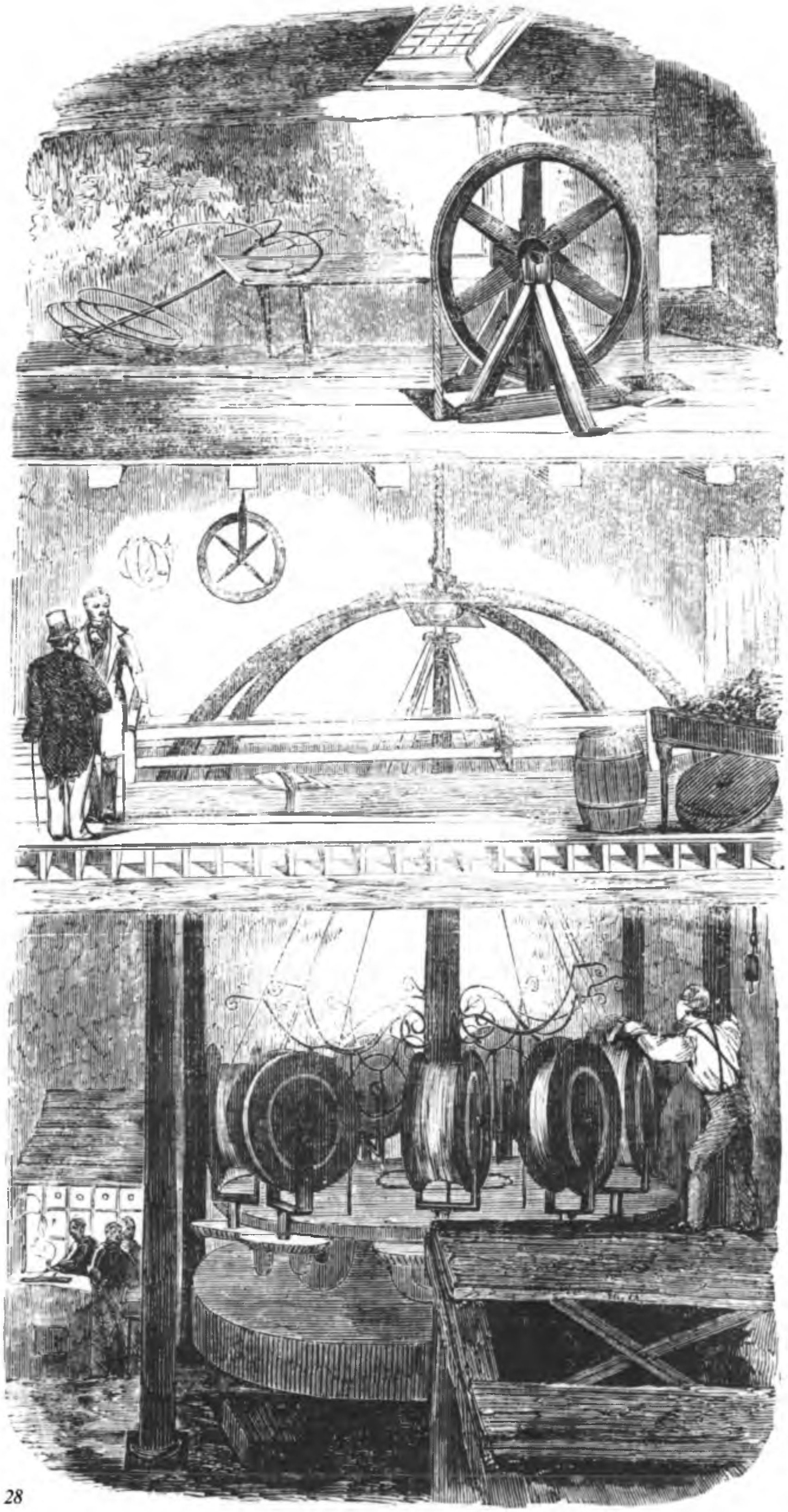
27 *Contemporary drawing of Samuel Morse's first telegraph equipment, 1837.*

28 *Special equipment had to be invented to manufacture the first submarine telegraph cable between England and France. It was installed on three floors, and the coils of wire rope were made to rotate around the central strand as it was wound over a wheel on the top floor.*

29 *A temporary telegraph station near Cape Southerland at Dover, the English terminal of the first undersea telegraph line.*

30 *Tug* Goliath *paying out the telegraph wire in mid-channel. Accompanying the Tug is H.M. Packet* Widgeon.

31 *Cap Gris-Nez, France, terminal of the first telegraph link across the Channel.*



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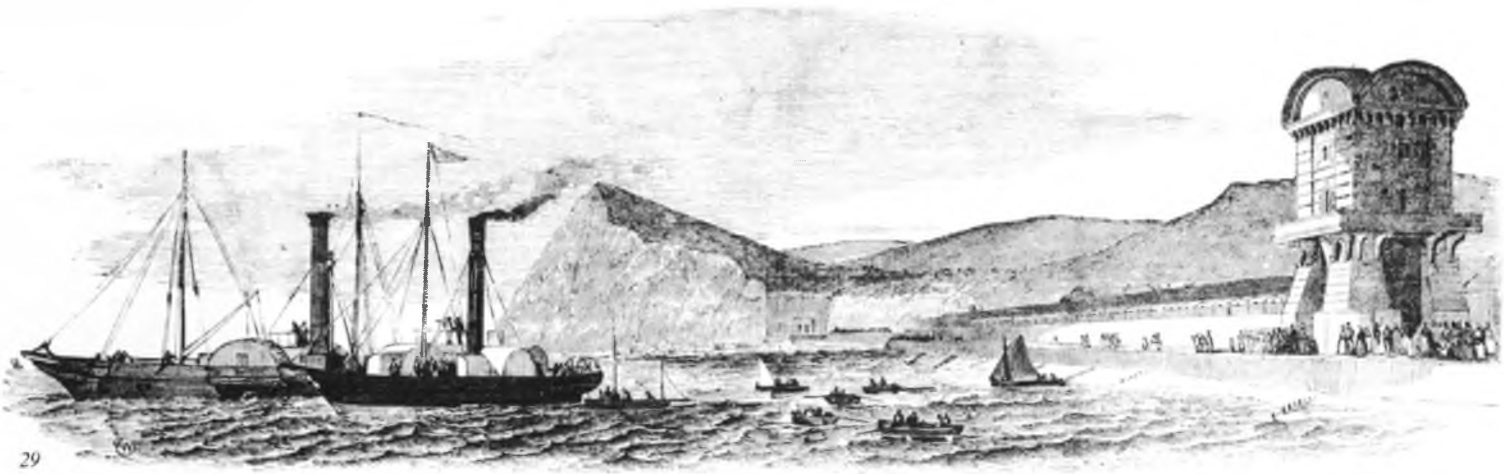

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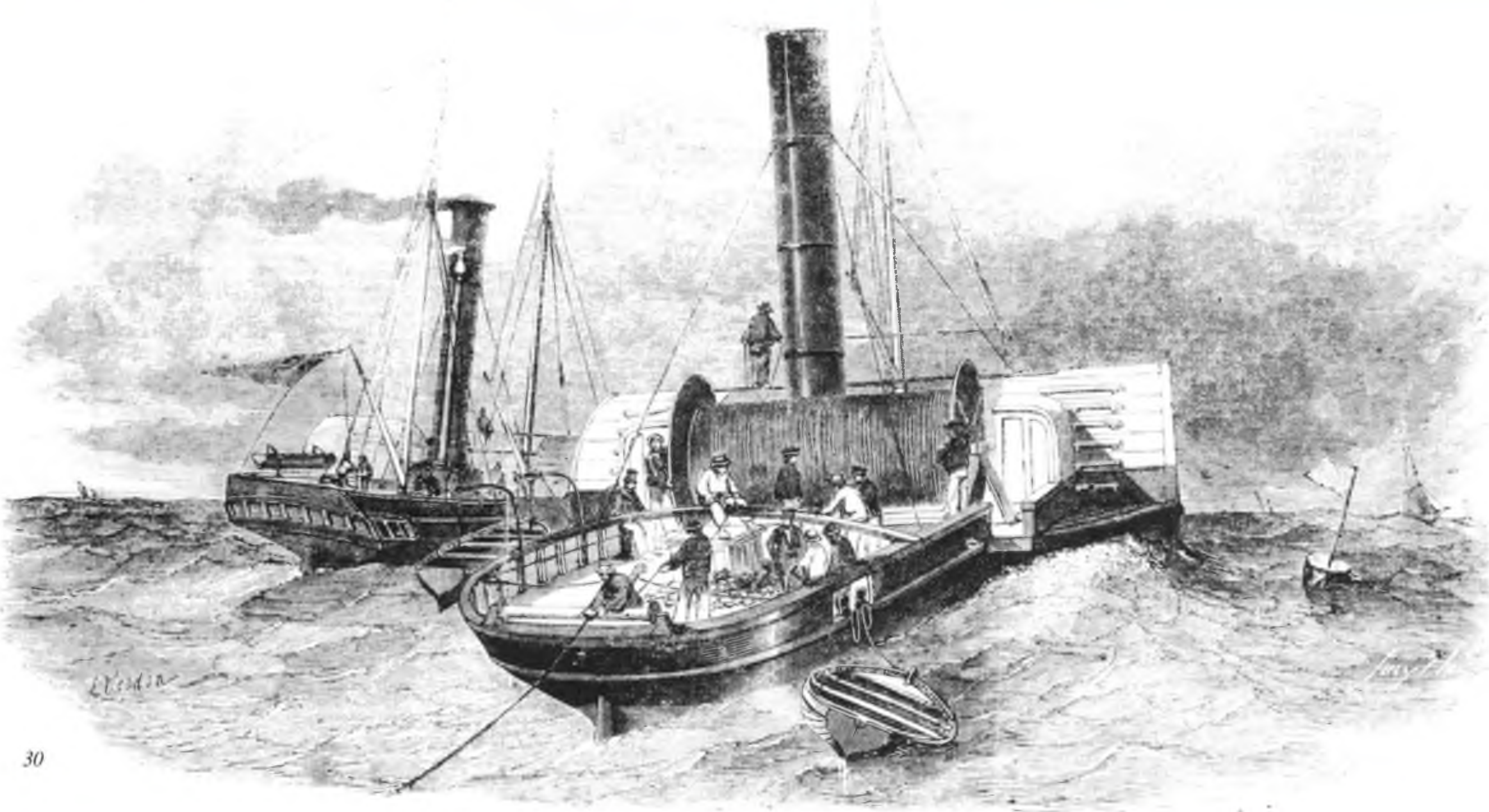

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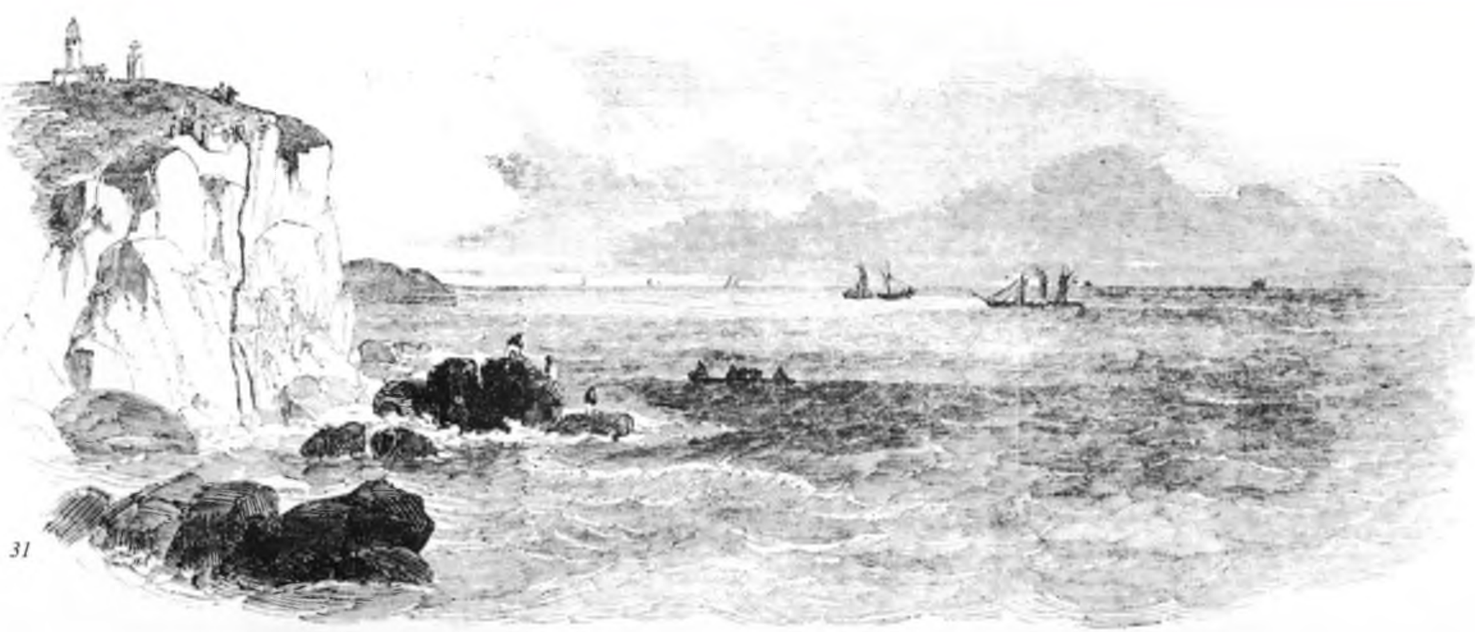

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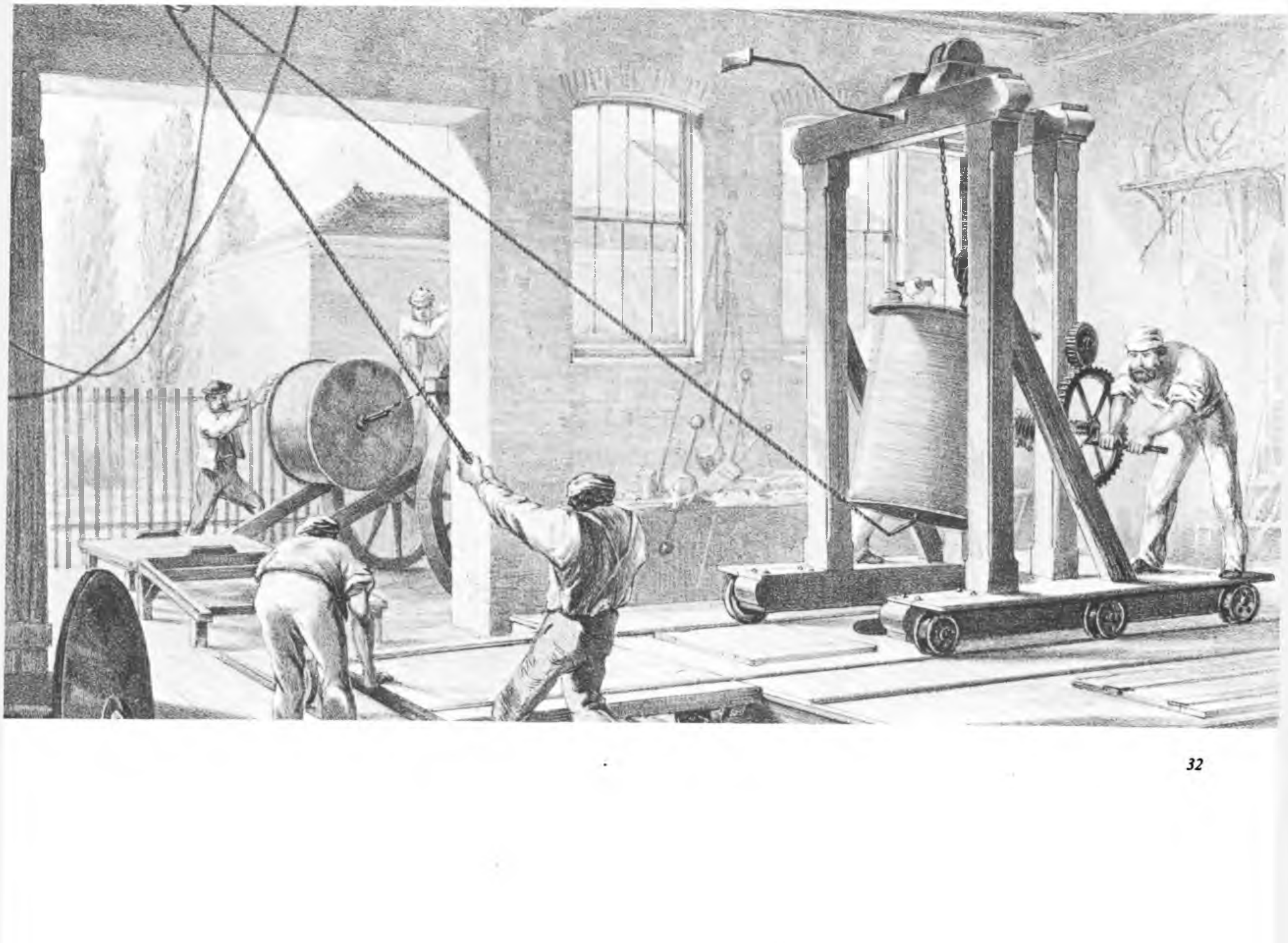

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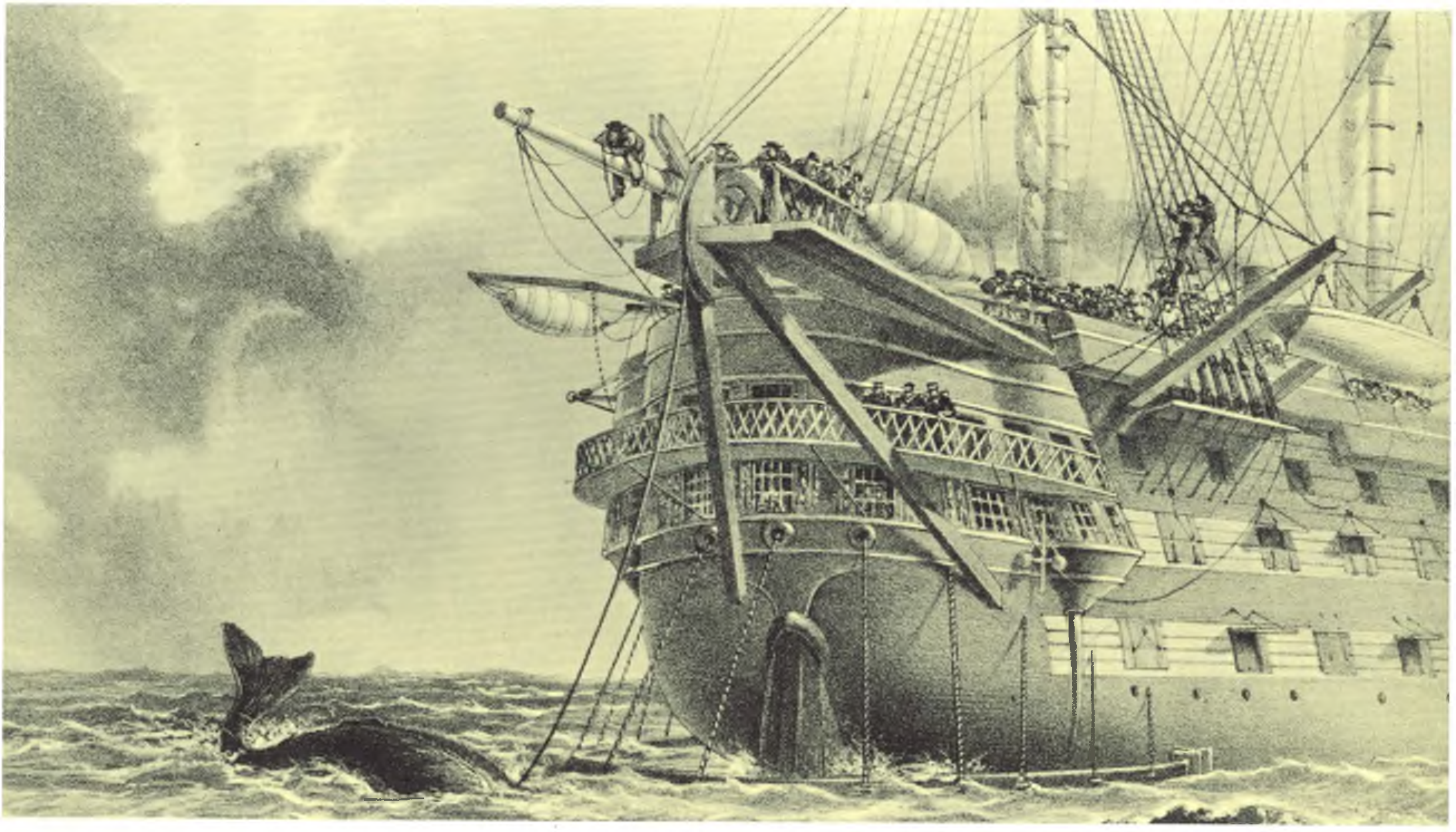
32 *The transatlantic cable of 1858 was made at Greenwich, near London. Here the reels of gutta percha covered copper wire are removed for storage in tanks.*

33 *H.M.S.* Agamemnon *laying the Atlantic telegraph cable in 1858. A whale crosses the line.*



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34 Searching for a fault in the cable after its recovery from the ocean bed.

35 The paying-out machinery on board the Great Eastern *during cable-laying operations, 1865.*

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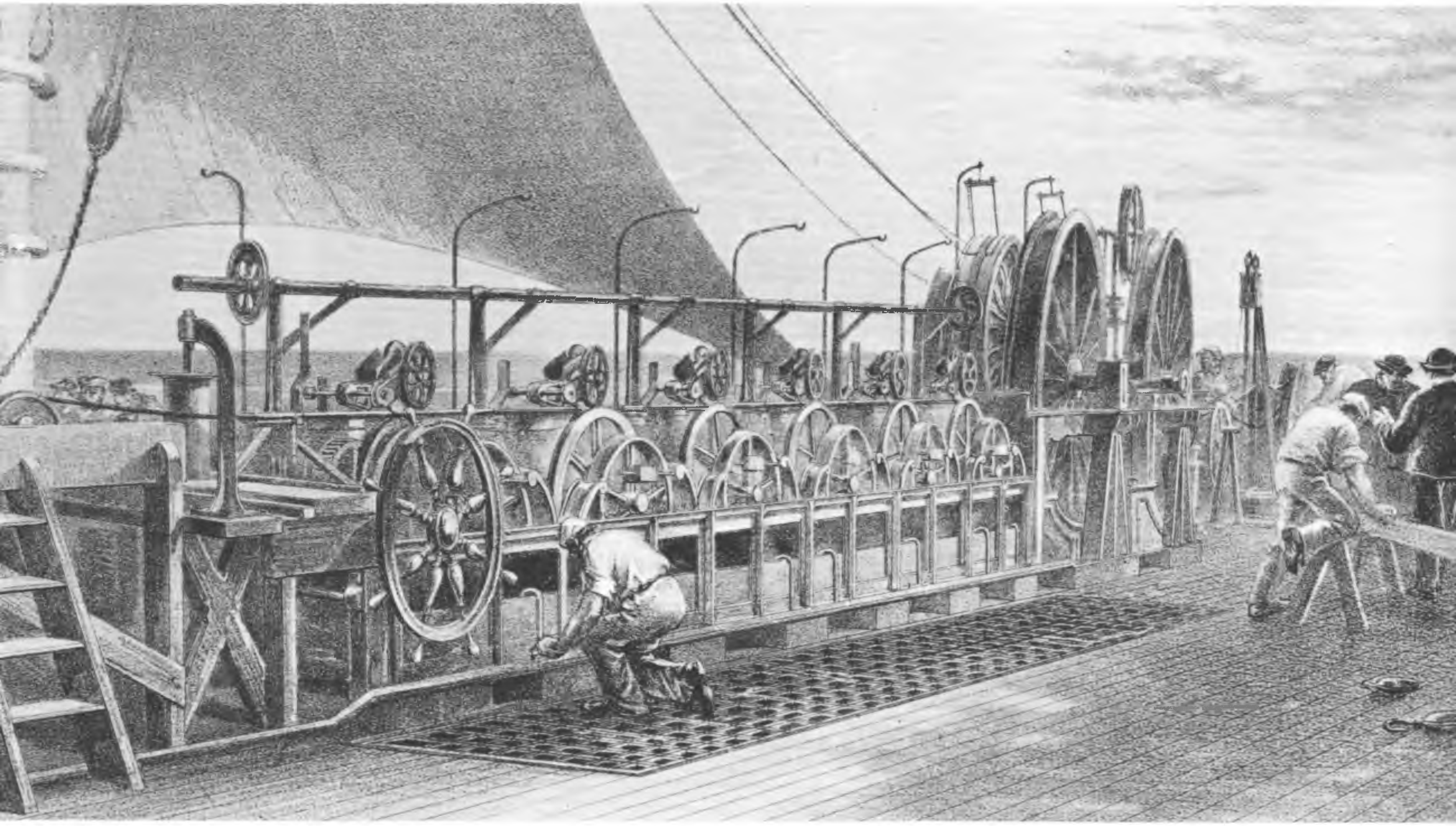

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of gutta percha to a diameter of nearly 12.2 mm. This core was then covered with a thin layer of hemp and yarn and it was armoured with 18 seven-wire strands of thin iron wire. A total of 3200 kilometers of this first cable was made, and stowed aboard H.M.S. *Agamemnon*, a jury-rigged and screw-driven wooden British warship. Paying out started on 7 August, 1857, from Valentia on the west coast of Ireland. On 17 August the cable broke in 2000 fathoms of water, and the project was abandoned for the year.

A different plan was adopted for next year's attempt. H.M.S. *Agamemnon* and U.S.N.S. *Niagara*, each loaded with a suitable length of cable, met in mid-ocean, and proceeded to pay out the spliced cable towards their respective home ports. On 28 June, the third splice having proved successful, both ships started from their meeting place, but after only 230 kilometers the cable snapped on the *Agamemnon*. Both ships then proceeded to Queenstown in Newfoundland to receive their new orders from the directors of the Company.

It was decided to repeat the attempt and on midnight, 28 July, 1858, the two vessels once more met in mid-ocean, spliced their cables and started out in opposite directions. On 5 August, a total of 3240 km had been laid, the *Agamemnon* now anchored in Dowlas Bay, Valentia, Ireland, and the *Niagara* anchored in Trinity Bay, Newfoundland. At 2.45 a.m. of that day the first telegraphic message passed across the Atlantic Ocean. It merely announced to the *Niagara* that the *Agamemnon* had landed the cable.

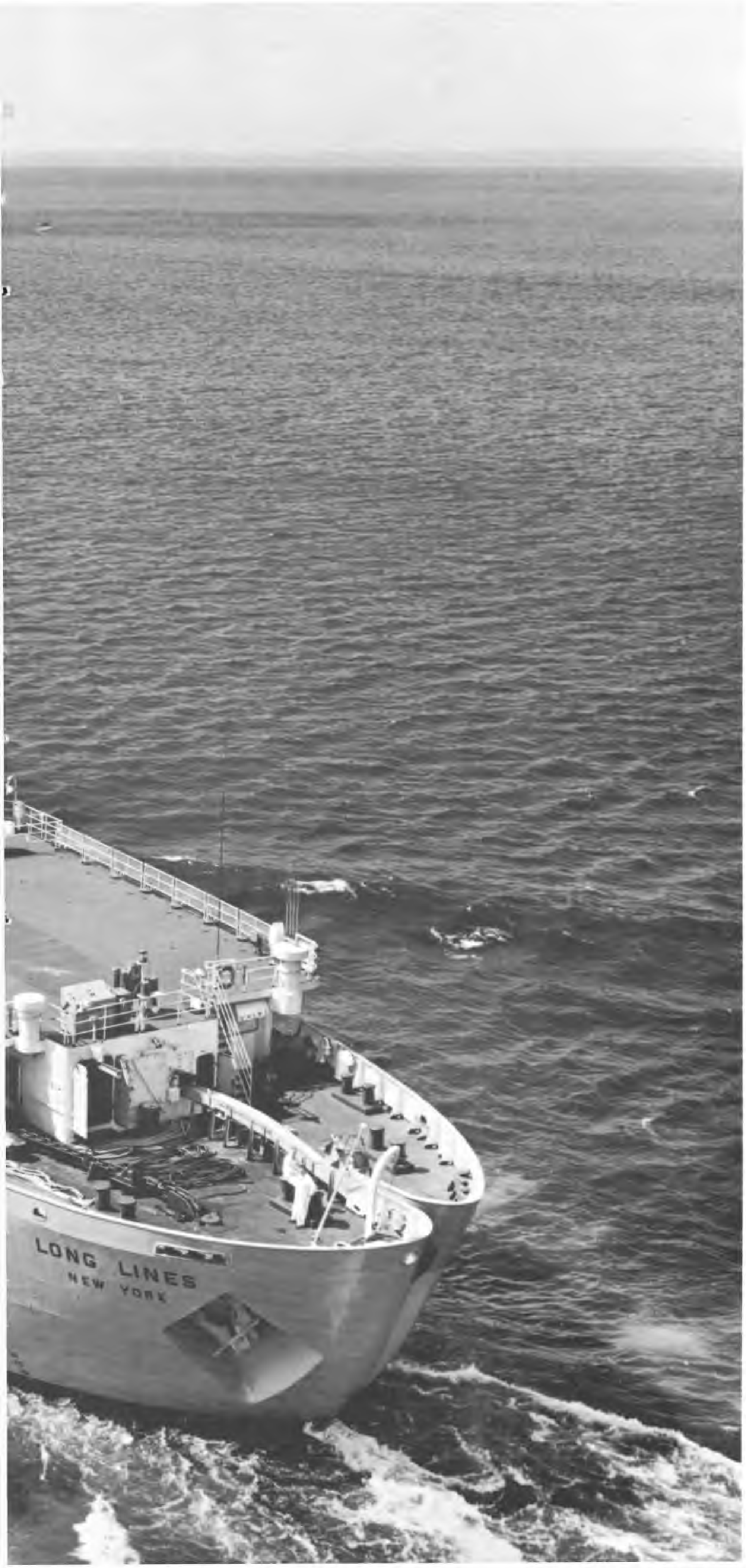
The news was received "in the Union with extraordinary manifestations of delight. The information was received more equably in England" as reported at the time. The directors in England sent congratulatory messages to their fellow-directors in the United States, and on 14 August Queen Victoria telegraphed her congratulations to President James Buchanan of the United States. Altogether 400 messages were sent over this cable, amongst them one from London to Halifax "that the 62nd Regiment were not to return to England". This warning was said to have saved England an expenditure of £50,000.

But by one o'clock of 3 September, 1858, less than one calendar month after the first message, a fault in the cable had brought all communications to a halt. It was later discovered that an operator, in a misguided attempt to apply land-signalling methods, had enlarged the battery to 500 cells, which, being used with induction coils, subjected the cable to a potential of 2000 volts.

The American Civil War between 1861 and 1865 brought only a temporary halt to Cyrus Field in his attempts to lay the Atlantic cable. New money was raised by the Atlantic Telegraph Company, a three-times heavier cable was spun and the *Great Eastern* was commissioned to lay its 3700 km across the Atlantic; she was then the only vessel afloat able to carry the cable in her holds. On 23 July, 1865, the *Great Eastern* left again from Valentia, Ireland, having joined her cable to a short length of shore line. She carried on board Professor William Thomson, later Lord Kelvin (1824-1907) the greatest name in Victorian science; his duties as a consultant were to report on the electrical behaviour of the cable during the laying operations. On August 2, 1900 km having been paid out successfully, an electrical fault was discovered in the cable and it was decided to pick up the cable, to cut out the bad portion, and splice in a new one. It was believed to be only 10 km distant. But on hauling it aboard it chafed over the drum at the bows, and suddenly it snapped. For the next nine days valiant attempts were made again and again to find the cable and three times the grapple iron lifted it for some distance above the ocean floor, only for the line to part under the terrific strain. When all available wire ropes and hawsers had been exhausted, defeat was reluctantly admitted, and the *Great Eastern* returned to Crookhaven in Ireland.

Final success came next year, in 1866, when the *Great Eastern* succeeded in laying a sound cable from Valentia in Ireland to Trinity Bay in Newfoundland. On 27 July of that year the cable transmitted the first message, and since that day transatlantic cables have become a normal means of communication. The *Great Eastern* rounded off her success, recovered the cable lost during the previous year, and spliced a new length onto it, thus providing a second complete cable.

As in so many other fields in the history of science and technology, electrical telegraphy did not come through the work of a single individual, however great he might have been. Nor can a single country claim to have been the sole pioneer of the first of the three great media of telecommunications. The names of pioneers are often forgotten, although their work lives on, and however much telegraphy has been improved during the last century, no tribute can be too great to those who showed for the first time that intelligence can be transmitted over the surface of our planet with the maximum possible velocity.



36 *Cable Ship* Long Lines *entered service in mid-1963 to help expand the network of under-ocean telephone cables. The vessel is owned by the Transoceanic Cable Ship Company, an American Telephone and Telegraph Company subsidiary.*

'Tis done! the angry sea consents,
the nations stand no more apart,
With clasped hands the continents
feel throbbings of each others hearts.
Speed, speed the cable; let it run
a living girdle round the earth,
Till all the nations 'neath the sun
shall be as brothers of one hearth (1859).

36

37 *In the 1840's mail coaches often took the name "Telegraph" to advertise their speed. Here the "Cambridge Telegraph" is ready to start its run from London to Cambridge.*

37

International Co-operation Begins

Robert Hooke was an excellent scientist in many fields, but when it came to optical telegraphy he was certainly an optimist. He wrote in his classical paper to the Royal Society in 1684: "All things may be made so convenient that the same character may be seen at Paris, within a minute after it hath been exposed at London, and the like in proportion, for greater distances". There is certainly no record that, when 150 years later semaphore signals were used on both sides of the Channel, any messages were passed across it.

Visual telegraphy was an exceedingly costly affair. The building of the many towers, not more than 8-10 km apart, demanded great capital, and to maintain the large staff on each station needed a constant source of finance. Visual telegraphy could only be afforded by the State, and then only for military or naval messages; it was certainly also used for political and police information, if this was deemed sufficiently urgent and important.

Once it had proved its success, Chappe's telegraph was widely imitated in other countries. Germany had a line 750 km long from Berlin to Coblenz in 1833, and in Russia, Czar Nicolas I himself inaugurated the line from Moscow to Warsaw in 1838; this required 220 stations with 1320 operators to man it. But whenever a line reached a national frontier, there it ceased. This was as much due to the different systems employed, each having its own code vocabulary, as to the obvious secrecy of all military and political messages which were sent by the telegraph.

Only the word "telegraph" has always been international. It was first used in April 1793 by Ignace Chappe the brother of Claude Chappe, and has found its way from French into many other languages. The word typified to all the ultimate in speed, and it gave its name to the fastest stage coaches. So, for example, there was the "Muddleton Telegraph" in which Mr. Pickwick and his friends rode to their X-mas party in 1827, as Dickens described it. Later, when the electric telegraph took up the image of highest velocity, the name of many famous newspapers included in their title the word "telegraph"; for example the London *Daily Telegraph*, founded in 1855, was anxious to impress its readers that their information was the latest available.

Only when electrical telegraphy had become an important instrument of communications did real international collaboration begin. Again, as in the case of the visual telegraph, at first there were only national networks, following closely the established railway lines. But then, railways did not stop at

الحمد لله لما تأملنا الوضع كما يجب العمل به في الاتفاقين المنعقدين في شأن خطوط السلك في الأقاليم

أولهما في بروكسيل ثاني يونيه سنة ١٨٥٨ ثمانية وخمسين وثمانمائة وألف مسيحية بين نواب الحكومات

من كل من دولة فرانسة ودولة البلجيك ودولة برويسيا اللذين أخذوا النسخة بعضهم من بعض بعد الموا...

من دولهم عليه في مدينة بروكسيل المذكورة في ثلاث جانفي سنة ١٨٥٩ تسع وخمسين وثمانمائة وألف مسيحية

والواقع ثانيهما في برنة في الشتمبر سنة ١٨٥٨ ثمانية وخمسين وثمانمائة وألف مسيحية بين نواب الحكو...

منهم من دولة فرانسة والبلجيك والصاردو والولاندة وسويسرة اللذين أخذوا النسخة بعضهم من بعض

بعد الموافقة من دولهم عليه في مدينة برنة في ٢٣ فبراير سنة ١٨٥٩ تسع وخمسين وثمانمائة وألف وكل

وأذنا ا...فقة على هذه الشروط على مقتضى الرخصة المذكورة في الفصل ٣٧ السابع والثلاثين والفصل ٤٠ ...

الماد بعض منهما المتوجهة للدول التي تطلب الدخول فيهما حررنا مكتوبنا هذا موافقا على جميع ...

الاتفاقين المذكورين من الشروط وجعلنا هذه الموافقة مع المكلف بأمور دولة فرانسة ...

والقنصل جنرال الجاج ... بتونس فسلمنا له هذه وأمضيناه بطابعنا حرر ...

عبده المشير محمد الصادق باشا باي صاحب المملكة التونسية بباردو المعمور في ... شوال الأبرك سنة ١٢٧٧

سبع وسبعين ومائتين وألف الموافق لـ ... أبريل سنة ١٨٦١ مسيحية

محمد الصادق باي

38 *Original Arabic manuscript text dated 19th April, 1861, signed by the Bey of Tunis, Mohamed Sadek. In this document the Bey of Tunis affirms his adherence to the Telegraph Convention concluded in Brussels in 1858 and in Berne in the same year by the delegates of France, Belgium, Sardinia and Switzerland.*

39 *The original Arabic text of a memorandum made by M. Cordaro Politit to Mohamed Sadek, Bey of Tunis, in 1855. It is proposed that the optical telegraph is replaced by the electric telegraph, following the example of the European countries. The inconveniences of the optical installation and the advantages of the electrical are pointed out and compared. It is suggested that four centres are created for the electric telegraph at La Goulette, Tunis, Le Bardo, and the official residence of La Mohammèdia. The memorandum concludes with the suggestion that in the future the Tunis Telegraph system should be linked to the European one, via Corsica and Sardinia.*

the frontiers, and information about them had to cross them like the passengers. But at first this was not easy.

We have, for example, a description of what happened at the frontier of France and the Grand-Duchy of Baden in 1852. A common station was established at Strasbourg with two employees, one from the French Telegraph Administration, the other from Baden. The French employee received, for example, a telegram from Paris, which the electric wires had transmitted to him with the speed of light. This message he wrote out by hand onto a special form and handed it across the table to his German colleague. He translated it into German, and then sent it again on its way. No wonder then that this delay led to the beginning of international co-operation which has so fruitfully continued now for more than a century.

The first treaty on record designed to link the telegraph systems of two states was signed on 3 October 1849, between Prussia and Austria. It provided for the connection of Berlin to Vienna by an electric telegraph line running along the then existing railway. Government messages were given first priority, messages concerning the railway operations came second, and public correspondence, when admitted, came last. On even days telegrams originating from Austria were given priority, and on odd days telegrams from Prussia. Each government reserved the right to suspend the telegraphic service in its own country, and the cost of the message, paid by the sender, was the sum of the then existing rates in the two countries. Such then was the first action of two independent states, regulating telegraphic communications between them, fixing priorities and settling the rates to be paid. From now on, it was not only up to the scientist and the engineer to improve the electrical means of communications, but also for the civil servant and the administrator to smooth their path from country to country, from continent to continent, and later right round the world.

The agreement between Prussia and Austria was soon followed by other similar agreements, between Prussia and Saxony in 1849 and between Austria and Bavaria in 1850. These four states, Prussia, Austria, Bavaria and Saxony went a step further, and created at Dresden in 1850 their "Austro-German Telegraph Union", which remained in existence until 1872, after the formation of the German Empire. It worked well, other German states adhered to it, and, in 1852, the Netherlands joined it. The Union held a further meeting in Vienna in 1851, and decided that the international telegraph lines should be physically connected,

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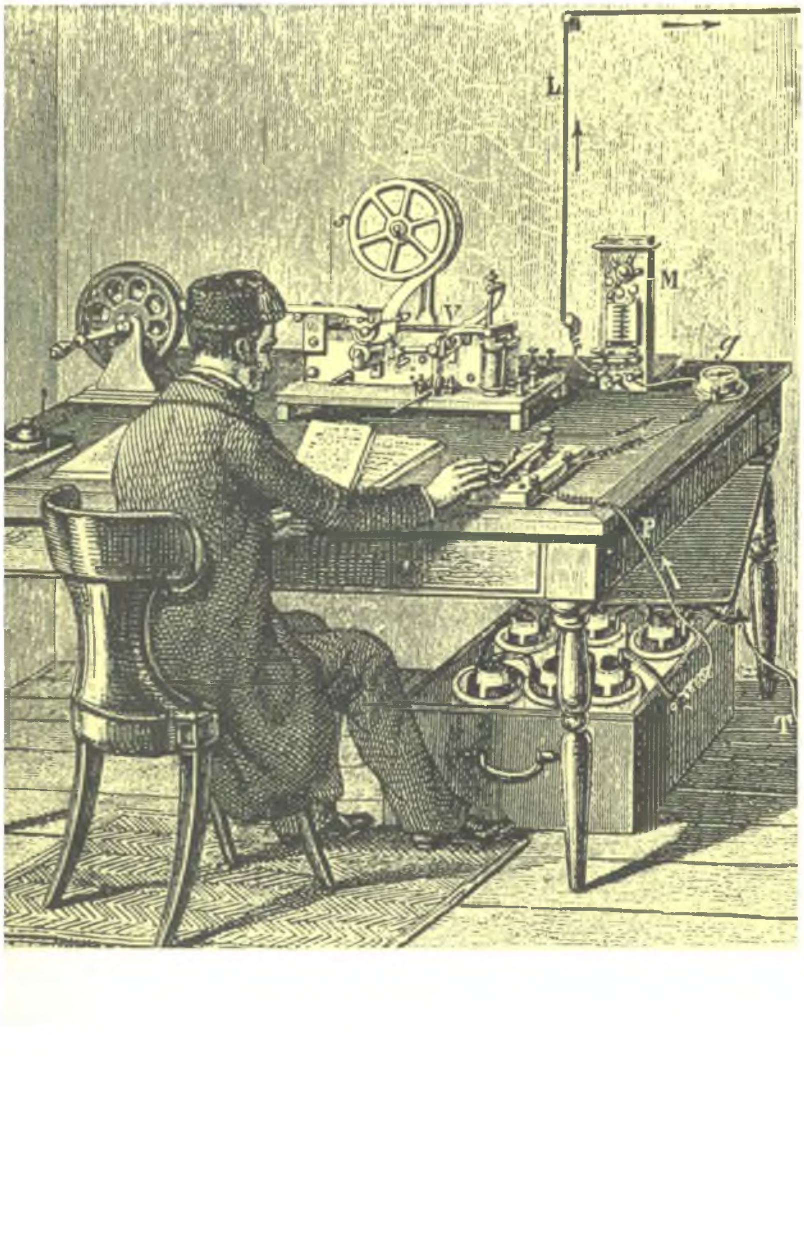

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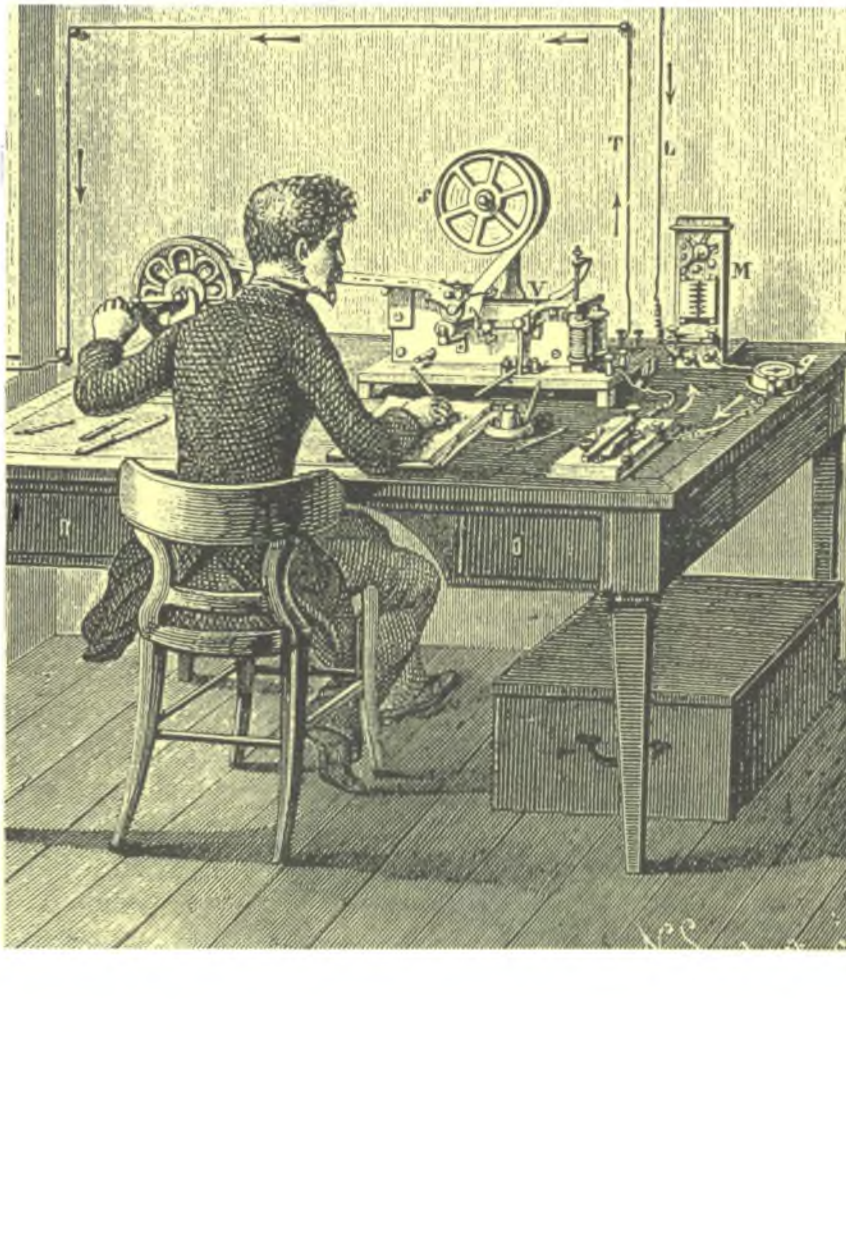

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40-41 Co-operation begins between the German telegraph operator on the left, sending a message, and the French operator on the right, receiving it. Both use Morse equipment.

42 The Indian Indore telegraph line with a single span, 1 km in length, coming down from the Hulner Ghat and crossing the Amar River about 1863.

43 Telegraph Map of India, 1855.

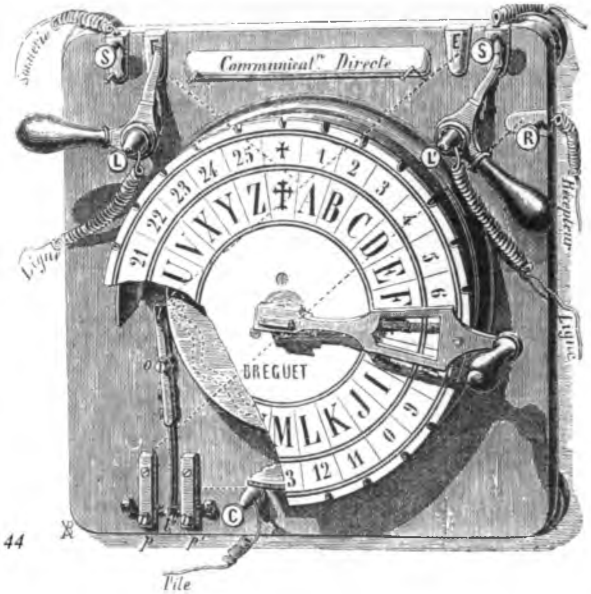
44 The Bréguet telegraph transmitter of 1845.

45 Music by electric telegraph (1850).

thus getting rid of the necessity of having operators handing forms across the frontiers. Morse telegraph apparatus was recognised as official for all international lines. Tariff zones were established and the cost of international telegrams calculated according to distance. Other meetings of the Union followed, Berlin 1853, Munich 1855 and Stuttgart 1857. At this last conference a sensible step was taken which laid the pattern for all subsequent conferences on communications and which is still to-day the guiding rule of the International Telecommunication Union, more than a hundred years later.

All the international provisions which were considered of a rigid nature, such as the legal relations between the contracting states or the bases for the fixing of the tariffs, were placed in a Convention. Other provisions, more likely to alter, were embodied in Regulations, annexed to the Convention; they dealt, for example, with all matters concerning the use of telegraphs by the public, and above all with technical matters. This dual system of permanent Conventions and more flexible Regulations proved invaluable when constant scientific progress forced upon the Members of later Unions frequent alterations at the technical level; these could be carried out by subject experts. The principles of the Unions embodied in the Convention were left untouched by such progress, but could of course be modified when the contracting parties wanted to do so on a diplomatic level.

The success of the Austro-German Telegraph Union led to imitation by other countries. Agreements between two countries for international telegraphy had been signed between France and Belgium in 1851, France and Switzerland in 1852, France and Sardinia in 1853, and France and Spain in 1854. Delegates from these five states met in Paris in 1855 and created their own, the West European Telegraph Union. With the exception of lower telegraph rates, their provisions were identical to the German Union. But in their case the question of language arose in which telegrams could be accepted for transmission. At Paris it was agreed that French and English could be used, although Great Britain was not a Member, as well as German, Italian and Spanish. Other conferences followed, Turin 1857, Bern 1858, Dutch and Portuguese became official languages, and other countries joined. It must always be counted to the credit of the Members of these two Unions, the Austro-German one and the West European one, that they soon got together and reached common agreement on international telegraphy. Belgium, France and Prussia signed a Convention in Paris in 1852, which was remarkable for the breadth of agreement that could be reached. The three governments undertook to construct telegraph lines to pass frontiers without inter-



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ruptions, they recognised the right of every individual to use the international service upon payment of the necessary charges at the point of origin, and they guaranteed the secrecy of telegrams sent; in case of loss, or undue delay, a refund was to be made. However, only Governments could use cipher telegrams.

This agreement was indeed a major achievement, and its basic provisions have held true until the present time. Two further conferences of these three countries followed, Berlin 1855, and Brussels 1858, at which the basic provisions were somewhat extended. For the first time telegrams containing numbers were admitted when they dealt with a commercial text, the rates were lowered, and individual telegraph offices were given the right to refuse telegrams which were contrary to good morals or public security.

No wonder that these foundations of international telegraphy appealed to many countries, and between 1859 and 1861 a further 11 independent states signed the Convention. They were, in chronological order, Switzerland, Spain, Sardinia, Portugal, Turkey, Denmark, Sweden and Norway, the Papal Government, Russia, the Two Sicilies, and Luxembourg. But still the flow of telegrams from country to country was impeded. For example, in 1859, a telegram, depending on its destination, might well be subject to as many as three different sets of regulations. Further conferences were held in an attempt to overcome this disadvantage, in Friedrichshafen, 1858, and Bregenz, 1863, but the final, and only logical answer came in 1865. A year earlier, the French Imperial Government had sent out invitations to all the major countries in Europe to attend a conference beginning in Paris on March 1, 1865, to negotiate a uniform international telegraph system.

Twenty states accepted this invitation and their delegates met in Paris until May 17, 1865, when they signed the first International Telegraph Convention. This was the date of birth of the International Telegraph Union, a date not only memorable for all concerned with electrical communications, but also for all who see in international co-operation the surest sign of progress for all mankind. In spite of many differences of opinion, sometimes heated, and often extending over many years, these differences have invariably been only about the best methods of achieving international collaboration.

Once co-operation on an international level had begun in 1865, there has not been a single voice raised for a demand to abolish it again. After a 100 years of success, and after a scientific evolution which would have dumbfounded the delegates to Paris in 1865, a reversion to independent national regulations would be quite unthinkable.

MUSIC BY ELECTRIC TELEGRAPH.

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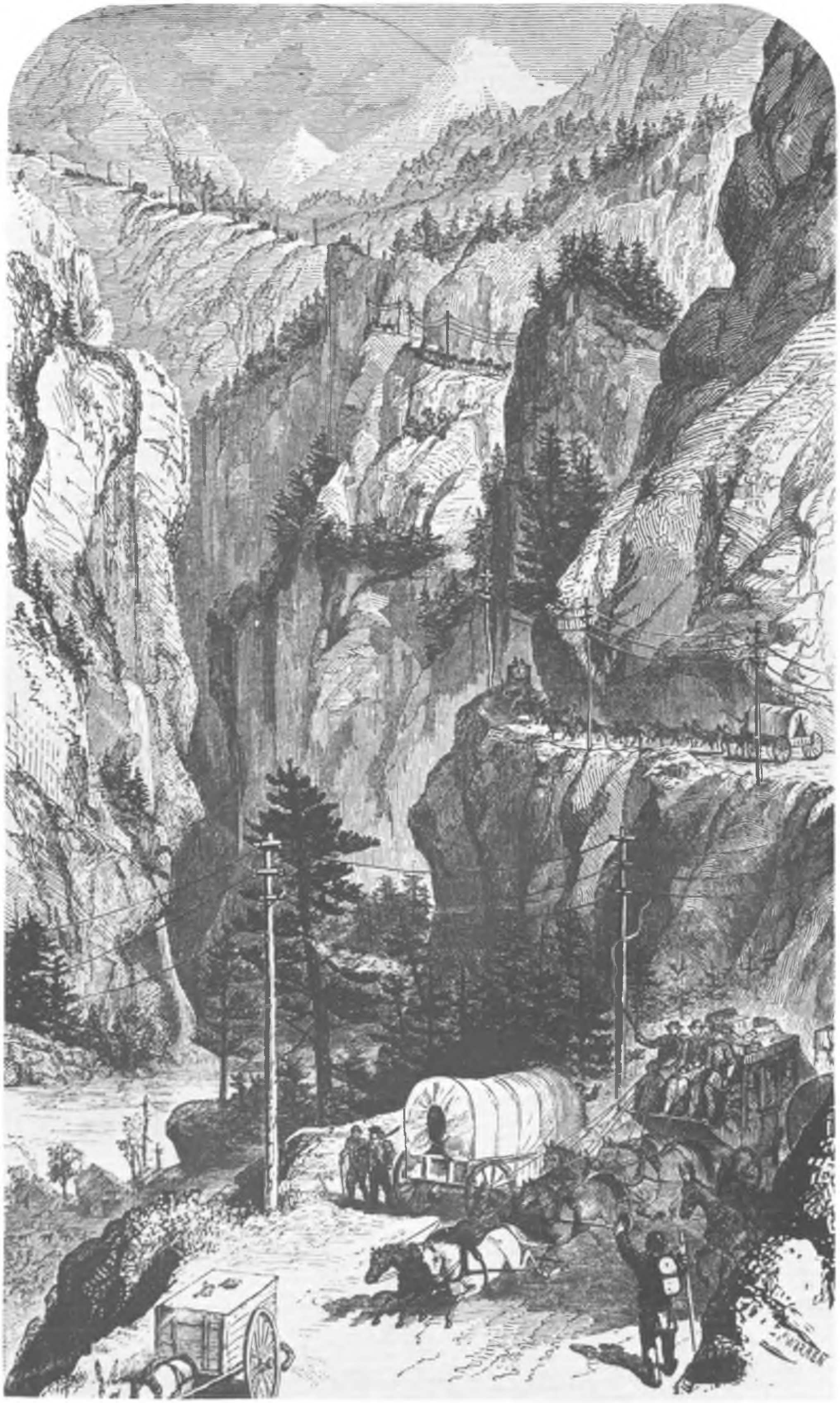

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46 One of the most difficult sections of the first transcontinental telegraph line across the U.S.A., laid in 1860, was the construction over the Sierra Nevada Mountains of the Far West. This artist's conception shows wagon trains travelling the telegraph route near Carson City, Nevada.

47 A Pony Express rider is depicted passing a transcontinental telegraph line construction crew in this painting by Norman Price. With the completion of the telegraph line across the U.S.A. in 1861, the Pony Express went out of business after 18 months of activity.

47

Paris — 1865

It is difficult to imagine in 1965 what the world looked like in 1865, a hundred years ago. Undoubtedly the centre of political power rested still firmly in Western Europe, with France ruled by her Emperor Napoleon III and England by her Queen Victoria. In the centre of Europe, the treaty of Gastein was signed in 1865; it gave to Prussia the administration of Schleswig and to Austria that of Holstein, two provinces of Denmark which Prussia had won during the war of the previous year. The treaty temporarily avoided a war between Austria and Prussia, and King William I of Prussia was so pleased about this that he created Otto von Bismarck a Count.

Across the Atlantic Ocean, still weeks distant from Europe by sea and not yet linked by submarine cable, other momentous events had occurred. The Civil War between the North and the South had come to an end on Palm Sunday, 9 April, 1865, when Lee surrendered to Grant. Six days later, President Abraham Lincoln died, murdered while attending Ford's theatre in Washington the previous night; Reuter's telegram reported this tragic event to London earlier than any other news channel.

Half way round the world from Europe, in far distant Japan, another event shook another people. An allied squadron of warships, composed of British, French, Dutch and United States men-of-war, was lying at anchor off Kyoto and imposed a treaty on Japan which opened this country to the world. It was indeed a time of changes, but the results of many were hardly yet apparent.

In London's British Museum Library a 47-year old reader was correcting the proofs of his book to be published in 1867; his name was Karl Marx, his book "Das Kapital". Perhaps even more unforeseen in its consequences was the work of Henri Sainte-Claire Deville, who in 1854 showed in Paris for the first time small quantities of the new metal aluminium; at the time it was more precious than gold, and when Napoleon III entertained Queen Victoria during a State visit to Paris her food was served to her on an aluminium plate.

The chemical sciences were also still in their infancy. However, one of the greatest of all discoveries in the field of inorganic chemistry was made at that time by Dimitri I. Mendeleyev, the professor of chemistry at the Technological Institute of St. Petersburg in 1865. He was then writing his fundamental book in which he revealed the Periodic Law of all chemical elements, setting them out in his famous table; his brilliant predictions of the properties of still unknown elements were a few years later completely confirmed.

48 *Heads of delegations attending the first Conference of the International Telegraph Union in Paris, 1865*

CONFÉRENCE TÉLÉGRAPHIQUE INTERNATIONALE

PARIS 1865.

48

FERNIQUE ✱ PHOT. 31, RUE DE FLEURUS, PARIS

Danemark	Bavière	Norvège	Wurtemberg	Belgique	Portugal	Secrétaire	Suisse	Bade	Turquie	Prusse	Italie	Grèce	Secrétaire	Espagne
Faber	*de Weber*	*Nielsen*	*de Klein*	*Vinchent*	*Damasio*	*de Lavernelle*	*Curchod*	*Poppen*	*Agathon Effendi*	*de Chauvin*	*Minetto*	*Manos*	*Dupré*	*de Hacar*

Pays Bas	Bavière	Hanover	France	Belgique	France	Suède	Espagne	Russie	Autriche
Staring	*de Dyck*	*Gauss*	*Jagerschmidt*	*Fassiaux*	*Vte de Vougy*	*Brandström*	*Sanz*	*Gl Mjr de Guerhard*	*de Wattenwyl*

49 *The first Convention of the International Telegraph Union was signed by twenty States in Paris on May 17, 1865. It embodies the basic principles which are still held by the I.T.U. of to-day. For example, the order of priority of telegraph messages: first those of the State, followed secondly by telegrams of the telegraphic administration, and only thirdly, private paying telegrams (Article 11).*

1865

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About this time another outstanding scientific event took place in England: Charles Darwin published in 1859 his book "The Origin of Species by Natural Selection"; it was immediately sold out. Also in 1859, on 28 August, E. L. Drake struck oil at a depth of 23.5 m near Oil Creek in Pennsylvania; this date is generally considered the beginning of the petroleum industry.

While these scientific events occurred in Europe, in far distant Australia a courageous explorer, John McDouall Stuart, made his third attempt in 1863 to cross the continent from Adelaide in the south to the Timor Sea in the north; after incredible hardships he succeeded as the first white man to do so. When later a telegraph line was laid which linked the Australian cities with London, it followed the route he had surveyed. Australia was then indeed a long way from Europe and from modern thought; the penal system which sent convicts from England only came to an end in Western Australia in 1868, although it had ceased earlier in the Eastern States.

But all these happenings may have meant little to the delegates who came to Paris in March of 1865 to attend the first meeting of the International Telegraph Union. However, there were two events in Paris itself which they could have hardly helped hearing about. One was the work of Baron Eugène Haussmann (1809-1891), who re-planned and rebuilt the centre of Paris; he laid out the Bois de Boulogne, created the now existing network of boulevards, planned a new water supply and a gigantic system of sewers, in which incidentally the wires of the early telegraph lines were laid. In 1865, Baron Haussmann had just received a loan of 250 million francs for the reconstruction of Paris.

The publication of his third book by a promising young author was the second event which the delegates might have discussed during their leisure hours. Its title was "De la Terre à la Lune", its author 37-year old Jules Verne. One of the most remarkable predictions of this book has already come true. The site for the firing of the giant cannon, which shot a shell with three astronauts towards the Moon, was at "Stone Hill", a mere 240 kilometers to the South of Cape Kennedy in Florida.

To this Paris of Baron Haussmann and Jules Verne came the delegates of Austria, Baden, Bavaria, Belgium, Denmark, France, Greece, Hamburg, Hanover, Italy, the Netherlands, Norway, Portugal, Prussia, Russia, Saxony, Spain, Sweden, Switzerland, Turkey and Würtemberg. No doubt, in their train journeys across Europe, they must have seen the telegraph wires strung alongside the railway tracks, and they may well have speculated on the relative speeds of their journey and of the messages flying

51

along the wires. Particularly the delegation from Turkey must have been deep in thought, as on part of their journey they still had to use the faithful horse. In 1865, there was no direct railway link as yet between their country and France. England, the only other European state with an important telegraph network, was not invited because her telegraph services were in the hands of private companies.

There to welcome the delegates was the French Minister of Foreign Affairs, M. Drouyn de Lhuys. He became the Chairman of the Conference and told the delegates in his opening speech that France wanted to draft a single Convention, to bridge the gaps between the two existing ones, the Austro-German and the West European Conventions. He also hoped that a single uniform telegraph rate could be arrived at. Draft documents had been prepared by France, and they formed the basis of the work in committee. Each delegation was given a single vote, and it was agreed that decisions would be made by a simple majority. The special committee met sixteen times, agreement was reached on all points, and the final documents were signed. It was indeed an easy birth.

The Convention and the annexed set of Telegraph Regulations followed closely the decisions of the 1858 Bern Conference of the West European Telegraph Union. A uniform rate of tariffs was now in force for most of Europe, with the concession, however, that Russia and Turkey were allowed to charge more for telegrams to the Eastern-most parts of their territories. The gold franc was accepted as the monetary unit for all international accounts, and private telegraph companies in States which were Members of the new International Union were asked to conform to its rules and regulations.

In only one point was the French draft found unacceptable; the conference was not willing to set up a permanent commission; it was meant to draw up special telegraph maps, undertake statistical work and study any special technical matters. It was agreed that the Convention should be periodically reviewed and that, for that purpose, further International Conferences were to be held from time to time in the capitals of the contracting parties. The first of these was in Vienna in 1868, and others followed.

Before considering in detail the achievements of these conferences and of the International Union we must briefly glance at the ever-growing telegraph traffic and the technical achievements which made them possible. So, for example, the lengths of telegraph lines of Member States of the Union were 500,000 km in 1865, and had grown to 7 million km by 1913; similarly, the total number of telegrams sent was 30 million in 1865 and by 1913 had surpassed the 500 million mark. How much the work of the

50 *Medal struck in 1866 by the Paris Mint to commemorate the first Conference of the International Telegraph Union, held in Paris in 1865. Two Bréguet telegraphs are shown. " Man's knowledge can encircle the earth by means of signals."*

51 *Title page of Jules Verne's famous novel, published in Paris in 1865. (The second part of the story, " Autour de la Lune ", was not published until 1870.)*

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52 *The Central Telegraph Office in Paris, about 1860.*

International Telegraph Union contributed to this growth we shall see in the subsequent chapters. This vast expansion would have been impossible with the primitive Morse instruments or with the oscillating needles of Wheatstone's apparatus. However, even to-day the single telegraph line with its handy Morse key on one end and the clockwork driven receiver with its tracing pen on the other are still serving simple needs of slow but telegraphic communications in countries which are just beginning to open up. Wheatstone's two-needle telegraph remained in use in England for many years after its invention, and great proficiency was achieved with it; its code was built up by counting the deflections of the two needles. For example, the letter *a* was one left deflection of the left needle, *b* two deflections of the same needle, and *e* one left deflection of the left needle and two right deflections of the right needle. At the height of its success over 1000 young telegraph operators, boys and girls about 15 years old, were employed in London alone; their rapidity of moving the needles was greatly admired by the privileged visitors who were allowed to watch their work in the Lothbury Head Office of the Electric Telegraph Company.

None of the other European countries adopted the Wheatstone telegraph, except Spain for a short time. The Morse system was universally preferred, and in the 1865 Telegraph Regulations drawn up by the Paris Conference it was stated that the Morse instrument was provisionally adopted for use on international lines. By 1903, when traffic had grown and more efficient apparatus had become available, the Regulations drawn up at the London conference of that date relegated the Morse apparatus to lines of moderate activity, the Hughes equipment was recommended for more active lines, and those that handled more than 500 telegrams a day were advised to use the Baudot system or similar improvements.

But on the whole the Union did not often recommend to its members the specific type of telegraph equipment to be used. It had become self-evident that the international telegraph service was of such political and economic importance that each member country would do its utmost to improve its own technical facilities. It was also thought that too strict a control might hinder scientific progress.

As traffic grew, the inherent defects of the Morse system became more and more obvious. First of all, a relatively strong current was needed to operate the electromagnet which moved the stylus, and later the printing wheel, which marked the moving strip of paper with its characteristic dots and dashes. This could be overcome on a long line by placing relays or repeaters into the electric circuit at intervals, but this meant additional installations. Secondly, the strip of paper with its dots and dashes could not simply be passed on to the user, but had to be transcribed into plain, uncoded language; this of course meant delay and extra staff.

The development of telegraphy has therefore moved in the direction of printing out the message in plain letters as they are sent and received, thus greatly increasing the speed with which messages can be handled at both sides. A second major improvement came with the design of telegraph circuits which allowed more than a single message to travel over the same wire at any given time.

The first step in the direction of plain language telegraphy came in 1855, 10 years before the Paris Conference, when David E. Hughes was granted a patent for a new telegraph. He, like Morse, was professor at New York University, but unlike him he was born in London and a professor of music. His apparatus was however mainly used in Europe, as the patent position in the U.S.A. prevented him from exploiting his invention there. Although his French partner, Gustave Froment, brought the new telegraph to a relatively high state of perfection, its mechanical parts were, to begin with, complex and often broke down. Yet it was a great advance over the Morse system which could send only about 25 words per minute, whereas even the early types of the Hughes telegraph achieved between 40 and 45 words per minute.

Its principle was simple. A continuously rotating wheel had 28 letters of the alphabet and other signs on it, and a clutch mechanism, actuated by an electromagnet, brought the wheel momentarily to rest when the desired letter was over a moving strip of paper. Ink was continuously fed to the type-wheel from a roller, and thus a message in plain language could be spelt out straight onto the receiving paper. For sending a message, the operator had in front of him a piano keyboard which relayed to the receiving post the electric impulses, which there stopped the type-wheel at the right instant of time. From this basic principle has grown over the decades the modern automatic telegraph printer, but only after many improvements in layout, design and detail.

The next step forward in telegraphy came from Emile Baudot, an officer of the French Telegraph Service. He introduced the five-unit code in which each letter of the alphabet was represented by a special combination of five elements. For each letter, therefore, five impulses were sent over the telegraph line, and on the receiving end actuated a set of five magnets. He combined the use of the five-unit code with

53

the time division multiplex system, thus allowing several telegraph communications to be transmitted over the same circuit.

The sending operator uses for his work a special keyboard of five keys, and on the receiving side, the strip of paper passes through an electrical printer, which prints out the telegram in clear language. In modern machines using these principles a speed of 60 words per minute, or one six-letter word per second, is allowed for in the design of the telegraph, it being considered the maximum speed at which operators can work economically for a long time. Baudot's system was first introduced in 1874, and officially adopted by the French Telegraph Service in 1877.

Although the United States of America had been linked to Europe by the two Atlantic cables of 1866, private American telegraph companies were not represented during the first conferences of the International Union. The first to come was a representative of the Western Union Company; he went to the Berlin Conference of 1885. But the ever increasing demands on telegraph services, in the United States as well as in Europe, led to many important technical improvements of the American telegraph system. One of the most important of these was the sending of more than a single telegraphic message over the same wire. It was Thomas Alva Edison (1847-1931), who in 1874 advanced this technique more than anyone else.

There can be little doubt that international co-operation occurred on the technical level of telegraphy as early as it did on the administrative side; and furthermore, the results of the discussions of the technical committees of the International Telegraph Union found their way across the Atlantic to the American telegraph engineers. The first to use a single telegraph wire for the sending of two messages, one in each direction, was a Dr. Gintl in Vienna in 1853. Without going into the technical details of his "duplex" circuit, it meant the incorporation of a balance filter in the circuit, thus making it unaffected by the signals sent out, but fully responsive to those coming in. This led to such economic advantages that many others carried on his work and improved it on both sides of the Atlantic. Artificial lines, Differential Duplex circuits, and Bridge Duplex circuits were all steps in this development.

Edison, who had himself earned his living as a telegraph operator since the age of 15—he was still only 18 years old when the Paris Conference met in 1865—naturally turned his superb inventive brain to the improvement of the telegraph services of his time. He took out patents for duplex circuits and

53 *A French Baudot telegraph, invented in 1875, was used in England from 1879 onwards on the Anglo-French submarine cable. This instrument was installed for quadruplex-duplex working, also between London and Birmingham in 1910.*

54 Complete telegraph installation as constructed by Bréguet in 1844.

55 A Morse installation for four telegraph lines, the standard of the French Post and Telegraph Department of 1889. This should be compared with the previous photograph, forty-five years earlier.

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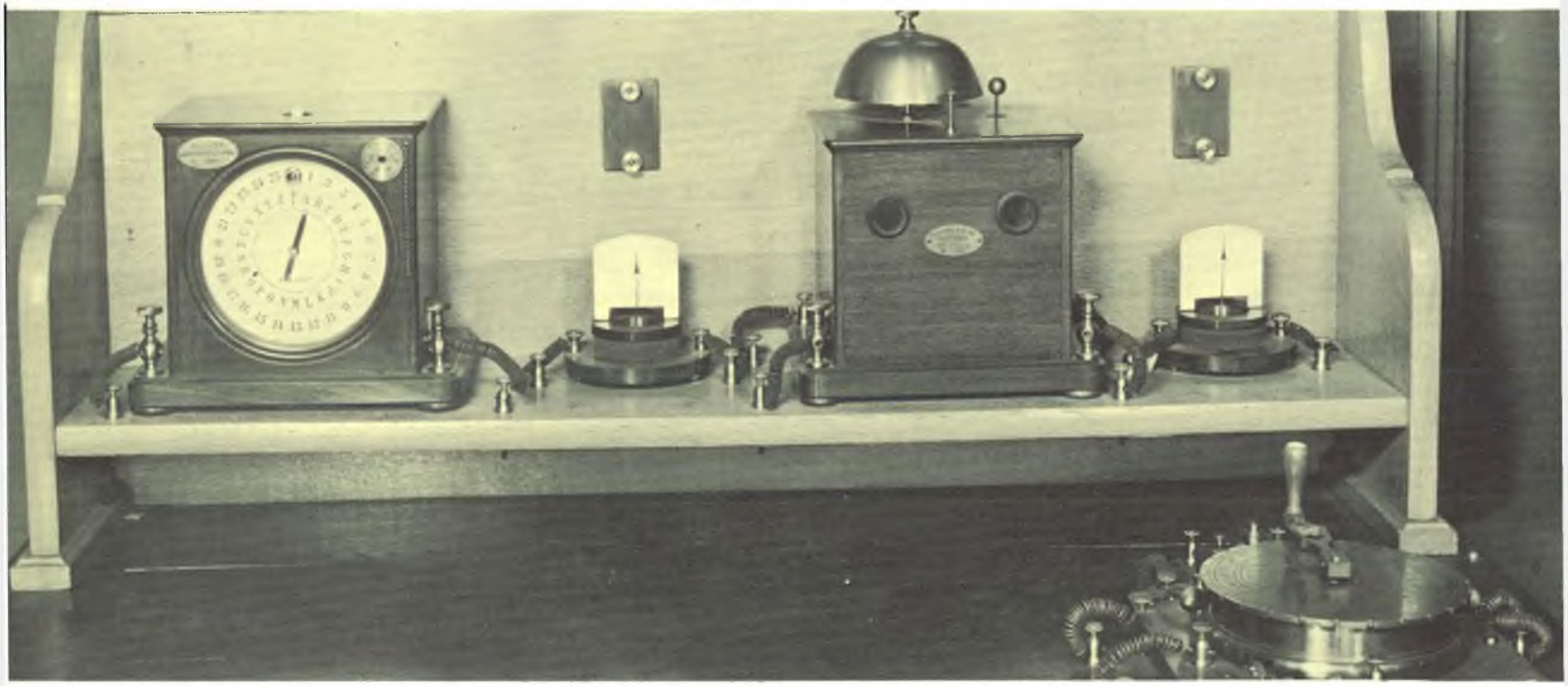

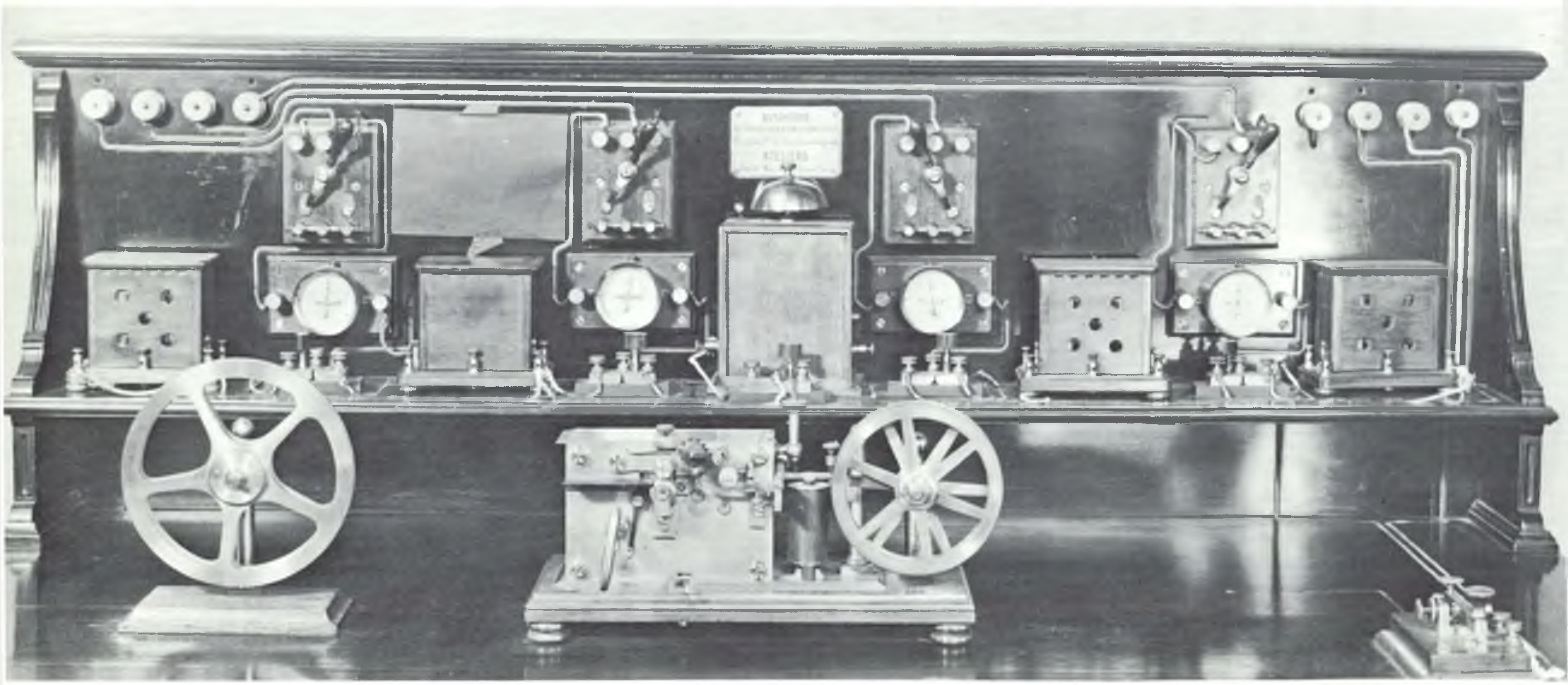

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56 *Brett's electric printing telegraph, patented by Jacob Brett who, in 1845, proposed to the English Government that it be used to connect London with the Channel Islands and the Colonies.*

57 *Hughes' telegraph sending equipment of 1855.*

58 *Caselli's facsimile telegraph transmitter, one of the first to send examples of hand-writing and simple pictures over telegraph wires.*

59 *The receiver of Caselli's facsimile telegraph.*

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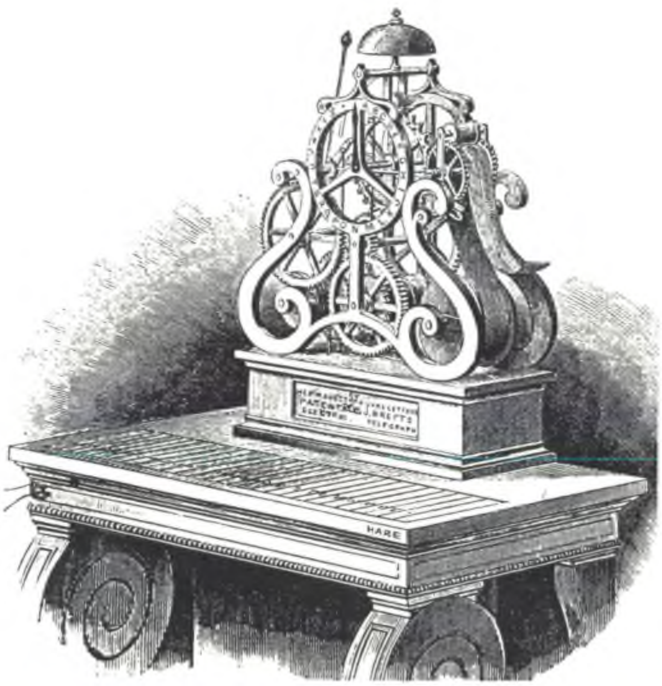

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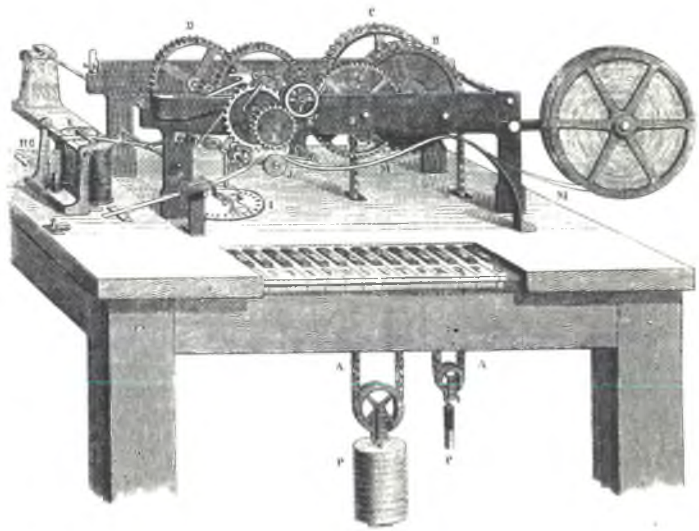

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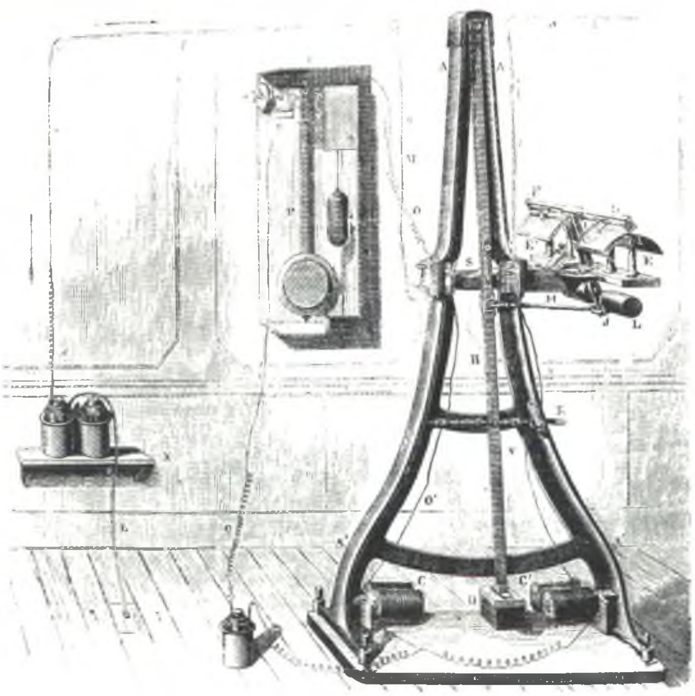

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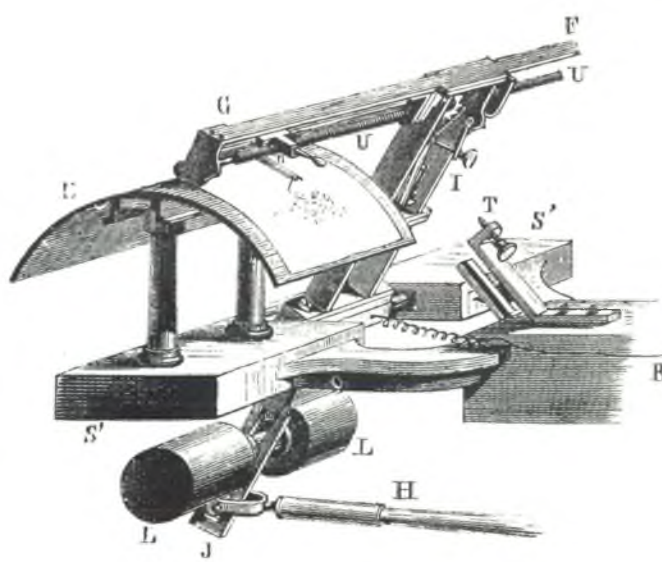

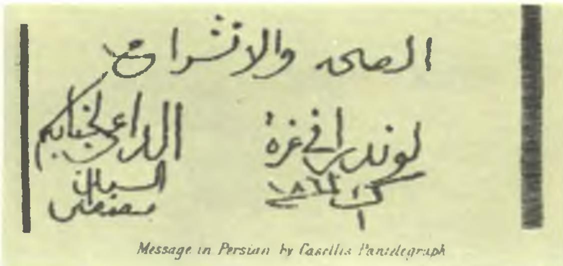

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60 Message in Persian by Caselli's facsimile telegraph.

61 An early American telegram of 1867.

62 An early telegram sent August 26, 1865, over the telegraph system worked by the English South Eastern Railway. The regulations printed on the back of the form state, amongst other details, that "messengers are despatched with Telegraph Communications, immediately on their arrival, at a charge, if on foot, of ½ shilling per mile for the first three miles."

in 1874 he invented the quadruplex circuit. With this technique it became possible for four messages, two in each direction, to be simultaneously transmitted over a single telegraph wire.

This trend of sending more and more messages over the same electrical conductor has continued ever since; in telegraphy it found its perfection in the multiplex system, and in telephony we can now transmit thousands of simultaneous telephone conversations over the same co-axial cable. If we think back for a moment to the early pioneers of telegraphy, using a single separate wire for each letter of the alphabet, and compare that with the thousands of simultaneous telephone conversations, we can see at a glance how tremendously the communications engineer has contributed to the progress of civilisation.

Undoubtedly, both the duplex circuit and the Hughes' telegraph were discussed at the Paris Conference of 1865. To some they might have appeared as much science fiction as Jules Verne's cannon shot to the Moon. But to others, these new ideas were a stimulus to improve the international telegraphy service both on the technical side and from an administrative point of view. The Paris Conference was certainly an outstanding event and had set the pattern for international co-operation for the next hundred years. As the delegates travelled back to their respective homes, by railway or by horse, they could certainly be proud of the work they had achieved.


THE WESTERN UNION TELEGRAPH COMPANY.

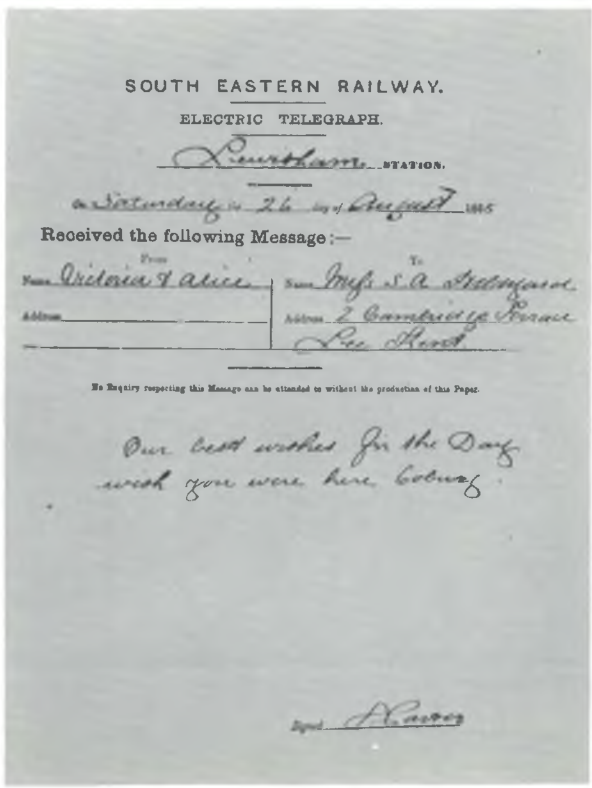
Dated, Camden Me 4th 7

Received at Boston Dec 4

To W. B. Spooner & Co

Gold appears weak buy when you think best. —

H. H. Hunt


SOUTH EASTERN RAILWAY.

ELECTRIC TELEGRAPH.

Lewisham STATION.

Saturday 26 August 1865

Received the following Message:—

From Victoria & Alice

To 2 Cambridge Terrace Lee Road

No Enquiry respecting this Message can be attended to without the production of this Paper.

Our best wishes for the Day wish you were here Coburg.

61

62

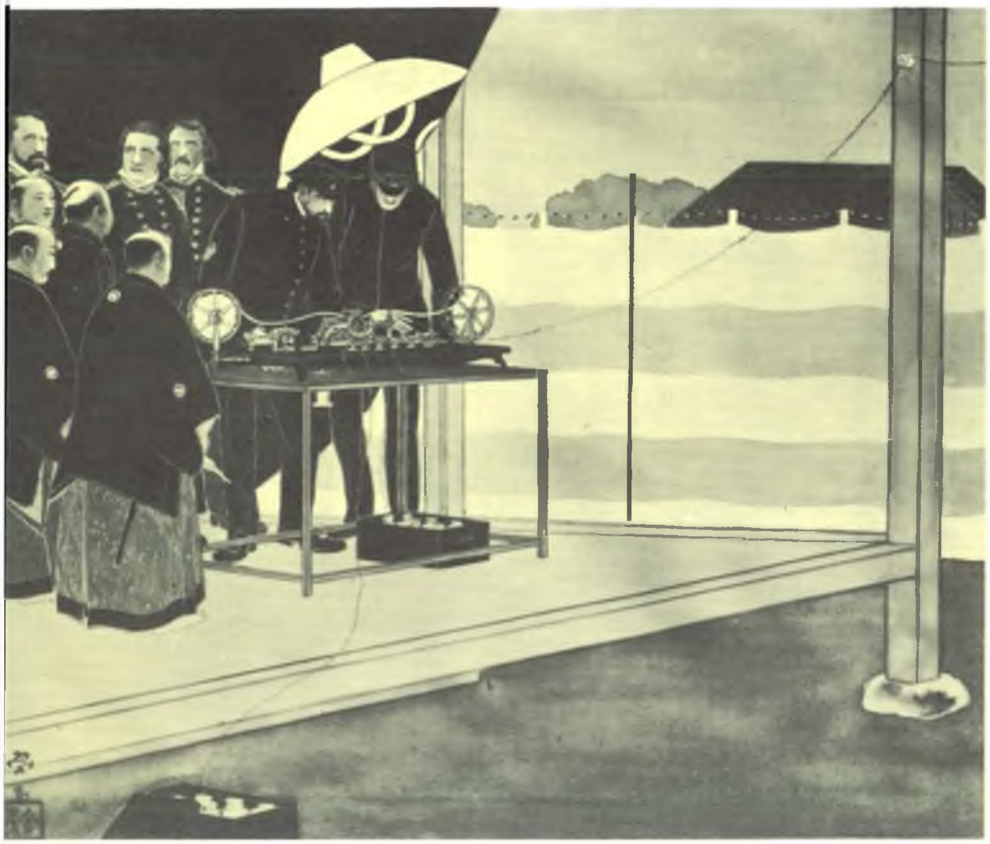
The Pioneering Work of the Telegraph Union

The Conference in Paris of 1865 started, without of course knowing it, at least a hundred years of uninterrupted universal co-operation in the field of telecommunications. The reasons for this unique success can to-day be clearly seen. They lie in the wisdom of its founder Members, coupled with luck and good fortune. Undoubtedly the Telegraph Union, earlier than any other organisation, evolved a policy of separating diplomatic and technical discussions, thus giving rise to separate documents and conferences. Only in this way could the extremely rapid growth of scientific and technical progress be absorbed and followed by relatively frequent changes in the Regulations of the Union. And yet it left the basic principles of international co-operation, embodied in its Convention, unchanged for many decades.

Another pioneering achievement of the Telegraph Union was the setting up, at its second International Conference at Vienna in 1868, of a permanent Bureau. It was to continue the statistical and technical information work for its members between the formal meetings of the conferences. These are indeed the tools of successful international work, imitated again and again, in many other fields of human endeavour.

Through the League of Nations to the United Nations of to-day, through the more recent work of the International Council of Scientific Unions, and through many other international bodies, there run again and again the same basic principles, separation of conferences at different levels, a permanent international secretariat, specialist publications, and a regular international monthly journal. One might almost say that these tools have been accepted sub-consciously. Without them, one cannot even imagine any organisation functioning at an international level. But when the Telegraph Union started, none of these tools had been thought of nor were they in existence.

There was one further reason which made international co-operation imperative for the Telegraph Union. And that was the speed of telegraphy sending its messages at the unimaginable velocity of about 300,000 kilometers per second. Even the earliest telegraph operators must have realised that their "useful and indeed marvellous instrument of communications" could only fulfil its functions if all attendant operations were carried out as fast and as efficiently as possible. Whatever human inferences occurred, even the simple act of transcribing the dots and dashes of the Morse signal into plain language, meant a delay of vast proportions when compared with the speed of electricity itself.



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63 *Commander Perry demonstrating to Japanese officials in 1854 the embossing Morse telegraph set at Yokohama, over 1.6 km of single wire line.*

64 *The first public telegraph service was inaugurated in Japan in 1870. It transmitted telegrams between Tokyo and Yokohama, using a Brĕguet telegraph, suitably modified for Japanese characters.*

65-66 *Brĕguet telegraph used in Japan in 1870. Left — the receiver. Right — the transmitter.*

66

This is not so for other branches of transport and communications. The transport of postal mail across frontiers led to the Universal Postal Union in 1874, following a preliminary conference in Paris in 1863. In 1882 the first international railway conference was held at Berne, as Switzerland was then considered the "turn-table" of Europe. Both for mail and rail, sorting and shunting are inevitable and bring delays, but of an order comparable to the speed of transport between their destinations. For the smooth dispatch of letters and trains across frontiers, international co-operation was highly desirable. For telegraphy, it was imperative.

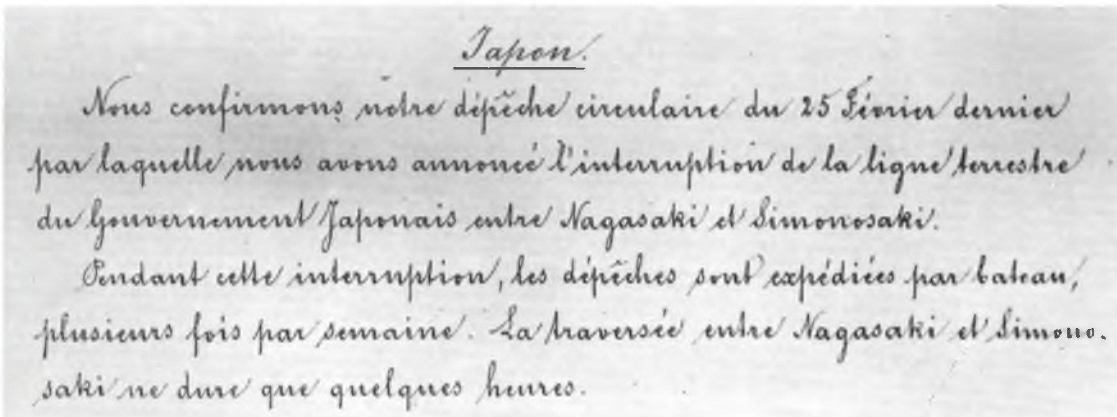
Let us then look at the Conferences of the Telegraph Union and at its structure, which made its success possible right from the beginning. The second plenipotentiary conference of the Union took place at Vienna in 1868, the next one at Rome in 1871, and the fourth and last plenipotentiary conference of the International Telegraph Union at St. Petersburg in 1875. At these plenipotentiary conferences, the Members of the Union were represented on both the diplomatic and the administrative level. The work of the diplomats was concerned with the drafting and revision of the Conventions which were in the form of international treaties concluded between the "High Contracting Parties" (*Les Hautes Parties Contractantes*). So successful was their final revision of the Convention at St. Petersburg in 1875 that they did not meet again until 1932, in Madrid. There the decision was taken to combine the Radiotelegraph Convention with the International Telegraph Convention, and to write the International Telecommunication Convention. This is still to-day the charter of the Union.

The major achievement of the Vienna Conference, apart from admitting Persia and India (the latter represented by Great Britain although not herself yet a Member) was the setting up of the permanent Bureau, charged with the routine administrative work of the Union. It was located at Berne in Switzerland from 1868 until 1948, 80 years. It then moved to Geneva and became the present general secretariat of the International Telecommunication Union, or I.T.U. as it is now universally called.

The Bureau was a purely secretarial body and had very limited powers to exercise any authority. The Swiss Government had, until 1947, complete charge of its organisation, including the advancing of its funds and the appointments of its Director and staff. Its duties were the publication of the Union's service documents, the preparation of the Union's Conferences, supplying a limited number of personnel for aid at the Conferences, and keeping records of telegraph, telephone and radio networks, as well as the important International Frequency List, all documents indispensable for the operation of international telecommunication services.

Among the many publications of the Bureau, its *Journal télégraphique*, begun in 1869 and carried on under this title until 1933, is undoubtedly in retrospect one of its most interesting publications. In its pages are chronicled not only the scientific and technical progress of all branches of telecommunications over a hundred years, but also many other milestones in the history of the Union. In 1934 it changed its title to *Journal des télécommunications*.

Among its outstanding services to international co-operation was the fact that it kept the spirit of the Union alive during the periods of two World Wars. In 1915, in the midst of World War I, it even published a brief commemorative history of the first 50 years of the International Telegraph Union. In it there is a description and an illustration of the commemorative monument which was erected on the Helvetia Square in Berne in 1915; its inscription: "LES ÂMES DES PEUPLES SONT RÉUNIES PAR L'UNION TÉLÉGRAPHIQUE" is certainly as true to-day as it was when the young Union held its first conferences.



Japon.

Nous confirmons notre dépêche circulaire du 25 février dernier par laquelle nous avons annoncé l'interruption de la ligne terrestre du Gouvernement Japonais entre Nagasaki et Simonosaki.

Pendant cette interruption, les dépêches sont expédiées par bateau, plusieurs fois par semaine. La traversée entre Nagasaki et Simonosaki ne dure que quelques heures.

67

67 When the Union was formed 100 years ago telegraph services were not always as reliable as they are to-day. An important aspect of the work of the Bureau at Berne was to issue notifications of break-downs, as for example the one shown here when the line between Nagasaki and Simonosaki was temporarily out of order. "Telegrams are sent by ship several times each week."

At Rome then, in 1871, Great Britain at last became a Member, having nationalised her telegraph services and thus qualified for membership. Japan sent for the first time an observer, a remarkable sign of her rapid appreciation of western thought and science. The Rome Conference also allowed private telegraph companies to be represented at all meetings of the Union, with the right of discussion but without the right to vote. The Conference must have met under the cloud of the Franco-Prussian War of 1870-1871, and we find that the Swiss delegate read to the Plenary Assembly two remarkable letters from the great American pioneers Cyrus Field and Samuel Morse. They both asked the Conference to take some action to neutralize telegraph lines in time of war. The Assembly found itself unable to adopt any resolution on this subject, but drew the attention of its Member governments to the views expressed.

The major achievement of the St. Petersburg Conference in 1875, the last of the plenipotentiary ones, was the re-drafting of the International Telegraph Convention. It consisted of 21 articles, in four major divisions: the relations of the contracting parties to the users of international telegraphy, the relations of the Members of the Union to each other, the composition of the Union itself, and finally the way in which the Convention and the Telegraph Regulations were to be applied. It was decided that the technical experts of the Members' telegraph administrations, for example of the British Post Office and of the French Administration des Postes et Télégraphes, to name only two, would be responsible for keeping the Telegraph Regulations up-to-date as well as revising the Table of Telegraphic Rates. These experts were to meet periodically at "Administrative Conferences", so called because they represented their own Telegraph Administrations.

Delegates from the Members of the Union with diplomatic powers were only to be called upon if and when it became necessary to revise the Convention, and this was not necessary until 1932 in Madrid. That the St. Petersburg Convention should remain in force for more than half a century, absorb a completely new medium of communications, the telephone, and weather the storm of World War I is indeed a tribute to the wisdom of the early planners of the Union.

Much of this credit must also go to the "Administrative Conferences" and their delegates. They met at London in 1879, at Berlin 1885, Paris 1890, Budapest 1896, London again in 1903, and Lisbon in 1908. By this time the membership of the Union had risen to 52 countries and 25 private companies.

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68 *The personnel of the Karlovo telegraph station in Bulgaria in 1881. In 1877 Bulgaria was liberated from the Turks by Russian troops, and at the London Conference of the International Telegraph Union in 1879, Bulgaria was represented by the Russian delegate. The Popular Republic of Bulgaria joined the Union in Berlin in 1885.*

69 *Instructing telegraph operators in the use of Wheatstone's telegraph at the London General Post Office, 1870.*

70 *This telegraph line was erected in 1880 to carry a single telegraph wire from Rawalpindi to Sukkur along the western bank of the river Indus. It runs through the Derajat plains and foot-hills and has not only faced the annual inundations of the Indus and its turbulent tributary torrents but has also withstood target practice by Baluchi and Mahsud marksmen. The telegraph line was taken as a symbol of British power by the tribesmen and damaging it was considered by them as a time-honoured method of registering their protest against the British. Though weak telegraph posts were replaced from time to time, the line still stands intact. The picture shows one of the original tubular posts set at 17.6 to a mile, with Baluchi peasants, telegraph linesmen and a Telegraph Supervisor.*

71 *The Indo-European Telegraph Line built between 1867 and 1870, by the German firm Siemens and Halske.*

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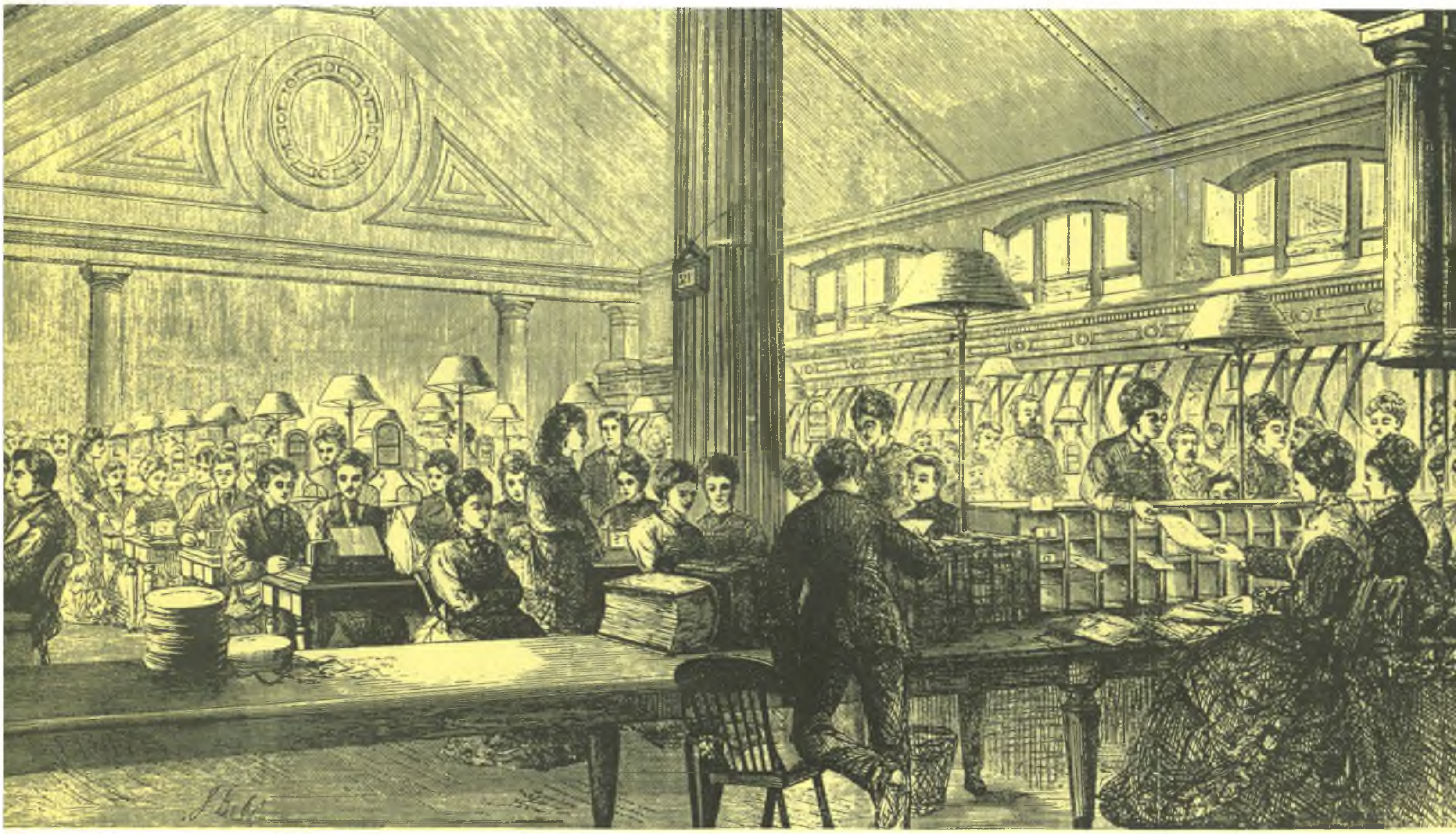
72 *The London Central Telegraph Office, 1874.*

73 *Various types of telegraph transmission and receiving equipment at the London Central Telegraph Establishment in 1874.*



72


Single Needle
Automatic
Old Double Needle or 'Cottage'
Hughes' Type Printing
Pneumatic Puncher
Direct Writer
American Sounder
J. Bell

73

World War I brought of course an end to this series of Conferences, and while it lasted international telegraphy was subject to the complete and arbitrary control of each national Government.

After the War, there were only two further Administrative Conferences, at Paris in 1925 and in Brussels in 1928; the re-arrangements of national frontiers after 1918 had an influence also on the Union, and, in consequence of it, its membership had grown to 78 by 1932. The most important achievement of the Paris Administrative Conference was the organising of two Technical Consultative Committees, the one concerned with Telegraphy, the other with Telephony. Each had its Plenary Assembly, the Telephone one meeting each year, the Telegraph one only every second year.

The *Comité Consultatif International des Communications téléphoniques à grande distance*, to give it its full name, had its own secretariat and laboratory in Paris, but the Telegraph Committee did not see a need for either a permanent secretariat of its own or a laboratory. Membership of these two Committees was open to any Member of the Union, and those who took part shared the costs of them. The Committees could not make any binding decisions, but the results of their study groups were issued as recommendations, published by the Bureau of the Union at Berne. The important results of the work of these two Committees, particularly in the field of international standards, will be reviewed in some detail later.

Finally a few words about the membership and the finances of the International Telegraph Union. Any telegraph administration could become a Member of the Union, a concept which had its origin at the very foundation meeting of Paris in 1865. In practice this meant that countries whose telegraph systems were owned by their governments could join the Union as full Members. Other countries, for example Great Britain until 1871, and the United States of America right through the history of the Telegraph Union, without nationalised telegraphy, could only send representatives of private companies. The United States took full advantage of this.

The other membership question which arose was concerned with colonial governments. So for example India, with its national telegraph system, became a Member before Great Britain. The principle of having colonial telegraph administrations as Members was accepted by the Union from its early days onwards.

A second important principle throughout the existence of the International Telegraph Union was that of simple majority decisions when it came to voting on any amendment. From this it should not be assumed that every decision was binding on every member government or member administration. After every majority decision there was a possibility of a refusal to be bound by this, if a formal statement to that effect was made; however, the use of this reservation was very limited.

The method of financing the activities of the International Telegraph Union was not simple. The expenses of the Bureau at Berne and of the Conferences were consolidated in one account, which were paid by the Members according to a Class-Unit system, first adopted at the Vienna Conference of 1868. As it is still in operation to-day, a century later, it must be judged as another one of the pioneering achievements of the early Union delegates.

Each Member chose a class for the payment of its obligations, there being then six classes: Class I with 25 units, II with 20, III with 15, IV with 10, V with 5 and Class VI with 3 units. The number of Members paying each class was multiplied by the units in that class, and the total of these six multiplications was added together; thus the total number of units available for that financial year was arrived at. The total expenses of the Union were then divided by the total number of units available, and thus the value of each unit was determined.

Hence each Member's annual payment was not only its own choice but was also related to the expenditure of the Union as a whole during that year. To take for example the year 1910, when the total expenditure was 126,000 gold francs; the total number of units available was 630, and hence the value of each was assessed at 200 gold francs. A Member who had decided to contribute in Class I would therefore have to pay 25 units of 200 francs each, i.e. a total of 5000 francs; a Member in Class VI, paying only 3 units would contribute 600 francs. Undoubtedly, it is a fair and equitable system which has indeed stood the test of time.

At the Atlantic City Conference in 1947, when the organisation of the I.T.U. was completely reconsidered, only two additional classes were added to the old system; a higher class of 30 units was added at the top of the scale, and a lower class of 1 unit at the bottom, making a total of eight. At the Buenos Aires Conference of 1952, the number of unit classes was enlarged to fourteen, ranging from 30 units down to ½ unit.

THE BATTERY-ROOM.

TRACING TELEGRAMS.

MESSAGE PRESSES.

THE CHRONOPHER, OR TIME-SENDER.

THE LINES TEST-BOX.

THE SYMPATHETIC CLOCK.

74

74 *Ancillary services at the London Central Telegraph Establishment of 1874.*

75 *Room with Hughes instruments for the traffic to and from Russia, established in the Central Telegraph Office in Berlin, 1896.*

76 *The monument erected in Helvetia Square, Berne, to commemorate fifty years of existence of the International Telegraph Union. It was inaugurated on December 16th, 1922.*

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76

Such then was the organisation and structure of the International Telegraph Union which lasted from 1865 to 1932. When it joined with the Radiotelegraph Conference to become the International Telecommunication Union, in Madrid, much of its structure and organisation was taken over and this continued until Atlantic City in 1947. There again those methods and techniques which had proved sound and efficient were continued, and still are so to-day. Plenipotentiary Conferences which alone are able to revise the Union Convention, Administrative Conferences to revise the Regulations for telegraphy, telephony and radio, technical consultative committees and a permanent secretariat, these all form the administrative apparatus of the Union, evolved and tested through many decades and directly descended from the original Telegraph Union. In the field of telecommunications, there has indeed been now a hundred years of uninterrupted international co-operation.

Telegraph Rates, Priorities, and Codes

If one of the primary objects in calling together the first International Telegraph Conference in Paris in 1865 was to fix an acceptable tariff for telegrams, then this was indeed a good choice of subject. It was discussed there and then at considerable length. More time has been devoted to rates and tariffs than to any other subject at this and at all the subsequent telegraph conferences of the International Telegraph Union. The two basic demands that were always so difficult to reconcile were for cheap international rates, so that the public would use telegrams as much as possible, and for a fair compensation for the various Government Administrations and for the private telegraph companies.

Constantly new factors were arising whenever telegram rates were discussed. Competition from new scientific discoveries, the telephone and radio, were only one aspect. Economic changes, such as the devaluation of currencies, and the cost of nationalising private telegraph companies, were other factors which made an agreement on international telegraph tariffs an ever new and always controversial subject for discussion at international conferences.

To illustrate the dramatic changes which have occurred in telegram rates during the last century, let us take the simplest case of the internal variations in a single country. Great Britain is here an excellent example. In the early 1850's, when telegraph facilities were still predominantly linked with railway stations, a telegram of twelve words between London and Manchester cost 5 shillings. In 1870, when the British Post Office had acquired the exclusive right to transmit telegrams within the United Kingdom, the charges for the same telegram had been lowered to 1 shilling. The lowest cost ever, in 1885, when 90 million telegrams were sent annually, was ½ shilling for a twelve word telegram. At present the cost of a twelve word telegram from London to Manchester has again risen to 5 shillings, almost twice as much as a 3-minute telephone conversation between the two cities.

If an international telegram is sent, say from Rome to London, then further financial complications immediately arise. The country of origin, Italy, and the country of destination, Great Britain, levy a charge for handling the telegram on dispatch and on delivery, the so-called terminal charges. In addition, if the telegram is routed through Switzerland and France, these two countries charge their own transit rates; and in the days when the submarine cable under the Channel was still the property of a private company, a further charge was payable for the use of this facility.

An international agreement on uniform terminal and transit charges was a highly desirable aim of the first Conference in Paris in 1865. This was particularly so, as several countries had different terminal charges, depending on the country of origin of the telegram they received. So, for example, Würtemberg, had a terminal charge of 3 francs for telegrams from all other Members of the Union, except for France, Italy and Switzerland, which were only charged 1 franc. Russia and Turkey also presented an exception, as they demanded different terminal charges according to the distance of the final delivery from their national frontiers. All these different terminal and transit charges were for the first time codified and published in a table annexed to the Convention of the Paris Conference in 1865.

Twenty years later, at the Administrative Conference of Berlin, a new system was established, which is still to-day the basis of the Telegraph Regulations of the I.T.U. In 1885, the world was divided into two parts: Europe and Extra-Europe. For Europe "*une seule et même*" elementary terminal charge and "*une seule et même*" transit charge was adopted for all states. The terminal charge was then 10 centimes per word, and later lowered to 6½ centimes; to-day it is laid down in the Telegraph Regulations that it should not exceed 15 centimes. For transit charges per word, the figures were 8 and 4 centimes and are to-day a maximum of 5 centimes. The Union of Soviet Socialist Republics have still to-day a maximum terminal charge of 32 centimes and Turkey one of 18 centimes.

Agreement on the terminal charges for telegrams outside Europe was not reached until the Administrative Conference of Paris in 1925, when maximum payments were established. The minimum number of words for a telegram inside Europe was also the subject of much discussion at the various conferences of the Union. A minimum of twenty words was for a long time the established figure; to-day it has been lowered to seven words, in the case of press telegrams to 14 words, and for letter telegrams to 22.

For all international accounting purposes, the French franc was accepted as the unit from the Paris Convention of 1865 onwards. This had to be revised in 1925, when the Gold franc had to be defined as the value of 100 centimes of a weight of 10/31 gram of gold of purity 0.900. This is still to-day the international unit for all telegraph accounts. When in 1931 Great Britain and many other countries left the gold standard but retained their old telegraph rates, this led to renewed difficulties. Many Continental telegraph users then found it cheaper to send their extra-European telegrams via England; in spite of the desire of the Continental and the British telegraph authorities to detect and to arrest this practice, it was impossible to stamp it out entirely.

77 *The remnants of a series of early telegraph poles used in Bolivia.*
They formed part of the first telegraph line between the cities of La Paz and Oruro in 1870. On top of the stone poles conventional galvanized iron cross-bars and porcelain insulators carried the copper wires.

78 *This open-wire telegraph line carrying 12 channels is in northern Finland. In remote areas where cable laying is not practical, use is still often made of these open-wire lines. Such weather conditions as those shown in the picture impose very great requirements on the maintenance of the systems.*

77 78

The priority of telegrams is another old telegraph practice dating back to the days of the optical telegraph, long before those of the International Union. It is still in force to-day. In the early days Government telegrams always came first, followed by service telegrams originating either from the railways or later the telegraph administrations, and lastly came the only telegrams that were paying, the social telegrams of the public and the commercial telegrams of industry and finance. The extent of the non-paying telegrams was dramatically revealed by the Berne Bureau in 1890, when the Belgian Telegraph Administration handled 5.3 million paying and 2.8 million non-paying telegrams; during that year the Belgian Administration made a deficit of 1.1 million francs.

A strict order of priorities is laid down in the current Telegraph Regulations issued by the I.T.U. Article 61 states that "telegrams relating to the safety of life on land, sea, or in the air, and exceptionally urgent epidemiological telegrams of the World Health Organisation shall have absolute priority over all other telegrams"; they bear the prefix: = SVH =. Next in order as laid down in Article 36 come telegrams of the United Nations, themselves arranged in the following order: The President of the Security Council, the President of the General Assembly, the Secretary General, the Chairman of the Military Staff Committee and so forth; certain United Nations telegrams have the prefix: = ETAT PRIORITE NATIONS =. Service telegrams, relating to serious interruptions of channels of telecommunications follow, having as prefix: = ADG =. Fourthly in order of transmission come Government telegrams for which priority has been requested; they must bear the paid service indication: = ETAT PRIORITE =.

Meteorological telegrams come next, identified by their prefix: = OBS =. Then follow urgent service telegrams, urgent service advice, paid service advice, urgent private telegrams, urgent RCT telegrams (dealing with persons protected in time of war by the Geneva Convention) and urgent press telegrams, all bearing the prefix: = URGENT = followed by the second prefix identifying the category. So for example an urgent press telegram would have the identification: = URGENT PRESS = as a prefix.

Then finally follow ordinary telegrams either of a private, government, or press nature, and letter telegrams which in the case of European ones carry the prefix: = ELTF = if they come from a Government, or simply = ELT =. Outside Europe, Government letter telegrams have = LTF =, and private ones = LT =. There are of course many other prefixes defined in the Telegraph Regulations, as for

79

example = LXDEUIL = meaning a de luxe telegram on the occasion of a mourning and = TR = meaning telegraph restant.

To send coded telegraph messages is a practice even older than the electrical telegraph. We have already seen that the great number of possible positions of the arms of the Chappe optical telegraph allowed single words and even whole phrases to be transmitted by a single code — position of the arms. The reasons for using a code have been the same for both the optical and the electrical telegraph: Secrecy and Economy.

It is doubtful to-day if secrecy can still be considered as the major reason for the use of commercial codes. Whereas in the past it took weeks and months to break a code, this operation can now be performed by electronic computers in a matter of a few hours if they have been suitably designed and programmed for this task. This is understood to be current practice when military and naval codes are used in the transmission of secret radio messages; apparently an hourly change of code is the only answer.

The reason of economy has also sometimes been self-defeating. Telegrams drafted in code were far more difficult to handle for the telegraph operator, as they had to be read and transmitted letter by letter. The difference of a single letter could change the whole meaning of a code telegram and operators were therefore often asked to repeat parts of, or even whole, telegrams. Not unnaturally, the telegraph administrations wanted to be compensated for the extra time and work involved.

The early Telegraph conventions and regulations permitted the public to draft its telegrams in any one of the "plain" languages used by Members of the Union, the only restriction being the length of words; they should not exceed seven syllables. By 1909, 47 official languages had been accepted by the Union, and amongst them we find Ammonitish, Annamese, Chinese, Croatian, Hebrew, Icelandic, Illyrian, Kiswahili, Lao, Latin, Luganda, Luxemburgian, Persian, Ruthenian, Siamese, Slovak and Slovenian, Turkish and Wolof.

The current Telegraph Regulations drawn up by the I.T.U. give no specific list of languages, but allow Latin and Esperanto. In addition they allow as plain language telegrams those to and from China, which are drafted in a four figure code, provided they are taken from the official telegraph dictionary of the Chinese Administration.

79 *Overhead line construction, mounting of the traverse supports on the pole.*

NOMENCLATURE OFFICIELLE

DES

BUREAUX TÉLÉGRAPHIQUES

OUVERTS AU SERVICE INTERNATIONAL

PUBLIÉE PAR LE

SECRETARIAT GÉNÉRAL DE L'UNION INTERNATIONALE DES TELECOMMUNICATIONS

21e ÉDITION

OCTOBRE 1961

SECOND VOLUME

M-Z

GENÈVE

PUBLIÉ PAR L'UNION INTERNATIONALE DES TÉLÉCOMMUNICATIONS

1961

SPRINGDALE — 142

Springdale, Newfoundland	Canada, Terre-Neuve.
Springdale, Arkansas	Etats-Unis.
Springdale, Connecticut	Etats-Unis.
Springdale, Iowa	Etats-Unis.
Springdale, Lexington Co.	Etats-Unis, Caroline du Sud.
Springdale, Montana	Etats-Unis.
Springdale, Ohio	Etats-Unis.
Springdale, Oregon	Etats-Unis.
Springdale, Pennsylvania	Etats-Unis, Pènsylvanie.
Springdale, South Carolina	Etats-Unis, Caroline du Sud.
Springdale, Utah	Etats-Unis.
Springdale, Washington	Etats-Unis.
Springdale, West Virginia	Etats-Unis, Virginie occ.
Springdell, Pennsylvania	Etats-Unis, Pensylvanie.
Springdell, Utah	Etats-Unis.
Springe, Deister	Allemagne, Hannover.
Springen bei Riefensberg	Autriche, Vorarlberg.
Springer, New Mexico	Etats-Unis, N. Mexique.
Springer, Oklahoma	Etats-Unis.
Springers Hot Springs	Etats-Unis, Nevada.
Springerton	Etats-Unis, Illinois.
Springerville	Etats-Unis, Arizona.
Springfield, Queensland	Australie.
Springfield South .... K	Australie, Tasmanie.
Springfield, Tasmania ...... K	Australie, Tasmanie.
Springfield, Annapolis Co.	Canada, N. Ecosse.
Springfield, Antigonish Co.	Canada, N. Ecosse.
Springfield Corner, New Brunswick	Canada.
Springfield, Manitoba	Canada.
Springfield, New Brunswick	Canada.
Springfield, Ontario	Canada.
Springfield Park	Canada, Quebec.
Springfield, Prince Co.	Canada, Prince Edouard (Ile).
Springfield, Queens Co.	Canada, Prince Edouard (Ile).
Springfield Ranch	Canada, Colombie brit.
Springfield, Bradford Co.	Etats-Unis, Pensylvanie.
Springfield, Colorado	Etats-Unis.
Springfield Corners, Wisconsin .	Etats-Unis.
Springfield, Delaware Co.	Etats-Unis, Pensylvanie.
Springfield, Fairfax Co.	Etats-Unis, Virginie.
Springfield, Florida	Etats-Unis, Floride.
Springfield Gardens, Queens Co.	E.-U. (T. de New York City).
Springfield, Georgia	Etats-Unis, Georgie.
Springfield, Hampshire Co.	Etats-Unis, Virginie occ.
Springfield, Idaho	Etats-Unis.
Springfield, Illinois .... N	Etats-Unis.
Springfield Junction	Etats-Unis, Oregon.
Springfield, Kentucky	Etats-Unis.
Springfield Lake	Etats-Unis, Ohio.
Springfield, Louisiana	Etats-Unis, Louisiane.
Springfield, Maine	Etats-Unis.
Springfield, Maryland	Etats-Unis.
Springfield, Massachusetts ... N	Etats-Unis.
Springfield, Michigan	Etats-Unis.
Springfield, Minnesota	Etats-Unis.
Springfield, Missouri .... N	Etats-Unis.
Springfield, Nebraska	Etats-Unis.
Springfield, New Hampshire ...	Etats-Unis.
Springfield, New Jersey	Etats-Unis.
Springfield, Ohio .... N	Etats-Unis.
Springfield, Oregon	Etats-Unis.
Springfield, Otsego Co.	Etats-Unis, New York State.
Springfield, South Carolina	Etats-Unis, Caroline du Sud.
Springfield, South Dakota	Etats-Unis, Dakota du Sud.
Springfield, Tennessee	Etats-Unis.
Springfield, Vermont	Etats-Unis.
Springfield, Walworth Co.	Etats-Unis, Wisconsin.
Springfield, Washington	Etats-Unis.
Springfield, Jamaica	Indes occ., Jamaïque.
Springfield, New Zealand	Nouvelle-Zélande.
Springfield, Transvaal	Union de l'Afrique du Sud.
Springfontein	Union de l'Afrique du Sud, Orange.
Springford	Canada, Ontario.
Spring Fork	Etats-Unis, Missouri.
Spring Gap, Maryland	Etats-Unis.
Spring Garden, Alabama	Etats-Unis.
Spring Garden, California	Etats-Unis, Californie.
Spring Garden, Missouri	Etats-Unis.
Spring Glen, New York State ..	Etats-Unis.
Spring Glen, Schuylkill Co.	Etats-Unis, Pensylvanie.
Spring Glen, Utah	Etats-Unis.
Spring Green, Wisconsin	Etats-Unis.
Spring Grove, New South Wales .... K	Australie, N. Galles du Sud.

1800	心	Cœur; centre.
1801	必	Nécessairement; il faut.
1802	忉	Inquiet.
1803	忌	Envier; éviter.
1804	忍	Supporter; endurer.
1805	忒	Changer; douter; excès.
1806	忖	Réfléchir; considérer.
1807	志	But; résolution.
1808	忘	Oublier; omettre.
1809	忐	Craintif.
1810	忑	Timide.
1811	忙	Occupé; pressé; se hâter.
1812	忝	Déshonneur.
1813	忠	Fidèle.
1814	忡	Triste.
1815	忪	Épouvanté; agité.
1816	快	Joyeux; prompt; rapide; vite.
1817	忭	Joyeux.
1818	忮	Féroce; cruel; batailleur.
1819	念	Penser.
1820	忱	Sincérité.
1821	忸	Honteux; habitué.
1822	忤	Désobéir; rebelle.
1823	忻	Content.
1824	忽	Soudain; négligent.
1825	忿	Colère.
1826	怍	Honteux.
1827	怎	Comment.
1828	怏	Mécontent.
1829	怒	Colère; se fâcher.
1830	怕	Avoir peur; craindre.
1831	怖	Craindre.
1832	怗	Soumis.
1833	怙	Père; appui.
1834	怛	Frayeur; douleur.
1835	思	Penser; réfléchir.
1836	怠	Paresseux.
1837	怡	Joie.
1838	急	Urgent; hâte.
1839	怦	Subit.
1840	性	Caractère; nature.
1841	怨	Haine.
1842	怩	Honte.
1843	怪	Douter; étrange.
1844	怫	Colère.
1845	怯	Timide.
1846	怱	Pressé
1847	怵	Crainte.
1848	怈	Habituer.
1849	恍	Trouble.
1850	怔	Craintif.
1851	恁	Penser.
1852	恂	Sincère.
1853	恃	S'appuyer; appui.
1854	恆	Constant.
1855	恇	Timide.

80 *There are about a quarter of a million telegraph bureaux at various post offices throughout the Member countries of the I.T.U. The names of these bureaux are recorded in a two-volume official nomenclature. The extract opposite shows clearly the need for its existence. A telegram simply addressed to "Springfield" would never reach its destination without the additional information whether it is in Queensland, Australia; Ontario, Canada; Louisiana, U.S.A.; Jamaica; New Zealand or the Republic of South Africa.*

81 Telegraphy in Chinese

Chinese characters convey meaning. They do not, like alphabet letters, convey primarily sound. This has the advantage that a Chinese can communicate, in writing, with those speaking different dialects from his own—or even not speaking Chinese at all. The characters convey the same meaning for everybody—just as a triangle by the roadside means "Attention!" to people of many language habits. There are as many characters as there are words. Most people use a stock of less than five thousand, so a knowledge of a few thousand characters satisfies all but the erudite, and serves all business and official purposes.

The disadvantage of learning "two languages", one written and one spoken, is offset by the fact that Chinese speech is difficult to write with an alphabet. A great many speech sounds can have more than twenty meanings; but the character-written form of each meaning is different, and hence leaves no ambiguity.

*Character coding for telegraphy is obviously more complex than for an alphabet. For most alphabets about fifty units—letters, numerals, punctuation—are all that have to be coded. They are conveyed by the binary notation (dot-dash) of Morse code. To devise a special "Sino-Morse" code for Chinese was hardly practical *).*

In 1882 therefore, soon after the first telegraphic line had been introduced, the first Chinese telegraphic code book was published. This gave to over 6000 commonly used characters a four-figure number. The numbers were telegraphed and de-coded at the receiving end. This system is the one in use to-day, though the present code, modified from the original, lists over 9000 characters. Transmission can be either by Morse code or teletype equipment, which can operate at 72 Chinese words per minute.

The 256-page official telegraphic dictionary is used simply, like an ordinary Chinese dictionary.

The Chinese character is made of two parts. One of these is always a "radicle", one of 214 basic characters. The radicle usually conveys some of the sense, much as the syllable "ex-", as in "extract", conveys the idea "from" (i.e. "extract" = "draw from"). Dictionary entries are based on the radicles, and are listed in order of ascending number of strokes.

A Chinese, sending the message (say) "Anger is unseemly" will look up the desired character for "anger" which will be under its radicle, "heart". On the page shown are characters based on the "heart" radicle, appearing at the top. (Its form is modified when at the side of a character.) The other part of the character (it means "to divide") has four strokes. The writer runs down the "four-strokes-beside-the-radicle" characters, which start at 1812, until the last one, which is that required, 1825. "1825" is transmitted in code. The receiving operator transcribes it back into character, and the recipient then reads it as "fên", "anger", "wut", "colère", "THEB", "cólera", or otherwise, according to his particular speech habit.

10,000 characters give a reasonable range. Though one misses the character "to screen off a temporary kitchen", that meaning "tiger-shaped wooden instrument for stopping music" is available.

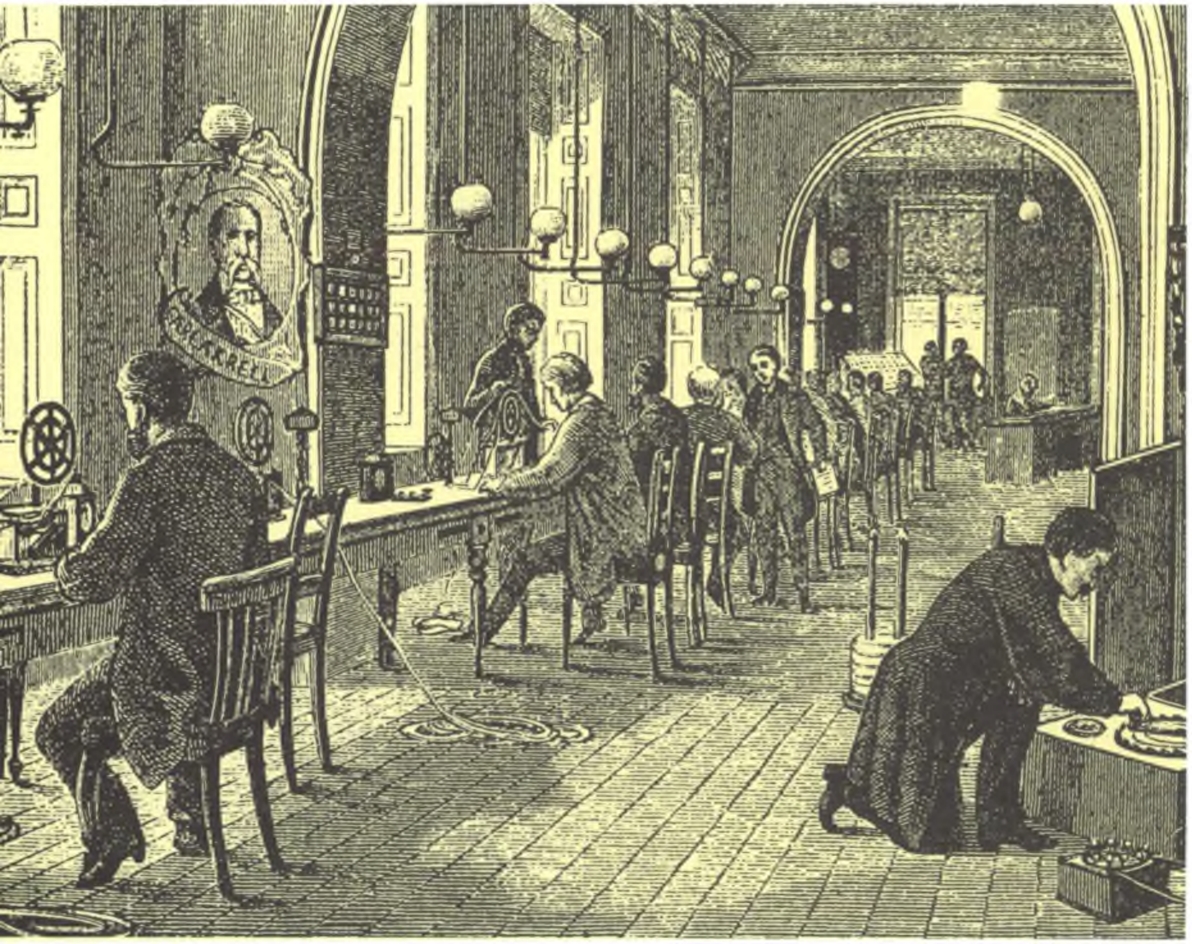
*) *A "Sino-Morse" code for, say, 50,000 characters would need communication units of seventeen dots-or-dashes, against the six used in Morse. Computer-type machinery could be devised to handle this, but at high initial cost.*

82

82 *Hydroplane enthusiasts met in Monaco in March 1912. A picture of one of the aircraft taken in front of the Casino was transmitted telegraphically to Paris.*

83 The Central Telegraph Exchange in Stockholm in 1872. On the wall is the portrait of the Director-General, Carl Akrell.

84 The International Telegraph Message Centre of the Radio Corporation of America in New York City in 1933, showing Morse operators at work.



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CHILE
SYRIA
PORTO RICO
CANADA
BRAZIL
TURKEY
COLOMBIA
ARGENTINA
CZ. SLOVAKIA

This might be the end of plain language telegrams, but as the early Regulations allowed plain words up to seven syllables, and as code words in telegrams were only allowed five letters, misuses of this distinction soon developed. So for example an early telegraph manual cites the following code words:
APOGUMNOUMAI
APUGUMNOSOMETHA
EKMISTHOSOISTHEN
CHINESISKSLUTNINGSDON (21 letters, but only 6 syllables)
They were certainly all pronounceable, but what their meaning was has apparently not been preserved.

At the early conferences, St. Petersburg 1875, London 1879, and Berlin 1885, attempts were made to control the length of code words to a maximum of 15 and 10 letters and to charge them at the same rate as plain language telegrams. But code users were not satisfied and new misuses occurred.

Dictionary words were intentionally misspelt and completely manufactured words, resembling dictionary words, were soon in use. At the Conference of Paris in 1890, a proposal was therefore made and accepted that the Union Bureau at Berne should draw up a complete official dictionary of all the permissible code words. Such an official vocabulary was indeed compiled, containing in alphabetical order 265,740 words, and 15,000 copies of it were distributed. Many criticisms were levelled against it, from insufficiency of numbers of words to typographical mistakes. The Budapest Conference of 1896 therefore instructed the Bureau to extend and to improve the official vocabulary.

One cannot but admire the officials of the Bureau. They set to work in an extremely thorough manner, and from the Members of the Union requested copies of all authorised codes; they received 218 public and private codes containing a total 5,750,000 words. Work commenced in February 1897, and by May 1901 four large volumes and one appendix, containing over 1,900,000 words were published and 7000 sets distributed; the cost was 300,000 Swiss francs. But this new official vocabulary was no more successful than its predecessor, and the London Conference of 1903 found it unacceptable, mainly because it did not contain sufficient words and because it rendered many private codes useless. The only alternative lay in standardising and legalising the then existing codes.

It was also laid down in the 1903 Telegraph Regulations that code language words must be pronounceable and not be longer than ten characters according to the Morse alphabet. But the Union

85 *A view of the Johannesburg Central Telegraph Office, 1960. All telegraph traffic is sent by automatic teleprinter over the Gentex system.*

85

86 *Electronic message switching system of the International Telegraph Message Centre of the Radio Corporation of America Central Telegraph Office, New York City, 1963.*

87 *Telegrams to-day are handled by high-speed, automatic methods. Here is a Western Union operator in the United States of America sending a message from a telegraph office. She simply types a routing symbol at the beginning of each telegram and then types the message. This appears in the form of a perforated tape. As the tape passes through the box-like automatic transmitter at the left, the coded symbol causes an electronic "brain" at the distant high-speed message centre to route and flash the message to its destination area.*

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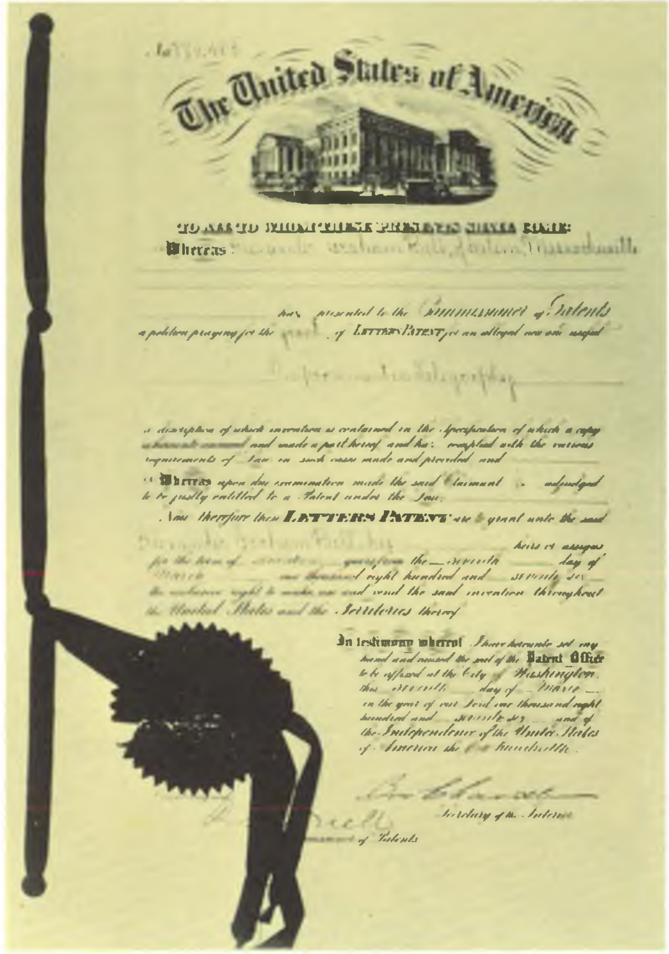


88 *Alexander Graham Bell's telephone patent, 1876.*

88

had not reckoned with the ingenuity of code compilers. In 1904, when these new regulations came into force, a completely new code system had been devised, consisting entirely of five-letter code words. By combining two such code words, the new word could be passed off as one ten-letter code-word and thus cutting the cost of the telegram in half. The user, in order to convince the telegraph operator of their pronounceability, would manage "by means of facial contortions to pronounce words containing up to four or five consecutive consonants".

To legalise the existing codes, the Union set up a Code Control Committee which was active between 1908 and 1913. Strict censorship during World War I prevented of course the use of any coded telegrams for the public, but after the war the code problem immediately resumed its intractable nature. Many new codes were compiled, and the Union set up another Committee for the Study of Code Languages; it met in Paris in 1925 and again in Cortina d'Ampezzo in 1926. Its majority report, fourteen countries, allowed only five-letter codes to be used; the minority report, by Great Britain alone, wanted to retain the ten-letter codes. At the subsequent Administrative Conference of Brussels in 1926, two code categories were allowed, *Category A* of pronounceable ten-letter words, and *Category B* of five-letter words made up in any way the user liked.

The current Telegraph Regulations allow only artificial words up to five letters; telegrams can also now be sent in which real words are used but having a meaning different from their normal content in plain language.

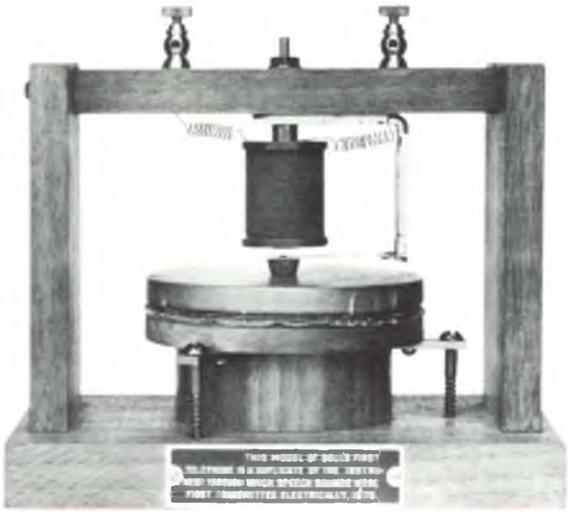
The Telephone

Telegraphy is of course relatively slow, although its signals and messages pass along the electric wire at nearly the speed of light. Time must be devoted to the most economical drafting of the telegram, perhaps a code dictionary has to be looked up, and the completed message must be physically handed over to the telegraph operator. He in turn, if confronted with priority telegrams, must delay yours, and can finally only transmit it at the maximum speed with which he can spell out the words into his electrical typewriting telegraph transmitter. To receive a reply from your correspondent will inevitably take hours. Instantaneous transmission of human speech over electric wires is of course very much faster. Furthermore, for the same expenditure of money, a very much greater amount of information can be exchanged.

These thoughts were perhaps only dimly perceived by the pioneers of the telephone towards the end of the last century. They explain, however, why, after a very slow start in Europe at the beginning of this century, the telephone has constantly gained upon the telegraph, and is now far more frequently used. " Much of the impressive progress that has been made in international telephone communications on the Continent of Europe may be attributed to the activities of the International Consultative Committee on Long Distance Telephone Communications ". This statement, made in 1929 by Walter S. Gifford, then President of the American Telephone and Telegraph Company, pays a just tribute to the work of the I.T.U. As in the case of the telegraph, so with the telephone, its world-wide extension, across man-made frontiers and across oceans, would have been exceedingly slow, if not impossible, without an efficient international organisation.

But there is another parallel between the telephone and the telegraph. It was again Robert Hooke (1635-1703), the great English scientist, who made the first suggestions of how speech might be transmitted over long distances. After some experiments on the transmission of sound over taut wires, he remarked: "Tis not impossible to hear a whisper a furlong's distance (201 meters), it having already been done; and perhaps the nature of the thing would not make it more impossible though that furlong should be ten times multiplied."

One further similarity occurred. As optical telegraphy preceded electrical telegraphy, so there is at least one recorded proposal that acoustical telephony might be tried. G. Huth suggested it in his little volume " A Treatise concerning some Acoustic Instruments... and the Use of the Speaking Tube in Telegraphy ", published in Berlin in 1796. This is only three years after Chappe built his first line of



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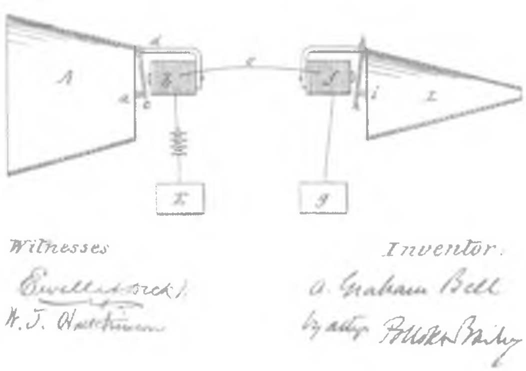
optical telegraphs in France. Huth had the impossible idea that during clear nights mouth trumpets, or speaking tubes, should be used to pass a shouted message from tower to tower; as optical telegraph towers were on the average about 10 km distant from each other, this could never have worked. However, his fame will always be assured for the one sentence in his book: "To give a different name to telegraphic communications by means of speaking tube, what could be better than the word derived from the Greek: *Telephone*".

The incentive to invent the electrical telephone was by no means as pressing as that of the electrical telegraph. The need for relatively rapid transmission of messages having been satisfied, we find that fewer men worked on the development of the telephone than on the telegraph. There was, for example, the American physician, Charles Grafton Page (1812-1868), of Salem, Massachusetts, who discovered in 1837 that when there are rapid changes in the magnetism of iron, it gives out a musical note; the pitch of the note depended on the frequency in the changes of magnetisation, and he called these sounds "galvanic music."

Many physicists repeated these experiments in their laboratories, but it remained for Philipp Reis (1834-1874) of Friedrichsdorf, near Frankfurt-am-Main in Germany, to be the first in 1860 to transmit a musical melody electrically over a distance. He stretched an animal membrane, to which a platinum wire was fastened by means of sealing wax, over a small cone in the shape of a human ear, and inserted this into the bung hole of a beer barrel. The platinum wire formed part of a battery circuit, and as the sound vibrated the animal diaphragm, the wire could make and break a contact in the circuit with a corresponding frequency. At the other end of the circuit, the wires led to a coil which was wound around a knitting needle. These rapid magnetisations and demagnetisations of the knitting needle reproduced the sound. Three years later he claimed " that words can also be made out ".

In 1875, when the St. Petersburg Conference of the International Telegraph Union drew up its memorable Convention, there were two Americans working on telephonic transmission, independently of, and unbeknown to, each other. One was Elisha Gray (1835-1901), the other was Alexander Graham Bell (1847-1922). Gray was an inventor and a manufacturer in Chicago. His telephone was not unlike that of Reis, but he attached a small iron rod to his membrane; the other end of the rod was immersed in a fluid of low electrical conductivity, part of a battery circuit. As sound reached the membrane, it



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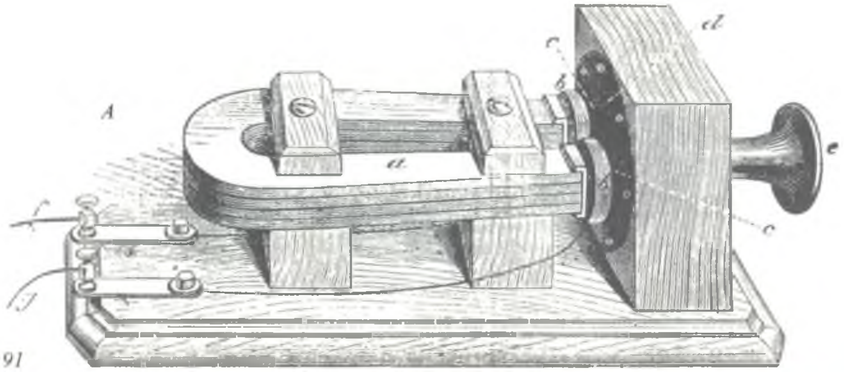

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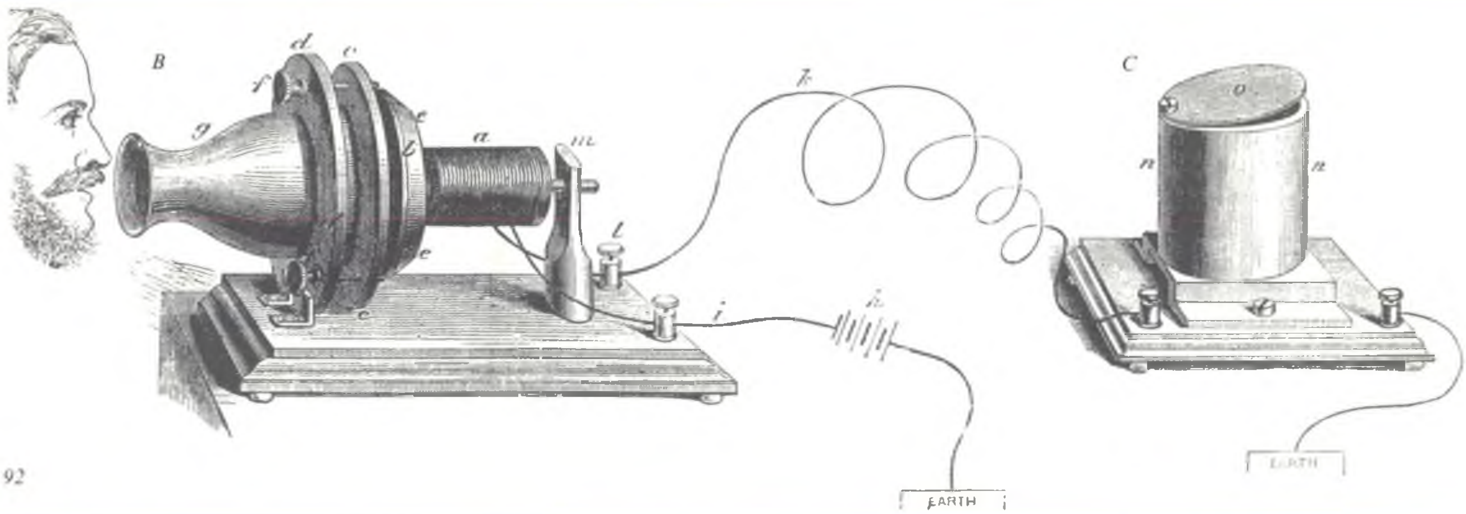
89 *Model of the original telephone invented in 1875 by Alexander Graham Bell. This model was manufactured from the original by the American Telephone and Telegraph Company.*

90 *Sketch of magneto transmitter and receiver from original patent application of A. G. Bell.*



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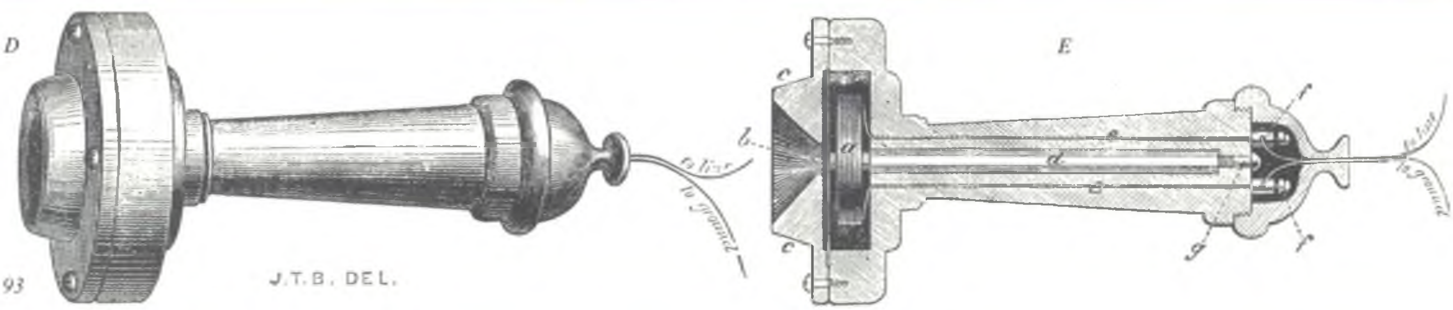

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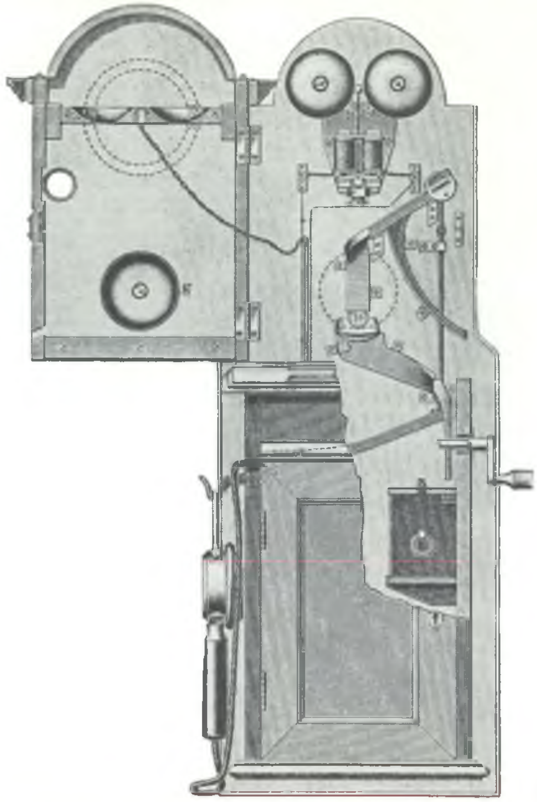
91-94 *One of the earliest illustrations of Graham Bell's telephone in 1877, drawn from the instrument shown at the Philadelphia Exhibition, and described by Sir William Thomson. A. The receiver. B. The transmitter. C. Slightly later form of long-distance telephone for office use. D. Portable telephone, being a transmitter and receiver. E. Section of the same. F. Telephone in use.*

95 *Section through a German telephone coin box of 1898.*

96 *Edison's loud-speaking telephone of 1879.*
1. Switchboard and telephone
(a) *receiver* (b) *transmitter* (c) *handle to rotate the chalk cylinder.*
2. Part of switchboard (larger scale).
3. Inside of receiver (a) *diaphragm.*
4. Another view of chalk cylinder.
5. Metal slip and platinum knob. 6. Part of carbon transmitter
(a) *carbon between two metal discs.*
7. Section of transmitter, with additions.
8. Transmitter opened.

97 *Installation of a dial telephone, introduced in 1898 in the offices of the Illinois Tunnel Company. The picture was taken in 1905.*



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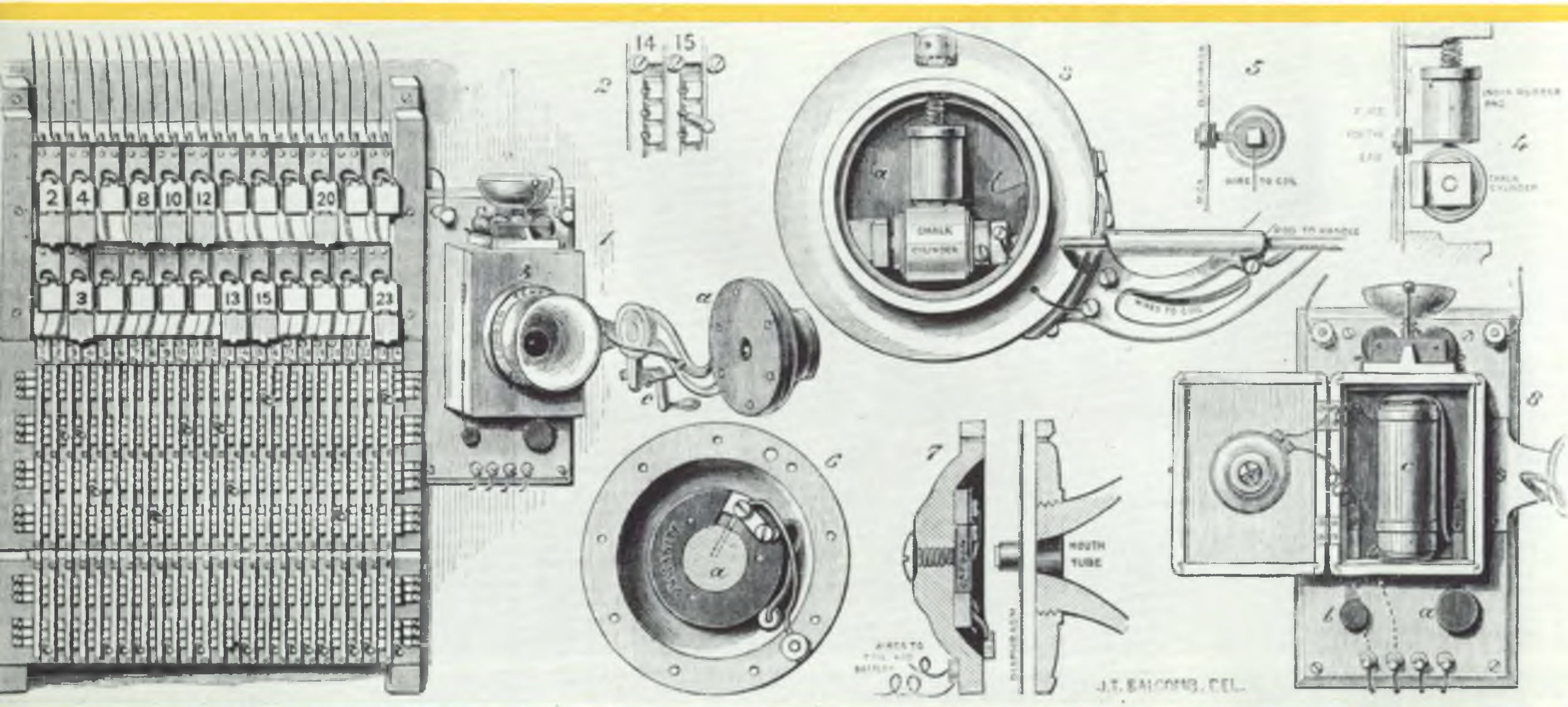

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vibrated the rod immersed in the fluid, and a fluctuating current passed down the circuit. On the receiving end, the wires of the circuit passed into the coil of an electromagnet, inside which was another small rod of soft iron, also attached to a membrane. Thus the sound reaching the sending diaphragm was electrically duplicated by the receiving diaphragm.

On 14 February, 1876, Gray filed in the United States Patent Office a caveat, a formal notice of his claim to the idea of the new instrument; he hoped with his caveat to prevent others from patenting the same idea within the period of a year. On the same day, but only a few hours earlier, Bell had applied for a patent for the same type of instrument. In later years there was a great deal of bitter legal dispute about priority, but in the end Bell was awarded the patent rights, and he received much credit for his invention.

Bell was born in Scotland and educated at Edinburgh and London Universities. At the age of 23 he emigrated with his father to Canada and settled two years later in Boston. Like his father and his grandfather young Bell was then devoting his life to educating the deaf, and he had acquired a considerable knowledge of the physiology of human speech and hearing. In 1873, Bell became Professor of vocal physiology at Boston University, but soon he devoted more and more of his time to the invention of multiple transmission of telegrams over the same wire. This was the time when the Duplex system had been invented, and Bell hoped that his six, electrically vibrated, reeds would lead to a better system of multiple telegraphy and bring him fame and fortune.

It has come down to us that on the afternoon of 2 June, 1875, one of his reeds got stuck to its electromagnet. When Bell told his faithful assistant, Thomas A. Watson, to pluck the sticking reed, Bell found in the adjoining room, that the corresponding reed began to vibrate and produced a sound of the same pitch. From this simple phenomenon, Bell deduced correctly that if a single sound could be transmitted electrically, so could complicated human speech and even music. A circular piece of gold beater's skin was stretched over a small cylinder into which one could speak, and the skin was connected to a reed over an electromagnet. After preliminary trials, the first complete sentence spoken over the telephone was the phrase: "Mr. Watson, come here, I want you"; the date, 10 March, 1876.

Although these early calling devices were crude and communications were poor, development was rapid in the U.S.A. Bell showed his equipment at the Philadelphia Centennial Exhibition of 1876, where the Emperor of Brazil, Dom Pedro de Alcantara, was impressed. Sir William Thomson (later Lord

98 *An early English telephone receiver designed by Dolbear in 1876-7.*

99 *The first telephone set produced in Japan, 1877.*

100 *An early telephone set designed by Bramão in 1879 and used in Portugal.*

101 *Desk telephone apparatus using magneto, by the Russian inventors A. A. Stolpovskyi and A. Kanger, 1886.*

102 *French telephone of 1890, designed by Mildé.*

103 *Telephone receiver 1893 by the Russian inventor, E. V. Kolbasev.*

Kelvin) was one of the judges at the Exhibition, and he wrote: "With somewhat more advanced plans and more powerful apparatus, we may confidently expect that Mr. Bell will give us the means of making voice and spoken word audible through the electric wire to an ear hundreds of miles distant". The first step came in the next year when an outdoor telephone line was run in Boston between the workshops of a Mr. Charles Williams, in which the first telephones were made by Watson, and Williams' private residence in Sommerville. Also in 1877, the first news dispatch was sent by telephone to the *Boston Globe*, and this feat inaugurated the public use of the telephone.

When, during his honeymoon visit to England in 1878, Bell was presented to Queen Victoria, the telephone was demonstrated to her at Osborne, Isle of Wight, and communications were established with Cowes, Southampton and London. Bell did not spare himself in making his invention known; he lectured widely in the United States, and demonstrated it first in Britain to the annual meeting of the British Association at Plymouth in the autumn of 1877. His reward came in the rapid expansion of telephones in the United States, the first telephone and switchboard for commercial service being installed at New Haven, Connecticut, in 1878, with 21 subscribers.

In 1880, the first telephone line between Boston and Providence was opened; Boston to New York in 1885; New York to Chicago in 1892; New York to Denver in 1911; and New York to San Francisco in 1915. Much of this early expansion came through the efforts of Theodore N. Vail, who had become the General Manager of the Bell Telephone System in 1878. This Company and the American Telephone and Telegraph Company, which operated the long distance circuits, have ever since then remained two of the greatest names in world telecommunications.

In Britain, the development of the telephone was at first greatly hampered by the Telegraph Act of 1869 by which the Post Office had acquired the monopoly of all telegraphic communications; we have already seen that this act of nationalising telegraphy gave Great Britain the right to join the International Telegraph Union. In 1880 a High Court decision was given in London holding that the telephone was a telegraph within the meaning of the act, thus greatly retarding the work of the private telephone companies; later they were amalgamated as the United Telephone Company. It was not until 31 December, 1911, that the British Post Office acquired by purchase all the then remaining private telephone interests.

104 *Early coin-operated telephone equipment, Jentsch system, as used in Austria from 1910 onwards.*

105 *An early Austrian telephone set, Förderl, of 1911. By manipulating four levers an automatic connection could be made with another subscriber.*

106 *Siemens and Halske table telephone of 1922 with a dial having a rotating finger plate carrying 25 holes.*

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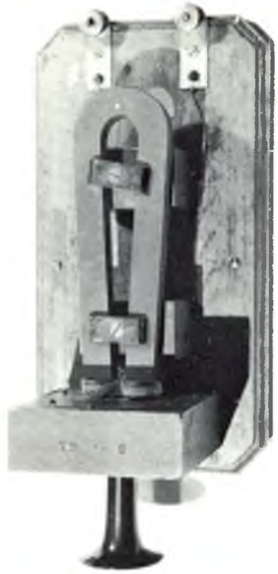

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107 *The first telephone used in London by the Post Office in 1881.*

108 *One of the first telephones constructed by the Swedish Telegraph Administration in 1884.*

109 *An early Bulgarian telephone. The first public telephone system was started in Sofia in 1886, although seven years previously, in 1879, a private line was in use linking the city of Plovdiv (Philippopoli) with the Chancery of the Governor-General at Sofia.*

110 *Automatic table telephone used for the first German automatic telephone service at Hildesheim in 1908.*

The development of the telephone in France was similar. It was shown first at the Paris World Fair in 1878, but it attracted little interest. Various private companies were licensed by the French Government to operate, and in 1880 they were consolidated in a single company, the Société Générale des Téléphones; in 1889, its entire system was taken over by the French Telegraph Authorities. In Switzerland, the Federal Authorities took over the telephones in 1886, in Belgium in 1896, and similar steps were taken by other European Governments, towards the end of the last century.

Of all the many improvements that have made the telephone the universal instrument of our present social and business communications, two stand out. One is due to an unsuccessful undertaker, Almon B. Strowger, who found that his business calls were, either maliciously or inadvertently, diverted by the local telephone operators to his rivals. Experimenting first with some collar bones and matches, he wanted to switch telephone calls automatically; his principle was to arrange the electrical contacts leading to other telephone subscribers in rows on the inner surface of a cylinder. An arm on the central shaft was moved step by step up the inner side of the cylinder, and then again step by step across, until the right contact had been reached. He worked on it from 1889 to 1896; it was much improved in later years, but the "step-by-step" principle of the Strowger system made the "girless, cussless telephone" with its millions of subscribers possible.

The second outstanding invention in telephone engineering came from the professor of mathematical physics at Columbia University, Michael Idvorsky Pupin (1858-1935). His coils made long-distance telephone cables possible. It was known before the end of last century that transmission efficiency of long telephone circuits could be improved by increasing their "inductance"; this is a measure of the rate of increase of magnetic flux through a wire with increase of current. Many had proposed to increase the inductance by including coils in the telephone circuits, but all had failed. It was reserved to Pupin to show that the regular spacing of his coils, the loading coils, at intervals of about 1 kilometer, could greatly increase inductance and thus reduce the attenuation of the waves of speech current in the telephone circuit. He patented his invention in 1900.

Pupin, at the American Institute of Electrical Engineers, in describing his development of the art of loading telephone cables, paid a generous tribute to O. Heaviside. He said: "Oliver Heaviside of England, to whose profound researches most of the existing mathematical theory of electrical wave propagation

111 *French telephone of 1908 designed by Pasquet.*

112 *A British magneto telephone of 1910. (Ericsson design of 1894).*

113 *French telephone of 1924, with one of the first dialling systems.*

114 *An early dial pedestal telephone as issued by the British Post Office in 1924.*

115 *Current French telephone of 1948.*

116

is due, was the originator and most ardent advocate of wave conductors of high inductance. His counsel did not seem to prevail as much as it deserves, certainly not in his own country."

During the following decades the network of telephone cables expanded over longer and longer distances, more rapidly in the United States than in Europe. Nevertheless France had for example, in 1927, about 1500 km, Germany 7400 km, Great Britain 9600 km, and Switzerland about 1600 km. It was on 7 January, 1927, that a public Transatlantic Telephone service was first opened, using powerful radio-transmissions from Rocky Point, Long Island, eastwards to Cupar, Scotland; westwards, the signals originated at Rugby, England, and were received at Houlton, Maine. Their success was a splendid example of international co-operation between the privately owned American Telephone and Telegraph Company and the British Government's Post Office.

Submarine telephone cables across the Atlantic had to await the design and construction of reliable repeater units, which could be incorporated into the cables to boost the weak telephone signals at regular intervals. To develop these complex electronic amplifiers, and leave them unattended at the bottom of the ocean for 20 years, has indeed demanded much research. It is therefore not surprising that the first submarine telephone cable between the United States and Britain was not laid until 1956. It was called TAT–1. It was followed 3 years later by TAT–2, jointly owned by A.T.T., France and Germany, then by CANTAT, joining Britain with Canada, and in 1963 TAT–3 was completed. TAT–3, is a polythene light weight cable with a central stress taking core; repeaters are included in it at intervals of every 37 km, and 128 simultaneous telephone conversations can pass over it, using a channel width of 3000 cycles per second. In 1960, there were over 3 million transatlantic telephone conversations, double the number of 1950. In the Pacific Ocean, the COMPAC Cable, which was opened to public traffic in December 1963, has brought about a completely new approach to communications.

Telstar, during its first days of orbiting the earth in July 1962, established telephone communications between 23 European and 23 United States towns; 80 simultaneous conversations could be transmitted. A century after Reis' first electrical transmission of a musical sound, the world's appetite for international telephone communications is quite insatiable. More underground and submarine cables, more radio relay systems, and the use of artificial satellites, either in a near orbit, or in a synchronous one with a distance of 42,000 km from the earth's center, are however likely to satisfy the needs in the years to come.

116 One of the latest push-button telephone models, designed by the Bell Telephone Laboratories in 1962.

117 Push-button telephone dialling is being tried out in Sweden on a large scale in the city of Nynäshamn, Sweden, with 3000 subscribers.


0 1 2 3 8 9 4 7 6 5

Telephone Regulations

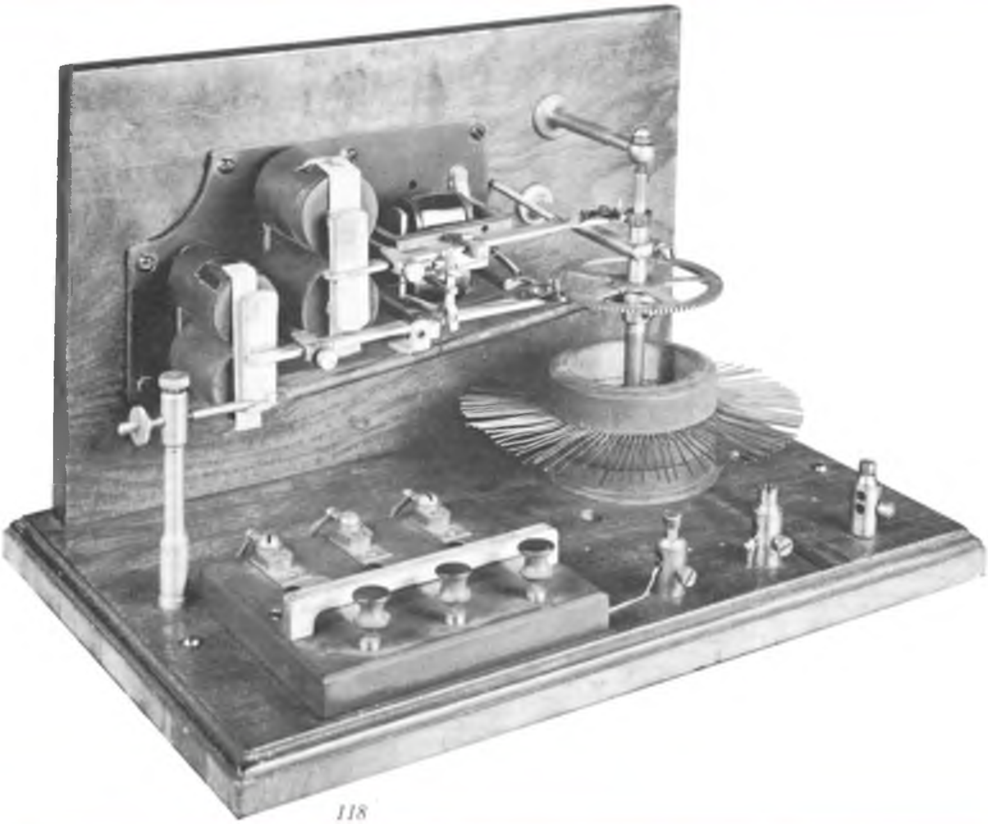
It was only in 1885, at its Administrative Conference in Berlin, that the International Telegraph Union took official notice of the telephone. It was undoubtedly then an unwanted competitor to the established telegraph, and was considered merely as a "supplement". It is also the first year for which we have international statistics of the telephone, drawn up by the Bureau of the Union at Berne; some of these are still worth looking at to-day.

The Telegraph Union in 1885 had 50 Members, but in all these Member States, including Europe, South Africa, Australia, Brazil, India, Japan, New Zealand, Russia and Turkey, there were only 1168 telephone exchanges, with 68,845 subscribers; however, between them they made more than 92 million city calls and more than 5 million inter-city calls. The length of urban lines in 1885 was 306,632 km, but inter-urban lines totalled only 304 km!

The development of the international telephone service differred markedly from that of the international telegraph. The practical development of the telephone occurred many years after the telegraph, and the public had become used to the telegraph as its rapid means of communications. For local use, where there were no language barriers, the telephone did provide a means of personal contact, and the early invention of the automatic exchange contributed greatly. Trunk lines did not really become efficient until Pupin's loading coils came into more general use, and that was only in the opening years of the 20th century.

Furthermore, in some countries the development of the telephone was hampered by the attitude of the telegraph administrations who had invested large sums in their national telegraph networks. Thus, for example, the British Government had sunk over £10 million of capital in the acquisition of the private telegraph companies, and naturally they made every effort to extend the telegraph business. The telephone, with its instantaneous communications and its voluminous exchange of information was then indeed a feared rival. The final barrier to truly international telephony, the linking of the Continents, was only overcome in 1927 by radiotelephony between the U.S.A. and Great Britain.

In the United States, the development of the telephone was more rapid. But in 1885, the United States was not a Member of the Union; only individual representatives of private U.S. companies attended the Conferences as observers. It was in 1885 that the American Telephone and Telegraph Company was organised to provide better long distance lines for the Bell system. Once this internal re-organisation



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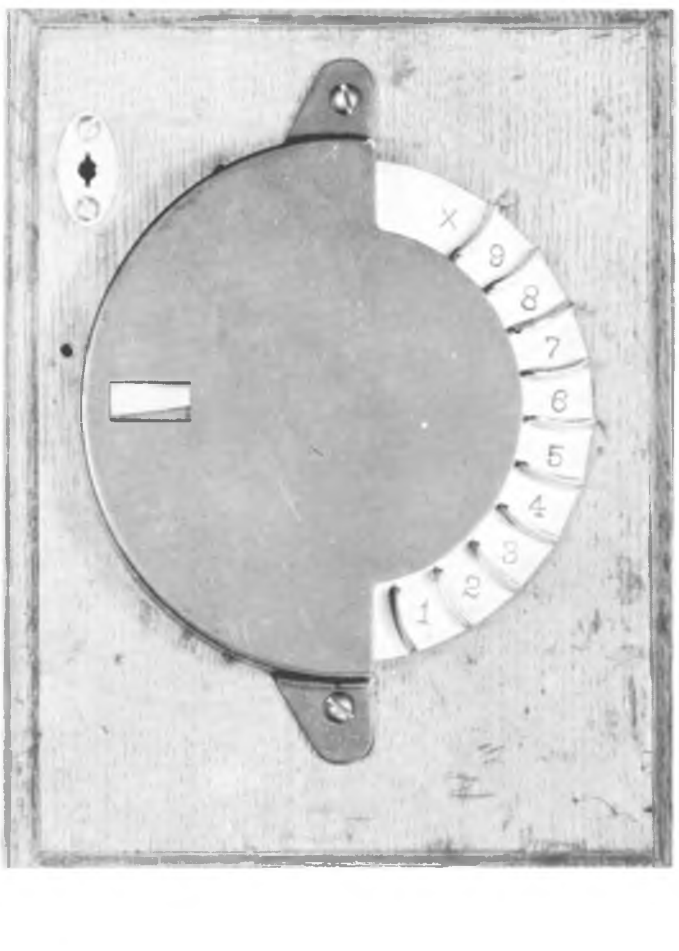

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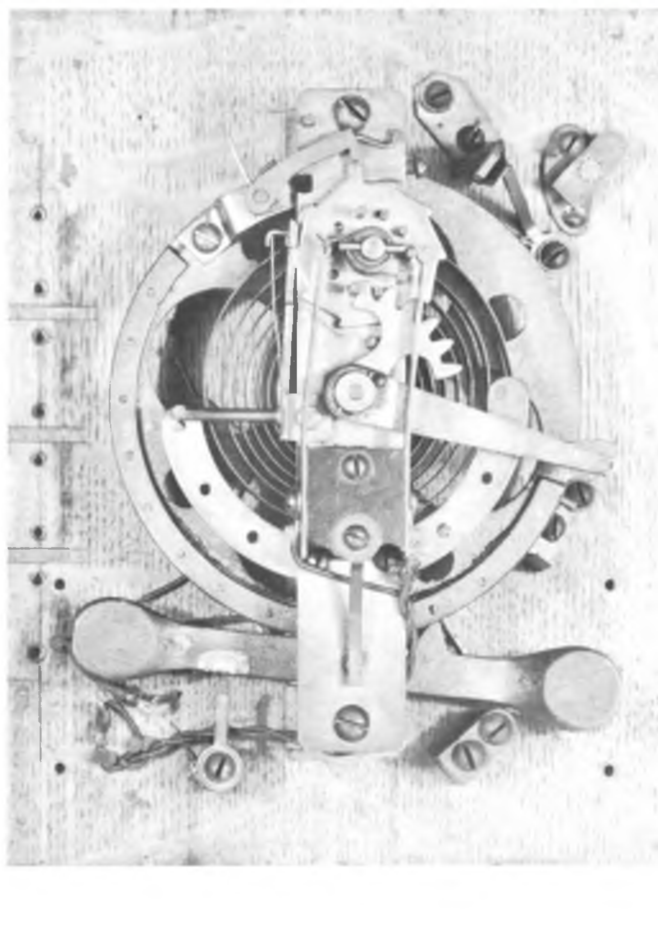
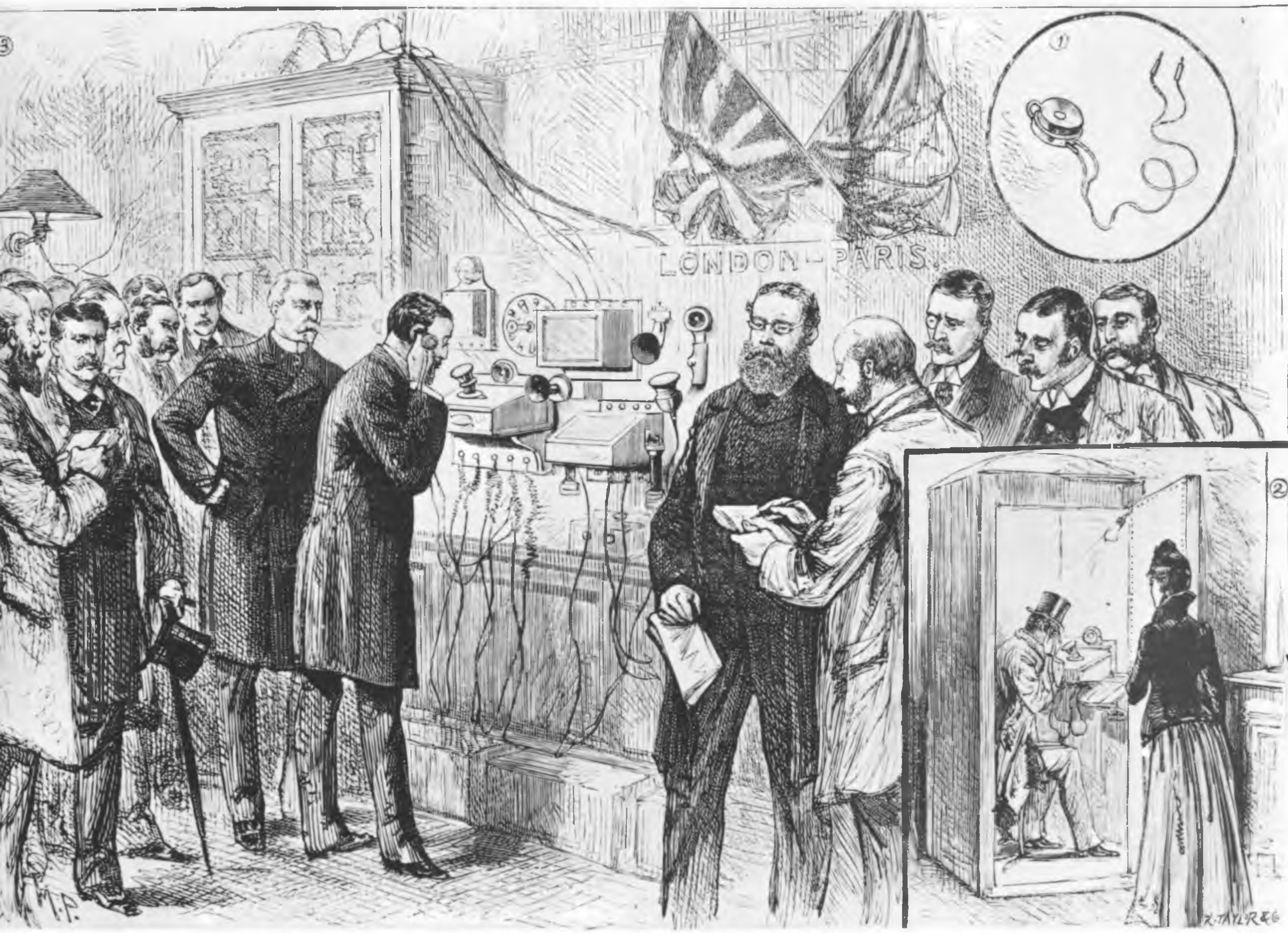


118 *Replica of original model on which A. B. Strowger based his patent. This differs from the drawings shown in the patent in having only one row of contacts while the patent drawing shows ten rows.*

119-120 *Photograph of one of the earliest telephone dials ever made, in 1896.*

121 *New Year's greetings by telephone in 1892.*

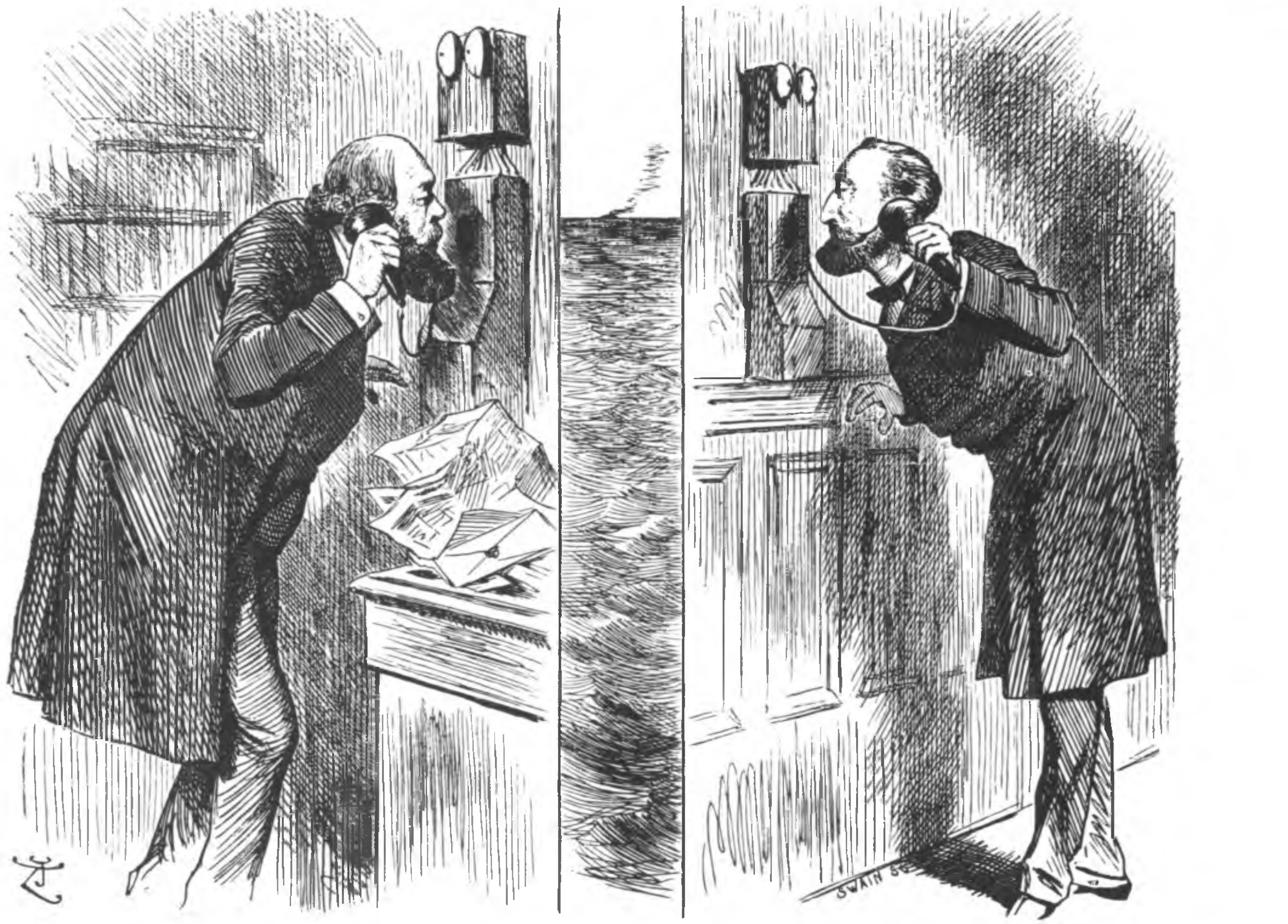
121



122

122 *Speaking to Paris from London on the completion of the Anglo-French telephone, 1891. Top right inset, the telephone wire testing equipment and bottom right inset, the subscribers' (silent) box.*
The Inaugural Ceremony at the London General Post Office.

123 *Comment by PUNCH on the opening of the Paris-London telephone, 1891.*



PRIVATE AND CONFIDENTIAL.

LORD SALISBURY. "HALLO!" M. LE PRÉSIDENT. "HALLO!" LORD SALISBURY. "YOU THERE?" M. LE PRÉSIDENT. "ALL THERE!"
LORD SALISBURY. "CAN YOU SUGGEST AN *ENTRÉE* FOR DINNER?"
M. LE PRÉSIDENT. "*HOMARD AU GRATIN*,—AND, BY THE WAY, HOW ABOUT NEWFOUNDLAND AND LOBSTER QUESTION?"
LORD SALISBURY. "NOT BY TELEPHONE, THANK YOU!!!" [*Telephone between London and Paris opened, Monday, March 23rd.*

123

124 *This is Broadway around the year 1890, showing the Western Union Building, on the left, at 195 Broadway. Telegraph and telephone poles and wires then formed a pattern against the sky, but the wires were put underground in cables later.*

125 *An early telephone tower in use in Johannesburg between 1894 and 1907.*

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MUTUAL LIFE INSURANCE
CASH SURRENDER VALUES.
A.N. LOCKWOOD. DISTRICT AGENT.
179
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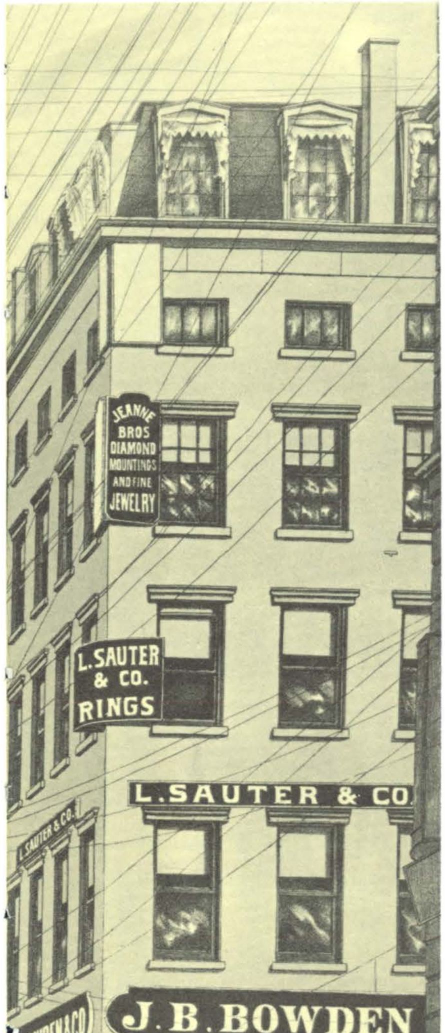
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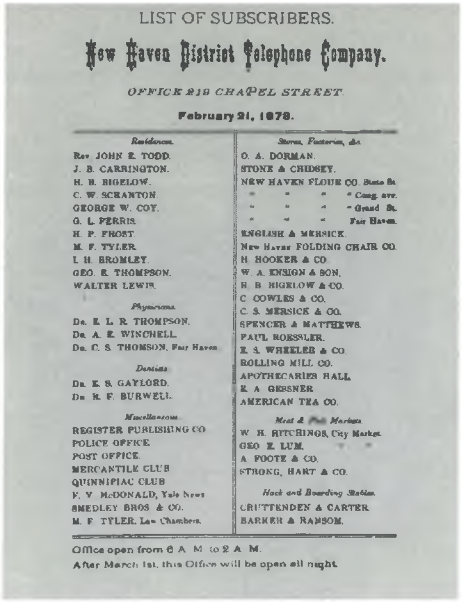
HAMILTON & HAMILTON JR. MANUFACTURERS OF FINE ROLLED PLATE CHAINS

124 125



LIST OF SUBSCRIBERS.

New Haven District Telephone Company.

OFFICE 219 CHAPEL STREET.

February 21, 1878.

Residences.

Rev. JOHN E. TODD.
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H. B. BIGELOW.
C. W. SCRANTON.
GEORGE W. COY.
G. L. FERRIS.
H. P. FROST.
M. F. TYLER.
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Physicians.

Dr. E. L. R. THOMPSON.
Dr. A. E. WINCHELL.
Dr. C. S. THOMSON, Fair Haven.

Dentists.

Dr. E. S. GAYLORD.
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CRUTTENDEN & CARTER.
BARKER & RANSOM.

Office open from 6 A. M. to 2 A. M.
After March 1st, this Office will be open all night.

126

had taken effect, we find that by 1902 there were over 2.4 million kilometers of telephone wires and just on 1 million telephones in service in the whole of the United States, operated by the Bell System and all other systems.

At the Berlin Conference of 1885, there was some discussion about international telephone regulations, but most delegates felt that this was premature, and that regulations should be treated by bilateral agreement. Nevertheless, five short paragraphs were added to the telegraph regulations, leaving almost complete freedom; the only interesting one was to fix a 5-minute maximum for a single call and single unit of charge. At the Budapest Conference of 1896, this time limit was cut down to 3 minutes, as there were already then more calls than could be handled; it has remained at 3 minutes ever since then in certain parts of the world.

It was not until the London Conference of 1903 that a set of 15 different articles on international telephony were drawn up and incorporated in the Telegraph Regulations; they dealt with the international telephone network, services offered to the public, standard administrative rules, the establishment of charges, and international accounting. Until the Paris Conference of 1925, these regulations remained virtually unchanged, although of course there was elaboration of detail.

The advent of the Consultative Committee on Telephony at that time allowed for a detailed technical study of the many divergent technical standards of telephone systems that had grown up in Europe, and thus a basis was laid for new regulations. These were discussed and agreed on at the next Conference of the Telegraph Union, at Madrid in 1932. There, for the first time, we find that the Telephone Regulations were taken out of the Telegraph Regulations and that they were limited to the European telephone system. As the list of signatories to the regulations demonstrated, Europe meant "all of the world except the Americas". This reluctance of the United States to join is difficult to understand to-day, particularly as the radiotelephone link between it and Europe had proved a success right from the very beginning. Two years after its opening in 1927, the service was available on a 24-hour basis, and the number of transatlantic calls increased sixfold between 1927 and 1931; the temporary economic depression of the following years somewhat decreased the rate of growth of the service.

The Telephone Regulations of the Madrid Conference in 1932 still left great freedom to the individual administrations, particularly as there was a complete absence of fixed international telephone charges.

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It was laid down that there should be terminal and transit charges, and that the unit of payment should be the gold franc, but that was about as far as they went. The Regulations were again fully discussed at the 1949 Paris Conference of the International Telecommunication Union. By then there were about 70 radiotelephone circuits in use for the traffic between the five continents, and it was perhaps not unnatural that at last the time was considered ripe to draw up telephone regulations which were not only applicable to Europe but to all circuits throughout the world. But this was not to be. Opposition came again from the United States, although it had become a Member of the Union at Madrid in 1932, by signing its Convention. The Telegraph Regulations were signed for the first time by the United States at the Paris Conference of 1949, although with many reservations, and the current Telephone Regulations of to-day are still without the signatures of Canada and the United States of America.

The outstanding opposition on the part of the United States, which, it has been estimated, has in its territories probably more than half of all the telephones of the world, was strongly voiced at the Paris Conference of 1949. "Such (telephone) regulations may result in an inflexibility that might tend to retard the development of the service". Minor improvements were made, and the work of co-ordinating the international telephone service has remained one of the main functions of the Telegraph and Telephone Consultative Committee.

A few interesting points from the Telephone Regulations, as in force at present in the countries which have signed them, might well conclude this chapter. In the absence of any special agreement, it is laid down that French shall be the service language between international operators of countries with different languages. The priority of telephone calls is considered in Article 20, and it begins by stating that international calls may be granted priority over similar national calls; then there are three classes of calls which may be recognised by administrations and private telephone companies: "Lightning Calls", at three times the ordinary rate, "Urgent Calls", at double the ordinary rate, and "Ordinary Calls".

Absolute priority over all other telephone calls is of course reserved to distress calls when and wherever life is in danger on land, in the air or on the sea. Following these, after United Nations priority calls similar to the telegram priorities, come "Lightning Service Calls" concerned with re-establishing international telephone routes which have been totally disrupted. Then in order of priority come "Lightning Government Calls", and "Lightning Private Calls". Next follow "Urgent Government Calls", "Urgent

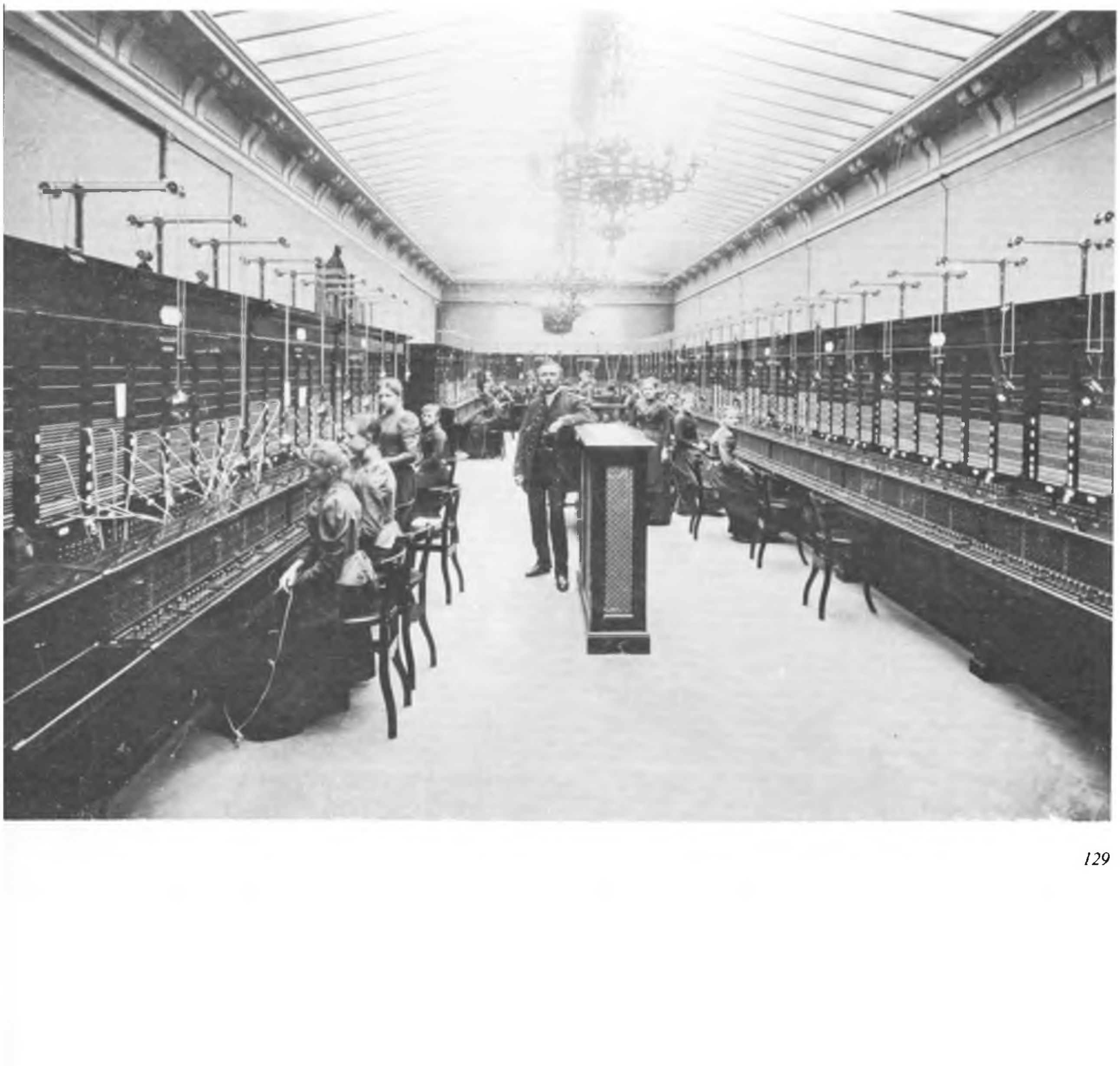
126 *Facsimile of first telephone directory ever issued in the world, at New Haven, Connecticut, United States of America, February 21st, 1878.*

127-128 *World-wide telephones have meant thousands of telephone directories in thousands of cities all over the world. These are the covers of two, from Sarajevo, Yugoslavia (left) and from Izmir, Turkey (right).*

129 *Hamburg telephone exchange in 1895.*

130 *A telephone exchange in Wellington, New Zealand, in 1888, showing the typical distribution of overhead telephone cables common at that time.*

131 *This was a typical rural telephone exchange in the Netherlands of about 1930. Since then they have all been replaced by automatic exchanges.*



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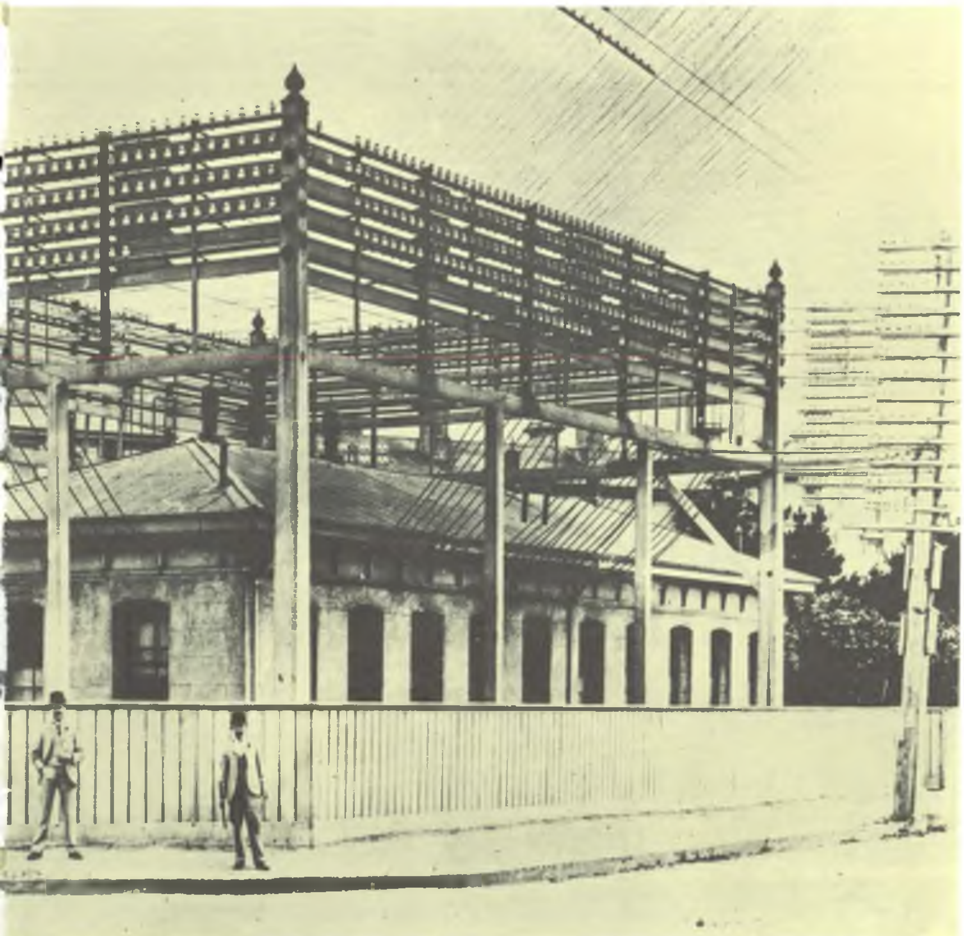

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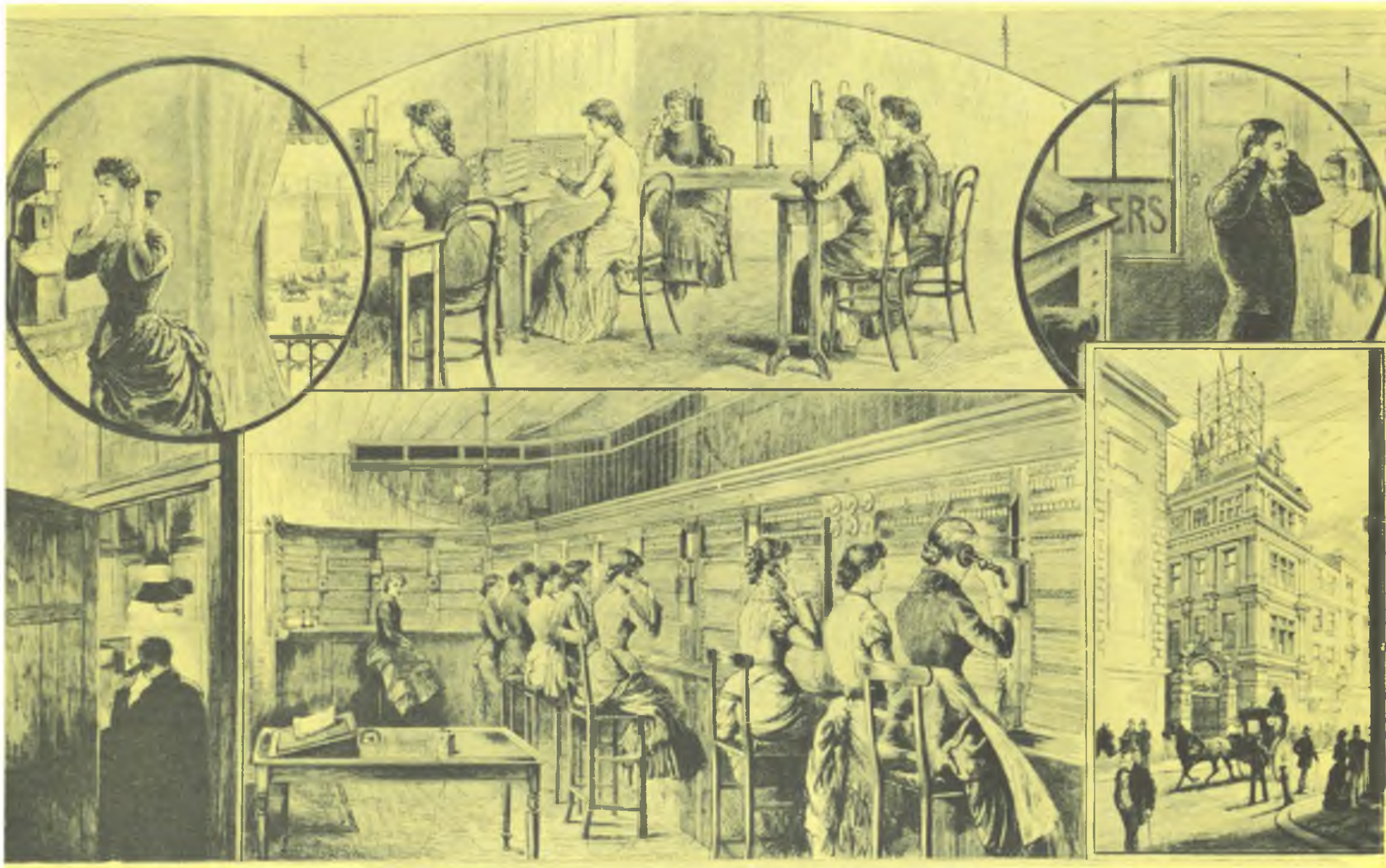
132 *The first telephone exchange in London, in 1883.*

133 *Tokyo telephone exchange in 1890.*

134 *One of the most modern telephone exchanges in Europe was recently installed in the Shell Centre, London. There are no telephone cords and 4500 line extensions are served from this one exchange.*



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Service Calls" and "Urgent Private Calls", and finally "Ordinary Government Calls with Priority", "Ordinary Government Calls without Priority", "Ordinary Private Calls" and "Ordinary Service Calls". If there is a great demand for high priority calls, a private call may be limited to 12 or even to 6 minutes, but in general the duration of a private call is not limited.

International telephone circuits can be leased but naturally the calls exchanged on these circuits must be concerned exclusively with the private business of the subscriber and not open to any member of the public. International telephone circuits can also be used for the transmission of sound broadcasting and television broadcasting programmes as well as for the transmission of photographs, but users are requested to book early! When it comes to charging for telephone calls, the unit of time is still to-day the three-minute period, first laid down in Budapest in 1896, and the gold franc is still accepted as the international currency for all international accounting.

There is however one limitation to the International Telephone arising from its very nature of being instantaneous. This is due to a basic geophysical fact, which no international regulation can overcome. Because of the time difference in business hours on various parts of our planet, telephone conversations of a commercial nature are somewhat limited between different cities. So, for example, working hours of nine to six overlap only one hour in San Francisco and Hong Kong, and the business days in New York and Tokyo, as well as those of Chicago and Calcutta, do not coincide at all. And there is nothing we can do about it, except change the hours of business to the time of night.

135 *Automatic telephone exchange, Socotel system, installed at St. Vallier, France.*

Part II — Radio

From 1888 to 1947

The Inventors of Wireless Telegraphy

Ironically, every offspring of the telegraph created competition for its parent, threatening the very invention from which it sprang. Everything in the science of communications is subjected to the test of survival of the fittest and in every instance the acid test is: What can this new invention do to improve or surpass an existing service, what does it offer that is more efficient or more economical, and to what further advances is it the key? To pass this test was not difficult for "Wireless Telegraphy", and a short decade after the first messages had been sent it was firmly established in a completely new field of communications, namely contact with ships at sea.

But the pace of progress had quickened. The leisurely story of the telegraph which we have told, and the somewhat quicker development of the telephone, are left far behind by the veritable revolution which radio brought to all our communications. Absence of costly wires along the ground and under the ocean was but one reason; instantaneous transmission of music, pictures and colour, but a second; spanning the globe cheaply and easily, the third; and finally it came into all our homes to entertain, to educate and to show to us the outside world.

And as the decades of the 20th century passed, revolution followed revolution in the field of radio itself. Each of the new radio inventions and services had in turn to pass the acid test, they too had to maintain pace with progress and quickly adapt themselves to new developments and change, or else they themselves suffered the penalty of extinction and oblivion. Such was to be the fate of the spark gap transmitters, the coherers, the alternators, and so many other radio instruments that served their day and vanished into antiquity.

And let no one think that the pace of progress is slowing up. On the contrary, as transistors are replacing valves, as satellites are opening richer channels of communication, and as electronic computers are taking over routine mental work, the revolutions to come in electronics and communications will still be far greater than those we have already witnessed. In the past, science was often described as being "on the march"; to-day it is in swift flight, and no story could better tell this transition than the coming of radio and its international implications. Only those who can read in it the exponential nature of scientific progress and who can adapt to it, will read it right and learn from it that change alone is the ever constant factor of all human activities, and especially of communications.

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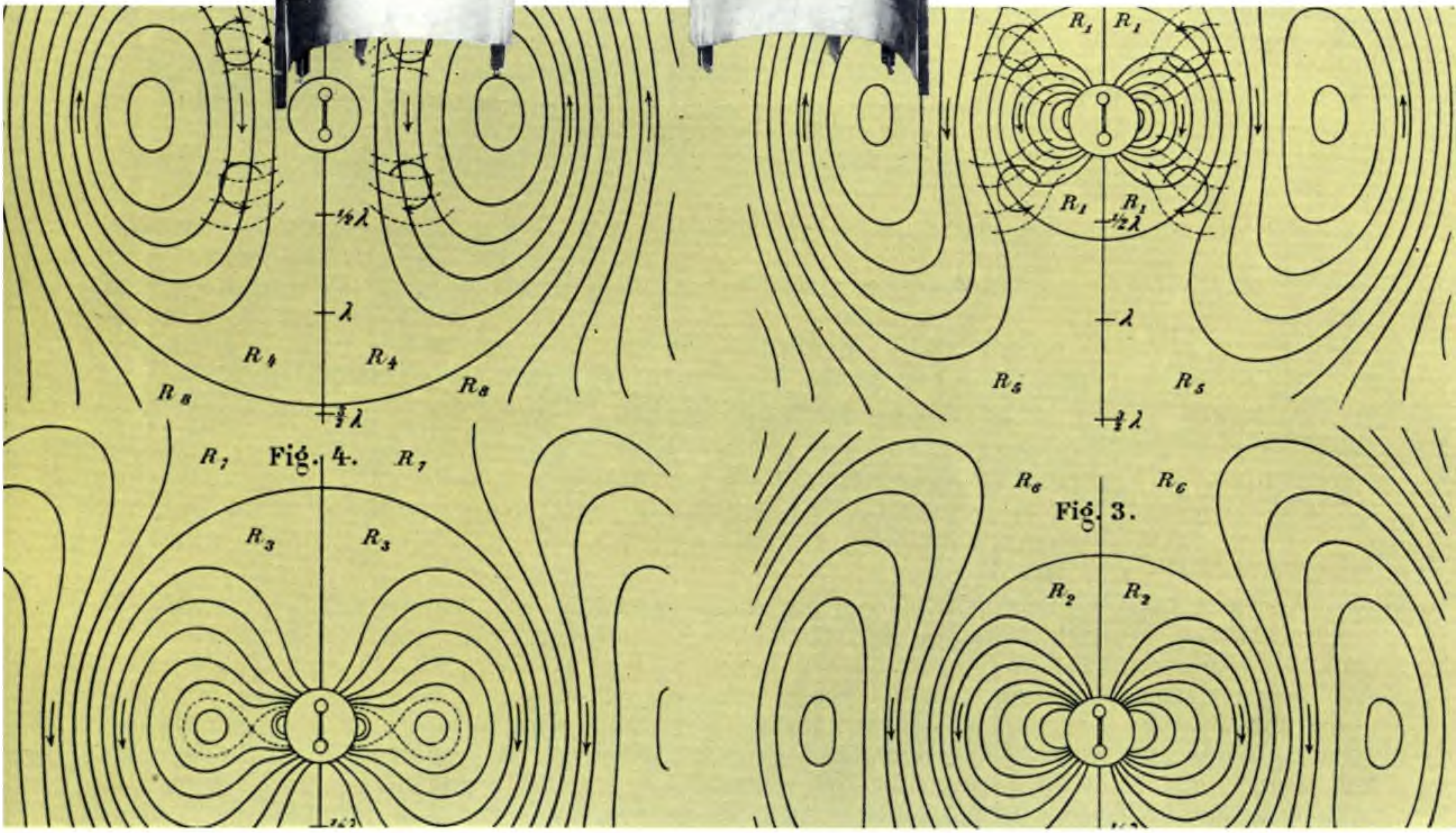

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136 Parabolic mirrors and generators of electromagnetic waves as used by Heinrich Hertz, 1886 to 1888.

137 Pictures of the lines of flux around an oscillating dipole from the original paper of Heinrich Hertz.

The story goes that in the closing years of the last century a high official of the Patents Office in Washington had reluctantly come to the conclusion that all there was to be invented had been invented. He drew up a memorandum therefore, recommending the closure of the Office, and his dismissal. And yet that very decade of 1895 to 1905 was probably richer in new discoveries than many other periods.

On December 28, 1895, at the Grand Café, Boulevard des Capucines, in Paris, the two brothers Lumière projected the first motion picture film; on the first night only a handful of people watched the arrival of a train and a gardener getting wet. Yet this was the beginning of the cinema.

In Würzburg, in Germany, a professor of physics published a paper in 1895, modestly called: " Über eine neue Art von Strahlen ". His name was W. C. Röntgen, and his *Strahlen* were X-rays. Antoine Henri Becquerel, Professor of Physics at the Ecole Polytechnique in Paris, discovered in 1896 that uranium gave off another kind of ray, and thus started a whole new science. In 1903, the Nobel Prize for Physics was awarded to him jointly with Pierre Curie and Marie Curie, for the " discovery of spontaneous radioactivity ".

Between 1897 and 1899, a British physician, Sir Ronald Ross, showed that the malarial parasite *Plasmodium* spent part of its life cycle in the female mosquito and thus he opened the way to the prevention and cure of malaria. He too, received the Nobel Prize in 1902.

Across the Atlantic Ocean, in North Carolina, Orville Wright climbed into the pilot's position of his *Flyer* at 10.35 a.m. local time on December 17, 1903; he was in the air for 12 seconds and covered a distance of 40 meters. Five people came to watch at Kitty Hawk; there was very little public interest in flying for several years. Two years earlier, almost to the day, another momentous event had taken place in a disused Barracks Hospital at St. Johns in Newfoundland. At 12.30 p.m., local time, on December 12, 1901, the three dots of the Morse letter *S* were heard by Marconi and his assistant, George S. Kemp; the signals had crossed the Atlantic Ocean by wireless telegraphy from Poldhu in Cornwall, England. It was indeed an almost miraculous decade.

" This (radio contact with ships at sea) is surely one of the greatest of many boons conferred upon humanity by patient, persistent, and often discouraging inquiry into natural laws, carried on, at all events in its initial stages, by students animated only by love of knowledge ". Thus commented *The Times*

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in April 1912, after the disaster of the *Titanic*. Without understanding the inquiries of pure science, we cannot follow the story of radio.

It begins perhaps with Joseph Henry (1797-1878), an American physicist, who discovered in 1842 that electrical discharges were oscillating. A gigantic step forward was that due to James Clerk Maxwell (1831-1879), a Scottish physicist and one of the great mathematical geniuses of the 19th century. His treatise on "Electricity and Magnetism" was first read as a paper to the Royal Society in 1864, and published in fully developed form in 1873. It has been called "one of the most splendid monuments ever raised by the genius of a single individual". By purely mathematical reasoning, Maxwell showed that all electrical and magnetic phenomena could be reduced to stresses and motions in a medium, which he called the ether. To-day we know that this "imponderable electrical medium" does not exist in reality, any more than the equator of the geographer or the average man of the statistician. Yet the concept of an ether helped greatly, and allowed Maxwell to put forward his theory that the velocity of electric waves in air should be equal to that of the velocity of light waves, both being the same kind of waves, merely differing in wave length. This we know to-day to be an elemental truth, yet to Maxwell must go the honour of having first shown it to us in pure mathematical form.

In 1857 Feddersen demonstrated that if an electrical condenser is discharged into a conductor, oscillations are set up which give rise to intermittent spark phenomena. Twenty-one years later, in 1878, David Edward Hughes (1831-1900), an Anglo-American physicist, made another important discovery in the pre-history of radio and its essential components; he found that a loose contact in a circuit containing a battery and a telephone receiver (invented by Bell in 1876) would give rise to sounds in the receiver which corresponded to those that had impinged upon the diaphragm of the mouthpiece. Hughes' "microphone" consisted of a carbon rod resting in grooves of two carbon blocks; from it developed many of the early carbon microphones of both telephone and radio. In 1883, George Francis Fitzgerald (1851-1901), an Irish physicist, suggested a method by which electromagnetic waves might be produced by the discharge of a condenser.

Next we must turn to Heinrich Rudolph Hertz (1857-1894), the famous German physicist, who was the first to create, detect and measure electromagnetic waves, and thereby experimentally confirmed Maxwell's theory of "ether" waves. In his experiments he showed that these waves were capable of

138 The original equipment as used by Heinrich Hertz in 1886 to 1888. On the left the polarized grid for electromagnetic waves. On the right a prism made from pitch to prove the refraction of these waves.

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reflection, refraction, polarization, diffraction and interference. They corresponded precisely in their behaviour to waves of light. Hertz produced his waves, soon to be called by others "Hertzian waves" from the sparks of an induction coil, and in order to study some of their properties he employed a zinc mirror. He described one of his experiments, in 1888-1889, as follows:

"The height of the (parabolic) mirror was thus 2 meters, the width of its aperture 1.2 meter and its depth 0.7 meter. The primary oscillator was fixed in the middle of the focal line. The wires which conducted the discharge were led through the mirror; the induction coil and the cells were accordingly placed behind the mirror so as to be out of the way. If we now investigate the neighbourhood of the oscillator with our conductors, we find that there is no action behind the mirror or at either side of it; but in the direction of the optical axis of the mirror the sparks can be perceived up to a distance of 5-6 meters". The half-wave length of this experiment was about 30 cm.

Hertz died at the early age of 37, and once said "...these are the ultimate problems of physical science, the icy summits of its loftiest range. Shall we ever be permitted to set foot upon one of these summits? ...We know not: but we have found a starting point for futher attempts which is a stage higher than any used before." There could be no truer epitaph to one of the greatest of inventors of wireless telegraphy.

But Hertz's experiments were half a century in advance of his time, and belong to the field we now call microwave optics. Many repeated them and extended them, typical amongst them being Edouard Sarasin (1843-1917) and Lucine de la Rive (1834-1924) at Geneva, Antonio Giorgio Garbasso (1871-1933) and Emil Aschkinass (1873-1909) at Berlin, Jagadis Chunder Bose (1858-1937) at Calcutta and Augusto Righi (1850-1920) at Bologna. We shall see in a moment that only Righi had an indirect influence on the technology of radio, as a young Italian by the name of Guglielmo Marconi (1874-1937) was stimulated by his books and lectures.

The next most important event was a lecture given to the Royal Institution in London by Oliver Joseph Lodge (1851-1940) on June 1, 1894; it was called " The Work of Hertz and Some of his Successors ", it was widely reported at the time, and was to have far-reaching consequences. Lodge, Professor of Physics at the new University of Liverpool, had himself worked extensively in the field of electromagnetic waves and was the first to comment on the phenomenon of resonance or tuning. In 1898 he took out a patent on an adjustable inductance coil in the antenna circuit of a wireless transmitter or receiver, or in both,

139 *A. S. Popoff's first receiver (1895): On 7 May 1895, Popoff demonstrated, at a meeting of the Physical section of the Russian Physico-Chemical Society, the world's first radio receiver, which he called: "an apparatus for the detection and registration of electrical oscillations".*

140 *A replica of Marconi's first transmitting apparatus, with a copper sheet aerial. He used this type of transmitter in Italy in 1895 and on Salisbury Plain, England, the following year.*

КРОНШТАДТСКIЙ ВѢСТНИКЪ.

МАСКАРАДЪ

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141 *A photographic copy of the newspaper "Kronstadt Herald" of 12 May, 1895, containing information about Popoff's experiments.*

"A. S. Popoff, a lecturer in the officers' school of mine-laying, is at present conducting experiments in the use of metallic powders, sensitive to oscillating electrical discharges, for the study of electrical oscillations occurring in the atmosphere. In certain circumstances, a metallic powder changes its electrical resistance when affected by an oscillating discharge. These unusual properties of powders were discovered as long ago as 1891, and thereafter were the subject of various investigations. In 1894, O. Lodge, in front of a large audience in the Royal Institution, London made use of these properties for experiments with Hertzian rays. Professor Popoff, in his experiments with these powders, devised a special portable apparatus which reacts to electrical oscillations by the ringing of a bell. In the open air, it is sensitive to Hertzian waves up to a distance of 30 sazhen. A report on these experiments was made last Tuesday in the Physics Section of the Russian Society for Physics and Chemistry, and was received with the greatest interest. The reason for these experiments is that it is, in theory, possible to transmit signals over a distance without wires, using electric rays."

142 *Post Office officials examining Marconi's apparatus when in 1897 he successfully communicated by wireless across the Bristol Channel, England. This was the first time a wireless transmission was conducted across water.*

143 *An impression by the artist Steven Spurrier of Marconi's demonstration on Salisbury Plain, England, in 1896 to officials of the Post Office and the Armed Services.*

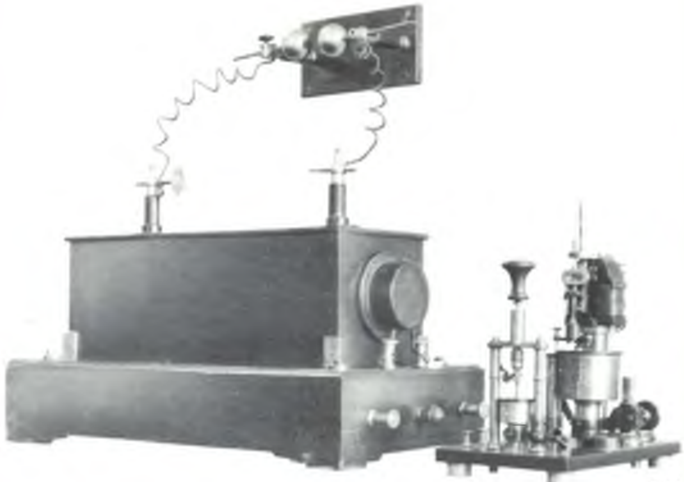
144 *The Kronstadt radio transmitter, 1900.*

145 *One of the earliest cathode ray tubes, as invented by C. F. Braun in 1897.*

146 149 *Experimental wireless apparatus of Sir Oliver Lodge, with coherers of about 1894.*

150 *The invention of the coherer, detector of wireless waves, is due to Edouard Branly. Marconi improved the Branly version and evolved his own pattern, shown here.*

151 *The original wireless transmitter, made by Captain H. Jackson in 1896-7.*



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in order to tune one with the other. This patent won him a high place in the history of wireless. His sharply tuned resonance circuits were a substantial advance over Hertz's relatively primitive arrangements, but Lodge himself, like Hertz with heavy academic commitments, had not the time to develop his ideas on wireless telegraphy and never made an attempt to transmit any intelligent signals with electromagnetic waves.

Alexander Stepanovitch Popoff (1859-1906) was one of the many who read Lodge's lecture and was inspired by it. Popoff was in 1895 lecturer in physics at the Russian Imperial Navy's Torpedo School at Kronstadt near St. Petersburg. He experimented with Branly coherers (see below), set up a receiver with a protruding wire in 1895, and read a paper about it, "On the Relation of Metallic Powders to Electric Oscillations", at the Meeting of the Russian Physico-Chemical Society on April 25 (May 7, New Style), 1895. By means of this equipment, Popoff could register electrical disturbances, including atmospheric ones; and in July of the same year a similar instrument with an ink recorder was installed at the Meteorological Observatory of the Institute of Forestry at St. Petersburg.

A more complete description of his experiments appeared in January 1896, and on March 12 (24 N.S.) of the same year he gave a further demonstration before the same society. Only a very brief minute appeared at the time in the records of the society: "A.S. Popoff shows instruments for the lecture demonstration of the experiments of Hertz. A description of their design is already in the *Zh.R.F.-Kh. Obshchestva.*" At that meeting the words "Heinrich Hertz" were transmitted by wireless telegraphy in Morse code and similarly received before a distinguished scientific audience. To the Soviet Union, Popoff has become the inventor of the radio, May 7 being celebrated each year as "Radio Day".

In view of the date of Marconi's first patent (it was applied for on June 2, 1896, the specification was completed on March 2, 1897, and it was accepted on July 2, 1897) there has in recent years been much discussion about the priority of the invention of radio. We have already seen a similar case in the invention of the telephone, when only a few hours separated the filing of a caveat and a patent application by Gray and Bell; in Germany, Reis is considered "*Der Erfinder des Telephons*" as it is recorded on his memorial statue.

Most historians of science and technology take the view nowadays that, given the right preliminary stimulus—here the work of Hertz and the lecture by Lodge—and the availability of the right materials and equipment, then a given invention might well be made simultaneously by more than one research worker. Once more looking back, but to the history of the early telegraph, we found that it was not only the act of invention that counted in technology, but also the successful communication of the idea, so that it could be applied and brought to fruition. There can be no doubt that in the case of radio Marconi invented a system of highly successful wireless telegraphy, and that he personally inspired and supervised its application until it spanned the world. This must be considered as ample justification for his award, in the year 1909, of the Nobel Prize for Physics. He shared it with Carl Ferdinand Braun (1850-1918) " in recognition of their contributions to the development of wireless telegraphy ", to quote the official citation of the Nobel Foundation at the time. Braun will always be remembered for his development of the cathode ray tube, the direct ancestor of the Kinescope and the television tube, quite apart from his other work in radio.

Marconi, at the age of twenty in 1894, was well acquainted with the work of Hertz, Branly, Lodge and Righi. As the son of a rich country gentleman, his education had been private, and his main interest lay in science and music. He began experimenting in the spring of 1895 on his father's estate at the Villa Grifone, near Pontecchio, Bologna. The idea had occurred to him that Hertzian waves might be the basis for a means of communication, signalling with them the dots and dashes of the Morse alphabet. Once he had convinced his father of the practical nature of his ambition, he received from him all the financial support he needed.

In his first experiments, he used an ordinary spark induction coil and home-made coherers of the Branly type (see below). To turn the discharge on and off, he placed a telegraph key in the primary circuit of the induction coil, and thus produced short or long trains of sparks. He could soon detect these dots and dashes all across the room, and in the summer of 1895 he moved out into the garden. In order to increase the performance and range of his transmitter, he followed previous experiments by others: he attached to one end of his transmitter circuit an elevated metallic object, the antenna, and to the other end a metal plate buried in the ground. He could now signal across the whole garden, and he soon found that there was a direct relationship between the height of the antenna and the distance of transmission.

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Marconi made important improvements in the components of his system, particularly in the design of his coherers. He also put a relay in series with it, which actuated the tapper of his coherers, and worked a telegraphic printing instrument to record the received signals. And here is perhaps the best place in our story to pay tribute to Edouard Branly (1844-1940), a great French physicist, officially described in France as "*Inventeur de la Télégraphie Electrique sans Fil*". His great contribution was the discovery of the coherer, that small fragile glass tube, looking like a thermometer, but filled with metal powder. He demonstrated it before the French Academy of Science, to which he was later elected, in 1891.

Branly found that electromagnetic waves, produced as much as 25 meters away from it, caused the individual metal particles in his coherer, first iron and later nickel and silver, to cohere and thus allow the passage of a current through them. A galvanometer was the instrument he used to show this effect; Marconi improved this greatly by using a telegraph printer. But the metal particles had to be separated again, and therefore an electric tapper, a tiny hammer precisely like that used in any electrical bell was added to the coherer. When it struck the glass tube it decohered the particles again, and thus stopped the current from the batteries.

Each successive impulse reaching Marconi's antenna produced the same phenomena in the coherer, first the coherence of the particles, then their decoherence, and hence the recording of the dots and dashes. Marconi used tightly fitting silver plugs in his glass tube, which he evacuated and sealed and thus the coherer became the first of many sensitive devices to receive wireless telegraphy. Before Marconi left Italy, to continue his work in England, he had reached a transmission distance of the order of 1 kilometer.

Such then is the story of the many inventors of wireless telegraphy, working with each other's equipment, adding new ideas and new improvements to them. It was a patient, persistent and often discouraging inquiry into natural laws and in these initial stages it was indeed only animated by the love of knowledge.

152 *The first experiments in radio transmission from the Eiffel Tower took place on the 5th November 1898, carried out by Ducretet. They were received four kilometres away, near the Panthéon.*

153 *A commemorative medal of Edouard Branly, struck by the Paris Mint.*

154 *The original thermonic valve made by Professor Ambrose Fleming in 1904.*

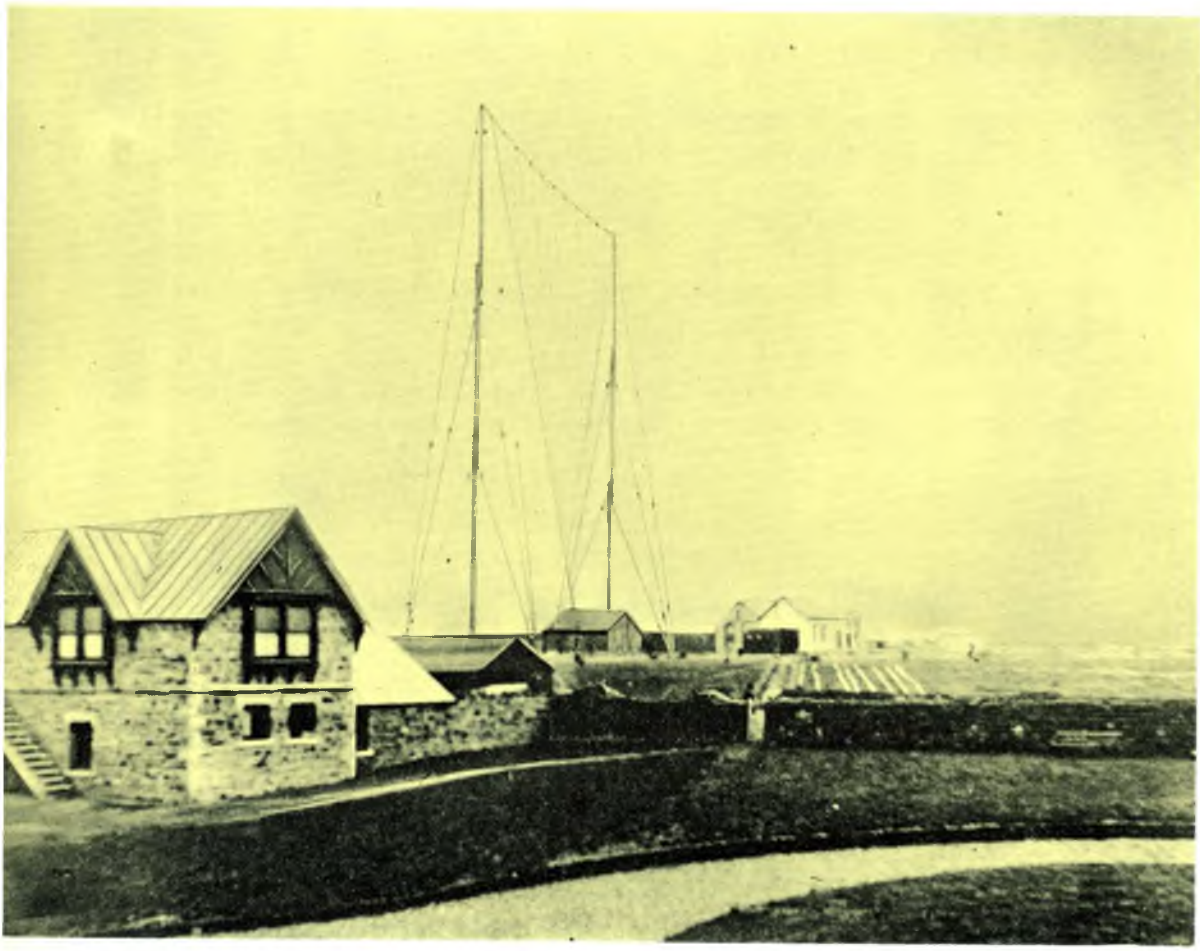
Wireless Grows up at Sea

The very nature of radio made it international, right from its first beginnings. Unlike the cables of the telephone or the wires of the telegraph, electromagnetic waves know no man-made frontiers; once emitted from their antenna, only their strength decides to what distance they travel. This immense advantage was first appreciated by naval and maritime authorities, who had in wireless the first possible method of keeping in touch with ships at sea. Such ideas might well have passed through the head of young Marconi, when in February 1896 he left Italy and came to London in order to exploit his invention.

As his mother had been Irish, and had relations living in London, it was easy to obtain for Marconi an introduction to Sir William Henry Preece (1834-1913), the Chief Engineer of the British Post Office. He had himself done much work on telegraphy by "induction", and later tried to approach wireless by the same technique. He was astonished by Marconi's achievements, and offered him the help of his department. The trials took place on Salisbury Plain in September 1896 and again in March 1897. When using an aerial supported by a kite Marconi achieved ranges of 6-7 km. Two months later, on May 18, tests were carried out over water, the Bristol Channel, and the then record distance of 14 kilometers was achieved.

Marconi's faith in the future commercial possibilities of wireless were very strong indeed, and on July 20 of 1897 his Wireless Telegraph and Signal Company Limited was registered in London. Cooperation with the Post Office had to come to an end, and radio had finally left the research laboratory to become a business enterprise. The Company, from 1900 to 1963 known as Marconi's Wireless Telegraph Company, had in 1898 a share capital of £100,000; by 1911 this had increased to £1,000,000, but no dividends were paid during that period. During those years the Company established a commanding position in the wireless business, including a virtual monopoly in Britain and Canada.

Marconi's efforts were continually directed towards an increase in the range obtainable. At this time Marconi had not appreciated the importance of resonance between his transmitter and receiver. This understanding came slowly, and it was not until the Naval trials in the autumn of 1899 that Marconi fully realized the importance of resonance. During these trials he found that the introduction of the "jigger", an elementary form of tuning coil, enormously increased the ranges obtainable. In September and October of this year, wireless went to America and there reported to New York City the results of the International Yacht Races off Sandy Hook.



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155 *Poldhu wireless station in 1901 with the fan-shaped aerial which sent the first wireless signal across the Atlantic to Signal Hill, Newfoundland.*

156 *Raising the kite aerial at Signal Hill, Newfoundland, with which in 1901 the first wireless signal across the Atlantic was received from Cornwall, England. Marconi is the figure at the extreme left.*

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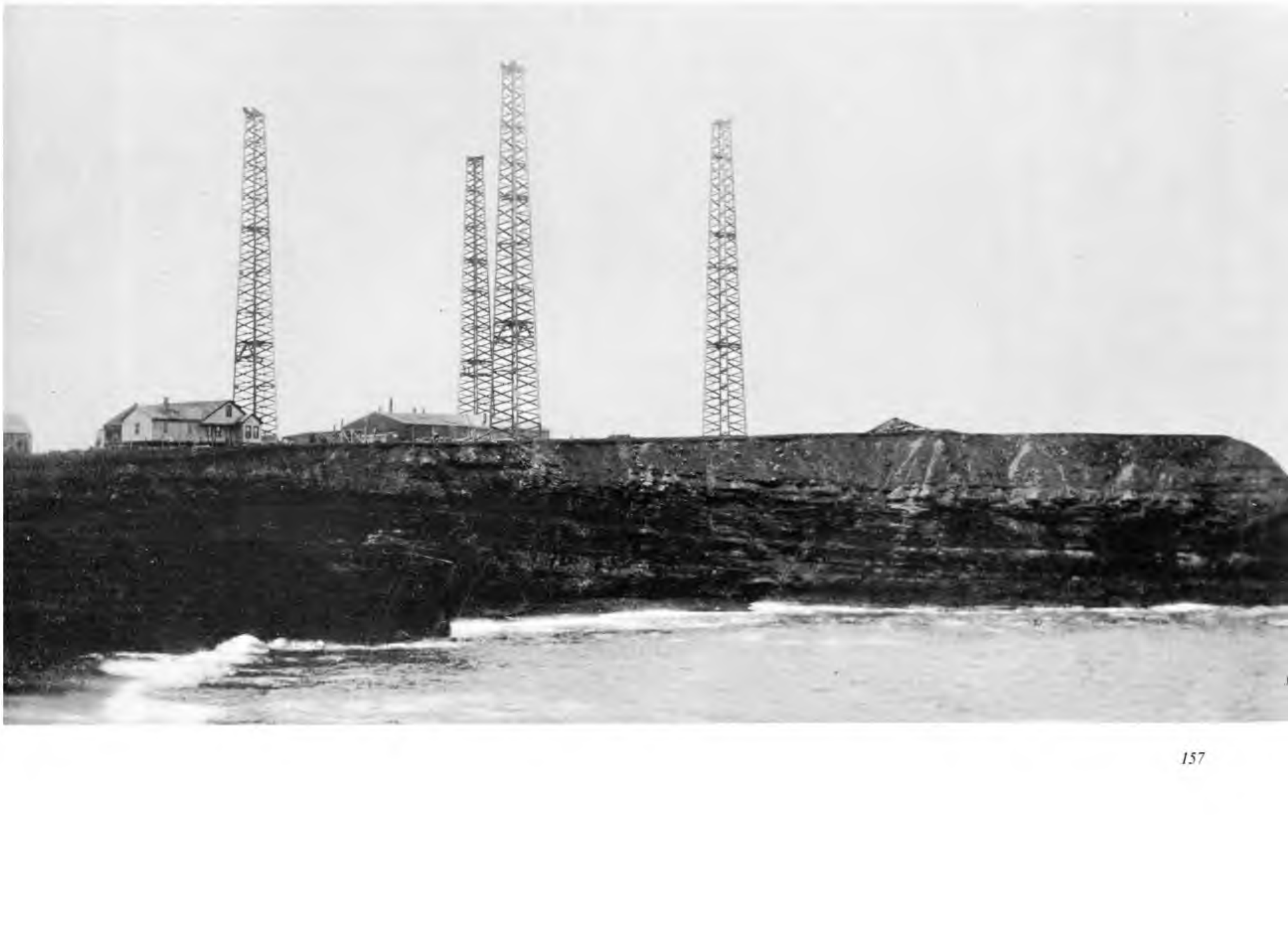
157 *Marconi towers at Table Head, Nova Scotia.*

158 *The first mobile wireless, 1901. A steam-driven wagon used by Marconi (standing at extreme right) in early experiments. The cylindrical aerial could be lowered to a horizontal position when the vehicle was on the move.*



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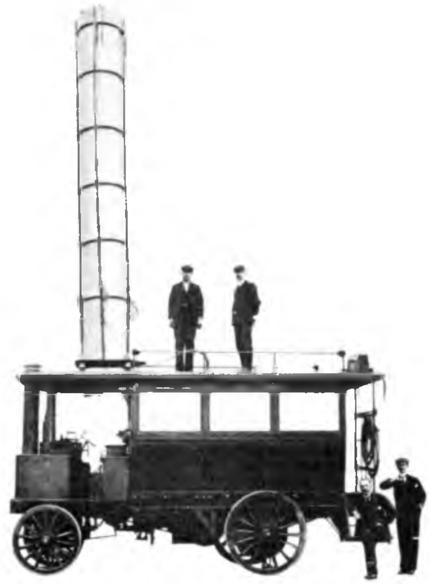

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The American liner *St. Paul* was apparently the first vessel to have a floating wireless station aboard and in November of 1899, eastbound to Southampton, she received a wireless message from The Needles, Isle of Wight, when still 105 kilometers out. The next ship to be fitted was a German one, *Kaiser Wilhelm der Grosse*, early in 1900, and from then on ship after ship followed suit, until to-day it is unthinkable to have anything afloat, from the largest liners to the smallest life-raft, which is not fitted with wireless apparatus.

But Marconi did not remain alone for long in the field of wireless. So for example, in Germany, Adolph K.H. Slaby (1849-1913), who had himself made distinguished contributions by the invention of resonant coils to measure wavelength, joined with Count George von Arco and the A.E.G. in the manufacture of wireless equipment. Their company, and those of Braun, as well as of Siemens and Halske were amalgamated in 1903 as Telefunken. To keep his lead, Marconi changed his business tactics. Instead of merely manufacturing equipment and selling it to anyone, he decided to organise a great wireless system of his own.

Marconi built his own transmitting stations on land, strategically located along the sea trade-routes, and placed his own operators on board ships fitted with his equipment. They were forbidden to communicate with any other wireless station on any other ship unless it also was a Marconi station. To carry out this plan, the Marconi International Marine Communications Company was created in 1900, and from May 1901 on many Marconi Stations were opened in Britain, Ireland, Italy, Canada, Belgium and Newfoundland. The first radiocommunication company in the United States was the Marconi Wireless and Telegraph Company of America; it was organised as a New Jersey Corporation on November 22, 1899.

Marconi was extremely successful in transferring radio from the research laboratory, where he had himself started, to a world-wide business. The reasons for this modern success story were his great scientific ability and his equally out-standing commercial acumen. But he never took a second place in scientific affairs as long as he lived, and we have already seen how he himself went to Newfoundland to receive the first Transatlantic radio message in 1901. One of the scientific advisers to Marconi's British Company, since 1899, was John Ambrose Fleming (1849-1945), the first Professor of Electrical Engineering at University College, London. He certainly helped Marconi in the design of the transmitting station

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at Poldhu in Cornwall, and stated later that it was a wavelength of "probably no less than 3000 feet" (915 meters or 328 kc/s) that was used for the first transatlantic transmission.

But Fleming was also adviser to the Edison Electric Light Company in London, and had made extensive studies of the "Edison Effect" in the late 1880s. This was the clean white line, formed on the inside of burnt-out electric light bulbs; the remainder of their inside being covered with a black deposit of carbon or metal. The white line was due to the shielding effect of the unbroken filament.

When working with Marconi, Fleming soon became thoroughly acquainted with the capricious coherer as a detector of wireless waves, and one day in 1904 he decided to try one of his lamps, in which a metal plate had been placed around the negative leg of the filament. When electromagnetic waves were transmitted to this lamp, and its metal plate connected to a galvanometer, a strong current was indicated. His great patent for the discovery of the thermionic valve was applied for on November 16, 1904. Two years later, in 1906, an Austrian engineer, Robert von Lieben took out a German Patent covering all electronic amplifiers.

Yet one further step was needed to wean the newborn valve. Lee De Forest (1873-1961), an American radio engineer, took it quite independently of Fleming in 1906, by placing a grid between the filament, or cathode, and the metal plate of the anode. Thus the stream of electrons from the cathode to the anode, discovered by Sir Joseph John Thompson (1856-1940) in 1897, was modulated by the grid, and any weak signals passed to the grid were greatly amplified.

De Forest with his "glass bottle full of nothing" probably contributed more to the rapid development of radio and the science of electronics than anyone else. By the middle of the 20th century, more than 200 million radio valves were manufactured annually in the world. This valve, the triode, or audion, was not only useful for the amplification of the weak signals arriving at the receiver, particularly when more than one audion was used in cascade. Furthermore when combined with an oscillator as was done by Alexander Meissner in 1913 it acted as a strong source of electromagnetic waves. By 1914, it had begun to replace the arc in radiotelephony as a producer of continuous radio waves.

But we must return to the sea, where wireless first proved its value to mankind, and to the early days of this century. So for example, on January 23, 1900, a small group of fishermen near the Island of Hogland in the Baltic Sea was saved by a radio call to the icebreaker *Yermak*. Marconi had just flashed

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the letter *S*, three dots in Morse code, from Cornwall to Newfoundland, a distance of 3500 kilometers. But this needed high and complicated aerials. The majority of ships fitted with wireless could during these first years just keep contact with the shore for the first few hundred kilometers and resume contact only when they approached the end of their voyage. Also, wireless was then thought of purely as means of point to point communications, a shipowner giving instructions to his captain, a financier ordering his broker to buy or sell, or the transmission of the latest news to the ship's passengers; often this was duplicated on board, and thus the first ship's newspapers came into being. Then, three dramatic events happened at sea, which showed to the whole world the real value of this new means of communication.

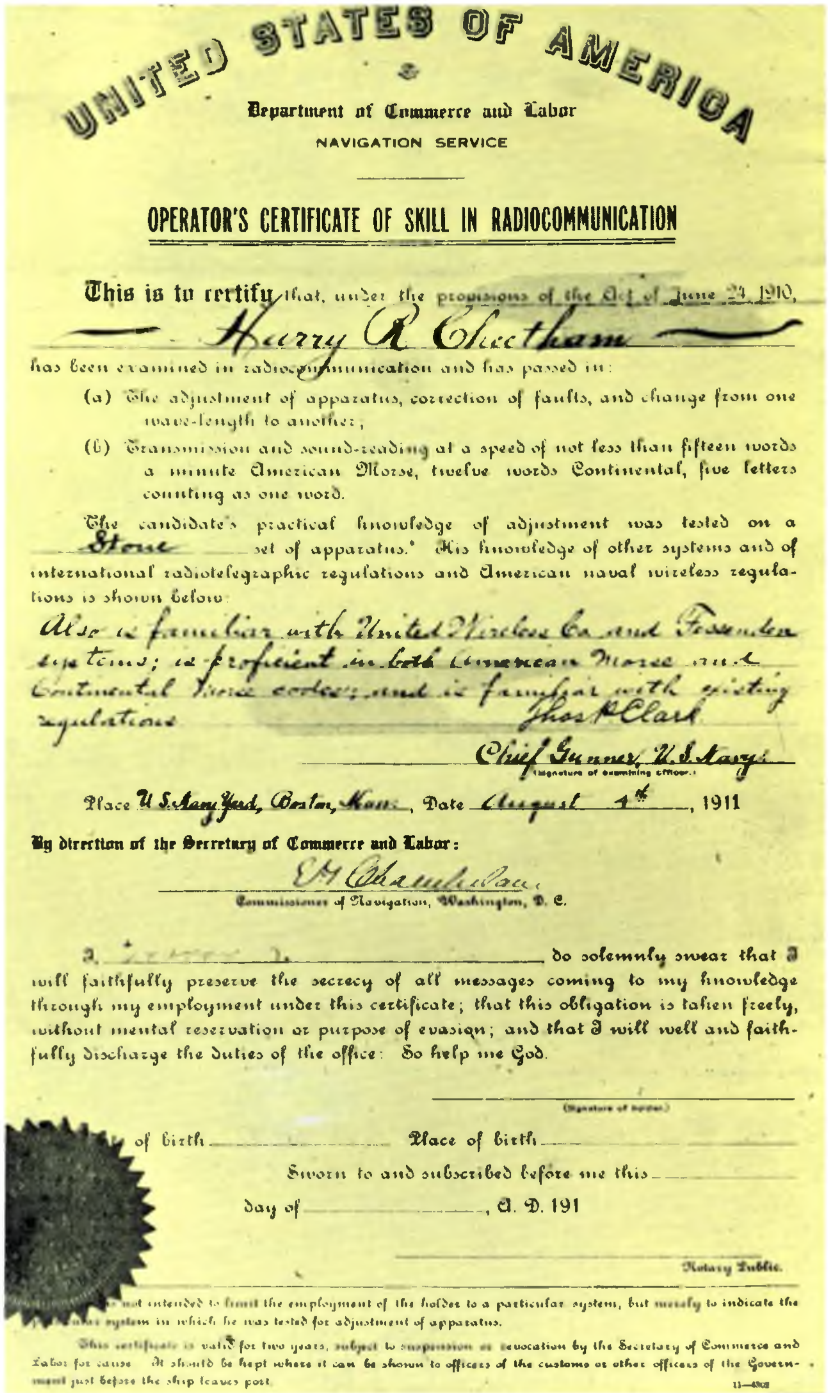
At 5.30 in the morning of January 23, 1909, the 15,000 ton ship *Republic* was in deep fog, about 280 km east of Ambrose light, off the East Coast of the United States. There and then she struck the Italian steamer *Florida*, with 800 emigrants aboard, westward bound to the new world. Jack Binns, radio officer aboard the *Republic*, got the wireless distress signal—CQD—to Siasconset, on the American coast, and from there it was relayed to other ships in the neighbourhood. The first to arrive at the scene was the *Baltic*, which had received the request for assistance only 30 minutes after it had been sent out. She was brought alongside entirely by wireless messages from the *Republic*, this being the only means of guiding her in the thick fog. All 1700 souls from the two ships were saved. For the first time the whole world had known and participated in a major tragedy at sea, and was able to follow in its newspapers the efforts made for rescue operations. Without wireless, no help could have been summoned, nor would anyone have known about the disaster.

But that wireless could render a quite different kind of service was shown only 18 months later. In July 1910, a notorious British murderer, Dr. Crippen, had escaped with his secretary and was fleeing aboard the Canadian Pacific liner *Montrose* from Antwerp. The captain's suspicions having been aroused by a strange passenger and his "son", he got in touch by wireless with his company's offices, which sent to him in return the detailed description of Crippen and his companion; she had disguised herself as a boy. Immediately he confirmed their presence aboard his ship, and had radioed this fact back to his company, Chief Inspector Drew, from Scotland Yard, set out for Canada in the *Laurentic*, a much faster vessel.

So began a race across the Atlantic, known to the whole world by wireless, but unbeknown to the two fugitives from justice. The imagination of the world was gripped by the intensely thrilling, almost

159 *An early "walkie-talkie" described in 1910 as a "portable wireless station—messages received while you walk in the garden—a new feature for garden parties." It was patented by Mr. Sharman, one of the principals of the British School of Telegraphy at Clapham, London.*

160 *Dr. Crippen and Ethel Neve snapped on board S.S.* Montrose *before capture. Their arrest, in 1910, was the first occasion on which wireless was used to apprehend a criminal.*



UNITED STATES OF AMERICA

Department of Commerce and Labor

NAVIGATION SERVICE

OPERATOR'S CERTIFICATE OF SKILL IN RADIOCOMMUNICATION

This is to certify that, under the provisions of the Act of June 24, 1910, Harry R. Cheetham has been examined in radiocommunication and has passed in:

(a) The adjustment of apparatus, correction of faults, and change from one wave-length to another;

(b) Transmission and sound-reading at a speed of not less than fifteen words a minute American Morse, twelve words Continental, five letters counting as one word.

The candidate's practical knowledge of adjustment was tested on a Stone set of apparatus.* His knowledge of other systems and of international radiotelegraphic regulations and American naval wireless regulations is shown below:

Also is familiar with United Wireless Co. and Fessenden systems; is proficient in both American Morse and Continental Morse codes; and is familiar with existing regulations

Thos. P. Clark

Chief Gunner, U.S. Navy

(Signature of examining officer.)

Place U.S. Navy Yard, Boston, Mass., Date August 4th, 1911

By direction of the Secretary of Commerce and Labor:

E. T. Chamberlain

Commissioner of Navigation, Washington, D. C.

I, ______________________ do solemnly swear that I will faithfully preserve the secrecy of all messages coming to my knowledge through my employment under this certificate; that this obligation is taken freely, without mental reservation or purpose of evasion; and that I will well and faithfully discharge the duties of the office: So help me God.

(Signature of holder.)

______ of birth ______________ Place of birth ______________

Sworn to and subscribed before me this ______________

day of ______________, A. D. 191

Notary Public.

* ... not intended to limit the employment of the holder to a particular system, but merely to indicate the ... system in which he was tested for adjustment of apparatus.

This certificate is valid for two years, subject to suspension or revocation by the Secretary of Commerce and Labor for cause. It should be kept where it can be shown to officers of the customs or other officers of the Government just before the ship leaves port.

11—4368

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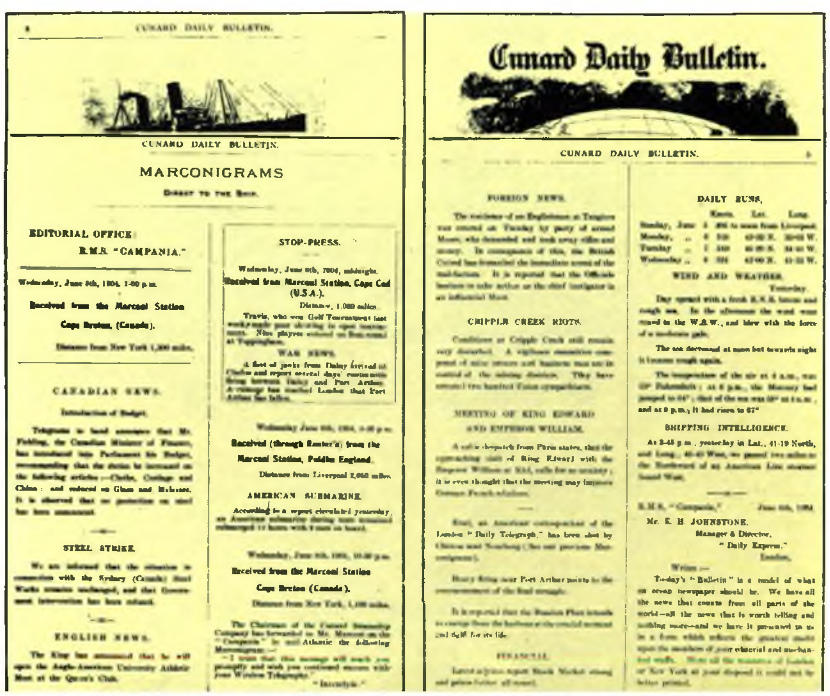


CUNARD DAILY BULLETIN.

CUNARD DAILY BULLETIN.

MARCONIGRAMS

EDITORIAL OFFICE:

R.M.S. "CAMPANIA."

Received from the Marconi Station

Cape Breton, (Canada).

STOP-PRESS.

Received from Marconi Station, Cape Cod (U.S.A.).

WAR NEWS.

CANADIAN NEWS.

Received (through Reuter's) from the Marconi Station, Poldhu England.

AMERICAN SUBMARINE.

STEEL STRIKE.

Received from the Marconi Station

Cape Breton (Canada).

ENGLISH NEWS.

Cunard Daily Bulletin.

CUNARD DAILY BULLETIN.

FOREIGN NEWS.

DAILY RUNS.

WIND AND WEATHER.

CRIPPLE CREEK RIOTS.

MEETING OF KING EDWARD AND EMPEROR WILLIAM.

SHIPPING INTELLIGENCE.

R.M.S. "Campania," June 8th, 1904.

Mr. E. H. JOHNSTONE,

Manager & Director,

"Daily Express,"

London.

FINANCIAL.

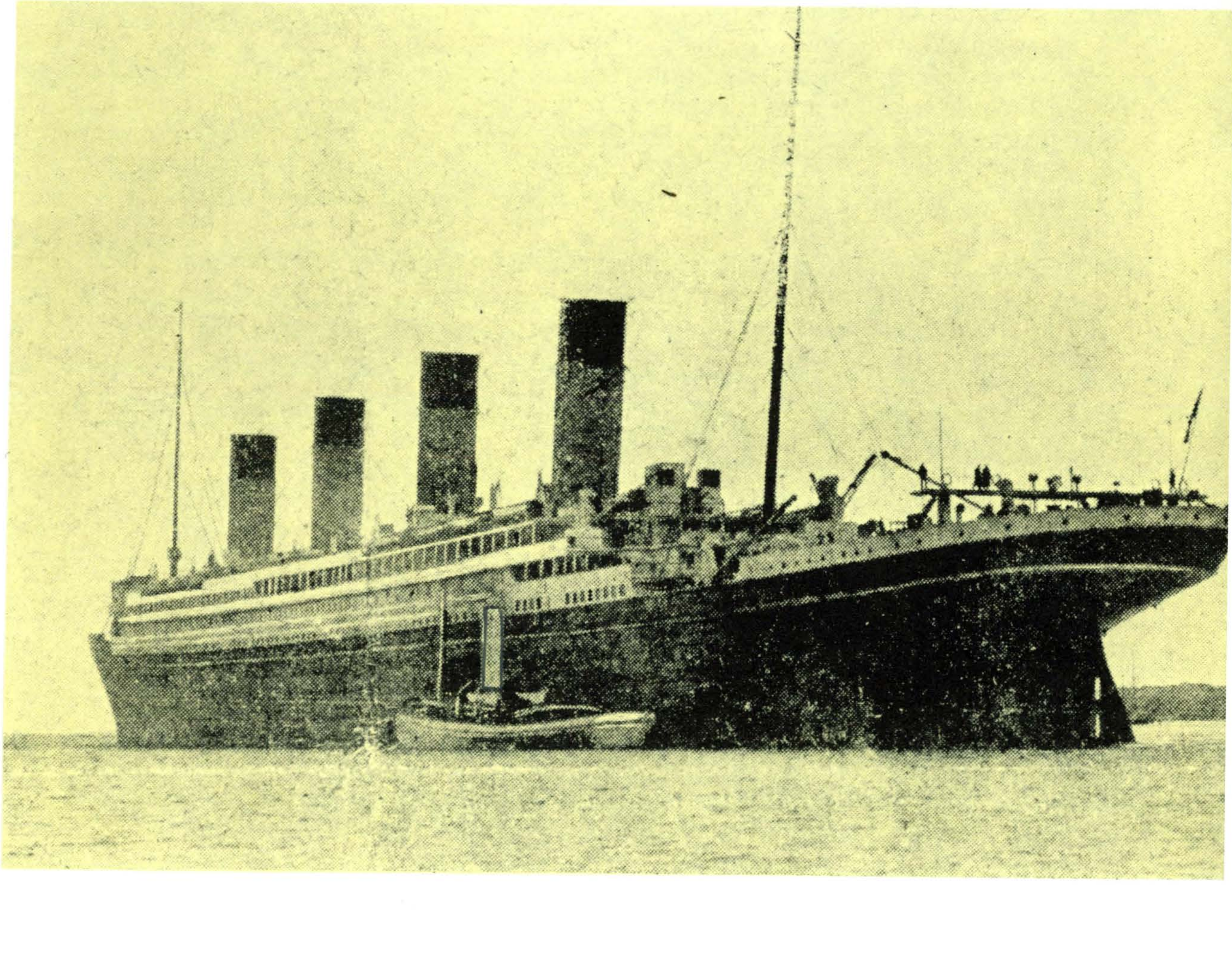
163

161 *Radio Operator's Certificate of Skill (Harry R. Cheetham, August 4, 1911).*

162 *An ocean newspaper of June 8, 1904, publishing news received by Marconi wireless.*

163 *Three-stage De Forest audion amplifier of the type first built in 1912 by the Federal Telegraph Company. This is the earliest known commercial cascade audio-frequency amplifier and was demonstrated to the U.S. Navy in September, 1912. The amplifier had a gain of 120.*

164 *The S.S.* Titanic *sailing on her first and last voyage, 1912. The heavy loss of life occasioned by her sinking might have been even greater but for her wireless.*



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weird, thought that these two passengers were travelling across the Atlantic, in the firm belief that their identity was unknown, while the news of both was being flashed with certainty to all quarters of the civilised world. They were both arrested on arrival in Canada. History had indeed repeated itself. It needed the spectacular arrest of a murderer to convince the world at large of the value of modern telecommunications, just as it had done in 1845, when the telegraph was able to achieve the same result between Slough and London.

Another landmark in the history of wireless communications across the sea came during the visit of King George V and Queen Mary to India in 1911. It was the first time that a British Sovereign had left England to visit the Empire across the sea; it was wireless telegraphy which kept him in touch with events at home, and even a Court Circular was dispatched on November 15, 1911, from Gibraltar.

But the most dramatic event of early wireless history at sea was the loss of the *Titanic* with 1503 souls, including her wireless operator J. G. Phillips. She struck an iceberg on April 14, 1912, when on a northern great-circle route to beat the record of an Atlantic crossing during her maiden voyage. Here are some extracts from the wireless log of the *Carpathia*, one of the rescue ships; it was kept by Cottam, her wireless operator.

New York Time—Sunday, April 14, 1912

5.30 p.m.	Signals exchange with *Titanic* at frequent intervals until 9.45 p.m.
11.20 p.m.	Hear *Titanic* calling SOS and CQD. Answer him immediately. *Titanic* says: "Struck iceberg, come to our assistance at once. Position: Lat. 41.46 N; Long. 50.14 W" Informed bridge at once.
11.30 p.m.	Course altered; proceeding to the scene of the disaster.
11.45 p.m.	*Olympic* working the *Titanic*. *Titanic* says weather is clear and calm. Engine room getting flooded.

Monday, April 15, 1912

00.10 a.m.	*Titanic* calling CQD. His power appears to be greatly reduced.
00.20 a.m.	*Titanic* apparently adjusting spark gap. He is sending "V". Signals very broken.
00.25 a.m.	Calling *Titanic*. No response.

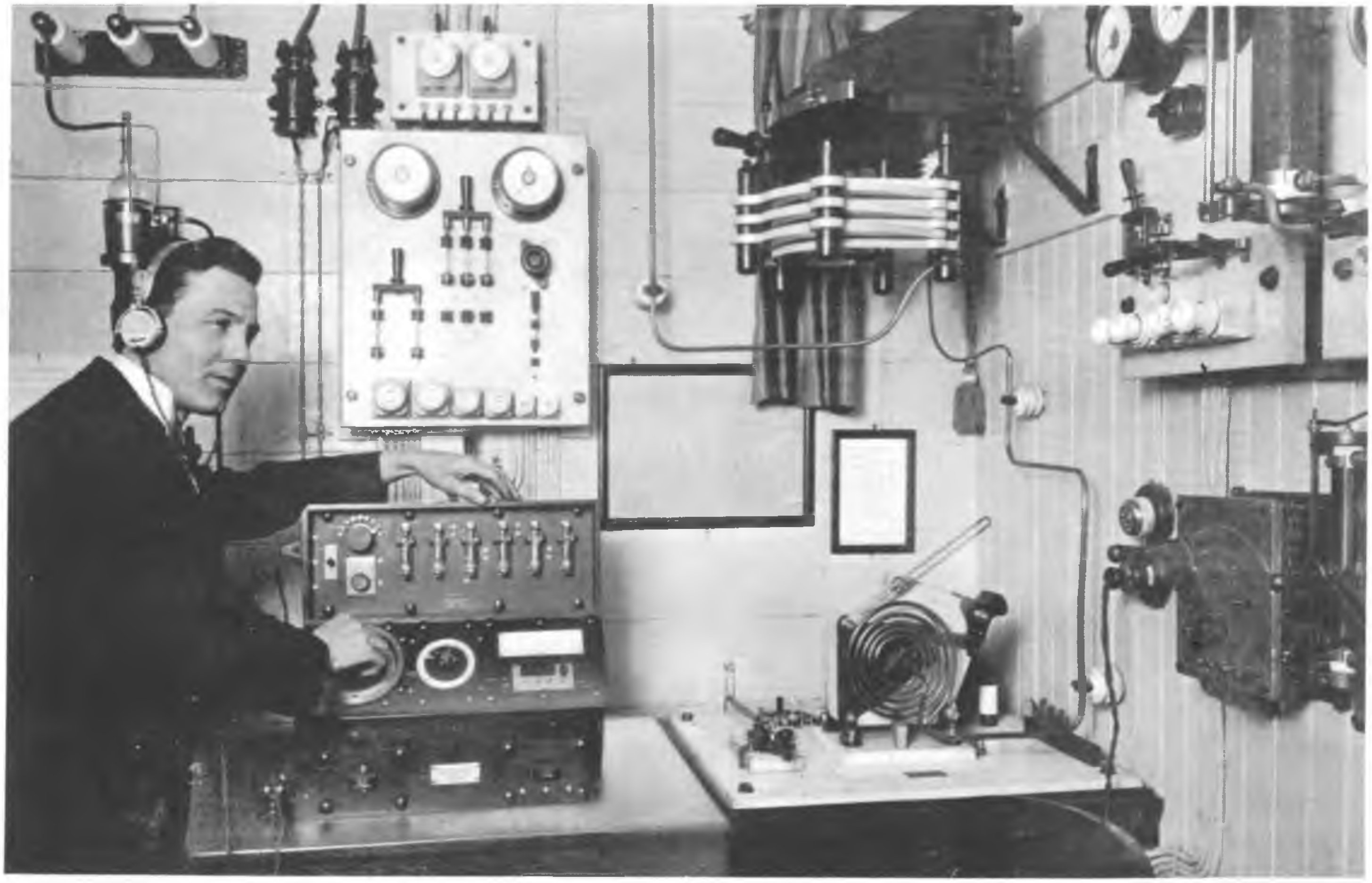
165 *A typical wireless telegraphy operator aboard a ship of 1912, not unlike the operator aboard the* Titanic.

00.28 a.m. *Titanic* calls CQD; his signals blurred and end abruptly.
00.30 a.m. Calling *Titanic* at frequent intervals, keeping close watch for him, but nothing further heard.
01.25 a.m. Called *Titanic* and told we are firing rockets. No signs of any response.
01.30 a.m. Continue to call *Titanic* at frequent intervals but without success.

At daybreak the *Carpathia* arrived at the scene of the disaster; she was able to rescue 710 survivors. A Special Committee of the U.S. Congress and a special commission presided over by Lord Mersey in England investigated the disaster and established rather perturbing facts. There were some bitter lessons drawn from that disaster. Ships were within radio reach, but did not know of the disaster, because they had no wireless. More distressing still was the story of the *California*, a small passenger vessel, also westbound. She had encountered an icefield in the evening, and her wireless operator sought to notify the *Titanic*; but the operator of the luxury liner, at the time exchanging messages with Cape Cod, told the other ship to "shut up", and keep out of the conversation.

The operator on the *California* listened for a few more minutes to the messages passing and then went to bed, having been on duty for 16 hours. The *California* was less than 31 kilometers away, although observers from the *Titanic* thought the distance was only about 10 kilometers. When later in the night officers of the *California* saw white rockets in the distance, they never thought of waking up their wireless operator; only when he resumed his duty at 04.00 a.m. did he learn of the awful disaster.

Of course, this kind of thing was nothing new. As more and more ships had become equipped with wireless, trouble had begun. To the operators, the thing was a new toy, and they had endless fun with their "Rock-crushers" as the spark sets of the early days were called. At first there were no international regulations in force, and every operator did pretty well as he pleased. No operator admitted any precedence to any other, and those on liners were particularly contemptuous of those on freighters and smaller vessels—fortunately not always with the disastrous consequences of the *California*—*Titanic* exchange of messages. To them there was always the thrill of picking up a chap on another ship, particularly if he was a personal friend, and of gossiping with him about nothing in particular.



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166 *The wireless room of the S.S.* Drotthingholm *of the Swedish Line, in 1921.*

167 *Two Poulsen generators at the Lyngby radio station near Copenhagen in 1920. The Danish radio physicist, Valdemar Poulsen, succeeded in 1902 as the first to produce continuous electromagnetic radio waves by means of an arc lamp. His theory was developed and improved by P. O. Pedersen. Radio generators of this kind were used extensively immediately prior to and during World War I.*

168 *A modern wireless room in a large merchant vessel, showing part of the comprehensive marine radio installation, including a Marconi " Globespan " transmitter and " Atalanta " receivers.*


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Because the spark sets used a very wide bandwidth, two chatting operators practically blanketed any other vessel within 100 kilometers that might have wanted to use the air. The only way to choke them off, and it was frequently used by some who wanted to send a message, was to " drop a book on the key ". This meant literally that he put a book or any other heavy object on the transmitting key, setting up such a continuous roar of interference that nobody could hear or send anything at all. Confusion was rendered worse confounded. These and many other inevitable interferences, with everyone operating at will on the same wavelength, naturally led to wireless feuds and quarrels, filling the air with curses, aspersions, and choice obscenities. With such conditions prevailing, naturally the service was far below the efficiency it could have reached even in those early days.

Clearly, with Marconi trying to establish a monopoly, and his operators only answering their colleagues of the same company, and with foul language being the order of the day, the need for international regulations arose much earlier in the case of radio than for telegraphy. The first preliminary Conference was called for 1903, only two years after the first transatlantic wireless signal had astonished the world.


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International Radiotelegraph Conferences

The physical existence of radio equipment aboard ships and land stations was obviously not enough to ensure an efficient international service. Two radio stations must communicate on the same frequency and if this frequency is also used by a third station then interference may occur. Throughout the history of radio it has always been the aim to choose and assign appropriate frequencies by international agreement, to lay down the rules for the operation of radio stations, whether on ship, on an aircraft or on land, and to approve standards for apparatus and their operators. It was indeed fortunate that a preliminary international conference on radio took place in Berlin as early as 1903. Undoubtedly an incident of the previous year had much to do with this. Prince Heinrich of Prussia had attempted to send a courtesy message to President Theodore Roosevelt, while crossing the Atlantic after a visit to the United States, but was refused service because the apparatus on his ship was not of the same make as that of the coast station with which he attempted to communicate. Freedom of correspondence was certainly one of the major aims of the preliminary conference of Berlin, where, incidentally, Popoff was one of the chief Russian delegates.

Nine countries, including the United States, met in Berlin in 1903 to undertake preliminary studies for the international regulation of radio. Part of the reason, if not the major one, for calling this conference was to stop the attempt of Marconi to monopolise radio, "Marconism" as it was called. In order to establish his monopoly, he had given instructions to his operators only to exchange wireless signals with other stations also manned by Marconi operators, and it was this action by a private company which stirred up most opposition.

In the Final Protocol of the Preliminary Berlin Conference, signed by seven of the attending countries, Britain and Italy excepted, it was laid down that "Coast stations should be bound to receive and transmit telegrams originating from or destined for ships at sea without distinction as to the system of radio used by the latter." In spite of the very elementary state of radio in 1903, this principle and the others of the Final Protocol became the basis for the regulation of radio communications. For the First Radio Conference in Berlin in 1906, the German Government had drawn up a complete draft convention and radio regulations; 29 Nations came to this, the First International Radiotelegraph Conference. The Radio Convention was closely modelled on the Convention of the International Telegraph Union of St. Petersburg of 1875, which had proved to be successful; it was accepted by the Radio Conference

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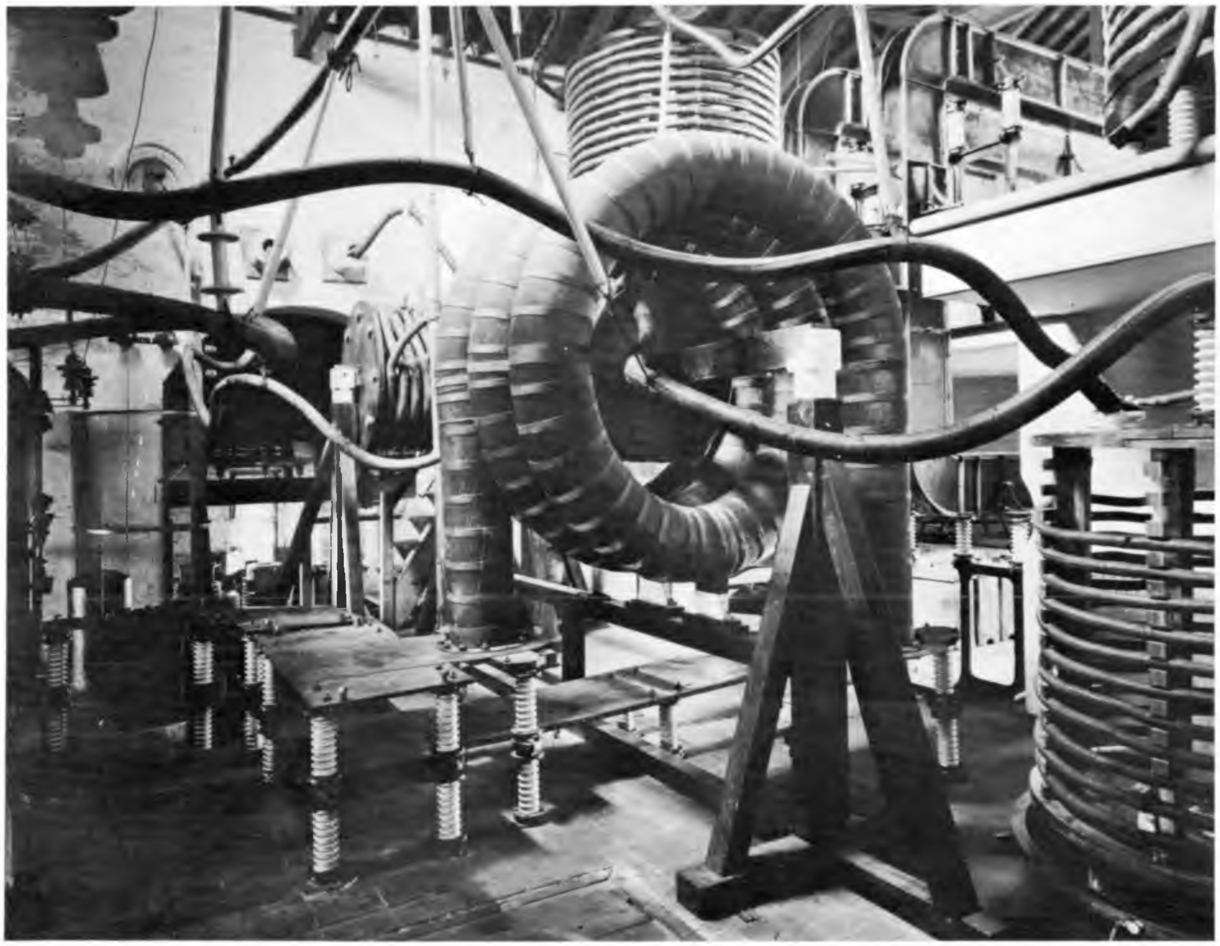
169 *Delegates to the Preliminary International Conference on Wireless Telegraphy in Berlin, 1903.*

170 *Some of the equipment at the Marconi high-power station at Caernarvon, North Wales, which, on September 22, 1918, sent the first direct wireless telegraphic message from London to Australia.*



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and embodied the fundamental structure for all subsequent conferences. In addition, the Conference drew up a set of Radio Regulations which were annexed to the Convention, again following the excellent example of the Telegraph Convention and its annexed Telegraph Regulations.

The principal issue at the Berlin Conference of 1906, as it had been in 1903, was the question of obligatory intercommunication between stations using different equipment. Italy and Britain again objected, and the German delegate revealed that a contract had been signed between the Marconi Company and the British Government in 1903, and an agreement with the British Post Office in 1904, which permitted the Marconi Company to collect a surtax if the British Government adhered to an international Convention based on the final protocol of the 1903 Berlin Conference. The British delegate tried to get this system of surtax internationally adopted, but his proposal was defeated in committee and it was never again re-opened.

The Conference did, however, permit certain coast radio stations that were particularly expensive to operate to charge more than the agreed maximum, but this privilege was restricted to stations whose range exceeded 800 kilometers. Other noteworthy provisions of the Berlin Convention were the obligation to connect the coast stations to the international telegraph service, to give absolute priority to all distress messages, and to avoid radio interference as much as possible. The Conference also decided that the Bureau of the International Telegraph Union at Berne should act as the central administrative organ of the Radiotelegraph Conference. The Convention came into effect on 1 July, 1908 for "an indefinite period".

But the main work of this, and of all subsequent radio conferences, was concerned with more technical questions, particularly those of frequency allocation. At Berlin in 1906, two wavelengths for public correspondence in the maritime services were established in the Radio Regulations at 1000 and at 500 kc/s; frequencies below 188 kc/s were reserved for long distance communications by coast stations. The range between 188 kc/s and 500 kc/s was reserved for "services not open to public correspondence", i.e. military and naval stations. All details of all stations, their frequencies, hours of operation, call signs and radio systems used, were to be sent to the Bureau of Berne.

The procedure for ship to shore radio communications, and of course vice-versa, was laid down in the Radio Regulations, giving coast stations priority of transmission and the right to determine the order


MARCONIGRAM

MARCONI TELEGRAPH – CABLE CO. INC.
MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA

Send the following message "VIA MARCONI", subject to the terms on back hereof, which are hereby agreed to.

NEW YORK, MARCH 1st, 1920

GODFREY C. ISAACS,
MANAGING DIRECTOR,
MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED
LONDON.

MAY THIS FIRST MESSAGE WHICH OPENS COMMERCIAL WIRELESS SERVICE BETWEEN AMERICA AND ENGLAND MARK AN EPOCH IN HISTORY FROM WHICH THE ACHIEVEMENTS OF THE FUTURE SHALL DATE. COMMUNICATION IS THE LEVERAGE WHICH SHALL LIFT THE WORLD TO BETTER UNDERSTANDING AND THUS LEAD TO CLOSER TIES OF FRIENDSHIP BETWEEN ALL NATIONS. IT IS THE MISSION OF OUR RESPECTIVE COMPANIES TO SO STRENGTHEN AND IMPROVE THE WIRELESS SERVICE THAT DISTANCE SHALL BE MADE NEGLIGIBLE AND COMMUNICATION PRACTICALLY INSTANTANEOUS.

BE 1 12.01 am

Edward J. Nally
PRESIDENT, RADIO CORPORATION OF AMERICA

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of receipt of messages. Technical standards were also laid down, although the choice of radio apparatus was unrestricted; it should "keep pace with scientific and technical progress". Stations had to have a Government licence and operators had to have certificates as to their competence, demanding from them a rate of receiving and transmitting of at least 20 words per minute.

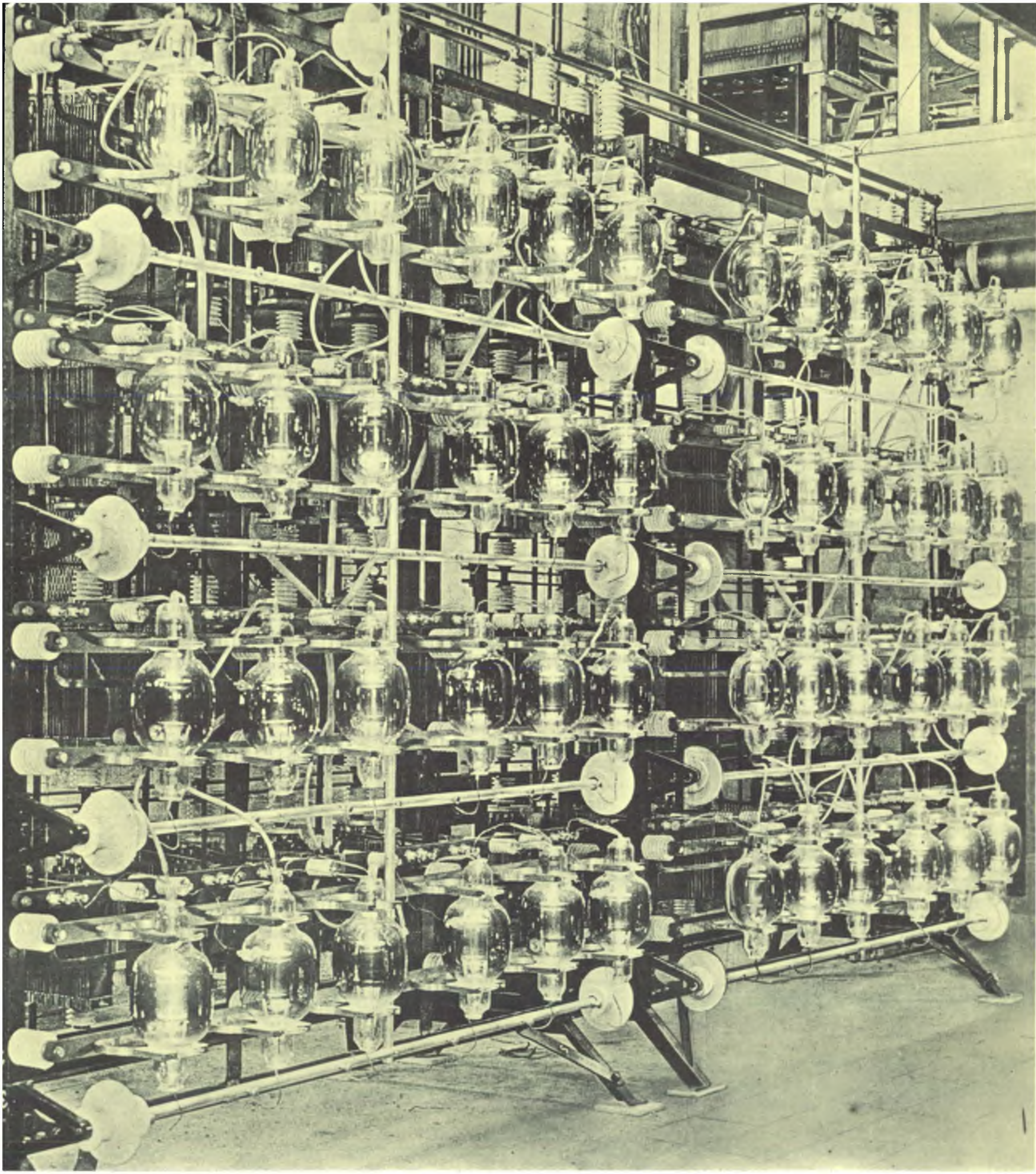
Finally, the Regulations adopted the new rhythmic distress signal ···———···, $\overline{\text{SOS}}$. There has been much speculation on the meaning of this and of the previous distress signal CQD. CQ was the general call signal at the time, and to distinguish its urgency in case of distress the letter D was added. CQD was interpreted by some to mean "Come Quick, Danger", just as others saw in $\overline{\text{SOS}}$ later the meaning "Save Our Souls".

The origin of $\overline{\text{SOS}}$ was however much more prosaic. German ships had always used the call signal $\overline{\text{SOE}}$, and as they were the host country at the conference in 1906, their request that this should be the new distress signal as well carried some weight. The letter E in the Morse code is, however, not a very satisfactory one, it being a single dot; after much argument at the Conference, $\overline{\text{SOS}}$ was finally adopted as being simple to remember; it was to be written and sent as $\overline{\text{SOS}}$ $\overline{\text{SOS}}$ continuously, as the letters have no intrinsic meaning. Although $\overline{\text{SOS}}$ was adopted by the Conference, it did not come into general use until years later, and we have already seen that at the *Titanic* disaster in 1912, both CQD and $\overline{\text{SOS}}$ were sent.

The steady scientific progress of radio communications led to the calling of the next radio conference in London in 1912. The International Bureau of Berne reported that by 1912 there were approximately 479 coast stations, 327 of which were for public use, and 2752 ship stations, of which 1964 were open for public correspondence; the difference being of course mainly naval stations. At that time, some aircraft and also some dirigibles had been fitted out with radio, but delegates felt it was too early to take any official action in this new sphere. Ships were after all much more in the foreground of their thoughts, particularly as the London Conference met only three months after the disaster of the *Titanic*.

One immediate consequence of it was that the old and intractable question of obligatory intercommunication between all ships, regardless of their radio system, could now be solved. In fact, during the actual conference, and before the coming into force of the new convention, the Marconi Company

171 A copy of the first commercial transatlantic wireless message sent on March 1, 1920.



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172 *The valve panel at the Marconi station at Caernarvon, North Wales, in 1923—the first high-power station to use thermionic valves for transmitting.*

173 *The Alexanderson multiple-tuned Very Low Frequency antennas, Radio Corporation of America, Rocky Point, 1924.*

174 *Dr. E. F. W. Alexanderson with his Very Low Frequency alternator of 17,500 to 16,465 metres wavelength. It was installed by the Radio Corporation of America at Rocky Point, in 1924.*

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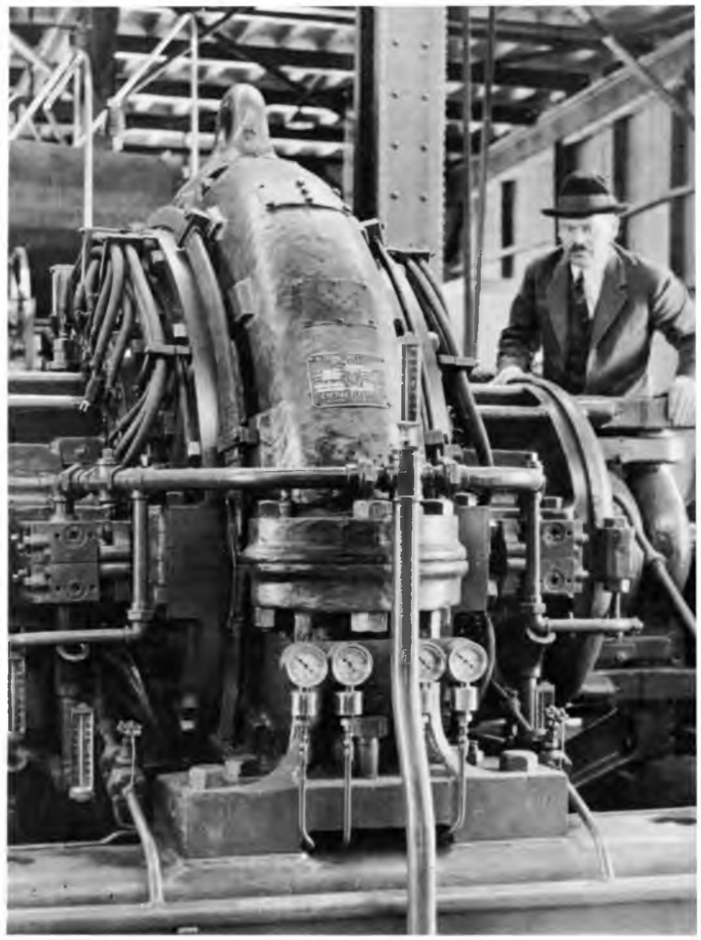

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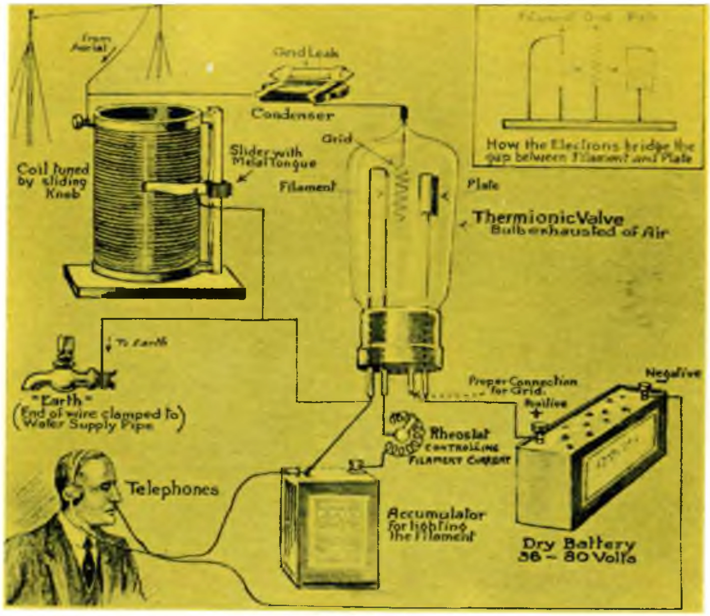

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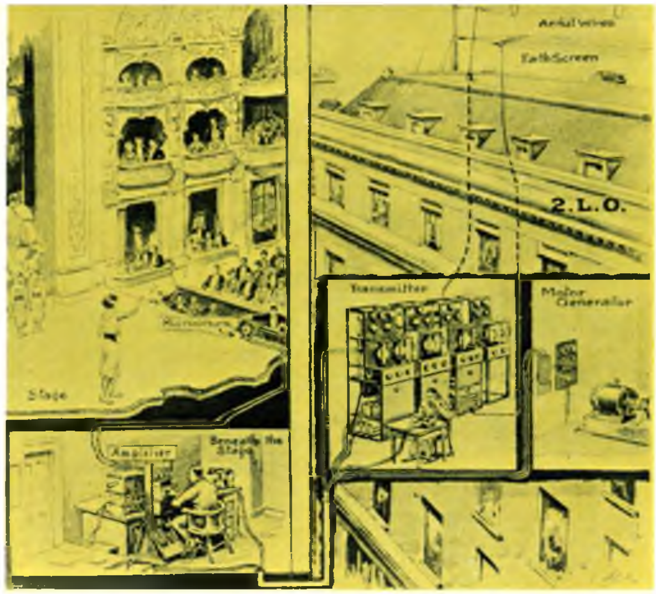
announced that it had instructed all its operators to "communicate with all other ships, regardless of the system adopted by the latter".

There was much of importance discussed at London. Obligatory installation of radio aboard all ships could, however, not be adopted, as it was considered to trespass on the internal jurisdiction of individual countries. Continuous radio watch-keeping was another topic, and it was decided to divide all ships equipped with radio into three classes: those having a permanent service, a limited service, and those which had no specific hours of service. For the first category there was no need to have any special watch regulations; stations of the second category were required to listen for distress signals for the first 10 minutes of every hour, outside the regular hours of service. Coast stations also had a period of silence imposed on them, three minutes at the end of each quarter of an hour, so that they could listen to distress signals.

The allocation of frequencies came up again for revision. It was decided that 500 and 1000 kc/s should be retained for coast and for ship radio stations, with preference being given to 500 kc/s. Small ships unable to transmit on this frequency were allowed to use the 1000 kc/s frequency, but were required to be able to receive on 500 kc/s.

Three new services were in use in 1912 for which frequencies had up till then not been allocated; they were radio beacons, weather reports and time signals. Radio beacon stations were allowed to use any frequency above 2000 kc/s, whereas weather reports and time signals were allowed to use any frequencies below 188 kc/s. Weather reports could be requested by ships at sea, and they had to pay for them. Storm warnings, which some members of the London Conference felt should be automatically sent to all ships, were only given second priority, and it was left to individual countries to make the best arrangements possible.

The routing of radio telegrams provided a difficult subject for the Radio Conference of London in 1912. Obviously, with the now more powerful ship equipment, it appeared ridiculous and very much more expensive to go through an intermediate coast station and then by land telegraph lines, when the radio telegram could be sent directly to the country of destination. A compromise was reached, keeping the general rule that a ship must transmit to the nearest coast station, but granting a number of important exceptions. Communication with a coast station further away was permitted if a ship was sending a



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radio message to its own home country. A frequency of 167 kc/s was allotted for these messages, if the transmission did not interfere with anyone else, and if the ship sending its message was at least 50 nautical miles (92.5 km) from any other coast station.

Such then was the state of radio and international co-operation when World War I began in 1914. When delegates from 80 countries met again for the next International Radio Conference, in Washington in 1927, three important scientific advances had been made in the field of radio. Broadcasting radio messages, instead of merely communicating from point to point, was probably the most important advance. Next came the installation of radio sets in aircraft, and finally, the extension of the frequency spectrum into the short wave bands of 3000 kc/s and above; this advance was greatly aided by the work of amateurs who had been denied the use of any of the other frequencies. The unending battle of the frequencies had now started in earnest.

We shall deal in a later chapter with the role of radio and of the other media of telecommunications during the course of the wars that occurred since the beginning of the International Telegraph Union in 1865.

The Washington Conference in 1927 might also be called the first of the truly modern telecommunication conferences. In addition to the 80 countries which were represented, there were 64 private companies, Broadcasting Organisations, and other international bodies which were interested in radio; they attended in a non-voting capacity. Mr. Herbert Hoover, Secretary of Commerce of the United States, was elected Chairman of the Conference, and at the suggestion of his delegation a new rule of procedure was adopted: "French is the official language of the Conference. Nevertheless, since the presiding administration has so requested, and as an exceptional measure, English may be used. Delegations are recommended to use this privilege with discretion." This was indeed a revolutionary step. French, the ancient language of diplomacy, had always been the official language of the International Telegraph Union, of the Bureau of Berne, and of the Radiotelegraph Conference. To-day, in alphabetical order, the official languages of the I.T.U. are Chinese, English, French, Russian and Spanish, with English, French and Spanish as the three working languages. But the current Convention lays down "In case of dispute, the French text shall be authentic".

175 *The principles of broadcasting as explained to the man-in-the-street in 1923, showing the central parts of a valve receiving set.*

176 *The principles of broadcasting explained to the man-in-the-street in 1923, by showing the transmitting arrangements for station 2LO, the first broadcasting station in England. 2LO later became the British Broadcasting Company and this in 1927 became the British Broadcasting Corporation.*

177 *Studio for the weekly "Sunday Concerts" established by officials of the former Deutsche Reichspost in the main radio station Königswusterhausen, in 1923.*

178 *Lauritz Melchior, the Danish tenor, broadcasting from the Chelmsford works of The Marconi Company in July 1920, two years before the British Broadcasting Company was born. In the previous month Dame Nellie Melba had given a similar concert from the same improvised studio.*

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179 *The first broadcast by a United States President was on May 30, 1922, when President Warren G. Harding spoke at the dedication of the Lincoln Memorial, Washington, D.C. The microphone, subtly boxed in white to match the marble columns and steps, can be seen on the steps of the Memorial. The broadcasting set-up was provided by the United States Navy.*

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180 *A German broadcast receiver of 1923 (so-called "express train"). From left to right: high-frequency amplifier, receiver, low-frequency amplifier.*

181 *Studio No. 1 of the British Broadcasting Corporation at Savoy Hill, London, in March, 1928.*

182 *A typical very early American radio broadcasting station, with the equipment used in the early 1920's. The station, apart from occasional announcements, depended largely on recorded music.*

183 *Radio broadcasting in a dining car of the London-Liverpool Express was tried out as early as March, 1923. A Marconi six-valve receiver was used, and reception was good up to 80 km out of London.*

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The Washington Conference had before it almost 2000 proposals, and it took nine plenary meetings and 156 sessions of committees and sub-committees before a new Radiotelegraph Convention, in French, was signed; it contained 24 articles, and the new General Radio Regulations had 34 articles and 8 appendices. The Additional Radio Regulations, which contained agreements about radio charges and international accountability, 6 articles and one appendix, were not signed by the United States, Canada and Nicaragua, as their radio communications were in the hands of private companies.

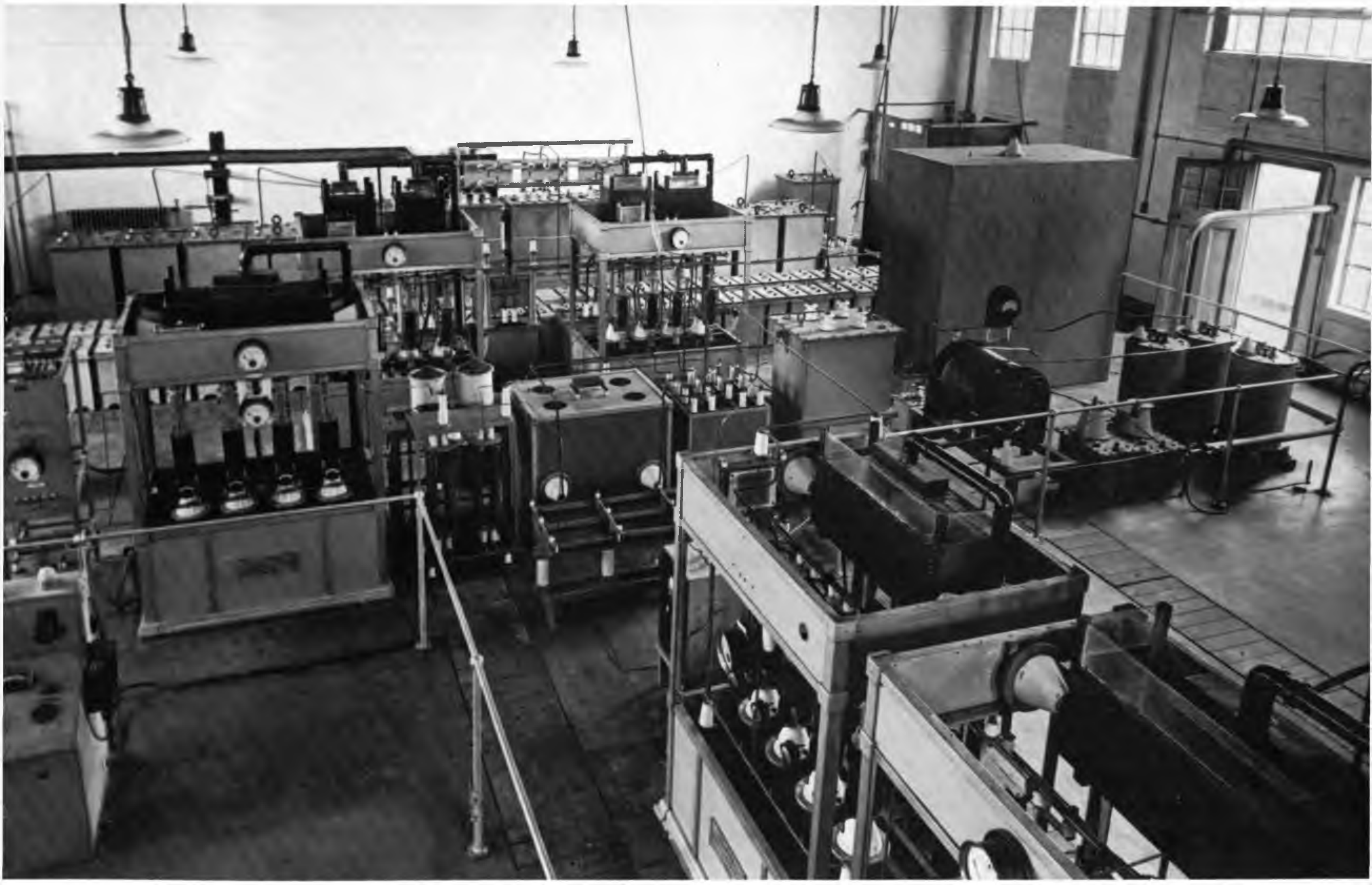
Undoubtedly, one of the most important actions of the Washington Conference in 1927 was to set up a Radio Consultative Committee, similar in terms of reference to those dealing with the telegraph and the telephone. A chapter is devoted to its work in a later part of this book. One of the main arguments for setting up the *Comité consultatif international technique des communications radioélectriques* was "to undertake studies and present conclusions to the next conference, thus eliminating part of the burden of exhaustive technical studies that had been necessary during conference time." Equally important was the drawing up of the first Frequency Allocation Table.

Washington also marked a turning point in the technical provisions of the Radio Regulations. During previous conferences, the main emphasis was on the regulation of the radio traffic and on the minimum standards that allowed an efficient international system of communications. Now it became necessary severely to restrict some of the older types of transmitters, the spark sets, and to divide up the radio spectrum in a highly efficient manner to deal with the ever-increasing demands on it. The demand for a complete outlawing of spark sets was pressed strongly, but not passed; mainly shipping interests requested their retention because in time of an emergency they were simple to operate by even unskilled seamen and their defect of occupying a wide bandwidth could perhaps be considered as a positive advantage for distress calls. However, the Conference decided that there should be no new sets of this type installed either on ships or in aircraft, and their use was to be completely forbidden by January 1, 1930, unless they were of low power, less than 300 watts.

The allocation of frequencies throughout the radio spectrum as then used and generally understood, from 10 to 60,000 kc/s, was another of the many major achievements of the Washington Conference of 1927. This task was fraught with many difficulties. First, there were many conflicting claims, based on both priority of use of a frequency and on operational efficiency. Then, new allocations had to be

184 *Cardboard clock issued by the RADIO TIMES in 1934. It helped to remind listeners at what time their favourite programme was to be broadcast.*

185 *The British Broadcasting Corporation's first long-wave station, Daventry 5XX, was built in 1925 and in regular use up to October 1934. It returned to service during the war, and closed down finally on 4 June, 1945. A bird's eye view of the transmitter.*



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made for broadcasting, for aircraft communications and for the new long-range communications in the higher frequency bands. But even when the table of allocations had been drawn up by the memorable Sub-Committee 1 of the Technical Committee, there were further problems to be solved. How should the rights of two conflicting parties be worked out, if a station shifted its frequency, or if a new station started up in a new frequency band; rights of priority of usage were proposed by some, but it was finally decided that when harmful interference occurred and no solution could be found, the two contracting governments must submit their case to arbitration. When all was said and done, it had not proved possible in practice to make adherence to the table of frequency allocations obligatory.

The last, but by no means the least of the many important decisions of the Radiotelegraph Conference at Washington was to fix the date and place of its next meeting. It followed the wish of the International Telegraph Union, as expressed at its Conference of Paris in 1925, to meet again in Madrid in 1932, so as to unify the existing Telegraph and Radiotelegraph Conventions. This was agreed to unanimously and on 25 November, 1927, another momentous step forward had been taken.

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186 *Delegates to the International Radio-telegraph Conference in Washington, in November 1927 inspecting the portable radio laboratory at the National Bureau of Standards. The laboratory truck is used to make field measurements of the fading and intensity of radio signals throughout the country.*

Madrid — 1932

The 13th International Telegraph Conference and the 3rd International Radiotelegraph Conference met simultaneously in Madrid in 1932.

As the two Conferences were different legal entities, they had to set up a Joint Convention Committee and other Joint Committees. The rules of procedure they adopted were to all intents and purposes identical, all questions being decided by a majority vote, and in the case of a tie the motion was considered as lost. Disagreement centred around the question of voting, conference language and new name of the combined union, but all three were finally solved by compromise.

A list of countries was drawn up, and all on the list were entitled to vote; French was used throughout the conference, in debates, and for drawing up the final documents. Translations into English were provided by a group of interpreters furnished by the United States delegation. Some wanted to retain the word "telegraph" in the new name, others wanted to mention all three media of communications, but, to keep it relatively short, the name finally selected was International Telecommunication Union. It has remained the same ever since. Let us remember that the word "telecommunication" was first used at the beginning of the 20th century by Edouard Estaunié, at that time the Director of the Ecole Supérieure des Postes et Télégraphes de France.

The new term Telecommunication was defined at Madrid as follows: "Any telegraph or telephone communication of signs, signals, writings, images and sound of any nature, by wire, radio, or other system or processes of electric or visual (semaphore) signalling". Comparing this with the present definition it will be seen how well the concept was established right from the moment of its creation. Telecommunication is defined to-day as: "Any transmission, emission or reception of signs, signals, writings, images and sounds, or intelligence of any nature by wire, radio, visual or other electromagnetic systems".

The single new Convention, covering all these technical fields, was not arrived at without much discussion. The delegates from the many countries which had come to Madrid had before them however, an excellent draft by M. Boulanger, one of the two Deputy Directors of the International Bureau of Berne; this formed the basis of discussions and of the final Convention. It was signed on 9 December, 1932, by all the 80 countries present, with the exception of one, which apparently had not received the necessary powers. The annexed Radio Regulations were not signed by 4 countries, the Additional Radio Regula-

187 The first practical application of radio frequencies between 300 and 3000 Mc/s was made in 1932 by Marconi between Vatican City and the summer residence of the Pope at Castel Gondolfo, the distance between the two being about 20 km. Here the directional antenna of Vatican City is being adjusted during tests at a frequency of 600 Mc/s.

188 The trials of a telephone operator when Marconi has installed his transatlantic wireless telephone system. Caricature from 1920.

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tions not by 3 countries, the Telegraph Regulations not by 4 countries, and 12 countries did not put their signature to the Telephone Regulations.

The new Convention leant heavily on the Convention of the International Telegraph Union to which was added a new Chapter dealing with Radio; this contained six articles on Intercommunication, Interference, Distress Calls, False or Deceptive Distress Signals, Limited Service and Installations of National Defence. The great achievement of the Madrid Conference was not only the drafting and acceptance of this single new Convention, but also by obtaining the adherence of the United States to it, to make the new Union truly International. Again, it has remained so ever since, and its membership has steadily grown through the following decades.

When looking back at this Madrid Conference, and the subsequent one at Cairo in 1938, it is not so much the political discussions and the resulting compromises which are impressive, but the way in which the technical experts kept international co-operation in step with the ever-increasing rate of scientific progress. Broadcasting had by then become a world-wide activity of the greatest social importance. Short-wave transmitters and receivers, first widely employed by amateurs and later taken over by commercial and governmental stations, had shown that a small power input was quite sufficient to send messages by radio around the planet.

In 1934 there was a kind of radar installation aboard the French liner *Normandy* and by 1936, television had become more than an experimental science. From that year until the outbreak of World War II, the British Broadcasting Corporation transmitted a regular service of electronic High-Definition television. From 1934 on the German Reichsrundfunkgesellschaft and the Deutsche Reichspost operated a regular broadcast service of 180-line (later on 441-line) electronic television. In 1936 the first public video telephone service on coaxial cable was opened between Berlin and Leipzig; in 1938 it was extended to Munich. In 1936 the Deutsche Reichspost transmitted for the first time pictures of the XIth Olympic Games in Berlin by television.

In March of 1936, a team of British scientists under R. Watson-Watt showed that an aeroplane, 120 kilometers away, could be tracked on a cathode-ray tube. These radar experiments were, of course, top-secret.

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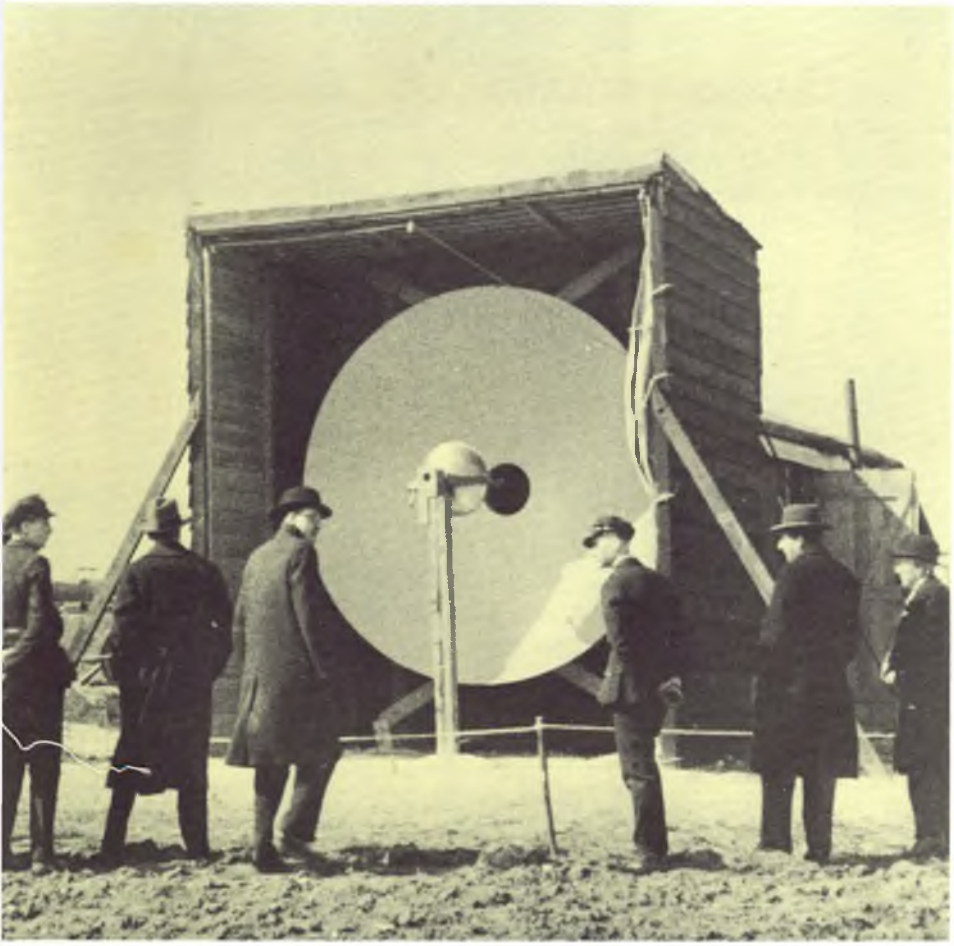
But such is the normal course of history. Small scale experiments precede by many years their industrial or military applications, and only when these have become widely used in different countries, arises the need for international co-operation. The only aspect that has changed during the course of the last century is the time that elapses between the first experiment and the need for international co-operation. In telegraphy, this interval was about 20 years, in telephony about 10 years, in the case of radio about 5 years, and now with satellite communications, the time lapse has been reduced to a single year. But in the still leisurely decade of the 1930's, the technical experts at the Madrid and Cairo Conferences did not have much difficulty in allocating the complete radio spectrum to users who wanted it. A decade later, at the Atlantic City Conference of 1947, this task proved very much more difficult.

At the Radio Conference of Washington in 1927, the band of frequencies that had caused the greatest difficulty was that between 150 and 1500 kc/s. Although the discovery and use of higher frequencies had by 1932 opened up a vast new territory, it was the need of the rapidly expanding broadcasting and aeronautical services which demanded in Madrid more space in the long and medium wave bands, broadly between 150 and 3000 kc/s. At Madrid, requests for more aeronautical frequencies came from the International Air Transport Association, I.A.T.A., and the International Commission on Air Navigation, C.I.N.A. A number of individual countries wanted more space in the radio spectrum for broadcasting, and their demands were backed by a comprehensive plan submitted by the International Broadcasting Union, U.I.R. As there were no requests at Madrid in 1932 from the Maritime Services, the conclusion can only be drawn that the Washington allocations of 1927 had fulfilled their needs; they did however defend the frequencies allocated to them with utmost vigour.

One further factor complicated the work of the radio experts at the Madrid Conference, namely the existence of radio stations outside the frequency allocation table. One reason for this was that the Soviet Union, which had not been invited to the Washington Conference, was bound only by the Radio Regulations of Berlin of 1912. Consequently, she had no obligation, not even a moral one, to be bound by the Washington Allocation Table of 1927. In a list prepared by the Broadcasting Union it was revealed that there were 32 Broadcasting Stations in Europe using "out of band" frequencies. Complaints about interference naturally arose on frequent occasions, and the whole question of frequency allocation was

189 *A model illustrating the double-beam radio-beacon used for guiding aircraft in June, 1926. A scientist who was engaged in research work in perfecting this aid to navigation is shown operating the model.*

190-191 *The first commercial microwave communications equipment installed across the English Channel in 1931 was made by subsidiaries of International Telephone and Telegraph Corporation. On the left the terminal at Calais and on the right the corresponding antenna at Dover.*



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referred to the Sub-Committee on Medium and Long Waves of the Technical Committee at the Madrid Conference in 1932.

A solution was finally reached by the use of two expedients. The frequency range most in demand, 150 to 1500 kc/s, was divided up into the European region and other regions; this was of course perfectly possible because these frequencies have regional propagation characteristics rather than the world-wide ones of some other frequency bands. Secondly, it was decided that a European Conference on broadcasting should be held before the coming into force of the Madrid General Radio Regulations, so that the available frequencies could be assigned with far greater efficiency. Once these troublesome bands of the spectrum had been dealt with, there was little difficulty with the rest of the allocation table; its upper limit was extended to 28 Mc/s from the previous one of 22.3 Mc/s.

To increase technical efficiency, tables of frequency tolerances and acceptable frequency bandwidths were also drawn up for the first time. One further important step taken at the Madrid Conference in 1932 was to lay down the rules for the frequency registration of any new radio station coming into operation; such a station had to notify all technical details to the International Bureau at Berne before being put into service. Six months, or in urgent cases, three months, were to elapse between notification and the beginning of a new service.

An immediate consequence of the successful Madrid Conference of the I.T.U. was the holding of the European Broadcasting Conference at Lucerne in 1933; a Convention was signed, and a frequency assignment plan for European Broadcasting was annexed. Although this plan was a great achievement, a number of the participating countries made reservations and did not sign the Convention.

The Madrid Conference also bore fruit on the American continent. At Havana in 1937, the First Inter-American Radio Conference met and the sixteen American States represented set up an Inter-American Radio Office and allocated frequencies in three different zones of the Americas. This Conference also made the recommendation to the I.T.U. that the frequency allocation table should be extended from 30 Mc/s to 300 Mc/s, and a draft allocation plan was prepared. The Havana Conference, only one year in advance of the next I.T.U. Conference, at Cairo in 1938, gave the American countries a rare degree of solidarity.

192 *A typical radio telephone used in 1926 on airplanes, allowing communication with the ground. It was designed by the U.S. Army Signal Corps and is shown here being used by the National Bureau of Standards for communicating with the experimental flying field at College Park, Maryland.*

The first Administrative Telegraph and Telephone and Radio Conferences of the new International Telecommunication Union were held at Cairo in 1938. Voting rights were discussed and English was again accepted as a supplementary language. But the main work of the Cairo Conference was a continuation of the Madrid Conference in the field of radio frequency allocation. One of the most far-reaching results was the allocation of radio channels for intercontinental air routes in the band 6500 kc/s to 23.38 Mc/s. Each channel was reserved for a specific air route, including both existing and future services, as for example the still-to-come transatlantic air services. This was the first allocation ever made in anticipation of the future, a marked progressive step to the usual procedure of legalising existing frequency uses.

When it came to allocate frequencies for broadcasting, the Cairo Conference had the usual difficulties. Extensive new demands had to be reconciled with existing channels, and it had been found by 1938 that certain frequencies were to be preferred in tropical regions where adverse atmospheric conditions were the rule; this was the case for the 2300 to 4900 kc/s band. Three bands were allocated for broadcasting, 2300 to 2500 kc/s, 3300 to 3500 kc/s and 4770 to 4965 kc/s. The International Broadcasting Union requested from the Cairo Conference an additional allocation of 950 kc/s as the absolute minimum necessary in order that all existing stations could be included, but this was considered somewhat excessive; as a compromise, the broadcasting service was given an additional 500 kc/s.

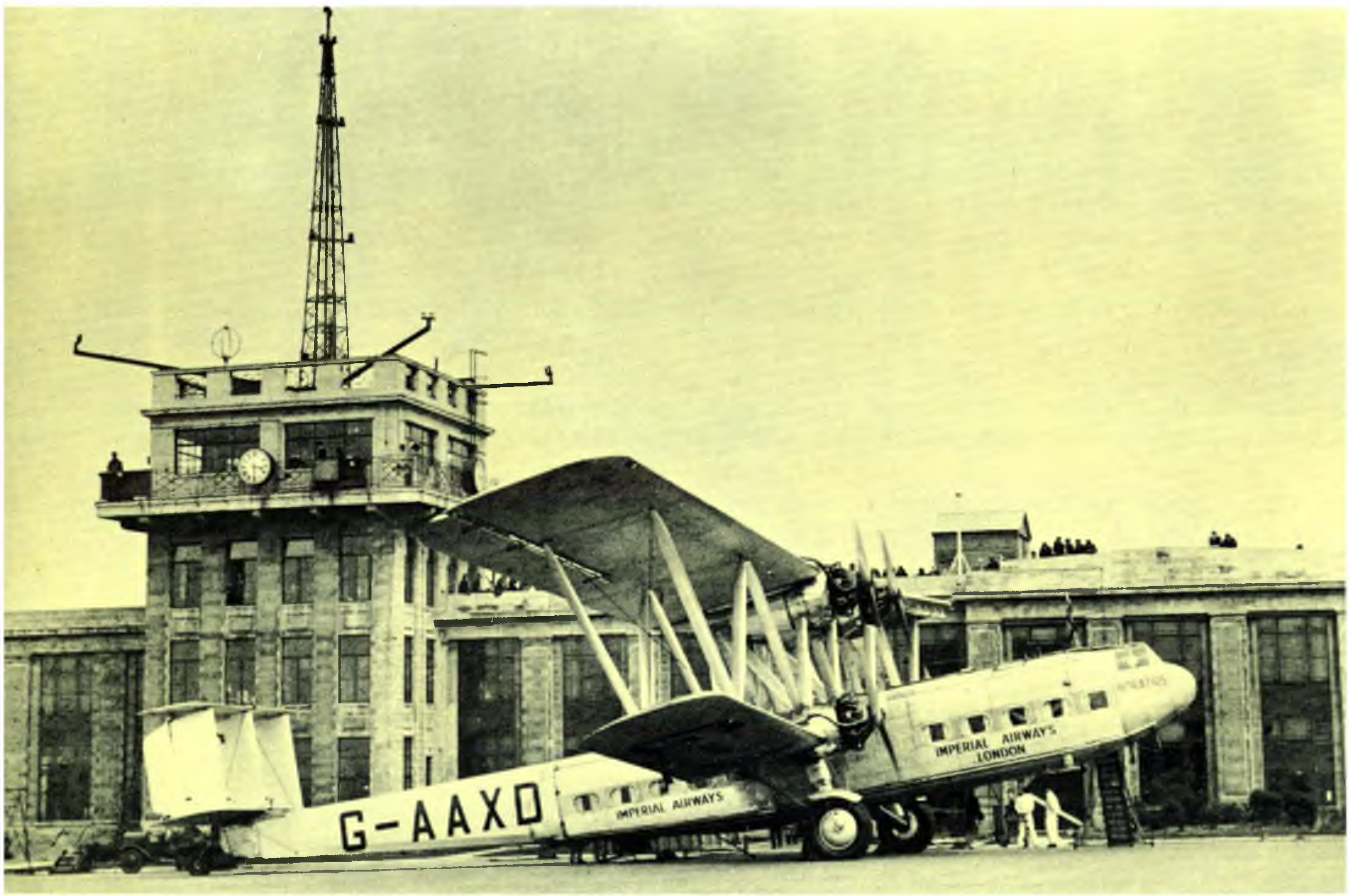
Another compromise was reached in the 7200 to 7300 kc/s band, which was allowed to be shared by the American Amateur services and the European high frequency broadcasting stations. It was found that little interference would result from this arrangement, as the time difference between the American and the European regions would in this case work for the benefit of international telecommunications.

The final allocation problem of the Cairo Conference in 1938 was the high frequency range above 25 Mc/s. Following the suggestions of the Inter-American Radio Conference of the previous year, an agreement was reached and the 25.6 to 26.6 Mc/s band was allocated for Broadcasting, and the 28.0 to 30.0 Mc/s band was reserved for Amateurs. The remainder of the band, from 30 to 200 Mc/s, was again divided between European and other regions; for the European region specific channels were, however, allocated to television, air services, radio-soundings, amateurs and other fixed and mobile services. The

193 *An Imperial Airways airliner of 1935 at Croydon Airport, which was equipped with a full range of Marconi radio aids.*

194 *Early wireless telegraphy in Ceylon, about 1937. Messages were received at audio-frequency, and typed immediately by the operator. Transmission was by Morse key.*

195 *The radio installation in an Imperial Airways Empire Flying Boat of 1937. A retractable DR loop, with hatch above and operating wheel, can be seen in the centre.*



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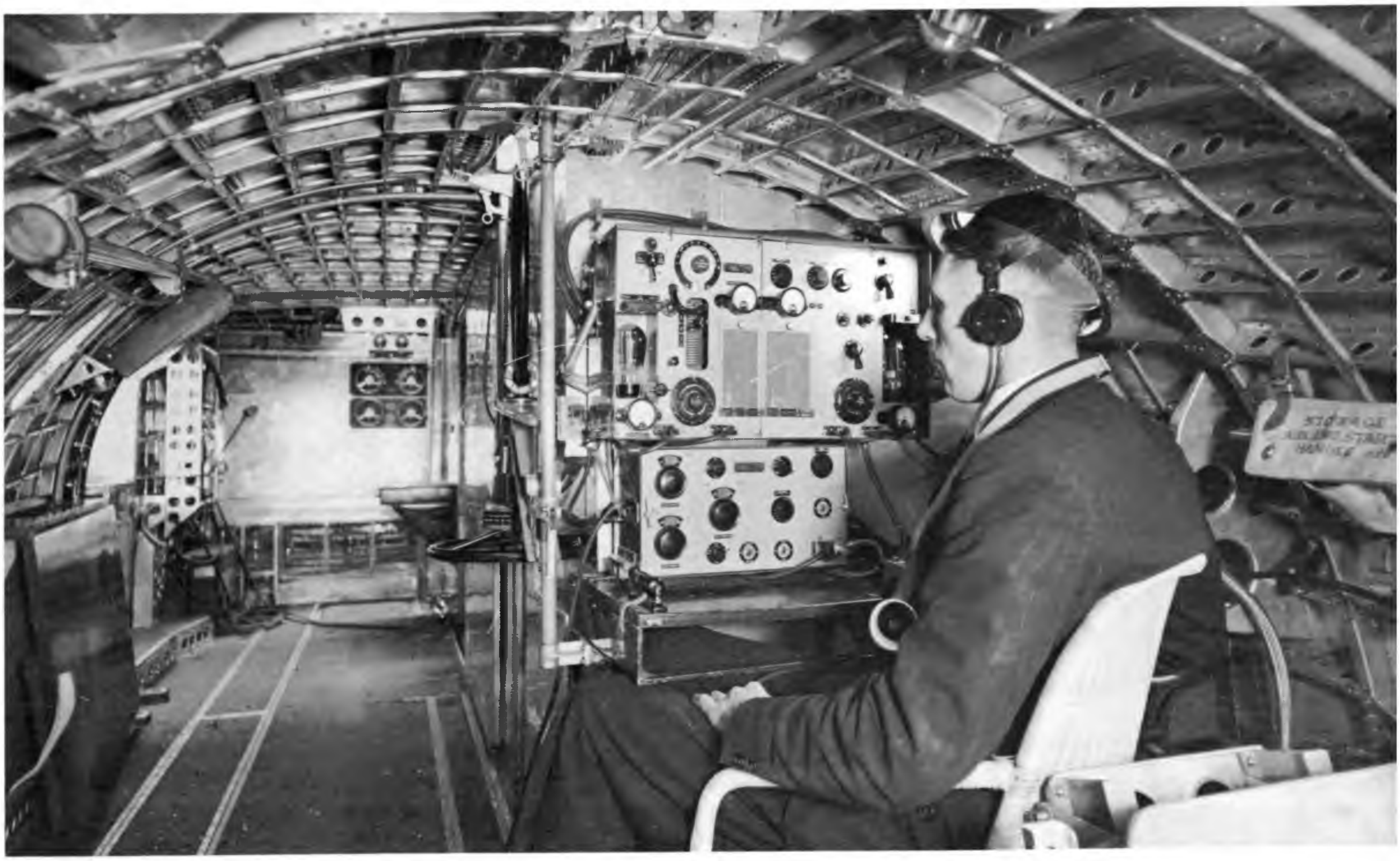

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196 *An early radio installation aboard a United States plane, the Consolidated PBY-1, in December 1937.*

197 *The rotary spark discharger of the famous Marconi station at Poldhu, Cornwall, photographed on the night of August 4th 1914, while transmitting to shipping the news of Britain's declaration of war on Germany.*

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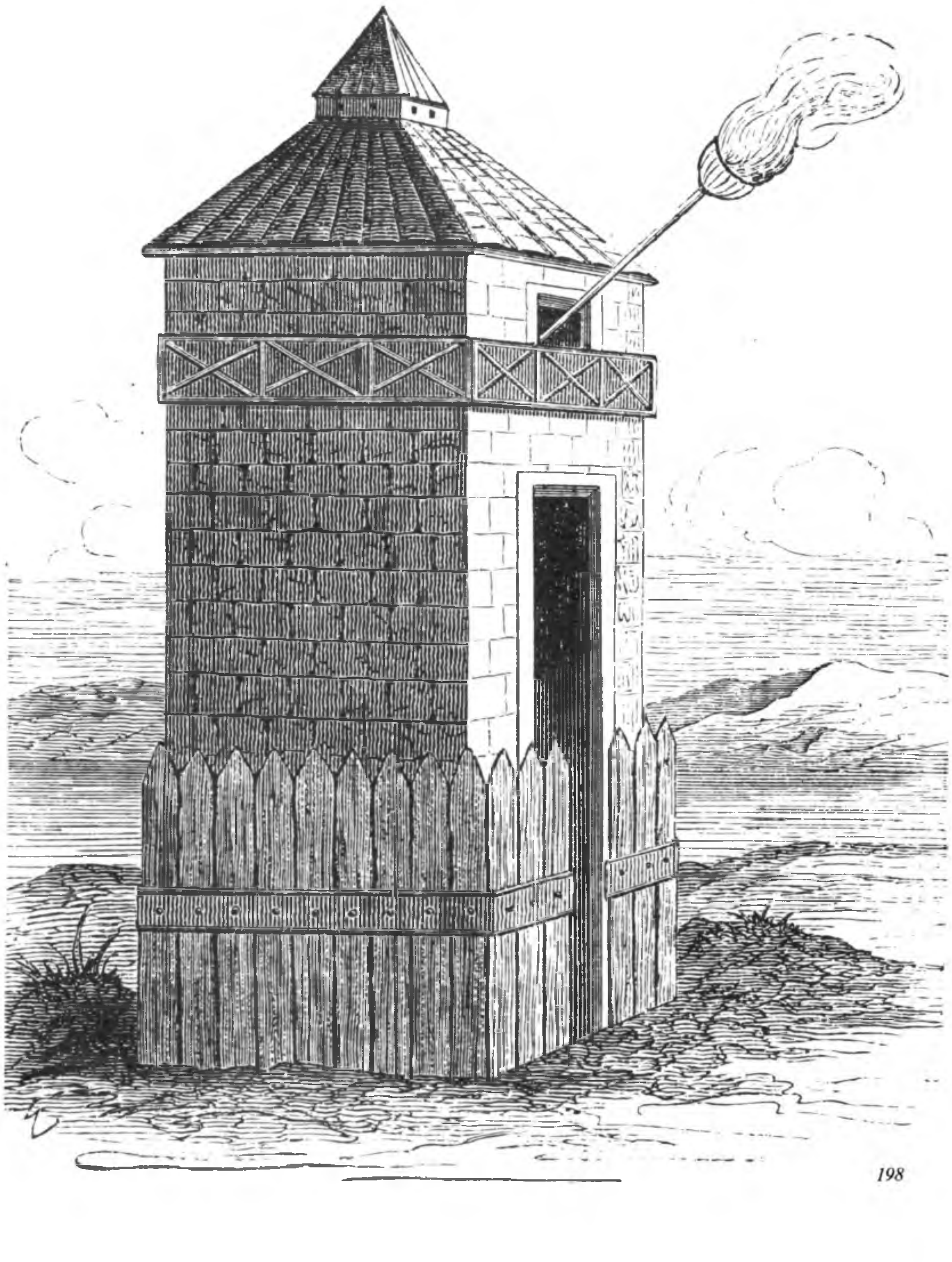
Cairo Conference also insisted on higher technical standards for transmitters through improved frequency tolerance and bandwidth tables.

The use of spark type radio transmitters was further restricted by the Cairo Conference, and only three frequencies were permitted: 375, 425 and 500 kc/s. The Radio Consultative Committee was given additional responsibilities, by being charged to study not only technical radio questions, but also "operating questions". To make the financial contributions to the Committee more equitable, the class-unit system, which had been worked out so successfully for the International Telegraph Union, was established, and the interval between meetings of the Committee was reduced from five to three years. All in all, the Cairo Conference certainly achieved a great deal, although of course its effective work was to be limited to an all-too-short period.

There was just one more European Broadcasting Conference, at Montreux in 1939, which succeeded in drafting a revised convention for itself and a new frequency assignment plan for its own members. Then there came again in August 1939, as it had come once before in August 1914, the announcement by almost all European Governments that as from midnight onwards, "all licences for the establishment of wireless telegraphy sending and receiving stations for experimental purposes are hereby withdrawn". Q R X, radio silence for amateurs, was again to last for six years, although the rest of the radio spectrum was to be of the most vital use for all belligerents.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Wars and Telecommunications — an Interlude

Half-way through our story of a hundred years of successful international co-operation in telecommunications, we must turn aside for an interlude. The two World Wars of 1914-1918 and 1939-1945 brought about a standstill in co-operation, so complete and so fundamental, that it must be considered one of the major achievements of the Union that it has successfully survived them both.

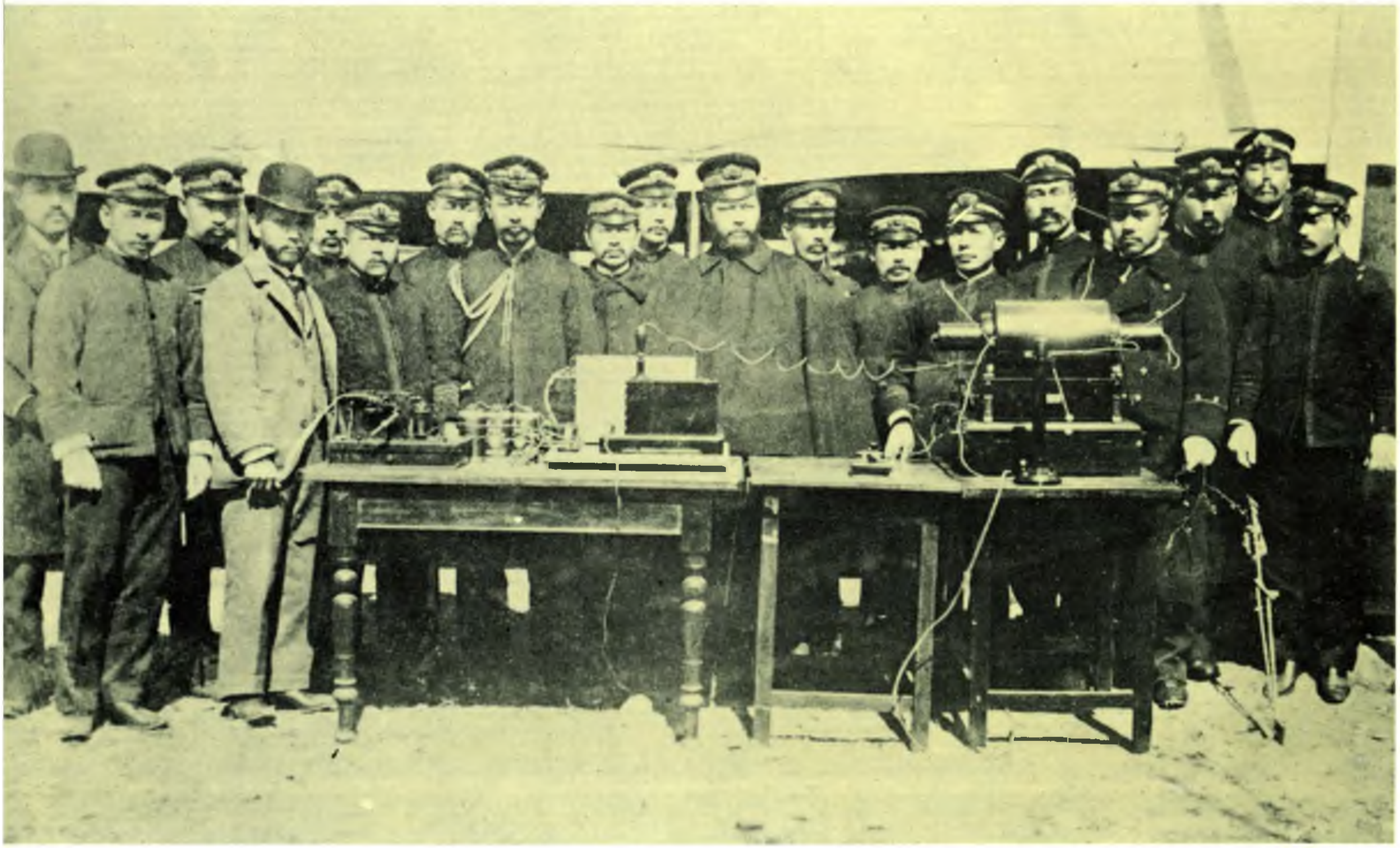
One of the main reasons for this survival was the location of the Union's Bureau at Berne, in neutral Switzerland, and the fact that it was able to continue its work, although only at a much reduced scale, throughout the periods of the two world wars. A second and less obvious reason can be found in the fact that each of these two wars stimulated a very great scientific upsurge in telecommunications techniques, the first in broadcasting and mass production of radio valves, the second in radar and in television, that international co-operation became even more urgent after the two wars, than it had been before them. Hence, after each war, urgent steps had to be taken not only to regain the pre-war position of international co-operation, but to extend it as fast and as far as possible.

There can be little doubt that the first messages sent over long distance, whether by bush drum, by smoke signals, or by semaphore, were signalling tidings of peace and war. In Homer's Iliad we find references to the use of beacon fires to herald the approach of a friendly fleet to relieve the beleaguered, and the Chinese, during the siege of Nanking in the 6th century A. D. used kites with lamps attached for signalling purposes. The beacon fires calling England to arms as the Spanish Armada sailed up the Channel in 1588 are perhaps one of the best-known examples of this kind of telecommunications. That the French and British semaphore systems were created to convey military and naval intelligence, we have already seen. War, more than any other kind of human activity, is absolutely dependent on communications, the best available at the time.

The first application of the electrical telegraph to war was made by the British Army in the Crimea in 1854, linking Lord Raglan's headquarters to established stations in the trenches. In the Indian War of Independence, or Mutiny as it used to be called, in 1857, the telegraph linked the government at Calcutta with the widely scattered British forces; it was one of the deciding factors of the struggle.

That the possession of one of the telecommunication techniques can mean complete and easy victory, when the opponent is either unaware of it, or unable to use it, was clearly demonstrated on many occasions.

THE ARMY TELEGRAPH—THE OPERATOR AT WORK.—[Sketched by Mr. A. R. Waud.] *199*



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198 *Reconstruction of a Roman signalling post, after a bas-relief on Trajan's Column in Rome.*

199 *An operator of a Beardslee Magneto Telegraph in 1863, sketched by A. R. Waud.*

200 *The first wireless telegraphy set tested by the Japanese Navy Ministry in 1904.*

201 *Running out the wire from the Signal Telegraph Train. Drawing by A. R. Waud (1863).*

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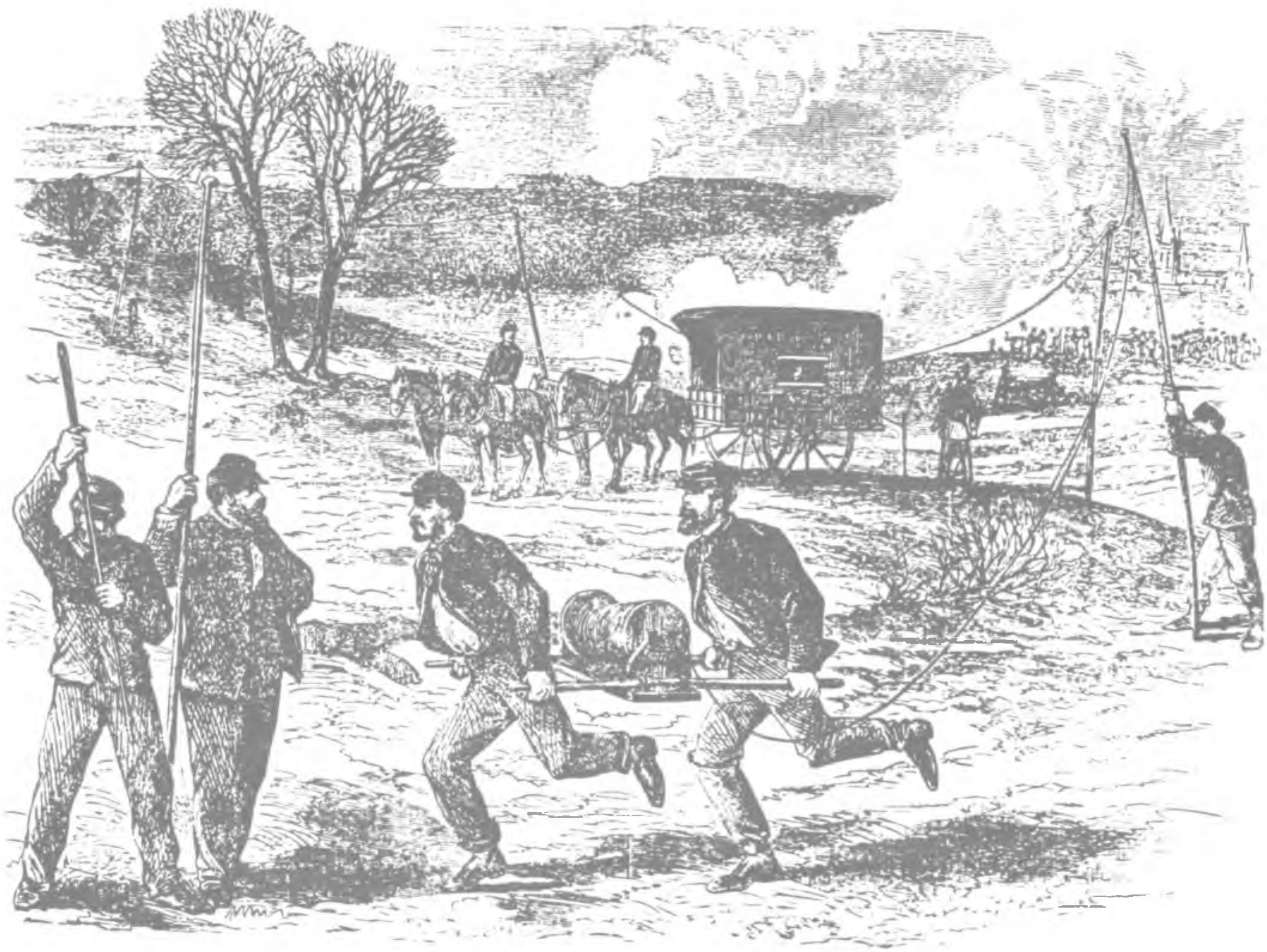

RUNNING OUT THE WIRE.

Let us turn now to the early days of the telegraph and the American Civil War of 1861-1865, which saw the first great use of this technique of communications during a war. The Federal Government built 24,000 km of telegraph lines during the war, and 6,500,000 messages passed over them. There are numerous tales of heroism of the very young boys who were then the telegraph operators, typical perhaps being that of Stephen Robinson, aged 15. General Forrest was raiding the Mobile and Ohio Railroad in the winter of 1862, capturing telegraph operator after operator as he went along. At Kenton, Tennessee, three companies of Illinois Infantry were forced to flee when Forrest dashed in from the South, leaving the boy operator Robinson behind, forgetting him in the heat of the struggle.

Robinson detached his instrument, a Morse key, rolled it up in his shawl, and walked away right through the enemy troopers who paid no attention to a young boy on his way home. He walked out of town, over the Obion River trestle bridge in the dark and, near the next telegraph station, climbed a pole, cut into the wire and telegraphed the news of the situation to a general's headquarters at Columbus, Kentucky. A locomotive was sent out and picked him up, returning safely to Columbus.

Cipher was extensively used by both the North and the South, and in the later stages of the war, wire-tapping became an important source of intelligence. One of the most remarkable jobs of this kind was carried out by C. A. Gaston, General Lee's operator, who entered the Union's lines at City Point, Virginia, while Grant was besieging Richmond and Petersburg. Gaston listened for six weeks to the messages passing over Grant's wires, one of them being about a herd of cattle. He passed this on, and the cattle were captured by Wade Hampton's greycoated cavalry.

There were women telegraph operators, and there was even telegraphing from a captive military balloon being flown by Professor T. S. C. Lowe. He made a number of successful ascents during the battles of Fair Oaks and the Seven Days. When peace came in 1865, the year of the first Conference of the International Telegraph Union, recognition was given to the heads of the American Union's telegraph services, but nothing was done for the rank and file of the operators. Years later, Andrew Carnegie, one of the heroic telegraph boys of the Civil War, was supporting many of his destitute friends from the fortune he had made out of his iron and steel companies.

It cannot be said that the American Civil War had any influence on the technical development of the telegraph; after the war, such lines as had been cut were repaired, and business went on as it had done before. Only when we turn away from this "Telegraph War" of the last century and come to consider the "Telephone War" of 1914-1918, and even more so the "Radio War" of 1939-1945, can we appreciate the strong impact of a modern scientific war on the technical development of telecommunication. By the time of World War I, all the combatant armies had formed their own Signal Units or Corps, being fully equipped with suitable telegraph and telephone installations adapted for warfare. Radio installations on all major warships were a commonplace by 1914, but at that time there were only a few mobile radio stations attached to the armies and even fewer airborne ones.

The outbreak of the War in 1914 soon showed up any weaknesses in communications. Once the War had settled down to one of attrition and of trench positions, the need for less mobile techniques of communications arose, and it was then that the telephone assumed its major importance. Radio aerials, then necessarily of considerable height, were far too conspicuous; they presented an unmistakable target indicating the location of a vital communication centre. As the intensity of warfare increased with ever higher levels of bombardment, telephone cables, at first laid on the surface and then buried, were, in 1918, laid as deep as 2 m to protect them.

Both sides developed vast networks of underground cables, and by using induction receivers were often able to tap the enemy's telephone communications. This was done by burying two copper mats, less than 1 metre square, as close to the enemy's cables as possible.

In the naval battles of World War I, wireless telegraphy often played a decisive role. Even more important was the contribution of radio to warfare in the air. Where, in 1914, a few scout-planes were gentlemanly shooting at each other with rifles, and occasionally dropped a hand-grenade or two on passing troops, by 1918 large squadrons of fighters and two-engined bombers had made aerial warfare a grim reality. The first radio stations in the air were those of Captain Brenot in a Blériot aircraft of 1910, and in a dirigible, the *Clément Bayard II* of Commandant Ferrier, of the same year. From these simple beginnings were soon developed ever more powerful radio transmitters and receivers, to send back to the ground the observations of the enemy's troop dispositions, to keep in touch with other friendly aircraft, and to receive orders from headquarters.

Thus the war demanded more and more far-reaching radio transmitters and more and more sensitive radio receivers. At that time E.F.W. Alexanderson's alternator provided one of the most powerful trans-

202-203 *The telegraph played an important rôle in the Franco-Prussian War of 1870-71. Here, telegraph lines laid by the French telegraph Corps (inset) are being cut by Prussian Uhlans (bottom).*

mitters, and by 1917 the U.S. Navy had one of 200 kW power at New Brunswick. This ensured contact with her fleets and a constant radio link with her armies in France. The more and more sensitive receivers were provided by the extensive use of vacuum tubes.

Mass production of radio valves was started during the war, and once the problem of producing an adequate vacuum in them had been solved by highly efficient pumps, they were able to give a superb service. Just what mass-production did achieve in the years of 1914-1918 can be seen from the figures of one single French firm, Société Française Radio-Electrique; it had produced for the allied armies during those four years, 63 fixed radio stations, 300 ship stations, 18,000 aircraft stations and 12,500 mobile ones.

The lavish funds and almost unlimited energy expended by all nations during World War I on scientific radio research had paid dividends. In peacetime, research which had been expended in the development of radio transmitters and, in particular, on radio valves was soon to lead to the establishment of broadcasting services all over the world.

The first broadcast, or demonstration of radiotelephony as it was then called, took place on Christmas Eve of 1906, when a station set up by Fessenden and Alexanderson near New York sent out two speeches, a song and a violin solo; the programme was clearly heard by a scattered group of persons provided with receivers. Two years later, De Forest staged a demonstration from the Eiffel Tower in Paris which was heard by all the French military stations in the area and by an engineer in Marseilles. In 1916, De Forest broadcast from an experimental station in the Bronx news bulletins covering the dramatic presidential election, but relatively few people had been able to listen to any of these early broadcasts.

With the end of the War, in 1918, the stage was set for an organized development of broadcasting. Pre-war experiments, the wide-spread use of radio during the war, the technical radio training which thousands of young men had received in the armed services, together with the availability of the technical know-how of powerful transmitters and sensitive radio valve receivers, all these combined to make efficient broadcasting a reality. This happened in the year 1920. In England, the Marconi Company arranged a "radio-telephone" concert, featuring, on June 15, Dame Melba; it was clearly heard as far away as Paris, Italy, Norway and even in Greece. A powerful transmitter had been constructed in the U.S.S.R. in 1919, and experimental broadcasts were begun from Moscow in 1920. In Germany, on December 22,

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204 Early mobile wireless set as used by the United States Army Signal Corps at Fort Leavenworth in October, 1909. It took one minute and eight seconds to erect the aerial.

205 Mobile communication truck of World War I, as used by the United States Army Signal Corps.


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1920, the Königswusterhausen Radio Station broadcast the first instrumental concert. KDKA, the station of the U.S. Westinghouse Company, under the direction of Frank Conrad, began on November 2, 1920. The Harding—Cox presidential election was its opening programme, and this caused a sensation.

Regular daily programmes started in England from the London station 2LO on November 14, 1922; this, the British Broadcasting Company, later became the Bristish Broadcasting Corporation in 1927. Regular French broadcasts from the Eiffel Tower began in the same year, and by 1927 there were 733 broadcasting stations in the United States. Broadcasting had been accepted as a mass communications medium in Europe. It had also achieved an important foothold in all the other continents of the world. By 1939, the outbreak of World War II, broadcasting was ready to become a new major weapon in the armoury of all nations. The concept of total war had created the psychological battlefront on the air, the warfare of ideas.

If we want to look at the credit side of the years 1939-1945, we must go into the scientific laboratories. Although there, too, all work was bent on destruction or defence, foundations were laid for much that proved later on of greatest peace time benefit. In Germany it was the liquid fuel rocket, in America the development of the atomic bomb, and in British laboratories penicillin and radar were born. But here our story must confine itself to radar.

Radar arose from Britain's need to defend herself. In January 1935, R. Watson-Watt, then head of the Radio Department of the National Physical Laboratory, was asked if a radio death ray could be produced; in his reply he discounted that possibility, but commented that location by radio of distant aircraft might be worth pursuing. This suggestion was taken up, secret laboratories were built at Bawdsey Manor near Felixstowe on the East Coast, towers over 75 m high were constructed, and, a year later, an aircraft flying at 500 meters could be successfully located at a distance of 120 km. At that time a frequency of 30 Mc/s was used from the radar towers, close to the famous 45 and 41.5 Mc/s bands used for British television from 2 November, 1936, on. By 1939, the British Government had spent £10 million on radar, aircraft could be detected at heights of 3000 meters and distances of 160 km, and Britain had become an island again.

The principles of radar are simple: pulses of radio waves of very high power, but of very short duration, are sent out, and when these pulses hit some object, such as an aeroplane, they are reflected and sent back

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as an echo. An antenna receives these echoes, and they are visually displayed on the screen of a cathode ray tube. There the distance between the original pulse and its echo is a measure of the distance of the object. If the centre of the tube is also made to represent the centre of the rotating transmitter and receiver, then the angular position of the echo gives at the same time the angular position of the object. In fact, the similarity of light and radio waves is strikingly borne out at these frequencies, a demonstration which Hertz was the first to show in his classical experiments of 1888.

The quest for higher radar frequencies and more powerful transmitters was pursued relentlessly throughout the war and has continued ever since. The magnetron, invented by J. T. Randall and A. H. Boot at Birmingham University in July 1940, is perhaps the most significant milestone in this development; its later versions produced hundreds of kilowatts at 10 Gc/s, and it was one of the most closely guarded secrets of the war. Already in 1924 Prof. A. Zacek of the Charles University in Prague had obtained a patent, No. 20293, for a magnetron, but this was apparently not followed up by any practical application. The klystron, developed in the United States by the brothers R. and S. Varian, was another of these famous ultra-high frequency microwave tubes, which were vital for radar.

Neither radar research nor the extension of its applications ceased at the end of the war. There is to-day no large ship or aircraft which does not make use of its radar to extend its sight in fog or clouds, to receive warning of unseen obstacles in its path, and to help it in its blind approach to harbour or airfield. The defence of many a country is to-day guarded by an elaborate and far-flung screen of radar stations to give warning of aircraft and ballistic missiles alike. Also for offensive purposes, radar is to-day indispensable, guiding missiles, feeding the computers on board military aircraft and naval vessels with data so that firing at an opponent is almost reduced to mere button-pressing when the right signal appears on the fire control board. Radar watches the rockets leaving for space, and shows the correctness of their path over vast distances.

World War II was certainly a "Radio War" affecting nearly all the nations of the world. During its six long years almost all the activities of the International Telecommunication Union were of course slowed down. But the war's harvest of new radio techniques was rich and all of these wartime developments were quickly and efficiently adapted to the expanding civilian needs; so, for example, Loran and the pictorial display on the screen of the cathode ray tube. The story of broadcasting was exactly duplicated by that of television, as we shall see.

206 *At a crossroads in the Argonne Woods, France, an important switchboard was rigged up. The lines connecting the regiments with Division Headquarters and Division Headquarters with Corps Headquarters met here. It was 1918.*

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207 Typical radar set as used in World War II in 1943. It was set up and used by the United States Army near an advance Air Force fighter strip.

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Atlantic City — 1947

In all countries where fighting had taken place, there was a terrible destruction of telecommunications equipment. Not only had the toll in human lives been immense during the two World Wars, but also the material damage they caused had to be reckoned in millions of any currency. Wars are waste, however much they accelerate technological progress; without them the same progress would merely have taken longer. But millions of human beings would have been allowed to continue their peaceful existence.

So for example, the French Government gave in 1946 a detailed picture of the destruction of its telecommunications. Two hundred buildings were seriously damaged, 90,000 km of overhead wires were down, 60 relay stations had been destroyed, 30 cities had their underground cable networks cut, 110 telegraph offices lay in ruins, tens of thousands of telephone sets had to be replaced, 50 submarine cables had been cut, and of the original 42 French national broadcasting transmitters, only four were usable. No doubt an even worse picture would emerge if details of the destruction in other countries were known.

Only the United States was relatively unscathed by the effects of World War II, and it was its desire to use this advantage for the benefit of all Members of the I.T.U. Acting on a suggestion of the United States, the Government of the U.S.S.R. invited the other four of the "Big Five" victorious powers, China, France, the United Kingdom and the United States, to meet with them in Moscow to prepare for the next International Telecommunication Conference. The Moscow Conference of 1946 was a preliminary conference, yet many of the modern features of the I.T.U. can be traced back to the discussions held at that time.

The setting up of an elected board to register all radio frequencies was discussed, so that new radio stations would not cause interference to established ones. Proposals were made to bring the I.T.U. into close association with the newly established United Nations Organization. Furthermore, it was planned to take the Secretariat of the I.T.U., the devoted Bureau of Berne, away from the control of a single one of its Member countries, namely Switzerland. To provide for continuity in the operation of the I.T.U. between Conferences, the United States and the U.S.S.R. proposed that an elected administrative council should be formed. After 21 days of conference, the delegations returned to their own countries; the United States Government, after hearing the report of its delegates, issued an invitation, through the Berne Bureau, to all the Members of the I.T.U. to attend at Atlantic City, in 1947, a Plenipotentiary

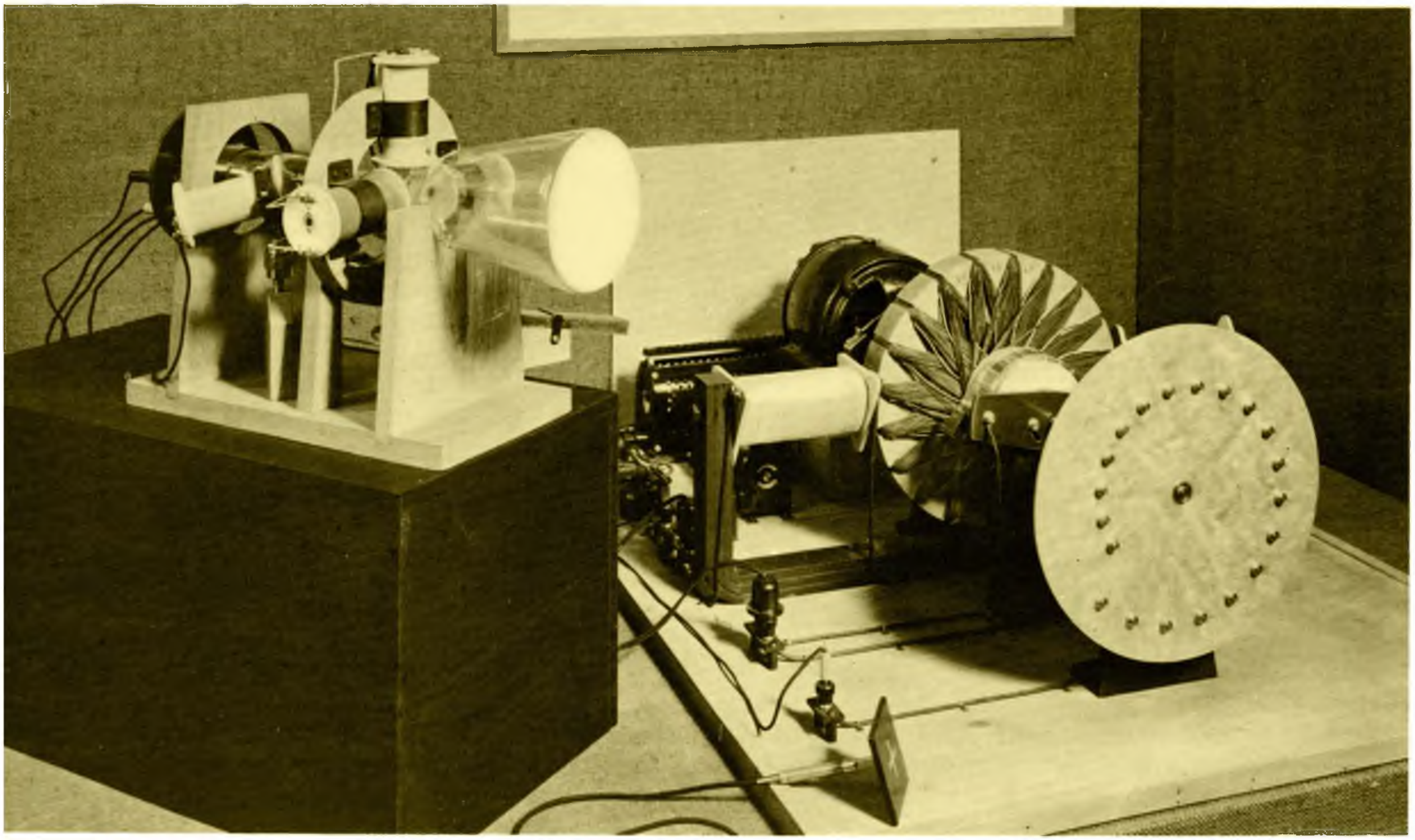
208 *Model of the first television receiver made in Germany, 1906, using the cathode ray tube originally invented by Braun.*

209 *An early television camera used in the first experimental broadcasts in Japan in 1935. It was made by the NKH Technical Research Laboratories.*

210 *An Emitron camera mounted on a dolly as used in the British Broadcasting Corporation Television Service, in April, 1937 for broadcast transmission.*

211 *Television receiver chassis of 1937, as made by Ferranti, England.*

212 *An early television receiver obtaining scanning by means of rotating Nipkov-discs. Invented in Austria, 1925.*



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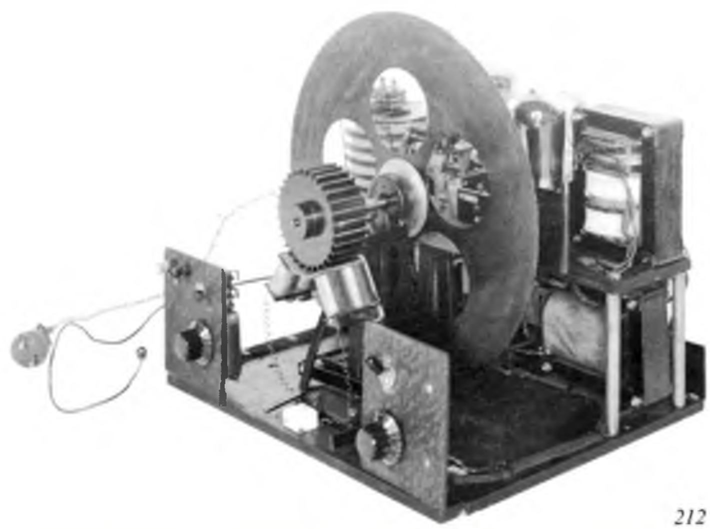

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213 *The television studio at Alexandra Palace of the British Broadcasting Corporation, in August, 1936. A Marconi-E.M.I. instantaneous television camera was used.*

214-215 *During the XIth Olympic Games in Berlin, in 1936, three electronic television cameras were used for the first time to transmit live pictures of various sporting events. These were shown by projection to over 150,000 visitors to the Games.*

216 *With the advent of miniaturization, even television cameras have become portable. The equipment shown is the so-called "walkie-talkie-TV" camera first used to cover the national political conventions in the United States in 1952. NBC News Commentator Chet Huntley is shown with the camera, transmitter, and monitor.*

Conference, together with an Administrative Radio Conference and an Administrative High Frequency Broadcasting Conference.

The summer months of 1947 cannot have been easy ones for the 600 delegates from the 76 countries which met at Atlantic City. Many of the old problems of the I.T.U. had assumed a new and much more pressing shape in the post-war world; other difficulties, due to scientific progress in the field of telecommunications demanded an urgent solution.

As usual, there was much discussion to begin with about which countries should be allowed to participate.

The question of voting was intimately linked with that of Membership, and for the first time in its history the I.T.U. laid down a Membership article; this declared as Members the countries which signed the Convention of Atlantic City, which became Members of the United Nations and then acceded to the Convention, and finally those whose application was accepted by two-thirds of the existing Members of the Union. This is still to-day the basic Article I of the I.T.U.'s Convention.

The creation of an Administrative Council, to carry on the work of the Union between the meetings of the Plenipotentiary Conferences, was one of the most important innovations of the Atlantic City Conference of 1947. At first many countries were not as enthusiastic about this proposal as had been the "Big Five" at Moscow. But during later discussions it was generally realised that the work of the I.T.U. had now become so voluminous and also so complex that a body had to be established, competent and able to make rapid decisions.

It was agreed that the Administrative Council should be composed of 18 Members of the Union "elected by the Plenipotentiary Conference with due regard to the need for equitable representation of all parts of the world". In the 1959 Convention of Geneva, the number of elected members was increased to 25; its duties, as defined at Atlantic City and re-iterated in the latest Convention can be summarised as "the efficient co-ordination of the work of the Union".

Once the existence of an Administrative Council had been agreed upon, the position of the Bureau of the Union had necessarily to come up for revision. All the delegates at the Atlantic City Conference were full of praise for the work it had so admirably carried out during its 79 years of existence, particularly during the two difficult war periods. One of the major reasons why the delegates at Atlantic City felt


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that the Bureau must be modernised, made truly international in its staff members, and placed under the control of an Administrative Council was that radio had developed in the last decade to such a remarkable extent that it was fraught with grave political implications.

It was laid down that the Secretary-General, the Assistant Secretaries General and the Staff of the I.T.U.'s secretariat "in the performance of their duty must not seek or receive instructions from any government or from any other authority external to the Union"; all the Members of the Union agreed to respect this exclusively international character of the Union's secretariat, and that of the Consultative Committees.

The finances of the Union came up for lengthy discussion at the Atlantic City Conference of 1947; the unit-class system was retained and further classes were added to it. The gold franc was retained as the international monetary unit of the Union, in spite of other proposals. An interesting suggestion was made by the delegate of Hungary that an International Telecommunication Bank, as a Limited Liability Company, should be set up. It was to work under the control of the I.T.U. and was to facilitate credits for the poorer members for the modernisation of their telecommunications equipment. The proposal was not accepted.

The question of the Union languages occupied eight meetings of the Organisation Committee. There were the "official languages", the "working languages" and the thorny question of an "authentic language". It was finally decided that Chinese, English, French, Russian and Spanish should be the official languages, that English, French and Spanish should be the working languages and that in case of dispute, the French text should be authentic. It must be said that this arrangement has worked well.

In their task of reorganising the Union, the problem of finding a new seat for the Secretariat also arose. Geneva was finally chosen since it was the subsidiary headquarters of the United Nations and a French-speaking city.

From a political point of view, the relationship between the United Nations and the I.T.U. provided a somewhat difficult problem for the Atlantic City Conference. There was a strong feeling amongst many delegates that the I.T.U. was a "technical and universal" organisation, and that the United Nations were "political and restricted". The experience of the I.T.U. with the League of Nations had not left a happy memory, as in 1929 the Communications and Transit Committee of the League of Nations had attempted

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to set up a special body dealing with the distribution of wireless wave-lengths. This attempt had been bluntly turned back by the Director of the Bureau of Berne, and the Transit Committee did not pursue it any further.

The United Nations Organization was more insistent that the I.T.U. should enter into relations with it than had been the League of Nations. A special committee was set up to deal with this question at the Atlantic City Conference, and protracted negotiations were held by a special group with the U.N.O. at New York and Lake Success. The I.T.U. gained its main points during these discussions; so for example the original agreement spoke of the I.T.U. being "*a* specialised agency" of the U.N.

However, the Negotiating Group could not " contemplate that any other Specialised Agency would act in the field of Telecommunications ". It therefore insisted, and the United Nations agreed, that the I.T.U. be recognised as " *the* specialised agency " in telecommunications.

Reciprocal representation took also a lengthy time to discuss. Although at first the United Nations wanted to be invited to all the meetings of the I.T.U., it was later agreed that the U.N. could send representatives only after appropriate consultation and without the right to vote to the International Consultative Committees and other meetings of the I.T.U. This agreement has worked well over the years, and both the Union and the Organization have derived mutual benefit from it.

World War II had left deep wounds in the body of telecommunications. But the delegates of the Conference could leave Atlantic City after their lengthy work with the feeling that they had done all in their power to fit the Union for the task of healing these wounds. A competent organisation had been set up, and its success in the next two decades has proved the wisdom of building on the tradition of pre-war experience.

217 *Colour television demands a very great deal of light for illumination. This is a studio of the National Broadcasting Company at New York in the 1960's.*

218 *Mobile Television in 1961.*

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Radio Frequencies and Radio Regulations

To understand the accomplishments of the Atlantic City Conference of 1947 in the field of radio frequencies, we must again return to the years prior to World War II. Only thus can we see the parallel between the development of broadcasting and of television, each in turn stimulated by a World War.

The first step towards the transmission of pictures by wires or by radio, after Caselli's telegraph, was Paul Nipkow's (1860-1940) scanning disk. An object and its transmitted image was analysed point by point by a rotating perforated disk, containing small apertures or lenses, spirally arranged; these were converted into electrical signals by a photo cell. This was the principle of John L. Baird's first mechanical television system adopted by the British Broadcasting Corporation in 1929 for regular experimental transmissions from its London studio. It is to be noted however, that, towards 1880, a Frenchman, Constantin Senlecq (1842-1934), described his invention of a "Telectroscope" using also a rotating perforated disk and selenium cells. By a strange irony of fate, Senlecq who may be called "the grandfather of television" became completely blind and was unable to see the first television pictures which it was first possible to transmit around the time of his death, in 1934.

But mechanical television was short-lived, soon to be replaced by the electronic camera, the Iconoscope, and the electronic projector, the Kinescope. Both are based on the cathode ray tube, originally invented by C. F. Braun in 1897; these were used for television purposes by M. Dieckmann in Munich in 1906. The most remarkable forecast of " Distant Electric Vision " was published by A. A. Campbell in *Nature* of 1908 suggesting the use of cathode rays and their deflection. The credit for carrying out this suggestion in practice must go to Vladimir Kosma Zworykin, a Russian-born electronics engineer working in the United States. He first demonstrated this publicly at a meeting of the Institute of Radio Engineers in Rochester, New York, on November 18, 1929. Scanning of the picture was done electronically.

Electronic television was demonstrated in various countries during the early 1930's, including France, Britain, the United States, Germany, Italy, the U.S.S.R., and Japan. However, to Germany and to Britain must go the honour of transmitting the first regular high definition television services, from 1935 and 1936 onwards. At first the Baird mechanical system, and the electronic system developed in the laboratories of Electric and Musical Industries Limited at Hayes, under the direction of I. Schoenberg, were used in Britain alternately, but the electronic equipment soon proved its superiority. The United States followed in 1939, and in 1941 the Federal Communications Commission approved a commercial television system.

219 *The long-wave broadcasting station at Motala in Sweden is the most powerful in the country. The antennae masts of the station are arranged in a circle around the central mast, here photographed with a long exposure at night, showing the star trails around the polar star, which appears to remain stationary. The station was inaugurated in 1962.*

220 *Part of the famous "Q" code.*

221 *"They catch the waves and measure their length". Cartoon from the* Radio Times, *December 19th, 1924.*

Abbreviation	Question	Answer or Advice
QRA	What is the name of your station?	The name of my station is...
QRB	How far approximately are you from my station?	The approximate distance between our stations is...nautical miles (*or* km).
QRC	By what private enterprise (*or* State Administration) are the accounts for charges for your station settled?	The accounts for charges of my station are settled by the private enterprise... (*or* State Administration).
QRD	Where are you bound for and where are you from?	I am bound for... from...
QRE	What is your estimated time of arrival at... (*or* over...) *(place)*?	My estimated time of arrival at... (*or* over...) *(place)* is... hours.
QRF	Are you returning to... (place)?	I am returning to... (place). *or* Return to... (place).
QRG	Will you tell me my exact frequency (*or* that of...)?	Your exact frequency (*or* that of...) is... kc/s (*or* Mc/s).
QRH	Does my frequency vary?	Your frequency varies.
QRI	How is the tone of my transmission?	The tone of your transmission is... 1. good 2. variable 3. bad.
QRJ	How many radiotelephone calls have you to book?	I have... radiotelephone calls to book.

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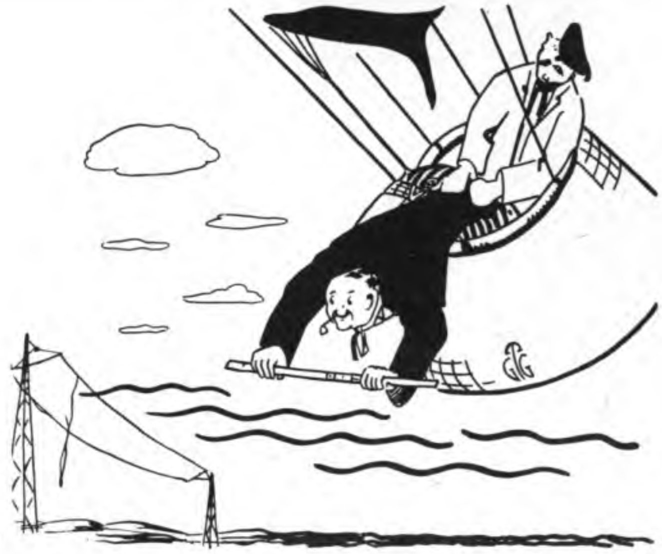

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World War II halted the development of television, but radar in this period 1938-1942 was helped in its development by the use of many of the techniques which had been developed for use in television. Furthermore, with the outbreak of war, radar technology was enormously facilitated by the very considerable supply of television engineers that became available. When the war came to an end, and television could be resumed, it was able to derive some technological benefit from the wartime developments of radar. By 1948, there were only a few countries, the U.S.A., the United Kingdom, France and the U.S.S.R., which showed regular television programmes; by 1957 there were about 50 countries and by 1965 television could be seen in almost 100 countries. The number of receivers had exceeded the 130 million mark.

Fortunately, television used one of the few radio frequency bands which constituted no immediate worry to the delegates of the Atlantic City Conference in 1947. Bands in the range of 30 Mc/s to 10.5 Gc/s could easily be allocated to radar, frequency modulated broadcasting and to television. But just what does happen when there is no international agreement in an expanding field of telecommunications is also shown by television: The United States uses 525 lines, France 819 and the United Kingdom 405. Elaborate and costly equipment is now available to change one system into another, but the so-called C.C.I.R. standard of 625 lines is only now gradually being adopted. Had it been possible to standardise on it in 1947, much trouble and expense could have been saved.

The frequency band of 2850 kc/s to 30 Mc/s was the most difficult to deal with for the Atlantic City Conference; during the period since its last allocation, at Cairo in 1938, an impressive expansion of aeronautical services had taken place, and there was a great desire on the part of the high frequency broadcasting services to expand in this band, because these frequencies have world-wide propagation characteristics. Both services achieved important gains at the expense of the fixed and amateur services; however the amateurs were still left with a good number of useful frequency bands, mainly due to the insistence of the United States delegation.

The lowest frequency band of 10 kc/s to 2850 kc/s provided problems of its own. During World War II extensive chains of Loran had been set up, and this system of radionavigation had proved very useful for ships and aircraft in the Atlantic and Pacific Oceans. Both the band in the 200 to 280 kc/s and in the 1850 to 1950 kc/s range were allocated to Loran, but opposition came from North Sea countries who found that it interfered with their own communications. The United States agreed to replace

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certain equipment free of charge by more modern radio instruments, and this proved an acceptable solution. There was no difficulty of this kind in the Pacific Area where the band of 1800-1900 kc/s was reserved for radionavigation.

The most important result of the Atlantic City Conference in the field of radio was the creation of the International Frequency Registration Board, the I.F.R.B. It had been realised from the early days of radio onwards that complete information about all used radio frequencies would be of greatest value, and since 1928 the Bureau of Berne had been entrusted with the drawing up and the keeping up-to-date of a Master Frequency List based on notifications made by Member countries. By 1947 some 45,000 notifications of frequencies below 20 Mc/s had been made. In any case, it was felt that the role of the I.T.U. in this field should be extended and that a new organ should be set up for this purpose. A later chapter in this book is entirely devoted to the I.F.R.B.

Just as the phenomenal increase in air and road traffic during the last few decades has led to a comprehensive body of air laws and traffic regulations, so the equally great expansion of radio led to the formulation of an entirely new volume of Radio Regulations at the Atlantic City Conference of 1947; since then they have been revised and again brought up-to-date. To-day it is an impressive document of 640 pages, with its 1632 paragraphs of regulations and 165 paragraphs of additional radio regulations, its 27 appendices, two of which are issued as separate books, its 15 resolutions and 37 recommendations of the last Administrative Radio Conference of Geneva in 1959.

The 1959 Radio Regulations deal with an astonishingly wide range of radio subjects, most important being the Table of Frequency Allocations from 10 kc/s to 40 Gc/s in the three defined Regions of the world, with their 26 different users of the radio spectrum. To this Table are annexed nearly 300 general remarks, some of them reservations for particular frequencies, others explanations, and others again of local importance. Detailed definitions, and explanations of the nomenclature of the frequency and wavelength bands of the spectrum, accompany this Table in the Radio Regulations.

Much space is devoted to the notification and registration of frequencies, the basic work of the International Frequency Registration Board, and how it is to go about this important task. A Table of International Call Signs Series, to identify radio stations, is part of the Radio Regulations; the Call Sign Series begins with AAA-ALZ allocated to the United States of America and ends with ZVA-ZZZ, Brazil.

222 *"Radio Central" at Rocky Point, Long Island, New York, was opened in 1961 by the Radio Corporation of America as a worldwide telecommunications transmitting station. Gradually transformed from a long-wave facility to a short-wave installation, Rocky Point continues to-day as one of the largest overseas transmitting stations in the world.*

223 *The relationship between band number, frequency range and corresponding metric sub-division of the radio spectrum.*

224 *The 333-meter high Tokyo Tower (completed in 1958). The programmes of five TV stations are broadcast from this tower.*

Band Number	Frequency Range (lower limit exclusive, upper limit inclusive)	Corresponding Metric Subdivision
4	3 to 30 kc/s (kHz)	Myriametric waves
5	30 to 300 kc/s (kHz)	Kilometric waves
6	300 to 3000 kc/s (kHz)	Hectometric waves
7	3 to 30 Mc/s (MHz)	Decametric waves
8	30 to 300 Mc/s (MHz)	Metric waves
9	300 to 3000 Mc/s (MHz)	Decimetric waves
10	3 to 30 Gc/s (GHz)	Centimetric waves
11	30 to 300 Gc/s (GHz)	Millimetric waves
12	300 to 3000 Gc/s (GHz) or 3 Tc/s (THz)	Decimillimetric waves

Note 1: "Band Number N" extends from 0.3×10^N to 3×10^N c/s (Hz).

Note 2: Abbreviations: c/s = cycles per second, Hz = hertz, k = kilo (10^3), M = mega (10^6), G = giga (10^9), T = tera (10^{12})

Note 3: Abbreviations for adjectival band designations:

Band 4 = VLF	Band 8 = VHF
Band 5 = LF	Band 9 = UHF
Band 6 = MF	Band 10 = SHF
Band 7 = HF	Band 11 = EHF

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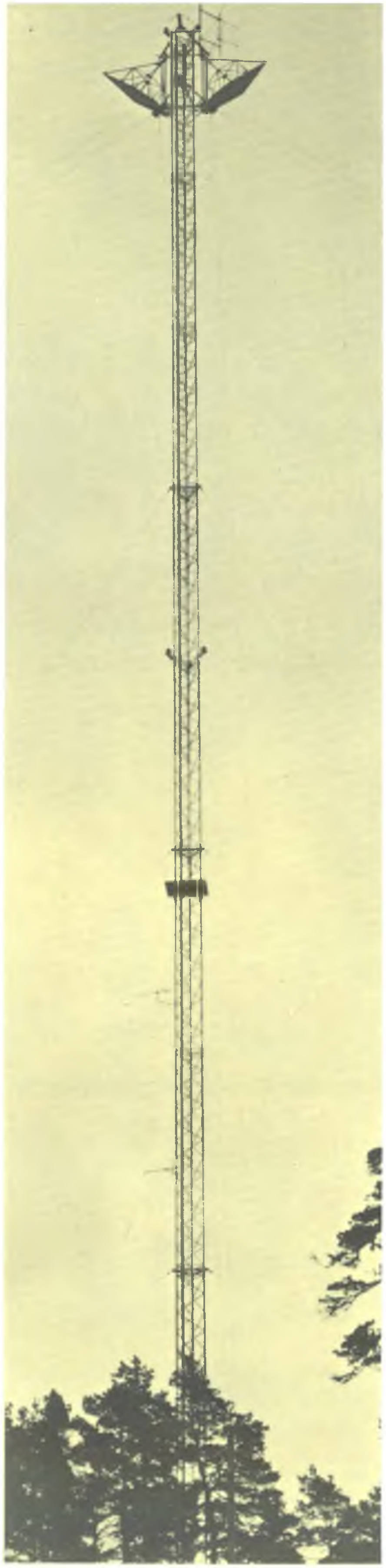

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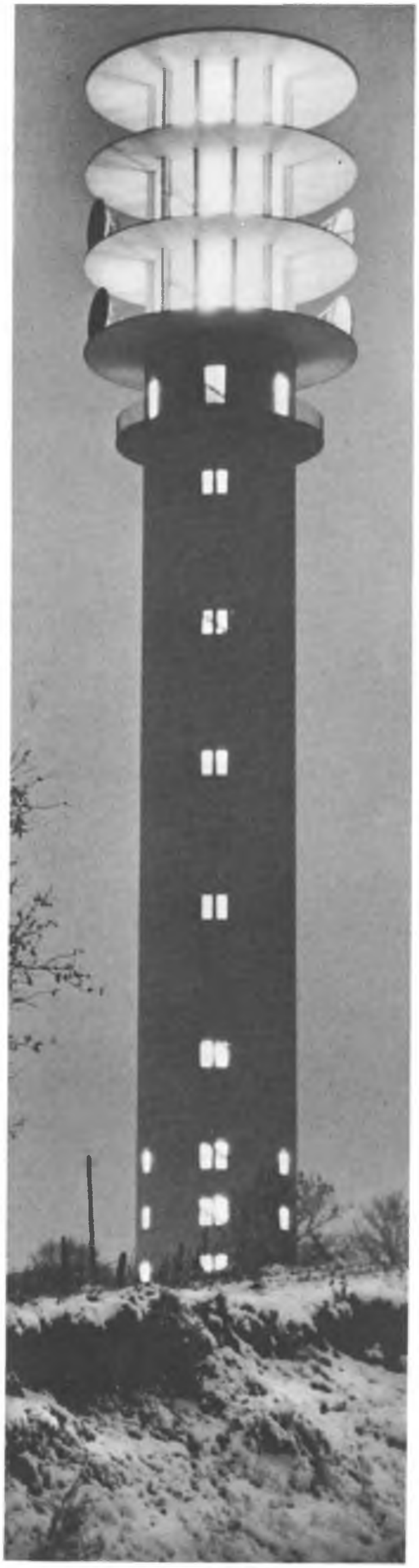
225 The 382 meter high television tower "Lopik" in the Netherlands, inaugurated in May, 1961.

226 The TV networks of Eastern and Western Europe (Intervision and Eurovision) were interconnected for the first time in April, 1961. This interconnection was made possible by the establishment of a TV link between Finland and the U.S.S.R. across the Gulf of Finland. Here is the Finnish terminal of this link in Porkkala, about 35 km south-west of Helsinki. The Finnish side of the link is operated by the Finnish Broadcasting Company.

227 Telecommunication tower on the roof of the Telecommunication Office, Bremen, 117 meters high with antenna systems for the television broadcasting, radio relay, public land mobile, and port operations services.



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228 Telecommunications relay tower of the Deutsche Bundespost at Wardböhmen, 69 meters high. In 1964 it was used for 3144 telephone channels and 8 television channels.

229-230 The demand for an ever-increasing number of telephone circuits has led to the use of micro-wave links between cities. Tall towers are needed for this, and in London in 1963 the Post Office was building one in Bloomsbury. When complete it will be 190 meters high and will provide 180,000 simultaneous telephone circuits as well as 40 television channels.

231 *Typical of the manufacture of modern radio components is this view of the making of radio valves by a French company.*

232 *A United States Navy communications room on the Antarctic continent, showing the teletype positions, receiver bank, patch panels and CW operations positions. This station maintains a twenty-four hour watch with weather stations all over the Antarctic continent and relays their information to distribution points in the United States, Australia and New Zealand.*

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However, as the letters of the alphabet were not enough, additional numerical call signs were added, amongst which are 4UA-4UZ allocated to the United Nations and 4YA-4YZ which have been given to International Civil Aviation Organization; these are the only two series for International Organisations.

The administrative provisions and working conditions of radio stations are also carefully defined, whether they are on board ships or aircraft, are coast stations or other mobile or fixed stations. The overriding authority of the ship's Master, the issues of certificates of competence for the operators, the methods of calling and reply, hours of watchkeeping, and tests, all these and many more are meticulously laid down. The General Procedure for using either radiotelephony or radiotelegraphy on various frequency bands from ships to shore and aircraft to ground, and vice versa, is an important part of the Radio Regulations.

As in the Telegraph and Telephone Regulations, the order of priority of radiocommunications is precisely stipulated. It begins of course with distress calls, and then follow urgent, and safety traffic. Next come communications relating to radio direction-finding, then navigation and safe movement of aircraft, followed by similar messages for ships, and, only in seventh place, government radiotelegrams: PRIORITÉ NATIONS. Government messages without priority, service communications and then all other radio traffic, is the rest of the priority order for radio.

The methods of sending, passing-on, and receiving of distress calls is precisely defined in the Radio Regulations. Two distinct frequencies are reserved for distress signals, 500 kc/s for radiotelegraphy and 2182 kc/s for radiotelephony, in all the three Regions of the world. For radiotelegraphy the signal consists of ···———··· symbolised by $\overline{\text{SOS}}$, and for radiotelephony of the word MAYDAY, pronounced as the French expression "*m'aider*", from which it derives its meaning. After this initial distress signal, the call must contain the name or the call sign of the station, followed by particulars of its position, the nature of the distress, the kind of assistance desired and any other information which might facilitate the rescue.

The use by amateurs of radiocommunications is covered in the regulations and 16 frequency bands are allocated to them; continuing the tradition, one of them being amongst the highest frequencies, namely 21-22 Gc/s.

It is impossible to detail here all the many other provisions of the Radio Regulations. They deal with Experimental Stations, Radiolocation, special meteorological services, medical advice, the standard frequencies of 20, 2500 and 5000 kc/s and 10, 15, 20 and 25 Mc/s, and time signals. The Appendices are

233 *With the ever-increasing size and distance of construction sites, radiocommunications are now used as a routine. Here, a small walkie-talkie is employed by an engineer during the construction of the large radio telescope near Arecibo, in Puerto Rico, giving the command to the crew on the winches which hoist the central structure 200 metres into the air.*

234 *View of the rotary beam antenna at the Naval Air Facility, McMurdo Sound, Antarctica.*

of a more technical nature, laying down for example the geographical zones for broadcasting, tables of frequency tolerances, reports on monitoring, documents which ship and aircraft radio stations must carry, the famous Q code, the phonetic alphabet to be used in spelling, technical characteristics for certain ship transmitters, the payment of balance of accounts, and the frequency allotment plan for the aeronautical mobile services. This last is a separate book of 75 pages defining the Major World Air Routes and their boundaries as well as the Regional and Domestic Air Routes and the exclusive bands to be used in each between the limits of 2850 kc/s and 17.97 Mc/s. The Additional Radio Regulations are mostly concerned with service regulations of radiotelegrams and their use by the public.

The last 115 pages of the Radio Regulations give the Resolutions and Recommendations of the Administrative Radio Conference of 1959. Perhaps one of the most important ones for the future of the I.T.U. was Recommendation 36, calling for an Extraordinary Administrative Radio Conference to allocate Frequency Bands for Space Radiocommunications. This was held in Geneva during October 1963, and achieved a great success, as we shall see in a later chapter.

The many thousand copies of the Radio Regulations—of the 1959 revision alone some 60,000 copies have been sold—which have found their way to radio stations all round the world have contributed as much as any other action of the I.T.U. to make telecommunications a truly international human activity. Whenever any radio operator has been in doubt as to the correct line to follow, the Regulations have always pointed towards the one aim of the I.T.U.: Co-operation.

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Part III — The Union after a Century

From 1947 to 1965

The Union and its Secretariat

We have now traced in barest outline the historical development of a remarkable feat of international co-operation. Beginning with the International Telegraph Union and its first meeting in Paris in 1865, we have followed the story right up to the greatest of the recent Plenipotentiary Conferences of the International Telecommunication Union, at Atlantic City in 1947. The Geneva Conference of 1959 ensured much detailed improvement in the working of the Union, but it did not give rise to any major changes.

When looking back over these hundred years of success, we find that there is remarkably little change in the basic structure of the Union. The supreme authority of the Union, which is ultimately responsible for all policy, is to-day as it was 100 years ago the Plenipotentiary or Diplomatic Conference. This Conference drafts now, as it has always done, the Convention of the Union, its basic charter, and lays down its guiding policy until the time comes when the next Plenipotentiary Conference feels a need for revision. These Conferences meet about every 5 years.

A recent innovation, dating from the Atlantic City Conference in 1947, is the creation of an Administrative Council, meeting once a year. Its 25 Members act for the Plenipotentiary Conferences between the latter's meetings. The establishment of the post of Secretary-General and his deputy, also dating from 1947, is nothing new in the history of the Union. The International Bureau of Berne has had, since 1868, a permanent Director at the head of its affairs, although these were incomparably smaller than those of the I.T.U. at present.

Turning now to the Administrative Conferences, which revise the Regulations for Telegraph and Telephone, or for Radio, these again are as old as the Union itself; the first purely Administrative International Telegraph Conference was held in London in 1879, the previous meetings being both Plenipotentiary and Administrative. For the sake of convenience and economy, the Administrative Conferences of the Union have often taken place at the same time and location as the Plenipotentiary Conferences.

The permanent staff of the Union's Secretariat at Geneva is now divided between four organs. First there is the General Secretariat, responsible for the general affairs of the Union, External Relations, Finance, Technical Co-operation, Personnel, Publications and Administration. Then there are three specialised secretariats, serving the International Frequency Registration Board, the International Radio Consultative Committee, and the International Telegraph and Telephone Consultative Committee.

235 *General view of the I.T.U. Headquarters at the Place des Nations in Geneva. In the right background can be seen the Palais des Nations which houses the European Office of the United Nations, the World Health Organization and other United Nations Organizations.*

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Naturally these four secretariats have many common services, such as the typing pool, translators, printing and so forth. All four are housed in the modern new building of the Union.

The move of the Union's Headquarters from Berne to Geneva was a wise choice. The International Bureau of the I.T.U. left Berne in 1948, and when the Atlantic City Convention came into force on January 1, 1949, it became the Secretariat of the Union. At first housed in the Palais Wilson and the Maison des Congrès, the new headquarters building in Geneva was formally inaugurated by U Thant, Secretary-General of the United Nations, on May 3, 1962.

At the Place des Nations, opposite the older Palais des Nations, stands the modern glass and aluminium mansion of the International Telecommunication Union. It is a worthy outward symbol of the modern spirit of the Union. Throughout its hundred years of history the Union has not only kept pace with the changing times but has often been well in advance of them, and yet it has never neglected to heed the lessons of its own tradition.

Any sensitive visitor to this building can feel these two influences at work. From the outside, the array of dipole antennae on its roof shows its links with the rest of the world; its amateur radio station was the gift of the United States of America. A modern system of internal inter-office communications is also a gift by the same government, and its magnificent automatic telephone exchange was presented to the I.T.U. by the Federal Republic of Germany on the occasion of the inauguration of the new building. The Kingdom of the Netherlands contributed to the efficient working of the I.T.U. with two sets of simultaneous interpretation equipment for the Council Chamber and the Committee rooms.

The traditional influence on the Union is shown by the splendid gifts which adorn its halls and passages, gracefully arranged between exotic plants, themselves a gift of Monaco. An ancient amphora from Cyprus, two traditional stools from Ghana, a bronze statue of Lord Krishna from the Republic of India, three glass vases—2000 years old—from Nazareth, the gift of Israel, silken tapestries from Japan, these antiques and many modern works of art and tasteful furniture—all gifts from Members of the Union—adorn the inside of the building. Outside stands a 2 meter high bronze statue, the present from the Soviet Union, symbolising man's striving for a better future. Such then are the beautiful and modern surroundings in which the Secretariat of the I.T.U. performs its daily work.

236 *The bronze statue which is the gift of the Soviet Union to the International Telecommunication Union. It is entitled " Towards the Sun " and is 2 meters high. It is the work of the famous Russian sculptor, A. P. Kibalnikov, and it stands next to the entrance of the Headquarters building of the I.T.U. in Geneva.*

237 *The Council Chamber in the International Telecommunication Union's Headquarters in Geneva. The tapestry in the background is a gift from Japan and was reproduced from a painting on a folding screen showing a " landscape with the Sun and the Moon ", which is owned by the Buddhist Temple Kongo-ji in the suburbs of Osaka. The desks are a gift from Portugal and the simultaneous interpretation equipment has been given by Philips S.A.*

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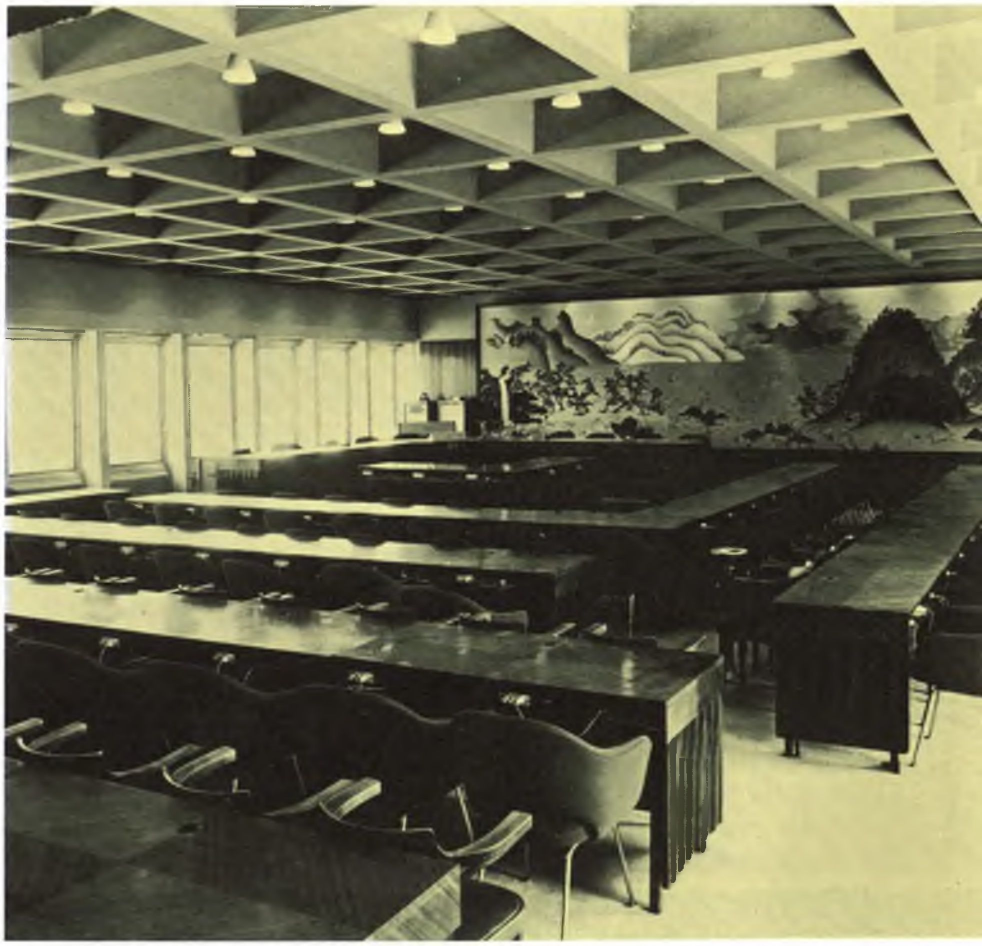

238 *The staff lounge in the International Telecommunication Union's Headquarters building in Geneva, a gift from the United States of America.*

239 *A statue which is the gift of India for the International Telecommunication Union's Headquarters building in Geneva. The statue represents the triumph of Virtue over Evil, the Lord Krishna, being depicted dancing on Kali, a five-headed serpent who was poisoning the water of the river Jumna.*

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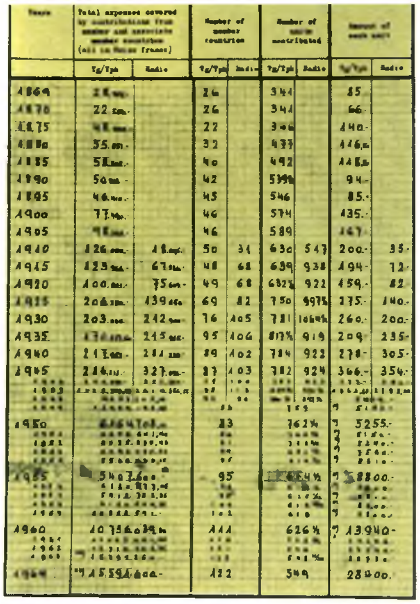

Years	Total expenses covered by contributions from member and associate member countries (all in Swiss francs)		Number of member countries		Number of units contributed		Amount of each unit	
	Tg/Tph	Radio	Tg/Tph	Radio	Tg/Tph	Radio	Tg/Tph	Radio
1869	[illegible]		26		344		85	
1870	22 [illegible]		26		341		66.-	
1875	[illegible]		22		[illegible]		140.-	
1880	55.[illegible]		32		437		[illegible]	
1885	[illegible]		40		492		[illegible]	
1890	50[illegible]		42		539½		94.-	
1895	46[illegible]		45		546		85.-	
1900	77[illegible]		46		574		135.-	
1905	[illegible]		46		589		[illegible]	
1910	126[illegible]	18[illegible]	50	31	630	547	200.-	35.-
1915	123[illegible]	67[illegible]	48	68	639	938	194.-	72.-
1920	100.[illegible]	75[illegible]	49	68	632½	922	159.-	82.-
1925	[illegible]	139[illegible]	69	82	750	997½	275.-	140.-
1930	203.[illegible]	242[illegible]	76	105	781	1064½	260.-	200.-
1935	[illegible]	215[illegible]	95	106	817½	919	209	235.-
1940	[illegible]	[illegible]	89	102	784	922	278.-	305.-
1945	[illegible]	327[illegible]	83	103	782	924	366.-	354.-
1950	[illegible]		83		762½		5255.-	
1955	[illegible]		95		[illegible]		[illegible]	
1960	10 756 0[illegible]		111		626½		13 940.-	
1964	15 59[illegible]		122		549		28 [illegible]	

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The Union itself has installed on the ground floor a large electronic computer, in use by the I.F.R.B., and its own off-set litho printing department. A standards telephone laboratory with its completely soundproofed room is housed in the basement of the building.

Our concern in this chapter is only with the General Secretariat of the Union. Responsible only to the Plenipotentiary Conferences is the Secretary-General; at present this post is filled with distinction by an American citizen, Gerald C. Gross.

The General Secretariat has many important functions to fulfil, the most arduous being undoubtedly its contribution to the preparatory work, as well as the resulting follow-up, of the many conferences held by the I.T.U. The publication of the numerous documents of the I.T.U. keeps a large staff fully occupied; during a recent typical year, 1962, 85,700 publications were dispatched from Geneva, which resulted in an income of 1,088,550 Swiss francs. The list of current publications available from the Union comprises about 200 separate items, ranging from the Convention and the official Radio, Telephone and Telegraph Regulations to the International Frequency List, voluminous statistics, lists of coast and ship stations, alphabetical lists of call signs, and so forth, right back to the International Telegraph Union's Jubilee book of 1915 when it celebrated its 50th Anniversary.

The publication of the *Telecommunication Journal*, the official monthly organ of the I.T.U., continues to-day, uninterrupted since 1869, although it changed its name in 1934. It is issued in three languages, English, French and Spanish, and enjoys a world-wide reputation for its technical progress reports, its diverse articles on the many activities of the Union, its book reviews, literature abstracts and calendar of I.T.U. conferences.

The decision of the Atlantic City Conference in 1947 that the Union should work in three languages, English, French and Spanish, and have two other official languages, Chinese and Russian, has meant in practice the need for an efficient and relatively large staff of translators and interpreters at the Conferences. Not unnaturally, interpreters are mostly engaged for a limited time during the actual conference, but some translators are members of the Union's permanent staff.

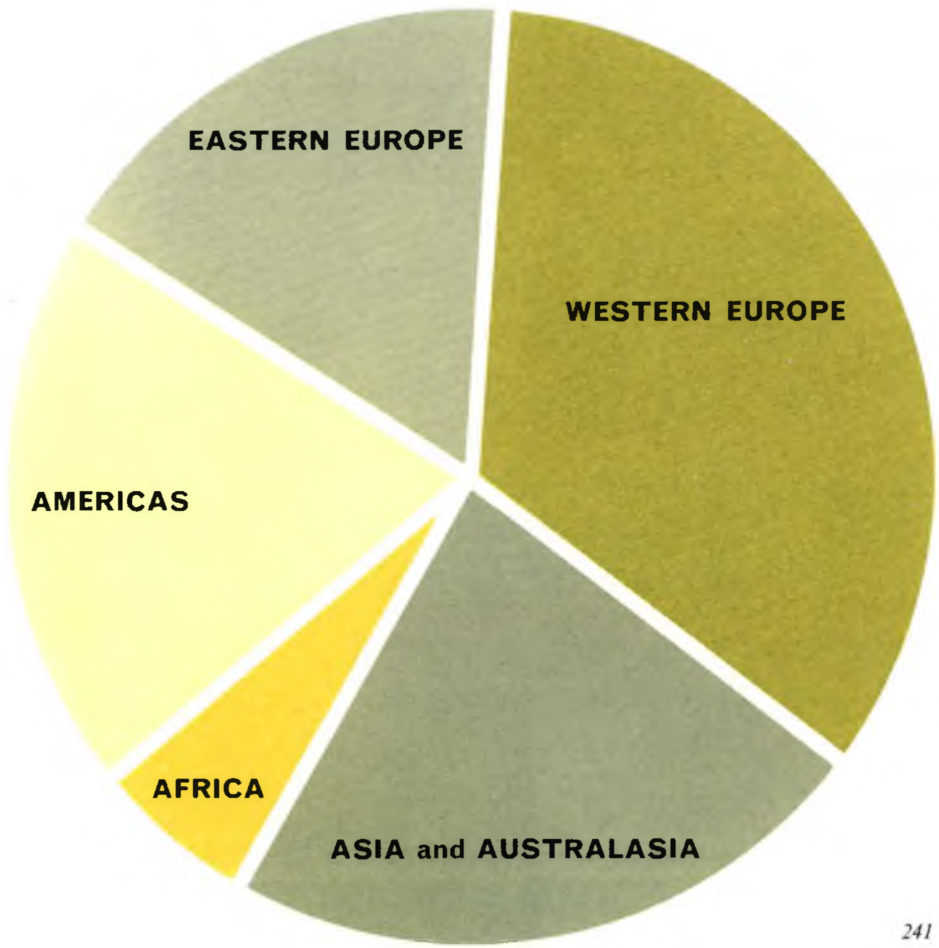
Another decision of the Atlantic City Conference has meant in practice some difficulty for the Secretary-General of the I.T.U. Paragraph 152 of the Convention states that the paramount consideration in the recruitment of staff for the Union must be the highest standards of efficiency, competence and integrity.

240 *The expenses and contributions from Member countries of the International Telecommunication Union from 1869 to 1964.*

Note 1. *In these tables the contributions tc the Conferences are not included. These are divided separately amongst the participant*

Note 2. *These figures correspond to the budget approved by the Administrative Council.*

(Tg = Telegraph, Tph = Telephone).



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241 *Geographical distribution of I.T.U. staff. Up to 1947, the staff of the Union was entirely of Swiss nationality except for two Deputy Directors. The first non-European Deputy Director was recruited in 1945. Since then, the number of nationalities represented among the staff of the Union rose to 14 in 1952, 22 in 1959 and 35 in 1963. The distribution by regions of the world was as follows in 1963:*
Western Europe *12 countries: Belgium, Denmark, Federal Republic of Germany, France, Ireland, Italy, Kingdom of the Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom of Great Britain and Northern Ireland.*
Asia and Australasia *8 countries: Afghanistan, Commonwealth of Australia, China, India, Japan, New Zealand, Pakistan, Turkey.*
Africa *2 countries: Republic of South Africa, United Arab Republic.*
Americas *7 countries: Argentine Republic, Canada, Colombia, Cuba, Mexico, Paraguay, United States of America.*
Eastern Europe *6 countries: Bielorussian Soviet Socialist Republic, Republic of Bulgaria, People's Republic of Poland, Czechoslovak Socialist Republic, Union of Soviet Socialist Republics, Federal Socialist Republic of Yugoslavia.*

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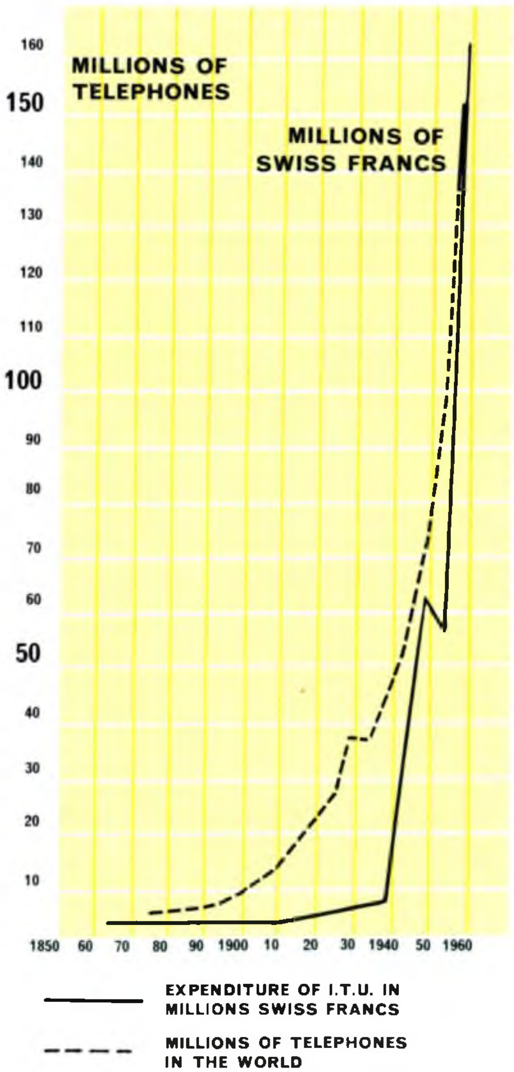

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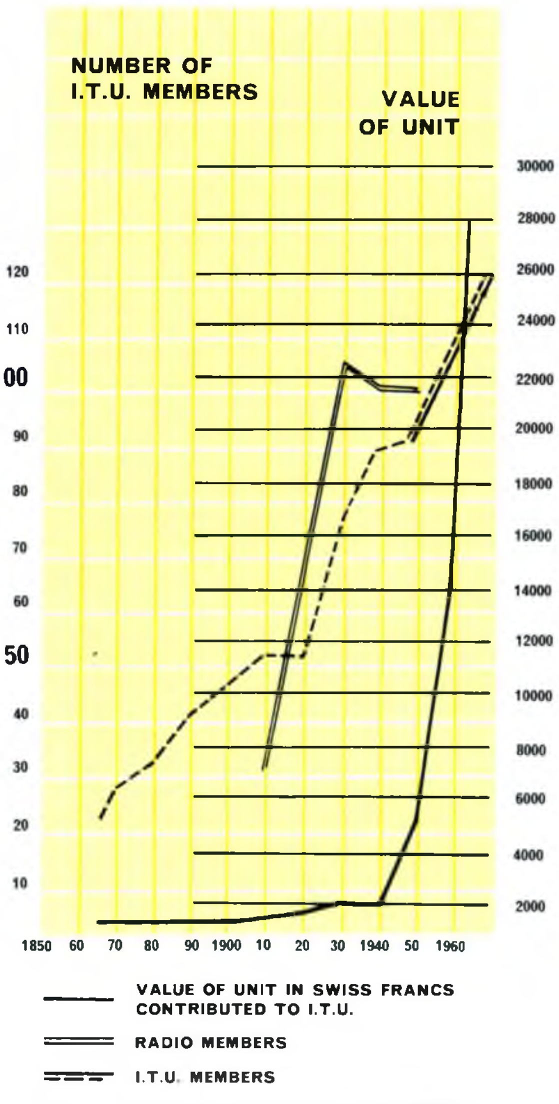

242 *Expenses of the Union (in Swiss francs) compared with the increase in telecommunications as shown by the total number of telephone sets in Member countries of the I.T.U. (Number of telephones left, expenditure right.)*

243 *The number of Member countries of the I.T.U. are here compared with the size of the unit as contributed towards the total expenses of the Union. Between 1903 and 1947 there were in addition to the International Telegraph Union, a number of Radio Telegraph Conferences to which many countries belonged as well. When, at the Atlantic City Conference in 1947, the financial contribution towards the Telegraph Union and the Radio Telegraph Conferences were joined in one contribution, the number of apparent members, belonging to both, was reduced to a single figure again.*

It continues " Due regard must be paid to the importance of recruiting the staff on as wide a geographical basis as possible ". When in 1948, the Berne Bureau became the Geneva Secretariat there was a total permanent staff of 27 Swiss, one Frenchman and one American, and the temporary staff of 27 showed a very similar distribution of nationalities. By 1963, the 142 permanent posts to which geographical distribution applies, were held by 36 different nationalities, a great step forward.

Many different considerations must be borne in mind when this question is discussed. First of all, geographical distribution applies only to posts in the professional and higher categories, as well as to some of the junior technical posts. Other junior posts are recruited locally from Geneva or its environs. Secondly, it must not be forgotten that a wide geographical distribution requires a lot of money. Travelling and removal expenses from distant countries on recruitment, home leave every two years for the whole family, and again on repatriation, and education grant travel every year for children is but one item; there are furthermore installation allowances and other special grants which can assume large proportions in the total budget for staff. A further difficulty lies in the fact that for many I.T.U. posts a good knowledge of one or two of the Union's working languages is an essential requirement. This may well present an insurmountable hurdle for some candidates who are technically well qualified for the vacancy.

Finally, many of the new and developing countries are in great need of their own trained telecommunications staff and generally cannot spare experts for an international organisation. It is significant in this context that up to 1962 the I.T.U. had not received any applications from the African countries although not one of them was then represented among its appointed staff.

A later chapter is concerned with the important work of the I.T.U. in helping the new and developing countries to expand their own telecommunications.

The Union's Finances are the last, but by no means the least, of the responsibilities of the General Secretariat. The Class-Unit System, first adopted by the Vienna Conference of 1868, has stood the test of time, and is still to-day the method of financing the Union's activities. Each Member freely chooses the class or the number of units, i.e. the percentage of the total expenditure of the Union, which he will contribute. To-day, the classes range from 30 units down to ½ unit. This unique system of finance is another good example of how freedom of choice for the Members has brought about a hundred years of highly successful international co-operation.

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244 *The proposed Commonwealth Round-the-world cable.*

The International Telegraph and Telephone Consultative Committee (C.C.I.T.T.)

The telephone and telegraph services found, like many other branches of technology, that scientific progress brought them not only more efficient installations, but also a correspondingly greater complexity. To take but one example. If the length of a telephone line increases by a factor f, then the area for which telephone services between two new subscribers becomes possible increases by a factor f^2, and hence the number of possible telephone connections between any two of these, grows by the factor f^4. Each connection demands in turn equipment for each subscriber, transmission lines, exchange facilities, maintenance and a corresponding increase in administrative facilities.

It was the Paris Conference of 1925 of the International Telegraph Union which decided that the complexities of the international telephone services needed more constant investigation than was possible at its periodic conferences. It therefore decided that the *Comité Consultatif International des communications téléphoniques à grande distance* (C.C.I.F.) should become an integral part of the I.T.U. and created a similar Consultative Committee for the telegraph [1]). Like the other Consultative Committees of the Union, they were true offsprings of the original ideas of the International Telegraph Union. Meeting periodically in Plenary Assemblies where their basic policies are determined, they possess their own secretariat, and they are open to membership by any Member of the Union or by any recognized private operating agency willing to participate in their work; until the end of 1960, members of the Committee paid towards its expenses, otherwise they were fairly independent. But they have always been, and still remain to-day, an integral part of the International Telecommunication Union.

The C.C.I.F. was charged at its inception with " the study of standards regulating technical and operating questions for international long-distance telephony ". Although much has changed from a technical and scientific point of view, as for example the introduction of transatlantic radiotelephony to the public in 1927, the primary aim of the Committee has remained unaltered. It established its secretariat at 44 Boulevard des Invalides in Paris, and its laboratory of the European Master Telephone Transmission Reference System at the Conservatoire National des Arts et Métiers, also in Paris. There they remained, apart from a temporary war-time transfer of the equipment to Limoges, until in February 1948 the Admin-

1) These Committees are better known under the names of "International Telephone Consultative Committee" (C.C.I.F.) and "International Telegraph Consultative Committee" (C.C.I.T.) which were given to them later.

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245 *An early Austrian teleprinter machine of 1894, designed by Hoffmann, Patent No. 54082.*

246 *An early teleprinter machine of the Morkrum Company which was founded in 1907 by J. Morton, using the inventions of Charles L. Krum.*

247 *The first start-stop telegraphic printing device, devised by the Soviet technician N. P. Trusevich in 1921.*

248 *Transmitter of the Siemens high-speed telegraph instrument for 1000 characters/minute of 1912.*

249 *The Creed teleprinter of 1928 was adopted as the standard British inland telegraph instrument.*

250 *In Japan a six-unit code is used for the telegraph code because the Japanese alphabet " Kana" has forty-eight letters. This is the first " Type J" Japanese tape teleprinter, manufactured in 1937.*

251 *The international Telex exchange in the Fleet Building in London routes Telex messages via cable circuits all over the world.*

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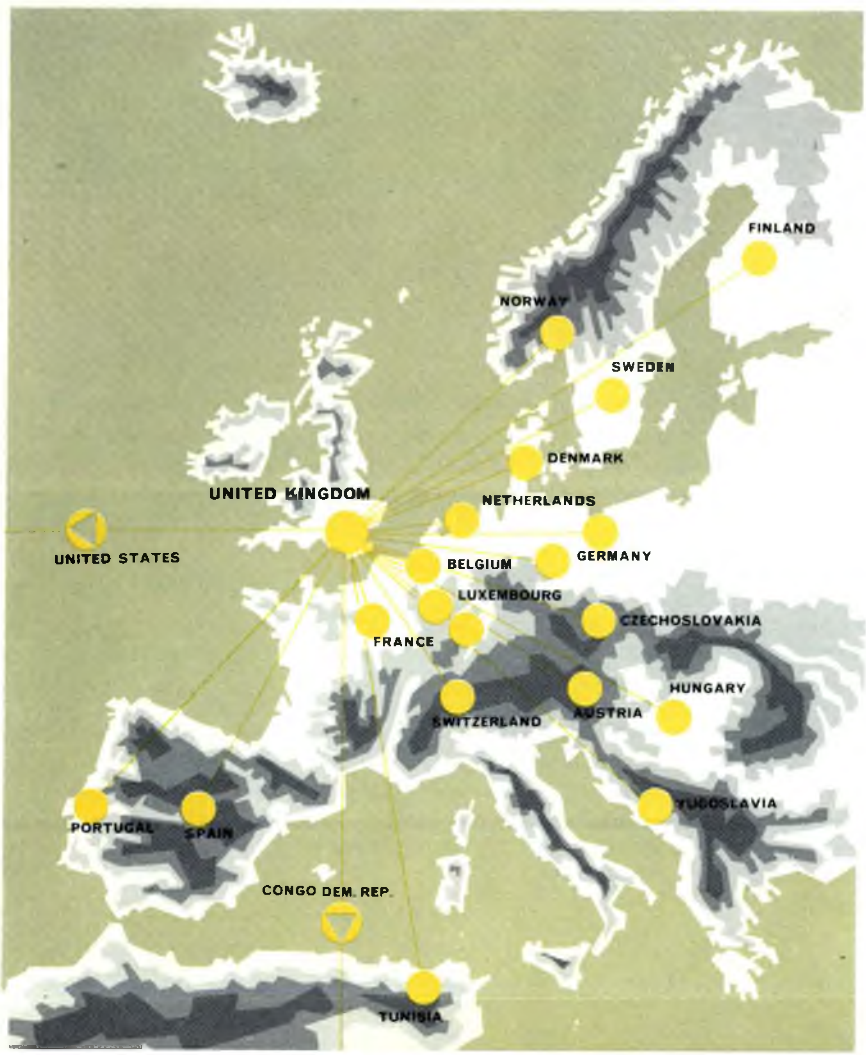

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252-253 *Telex, assuming the position of telegraphy in many parts of the world, is now expanding at an ever-increasing rate. For example, the English system is closely linked with both the United States and Europe.*

254 *World telephone statistics showing the increase from 1877 to 1963.*

January 1	United States	All Other	Europe	World	January 1
1877	2,600	0	0	2,600	1877
1878	9,300	0	50	9,350	1878
1879	26,000	0	1,000	27,000	1879
1880	31,000	0	1,900	32,900	1880
1881	47,900	2,200	5,600	55,700	1881
1882	71,400	3,000	13,400	87,800	1882
1883	97,700	5,400	25,000	128,100	1883
1884	123,600	9,500	39,000	172,100	1884
1885	147,700	11,800	58,000	217,500	1885
1886	155,800	14,300	77,000	247,100	1886
1887	167,100	17,100	99,000	283,200	1887
1888	180,700	23,300	122,000	325,000	1888
1889	195,000	26,500	150,000	371,500	1889
1890	211,500	31,500	177,000	420,000	1890
1891	227,900	36,100	214,000	478,000	1891
1892	239,300	40,700	254,000	534,000	1892
1893	260,800	49,200	295,000	605,000	1893
1894	266,400	55,600	336,000	658,000	1894
1895	285,400	78,600	386,000	750,000	1895
1896	339,500	84,500	439,000	863,000	1896
1897	404,300	95,700	503,000	1,003,000	1897
1898	515,200	106,800	578,000	1,200,000	1898
1899	680,800	130,200	671,000	1,482,000	1899
1900	1,004,700	154,300	803,000	1,962,000	1900
1901	1,322,000	172,000	950,000	2,444,000	1901
1902	1,762,000	197,000	1,100,000	3,059,000	1902
1903	2,333,000	231,000	1,260,000	3,824,000	1903
1904	2,772,000	269,000	1,410,000	4,451,000	1904
1905	3,317,000	509,000	1,577,000	5,403,000	1905
1906	4,086,000	347,000	1,800,000	6,233,000	1906
1907	4,888,000	411,000	2,030,000	7,329,000	1907
1908	6,072,000	467,000	2,265,000	8,804,000	1908
1909	6,437,000	507,000	2,500,000	9,444,000	1909
1910	6,950,000	669,000	2,752,000	10,371,000	1910
1911	7,590,000	671,000	2,966,000	11,227,000	1911
1912	8,303,000	865,000	3,239,000	12,407,000	1912
1913	8,683,000	1,210,000	3,631,000	13,524,000	1913
1914	9,494,000	1,334,000	4,013,000	14,841,000	1914
1915	9,997,000	1,530,000	4,200,000	15,727,000	1915
1916	10,475,000	1,619,000	4,300,000	16,394,000	1916
1917	11,191,000	1,709,000	4,400,000	17,300,000	1917
1918	11,663,000	1,801,000	4,500,000	17,964,000	1918
1919	12,025,000	1,888,000	4,625,000	18,538,000	1919
1920	12,617,000	2,079,000	4,950,000	19,646,000	1920

January 1	United States	North America	Middle America	South America	Europe	Africa	Asia	Oceania (Incl. Hawaii)	World	January 1
1921	13,273,000	14,141,300	104,000	287,100	5,288,100	103,500	541,000	335,000	20,800,000	1921
1922	13,817,000	14,738,500	104,300	306,300	5,619,500	116,400	655,300	359,700	21,900,000	1922
1923	14,294,000	15,238,700	131,500	327,000	5,906,100	127,900	776,200	392,600	22,900,000	1923
1924	15,316,000	16,325,600	145,500	346,600	6,352,200	138,400	761,500	430,200	24,500,000	1924
1925	16,015,000	17,088,300	154,200	373,200	6,896,700	151,800	856,900	478,900	26,000,000	1925
1926	16,875,000	18,020,000	170,300	403,300	7,462,700	168,100	943,600	532,000	27,700,000	1926
1927	17,680,000	18,883,700	180,900	428,200	8,055,700	184,500	985,700	581,300	29,300,000	1927
1928	18,446,000	19,707,900	194,500	463,800	8,624,900	198,400	1,081,400	629,100	30,900,000	1928
1929	19,256,000	20,593,200	215,800	502,000	9,218,700	212,000	1,188,900	669,400	32,600,000	1929
1930	19,970,000	21,355,200	241,900	587,100	10,032,600	224,500	1,263,600	695,100	34,400,000	1930
1931	20,103,000	21,508,000	229,100	619,800	10,592,400	231,500	1,317,200	702,000	35,200,000	1931
1932	19,602,000	20,969,100	218,300	637,500	10,921,900	238,000	1,333,000	682,200	35,000,000	1932
1933	17,341,000	18,605,300	211,300	645,200	11,124,700	244,500	1,397,900	671,100	32,900,000	1933
1934	16,628,000	17,822,700	201,500	651,900	11,316,900	258,000	1,473,100	675,900	32,400,000	1934
1935	16,869,000	18,068,900	206,700	685,500	12,002,900	276,000	1,557,400	702,600	33,500,000	1935
1936	17,424,000	18,635,600	226,600	708,400	12,734,500	298,300	1,654,200	742,400	35,000,000	1936
1937	18,433,000	19,702,500	249,900	765,400	13,522,700	331,600	1,741,400	786,500	37,100,000	1937
1938	19,453,000	20,779,100	270,900	835,400	14,221,000	368,200	1,866,600	858,800	39,200,000	1938
1939	19,953,000	21,316,500	281,500	907,000	15,131,500	400,300	1,956,600	906,600	40,900,000	1939
1940	20,831,000	22,233,700	307,000	971,100	15,479,200	420,000	2,037,800	951,200	42,400,000	1940
1941	21,928,000	23,395,400	319,800	1,035,000	15,271,400	439,500	2,043,400	995,500	43,500,000	1941
1942	23,521,000	25,089,900	331,300	1,136,200	15,146,500	457,300	2,010,100	1,028,700	45,200,000	1942
1943	24,919,000	26,554,500	343,000	1,172,700	15,021,500	464,400	1,978,500	1,065,400	46,600,000	1943
1944	26,381,000	28,081,300	356,700	1,222,200	15,303,700	466,700	1,952,000	1,117,400	48,500,000	1944
1945	26,859,000	28,620,200	376,100	1,256,900	14,162,100	472,500	1,956,500	1,155,700	48,000,000	1945
1946	27,867,000	29,725,400	393,200	1,307,400	14,756,400	512,400	1,607,400	1,197,800	49,500,000	1946
1947	31,611,000	33,648,500	411,100	1,383,300	16,332,500	618,700	1,657,400	1,248,500	55,300,000	1947
1948	34,867,000	37,109,400	454,500	1,489,000	17,837,000	660,000	1,927,400	1,322,700	60,800,000	1948
1949	38,205,000	40,670,100	494,400	1,574,000	19,069,500	735,000	2,125,000	1,432,000	66,100,000	1949
1950	40,709,000	43,423,700	523,900	1,657,000	20,299,000	805,600	2,468,400	1,522,400	70,700,000	1950
1951	43,004,000	45,939,000	555,000	1,815,000	21,574,000	895,200	2,875,800	1,646,000	75,300,000	1951
1952	45,636,000	48,770,000	593,700	1,931,000	22,811,000	986,000	3,121,300	1,787,000	80,000,000	1952
1953	48,056,000	51,430,800	627,400	2,094,800	24,324,000	1,084,300	3,428,700	1,910,000	84,900,000	1953
1954	50,373,000	54,003,100	670,000	2,245,500	25,979,000	1,181,200	3,881,400	2,039,800	90,000,000	1954
1955	52,806,000	56,691,700	700,300	2,422,900	27,787,000	1,247,400	4,261,200	2,189,500	95,300,000	1955
1956	56,243,000	60,422,900	733,100	2,568,300	29,990,000	1,411,200	4,708,800	2,365,700	102,200,000	1956
1957	60,190,000	64,720,700	772,800	2,695,300	32,510,000	1,546,100	5,229,500	2,525,600	110,000,000	1957
1958	63,624,000	68,484,000	835,900	2,845,000	35,218,700	1,663,200	6,062,500	2,690,700	117,800,000	1958
1959	66,645,000	71,799,300	910,800	2,999,600	37,598,100	1,768,600	6,855,700	2,867,900	124,800,000	1959
1960	70,821,000 [1]	76,036,400	1,008,000	3,145,900	40,340,900	1,904,500	8,110,000	3,054,300	133,600,000	1960
1961	74,342,000 [1]	79,830,600	1,075,900	3,337,600	43,172,700	2,005,300	9,053,400	3,224,500	141,700,000	1961
1962	77,422,000 [1]	83,186,400	1,167,300	3,475,500	46,377,000	2,081,800	10,303,300	3,408,700	150,000,000	1962
1963	80,969,000 [1]	87,029,400	1,275,800	3,732,600	49,734,800	2,155,100	11,677,200	3,595,100	159,200,000	1963

[1]) Includes Alaska and Hawaii.

istrative Council of the I.T.U. asked the C.C.I.F. to transfer its secretariat and its laboratory to Geneva, the seat of the Union. In the new Headquarters Building of the Union, the laboratory has excellent facilities for its testing and research work.

The first few years of the work of the C.C.I.F. were particularly fruitful. It was the period when many European Telephone Administrations were changing over from overhead lines to underground cables; so for example in 1925 a cable was laid between Basel and Frankfurt-am-Main, and in the next year a similar cable joined Paris with Basel. Without the work of the Committee, the standardising of terminal equipment, of cable performance, and of administrative matters like tariffs, these new international links would have taken much longer to establish, and would not have been so efficient. The public using the telephone soon noticed their superiority.

A similar consultative committee for the telegraph service was set up in Paris in 1925; it was called the *Comité Consultatif International des communications télégraphiques* (C.C.I.T.)[1]. It had very similar terms of reference, to study technical and operational questions of interest to long-distance telegraphy. But unlike the C.C.I.F. it had no separate secretariat but worked through the International Bureau at Berne. Nor did it set up any special laboratory of its own. It held a number of meetings of its Plenary Assemblies, and like the C.C.I.F. it worked through Study Groups, originally called "Committees of Reporters".

These groups of experts were assigned specific technical questions by the Plenary Assemblies, they corresponded, and they met to find a solution; they reported back, and if their recommendations were accepted by the Plenary Assemblies they were then published as recommendations to the Member Administrations. Although this chain of command might appear lengthy and cumbersome, it did ensure that subject experts had agreed on an internationally acceptable solution.

It was perhaps not surprising that in view of the basic similarity of many of the technical problems, proposals were made, from the Atlantic City Conference in 1947 onwards, to merge these two committees. A decision to this effect was taken at the Administrative Council of 1955, and from the end of 1956, the two Committees became the single International Telegraph and Telephone Consultative Committee, the *Comité Consultatif International Télégraphique et Téléphonique*, the C.C.I.T.T. as it is known for short. Their

[1] See page 215.

255 *A Telex installation featuring on automatic transmitter and teleprinter with perforating attachment.*

256 *A modern touch-tone dial Teletypewriter, as used currently in the United States of America.*

specialised secretariats were combined into one, but their basic working methods were left unchanged, with Study Groups reporting to the Plenary Assembly.

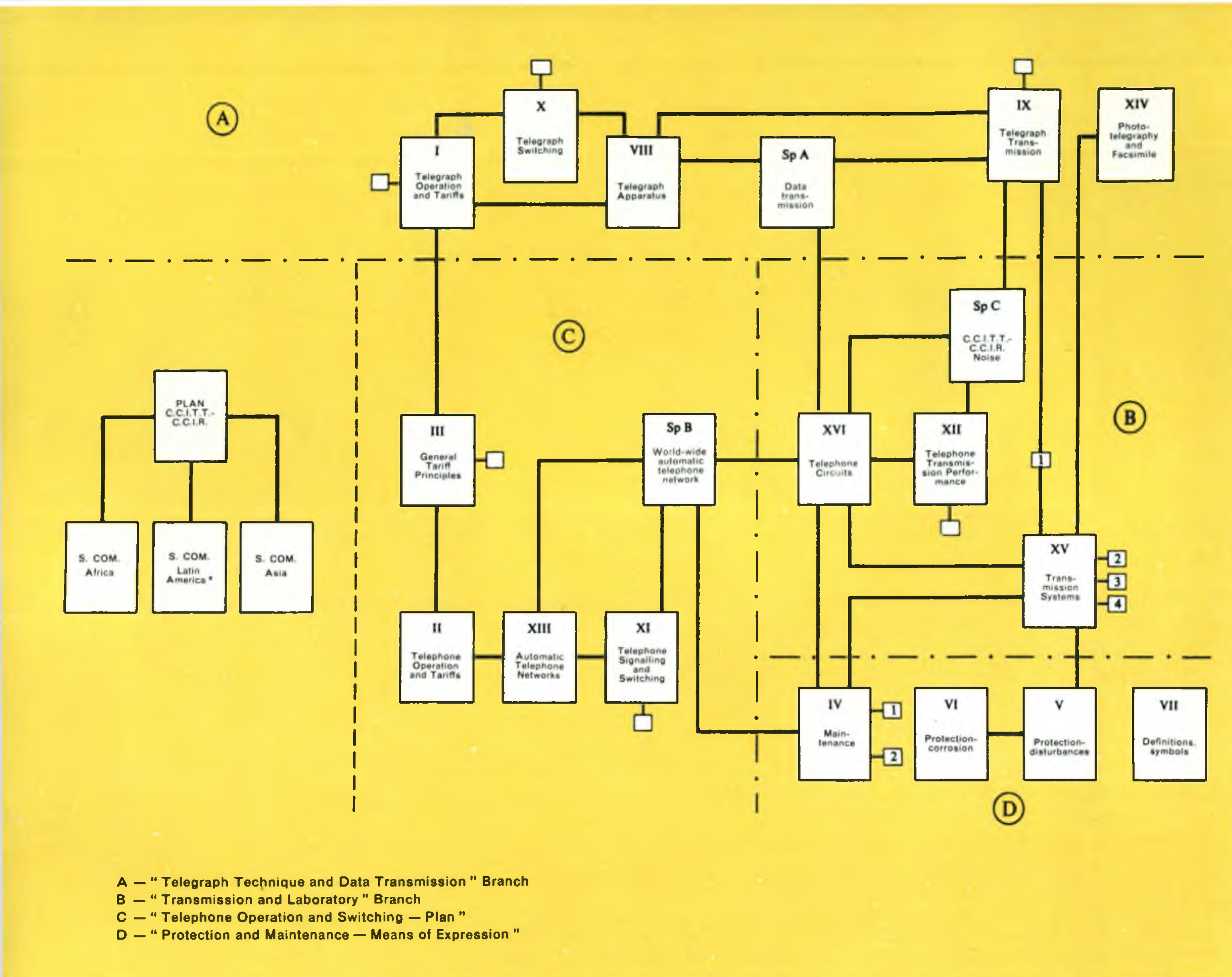
At the first Plenary Assembly of the C.C.I.T.T., December, 1956, the Telegraph Committee passed on the following chief questions to its successor:

Continuation of study of telegraph distortion.
Practical application of the concept of rate of error.
Standardisation of voice-frequency telegraph equipment.
Standardisation of equipment for direct-recording facsimile telegraphy.
Standardisation of telex networks for fully automatic switching.
European answer-back and numbering plan.
Revision of the Telegraph Regulations.
Establishment of a new telegraph alphabet.

For its part, the Telephone Committee passed on to the C.C.I.T.T. 109 old and new questions, amongst which were:

Study of the characteristics of international telephone circuits.
Determination of performance impairment due to circuit noise.
Permissible limits of high-level noise of short duration.
Extension of recommendations on long-distance television signal transmission.
Transmission of accounting data.
New system of international accounts.
Detailed operating and tariff procedure in the fully automatic international telephone service.
Preparation of List of definitions and telecommunications vocabulary.

The new International Telegraph and Telephone Consultative Committee could certainly not complain of lack of work when it started in 1957. The merger of the two Committees was a perfectly logical and sensible step to take and it was also natural to pass on many of the unsolved questions. For a long time, telephony and telegraphy had developed separately. They had had their own lines, their own technical centres, and their own methods of charging for their services, the one by length of time, the other by


A
B
C
D
I
Telegraph Operation and Tariffs
X
Telegraph Switching
VIII
Telegraph Apparatus
Sp A
Data trans-mission
IX
Telegraph Trans-mission
XIV
Photo-telegraphy and Facsimile
Sp C
C.C.I.T.T.- C.C.I.R. Noise
PLAN C.C.I.T.T.- C.C.I.R.
S. COM. Africa
S. COM. Latin America *
S. COM. Asia
III
General Tariff Principles
Sp B
World-wide automatic telephone network
XVI
Telephone Circuits
XII
Telephone Transmission Performance
XV
Trans-mission Systems
II
Telephone Operation and Tariffs
XIII
Automatic Telephone Networks
XI
Telephone Signalling and Switching
IV
Main-tenance
VI
Protection-corrosion
V
Protection-disturbances
VII
Definitions, symbols
1
2
3
4
A — " Telegraph Technique and Data Transmission " Branch
B — " Transmission and Laboratory " Branch
C — " Telephone Operation and Switching — Plan "
D — " Protection and Maintenance — Means of Expression "

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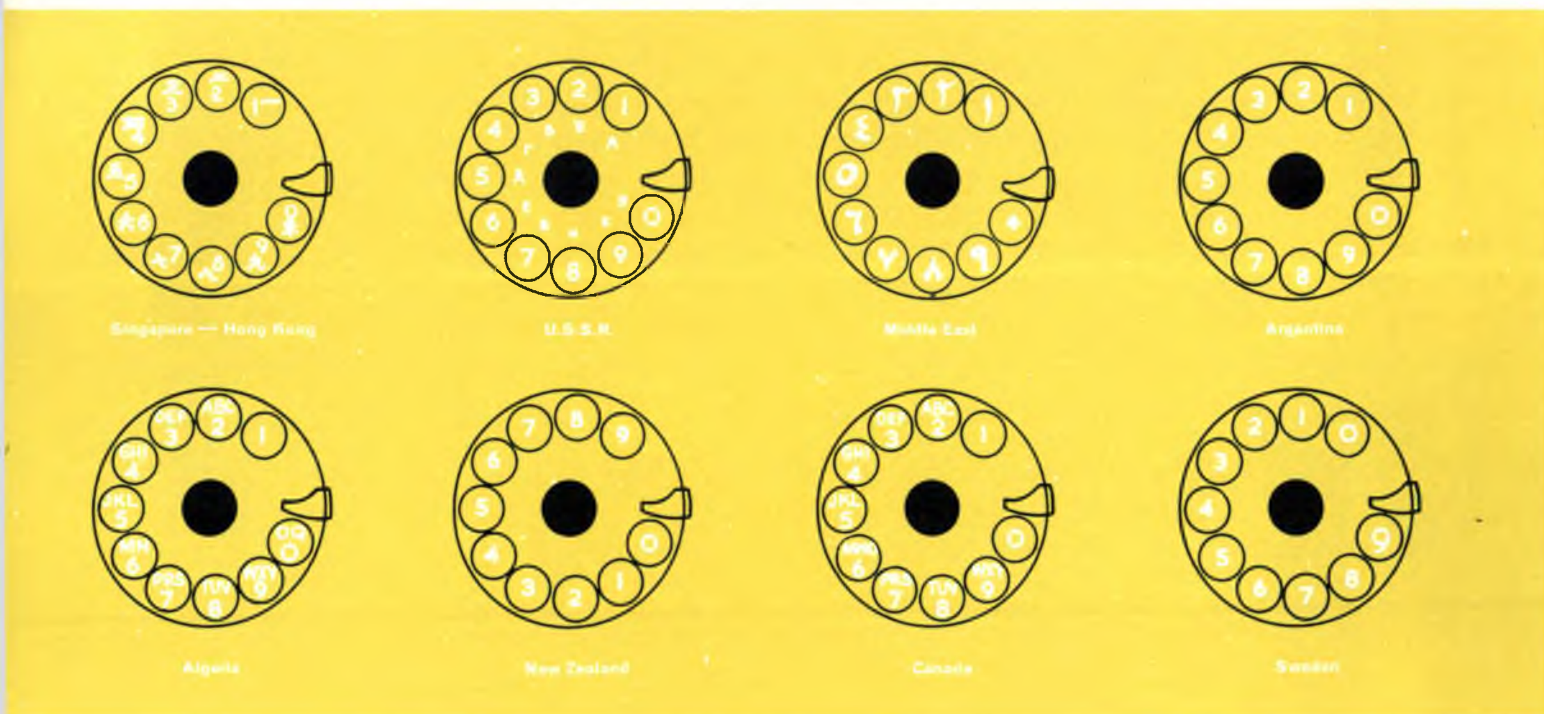

Singapore — Hong Kong
U.S.S.R.
Middle East
Argentina
Algeria
New Zealand
Canada
Sweden

258

259

260

257 *Organisation of the C.C.I.T.T. Study Groups.*

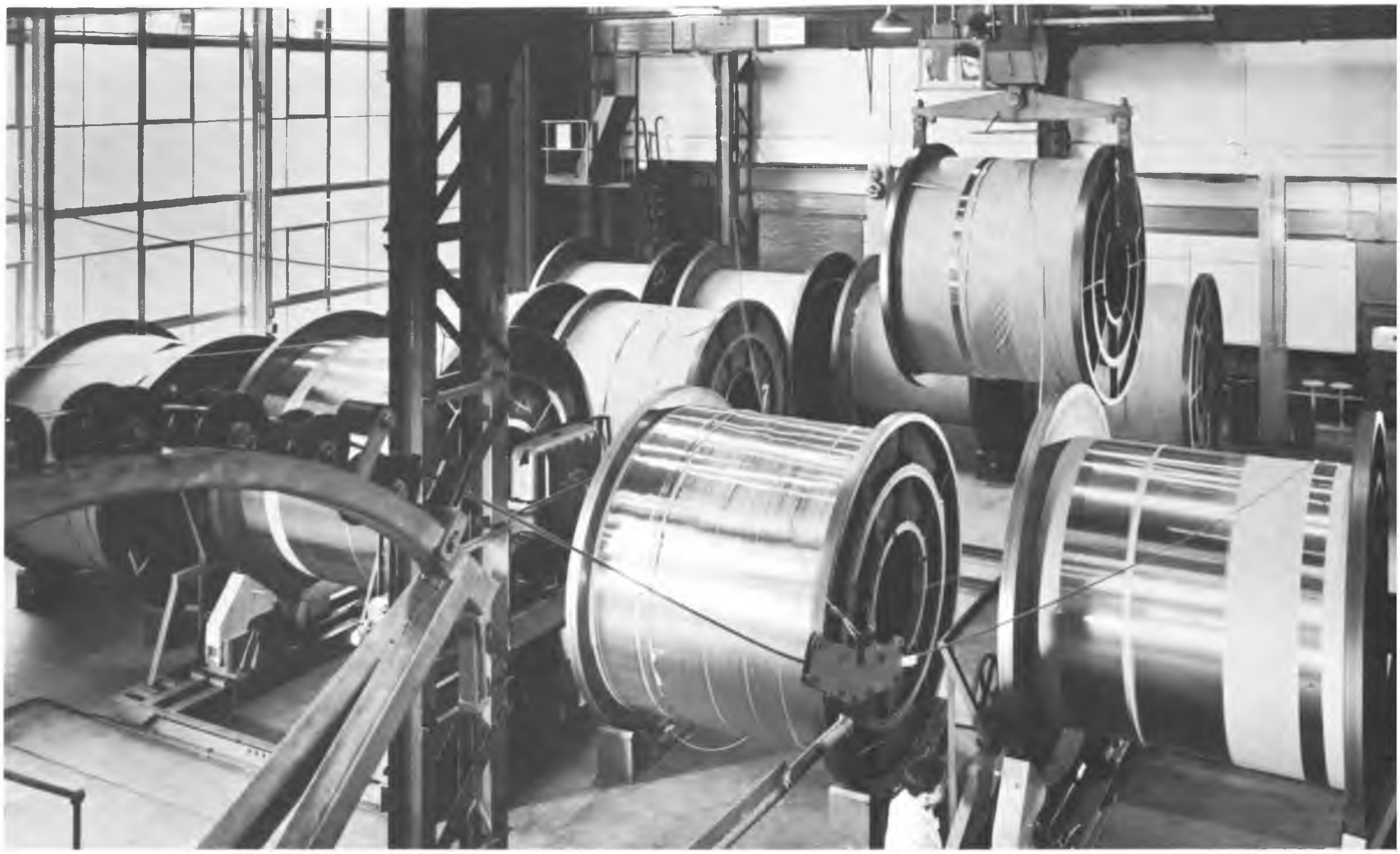
258 *To-day a number of different telephone dials exist in the world, of which a few examples are here reproduced. It is one of the tasks of the C.C.I.T.T. to bring about their standardisation in the future.*

259-260 *The great increase in telephone traffic in Syria (for example, 3000 subscribers in 1946, 15,000 in 1950, 58,000 in 1960 and 73,000 in 1963) has demanded the laying of new cables both in the cities and between them.*
Above, a cable being laid in open country.
Below, a cable being laid in a Syrian city.

261 *Manufacture of a modern submarine cable is carried out in this long hall beginning far back on the left and finishing, at least with the inner core of it, on the right. Forty-one high tensile steel wires are stranded together (background) and the copper tape seam-welded around them (foreground) to form the cable's inner conductor and strength member. Processing is entirely automatic and carried out in 20 nautical mile lengths without a break.*

262 *The inner conductor of a modern light-weight submarine cable is stored ready for the application of the polyethylene plastic around its outside.*

261



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263 *A comparison of present undersea cable (left) with the new armourless cable, as used by American and British telecommunications services, shows that they are alike in over-all size. A more efficient use of space in the new cable enabled engineers to increase the size of the insulator and thus decrease transmission losses. The older cable consists of the centre copper conductor, a polyethylene insulator, a helix of six copper return tapes, a helix of copper tape to prevent damage by teredos, a cotton binder coated with rubber, two layers of jute bedding, steel " armour " and an outer layer of jute impregnated with coal tar. The simpler armourless cable contains an inner steel spine, the inner copper conductor, the polyethylene insulator, the outer copper conductor and a protective layer of black polyethylene.*

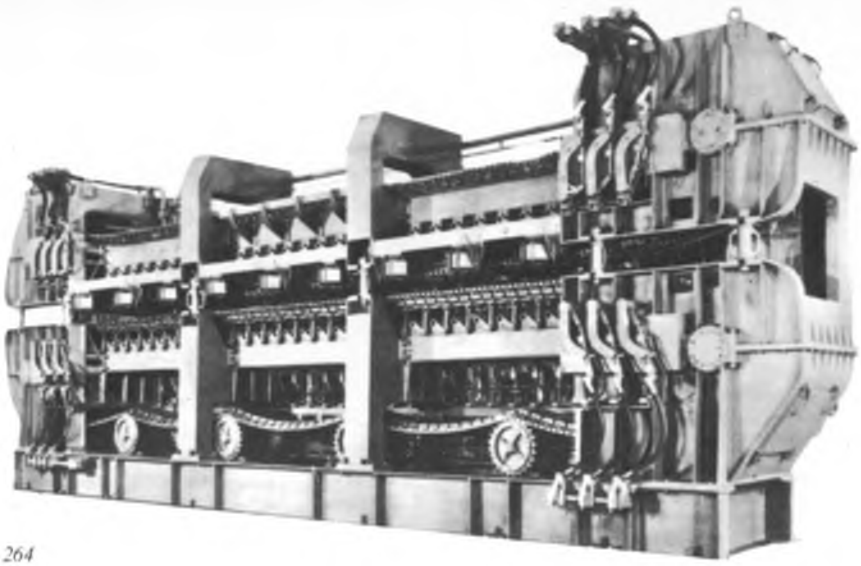
number of words. But they had tended to grow together, using similar and often the same engineering techniques.

By the middle of the present century, they were often employing the same transmission channels, overhead wires, underground cables, underwater cables and radio circuits. The rise of telex, the subscribers teleprinting service, gave to its users in increasing numbers the international automatic selection which was so much enjoyed by telephone users. An outstanding example of this community of technical means was the laying of the first trans-atlantic telephone cable with submerged repeaters in 1956; it linked Oban in Scotland with Clarenville, Newfoundland on 25 September. Its co-axial cable with its 36 telephone circuits can be used either partially or wholly for the transmission of telegraphy, when it is equivalent to 864 telegraphy circuits.

These then were the tasks, the philosophy and the state of scientific development which gave the background to the work of the newly established International Consultative Committee on Telephony and Telegraphy, the C.C.I.T.T. Two outstanding scientific developments have overshadowed all its work, the extensive growth of transocean telephone cables and the ever increasing use of electronic computers. The success of the first telephone cable, used to full capacity only a month or so after its inauguration, led in the succeeding years to the laying of others and thus for the first time in history made it possible to envisage the introduction of semi-automatic, if not fully automatic, operation of telephones on a truly world-wide scale.

This entirely new, extremely complex and vast problem concerns all branches of line telecommunications and has been intensively investigated by the Study Groups of the C.C.I.T.T. dealing with operation, signalling, switching, transmission and maintenance. It has involved the preparation of a world-wide routing plan as well as plans for world-wide numbering of telephone or telex subscribers. Before they can come into successful operation, many new technical standards will have to be adopted which are completely different from the present ones.

The increased use of electronic computers has led another Study Group to work out plans for their remote control and for the exchange of data between them. The requirements for this are the existence of a very high speed telegraphy system with a very great degree of protection against error. This second



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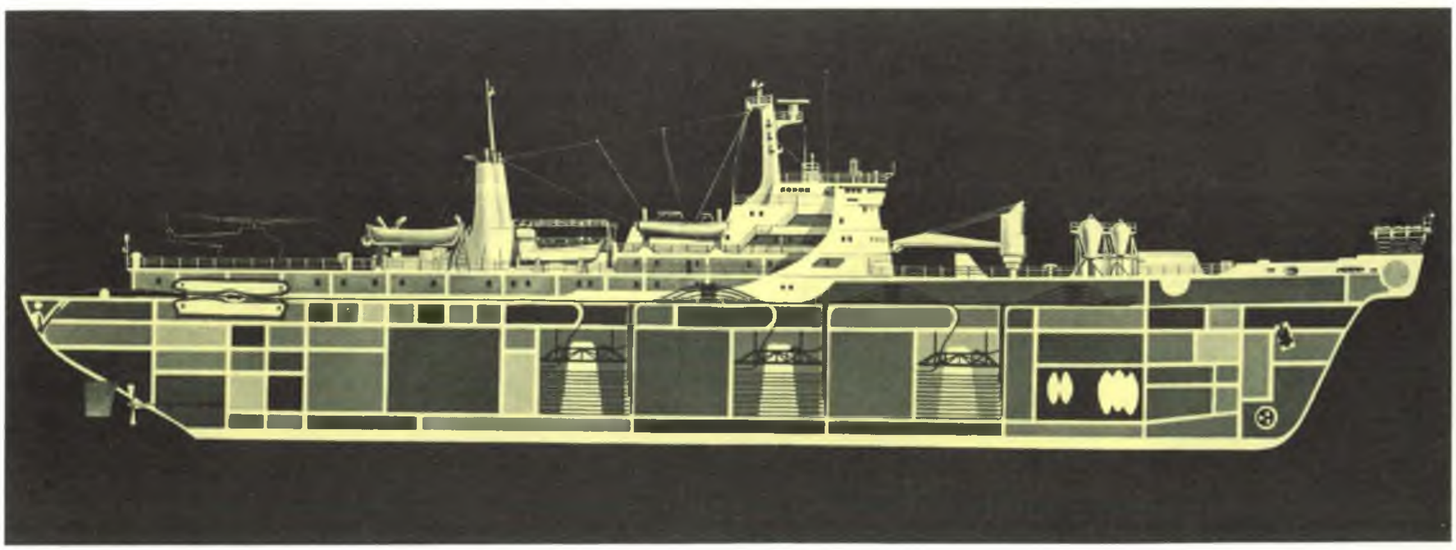
264 *The " linear cable engine" on the Cable Ship* Long Lines *performs in 1965 a similar function to the paying out machinery on the* Great Eastern *a hundred years earlier (See figure 35). The cable, as it passes from the hold is tightly gripped between two treads of a caterpillar tractor, so as to pull it out of the tank when laying the cable in shallow water or to brake it when it is laid in deep water. The bulky repeater can pass through this engine without damage.*

265 *Cross-section through Cable Ship* Long Lines *(See figure 36), one of the most modern specially-designed cable ships. The ship can lay 1800 nautical miles of deep-sea cable. She sails under the United States flag.*

vast and most complex problem is of equally great interest to the Administrations of I.T.U. Member countries, the private operating companies, and to the manufacturers of the computers.

Apart from these two major, forward-looking problems, the Study Groups of the C.C.I.T.T., working by meetings and international correspondence, have dealt with many of the questions they inherited from their predecessors, and also many new ones. To mention here only a few. Very long-distance telephone calls, of the order of 24,000 km, are now becoming available, and demand the same speech quality as shorter ones; international co-operation has been essential to achieve this. Much thought has been given to using transistor amplifiers with small diameter co-axial cables, and to the study of admissible noise limits for telephony and telegraphy particularly over radio-relay links. The foundations have now been laid for a world-wide automatic telex plan through standardisation of message retransmission and switching systems and through synchronous telegraphy systems.

A landmark in the history of the C.C.I.T.T. was reached when it held its second Plenary Assembly in New Delhi in 1960; it was its first meeting outside Europe and thus symbolised the truly world-wide character of its working. During the next year, when the effects of the 1959 Geneva Convention came into force, all the Members of the I.T.U. were brought into the work of the C.C.I.T.T. without any extra payments. The Committee's membership rose from 58 in 1960 to 114 Member countries; at the end of 1963 there were 4500 registered members of the C.C.I.T.T. Study Groups. In the Centenary Year of the Union, they could proudly look back on many solid achievements in telephony and telegraphy.



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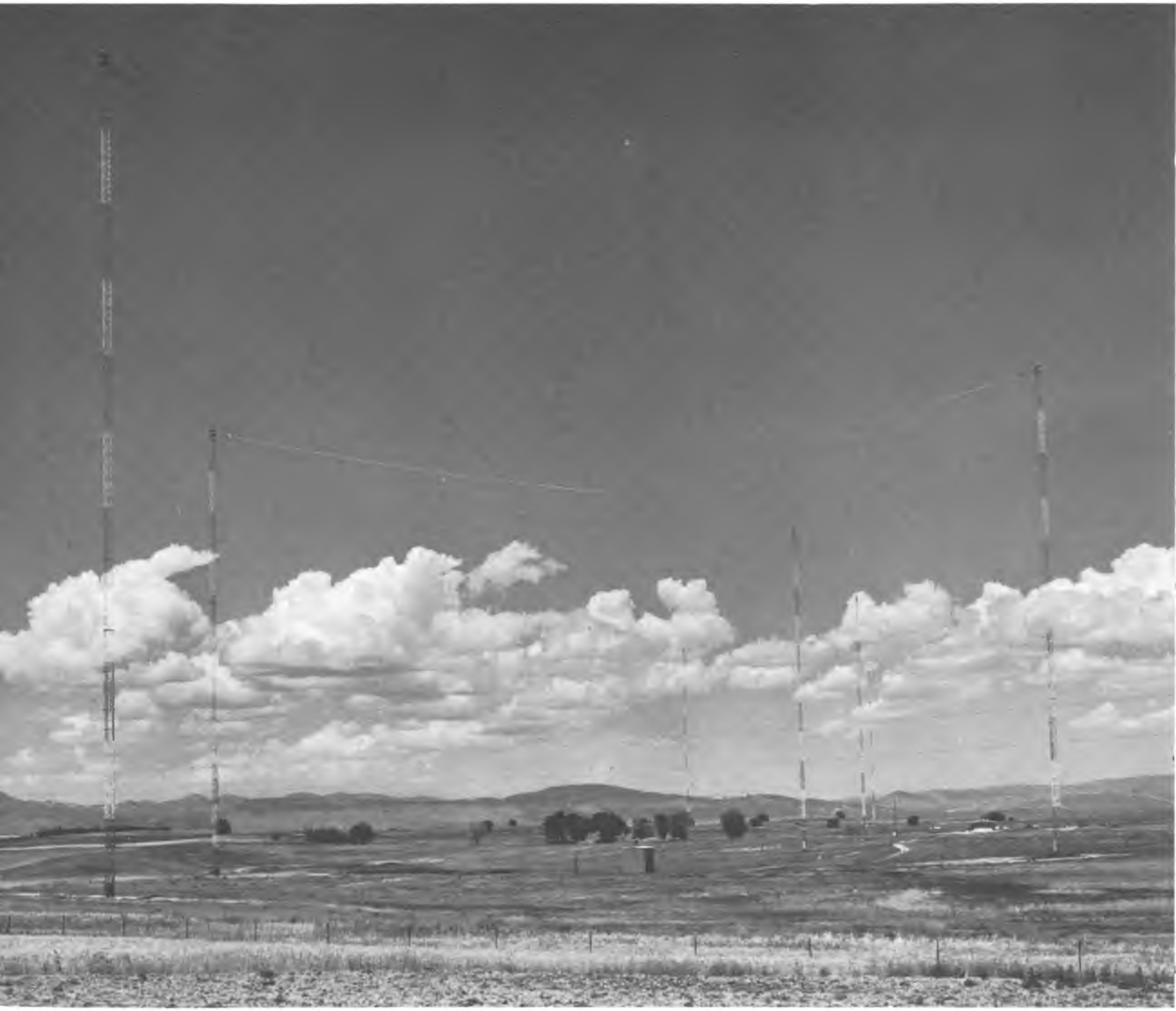


266 *Boulder, Colorado, looking northwest at the new Fort Collins standard radio transmitting site of the Boulder Laboratories, National Bureau of Standards. In the centre just below the cluster of trees is the helix house for station WWVB (60 kc/s). To the right of the trees is the helix house for station WWVL and somewhat to the right of that is the transmitter building. Seven of the 130 m, guyed, steel antenna towers may be seen. The principal purpose of WWVB (a low-frequency 60 kc/s station) and WWVL (a very-low-frequency 20 kc/s station) is to give the radio users an opportunity to obtain quicker and more accurate standard frequency and time signals than had been obtainable before.*

266

The International Radio Consultative Committee (C.C.I.R.)

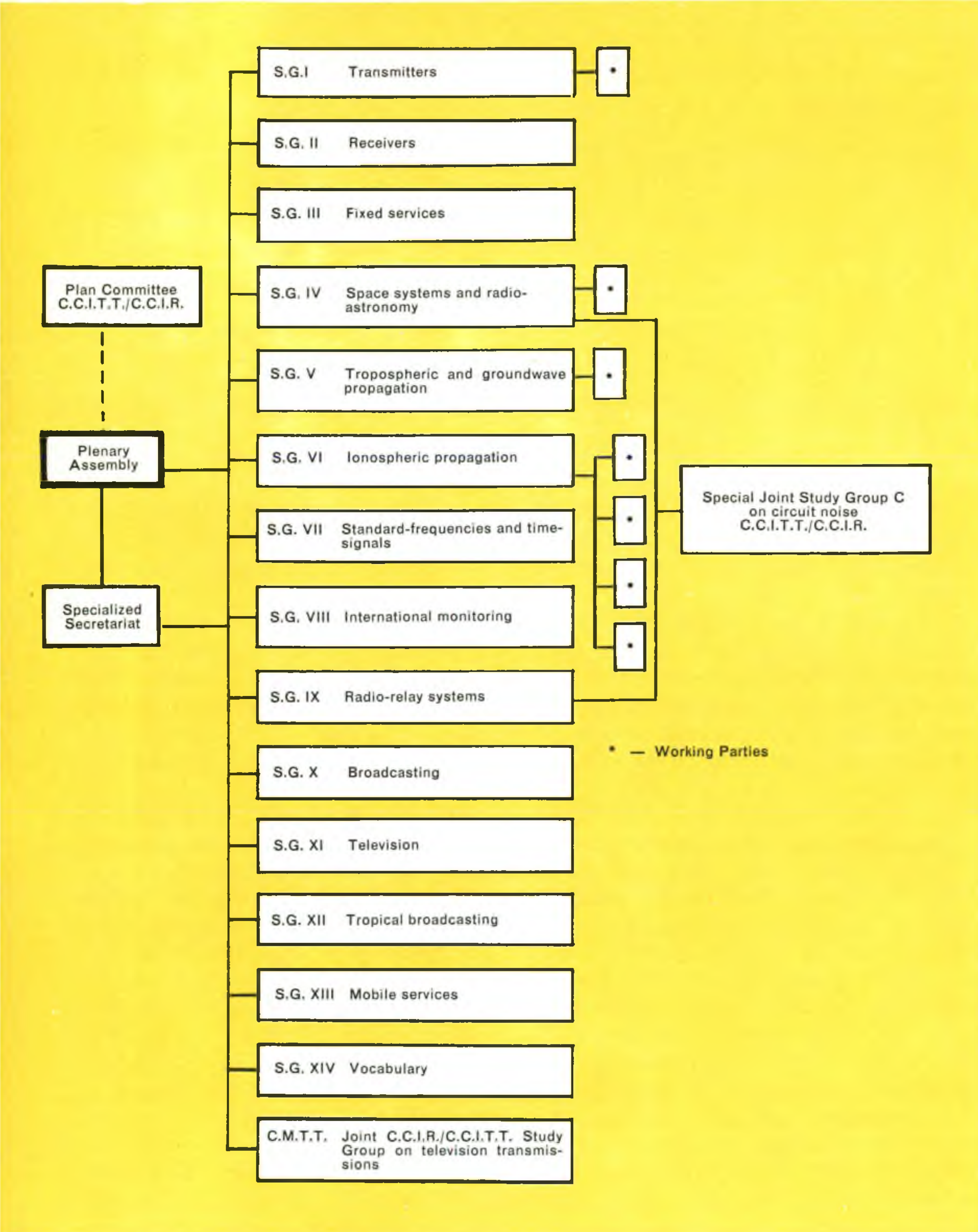
If the need for constant technical discussion in telephony and telegraphy led to the establishment of a consultative committee, one might suppose that a similar step would have been taken equally easily in the field of radio. But this was not the case. Although the idea for such a radio committee went back to 1920, it was not until the Washington Conference of 1927 that one was set up and even then there was much opposition to its establishment.

The United States delegation feared that a committee might retard the progress of radio by establishing too rigid principles, an argument that has been heard throughout the hundred years of existence of the Union. France was afraid that any official approval given by the committee might lead to commercial advantages for private operating companies, and Marconi's attempt to obtain a world-wide radio monopoly at the beginning of the present century might still have been in the minds of the French delegation. Britain objected to the proposal because no committee could make any alteration to the Radio Regulations between administrative conferences, and hence it would be useless.

These arguments appear extremely narrow-minded to-day. Less than four decades later, the committee made the arrangements for international radiocommunications in space and for the allocation of exclusive frequencies for research in radio-astronomy. But then in 1927 satellites were science fiction, and it was only in 1931 that Karl Jansky, an engineer working for the Bell Telephone Laboratories, was the first to study radio signals from space and thus laid the foundation for radio-astronomy. The great historical lesson here is tolerance and foresight, and a deep appreciation of the fact that small scientific beginnings may be of vast technological importance in a very short time.

The supporters of the plan to establish a Radio Consultative Committee, the delegations of Germany and Italy, finally won the day, at Washington in 1927, but by a very small majority; thirty voted for it, twenty-six against, with eleven abstentions and thirteen absentees. Once established, the Committee has certainly proved its usefulness, and since 1927 it has held ten Plenary Assemblies, in The Hague in 1929, in Copenhagen in 1931, in Estoril (Lisbon) in 1934, in Bucharest in 1937, in Stockholm in 1948, in Geneva in 1951, in London in 1953, in Warsaw in 1956, in Los Angeles in 1959 and in Geneva again in 1963.

Its duties are to-day well defined. The International Radio Consultative Committee, the *Comité Consultatif International technique des communications radioélectriques*, or the C.C.I.R. as it is generally known, shall "study technical and operating questions relating specifically to radiocommunications and



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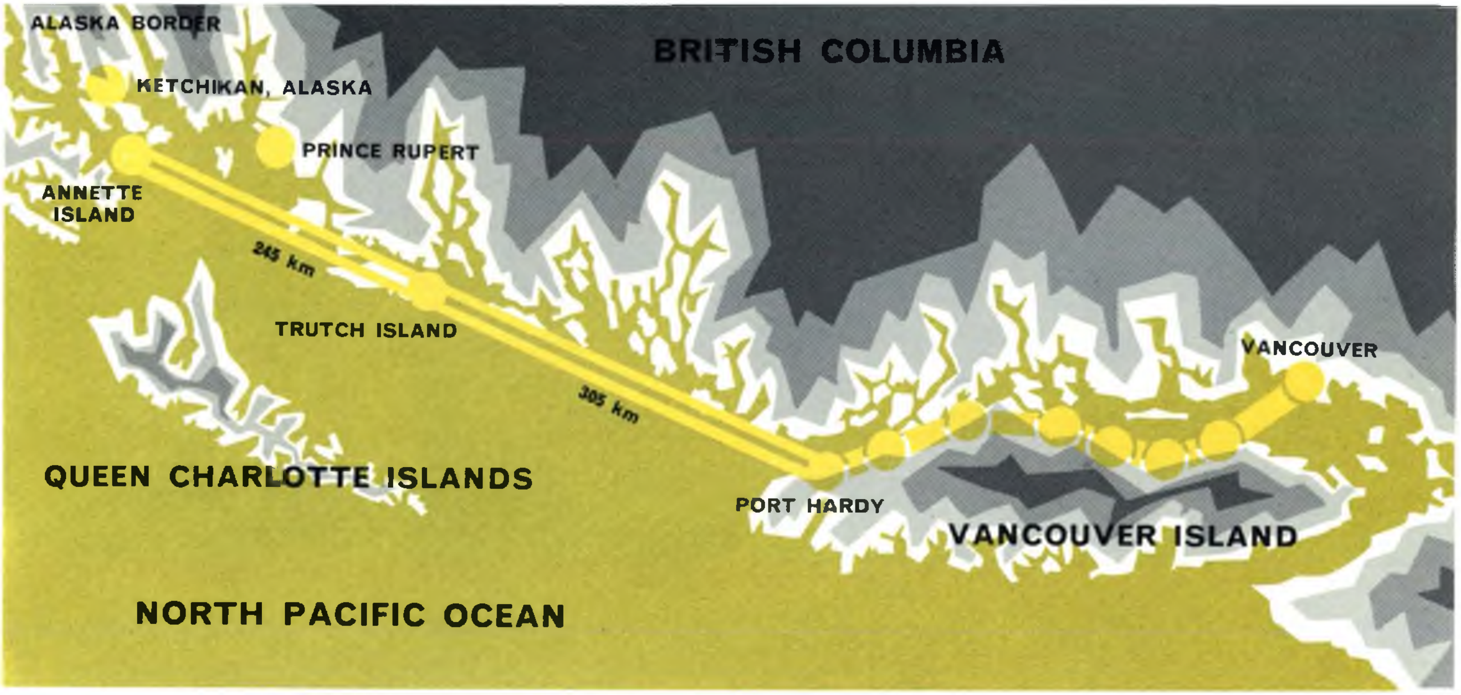
267 *Organisation of the C.C.I.R. Study Groups.*

issue recommendations on them ". The Committee " shall pay due attention to the study of questions directly connected with the establishment, development and improvement of telecommunications in new and developing countries, in both the regional and international fields". The Radio Committee, like the Telegraph and Telephone Committee, shall work, as laid down in the I.T.U. Convention, through the medium of its Plenary Assembly, through Study Groups, its Director elected by the Plenary Assembly, and its Specialised Secretariat.

Part II of the General Regulations, annexed to the I.T.U. Convention, specifies in detail how the C.C.I.R. and the C.C.I.T.T. are to work. Membership of the Committees is by right open to all Members of the Union; the duties of the Plenary Assembly are to consider the reports of the Study Groups, to decide on new questions to be posed and to allocate them to specific Study Groups, and to consider and approve the report of the Director. Meetings of the Plenary Assemblies are to take place every three years, and the working languages of the Union must be used for the publication of all documents of the Committee. The duties of the Director and of the Specialised Secretariat are defined, and finally the C.C.I.R. " may make proposals for the modification of the Regulations " and these " shall be sent to the Secretary-General in good time ".

At present there are 14 C.C.I.R. Study Groups, having as their subjects the following fields of radio-communications: Transmitters, Receivers, Fixed Services, Space Systems and Radio-astronomy, Tropospheric and groundwave propagation, Ionospheric propagation, Standard frequencies and Time-signals, International Monitoring, Radio-relay systems, Broadcasting, Television, Tropical broadcasting, Mobile Services, and finally Vocabulary. In addition there are two joint study groups on television transmissions, administered by the C.C.I.R., and on circuit noise administered by the C.C.I.T.T. Furthermore, there is the joint C.C.I.T.T. and C.C.I.R. "Plan" Committee, with its Committees for Africa, Latin America and Asia; the Plan Committee aims at providing the information and co-operation necessary for establishing a telegraph-telephone-radio network that will link together the whole world.

It is of course not possible here to review all the many technical questions which the C.C.I.R. has studied during its 38 years of existence, when, in 1965, the Centenary of the Union was celebrated. Perhaps basic to all its work is the propagation of radio waves; this large subject had to be divided into three groups, waves following the surface of the earth, the ground-waves, waves clear of the surface but



controlled by the lower atmosphere where all the meteorological phenomena are manifest, tropospheric propagation, and finally waves beyond the troposphere. This region, the ionosphere, is roughly defined as 100 to 300 km above the surface of the earth. Although the basic theory of wave propagation goes back to Oliver Heaviside and to Sir Edward Appleton in the 1920's and 1930's, modern practical radio problems have demanded a constant review of the subject.

A second equally basic problem for efficient radiotelecommunications is the investigation of radio noise. This unwanted natural background " crackling " is partly due to atmospheric thunderstorms, and, in collaboration with the World Meteorological Organization, the C.C.I.R. has studied for many years the occurrence of thunderstorms, particularly with reference to tropical broadcasting which is most affected by them; diurnal and seasonal variations have also been carefully analysed.

A further source of radio noise is the Sun, and is closely linked with the occurrence and frequency of sunspots. The overriding importance of sunspots is based on their effect on the atmosphere of the earth. Electrifying it, long-distance radiocommunications are possible, by reflection from the ionosphere. For many years the C.C.I.R. published monthly predictions of sunspot numbers in the *Telecommunication Journal*, the official journal of the I.T.U., thus giving radio operators a useful advance warning of maximum sunspot activity. It will be recalled that such a period of maximum activity was chosen for the International Geophysical Year of 1957-1958; many of the simultaneous world-wide measurements then carried out were concerned with radio phenomena, and close collaboration occurred between C.C.I.R. and the International Scientific Radio Union, U.R.S.I. This has continued fruitfully ever since.

Another basic research project in which the C.C.I.R. has taken an active part is concerned with the theory of communications, or information theory, as it is often called; it is of course equally applicable to telephony or telegraphy. Its essence is that information contained in messages, transmitted by telecommunications, is measurable and can be treated mathematically. So for example, loss of information, by radio noise, can be evaluated. The basic unit of measurement is called a " bit ", short for binary digit,

268-269 *A tropospheric scatter link across British Columbia was inaugurated in 1963 giving a high-capacity voice and data link between the coastal regions of Alaska, British Columbia and the telephone circuits of the United States. It is 550 km long and provides 240 channels for voice communication and data transmission.*

270

and is represented by a " yes-or-no " choice. For communication purposes all information can be expressed as, or encoded into, sequences of on-or-off, i.e., binary pulses. Transmission factors, such as bandwidth, noise, distortion and the relations between them, can therefore be expressed in quantitative terms.

Information theory was at first mainly applied to questions of bandwidth and frequency spectra, calculating how more information could be sent through a given system of telecommunication. In recent years the time aspect of the theory has come to the fore, laying the theoretical basis for pulse modulation, pulse-code modulation and time-division multiplex, all techniques of sending different messages over the same system, separated not into frequency bands, but rather by interleaving them in time. For many years the C.C.I.R. took a leading part in bringing this theory to the notice of the practical engineers of its Member countries by publishing extensive bibliographies on the subject; so for example a fifth supplement to these, a volume of over 100 pages, was published in October 1960.

But the C.C.I.R. has not only concerned itself with basic theoretical aspects of radiocommunications. Many practical problems have been investigated by its Study Groups, as for example telegraphic distortion, spurious emissions, frequency stabilisation of both transmitters and receivers, bandwidths and speed of transmission. Other practical problems studied were the specifications for automatic alarm signals on the maritime radiotelephone distress frequency aboard small ships, and for radio direction and position finding systems both for ships and for aircraft. Radio-relay systems for transmission of television signals, and for telephony, have occupied much time of the C.C.I.R. Study Groups. It is sincerely hoped that the lack of international standards for black-and-white television will not be repeated when colour television is transmitted over international links. Since 1960, the C.C.I.R. has given much thought to the design of a low-cost sound broadcasting receiver for the new or developing countries, a problem referred to the I.T.U. by U.N.E.S.C.O.

To turn finally to the latest Study Group, dealing with Space Systems and Radio-astronomy; it was established in 1959. Its work, first through correspondence, and then at Meetings in Washington in 1962 and in Geneva in 1963, has increased greatly. Its documents including recommendations, reports, questions and study programmes cover 220 printed pages in Volume IV of the Proceedings of the Xth Plenary Assembly held in Geneva in 1963. Broadly speaking the subject was divided into communication satel-

270 Modern continuity suite for sound broadcasting at Broadcasting House, London.

271 The new Western Union transcontinental microwave beam system includes a number of stations such as the one above. This type of repeater station, with the beam antennae mounted directly on the roof, is usually found at high elevations such as this office building in Cleveland, Ohio.

272

272 *Presentation TV Studio Control Room in 1960.*

273 *" Maison de la Radiodiffusion Télévision Française ". From a medal struck by the Paris Mint and issued on the occasion of the opening of this centre.*

274 *A general view of the B.B.C. Television Centre, 1961.*

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lites, both of the active and the reflecting type, direct broadcasting from satellites, radionavigation by satellites, meteorological satellites, space research, radio-astronomy and radar astronomy.

To take again only a single example, that of the important hydrogen line in radio-astronomy. It has now been known for some time that in neutral hydrogen gas the atom can be pictured as an electron spinning in a circular orbit around the proton. The energy of the atom depends on the direction of the spin of the electron, and it has been calculated that on the average once in 11 million years an electron reverses the direction of its spin. Such a reversal of direction of spin results in the emission of radiation on a wave-length of 21 cm, or, more precisely, at a frequency of 1420.40 Mc/s.

Although the event is so exceedingly rare, such vast numbers of atoms are involved in the gas clouds of the Milky Way that the emission of radiation may be measured by radio-telescopes on earth. As this emission is subject to the Doppler effect, small variations in the frequency give an indication of how fast and in what direction the hydrogen clouds are moving with respect to our solar system and hence to our own planet. Naturally, radio-astronomers have been most anxious to make full and undisturbed measurements in this frequency range.

At the Geneva Radio Conference of 1959 the 1400 to 1427 Mc/s band had been allocated to radio-astronomy although, however, a few countries reserved the right to use this band also for other radio services.

Recommendation 314 of the C.C.I.R. Plenary Assembly of 1963, which was adopted without reservation, read in part as follows:

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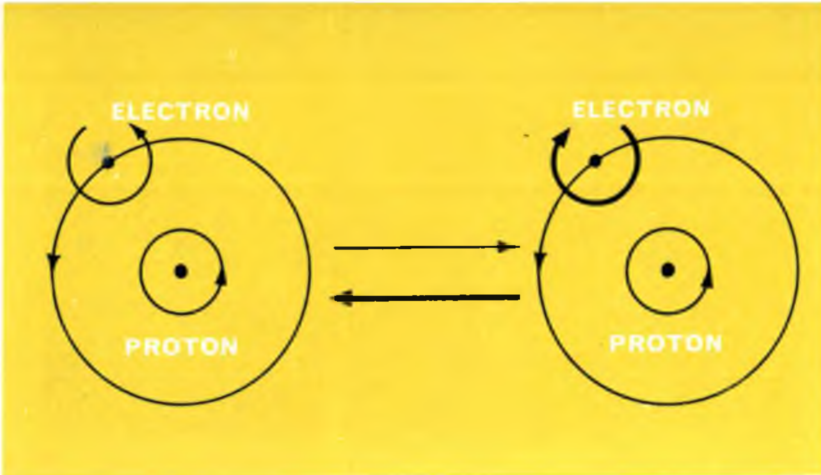

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" The C.C.I.R.,

CONSIDERING

.....

(b) that protection from interference on certain frequencies is absolutely essential to the advancement of radio-astronomy and the associated measurements;

(c) that, for the observation of known spectral lines, certain bands at specific frequencies are of particular importance;

.....

UNANIMOUSLY RECOMMENDS

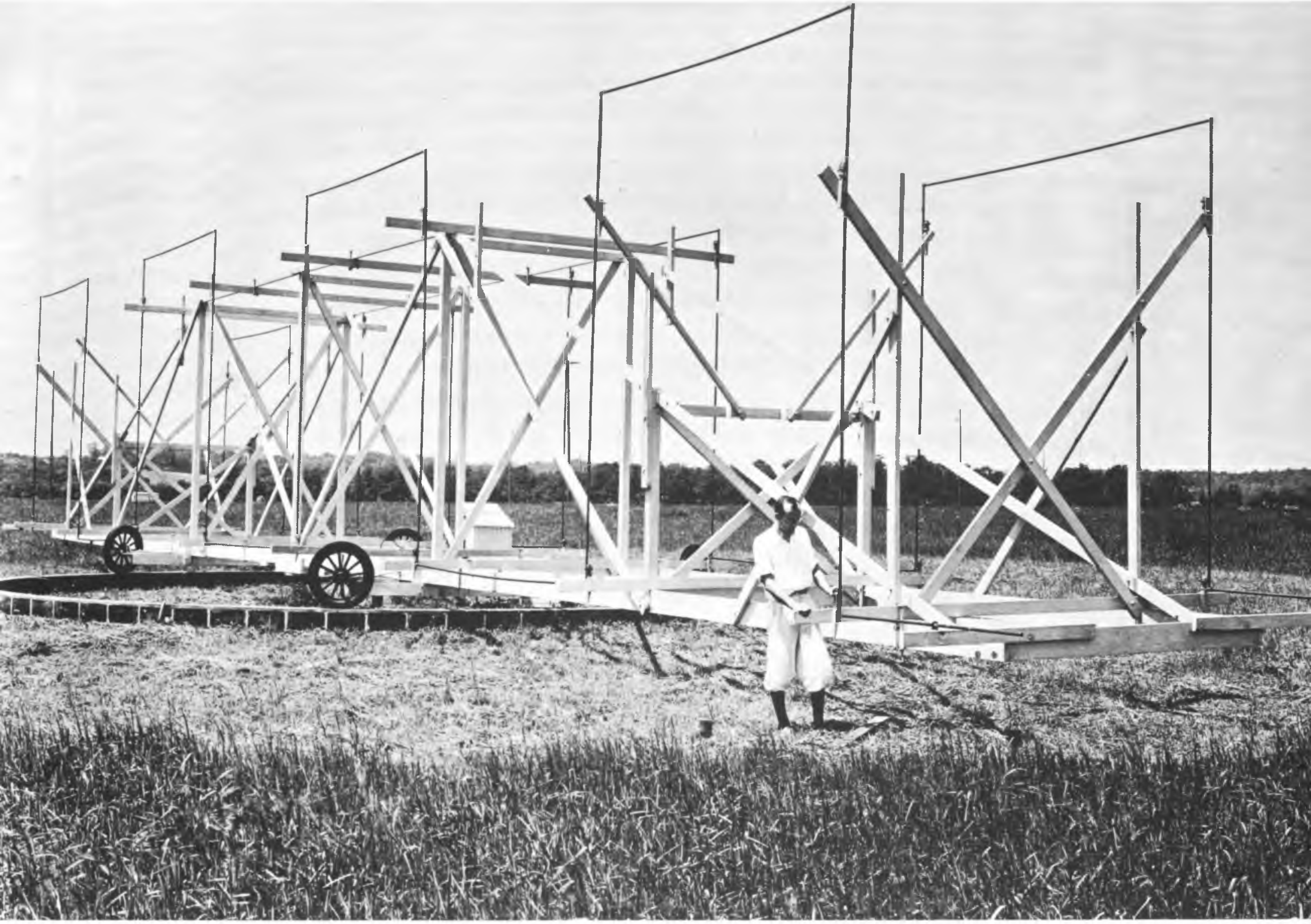
.....

3. that particular care should be taken to give complete international protection from interference to observations of emissions known or thought to occur in the following bands:

Line	*Frequency Mc/s*	*Band to be protected*
Deuterium	327.4	322- 329
Hydrogen	1420.4	1400-1427
OH	1667	1645-1675 "

This recommendation was brought to the attention of the Extraordinary Radio Conference in Geneva, 1963, which dealt only with space communication and radio-astronomy. This Conference unanimously accepted the C.C.I.R. recommendation and freed the 1400-1427 Mc/s frequency band for exclusive worldwide use of radio-astronomy. It was a decision of vital importance for the future of radio-astronomy and in the true tradition of the I.T.U., the peaceful international co-operation in the pure and the applied sciences of telecommunications.

275 The reversal of the electron spin of a hydrogen atom occurs only once over 11,000,000 years. This exceedingly rare event, however, occurs so often in the vast gas clouds of our galaxy that it can be detected by radio-telescopes on earth using the 21 cm or the 1420.4 Mc/s frequency, which is now reserved for radio astronomy by all countries of the world.



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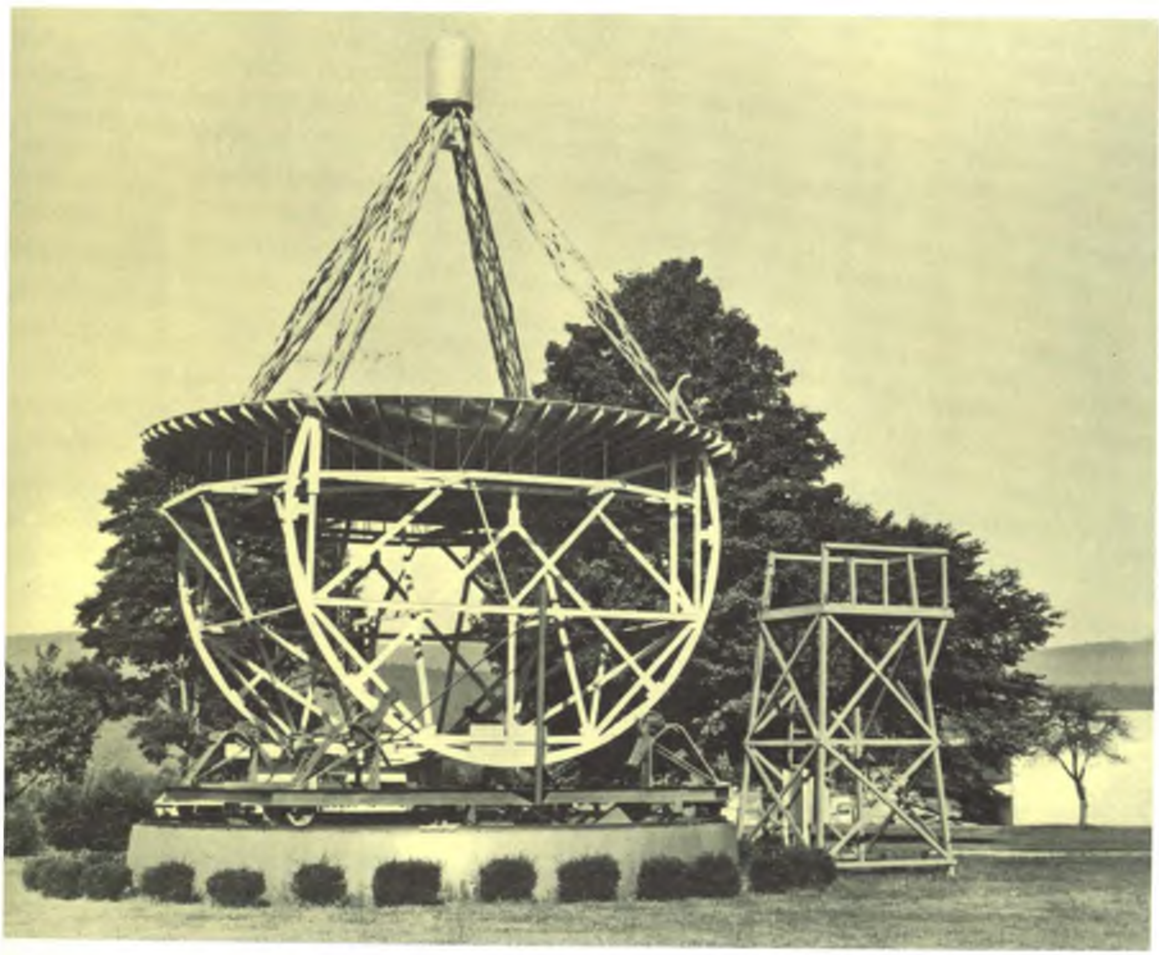
After forty years, the scope of the C.C.I.R. has grown beyond the dreams of its somewhat reluctant founders. Yet its work may only be beginning. There has been much speculation in recent years about the existence of other intelligent beings in the universe, and a number of sound scientific papers have been published on our chances of contact with them. This of course could only be done by radio, and the only suitable receivers are radio-telescopes. Many may shrug their shoulders and consider this subject as science fiction, just as the delegates to the Washington Conference in 1927 would have done if earth satellites had been mentioned. But should radio contact ever be established with extra-terrestrial intelligence, there can be no doubt that it would be up to the C.C.I.R. to provide technical information and to indicate the most suitable frequency ranges to be freed from other radio-traffic so as to let mankind receive the most important radio messages ever sent.

276 *An historic photograph of the late Karl G. Jansky of Bell Telephone Laboratories with the rotating antenna which he used in the discovery of radio waves coming from the Milky Way. His studies resulted in the science of radio astronomy. The work was done at Holmdel, New Jersey. This antenna was dismantled in 1944.*



277 *Early radio-telescope of Grote Reber, now at Green Bank, West Virginia, U.S.A.*

278 *A complete view of the antenna field of the Jicamerca Observatory, Lima, Peru.*

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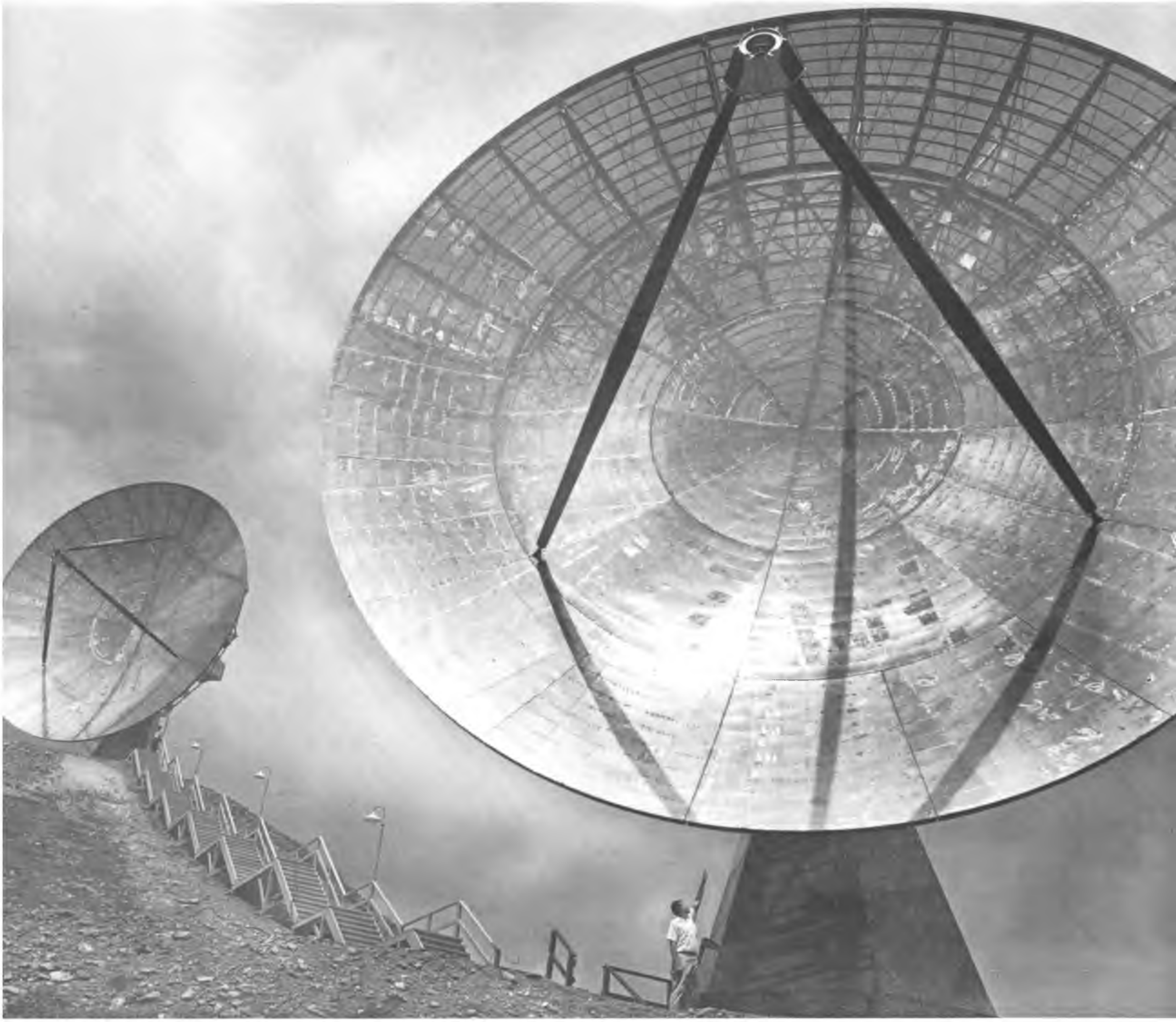

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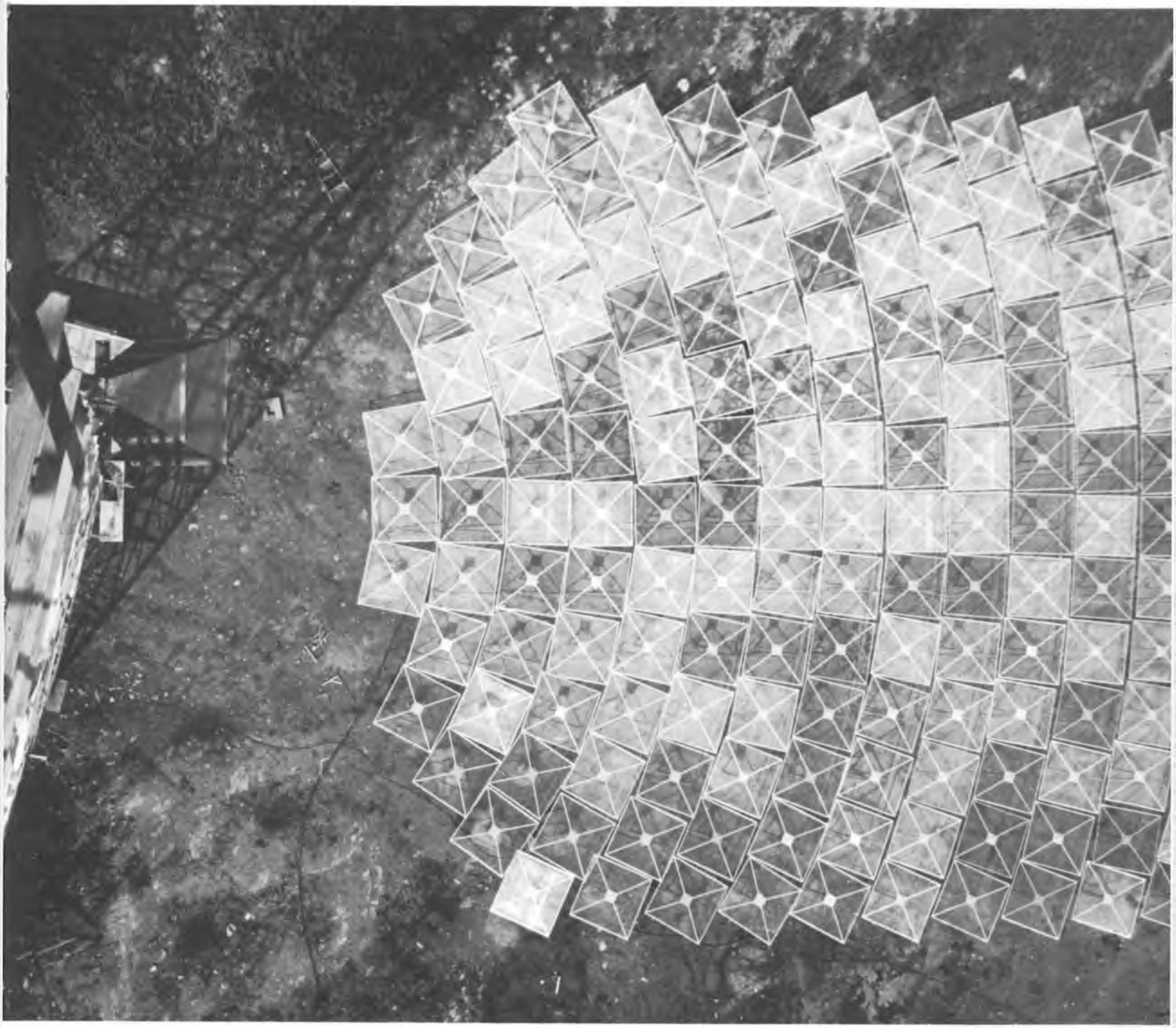
279 Two 20 m parabolic antennas used at the Table Mesa field site in Boulder, Colorado, U.S.A., for tropospheric measurements.



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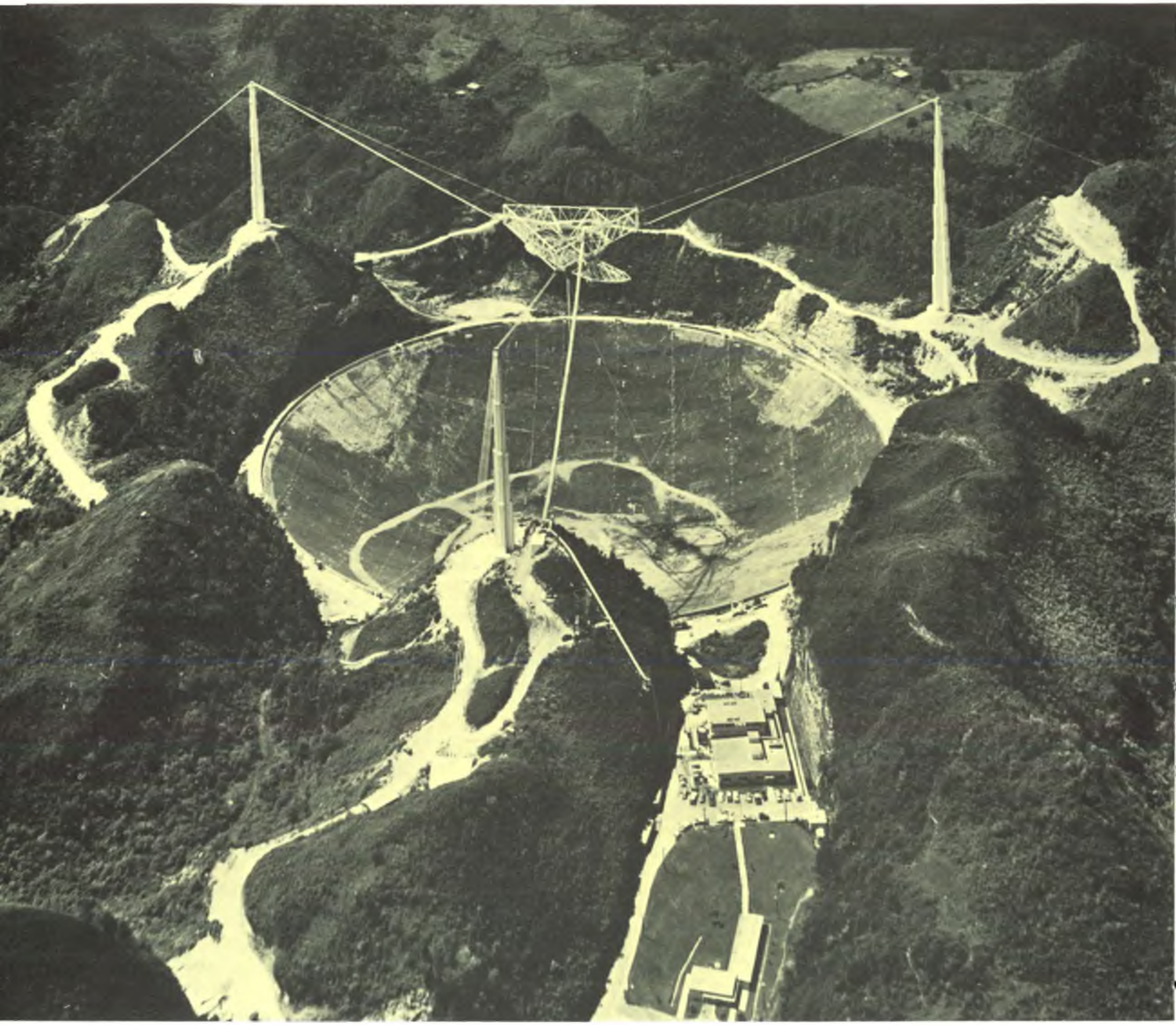
280 *In radio-astronomy, as in all other scientific fields, constant research is carried out to find new and more powerful instruments. Here a new concept, that of building up an antenna from many small individual components, a multiple-plate antenna, was tested by the United States Office of Aerospace Research. From a 30 meter high tower, from which this photograph was taken, a small number of such antennae can be seen. Each plate is adjustable in height and orientation, and a computer is used to determine their best position. The test section shown here measures 20 m × 40 m, each plate being 1.5 m square. In this test the plates are directed to receive energy from Cygnus A.*



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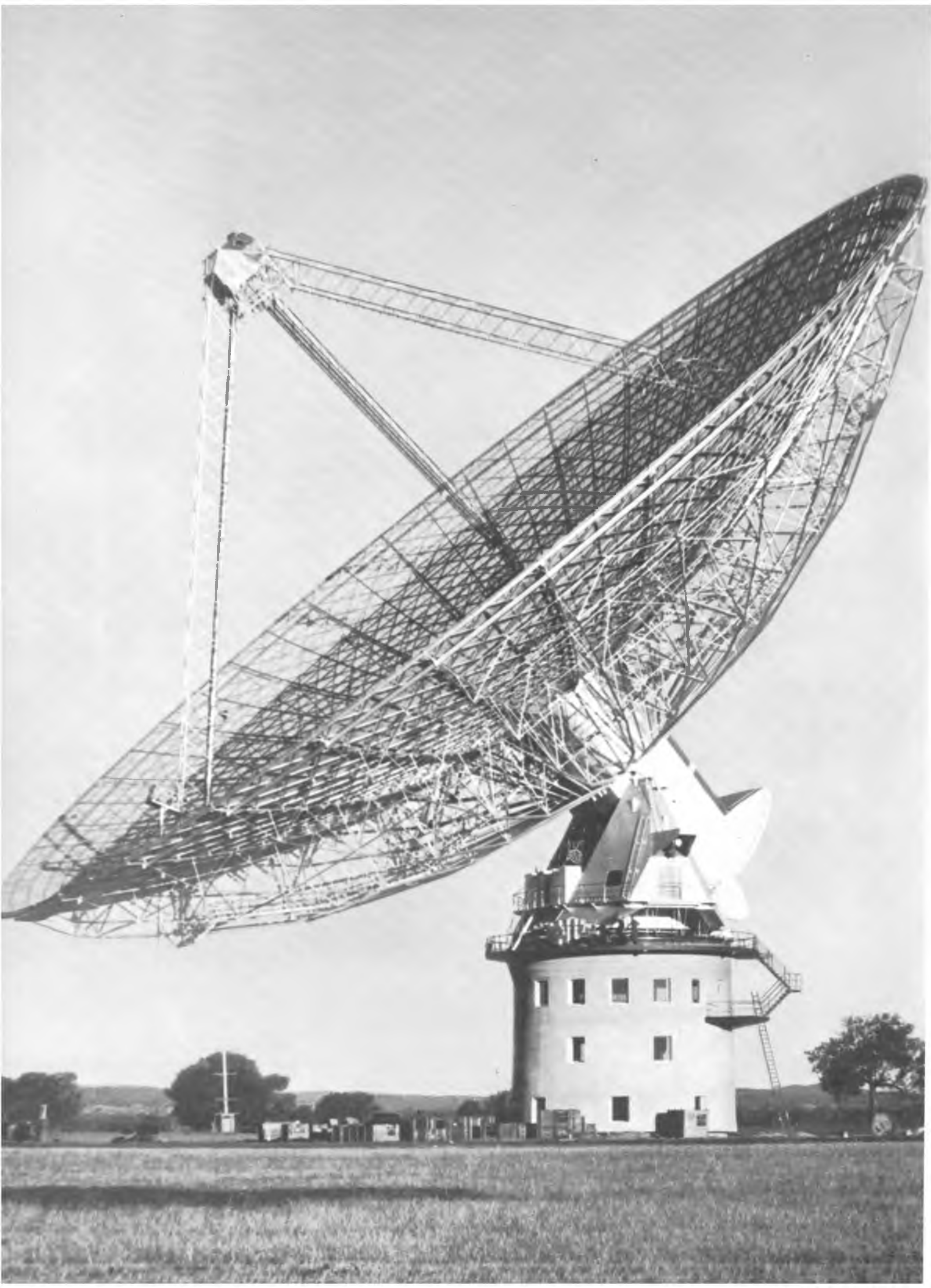
281 The Arecibo Ionospheric Observatory is located in a mountainous area south of Arecibo, Puerto Rico. The mountain peaks in the area are approximately 600 m high. Shown here is the dish, the towers and the feed mechanism with support structure suspended over it, and the radio-telescope's administration building. The Observatory was conceived by Cornell University scientists who now operate it. The Advanced Research Projects Agency of the U.S. Department of Defense funded the construction at a total cost of nearly \$9 million. It became operational on November 1st, 1963.

282 The feed mechanism dangles from the support structure which is suspended over the dish of the Arecibo Ionospheric Observatory. The support structure and the feed antenna weigh 550 tons — said to be twice the weight of the Statue of Liberty in New York Harbour. The structure is suspended by cables from three towers near the rim of the dish. The antenna is 30 m long and may be taken down during hurricane weather.

282

283 *The radio-telescope at Parkes in the state of New South Wales, Australia. Its 64 m diameter antenna is completely steerable and became operational in October, 1961. It has already greatly contributed to our knowledge of the universe. (Parkes is 320 km west of Sydney, and in this remote location there is a minimum of electrical interference.)*



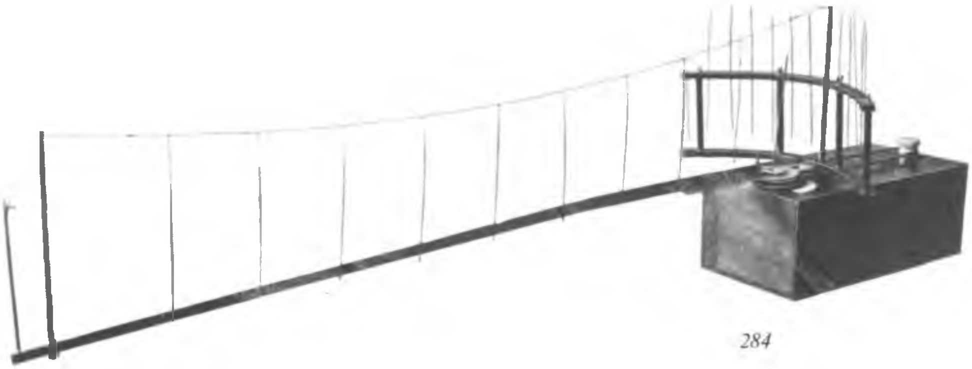
The International Frequency List and the International Frequency Registration Board (I.F.R.B.)

Undoubtedly the toughest and most intractable problem which has confronted the I.T.U. during the second half of its first 100 years of existence has been the allocation, assignment, registration and orderly use of radio frequencies. In this field, amongst all other activities, delegates to Conference after Conference had to fight against an immutable fact of Nature. This is the limited extent of the usable radio frequency spectrum and, consequently, the limited number of individual radio communication services which can be operated, throughout the world, without intolerable mutual interference.

Right from the first International Radiotelegraph Conference ever held, in Berlin in 1906, it became desirable to allocate certain frequencies for certain types of use. In Berlin, the frequencies of 500 kc/s and 1000 kc/s were established for public correspondence in the maritime mobile service, and frequencies below 188 kc/s were allotted for long distance communications between coast stations. Further allocations were made to services at subsequent radio conferences as an ever increasing number of users demanded them. Fortunately for a time, this was not too difficult when the total number of radio services in use throughout the world remained relatively small.

About forty years ago radio research, to which the experimental work of amateurs also contributed, opened up the higher frequencies of the spectrum, and as the potentialities of these higher frequencies were progressively realised they were allocated for new uses. At the Administrative Radio Conference of Washington in 1927, the upper limit of frequency allocations was 30 Mc/s, at Madrid in 1932 it was extended to 60 Mc/s, at Cairo in 1938 to 200 Mc/s, at Atlantic City in 1947 to 10.5 Gc/s and at Geneva in 1959 to 40 Gc/s. The lower limit remained the same, at 10 kc/s.

One of the most important and far-reaching decisions of the Washington Conference in 1927 was to add a provision to the Radio Regulations which required each Administration to notify to the Union's Bureau at Berne, any new radio station, together with its frequency and other technical characteristics. Thus in 1928, when the Washington Regulations came into force, the Bureau at Berne began to compile its *Liste des Fréquences*, the Frequency List. But the Bureau had no discretionary powers, it could merely take note of a new station and its frequency. If there was already another one using the same frequency and interference to the existing station was obvious, there was very little that the Bureau could do. No mediative machinery existed.



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By the time of the Atlantic City Conference in 1947, there were at the offices of the Berne Bureau no fewer than 45,000 notifications of frequencies below 20 Mc/s. Moreover, as a result of the tremendous growth in radiocommunication services for military purposes during World War II, an enormous number of stations were operating on frequencies which had never been notified to the Bureau. They were often using frequencies which had been employed before the war by other countries and whose services had been temporarily suspended by the war. In view of the resulting chaotic state in the use of the spectrum, and the technical progress that had been made since the preceding Radio Conference in Cairo in 1938, particularly in knowledge of HF propagation, it was recognised that an agreed machinery for the international coordination, control or mediation in the use of radio frequencies had become essential. In order to secure this, an International Frequency Registration Board, the I.F.R.B., was there and then envisaged.

The Working Group of the Atlantic City Radio Conference charged with the task of drafting the terms of reference soon realised the fundamental difficulty they were up against: how to give the Board fuller powers than the Bureau at Berne had enjoyed, yet not unduly infringe the rights of any country to use any frequencies it deemed appropriate. The Chairman of the Group considered the role of the Board "as that of witness and nothing more", and likened the function of the I.F.R.B. to that of Lloyds of London, as a Verification Board.

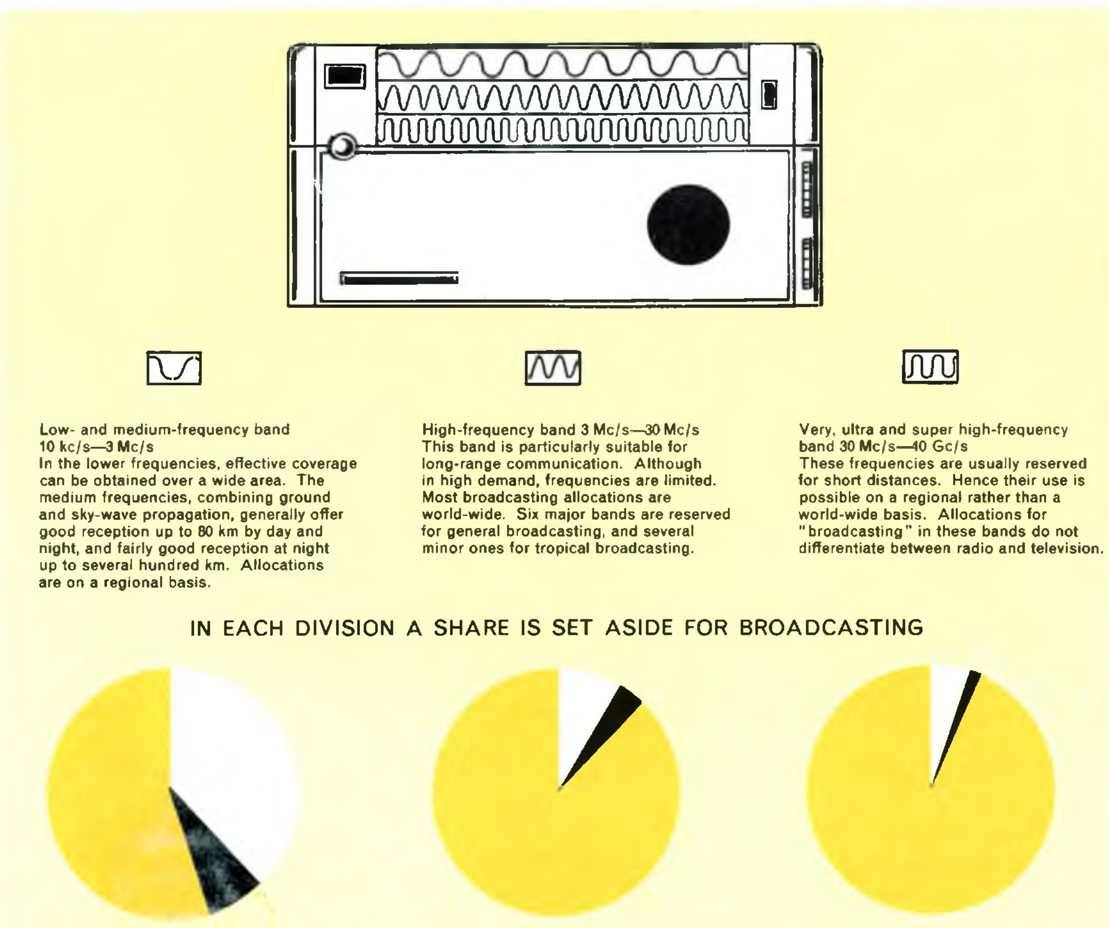
However, it was obvious that this Board would have the duty of trying to avoid interference between the radio services of one country and another. The Board would also have to try to secure the more efficient and orderly use of the spectrum. Into the International Frequency List, columns of " Notification " and " Registration " were introduced, the first merely to show the date of receipt of the notice of a new station using a particular frequency for a specific purpose. The second was to give a frequency assignment "the right to international protection from harmful interference", if it also complied with the relevant requirements of the Radio Regulations. This second duty, registration, gave the Board tasks of a judicial nature and made it necessary that its status and impartiality should be such as to command the willing respect of all Administrations.

Ultimately, it was agreed at Atlantic City that a Board of eleven technical radio experts, nominated by their country, all of whom were to be nationals of different countries, should be elected in a world-wide

284 *Very high frequency beam antennas were invented by Dr. Hidetsugu Yagi and Dr. Shintaro Uda in 1925. " Yagi antennas" are widely used throughout the world. This is the first Yagi antenna as preserved in Tokyo.*

285 *The three major divisions of the internationally allocated spectrum.*

286 *VHF sound transmitting station mast and cylindrical slot aerial at Wrotham, England, 1950. At combined television and VHF sound stations the two aerials are mounted on the same mast with the television aerial normally at the top.*



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EXCLUSIVELY FOR BROADCASTING

SHARED WITH OTHER SERVICES

OTHER SERVICES ONLY

competition, held by the Radio Conference, in which radio experts of Member-countries would be present. The members of the Board were to be chosen on the basis of equitable geographical distribution. In the Convention signed at Atlantic City in 1947, a provision was included that they should be thoroughly qualified and " they shall serve not as representatives of their respective countries, or of regions, but as custodians of an international public trust ". They were also required to be " familiar with geographic, economic and demographic conditions " within the area from which they came. Such a Board has been functioning since 1948 in accordance with the I.T.U. Convention and Radio Regulations.

The first task to be performed under the decisions adopted by the Atlantic City Conference was the preparation of a new International Frequency List. It was to serve as a starting point for this new Board after the entry into force of the new Table of Frequency Allocations drawn up by the Atlantic City Radio Conference. This new Table was quite different from the Table drawn up by the Cairo Conference in 1938, particularly due to the considerable importance acquired by the aeronautical mobile and maritime mobile services.

Also its legal significance was greatly strengthened as compared with that of the Cairo Table—which constituted a mere recommendation. Furthermore, it was hoped that the preparation of the new International Frequency List would facilitate and speed up the many transfers of frequency assignments required in the part of the frequency spectrum below 27.5 Mc/s. However, since each Member-country of the Union attached great importance to the uninterrupted operation of its own radio circuits, particularly its long-distance ones, it was decided that the new International Frequency List should be approved before being put into effect by an Administrative Radio Conference specially convened for that purpose.

A series of Conferences and Meetings were convened as from the beginning of 1948 in order to prepare the new draft International Frequency List. Regional conferences for Region 1, Region 2, Region 3, the European Broadcasting Area, the North-American Broadcasting Area, the European Maritime Area, maritime radiobeacons in Europe, and others, drew up the draft List for the frequency bands between 150 kc/s and 4000 kc/s. In 1948 and 1949, an Aeronautical Conference treated the frequency bands allocated exclusively to the aeronautical mobile service between 2850 kc/s and 18.03 Mc/s.

The frequency bands allocated exclusively to the broadcasting service between 5950 kc/s and 26.1 Mc/s were dealt with by a series of conferences, of which the first was held in Atlantic City in 1947, followed by later conferences in Mexico City and Florence/Rapallo.

The use of HF for broadcasting and for other services is characterised by the instability of the HF propagation characteristics. These characteristics vary according to the time of the day, the season of the year and the 11-year sunspot cycle. It is therefore not possible to use the same frequency throughout the year if one wants to broadcast half-way round the world. It was therefore decided that a frequency assignment plan should be specially prepared for HF broadcasting to enable the needs of different countries to be met, from season to season and throughout the whole sunspot cycle.

A large group of experts from the Administrations, together with the members of the I.F.R.B., was designated " The Provisional Frequency Board ", P.F.B. It was entrusted with the preparation of the new draft International Frequency List for the other frequency bands between 4000 kc/s and 27.5 Mc/s, mainly those allocated to the fixed services and to the maritime mobile service. It was to incorporate the results of the work of all the afore-mentioned Conferences in the draft International Frequency List so that the latter might be submitted in a complete form to the special conference.

The P.F.B., which met in Geneva from January 1948 to February 1950, held 38 Plenary Meetings, apart from numerous committee and working group meetings. The work of the P.F.B. was certainly not easy, and to take but one example: in frequency band " 0 ", 6765-7000 kc/s with its available 235 kc/s, the P.F.B. was faced with 3236 requests for individual frequency assignments. This would have required a band of 16,100 kc/s if it had been necessary to assign each frequency exclusively to a station in a single country.

In the end, disagreement among participants became so acute, that in October 1949 the delegates of seven countries withdrew from the P.F.B. and went home. Yet when the P.F.B. finally ceased its work, it had succeeded in producing assignment plans for almost 82% of the spectrum space which had been referred to it for planning, those from 14 kc/s to 150 kc/s and from 4000 kc/s to 27.5 Mc/s.

The Administrative Council of the I.T.U. having reviewed the work of the P.F.B., and of the other Conferences called upon to prepare the draft International Frequency List, decided to call in 1950 the Special Administrative Radio Conference envisaged at Atlantic City. But because chances of reaching any substantial agreement appeared very slight, it later postponed the Conference until August 1951. It met for five months in Geneva as an Extraordinary Administrative Radio Conference.

This Conference accepted the lists which had been prepared for the frequency bands below 4000 kc/s and for the high frequency bands allocated exclusively to the aeronautical and maritime mobile services. It adopted certain interim "evolutionary" procedures for the other bands below 27.5 Mc/s, which provided for a progressive transfer of stations into their appropriate frequency bands. It charged the I.F.R.B. to coordinate the application of evolutionary procedures and so enable the frequency assignments which were not in conformity with the Table of Frequency Allocations to be transferred in an orderly manner.

As the High Frequency Broadcasting Conferences had unfortunately failed to produce a plan which would be acceptable to all Members of the Union, the Conference also charged the I.F.R.B. to draw up 11-year plans for HF broadcasting services based on new requirements for such services and to be submitted by the Administrations. Finally, the Conference also requested the Administrative Council of the Union to review progress made in the implementation of the Atlantic City Frequency Allocation Table. This Extraordinary Administrative Radio Conference could not bring about overall harmony and, although the final agreement was signed by 63 of the participants, nine countries, including the seven whose representatives had left the P.F.B., did not sign the Final Acts.

The efforts of the I.F.R.B. and the whole-hearted co-operation which was extended to the Board by Members of the I.T.U. had the effect that the Administrative Radio Conference, when it met in Geneva in 1959, could note that the Atlantic City Table of Frequency Allocations had been brought into effect. This was due to the implementation of the frequency plans and lists for those bands for which agreed Plans and Lists had been adopted by preceding Conferences and to the successful application of the evolutionary procedures adopted by the E.A.R.C. in 1951. This covered, in practice, the vast majority of frequency assignments between 14 kc/s and 27.5 Mc/s.

The Conference therefore decided that it should be put into legal force, without amending it appreciably in this part of the spectrum. Under the terms of the Radio Regulations, any station operating in violation of the Table or of the other provisions of the Radio Regulations, must not cause harmful interference to stations operating in accordance with these Regulations. As will be seen later on, the 1959 Conference considerably extended the tasks of the I.F.R.B. This meant going beyond the keeping up to date of the Master International Frequency Register, whose contents are brought to the notice of Administrations at periodic intervals in the form of the International Frequency List.

At present the latter comprises 573,000 lines of information, of which 468,000 concern frequencies below 28 Mc/s. The Board is also required to send a Circular to Administrations each week, so that they may be quickly informed of the notifications received and of the findings issued by the I.F.R.B.

The work of keeping the Master Register up to date in accordance with the procedures set out in detail in the Radio Regulations involves the technical examination of every new assignment, or modification of an existing assignment, in the low, medium and high frequency bands. This is done to assess the probability or otherwise of harmful interference being caused to services already in operation. This task is of considerable magnitude and great importance.

According to the results of its technical calculations, the Board reaches a finding, favourable or unfavourable, which is entered in the Master Register and in the International Frequency List when the frequency assignment concerned is inserted. These findings by the Board, based on strictly technical data, confer certain rights on Administrations, the right to international protection, or at least the right to official international recognition, and place certain obligations on them, the obligation to respect the rights conferred on others. These rights and obligations are invoked by Administrations when they discuss cases of harmful international interference that have actually occurred in practice.

Due to the limited extent of the radio frequency spectrum, it can easily be understood that any right conferred on one Administration implies a reduction, or at least some restriction, of the rights of other Administrations. Moreover, such rights in respect of radio services may be extremely valuable from the commercial as well as political and cultural aspects. The nature of this task can be compared to traffic control on the radio roads in which the Board, before giving an indication with a green, yellow or red light, has to take careful stock of the existing traffic situation.

Both the Radio Conference of Atlantic City in 1947 and that held in Geneva in 1959 decided, therefore, that only an international body made up of independent experts, and of which no member " shall request or receive instructions relating to the exercise of his duties from any government or a member thereof, or from any public or private organisation or person ", could be expected to arrive at impartial findings based exclusively on technical considerations. Also, as the Board should reach its decisions unanimously so far as possible or, failing unanimity, by a two-thirds majority, its findings would have the authority required for them to be accepted and respected.

The Board makes its calculations using its own technical standards which are based on the Recommendations of Conferences, the International Radio Consultative Committee Recommendations, and on other relevant data. An electronic computer was installed in the I.T.U. building in 1962 to help in the calculations needed in the Board's work and for the publication of the International Frequency List, the Board's Weekly Circulars and other documents.

In order that the Master Register should at all times reflect the actual state of affairs about frequencies in use, a procedure is laid down in the Radio Regulations enabling the I.F.R.B. to make enquiries when any doubt arises. For example, when the I.F.R.B. has given an unfavourable finding to a new assignment because of the probability of interference with assignments already registered, the Administration asking for registration of the new assignment can say that it has used the new frequency for at least sixty days and yet received no complaint.

In such a case, the I.F.R.B. questions the other Administrations whose frequencies are already registered and which would have, according to the entries in the register, been interfered with by the new assignment. Depending upon this enquiry, the I.F.R.B., in co-operation with all the Administrations concerned, takes action to verify the correct position and to delete any of the existing entries which may not actually have been in use. The results of the enquiry are entered in the Master Register, so that eventually, so far as the frequency bands for which no new list was adopted by the 1951 E.A.R.C. are concerned, the International Frequency List will resemble one based on the application of sound technical principles.

The notification and recording of frequency assignments to satellite stations in space, and to the earth stations with which they are in communication, are subject to a special procedure which was laid down by the Extraordinary Administrative Radio Conference on Space Communications held in Geneva in October-November 1963. It is also a function of the I.F.R.B. to intervene in cases of harmful interference when direct negotiations between the Administrations concerned have either been impracticable or have not produced satisfactory results.

In the field of high-frequency broadcasting, the Administrative Radio Conference held in 1959 examined the draft 11-year plan drawn up by the I.F.R.B., following the decisions reached by the Extra-

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287 *Navigational radio for civil aviation at Vanghärad, near Stockholm, using VHF omni-range equipment.*

ordinary Administrative Conference of 1951, and finally agreed to abandon the idea of long-term planning. The Conference, instead, adopted a special procedure, which is basically a method of very short-term planning. This procedure allows the Member-countries of the I.T.U. to keep a close check on the frequencies being used in the frequency-bands allocated exclusively to the high-frequency broadcasting service at different times of the day or night. It also permits Members to notify the Board of their projected services and corresponding frequencies, for each season, so as to ensure the satisfactory operation of their services.

These frequency notifications are not printed as lists but are presented every three or four months as diagrams of operating Schedules. It is thus a simple matter to read off not only the frequency and technical characteristics of each station but also the time of the day when it is in operation.

Furthermore, the Board submits to Administrations suggestions for the use of specific frequencies and inserts in these diagrams the " incompatibility ", that is, danger of mutual interference which might arise between two stations broadcasting on the same or closely adjacent frequencies to the same or closely adjacent areas. The Board, on request from any Administration, then endeavours to find a suitable frequency, or frequencies, for its services, and issues suggestions to Administrations for changes of frequencies which might lead to improved operations. Every week, in the circular which is sent to Administrations, the Board shows the latest modifications to the current quarterly Schedules which have been received in Geneva. A quarterly summary, which includes all the changes, is published as the High-Frequency Broadcasting Schedule.

Another task of the I.F.R.B. is the publication of technical monitoring reports. The technical monitoring of radio stations is necessary to tell whether a station is really occupying the notified frequency or if it has strayed from its position sufficiently far to cause interference with stations using adjacent frequencies. The actual monitoring is not carried out by the I.F.R.B., but by the Administrations of Member-countries, which notify the Board of the results obtained at their monitoring centres. These results are then correlated by the Board, summarised, and published as monthly international monitoring summaries.

The I.F.R.B. has also to help Administrations, especially those of the new and developing countries, to find frequencies to meet the growing needs of their radio systems. This work occupies an increasingly large place in the Board's activities, particularly since the spectrum is now so congested that the new use of a frequency may only be possible by another Administration, giving up, or curtailing, an existing use.

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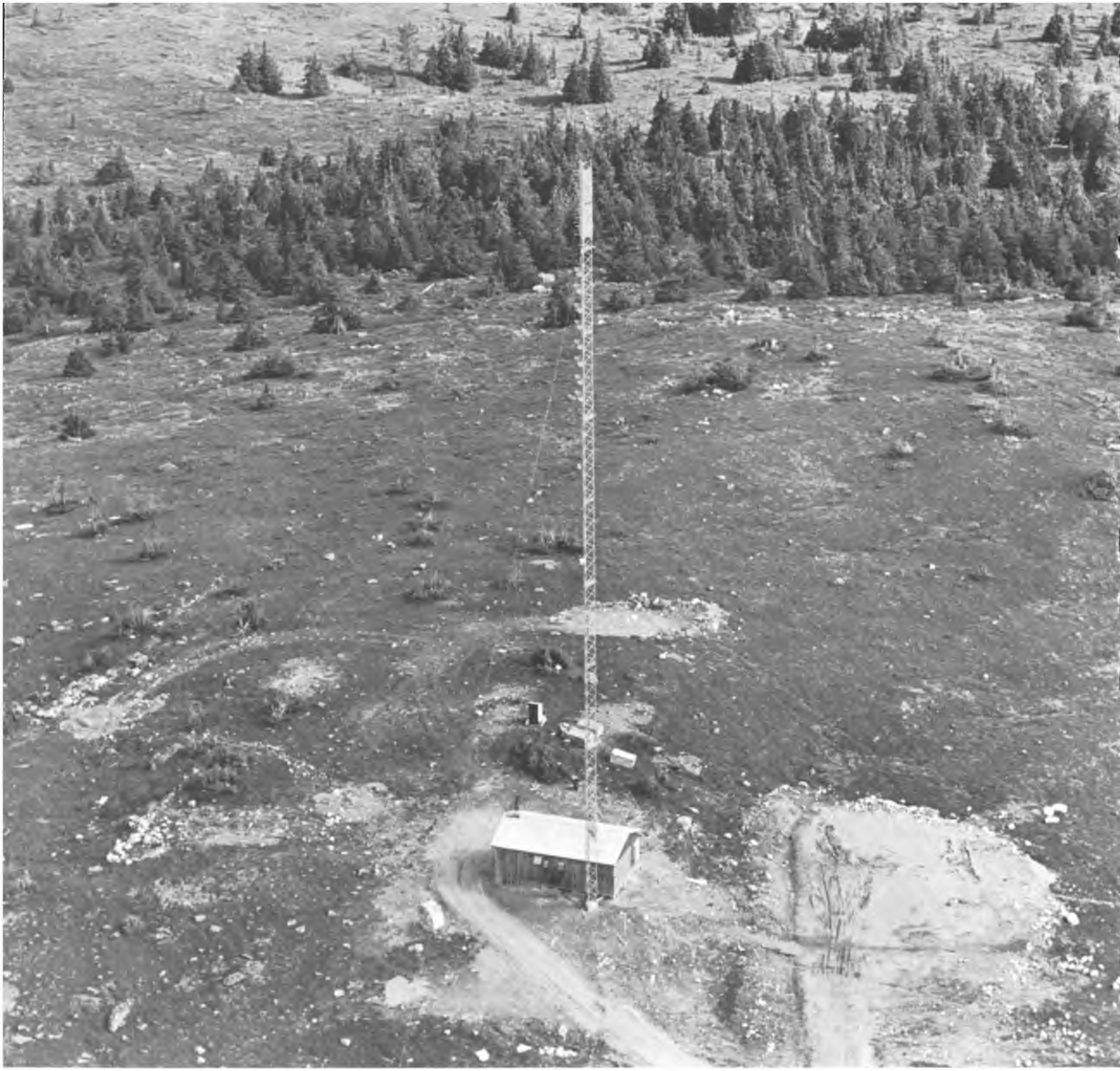
288 *World-wide aviation would be impossible without telecommunications, both for in-flight information and for landing control. Typical of modern airport facilities is this control building at London Airport in 1956.*



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289 *A lonely mast in Sweden brings the benefits of television to many viewers.*

In order to assist the staff of the new and developing countries in matters like the choice and use of frequencies and the necessary equipment, the Board organizes seminars from time to time in Geneva. These have been highly successful and have done much to inform officials of the telecommunication Administrations of the problems involved in the use and management of the radio frequency spectrum.

The I.F.R.B. is also responsible for the technical planning of radio conferences to ensure that their duration is reduced to a minimum. Thus, between 1960 and 1965, it submitted to various radio conferences, both of regional and world-wide scope, an extensive series of documents containing the results of its studies on the subjects to be dealt with, as well as draft frequency assignment plans, draft Agreements, and so on. The Board also closely participated in 1961 and 1963 in the work of a Panel of Experts which was created by the 1959 Administrative Radio Conference to study ways of reducing congestion in the frequency bands between 4000 kc/s and 27.5 Mc/s.

Its various duties lead the Board to co-operate very closely and consistently with many International Organizations, which are concerned with the use of frequencies. These Organizations include the United Nations, as far as the operation of its own radio network is concerned, the U.N. Specialised Agencies such as the International Civil Aviation Organization, the World Meteorological Organization and UNESCO (in respect of the Intergovernmental Oceanographic Commission), International Organizations concerned with broadcasting, such as the International Broadcasting and Television Organization and the European Broadcasting Organization; Scientific Organizations such as the Committee on Space Research and the Inter-Union Committee for Allocation of Frequencies, and finally specialist organisations such as Interpol, the Danube Commission, and the International Radio-Maritime Committee.

As custodian of an international public trust, the radio spectrum, the I.F.R.B. has had an international and completely independent character from the day of its inception. Under its constitution, the Chairman of the Board changes from year to year, which in itself tends to ensure that no individual member will exercise an undue influence on the Board's work and decision.

In the almost twenty years of its existence, the I.F.R.B. has not always had an easy task. The science of radio-communications has considerably advanced since the Atlantic City Conference of 1947 and the growth in the use of radio-communications on the whole has made it necessary that the fundamental work of maintaining the Master Register with the rights to international protection be supplemented in recent

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years by the more dynamic pursuit of frequency management. By this is meant the wider aspect of planning the use of frequencies on a national or international scale, the assessment, through long-term studies, of future trends in frequency usage, and foreseeing in good time any difficulties which may be created by certain policies of frequency usage.

290 Perhaps the most lonely amateur radio station is KC4USV, situated at McMurdo in the Antarctic. Antarctic exploration is to-day unthinkable without extensive radiocommunications and wherever they take place, in crowded cities, in the countryside or even in the Antarctic, the amateurs at their stations are always ready and willing to help.

Helping the New and Developing Countries

The idea that a country technically advanced in telecommunications should, and will, help another, not equally well equipped with experts or instruments, is as old as the idea of international co-operation. Indeed, it is the very basis of it. Ever since the first meeting in Paris of the International Telegraph Union in 1865, Members of the Union have held formal and informal meetings, discussing " technical assistance " with each other.

From these very first telegraph conferences onwards, the Members of the Union agreed to inform each other of technical progress made in telegraph techniques. Later on, mutual assistance became essential for all, in order to speed up the development of the international communications network. International Consultative Committees were formed for this very purpose, and the consequent establishment of the European telephone system is one of the best examples of that co-operation which we should now call " technical assistance ".

To-day this term has assumed a new and urgent meaning as the gulf separating the technically developed, and the new and developing countries has become wider with each successive decade. With the end of World War II and with the beginning of the United Nations Organization, the concept of technical assistance has assumed a more definite and more carefully planned form.

Basic then to the idea of helping is the concept that technical assistance is not charity, but a combined effort to co-operate in the general interest. Most countries are in the position to give and to receive. It has always been one of the fundamental aims of the I.T.U., and of the International Telegraph Union before it, to spread and to standardize every kind of telecommunication technique, including administrative measures, so as to help one and all. Such work, on a broad international basis, and carried out by many agencies of the United Nations, as well as by individuals and scientific foundations, covers to-day not only telecommunications, but also agriculture, medicine and education, to mention only the most important ones.

It has been argued that food and medical advice should have priority when aid is given to a new country. Others have advanced claims for education, and some telecommunication experts have stated that without their help, none of the other services could start to develop. There is certainly a good case to be made for each of these, and we have seen that when the telegraph first began to spread in European countries about 100 years ago Governments found it an extremely useful service to strengthen their central


KYRENIA
MORPHOU
NICOSIA
FAMAGUSTA
LEFKA
LARNACA
PAPHOS
LIMASSOL

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Z1 = 848
Z2 = 212

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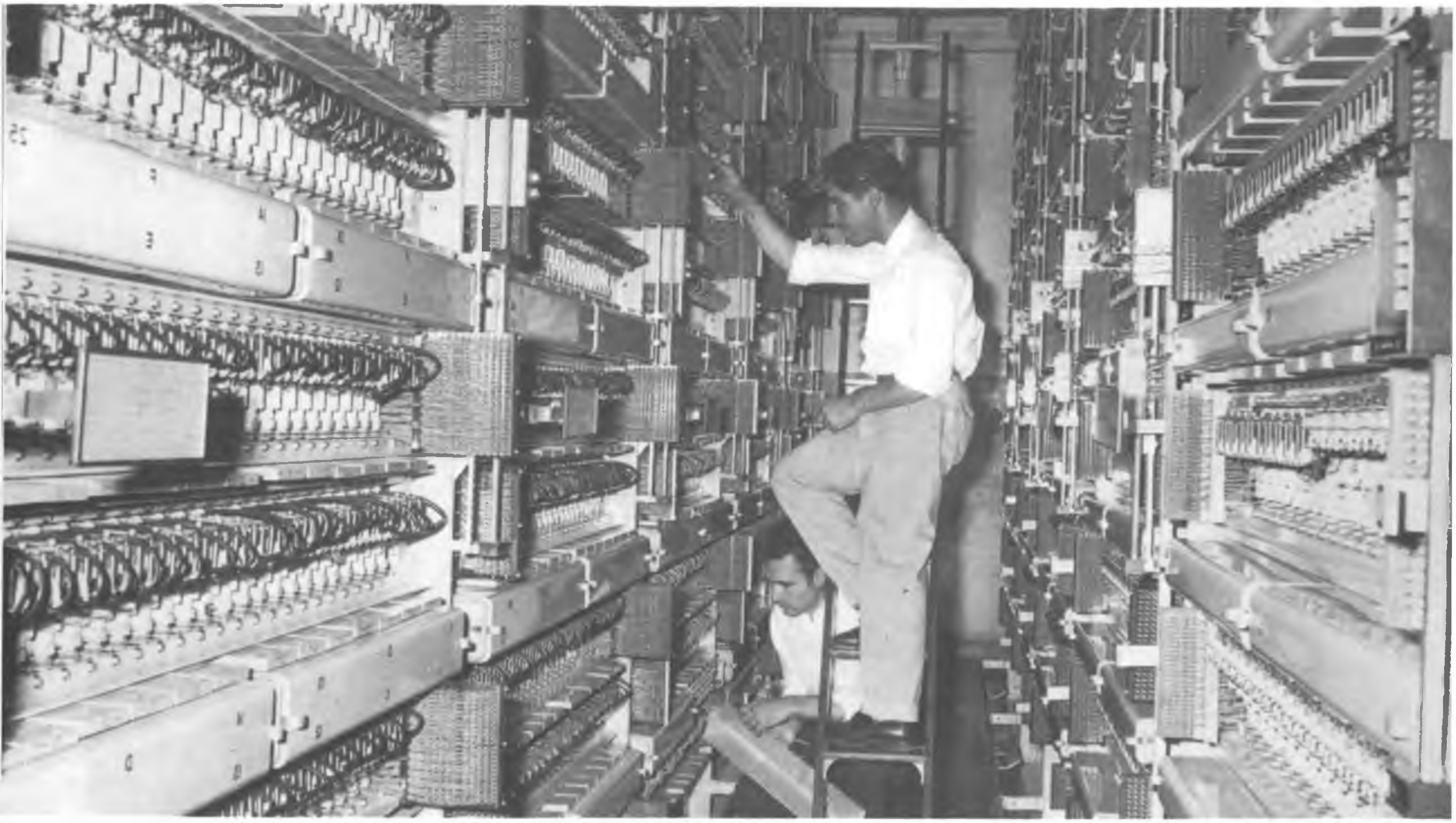
291 *Development of the telephone network in Cyprus between 1940 and 1963. By 1946, at the end of World War II, there were 17 manual telephone exchanges connected to 3003 telephones. This number had increased to 14,571 by 1963. The black dots are manual exchanges, the small circles call offices.*

292 *Many electronic engineers from the new and developing countries have come to Europe for training and instruction. Here one of them attends a training school of the British G.P.O. at Stone, Staffordshire.*

293 *Part of the telephone subscribers' uniselector racks at Nicosia.*



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administrations, that industrialists relied on it for expanding their trade and commerce, and that the public started to rely on the telegraph for obtaining its news through the newspapers and for many other social purposes. All this and more is equally true to-day for the new countries.

But if medical advice is given absolute priority, as it has been in many countries, a population explosion is the inevitable consequence. If agriculture is fully mechanised, unemployment follows. If modern universities are built, equipped and staffed, they remain empty of students unless primary and secondary schools are constructed first. Similarly telecommunications without an educated public, at least able to read the numbers on a telephone dial, are of little value to a new country, nor is broadcasting or television which mostly aims at entertainment, and hardly includes education at all. No, the only correct approach is advance on a broad front, developing hygiene, education, agriculture, transport and telecommunications simultaneously and at an equal rate, without giving to any one of these exclusive priority.

In all planning, and in particular for telecommunications, four essential steps need to be taken: the precise need in relation to the geography, the economics and the social conditions of the country must be formulated, secondly a plan must be prepared which can fulfil this need, then the training of the necessary staff to operate the telecommunications network must be undertaken and the financing of the plan must be organised. In practice several or all these steps are carried out at the same time, and in all of these, the I.T.U. has a great deal to contribute.

Just because mutual help has always been one of the basic activities of the I.T.U., the Union was somewhat reluctant, at least to begin with, to join in the formal acts of technical assistance proposed by the United Nations, soon after the end of World War II in 1945. It was not until 1952 that the United Nations formally recognised the I.T.U., and incidentally also the World Meteorological Organization, as full Members of the Technical Assistance Board with full voting rights. However, since then the means of international mutual aid, such as the Expanded Programme of Technical Assistance, the United Nations Special Fund, the World Bank, and the own means of the I.T.U. have been used to their maximum extent to aid the development of telecommunications in the new countries.

In practice, this technical co-operation of the I.T.U. has taken three forms: the sending of experts to study special problems or the training of staff, scholarships, fellowships and seminars, and finally the supply of training, measurement and demonstration equipment. By now the number of telecommunica-

294 *An ultra high frequency link has now been installed between Damascus and Beirut.*

295 *The I.T.U. worked closely with the Government of the Congo in 1963 to overcome difficulties that resulted from the initial disruption of telecommunication services and has established a normal long-range programme of technical co-operation in this field. The I.T.U. provided some 36 experts to train about 400 students in all phases of telecommunications. New long-distance radio, telegraph and radio telephone networks were established. Here is a Congolese technician servicing a Multiplex machine.*

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296 *Work was resumed in 1962 near Leopoldville on the construction of a national radio centre which will be powerful enough to handle programmes from all provinces and from abroad. The United Nations contributed 5,000,000 francs in order that the project could be resumed. A 100 kilowatt transmitter was first installed. Plans were then made for other transmitters which will make the station a powerful national and international unit. Premier Cyrille Adoula of the Congo is seen here addressing a gathering at ceremonies marking resumption of the project.*

297 *Congolese national operating telecommunications equipment at the Flight Information Centre of N'Djili Airport in Leopoldville.*

298 *Automatic Telephone Exchange in Accra, Ghana, with the first group selectors of the 4000 type switches.*

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tions experts which have been sent to study, help and advise, runs into a hundred or two. For example, a German expert on carrier systems has worked in Afghanistan since 1958, a radio engineer from Yugoslavia helped Guinea for a year during 1961, a telegraph and telephone adviser from Pakistan together with a colleague from the U.S.S.R., was in Ghana during 1962, and a New Zealander, expert in the usage of radio frequencies, advised the Libyan Government during three months in 1962. The list is long, and the benefits of their work inestimable.

Scholarships, fellowships and seminars have helped to an equally great extent to expand knowledge of modern telecommunications in the new and developing countries. There has been a marked trend in recent years throughout the whole of the United Nations Expanded Programme of Technical Assistance to give preference to fellowships rather than to sending experts. In this way a more lasting transfer of knowledge and experience can be effected, and the I.T.U. has awarded and implemented, for example, a total of 166 fellowships during 1963. From 31 countries these telecommunications engineers went to most of the West European countries and to the United States to study the most suitable ideas for their own telecommunications networks.

For the same purpose, the first seminar in the history of the I.T.U. was held in Japan in 1961, organised by the Administration of that country. Its success clearly demonstrated the effectiveness of seminars as a means of helping new and developing countries within a short period of time. It was followed a year later by a second one, in Paris. This was intended specially for the newly independent French-speaking countries of Africa and the I.T.U. could be equally pleased with the results. Since then further offers to hold similar seminars have been received by the I.T.U. So, for example, China intended to hold one at its Telecommunications Institute at Taipei, and Colombia invited experts from its neighbouring countries to its Empresa Nacional de Telecomunicaciones. Seminars were also organised at the Union Headquarters by the I.F.R.B. in Geneva in 1963 and 1964.

A certain amount of telecommunications equipment, representing a total value of $187,000, was supplied during 1962 to thirteen countries, of which 10 were in Africa. This equipment, mainly for training and demonstration purposes, and also for conducting tests, was generally associated with the sending of expert missions. During that year, a total sum of $1.1 million was administered by the I.T.U. for its Expanded Programme of Technical Assistance.

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299 *An unusual look at one of All India Radio's self-supporting towers at a transmitting station.*

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But undoubtedly the greatest contribution for the new and developing countries in the field of telecommunications comes from the United Nations Special Fund projects, being of the order of $5.4 million in 1962. There were then 7 of these projects, the training and research centre at Hsinchu, Formosa, and the telecommunications training centres at Tripoli in Libya, at Kuala Lumpur in Malaya, at Manila in the Philippines, at Baghdad in Iraq, at Khartoum in the Sudan and at Seoul in Korea. In addition to the contribution from the United Nations, each government concerned made its own allocation and for these 7 projects this came to $8.5 million; the overall total thus being $13.9 million.

But when all possible expert advice has been received, when the best plans have been made, and when the trained engineers return from their fellowships abroad, the final building of the telecommunications in a developing country needs capital for the purchase of the telephone wires, for the exchanges and for their installation. It is here that another specialised agency of the United Nations, the International Bank for Reconstruction and Development, or the World Bank as it is called, has in several cases provided the funds with which to realise the projects conceived by the I.T.U. experts.

To mention only a few of the major loans which the World Bank has made to improve modern telecommunications: In 1949, a loan of $75 million for the expansion of hydro-electric power and telephone installations in Brazil. Local telephone services were increased by 40%. In 1950, the World Bank lent $33 million to Uruguay to expand its power and telephone systems; improved communications were vital to the country's economic life. In Montevideo alone, 28,000 new telephones were provided, a new international switchboard was installed there, and new long-distance circuits and lines were constructed.

In 1951 Ethiopia received a first loan of $1.5 million for the complete modernisation of its telephone and telegraph system. A new Imperial Board of Telecommunications was established in Addis Ababa, and a second loan of $2.9 million was granted in 1962. With it, 50 new exchanges were to be installed to bring telephone services to provincial towns, a 1000 new lines added to the automatic exchanges in the capital, built with the first loan, and in addition, the second loan will go a long way towards providing the radiotelephone equipment to connect Addis Ababa with capital cities in Europe, Asia and other African capitals. Up till now, it has often been necessary to connect one African capital to another via Europe. A highly successful training programme has been carried out for Ethiopian technicians, both male and

300 *Engineer checks repeater station of the radio telephone network in Malaya.*

301 *In 1945 a member of an American mission to Tibet demonstrates a field radio unit to local people.*

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302 The new building of the National Administration of Telecommunications of Paraguay in Puerto Presidente Stroessner, Paraguay.

303 Telex services were installed in Ceylon in 1963, giving communication with Britain, most European countries, Canada, the United States of America, Australia, Bermuda, Nigeria, Ghana, Sudan, Iran and East Africa. All Telegraph circuits have been converted to five-unit working.

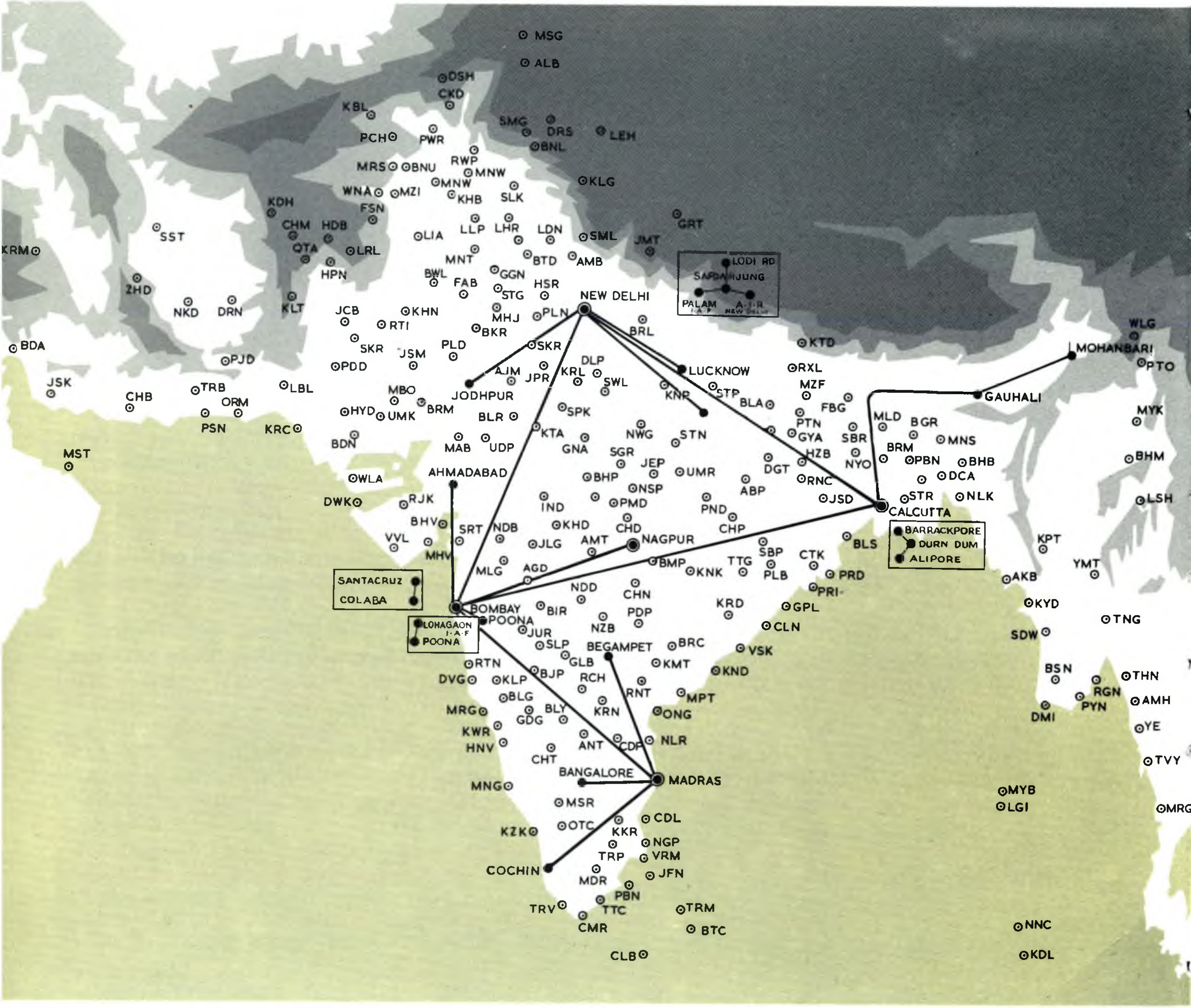
female, and it was expected that the entire management of the Ethiopian Imperial Board of Telecommunications will soon be in the hands of Ethiopians.

In 1962, the International Development Association, an affiliate of the World Bank, granted a development credit of $42 million to the Indian Post and Telegraph Department for the purchase abroad of new telephone and telegraph equipment. At that time India had only 1.2 telephones per 1000 inhabitants.

Among the more recent loans was one of $22 million made in 1963 to Costa Rica for expansion of electric power facilities and the construction of a modern telecommunications system in the country. New automatic exchange equipment for 14,000 telephone lines, triple the existing number, is to be put into operation in San José, the capital. The suburban areas will be served by six unattended satellite exchanges with a total of 1310 lines, and in five provincial towns will be installed central exchanges having a combined total of nearly 5000 lines. It is envisaged that at a later stage a micro-wave system will cover the whole country.

Such then are the relatively few projects to bring telecommunications to the still vast, underdeveloped regions of the world. Much has been done, but much larger efforts will be needed before the far-off ideal can be reached which hopes that every human being on this planet can communicate with every other one.

The development of broadcasting and of television for the new and developing countries is at present dependent on the resources of the individual country, or covered by aid from a second, richer nation. And yet, it might be just that through these two media of mass communications, fundamental education can come relatively easily and cheaply to the millions which cannot even read or write. When broadcasting and television are finding their major use for basic, secondary and vocational education rather than for purely entertainment purposes, then the pace of development will substantially increase. With worldwide television coming, it will need great efforts to ensure that its use for the benefit of all mankind will receive the highest possible priority.



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304 *Meteorological teleprinter network of India.*

Telecommunications in Government, Industry, and Private Life

In the modern technological countries life without telecommunications is to-day unthinkable. Private messages flow in an unending stream, industrial decisions are conveyed around the globe, and government communications must reach distant embassies and consulates in the minimum of time. In all this flow of communications, the regulations made by the International Telecommunication Union, and the work carried out by its permanent organs, play an indispensable part.

It is not possible here to trace a detailed historical development of telecommunications in government, industry or private life. All that can be done is to give three outstanding and perhaps little known examples in these fields as they occurred at about the time of the centenary of the Union. Each shows in its own way a development of telecommunications hardly expected a few years before. Yet all three will be superseded by further developments in the future.

Let us begin with the example of the use of telecommunications in government work, and choose the flow of communications between the State Department of the United States of America in Washington and its Paris Embassy. The State Department was faced with a need for a high-speed communications system between Washington and Paris, where the American Embassy is the major communication centre for many of its other embassies. From Paris links extend to other American embassies, consulates and legations as far afield as South, Western and Central Africa, the whole of Europe and east as far as Moscow, New Delhi and Karachi. A total of 58 other offices are linked with the Paris Embassy in this communications network.

To communicate with all these could only be achieved by an advanced electronic installation, capable of handling with the utmost accuracy a voluminous flow of messages in a complex pattern. In 1962 an automatic exchange system was installed in the American Embassy in Paris to fulfil this requirement. The system is flexible and can deal with an input ranging from high-speed electronic computers to the flow of messages by the relatively slow sixty-words-a-minute teleprinters. It sorts out messages of high and low priority and routes the most important communications immediately to their destinations. The lower priority messages are stored temporarily in either a magnetic core or a magnetic memory and these are retrieved and sent on in a fraction of a second as an outgoing line becomes available.

At the time of its installation in 1962 it was the first of such systems available for automatic sorting of world-wide communications. Its ability to receive, analyse, process, store, re-route and transmit messages

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305 Weather charts presenting meteorological information are broadcast round the world and received at meteorological stations. Here a facsimile chart broadcast from Moscow is received in an Indian meteorological station using a Mufax set. A scanning transmitter for broadcasting weather conditions in India to other parts of the world is seen on the left.

306 Radar display Console in operation at an international airport in India.

307 A high-speed facsimile network for the transmission of weather maps to 650 government, military and other stations in 330 cities began operating in 1963 for the United States Weather Bureau. The system transmits twice the number of weather maps daily at double the speed previously provided. Here a technician at the Weather Bureau's Centre in Suitland, Maryland, is shown receiving statistical information on a facsimile recorder for use in the hourly map forecasts. At his right are the transmitters over which finished maps are being sent to stations around the country.

and data gave the State Department of the United States of America an outstanding tool in the handling of its world-wide telecommunications. It replaced a great number of manual operators, and by its efficient use of available cable and radio links between the United States and Europe it saved the State Department a great deal of time and money. In the sphere of government telecommunications it set a new standard.

In industry the need for world-wide and rapid telecommunications is no less demanding than for governmental agencies. Decisions from a central headquarters may have to be transmitted by telephone or telex to executives either next door or at the other end of the world. Large international industrial concerns could not operate to-day without efficient telecommunications. As in many other fields, these are taken for granted and hardly given a second thought. Industry's profit motive has stimulated a great deal of scientific and technological research; in the present example it is the most efficient performance of oil tankers at sea that has led to a new device for the automatic telecommunication of data from sea to shore.

The problem investigated by Shell dealt with the performance of its tankers at sea. It had been known for a long time that a ship's performance at sea changes during the years as a result of the deterioration of its boilers and other machinery, the growth of organisms on the hull of the ship, corrosion and damage to the propellers. The only means of measuring the results of these changes up to 1964 required the ship to be taken out of service and to be put through tests over an accurately measured distance. This was an expensive and time-consuming procedure, complicated by the fact that for large tankers only two places were suitable for these measurements, one off Scotland, and the other off the coast of Malta.

It might be assumed that a constant watch could be kept on the performance of an oil tanker by analysing the entries in the ship's log book, but this approach was unsatisfactory for several reasons. Log books are only available when the ship is in port, and entries have been found inadequate and too inaccurate for statistical analysis. The whole aim of Shell's research project on the transmission and analysis of data was precision and speed.

The first task was the obtaining of precise data aboard an oil tanker during the normal course of its voyage. Instruments had to be developed, for example a torsion meter, to feed accurate data automatically into the radio transmitting equipment. The information collected by the data recording instruments, such as, for example, the relative speed of the ship to the water, the horse power on the propeller shaft, fuel consumption and other parameters up to a total of 42, was transferred to punched tape on board the ship.

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308 *The communications network of the United States State Department, as centred on Paris, built by I.T.T. It is displayed by means of a full colour, lit wall chart. From Paris many major United States embassies, legations and consulates throughout Europe, Africa and Asia are serviced with information and data.*

309 *IMP is a combination of a sensitive colour meter, the transmission of its reading by Telex and the feeding of this information into a computer. It is instrumental match prediction (IMP) which will allow a more rapid colour-matching service for textile and dyestuff manufacturers.*

310 *This electronic complex thinks for itself in automatically directing and speeding the intercompany communications of large industrial organisations. It can handle up to 1,000,000 bits of electronic information per second in processing data and routing messages to their destinations. Although the Automatic Data Exchange System, or ADX, as it is known, normally is not closely monitored, an employee might enter the room to make a manual change in its operating procedures as is being done here. It was installed at the Aluminum Company of Canada in Montreal in August, 1962.*

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311 *The Shell tanker S.S.* Sitala, *74,000 tons, built for the Société Maritime Shell, by Chantiers de l'Atlantique, St. Nazaire. Its performance is transmitted by telecommunications to a computer in London. This is an outstanding example of telecommunications research carried out by industry.*

312 *The Chief Engineer of the Shell tanker* Sitala *examining the information on the performance of his ship as printed on punched tape aboard the vessel.*

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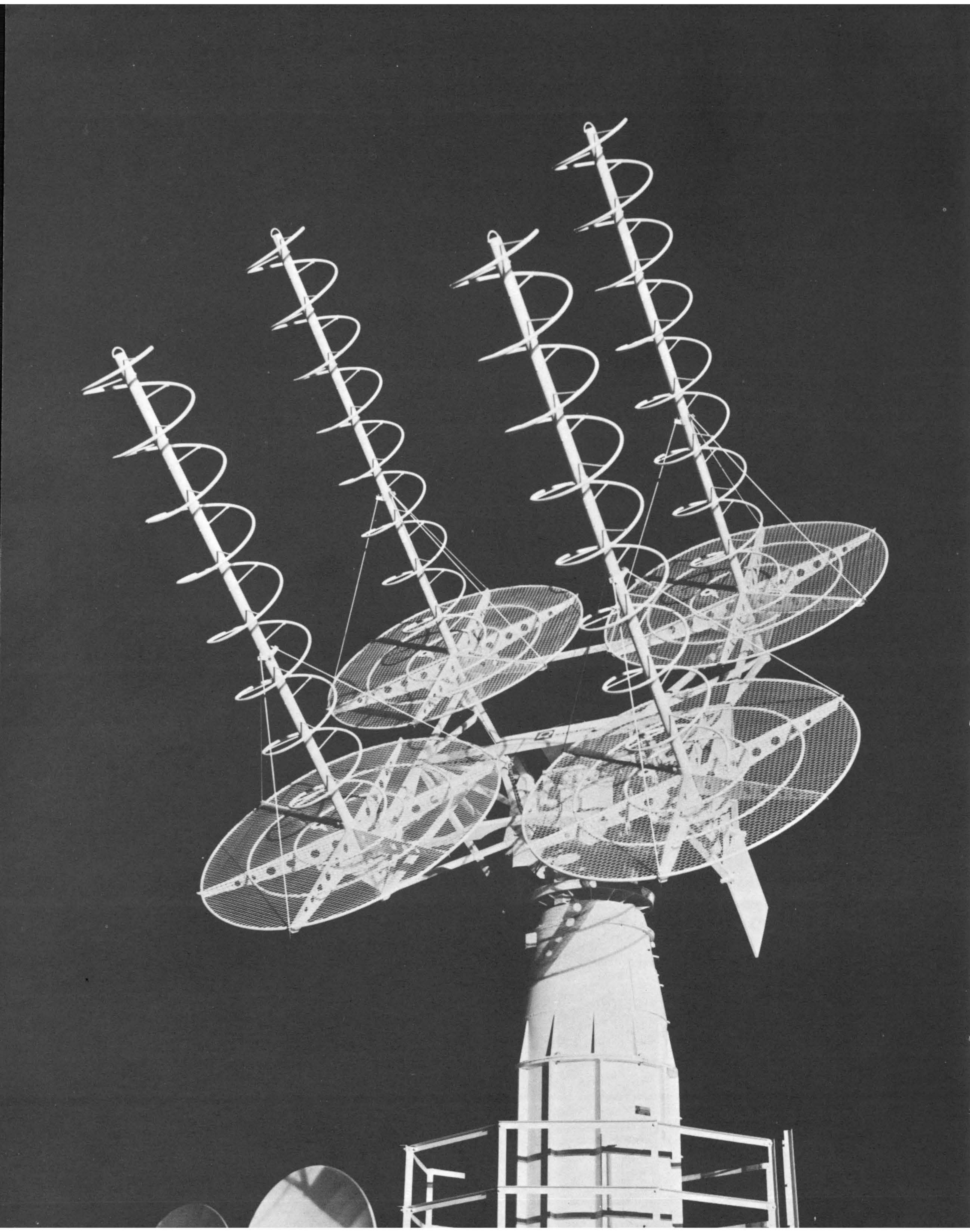
The information on this tape provides the signals that are sent by the ship's radio transmitter on wide band telegraphy channels directly to the Shell Centre in London, either through the network of the British General Post Office or the Dutch P.T.T. At the Shell Centre in London the incoming data punch out an identical tape and this is directly fed into a computer. There the performance of the ship can be analysed automatically even though it may well be on the other side of the world. Two major difficulties were present in this work. One, development of mathematical procedures for extracting from the raw data the information desired on the changes in the ship's performance. The second difficulty was to provide a radio link as free of errors as possible. Both these problems were solved and completed by the beginning of 1964.

This example of world-wide data transmission to check performance of ships at sea is but one instance of the ever-increasing use of existing telecommunications channels for the transmission of computer data. Recently one of the largest computer manufacturers established a special research laboratory to study the telecommunication of data to computers. It is most likely that in the decades to come existing communications channels, whether undersea cables, communications satellites or simple telephone circuits will find increasing use for this purpose. As computers learn to "communicate to each other" they will demand more and more accurate channels for their communications. This is the subject of a C.C.I.T.T. Study Group at present. These new channels will facilitate to an ever greater extent the world-wide exchange of information between individuals, organisations, industries and government departments.

Finally, one example of how telecommunications have brought about a very minor, but none the less interesting, development in communication between people. In many parts of the United States of America, children have found that the telephone is not only an instantaneous means of communication, but also a delightful tool for chatting to their friends. Having discovered this, they used their parents' telephone for hours at a time, in fact to such an extent that their parents found it impossible to use it themselves. One simple solution was the installation of a second telephone line to the home. These special "Children's Telephones" are now fairly common, and a special entry in the telephone directory gives this additional information under the name of the parent subscribers. Although it is unlikely that children's telephones will be copied on a world-wide scale, their existence shows that telecommunications have become an integral part of modern life, for both the old and the young.

313 *Transmitted by radio, the performance of the Shell tanker* Sitala *is received at the Shell Centre in London, and there delivered in the form of a tape identical to that produced on board the ship. The operator monitors the radio call and keeps a log of the circuit conditions, particularly of any errors recorded on the error detector machine.*

314 *Young people use the telephone as much, if not more than, grown-ups, at least in certain parts of the world to-day. From an original drawing by Dodie Masterman.*



Telecommunications in Space

When, in a few hundred years' time, the history of the present century is written, two outstanding scientific dates will be remembered long after the names of our present rulers, politicians, artists and architects have been forgotten. It was in Chicago on December 2, 1942 that the first atomic pile became critical, and it was on October 4, 1957 that the first artificial satellite launched by the Soviet Union orbited our planet. These two events heralded the atomic age and the space age. For man's future they are equivalent to the invention of fire and of the wheel.

Although it is quite possible that in a decade or so these two inventions may be used together as an atomic rocket drive, here we are concerned only with a small aspect of space technology, namely the relationship between radio and space communications. Nevertheless, three names must be recorded, the three outstanding pioneers of rocket technology. The first was a Russian, Konstantin Eduardovich Ziolkovsky (1857-1935) who published his first calculations on rocket propulsion in 1903. The second was Dr. Robert H. Goddard (1882-1945), Professor of Physics at Clark University, Worcester, Massachusetts, who in 1919 published a classic paper on rocket propulsion, and who was the first, in 1930, to launch a small liquid fuel propelled rocket into the atmosphere. The third was Dr. Hermann Oberth, born in 1894 in Austria; his classical book in 1923 laid the mathematical foundation for much of our present rocket technology.

World War II gave the first indication that liquid fuel rockets, using kerosine and liquid oxygen, were an engineering possibility. The first German V2 rockets fell on London in September 1944, but it took 13 years before this basic type of vehicle was sufficiently improved to launch *Sputnik I.* The bleeps of *Sputnik I*, the radio signals which were heard by a large part of the world, were the first proof that rocket technology could not exist without radio technology. Ever since then, and as far as one can see into the distant future, radio and space vehicles will be inseparable through the four functions of tracking, telemetry, command and control.

Tracking provides information on the location of a satellite, a deep space probe, or a manned rocket vehicle. Location is important for the scientist because he must correlate an event measured by the spacecraft with, for example, its distance from the Earth or the Moon. Location also must be known for guidance evaluation and correction, for re-entry and recovery of the spacecraft, and for other scientific analysis.

Telemetry is the remote measurement of events and conditions, ranging from an astronaut's blood pressure to the strength of the lunar gravitational field. The spacecraft's instruments react to an event. This reaction is transformed into a coded radio signal and transmitted back to earth. There it must be recognized as an information-bearing signal, recorded, decoded, and the resultant information made available to the scientist either in charts or tabulations.

Command means the use of a ground transmitter to send a coded radio signal to the space vehicle to order it to do certain things such as the starting of a camera, the firing of a rocket, or the starting and stopping of data transmissions.

Control is the ability to direct the spacecraft and the network of ground stations so that the desired mission can be carried out successfully. Some flights, such as manned space flight, require that all information be gathered and centrally displayed almost as quickly as they occur or in "real time". Others require that each ground station be able to inform the next as to the predicted spacecraft position on a subsequent orbit. Still others require control of telemetry sequences based on specific events such as solar flares or atmospheric storms. In the case of the United States National Aeronautics and Space Administration, NASA, its weather satellites *Tiros*, for example, are told by proper controls when to take pictures of storms and when to transmit the pictures to a station on the earth.

Let us now consider these four functions of telecommunications in some detail. NASA operates three ground tracking and data acquisition networks. The first, the Minitrack network, established during the International Geophysical Year of 1957-1958, efficiently tracked and gathered data transmitted from unmanned scientific satellites such as *Vanguard* and *Explorer*. The second, the Deep Space Tracking network, is equipped with powerful transmitters and sensitive receivers which can maintain contact with spacecraft travelling to the Moon and beyond. The third, the *Mercury* network, built to meet the specific requirements of Project *Mercury*, is capable of faster data handling and tracking than Minitrack.

Telemetry in its modern usage refers primarily to the utilization of radio to make measurements at a remote location and to transmit these measurements for reproduction at some nearby location. The information obtained may be in a form suitable for display on a cathode ray tube, for recording by cine camera or for insertion into data reduction equipment like computers. In unmanned space exploration, telemetry has helped to perfect the design of every vehicle by monitoring its performance during flight. When a

316

315 *This quad-helix command tracking antenna is located at Space Hill, Andover, Maine, and is part of the Bell System of Satellite Communications. This antenna locates the satellite, turns it on and off and receives telemetry data from it.*

316 *Tracking the manned spacecraft* Faith VII *on a world map demands specialized international telecommunications systems. Here the spacecraft has just passed over Zanzibar on its 16th orbit, as shown by the bright light on the world map. Tracking stations are shown on the map and the circle around them indicates their range.*

317

317 *Blockhouse 37, the command centre for launching* Saturn SA-5 *at Cape Kennedy. To this centre important data are fed by radio, television, telephone and telegraph prior to launching and while the rocket is orbiting. It is likely that in future rocket experiments of this kind these large-scale human operations will be taken over by electronic computers.*

318 MARINER II *Launched August 27, 1962.*

Orbital data: In orbit round the sun.

Mission: Venus fly-by. Achieved December 14, 1962 at range of 32,000 km from Venus while 57 million km from Earth.

Communication characteristics:

Receiver: 890 Mc/s.

Transmitter: 960 Mc/s 3 watts output, bit rate 33.3 or 8.3 bps.

Encoder: Three modes of operation encoding data from the various analogue and digital sources relating to both experiments and spacecraft performance. Mode I gives 48 analogue and 12 digital measurements. Mode II gives 50 scientific and 50 spacecraft measurements on scientific experiments.

Decoder: Accepts 12 real time and 3 stored commands.

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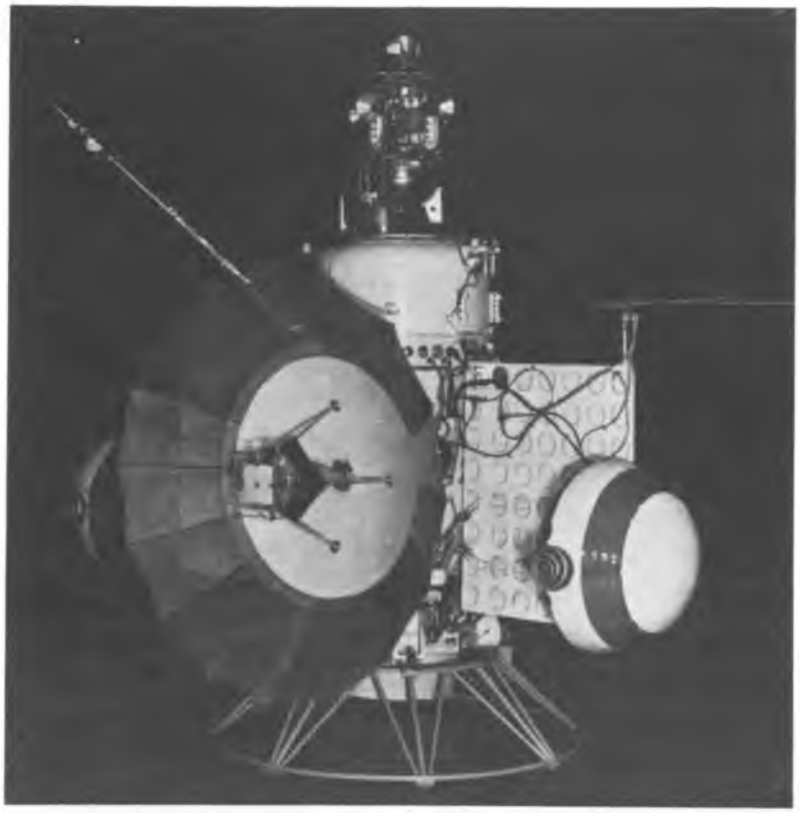

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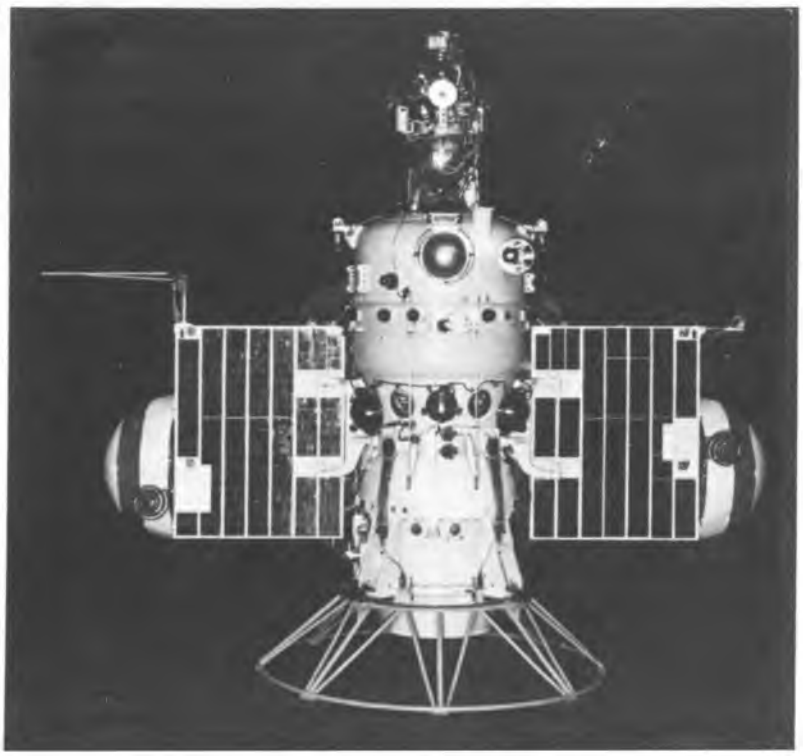


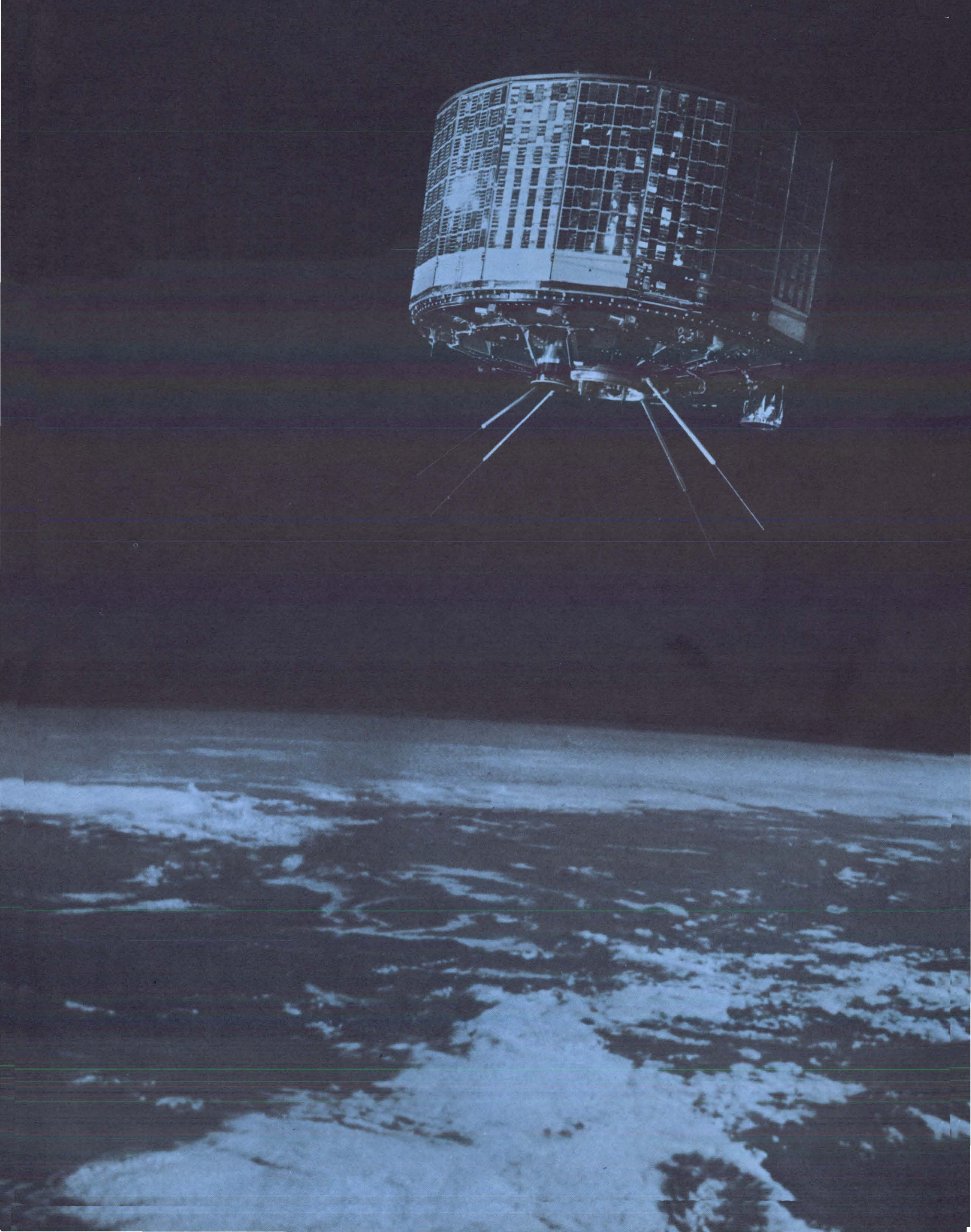
319-320 *Interplanetary station* Mars I *which was launched by the U.S.S.R. towards the planet Mars on November 1st, 1962.*

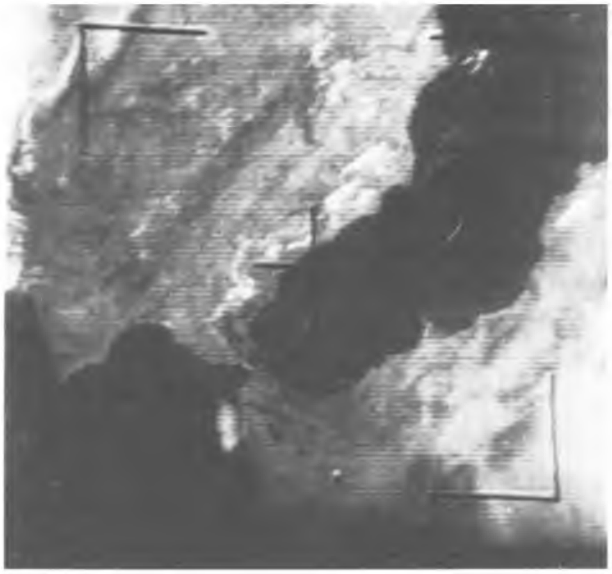
321 TIROS VIII *Launched December 21, 1963.*

Orbital data:
Apogee 750 km
Perigee 695 km
Period 99 minutes
Inclination 58.5°

Mission:
Devoted to development and utilization of satellites for observing basic meteorological processes.

Communication characteristics:
One television system including tape storage, 235 Mc/s transmitter
with output power of 2 watts.
One automatic picture transmission system to take cloud pictures and immediately broadcast the video information through a 137 Mc/s 5.5 watt transmitter.





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space vehicle fails, the data which have been telemetered back from its flight, however brief, tell the space scientist what went wrong. In manned flight, telemetered signals supplement the messages sent back by the astronaut and permit the use of complex computing equipment on the ground which would be much too heavy to carry in the space vehicle.

The power required to send telemetered signals from satellites and space probes is infinitely smaller than that required for commercial radio and television stations. So for example, signals of the five-watt transmitter of the U.S. *Pioneer V* were received on earth from a distance of 36 million kilometers. There are several reasons why such range can be achieved with so little power. One is that the space vehicle is always in line of sight with a receiving antenna. Electromagnetic waves (on which radio signals travel) are somewhat like light waves. They travel in a relatively straight line. Hence, while terrestrial transmissions are limited by the curvature of the earth and such obstructions as mountains, in space this is not a problem.

Also, the telemetry systems used for space communications have considerably better receivers and antenna than has the average radio listener. The 76-meter, 250-foot, parabolic antenna at Jodrell Bank, England, for example, can detect very minute signals, and has done so from both U.S. and U.S.S.R. spacecraft. The signals emitted by satellites and other spacecraft permit ground stations to track them with a high degree of accuracy.

Power for the transmitters may come from chemical batteries with varying periods of life, from solar cells (often with a very long life) or from other, atomic, power sources. A small nuclear generator, the U.S. *Snap*, has already been used for this purpose and probably offers the greatest promise of almost indefinite power at the moment. Ion power is, of course, another possibility but at the present is only in its early experimental stages.

Unmanned spacecraft may carry one or more transmitters, sending VHF or UHF signals. Manned spacecraft carry more varied transmitting equipment as a guarantee against practically any emergency. The first two manned *Mercury* flights, and the Soviet *Vostok* flight carried multiple communications systems. In *Mercury* there was ultra high frequency and high frequency for voice use, and there were two UHF telemetry links. In addition there was a separate emergency two-way voice system of UHF and HF transceivers. In *Vostok* there was a further television channel.

322 TIROS VI, *the United States weather satellite, took this picture showing Portugal, Spain, the Straits of Gibraltar, the Mediterranean Sea and Northern Morocco on its second orbit on September 18, 1962. Both television camera systems aboard the satellite were supplying pictures of excellent quality for operational use.*

323 *" Could it be those ' phone-in-the-sky communication satellites ' ? " Cartoon from the SPACE DIGEST, December, 1963. From an original drawing by J.G. Farris.*

323

To turn now to those satellites that are used for the telecommunication of messages. The actual idea of communicating outside the Earth proper, of which satellites are the first successful example, is much older than many realise. The first suggestion of this kind was made by one of the greatest mathematicians of all time, Karl Friedrich Gauss (1777-1855). He was of the opinion that there might be "intelligent inhabitants" on other neighbouring planets of our solar system, and that the only possible way of communicating with them was by the language of mathematical symbols. He seriously proposed to use the Siberian tundra as a blackboard large enough to draw on it mathematical concepts, as for example the proof of Pythagoras.

Gauss suggested that an outline of these symbols would have to be planted in dark pine forest, each line 15 km wide and for contrast that the interior of the triangle and of the three squares could be seeded with rye or wheat. Another astronomer, Littrow of Vienna, famous for his basic work on spectrography, followed up Gauss' suggestion with a similar idea. He intended to use the Sahara as his blackboard and to dig in it a large annular channel of 30 km in diameter. He then proposed to fill it with water and pour on to it kerosine enough to burn for six hours. This was to be ignited during the night, and followed on the next night by a square trench and a triangular trench on the third night. This regular succession of mathematical symbols would be enough, he thought, to convince inhabitants on other planets of our intelligence.

Needless to say, none of these schemes was ever carried into practice, and only with the launching of *Echo I* in 1960 was the first real step taken to use man-made equipment outside the atmosphere for communications.

Communication satellites can be considered to fall into two distinct categories, beginning with passive satellites which merely reflect signals beamed to them and act only as an artificial ionosphere. Secondly there are the active satellites which receive the incoming signal, change its frequency, and re-transmit it again suitably amplified. If the retransmitted signals were of the same frequency as the incoming signals then an oscillating loop would be set up between the output and the input antennae of the satellite.

Echo I was the first passive communications satellite put into orbit, on August 12, 1960; it was launched by NASA. Its 30-meter diameter sphere served well for a time, before it crinkled up again. But even before then, the U.S. Navy had used another, a natural satellite, for communication purposes between

Hawaii and Washington. Using two 25-meter diameter steerable radio-telescopes at either end, signals were bounced off the Moon, and received at the other end; this system could of course only be used when the Moon was above the horizon at both terminals.

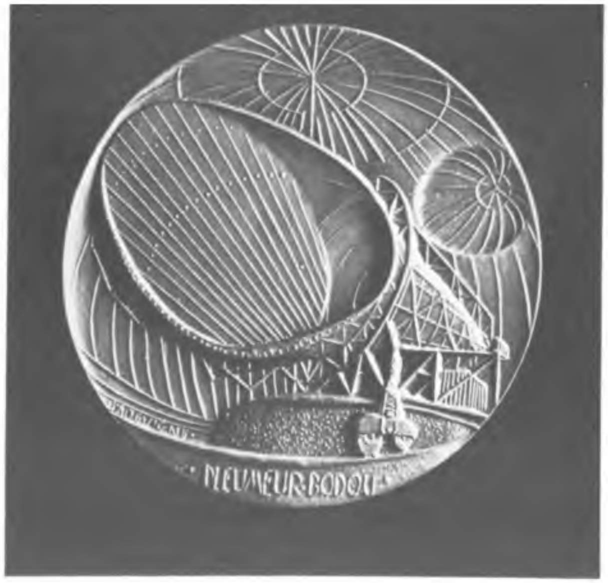
Echo II was launched also by NASA on January 25, 1964, its diameter being 41 meters; with it, scientific experiments were carried out by United States, British and Soviet engineers, working in close harmony. It was hoped that it would stay at its original diameter for a long time.

The first active communications satellite, *Telstar I*, was launched by NASA on July 10, 1962. It was a great engineering achievement of the Bell Telephone System, the private company which had designed, made and paid for the launching of *Telstar*. Within hours of launching, telephone conversations, television pictures and telephoto-microwave transmission had taken place from the Bell System earth antenna at Andover, Maine. Within the next few days, live television pictures crossed the Atlantic via *Telstar* and were received in France at Pleumeur-Bodou and in England at Goonhilly Downs in Cornwall. To many millions of Europeans and Americans *Telstar* had become the symbol of a new age, that of space telecommunications. The satellite was used for every conceivable test and even transmitted colour television pictures of a surgical operation; it failed permanently on February 21, 1963.

Relay I, similar in basic principles to *Telstar*, was launched on December 13, 1962; it performed an equally wide number of tests and experiments. It was used for television transmissions between Europe, South America, Japan and the United States. It was still working perfectly during January 1964.

One of the necessary requirements for almost all active and passive communications satellites is a steerable antenna at both the sending and receiving terminal. Furthermore, there is an additional need for complex computers to forecast accurately the times and positions when the satellite is above the horizon; only thus can the antennae be pointed on to it, during the relatively short time when the satellite is visible to both. To provide a continuous communication system with satellites of either the *Echo*, *Telstar* or *Relay* type requires that as soon as one of them ceases to be above the horizon for both earth stations a second satellite must appear to take its place. Systems using as many as eight or even twelve satellites of this type have been proposed.

There is however one further possibility, suggested as long ago as October 1945 by a British scientist, Arthur C. Clarke, in the journal *Wireless World*. He pointed out that if artificial satellites ever became



reality, then there would be one single orbit for such a satellite at a height of 42,000 kilometers above the earth's center, "and if its plane coincided with that of the earth's equator, it would revolve with the earth and would thus be stationary above the same spot on the planet. It would remain fixed in the sky of a whole hemisphere and unlike all other heavenly bodies, would neither rise nor set... Let us now suppose that such a station were built in this orbit. It could be provided with receiving and transmitting equipment and could act as a repeater to relay transmissions between any two points on the hemisphere beneath, using any frequency which will penetrate the ionosphere... A single station could only provide coverage for half the globe and for a world service three would be required, though more could be readily utilized."

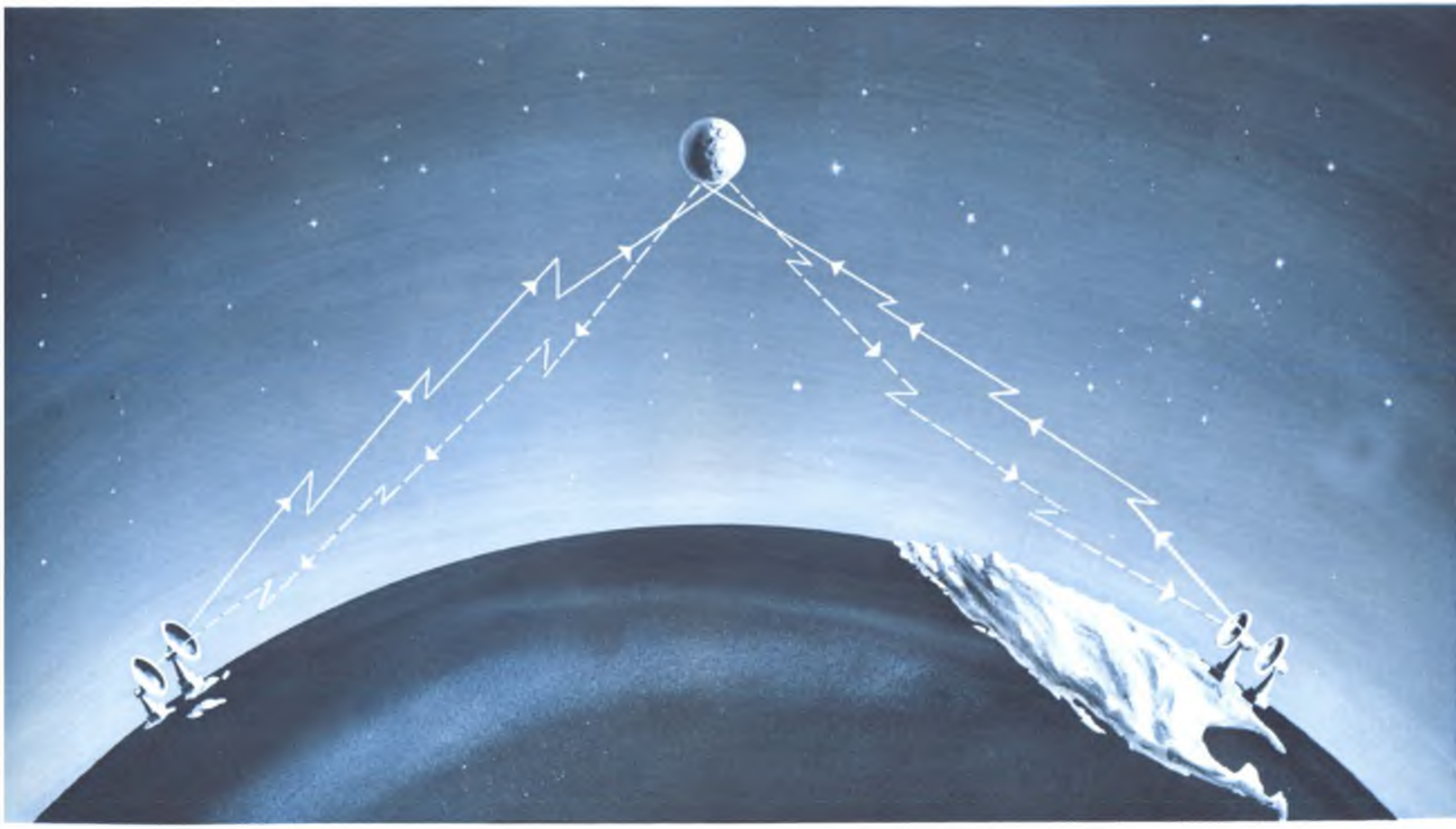
This orbit suggested by Clarke has now become known as the synchronous orbit, and *Syncom I*, the first satellite of this type, was launched by NASA on February 14, 1963; it went silent 20 seconds after ignition of its apogee motor. *Syncom II* followed it on July 26, 1963, and has worked perfectly, being used for telephone, teletype, and facsimile transmissions between Africa, Europe and the United States. The third synchronous satellite, *Syncom C*, was launched on August 19, 1964, and was able to transmit television pictures from Japan to the West Coast of the United States of America during the Olympic Games of that year.

The outstanding success of these early communication satellites, all of which were on a purely experimental basis, decided the United States Government to put the whole subject of communications satellites on to a commercial basis. An Act, The Communication Satellites Act of 1962, was passed through Congress. This Act set up the Communication Satellite Corporation in Washington, D.C., and charged it with the commercial development of communication satellites.

Official I.T.U. interest in outer space started in 1959 when the C.C.I.R. had its IXth Plenary Assembly in Los Angeles and set up a Study Group (S.G.IV) to deal with space communications. Later in 1959 the Administrative Radio Conference, in its Resolution No. 7, invited the C.C.I.R. to carry out certain studies relating to radio emissions from artificial satellites and other space vehicles. The Plenipotentiary Conference, in its Resolution No. 34, instructed the Secretary General to inform the United Nations and the other international organizations concerned of the decisions of the Administrative Radio Conference and of the technical studies being undertaken by the C.C.I.s. It accepted the recommendation of the Radio Conference that an Extraordinary Administrative Conference be held in 1963.

324 *The receiving antenna at Pleumeur-Bodou for satellite communications. It was constructed by the Bell Telephone Laboratories, and is similar to the one erected at Andover, Maine, U.S.A. To commemorate the first television transmission to France on July 11th and 12th, 1962, this medal was struck.*

325 *On January 28, 1960, the first regular telecommunications channel via a satellite was demonstrated to the public by the United States Navy. Using the moon as a reflector, one terminal was at Pearl Harbour and the other at Washington, D.C. Communication could only be effected between the terminals when the moon was above the horizon at both terminals. The channel was used only for United States Navy communications purposes.*



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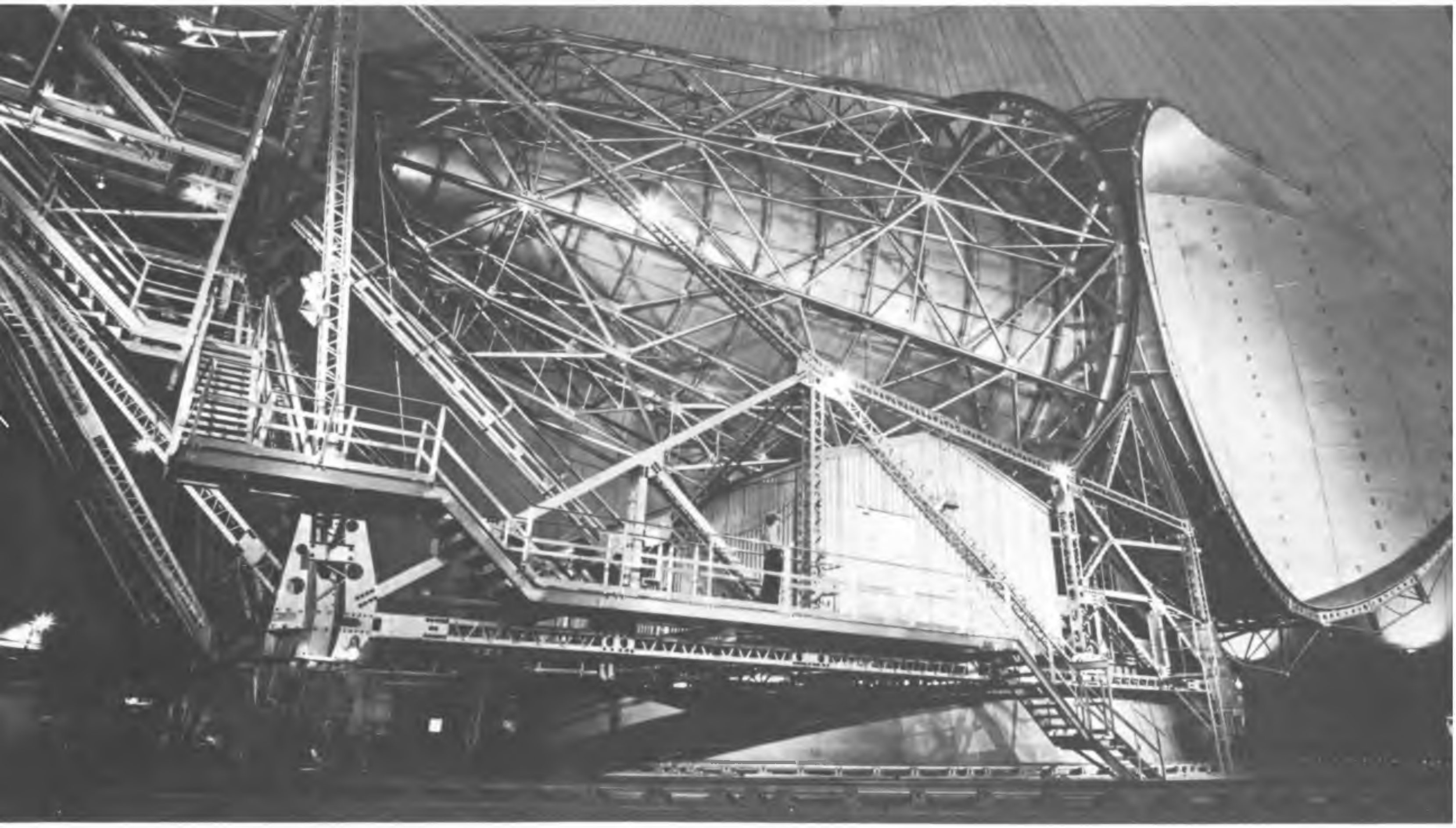
326 *Bell System's satellite communications antenna at Andover, Maine, is a huge horn reflector, 60 metres long, weighing 370 tons. It is a greatly enlarged and steerable version of similar antennas used for overland micro-wave radio.*
Bell Telephone Laboratories engineers used this antenna to carry out experiments in broadband communications via Telstar, *launched on July 10, 1962. Despite its size and weight, the horn antenna was built as rigidly and accurately as a fine watch. It tracked* Telstar *to within 1/20th of a degree, even when the satellite was at its apogee, 5600 km in space. The entire structure is covered with a Dacron and synthetic rubber radome to protect it from wind, stress, icing and rapid temperature changes.*



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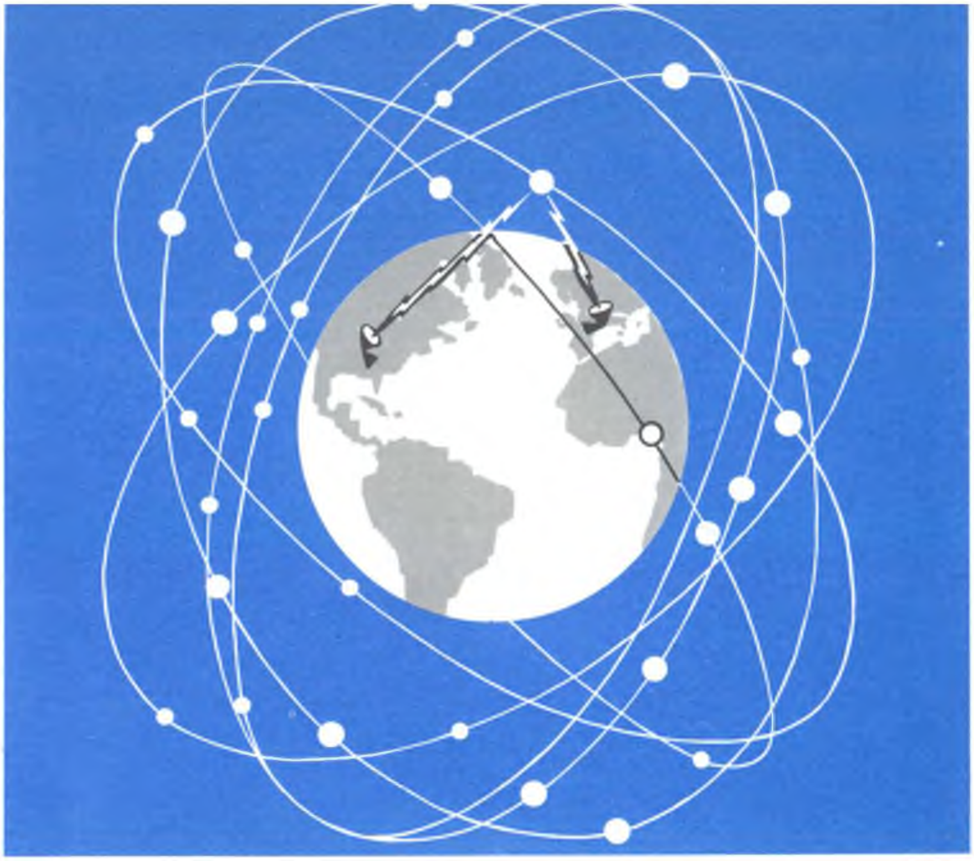
KEEP LEFT



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327 *The Goonhilly Downs aerial in Cornwall, England, which was used in 1962 to receive the signals transmitted by the artificial satellites* Telstar *and* Relay.

328 *Passive satellites of the* Echo *type and active satellites of the* Telstar *and* Relay *type, both types in relatively low orbits of several thousand kilometres would need to be numerous to give continuous and complete telecommunications coverage to the whole earth. The numbers have been variously estimated between ten and one hundred.*

329 *A transportable satellite receiving station, as first used in Germany on November 8, 1963. It was constructed by the International Telephone and Telegraph Corporation of New York and Standard Elektrik Lorenz, together with the Deutsche Bundespost. The diameter of the antenna is 9 metres, and it can make a complete revolution of 360° in 60 minutes in a wind velocity of up to 80 km per hour.*

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330 ECHO II *Launched January 25, 1964.*

Orbital data:
Apogee 1300 km
Perigee 1260 km
Period 111 minutes
Inclination 82°

Characteristics:
41 m diameter RF reflective sphere.
In orbit weight is 258 kgs.
Material: three layer sandwich of aluminium —mylar—aluminium 0.000018 mm thick.
Beacons: 2 beacons radiating 35 MW at 136.02 Mc/s and 136.17 Mc/s respectively. Telemeters skin temperature and balloon pressure.

This satellite remained smooth and spherical even after pressure had leaked out, thus retaining steady RF reflective characteristics indefinitely.

331 TELSTAR I *Launched July 10, 1962.*

Orbital data:
Apogee 6140 km
Perigee 960 km
Period 158 minutes
Inclination 44.8°

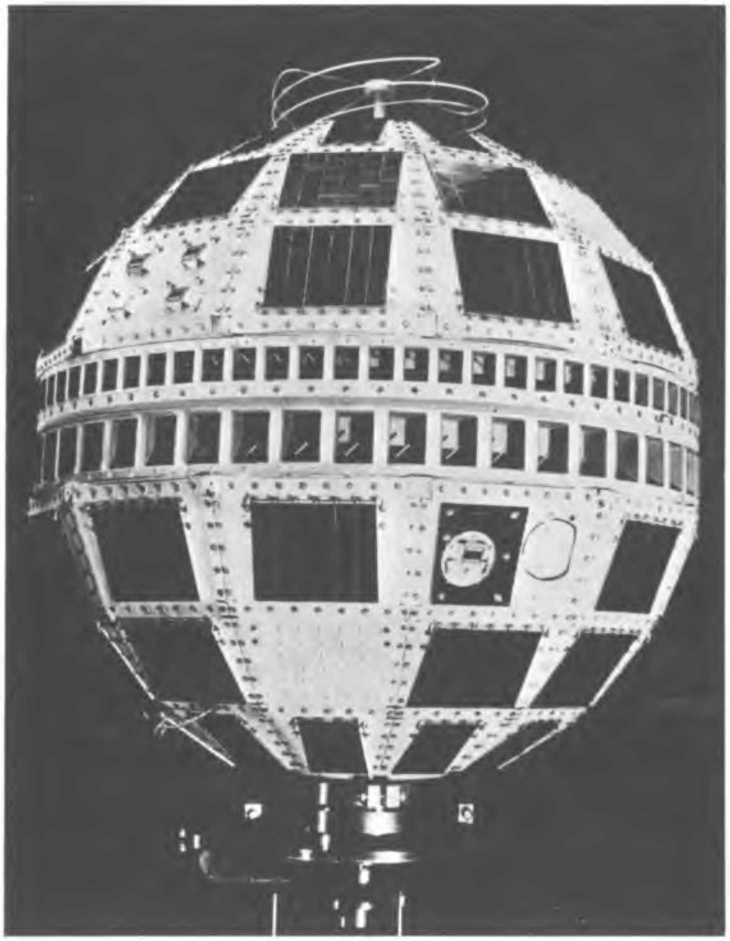
TELSTAR II *Launched May 7, 1963.*

Orbital data:
Apogee 10,000 km
Perigee 974 km
Period 225 minutes
Inclination 42.7°

Communication characteristics:
One wideband transponder RF bandwidth 50 Mc/s.
TWT power output 2.25 watts.
Frequency up 6390 Mc/s.
Frequency down 4170 Mc/s.

Telstar I *operated successfully from launch until command system malfunctioned November 23, 1962. Changed operational procedures revived satellite January 3, 1963. Failed permanently February 21, 1963.*

Telstar II *operated successfully from launch until July 16, 1963, when an unidentified failure caused it to cease operation. Returned to operation on August 12, 1963, and has been working ever since. Cause of failure has not been found.*
Both Telstar I *and* Telstar II *carried radiation and damage experiments to determine the effects and levels of particle radiation over the orbital path. This information has been of great value in finding radiation belts and providing information on damage to solar cells and transistors.*



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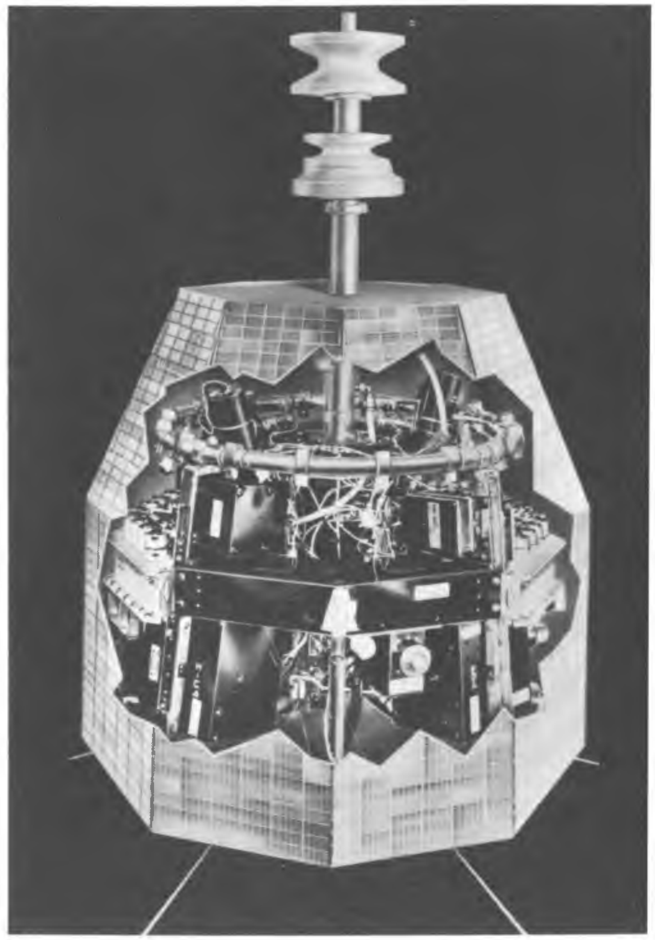

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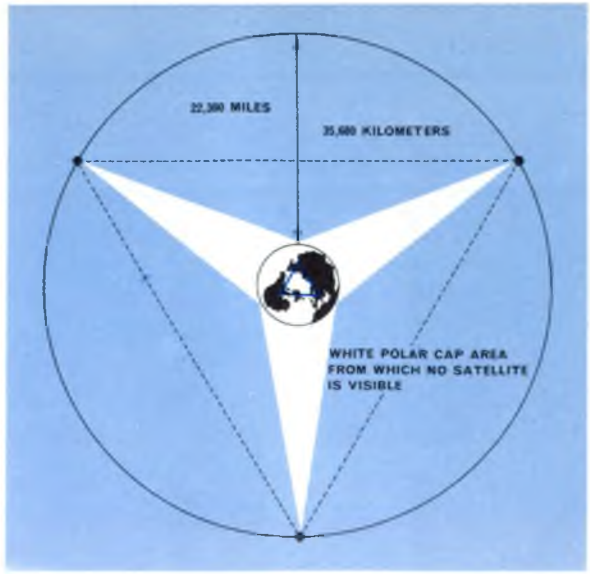
332 *A cut-away picture of the* Relay *communications satellite, showing its internal cruciform construction and the mounting of communications components and specialized equipment for space experiments. The television antenna at the base weighs only 1 kg.*



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This Conference met in Geneva for five weeks, from October 30 to November 8, 1963, and was an outstanding success. One of its highlights was a demonstration when Geneva in Switzerland was linked by television via the *Telstar II* satellite with the United Nations in New York City. Delegates and European viewers saw and heard the Secretary General of the United Nations speaking to members of the Conference from New York and American viewers heard and saw the Secretary General of the I.T.U. replying. The second demonstration was a telephone link via *Syncom II.* This took place during the Extraordinary Administrative Radio Conference and over 200 people representing 27 countries and 10 international organizations spoke over the satellite link. The telephone connection between Geneva and the United States was routed by land lines to Rota, Spain, where the U.S.N.S. *Kingsport* was anchored. The *Kingsport*, having complete satellite communication facilities, beamed the telephone conversations from the ship to *Syncom II*, some 36,000 kilometers from the earth's surface and then down to the U.S. ground station in Lakehurst, New Jersey. From Lakehurst, the telephone circuit was completed by land lines to New York and Washington. The usual comment from those persons using these satellite communications for the first time was that it was very satisfactory and at least equivalent to the usual long-distance telephone quality.

The final act of the Conference was signed on November 8, 1963. The main task of the Conference, which had been attended by more than 400 delegates from 70 I.T.U. Member Countries, had been the allocation of radio frequencies for outer space activities and the consequent partial revision of the Table of Frequency Allocations. This, the heart of the Radio Regulations, contains the basic provisions regarding the operation of radio throughout the world, and was last revised by the Geneva Radio Conference of 1959. The allocation of an adequate number of frequency bands for outer space had become an urgent task since then, due to the rapid growth of activity in space.

The Conference finally allocated, on a shared or exclusive basis, frequency bands totalling 6076.462 Mc/s for the various kinds of space services, 2800 Mc/s of which were for communication satellites on a shared basis with other services. Thus, while at the 1959 Conference only about 1 per cent of the allocated frequency spectrum was made available for outer space, about 15 per cent had by 1963 been made available.

333 *The synchronous orbit system which only requires three satellites (and perhaps a stand-by one for each) for world-wide telecommunications. Each satellite is placed above the equator at an altitude of 35,680 km orbiting eastwards at the same apparent speed as the earth, and would seem to stand motionless in the sky. Only the small areas over the North and South Poles are not covered by this system.*

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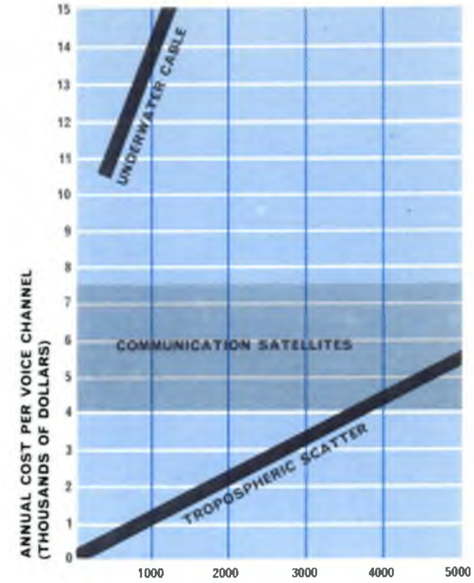

In addition, the Conference adopted a number of important Resolutions and Recommendations. One of these dealt with the future action to be taken by the I.T.U. in the light of developments in space radiocommunications. It recommended that Members and Associate Members of the Union make data available to the appropriate permanent organs of the I.T.U.; that the Administrative Council should annually review the progress of Administrations in space radiocommunications and should, in the light of this review, recommend the convening of a new Extraordinary Administrative Conference at a future date to work out further agreements for the International regulation of the use of the frequency bands allocated by the 1963 Conference; and that notification and registration of frequency assignments to space services should, until revised by this future conference, be in accordance with the procedures adopted by the 1963 Conference.

One of the most important Resolutions dealt with space vehicles in distress or emergency, noting that the frequency of 20.007 Mc/s had been designated by the Conference for this purpose and resolving that for the time being the distress signal used by ships or aircraft ($\overline{\text{SOS}}$ in radiotelegraphy and MAYDAY in radiotelephony) should also be used by spacecraft.

Another Recommendation was addressed to the International Radio Consultative Committee (C.C.I.R.) pointing out that " the use of satellite transmissions for direct reception by the general public of sound and television broadcasts may be possible in the future " and urging the C.C.I.R. to expedite its studies on the technical feasibility of broadcasting from satellites. Thus, a further important step had been taken towards the future possibility of the general public being able to receive radio and television programmes in their own homes direct from satellites.

A further Recommendation called on the I.T.U. Aeronautical Conference to provide high frequency channels (bands between 2850 kc/s-22 Mc/s) for communications for the routine flight of transport airspace vehicles flying between points of the earth's surface both within and beyond the major part of the atmosphere.

Finally a Recommendation was adopted recognizing " that all Members and Associate Members of the Union have an interest in and right to an equitable and rational use of frequency bands allocated for space communications " and recommending to all I.T.U. Members and Associate Member Countries " that the utilization and exploitation of the frequency spectrum for space communication be subject to

334 *Comparative costs of competing telecommunication systems.*

335

335 *The U.S.N.S.* Kingsport *is specially equipped to take part in satellite communications research programmes.*

336 SYNCOM I *Launched February 14, 1963.*

Orbital data:
Apogee 36,400 km
Perigee 35,200 km
Period 23 hours 44.8 minutes
Inclination 33.3°

SYNCOM II *Launched July 26, 1963.*

Orbital data:
Apogee 35,700 km
Perigee 35,690 km
Period 23 hours 55.9 minutes
Inclination 33.1°

Communication characteristics:
One wideband transponder 50 Mc/s.
One narrowband transponder two channels 500 kc/s each.
Power output 2 watts.
Frequency up 7.36 Gc/s.
Frequency down 1.82 Gc/s.

Syncom I *went silent 20 seconds after ignition of apogee motor. Orbit confirmed by optical sightings.*
Syncom II *was the world's first operating synchronous satellite. It has carried traffic of various types, including 2-way voice, teletype, and facsimile between the United States of America and Africa, and the United States and Europe, as well as television transmission between two United States stations in a special test.*

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international agreements based on principles of justice and equity permitting the use and sharing of allocated frequency bands in the mutual interest of all nations ".

When the I.T.U. celebrated its centenary in 1965, telecommunications in space had reached about the same stage as telegraphy had in 1844 or telephony in 1877. Extra-terrestrial relay stations had been proved, they had been demonstrated to the world, but they had not yet grown to a world-wide and economical system. There is little doubt that they will. Furthermore, there is no possible indication that the close links which have so far existed between rocket and radio will ever be dissolved. When, perhaps very soon, the first man sends his triumphant message from the surface of the Moon, he will be bound to let this message be carried back to his planet by radio waves. It is even possible that by then the light waves of a laser might be used.

337 *Sponsored by the International Telecommunication Union, a world conference on space communications opened in Geneva on October 7, 1963. More than 400 delegates from about 70 countries attended the five-week conference. Here is a general view of the conference room just before the meeting got under way. Television cameras and television receivers can be seen in the conference hall, which linked Geneva with the United Nations in New York. The Secretary-General of the United Nations, U Thant sent his opening greeting to the conference by means of a communications satellite.*

Conclusions
The Achievement of a Hundred Years

To-day the purposes of the International Telecommunication Union are clearly laid down in its Convention:

To maintain and extend international co-operation for the improvement and rational use of telecommunications of all kinds.

To promote the development of technical facilities and their most efficient operation with a view to improving the efficiency of telecommunication services, increasing their usefulness and making them, so far as possible, generally available to the public.

To harmonize the actions of nations in the attainment of these common ends.

Although never so clearly and precisely stated before, these purposes embody the achievements of the Union's hundred years' history. What were the reasons for its unique success of lengthy and productive international co-operation?

Above all others, telecommunications are a scientific commodity. As generation followed generation of delegates to the working meetings of the Union, they had one common background: they were scientists and engineers, and whatever country they represented, their basic education had been the same, imbued by the international spirit of science. We ourselves have seen in this very history how the invention of the telegraph, the telephone, and of radio, were not due to a single individual, nor a single nation, but were broadly based on the work of scientists and engineers from many different countries. This international spirit of science has been the unseen guardian angel of the Union which has slowly but surely directed all its work, throughout the hundred years, towards co-operation in ever wider fields of human activity.

The conferences, the real growing points of the Union, rarely dealt with the imponderables of the future. They confined themselves to the concrete scientific facts of the situation, which by definition, are susceptible to a concrete answer. In retrospect it is easy to see that it was one of the fundamental virtues of the Union that it has often been somewhat late in its decisions, and that it has never tried to forecast, nor to solve, future problems. Final decisions were often delayed, temporary compromises were adopted, then found to work, and became later the final regulations. The Union's history might indeed be considered a triumph of empiricism, a triumph of observation and experiment, and not of theory; as such it has strictly followed the precepts of scientific research.

338 *By Telex, words flash across continents, from keyboard to printer, bringing the instant messages needed in the speed of the modern age.*

339 *An important international telephone exchange. There are more than 150,000,000 telephone subscribers in the world, and the number is increasing every day. The fact that any one of them is able to call another outside his own country means that nations throughout the world must agree to co-operate in international organisation of their telecommunications.*

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340-341 *To ensure the safety of their passengers, the pilots of the thousands of aircraft that fly the world every day must be constantly in touch with the ground by radio.*

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342 *News broadcasts and television programmes. These are just two of the ways in which the limited number of radio frequencies around the earth are kept filled every day.*

343 *The news reaching the newspapers of the world is to a large extent transmitted by teletype over the telegraph networks of the Member administrations of the International Telecommunication Union. Here an operator is testing and receiving on March 6th, 1964, at Reuters, Fleet Street, London.*

343

Once a decision had been made, the inherent conservative character of all established organisations has kept it in being as long as possible. The validity of its usefulness was however measured against its performance, never against a promise, and if necessary the decision was changed when there was sufficient demand for a revision. This philosophy of slow and cautious advance can be seen as clearly in current committee discussions as it was present a hundred years ago. To take as an example the need to allocate radio frequencies in space. At the Conference concerned with this question in 1963, the view was expressed that the science of space communications was not sufficiently advanced to make regulations, as these would only hinder further scientific progress; yet some decisions had to be made, and were made. At the earliest Conferences of the International Telegraph Union in the middle of the last century, delegates were equally anxious not to standardise on any specific telegraph apparatus, as such a decision was then thought to hamper scientific progress in this new and rapidly expanding field.

The second major reason for the continuous success of the Union can be found in its attitude to its Members. What other international organisation, or for that matter what other club or group, allows its own Members to choose freely the amount of its annual subscription? Only the Universal Postal Union has followed the example of the I.T.U. from 1874 onwards. Yet this has been the I.T.U. basic financial principle now for 100 years, and it has worked well. The I.T.U. has never forced any Member to sign any convention or regulation, with which it did not wholeheartedly agree; attached to each, there are a number of exceptions and reservations made by Members who do not agree with points of detail, or who want to reserve their freedom of action. Yet such a reservation has never meant a disagreement in principle, and during its whole history not a single Member has ever resigned from the Union. Even the non-payment of many years' subscriptions, freely published in the annual report, has never deprived any Member of its voting rights or its participation in the work of the Union. This spirit of latitude and tolerance is then a further explanation for a hundred years of universal international co-operation.

The third factor is the very nature of telecommunications, seeking as their proper and profitable function to bring the greatest number of human beings into contact with one another. Thus each administration of each Member Country found it of benefit to handle telegrams destined to other countries, for which they could charge a handling fee, or to receive telegrams from abroad for which again they could charge. The same arguments applied later for telephone and for radio. International co-operation meant profits and more. It meant facilities, granted by neighbours on a reciprocal basis, without which telecommunications would have remained of purely local interest. The whole expansionist economic and political history of the 19th century was against such local tendencies, and once the 20th century got going, its overwhelming scientific and technological revolution forced an expansion of international co-operation onto the most unlikely fields, let alone such an essential one as telecommunications.

That the International Bureau at Berne has greatly contributed to the success of the Union is generally recognised. The Bureau, established in 1868, was the first permanent international organisation of its kind, and its strict neutrality in all political questions greatly enhanced its prestige. In this policy, it followed of course only the directions of the Conferences, but the lasting wisdom of this policy can only now be seen, after almost a hundred years.

With its established reputation of political impartiality, and knowing that the I.T.U. has no commercial or political interests whatsoever, the newly independent states turn without hesitation to the I.T.U. for technical advice and for the submission of names of suitable experts. It is no exaggeration to state that in this context the I.T.U. is now looked up to by the new or developing countries. This reputation of political impartiality has been laboriously built up, often at great cost and delay; it is the fourth reason for the I.T.U.'s hundred years of success.

Looking at this broad sweep of a hundred years' history, the international spirit of all scientific work, the tolerant attitude of the Union to its members, the expansionist nature of telecommunications themselves, and political impartiality, these can be considered as the major foundations for the I.T.U.'s success. Not included in this lofty view are the many frustrations which have occurred during the years, the avoidable delays and inefficiencies, and the inevitable disagreements which have taken place. This inescapable short-term vision which presents itself to certain members of the secretariat, many delegates to a Conference or any outsider, cannot be anything but critical. This is perfectly natural and highly desirable, because only through such constant criticism during the last hundred years has success been forged.

The urge to critical appraisal of the Union and of its secretariat is strongly reinforced by the speed of modern scientific progress. So for example, administrative procedures for publications are progressively adapted to take advantage of new techniques.

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The outward symbols of success are clear. The Union has completed a century of universal international co-operation, and during that time has gone from strength to strength, absorbing staggering scientific progress at the same rate as it occurred. It has survived two World Wars, during which its work was seriously slowed down, and has after each one risen to still greater heights.

But its success could also be measured in other terms. Each year, millions of messages pass across the man-made frontiers of our planet, either through the wires of the telegraph or the telephone, or by radio. Countless lives have been saved during the last hundred years, whether on land, at sea or in the air, by getting the right message to the right place in the shortest possible time. Fortunes have been made, and lost, millions of words are daily sent all round the globe, to newspapers and any telephone subscriber can now call almost any other owner of a telephone, anywhere else. These facts are taken for granted to-day and only rarely discussed. And yet they are the greatest compliment to the efficient working of the International Telecommunication Union, for without it, we would only have national communication networks and letters for messages. Much of our modern life would be impossible. Like clean water from a tap, we take efficient international telecommunications for granted, and this is perhaps the real measure of the achievement of the last hundred years.

344 *As the world telecommunication network grows daily vaster and more complex, its equipment reaches nearer and nearer towards technical perfection.*
Networks and equipment require international co-operation and standardisation.

The Social Effect of Telecommunications

In the air, at sea, or on land, telecommunications are to-day an essential part of modern life. The more technologically advanced countries show this tendency in the extreme, and most new and developing countries are anxious to achieve the same.

To-day, thanks to radio, all aeroplanes and ships are no longer isolated in the air or at sea. Many vehicles on land, those of the police, the armed services, ambulances, fire engines and numerous private cars and trucks have their own system of radiotelephony, if they have no radio for single-way reception. Wherever men and women congregate, in an office building, a stock exchange, a club or a University, in research laboratories, embassies, hospitals or hotels, in every factory or newspaper building, in an oil refinery or in a gold mine, there will be private telephone exchanges. Many calls will be of an internal or a local nature, but with the increasing interdependence of one country's economy with that of its neighbours, more and more telephone calls will be of an international nature. All available statistics prove that the demand for international telephone calls has increased constantly since the first international telephone line was installed.

The use of public telegraphy has declined since the beginning of the present century, but since the early 1930's, its place has been taken by Telex, which might well be called a private telegraph installation in home or office. Its instantaneous nature and permanent record have made it particularly valuable for commercial operations, and since its inception the number of internationally linked teleprinters has also been constantly on the increase. The phenomenal rise of broadcasting in the 1920's, exceeded only by the still steeper growth of television in the late 1950's and 1960's, is only a further proof that telecommunications follow closely the trend of scientific and technological progress.

And in all telecommunications, whether national or international, the I.T.U. has played its highly significant part. By laying down standards through its consultative committees, by allocating radio frequencies, by regulating telephone and telegraph traffic and charges across international borders, its constant and universal influence is felt. In this book, we have traced briefly the historical development of this influence, how it first was applied in telegraphy, then through the telephone and finally through radio and its diverse manifestations. It is only right and proper that we finally pose the question: What is the social effect of modern telecommunications on its millions of users. A historical study of this social effect or of the economic effect of telecommunications would require two further volumes.

345 *In 1865 the American nation mourned the assassination of President Abraham Lincoln. Then the news of the tragic event reached Europe and the rest of the world only weeks later as no Atlantic cable was in operation at the time. Illustrations of the body of President Lincoln at the City Hall in New York, as this one, were reproduced by engravings in the leading picture journals of the world.*

"Like other airport receptions, flowers for the ladies..."

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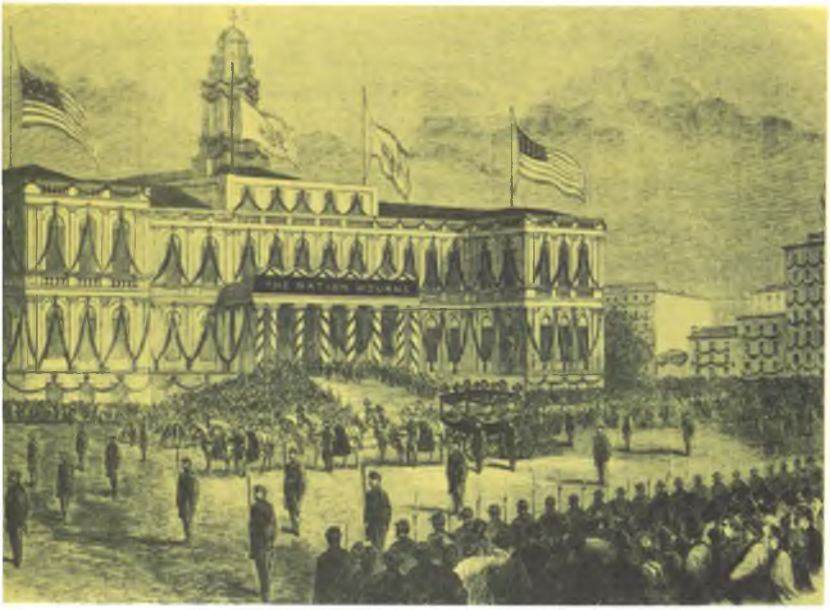


"... A loss that cannot be weighed... I ask for your help and God's..."

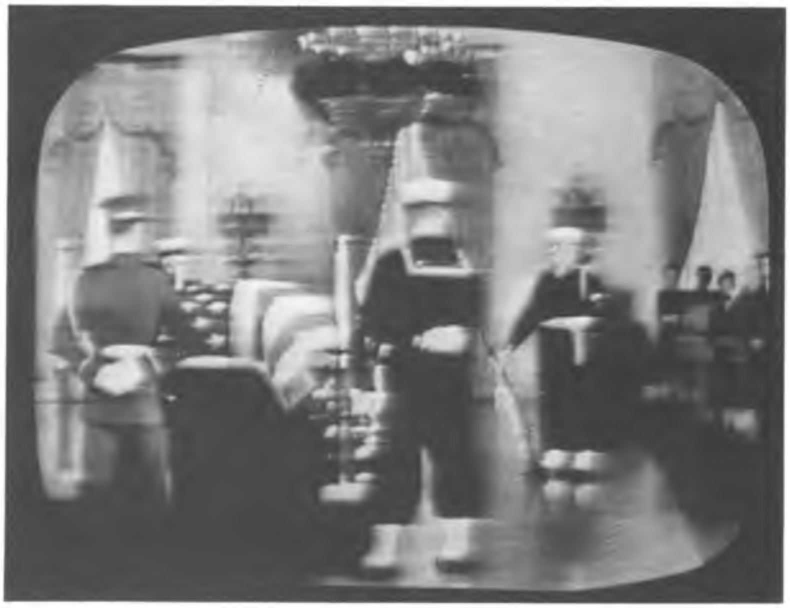
346 *In 1963 the assassination of John F. Kennedy was mourned by the world. News of the event were relayed via radio and television everywhere within minutes of its occurrence. When leaders from all over the world attended the funeral in Washington, television, relayed by communications satellite, to Europe and to the Soviet Union for the first time, allowed many millions to take part in the service and the funeral rites.*

346

"In the great rotunda the crowd kept filing past... they stood outside... a dark river stretching for as much as five miles..."

" President Johnson was sworn in at 2.38 p.m. Central Standard Time, aboard the Presidential plane..."

" The young widow rode with her husband..."



" Saturday at 4.30 p.m. the coffin was placed in the East Room of the White House... to remain all day..."

" The caisson, jet black, moving silently, drawn by six grey horses followed by the riderless black horse... symbol of the fallen warrior..."

" Mrs. Kennedy and her daughter kneel at the casket."

" And so this stately, magnificent funeral procession has passed the Lincoln Memorial and moves across the Potomac River... towards the final resting place."

347 *An early street telephone box in Chicago, 1893, showing a policeman calling for aid after a street accident.*

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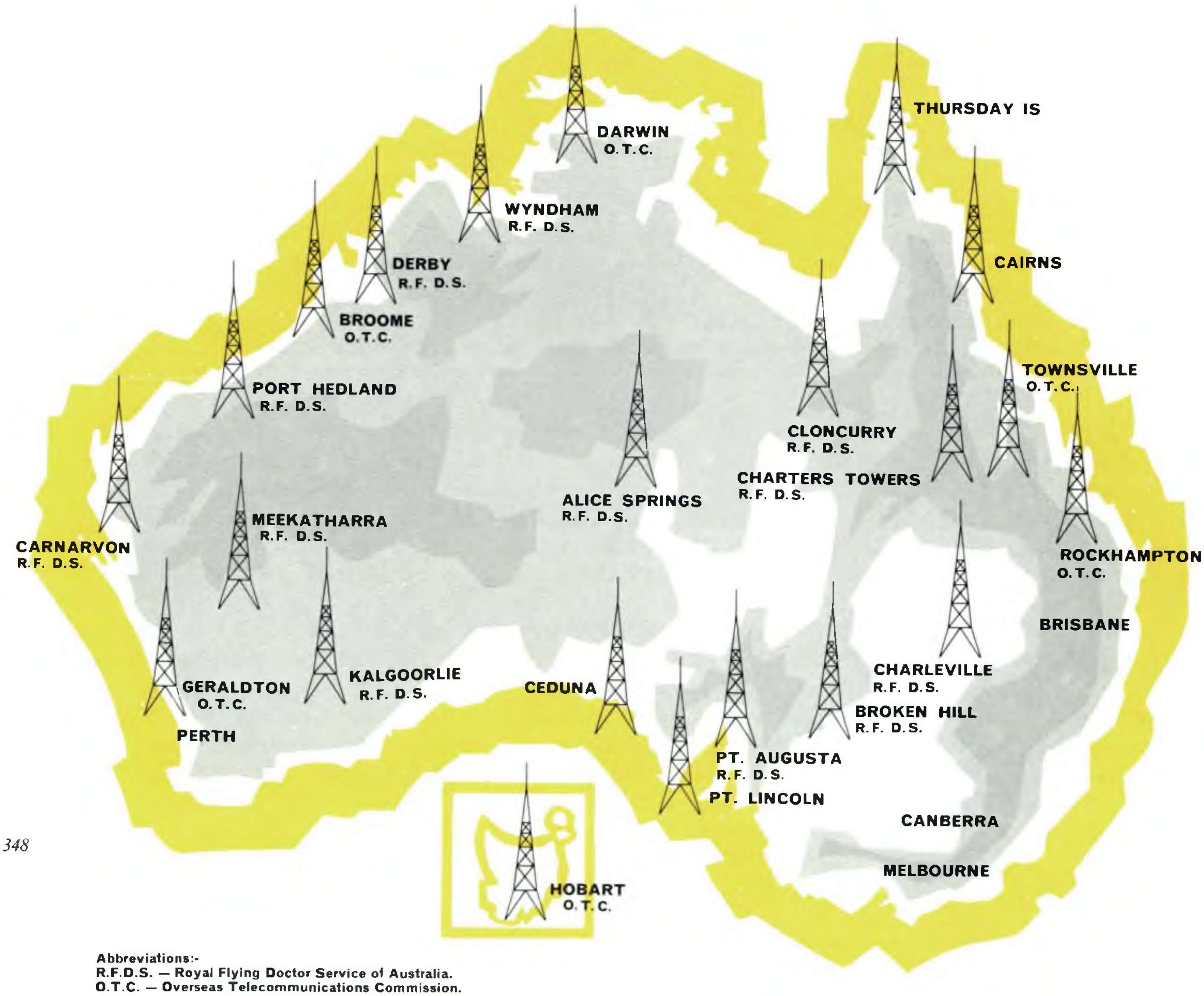
348 *To-day almost all isolated stations in Australia's outback have a radio-communications set. This map, based on information from the Radio Branch of the Telecommunications Division, Postmaster General's Department in Melbourne, shows only the major stations in constant communication with hundreds of local stations. The use of this network may vary from the casual chit-chat between two lonely women to emergency calls to the Royal Flying Doctor Service bringing rapid help in case of need. Radio has probably meant more to these isolated families than any other benefit of modern technology. It has kept them in constant touch with other human beings. This was not always so, and particularly in the beginning, when the first radio sets were introduced in 1929, the primitive equipment of those days often led to breakdowns which sometimes had tragic consequences.*



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Abbreviations:-
R.F.D.S. — Royal Flying Doctor Service of Australia.
O.T.C. — Overseas Telecommunications Commission.

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Every message sent by telegraph, every word spoken over the telephone, or broadcast by sound, and every picture sent by television, must have both a sender and a recipient. And every message sent produces an effect on the recipient. This may be good news of a personal and private character, or it may be a statistical fact on which a business operation can be planned, or it may be a television educational programme of a scientific nature. The recipient is bound to be influenced by the messages he receives, and if these messages are sent daily by the million they have a widespread and a cumulative influence.

They produce a social effect. This of course will vary. Doctors the world over would find it difficult to work without a telephone. Newspapers could not bring up-to-the-minute news without telegraphy and airlines could not be operated regularly and safely without constant use of radio links. Efficient medical services, rapid dissemination of news, and good transport have a marked social influence on the community. These instances could be multiplied indefinitely.

Here we must also distinguish between "private" and "broadcast" telecommunications. There can be no doubt that private messages, by telephone, telegram and teleprinter, have had a beneficial social effect. Rapid, if not instantaneous, private communications are to-day taken for granted, and any telephone user can get into touch with almost any other, wherever he may be on this earth. This fact alone has led to a vast exchange of views, opinions and information. It has helped the recipient in such mundane matters as planning his private affairs, and it has given the statesman the possibility of settling differences with other countries. Even if the message has an intrinsically disturbing content, the ability to convey it instantaneously may give time to plan counter-measures. Every day hundreds of traffic accidents occur. The rapid transmission of their location by radiotelephony will bring police and ambulance services to the rescue.

The social effect of "broadcast" telecommunication, by sound or television, has so far been beneficial but also to a certain extent detrimental. And in this category we must include the sending of private telecommunications for public dissemination, such as press telegrams to newspapers and press agencies. The press, sound broadcasting and television have undoubtedly been of infinite benefit to the public. Above all, they have brought people in different parts of the world closer together, showing their home life, their work, their pleasures and troubles. This exchange has not been without its deep social effect, and has often extended further into the political realm.

349 *Flying Doctor Service in Australia. Originally it was necessary to produce electric current as cheaply as possible, and the first "pedal" transmitters were powered by the machine shown here together with its radio transmitting equipment. No. 1 of this type was installed at a sheep station at Augustus Downs on the 19th June 1929.*

To lonely and elderly people a radio or television set is often the only link with the outside world. This is entirely due to efficient telecommunications, both in the national and the international range. In the fields of culture and education, the contributions of radio and television have also been immense. Standards of taste and values have been raised, but have sometimes led to uniformity of speech, by the loss of local dialects, and to uniformity of personal belongings, partly through the powerful advertisements on television. There is at present a great deal of sociological research to determine if these effects can be considered as beneficial or as detrimental to the culture in which they occur. Neither Intervision, the Eastern European television network, nor Eurovision, its Western European counterpart, have so far carried advertisements on their international television links.

There are other aspects of social welfare where radio and television have brought together people from different parts of the world. School education is perhaps the most important aspect, showing programmes of a scientific nature, and explaining the international co-operation of scientists in their research work. Then there are many other school programmes which set out to explain in detail the habits and customs of other nations. The growth in popularity of classical music or of modern art, by composers, painters and sculptors of many different nationalities has done much to break down cultural barriers between nations. The teaching of foreign languages by radio, the viewing of international sports events like the Olympic Games on television, the almost worldwide participation in such rare public functions as a Coronation ceremony, the inauguration or even the assassination of a President, all these have had a tremendous social influence, leading to an acute awareness of foreign affairs.

But at the same time, this very close proximity of foreign affairs to your own home, whether they enter through the newspaper, the radio or through television, has demanded an adult approach and an international understanding that is only just beginning. Politicians who are using television for their political statements are finding that this medium reaches millions effectively but shows them to their audience bare and bereft of the usual outward symbols of power; their sincerity is thus put to a stringent test. Similarly in foreign affairs, when news pictures show the stark reality on television, the true facts of the situation may become clear and bring about a conflict with established or pre-conceived concepts. Just as a social conscience was aroused during the last century by exposing conditions in factories, so to-day a "foreign conscience" is beginning to form by seeing for oneself the conditions in the new and developing countries.

350-352 *Teaching by television, particularly of science, is being widely developed in the more advanced countries. An interesting example is the use of aircraft to ensure a wide range of reception of these school television broadcasts. The television programme is produced in a studio in Cincinnati, Ohio, and the Midwest Programme on Airborne Television Instruction is relayed by the broadcasting plane flying a figure-of-eight, 5½ hours a day over the flat Indiana landscape. Technicians inside the plane monitor the lesson which is received as for example by the Ballardsville School.*

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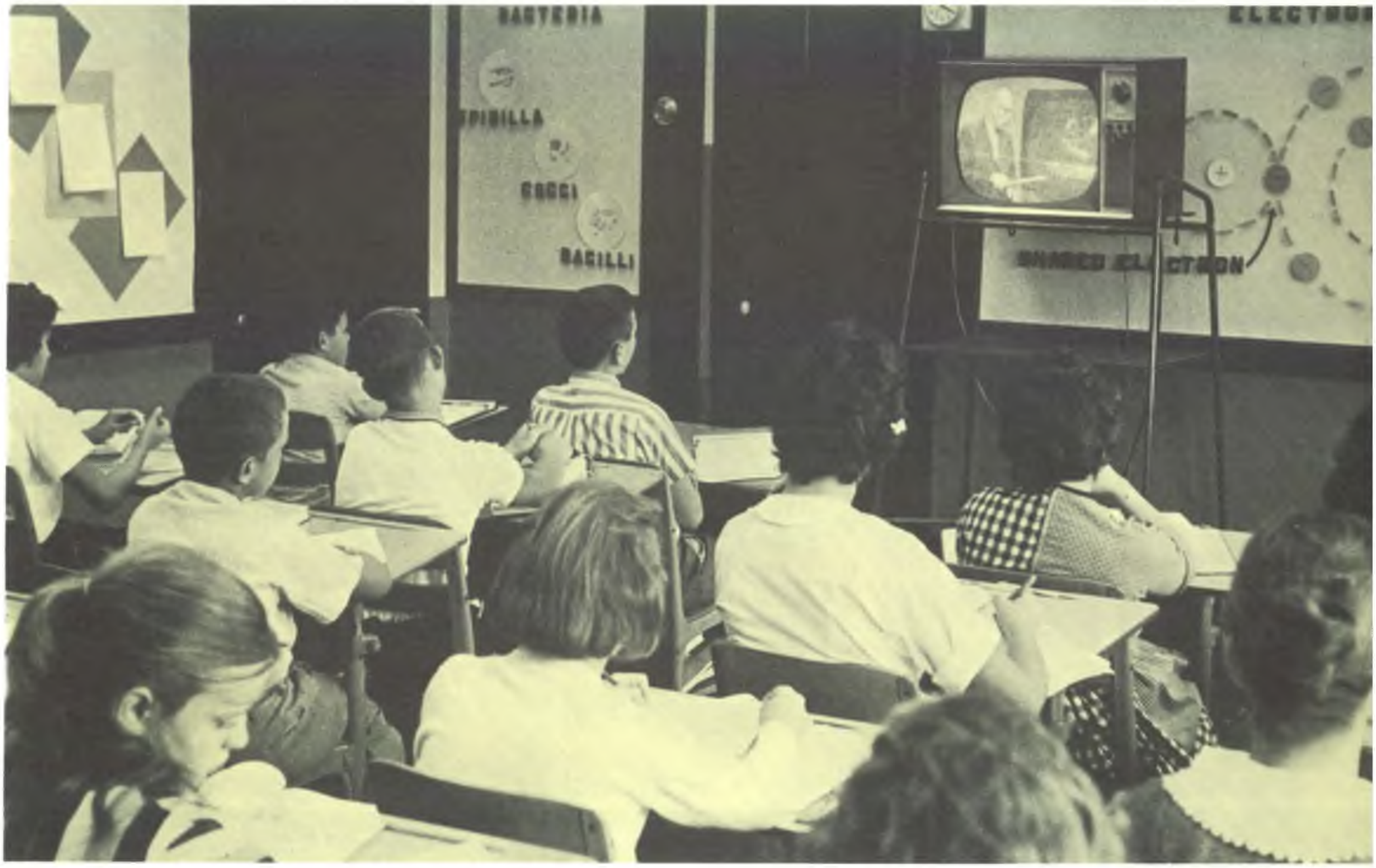

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353 *Telephone kiosk constructed from stainless steel, in a Paris street, 1955.*

354 *Mobile communications by means of a direct-dialling telephone is now a relatively simple installation in many countries. The present model MT 600, built by the International Telephone and Telegraph Corporation has a range up to 80 km and it looks and works very much like the telephone installation at home. It is here demonstrated in Dallas, Texas, U.S.A.*

355 *The social effects of installing a telephone.*

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"To me, it isn't just installing a phone, Lou. It's giving one human being a means of reaching out to other human beings."

Hunger in one country is no longer a national worry, it has through telecommunications become an international concern.

This realisation amongst the older nations that they are indeed "their brother's keeper" has led to a great deal of action, and in so far as it is concerned with telecommunications, we have already discussed it. But the increased tempo of modern life, largely due to efficient national and international telecommunications, has brought with it great demands on the individual recipient of its messages. To absorb, retain and digest the constant stream of information needs a mental background and an understanding which is often absent. Or worse, when present, it may break down and lead to an inability to handle the situation in a healthy and normal manner. Much mental illness is blamed on the rapid tempo of our life, and telecommunications cannot escape its share. But here again, telecommunications have also had a beneficial answer to offer. In certain European cities there is now a telephone service, available for 24 hours, which those in mental distress can dial. A qualified social worker is ready to give advice and counsel, to dissuade the potential suicide, and to pass on information about qualified medical and mental help to the sufferer.

Apart then from this aspect, the social effect of telecommunications has been wholly beneficial. If we believe that close international understanding amongst people is an essential part of progress then the contribution of telecommunication towards it has been outstanding. And with the continued growth of international communications by overland line, submarine cable and by radio, and even by satellite, there is certainty that more people will know more about their neighbours far and near. If this trend is allowed to continue undisturbed, beneficial effects for the whole of mankind are bound to follow.

One further aspect of the social effects of television must be considered, particularly when it has become world-wide through communication satellites. We have seen how it has made an overwhelming impact on national politics by creating a new class of politicians, who must at the same time be also acceptable as television personalities. When United Nations debates in the General Assembly and in the Security Council become visible to the whole of mankind, then a further step will have been taken towards universal peace and progress. World-wide television will also have a tremendous social impact on education, when teaching programmes from one country can be shown in other countries; although many of these will be recorded on film or tape, their dissemination to world audiences of young people will bring about more common understanding than any other channels of international telecommunications.

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356 *Electronic telephone exchange using the E-A-X system. This equipment operates on a time division basis and provides the logic and memory equipment for receiving and sending telephone switching instructions.*

The Future

All predictions of a short-term nature are dangerous, because they might easily be proved wrong. Forecasts dealing with a longer period of time cannot be checked and thus take away from both reader and author the pleasure of verification. Nevertheless, it is possible to see certain trends in the scientific development of telecommunications. The future of the I.T.U. itself can be forecast with considerable certainty.

One of the most interesting developments of the future is already occurring in the field of the telephone. It is likely that during the next decades the familiar dial will be replaced by push-button selection on a worldwide scale, working more quietly, efficiently, and giving rise to fewer mistakes. It will be sincerely hoped by all, that international co-operation will ensure that only one single pattern will be adopted by all the countries in the world, while they are at present still in the early development stages.

Plans are already being implemented to install direct automatic dialling between subscribers, not only from country to country, but also from continent to continent, and finally, across the whole world. This is perfectly possible theoretically, but will require much work, especially by the I.T.U., to bring it to fruition. In some countries many telephone calls, although they could be dialled, still require the intervention of a human operator. As time goes on these manual services will no doubt be replaced by new automatic exchange facilities.

Another exciting new development in the telephone field will be the extension of TASI, the acronym for Time Assignment Speech Interpolation. This has already proved its worth on transatlantic telephone cables, and consists of sampling, in time, a telephone conversation many thousand times a second. When telephoning, a speaker only takes up about 40% of the time and is silent for the remaining 60%. By fast electronic switching it is possible to use the silent time for other telephone conversations. TASI will bring about a great economy in frequency bandwidth in ordinary telephone services when it is introduced during the next decades.

Pulse Code Modulation, PCM, is another kind of sampling. Here the human speech is translated into binary code and transmitted as such over telephone wires. As this is a very rugged method of transmission, it is not affected by background noise and hence constitutes a great advantage.

Many other electronic improvements are about to come into operation. One of these is miniaturization, which will help not only telephones, but also radio and television. A radio receiver the size of a

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wristwatch may soon become a reality, and small portable television receivers are already on the market. Further extensive use of transistors will also help in the laying of submarine cables, where at present their repeaters use radio valves. It is confidently expected that before the end of the present decade the first transistorized transatlantic cable will be in existence, with 700 simultaneous telephone conversations. All these developments are only examples of the extension of present knowledge, already in an advanced stage of testing.

But there are many other, even more exciting, possibilities in the field of telecommunications, so far only at the stage of scientific experiment. Perhaps the most interesting of these is the use of waveguides for the transmission of numerous communication channels. A 5 cm diameter steel pipe filled with nitrogen can transmit 100,000 simultaneous telephone conversations, or a hundred television channels, at the same time. A pipe of this kind is not easy to manufacture, and because it must be laid in a perfectly straight line, it is difficult to install. Moreover, the very nature of transmitting so many simultaneous conversations will present a difficulty in their use. There are at present few locations where their maximum capability can be employed. But no doubt the ever-increasing demands for communication channels will find waveguides ready, when they are needed.

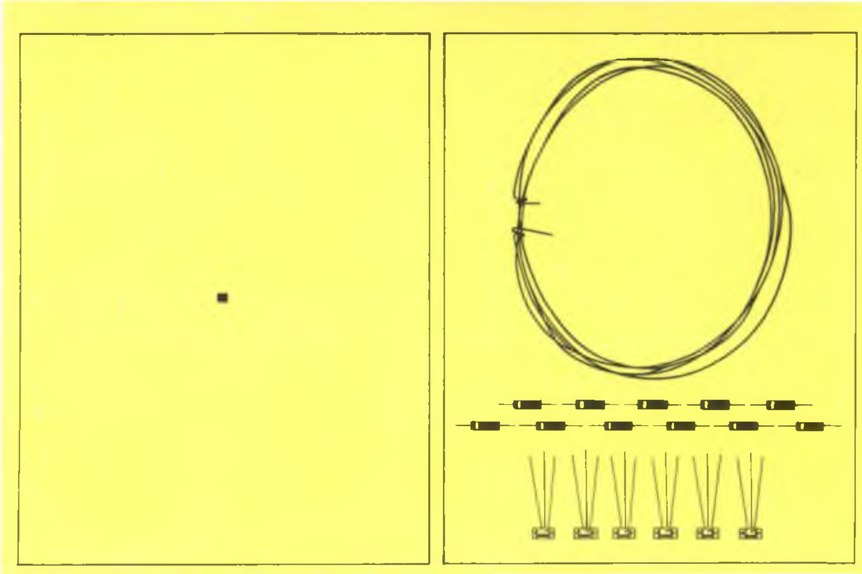
The telecommunication of data between computers is another example of a new technique just beginning to be utilized. Here the problem is one of translation. This can be done by means of amplitude, frequency, or phase modulation. There is no doubt that computers will " communicate " to each other to a great extent in the future.

A fascinating future application of existing facilities is a simple combination of electric typewriter and telephone. With both these available by the millions, and standing side by side on many office desks, only a little more ingenuity and additional equipment would be needed to permit electric typewriters to " write " to each other. This would eliminate a large fraction of present day business mail, and most of this " writing " could be done at night and at accelerated speeds. In fact, there is no basic reason why telex should not become as universal as the telephone before the end of the present century.

There are innumerable further applications of telecommunication techniques which one can suggest, and here two original ideas proposed by Hugo Gernsback, the well-known American electronics engineer, deserve mention. One is the " instant newspaper " continuously transmitted by radio directly to the reader.

357 *Push-button telephones are now being experimented with in many countries. Here, one produced by Shipton Automatic Limited, London, is being tried out in 1964.*

358 *Micro-miniaturization. The integrated circuit, right, replaces the transistorised components.*



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All the practical facilities for the transmission and reception of it are in existence to-day. His second suggestion is concerned with the field of medicine and the extension of the techniques of telemetry. It has already been possible to monitor the body functions, such as the heart beat, pulse rate and temperature of an astronaut orbiting the earth, and transmit these variables by radio to earth. Gernsback suggested that this system could find far wider application and would allow busy doctors to keep a check on many hundreds of patients simultaneously. All that would be required of the patient would be to wear an electronic wrist transmitter no larger than a watch which would by radio transmit to the doctor medical information.

However, the most exciting developments in all telecommunications will undoubtedly occur in space. With the excellent success so far achieved by *Telstar*, *Relay* and *Syncom* it can be predicted with a fair degree of certainty that many more telecommunications satellites will be in orbit during the next decades. While a synchronous orbit of 42,000 km above the centre of the earth might well be chosen in the end, because the number of satellites in orbit is smaller than with those in a closer orbit, the delay due to the lengthy travel of the signals when more than one re-transmission is employed may well be a factor against it. On the other hand, however, synchronous satellites will permit the public at large to receive in their own homes the signals emanating from them with appropriate simple receivers. With all closer orbits large steerable antennae are required, and these greatly increase the cost of communications and transmissions.

Finally, we might well stand at the brink of a telecommunications revolution as fundamental as the invention of radio. Lasers, at present still research tools in scientific laboratories, are opening up a vast new field of the electromagnetic spectrum for telecommunications, and thus with one stroke are removing one of the greatest difficulties which has faced the I.T.U. during its second half-century of existence. The allocation of radio frequencies for ever-increasing needs has undoubtedly been one of its major problems, but also one of the major successes.

The word "Laser" is derived from *L*ight *A*mplification by *S*timulated *E*mission of *R*adiation. They were preceded by Masers, (*M*icrowave *A*mplification by *S*timulated *E*mission of *R*adiation) described by N.G. Bassov and A. M. Prokhorov of the U.S.S.R. first in 1954 and in 1955 in the U.S.A. by J. P. Gordon, H. J. Ziegler and C. H. Townes, who gave the name Maser to this new device. A Laser produces a

359 This may be the switching plus transmission system of 1980. This consolidation seems to promise substantial economies in the cost of future telephone plant. The system is presently embodied in an experimental solid-state exchange, still in the research department. Each line to the central office will serve perhaps 50 phones, and up to 24 phones will be able to use the line at one time. This is accomplished by the "concentrator", left, which samples the voice signals on a series of lines (here only three), converts the signals into a digital code ("pulse code modulation"), and feeds the new signals through the line in tightly spaced sequence. Each voice signal is sampled 8000 times a second. The big trick is to see that when the pulses of speaker A reach the central office they are connected to the proper line and that an instant later B's pulses are connected properly, and so on.

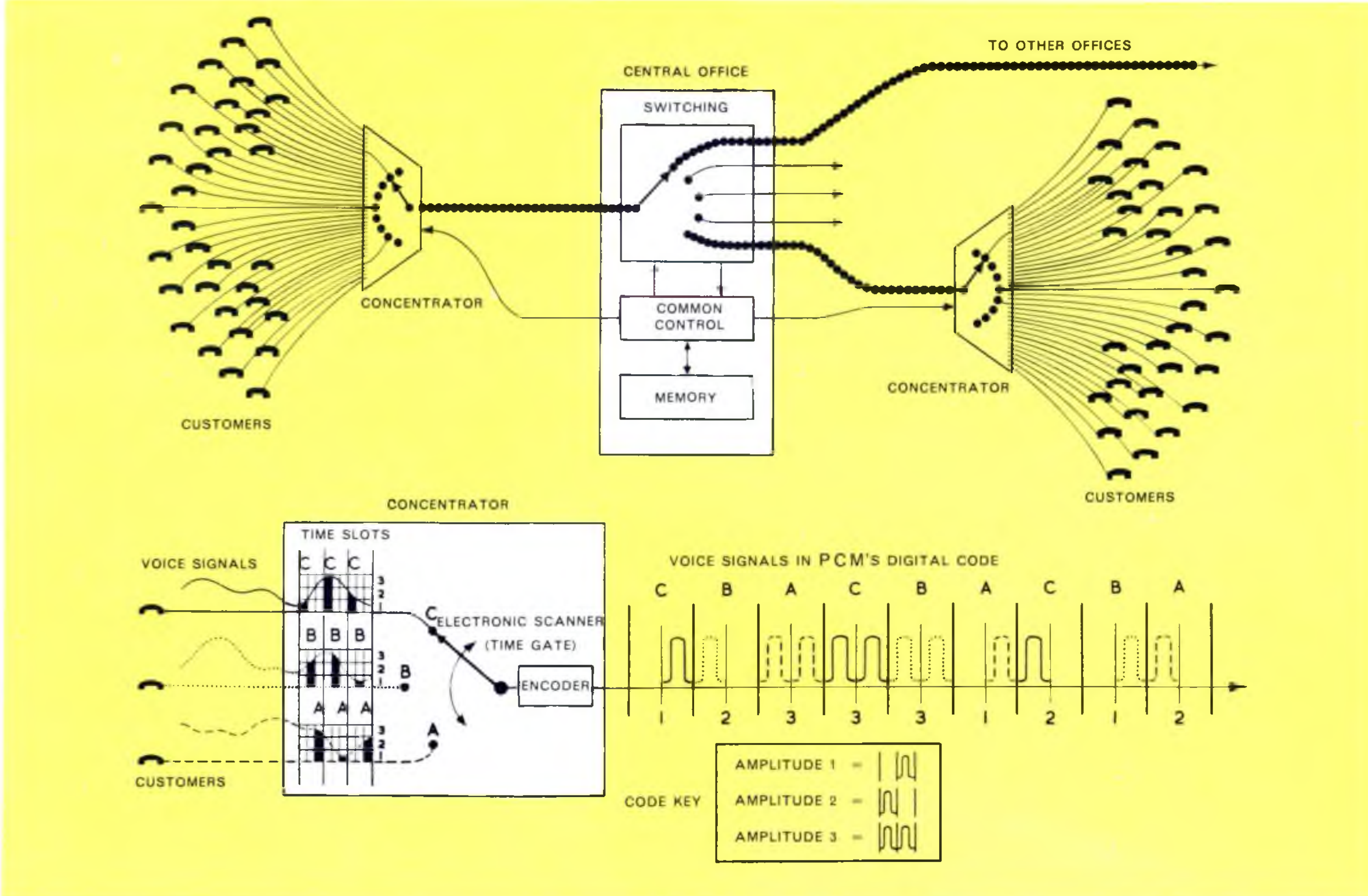
narrow beam of light which is monochromatic, that is of a single sharply-defined colour or wavelength, and coherent, that is with all its light waves in a regular order. Lasers were theoretically predicted in 1958 by Dr. C. H. Townes of Columbia University and by Dr. A. L. Schalow of the Bell Telephone Laboratories. The first operating Laser was built in 1960 by Dr. T. H. Maiman of the Hughes Aircraft Company, also of the United States of America. Lasers and their light beams have already found many exciting scientific applications, from flashing a light beam to the Moon and measuring its reflection, to the drilling of a diamond, and eye surgery.*

But it is in the field of communications that Lasers may well prove to have their most outstanding application. A light beam from a Laser may be modulated by means of radio, television or telephone signals. At the receiving end a demodulator of the light beam would then reproduce the original signal. As the information capacity of a communication carrier is directly proportional to its frequency, and as the light portion of the electromagnetic spectrum is at a very much higher frequency than those parts of the spectrum conventionally used for radio signals, a laser beam can carry a very large number of communication messages. In fact a single laser produced light beam has the theoretical ability to carry all the information transmitted by all the telephone lines in the world operating at the same time.

So far only experiments have been carried out. The Laser has however all the disadvantages of light. It is greatly attenuated by clouds, water vapour and fog. A possible way of overcoming this difficulty might be to "pipe" the laser beam through an evacuated pipe, in which no atmospheric hindrances could exist. Another major application of laser beams would be in the communication of messages across space. There, a perfect vacuum would allow light beams to carry for astronomical distances. At the time when the I.T.U. celebrated its Centenary in 1965, the research effort in laser development was of a very great magnitude. If past scientific developments are any guide to the future, then laser beams are likely to bring many benefits to mankind.

But, whatever the future may hold in the scientific field of telecommunications, and the few ideas mentioned above will only prove a small sample of the developments of the next century, one fact can be predicted with almost complete certainty. The International Telecommunication Union will be in exist-

* The Nobel Prize for Physics was awarded in 1964 jointly to Messrs. Bassov, Prokhorov and Townes for their work on the Maser principle.



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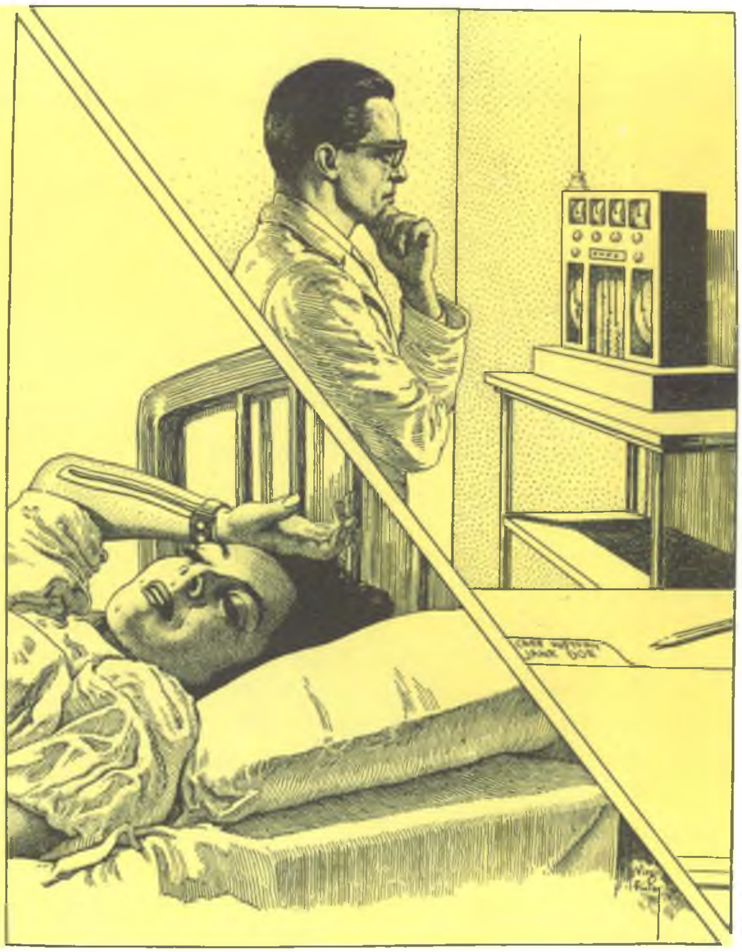
ence in the year 2065. There could not have been a more difficult time for an international body to survive than the last hundred years, with the invention of telegraphy, the telephone and the radio. These three major inventions, and all other subsequent developments, were absorbed by this international body of experts, sometimes with difficulty, but without ever leading to a splinter organisation or the resignation of any Members. In addition, the Union survived two major World Wars and a number of minor wars. At the end of its first century the Union's prestige and its power are greater than they have ever been before. There can be no foreseeable circumstances which would prevent the continuation of its success for at least another century.

However, all human work and effort is but of a temporary nature. The telegraph, the telephone and the radio equipment which we know so well to-day may well become one day mere scientific curiosities of a museum. There are many instances in the history of science and technology where the supreme instruments of the day are later relegated to the national collections. When this has occurred, it can only be hoped that our present instruments of telecommunication will be preserved as evidence and testimony of the immense patience, the consummate skill and the astonishing ingenuity of their makers, and of those who ensured that they were used efficiently on a worldwide basis.

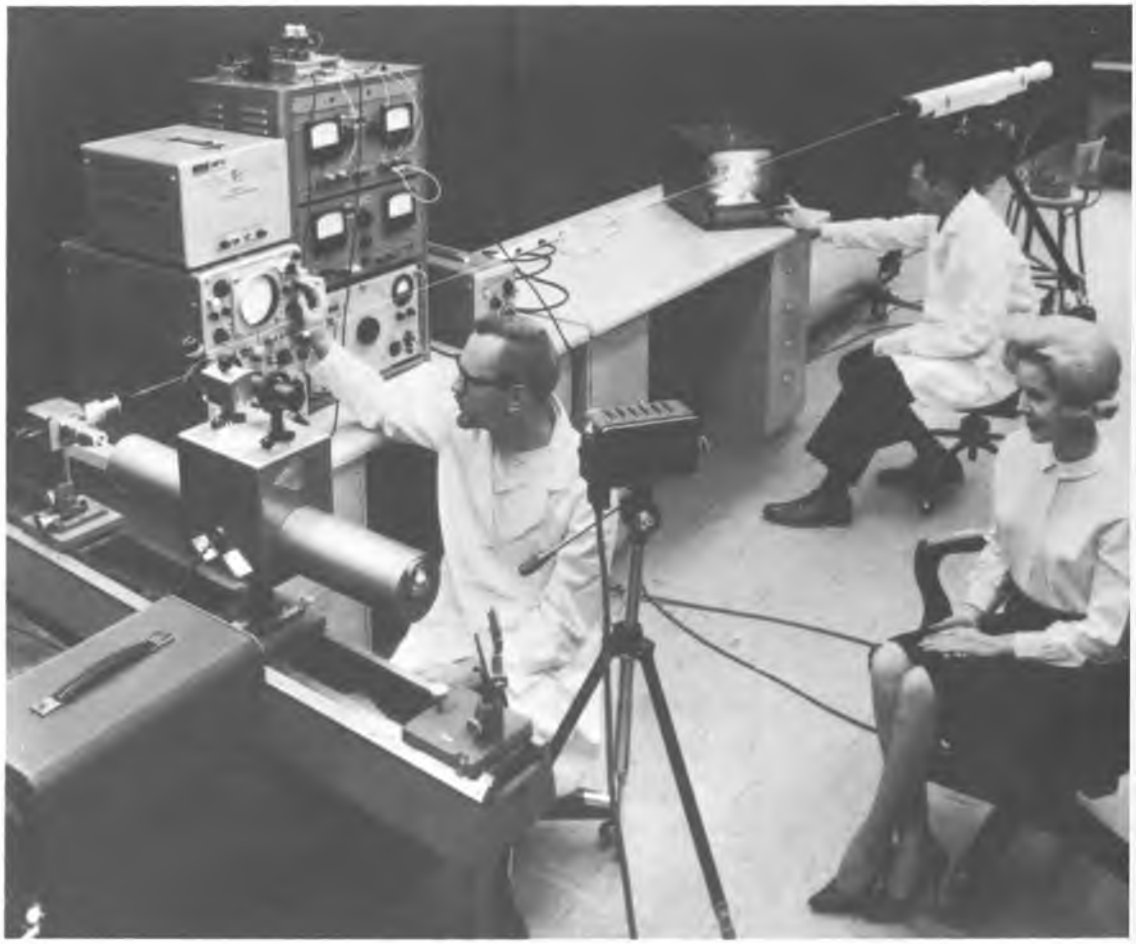
360 *The instant newspaper of the near future. It is entirely radio transmitted, directly to the reader, ready before breakfast. It is displayed optically enlarged to the reader. It will be possible for him to have more than one newspaper at no extra charge except for the additional cost of roll paper. Hugo Gernsback, who suggested this in March 1963, pointed out that there is nothing visionary about this set-up and that practically all the facilities for instant newspaper transmission and reception are in existence to-day. It may well take several years before newspapers would transmit papers by radio exclusively. In the interim, newspapers would still be sold on newsstands, but as new receivers were installed, few and fewer physical newspapers would be sold in this way.*



360 *361*

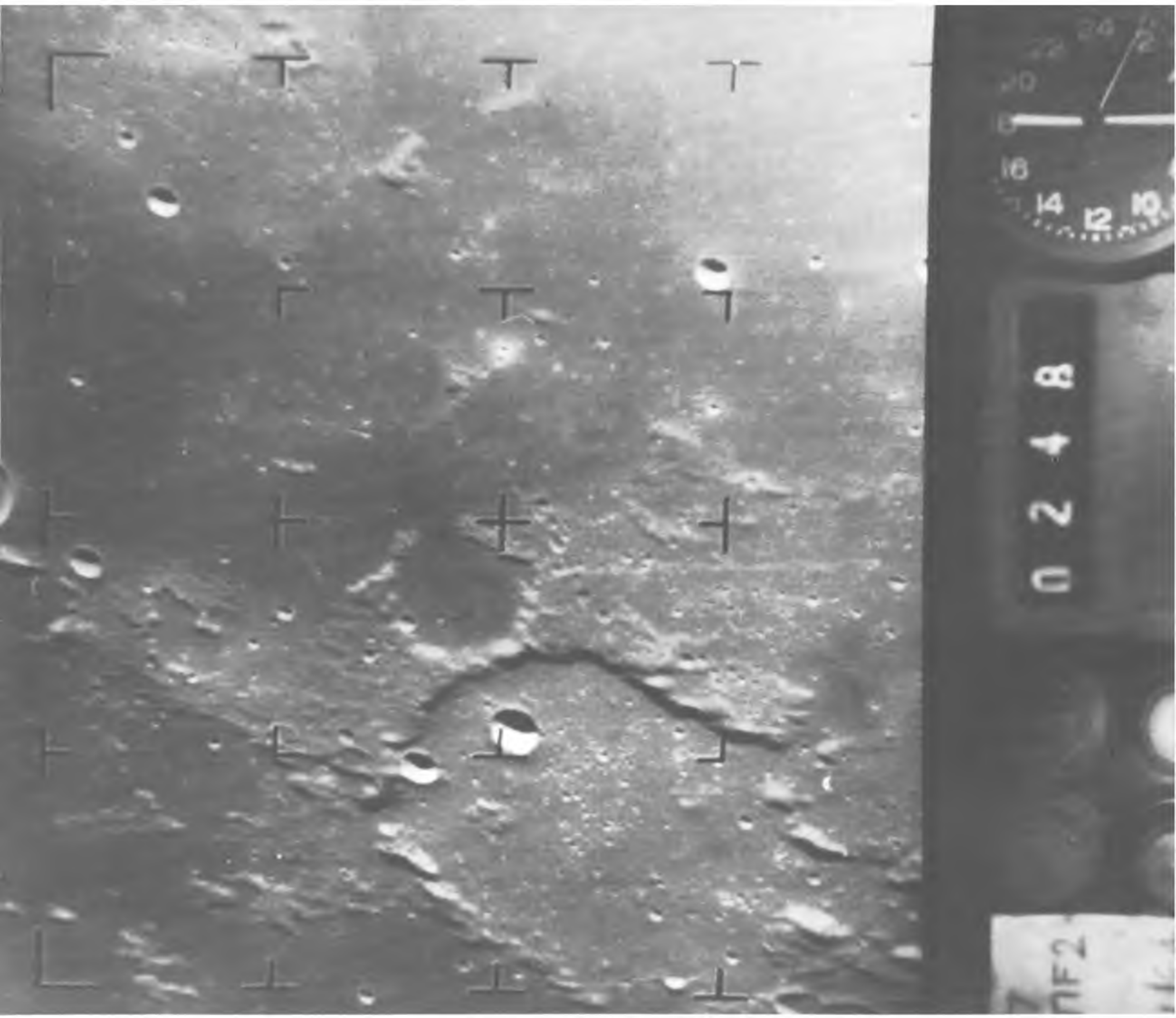
361 *In the future, because of the shortage of doctors, patients may well wear electronic wrist transmitters. No larger than a watch, they will broadcast to the doctor the patient's temperature, heartbeat, respiration and other information via radio. Note the transmitting aerial taped to the arm. This forecast was made by Mr. Hugo Gernsback in December, 1962.*

362 *One of the most exciting laser experiments was performed on a moon-light night in May, 1962. When the beam from the Laser (in lighted area at lower right) was flashed into space for the first time in history, it lighted a small spot on the moon and then was reflected back to earth. The beam made the round trip in two and a half seconds. On three successive nights, United States scientists carrying out this project at the Massachusetts Institute of Technology sent 83 thin light beams pulsing through space, successfully lighting the moon each time.*



362 *363*

363 *A young lady (right) is photographed by the small television camera in front of her. Her TV image is carried from the camera by the beam of a Laser (left) to a telescope-like optical receiver (rear right). There it strikes a photo cell, is converted into original TV signals and placed on the TV screen (also rear right). A device called an optical modulator (left) is the key to this demonstration. The modulator was developed recently to make possible communication by means of a Laser. It is hoped that eventually one laser beam will be able to carry simultaneously one thousand million telephone conversations or one thousand television programmes.*



365

364 *Three Bell Telephone Laboratories scientists P. K. Tien (right) D. McNair (left) and H. L. Hodges (centre) examine their new triode Laser. The intensity of the laser light can be modulated by varying the voltage of a grid inside the laser tube. The grid controls the electrons emitted from a cathode to have nearly identical energies, and results in a hundredfold increase in efficiency per electron over ordinary Lasers. There are two Lasers parallel to each other in this photograph.*

365 *Man's most exciting adventure of the next few decades will be the exploration of the Moon and perhaps Mars. But only a few astronauts will ever reach them, if not most of it will be done by instrumented satellites. But millions of people on Earth will be able to see by television what the planets are like. The first of these historic pictures showed the back of the Moon, taken by the U.S.S.R.* Lunik III *in October 1959. Here is a close-up view of the Moon's surface, the Crater Guericke, from 750 km, as taken by the U.S.A.* Ranger VII *in July 1964.*

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(As of January 1, 1965)

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Vatican City State
Colombia (Republic of)
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Congo (Republic of the) (Brazzaville)
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Costa Rica
Ivory Coast (Republic of the)
Cuba
Dahomey (Republic of)
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Dominican Republic
El Salvador (Republic of)
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Haiti (Republic of)
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Indonesia (Republic of)
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Iraq (Republic of)
Ireland
Iceland
Israel (State of)
Italy
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Kuwait (State of)
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Senegal (Republic of the)
Sierra Leone
Sudan (Republic of the)
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Switzerland (Confederation)
Tanzania (United Republic of)
Chad (Republic of the)
Czechoslovak Socialist Republic
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Union of Soviet Socialist Republics
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Venezuela (Republic of)
Viet-Nam (Republic of)
Yemen

B. Associate Members

Malawi
Zambia (Republic of)

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