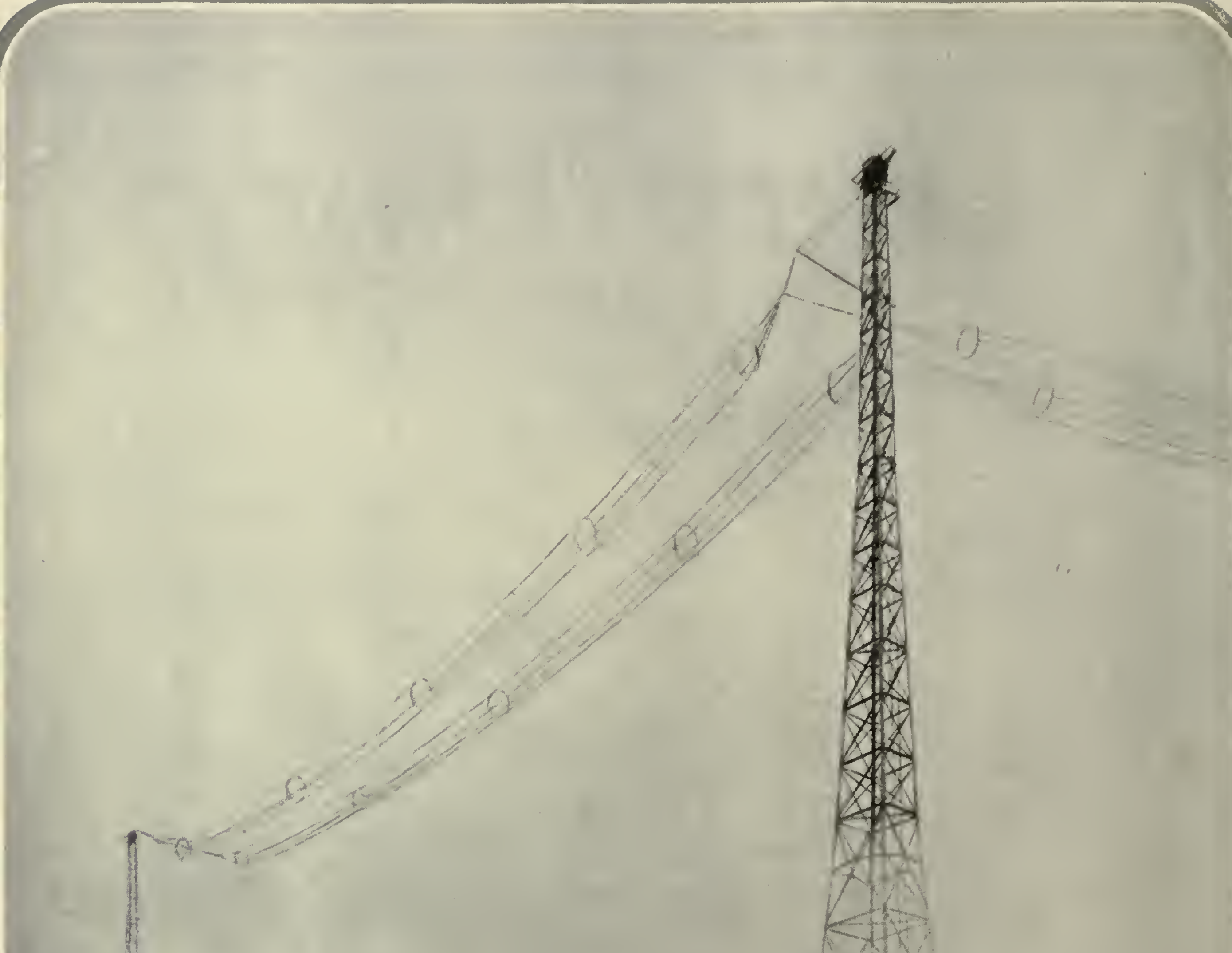

THE ANTENNA SYSTEM AT 2 LO, LONDON, THE MAIN BRITISH STATION

The "parent station" of the British Broadcasting Company system has its towers located atop Selfridge's store, Oxford Street, London. The antenna is 125 feet high. Many British listeners are content with simple crystal reception, using head phones. This station, in common with the other main stations of the system, gives a crystal range of about twenty five miles. Signals from this antenna have been received frequently in the United States and Canada, mainly during the three International Radio Broadcast Tests

RADIO BROADCAST

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How New York Talks to London

The Story of a Wonderful Radio Engineering Accomplishment Due to Many and not a Single Individual How the Principle of "Single Side Band" Transmission Made Possible Transatlantic Telephoning A New Triumph for the Vacuum Tube

By EDGAR H. FELIX

HISTORIANS have leaned heavily on Samuel Morse's "What God hath wrought," and Alexander Graham Bell's "Come here, Watson, I want you," in describing the first telegraph and the first telephone. But the recent demonstration of two-way transatlantic telephony, exactly fifty years to a day after Bell delivered his famous message to Watson, produced no significant sentence to inspire future generations of high school essayists. Instead, twenty or thirty newspaper men on this side of the Atlantic conversed with an equal number of their confreres on the other side about the weather, short skirts, and prohibition. No one utilized the opportunity to crystallize the significance of the occasion in an apt and epigrammatic phrase.

But the reason is not hard to find. The first telegraph and telephone were largely the products of a single individual's effort; their contribution, the successful solution of a problem pursued in the face of pioneer difficulties. The transatlantic telephone, on the other hand, is the product of hundreds of creative minds. No one man may point to it as his achievement, for, in the equipment installed by the America, Telephone and Telegraph Company, the Radio Corporation of America, and the British Post Office, literally thousands of inventions and processes, each contributing its part to the success of transatlantic telephony, are utilized.

It was an extraordinary radio telephone which accomplished these results, not a mere overgrown super-power broadcasting installation. A fairly new principle was applied, known as single side band transmission.

Engineers can understand exactly just how single side band transmission works, but to the layman it is simply another new phrase added to radio's growing vocabulary. Its methods are complex but what they accomplish is easy to comprehend. Only one-fourth to one-sixth the power is required to transmit a given distance; it occupies only one-half the wavelength band required by the usual broadcasting transmitter, and it is less subject to fading than the older methods of radio telephone transmission.

THE LOW-POWER UNITS
Of the Rocky Point transmitter. The speech input, modulating, filter, and amplifying panels, are depicted. The operator is regulating the volume of the incoming speech from New York by means of a potentiometer

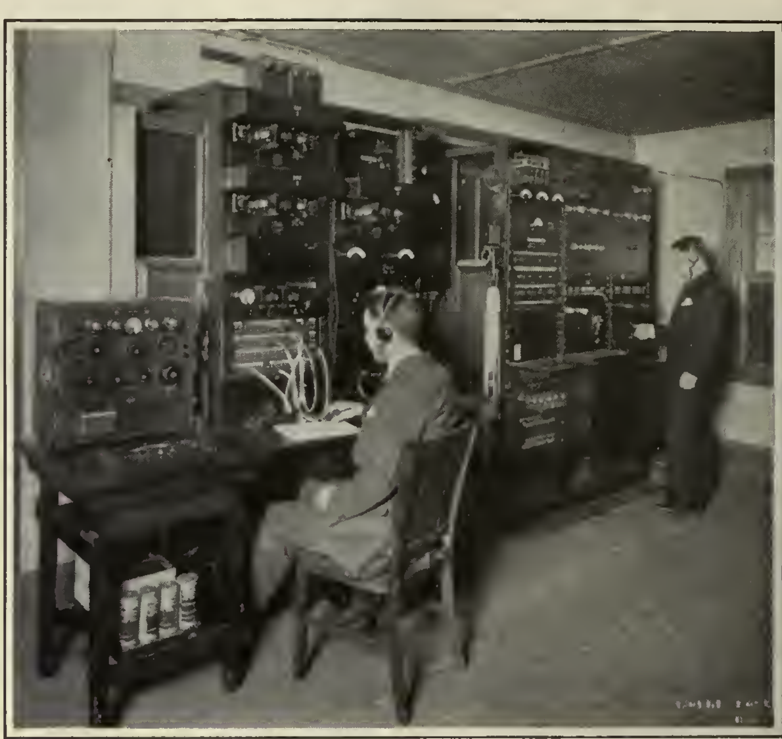
But what is single side band transmission, and how is it accomplished? You probably know that when speech or music is heard from your receiver, it is responding to a carrier wave, varied in intensity by the process of modulation, to accord with the sound waves at the broadcasting studio. The carrier wave acts as the bearer or carrier of the audiofrequency currents. But what you actually hear with your radio receiver is the result of modulation.

In your experience of fishing for long distance stations with a regenerative receiver, you have often heterodyned the carrier wave of a far-away stranger without being able to "clear up" the signal to make it intelligible. Inveterate distance enthusiasts often become dyspeptic from exasperation if frequently subjected to this experience. What they are after is modulation, not carrier. Single side band transmission accomplishes the remarkable feat of transmitting only modulation, suppressing the carrier before it reaches the transmitting antenna.

Perhaps we can make this more clear by an analogy. Suppose you have a gold coin, deeply engraved with both faces alike, which you wish to reproduce at a distant place. In order to reduce the cost of the sample coin you would naturally slice it in half, since the design on one side, being the same as that on the other, would serve as a satisfactory model. Still greater economy is affected by making the sample slice of the coin just thick enough to include the deepest part of the engraving. The indentations in the coin correspond to the variations in the carrier wave produced by modulation. As long as these variations are transmitted, we have all that is necessary.

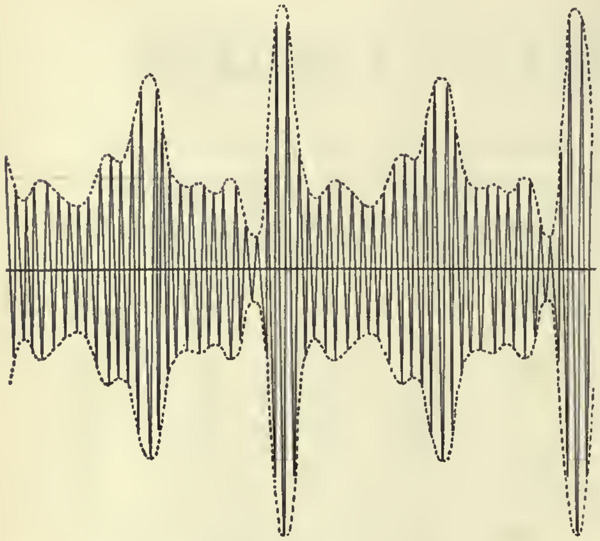
Carrying the analogy still further, to reproduce the coin at the distant place, it is necessary to restore it to its normal thickness, in order to have a coin exactly like the one of which it is a replica. This, too, is one of the requirements in the reception of single side band transmission. A local oscillator, set precisely to the suppressed carrier frequency, is necessary to restore the carrier in the receiver. This feature contributes to the secrecy attainable by the new system.

The sine curve, representing the carrier wave, is familiar to almost every broadcast listener. So is the effect of modulation upon the carrier. But observe, in the accompanying diagram, that modulation is really twice accomplished in that both the upper and lower components



THE RECEIVING EQUIPMENT IS SHOWN HERE

To the right the operator is adjusting the apparatus which is used to pick up Rugby's signals, while the gentleman sitting is responsible for the wire line circuit to New York. The necessary oscillator for restoring the carrier wave to the incoming single side band impulses is incorporated in the receiving equipment to the right

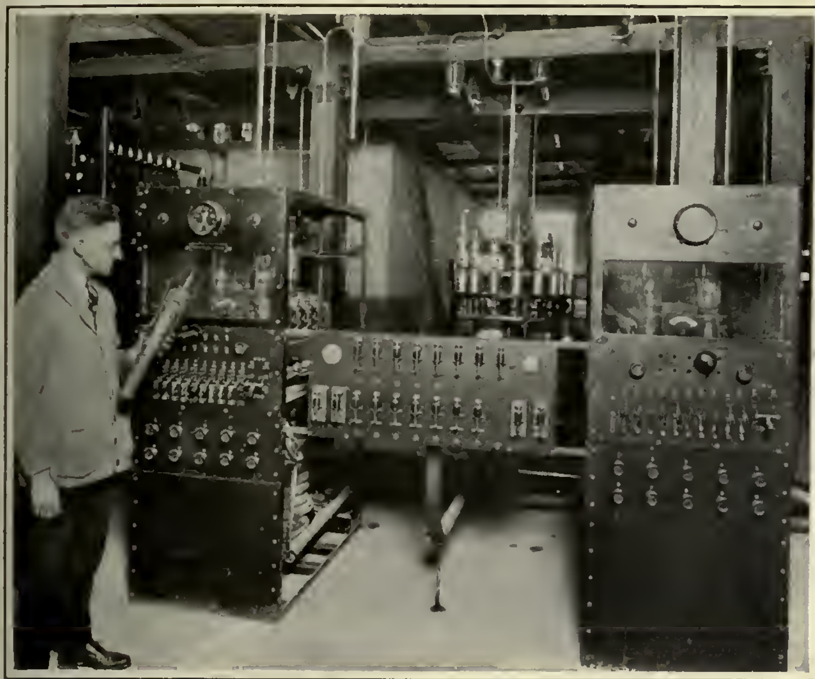


A MODULATED RADIO FREQUENCY WAVE

Would look like this if we could see it. As the author points out, modulation is really twice accomplished. Both the upper and lower components of the carrier wave are varied

THE POWER STATION AT ROCKY POINT, LONG ISLAND

In this building are housed the commercial radio telegraph transmitters in addition to the radio telephone used for the transatlantic experiments



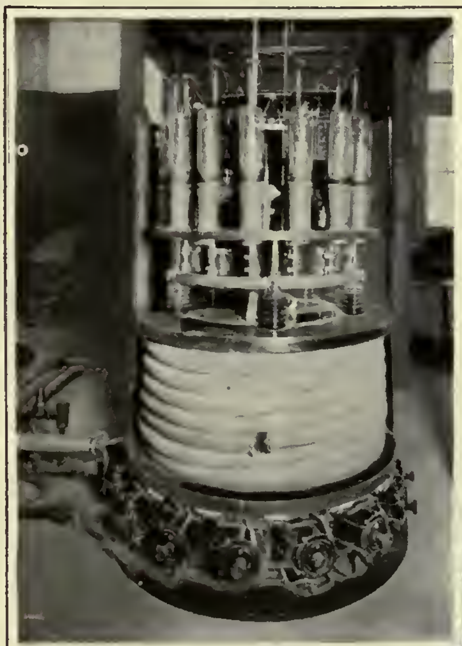
TWO AMPLIFIER UNITS

Or the high-power section of the transmitter. The ratings of the amplifiers are 15 kilowatts, and 150 kilowatts. A circular bank of water-cooled tubes may be seen in the background. The position of these amplifiers with relation to the rest of the equipment can be followed by referring to the picture diagram on page 114

of the carrier wave are varied in accordance with the speech or music. In fact, if you have a receiver which tunes with exceptional sharpness, you may have observed that there are two places on the dial, extremely close together, at which you hear a station with maximum volume. These two modulated waves are called the upper and lower side bands. In single side band transmission, only one of these side bands is radiated into the ether.

HOW THE TRANSMITTER WORKS

BRIEFLY, the transmitter works somewhat as follows: A telephone transmitter is used to secure an audio frequency current which is an electrical equivalent of the sound waves fed into it. For intelligible conversation, a frequency band from 300 to 3000 cycles in width is required. This is used to modulate the output of a low power oscillator set to 33,000 cycles a second. The output of this oscillator, when modulated by speech, has the usual two side bands, the lower from 30,000 to 32,700 cycles and the upper from 33,300 to 36,000 cycles. The next process is to pass this carrier and two side bands through a filter which suppresses the upper side band. The lower is now used to modulate the output of the second oscillator working at a much higher frequency, 88,500 cycles. When two alternating currents are combined in this way, a carrier and two side bands are again produced. The upper side band is equal to the sum of the combined frequencies (i. e. 30,000 to 32,700 plus 88,500 or 118,500 to 121,200) and the lower to their difference (i. e. 30,000 to 32,700 minus 88,500 or 55,800 to 58,500). The two side bands are so widely separated that they are easily filtered. The lower side band, 55,800 to 58,500 cycles, is isolated by a filter, and fed to a series of power amplifiers.



FIFTEEN WATER-COOLED TUBES

On a circular bank, are shown above. The lower picture, to the right, shows the telephone control board in the General Post Office in Queen Victoria Street, London. It was from this point that British newspaper men recently spoke to their American brotherhood by means of the transatlantic radiophone

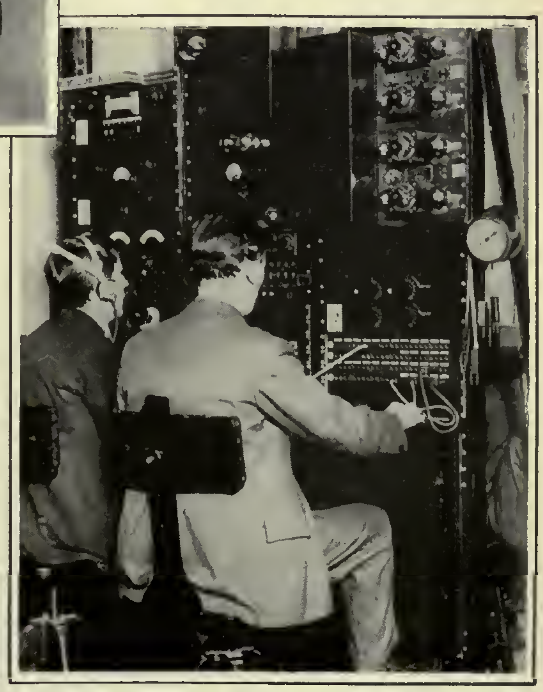
Up to this point, only feeble currents have been used to produce the single side band of the desired frequency. This desired side band having been isolated by successive modulation and filtering is now amplified by three power amplifiers, a 750-watt, a 15-kilowatt and, finally, a 150-kilowatt unit. The output of this huge amplifier energizes the antenna system at Rocky Point, and about 100 kilowatts of power is radiated into the ether. The diagram on page 114 clearly explains the operation of the transmitter.

The illustrations show the various instruments which accomplish these progressive steps. The picture on the first page shows the low-power parts of the transmitter. The two panels at the left comprise the speech input equipment, which is connected with the telephone circuit to New York. The operator is adjusting the volume by means of a potentiometer. These and the next panel include the two oscillators and filter systems which secure the desired lower side band between 55,800 and 58,500 cycles. At the right is the panel containing the low-power amplifiers, which increase the side band to the 750-watt power level.

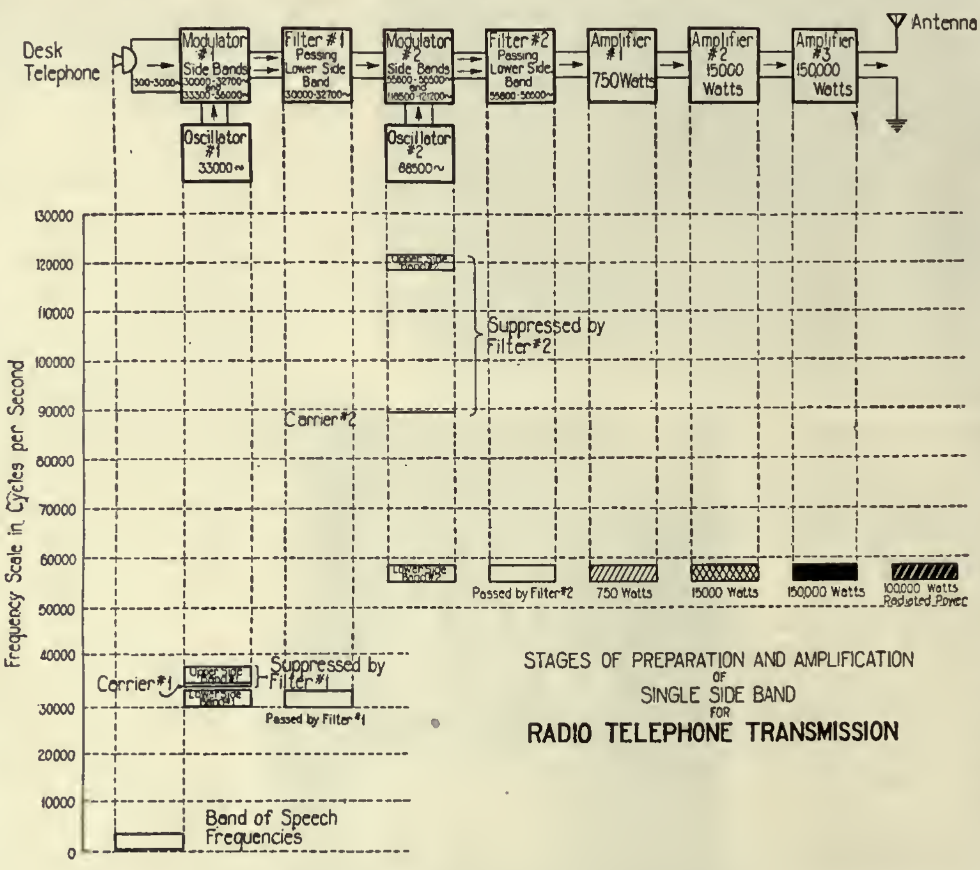
The upper picture on this page shows the 15-kilowatt and the 150-kilowatt amplifiers. The many fuses provide protection to the filament circuits. Above the fuses are a series of plugs, through which the plate current of each tube may be measured. The panel shown in the center of the picture switches in timing and recording mechanisms by means of which the hours each transmitter tube is used is automatically recorded. A close up view of a bank of 15 water-cooled power amplifier tubes is shown in the middle picture on this page. Note the elaborate water-cooling arrangement necessary to dissipate the heat generated by the tubes.

THE WATER-COOLED TUBES

ALMOST as essential to transatlantic telephony as the development of single side band transmission, are the high power water-cooled tubes. In the accompanying picture of one of these



tubes, half of the plate has been cut away in order to reveal the rugged filament, which draws 750 watts, and also the grid controlling the electrons which flow to the plate. The plate serves as the outside of the tube. This element cannot be sealed within a glass tube, as is done with smaller tubes, because glass would melt under the high temperatures generated by these huge power tubes. The lower half of the tube is immersed in water circulated by a pump. Those parts of the tube showing through the glass are the supports for the elements, and conducting terminals for the grid and filament connections. A considerable length of hose is required to insulate the plates of the tubes which are (the plates are, of course, electrically connected to the water jackets) at from 6000 to 10,000 volts above ground potential. The plate potential is secured through high-voltage transformers and rectified by two-element water-cooled tubes. Perhaps the most difficult problem which had to be met in the design of these tubes was a method of sealing the copper plate to the glass in order to maintain the vacuum within the tubes throughout the range of temperatures encountered.



HOW THE SINGLE SIDE BAND SYSTEM WORKS

Is clearly shown in this picture diagram. By reference to the amplifier part of the diagram, it will be seen that the output power of the Rocky Point station is considerably greater than that of any comparatively simple broadcasting station

THE RECEIVING APPARATUS

IN ONE of the accompanying photographs may be seen the receiving apparatus, a highly efficient yet altogether unconventional unit. The amplification equipment necessary to convey the received matter to New York by wire line, is also shown in this illustration. The three units at the right comprise the radio receiving equipment, including the necessary oscillator which restores the carrier wave. The two panels at the left include the line amplifiers and the switchboard by which the correct line to New York is selected for conveying the received signal, and the necessary service wires for intercommunication purposes. At the far left is the testing equipment for the wire line circuit to permit undisturbed speech between the receiving point in Maine and in New York. The B batteries shown are used to secure an unfluctuating voltage for test purposes, should it be required.

Considering that ten kilowatt broadcasting stations are frequently heard in Europe, it may seem surprising that 150 kilowatts of single side band transmission are required for transoceanic telephony, especially considering that the new method of transmission is four to six times as efficient as the old. But there are vast differences between occasional freak reception and the requirements of reliable commercial communication. The signal strength is very closely dependent upon the amount of light and darkness over the course which the signals follow. Unlike a copper wire conductor carrying an electric current, the medium through which radio waves are transmitted varies greatly in efficiency under different conditions.

During the winter, when the least variation is encountered, the average minimum signal strength required for good reception across the Atlantic is six micro-volts per meter, and runs up to 150, a ratio of about 25 to 1. The variation of disturbing noise, even in winter, follows as wide a ratio. Fortunately, the noise level falls during the day, when the signal volume also falls, and this factor serves to enhance the possibilities of reliable transmission. Magnetic disturbances still further aggravate the variabilities of the ether medium. With so many conditions contributing to the vagaries of the ether, it becomes easier to see why relatively immense power is required to accomplish reliable transatlantic telephone trransmission.

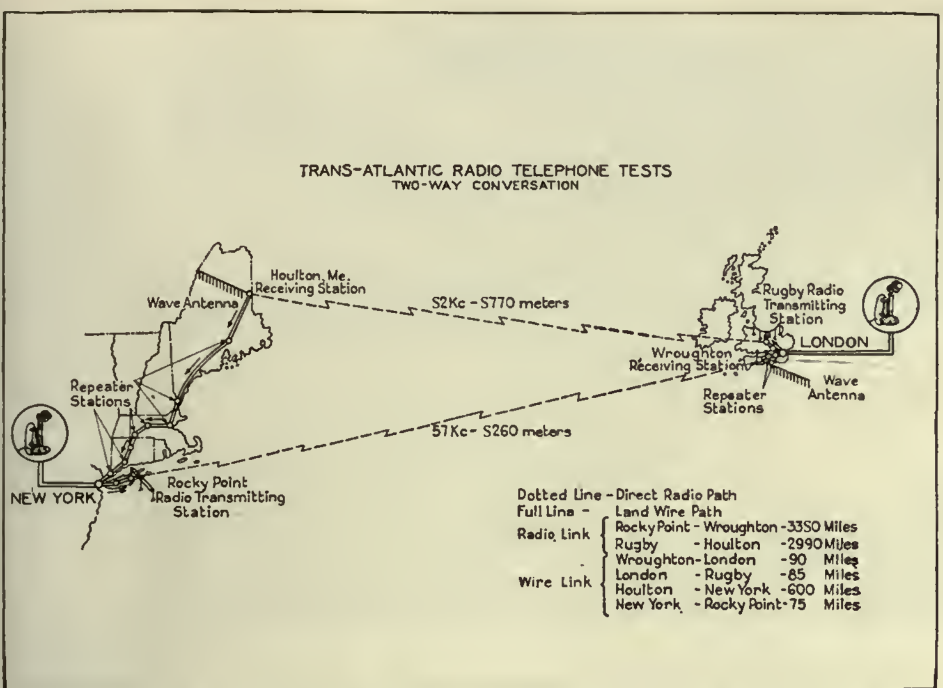
An indication of the difficulties of the problem to be met is given by the varying power requirements to obtain an equally loud signal under all conditions. Night time transmission in winter requires but little power—a few kilowatts. When it is sunrise in England and still night over here, much greater power is necessary. When heavy summer static prevails, a tremendous power increase over that required under the best winter conditions, is necessary. The engineers who have been carefully measuring signal strength at all hours and seasons estimate that 10,000 times as much power is needed to force a signal of the same volume and quality when the worst conditions prevail, as compared with that required under the most favorable.

Nevertheless, the single side band transmitter already installed has maintained a fair degree of reliability even under the relatively poor conditions. The proof is graphically shown in the percentage of test words understood in England as transmitted by Rocky Point during March, 1924. Between midnight and noon, the percentage is generally better than 95, but during the afternoon, when the sunset effect begins to manifest itself, there is a marked falling off in intelligibility.

One might suppose that this falling off in strength during the afternoon would be so pronounced in the summer afternoons as to decrease the value of the transatlantic service almost to nil. However, even during the experimental essays of these tests, on the worst afternoons, it has been possible to understand enough of the words to supply by implication those missed. Two-way communication has the advantage that repetition may be requested in an emergency.

COMMERCIALIZATION UNLIKELY YET

ALTHOUGH the recent experiments have been highly successful, telephone officials are unwilling to make definite predictions as to the likelihood of regular commercial transatlantic telephony, when,



A BIRD'S-EYE GLIMPSE OF THE ROUTE FOLLOWED BY THE RADIO WAVES

As they hurtle from Rocky Point to England. Note the frequent repeater stations which are necessary to boost up the telephone conversations as they travel the wire lines. The main receiving stations, both in England and America, are some distance from the transmitters, but wire connecting lines enable persons at both Rugby and Rocky Point to listen-in to the conversations coming from across the Atlantic

to speak to someone in Europe, you need merely call the long distance operator and give her the usual information. It must be born in mind that the tests were conducted by engineers who have devoted several years to the design and maintenance of the experimental single side band transmitter. To be commercially practical it must be within the province and ability of commercial personnel to maintain and operate the complex equipment.

For ordinary messages of greeting, the apparatus of to-day is adequate, when conditions are favorable, but the commercial possibilities of transatlantic telephony will not be fully realized until the system is perfected to a degree that it can be used without flaw for business, news, and official conversations. This requires an adequate degree of secrecy, adding still further complications. Means have already been developed, however, for attaining the same degree of secrecy in radio transmission as is possible for wire communication. Undoubtedly, this work can be successfully applied in single side band transmission.

It is idle to speculate upon the possibilities of better human understanding which will follow widespread international telephone communication. Political divisions have grown larger in direct proportion to improvements in communication. Tribes cemented into nations when roads were built and when ships began to travel the seas. The telegraph and telephone has expanded nations to the size of continents. Perhaps the new influence of the radio telephone will play a vital part in cementing nations all over the earth into a single harmonious whole. The least that may be said is that international telephony will help to better mutual understanding; mutual understanding means more tolerant adjustment of differences, and that, in the last analysis, means greater stability and more enduring peace.

THE NUCLEUS

Of the whole transmitter consists of the water-cooled tubes, an example of which is here shown. The plate element has been cut away to show the grid and filament which, ordinarily, are hidden from view

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A CLOSE-UP OF THE ANTENNA SYSTEM

Six towers, one of which is shown below, support a six-wire system. The towers at Rocky Point are 410 feet high and 1250 feet apart. They lie in a north to south direction