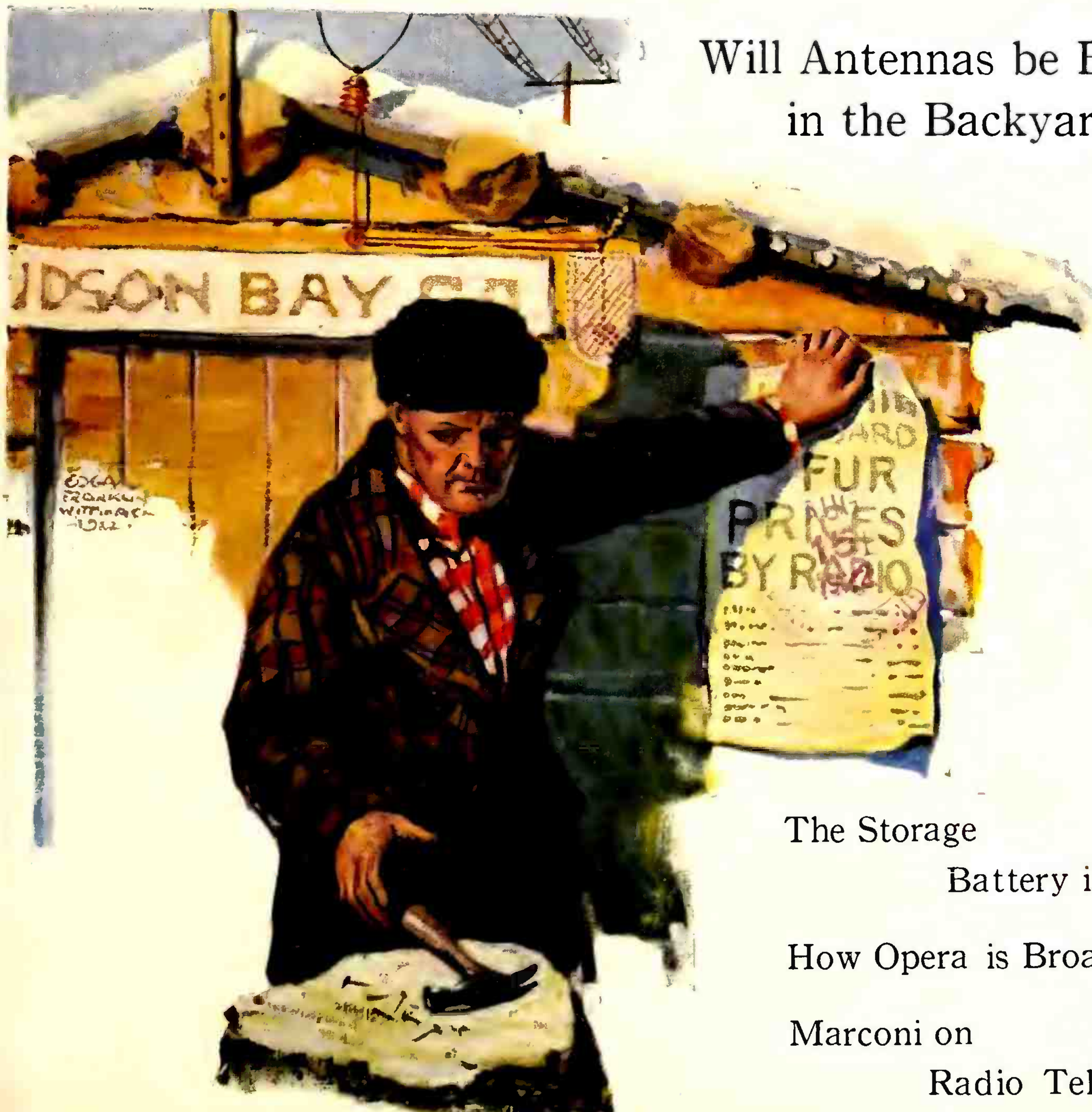
AUGUST, 1922 PRICE 25 CENTS

RADIO BROADCAST

RADIO FOR EVERY PLACE AND PURPOSE



Will Antennas be Buried in the Backyard

The Storage Battery in Radio

How Opera is Broadcasted

Marconi on Radio Telegraphy

DOUBLEDAY, PAGE & COMPANY, Garden City, N. Y.

Radio Broadcast

ROY MASON, EDITOR — ARTHUR H. LYNCH, TECHNICAL EDITOR

CONTENTS FOR AUGUST, 1922

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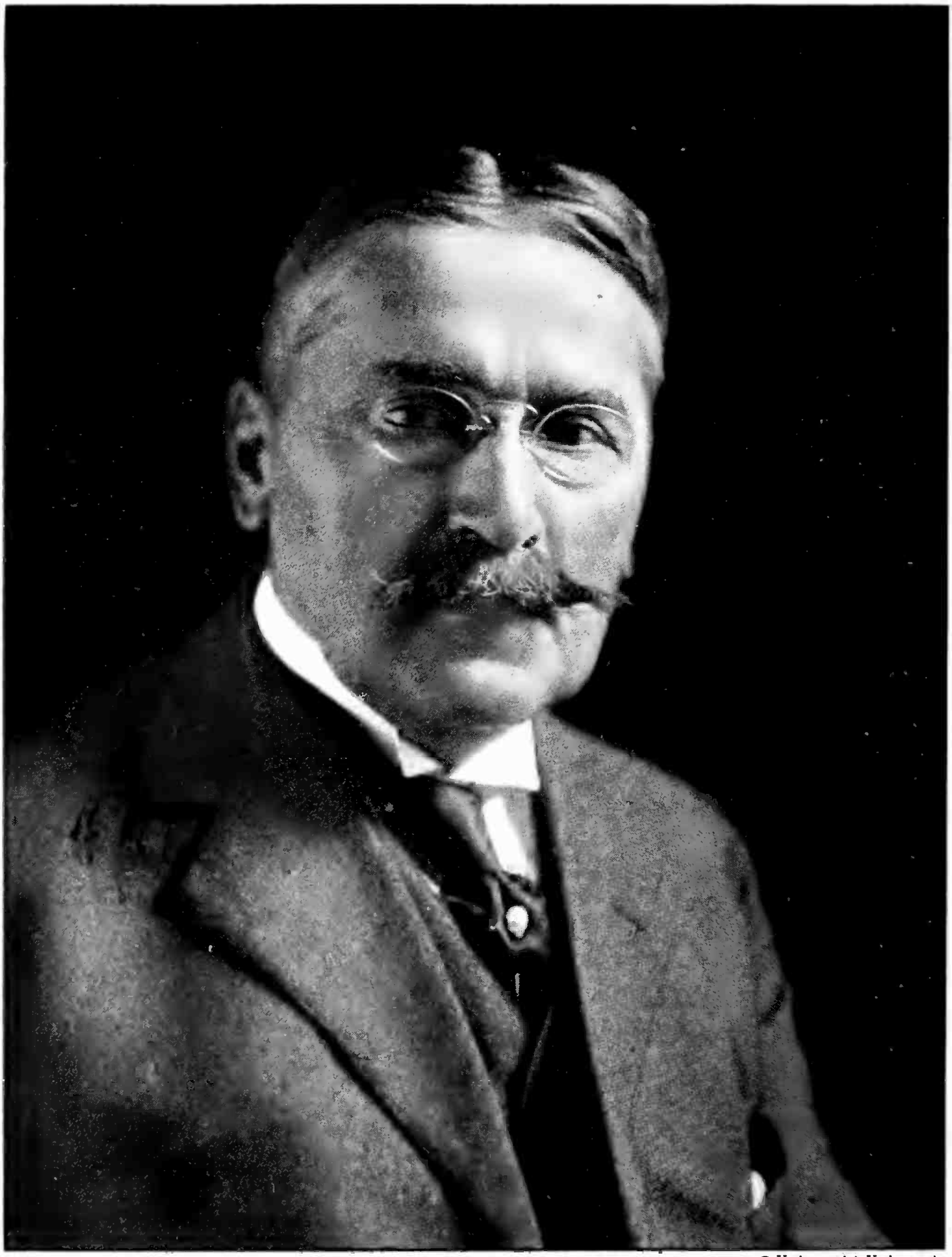


PROFESSOR MICHAEL I. PUPIN

Head of the Electro-mechanical Department of Columbia University, New York

RADIO BROADCAST

Vol. 1 No. 4 August, 1922

The March of Radio

RADIO MIGHT HAVE PREVENTED THIS ACCIDENT

THERE are still definite, important, applications which we are slow to perceive and put into effect. Years ago Professor Trowbridge suggested the scheme of using loops of wire, strung in the rigging of a ship, for sending out and receiving messages over short distances, but in so far as we know his scheme was never actually installed. His idea of using audio frequency currents through the transmitting loops would have required quite powerful apparatus to make it sufficiently serviceable to warrant the expense of upkeep of the sets. The distance over which communication could have been carried out was rather small.

With the use of high frequency radio currents, however, the idea Trowbridge put forth is easy of accomplishment, and there is no good reason why it should not have been in operation while the *Egypt* was proceeding cautiously down the French coast, through a thick fog. We read: "For some time previous to the crash the vessel had been going very slow on account of the fog and *the usual fog precautions had been taken* (italics ours). Not until there was no possibility of avoiding the accident, it appears, did the watch officers on either vessel become conscious of the proximity of the other."

So we are evidently to conclude that this was an unavoidable accident, one to which each of us is exposed when afloat, even when all the usual fog precautions have been taken! Blowing the fog whistle—and stationing extra lookouts at the bow—these were probably the usual precautions. Now it is evident to any one who has passed through fog banks that the extra lookouts are nothing but a form; they might tell the navigating officer that he was going to hit a vessel a few seconds before the crash occurred and that's about all the use they would be.

The fog whistle, with its penetrating roar, is probably the best protection we have to-day, but those who have made experiments on sound transmission know that there are silent spots, or zones, in which the sound of the fog whistle may not be heard even though the vessel may be close to the source of the sound. These silent zones occur because of the refractions and reflections of the sound waves by the dense fog banks and they shift around in haphazard fashion. And even though the fog whistle is heard, its direction is often problematical because of these same effects.

Now, a proper radio installation on board a ship would make practically impossible such an accident as that which caused the loss of a hundred lives on the *Egypt*. It will of course be said that there was undoubtedly radio apparatus on board. Of course there was, but this apparatus was also undoubtedly being used at the time of the collision, to listen on the 600-meter wavelength—to listen for distress signals from other possible collisions!

How should this possibility of collision in fog be avoided? It seems that an extremely simple and feasible expedient would be to have an extra radio set on board, which would be used when passing through a fog, this extra set to be manned in addition to the regular set. The transmitter should be a non-directional, low-powered, set to send at perhaps 100 meters, to send sufficient power to be heard a mile or so. The transmitter would be kept in operation automatically, sending out a dash perhaps every five seconds, and the special fog operator would be listening on a 100-meter wavelength by means of a rotatable loop, or radio compass. This listening loop could be kept rotating automatically until a signal was picked up, and then the operator could stop its motion and at once locate the direction of the source of the special wavelength signal.

Just as the ordinary radio set has decreased tremendously the dangers from collisions at sea (after they have happened) so this fog radio would tremendously decrease the possibility of collision, that is, it is a preventive measure rather than a remedial measure The apparatus being low powered and of such short wavelength, would cause no interference at all with regular traffic, and the outfit could be manned without any extra number of operators, in fact, as it would not be necessary for this operator to read Morse, he might be one of the ship's crew, working under the ship's regular operator. In the future the putting into operation of this special fog radio should form a part of the "usual fog precautions," which, in the case of the *Egypt*, proved so inadequate.

THE PASSING OF THE "RADIO REVIEW"

SHORTLY after the close of the war there was projected in England a high class, scientific journal on Radio; tentative subscriptions having warranted a start, it began publication in October, 1919. Its first editorial, by G. W. O. Howe, sounded its policy. "The sole aim of the *Radio Review* will be to record the scientific developments of radio telegraphy and of those branches of allied sciences which are related to that subject." True to this aim, its standards were held high, meaning by high, such treatment of the subject matter as would appeal to the specially trained radio engineer. Its appeal was necessarily to a rather narrow field of subscribers, and like all such truly scientific journals, its publication costs exceeded the income from subscribers and advertisers; the subscription rates were raised to the rather excessive amount of about $14 (five pounds) per year, but the high cost of paper and printing have forced its suspension.

It is intended by the editors to continue the publication of scientific articles in connection with the *Wireless World*, which has been renamed *The Wireless World and Radio Review*, We regret exceedingly the suspension of the *Radio Review;* during its short life, the radio engineers have received from its columns a great deal of valuable and much appreciated information. It is to be hoped that the section of the new magazine can keep the quality of its scientific section up to the excellent standard set by its suspended predecessor.

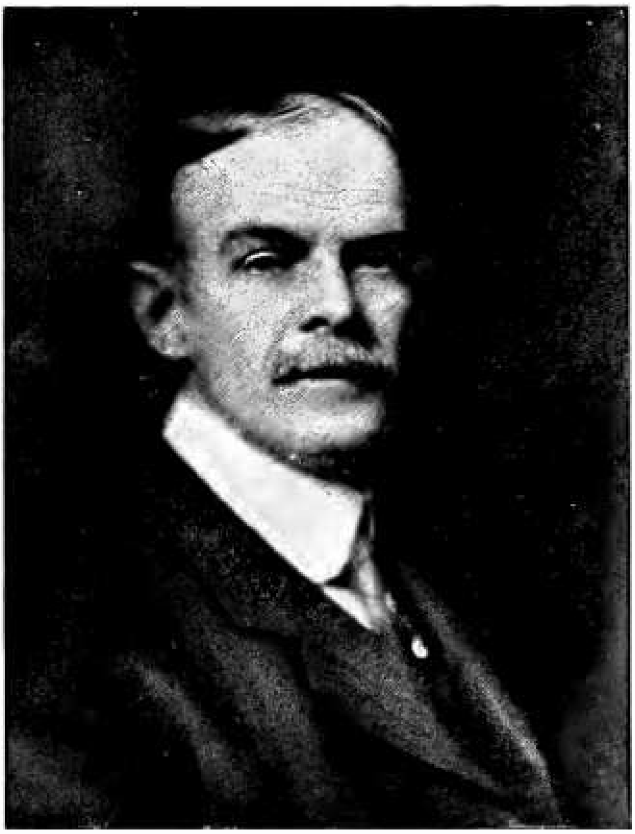
UNDERWRITER'S REQUIREMENTS

THE National Board of Fire Underwriters apparently believe in playing safe in their bets against fires. The apparently harmless receiving antenna at first received rather strenuous treatment at their hands and if any one, dwelling, let us say, on the tenth floor of an apartment house in New York City, had complied with their requirements of a few months ago, the antenna installation, instead of being a rather small part of the cost of an installation would have cost as much as the whole receiving set, even including the tubes!

The requirements of the Underwriters are gradually becoming more sane; their latest modifications seem eminently reasonable and easy to comply with. A few months ago a No. 4 wire was required for the ground connection, installed in a very particular fashion; later a No. 8 wire was acceptable, and now a No. 14 copper wire or a No. 17 copper-clad steel is allowed for the ground connection, and this same ground connection may be used as the ground wire of the set. A lightning discharger, or protective device, is still required, but the types allowed are comparatively cheap and easily installed.

Evidently feeling that inside antennas do not cause an extra fire risk, no provisions are given regarding their installation. It is to be pointed out, however, that an antenna located in the attic of a wooden house is probably a greater fire hazard than one of equal height installed outside, by the side of the house. If we accept the general assumption that such antennas "attract" lightning, it is a fact that both antennas do it equally well, and so are equally likely to be struck. The fact that one is inside the house and the other outside does not influence the lightening bolt when it is making its choice. However, the inside antenna can only be struck after the bolt has passed through the roof of the house! Evidently its damage, as far as fire risk is concerned, has been accomplished even before it gets to the antenna. The outside antenna might be struck many times without much likelihood of fire, if it is properly grounded.

As we see the problem, the increased likelihood of being struck by lightning is directly proportional to the receiving efficiency of the antenna. The higher the antenna the more likely to be struck and also the better a receiver it is. The only antenna which is free from the possibility of being struck is one located beneath a grounded metal roof; this is an extremely poor receiving antenna, as many enthusiasts know too well.



PROF. FRANCIS BACON CROCKER

THE FRANCIS BACON CROCKER FOUNDATION

AT A recent meeting of the New York Electrical Society, Professor M. I. Pupin made announcement of the donation of $10,000 by the Marcellus-Hartley Corporation to establish the Francis Bacon Crocker foundation. The Marcellus-Hartley Corporation was organized by Mrs. Helen Hartley Jenkins to give support to various institutions doing useful work in the arts and sciences; evidently the New York Electrical Society falls into this category.

It offers to its members about ten lectures a year on various electrical topics of general interest; having a rather small membership and low dues, it has recently been in financial difficulties. The income from the Crocker fund will be used to defray current running expenses.

Professor Crocker was one of the electrical pioneers of this country; he was intimately associated with many of the important activities of the electrical industry during his lifetime. He was one of the founders of the C and C Electrical Co., and was later vice-president of the Crocker-Wheeler Co. of Ampere, N. J. As head of the department of Electrical Engineering at Columbia University he made a reputation as an educator and teacher of electrical science and was warmly esteemed by the many students coming in contact with him during his long term of service with the University.

The Francis Bacon Crocker foundation will do a doubly useful service in helping to support the activities of the Electrical Society and in helping to keep alive the memory of Professor Crocker.

THE AMATEUR RADIO RESERVE

IN OUR last number there appeared a short article telling of the work carried out by the special branch of the Signal Corps which goes by the above title. Developed and encouraged by the Chief Signal Officer of the Army, this work of banding together the enthusiastic group of radio amateurs who would jump to the aid of the country in the event of another war, seems like an excellent work to carry on. There is no waste of time in what we ordinarily think of when military training is mentioned, but the activities consist largely in keeping the amateur in touch with the local Signal Officer and other amateurs in his district, with whom he would very likely have to work in case of need.

Radio instruction in general, and specifically in the operation of Signal Corps outfits, is carried on under a Signal Corps expert, so that the amateur would be fitted to join at once that service where he would undoubtedly count the most, the radio section of the Signal Corps. Although but little money is needed for the activities of the Amateur Radio Reserve, we understand that, the appropriation having failed to pass, they must soon cease. It seems that this very peaceful "preparation" well deserved the necessary appropriation to continue its existence, and we hope means will be found to permit it to do so.

DANGER FROM STATIC

FROM what we have recently heard discussed by the hosts of new radio enthusiasts, it seems that between the publications of such organizations as the National Board of Fire Underwriters, talks by many radio men who should know better, and the rattling, hissing, crackling of the loud speaker during the last month, the radio public is pretty well scared of the phenomenon which goes by the name of static.

To be sure, when one is listening with head sets, at the output end of a two step audio frequency amplifier and one of those whip-crack atmospheric disturbances comes in, the listener is well prepared to believe that there must be some danger associated with such a vicious sounding discharge. As a matter of fact it is our opinion that there is no fire risk at all due to ordinary static; with a small antenna such as the average receiving station uses it seems that the voltage of one of these heavy static disturbances is comparatively small, certainly not more than ten volts for the average "crack". The amount of current associated with this voltage is not more than a small fraction of one ampere, so that the actual electrical energy in the antenna which gives the rattling of the telephone receivers is probably much less than that required to ring the door bell! And no one has ever entertained the idea that his house was going to be burned down because of the electrical power flowing over his bell wires.

Whatever extra risk a house is subjected to when a receiving antenna is installed is not due to static at all but due to the remote possibility that the chance of the house being struck by lightning is increased by the presence of the antenna. It is embarrassing to put forth theorems as to how lightning behaves, because probably the first case under observation after the theory has been expounded will happen in exactly the way the theory says it will not. It seems as though the answer as to whether or not the presence of antennas do increase the fire risk will have to wait on the statistics of the next year or two; with the number of antennas in operation increasing by the hundreds of thousands, any real risk associated with the antenna must certainly show itself in the form of a greatly increased number of fires attributable to lightning strokes. In other words, if you wonder if the antenna does increase your fire risk, join the ranks of statistic providers, put up the antenna, and wait for a year or two. In the mean time enjoy the radio news and concerts without worry.

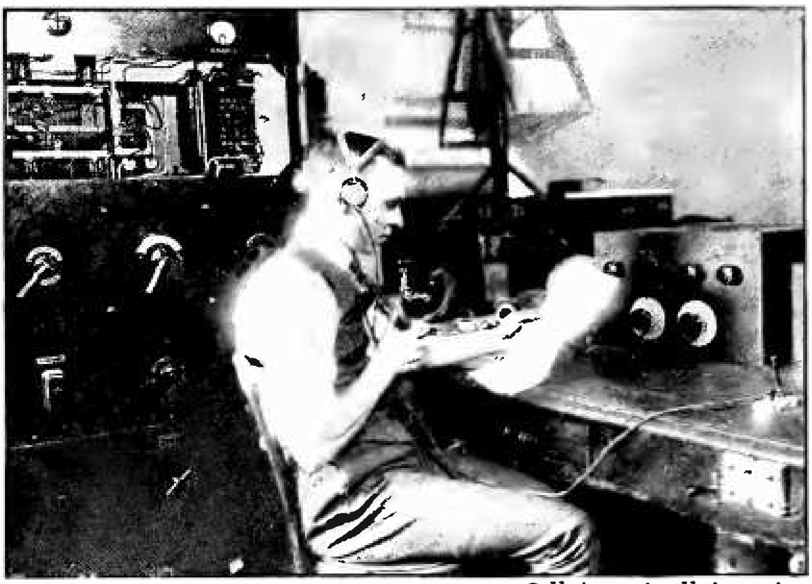
The electrical theorist can argue quite soundly, on either side of the question, as to whether or not the fire risk is increased, but it seems most likely to the writer that in the average well installed antenna station it has been decreased. Undoubtedly the chance of lightning landing in the neighborhood of the house has been increased, but the likelihood of damage therefrom has just as probably, perhaps more so, been decreased.

STATIC ELIMINATORS

AS THE number of radio listeners increases, so does the chance of profit for the dispenser of patent devices to improve radio reception. By this time the radio public knows much more about static and its interfering effects than it did in April. And after having an interesting lecture or well-executed musical selection spoiled by the cracks and hisses of the atmosphere, the radio enthusiast is psychologically in the proper status for the operations of the vendor of a static eliminator. At the time of this writing such a thing does not exist, nor is there any immediate promise of such a device; there has not yet been put forth anything of the kind which is worth the trouble of installation. The U. S. Patent Office is full of descriptions of hopes and aspirations along this line, but none of the patented projects does what the inventor hoped it would do. So unless you have some money you want to lose, it will be wise not to invest it in some cartridge shaped affair (or any other shape) which draws static out of your receiving set and disposes of it in a way you don't understand.

The best attempt at static elimination is the employing of the loop antenna; for two reasons the loop antenna compared to the ordinary overhead antenna gives a greater ratio of signal strength to static disturbance. Static comes from all directions and the signal comes from only one; the loop is very selective as regards picking up signals from different directions so that when oriented toward the desired station it receives full signal strength and comparatively little static because only those static waves which are travelling in the same line as the signal will be received with full strength. Also as the waves of static are generally long compared with the waves used for broadcasting, and as the loop is a very poor receiver for long waves, here again static is discriminated against, in favor of the signal.

If the static eliminators are no good, it seems likely that the stock of companies formed to manufacture and dispose of these devices (or any other of similar import) is not a very attractive investment in spite of the large returns promised. Not all of the fake radio schemes have yet been floated!



© Underwood & Underwood

One of Uncle Sam's agents broadcasting weather, crop, and market reports for the benefit of our farmers. Thousands listen to this service

The radio novice must frequently be puzzled in trying to make sense out of the radio articles he may read. In the same magazine we read in one place that "all broadcasting stations are transmitting on the same wavelength, namely 360 meters"; in another part we read that two signals of the same wavelength cannot be separated by any known scheme, and in a third section we read how so-and-so, by a slight turn of a handle tunes out W J Z and receives either K D K A or W G Y.

If such is possible, then one of the previous statements made must be inaccurate. As a matter of fact it *is* generally possible to tune out one broadcasting station and get another if the set used is well designed for selectivity and if the receiver is not too close to any one of the stations. This is because, in the first case, a good receiving set can successfully separate two signals of very nearly the same wavelength and in the second, the different broadcasting stations *do not* send on the same wavelength, but only approximately so; if they lived up to the letter of the law it would be impossible to ever separate one from the other.

DISTANT CONTROL OF APPARATUS BY RADIO

THE remote control of different devices by the use of radio waves has frequently brought forth spectacular articles in the press; the explanations given are generally entirely inadequate and worded in such a way that the action is made to appear much more mysterious than it really is. A technical description of the schemes customarily used in controlling torpedoes, vessels, free automobiles, etc. is well outlined in a short article by F. W. Dunmore of the Bureau of Standards, published in the Proceedings of the spring convention of the American Institute of Electrical Engineers. Circuit diagrams as well as illustrations of actual distant control relays are given, together with an easily understood explanation of the operation of the apparatus for cases where batteries only are available and when alternating current supply is the source from which the tube circuit must be actuated.

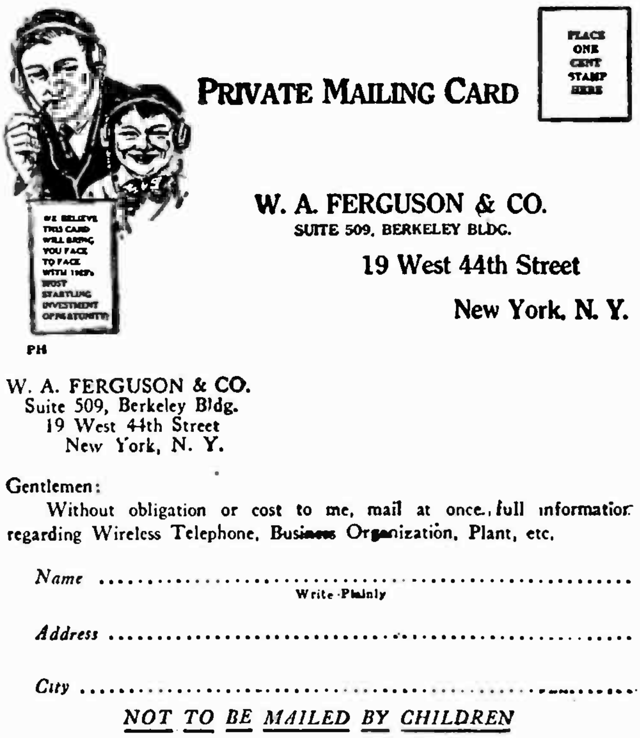
Using just the schemes described here, it would evidently be possible to accomplish almost any reasonable operation by the use of radio waves; the distant control of a warship under way, being used for target fire, or the gyrations of the driverless automobile become easy to understand. Wireless transmission of pictures or simultaneity of several distant and apparently unrelated events are not only possible but are comparatively easy of accomplishment with apparatus such as described in this paper.

J. H. M.

Beware of Radio Stock Offerings

THE return postcard of W. A. Ferguson & Co., of 19 West 44th Street, New York, reproduced below came to the attention of the editors of RADIO BROADCAST because it bears on its face a copy of the design showing a father and son enjoying radio which appeared on the May issue of RADIO BROADCAST. W. A. Ferguson & Co. reproduced this to get capital by soliciting funds from the public by extravagant promises.

Broadcasting does not reach 75,000,000 people, or 15,000,000 homes, as stated on the reverse of this card. The statement that profits on radio equipment run from 100 to 1,000 per cent. is calculated to mislead, because, if there were any such profits, the public



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PLACE ONE CENT STAMP HERE

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Gentlemen:
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Write Plainly

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A little self-confidence and the courage to investigate are all the price that you are asked, to have the greatest opportunity given you ever offered the investing public.

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If these facts won't prove mighty money makers for you—what will?

ON December 20th, 1920 the first broadcasting station was placed in operation in Pittsburgh. Since then some fifty-two stations, reaching 75,000,000 people or 15,000,000 homes, have been constructed.

SINCE 1901 the annual average of gross business done in the sale of Radiophone apparatus has been $50,000. Based on the business done by the manufacturers since the first of the year, gross sales for 1922 will amount to $50,000,000, an increase of one thousand fold. And this is but the beginning.

THE profits in the manufacture of radio equipment run from 100 to 1000%. The most fascinating invention of modern times opens up investment opportunities unequalled since the Telegraph, Telephone, Eastman Kodak, Victor Phonograph and Ford Motors were in their infancy.

RADIOPHONE securities are the opportunity of to-day. Millions have been made and are being made. The men with vision and courage, who invested their small savings with Mr. Morse and his "toy", are as independent to-day as those who invested with Mr. Bell and his "toy" Exactly the same opportunity may be yours to-day with the RADIO TELEPHONE.

NOW - MAIL THIS CARD TODAY AND GET DETAILS OF OUR SPECIAL OFFERING—TOMORROW MAY BE TOO LATE - NOW

without permission. They reproduced it upon a type of literature with which RADIO BROADCAST does not desire to be associated in any way, and the object of this notice is to make it clear to all readers of RADIO BROADCAST that the use of its cover design by W. A. Ferguson & Co., does not imply the endorsement or approval of W. A. Ferguson's offer in any way, shape, or form. On the contrary, we think it proper to warn our readers against new stock offers of radio manufacturing companies. Radio is not producing millionaires daily as is stated on the face of this card. It is a rapidly expanding business, but the expansion is of a solid nature and in the hands of men who have been devoting their energies to this field for some time, and their businesses do not need need not think that men who had the foresight and ingenuity to be in the radio business successfully in this boom time would need to give away to the public the profits which long investment, effort, and foresight have brought them. These misleading statements are followed by the time-worn get-rich-quick device of comparing the present investment opportunities in radio with those which existed when the Telegraph, Telephone, Eastman Kodak, Victor Phonograph, and Ford Motor companies were in their infancy.

RADIO BROADCAST objects most strenuously to being associated, even by implication, with this enterprise, and we wish to state that its reproduction of the copyrighted drawing on our May cover is a plain case of theft.

How Opera Is Broadcasted

Difficulties That Must Be Overcome in Order to Obtain the Best Results. How Singers Must Be Especially Drilled and Grouped, and How the Opera Must Be Revised, Interpreted, and Visualized to Make Up for the Lack of Action, Costumes, and Scenery. Artists Are Put in a Musical Straitjacket. Moving, Whispering, Even Deep Breathing a Crime

By C. E. LE MASSENA

IF THERE be a sixth sense, it must be that undefinable thing called *sensation* for which the modern public seeks in every department of daily life, and its latest form is radio. The present tremendous popularity of radio is due to its uncanny character, the unbelievable things which it accomplishes. It is, in truth, a novelty sensation. "The Choir Invisible," "In Tune with the Infinite," "The Voice of Nature," "There's Music in the Air"—all heretofore poetic fancies—are now real factors in our existence. If the world has gone daft over radio, it is because radio has brought us into closer relationship with one of nature's great mysteries—Ethereal Communication.

With a multitude of listeners, the radio broadcasting stations have had, of late, to provide increasingly adequate programmes. At first, talks, phonograph music, and news reports sufficed, but, like the proverbial snowball, radio broadcasting gathered volume as it moved, and a larger scheme had to be devised which to-day includes recitals by artists, concerts by bands and instrumentalists, lectures, sermons, and finally opera—and all within the space of a year. Naturally, such a schedule offered some problems and difficulties, all of which have been overcome successfully, but there is still room for improvement, especially in the realm of opera, the broadcasting of which is a problem quite different from anything else. Here we have to deal not with a single voice or instrument or with a unit, such as a band or orchestra or chorus, but with a combination of several such elements—solos, ensembles, choruses, instrumental numbers, dialogue,—and all must be rendered in such a manner as to provide a finished result. How to manipulate these forces quietly, without interruption or stop, or the introduction of sounds other than those desired, offers some food for thought.

There are certain mechanical limitations associated with this new instrument of communication. Talking machine companies solved their problems by recognizing these limitations both as to sound volume and frequency of vibration, and accordingly they evolved a recording technique which is almost perfect. The radio has just begun to feel its way, and no such technique has been developed but it is only a question of time before it will be perfected. The conspicuous facts are these: Radio fans who "listen in" know that phonograph records broadcast well, also solos, both vocal and instrumental. Duets, trios, quartets, choruses and operas reproduce less perfectly, owing to the fact that radio recording technique is in the experimental stage. Orchestras, bands, and large vocal bodies lose much of their detail in the ether. Volume is imperceptibly decreased, and words emitted by more than a single person are apt to become blurred and muffled. Yet, every problem has a solution, and one for this will undoubtedly emerge at a not too distant date.

Performances of opera have been transmitted from the Berlin Opera House and the Chicago Opera House and heard at long distances, but the actual broadcasting of a complete opera was not undertaken until March 15th last when Mozart's "The Impresario" was presented at the WJZ station at Newark, N. J. The writer had the honor of being associated with this enterprise. As soon as the date had been fixed, William Wade Hinshaw, manager of the company and president of the Society of American Singers, assembled his forces, and, with a dummy microphone, practised broadcasting the opera in his New York studio.

NO SCENERY, NO ACTING—JUST SONG AND SPEECH

THE company had just returned from a twenty-five weeks tour. They were familiar with every detail, line, phrase, and position, but these had to be set aside for the nonce and a new version prepared. Action, costumes, facial expression, entrances, exits—all had to be abandoned. The music and the dialogue alone could be retained. The opera must be done with just these two factors. No scenery, no acting—just song and speech.

That was a job in itself, but the end justified the means. After the concrete materials had been properly adjusted to circumstances, another problem loomed up—that of arranging the producing elements so as to secure the maximum tonal effect. This was accomplished by introducing a shifting process, each singer having a fixed position from which he moved forward, backward, and sidewise according to a prearranged scheme, precisely like a football line that opens and shuts and moves by a code of signals. This opera, having to deal with principals only and a pianist, presented no difficulties as to chorus or orchestra; therefore, as soon as the singers understood how and when to move, the hard work was done. As a preliminary measure, however, Mr. Hinshaw journeyed to Newark several days in advance of the performance and delivered a lecture by radio on "Opera Comique," thereby preparing his invisible audience for the novelty in store for them. He explained the meaning of this kind of entertainment, recited the plot, told about the artists who would sing the various rôles, and made a strong plea for better music and a deeper appreciation of good music such as Mozart composed. He decried jazz and the modern dance music as unhealthy and immoral, and asserted that pure, wholesome opera comique would do much to turn the world of music back to normalcy.

THE BROADCASTING STATION AT WJZ

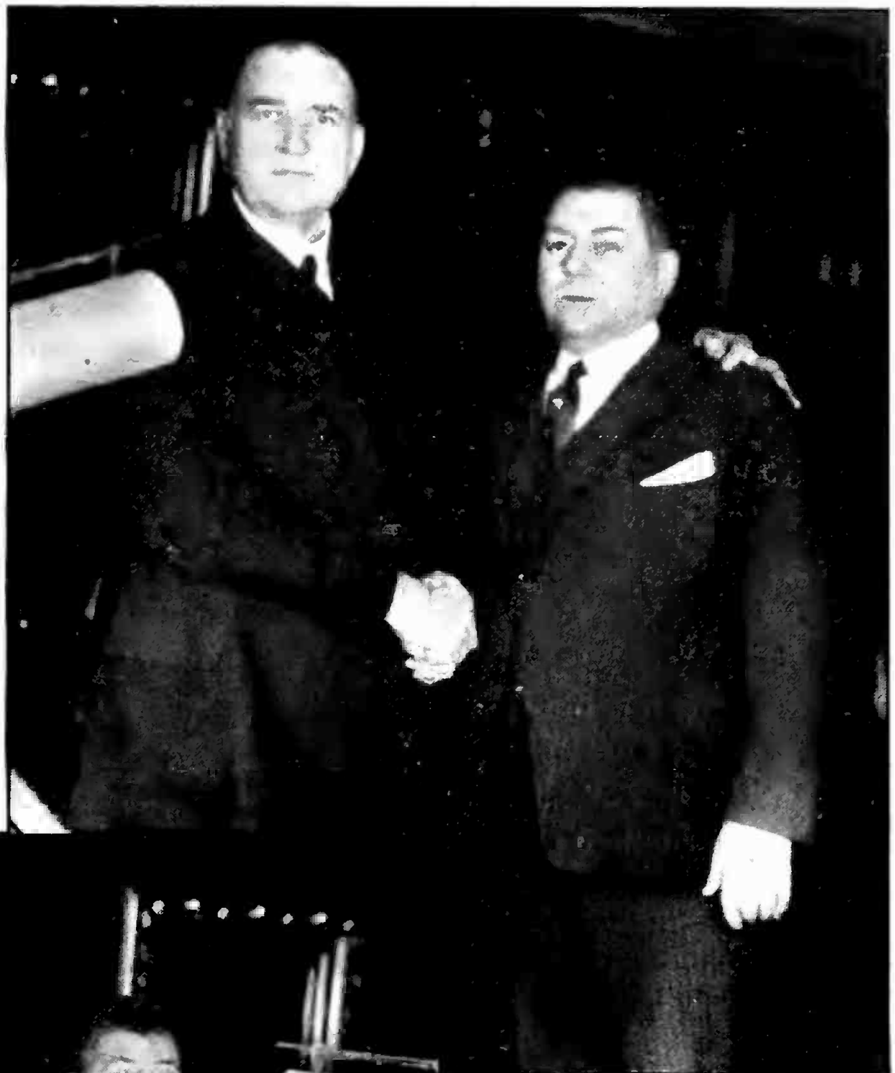
AT NEWARK, the recording took place in a small room, about 10 x 40 feet, on the second floor of the Westinghouse plant. At one end is a grand piano. On one side is the electrical apparatus which conveys the message to the amplifying station on the roof. On the opposite side is the switch and a set of head phones, also a phonograph and an orchestrelle. In the centre is the portable microphone into which the sound waves are directed. At the back of the room are chairs and tables for auditors and reporters. There have been several kinds of microphones employed—a platter disc, a cup and a cylindrical tube. The last named was in use at this time. It is about six inches in diameter, lined with felt, and is suspended from an adjustable tripod.

Obviously a double operation is necessary in broadcasting music by radio-telephone. The singer or player produces a series of tones, each of which proceeds, not of itself, but via a sound wave. This wave enters the cup, is transferred to the station on the roof over a telephone wire and then broadcasted through the ether by means of electromagnetic waves.

THE ACTUAL BROADCASTING OF OPERA

THE programme for the evening has been announced through the press and by bulletin, and the thousands of radio fans are adjusting their headpieces at the scheduled hour. Of course, they do not hear the voices of the singers or the tones of the instruments any more than they do over the ordinary telephone. They hear a reincarnation, a recreated voice and tone, because the original tones are not conveyed but first transformed into etheral waves and then transformed back again by means of the many receiving outfits within range of the broadcasting stations. This is what makes the whole thing so uncanny, mysterious, and sensational. It is the thrill of thrills. Not only do the listeners experience a new sensation, but the performers also. To talk or sing or play to an invisible audience of unknown proportions is sufficient to make the most seasoned opera star or concert artist quake. A new experience—a novel sensation, even to those who knew nought of awe or fear.

The company arrives and is shown into the *sanctum sanctorum*. They take their places. The announcer explains that they are subject to certain radio traffic regulations, as other broadcasting stations are also operating and it would be discourteous to begin until the exact hour announced, when the air lanes are free. Now the usual running time for "The Impresario" is an hour and forty minutes, but in the tabloid version for broadcasting twenty-five minutes have been eliminated. Even an hour and a quarter in this musical straitjacket is enough to tire any artist. Movement is prohibited, whispering is little short of criminal, and even too deep breathing is forbidden. The announcer cautions all regarding these details and asks if they are ready. With a final admonition of "Sh-h," he closes the switch and then speaks into the microphone, while the members of the company stand silently by, with eyes dilated, enwrapped in a new experience. "This is the WJZ station at Newark, N. J." he begins, "broadcasting Mozart's opera com-



William Wade Hinshaw (Manager) introducing Percy Hemus (Star) to the radio audience

Thomas McGranahan, Regina Vicarino, and Percy Hemus singing "The Impresario" for the invisible audience ique 'The Impresario' under the direction of William Wade Hinshaw. Announcer ACN. I take pleasure in introducing Mr. Hinshaw." Mr. Hinshaw silently slides into the position promptly vacated by ACN and addresses his audience. Anxiety! Suspense! Yes, 100 percent! The nervous strain is intense, and all are glad when he concludes and they can do something. This tension acts as a stimulant. In most cases, radio singing and playing inspires the artists to do even better than their best. That is why the radio concerts are of such excellence.

HOW "THE IMPRESARIO" WAS BROADCASTED

MR. HINSHAW proceeds to introduce the several artists by name, requesting them to speak and tell who they are and what characters they impersonate. This done, the signal is given to the pianist to proceed, and the opera is on.

As each character appears, the singer steps forward, delivers his lines or sings, as the case may be, then retires to make way for the next, who takes up the thread immediately. When two or more are engaged in dialogue or ensemble musical numbers, the heads come together so that everything may be recorded and no one be more prominent than another. At the end of the hour and a quarter, the company is ready to draw a long breath and a handkerchief and relax. It is fun, but it is hard work, too.

Having no chorus or orchestra to handle, "The Impresario" was an admirable composition with which to initiate the broadcasting of opera. It was the first work of its kind ever sent out on the air, and proved a great success. Mr. Hinshaw received numerous letters from many sections of the country, some from far distant points, expressing the pleasure and satisfaction of the hearers.

HOW "PANDORA" WAS PREPARED

HAVING made close observations, during the presentation of "The Impresario" and having carefully noted the conditions under which the music is recorded, I was able to conduct the rehearsals of "Pandora" with some degree of certainty as to the arrangement of the forces employed. Compactness was the first consideration, and this meant curtailment to the last degree. I judged that eight voices—all of good quality and power and all using the same vocal method—would serve better than twice or thrice the number chosen at random. To this end, I enlisted the coöperation of Mme. Minna Kaufmann, the well-known vocal teacher and coach, who selected the required number of singers from among her best pupils and taught them the choruses with the most gratifying results. Those who heard the rehearsals and later the radio performance said that the volume of sound was like that emitted by a large chorus.

Then I arranged the music so that it would be sung in unison or in two-part harmony, as a more involved harmonic structure would only weaken the effect due to the inner voices being lost in the volume of sound while, on the other hand, with the simple harmony arrangement, each voice was reinforced and the waves made that much stronger. I had the four solo voices sing along with the chorus, thereby increasing its power. My method of grouping was entirely new to the operator who at first wanted to employ the usual method with the singers in front and the instruments further back, but I prevailed upon him to try my arrangement.

Every instrument, every voice, every phrase, and most of the words came through the air distinctly and clearly and there were no discordant elements noted. One more detail. I instructed the instruments to play with gusto and the chorus to sing with vim. The soloists could enjoy a little more freedom, but precision and dynamic force were necessary as a first consideration. My contention proved correct. Except in some of the very loud choruses, wherein the words were lost in the mass of tone, our efforts met with surprisingly good results.

While vocal music carries better than instrumental music by radiophone, there is no occasion for dissonance, if the forces are properly adjusted, selected, and placed. But if the same grouping employed in concert and stage performances is adhered to, trouble is sure to follow. Adequately to broadcast an opera employing an orchestra, soloists, and chorus means a lot of hard thinking and much preliminary practice. With the present method, only a limited number of the sound waves from so large an assemblage will find their way into the microphone. Therefore we should retain only such a force as will meet the demands and eliminate the rest. The quandary then is how to ascertain which record and which do not. This problem can be solved only through experiment and practice.

With a score like my "Pandora," several

Below: "The Impresario" company at the broadcasting station and above: the same company on the stage. The artists in both pictures are in the same positions and include, Thomas McGranahan (Mozart), Gladys Craven (pianist), Regina Vicarino (Mme. Hofer), Percy Hemus (Schickaneder), Hazel Huntington (Mlle. Uhlic), Francis Tyler (Phillip)

new elements were introduced. In presenting this, I undertook to broadcast a work requiring the services of principals, chorus, and instruments, so April 6, 1922, marks the date of the first complete operetta ever given in this manner. That it proved successful was due to the care and thought bestowed upon the preliminary rehearsals, and to the selection of the participants. The first problem was how to place the forces to best advantage. There was no precedent to follow, and therefore experiment was the only avenue open. An arrangement had to be devised so that none of the music would be lost and none be too loud or too soft. A dummy microphone was secured, and the chorus was grouped compactly in front of the piano with lid raised. The four solo singers were placed in front of the chorus and the two stringed instruments at either side near the microphone. In this way a good ensemble was secured with the weaker close to and the stronger forces back from the recorder. The same plan of movement as to positions was carried out as in "The Impresario," except that I explained the plot between the musical numbers, omitting the dialogue, and in this way made a condensation that occupied just an hour in delivery.

"Well, your company certainly sang their heads off," was the pleased comment after the performance. Why? Because they were singing under the influence of a new sensation which gave an added stimulus to their efforts and lent zest to their work. Both productions were broadcasted without a hitch or slip, and the results justify more entertainments of like character. Two other operas—"Martha" and "La Traviata"—were given in radio form with piano during the interim between the broadcasting of "The Impresario" and "Pandora," but I am not in a position to discuss them, not having heard or seen the presentations. However, as a result of these experiments, it is evident that not every form of opera can be presented by radio successfully. Mr. Hinshaw asserts that "the ultra-modern opera is an impossibility . . . that one must choose a work that is melodious and in which solo voices do the greater part of the singing." I am not convinced as to the last statement. I think duets, trios, quartets, and other combinations, even choruses, are capable of being successfully broadcasted, just as they are successfully reproduced on the phonograph. It all depends upon how thoroughly the problem is studied and how well it is solved. Mr. Hinshaw says further that a Wagner opera could not be produced successfully, and that the best of all for radio are those of the classic style, and particularly the works of Mozart.

WHAT THE FUTURE HOLDS

TO-DAY, that is true; to-morrow, it may not be true. I would not go so far as to assert that all modern opera is impossible for radio presentation. Anyone who has been associated with broadcasting music readily realizes that such an enterprise requires much more careful preparation and training than do concert and stage productions. The singers have only their voices with which to convey the tonal message; therefore they have to sing well and invest their song with all that the eye can not see. That is the huge and difficult task that makes radio opera such a hazardous and precarious undertaking under present conditions.

Stringed instruments, by reason of their inferior potency as wave generators, must always be close to the microphone, just as they are placed closest to the horn during the process of making a phonograph record. Before it was possible to obtain a good tonal balance of orchestral instruments for phonograph records, much experimenting had to be done. The same thing is true of radio broadcasting. A brass band where all the instruments are of the same timbre will sound very well via radio, likewise a chorus, but when two or more dissimilar elements are broadcasted simultaneously, it is highly important that they be placed in the most advantageous positions. Violin and piano, voice and piano, two voices, an instrumental trio or quartet, an accompanied chorus, an orchestra—all these offer problems which must be solved before such combinations can be broadcasted in a manner to give complete satisfaction to the listener. A violin string is rubbed with a bow, while the piano's strings are struck by hammers. The tones are different and so are the sound waves produced —both as to strength and character. The

"PANDORA" PRINCIPALS REHEARSING
Philip Spooner (Epimetheus), Mrs. C. E. Le Massena (Pandora), Marion Heim (Hope), William H. Henningsen (Quicksilver)

A rehearsal in Mme. Kaufmann's studio, Carnegie Hall, New York. C. E. Le Massena, composer and director, at extreme right

weaker ones must be closer and the stronger farther from the recorder. Moreover, as men's voices carry better than women's—because they are deeper and consequently have fewer vibrations per second—it is advisable to place the women nearer the microphone in ensembles. Just how far from the recorder each should be placed is a matter of careful experiment. The same rule holds good for the voice and piano and all other dissimilar combinations.

BROADCASTING SHOULD BE ON A COMMERCIAL BASIS

WHEN the programmes announcing celebrated artists were first made public, they created a widespread demand for receiving sets, for there were thousands who had never heard these artists and others who wanted to hear fine voices and players by radio. There was a rush for bookings and talent from which to choose was plentiful. But now the novelty has worn off. The best artists refuse to appear or to repeat; managers and associations are inserting a clause in their contracts prohibiting artists from giving radio recitals without remuneration. That is right. Why should artists give their services for this kind of work, which is not charitable, but solely for the benefit of the companies who sell radio receiving sets? Artists get some publicity, naturally, but it soon expires in the rush of events.

What is the future of radio opera, and indeed of radio music in general? It all depends upon how far the broadcasting companies are willing to coöperate with artists and musical organizations. So long as the programmes were good, and so long as leading artists were willing to appear thereon, the sale of sets mounted enormously. But what about the present situation? It is evident that unless the former high standards of excellence are maintained, radio fans will register a vociferous protest.

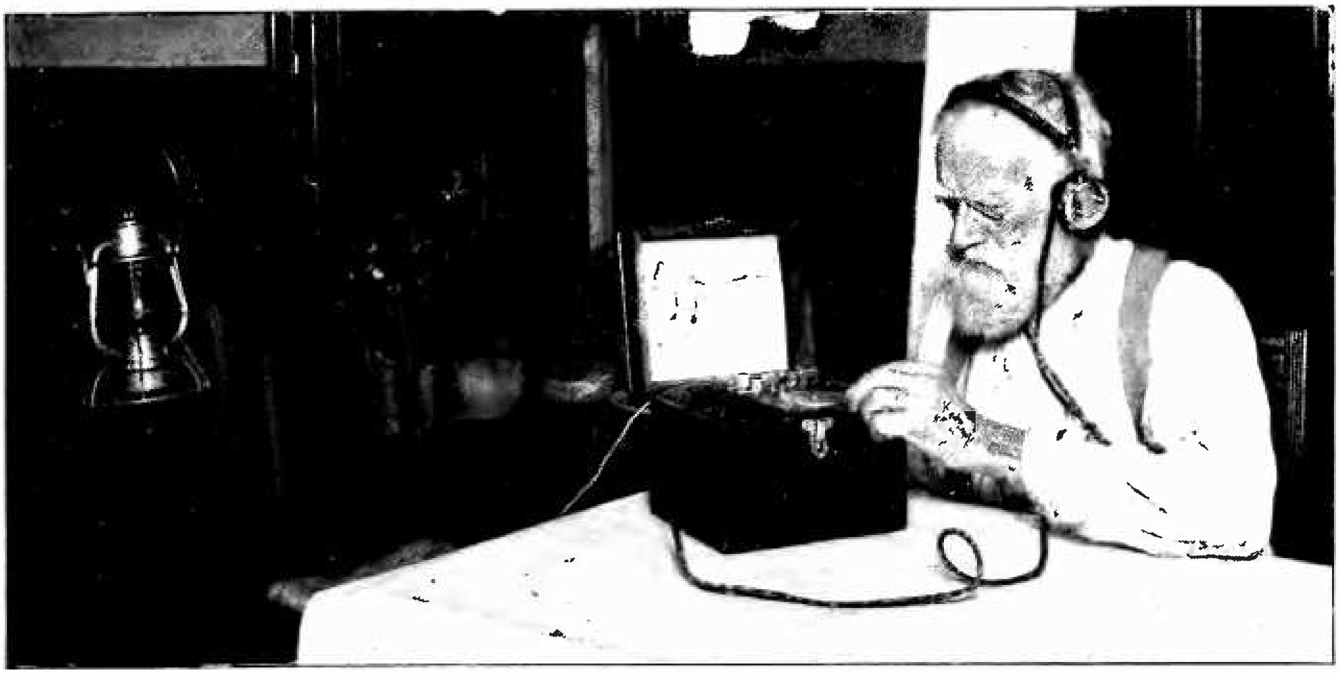
Mme. Galli-Curci, one of the most celebrated singers in the world, was invited to sing via radio, and promised big advertising. She was also guaranteed an audience of a million and an orchestra to assist her. Of course the lady's managers declined the invitation. As she can earn $4000 to $5000 a night, why should she waive this sum in order to sing for thousands who already know her, and the majority of whom have probably heard her? The commercial profit to the company would have been enormous, but wherein could it benefit her?

The whole trouble at present is that the manufacturers are lacking in foresight. The time is coming, and soon, when they will have to engage such artists as they require, or resort to cheap musical programmes. For example, when Mr. Hinshaw took his opera company to Newark, the expense to him was considerable. This production sells for $1000 with piano and $1500 with orchestra. Taking into consideration the rehearsals and the time expended in traveling, the loss was probably not less than the latter amount. As an advertising proposition, there was a certain value received, but nowhere in proportion to the service rendered. Broadcasting should be put on a commercial basis. Companies are making big money out of this novelty and can afford to engage artists and pay them for their services.

One of the officials of a prominent manufacturing company, when confronted with this argument, stated that if the artists refuse to sing gratis, they may force a discontinuance of concerts and drive the broadcasting stations into another avenue of activity. This is a very commercial way of looking at so important a phase of a wonderful industry, and obviously is the wrong attitude. Moreover, the programmes are not arranged at present with a view to the best results. There is too much variety, good and bad all jumbled together, in an effort to fill out the broadcasting time. Artists realize that it is detrimental to appear on a jazz programme, or to be sandwiched in between a comic singer and an amateur band. The time is coming soon when programmes will have to be planned with more skill. There must be an "opera" night, a "popular" night, a "band" night, a "jazz" night, an "artist" night, a "juvenile" night, etc. The time is hastening when it will be necessary to engage artists and organizations precisely as is done in the regular concert field. A laborer is worthy of his hire, and as soon as programmes are made up with a view to their artistic value, and not with a view to securing something for nothing, then there will be proper coöperation and a mutual benefit for all participants.

All the world wants music. The easiest and cheapest way to get it is by means of the radio telephone which affords opportunities to a vast multitude of persons who otherwise would be unable to hear any. The man in the lighthouse, the farmer in his kitchen, the lumberman in his shack, the traveler at sea, literally thousands of persons hitherto isolated,

JUST A SMALL PART OF THE AUDIENCE



HEARING HIS FIRST OPERA

are now able to relieve the monotony of their existence by introducing culture and entertainment into it by means of radio-telephony. Music is no longer confined within the four walls of concert halls and opera houses. Radio-telephony has freed the captive bird from its prison, and it is now at liberty to soar and to sing for all who may care to hear.

ADDITIONS TO LIST OF PRESENT RADIO BROADCASTING STATIONS IN THE UNITED STATES PUBLISHED IN THE JULY ISSUE OF RADIO BROADCAST

CALL SIGNAL	OWNER OF STATION	LOCATION OF STATION	WAVE LENGTHS
KDYL	Telegram Publishing Co.	Salt Lake City, Utah	360
KDYM	Savoy Theatre	San Diego, Calif.	360
KDYN	Great Western Radio Corp	Redwood City, Calif.	360
KDYO	Carlson & Simpson	San Diego, Calif.	360
KDYQ	Oregon Institute of Technology	Portland, Oreg.	485
KDYR	Pasadena Star-News Publishing Co.	Pasadena, Calif.	360
KLX	Tribune Publishing Co.	Oakland, Calif.	360
KNX	Electric Lighting Supply Co.	Los Angeles, Calif.	360
KQI	University of California	Berkeley, Calif.	360
KYI	Alfred Harrell	Bakersfield, Calif.	360
KZV	Wenatchee Battery & Motor Co.	Wenatchee, Wash.	360
WAAD	Ohio Mechanics Institute	Cincinnati, Ohio	360
WCAB	Newburgh News Printing & Publishing Co.	Newburgh, N. Y.	360
WCAC	John Fink Jewelry Co.	Fort Smith, Ark.	360
WCAD	St. Lawrence University	Canton, Ohio.	360
WCAE	Kaufman & Baer Co.	Pittsburgh, Pa.	360
WCAG	Daily States Publishing Co.	New Orleans, La.	360
WCAJ	Nebraska Wesleyan University	University Place, Nebr.	360,485
WCAK	Alfred P. Daniel	Houston, Tex.	360
WCAL	St. Olaf College	Northfield, Minn.	360
WCAM	Villanova College	Villanova, Pa.	360
WCAN	Southeastern Radio Telephone Co.	Jacksonville, Fla.	360
WCAO	Sanders & Stayman Co.	Baltimore, Md.	360
WCAP	Central Radio Service	Decatur, Ill.	360
WCAQ	Tri-State Radio Manufacturing & Supply Co.	Defiance, Ohio	360
WCAR	Alamo Radio Electric Co.	San Antonio, Tex.	360
WCAS	William Hood Dunwoody Industrial Institute	Minneapolis, Minn.	360
WCAT	South Dakota State School of Mines	Rapid City, S. Dak.	485
WCAU	Philadelphia Radiophone Co.	Philadelphia, Pa.	360
WCX	Detroit Free Press	Detroit, Mich.	360,485
WHB	Sweeney School Co.	Kansas City, Mo.	360,485

What Everyone Should Know About Radio History

By PROF. J. H. MORECROFT

PART II

A FEW years after the publication of Hertz's work in 1888 the scientific world heard rumors of the experiments of Guglielmo Marconi, then about 20 years old. He had been a student of Physics under Professor Rosa, at the Leghorn Technical School, and had especially made himself acquainted with the work of Professor Righi, who had been making experiments similar to those of Hertz, extending Hertz's work into the region of very short electric waves, about one centimeter long.

MARCONI'S METHODS

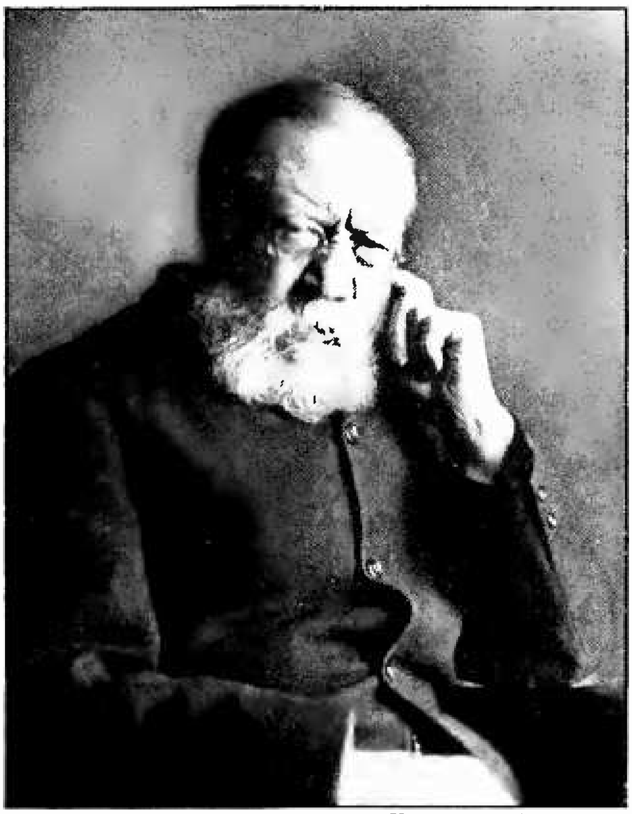
MANY contributions to scientific development have been the result of accident; something strange and unexpected has happened in the course of an experiment and has thus started a keen mind in search of its significance. But not so with Marconi; it is evident in reading of his early experiments and progress that he had set out, intentionally and with premeditation, to develop the laboratory work of Hertz into a successful scheme of communication. And once having started on the problem he stuck to it with a persistence seldom seen in a scientific worker. His progress was methodical, and followed the line suggested by his experimentation; there are no wonderful jumps in the methods of attacking the problem or in the results achieved. The development brought out by Marconi from 1895 to 1902 is an excellent example of scientific attack and accomplishment; with keen insight as to what was happening, Marconi took the logical steps to increase the distance over which he could carry on signalling and also the certainty of the communication.

His enthusiasm and ability steered him clear of the thorny and tedious path which must be trod by many inventors; the British Post Office Department and many prominent scientists gave him assistance and encouragement in carrying out his tests. It was in England that Marconi found the conditions best suited to the development of his new scheme of telegraphy; the British Empire has always been foremost in the development of communications as it is evidently of utmost importance for the close coöperation of its component parts. Until the United States entered the field of world-wide radio the British cables practically controlled the field of international communication. This of course gave to her traders a great advantage over others and enabled them nearly to control world trading. It is no wonder therefore that Marconi was so ably assisted in his development work in England. Its success would give the British Dominions still better control over the world's trade routes.

As everyone at all acquainted with radio knows, it involves the generation and radiation of high frequency waves at the transmitting station and some means of detecting them at the receiving station. Marconi started by using at his transmitting station radiators similar to Hertz's, but used at his receiving station a more sensitive indicator than was used by Hertz—a device known as the Branly coherer. The coherer, in the form first used by Marconi, was a small piece of glass tubing with metal terminals in each end, the space between these ends being filled with metallic filings, loosely in contact. It possessed a remarkable property by virtue of which if high frequency voltages were impressed on its terminals the contacts between its particles of metal dust became much more intimate so that the electrical resistance of the device became much less. This effect could be taken advantage of in the scheme of Marconi very well; a battery connected through the coherer could ordinarily force but little current through it because of its high resistance, but when it was affected by the high frequency waves sent out by the transmitting station its resistance fell to a low value and thus the battery could send much more current through it and so ring a bell or operate a printing telegraph, etc. This coherer of Branly, which was considerably improved by Marconi, was probably the most important single factor in Marconi's early work, it so far exceeded in sensitiveness Hertz's spark-gap receiver that it increased the possible distance of communication hundreds of times.

EFFECT OF HEIGHT AND SIZE OF ANTENNA

EARLY in his work Marconi got the idea of using at his transmitter and receiver a vertical wire, to the upper end of which was connected some large metallic body (such as a tin-covered cubical frame) and the lower end of which was connected to metal plates laid on the ground. He found that with his vertical wires six feet high he could communicate one hundred feet and with them twelve feet high he could get the same amount of signal at a distance of three hundred feet, and when they were twenty-four feet high he got the same signal strength at twelve hundred feet. Furthermore with his twenty-four foot wires—, if he increased the size of the metal bodies connected to the upper end, the possible distance was very much increased; thus with metal cubes about three feet on a side his transmission distance was three times as much as when they were only one foot on a side. These experiments, which were carried out in 1895, it will be noted, gave to Marconi ideas regarding the effeciency of an antenna as a radiator or receiver which we accept as correct to-day after much more refined measurements of the quantities involved. If an antenna is to send out much power, it must be high, and, further, it must have a large spread of wires at the top and be suitably connected to good earth plates, or ground, as we call it.



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SIR WILLIAM H. PREECE

In 1896 Marconi went to England with his apparatus and there took out his first patent on wireless telegraphy in that year. His work interested Sir William Preece, of the British Government telegraph service; this eminent engineer at once realized the wonderful advance Marconi had made over previous attempts along this line, and gave to the young inventor his hearty support and approval. Although Marconi made no startling new invention he had availed himself of the known possibilities of Hertzian waves and had improved the Branly coherer and had made a combination which worked. When the validity of Marconi's claim to an invention was questioned Sir William Preece made the following comment:

"He has not discovered any new rays; his receiver is based on Branly's coherer. Columbus did not invent the egg but he showed how to make it stand on end, and Marconi has produced from known means a new electric eye more delicate than any known electrical instrument and a new system of telegraphy that will reach places hitherto inaccessible. Enough has been done to prove and show that for shipping and lighthouse purposes it will be a great and valuable acquisition."

Sir William's belief in the usefulness of the young inventor's scheme has been amply justified, as we now know; in fact, his estimate of the value of Marconi's work was all too small.

From 1896 on Marconi gave many demonstrations, gradually increasing the size of his apparatus and correspondingly the distance over which he could communicate. In 1898 a set was in actual operation connecting the Goodwin Sands lightship with the shore; with the success thus far reached it was evidently only a matter of perseverance and material resources to accomplish transoceanic communication, the goal towards which many of the earlier experimenters, dealing with currents in the ocean water, had striven with no success.

In 1899 he had in operation two stations bridging the English Channel, and during the month of December, 1901, the first transatlantic signals were received by him in Newfoundland. For these first transoceanic tests his receiving aerial in Newfoundland was a wire supported by a kite, and the transmitting aerial, in Cornwall, on the west coast of England, was two hundred feet long and one hundred and sixty feet high. The spark transmitter used in Cornwall had an electrical capacity of only about 10 kilowatts and its efficiency must have been extremely low. In judging the ability required of Marconi in getting these first messages it must be remembered that to-day, with much more efficient transmitting sets, and receiving circuits thousands of times as sensitive as was Marconi's coherer, we use hundreds of kilowatts of power to get reliable transoceanic communication. The success of Marconi's first transoceanic tests speaks volumes therefore for his experimental ability. Bold indeed would be the experimenter to-day who would attempt transoceanic signalling with an inefficient spark coil transmitter, and a coherer for a receiver!

TUNING OF TRANSMITTER AND RECEIVER

THE waves used in the early experiments were not much more than "splashes" in the ether (whatever that mysterious substance may be); the receiving apparatus could not be tuned, and the great gain in loudness of signals which tuning makes possible could not be obtained. Pupin, in America, had pointed out the possibility of using tuned circuits at low frequency, and from 1899 to 1901 Marconi did much experimental work in trying to use tuning (or syntonizing, as it was then called) and took out several British patents on the application of tuned circuits to wireless communication.

He accomplished a great deal, using two tuned circuits, loosely coupled at the transmitting station and two similarly arranged circuits at the receiving station. The arrangement of circuits he used in 1900 was as good as that we use to-day in a modern spark transmitting set; of course there are certain features which have been improved since then, such as the quenched spark gap, and the crystal detector or vacuum tube detector, at the receiving station. We must remember that in all this important development work of Marconi's he was using as detector the coherer, which, although Preece regarded it as the most sensitive electrical eye possible, was but a very crude and insensitive piece of apparatus compared to that we use at present. It had to be continually tapped by a buzzer attachment to maintain it in a sensitive condition; after a signal had been received through the coherer the dust particles were cohered, and had to be shaken apart by the taps of the buzzer before they could again function to receive another signal.

PRACTICAL TRANS-ATLANTIC COMMUNICATION

IN 1907 the company developing Marconi's work opened the well known stations at Clifden, in Ireland, and Glace Bay, in Nova Scotia. Regular commercial business was carried on at the rate of ten cents a word. This Clifden-Glace Bay service was the pioneer radio link between America and Europe and much very valuable data was gained during the first few years of its operation. In spite of its novelty and isolation in the technical field (for years no other radio transmission rivalled it), the service was surprisingly uniform and reliable. It was in the study of the operation of this service that Marconi first found out that it was very difficult for a radio signal to cross the sunrise or sunset line; when the sun had risen in Ireland but had not yet come up in Glace Bay the sunrise line was somewhere in the Atlantic and the signals had to cross this line. A remarkable fading effect in the strength of signals was noted; in fact transmission across the line was practically impossible. We still have to contend with strange fading phenomena in radio transmission, but this special sunrise seems to occur to an appreciable extent only for the comparatively short waves used in the early days. Now, with waves 20,000 meters long, the effect is of much less importance. It was in the operation of this Clifden-Glace Bay service that the tremendous difference between transmission in the summer and that in the winter was forcibly brought out. The interference by atmospheric disturbances is thousands of times as troublesome during the summer as in the winter months, so that the amount of power required for summer traffic must be many times as great to get the same reliability in transmission as in the winter months.

Many of the amateurs will recall the consistent transmission of the low pitched musical note of Glace Bay; it used to be the station by which we could test the condition of our sets, regularly sending its dots and dashes across the ocean. The Clifden station was not as easy to "get," of course, as was Glace Bay but many of the good amateur experimenters used to do it, nevertheless.

OTHER EARLY WORKERS IN THE FIELD

OF COURSE, work as remarkable as was that of young Marconi excited the interest of every scientific and technical man of the day and many of them contributed valuable ideas to the rapid development of the new art. In England Fleming was closely associated with Marconi, and was undoubtedly of great assistance in the early experiments helping to design properly the circuits and apparatus. Later he contributed the Fleming valve about which more is said later on. Lodge and Muirhead made important contributions and were granted various patents, particularly with regard to the coherer, which was unquestionably the weakest point in Marconi's whole scheme. This coherer, which occupied the same position in the receiving circuit as does the crystal or tube detector of to-day, with its buzzer for de-cohering after every dot, was rather complicated and unsatisfactory in its performance, and many of the workers endeavored to modify it so as to improve its performance. With the simple crystal detector of to-day, or the vacuum tube, the work of the early experimenters would have progressed much faster and farther.

© Paul Thompson

JOHN STONE STONE

MARCONI'S WORK TAKEN UP IN GERMANY

WORD of Marconi's work having reached Germany, Professor A. Slaby came to England in 1897 to see the experiments. He himself had been trying to use the ideas of his illustrious countryman, Hertz, to obtain communication over appreciable distances, and had met with but meager success. Slaby was quick to recognize the superiority of Marconi's work over his own and gave him generous praise after seeing but a few of his experiments. In analyzing Marconi's work, Slaby (who afterwards became one of the foremost wireless inventors of Germany) replied to some of the criticism which had been raised against the novelty of Marconi's work in the following words: "It was urged that the production of Hertz rays, their radiation through space, the construction of the electrical eye*—all this was known before. True; all this had been known to me also, and yet I was never able to exceed one hundred meters.

"In the first place Marconi has worked out a clever arrangement for his apparatus which by the use of the simplest means produces a sure technical result. Then he has shown that such telegraphy (writing from afar) was to be made possible only through, on the one hand, earth connection between the apparatus, and, on the other hand, the use of long extended upright wires. By this simple, but extraordinarily effective, method he raised the power of radiation in the electric forces a hundred fold."

After witnessing Marconi's experiments and returning to Germany, Slaby began active development of wireless along the lines already taken by Marconi, and, associated with Count von Arco, developed the well known Slaby-Arco wireless apparatus. Professors Braun and Zenneck made valuable contributions also to the German wireless development. In 1903 Slaby and von Arco and Braun joined interests with the *Allgemeine Electricitäts Gesellschaft* and Siemens and Halske to found the *Gesellschaft für Drahtlose Telegraphie*, which firm put out the excellent wireless apparatus used in the "Telefunken" system.

To the scientific and theoretical side of radio Drude, Abraham, Wien, and Seibt, in Germany contributed; in France Poincaré, Branly, and Ferrie; in Italy, besides Righi there were Bellini and Tosi (who did the pioneer work in the

*By which was meant the coherer.

radio compass); in America, Pupin, Trowbridge, Pierce, Fessenden, and Stone helped in the early developments.

WORK OF FLEMING

ALTHOUGH there were many engineers and scientists of valuable assistance to Marconi in his early work, of these J. A. Fleming was by far the most important, judging by the contributions he made. Fleming assisted in making the generating apparatus at the transmitting stations more powerful and reliable, using an alternating current generator and transformer in place of the spark coil used earlier by Marconi. His great contribution to the art was not along these lines, however, but in furnishing a more reliable and sensitive detector of the high frequency radio currents set up in the receiving aerial. The coherer, and later the magnetic detector, had been used by Marconi; the magnetic detector was more reliable than the coherer but even this was far less useful than the Fleming valve, the forerunner of the wonderful vacuum tube used to-day in all good sets.

In 1883 Thomas A. Edison had noticed a peculiar action taking place in some of the special incandescent lamps with which he was working at the time. Experiments carried out with a bulb in which there had been sealed a metal plate close by the filament but insulated therefrom, showed that if the metal plate was made electrically positive with respect to the filament, current could pass through the vacuous space between the filament and plate, but if the plate was made negative with respect to the filament no current could flow. Here there was evidently a kind of electrical gate, or one-way valve, and the idea was patented by Edison in 1884. The phenomenon was given the name "Edison effect."

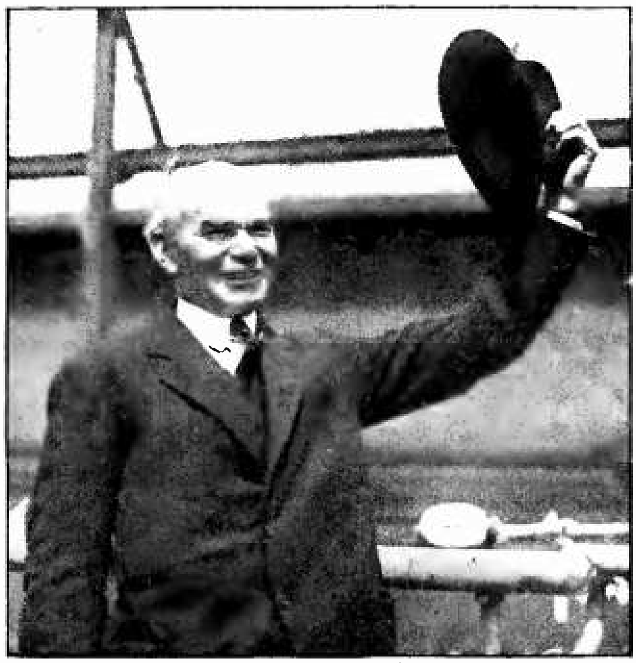
Fleming had used some of these bulbs having the extra electrode inside and when working with Marconi he got the idea of using this effect to permit the detection of the high frequency currents in a receiving aerial. Using a coil for transmitter and another for receiver, the same as Hertz had done, he utilized one of these bulbs with a direct current galvanometer in series to see if the direct current instrument would indicate. His first tests were successful and indicated that such a type of rectifier would probably be much more useful than the coherer.

Fleming took out a patent in Great Britain in 1904 and in America in 1905, the patent covering the idea of using the Edison effect in detecting high frequency signals. It has been frequently stated that Fleming did not invent this device, the well-known Fleming valve,—that his accomplishment was merely the application of an old idea in a new field. This is undoubtedly true, but such application has repeatedly been rated as invention and it has been judicially confirmed that Fleming's work did constitute an invention. The life of this patent is, of course, now expired, so that the construction of a two electrode tube for detecting radio signals is now permissible for anyone.

Marconi used some of the early Fleming oscillation valves (as Fleming called them), and found them much more satisfactory than the coherer then used. The ordinary crystal detector had not yet been discovered, so the production of the oscillation valve by Fleming constituted a real advance in the art. In sensitiveness those valves which have been tested by the writer are about equal to an ordinary crystal, but they have the advantage, of course, compared to the crystal that it is not necessary to hunt for a "good point." As long as the batteries are not run down, and the filament is hot, a valve will always function properly, whereas it cannot similarly be known for a crystal that it is operative or not, but recourse must be had to testing with locally produced signals.

Fleming apparently made a quite thorough investigation of his valves, and it is worth while noting some of his remarks regarding their behavior. He had noticed that the current flowing across the vacuous space in the valve was strongly affected by the action of either an electric or a magnetic field. The control of the electron stream by the magnetic field is the basis of the action of the "magnetron," a device developed in the General Electric Laboratory during the last year or two. The action of an electric field on the electron flow to the plate of course foreshadows the control of the plate current by an electric field applied either internally (the De Forest audion) or externally, as done in the Marconi audion, with external grid, a type of tube known to but few radio experimenters. It seems strange that Fleming did not at once jump to the idea of the audion, but the history of science is full of just such occurrences—a worker on the point of making an important discovery, yet missing it by the merest chance.

In recent years developments have been carried out and patents have been granted for Fleming valves which have been more thoroughly evacuated than were Fleming's valves. It scarcely seems that these devices (styled "kenotrons") are inventions; they employ no action unknown to Fleming, even though they do permit the use of much higher plate voltages than was possible with Fleming's original tubes. It seems, however, that Fleming appreciated the significance of a good vacuum for the proper operation of his valves. In one of the specifications of his 1904 patent he states: "As a very high vacuum should be obtained in the bulb, and a considerable quantity of air is contained in the conductors, these should be heated when the bulb is being exhausted. The filament can be conveniently heated by passing a current through it while the cylinder* can be heated by surrounding the bulb with a resistance coil through which a current is passed, the whole being enclosed in a box lined with asbestos, or the like. When the cylinder is replaced by any form of conductor which can be heated by passing a current through it, this method is usually more convenient than that just described."



DR. LEE DE FOREST

It is evident from this, to anyone, that Fleming did appreciate the importance of high vacua in electron tubes and it therefore seems that later tubes, which are much more completely exhausted than were Fleming's, do not constitute an invention, but are merely the embodiment of Fleming's ideas, carried out to a higher degree than was possible for him with the then rather imperfect and difficult methods of evacuation available to him.

In 1911 Willows and Hill developed a Fleming valve in which the hot filament was a lime-coated strip of platinum, a so-called Wehnelt cathode, because Wehnelt was the first to point out the advantage of using such a cathode. If the hot filament is covered with certain oxides the electrons are emitted at a much lower temperature than if a pure metal is used, and thus less filament current is required to get a certain number of electrons. This type of oxide coated filament has been developed by the Western Electric Company for its long distance telephone repeaters.

In 1904 Dr. Lee De Forest was working in America on the use of the flame as a rectifier for high frequency radio currents. He took out a patent in 1905 on a bulb having two hot filaments connected in a peculiar manner, the intended functioning of which is not at all apparent to one comprehending the radio art. The wording of the patent claims is not that of a scientist but that of a shrewd patent attorney trying to hide some mysterious secrets in a superfluity of high sounding terms, instead of giving the exposition of a fact or operation discovered by the inventor. This is the trouble with too many of our patents, from the standpoint of one trying to understand what the inventor has done; the patent attorney tries to put the wording in as indefinite a form as possible so that, no matter what may happen in the future, the wording of the patent, it may be argued, anticipates just that development.

De Forest's claims were gradually changed until they finally described a device identical with Fleming's valve, which he styled the "audion". In the published accounts of the action of the audion De Forest seems to have thought the action very mysterious although Fleming had explained the action apparently quite satisfactorily some time before. During his early work it seems as though De Forest were deliberately trying to avoid giving Fleming credit for the work done in developing the oscillating valve. Had De Forest studied Fleming's writings at all, he would not have thought the action of the valve so mysterious.

*Fleming's plate.

In 1907 De Forest made his real contribution to the radio art; he somehow conceived the idea of interposing a metallic mesh, or grid, between the two elements of a Fleming valve and thus gave us that wonderful piece of apparatus, the three electrode tube. Much litigation ensued because of De Forest's claims that his device did not embody the principles of the Fleming valve. De Forest's claims and explanations were extremely dubious; it was about this time that the writer asked De Forest, at a public scientific meeting, a simple question as to how the audion functioned and to which answer was made that "his patent attorneys had told him to say nothing as to how the audion functioned." What patent attorneys can do for a scientist! Had it not been for experimenters like Armstrong of Columbia University, Langmuir of the General Electric Company, and van der Bijl of the Western Electric Company, we should know but little to-day of the action of the three electrode tube.

It is to be pointed out, however, that little as De Forest contributed to an explanation of his device, the thing which he actually did, namely the insertion of the third electrode into a Fleming valve, was a most wonderful contribution to the radio art. As a matter of fact, in the opinion of the writer, this was the most important single step taken in the whole development of radio communication. Let us give De Forest credit for this wonderful achievement, even though he was so reluctant to give credit to the other workers in the field, principally Fleming, on whose work the possibility of the audion depended.

R. A. FESSENDEN

FROM 1900 to 1907 Professor R. A. Fessenden was extremely active in the development of various phases of radio. The files of the Patent Office at Washington pay tribute to his activities during this period—his patents are counted by the dozen. Besides several patents on rectifiers, to compete with the coherer and the magnetic detector, he devoted himself among other things to radio-telephony; as early as 1901 he had laid down the essential principles of the art. The high frequency alternator which was later taken up by the General Electric Company, and further developed by their staff of engineers, and given the name Alexanderson alternator, was first conceived, patented, and built by Fessenden. The compressed air condenser, a very efficient form of condenser for large transmitting stations, is an invention of Fessenden; many of these are used to-day in the U. S. Government station at Arlington from which the standard time signals are sent out.

The most important of Fessenden's contributions to present day radio, however, is probably that by which he showed possible the reception of continuous wave telegraph signals by the so-called "beat method," or heterodyne reception. He first mentioned this scheme in 1902, but did not apparently use it much until 1907 when he described the method and gave several schemes for using it, among others the electrostatic and electrodynamic telephones. The heterodyne method of reception is not only a very ingenious scheme for overcoming a difficulty (absence of wave train frequency in continuous wave transmission), but it is an extremely sensitive method and it made feasible most of the early long distance radio transmission. The importance of the heterodyne scheme was increased tremendously when Armstrong discovered that the vacuum tube detector itself could be used for generating the required local high frequency currents.

WORK OF ARMSTRONG

DURING 1911 and 1912 E. H. Armstrong was studying for the degree of Electrical Engineer at Columbia University; he was not an especially brilliant student, in fact in many of his courses he did rather poorly. The writer knows because Armstrong was one of his students. The characteristics of alternating current machinery in general, did not prove very enticing to the young student, not because he was lazy or indifferent but because he had a hobby—and a vision. He was experimenting at his home with wireless apparatus and trying to find out how the three electrode audion of De Forest worked. If De Forest confessed in public that the action was too mysterious for him to explain, then Armstrong would explain it for him! Which he promised to do, and did very shortly.

After graduating, Armstrong continued at Columbia as assistant to the writer in the radio laboratory; later he worked with Prof. M. I. Pupin, continuing his study of the three electrode tube. As the writer looks back to those days it seems undoubtedly true that Armstrong understood the action of the audion better than anyone else in the world. Day and night he thought and talked of nothing but the audion;

his devotion to this study, and perseverance therein finally brought rich reward—he was granted a patent, the validity of which was recently confirmed, which gives to him credit for being the first really to understand the action of the three electrode tube.

In using the audion as a detector of wireless signals certain coils were required, and Armstrong accidentally placed two of these coils much nearer to each other than they should normally be and lo—a strange noise was heard in the telephones. This strange noise started Armstrong to work on his wonderful discoveries.

It was noted in the first part of this history that the more or less accidental occurrence of a small spark started Hertz on his epoch making discoveries, and certainly it was as much an accident that led to Armstrong's work. But by those who may, at this point, think that an accident may some day make them also famous, let it be remembered that after the accidental noting of something unusual it was a long and difficult road which lead to the complete explanation and utilization of the phenomenon involved.

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R. A. FESSENDEN AT WORK IN HIS LABORATORY

The noise which Armstrong heard was the beat note between the oscillation being set up by the De Forest audion he was using and a signal being sent out from some continuous wave station. He found that the pitch of the note varied with the adjustment of his circuit, and by keen intuition he came to the conclusion that the tube he was using was oscillating at a high frequency. He pursued the study of the action until it became very clear to him and he made patent application for his idea—which is fundamentally this: If the plate circuit of a three electrode tube and grid circuit are suitably connected (by magnetic induction or otherwise) the reactions occurring between the two circuits tend to set up alternating current in that circuit which has a condenser and coil connected together, the value of inductance and capacity determining the frequency of the alternating current generated.

He found out that even if the adjustment was not sufficiently carried out to make the tube oscillate, still the interconnection of the plate and grid circuits might cause a tremendous increase in signal strength. This is the "feed-back" or regenerative idea for which Armstrong's work is known.

Since Armstrong's first work appeared, innumerable circuits, with fancy names sometimes attached, have been published, the "inventor" probably thinking many times that the idea was entirely new. They are all embraced by Armstrong's patent, however, if they function by the interaction of the plate and grid circuits of the tube which can be brought about by the use of various connections of condensers and coils. In general there must be made provision for the energy which is resident in the plate circuit battery to get into the grid circuit if oscillations are to be maintained; if this provision involves the electrical or magnetic interconnection of the plate and grid circuits by use of condensers and coils suitably arranged, the idea comes under Armstrong's feed-back claims. It is of course possible, that some other action may be found by which case the present monopoly on the use of regeneration would be temporarily broken.

WHAT ARMSTRONG'S CIRCUIT MAKES POSSIBLE

IT SEEMS a simple thing to couple together the plate and grid circuits of a vacuum tube and one would scarcely believe the importance of such an evident possibility. The results of the coupling are however very important. When a continuous wave signal is received the ordinary crystal detector or vacuum tube detector does not yield a signal because there is no variation in the amplitude of the high frequency current, a variation with a frequency in the audible range. If, however, the local circuit is continually excited by a high frequency current, when the high frequency signal is received the two high frequencies will act together and produce "beats", and the frequency of these beats is the same as the difference in frequency of the two different currents. This method, as mentioned previously, is the result of Fessenden's work.

Armstrong's idea evidently enables the vacuum tube which is being used as detector to act also as a generator of the high frequency currents which serve to produce the beats when the continuous wave signals arrive. Not only does the simple coupling idea of Armstrong thus permit the audion to act as a receiver of continuous wave signals, but it also makes it an extremely sensitive receiver at the same time, if the adjustments are carefully carried out. The writer well remembers one night, before Armstrong had published his explanation of the action of the oscillating tube, spent at the Marconi's then new station at Belmar, N. J. Mr. Weagant, the chief engineer of the American Marconi Company, and Mr. Sarnoff, at present manager of the Radio Corporation, were also witnesses of those early tests when Armstrong showed us how his circuits could "pick up" the continuous wave stations on the Pacific coast—stations with only a few kilowatts of power. To hear the note of the station changed at will, by a turn of a handle on one of the boxes, was a severe puzzle for the Marconi engineer, especially as Armstrong, like a proper inventor, had everything completely hidden in boxes, with the lids securely screwed down. And nary a chance did the chief engineer have to peep inside! He would surely have been surprised had he seen how simple the whole thing was.

As another illustration of the remarkable advance in sensitiveness made possible by Armstrong's invention, the writer recalls hearing in his laboratory at Columbia, on several occasions, a station on our west coast in communication with one at Honolulu, and the two stations were continually calling for "repeats". They were only 2,000 miles apart, over the ocean, and the laboratory was 3,000 miles over land from the nearer one and 5,000 miles from the farther. Both stations were received at the laboratory clearly by using Armstrong's apparatus, yet they could not understand each other, using the receiving apparatus then in general use.

Besides the wonderful amplification of signal obtainable by the feed-back principle, the selectivity of a circuit is greatly improved so that stations sending on nearly the same wave length cause no interference. This idea is of more value in telegraphy than in telephony; in the latter the receiving circuit must not be too selective or else the speech will not be clear but will be drummy in quality, and indistinct.

Armstrong has also given to us a valuable idea in his special short wave amplifier, and has just startled the radio world with what he has named his "super-regenerative" scheme whereby the present amplifying power of his circuit is greatly increased.

OTHER WORKERS IN THE FIELD

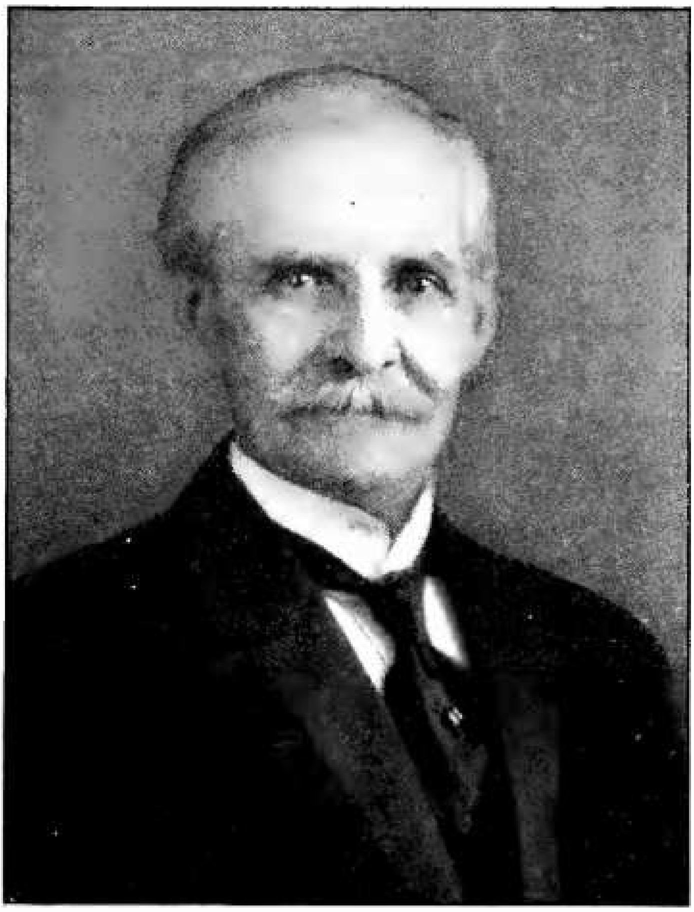
IN THIS brief history of the art many names have necessarily been omitted. Pupin, in his early work on tuning alternating current circuits, did much to show how to make radio signals more free from interference; Lowenstein showed the importance of properly adjusting the potential of the grid of the three electrode tube if it is to operate efficiently as an amplifier; Pickard and others discovered the utility of the various crystal detectors used in the cheaper radio sets of to-day. Round, in England, and Meissner, in Germany, both were on the track of the regenerative action of the tube when Armstrong found it, and they were not far behind Armstrong. Poulsen and Pederson, in Denmark have been responsible for the development of the tremendous arc generators used in long distance transmitting stations, such as that erected at Lyons, France, by the American engineers during the war. Alexanderson, in America, and Goldschmidt, in Germany, have perfected wonderful high frequency generators. General Squiers has shown possible the transmission of radio frequency currents over ordinary telephone wires resulting in our present "wired wireless". And the great research laboratories of the General Electric and Western Electric companies, with such men as Hull, White, Heising, and others, have contributed tremendously to bringing the art of radio to its present high state of development.

Will Antennas be Buried in the Back Yard?

By LEWIS WOOD

The first successful long-distance underground reception was effected in 1916 by Dr. J. H. Rogers who passed his ideas on the subject over to the Government when we were at war. By his system static, which usually occurs in the air strata above the earth, is considerably reduced because the energy collectors for the receiver are kept away from these strata. The use of the Rogers system was looked upon with favor during the war and is now in use in various Naval Stations. The Navy spent thousands of dollars experimenting with this receiving system, much of the work being done at Belmar, N. J., Bar Harbor, Me., and New Orleans, La. In addition to reducing static, this character of receiving station has the property of being very directional, which also reduces interference from undesired stations. Long waves are received much more satisfactorily than short waves, and for this reason it would seem as though the system is better adapted to commercial and government radio than for use by the man-in-the-street. No towers are required, but these qualities are limited to receiving only, for the present system does not function satisfactorily as a transmitter.—The Editors.

IS THE day coming when aerials will be buried in the back yard instead of running across the roof or sticking up on high poles as at present? Dr. J. Harris Rogers of Hyattsville, Md., thinks so, and he has given such an emphatic demonstration of his theory that scientists and navy and army experts who have witnessed his tests believe it will not be long before the tall towers that have cost so much money will be unnecessary.



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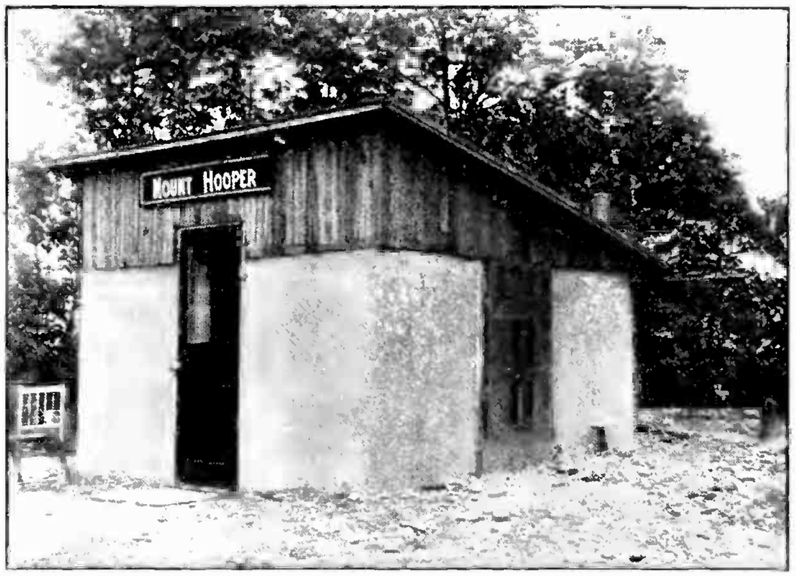
Dr. J. Harris Rogers of Hyattsville, Md., discoverer of the underground and undersea system of radio communication

As far back as 1908, in experiments whose subsequent developments proved of incalculable benefit to the American Army and Navy during the World War, Dr. Rogers, a scientist of reputation, conceived the idea that the earth instead of the ether furnished the real medium for transmitting radio waves. This premise will come as a jolt to the poetic. Perish the thought that Galli-Curci's voice comes in via the sink-pipe instead of out of the broad sky. Yet Dr. Rogers has no less an authority to reinforce him than the great Charles P. Steinmetz who lately declared that under certain circumstances it would be easier for wireless waves to course through the ground than through the air.

DR. ROGERS' METHOD HELPS ELIMINATE STATIC

ONE of the most startling and interesting features of the Rogers discovery is the practical elimination of static through the underground aerial. The writer knows that during a heavy electrical storm when the ether was enormously disturbed, Dr. Rogers, using a loop aerial suspended in a brick-walled well, heard KDKA and WJZ with absolute distinctness, and no interference to speak of. The contrast has been illustrated many times, and in the most dramatic fashion, for Dr. Rogers, by manipulating a switch, throws his receiving set first in on an outdoor aerial and then on his underground loop. The difference in effect is always marked.

Recent experiments in Dr. Rogers's laboratory brought in vocal and instrumental music on a 360 meter wave length over a distance of 220 miles. The instruments used were three stages of radio-frequency, a detector, two stages of audio-frequency amplification and the underground loop. For a long time, Dr. Rogers has been receiving radio telegraph waves by this underground method, but the new experiments concerned themselves not with the long wave lengths but with the short lengths which to-day make up the chief percentage of radio traffic. There was strong static in the air at this time and street cars and passenger and freight trains were speeding to and fro not 200 yards away from the laboratory, but none of these disturbances interfered with the reception of the concerts.



The field laboratory built by Dr. Rogers, where a secret delegation of Naval Officers first heard German Army communications by means of an underground antenna

RECEIVES THROUGH WATER AS WELL AS EARTH

DR. ROGERS has worked for years on his discovery and against the utter skepticism of some of the most eminent radio engineers and experts in the world, he has turned their opposition topsy turvy. When with a 4,000 foot wire buried three feet in the earth inside a tile pipe and leading in a westerly direction, he clearly heard communications between German army units on the European battlefront, he amazed naval and army officers. Then he set out to prove that water as well as earth was a communicating medium for electro-magnetic waves. Naval officers, Marconi and Dr. G. W. Pierce, radio expert of Harvard University, all said this was impossible, but Dr. Rogers the dreamer promptly invented the method of communicating with submerged submarines.

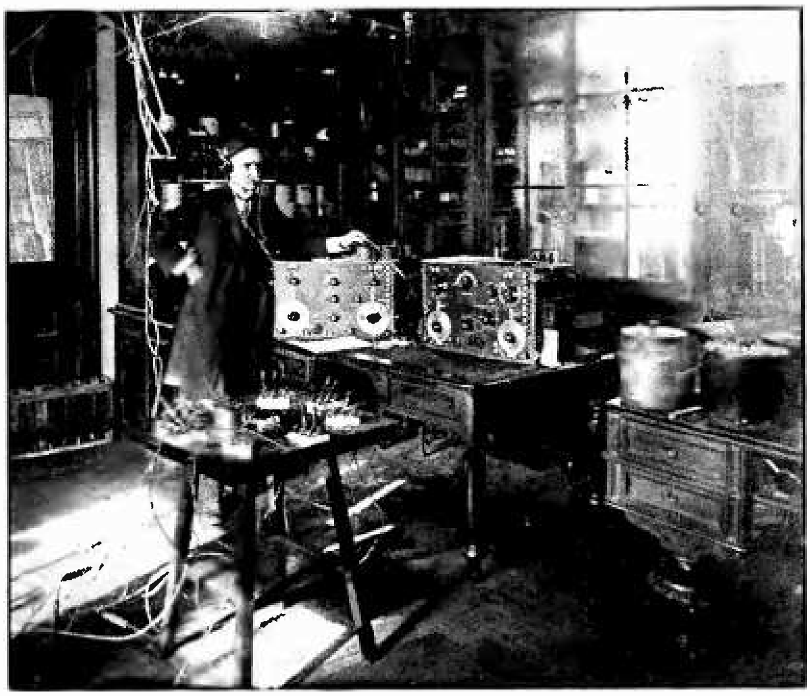
Coming from patriotic and fighting stock, for his grandfather was an American naval lieutenant and his father a Confederate soldier, Dr. Rogers was intensely anxious to aid his country during the World War, and it is notable that although he naturally applied for letters patent he gave the benefit of his discoveries to his government without compensation. At the age of sixty-seven, he bent every energy to his task. In 1916 in an obscure piece of land he owned not a great distance from "The Parthenon" where his fathers had lived before him, he reproduced a dug-out on the Western front and from this central receiving station he ran scores of subterranean wires. They were laid like the spokes of a wheel, buried at various depths in the ground and of numerous lengths. The inventor worked with the most intensive application using combination after combination of the wires, in the main, however, obtaining his best results with his "ground" and "antenna" either set at right angles to each other or in opposite directions.

A SECRET SESSION

TO THIS little field laboratory, which he afterwards named "Mount Hooper" in honor of Commander Stanford C. Hooper, then in charge of the navy's radio division, Dr. Rogers invited the officers. They doffed their uniforms and came inconspicuously in citizens' clothes, to Hyattsville which is seven miles from Washington. Like Dr. Rogers, they listened clearly to German official reports, and daily heard Nauen, the Eiffel Tower, and many American stations on long waves, including

Darien, and all without the annoyance of static, strays, or other ethereal clashes. In this experiment Dr. Rogers used a large tuning coil, a variable condenser, a one-step amplifier and a pair of telephone receivers. The antenna was formed by a rubber-covered cable. It was only a little while then before the Rogers system was installed in the government naval station at New Orleans where astonishing results were secured. Not long afterwards, Lieut-Commander A. Hoyt Taylor was ordered to install the system at the Great Lakes naval station.

The next and most important step came when the underground aerial was placed in operation at Belmar, N. J., for trans-ocean work. Six wires were laid under the ground at that point, and six operators were able to hear as many different European stations at the same time. So absolutely perfect was the scheme that all communications from the Allies to the United States were received through the underground antenna, and messages came in with great distinctness and with regularity even on days when the overhead towers would have been useless because of storms and when the lives of operators might have been in danger. The system was used in the American trenches in France, and many times it supplied the only instrumentality of communication.



Dr. Rogers using an underground loop antenna receiving a radio concert 220 miles. On the table in the foreground a group of switches, connected to various underground antennas, serve to alter the direction of reception and the wave length

COMMUNICATION BETWEEN SUBMARINES

THIS achievement did not content Dr. Rogers, for he was even then working diligently on his supposition that water provided a medium of communication. At the same time he was experimenting at "Mount Hooper" he was making tests below the surface of a little pond near by. He met success almost immediately in this undertaking for from a small boat he transmitted messages with underwater wires to his home two miles away. But submarines operate not in fresh water but in the salt sea, so he transferred his operations to Piney Point a promontory in Chesapeake Bay. Here the naval experts cooperated fully and perfect communication was established between two submerged submarines.

The wildest dreams of fancy seemed to have been realized for a submarine beneath the sea, a battleship on the surface, an airplane hovering in the sky and an army base employing the Rogers underground system all talked to each other. A submarine submerged eight feet off the Atlantic coast heard Nauen, Germany; twenty-one feet submerged it heard distant stations on 12,000 meters wavelength. A transmitting station operating with forty-eight amperes antenna current 600 feet away from a receiving station, using the Rogers underground aerial system, did not interfere with Nauen being picked up on 12,600 meters and New Orleans on 5,000 meters. No interference and no static. Aerials far under water were used to receive Cavite, Philippine Islands, 8,100 miles distant, on its regular 11 a. m. and 5 p. m. schedules.

THE ROGERS THEORY

THE basis of the Rogers theory is a complete upset to accepted theories. Ever since the days of Hertz, scientists have believed that electro-magnetic impulses pass through the space above the earth's surface. But Dr. Rogers, who had already secured fifty electrical patents in 1908 formulated another hypothesis.

"The energy liberated at the base of the aerial is propagated through the earth as well as through the ether above," he said. "An elevated aerial at a great distance would be actuated by these earth waves just as effectually as if the waves reached the same point through the ether. When these earth waves reached the base of the aerial the potential of the plate (earth) would be raised and lowered and the aerial energized accordingly."

This did not make any hit with the hard and fast scientists. In answer to Dr. Rogers' question, "if fifty units of power go into an aerial, what becomes of the equal amount of energy that goes into the ground?" they replied that this was dissipated in the form of heat. The scientists held that ether was the only conducting medium through which the electro-magnetic waves could be sent. But in contra-distinction Dr. Rogers says: "Electric energy liberated at the base of an antenna will be propagated through the earth even in the absence of the space above, were this condition possible. The earth and water waves are not dependent on each other, except when first propagated. Both the earth and the air waves are propagated at the same time, one above and the other below the surface of the earth."

It must not be held that Dr. Rogers believes that no ether waves travel through the air. He admits the presence of the air waves, but nevertheless he holds that because of the earth's curve, they die out in strength as they proceed. In fact he asserts that at great distances many of these waves transmitted through the ether never reach their destination, the result being really achieved through the earth-medium.

It was on the theory that the electro-static waves pass perpendicularly over the earth's surface that high towers were first erected. Great height of the antenna and great length were always thought to be an advantage. But if Dr. Rogers is right in saying that the ether waves fade out in intensity, then there is no necessity for this enormous capacity for reception. "Ether waves die out eventually in proportion to the earth's curvature and the distance over which they are propagated," Dr. Rogers says in explaining this particular theory. "At great distances ether space waves have no appreciable effect on receiving apparatus. The apparatus is energized by energy transmitted through the earth. Ground currents travel with the speed of light and are picked up at the receiving station. The space waves persist for an appreciable distance, which accounts for airplane to airplane and earth to airplane communication. Long transmissions such as 12,000 miles never reach the receiving station due to the high resistance of the atmospheric envelope."

TRANSMITTING RANGE LIMITED

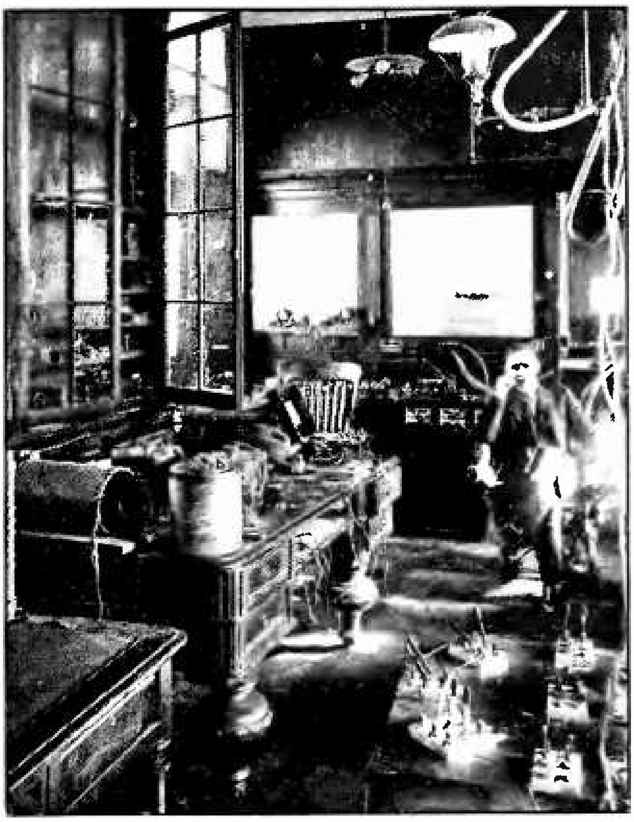
TRANSMISSION by means of Dr. Rogers's invention has not been developed as fully yet as has been the receiving of messages. While transmission has been accomplished over a distance of seven miles, it has not been possible to send to greater lengths because insulating material that will stand the heavy current used in sending has not been found. Radio telegraphy is received over long distances regularly, and Stavanger and Nauen come in easily. The most recent experiments seem to show that short wave messages and radiophone communication of all kinds will have no limits eventually, and so in time it may be possible to abandon all the expensive, unsightly, and undesirable towers and overhead aerials.

The towers have always been a nuisance. Those used in transatlantic work and even in the high-power stations of this country are costly, require time to build, are magnets for all atmospheric disturbances, are not directional and are menacing targets in time of war. Even though many experts consider towers necessary for transmission and for short wavelength work, Dr. Rogers believes they will be done away with. He urges that his system is far ahead of the towers because it eliminates static, and expense, is very directional, is safe for operators, is secret in time of war, is unimpaired by storms, and is economical to maintain.

A SCEPTIC CONVINCED

MOST of Dr. Rogers experiments are now conducted in a well covered by a building insulated against the ether. He has suspended in the well a loop aerial, which he can turn at will. Not long ago an experimenter who turned out to be a "doubting Thomas" visited the Rogers laboratory. He praised the doctor's work but it turned out later that when he left Hyattsville he conducted some experiments of his own to see how the Rogers system worked. Evidently he was satisfied, for he said that tests in a concrete lined cellar with a galvanized iron housing brought him fine results. He said he employed a magnavox which made signals audible for a distance of several hundred feet, and that during one rainy evening the presence of considerable water in the bottom of his pit did not affect the outcome.

Signals and voice received over the underground antennae do not come in as strongly as through the overhead aerial, but this is entirely compensated for by the fact that the absence of static renders the communication clear. During the war Lieutenant-Commander Taylor reported this condition and added that signals received at the Great Lakes station from both Arlington and San Diego could be copied with much more accuracy than when received via the overhead antenna. While Dr. Rogers has used various lengths of antennas, he finds that he obtains best results through a 2,000-foot wire insulated from the ground throughout its length. Although his first trials were with straightaway antennas, he early became convinced of the efficacy of the loop aerial, telling Lieutenant-Commander Taylor in 1916 that this would be better than the former method.



Upon the huge tables Dr. Rogers tries out various circuit arrangements, and he has all the necessary instruments handy for making accurate comparisons of results obtained by various methods—nothing is taken for granted or "judged"; if it can not be observed by employing his delicate meters, it is not passed

OFFICIAL RECOGNITION

OFFICIAL recognition of his work for the American cause was early accorded to Dr. Rogers. After the confidential investigation by naval officers in 1916, Josephus Daniels then Secretary of the Navy asked the patent office to expedite action on the scientist's application. Captain S. S. Robison a distinguished naval expert and author of the "Manual of Radio Telegraphy and Telephony," Admiral William Strother Smith and many other notable experts complimented Dr. Rogers highly and Commander Hooper wrote in Nov. 1917, "Your invention is the one above all which has been of greatest interest to me and the one which I consider of greatest value, especially during the present crisis." Georgetown University and the University of Maryland both conferred the degree of Doctor of Science upon the inventor, while the General Assembly of Maryland extended a vote of thanks in a joint resolution. The Maryland Academy of Sciences, in addition to bestowing a gold medal, recommended Dr. Rogers for the Nobel prize. Admiral R. S. Griffin chief of the Bureau of Steam Engineering, wrote: "There have been other claimants to methods of underground signaling, but none was useful, within the Navy Department's knowledge, to the extent of being a valuable asset to the general scheme of radio communication. The introduction of Dr. Rogers's receiving system marked the beginning of the use of underground aerials for receiving to great advantage over raised aerials, and has been valuable to the navy during the war."

GAS PIPE GROUNDS AND THE FIRE LAWS

In an article entitled "Mistakes to Avoid in Erecting Antennas," by G. Y. Allen published in the June issue of Radio Broadcast, the author stated that the ground connection could be made to a water, steam, or even a gas pipe. Since the publication of that article the National Board of Fire Underwriters has drawn up some new rules. The use of gas pipes for ground connections is now forbidden. The reason for this rule is that some gas systems in the house are electrically insulated from the ground, and would therefore resist the flow of current to the ground and a high potential surge might cause a fire.—THE EDITORS.

The Storage Battery in Radio Service

How to Select a Battery of the Right Capacity, Where to Install It, What Care Must Be Given It, and How It Is Charged

By JOHN GAREY
The Electric Storage Battery Company

WHERE vacuum tubes are used with radio receiving equipment a small current of electricity at a constant voltage is required to heat the filament in the vacuum tubes in order to make it sensitive for receiving. A great deal of experimenting and investigating has been done to determine the best means of supplying a current which will be suitable for this purpose, but so far the only really practicable method which has been found is the use of a storage battery

It might seem offhand that the ordinary lighting current from the city supply after it had been properly reduced through resistance would be ideal for this purpose, but the fact of the matter is that this current is not at all suitable as there is a humming noise which accompanies it which is distinctly audible in the head phones and which therefore seriously interferes with the receiving of music, speech, or other broadcast messages. It is possible to eliminate these noises to a large extent by means of complicated tuning processes but one must be an experienced radio engineer in order to obtain satisfactory results by this method.

A storage battery is, therefore, the most practicable source of current for the filament circuit as a storage battery will supply a noiseless current at an approximately constant voltage and it can be connected up and operated by any one by merely following a few simple rules. The battery used to heat the filament in a vacuum tube is known as the "A" battery.

DETERMINING THE PROPER SIZE OF BATTERY TO USE

THE capacity of a storage battery is measured in ampere hours or the ability of the battery to give a discharge of a certain number of amperes for a given number of hours. Thus a battery which will give a discharge of 1 ampere for 80 hours has a capacity of 80 ampere hours, which is the product of the discharge rate in amperes multiplied by the time in hours for which the battery will give this discharge.

In determining the proper size of battery for use with your radio set, there are two factors to be considered. The first is the number of vacuum tubes which are to be used, and the second is the facilities which are available for recharging the battery when its charge has been used up.

Most receiving vacuum tubes now on the market each require a current of approximately 1 ampere. The current required by two tubes is thus about 2 amperes and by three tubes 3 amperes, etc. These tubes also require a voltage of approximately 5 volts and this means that a 6-volt, 3-cell storage battery must be used. Each cell of a lead type storage battery delivers approimately 2 volts. Suppose, for instance, that your radio set uses two vacuum tubes and that the set will be in operation on an average of 2 hours per day, the discharge current required will then be 2 amperes and this discharge over a period of 2 hours will take 4 ampere hours per day out of the battery. A 40 ampere hour battery would carry this discharge for about ten days before recharging, and an 80 ampere hour battery would carry this discharge for about twenty days.

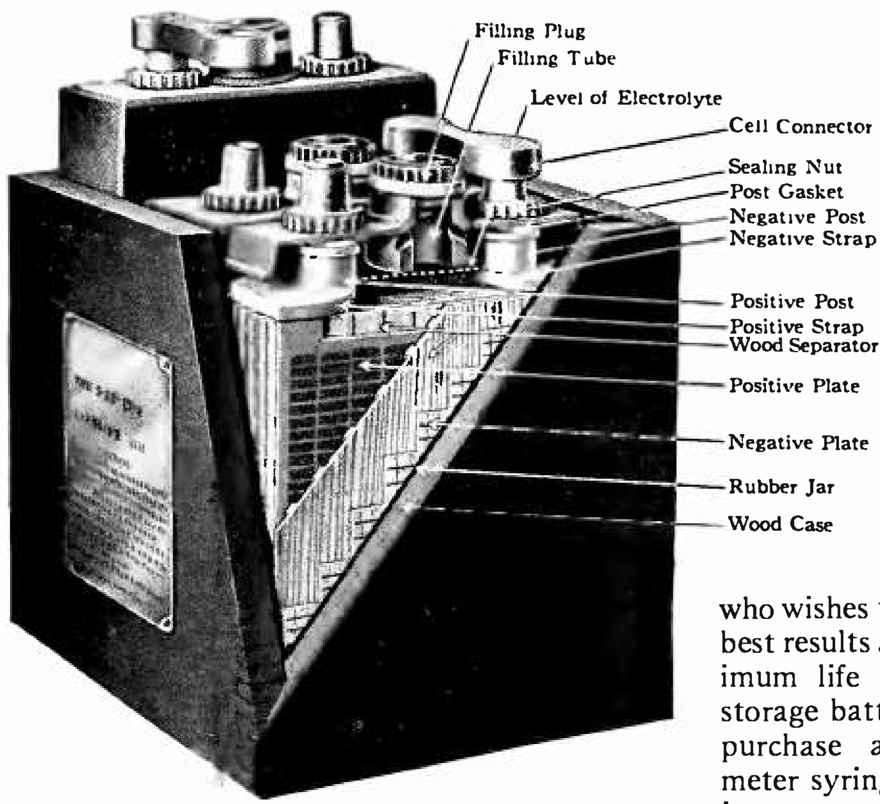
If there is either alternating or direct current available in the home, the storage battery will need to have only sufficient ampere hour capacity to take care of the discharge to the vacuum tubes over a period of about a week as it is always a simple matter to recharge the battery by the methods which are outlined below. In general either a 40 or an 80 ampere hour battery is used under these circumstances.

If, however, there is no current available in the home and it will be necessary to transport the battery to a charging station every time it requires recharging, it will be well to obtain a storage battery of sufficient capacity to take care of the required discharge for a considerable period to avoid the inconvenience of this transportation at short intervals. It is generally best to use an 80 or a 120 ampere hour battery in this case.

WHERE TO INSTALL THE BATTERY

IN INSTALLING the battery, choose a place where it will be readily accessible for the addition of water to replace evaporation of the electrolyte and also where it will neither be cut off entirely from all ventilation nor will be near any exposed flame.

The solution or electrolyte in the battery is a dilute solution of sulphuric acid and it will be wise to install the battery in such a place that no harm will be done to expensive rugs or hardwood floors in case any of this electrolyte is accidentally spilled. If by chance any of the solution is spilled, the effect of the acid can be counteracted by the prompt use of a dilute solution of ammonia.



This is a sectional view of a six-volt lead plate storage battery such as is commonly employed in radio circuits. There are three individual cells, each having its own composition case, as may be observed in the picture. The rear cell has been raised to show its appearance. The centre cell is in normal position and the front cell is cut away to show its parts

The best practice when installing a storage battery is to place it in a closet or in a covered box where it will be out of the way but readily accessible. In some cases the storage battery can be installed on a shelf in the cellar and the lead wires brought up through the floor to the radio set.

A number of the more expensive cabinet radio receiving sets have a space provided at the base of the cabinet so that both the storage battery for the filament circuit and the dry cell battery for the plate circuit can be installed in a convenient but out of the way position.

In some cases ingenious amateurs have built a small box or cabinet divided into sections to hold both filament and plate batteries and also the rectifier or battery charger. The outside of this box may be given a stained finish in order to match the finish of the remainder of the apparatus.

Although a well-built storage battery has a neat and well-finished appearance, it is not ornamental and there is really no more reason why it should be installed in the parlor than there is, for instance, that the battery which rings the front door bell should be placed in a similar position.

The first step which any one should take who wishes to get the best results and maximum life from his storage battery is to purchase a hydrometer syringe. This instrument consists of a glass barrel with a rubber tube on one end and a rubber bulb on the other, as shown in an accompanying illustration. Inside the glass barrel there is a hydrometer float with a graduated scale.

Due to the chemical reaction which goes on in a storage battery during charge or discharge, the specific gravity or density of the solution varies from a maximum at full charge to a minimum when the battery is completely discharged. The gauging of the specific gravity of this solution is the only reliable means of determining the state of charge or discharge of the battery.

In batteries used for radio service, the specific gravity of the solution ranges from about 1.275 at full charge to 1.175 at complete discharge. The scale of the hydrometer float is graduated from about 1.300 to 1.100.

The procedure to follow in taking a specific gravity reading is as follows:

Remove the vent cap from one of the cells, gently squeeze the rubber bulb of the hydrometer syringe expelling the air and insert the rubber tube through the opening, down into the solution. Then allow the bulb to expand, thus drawing some of the solution up into the glass barrel. A little practice will show how much the bulb must be squeezed in order to draw sufficient solution up into the glass barrel to float the hydrometer but still not have it in contact with the top of the glass barrel.

With the hydrometer floating freely, the next step is to find where the top level of the solution in the glass barrel comes on the graduated scale of the hydrometer float. The reading of the scale at this point is the specific gravity of the solution.

If the reading is 1.275 the battery is fully charged. If it is 1.225 the battery has practically half of its capacity remaining, but if the reading is as low as 1.175 the battery is in a discharged condition and should be recharged as soon as possible. When the reading is completed, care should be taken to return the solution in the glass barrel to the same cell of the battery from which it was withdrawn.

The taking of hydrometer readings is really a very simple process which can easily be learned by any one after a little practice.

In order to obtain satisfactory results from a storage battery in radio service the following few simple rules should be followed:

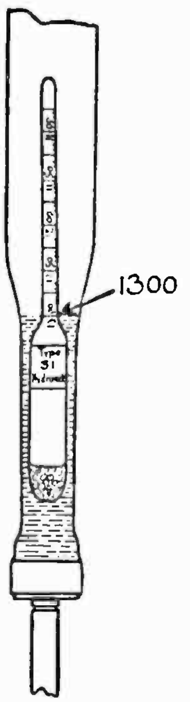
1.—Keep the level of the solution in all cells above the top of the plates by replacing evaporation with pure distilled water only, as required. (About once per month.) The best time to add the distilled water is just before the battery is to be charged.

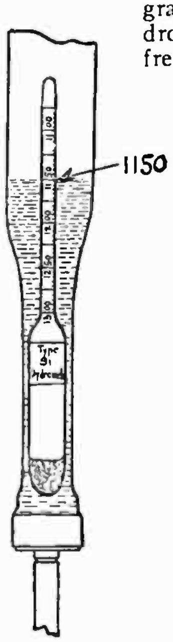
2.—Keep the tops of the cells wiped clean and dry.

3.—Never let the battery stand in a completely discharged condition any longer than is absolutely necessary.

4.—Never add acid to the solution. The

This is a hydrometer syringe, used for determining the condition of storage batteries. The tip is placed in the cell to be tested and by merely pressing and releasing the rubber bulb some of the battery liquid is brought up into the syringe barrel which is of glass. The position on the hydrometer scale to which the surface of the liquid rises is the value of the specific gravity. The hydrometer must float free of the glass barrel





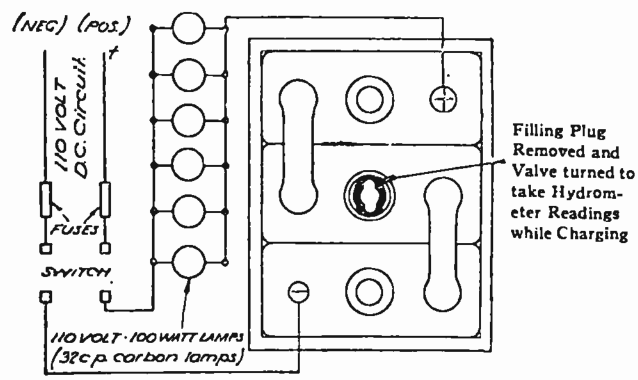
The figure to the left illustrates the position the hydrometer will take in the syringe when the battery is fully charged—it shows that the specific gravity of the electrolyte, or liquid, is 1300. When the electrolyte forces the hydrometer to only 1175, it is time to recharge the battery

The vent-cap has been removed from the centre cell of this battery—there are three cells in a six-volt storage battery of the lead type—with the cap removed the tip of the syringe may be inserted and the electrolyte tested original acid is all that is ever needed in the battery unless it has been spilled—in this event have new acid added at a service station.

CHARGING THE BATTERY

IF THERE is lighting current available, the first step to be taken is to find out from the lighting company the voltage of this current and whether it is a direct or an alternating current.

If the current is found to be direct, the battery can be charged either through a battery charging resistance which can be readily obtained or through a combination of lamps of the proper size and rating. An accompanying diagram shows the arrangement for charging a 6-volt battery from a 110-volt, D. C. circuit, the lamps being carbon filament lamps rated at 110 volts and 32 candle power. As shown, they are arranged in parallel with each other and the combination is in series with the battery. With this arrangement, each lamp will allow 1 ampere of charging current to pass through the battery, so that the number of lamps to be used will depend upon the charging rate of the battery, which is generally stamped on the battery name plate. The diagram shows six lamps which will allow 6 amperes to flow and is therefore suitable for use with a battery having a charging rate of 6 amperes.



By employing a lamp bank in series-parallel as shown here, a storage battery may be charged from a direct current (D. C.) supply. Where lamps of the size indicated are employed, each permits a current flow of approximately one ampere. With six lamps burning, the charging rate would be about six amperes. Almost any desired charging rate may be obtained by using lamps of suitable values

It is very important that a storage battery should not be charged at a rate higher than the charging rate given on the battery name plate.

Care should be taken to see that the positive terminal of the battery is connected to the positive lead of the lighting circuit. If the battery is charged in a reverse direction for any period of time it will be ruined.

A simple method of determining which is the positive or negative lead from the lighting circuit is to dip the ends of the two wires, one from each side of the lighting circuit, into a glass of water in which a teaspoonful of salt has been dissolved, taking care not to allow the ends of the wire to touch. Fine bubbles of gas will be given off from the *negative* wire. After this has once been determined, it will be a good plan to so mark the positive wire that it may always be distinguished from the negative one.

In the event that the lighting current is found to be alternating, a suitable rectifier must be obtained to convert this current to direct current before it can be used for charging the battery. With a rectifier the use of resistance, as given above, is not required as the current is automatically reduced by the rectifier. The only precaution to be taken is to be sure that the charging rate of the rectifier does not exceed the proper charging rate of the battery as given on the battery name plate.

In either of the above cases the battery may be considered to be completely charged when, with the charging current flowing, all cells are gasing (bubbling) freely and the specific gravity of the solution, as read by the hydrometer, has reached a maximum and shows no further rise over a period of 5 hours.

Provided the charging rate used does not exceed the proper charging rate of the battery, no serious harm can come from continuing the charge for a number of hours after the battery has reached a fully charged condition. It will therefore be possible to leave the battery on charge over night without risk of damaging it.

The storage battery in radio service is by no means an experiment but is a dependable source of power which will give better results for use with the filament circuit than any other method that has been found.

Storage batteries have been in very general use in the electrical industry for many years. Wherever an absolutely dependable source of non-fluctuating current has been required. They have been used universally in wireless telegraph service ever since that method of communication came into commercial use. Every time you telephone or send a telegram a storage battery is used.

In obtaining a radio storage battery just as in making any other purchase it is the best economy to buy one of the highest quality.

Radio Frequency Amplification

Its Problems and Possibilities

By ZEH BOUCK

I

THE advantages of *radio* over *audio* frequency amplification are many, but its general use in amateur installations has been retarded by attendant complications which radio science is to-day just overcoming.

Audio and radio frequencies refer to frequencies or vibrations as divided into bands, one (audio) affecting the human ear as sound, and the other (radio) of a pitch above that to which the ear responds. An interesting experiment that will clarify and illustrate the difference between audio and radio frequencies is unconsciously performed by the operator in seaching out bulb or arc stations with his receiving tube oscillating. At certain variations of the series or shunt condenser the howl of the transmitting station is audible, the note becoming lower and lower as the variation is continued. At the resonance point the sound disappears to be heard again on the other side, rising in tone until it leaves the audio range at approximately ten thousand cycles, and vibrates at radio frequencies that cannot be heard.

Throughout this article, and in similar papers, it is well to bear in mind the relation of frequency to wavelength, understanding that they vary inversely: the higher the frequency, the lower the wavelength. The layman can easily comprehend this relationship by visualizing the analogy of a piece of string equal in length to the distance radio waves travel in one second; imagining the string "chopped" into homologous parts. It is obvious that the more sections (higher frequency) into which the string is clipped, the smaller will be each individual piece, (wavelength) or vice versa.

The principal advantage of radio frequency amplification is that it makes audible signals that were originally too weak for detection and which, therefore, unlimited stages of conventional amplification would not have affected. Ordinarily, to receive radio signals, phone or spark, the potential applied to the grid of the first tube must be of sufficient intensity to vary the plate current at *audio frequency*. However, if the original current induced from the antenna circuit is not of the requisite strength, it can be augmented by successive steps of radio frequency amplification to that point where it can be detected or transformed into sound impulses. From there on, if desired, it may be amplified further by audio frequency methods.

Thus radio frequency intensification makes practicable reception on loops, small indoor and ground antennas, in which only a comparatively small amount of current is induced and picked up.

Radio frequency amplification is also opening up unthought-of possibilities in the field of static elimination: first, by permitting, as explained in the preceding paragraph, the use of underground antennas, and loops located in cellars, with which atmospheric disturbances are almost nil, reception being often possible in the midst of an electrical storm; and secondly, on short waves by a tendency to amplify signals in greater proportion than static due to the fact that QRN (*static*) is more prevalent at lower frequencies (higher waves). Listening in alternately on long and short wave sets of a summer evening will demonstrate this.

Another advantage of this system of intensification is the discrimination against extraneous noises, amplifying only the signals which come through loud and clear, free from rattle and scratching so characteristic of present day amplifiers. Such sounds are practically unavoidable and are due to one or all of the following causes:

1. Noisy batteries and poor connections.
2. Mechanical vibration of the tubes.
3. Induction from telephone, electric light and bell wiring.

To acquire a knowledge of radio frequency amplification applicable to everyday receiving problems, it is necessary to grasp the fundamentals of bulb operation, particularly the significance of the characteristic curve; and the phenomenon of resonance with the difficulties imposed on radio frequency currents by reactance.

It is fairly well understood that the plate current through a vacuum tube is directly dependent on the electrification of the grid, and that any change in the grid charge will cause a similar but greater variation in the plate current. Thus when a high frequency current, such as exists in the secondary circuit during reception, is impressed on the grid, the plate current will fluctuate with each alternation; in other words it will vary at a radio frequency equal to that of the original current. But the plate current also fluctuates at audio frequencies, owing partly to what is known as the assymmetrical action of the valve, and partly to the periodic discharges from the grid condenser. In this manner the space or plate current of a receiving tube is divided into two parts, the radio frequency and audio frequency components, a phenomenon that is shown diagrammatically in Fig. 1.

In radio frequency intensification it is of course the radio frequency component in which we are interested and which is passed on to the succeeding tubes for amplification. But the comparative values of the two components vary

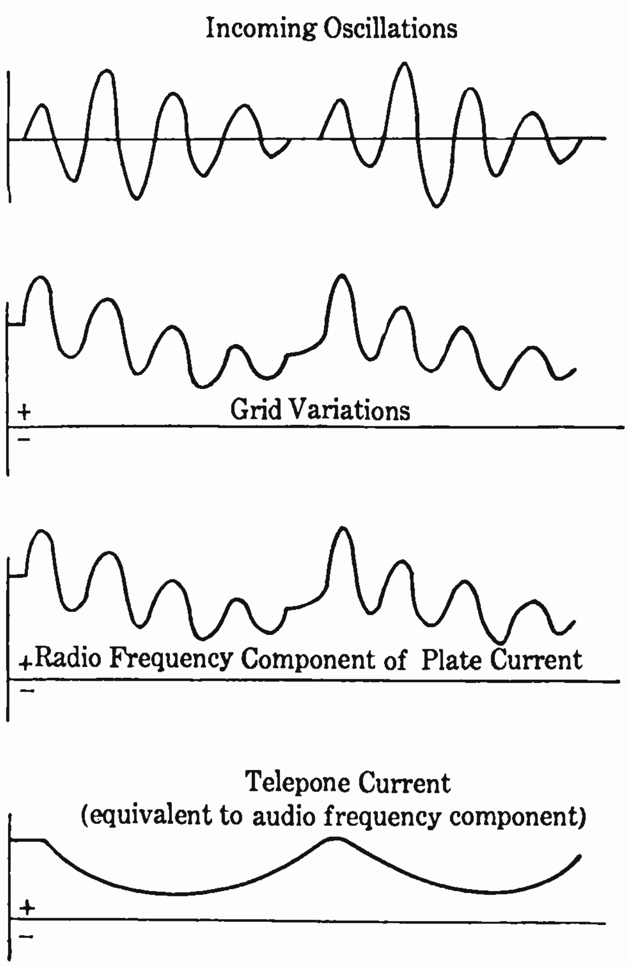


Fig. 1.

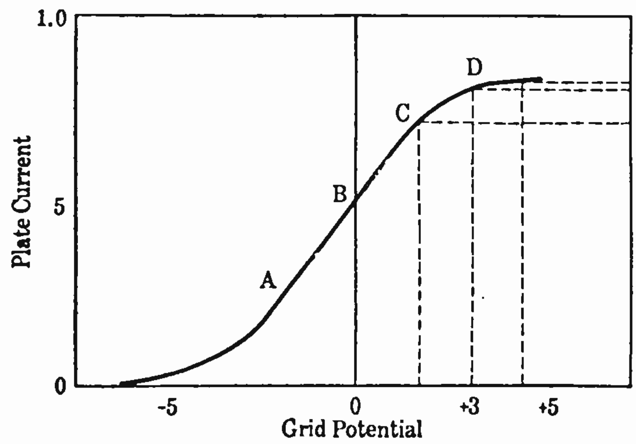


Fig. 2.

with the average grid potential as determined by the grid condenser and leak.

The characteristic curve of the three element tube is shown in Fig. 2, and it perfectly illustrates how grid variation at different potentials will have certain effects on the radio frequency and audio frequency components. If an alternating e. m. f. is applied to the grid, on one half cycle it will augment the grid potential, while the other half alternation will decrease it, with corresponding changes in the plate current. But if the original grid potential is plus three volts, i. e. the tube is being operated at point D of the characteristic curve, study of the diagram will show that the change in grid potential toward zero will cause the plate current to drop in greater proportion than an equal change away from zero will increase it! This is called the asymmetrical action of the tube, and in virtue of this lack of uniformity each group of incoming oscillations will cause an average drop in the plate current (always providing the bulb is operated at point D), a drop that occurs at audio frequency. If, on the other hand, the audion is operated somewhere on the straight portion of the curve, from A to C, such as at point B, the alternating potential on the grid will cause an equal rise and fall of the plate current, thereby decreasing the audio frequency component, but strengthening the radio frequency component. Therefore, in order to secure the best results with radio frequency amplification, some method of determining the grid potential should be employed. In hookups calling for neither the grid condenser nor leak, the same effect can be partially secured by a careful adjustment of the filament and plate batteries. In some cases the condenser and leak will be found necessary to control oscillations as the radio frequency amplifier is, *per se*, a tuned plate circuit and at times will oscillate.

Having determined a method of taking the fullest advantage of the radio frequency component, it now remains to pass it on to similar stages for amplification, and finally to a detector. The plate current of the detector tube is caused, by grid adjustment, to vary powerfully at audio frequency and is passed either through the phones or the primary of an audio amplifying transformer. Where leaks and condenser are used in each step of amplification, the last tube is generally a soft bulb, which, with a different grid adjustment, functions as the detector.

Any system that will impress the radio frequency output of one tube on the grid of a succeeding one, while discriminating against audio frequency vibrations, will act as an amplifier. Two methods, the resistance coupled (Fig. 3), and the inductive or transformer type (Fig. 4) have been popular on low frequencies, but until recently neither had been very successfully adapted to short waves. Previous to the perfection of the present day amateur tube, the high internal capacity of the available bulbs, acting partly as a shunt condenser across any added inductance in the plate circuit, made tuning down to two hundred meters very difficult. Also the adjustments in the inductively coupled amplifier are extremely critical at the higher frequencies. Each successive step of radio frequency amplification must be in resonance with the preceding one (in tune with it) just as the set itself is in resonance with the transmitting station. Resonance is a condition in radio frequency circuits in which an alternating currect of a certain period will pass through it with the least loss, and it is determined by the balancing effect of inductance and capacity. Hence, as resonance is dependent on these two qualities, a change in either inductance or capacity will shift the resonance point to another wave. And the reverse of this is a corollary, i. e. that a shift in wave will necessitate a corresponding change in either

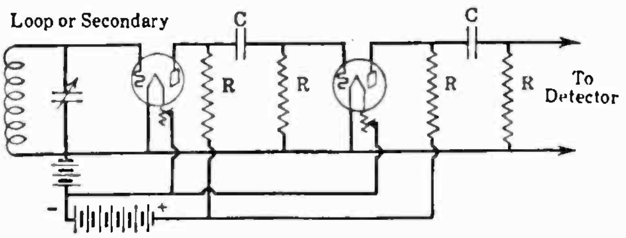


Fig. 3.

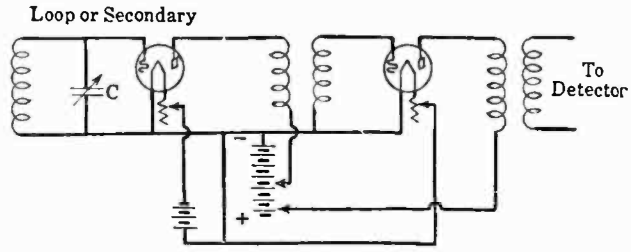


Fig. 4.

inductance or capacity or both to regain resonance. But this phenomenon is much more apparent at higher frequencies where a minute change in the values of L and C will shift the wave several meters, while on a higher wave it would have little effect.

Thus every change in wavelength on a short wave radio frequency amplifying set made necessary, and to an extent still does, a complete retuning of each step of amplification. However, the modern vacuum tube with its low internal capacity, and transformers designed to be operative over a band of high frequencies, have done much toward solving the problem. Some attempts have been made to broaden the range of operative waves in radio frequency transformers by the introduction of an iron core, but this, as a rule, is very inefficient owing to hysteresis loss. Hysteresis loss is a diminution of power occasioned by the utilization of energy to reverse the magnetic field of the iron core. When the current, and with it the magnetic poles, fluctuate a million or more times per second (on low waves) the loss is comparatively large.

The condensers C, in the third diagram, are placed between the successive steps of amplification. This capacity offers a low reactance to radio frequencies, passing them on for amplification, but impedes audio variations.

The inductively coupled system in Fig. 4 employs radio frequency transformers such as have been placed on the market by several manufacturers, and which are operative with fair efficiency from two hundred to five hundred meters. The primaries and secondaries are tuned broadly to the same wave and freely pass the radio frequency components through each bulb, but due to their low inductance there is little transference of audio frequency energy. The circuit in Fig. 4 was designed for broadcast reception on three hundred and sixty meters. The loop is wound on a frame twenty-four inches square with six turns of wire spaced one inch. Condenser C has a capacity of .0015 mf.

with an almost indispensable vernier adjustment. With two steps of radio, a detector and one step of audio frequency amplification, signals from WJZ received in Jersey City, comfortably actuated a loud talker. The speech was of unusual clarity, unmarred by distortion, microphonics or scratching sounds.

Loops have been indicated in Figures 3 and 4, but in each case the secondary of a tuning transformer or variocoupler may be substituted and the set operated from an open antenna.

One of the most ingenious circuits for radio frequency amplification,—one that completely eliminates the undesirable features of other systems, which are low efficiency and critical adjustments on short waves, and the tuning of each step for different frequencies—is the external heterodyne or (later) the super-autodyne system of Major Armstrong.

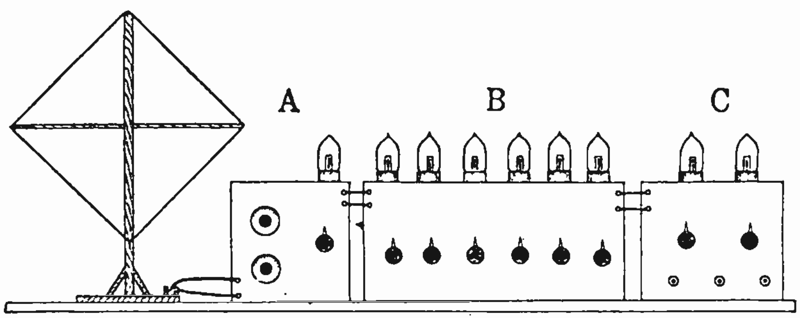


Fig. 5.

The phenomenon of beats caused by heterodyning, is fairly well understood, but for the benefit of the new enthusiast it might be well to mention that the beat is a wave or frequency resulting from the superimposition of one frequency on another, or, still more clearly, the difference between them. In the experiment mentioned before as an illustration of audio and radio frequencies by tuning in a continuous wave station with the receiving set oscillating, the sound or squeal was the beat set up by two frequencies (those of the transmitting and receiving bulbs) whose differences were less than ten thousand, or within the audio range.

A fundamental idea of the functioning of the Armstrong circuit can be had from Fig. 5 without recourse to a complicated diagrammatic dissertation. A is the heterodyne bulb in a circuit designed to set up oscillations of any desired frequency. Cabinet B encloses five steps of radio frequency amplification, with the final detecting tube, each step tuned sharply to a predetermined frequency, for example, 500,000 cycles (600 meters). Cabinet C is an audio frequency amplifier of one, two or three stages. An incoming signal is heterodyned by the local oscillations so that the resulting beat frequency (or the difference between the incoming and the local oscillations) is equivalent to a six hundred meter wave to which the amplifier is tuned! If the desired station is an amateur working on two hundred meters (1,500,000 cycles), the heterodyne will be adjusted to one million cycles (1,500,000 minus 1,000,000 equals 500,000). In three hundred meter reception (1,000,000 cycles) the local oscillations would be tuned to the frequency of five hundred thousand, etc., always bearing in mind that the beat frequency must be that to which the amplifier is tuned.

An efficient two step radio frequency amplifier can be made of honeycomb coils,—a set that will prove not merely an interesting experiment, but a desirable addition to any station. Two-coil mounts are used and wired in place of the radio frequency transformers in Fig. 4. In making large wave shifts, different coils are plugged in (the same size throughout) permitting reception on any wave, while very fine tuning is accomplished by coupling variation. Strange to say, the circuit seems to give better amplification on loop than on a conventional antenna.

Special care should be taken in wiring up radio frequency amplifiers. Bare wire is preferable, well spaced, and run as much as feasible at right angles. Leads must be short, and every precaution taken to avoid adding either capacity or inductance to the circuit.

It is difficult to make comparisons between regenerative sets and straight hookups with radio frequency amplification, because, as explained before, the radio frequency set is virtually a tuned plate circuit and regenerates to a certain extent. However, one step of radio frequency intensification, in an ordinarily non-oscillating circuit, will give louder and clearer signals than the average short wave receiver with a single bulb.

To sum up: Radio frequency amplification consists of taking full advantage of even the almost infinitely weak radio wave in nearly its original form, and strengthening it through cascade amplification. In this manner it differs from the audio systems which only amplify, along with other noises, a sound wave corresponding roughly to a radio wave of sufficient strength to cause it. Radio frequency is the more difficult to handle, but improvements that are steadily simplifying the system will soon place its advantages at the disposal of the layman.

Clearing Up the Ether

What the Conference Called by Secretary Hoover Did to Find a Satisfactory Basis on Which to Build Stable Radio Development for the Best Interests of All Who Would Use This Means of Communication

By PAUL F. GODLEY

This is a thoroughly comprehensive discussion in everyday "American" of the most important radio question of the day. The author of this article is recognized internationally as an authority on the subject, and represented American amateurs at the conference, called by Secretary Hoover in Washington.—THE EDITORS.

ALL this discussion about wavelength—what does it mean? What is the great significance which attaches to the discussion? Why the need for a national conference on the subject, and what has been the outcome? Will the wavelengths of existing stations be changed? If so, why? Will many thousands of receivers be scrapped as a result, and would such scrapping of receivers, if found necessary, be justified?

Questions such as these have been uppermost in the minds of radio fans for many weeks, and few there are who seem to have been able to get to the bottom of the whys and wherefores of the recent radio conference to which so much space was given but a short time ago in our daily press. To close students of the Art it became apparent many months ago that some radical changes in the methods of apportioning wavelengths for transmitting stations must be made at once if the rapid development of the radiophone were not to be choked at its birth. Interests of all sorts have been clamoring for licenses to broadcast: concerts, news, sports events, advertising, whatnot,—everything was to be thrown pellmell into the air. In order that the air might be kept as free as possible from the "squatters," the Department of Commerce, which has it within its power to license radio stations of all classes, has made it a policy to place all broadcasting stations on one wavelength—360 meters. That is now to be changed.

Thousands of newcomers have entered radio fandom. Nearly all of these have little knowledge of radio—either its limitations or its possibilities. A great percentage of these in some fashion gained the idea that all interference was of "amateur" origin. Seasoned radio men knew better, of course, but the demands of these newcomers, fortunately, hastened a conference which came none too soon.

In order that you may understand something as to the nature of the situation as it exists at the time this is written, it would be well for you to get some idea (1) as to what electric waves are and something concerning their length and the number which are useful in radio communication, (2) the different classes of service which are demanding accommodation and their degree of importance, (3) the number of stations which can be operated in a given community within a certain band of wavelengths, and (4) what steps have been taken by the committee of experts called to Washington by Secretary Hoover to utilize most economically those wavelengths available for radio communication. An understanding of these things should give you a clear picture of what the situation is and what future developments should promise.

THE ETHER

SCIENTISTS have formed a theory which assumes that our universe floats in and is pervaded with an invisble, *extremely* elastic fluid. We do not know its nature. This sea of elastic fluid is not quiescent, it is troubled at all times by vibratory disturbances. These disturbances vary in characteristics. Some recur at inconceivably short intervals, others recur at longer intervals. We are able to both create and detect some of them. Our eye detects a few of these vibratory disturbances and we have classified those as "light." Our bodies detect others of these ether disturbances and we have classified them as "heat." A camera will detect still others which neither the body nor the eye will indicate, such as X-rays, etc. There are many groups of disturbances in this elastic fluid—it has been named the ether—which we have not "discovered," but many years ago, a German scientist, Hertz by name, discovered disturbances which produced electrical effects and which could be reproduced by electrical effects. These have been called Hertzian, or electric waves. In reality they are the same sort of disturbances and, generally, exhibit the same characteristics as *all* ether disturbances. It is this group of electrical disturbances which is used in radio communication. The intervals between these electrical disturbances in the ether vary as does also their magnitude. Both the magnitude and their intervals are determined by certain factors. For example, the greater the force used in creating the electric disturbances in the ether, the greater the magnitude of the disturbances, and the greater the electrical dimensions of the machine or system used in the creation of the disturbances, the greater the interval of time between their recurrence.

Ray or Wave	Frequency per Second	Wave Length, Meters	Receiver
Gamma Rays Given off by Radium and radioactive substances .	30,000,000,000,000,000,000.	.000,000,000,01	Photographic plate or fluorescent screen.
X-Rays Used for medical purposes.	4,700,000,000,000,000.	.000,000,638.	
Shortest Ultra-violet Rays .	3,000,000,000,000,000.	.000,000,1.	
Violet Light .	830,00c,c00,0c0,c00.	.000,000,36	The eye
Blue " .		.c00,000,454	
Green " .		.000,000.49	
Yellow " .	down to	.000,000,588	
Orange " .		.000,000.652	
Red " .	270,000.000,000,000.	.000,000,8	
Infra-Red Rays which include what we know as heat. . .		down to .001.	The skin
Electric Waves used in radio .	6,000,000 down to 12,500	50 to 25,000	The aerial with suitable detector circuits.

This table is a word picture of the various movements in the "ether" which register upon our senses in the form of heat, light, and color; and vibrations which may only be detected by scientific processes. Radio waves are at the base of the table and vibrate at a very much slower rate—though even these waves are too rapid in their alternations for the human ear to detect.

All of these disturbances travel through the elastic conveying medium at the same rate of speed, which is 300,000,000 meters per second. (which equals 186,000 miles, or approximately 7½ times around the world).

Knowing that these disturbances travel at a certain rate and knowing that they reach a given point at certain fixed intervals, it is seen at once that in their travels they are spaced a certain distance apart. Therefore, we may find the distance of spacing by dividing their rate of speed by the frequency of their recurrence. The result will be an expression in meters and this is what is termed, "wave-length," for the disturbances are undulatory in form like a wave disturbance on water.

Electrical disturbances in the ether which are of use in radio communication vary in frequency between about 3,000,000 per second and 12,000 per second, or, converting frequency to wave-length, from 100 meters in length to 25,000 meters in length. We know of certainty that there are disturbances in the ether of much higher frequency as well as much lower frequency, but we have not yet learned how to use them in radio communication and we cannot say that they will ever prove useful unless our present limitations are somehow swept away.

THE CAUSE OF INTERFERENCE

IT MIGHT seem to the uninitiated that even with this great number of different frequencies from which to choose it should be possible to erect and operate an unlimited number of electric wave (radio) transmitting stations without their interfering with each other. Some day this may be possible. At the present time, however, the machinery used for the generation of these electric waves as well as those machines used for detecting them at distant points, is in a state of development which by no means permits this. Although we desire to create a disturbance of a very definite frequency, we find that in using the means now available, we also create disturbances of slightly greater frequency and slightly lesser frequency. And, too, although we may wish at the distant receiving stations to register the effects of disturbances of but one definite frequency, the lack of perfection of our receiving equipment as yet makes this impossible. To avoid interference between transmitting stations it is obvious, then, that the frequency of the disturbances which they create must differ to a sufficient extent to offset the short-comings of the available apparatus and methods. The *very best* that we are able to hope for now is a difference in frequency, for adjacent transmitting stations, of at least 10,000 cycles. This means that within a given small area it would only be possible to erect a comparatively small number of stations, and at the same time avoid interference. But, if stations are *separated* sufficiently, and if they are *limited* in their range of transmission, two or several may operate on the *same* wave length without producing interference at the receiving station.

These things have all been taken into consideration in the division of available wavelength bands among the various classes of service.

RADIO'S MOST IMPORTANT SERVICE

RADIO telegraphy quite naturally found its first application in providing communication between points excluded from the use of other methods. First of all came communication between ships at sea and between ships and shore. Communication of this class is a very important one, since it insures the safety of both life and property at sea. Communication of this class is still considered as the most important use to which radio telegraphy and telephony may be put, and now that we have discovered the wonderful potentialities in connection with the broadcasting of vital news information, educational matter, entertainment, etc., it is the consensus of opinion, of American radio men at least, that radio broadcasting ranks second in order of importance. Perhaps that class which ranks third in this list is intercommunication among amateurs, for neither our Army or our Navy can forget the importance of a personnel trained in modern signal methods during wartime. It is doubtful whether enough money could be appropriated by our Government to train such a vast body of communication men as those amateurs who train themselves in their fascinating pursuit of radio telegraphy. It has been recommended by this Conference of experts that the status of amateurs be established by law, and that certain wave bands be allotted to them and specified in the law. And, so good has been the impression which amateurs and amateur organizations have made upon this committee that it has also been recommended that amateurs "police" themselves,—that they be a self-governing body with regard to operation, violations, etc.

HOW THE ETHER IS DIVIDED

THERE are many other classes of service, too, and they all have been given proper consideration. Intercontinental radio telegraphy service has been allotted its band of waves; naval service, army service, aircraft service, radio compass service, radio beacons, city and state public safety service, technical and training schools, and, in certain cases, private radio stations have all been taken care of.

Most of the intercontinental service requires the use of very high power. High power stations best fit themselves to the lower frequencies, i. e., long wavelengths. Low power transmitters such as those used by amateurs, and such as those used in broadcasting and for ship to shore work, adapt themselves to the shorter wave length. Some idea as to how these wavelengths have been divided is given in the table showing allocation of wave bands for radio telephony.

WHAT THE TECHNICAL TERMS MEAN

FOR an understanding of this table, some of the terms used in it are defined.

"Broadcasting" is that type of transmission which is intended for consumption by an unlimited number of receiving stations, no charge being made for the service. This includes service broadcasted by departments of the Federal Government (Government broadcasting); the dissemination by radio of educational and informational service by public and state institutions, universities, etc. (public broadcasting); the broadcasting without charge of news, entertainment, and other service by the owner of a station, such as a newspaper, or other private or public organization (private broadcasting); and broadcasting by a transmitting station of a public service corporation where a charge is made for the use of the station (toll broadcasting).

By "fixed" service radio telephony is meant radio telephone service between two fixed points.

"Radio beacons" are radio transmitting stations which transmit signals by means of which a mobile direction-finding station may determine its bearing or position.

HOW THE ETHER IS DIVIDED

	USE	WAVE LENGTH METERS	WAVE FREQUENCY KILOCYCLES PER SEC.
(1)	Transoceanic radio telephone experiments, non-exclusive .	6,000 5,000	50. 60.
(2)	Fixed service radio telephony, non-exclusive	3,300 2,850	90.9 105.2
(3)	Mobile service radio telephony, non-exclusive	2,650 2,500	113.2 120.
(4)	Government broadcasting, non-exclusive	2,050 1,850	146. 162
(5)	Fixed station radio telephony, non-exclusive	1,650 1,550	181.8 193.5
(6)	Aircraft radio telephony and telegraphy, exclusive . . .	1,550 1,500	193.6 200.
(7)	Government and public broadcasting, non-exclusive . .	1,500 1,050	200. 285.7
(8)	Radio beacons, exclusive	1,050 950	285.7 316.
(9)	Aircraft radio telephony and telegraphy, exclusive . . .	950 850	316 353
(10)	Radio compass service, exclusive	850 750	353 400
(11)	Government and public broadcasting, 200 miles or more from the seacoast, exclusive	750 700	400 428
(12)	Government and public broadcasting, 400 miles or more from the seacoast, exclusive	700 650	428 462
(13)	Marine radio telephony, non-exclusive	750 650	400 462
(14)	Aircraft radio telephony and telegraphy, exclusive . . .	525 500	572 600
(15)	Government and public broadcasting, exclusive	495 485	606 618
(16)	Private and toll broadcasting	485 285	618 1052
(17)	Restricted special amateur radio telegraphy, non-exclusive.	310	968
(18)	City and state public safety broadcasting, exclusive. . .	285 275	1052 1091
(19)	Technical and training schools (shared with amateur) . .	275 200	1091 1500
(20)	Amateur telegraphy and telephony (exclusive, 150 to 200 meters) (Shared with technical and training schools, 200 to 275 meters.)	275 150	1091 2000
(21)	Private and toll broadcasting, exclusive	150 100	2000 3000
(22)	Reserved	100 above	3000

"Radio compass service" consists of a direction-finding service to which a mobile station transmits, and which in turn transmits back to the mobile station its bearing or position.

Marine radio telegraphy includes all radio service between ships at sea and between ship and shore.

By "technical and training school" is meant a school which carries on instruction for the training of men for the radio service.

"Amateur" is defined as one who operates a radio station either transmitting, receiving, or both, without commercial gain, merely for personal interest, or in connection with an organization of like interest.

It is also of interest to note that public safety broadcasting on the part of city and state organizations, in small cities especially, is expected to be conducted by the interruption of other types of broadcasting service in case of emergency. In the larger cities, however, this service is quite apt, ordinarily, to employ its own stations, under which circumstances it will be confined to the use of the wave band 275 to 285 meters. A coöperation of private detective agencies with municipal or state services in the use of this wave band is recommended.

HOW AMATEURS ARE AFFECTED

OTHER provisions which have been recommended have to do with that band of wave lengths allotted to amateur radio work, for it would seem best that this band be divided into smaller bands of different types of transmitters. The lowest wave lengths within this band would naturally fall to that type of station which creates disturbances over the broadest band of wavelengths, while the higher wavelengths (those nearest the waves assigned for private broadcasting) are available only to that type of transmitter which uses the most advanced methods,—continuous wave transmitters. Between these, in the order of their merit, fall radio telephone stations and interrupted continuous wave stations, and any radiophone broadcasting carried on by amateurs must be done within this wavelength band.

Further recommendations have to do with the limitation of power, the geographical distribution, and the hours of operation of broadcasting stations. Thus all present broadcasting needs may be taken care of for the time at least, while it is expected that greater freedom will follow the expected rapid advancement of the radio art.

In considering the causes for interference and some unnecessary sources of interference, it is expected, of course, that effort be made to utilize the most improved types of transmitting and receiving machines. Certain classes of transmitters cause far greater percentages of unnecessary disturbance than others. Time will eliminate those in favor of the improved types.

REGARDING RECEIVERS

WITH regard to receivers, some types reject a great portion of any disturbing influence while others do not. Here, too, it is to be expected that the most efficient types will survive.

What may seem rather surprising is that certain types of receiving instruments, because of the methods which are employed in them to build up the strength of the signal, also act as miniature transmitters. That is to say, some of the energy which is supplied locally for the reinforcement of the feeble incoming signal gets on to the antenna of the receiving station and escapes, creating disturbances in the ether of exactly the same character as would be created by a small transmitting station. Under certain conditions, even though there may be several hundred receivers of this character within a small area, the disturbances which they created would be of no moment (where the signal from the station which it is desired to receive is strong). On the other hand, where a number of such "transmitting" receivers are within a small area and this area is located at a point remote from the broadcasting station, considerable interference results, and it is common knowledge that in certain communities great difficulty is frequently found in receiving the broadcast programmes satisfactorily. All of these receivers are attempting reception at the same time. They all are adjusted approximately to the same wavelength. Under these circumstances, and, as indicated above, when the broadcasted signal is weak, considerable interference results.

Development will, in a great measure, take care of these things and it is entirely reasonable to assume that within a comparatively short time radio broadcasting will have become stabilized, and as much a part of our daily life as our newspaper, our telephone, or even our meals.

Broadcasting Church Services

By W. W. RODGERS

NO ONE thing broadcasted by radiophone has caused so much discussion or brought about so general an interest in radio as has the broadcasting of church services. Probably because of the fact that sending out broadcast an entire church service was iconoclastic—in the nature of breaking a few idols of very ancient standing—and because it seemed to oppose a movement of the church to get members into the edifices, there has been some question raised as to the propriety of this sort of broadcasting. Of course, its value to the shut-in, the sick or the feeble, or even the people not within reasonable traveling distance of a church, has never been questioned.

The Rev. Edwin J. Van Etten, rector of Calvary Church, Pittsburgh, Pa., the first minister ever to have his sermons and church services broadcasted. They have been sent out from radiophone station KDKA, East Pittsburgh, Pa., almost every Sunday evening since January 2, 1921

But, does sending out these church services over immense areas increase or decrease attendance at the churches? Is it doing a service or harm to the church? Is it a fad, and will it last? What is the effect upon the hearer? Really, is it worth while as something more than an entertainment?

These questions are continually asked of radio broadcasters, and of the ministers themselves who have the services of their churches broadcasted. These ministers, truly "Sky Pilots," have various answers, but a history of church service broadcasting and a review of the details of its growth will naturally give the reader an opportunity to decide for himself.

The first church services ever broadcasted by radiophone were sent out from the Calvary Episcopal Church, Shady Avenue, Pittsburgh, Pa., Sunday evening, January 2, 1921, from Station KDKA located in the East Pittsburgh Works of the Westinghouse Electric & Manufacturing Company, about nine miles distant from the church. The connection between these two points was, of course, a telephone line.

Those who arranged to have the services broadcasted can now look back at this first service with some amusement, but it was serious business then, for the radiophone had not come into such great popularity as it now enjoys. Strangely enough, obtaining the consent of the minister to broadcast the services from the church was comparatively easy, as the Rev. Edwin J. Van Etten happens to be a very progressive minister and the radio idea appealed to him from the start.

It was not easy to get a good test from the church. The first services were sent out through a phonograph horn placed in the chancel. One end of the horn was attached to a telephone receiver, and, with this crude device, such sounds as were picked up by the horn were sent along the wire to East Pittsburgh and from there out into the ether.

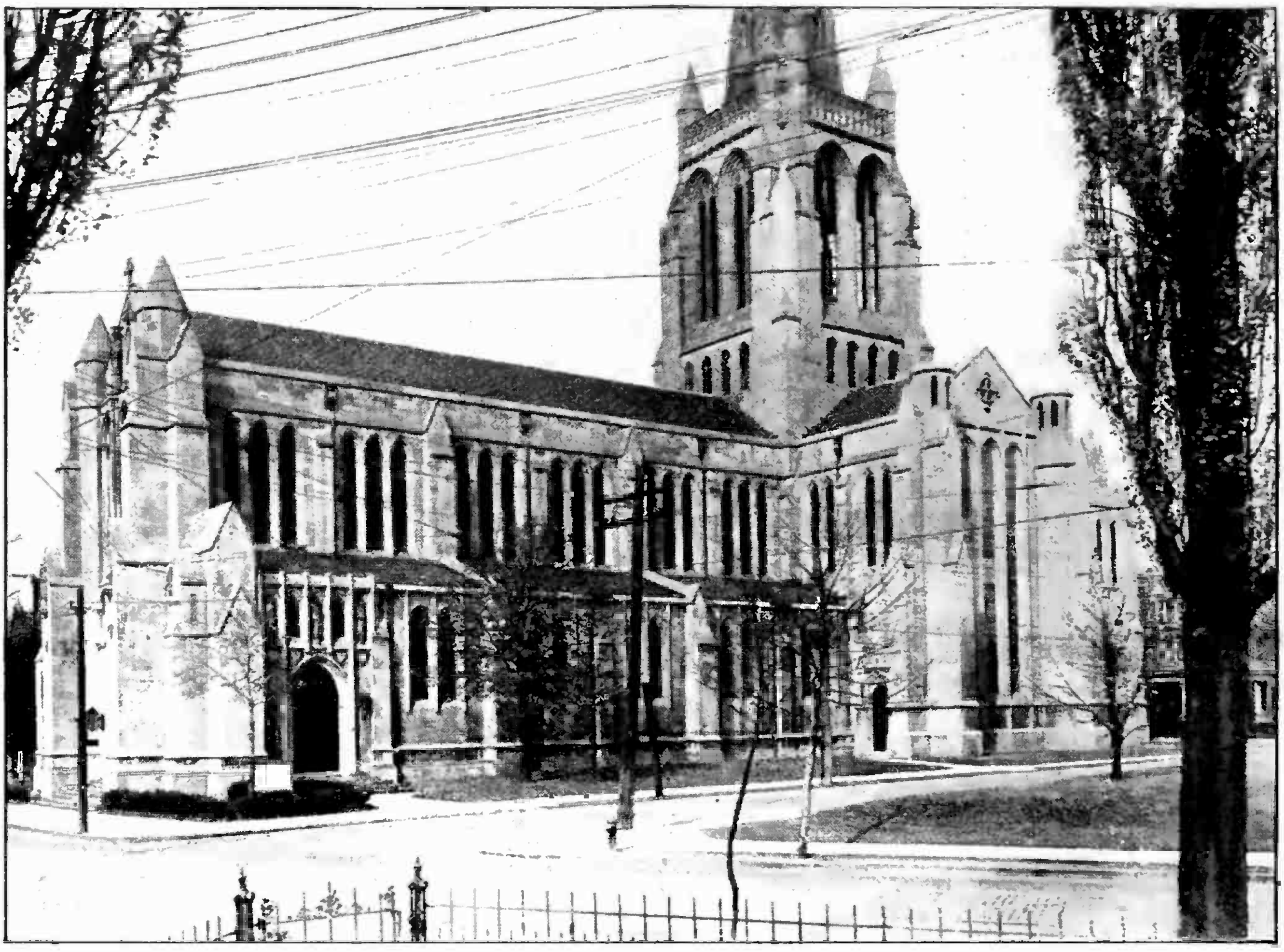
It may seem odd to radio engineers, but the radio church services were picked up clearly by local receiving sets. In fact, so well did the signals come in, that the church was the recipient of many congratulatory letters on the installation of a radio transmitter. During the next week, many people called at the minister's home for the purpose of seeing the antenna and sending set. When they saw the large horn, their disappointment was manifest. Most of them could not imagine the idea of sending through such an apparatus.

The horn was merely tied in place with stout cord high up in the chancel, out of sight of the congregation. Situated as it was, the vibration of passing street cars or the reverberations of the organ set up a rattling that was easily distinguishable.

The next week the horn was placed in the same place, but in order to guard against vibration, it was hung on rubber bands. In addition it was placed in full view of the congregation, to eliminate any skepticism regarding the method of sending out the services. Any member of the church questioned as to the manner in which the services were being broadcasted, had only to point to the horn and say "The music and the voices go out there," and his explanation was accepted. There was no ground left for more queries by the interested one who simply had to look at the horn situated "there," so prominently, to know where the services went.

However satisfactory the horn was for the purposes of demonstrating to skeptics the ability to catch church services, it left much to be desired when it came to catching sound. Telephone transmitters were next resorted to, and these were placed in various positions about the choir. One of these transmitters was placed in front of the minister, another over the choir, another near the chimes, etc.

The telephone transmitters worked fairly well, but still were not entirely satisfactory, so some amplification was placed in the line to boost the sound on its way to the station. This was a decided improvement. And when microphones were substituted for the telephone receivers, still more improvement was noted.

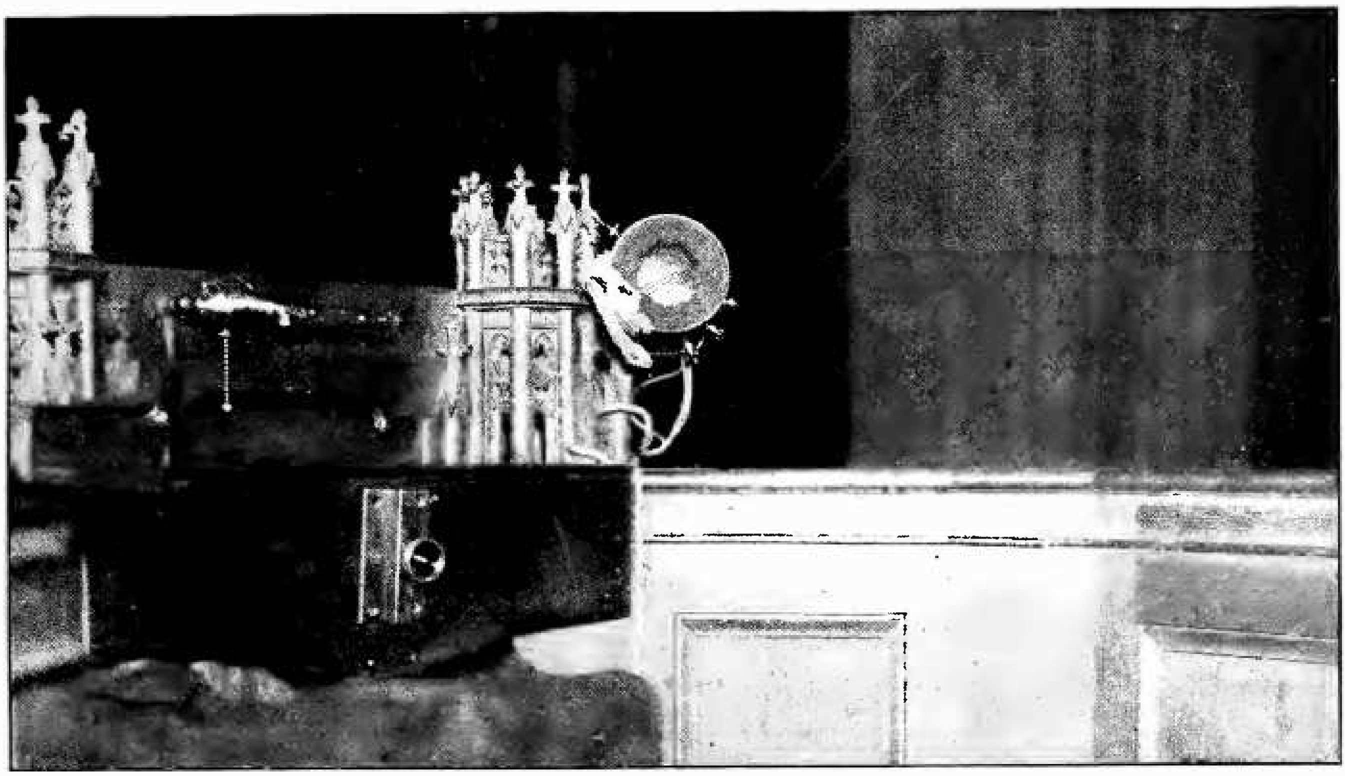


Calvary Church, Pittsburgh, Pa., the first church in the world to have its services broadcasted by radio

So, as the situation now stands in Calvary Church, there are eight microphones placed about the church. The chimes, the pulpit, the chancel, the organ, each has a microphone, while the others are placed advantageously above the choir. These microphones were tried in more than a hundred and fifty different places in the church before the results were entirely satisfactory.

though now in operation more than a year, has never been more than a week old at any time. This is due to the fact that constant changes are made in the broadcasting apparatus. The KDKA of December 23, 1920 and the KDKA of May 3, 1922, which was heard in Iquique, Chile, 4200 miles away, are two very different stations.

With the improvement in their broadcasting,



The microphone in the pulpit of Calvary Church, Pittsburgh, Pa.
Note its location and the felt padding used to guard it against vibration

All these microphones lead to a switch box which also contains tube amplifiers. An operator sits up with the choir and throws the switches for the different microphones. When the choir sings, a switch connected to the microphones in the choir loft is thrown so that these particular microphones are open. When the minister speaks, the microphone in the pulpit is thrown open. When the chimes are played the switch for them is thrown.

As a matter of fact, experimenting is still going on to perfect the telephone line system in order to get the voices to the broadcasting station as clearly as possible.

Remember that, in addition to experimenting with the mocrophone system at the church, tests were being continually made from the station. The equipment was changed almost as much as the microphones, for KDKA, al-

increasing interest was manifest in the church services. Letters began to stream in every Sunday from every part of the country and from all classes and conditions of people. The old lady in Maine enjoyed the sermons as much as the lady in Pittsburgh who was ill and in bed. In fact, popular sentiment seemed to be decidedly in favor of the church services being broadcasted.

After a few months of broadcasting from Calvary Church, an event happened which seemed to open the columns of all the newspapers to radio. The Herron Avenue Presbyterian Church lost its pastor, and one of the trustees, himself interested in radio, suggested the idea of installing a loud speaker and loop antenna in the church to receive the services from Calvary. This was done, and, after a few tests which were pronounced satisfactory,

Amplifying box and switches leading to the various microphones located in different parts of Calvary Church. An operator (in this photograph, W. W. Rodgers, author of this article) sits up with the choir, and throws the switches to open the proper microphones at the right times

the Herron Avenue Church actually went through the Episcopal service received from Calvary. The congregation even contributed to the collection. News of this event was published in newspapers throughout the country, from Maine to California, and it seemed to open the minds of thinking people to the great possibilities of the radiophone. At least an impetus was given radio which lifted it beyond the playtoy stage. Serious business men began to take it up, and the radiophone really entered the home as a serviceable equipment.

Some people may take exception to the statement that church services are really the backbone of the radiophone broadcasting programmes. But they are. The church is the most powerful factor in America. It wields a tremendous influence on the individual citizens. And the mere fact that church services are being broadcasted is proof enough that radio broadcasting is not merely a means of amusement for idle hours, but is also a messenger of hope and uplift for serious minded men and women.

The broadcasting of church services is practically the history of radio broadcasting. It was started with almost the first of the regular concerts sent out by KDKA, a pioneer radiophone station, and these services are the only part of the programme which has survived the first year and a half of broadcasting. All the other things tried on the radiophone in those first few months have made way for something better.

The morning services of Calvary Episcopal Church were eliminated from the programme after a time, to give way to those of other churches. The idea, which had at first been viewed with distrust by other ministers, had by now been demonstrated to hold wonderful possibilities for sending out the Gospel. So, when it was decided to give these other churches an opportunity to have their services broadcasted, there was no opposition to meet, only whole-souled coöperation on the part of the clergy.

The microphones and apparatus with their telephone line to KDKA have at various times been installed in the Point Breeze Presbyterian Church, where the Rev. Percival H. Barker is minister; the Emory Methodist Episcopal Church where the Rev. W. Wofford T. Duncan is pastor; the First Presbyterian Church, where the Rev. Maitland Alexander is in charge, and the Trinity Episcopal Church where the Rev. Edward Scofield Travers, formerly a chaplain at West Point, is rector. All these churches are in Pittsburgh. At the present time, the morning services of the Point Breeze Presbyterian and those of the Emory Methodist Episcopal churches are broadcasted alternating weeks. The Calvary Episcopal Church service is sent out every Sunday evening, as it has been, with but few exceptions, every Sunday since January 2, 1921.

The story of church service broadcasting can all be told from KDKA, for this station was first in the field and made all the innovations in this form of broadcasting. Take, for instance, radio chapel, now a feature of nearly all radio broadcasting programmes.

These chapel services were started in order to give ministers of denominations other than those whose services were regularly broadcasted an opportunity to use the air. Many ministers in Pittsburgh have taken advantage of this opportunity to address the "invisible radio audience" and as many more are anxious to embrace it. Each is given a Sunday afternoon, in his turn.

No better idea of the effect of the minister's voice on his radio flock can be given than by relating the recent experience of William Jennings Bryan. Mr. Bryan had accepted an invitation to address the congregation of the Point Breeze Presbyterian Church from the pulpit regularly occupied by Dr. Percival H. Barker. Owing to the fact that no word could be sent to Mr. Bryan previous to the date on which he was to come to the Point Breeze

William Jennings Bryan as he looked preaching his famous sermon "All" to the congregation of the Point Breeze Presbyterian Church, Pittsburgh, Pa., and by radio to unseen thousands. Note the microphone just under the pulpit lamp. Mr. Bryan received more than 5000 letters about this, his first sermon by radio

church, the radio department took it for granted that the Great Commoner's sermon would go out from the broadcasting station.

The same day that Mr. Bryan came to Pittsburgh, his manager was approached regarding the broadcasting of the sermon. The request, supposedly a mere matter of form, was at once refused. This refusal was quite unexpected, but, as the manager explained, he was unfamiliar with radio demonstrations and did not care to risk the consequences, whatever they might be.

The difficulty of finding a substitute was explained, as it had been announced in the newspapers and over the radiophone that Mr. Bryan would be certain to deliver his famous sermon "All" from Dr. Barker's pulpit that Sunday evening, but the manager was obdurate.

Meanwhile Dr. Barker and Mr. Bryan were together at the Hotel Schenley. Neither one knew of the decision of the manager, and, as they were discussing the coming sermon, Dr. Barker said:

"Do you know, Mr. Bryan, that you are going to have the largest audience of your career this evening?"

"That's interesting," said the Great Commoner, "Do you expect your church to be crowded?"

"Crowded! Indeed, yes," was the answer, "but my congregation will not comprise the whole of your audience. Most of it, you'll never see."

"How's that?"

"Why, don't you know, the pulpit is connected to a radiophone broadcasting station and your sermon will be sent out into the ether over a radius of several thousand miles."

"Well, that's fine. I shall be glad to speak by radio," said Mr. Bryan.

He did speak by radio, and his audience, as Dr. Barker assured him, did number many thousands scattered over nearly all portions of the United States. Mr. Bryan delivered his sermon on Sunday evening, and by Tuesday evening more than 1500 letters had been received either at East Pittsburgh or at the Point Breeze church from interested radio listeners. The statesman was greatly astounded at the size of an audience which would write a minister or public speaker 1500 letters. He had occasion to leave the city for two weeks, and, when he again returned, he found more than 5,000 letters addressed to him. This completely convinced him of the sincerity and interest of his radio congregation, as indeed it would convince even the most skeptical of the size, intelligence and interest of this wonderful "invisible audience." It is safe to say that the letters almost convinced the manager of the benefits to be derived from a radio lecture, or, as in this particular case, a radio sermon. There should be little difficulty in getting Mr. Bryan to speak by radio in future.

This little incident in which a sermon brought forth 5,000 letters is proof that a minister using the radiophone as a winged messenger for his teachings, will wield a powerful influence over an immense territory. The radio minister reaches people he could not get in touch with otherwise. Radio carries the Gospel right into the home, there to sow its seed and bear Christian fruit.

All manner of people are reached by these radio sermons. This fact is clearly shown in the following typical letters to Dr. Van Etten. These letters were picked at random from a collection of several thousand received by this minister, and are quoted verbatim. The names and addresses are omitted for obvious reasons.

Heard in Ohio

Columbus, Ohio,
March 27, 1922.

DEAR SIR:

I heard your entire service, from the ringing of the church bells to your closing hymn over the radiophone at my home last evening. It came through so loudly that I had to cut out some of the amplification. Your enunciation was perfect. I did not miss a word of your sermon and was only sorry that I could not join you at the gathering at the Parish House after the services.

Yours very truly,

From Illinois

Joliet, Ill.,
Jan. 24, 1922.

MY DEAR, DEAR FATHER:

You will be surprised to receive this letter and I know you will excuse me for taking the liberty of addressing you, but last Sunday night, January 22, I heard every word you uttered about Bishop Whitehead and his forty years of service in your diocese, the prayer which you delivered, together with other prayers that I have often read in our prayer book, as I belong to the Christ Episcopal Church Joliet, Illinois, Father Tanner, rector.

To further acquaint you with the matter, I live in a little five room bungalow. . . . The thrill that came over my wife and myself when we heard your voice in our radio set, brought the tears, it was so wonderful, and, as we heard the soloist sing during the offertory and the pipe organ play, we really forgot where we were, for the time being.

Thanking you and trusting and hoping that I may be with you again next Sunday over the wireless, I am, with kind regards

Yours truly,

From Connecticut

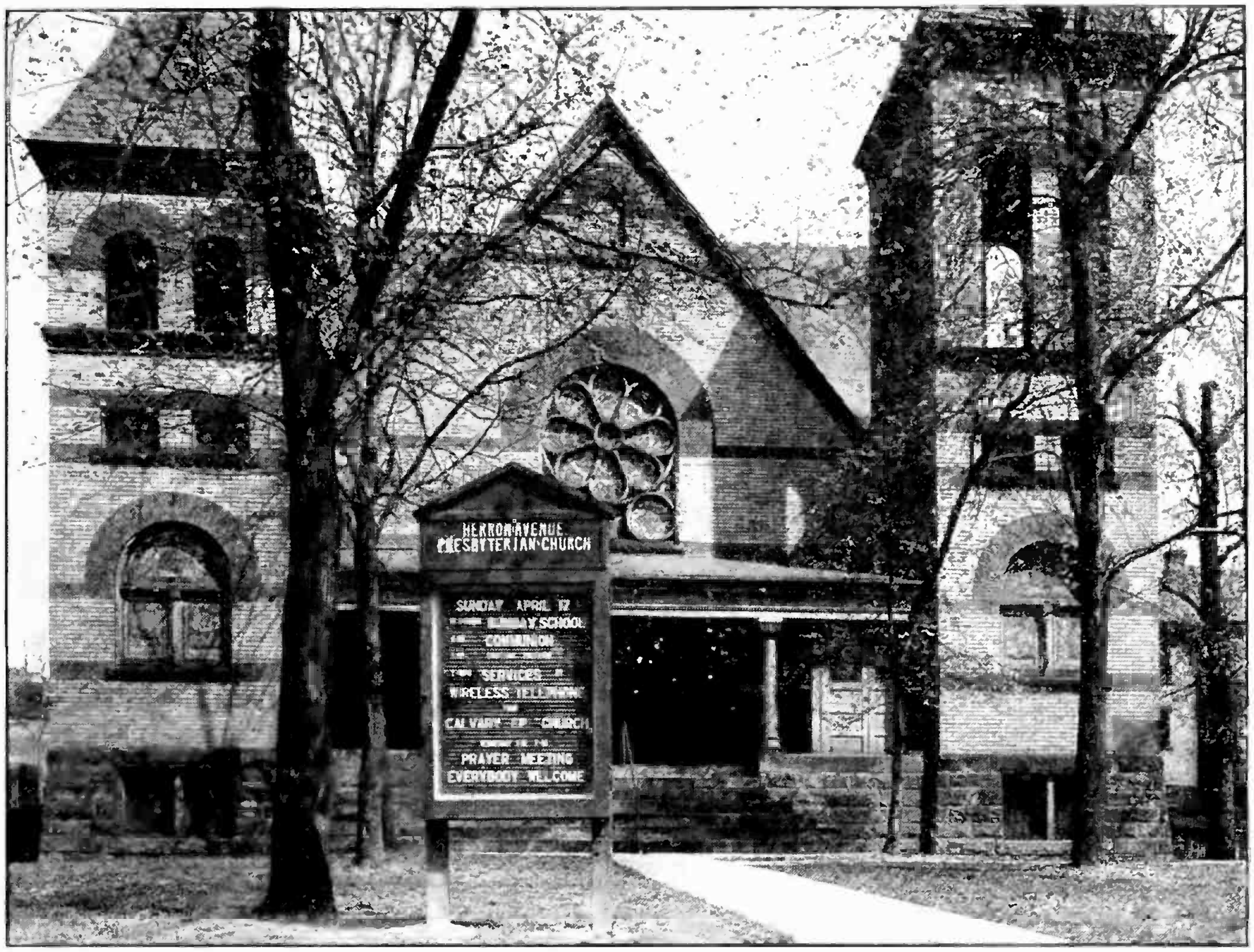
Rockville, Conn.

Dear Sir:

The distance in a direct line from your pulpit to my receiving set is, as near as I can determine, four hundred miles, so the broadcasting of your Sunday evening service has put Pittsburgh and your church on our map.

Last evening four of us "listened-in" to your services and occasionally tuned in to jazz music. My son said "Let's go back to the Minister, I like that better." Seriously my family looks forward to your Sunday evening service with anticipation. I wonder about the size of your wireless audience. It is difficult to estimate. Allow me to congratulate you upon being a pioneer in the broadcasting of church services by wireless.

Yours truly,



Herron Avenue Presbyterian Church, Pittsburgh, Pa., the first church to receive by radio the services of the Calvary Episcopal Church miles away. The Herron Avenue Church had lost its pastor, and one of its trustees brought about this innovation. The congregation even contributed to the collection

This man has decided to go to church, at least once.

Pittsburgh, Pa.,
February 2, 1922.

Dear Sir:

Just a few words to say how much we enjoyed your services Sunday evening, February 26, via radio, My father-in-law has not been inside a church for almost fifty years but has not missed a sermon broadcast from Calvary since last April.

Our home is in Mt. Oliver. Am going to sneak in the side door of your church some evening.

Yours truly,

From Vermont

Enosburg Falls, Vermont,
January 23, 1922.

REVEREND SIR:

I think you will be interested to know that your service last night was very plainly and clearly heard by me and the members of my family and this, in spite of the fact that a gale was blowing at the time. That you may know the extent of the gale, would say that some of the local churches cancelled their evening services on account of it.

We are located in Franklin County, Vermont, in the very northern part and within six miles of the Canadian Boundary.

Yours truly,

"Or Those on the Sea"

S. S. City of Alameda,
Sunday Night at Sea,
January 15,1922.

DEAR SIR:

Imagine several old, profane, sailor-men, sitting around a table with receivers clamped closely to their heads, listening to the word of God as spoken by you, and you will know what took place aboard our ship to-night. I enjoy your services each Sunday night. To-night I called in the other men. We all extend to your church hearty good wishes, and may your services continue being transmitted. We are just off the coast of Florida.

Respectfully,

From Massachusetts

Worcester, Mass.
Feb. 27, 1922.

DEAR SIR:

One of the finest sermons I ever heard came over the wireless last night from your tongue.

I could hear you distinctly, even hear you breathe and clear your throat. Surely the work is wonderful. I am a new man at the business and am free to confess it is the most interesting and entertaining pleasure I ever took up.

I could hear you better than stations nearer home, either Newark, N. J. or Medford, Mass.

Very truly yours,

A Philosophical Amateur

DEAR SIR:

Three neighbors joined us last evening in attending your services via "Radiophone."

The first time you shouted your name and address (evidently in an endeavor to reach the Pacific Coast or perhaps Japan and the Philippines) we heard you and the very walls vibrated—then that long deep breath—and you charged again—we never heard the rest—one of the bulbs blew out.

My set has three bulbs, two at $6.50 and one at $5.00. The one you blew out was of the $5.00 variety, when in another second it might have cost me $6.50, therefore I figure I owe the Calvary Episcopal Church $1.50, which I cheerfully enclose for your next Sunday collection.

Keep on shouting the Gospel you are doing a great work. I don't care if you blow out all the lights.

With kindest wishes,

Very truly yours,

From Georgia

Macon, Georgia,
Jan. 23, 1922.

DEAR BROTHER:

At 7:45 Sunday night the service from your Church by the Assistant Pastor was all heard in our room, we certainly enjoyed the sermon. We heard distinctly the first and second lesson read from the Bible also the appeal from the Minister in behalf of a Memorial Window and we listened with a great deal of interest to the sermon.

With best wishes and success in the winning of many souls to Christ, we are

Yours truly,

Heard in Germanton, N. C.

Germanton, N. C.,
April 24, 1922.

Rev. L. B. Whittmore,
Pittsburgh, Pa.

MY DEAR SIR:

A gentleman here has the "radio" and I take this liberty to thank you for your "congregation" here for your sermon last night (Sunday).

Every word was as plainly audible with few exceptions as if we were in your own church listening to you.

Your sermon was a winner and the music and singing simply glorious and the writer of the uncomplimentary letter should listen in on every one of these sermons and get some *Christian religion*, or else he has no feeling for the finer things that are.

We certainly enjoyed the sermon, the music and singing more than I can express and we hope to have the pleasure of hearing you again.

Again thanking you and with kindest regards, I remain

Yours very truly,

These letters, the ones quoted above, and the others that have been received come from people living all over the United States, are *bona fide* evidence that wireless church services are not a fad and that they are not merely an entertainment but are a help and benefit to all who hear them. They are convincing proof of the spiritual value of radio sermons as well as interesting information upon the manner in which these services affect different hearers. And there are literally thousands of similar letters now on file in the studies of the Rev. Van Etten, Dr. Barker and the Westinghouse radio division.

Only passing mention has been made in this article of the benefits of the radio services to the sick, or shut-in.

The great help the radiophone has been to the unfortunate who for some reason is prevented from attending church when he desires is so self-evident as to need no explanation. Possibly radio services are doing their greatest work in bringing comfort and cheer to the lonely sick or invalid.

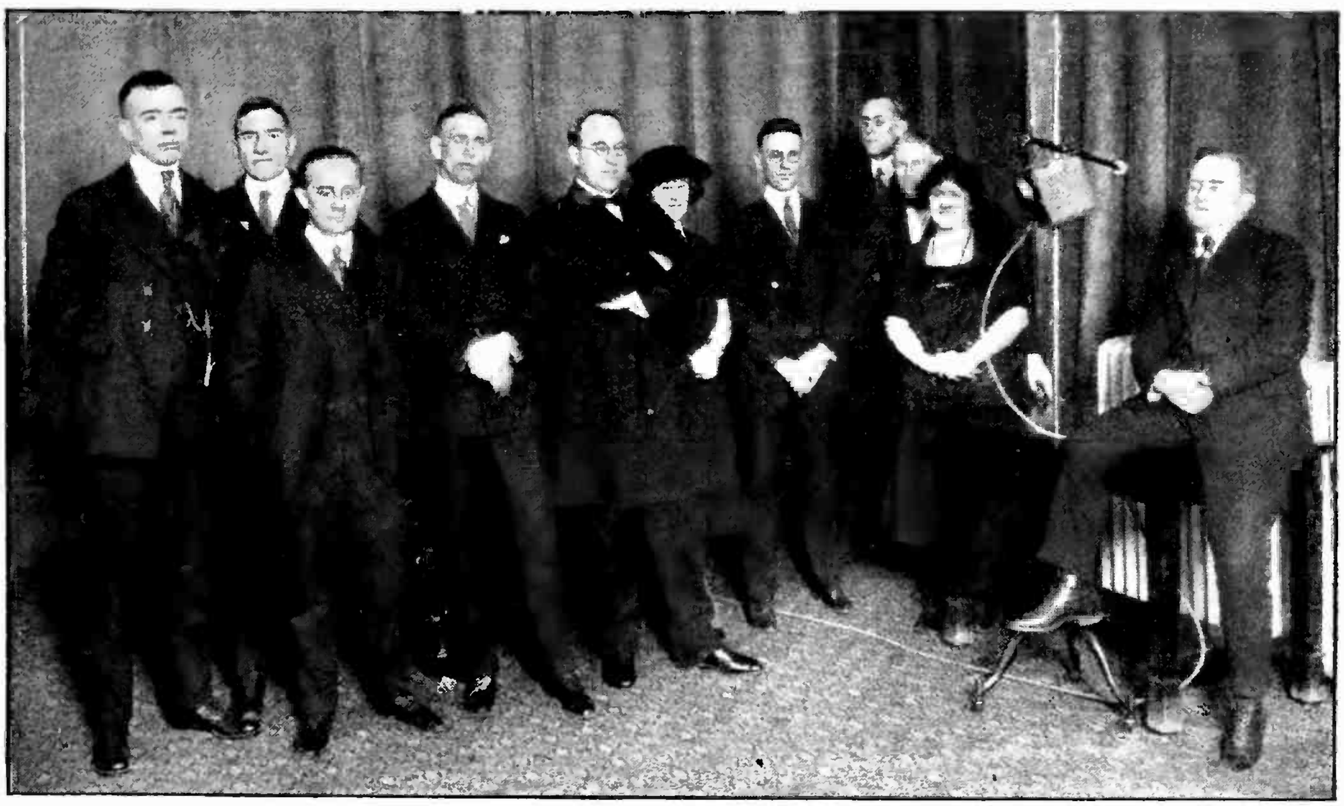
There is just one more question to be answered. "Will radio services have a detrimental effect on church attendance?"

Dr. van Etten can answer this from his experience.

He states, "It will greatly increase the church attendance. It is the greatest advertisement the church has ever had. Every Sunday, I meet new people drawn here because they know me over the wireless.

"Every week letters say: When we are in Pittsburgh, we shall surely come to Calvary Church. The radio will increase church attendance as the phonograph has increased interest in musical concerts. It is not, after all, a satisfactory substitute for the real thing, but advertises the church services far and near."

The Rev. Daniel L. Marsh of the Smithfield Street Methodist Episcopal Church, with his choir and the operators and announcers of KDKA in the broadcasting studio just before a Radio Chapel Service on Sunday afternoon



A Few Ideas on Radio

By W. D. TERRILL
Chief Radio Inspector, U. S. Department of Commerce

IT WILL be remembered that Edward Bellamy published a book entitled "Looking Backward" in 1887. This book created a great sensation. One passage of it deals with the hero's experience in a home in which he woke after a kind of Rip Van Winkle slumber of many years. On answering "yes" when asked if he would like to hear some music, he was led into a room where, strangely enough, he saw no musical instruments. He asked his hostess where and how the music was to be played. She smiled and asked him to sit down.

She then crossed the room and so far as he could see merely touched one or two screws. At once the room was filled—but not flooded—with the music of a grand organ anthem, with the volume of melody perfectly graduated to the size of the room. Scarcely breathing, he listened to music such as he had never expected to hear.

On asking his hostess when such concerts were available, the hostess replied, "Oh, our people keep all hours; but if music were provided from midnight to morning for no other purpose, it still would be sent for the sleepless and sick. All of our bedchambers have a telephone attachment at the head of the bed by which any person who may be sleepless can command music at pleasure."

The hero was even more surprised when on Sunday the family, after consulting the newspaper to see who was going to preach in the various churches, assembled in the music room, where, while seated comfortably in their own easy chairs, they heard an excellent sermon.

Now, only about thirty-five years of Mr Bellamy's estimated one hundred and thirty have passed. His only mistake was that he thought it would take us longer to accomplish these things.

I must leave it to another Edward Bellamy to predict the future possibilities of radio. It is only in its experimental stage and we shall no doubt see great improvements in the art before next winter, in point of the results we are able to get through broadcasting.

On June 1st there were 301 licensed radio telephone broadcasting stations in the United States. On that date there were only seven states without radio telephone broadcasting stations—New Hampshire, Delaware, South Carolina, Mississippi, Kentucky, Wyoming and Idaho. California has the largest number —59. Ohio has 23; Pennsylvania, 20; New York, 18.

Los Angeles, California, has the largest number of radio telephone broadcasting stations licensed in any city of the United States—18.

There are now forty-three newspapers broadcasting in the United States. Of these the *Detroit News* was the first.

One can only approximate the number of receiving stations in use in the United States.

On June 1st it was reported by the National Radio Chamber of Commerce that a careful survey of the entire country had been made relative to radio developments and that there were approximately 1,500,000 radio receiving sets in homes in this country.

It was also reported to the Department of Commerce that a small group of manufacturers in New York City had unfilled orders on June 1st amounting to $30,000,000.

The same report reveals the fact that at present there are in use in the United States approximately ten million automobiles, six million phonographs, and that, according to present indications, there will be approximately six million radio receiving sets in use within five years.

Since the estimated value of the average receiving set is placed at fifty dollars, on the basis of receiving sets alone, it is estimated that approximately fifty million dollars will be spent annually for new installations in the United States. Five million pounds of brass and copper alone, it is estimated, are required for every million instruments.

The National Retail Dry Goods Association estimates the annual volume of radio business open for exploitation at $70,000,000. It points out that in New York City, Chicago, and Pittsburgh there are department stores handling radio equipment at the rate of from $5,000 to $6,000 weekly.

The Bureau of Foreign and Domestic Commerce reports that in one of the early months of the present year the Westinghouse Company sold, at jobbers' figures, $2,000,000 worth of equipment. The General Electric Company reports that it will soon be manufacturing from 8,000 to 10,000 complete receiving sets a month. Another indication of the demand for radio equipment is the fact that between January 1st and May 1st of the present year the Secretary of State of New York issued charters to 1,800 corporations having something to do with radio. The Bureau of Foreign and Domestic Commerce estimates that there are now at least 300 "real" corporations manufacturing radio equipment exclusively, in addition to hundreds manufacturing parts as a side line along with amateurs and others such as electricians, Yet, according to figures compiled no longer ago than 1919 the total radio business for the entire country for a year was estimated at $7,000,000.

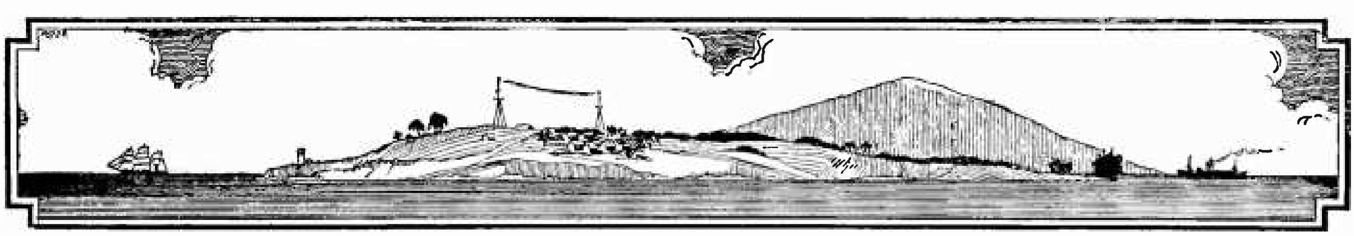
It has been estimated that Washington, D. C., has 1,800 private receiving sets; that in Detroit there are between 40,000 and 60,000; and that one home in every six in Pittsburg is equipped with a receiving set.

There is no way in which the Bureau of Navigation, which licenses all broadcasting stations and operators except governmental stations and army and navy operators, can determine the exact number of receiving sets in the United States, because no license is required for the operation of a receiving set.

The Radio Service of the Bureau of Navigation, which is able to function more or less judicially because it is not operating stations of its own, was created July 1, 1911 by Act of Congress passed in June, 1910. That Act provided that no ship of any nationality should leave an American port with fifty or more souls on board without radio equipment to permit it to send distress signals in an emergency for four hours. Ship inspection was the beginning of the radio work of the Bureau of Navigation, which, by law, was extended, so that the Bureau, with its nine established inspection offices, was in position to meet the enormous expansion of radio activities that has come during the past two years. It feels that its ship inspection work has proven invaluable in saving lives and property. To quote only one incident, a few years ago a British ship about to put out from Baltimore with a cargo of horses and with more than fifty persons on board, was held up by the local radio inspector. The master of this ship resented the authority of the United States requiring him to have radio equipment and an operator on board. In mid-ocean the ship caught fire. She burned to the water's edge. Her radio equipment was the means of saving everyone on board, a fact that the master of the ship himself, on his return to Baltimore some months later, acknowledged, going to the office of the radio inspector personally to thank him.

Without some regulation of sending stations, anarchy in the ether would be the inevitable result. But those who are regularly listening in realize that there is still a large necessity for better control of radio which cannot be accomplished, as the Radio Conference pointed out, without new legislation. It is therefore hoped that new legislation will be enacted during the present session of Congress which will improve radio conditions, particularly broadcasting, by making available for this purpose several bands of waves in addition to those now used so that one can more effectively tune in the station desired and tune out those not desired.

In the present rapidly developing situation there is, in fact, no more imperative need— a need that the Department of Commerce can properly advance because its interest in the situation is solely in behalf of those who are served by the art.



A Review of Radio

By LEE DE FOREST, Ph.D., D.S.C.

In this interesting article Dr. De Forest not only relates the steps in radio which led up to his invention of the Audion, or vacuum tube, but dips into the realm of prophecy and tells vividly and convincingly what he believes the immediate future of radio will be.—The Editors.

AND while I thus spoke, did there not cross your mind some thought of the physical power of words? Is not every word an impulse on the air?"

Poe, in his mystically suggestive dialogue of Onios and Agathos, tells of the birth of a wild star, brought into existence by a few sentences, spoken on the distant earth.

That which was in his time a vague dream assumes to-day a guise of reality. Earthly sounds, spoken words, air waves, limited hitherto to the confines of our atmosphere, have now been transmuted into ether vibrations, and, in theory at least, pass outward to the uttermost limits of space.

It is a pleasing, if perhaps an idle, thought that at last, after these million years of silence, human words, mortal music (and some of it most sweet, "even to other ears, than ours") can be heard, however attenuated and dim, in the wilderness of stars. Let not some cynical physicist point out that the rarefied and electrically conducting regions of our upper atmosphere offer an impenetrable barrier to all Hertzian oscillations. Until such a one has been beyond, and returned with proof, let us pin our faith to Poe's fable.

The acceleration of progress in these latter years is perhaps the most striking phase of man's advancement in physical science. Thirty years ago the existence of Hertzian, or electrical waves, was theory alone. That great searcher, Heinrich Hertz, discovered for us an empire vaster than Columbus', wider than any land or sea. To-day the ether waves he taught us how to find are of more utility than those of all our oceans.

Twenty-five years ago wireless telegraphy was hardly a word in our vocabulary. To-day scarcely a ship bearing passengers, or a vessel of war, but is able to telegraph to its mates lost below many horizons, through night or storm—to summon help in danger, or to exchange the news of the world. And undoubtedly "To-morrow" the commander of every vessel that floats will converse, voice to voice, with other captains, near or far, and with friends in port, a hundred, five hundred, then thousands of miles away.

This latest Hertzian offspring, the wireless or radio telephone, is a child already outstripping in speed of growth its elder brother. Not two decades have passed since the press heralded the first experiments in voice transmissions without wires, by electrical waves. Yet already the navies of many nations now have ships equipped with radio telephones, and their introduction to the merchant marine has begun.

It was five years after Marconi's first demonstration of "spark" telegraphy in England before an authentic distance record was established in telegraphy; the same distance record was established by the radiophone in less than two years!

This startling progress is, however, largely due to the similarity in methods employed in telegraphy and telephony. Many a knotty problem, wrought out at the cost of toil and error in the telegraph, was found ready solved for the younger art. Intricate though the way may be, delicate of handling, and difficult of solution the puzzles, I doubt if even the developers of the radio telephone will ever meet with as great discouragements as they overcame in the "good old early days" of the wireless telegraph.

ODDITIES IN EARLY VENTURES

THE earliest attempts at telephony without wires employed entirely different methods from those in use to-day. Thirty years ago Sir William Preece established such communication between the Skeeries Islands and the English mainland.

Long wires were strung on telephone poles parallel to the coast line, and connected to earth plates at either end of the line. A similar stretch of wire on the Skeeries ran parallel to those on the mainland, and were similarly earthed at either end. A battery and telephone transmitter were connected in one line, and an ordinary telephone receiver in the other. Telephonic currents passing through the first line and into the earth spread out as "leakage" currents in the earth. A few of these weak "strays" found their way into the earth plates of the distant wire, and, traversing this latter, produced faint words in the receiver, but the transmission distance possible by this means is little greater than the length of the wire lines involved.

Another early attempt to solve the problem was by low frequency "magnetic induction," as it is called. This method, depending upon the electro-magnetic induction between parallel loops of wire, is also extremely limited in range and utility.

Professor Bell, at the Columbian Exposition in Chicago, in 1893, talked over a beam of light. In Germany, Ruhmer, using Simon's "Talking Arc" lamp in a powerful parabolic projector, detected light fluctuations on a selenium cell, which translated them into telephonic currents. The maximum distance thus attainable was only five miles; and the slightest barrier in the path of the light beam cut off all communication.

Mme. Mazarin, noted French soprano singing a selection from "Carmen" over the De Forest wireless telephone in New York City in 1909

FOLLOWING THE OLDER BROTHER

TO-DAY the principles employed in the methods of telephoning without wires are in many ways analogous with those of the wireless telegraph, by which transmission over great distances is a matter of every-day occurrence. These principles are, moreover, in a way similar to those employed in the line telephone.

In the simplest form of wire telephone circuit, electric current from the battery passes through a microphone transmitter, out over the line, through the distant telephone receiver to the earth, and through the earth back to the battery.

The intensity of the continuous current here employed is controlled by the resistance of the carbon granules in the microphone transmitter. With each vibration in the speaker's voice against the transmitter diaphragm this resistance is made greater or less, and the flow of current is thus controlled. These changes in the current produce corresponding vibrations in the iron diaphragm of the telephone receiver, which is attracted more or less strongly by the small electro-magnet around which the wire is wound.

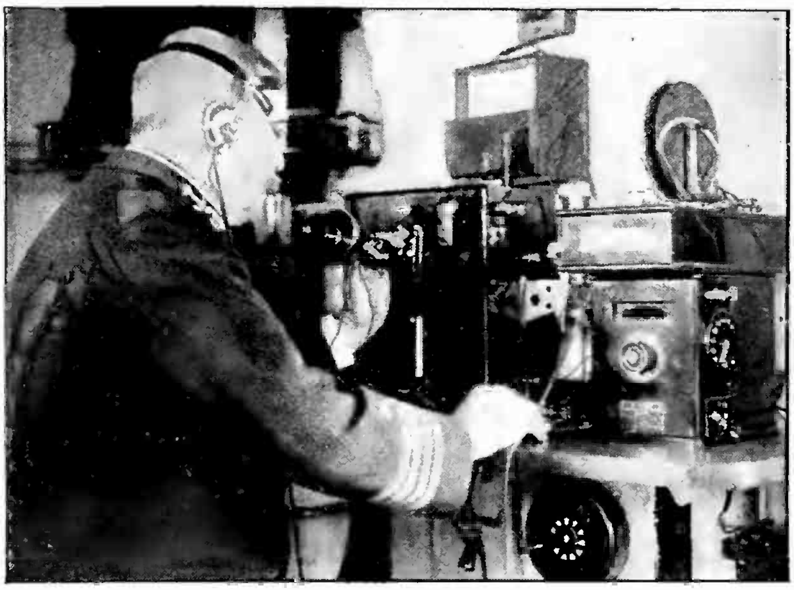
In the wireless system, alternating currents of very high frequency, generated by the electric arc, replace the continuous current. These currents surge up and down in the vertical wires of the station and excite in the space surrounding it electric, or "Hertzian" waves, which radiate outwardly from the station in all directions, in everwidening circles.

A portion of these radiated waves cuts the other wires at the receiving station, and generates high-frequency currents in that conductor, which are exactly similar to, but very much weaker than, the currents surging up and down at the sending station.

The voice, by means of the microphone transmitter inserted in the wire of the sending station, controls the strength of these high-frequency currents, exactly as it controls the continuous current in the wire telephone.

At the receiving station, the "wireless detector," is influenced by the received high-frequency currents, and translates these into telephonic currents which operate the telephone receiver exactly as in the case of the "wire" telephone receiver. In this way the voice vibrations are reproduced, although no wire connects the two stations.

It was therefore only after the advent of wireless telegraphy by means of "detached," or "radiated," electric waves that one saw the possibility of voice transmission over considerable distances without wires. Not for several years after the first wireless telegraph message had stolen its silent way over English waters was it plausible to suppose that spoken words could be similarly transmitted. The earliest form of detector, the "filings" coherer, certainly gave no indication of such things in store.



Capt. Ingersoll, Chief of Staff to Admiral Evans using a radiophone on the U. S. S. *Connecticut* at Hampton Roads in 1907. In the upper right hand corner of the picture may be seen what was termed a pancake receiving oscillation transformer, the number of turns on either coil being regulated by the movement of a slider arm

The coherer device consisted of a small mass of metallic filings, placed loosely between two silver electrodes, contained in a small glass tube and connected, one end to the vertical wire, the other to a plate buried in the earth. When an electrical wave passing through the ether cut this elevated wire, a minute electric current was generated therein. This current, traversing the loose-lying filings on its way to earth, caused them to cohere. Thereupon a current from a local battery was enabled to pass through the coherer, following the wave current, and this local current was used to ring an electric bell or operate a Morse "ticker." But the filings remained cohered until an automatic tapper, by agitating the glass tube, again interrupted the passage of the current.

Not until the first "anti-coherer" or "auto-coherer" was discovered (a detector not requiring the slow "decohering" operation) was it possible to detect continuously the rapid succession of electric waves, which were sent out from the transmitting station while the sending "key" was held down.

With these new forms of detectors it was possible to use an ordinary telephone receiver in place of the Morse ticker, and therein to hear a sound which actually reproduced the sound of the spark at the transmitting station. It was now noticed that every acoustic property of the spark was faithfully transmitted, its change in "pitch," which depends on the number of sparks per second and all its variations in intensity and sound quality.

"If one can only teach the spark to talk, we will have wireless telephony," was remarked.

Various methods for making the sparks talk at once suggested themselves. The simplest and the crudest of these was to talk through a megaphone directly into a long or flaming spark. This was as inefficient as it was simple! In the ordinary wireless telegraph transmitter the number of sparks per second or "spark frequency," is very low compared to the vibrations of the human voice, and very little influenced by any such means.

Hence methods were investigated for increasing this spark frequency beyond that which the human ear can detect, to 50,000 per second. In 1900 the investigations of Duddell, coupled with those earlier, but less heralded, of John Stone Stone brought attention again to methods for producing enormously rapid electrical pulsations from direct instead of alternating currents.

The remarkable work of Nikola Tesla in this particular branch, as first described by him before the Franklin Institute in 1893, never commanded the attention it deserved.

It was found by these investigations that if across the wires leading to an electrical arc a small coil of wire and a condenser were connected, then this arc would under certain conditions emit a musical note. This indicated that the arc was in some manner acting rapidly to interrupt or disturb, the electric current flowing through it; and the frequency of these fluctuations, as indicated by the pitch of the note emitted, depended upon the size of the coil of wire and on the capacity of the condenser, which were connected across the arc.

It was found that the pulsating or alternating currents thus generated in the branch or condenser circuit possessed many of the properties of the high-frequency alternating currents generated by the spark discharge in wireless telegraphy. They were, however, small in intensity compared with those used in wireless, and generally of much lower rates of vibration. However, they possessed the very desirable quality of persistence and regularity; each alternation was exactly equal in strength to those preceding and following it. The oscillations, in other words, were not "damped."

Various ways were next devised for making these arc oscillations more rapid and more intense. The former object was attained by placing the arc itself in a partially exhausted vessel; or in the chimney of a lamp, where it was exposed to hydro-carbon vapors; or later, by Poulsen, in an atmosphere of pure oxygen, or of ordinary illuminating gas.

Earlier investigations had shown that by keeping the arc electrodes artificially cooled, by making them hollow and circulating water through them, it was possible to cause the arc to oscillate at very high frequencies, even in the open air. In very early experiments I found that placing the arc in steam is a particularly effective method.

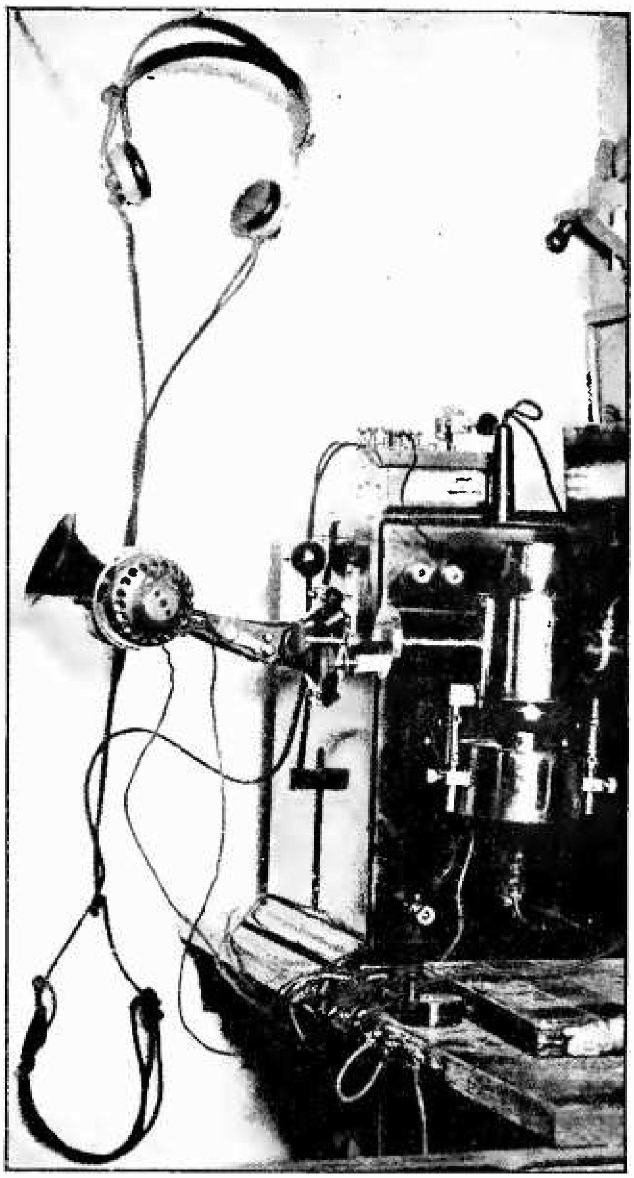
THE TUNE OF THE WAVE

IT MUST be remembered that in all these arrangements of the arc the actual rate of electrical vibration is determined largely by the amount of capacity and the dimensions of the inductance coil which are connected across it. By these two adjuncts the "tune" of the electrical waves which are being generated is determined.

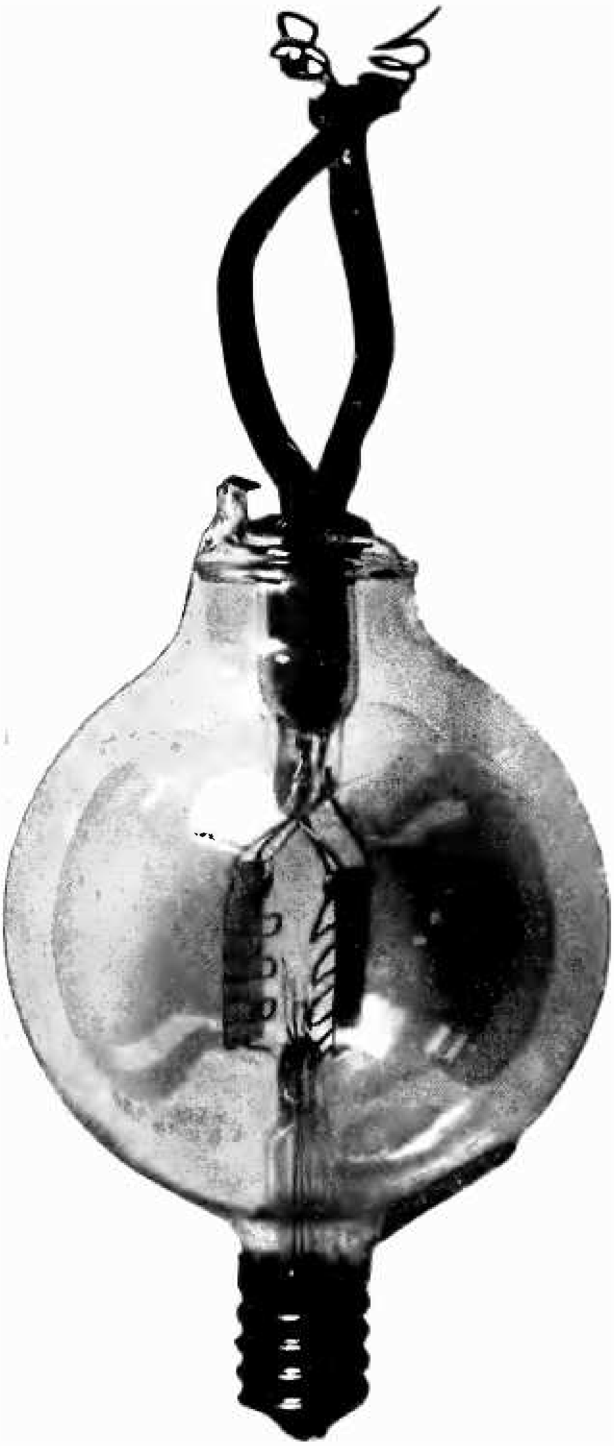
The smaller these elements, the higher the electrical "tune," which may vary from 100,000 vibrations per second to 1,000,000 or more. The radiated waves travel outward from the antenna with the velocity of light—186,000 miles per second. Their "wave lengths" therefore at these frequencies range from about 3000 meters down to 300 meters.

The radio telephone apparatus employing such an arc oscillation is, as we say, very "sharply tuned." For the reason that each wave is exactly similar in length and intensity to every other one of the wave train which a certain transmitter sends out, it is necessary that the distant receiving apparatus should be very accurately attuned to these particular waves in order to respond to them at all.

These periodically received impulses, each weak in itself, may represent in their aggregate



De Forest radiophone installed in Metropolitan Tower for New York to Paris tests. This transmitter was of the arc type and the arc chamber may be seen to the right. Parallel microphones were employed to modulate the antenna current



© Paul Thompson

This is a real old De Forest audion. Several years ago radio amateurs saved for long periods to procure one of these magic bulbs. As may be observed, two filaments, two plates, and two grids were employed. The stability of this type tube was anything but constant due to imperfect evacuation

a great amount of energy (as energies go in wireless!), but unless the receiver system is so tuned that each little surge set up in it by an incoming wave occurs at exactly the right instant to fit in, or harmonize with, the succeeding wave, interference will occur in the wires, and the surgings, instead of gradually becoming stronger, will be completely or partially nullified.

It is exactly as one sets a pendulum in vibration by slight successive taps properly timed. Let these taps vary from the proper interval ever so little, and the pendulum almost immediately comes to rest.

So with our sustained oscillations in the radio telephone receiver. The electrical circuit there is essentially the same as at the arc transmitter. It is built-up "capacity" and "self-inductance," but with a detector, or responder, substituted in the place of the transmitter arc.

Now if this capacity and inductance are the same as in a certain transmitter, that and no other transmitter can awaken a response in this particular detector circuit.

TRANSFORMING THE VIBRATIONS

HOW have we "taught the spark to talk"? As so often in the history of invention —by not doing it—by suppressing the spark!

By the little silent arc, or by very high-frequency alternator (which later accomplishes at great expense and complication only what Nature is willing to do for us, simply and automatically), we first secured our sustained electrical oscillations, smooth and continuous radiations from the aerial wires.

Their frequency, as we have seen, is far beyond the range of the ear, so that although each wave gives a little kick to the distant detector, the ear listening in at the telephone hears not a sound.

But the intensity of these rapidly succeeding impulses we can vary by the voice, exactly as the voice in the ordinary telephone transmitter controls the momentary strength of the current therein flowing. We also employ the microphone, only instead of connecting it in the "line" it is inserted in the lead which runs from the oscillating system to the earth-plate.

Every inflection, every shade of articulation, the timbre of each instrument of an orchestra will be instantly carried and reproduced with surprising fidelity, notwithstanding all the strange transformations through which the original vibrations have passed.

THE LIGHT THAT DID NOT FAIL

THE radio telephone transmitter of 1907-12 employed the electric arc very similar to the arc light. But the wonderful sensitiveness and adaptability of the little audion incandescent lamp, first as a wireless detector, then as an amplifier for weak wireless telegraph or wire telephone currents, kept haunting me. I was finally convinced that it contained the possibilites of a transmitter, of a generator (as well as a detector) of alternating currents. I reasoned that if, as a detector, it transmuted alternating into direct currents, this process could be reversed; that it could equally well transform direct into alternating currents.

In 1912 I determined this to be a fact. I found then that I had in the simple incandescent audion lamp with its filament, and plate and grid elements, a marvelous little generator of alternating currents, set up in the proper circuits connected to its elements and containing capacity and inductance.

A large number of circuit arrangements permit the audion thus to oscillate and transform the energy supplied from the battery or dynamo into alternating currents of low or high frequency, as desired.

The audion itself is a small incandescent lamp containing, besides its filament, two metallic plates or wires, one of which is connected to the telephone receiver and local battery, the other to the wires which carry the high frequency oscillations. The conducting medium inside the audion bulb is exceedingly sensitive to the minutest electrical effects, and serves as a medium by which the incoming electric waves can control the local telephone currents. The one most essential and completely novel element in the whole strange device is the "grid" member, interposed across the path of the traveling ions ("wanderers" as their Greek name implies). Try to imagine one of these ionic carriers of the voice currents of electric charges, and contrast it with a carbon granule of a microphone transmitter of the early "telephone relays." Compare a soap bubble with a load of coal, and you will have some relative idea of the sensitiveness of the audion and that of the old microphone relay.

Here we have, then, light speaking unto light—an arc lamp to an incandescent, over miles of city or wastes of sea, through the walls of hundred of buildings—and by means of other light waves—invisible because so long, yet still light waves in their nature!

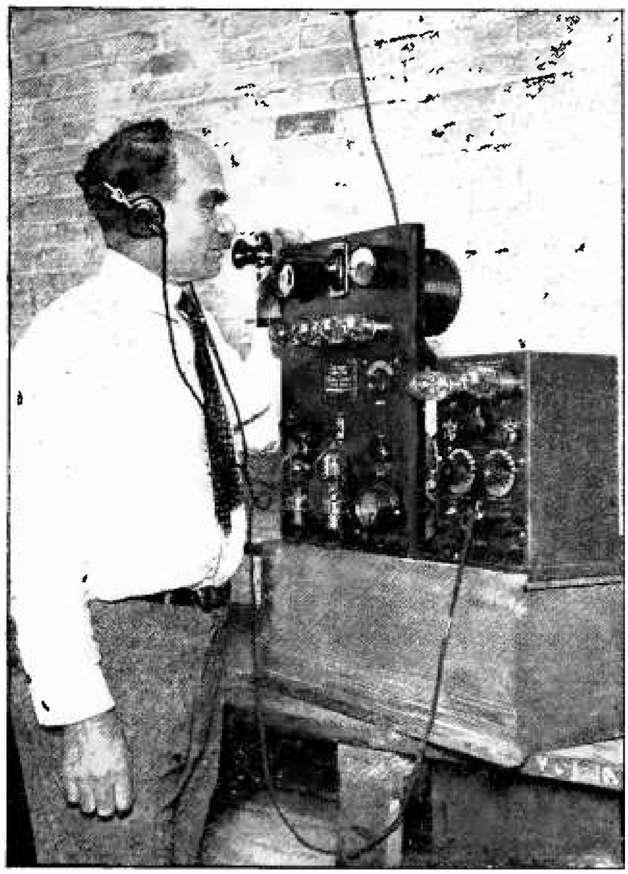
In appearance the radio-telephone transmitter is not very unlike the old style "wall-set" telephone. An instrument having a range of seventy-five miles occupies only about a square foot of table space, exclusive of course of the small dynamo required.

UNCLE SAM AN EARLY CONVERT

IN NOVEMBER, 1907, the United States Navy installed twenty-six sets of radio telephones upon as many battleships, torpedo-boat destroyers, and auxiliaries, prior to their famous round-the-world cruise. The specifications at that time called for five-mile transmission for inter-fleet work! Some of those instruments, crude though they were compared with the present type, maintained communications for forty and fifty miles. To-day —such is the progress in this new art—the Navy calls for instruments capable of a hundred mile conversation between warships and nearly as many miles between seaplanes and ship stations. In another year, it is safe to forecast, the requirements will be twice as rigorous as these, but the development of the science will keep pace.

In the spring of 1908 a first demonstration of the early American arc transmitter system was made in Paris, before representatives of the Government of France. The tall aerial

Dr. De Forest trying out one of his more recent inventions, a portable wireless telephone operated entirely by current from a lamp socket.



at the Eiffel Tower wireless telegraph station was not then used, as it was desired to approximate conditions obtaining on shipboard. From a small antenna communication was demonstrated to a government station at Melun, sixty kilometres distant.

The Italian Navy, following the examples of our own, decided then to install the radio telephone on several war vessels at Spezia. Between the arsenal wireless station, at San Vito, and the little scout vessel *Partenope*, conversations were maintained up to eighteen miles, notwithstanding that the scout's aerial was only thirty-five feet high.

Skirting in close under the lee of Palmuria's Isle, a rocky cliff and mountain 1500 feet in height separated the two stations, and yet the distant voices came in clear and distinct. Through the port-hole of the little cabin I could look straight into the black entrance of Byron's Cave, where it is said the poet has written some of his best lines. As I repeated to the hidden listener those first lines from the Corsair:

"O'er the glad waters of the deep blue sea,
Our thoughts as boundless and our souls as free,"

I wondered if ever in that rocky cliff Byron's vivid imagination had fared so far as to picture this strange reality!

The growing realities of the possibilities of the radio telephone for naval purposes was shown when the British Admiralty next expressed a desire to witness its operation. In September, 1908, an elaborate demonstration was made at Portsmouth, between H. M. S. *Furious* and H. M. S. *Vernon*. Here was established the longest range record up to that time in an official test—over fifty sea miles, although the limit of the apparatus was by no means reached. As proof of accuracy, and significant of what the "sea-phone" could accomplish merely as long range, day or night, substitute for flag-signalling, lists of numerals were read off on the *Furious* and copied on board the *Vernon*. Lists of figures read at fifty miles were received without an error.

Then came 1914, and the swift development of radio communication through the needs of war. In the light of what the Oscillion radio telephone accomplished for the Allies during the war, these bits of ancient history in this new young art (already "old" after ten years) now take on a new interest, for, thanks to this new young art, we had the voice-commanded squadron, airplane artillery fire control, and immediate communication at sea between ships, and between ships and shore stations, all of which is now taken as an ordinary matter of course.

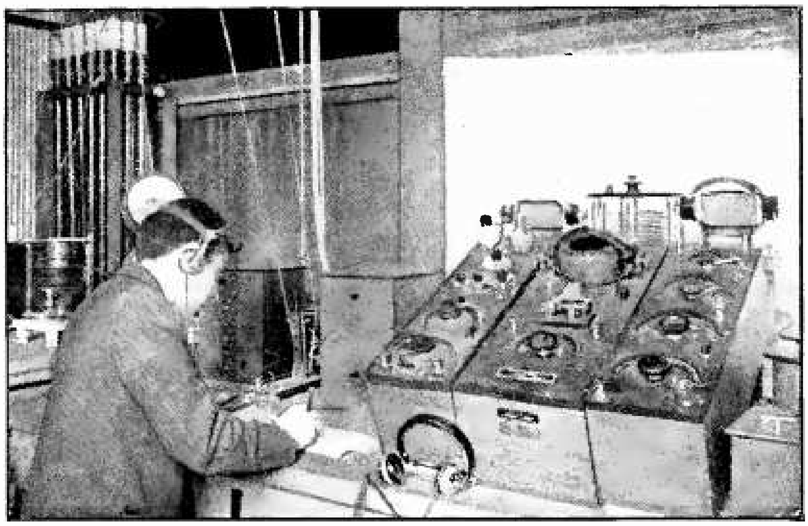
Obviously the prime field for the radio telephone is to furnish communication where it is impossible or inexpedient to stretch or maintain wires or cables, and yet let us not forget also that one of the big advances in wire telephony to-day, the recently heralded multiplex telephone, whereby several distinct, individual telephone conversations may be held over one wire at one time, is in truth nothing more or less than the practical use of a telephone wire in serving as a guide to a number of wireless waves of varying length, each wavelength in turn acting as the unseen messenger of the individual wire "telephone" conversation. Here, too, it is pleasing to note the results of pioneer work done by an American inventor; on this occasion, an expert who has long used his efforts in behalf of the advancement of the radio art, Major General George O. Squier.

BROADCASTING

IT IS in the field of Broadcasting, however, that I personally find an especial interest, no doubt through the fact that for many years, indeed since my first experience with the transmission of news and music by radiophone, in 1907, I have taken an eager part in dreaming of what was to come on this particular side of radio development. At no time throughout those many years, when so many of our foremost citizens refused to pay heed to the art of the radiophone, could I see anything but the practical service to be rendered by it. Failure to convince men of standing in the world of public interest, as well as in the commercial field, led to numerous disappointments, and further delays. The endless number of demonstrations we arranged with a view to convincing the public that the day of radio was here, were seemingly of no avail.

To-day I would not, in dwelling on this almost uncanny Radio Renaissance which the broadcasting idea has brought upon us, overlook the all-important part therein which the newspapers have played. Without the discerning vision of certain of our more progressive editors, the already immense success of our radio broadcasting idea could never have been realized. Possibly their change of attitude during the last three years has been even more surprising than that of the Government and radio company officials in general.

In 1919, when I began a quiet little campaign of education and persuasion with certain editors, I sought to show what unlimited possibilities for the education and amusement of all America, and particularly of the dweller on farms and in isolated districts, the radio telephone possessed. By the very nature of its propagation, the medium it employed, by the astonishingly simple and inexpensive receiving apparatus required, should it not have been clear to anyone giving the matter a little thought, that a few powerful, well-located radiophone transmitters could afford a means for nation-wide announcement for one-way communication, which was absolutely new in man's experience? Yet while this technical phase of the situation was (perhaps doubtingly) admitted, yet none of those newspaper men with whom I came in contact seemed at that epoch to realize the possibilities for genuine good to the public of this proposed service.



In 1908 messages were sent from the Metropolitan Tower, New York, to Milwaukee and Key West by the "Sparkless" radio telegraph. The arc chamber employed for this transmission may be seen at the extreme left over the operator's shoulder. The huge boxes before the operator constitute the receiving equipment. The radio amateur of yesteryear will recognize the old fashioned variometers, variable condensers, audion detectors, and adjustable pillar inductances

Yet, let it be known, the managers of the Detroit *Daily News* grasped the germ of the idea as soon as it was presented. A small transmitter was installed on the roof of their building shortly thereafter by the Radio News and Music Inc., a company which at that time sought but failed to interest the other newspapers of the country; and to that newspaper belongs (as told in Radio Broadcast for June) the honor of establishing the first "radiophone newspaper service," interesting and up-to-the-minute news bulletins, interspersed with music or monologue to make the service doubly attractive.

Then, not many months later, the Westinghouse Company, whose progressive directors had long before determined to break into radio regardless of what millions this might involve, took up the possibilities of the broadcasting idea. Backing faith with works, they opened up their regular station at Pittsburg, then one at Newark. So at last Broadcasting began to come into its own.

Now that a few years will see every fair-sized vessel, on ocean or lake, equipped with this safeguard for the mariner, is, I take it, as certain as progress. Then, fog-bound, or lost near shore, unacquainted with his bearings, knowing nothing of the telegraph code, every skipper can call to some listener at the nearest life-savers' station, or lighthouse, and hear in a still small voice his vessel's name repeated and its whereabouts revealed. Or, he will hear an answering "Ahoy," and be told that another craft, steering a certain course, is close upon him. The tug captain will be in telephonic touch with his barge office, miles distant, or with the steersman of his tows, even if the hawser has parted. A yacht-owner, without the luxury of a Morse operator in his crew, can already call up his club miles away over the waters. Cities separated by a hundred, a thousand miles of gulf are to be connected by telephone over the water, although the distortion and alternation of currents in a submarine cable of such length render voice transmission utterly impracticable.

It is of course no longer necessary that the speakers themselves be at the radio telephone stations in order to use them. Wire telephone instruments are directly connected to the wireless at terminal stations, thus giving all the elasticity of the present telephone exchange, yet employing the radio telephone as the "trunk line" or connecting-link.

Ranchers in sparsely settled districts will subscribe to a radio-telephone, and be in close contact with distant neighbors. Mining camps, mushrooming on a mountain-side, will have their radio telephone with town long before a telegraph company feels justified in stringing wires. And when snowslides or storm have felled all wire lines, the radio telephone will be unhampered; for the medium it employs lets the avalanche slip under it, and the snowflakes sift unhindered through it.

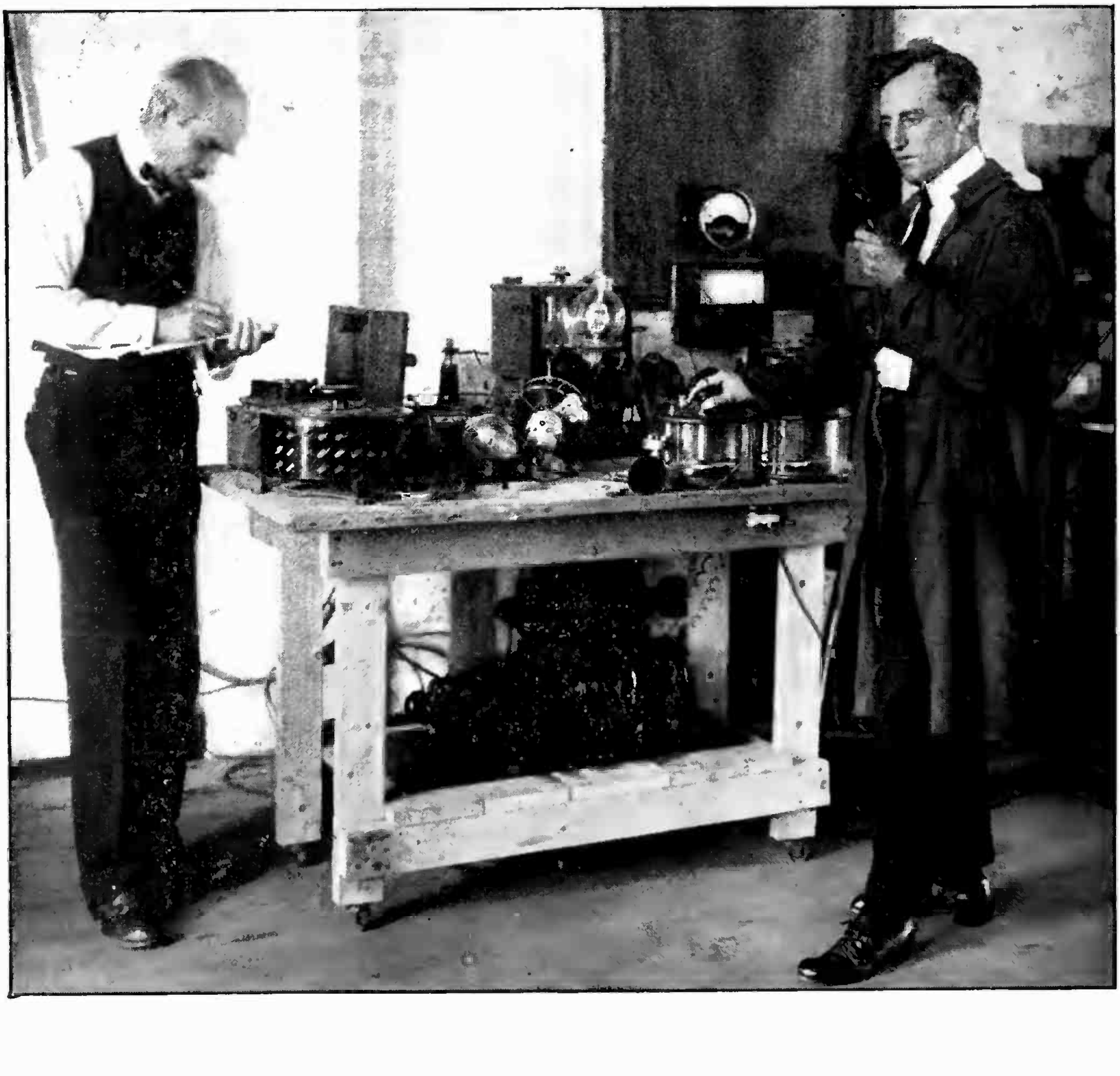
In great cities, also, as well as in far-off villages, and farm lands, we already see at hand the sweet music of opera, or orchestra; or the lines of a play, sent over the wire telephone from microphones on the stage to a central radio telephone plant, and there translated into ether vibrations, to be absorbed by the wires of a thousand new aeolian harps, and carried down thence to a tiny receiver in each home.

Plans for distributing such eternal music from some lofty tower in New York, I understand, are already under way, and on a not far distant Christmas dawn, the wireless operators and cabin listeners on steamers far out on the Atlantic may hear carols and glad tidings from the home city, far down in the West.

And what more does the future hold for the newest, farthest-reaching art? Ask of the Sphinx of Science, who ever remains silent in the shadow of dawn. Could Poe, the dreamer, the idealist, live again to-day, he might not call as he did, to science:

"Vulture, whose wings are dull realities!"

Dr. De Forest measuring the current in various circuits employing a large sized vacuum tube for wireless telephone transmitting



Radio Telegraphy

By GUGLIELMO MARCONI

The most striking point in Senator Marconi's lecture before a joint meeting of the American Institute of Electrical Engineers and the Institute of Radio Engineers, held in New York City on June 20th, was the suggestion that the shorter wavelengths have been practically abandoned by experimenters and commercial interests. Due to recent advances in the radio art, especially the development of the vacuum tube, effective signalling on short waves is now possible. Mr. Marconi suggested that this will undoubtedly stimulate a great interest in American amateur radio circles which should result in further radio success. In speaking of his parabolic reflector system, he mentioned wavelengths of 15 to 20 meters, which, it would seem, are hardly possible for the average amateur worker, for the erection of a reflector 15 meters high covering an area 15 or 20 meters in diameter would involve a considerable expenditure. For the most part, American amateurs will have to devote their efforts to short wave propagation without the use of the reflector, and it is interesting to note that, even prior to Mr. Marconi's lecture, American amateurs have made some very successful attempts to communicate by this method. Space does not permit us to reproduce Senator Marconi's entire lecture, but the following material covers the most salient points he made about radio telegraphy's past, present and future.—The Editors.

THE first occasion on which I had the honor of speaking before the members of the American Institute of Electrical Engineers was of a very festive nature.

It is more than twenty years ago, to be exact, on January 13, 1902; (there was not then any Radio Institute in existence) and on that date, memorable for me, I was entertained by more than 300 members of your Institute at a dinner at the Waldorf-Astoria in this City. I was offered that dinner following my announcement of the fact that I had succeeded in getting the first radio signal across the Atlantic Ocean.

Many men whose names are household words in electrical science were present, men such as Dr. Alexander Graham Bell, Professor Elihu Thompson, Dr. Steinmetz, Dr. Pupin, Mr. Frank Sprague, and many others.

The function was one I shall never forget, and displayed to the full American resource and originality, as only forty-eight hours' notice of the dinner had been given, but what has left the greatest impression on my mind during all the long twenty years that have passed is the fact that you believed in me and in what I told you about having got the simple letter "S" for the first time across the ocean from England to Newfoundland without the aid of cables or conductors.

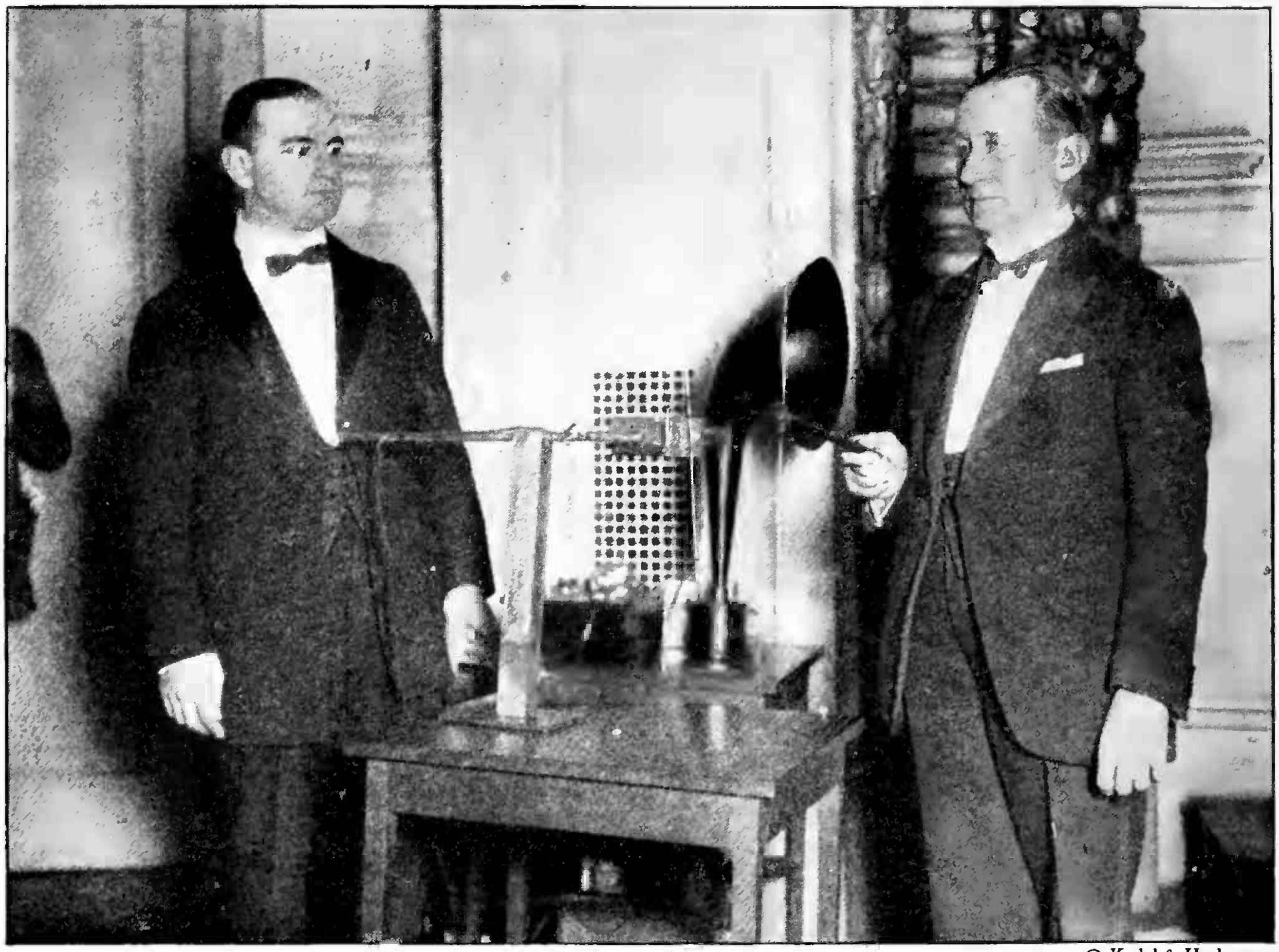
It gives me now the greatest possible satisfaction to say that, in some measure, perhaps, your confidence in my statement was not misplaced, for those first feeble signals which I received at St. John's, Newfoundland, on the 12th of December, 1901, had proved once and for all that electric waves could be transmitted and received across the ocean, and that long distance radio telegraphy, about which so many doubts were then entertained, was really going to become an established fact.

I propose to-night to bring to your notice some of the recent results attained in Europe and elsewhere and to call your attention particularly to what I consider a somewhat neglected branch of the art; and which is the study of the characteristics and properties of very short electrical waves. My belief is always that, only by the careful study and analysis of the greatest possible number of well authenticated facts and results, will it be possible to overcome the difficulties that still lie in the way of the practical application of radio in the broadest possible sense.

A very great impulse has been given to radio telegraphy and telephony by the discovery and utilization of the oscillating electron tube or triode valve based on the observations and discoveries of Edison and Fleming, of those of De Forest and of those of Messiner in Germany, Langmuir and Armstrong in America, and H. W. Round in England, who have also brought it to a practical form as a most reliable generator of continuous electric waves.

THE VACUUM TUBE

AS THE electron tube, or triode valve, or valve, as it is now generally called in England, is able, not only to act as a detector, but also to generate oscillations, it has sup-



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Marconi demonstrating the effect of placing a tuned inductance between the transmitter and receiver of a short wave directive system. Where the inductance is of the same wavelength as the wave of the transmitter, the signals at the receiver are entirely cut out when the shield is between the two stations. The signals are considerably augmented, however, if the tuned inductance is placed behind the receiving antenna. Where reflectors are employed at the receiving station, the signal intensity is increased approximately five times. The gentleman at the left is Dr. Alfred Goldsmith, President of the Institute of Radio Engineers

plied us with an arrangement which is fundamentally similar for both transmitter and receiver, providing us also by a simple and practical method with the means for obtaining beat reception and an almost unlimited magnification of the strength of signals.

A result of the introduction of the triode valve has been that the basic inventions which made long distance radio telegraphy possible have become more and more valuable.

It has been so far our practice to use a plurality of tubes in parallel at our long distance stations. High power has been obtained in practice up to 100 kilowatts in the antenna by means of a number of glass tubes in parallel, and for the present we are standardizing units capable of supplying 4 kilowatts to the antenna, in the numbers required and sufficient for each particular case.

Some difficulty was at first experienced in paralleling large tubes in considerable numbers, but no difficulties now occur with groups of sixty bulbs working on voltages of 12,000 on the plate.

I am told that no insurmountable difficulty would be encountered if it were desired to supply 500 kilowatts to the antenna from a number of these bulbs. The life of the bulbs has been very materially increased and the 4-kilowatt units are expected to have a life, which, based on a great number of tests carried out both in the laboratory and at our Clifton station, should be well in excess of 5,000 hours.

The development of single unit tubes of considerable power is also progressing. We have lately concentrated on the production of high power tubes made of quartz, and two sizes of each bulb are now being made, one for 25 kilowatt to the antenna, and another for 75 kilowattss but it is not expected that the efficiency of the high power single units will be as good as that of the multiple units, and the work on the large tubes is being considered so far as experimental.

EFFICIENCY OF TRANSMITTERS

IN transmission work, a large amount of investigation has been carried out during the last two years on the efficiency of the circuits and in regard to the best way of utilizing the available energy.

Considerable increases in efficiency have been obtained in the aerial or antenna circuits and also in minimizing the losses in the attendant loading coils, and the latest results indicate that it is possible to obtain efficiency of radiation into space as high as fifty per cent. on wavelengths as long as 20,000 meters, when, in this particular case, towers of a height of 250 meters would, of course, have to be used, owing to the length of the wave.

Very careful investigations have been carried out by Mr. H. W. Round of all the losses in the loading coils and other parts of the tube circuits, and actual measurements on considerable power have shown that an over-all efficiency from the input power on the plates of the tubes to the aerial of seventy per cent. is possible with a complete avoidance of harmonics, that is, an efficiency from the power input to the plates of the tubes to actual radiation into space of about thirty-five per cent.

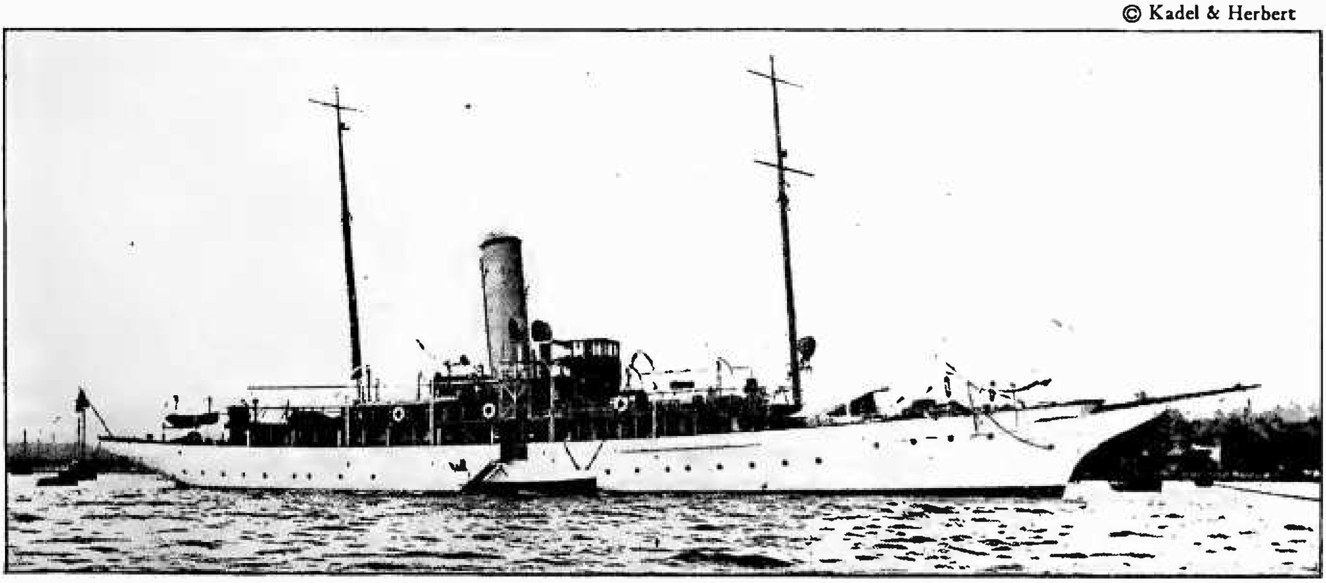
On shorter wave stations it is quite practicable still further to increase this efficiency although possibly it is hardly worth the extra expense involved. We have at present one station in England working on a 3,000 meter wave length with a height of mast of 100 meters which has an efficiency from plates to radiation into space of 40 per cent.

In high speed transmission, we are maintaining public services at 100 words per minute to two places in Europe, namely, Paris and Berne, using a single aerial transmitter with two wavelengths on the same aerial, and although the operation of utilizing a single aerial for two wave lengths is not an advisable one for high power work, it has certain points to recommend it in medium power work, where the consequent loss of efficiency can be made up for by a slight increase of power.

These two waves are working duplex to both Paris and Berne and practically all traffic is taken on printing machinery, although there are occasions when, because of static, reception has to be done on undulator tape, and, in some rare cases, on the telephones, by sound.

The reception at these shorter distance stations is carried out by means of a cascade arrangement of high and low frequency tuned amplifier circuits attached to the directional aerial system of the Bellini type, arranged for unidirectional reception when necessary. Very great care is taken in the receiving circuits to shield them so that the tuned circuits come well into action and to prevent any direct effect or influence of the aerial on circuits other than those intended to be acted upon. The char-

Marconi's yacht, the *Elettra,* which is fitted with a very complete radio laboratory. While the yacht was in the Hudson River Mr. G. Mathieu, who accompanied Marconi, received signals from Europe with remarkable intensity, by a system of amplification he has perfected, using a loop antenna



acteristics of all these circuits have been very accurately measured so as to give filter curves suitable to the required speeds of working, and the adjustments are easily performed by the operators. Aside from the protection from interference given by directional reception, a close filtering, and an element of saturation, no particularly sensational methods or ideas in regard to static elimination have been so far introduced into practice.

WHERE STATIC COMES FROM

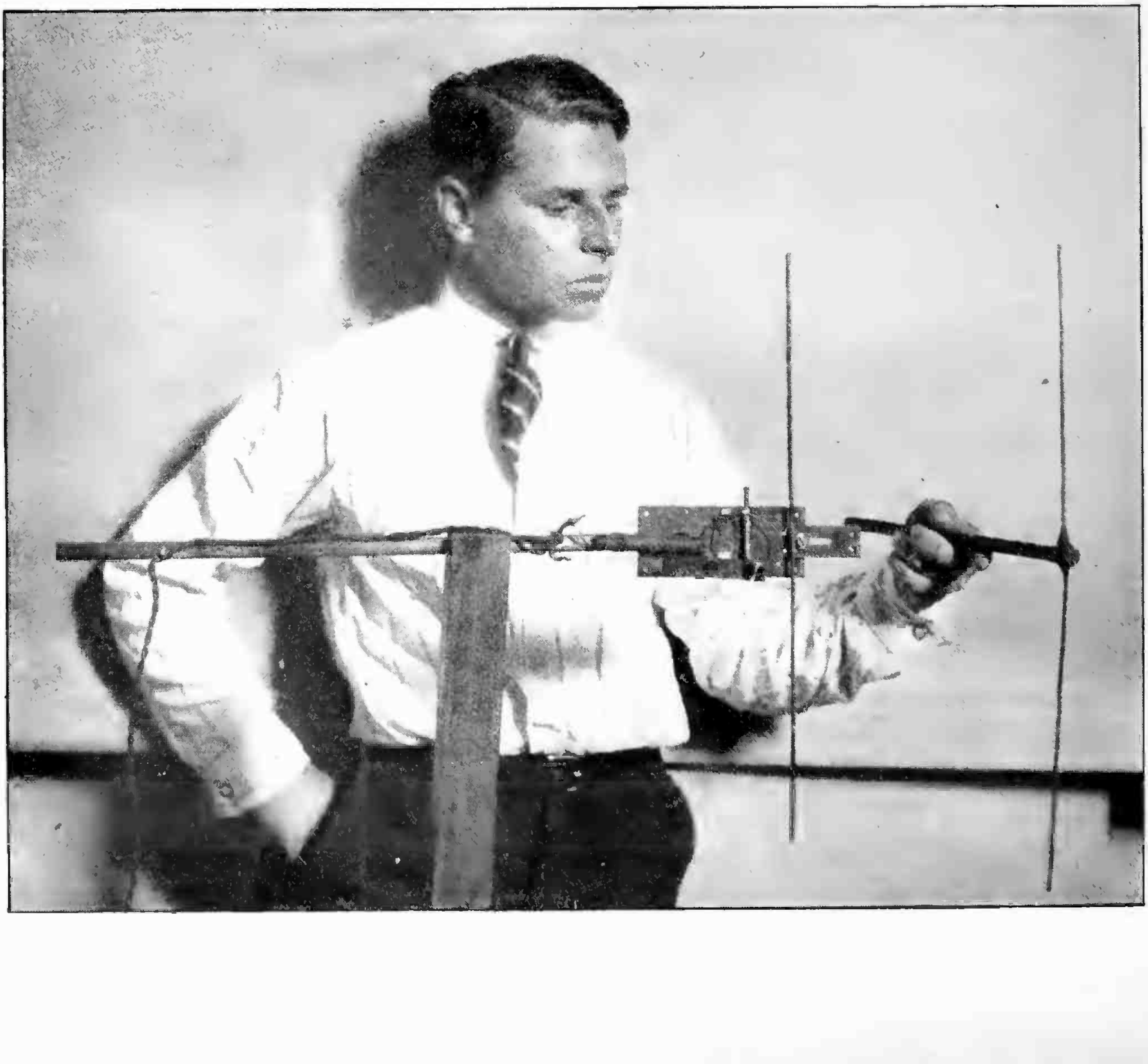
DURING my present journey across the Atlantic on board the Yacht *Elettra*, we noticed that up to about half way across (apart from the effects of local storms, static interference appeared to be coming mainly from the European and African continents, while at more than half way across they were coming from westerly directions, that is, from the American continent.

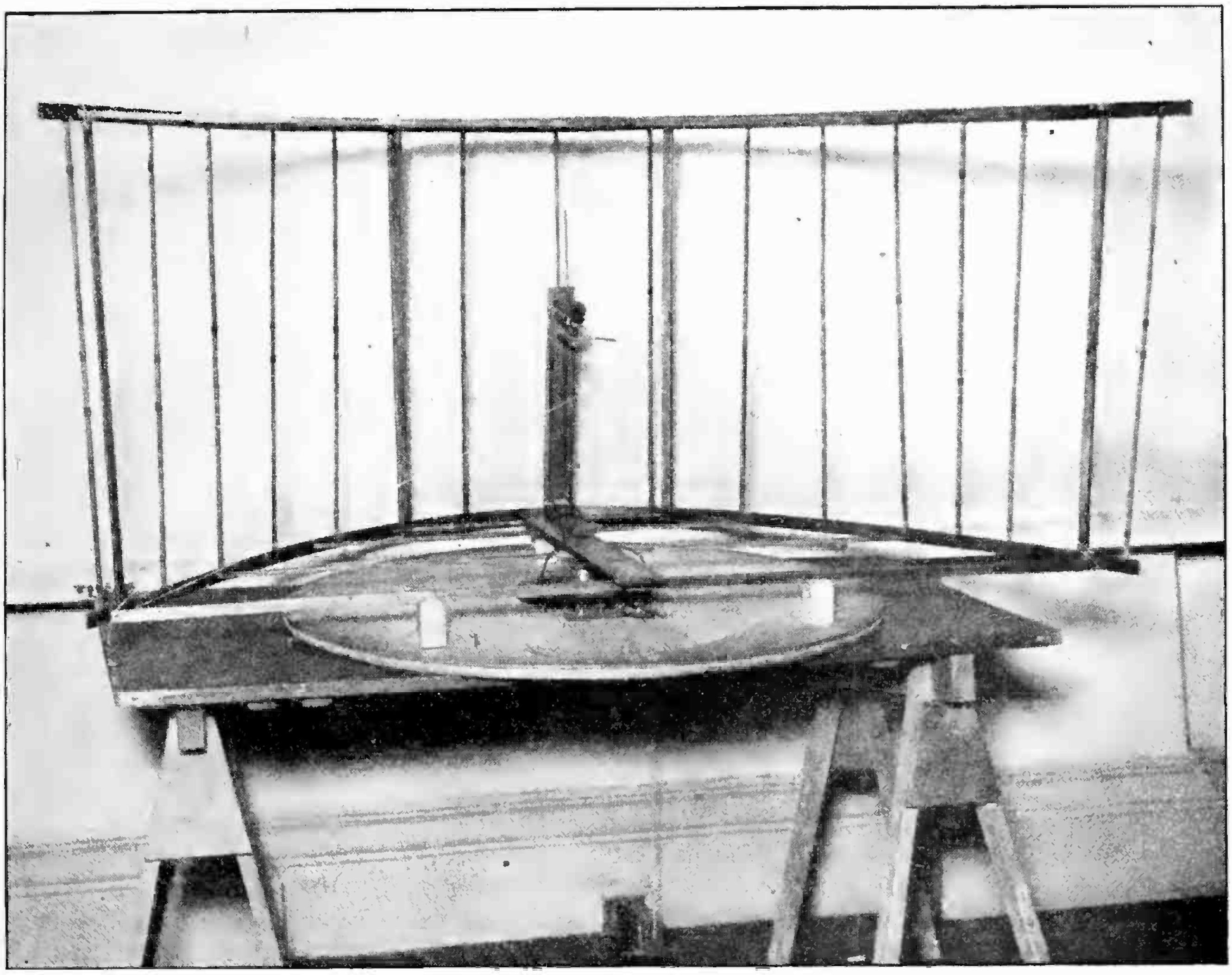
The changing over of the direction of origin of these disturbances has also been noted under similar circumstances by Mr. Tremellen in crossing the Pacific.

The protection of receivers against the troubles of atmospherics or static can only be, and is likely to continue to be, a relative matter, as it is quite obvious that a static eliminator under certain conditions will cease to be effective, where the static arrives with much greater intensity than had been anticipated, and will also frequently fail when, in consequence of the weakness of the received signals, amplification

A very good idea of the receiving antenna may be had from this photo. The young man is demonstrating the effect of placing a tuned inductance between the transmitter and receiver. A slight movement to one side or the other permits the signal to be received, but when it is placed directly before the receiving antenna, signals are entirely cut off. If we are to have directional, short wave transmission it would seem as though both sending and receiving stations would have to be high enough to offset the possibility of any shielding objects coming between them. Operation in large cities would be quite difficult. The receiving rod is slightly shorter than the reflector rod because the former is connected to a circuit having a certain amount of inductance

Courtesy Radio Corporation of America





The transmitter Marconi used to demonstrate his directive transmission system for extremely short wave work. The table supports a pivoted disc which carries the transmitting antenna and the parabolic reflector. The direction of transmission is altered by orientating the reflector. The upright rods in the reflector are insulated from each other and are of one and one half the transmitting wavelength. Directional transmitting of this nature on 15 or 20 meters would present great difficulties for the amateur to overcome due to the complexity of building the reflecting system.. However, where the transmitter could be installed on the roof of a building and a higher building was adjacent to it, the reflecting wires could be suspended and insulated from the latter

has to be increased to any considerable extent.

RECENT DEVELOPMENTS

IT WOULD be really interesting to know how much the increased number of C. W. transmitters, the development in directional reception, and the improvements in tuning that has taken place during the last few years have really increased our speed of readability and reliability over given distances.

As the development has been gradual, the tendency is toward pessimism, but I think we are now able at the same expense to work at about 8 to 10 times the effective speed that we were able to work at in 1912 under the same atmospheric conditions.

Interference from other stations has, of course, enormously increased, and this has perhaps somewhat checked the increase of speed, but fortunately prevention of interference from other radio stations is a very much easier problem than the prevention of the disturbances caused by natural electric waves, or static.

Amongst the different types of tube amplifiers used in modern radio receiving stations, the tuned high frequency and audio frequency amplifier is probably the one which excites the greatest technical interest. In fact, its selective qualities, combined with the comparatively better ratio of signal strength to interference which it secures, justifies such interest.

If those researches were generally not quite successful in regard to preparing or fixing the design of practical apparatus, they however indicated that the main difficulty to be overcome was to combine considerable amplification with stability and that the solution of the problem became rapidly more difficult with the increase of the number of tubes used in cascade.

By stability, in this case, I mean the freedom from any sudden generation of oscillations in any part of the circuits of the amplifier.

RECEIVING DEVELOPMENTS

IN 1920, however, an important step was made by Mr. G. Mathieu, as to the path to be followed out in order to obtain a practical solution of the problem. This consisted in the design of a new type of air-core tuned intervalve transformer arranged in such a manner as to possess only an extremely electrostatic capacity between the windings, and having its effective primary impedance about equal to the effective internal plate to filament resistance of the tube in use when the secondary circuit was brought into resonance with the frequency of the oscillations to be amplified.

The results to be achieved during the first tests of these new transformers appeared to be quite amazing, the amplification factor for one tube having passed suddenly from 5 to about 15 for the particular tube tested, whilst the stability proved incomparably better than what had been obtained previously, even when the grid of the tube was kept to a negative potential of 1 or 2 volts.

The same principle has proved quite as successful when applied to the design of iron-core low frequency transformers. In this case, however, it was found necessary to adopt an iron magnetic shunt between the windings so as to provide a sufficiently loose coupling between the primary and secondary circuits of the transformer. Recently, Mr. Mathieu has further improved the design of his high frequency transformer by making it astatic.

THE IMPORTANCE OF SHORT WAVES

I SHALL now deal with another and most important branch of the science of radio telegraphy; a branch which I might say has been a long time most sadly neglected. It concerns the use that can be made of very short waves, especially in regard to their application to directional radio telegraphy and radio telephony.

The study of short waves dates from the time of the discovery of electric waves themselves, that is, from the time of the classical experiments of Hertz and his contemporaries, for Hertz used short electric waves in all his experiments, and also made use of reflectors to prove their characteristics and to show among many other things that the waves, which he had discovered, obeyed the ordinary optical laws of reflection.

As I have already stated, short electric waves were also the first with which I experimented in the very early stages of wireless history, and I might perhaps recall the fact that when, more than 26 years ago, I first went to England, I was able to show to the late Sir William Preece, then Engineer in Chief of the British Post Office, the transmission and reception of intelligible signals over a distance of $1\frac{3}{4}$ miles by means of short waves and reflectors, whilst, curiously enough, by means of the antenna or elevated wire system, I could only get, at that time, signals over a distance of half a mile.

The progress made with the long wave or antenna system, was so rapid, so comparatively easy, and so spectacular, that it distracted practically all attention and research from the short waves, and this I think was regrettable, for there are very many problems that can be solved, and numerous most useful results to be obtained by, and only by, the use of the short wave system.

Sir William Preece described my early tests at a meeting of the British Association for the Advancement of Science, in September, 1896, and also at a lecture he delivered before the Royal Institution in London on the 4th of June, 1897.

On the 3rd of March, 1899, I went into the matter more fully in a paper I read before the Institute of Electrical Engineers in London, to which paper I would recall your attention as being of some historical interest.

DIRECTIONAL TRANSMISSION

AT THAT lecture I showed how it was possible, by means of short waves and reflectors, to project the rays in a beam in one direction only, instead of allowing them to spread all around, in such a way that they could not affect any receiver which happened to be out of the angle of propagation of the beam.

I also described tests carried out in transmitting a beam of reflected waves across country over Salisbury Plain in England, and pointed out the possible utility of such a system if applied to lighthouses and lightships, so as to enable vessels in foggy weather to locate dangerous points around the coasts.

I also showed results obtained by a reflected beam of waves projected across the lecture rooms, and how a receiver could be actuated and a bell rung only when the aperture of the sending reflector was directed toward the receiver.

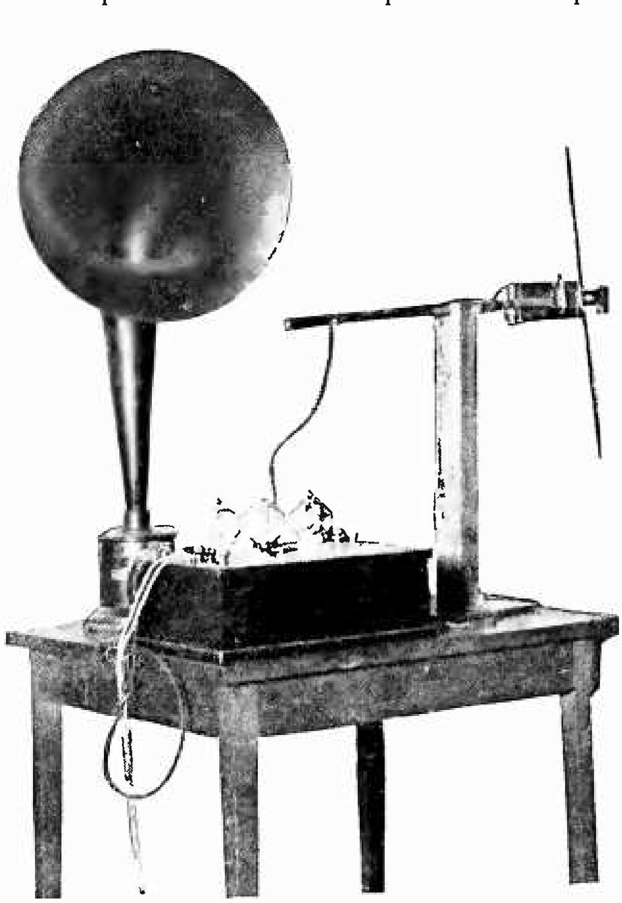
Since these tests of more than twenty years ago, practically no research work was carried out or published in regard to short waves, so far as I can ascertain, for a very long period of years.

The investigation of the subject was again taken up by me in Italy early in 1916 with the idea of utilizing very short waves combined with reflectors for certain war purposes, and at subsequent tests during that year, and afterward, I was most valuably assisted by Mr. C. S. Franklin, of the British Marconi Company.

Mr. Franklin has followed up the subject with thoroughness, and the results obtained have been described by him in a paper read before the Institution of Electrical Engineers in London on the 3rd of April, 1922.

Most of the facts and results which I propose to bring to your notice are taken from Mr. Franklin's paper.

The waves used had a length of 2 meters and 3 meters. With these waves, disturbances caused by static can be said to be almost nonexistent, and the only interference experienced came from the ignition apparatus of automobiles and motor boats.



The receiving outfit used by Marconi to demonstrate the reception of extremely short waves sent out by a directive antenna. For the demonstration, he used a loud speaker of American make so that the audience could observe the effect of his directional antenna. The signals of extremely short waves are picked up and then pass through a circuit similar to the superheterodyne and thus changed to a wavelength of six hundred meters. Although six hundred meters is the wavelength for ship use no interference is experienced from this source because only those waves which influence the detector circuit are passed on. This feature of the receiver was not pointed out by Marconi and is therefore not generally realized

The receiver at first used was a crystal receiver, whilst the reflectors employed were made of a number of strips of wires tuned to the wave used, arranged on a cylindrical parabolic curve with the aerial in the focal line.

The tests were continued in England at Carnarvon during 1917. With an improved compressed air spark gap transmitter, a 3-meter wave, and a reflector having an aperture of 2 wavelengths and a height of 1.5 wavelength, a range of more than 20 miles was readily obtained with a receiver used without a reflector.

In 1919 further experiments were commenced by Mr. Franklin at Carnarvon for which electron tubes or valves were used to generate these very short waves, the object being to evolve a directional radio telephonic system.

A 15-meter wave was chosen, which could quite easily be generated by the type of electron tube employed.

As a result of the success of these experiments it was decided to carry out further tests over land across a distance of 97 miles between Hendon (London) and Birmingham.

The power supplied to the tubes employed is usually 700 watts. The aerial is rather longer than half a wavelength and has a radiation resistance which is exceedingly high. The efficiency input to the tubes to aerial power is between 50 and 60%, and about 300 watts are actually radiated into space.

With the reflectors in use at both ends, speech is usually strong enough to be just audible with a $\frac{1}{4}$ to $\frac{1}{2}$ ohm shunt across a 60-ohm telephone.

With both reflectors down and out of use, speech is only just audible with no shunt.

By means of suitable electron tubes or valves, it is now quite practicable to produce waves from about 12 meters and upward utilizing a power of several kilowatts, and it is also practicable to utilize valves in parallel.

Reflectors besides giving directional working, and economizing power, are showing another unexpected advantage, which is probably common to all sharply directional systems. It has been noted that practically no distortion of speech takes place, such as is often noticed with non-directional transmitters and receivers, even when using short waves.

It has thus been shown for t[illegible] first time that electric waves of the order of 15 to 20 meters in length, are quite capable of providing a good and reliable point to point directional service over quite considerable ranges.

I have brought these results and ideas to your notice as I feel—and perhaps you will agree with me—that the study of short electric waves, although sadly neglected practically all through the history of wireless, is still likely to develop in many unexpected directions, and open up new fields of profitable research.

BROADCASTING

NO REMARKS from me or from any one else are required to tell you what has already been done with radio in America, as a means of broadcasting human speech, and other kinds of sound which may also be entertaining if not always instructing.

In thousands of homes in this country there are radiotelephonic receivers, and intelligent people, young and old, well able to use them—often able to make them—and in many instances contributing valuable information to the general body of knowledge concerning the problems, great and small, of radio telegraphy and radio telephony.

But I think I am safe in saying that if radio has already done so much for the safety of life at sea, for commerce, and for commercial and military communications, it is also destined to bring new and, until recently, unforeseen opportunities for healthful recreation and instruction into the lives of millions of human beings.

Sharpness of Tuning in a Radio Receiver

By JOHN V. L. HOGAN

Consulting Engineer, New York; Fellow and Past President, Institute of Radio Engineers; Member, American Institute of Electrical Engineers

IF WE set up a simple radio receiver as shown in Fig. 1, connecting a sensitive direct-current meter in the place usually assigned to the telephones, we will be able to determine approximately the strength of the radio-frequency alternating current which any arriving wireless wave may set up in the antenna to ground system. As has been pointed out in an earlier article,* the natural frequency of the aerial system may be altered within wide limits simply by changing its effective capacity or its effective inductance. Further, it has been shown that the greatest amount of current will be induced in any antenna-to-earth circuit when its natural frequency agrees exactly with the frequency of the arriving radio wave. Still further, we have seen that the aerial current for this harmonious or tuned condition will be the larger, and will depend the more critically upon care in adjustment, when the electrical resistance of the circuit is made as small as may be feasible. Thus it becomes evident that a good radio receiver, one which is both efficient and selective, will need to have convenient instruments for the control and adjustment of its natural frequency as well as a minimum of resistance or opposition to the flow of electric current.

THE TUNING CIRCUITS

IN THE arrangement of Fig. 1, there are two tuning coils A and B, and a tuning condenser. The coils may be assumed to be of the well-known variometer type, although similar effects would be had if other forms of adjustable coils

* "Increasing the Selection Power of a Radio Circuit," by John V. L. Hogan. *Radio Broadcast*, July, 1922, page 211.

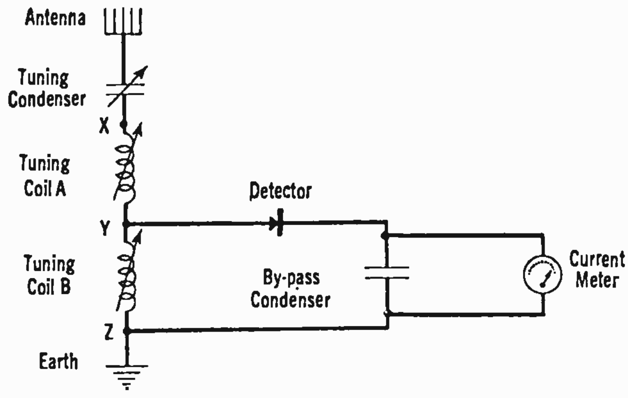


Fig. 1: A conductively coupled radio receiver arranged to permit variation of the detector voltage by tuning the detector circuit

were used. The condenser should be closely adjustable as to capacitance, as is the usual interleaved segmental-plate arrangement. Increasing the inductance of either coil or increasing the capacitance of the condenser will lower the natural frequency of the circuit, thus making it resonant to a longer wavelength. From the point of view of tuning, it is immaterial whether we increase the inductance of coil A or of coil B, for the two are connected in series and the effective inductance of the circuit (which controls its free or natural oscillation frequency) depends upon the total value of both.

However, it will be noted that the detector and current-meter branch of the receiving circuit is connected across only the lower of the two coils, that is, across coil B. To understand the effect of this, we must appreciate that for any particular amount of current which any one series of radio waves may generate in the antenna-to-ground circuit, there will be produced a certain definite quantity of electric pressure or voltage between the points X and Z marking the outside terminals of the pair of inductance coils. We must realize, beyond this, that the voltage so produced will be divided between the points X and Z and the points Y and Z (or between the terminals of the two individual coils), in proportion to the relative amount of inductance in each tuning coil. Thus, if coil A is equal to coil B in size, the total voltage will be divided equally across each. If coil A is twice as large as coil B (in inductance), two thirds the total voltage will appear across X-Y and one third across Y-Z. Consequently it becomes evident that by dividing between the two coils in various ratios the total amount of inductance required to tune the receiving antenna circuit, we may alter the proportion of the total voltage which is applied (across the points Y-Z) to the part of the receiver containing the detector and current-meter.

Clearly, it would not be necessary or even desirable to provide two separate inductors or tuning coils if we were concerned merely with adjusting the natural frequency of the antenna system. In a radio receiver, however, we wish to provide not merely a resonant condition but also a *sharp* resonant condition, or one in which all resistance effects are minimized. In this way we secure not merely loud signals from the station to which we desire to listen, but also the least amount of interfering signal intensity from disturbing stations which may be transmitting simultaneously with neighboring wave frequencies.

RESISTANCE OF THE RADIO RECEIVER

THE total resistance of a radio receiver, which we desire to keep as small as possible, may be divided into four portions. The first of these, and usually the smallest, is simply the electrical resistance of the wires in the aerial, the tuning coils and connections. In well-designed instruments this amount is too little to require much consideration. The second portion is the so-called ground resistance, which includes the opposition to current flow existing in the connection to earth and, near the receiving station, in the earth itself. This part may be kept small by using firmly made and well-distributed ground connections, or, where that condition is difficult to secure, an artificial ground or counterpoise. The third part of the total is not a true or simple resistance, but represents the losses in the receiver due to re-radiation from the aerial of high-frequency current energy set up in it by arriving waves. The proportion of this third part is not easily controllable, for it depends mainly upon the size and form of the receiving antenna; in any event, it is not a resistance to worry about, for the general conception is that the higher the re-radiation loss the better is the antenna for intercepting wave-energy and therefore the better one can afford such losses.

The fourth portion of the total resistance is the one with which we are mainly concerned, for it may be controlled by the design or adjustment of our receiving outfit. It represents the part of the total received energy which goes into the detector and in part performs useful work by producing signals. At first sight one would be inclined to say: "Let us make this fourth or useful part of the resistance as high as possible, for the greater it is the more energy will pass to the detector and the louder will be our signals." A little study will make clear the fallacy of this idea, however. It is true that the higher this useful resistance (in proportion to the other three parts) the greater the percentage of the whole received energy which will be impressed upon the detector. But is it true that the signals will be louder, or that the amount of energy thus put into the detecting system will be greater? Beyond rather low limits the answer is emphatically no, for the increase in total resistance will reduce the total energy set up in the antenna system by the received waves and there will be less power available to produce signal effects.

SIGNAL STRENGTH AND SELECTIVITY

THUS it appears that in such a receiver there exist two effects working against each other, either of which alone would tend to improve the strength of the signals heard. We desire to make our detector resistance effect as great as is feasible, since a substantial part of it represents work done in producing what we want, i. e., radio signals (which term, of course, includes speech or music received by radiophone). On the other hand, if we increase the resistance effect too greatly the resonance in our receiving aerial circuit will be spoiled; signals from waves to which we are tuned will not build up to so strong an intensity, and interfering waves will cause disproportionately loud disturbances. Evidently, we must strike a happy medium, a satisfactory balance between loss of signal energy and loss of selectivity.

By dividing the tuning inductance into two parts connected as in Fig. 1 we are enabled to strike this balance. The resistance effect of the detector is proportional to the amount of electrical power delivered to it from the antenna circuit. The power applied to the detector depends upon the radio-frequency voltage impressed upon it. In Fig. 1 the detector is connected to the points Y and Z; the voltage across these points is controlled by the amount of inductance in tuning coil B. Thus by changing the proportion of the total requisite tuning inductance in coil A as compared to coil B, we can vary the voltage affecting the detector and can control its resistance effect in the antenna circuit. The smaller the percentage of the total inductance allotted to coil B, the lower will be the voltage on the detector, and the less the resistance effect. The less this resistance, the weaker will be the signals, but the sharper the tuning.

HOW DETECTORS VARY

WHERE the detector has the capability of absorbing a good deal of energy, as when a crystal rectifier is used, this adjustment is of great importance. Many of the crystal receivers now on the market are very poor from the point of view of tuning because in them the detector voltage is made too great a percentage of the available total. Where the audion vacuum tube detector is used, the grid or input circuit (to which the detector oscillation voltage is applied) refuses to take a great deal of power, and consequently the careful division of the total inductance is not ordinarily necessary. The principle, however, should be understood and kept in mind, for it explains many tuning difficulties experienced by novice users and designers of radio apparatus.

There is another exceedingly useful way in which the proportion of detector resistance in the tuned antenna circuit may be controlled. If instead of the conductive or wire detector connection of Fig. 1 we substitute a magnetic coupling as in Fig. 2, we may vary the voltage impressed upon the detector by changing the position of the secondary coil B with respect to tuning or primary coil A. The nearer the two coils are together, the closer their coupling is said to be and the higher will be the radio-frequency voltage impressed upon the detector. As before, the higher detector voltage causes the abstraction of a greater part of the antenna power and produces the effect of larger detector resistance, which will reduce sharpness of tuning but, up to a certain point, will increase signal strength. In this simple coupled circuit of Fig. 2 the natural frequency of the antenna system is controlled almost exclusively by the tuning condenser and the primary coil A; the position of the second coil B does not greatly affect the resonant frequency unless the coupling is quite close. Changes in the coil A, however, do alter the coupling to the detector circuit, since as the inductance of A is reduced the strength of the magnetic field about it (which is what induces the secondary coil voltages applied to the detector) will ordinarily be weakened; and the secondary coil will need to be moved closer to the primary if the same

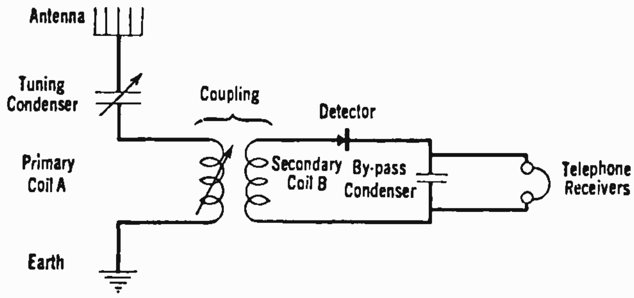


Fig. 2: The inductively coupled receiver with broadly-tuned secondary circuit

coupling is to be maintained. Probably the most convenient way to adjust the circuits natural frequency to resonance with an arriving radio wave is by using the tuning condenser shown, since the coupling is not appreciably changed by the variations of capacitance of this instrument. It is entirely feasible to use the arrangement of Fig. 2 with a non-adjustable primary coil, the tuning being then entirely dependent upon the variable condenser.

CONCERNING DETECTOR VOLTAGE

HOW will changing the detector voltage or coupling affect the practical operation of the two circuits shown? If the circuit of Fig. 1. is arranged so that with the tuning condenser at a mid-scale setting and each of the two inductors A and B at one half its maximum value, the natural frequency of the antenna agrees with the frequency of an arriving stream of radio waves, the receiver will have the capability of tuning considerably above or below this frequency. When such a stream of waves arrives, it will generate radio-frequency currents in the antenna-to-ground circuit. Corresponding voltage impulses at the points Y and Z will be impressed upon the detector; by its characteristic rectifying action the voltages which occur in one direction will produce a larger current through the detector circuit than will those in the opposite direction; thus a rectified or direct current will flow through the meter and cause a deflection of the indicating needle, the scale reading of course being larger as the applied voltage is increased. Let us suppose that with the inductance evenly divided between the two coils A and B and with the condenser scale at 90°, the receiver is tuned to 360 meters wavelength (833,000 cycles per second). Let us further assume that some near-by station is transmitting a constant, unmodulated (or unvarying) stream of waves at this resonant frequency, of such intensity as will cause the current meter to show a deflection of 50 milliamperes. If now the tuning condenser is altered to a scale reading of 100°, the natural frequency of the antenna will no longer be 833,000 cycles, but something less; the antenna current will no longer attain its resonant maximum, the detector voltage will fall, and the meter reading will drop off to, perhaps, 10 milliamperes of current. The same reduction of current may be secured if the tuning condenser is turned away from the resonant point in the opposite direction, say to 80° on the scale, since the natural frequency will then be higher than the frequency of the arriving wave.

WHY VARIABLE UNITS ARE VALUABLE

NOW suppose that instead of dividing the total inductance equally between coils A and B, we put one quarter of it in A and the remaining three quarters in coil B. Since the total inductance remains as before, the resonant setting of the condenser will again fall at 90°. However, we may expect to find that the increased resistance effect of the detector will decrease the antenna current so much that the meter reading even at resonance will be less than before, or, say, 40 milliamperes. Moreover, the sharpness of tuning will be decreased, so that when the condenser is moved off resonance to either 80° or 100° the current indicated by the meter will not fall so greatly but may remain as large as 25 milliamperes.

For the opposite case, in which coil A is given three quarters of the inductance and only one quarter placed in coil B, the resonant antenna current will be greater than before. The part of the total voltage applied to the detector may be less, however, so that the meter reading will reach only 45 milliamperes as a tuned maximum. Nevertheless, reduction of the resistance effect will sharpen the tuning very greatly, so that even if the condenser is moved only 5° on either side of the resonant point (i. e., to 85° or to 95°), the current reading may drop as low as only one or two milliamperes.

An entirely similar set of effects will be found with the arrangement of Fig. 2 The signals and tuning will both be bad if the coupling between primary and secondary is too close; loosening the coupling somewhat will improve both signal strength and sharpness of tuning; further separation of the coils will cause some weakening of signals but will allow still sharper tuning. The inductively coupled circuit in

Fig. 2 is a little more flexible in adjustment than the directly connected system of Fig. 1, and somewhat more free from interference produced by near-by stations. It is, however, usually considered harder to adjust for equivalent signal strength.

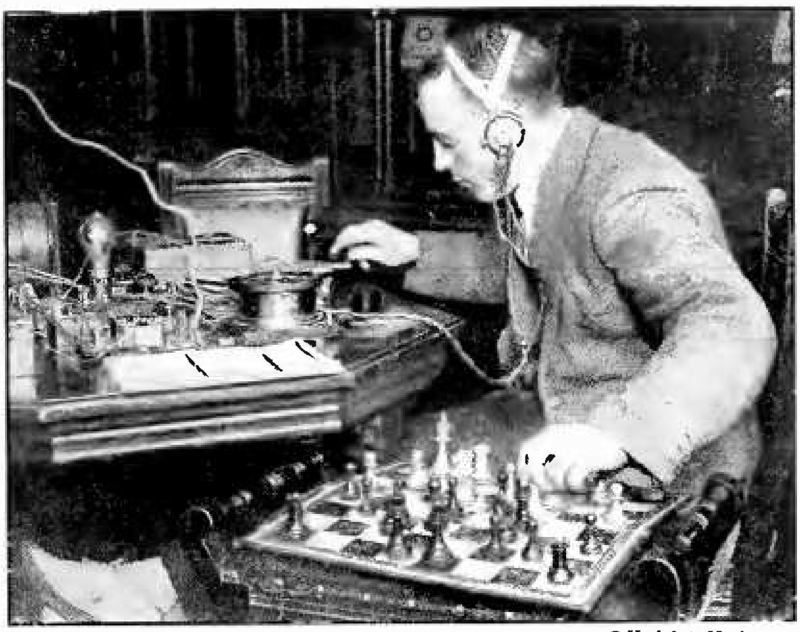
Progress of Radio in Foreign Lands

SEVERAL more or less common applications of the vacuum tube are described in a recent issue of the British periodical *Nature*, but the author, M. Joseph, tells of its use for the testing of hearing capacity, which is certainly an unusual application. In this connection the usual three-element vacuum tube is employed in a heterodyne circuit. This means that it is employed as an oscillator or generator of current of any frequency from one to several million alternations per second, while a second current, generated by another oscillator, is introduced so as to set up the well-known phenomenon of "beats" or pulses set up by the difference between the two rates of oscillation. The "beats" cause audible sounds in a telephone receiver connected with the oscillating circuit. This method is employed in the reception of continuous wave signals, the frequency of which is such that they are by themselves absolutely silent when intercepted with the usual receiving set. The heterodyne action, however, causes the "beat" effect to actuate the telephone receiver so that the signals can be heard. Now M. Joseph comes forward with the suggestion that this principle be applied to the testing of hearing capacity. Never before has there been such a simple and accurate device for determining the audibility range of the human ear. Ordinarily, the human ear responds to sounds the frequency of which does not exceed 3,000, although in certain instances some sounds of the frequency of 18,000 and even 30,000 and 40,000 have been heard. On the other hand, some ears are deaf to sounds of 500 cycles frequency, while others find it impossible to distinguish between different frequencies or notes, just as some eyes cannot distinguish between shades and even colors. The heterodyne device now enables us to produce the full range of sound frequencies accurately and simply and in any desired volume. Thus we have an extremely valuable method of testing human hearing capabilities.

GERMANY'S DISTRIBUTION OF RADIO NEWS

FROM long and systematic experiments the German Post Office has come to the conclusion that radio telephony is the simplest and cheapest means of distributing news from a central point. The Post Office administration has entered into an agreement with a news distributing agency for the circulation of market prices of stocks, prices of material, and so on, according to the *Elektrotechnische Zeitschrift*. Subscribers to the service pay 4,000 marks per annum to the Post Office for installation and maintenance and a subscription for the news service to the Press Agency. Reception of news service which is not subscribed for is partially prevented by changing the figures, which have to be decoded by the subscriber entitled to the particular service. The apparatus employed in Germany for the reception of the Post Office broadcasting service consists of a single-wire antenna. A loop antenna is not employed since it involves expensive amplifying devices. A single-tube receiving set is regularly supplied, but in special instances where the distance is greater than usual, a two-stage audio-frequency amplifier is also supplied. The filaments and the plate circuits are supplied with current taken from the ordinary electric light socket through suitable resistances. This is an interesting fact, in view of the Bureau of Standards experiments which have been under way for some time in Washington, D. C., and the report on which has been promised for some time past. This practice eliminates the troublesome storage battery and the expensive B battery of the usual vacuum tube apparatus. All the German apparatus is sealed in neat cases, but inspection windows are provided so that the condition of the vacuum tubes may be studied.

THE Imperial Wireless Telegraphy Committee of 1920, which is the British organization charged with Great Britain's world-wide radio plans, described the arc as "preeminent at the present moment among methods of long-range wireless transmission." Whether we agree with this conclusion or not, the fact remains that the Leafield station, the first station of the Imperial Chain, has now been equipped with Elwell-Poulsen arcs similar to those at Lyons, Rome, Nantes, and so on. Transmitting press messages at low power preparatory to the opening of the similar station in Egypt, Leafield's signals were regularly received in Australia, India, and other distant points, as well as by British shipping throughout the routes to America, South Africa, and Australia. Our British friends claim that arcs handle traffic with certainty and at low cost. Arcs are particularly suited for use in districts remote from the great industrial centres. Arcs are recommended by the Wireless Telegraphy Commission of 1921 for installation in East Africa, Hong Kong, and Singapore.



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Frank Walsh, an inventor of Brighton, England, playing a game of chess by radio with his brother who is in Paris

THE "ALL RED" RADIO AND WORLD COMMUNICATION

THE name "All Red" Radio no doubt suggests the Soviet rule of Russia, but as a matter of fact it is the name adopted for Great Britain's world-wide radio plan. According to a report to the Department of Commerce from Consul General Sammons of Melbourne, Australia, direct radio communication between Australia, Canada, and Great Britain, supplementing the "All Red" cable line of the Pacific Cable Board, is likely to be established within two years as a result of a contract just concluded between the Australian Government and the Amalgamated Wireless Company, Ltd. The main Australian station will probably be located in New South Wales. According to the Melbourne *Argus*, the power used will be about 3,000 kilowatts, and the combined cost of the central station and of a feeder station in each of the six states will be about £1,000,000. The plant for the central station will be manufactured in England, but those for the smaller stations will be made in Australia. The controlling interest in the Amalgamated Wireless is vested in the Commonwealth Government of Australia, and of the seven directors, the Government and the minority stockholders will each have three, the seventh being chosen by vote of the first six. An important clause is that prohibiting the Amalgamated Wireless from combining with any other commercial interest and requiring it to remain always "an independent British concern." The company is also to develop, manufacture, and sell radio apparatus and to furnish service to ships and aircraft. It has been made a party to the general agreement for the interchange of wireless patents entered into by the principal radio equipment companies of the world. New high power radio stations to communicate with Australia are planned for Great Britain and Canada. The proposed rates for radio service are about two-thirds of the present cable rates.

THE INTERNATIONAL WIRELESS CONFERENCE

COMPOSED of representatives of the Radio Corporation of America, Compagnie Generale de Telegraphie sans Fil, Gesellschaft fur Drahtlose Telegraphie m. b. h., and Marconi's Wireless Telegraph Company, the International Wireless Conference recently completed its deliberations. A number of important questions dealing with the development in different parts of the world of radio telegraph and telephone communication have been considered and satisfactorily settled. As a result of the agreement between the four companies, a number of new international radio telegraph services are to be opened in the early future. In order that commercial wireless telegraphy and telephony should be developed to the best advantage in the interests of the public and of international commerce, it has been decided that the companies should not erect any stations which would entail the harmful radiation outside an agreed radius of harmonics or secondary waves which are beyond the definite wave bands allotted to each particular station.

JOHN BULL CONSIDERS BROADCASTING

OUR British cousins have been casting inquisitive and even longing eyes across the big pond ever since they received word concerning our wonderful radiophone broadcasting activities, and now they are anxious to do a little broadcasting on their own account. And we do not blame them; they have been missing the fun long enough. At any rate, an English authority on radio, Mr. Kellaway, has given considerable study to broadcasting and has now formulated certain plans which tend to give the maximum service to the British public with the least interference to commercial and Government radio traffic. He would allow a limited number of radiophone broadcasting stations. The country would be divided roughly into areas centring upon London, Cardiff, Plymouth, Birmingham, Manchester, Newcastle, Glasgow or Edinburgh (or both), and Aberdeen, and one or more broadcasting stations would be allowed in each of those areas. Permission for those stations would only be granted to British firms who were *bona fide* manufacturers of radio equipment. If too many applications for broadcasting privileges were received, then he would ask the various firms to come together at the Post Office—this department has charge of communications in Great Britain, following the practice prevalent in European countries—so that an efficient service might be rendered, that there might be no danger of monopoly, and that each service should not be interfering with the efficient operation of the other. The stations would be limited to a power of 1½ kilowatts, and furnished with wavelengths which should not interfere with other services. The normal hours for broadcasting would be from 5 p. m. to 11 p. m., except on Sundays, when there would be no limit. There would be certain regulations in regard to the character and class of news which these agencies could transmit. And, most important of all, we might add, incidentally, that Mr. F. G. Kellaway, aside from being very well posted on radio matters, is Postmaster General of Great Britain.

THE LONG ARM OF SOVIET RUSSIA

PERHAPS Soviet Russia is decadent in transportation, industry, and other features of present-day life, but so far as communication is concerned, the mysterious republic, if it can be called such, is certainly quite up to date. It is reported from Moscow that the Council of People's Commissaries have granted a concession for telegraphic and radio communication between India and Europe. Communication will be through Russian territory, and there will be connection with Turkey, Egypt, Persia, and the Mediterranean countries.

GREAT BRITAIN'S WEATHER BROADCASTS

OWING to numerous requests from amateur users of radio receiving sets, according to the London *Electrician*, the two daily weather messages sent out from the Air Ministry are now being distributed or broadcasted at a slightly lower rate than previously. Investigation of the requests showed that a number of amateur radio users, situated in remote rural localities, are carefully picking up the Air Ministry weather forecasts, and are handing them on at once to neighboring farmers.

THE INAUGURATION OF THE ANGLO-EGYPTIAN SERVICE

SOME time ago the Anglo-Egyptian radio service, via the Imperial radio stations at Leafield and Cairo, was inaugurated. Telegrams are accepted at any post office in Great Britain for Egypt, Palestine, and Syria for transmission, and a corresponding service is available in the opposite direction. The rates of charge are 3d. a word less than the corresponding cable rates for full-rate traffic and 1½d. a word less than the corresponding cable rates for deferred traffic. Press messages may be sent to and from Egypt and Palestine at 2½d. and 3½d. a word respectively. Telegrams intended for transmission by this route should be marked "via wireless." In

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Paris has inaugurated the first wireless telephone police patrol. A radio outfit has been installed on a truck to keep in touch with headquarters while in pursuit of criminals

addition, arrangements have been made, pending the provision of further stations of the Imperial wireless chain, for telegrams addressed to places beyond Egypt, served by the system of the Eastern Telegraph Company, to be forwarded by wireless to Cairo and thence by the company's service to their destination at the normal through rates of charge.

CHINA'S RADIO TELEPHONE SERVICE

A RADIOPHONE service, claimed to be the longest span of its kind in the world open to public use, was inaugurated recently between Peking and Tientsin. The equipment was supplied by the China Electric Company and was manufactured exclusively by the International Western Electric Company of New York. The system as perfected in the Peking-Tientsin service insures transmission when connected with telephone central offices. The tests that were applied at the opening ceremony were entirely successful. The distances between Peking and Tientsin is 80 miles.

WHEN MEXICO REFUSED RADIO STATIONS

FROM good British sources it is learned that the Marconi Company has proposed to the Mexican Government a scheme whereby the company would control for fifty years all radio stations built or to be built on Mexican territory. After the expiration of the fifty years the radio stations would be turned over to the Government or the concession renewed. The Government is reported to regard the offer in its present form as unacceptable, but it is believed would be prepared to give it favorable consideration if modified. To which we ourselves can add, truthfully and unflinchingly, that fifty years is a long, long time in radio development. Perhaps that is the impression of the Mexican Government, too.

RADIO EQUIPMENT OF ATLANTIC LINERS

A RECENT issue of *Radioelectricité* contains a description of the radio equipment aboard the steamships *Paris* and *Lafayette* of the French Line. On both steamers a 5-kilowatt vacuum tube transmitter has been installed with a wave range of between 2,000 and 9,000 meters. A 5-kilowatt motor-generator set is employed to produce the plate high-tension current for four oscillating tubes, while the low-voltage current for the filaments of these tubes is obtained from the same machine. Both vessels are equipped with radio compasses or radiogoniometers. A distance of over 2,000 miles has been covered by the transmitter of the *Paris*.

THE RADIO STATION ON RUNDEMANDEN MOUNTAIN

THE radio station on the Rundemanden, a mountain towering 2,500 feet over the city of Bergen, Norway, is being modernized and equipped with more powerful equipment as well as radio telephone apparatus. As the new equipment has a radius of 1,800 miles, it is believed that direct communication with American radio stations will be possible under good conditions. Radio telephones with a 500-mile radius are also to be installed and communication established with England and continental Europe. These improvements, estimated to cost about $25,000, are to be completed by the time this is read. The work will be carried out for the A. S. Telefunken Com-

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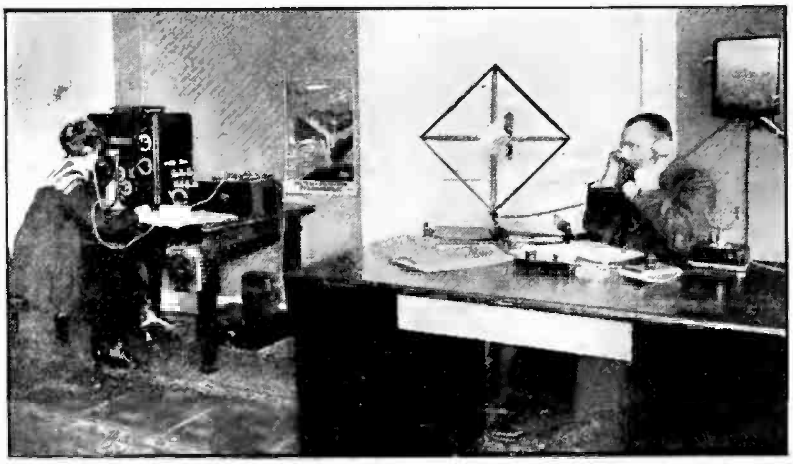
This is a receiving and transmitting station in the French police truck. Note that the operator is wearing an American made head set pany, a Norwegian corporation, by the German company, of that name.

AMATEUR STATIONS IN FRANCE

AN AMATEUR transmitter is such an unusual thing in France, because of the strict radio laws applying in that Republic, that considerable honor attaches to any amateur transmitter as is evident from the following notices, appearing in *La Nature:* "A certain number of transmitting stations of amateurs, intended for the study of radio and for experimental purposes, are operating at present, viz.: M. L. Deloy, at Nice—Call letters, 8AB, continuous wave at 525 meters; works every day at 21 to 22:30 hours. (In France the twenty-four hours of the day are not divided into two periods of twelve hours each, with the A. M. and P. M. designation. Instead, the day begins at midnight and continues for twenty-four hours until the following midnight. Therefore, 21st hour would be eight o'clock.) M. J. Roussel, at Juvisy-sur-Orge—Call letters 8AD, damped wave, 600-cycle alternator, at 200 to 400 meters. Works every evening except Saturday, at 20:30 hour (summer time), and Sunday at 15 hour. Transmitter employs tubes as definite installation . . . 8AE, experimental station in the district west of Paris . . . 8AH M. M. Coze, 8, rue Lalo, at Paris, station for experimental work, with irregular transmitting periods."



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Through an arrangement with Huth Funken Company, the Berlin stock exchange has installed radio in its office for supplementing the ticker. The operator on the left is transmitting reports. The man at the right is receiving reports by radio and forwarding them to an associate over an ordinary land line telephone

THE TRANSATLANTIC STATION AT EILVESE

ALTHOUGH not as well known as the Nauen station, the Eilvese station is by no means unknown to ambitious American amateurs who can receive its signals providing their sets tune up to extreme wavelengths and they make use of good amplifying equipment. The Eilvese station in Germany obtains its power supply from the Weser power station as three-phase, 15,000-volt current, and transforms it into 5,000 volts before it is rectified in a 600-horsepower motor-generator set consisting of one alternating-current motor and two direct-current dynamos, one for 220 volts and the other 440 volts. The 440-volt generator feeds the Goldschmidt high-frequency machines. To be assured of continuity of service there are also installed five Diesel oil engines of 200-horsepower each. For the regular telegraph service, 400 horsepower to 600 horsepower is needed. There are two aerials, one of the umbrella type for waves of 7,000 meters, to 12,000 meters and a ring type for longer waves. The main tower is 800 feet high, and the six smaller towers are 340 feet high. Six weights of 3,200 pounds each keep the wire network under proper tension mechanically. The receiving station is at Hager, three miles from Eilvese, and is connected to two 3-mile straight-line antennas, laid out and built like a double high-tension line on poles with disk-type insulators, with two wires 30 feet above the ground and two wires 60 feet above the ground, both lines on the same poles, one above the other. Eilvese works with the Goldschmidt station at Tuckerton, N. J.

INTERESTING FACTS ABOUT TELEPHONE RECEIVERS

THE telephone receiver, which is used in radio work to convert the oscillatory electric energy of the detecting circuit into acoustic vibrations or sound, has been studied by J. Brun of France, who tells of his findings in *Radioelectricité.* For the efficiency of conversion to be a maximum, states the author, it is advisable to make the diaphragm resonant to the pulse frequency of the receiving circuit. Under the best conditions, the transformation

of energy is accomplished with an efficiency of not more than $\frac{1}{700}$, owing to hysteresis and eddy currents. (These scientific terms apply to magnetic losses which occur in all electromagnetic devices). Telephone receivers used for radio purposes give an audible signal with a minimum current of from 1 to 10 thousandths of a micro-ampere at a frequency of 1,000 cycles per second. The relative sensitiveness of different types of telephone receivers is characterized practically by their ohmic resistance. In practice, however, it is not always advantageous to employ receivers of high resistance, according to this authority, since extreme sensitiveness is a defect if selectivity with signals of varying intensity and notes is desired. Efficiency in reception depends in part on the employment of telephones of resistance appropriate to the detector used. For the same amount of received energy, a crystal detector (average resistance 8,000 ohms) produces in the receiver a current of low intensity at a high voltage, while a magnetic detector (resistance 140 ohms) gives, on the contrary, a current of low voltage and of high intensity. In the case of high-resistance receivers, the best results will be obtained when working with crystal detectors or vacuum tubes, and with low-resistance receivers, the best results will be obtained with magnetic detectors and other low-resistance detectors. (The magnetic detector, which makes use of a soft iron core wire band, passing continuously through the magnetic field of a pair of permanent magnets and a winding connected with the telephone receivers, was employed several years ago in radio communication, prior to the introduction of crystal detectors and vacuum tubes which are simpler, yet more sensitive to signals.)

The Grid

QUESTIONS AND ANSWERS

The Grid is a Question and Answer Department maintained especially for the radio amateurs. Full answers will be given wherever possible. In answering questions, those of a like nature will be grouped together and answered by one article. Every effort will be made to keep the answers simple and direct, yet fully self-explanatory. Questions should be addressed to Editor, "The Grid," Radio Broadcast, Garden City, N. Y. The letter containing the questions should have the full name and address of the writer and also his station call letter, if he has one. Names, however, will not be published.

Variable Condensers

I have a 43-plate variable condenser and a receiver with two variometers. May the condenser be employed to advantage with this receiver?

—*M.M., Detroit, Mich.*

A 43-PLATE condenser of the commercial type ordinarily approaches .001 mfds capacity. A capacity as high as this is rather difficult to employ in short wave work, although it is very satisfactory for use in conjunction with long wave reception. However, where a large antenna is employed for short wave reception, a condenser of this character connected between the antenna and tuner or the tuner and the ground reduces the natural period of this circuit and permits the use of more turns in the antenna circuit. The increased number of turns in this circuit is frequently accompanied by a greater transfer of energy to the secondary tuning circuit resulting in louder signals.

A 43-plate condenser causes a material change in the wave lengths for a very slight change in the position of its plates and is, therefore, rather critical. As a general rule any well-made variable condenser in the antenna circuit permits more selective tuning and better all-around results, though it is sometimes accompanied by a slight reduction in signal strength where a small antennna is used.

Is it possible to secure better results by using a variable grid condenser and what size should such a condenser be? Should a grid leak be employed with it? If so, what resistance should it be?

—*D.B., Trenton, N. J.*

AS A general rule variable units in all radio circuits aid in obtaining better results because they afford a ready means for bringing the circuits into the most suitable balance; that is, for a given frequency or wave length best results may be obtained by employing a certain amount of inductance and capacity. Changing the inductance or the capacity may result in bringing the circuit in tune with a given wave length but its power of selection as well as its energy-absorbing values are found to exist in the greatest degree when a suitable balance of inductance and capacity is found. A variable grid condenser helps to make this balance possible in the grid circuit and it offers a convenient method for making up the differences found to exist in

Radio brings it MAGNAVOX tells it

TO make your receiving set really complete, equip it with a Magnavox Radio—the Reproducer Supreme.

The electrodynamic principle involved in its construction, makes the Magnavox Radio a most efficient converter of electrical energy into sound waves.

With either type Magnavox Radio the hook-up is as simple as connecting the ordinary head receivers.

R-2—Magnavox Radio with 18-inch horn, for those who wish the utmost in amplifying power: for large audiences, dance halls, etc.

R-3—Magnavox Radio with 14-inch horn, ideal for homes, amateur stations, offices, etc.

Model C—Magnavox Power Amplifier insures largest possible power input for Magnavox Radio.

Any radio dealer will demonstrate the Magnavox for you.

The Magnavox Co.
Oakland, California
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MAGNAVOX
Radio
The Reproducer Supreme

vacuum tubes. In the same circuit one vacuum tube may require a very small grid capacity for its best operation while another tube may require comparatively more capacity. With a variable grid condenser the most suitable capacity may be had instantly. The same thing applies to a given circuit and a given tube receiving from several stations. A variable grid condenser aids materially in building up desired signals and eliminating undesired signals. A variable grid condenser should be of comparatively low capacity; that is, it should have a maximum of approximately .0006 mfds.

It is rather difficult to determine without actual experiment whether or not a grid leak is required in a given circuit or with a given tube. Vacuum tubes vary greatly and the function of the grid leak is to keep a constant potential on the grid of the vacuum tube in order that the electronic flow may be thoroughly controlled. Some vacuum tubes operate most satisfactorily without a grid leak. It is also significant that a tube of this character employed in one circuit would give results without the grid leak, while in another circuit, the grid leak would have to be used in order to obtain the best results. The resistance value of a grid leak is also a matter of experiment. As a general rule a grid leak resistance of 2 megohms will suffice. It is generally a safe practice to employ a grid condenser and grid leak unit of the character now on the market having a capacity of .0005 mfds and a resistance of 2 megohms.

Lightning Protection

Do I need to install a ground switch for lightning protection? I am using a crystal receiving set.

—*N.M., Topeka, Kansas.*

What size wire must I use for grounding my receiver? Does the installation of the receiving set cut off the insurance on my home?

—*K.P., New York City.*

My receiving set is on the tenth floor of a city apartment. Is it necessary for me to run a heavy copper wire to an outside ground connection keeping the wire seven inches from the building wall?

—*J.D., Brooklyn, N. Y.*

UNTIL a very short time ago, the National Board of Fire Underwriters required all radio stations to be fitted with a heavy current carrying ground switch. This rule has been materially changed in the case of receiving apparatus and it is now only necessary for a receiving station to employ a suitable lightning protective device which has been passed by the Board of Fire Underwriters.

According to the new Fire Underwriters' regulations recently proposed receiving sets may be grounded by any copper wire not smaller than No. 14 B & S gauge. The installation of a radio receiving set, when the provisions of the National Board of Fire Underwriters have been lived up to, should not interfere in any way with the insurance on a house. The regulations are quite easily lived up to and if you entertain any doubt as to the wiring of your receiver, it might be well to have the installation passed on by some representative of the Board. It is possible, however, that such a representative might not be informed of the recent alterations in the code of regulations and it may be necessary for you to communicate with the headquarters of the underwriters' organization. The new regulations make it unnecessary for any one installing a receiving set to employ a heavy lightning switch and heavy wire running to the outside ground connection separated from the building by insulators several inches long. It is now merely necessary for you to employ an approved lightning protective device connected to some permanently grounded metal system in the house or apartment, by a No. 14, or larger, B & S gauge copper wire.

By a permanently grounded system is meant the steel frame of the building; the pipes of the water supply system pipes of a steam or hot heating system, but *not the gas pipes*. Where a connection is made to the grounded metal system, the copper wire should be attached by soldering or by an approved ground clamp after the building frame or piping has been thoroughly scraped with a coarse file or sandpaper.

Lamp-Socket Antennas

There are several devices on the market for use in a lamp socket to replace the outside antenna. Will they really work or are they fakes?

—*F.S., Long Branch, N. J.*

THE devices you refer to have been rather thoroughly tried out and in most instances have proven almost as satisfactory as the average outdoor antenna. These devices are designed to cut out the noise in the telephone receivers which would be caused by low-frequency electric charges such as exist in electric light wires, while permitting the high-frequency radio charges to pass through; they are actually filters.

Where the electric light wires are run under ground the results obtained are not as good as where these wires are carried on poles such as is the case in the country. Devices of this character made by reputable manufacturers should give satisfaction, but it is quite possible that the demand for them will be so great that many irresponsible makers will exploit these machines shortly. This is likely to be disastrous to many receiving sets.

The device includes a condenser made in a similar manner to most other condensers where metallic plates are separated by some insulating substance such as mica, but of different capacity. Where these units are employed there is no ready means of determining which side of the lamp socket in the house is connected to the line side and which is connected to the ground side of the electric light circuit. Where a connection is made to the ground side of the lighting system, no danger exists. However, if the device is connected to the line side of the electric light circuit and for any reason the plates of the opposite sides of the condenser should come in contact with each other or the insulation between them should break down, it would be possible for a short circuit to take place, because the line wire would then be connected through the device and your receiving set to the ground. In all likelihood this would blow out the fuse in the lighting circuit but, before the fuse was blown, it is almost certain that some of the wire on your receiving set would be pretty badly burned up. For this reason care should be used in determining upon the purchase of this device, and manufacturers should subject these units to a severe test before offering them for sale, in fact, they should be passed upon by the National Board of Fire Underwriters.

Radio and Audio Amplification

What is the difference between radio and audio frequency amplification? Can the former be used with a loud speaker?

"Stop those back fence concerts"

THE yowls of a prowling Tommy are as mere love-songs beside the ear-splitting howls of a perturbed radio set (and you'll be surprised how often one gets perturbed without the calming influence of the proper Amplifying Transformer).

Most any transformer can amplify sound, but it will also amplify the stray fields which produce howling and distortion. It takes the Acme Amplifying Transformer with its specially constructed iron core and coil to put an end to the "back-fence" concerts. Only when you add the Acme do you get the realistic tone and volume so markedly absent in the ordinary radio receiving set.

The Acme Radio Frequency Transformer greatly increases the range of any receiving set, either vacuum tube or crystal detector type. The Acme Audio Frequency Transformer produces not only volume, but reality of tone. It is indispensable to the satisfactory operation of loud speaking devices. The combination of one or more stages of Acme Radio and Audio Frequency Transformers assures the maximum of range, of volume and of reality in tone.

The Acme Apparatus Company, pioneer radio engineers and manufacturers have perfected not only Radio and Audio Frequency Transformers as well as other receiver units and sets, but are recognized as the foremost manufacturers of Transmitting Apparatus for Amateur purposes. Sold only at the best radio stores. The Acme Apparatus Company, Cambridge, Mass., U. S. A. New York Sales Office, 1270 Broadway.

Type A-2 Acme Amplifying Transformer
Price $5 (East of Rocky Mts.)

ACME

for amplification

Must different transformers be employed for various wave lengths?

—*J.B.W., Oakland, California.*

THE essential difference between radio and audio frequency amplification is this: With radio frequency, the very slight current produced in the receiving antenna system by passing waves from a transmitting system are caught and passed through amplifying devices designed to permit this current to oscillate—that is, to flow back and forth at the same frequency it passes through the ether. With audio frequency the current from the detector tube is passed through successive amplifying stages, not at the natural frequency of the signal as it passes through the ether, but at a frequency very much lower, which is within the range of audibility. In the case of radio frequency amplification, the incoming signals are amplified by means of a local source of energy before they reach the detector tube, while audio frequency amplification takes place after detection.

Detection requires a certain amount of energy for its proper functioning and it is obvious that several stages of audio frequency amplification would be valueless where the strength of the incoming signal was insufficient to produce detection. It is here that radio frequency is valuable for it builds up the infinitely weak signal to a point where proper detection may take place, and from this point on it is possible to increase the signal audibility by the audio frequency amplification method.

Radio frequency amplification alone will not operate a loud speaker over any material distance. In fact, the general rule may be laid down that loud speakers may only be employed where at least one or two stages of audio frequency amplification are employed. Radio frequency amplification has not been very popular in amateur circles until recently for the reason that different transformers were required for the various wave length ranges and the range of any one transformer usually covered but a few hundred meters. This difficulty has been materially reduced by the introduction of a new radio frequency transformer designed to function satisfactorily over a particularly broad range of wave lengths. This broad range is made possible by taking advantage of the balancing effect found to exist when an iron core radio frequency transformer is employed. A transformer of this character having a wave length range of 200-5,000 meters may now be had and another transformer having a range of 5,000-25,000 may also be procured. For all practical purposes, the wave length ranges covered by these two transformers permit the operator to receive on practically all of the wave lengths now in use.

A very significant fact regarding radio frequency amplifiers is that the results obtained by a single stage of radio frequency amplification and a vacuum tube detector non-regenerative circuit are approximately the same as those obtained by a vacuum tube detector alone, employed in a regenerative circuit of proper design.

Will you please furnish me with a suitable circuit diagram for employing radio frequency amplification with a regenerative receiver and two steps of audio frequency amplification?

—*O. H., Brooklyn, N. Y.*

THE accompanying diagram illustrates a suitable method for employing radio frequency with a regenerative receiver and two stages of audio frequency amplification. As will be observed, a tuning coil and variable condenser are connected in series with the aerial and ground. An energy-absorbing circuit is thus formed, which feeds into the first radio-frequency amplifier tube. The second tube also acts as a radio-frequency amplifier and its transformer is of the tuned variety made by shunting a variable condenser across what would ordinarily be the antenna and ground connections of a vario-coupler or loose coupler, for the primary and the usual secondary circuit for the tuned secondary.

Two potentiometers are used in this circuit; one to supply the correct plate potential for the detector tube and the other as a stabilizer for the radio-frequency amplifier tube. The transformer between the first and second stages of radio frequency is of the laminated iron core type having a wavelength range of 200 to 5,000 meters. When audio frequency is not desired, it is merely necessary to connect the telephones between the variometer in the plate circuit and the negative side of the "A" battery.