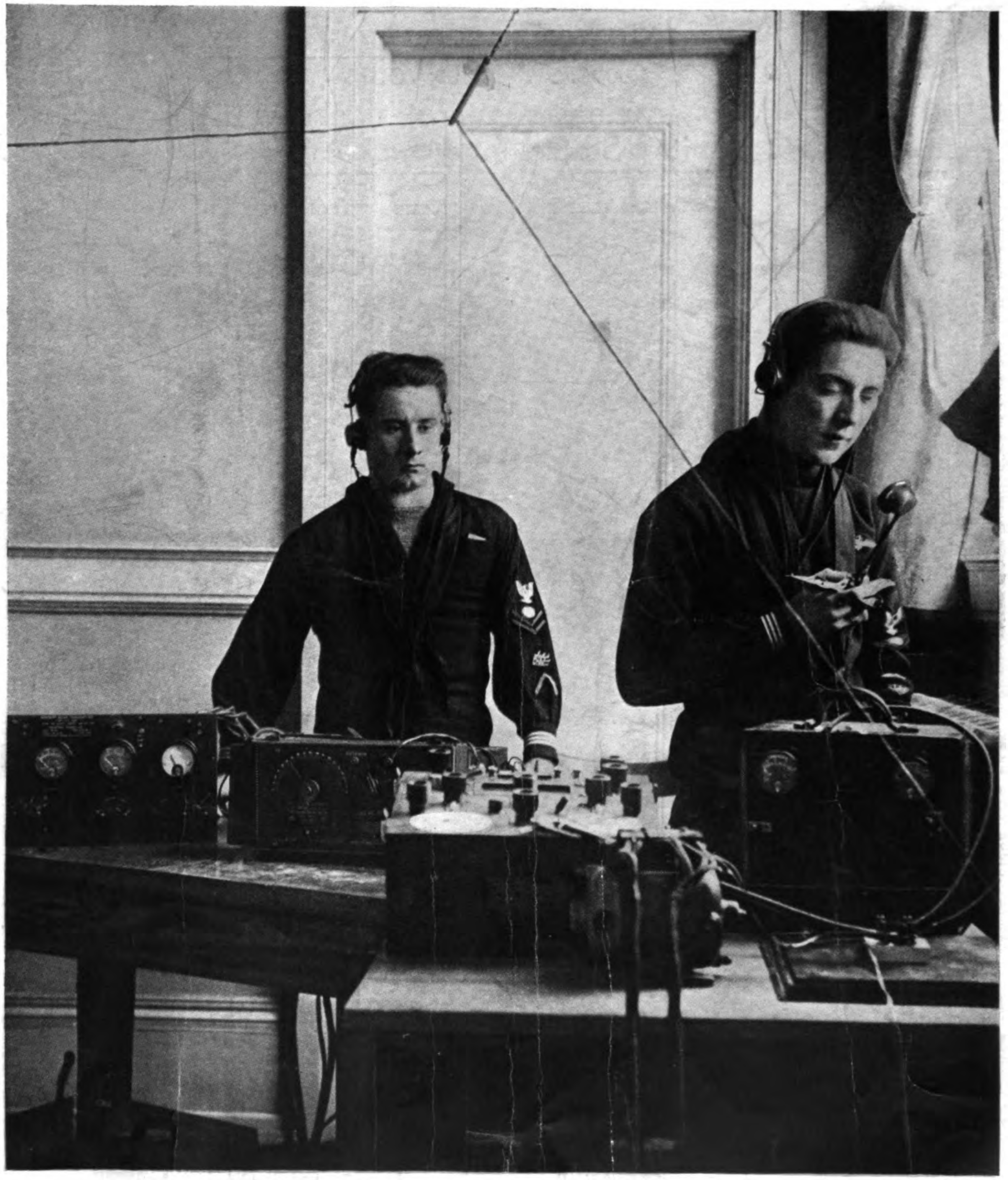
March, 1919

20 Cents

The WIRELESS AGE

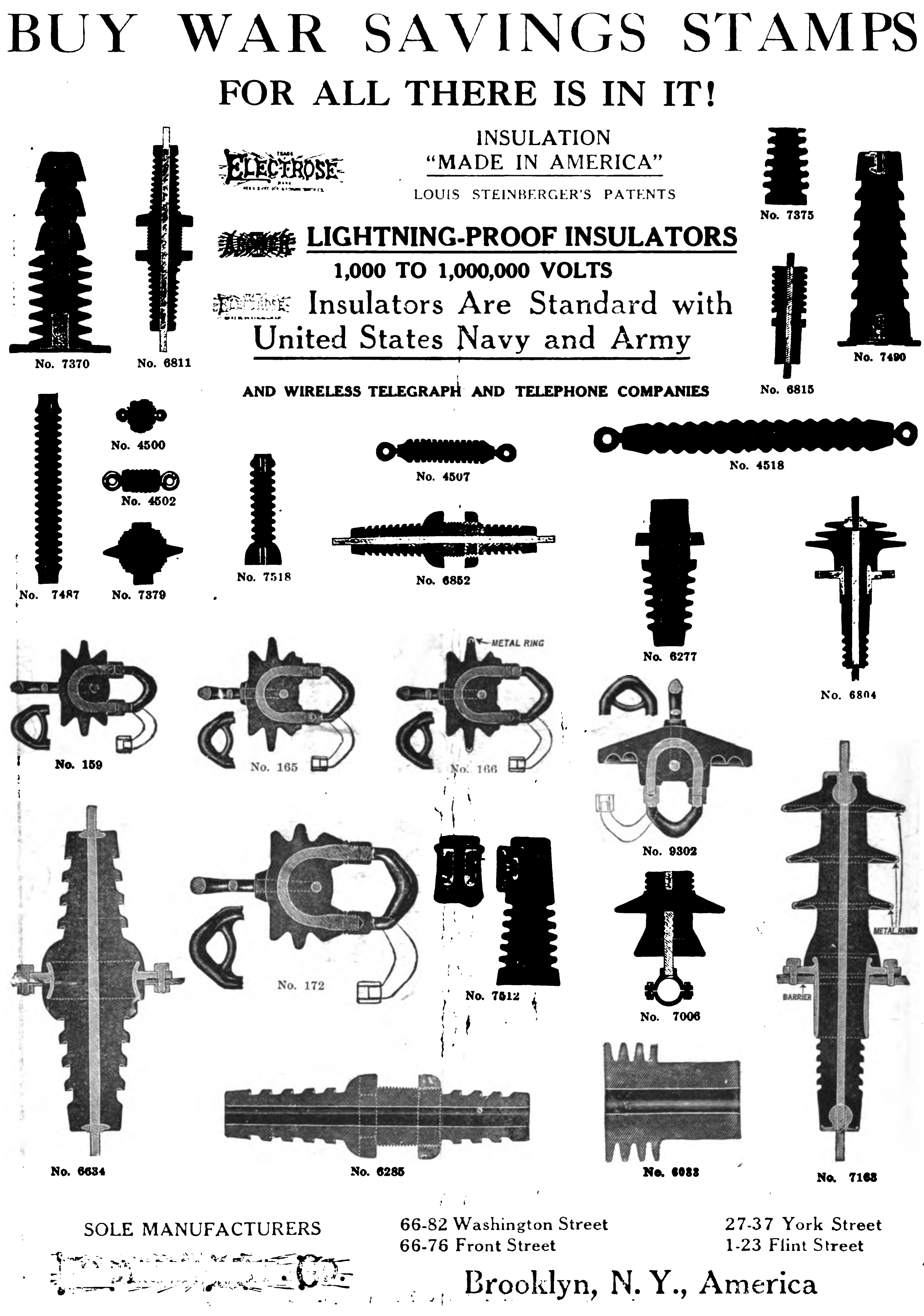
Volume 6

Number 6



Directing Aircraft By Wireless Telephone

Views For and Against Government Ownership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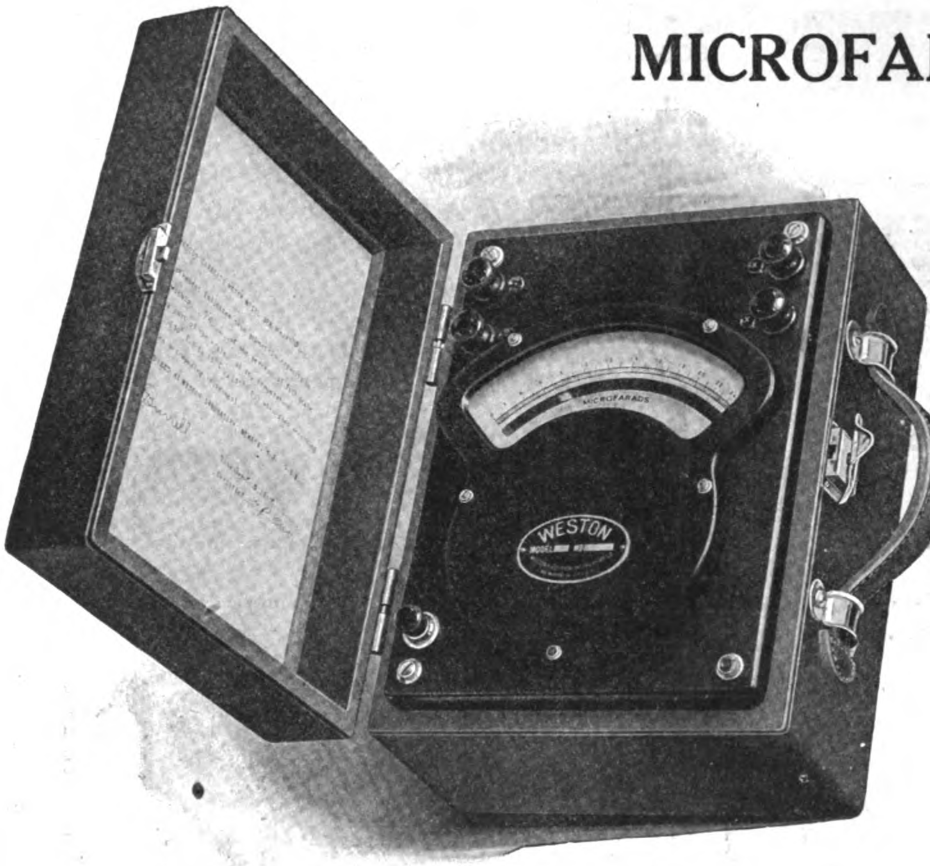
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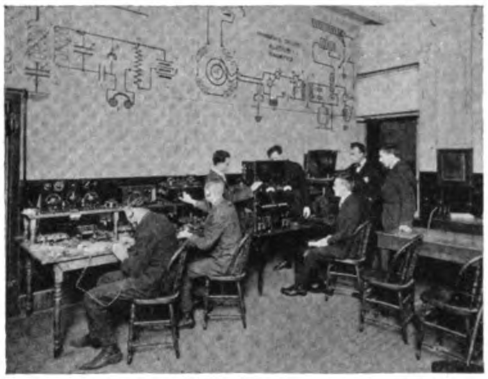
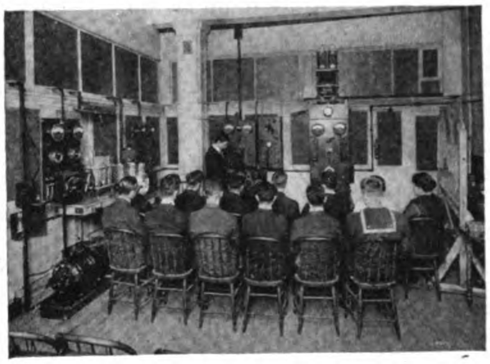
Code Instruction



Practical laboratory experimenting



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The Wireless Age

Edited by J. ANDREW WHITE
E. E. BUCHER, Technical Editor

Vol. 6 — Contents for March, 1919 — No. 6

Index of Equipment

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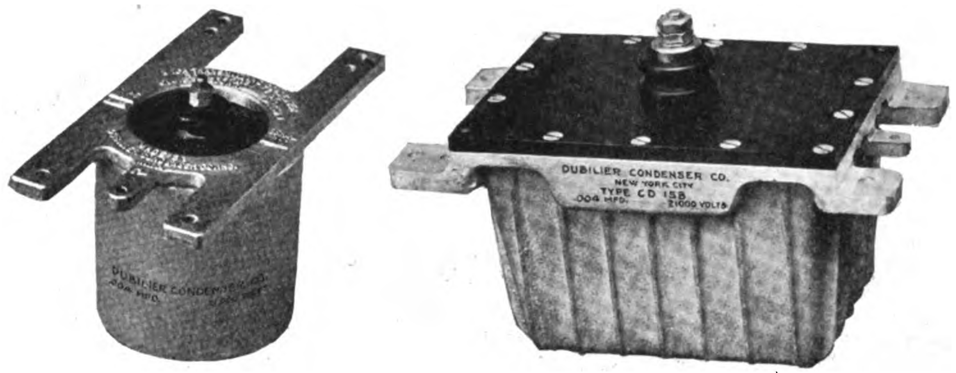

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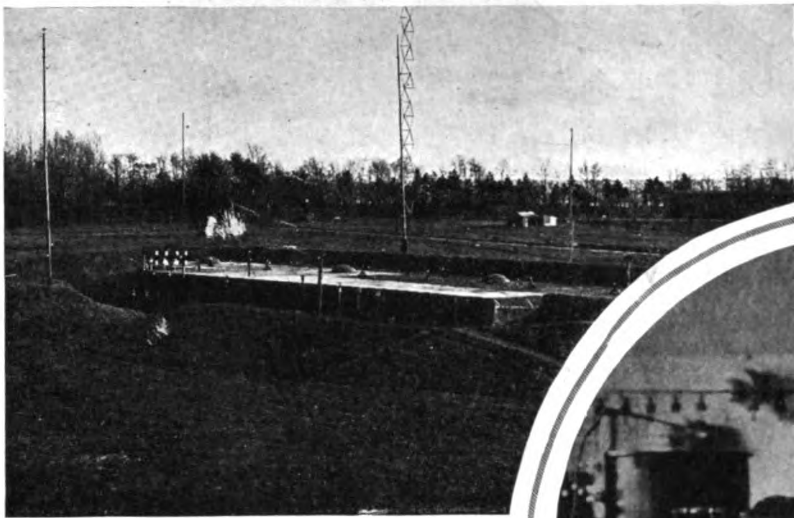
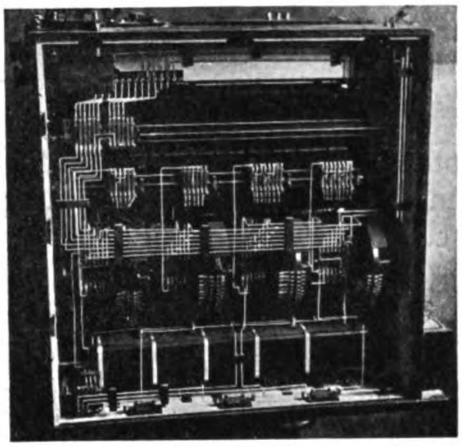


French Official Photos

Metz

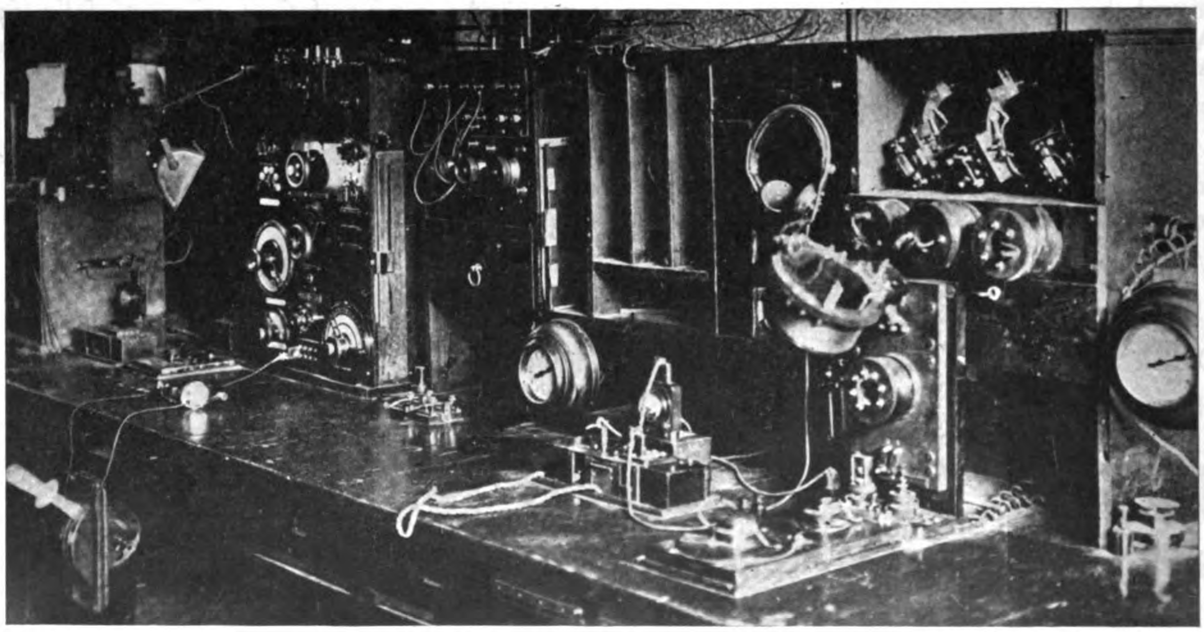
Taken from the Hun

To the left, a general view of the powerful wireless station maintained underground at the stronghold at Metz, delivered to the Allies under the armistice terms



Above, in circle, the transmitting apparatus which was hooked up to the antenna on the 85-meter tower shown in the upper view

To the left, the receiving tuner with the front cover removed, revealing the elaborate mechanism for changing to the numerous wave lengths used for secrecy in transmission



The operating table with a typically German multiplicity of tuning appliances

Vol. 6. No. 6. March, 1919

THE WIRELESS AGE

WORLD WIDE WIRELESS

Blimp Flying Over N. Y. Directed by Wireless Phone

A DEMONSTRATION in directing aircraft by radio telephone was given on January 17th from the roof of the Equitable Building, New York. It was arranged by the navy as a feature of the opening of the $2,000,000,000 War Savings Stamp campaign. The radio communication was between a group of men on the roof of the Equitable Building and Navy Dirigible A242, escorted by a formation of airplanes from the Rockaway Station. The airship, commanded by Ensign John Benridge, cruised over the city for about half an hour, following the directions given by wireless telephone. The weather was thick and the machines appeared at an altitude of about 1,000 feet.

James S. Alexander, President of the National Bank of Commerce, was the first of the civilians present to communicate with the airship. He got into touch with Ensign Bark, the radio man on the dirigible, after the navy operators had made the necessary adjustments. At that time the weather was so thick that the aircraft could not be seen. Mr. Alexander inquired when they would come into sight, and almost while he was talking the formation came through the mist.

"You will circle about the Woolworth Building," directed Mr. Alexander. The Blimp almost immediately changed her course, and headed to execute the order. This accomplished it carried out other spoken orders from the group on the housetop. Mr. Alexander said Ensign Bark's brief replies had been quite distinct. He had requested the Ensign to speak slowly and distinctly, and when this was done he heard every word clearly.

Others who conversed with the operator on the airship as it circled over the lower part of the city were George T. Wilson, Major General Thomas H. Barry, Major General Davis C. Shanks, Guy Emerson, Vernon Munroe and A. M. Anderson.

New Stations for Mexico and Nicaragua

A DAILY NEWSPAPER of Managua states that a Mexican gunboat is soon expected to arrive at Corinto with material for the installation of a wireless telegraph station presented by the Government of Mexico to that of Nicaragua. The wireless station is to be of the same power as the one given by the Government of Mexico to the Government of Salvador. The same vessel will also bring the Charge d'Affaires of the Mexican Government, near the Government of Nicaragua. With the members of the Mexican legation in Nicaragua is a detachment of Mexican marines who will accompany the party into the interior for the purpose of presenting to the President the wireless station referred to.

It is further stated that in Mexico a wireless telegraph station was recently established at Pungarabato, State of Guerrero, powerful enough to communicate with the stations at Chapultepec, Acapulco, and other distant points of the Republic.

British Marconi Company Declares Dividends

THE directors of Marconi's Wireless Telegraph Co., Ltd. (British corporation) have decided to pay a dividend of 7 per cent, less income tax, on the preference shares and a dividend of 5 per cent, less income tax, on the ordinary shares, both dividends on account of the year ended December 31 last.

Photo Paul Thompson

Radio telephone test in New York consisting of the direction of aircraft, conducted by Major General D. C. Shanks and General Thomas Barry

Navy Protests Tuckerton Tax Value

THE United States Navy, which has control of the Tuckerton Radio Station, has appealed from the assessment of $400,000 on the property, fixed by the County Board of Taxation, and has asked its reduction to $225,000. The board has granted naval officers time to file an inventory.

The station was built by a German company in which the Kaiser was said to be a heavy stockholder. It was subsidized by the German government and exploited at the time as having cost two millions. Conservative investigators concluded that the two millions were marks, which would make the cost $500,000.

The station was seized by the United States in the summer of 1916, and has since been in charge of the Navy Department and is guarded by 500 marines.

Shipping Growth Requires Call Letter Expansion

A CURIOUS illustration of the fact that growth of the American merchant fleet is greater than experts believed would be possible is afforded by inadequacy of the radio call code. The allotment of alphabetical call letters has been upset by additions made to American shipping. To the United States were assigned combinations from KDA to KZZ, all beginning with N and all beginning with W.

The American merchant marine has reached such proportion that supply of calls alloted to the United States has been exhausted, and many four letter calls have been adopted as a makeshift. A commission on interallied radio communication will meet in Paris to consider revisions of the code and other important post-war problems.

The powers of this commission will be limited to recommendations. Radio reform can be accomplished only by a more representative body, the International Radiotelegraphic Conference, which should have met in Washington in 1916, but was prevented by the war.

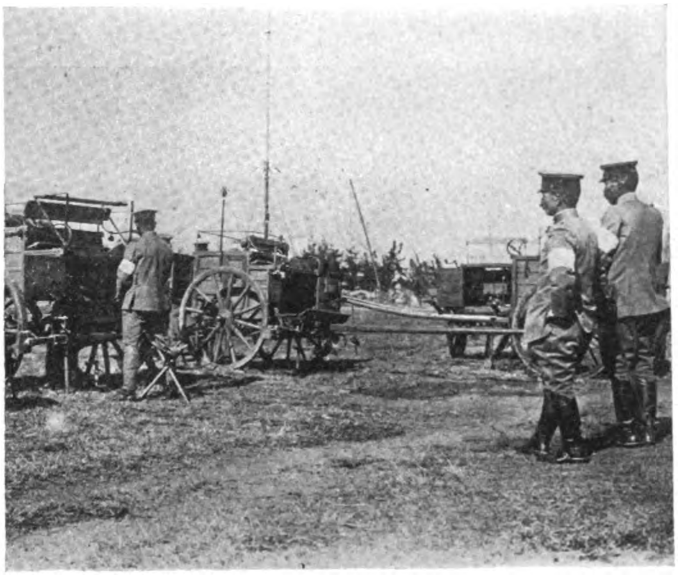


Photo Press Ils. Svce.
Japanese wireless station of the field cart type which shows the similarity with U. S. Army equipments

Distress Call Wirelessed When Fire Puts Out Beacon

A RECENT fire partially destroyed Execution Lighthouse and burned its machinery, leaving the station without power to flash its signal and operate its foghorn. The lighthouse is located between New Rochelle and Sands Point, N. Y., and with the Sound shrouded at night in a heavy fog, several naval craft were sent to patrol in the vicinity and warn vessels of dangerous rocks.

A wireless calling for aid was sent out by Peter Forget, keeper of the lighthouse. It was picked up at Police Headquarters in New York City, and a fireboat was immediately despatched to Forget's assistance. The Navy Department also sent vessels, and four launches filled with soldiers put out from Fort Slocum.

The fire started in a wooden shed and quickly spread to the generating plant. Because of the fog the blaze was not seen from the shore until it was at its height.

It will take several days to install new machinery, and in the meantime the naval craft will remain off Execution Rocks.

New Commercial Wireless Service for Airplanes

FURTHER details of the scheme for supplying Marconi service to airplanes, announced in the February issue, are now at hand. From London, word has been received that Godfrey Isaacs, managing director of Marconi's Wireless Telegraph Co., Ltd., has made public some of the arrangements made in connection with a new organization for the development of air service for passengers, mails, parcels post, and parcels delivery for even larger goods.

The service will commence in the United Kingdom and the Continent, but will later develop to all parts of the world. A measure of safety is going to play an important part in the rapidity with which the services are developed, and it must be apparent that safety will be increased by the assistance of wireless and a thorough and complete organization for its effective use.

The company will be prepared to supply every airplane with a combined wireless and telegraph installation, and to supply with it an efficient and thoroughly qualified operator, adopting the same system as is in force with regard to ships—namely, keeping the apparatus up-to-date, maintaining it in perfect working condition, and supplying the operator at a combined charge rate per annum.

They will issue charts giving the exact position of a number of their stations in all parts of the world, and these will be furnished with direction-finders, which will show to the operator the exact position of the airplane wherever it may be. There will also be charts issued dividing the air into zones, each of which will be numbered. They will at given periods send out air reports and in return will receive air reports. Record charts will be issued from time to time showing these reports, which will serve as comparisons of disturbances in the air, and will furnish valuable information for the guidance of pilots.

Russian Station Connects with France

OMSK, in which are centered the hopes for the rebuilding of a new Russia, after months of isolation, is now actively in wireless communication with the outside world. Hourly reports, containing a complete news service, are received in Omsk direct from the French wireless station at Lyons, France. Outgoing communication will be inaugurated soon.

The wireless tower which dominates the city is the result of the enterprise of M. Nettenent, a Frenchman, formerly consul in New York. In company with a wireless expert and a number of compatriots Nettenent brought the material on a perilous journey from Archangel across the Kara (Black) Sea to the Gulf of Obi. The material was then brought down the Obi and Irtish rivers to Omsk.

From Omsk to Lyons is 3,000 miles on a direct air line over Bolshevik Russia and Central Europe. Omsk is about midway between the Atlantic and Pacific oceans.

German High-Power Station for Dutch

DETAILS of the giant wireless telegraph station to be erected in Holland by German interests for the purpose of facilitating communication between Holland and her East Indian possessions, according to a contract concluded September 23 between the Dutch government and the Telefunken Company of Berlin, are found in a recent issue of Commerce Reports.

Paul L. Edwards, Commercial Attaché at The Hague, reports that the receiving station of the new plant, which is expected to cost about $2,000,000, will be at Boxmeer, in the Province of North Brabant, and the sending station will be located on a hill at Kootwijk, Province of Gelderland, near Apeldoorn, some thirty-five miles from the receiving station. The sending station will consist of six steel towers, each 210 meters (about 688 feet) in height. The Radio-Nieuws says that the Kootwijk sending station will have the same reach as the German station at Nauen. The installation will be able easily to transmit to and receive from a station of like dimensions and capacity which is shortly to be built at Bandoeng, Java. The distance between the Kootwijk and the Bandoeng station is about 6,830 miles.

It is understood that an engineer representing the Telefunken Company is in Java with a view to supervising the construction of the station at Bandoeng. De Nieuwe Courant said some time ago that all of the apparatus and raw material for the construction of the Bandoeng station were in Berlin ready for shipment at the first opportunity. The apparatus for the station in the Netherlands is not yet completed, but parts are already said to be arriving from Germany.

Standardization of Wireless Before Interallied Conference

IMPORTANT problems involved in the standardization and maintenance of radio communication the world over will be taken by the provisional interallied communication conference which convened in Paris January 25. Under the shadow of the greater peace conference this organization will take up a series of questions relating to radio communication between the allied powers.

The United States Navy representatives are Admiral W. H. G. Bullard, formerly director of naval communications; Captain D. W. Todd, present director of naval communications; Commander M. F. Draemel, in charge of the code and signal section of the naval communication service; Lieutenant Commander E. G. Blakeslee, communication officer on the staff of Admiral Sims; Lieutenant Commander H. P. Le Clair, formerly head of the radio division of the Bureau of Steam Engineering, now radio material officer on the staff of Admiral Sims, and Lieutenant T. A. M. Craven, of the office of the director of naval communications. In the absence of Captain Todd, Commander E. B. Woodworth is acting as director of naval communications.

At this conference all of the allied governments are to be represented and questions of the utmost importance will be discussed concerning the wave lengths to be employed by high-power radio stations, automatic transmission and reception of radio messages at high speed, the call letters to be used for radio communications, the relation of high-power radio telegraphy to the cable situation, and various other matters concerning the transmission of intelligence between the allied countries.

Its primary purpose is to standardize radio communication, and to facilitate the exchange of views relative to the advancement of the art of radio communication for the purpose of insuring the safety of vessels at sea and of serving the needs of commerce in general.

It is possible that the commission may make recommendations to the next International Radiotelegraphic Conference, a meetng of which was called for in Washington in 1916 but was postponed on account of the war. This is a larger body than the provisional interallied communication commission, as it is composed of delegates of virtually all the countries of the world.

Beatty Used Wireless Instead of Guns

THE following are three wireless messages typical of those that Admiral Beatty has been sending across the seas to Kiel these last few days, according to the London Daily Mail.

"Request you will report on sinking of U-93, as same appeared avoidable."

"Torpedoes you failed to send with latest convoy of submarines you will forward by next transport."

"You will stop using your wireless till further orders."

Few who were up with the Grand Fleet for the recent surrender have returned without reverence for the whole attitude and bearing of the British Commander in Chief.

Deprived of his Trafalgar, Beatty has been sending wireless broadside after broadside into the Huns. Said a commander at Rosyth, "They are eating the dirt thrown them by Beatty."

Daniels Acknowledges World's Debt to Marconi

THE part Italy played in the war was warmly praised by Josephus Daniels, Secretary of the Navy; Charles E. Hughes, and Major Fiorello La Guardia, U. S. A., at a meeting held January 26 at the Metropolitan Opera House, New York, under the auspices of the Italy-America Society.

Secretary Daniels said in part:

"I wish today to express the obligations which this republic, which the people of every nation, feel particularly to the naval constructors of Italy, for the contributions they have made which have revolutionized naval warfare.

Photo Intern'l

Speculation on communication with Mars and the successful installation of wireless service between England and Australia by Marconi has again attracted world-wide attention to him

"Nor do we forget the debt the world owes to Marconi, who caused the electric spark to leap at the bidding of man and not to be tied to the cable, so that men on ships speak to each other not hundreds of miles apart, but thousands, and space, so far as communication between man and man is concerned, has been annihilated."

Inter-Stellar Wireless a Possibility to Marconi

IN an interview which Harold Begbie, a representative of the London Chronicle, had with him, Marconi discussed the possibility of communicating by wireless "with the stars"—that is, bodies in our own or other solar systems on which there are intelligences.

When asked if he thought the waves of ether were eternal, Mr. Marconi replied: "Yes, I do. Messages that I sent off ten years ago have not yet reached some of the nearest stars. When they arrive there, why should they stop? It is like an attempt to express one-third as a decimal fraction; you can go on forever without coming to any sign of an end. That is what makes me hope for a very big thing in the future." (Communication with intelligence of other celestial bodies.) "It may some day be possible, and as many of the planets are much older than ours the beings who live there ought to have information for us of enormous value. It is silly to say that other planets are uninhabited because they have no atmosphere or are so hot or are so different from the earth. If there were no fish in the sea we should say life there is impossible, and so it is impossible for man." When the interviewer objected that the language difficulty seemed to present an obstacle impossible to surmount, Mr. Marconi replied: "Well, it is an obstacle, but I don't think it is insurmountable. You see, one might get through some such message as 2 plus 2 equals 4, and go on repeating it until an answer came back signifying 'Yes,' which would be one word. Mathematics must be the same throughout the physical universe. By sticking to mathematics over a number of years one might come to speech. It is certainly possible." Mr. Marconi stopped speaking for a moment, and then, as if the matter was something so uncertain that he did not feel it worthy of more than passing mention, said he had often received strong signals out of the ether which seemed to come from some place outside the earth and which might conceivably have proceeded from the stars.

Wireless Stages the World Drama

WHAT appears to be inside "dope" on the radio communication incidents that dramatized the receipt of the news of Germany's surrender is contained in a description from Guy Hickok, of the Eagle Bureau, Paris. He writes:

"A group of lads in olive drab sat in an American wireless receiving station not far from Paris.

"It was a long evening in the early part of last November. The man with the headpiece pinching his ears was thinking of the old days when baseball scores used to click into his little wireless house on board a big fruit-carrying ship. He listened absently to the calls ripping the atmosphere with code that he didn't understand. He had to listen, for no one knew when there might come whispering out of the sky a message that he could understand, a message that he was stationed there for the sole purpose of receiving.

"Suddenly the zip-zip-zipzip of the receiver ceased being a meaningless succession of whispers without sense. It dropped from code to simple speech. It—he listened for awhile—it was incredible. He turned to the others, his face contorted with the effort to believe the unbelievable.

"'Good—! Good-God! It's Germany talking to Foch!' he cried in a strained voice.

"A small shower of cigarette stumps shot into the corner of the room. Every lad in the tiny place sprang up and leaned over the table. It was a long time before any of them moved away—for what they heard there, what they saw the man with the steel bands around his head scribble on the paper they slid under his hand, was one of the most dramatic events in the history of the world.

"Some day this moment of history will be fully written. As these American boys heard it, the tremendous import of the moment was so overpowering that they could scarcely realize what they were hearing. Fragment by fragment the truth dawned upon them.

"Erzberger—yes, Mathias Erzberger—was talking to [illegible] Great Headquarters —talking about an armistice. It was the first hint of such a thing. Talking about cessation of hostilities.

"It was not very clear. And there were confusing interruptions. For a time both of the great German sending stations were talking at once. Erzberger was speaking from the Berlin station. And somebody—somebody who hated talk of armistices—was 'jamming the air' from the German station at Nauen. For a time it seemed doubtful if Erzberger would ever get anything said. For the Nauen station would always begin stuttering in time to break up the sense of his sentences.

"At last Nauen relapsed into silence, and what had sounded like a three-cornered backyard wrangle straightened itself out into the magic talk that ended four years of horror.

"But before even the beginning of an agreement was reached another wireless voice interrupted: It was a British ship of war and it wanted to know what was up.

"A deeper British wireless throat broke in and told the first to keep silent.

"Another whisper from the sea, American this time, queried insistently, demanding to know a lot of things. And another command, identified as from the American flagship in European waters, hushed the query.

Pieced Fragments Spell Victory

"It was a long time unraveling. It came in fragments, half statements—like actual dialogue at a great crisis.

"Erzberger, talking for Germany, wanted armistice discussions opened. Another faction, that in possession of the German wireless at Nauen, would rather eat nails *au natural* than talk any kind of peace. Allied headquarters were meticulous. They were not going to snap up any old appeal for an armistice that came along. It had to be a *bona fide* one bound by all kinds of guarantees before they would even glance at it.

"After a period of getting nowhere Erzberger asked permission to talk to the German army chiefs in code. Permission was peremptorily refused.

"There followed a pause, after which Erzberger sent eight long messages, not in code, each of which was answered from German army headquarters by one word.

"Conversation with Allied headquarters began again. This time brass tacks became much more apparent than hitherto.

"They began dickering over the actual means of bringing about a conference of envoys. Germany wanted to send them over the Allied lines in airplanes. Oh, airplanes plainly marked with proper identification of course.

"But Allied chiefs wouldn't have it. No German airplane was coming over their lines with their consent. Immunity would be promised to none. They had had experience with Germans before. And a plane promised immunity could see a lot, and report back. The answer was an uncompromising 'No.'

"Then Germany proposed an alternative.

"'Send your envoys over our lines in a plane of your own,' was the substance of their next proposal.

"Again the Allies answered 'No.'

"Even if the chief should guarantee safe conduct to an Allied plane, individual battery commanders and gunners could not be trusted. The lives of men important enough to be plenipotentiaries were too important to expose thus.

"Then the Allies made a proposal, and the road that the German envoys were to follow in crossing the French lines was laid out. It was the road from Chimay through Fourmies and La Capelle to Guise. And the Germans were instructed to come by automobile and to carry white flags. They were told where the French sentries would challenge them and what they were to do.

"What followed? The conference in the railway car, at which Marshal Foch read to the German delegates the terms that meant—if they did not actually say—'Unconditional surrender,' everybody knows."

Both Sides of the Government Ownership Question

A Summary of Opposing Testimony Given in the Congressional Hearings on the Alexander Bill

IN the February issue amateur aspects and arguments on the question of government ownership of wireless were given. The present article summarizes the general trend of argument, other than amateur, on the Alexander Bill, as heard before the Merchant Marine Committee of the House of Representatives in Washington from December 12 last, to December 19.

The case for the Navy was opened by Secretary Daniels, with the initial statement: "This is a bill that would give the Navy Department the ownership, the exclusive ownership, of all wireless communication for commercial purposes."

In general substance the remarks of the Secretary of the Navy then attempted justification of the proposal because of the excellence of the radio communication organization which the Navy had builded up during the war, the argument being that only through similar peace-time control by one agency could interference be eliminated. He outlined the "receiving center" scheme on the Atlantic coast, the principal stations being at Belmar, N. J., and Otter Cliffs, Me., these stations being connected by wire with Washington. A control station at the capital also served for the simultaneous operation of the four high-power transmitting stations at Annapolis, Sayville, Tuckerton and New Brunswick.

The plan for recording any violation of regulations which would enable enemy submarines to locate merchant vessels off the Atlantic coast was mentioned, this scheme having provided for daily "logs" kept by 37 "intercepting stations," which were equipped with radio compasses for locating suspicious or enemy stations. The equipment of seaplanes and submarine chasers with radio telephones and listening devices was also reviewed.

The Secretary next told of the purchase of the Marconi and Federal shore stations, excepting the Marconi high-power equipments, which increased the number of naval shore stations from 58 to 111. Commending the Navy for its transactions of commercial wireless business, he then said that it but required the passage of the bill to enable it to continue its control for all time.

Congressmen Green and Edmonds viciously attacked the principle of Government ownership revealed in the proposal for monopoly, immediately after Secretary Daniels ceased speaking. Following this, inquiry was made as to the probable cost of the acquisition, which Mr. Daniels estimated, "somewhere in the neighborhood of $5,000,000," which would not include patents and patent rights, a matter for adjudication in the courts.

A heated controversy arose over the Navy's purchase of commercial ship and shore wireless equipment, Congressman Edmonds stating that "after this committee refused to bring out a bill to purchase wireless apparatus, you utilized the Government's money to purchase this wireless apparatus and took over the commercial systems without the consent of Congress." Mr. Daniels said the action was not in defiance of Congress, but the purchase had been made as a good business proposition with funds available through the naval bill. The discussion then disclosed that the buying proposal so far as it relates to the ship sets, originated with the Shipping Board and that the Marconi Company had at first objected to the sale. Congressman Edmonds stated that the action had embarked the nation on a project which should have had the authority of Congress. "The operation of ships by the Shipping Board is limited to a certain term of years," he said, "whereas you are trying a permanent policy on the Government of having a monopoly of the radio business."

Commander S. C. Hooper, U. S. N., executive officer radio division, Bureau of Steam Engineering, Navy Department, soon afterward received permission from Secretary Daniels to speak about the board appointed to look into the patent situation. First explaining the complications which have arisen over existing radio patents and the arrangement made by the patriotic manufacturers to "call off all patent rights until after the war," he said that several months prior to the ending of hostilities a board had been appointed to settle up the patent situation. Its composition included a representative of the Departments of Navy, War and Justice, with a general policy of trying to see "that everybody gets what is coming to him."

Referring again to the bill itself and questioning Mr. Daniels, Congressman Saunders asked if the present law did not give the Navy everything required for the public protection in time of war. The Secretary replied that this was so. Then, under a hot verbal cross-fire from several members of the committee, Secretary Daniels and Commander Hooper narrowed the argument for ownership down to the problem of interference, which, in their opinion, could only be solved by giving a complete monopoly of radio either to the Government or a single commercial company.

Captain David W. Todd, U. S. N., Director of Naval Communications, opened the first afternoon's session by introducing the amendment to include amateurs in the scope of the bill. This subject was clearly outlined in the February issue and will not be again reviewed here. The Navy's representative then summarized the history of radio regulation by law, and outlined the condition which prevailed up to America's entrance into the war. With this as a basis, his argument was then directed to the economic value of a monopoly in ship-to-shore wireless. For a commercial station to be located and operated alongside a station in Government hands he considered an economic loss, because naval stations must have full crews and be maintained day and night; by permitting them to handle commercial business it looked to him as if the ship-to-shore traffic would gradually drift into the hands of the Government. In the matter of high-power stations, he noted their increase and mentioned how Great Britain had encouraged the English Marconi Company, nearly all privately owned stations in that country being Marconi plants, although there was no monopoly by law. On question from Congressman Saunders, who thought Great Britain's shipping interests gave her more convincing arguments for Government ownership, Captain Todd replied that he expected Great Britain would buy out the English Marconi Company, but added, "I may not have good reasons for believing that."

Congressman Green gave his opinion that if the British Government had such an idea, it was not necessarily a good example for us to follow. Arguing then that monopoly of operation required ownership also, Captain Todd thought the control under the present law too weak, because any foreign Government could secure a license and erect a station anywhere in the United States. Congressman Humphreys said, of course Congress could amend that feature of the law. The naval communication official then voiced his expectation that, at the next international radio conference the consensus of opinion of the nations represented would be for absolute Government operation of high-power stations, or they would call for such strict control that it would amount to the same thing.

Captain Todd thought Government ownership also necessary for the reason that with hostilities impending at some future time the transfer of control might be looked upon as a hostile or unfriendly move. Congressman Humphreys closed the discussion in this point by the statement that it was hoped the United States "would not come into any war of its own choosing except as a defensive matter," and preparation in such case would rather have the effect of letting a belligerent nation know "perhaps he had better not be so quick to embroil us."

It was next pointed out by members of the committee that one section of the bill was so worded that, should the Government take over the stations, owners could only be compensated in the event that a claim was filed within two years. This wording was defective in the opinion of Captain Todd, and the time-limiting clause was stricken out.

Following an extended discussion on the necessity for keeping naval shore station operators idle when they might be, in time of peace, engaged in handling commercial messages, the director of naval communications noted that the present law did not specifically apply to high-power stations, and that it would be a very great waste for the Government to keep its high-power station quiet; that, in short, permission to handle commercial business with these long-distance equipments was very desirable. Various aspects of the possibility of international complications resulting from such practice were discussed, Congressman Edmonds noting that England and Germany and the United States—three great commercial nations of the world—have not owned their wireless. The question rested with the observation of Congressman White that it made a material difference whether governments had forbidden private enterprise in radio or that private persons had not been encouraged by commercial business to build stations.

Lieutenant Cooper, U. S. N. R. F., the former amateur whose discussion of the experimenters' problems was outlined in the February issue, followed at the conclusion of Captain Todd's testimony. In dealing with the high-power situation, he made the broad statement that, due to war experience, the Navy was in a superior position from a practical operating basis. He explained the distant control system of transmitting, by which four operators in one room in Washington operated the stations at Annapolis, Sayville, Tuckerton and New Brunswick. The Marconi station at Belmar and the naval station at Otter Cliffs, near Bar Harbor, Me., were used for receiving. He then added the opinion that the number of high-power stations now on the Atlantic coast was close to the practical limit, stating that the longest wave length at present in use is about 17,000 meters and that he doubted whether any practical working wave lengths were left. In explanation of this statement he noted that Tuckerton used about 8,900 meters and Nantes, in France, used 9,000 meters on some of its schedules, causing interference. The regular wave for trans-Atlantic traffic he gave as 10,000 meters.

On question from Congressman Edmonds, the naval reservist thought 500 to 750 meters difference was required between very sharply tuned high-power stations to prevent interference. He was not prepared to definitely state, however, he admitted, whether with increasing demand for high-power equipments the maximum wave length would not be extended beyond the present 17,000 meters, making more wave lengths available. His concluding statement to the effect that the Navy was ahead of commercial companies in installing the newest long-distance apparatus, met with the rejoinder from Congressman Edmonds that the Navy did not have to exercise any care as to how much money it spends or pays for patents as private companies do.

Commander Hooper appeared next as the Navy's technical officer, paying the fine initial tribute to the commercial and scientific radio men in civilian life which was quoted in full in the February issue. Speaking on the question of interference, he thought that average gradations of 300 meters between stations, practically speaking, would prevent interference; with low-power stations, tuning within 25, or even 15, meters was practicable. In the matter of coastal stations the substance of his argument was that waste was encountered by having two systems and that through Government ownership safety at sea would be best insured. For high-power stations, he argued, Government ownership presented many advantages and on the interference problem, trouble was being stored up if no Congressional action was to be taken. Otherwise, he looked forward to complaints of alleged disrespect to foreign nations becoming a matter to be taken up through diplomatic channels. Commander Hooper thought that with a multiplicity of high-power stations built in different countries an international commission might decide that only one station could be used in a country and commercial interests might lose on their investment of millions. Congressman Edmonds said that this was a matter of commercial risk, and it was no business of Congress to regulate a man's commercial desires.

The technical officer read a review of naval radio activities during the war, dated October 24, 1918. It showed that during the fiscal year, 1,282 new installations for naval vessels had been provided for. Contracts had been made for wireless equipment for about 2,500 new vessels of the Shipping Board. The total number of existing and prospective installations provided for and maintained was in excess of 4,000. Coastal stations maintained and operated totaled 125, of which 75 were commercial plants taken over by the Government. In aircraft radio, 50 service and 40 training 'planes had been equipped, and 60 outfits shipped abroad. Contracts had been awarded for approximately 3,000 complete airplane sets. A large proportion of the report was commendatory of the technical advances made.

At the conclusion of the reading Congressman Edmonds developed the fact that advances in the art had not been made by employees of the Navy Department. The radio telephone was instanced, and Commander Hooper offset the newspaper credit given to the Government for this invention, stating that commercial companies deserved the credit.

Hon. Breckinridge Long, Third Asst. Secretary of State, next appeared as a proponent, saying that the State Department desired to express its entire approval of the substance of the bill. The primary reason, he said, was the international one and its specific application to communications during war. The Chairman inquiring whether there had been any lack of power under the existing law, Mr. Long replied that he was speaking only from the point of view of policy. Mr. Long admitted later that by Congressional act, regulation could be established which would meet the situation.

Commander Hooper, in a supplementary statement, dealt with the patent situation, pointing out its complexity. He explained that manufacturers of wireless apparatus had been required to protect the Government from all infringement claims, a clause which was stricken out of contracts during the war. To attempt settlement of various patents rights, he said, the board which Secretary Daniels had earlier referred to had been created, which would try to decide the merits of claims represented in purchases of apparatus amounting to $30,000,000 or $50,000,000. The decision, when agreement was reached, would then be referred to the Court of Claims. This arrangement being termed irrelevant to the bill's provisions, the navy's technical representative was questioned at length on the lack of reward to the inventor under Government monopoly. He said that he believed inventors "would rather take a chance with the Government," to which Congressman Edmonds returned: "I have not seen any of them rushing around here yet to support the bill."

From the viewpoint of interference at present, Commander Hooper admitted that it was not essential to take the high-power stations, but thought it bad policy to permit commercial companies to build a lot of expensive stations which they might find could not be used because of interference.

C. B. Cooper, New York manager for Kilbourne & Clarke, supported the bill in the interests of his own company and three Pacific coast shipping concerns. The substance of his plea for the bill's passage was the opinion that Government ownership provided the most efficient means of handling the ship-to-shore radio service.

The attack by the opponents of the bill was opened by Edward J. Nally, vice-president and general manager, Marconi Wireless Telegraph Company of America, and president, Pan-American Wireless Telegraph and Telephone Company.

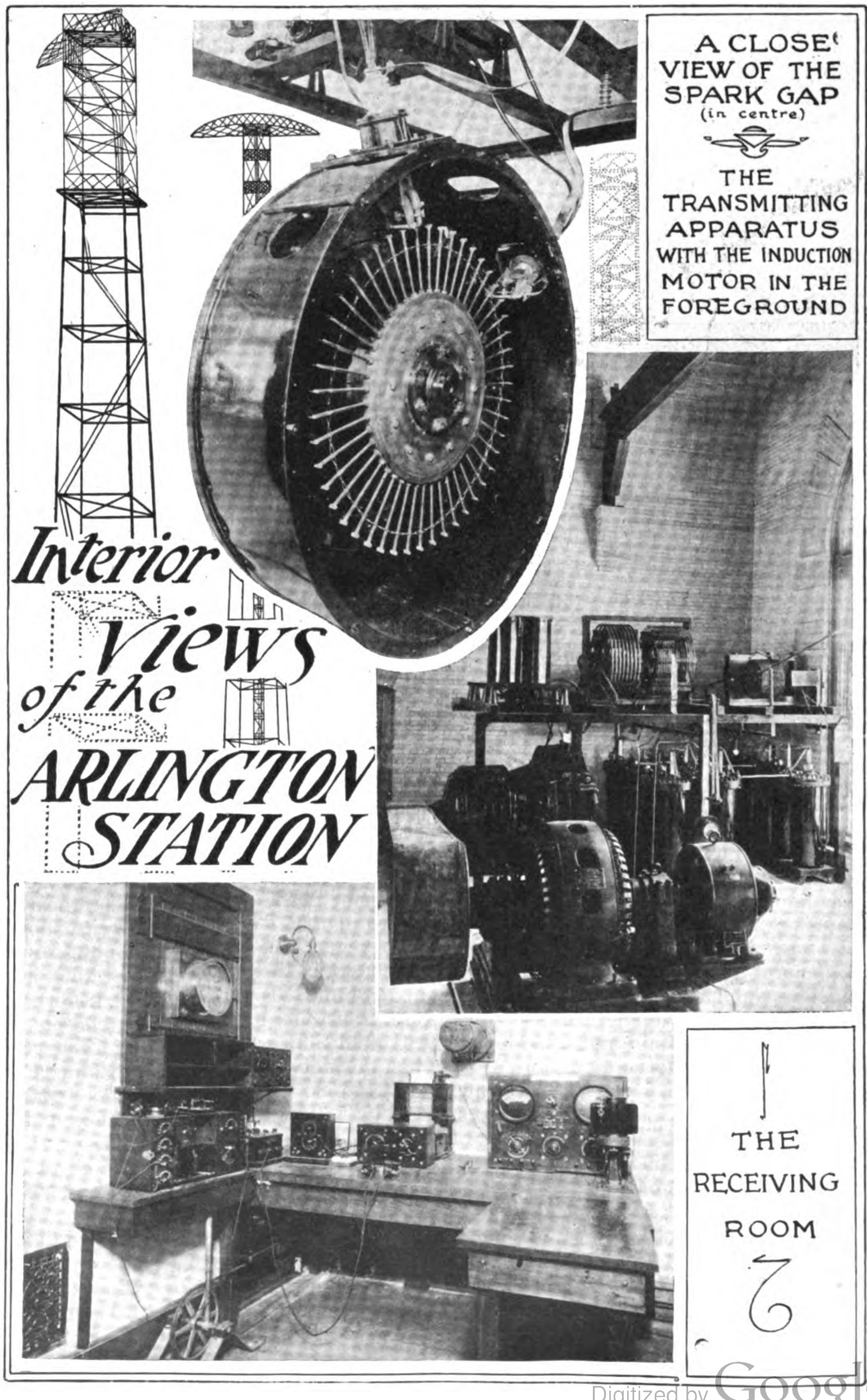
After establishing, on question from the Chairman, that the Pan-American Company was organized a year ago to operate in South America and represented majority American holdings, Mr. Nally called attention to the press statement of Congressman Alexander, which incorporated the Navy Department's reasons for Government ownership. He took exception to the statements that "radiotelegraphy is not a serious competitor of the cables," and "high-power stations are not yet able to receive from one another all day in all seasons," referring to the evidence of the Navy officials before the committee which was strongly to the contrary, especially Commander Hooper's statement on the reliability of communication across the ocean, literally, "now we never miss a message from the other side; that is a fact."

On the question of secrecy Mr. Nally said: "It had always been acknowledged that cable communication possesses the virtue of secrecy, but I was startled some months ago by a report coming from a representative of the Navy Department that there were reasons for the belief that submarine cable communication would be no longer secret, and it was feared that the enemy was copying all of the intelligence which passed between the United States and our allies.

"This was supposed to have been accomplished by laying a short length of submarine cable parallel to and alongside of the existing cable, and continuing the short length into Germany, where signals induced in the short length of cable were easily read by means of recorders and magnifiers.

"This is an old trick, often played on land, but the report was not credited by practical cable engineers; nevertheless, it was an interesting possibility and inasmuch as it was sponsored by representatives of the Navy Department there is no reason why they should not be expected to support the statement in contradiction of their present statement that submarine cable communication is secret.

"It is quite true that 'signals from radio stations are transmitted equally in all directions,' but it is not true



A CLOSE VIEW OF THE SPARK GAP (in centre)

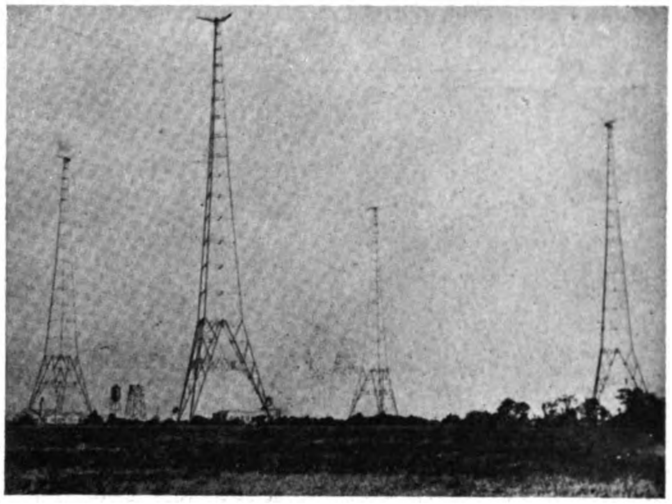
THE TRANSMITTING APPARATUS WITH THE INDUCTION MOTOR IN THE FOREGROUND

THE RECEIVING ROOM

that 'all nations can read the business of all others.' That one individual may not learn the business of another and that one nation may not know the private correspondence of another is the prime reason for the use of codes and ciphers."

He thought it misleading to say that wireless telegraphy is not a serious competitor of the cables, noting that both have distinct and separate value, and that some of the reasons urged against radio would not bear analysis.

He then anticipated the possibility a world-wide range station broadcasting a daily digest of American news in the interests of international harmony, a service impossible of duplication by submarine cables.



The 650-foot towers of the new Annapolis station, the naval high-power installation which was prominently featured in the discussion of the bill

Lieutenant Cooper's testimony was the next subject for his examination. The attempt made by the ex-amateur to imply that sensational progress in the art had been made during the eighteen months of war was misleading, he showed, by analysis of the three most important advances Lieutenant Cooper had related. These were (1) distant control; (2) success in duplex operation; (3) the design of a directional antenna.

Commenting on the first so-called advance in the art, Mr. Nally said:

"In order that the committee might appreciate the correct facts in the development of distant control and duplex operation, and of which apparently some naval officers are not even aware, it is only necessary to mention that transoceanic communication was first established by the Marconi Company between Ireland and Nova Scotia, in 1907, or 11 years ago. The service rendered at that time was limited in character and was utilized mainly by newspapers. The service, however, was so successful that it was opened the following year, 1908, or 10 years ago, to general public correspondence in competition with the existing submarine cable facilities, and many hundreds of thousands of commercial messages were transmitted between Great Britain and Canada, or the United States, without serious interruption, until 1917, when the stations were utilized exclusively for governmental purposes. In passing, I might mention that this same trans-Atlantic service has been released by the British and Canadian naval authorities since the armistice was signed, and is again open to commercial intercourse in competition with the submarine cables.

"This was the first and most important long-distance wireless commercial circuit, and the experience gained in the operation of this pioneer circuit has been of inestimable value to the art in the development and progress of later and higher powered transoceanic wireless circuits. During all this time, when the obstacles appeared almost unsurmountable and when the financial success of such service was seriously doubted by most people, there was no particular interest in international radio communication shown by our Navy Department. It is true that the Navy Department, within the last five years, has built a number of high-power stations, the object of which was to communicate in emergency with our naval outposts, such as Hawaii, Guam, and the Panama Canal; but the first noticeable desire of the Navy Department to engage in commercial international communication, was discernible shortly after circumstances, with which the committee is thoroughly familiar, placed the operation of the Sayville and Tuckerton high-power stations in the hands of the Navy Department. They immediately realized the full possibilities of an international high-power radio circuit, and we have it on record, in the minutes of the previous hearing, that the operation of these stations was so profitable that within a period of two years, and after deducting all naval operating charges, a return of over 30 per cent has been earned upon the investment. This high return, however, was not so much due to the efficient operation of the stations, as claimed by the Navy Department, as to the exorbitant tolls which were charged on the traffic handled. Prior to the severance of the submarine cables connecting the United States with Germany, the tariffs were 25 cents and 12½ cents per word, but during the time that the radio stations were operated by the Navy Department, this tariff was set at 50 cents per word.

"As Secretary Daniels openly informed us, a few days ago, it would be 'good business' for the Navy Department to take over the operation of all high-power radio stations, but it should not be forgotten that this 'good business' was foreseen in 1908 by the Marconi Company and ever since that time we have been striving to improve our high-power machinery, so that we might have an opportunity to fully enjoy the fruits of our labors, and also to earn for our 22,000 stockholders some suitable return on the investment of the many millions which we have placed into high-power stations waiting at this moment to furnish a commercial international high-power service to Great Britain and Ireland, to Scandinavia and Russia, and to Hawaii, Japan, and the Far East."

Claims had been made by the Navy for the specific improvements represented by distant control and duplex operation; on this question Mr. Nally observed: "Radio engineers the world over will corroborate my statement that the Marconi Company was the originator of the schemes of duplex operation and distant control. In the year 1912, the original trans-Atlantic service having become congested with traffic, it became necessary to increase its carrying capacity, and Marconi engineers planned the method by which the capacity of that circuit was doubled by the use of duplex operation; and, since that date—I repeat, this was six years ago—the trans-Atlantic service spoken of, has been continuously worked duplex. At the same date, Marconi engineers arranged for the operating key to be placed some 50 miles away from the transmitting machinery, and this has since that time been the sole manner in which all Marconi high-power stations have been operated. This, gentlemen, is the same distant control of which you have heard Lieutenant Cooper speak in connection with his concentrated telegraph office in the Navy Department Building.

"The American Marconi high-power stations, which were completed on the Atlantic coast in 1914," he continued, "were designated for exclusive duplex operation and are so arranged today. The American Marconi trans-Pacific high-power stations, which have seen commercial operation since September 24, 1914, were designed for duplex operation and were operated by this same system of duplex control. For confirmation of this fact Lieutenant Cooper need only ask several of his ex-Marconi operators now working for him in the Navy

Department Building, and who formerly operated in a highly efficient manner the Marconi trans-Pacific high-power service to Hawaii and Japan.

"We are particularly gratified to learn of the Navy Department's success with the egg-shaped wave," the speaker next observed, "and it will surely interest Mr. Marconi, who invented and patented the well-known Marconi directional aerial many years ago, the effect of which is to project a wave more effective in the direction of the receiving station than in any other direction. All Marconi high-power stations in this country were equipped with this 'egg-shaped wave' producing antenna in 1913 and 1914."

Mr. Nally recalled to the committee's attention the statement of Lieutenant Cooper that the Navy Department was best able, from a practical operating basis, to say what could be done, because the Navy, during the war, had more experience in handling high-power radio traffic. "The radio traffic expert," Mr. Nally observed, "who was singled out by the Navy to directly supervise the operators employed in this central radio station in Washington, where such alleged wonders have been worked, was, up to the date of our entering the war, in direct charge of the Marconi high-power trans-Pacific circuit. He has devoted his career to the problems of radio communication and patriotically offered his services to the Navy Department when they were in need of highly qualified men. We do not claim to have a monopoly on operating talent, but the fact stands out strongly that the Navy Department, in April, 1917, when this country entered the war, was short of really competent, high-grade transoceanic operators and appealed to this company for such men as we had specially selected and specially trained for this important branch of radio.

"It should be realized that there is a vast difference in the efficient operation of a ship-to-shore service and the requirements of a high-powered international service. This latter work is most exacting, and perhaps not more than a few out of a possible hundred average wireless operators have the requisite ability to satisfactorily cope with the heavy and high-speed work encountered on a transoceanic wireless circuit. I have already said that this company had picked a group of specialists, and it was these men the Navy Department made special call for, to assist in the new high-power responsibilities when this country entered the war. With one or two exceptions, the whole of this force volunteered its services to the Navy Department, and they are today to be found occupying responsible positions both in the high-power stations being operated by the Navy Department and also in the central radio office, with which Lieutenant Cooper himself is connected.

"I might also say," he continued, "that the Marconi Company has successfully operated transoceanic radio service at a higher rate of speed than has ever been accomplished by other agencies. The Marconi Company was the pioneer in automatic high-speed transmission and automatic high-speed reception. It has developed this system to a remarkable degree of proficiency. Whereas it is not possible to operate a radio circuit by hand (or, as we term it, manual operation) at more than 30 words per minute, the Marconi Company has successfully and for long periods transmitted by automatic-speed operation at speeds varying from 60 to 100 words per minute. This remarkable advance in the art, as can readily be seen, immediately doubles and even quadruples the capacity of a single circuit. I believe I am safe in saying that the Navy Department still makes use of the old system of manual transmission in the operation of its high-power stations."

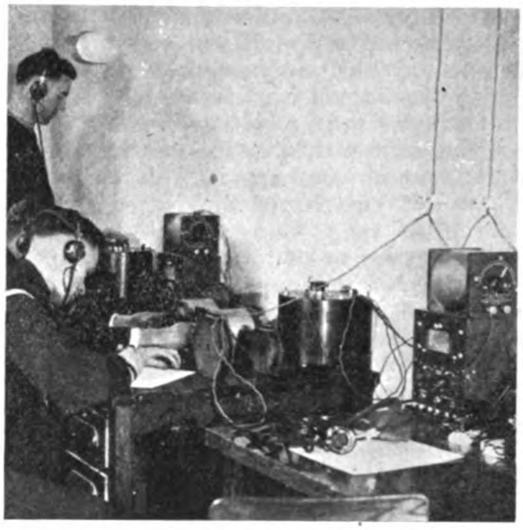
To illustrate that no essential difference in principle existed between radio and wire communication—quoting a statement made by the Postmaster General Burleson—Mr. Nally referred to his personal career of pioneering in all forms of electrical communication, a continuous experience since 1875, and said that he felt no appreciable change when, in 1913, he transferred his activities to wireless. He then touched upon the unfortunate early history of the art in the hands of unscrupulous promoters. The change in conditions he made clear, then, by the observations: "The year 1912 found the Marconi Wireless Telegraph Company of America in full possession of all property formerly belonging to the defunct and dishonest United Wireless Telegraph Company, and the Marconi Company undertook to construct a substantial and highly efficient organization to serve the public, and I can truthfully say that it has succeeding in doing so. The corporation today is as clean as a hound's tooth, it is vigorous and virile, and it has made surprising strides in the last few years and in the face of a most difficult and, at times, most discouraging condition and under circumstances that would ordinarily have caused failure to a less vigorous organization."

Acknowledging the tribute which had been made by Commander Hooper to the Marconi Company and its general manager, Mr. Nally briefly summarized the pre-war and war activities which had earned this credit. He explained how the chain of high-power stations had been built and a highly skilled operating personnel selected and trained for the various transoceanic services, which the Government took over with our entrance into the war. He also noted that the largest source of supply from which trained wireless operators were drawn was represented in the many thousand graduates of the Marconi schools of instruction. The subsidiary company's magazines and textbooks, he noted also, could be found in the homes of nearly every wireless student in the country. Expansion of the Aldene factory to meet Government demands was dwelt upon, more than 3,000 wireless sets being there designed and developed for use in the war.

The object and program of the Pan-American Company was explained in detail from its inception by letters written to the Navy Department and Secretary Daniels by Mr. Nally as the company's president, This correspondence developed the fact that the only opposition to Americans owning and operating wireless stations in South America came from our Government; none from the South American governments; in fact, all of the government officials on the southern continent were enthusiastic and anxious to assist in every way. Secretary Daniels, it was said, was absolutely committed to Government ownership, but the Navy Department hoped the Pan-American Company would go ahead with construction of its Argentina station without any assurance of being allowed to erect the United States communicating station.

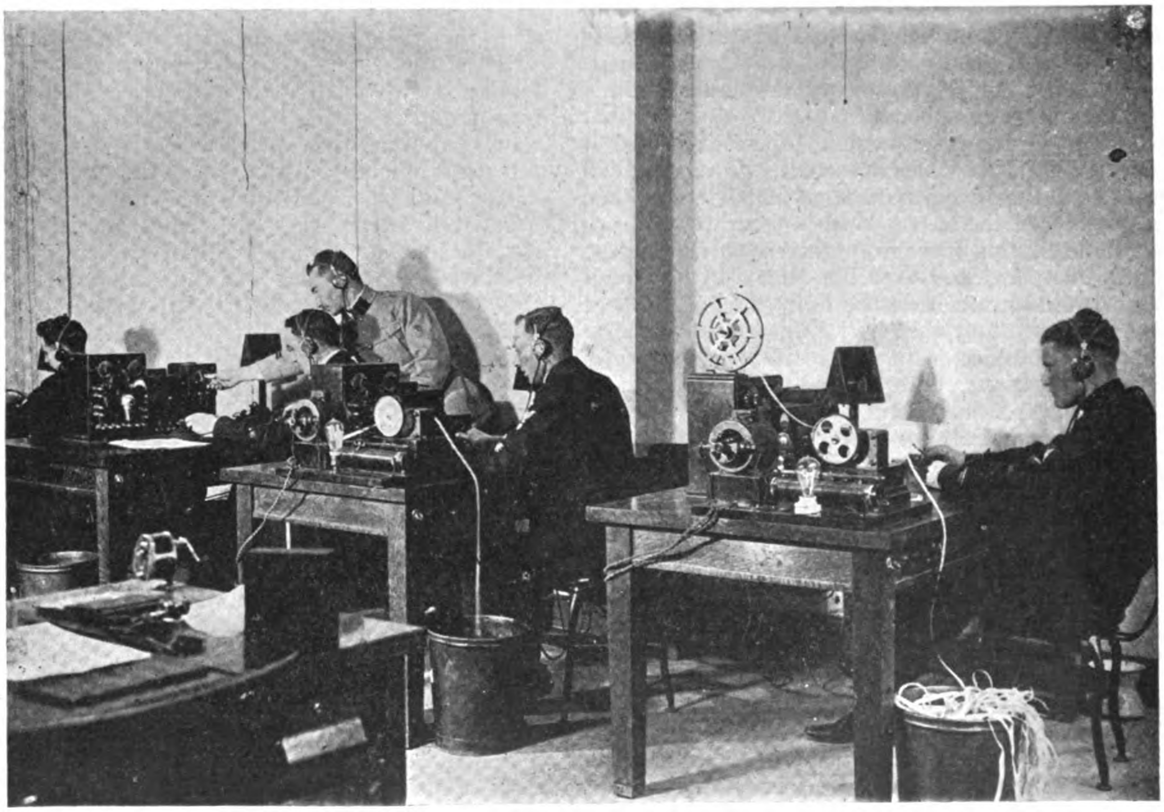
By contrast with commercial wireless agencies of other countries, many handicaps were suffered by United States manufacturers and operators, a fact which was illustrated by a referenee to conditions encountered in Mexico. In this country, Mr. Nally said, the Germans were in full control of the wireless stations. The new Mexican constitution of 1916 provided for Government ownership and, lacking capital for extension of service, the Carranza government fell an easy victim to the wiles of the German Telefunken Company. "There exists no particular prejudice in the matter of doing business with American private corporations," Mr. Nally remarked, "and if our company had been in position to go ahead freely and with the support and cooperation that our business men have a right to expect from the United States Government in their dealings abroad, it might have happened that, instead of there being upward of 25 wireless stations in Mexico under German control, as at present, there would be 25 under American control. And if an American private company were in control in Mexico I am sure that neither Secretary Daniels nor this committee, nor the people of the United States in general, would fail to see anything but a decided military advantage in times

Multiplex Radio Sending



Above: The receiving room of the central control station in Washington which handled all transoceanic naval messages during the war

To the left: Secretary of the Navy Daniels, whose campaign for government ownership was largely based upon the contention that interference could only be removed by centralizing control of high-power station operation



Photos by Int'l.

A general view of the perforating machines for messages transmitted from the centralized station by distant control

of war and an equally valuable commercial advantage in times of peace.

"Although the Mexican Government claims title to all these stations," he explained, "the apparatus is strictly German and there have been German operators in every one of the 25 odd stations. Moreover, there have sprung up Government electrical shops with German superintendents, and the whole system has been supervised by German radio experts who were formerly employed at Sayville and Tuckerton and on the German liners which were interned in this country at the beginning of the war."

Answering the federal ownership advocates who had stressed economic loss and retention of obsolete equipment under private ownership, the Marconi executive maintained that large undertakings were retarded because of the Government's wet blanket of ownership causing uncertainty, and gave instances where high-power apparatus had been scrapped and replaced, to prove that private enterprise made this a practice in the interests of increased revenue.

In closing, Mr. Nally submitted a concrete plan designed to bring to an end costly controversy between the Government and private companies. This scheme gave (a) the Government exclusive right for ship-to-shore commercial wireless, (b) private companies to receive governmental sanction to develop and extend commercial transoceanic and overland wireless, without commercial competition from the Government, and (c) amateur regulation satisfactory to both federal officials and the experimenters. He suggested that the Secretary of Commerce continue the licensing function and a national radio commission representing in its membership of five, federal and private interests, to apportion wave lengths, hear appeals where licenses may be refused or revoked, and recommend to Congress whatever additional legislation may be necessary from time to time. In the interests of national safety he offered, in behalf of the Marconi Company, that only American citizens be employed to operate high-power stations and all to be enrolled in a reserve subject to military call.

Following a considerable period of cross-questioning by the committee dealing mainly with the principle of Government ownership, Mr. Nally was succeeded by David Sarnoff, commercial manager of the Marconi Company and vice-president of the Pan-American Company. Mr. Sarnoff explained in detail the circumstances which led up to the sale of the Marconi coastal stations and ship-sets to the Navy Department, showing that as soon as the Navy obtained complete control of all wireless stations and operations at the outbreak of the war "it followed a line of action which appeared to us calculated to destroy the Marconi rental system and to render the Marconi coastal stations worthless at the end of the war," so there would be no alternative but to sell the coastal stations to the Government.

He then attacked the bill as a measure that would stifle the development of the radio art. He quoted the utterance of Hon. Thomas Ewing, U. S. Commissioner of Patents, who, in 1917, said that if the Government took over wireless it would largely be the end of its development and that, in the "matter of encouraging scientific invention the Government is not a shining success in comparison with private enterprise." Mr. Sarnoff drew attention to the fact that actual operating experience had in most cases been the basis upon which invention and improvement rested, questioning then where the outside technical experts could obtain further experience and knowledge of operating conditions under a naval monopoly of operation. Government salaries, too, were noted to be unattractive to commercial experts and offered no inducement to them to become a Government employe.

Restriction of overland communication was another of the bill's evils, Mr. Sarnoff contended; he illustrated its utility on railroads, showing that in one paralyzing storm the wireless equipment of the Lackawana saved the company $150,000.

"And what shall we say about the future of the wireless telephone, which is rapidly coming to the front," he added, "and to which the world war has given great impetus? Leave the commercial expansion of the radio art unhampered and I am confident that it is only a matter of a few years when we shall have transcontinental radiotelephony. That this is scientifically possible has already been demonstrated; it but remains for technical experts to perfect existing wireless telephone apparatus, and for private enterprise to erect high-power radio telephone stations to effectively compete with telephone lines and materially reduce telephone tolls. It could not help but reduce the rates, because a radio telephone station located in New York and another in San Francisco, capable of continuous transcontinental communication, will be possible of erection at an investment of approximately $1,000,000, and this investment is small, indeed, compared with the investment which the users tie up when talking over a long-distance wire telephone circuit strung between New York and San Francisco, which investment, I should say, roughly, represents $20,000,000."

His next subject was the interference problem, which he termed the keynote of the proponents' arguments, as expressed by Secretary Daniels as the "sole reason" for the proposed monopoly.

"The fact that Navy Department admits that there is no way in which to solve the interference problem except by legislation bears the most eloquent testimony to its poverty in scientific perception and its lack of faith in human genius to overcome this problem," he said. "In my judgment and in the judgment of men whose scientific opinions are infinitely more valuable than mine, the problem of static interference—which interference Prof. Pupin so aptly termed an 'act of God'—was a far more serious and more puzzling and less hopeful problem to solve than that of wave-length interference—'the act of man.'

"In discussing the static problem with radio men I have in the years gone by been told by some of the leading scientific experts that in their opinion the static problem was unsolvable and that there was no way to overcome it, and yet this baffling problem, an obstacle to continuous radio communication over long distances, has been solved, and solved by an American in civilian life, who has never been connected with the Navy Department or any other Government agency.

"Only yesterday I discussed anew with the inventor of the static preventer the question of interference and asked his opinion in the matter. He unhesitatingly replied that he felt confident of the complete solution of the interference problem, and, what is more, he stated that right now, every day, definite and important progress is being made and that the complete solution of what is left of the interference problem is almost in sight.

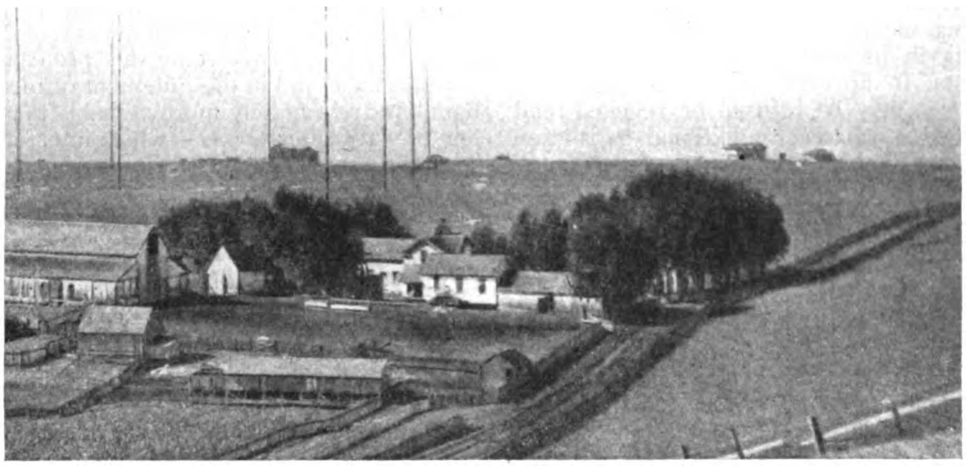
"If the members of this committee can find an opportunity to refer to the records of the last hearing, held in this room on a similar bill, when the matter of interference was discussed, they will find that what I have said and quoted is confirmed by the opinions expressed by such scientific geniuses and men skilled in the radio art as Prof. Pupin, of Columbia University; Prof. Kennelly, of Harvard University, and Prof. Goldsmith, of the College of the City of New York.

"As against the opinions of leading scientific minds, let me ask which of the proponents of this bill who have thus far appeared before your committee are willing to take issue with these men and their opinions, and to state as a scientific conclusion that the interference problem is unsolvable? And, further, that there is no other way to meet the emergency except by legislating interference out of existence, which, perforce, means limiting the number of stations operating at the same time and consequently limiting the number of messages which can be sent and received at the same time. This would place an artificial barrier on the expansion and development of a public utility, which bids fair, under commercial operation, not only to rival but to surpass every other means of intelligence transmission. If such there be among the proponents of this bill, let me say for his information that "interference" has not singled out radio communication for its sole attack. Mr. Interference has simply come to life again, and is at present in the air but looking down upon the Navy Department, which seems to include the only people fearing his power and who have complained to Congress, seeking his destruction and annihilation through this present bill.

"Our old friend 'interference' seems to have a particular dislike for those who wish to communicate," he added, "and a study of this scientific subject will illustrate that in the early days of land wire telegraphy and telephony they experienced exactly the same trouble from inductive disturbances on the telegraph lines, and cross-talk on the telephone lines. These disturbances were produced in a wire by the operation of neighboring wires. Now, if at that time legislation similar to that now being sought by the Navy Department had been enacted, prohibiting the stringing of telegraph and telephone wires on the same poles and compelling duplicate sets of poles and lines, separated miles apart, would the present high state of perfection of the telegraph and telephone systems have been reached? I think not.

"What happened instead? The scientific minds struggled with the problem until they solved it, and interference from neighboring wires is no longer a problem, and as many wires can be strung on a pole line as the poles will hold, and they can be placed almost as near together as you please. This, of course, means a tremendous saving in the expense of installation and operation of telegraph and telephone lines.

"The honorable Secretary has stated that 'there is a certain amount of ether, and you can not divide it up among the people as they choose to use it; one hand must control it.' Now, the ether knows no national boundaries, or 3-mile limits; it is a common and international medium, and therefore it is not possible for one hand to control it. It is not the American people, and not the American stations which our Government will have difficulty in controlling, because it has the power of the present regulations, and the ability to obtain more regulation if this, in the judgment of Congress, seems necessary. It is the foreign stations that may cause the greatest amount of interference, and we have no means of controlling them except by international agreement, and if we can get along harmoniously with all of our neighbors in the rest of the world by living up to international agreements, why is it impossible or impracticable for the Navy Department to get along amicably, and to work harmoniously with its friends on American soil? One hand —to use the Secretary's phrase—may control all the high-power stations in the United States, but that will not prevent interference from such stations as may be erected in Canada, or in Cuba, or in Mexico, or in any South American country.

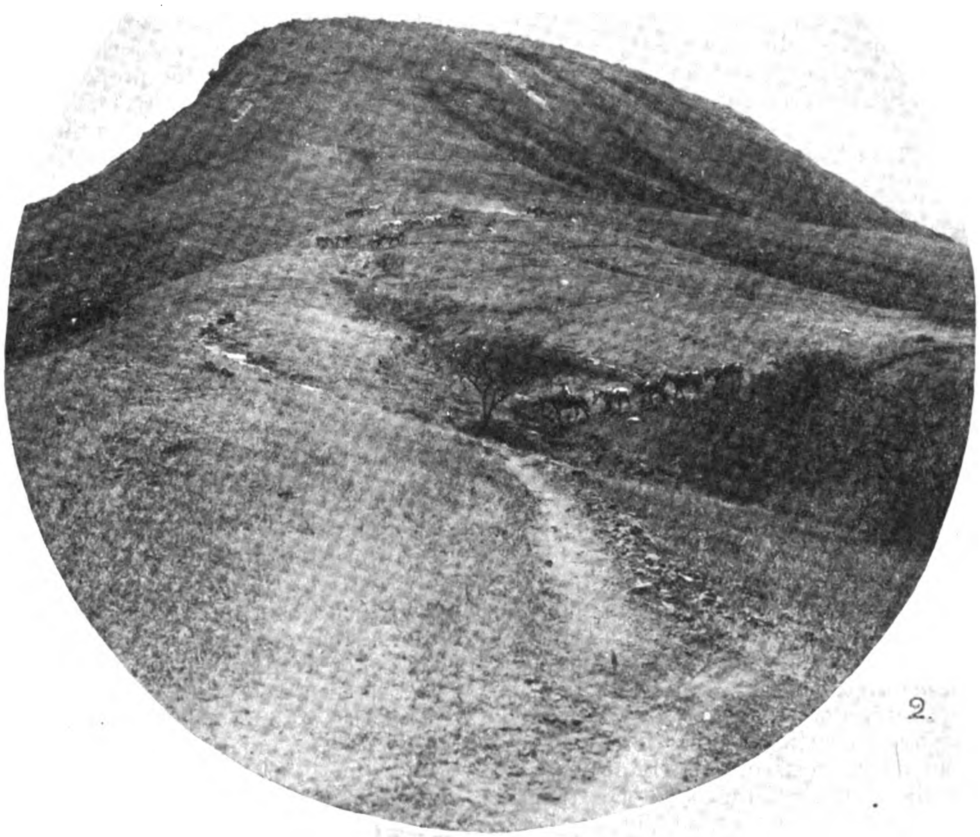


One view of the California end of the Marconi trans-Pacific circuit, for the operation of which it was stated few operators could qualify

"Gentlemen," he continued, "it must be evident to you that this question of interference, which, it has been stated, is the sole reason for this bill, is really not a reason—it is an excuse for obtaining Government ownership and Government monopoly of all radio communication in this country. Our friends the English, who have had experience in telephone lines, do not seem to fear the increasing number of high-power stations, and are making extensive arrangements for some long-distance stations, and it is significant, too, that the British Government, while operating telegraph and telephone lines, has not, so far as we know, launched on a policy of Government ownership of high-power radio stations.

"It has been stated to you that only seven countries at present favor or permit private ownership of radio stations, but it has not been stated that these seven countries are the only countries which have helped to develop wireless communication, and, therefore, the proponents of this bill have not claimed that ship-to-shore radio communication would be interfered with by the working of high-power radio stations, and I merely wish to emphasize this important fact that private operation of commercial high-power international radio stations has nothing whatever to do with the interference problem—so far as this problem applies to ship and shore work."

1.



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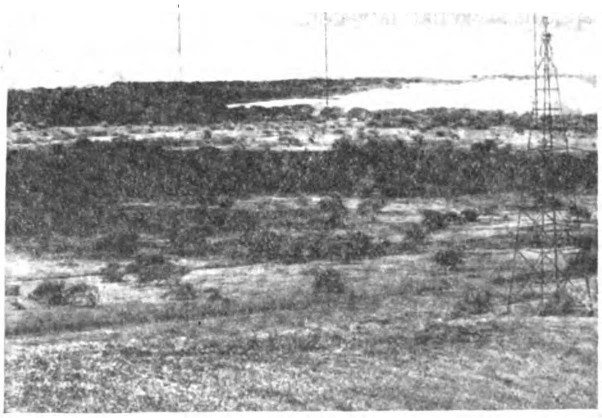

1. An extinct crater in Hawaii which serves as the site for mast erection of one of the Marconi stations, illustrating the type of engineering problem encountered in establishing a world-wide wireless system

2. The utility of wireless in Hawaii was emphasized by a representative of the mid-Pacific business men who protested against the Navy's bureaucratic administration; the photo shows the mast line of Marconi's receiving station

In summary of his remarks on interference, Mr. Sarnoff gave his opinion that the enforcement of intelligent regulation would provide all of the benefits sought with none of the perils to the art the bill imposed.

Hon. John W. Griggs, president of the American Marconi Company, was heard next. He observed that the bill seemed to bear most directly and hardest on his company, the most important in capital, property and stockholders, and the oldest company in the United States. "Its present capital," he said, "is $10,000,000, and I think its total assets, as figured on its statement, amounts to something like $12,000,000. It has no bonded indebtedness—it has no indebtedness whatever except the week-to-week current bills that it incurs. It has paid two dividends in the course of the 15 or 16 years it has been engaged in business. It has 22,000 stockholders, the most of whom are residents of the United States, who acquired their stock with the hope and expectation that eventually the Marconi Company would be able to become a successful competitor of the oceanic cables, and thereby would derive a large income which would justify an investor in waiting 10 or 15, or even 20 years, for a dividend, because he expected when the result was obtained he would reap largely in returns."

The scope of the tansoceanic scheme was explained and the expenditure of $5,000,000 in building stations for the international business. He referred to the taking over of these stations at the outbreak of the war, and now that hostilities had ceased, "in comes the military arm of the Government, the Navy Department of the United States, and asks power of Congress to take away from the Marconi Company not only these stations but all of this prospective business that it has been planning and working and spending money for 20 years to develop and build up. Just when the farmer has planted his seed, plowed his field, and harrowed it, and cultivated his crop, and the corn is ready to husk, the Government comes in and says, 'We want that crop.'

"Well, there must be some justification for such action as this. It is unusual; it is severe. The requisitioning of the property devoted to the uses of commerce or manufacture by citizens of America, the requisitioning of that property is harsh, unusual in time of peace, and ought not to be permitted by Congress except on grounds of public necessity. You cannot take ground for a railroad under the laws of condemnation of any State in the Union, unless it is necessary. You cannot take the right to string telegraph or telephone poles unless it is necessary for the purposes I have named."

Governor Griggs then showed the inconsistency of the Navy's reasons for the supposed necessity. He referred to the fact that arguments in 1917 had been military necessity, reasoning which experience had proved fallacious; the present reason was, therefore, a new one—interference. He did not deal with that technical feature, but he referred to the broad question of interfering with the operation by the Navy of its stations when the nation was not at war. "In time of peace the interests of commerce and business are superior to all the navies of the earth," he noted. "This country does not exist for the benefit of the Navy. The Navy Department exists for the benefit of this country, and no interests of this country should be subordinated to the control of the Navy Department merely because they want it, and substantially that is the only reason that is behind this bill so far as these officers of the radio bureau of the department are concerned.

"Let me ask you this: What law compels the Navy Department to transmit official business or press messages by these stations if they take them over? And if they are willing to transmit messages, if they find that the needs of communication in time of peace, when battleships will lie rusting in harbors—if they find that the needs of their service will still permit some business to be carried on, how will they carry it on? We have had a censorship for the last year and a half. No man could send a message by cable unless it passed a Government censor. No newspaper could get a communication from the front unless it was such as the censor permitted to come over the wires. Do you want to perpetuate a censorship in the Navy Department? If, then, the power, the only power, to operate transoceanic stations is the Navy Department, what newspaper, what correspondent, what business house but what would be at the mercy of some lieutenant commander who had a prejudice against the paper or the correspondent or the business house and did not like it, and who would not take their messages unless they conformed to his ideas of what was proper news to send across? Is there anything to hinder that? The interests of the Navy Department could always be cited as the reason why particular news should not come. I do not hesitate to say that I can conceive of no emergency in time of peace connected with the maintenance and operation of the American Navy or naval stations which would require that they should have first control of long-distance wireless. I say the first use belongs to business and commerce; it belongs to the business people, belongs to the press people, to the commercial people of the United States, and it does not belong to the officers of the Navy Department."

Tying up the proposition for radio monopoly to the policy of Government ownership projected by Postmaster General Burleson, the Marconi Company's president called the bill inadequate and inartistic. He strongly attacked its provisions for compensating station owners after confiscation of their property. The methods of dealing with the person whose property is thus taken he termed unjust, unfair and arbitrary. "I want to call your attention," he said, "to the fact that that does not provide at all for just compensation. Just compensation is what the Government owes for the property taken.

"If you have a company like the Marconi Company, that has been 20 years elaborating, improving, expanding, building up to a certain point of perfection, and then the Government comes in and takes that merely at its scrap-rate value, or its value as it stands, and does not take it as its value as a going company, nor take into account what it is capable of earning, nor take into account the money that has been spent working it up, scrapping of machinery and apparatus, and has taken all these 20 years—you see how much encouragement you are giving people to invest their money in enterprises of this kind, and you see how unjust it is to these stockholders, who have been willing to wait, 5, 10 or 15 years until the company could do this business and earn dividends, to buy them out for the scrap value of their stations.

"Two years ago Captain Todd said significantly that he thought these stations could be got for $5,000,000 and if we waited five years they would be worth $20,000,000," he continued. "There was evidence that Captain Todd knew when these stations were put in operation the large business that we expect was coming to them and the profits that were earned by the company, property which represented merely on the ground $5,000,000, as a going concern would be worth $20,000,000. I do not tie myself to any figures, but you know the difference between the preparation to do business and the doing of business.

"Let us see what it is that they propose thus to take in this arbitrary way. They propose to take the Marconi system in the United States. Well, what is the Marconi system and who is Marconi? I would like to read to you a judicial statement made in 1905 by Judge Townsend, of the United States Circuit Court for the Southern Division of New York, in a patent suit. I read from One Hundred and Thirty-eighth Federal Reporter, page 673:

> The exact contribution of Marconi to the art of spark telegraphy may be stated as follows: Maxwell and Crookes promulgated the theory of electrical oscillations by means of disrupted discharge. Hertz produced these oscillations and described their characteristics. Lodge and Popoff devised apparatus limited to lecture or local experiments or to such impracticable purposes as observation of thunderstorms. Marconi discovered the possibility of making these disclosures available by transforming these oscillations into definite signals, and, availing himself of the means then attained, combined the abandoned and laboratory apparatus and by successive experiments, recognized and developed them into a complete system, capable of commercially utilizing his discoveries.

"Marconi has been recognized by almost all the great scientific societies of the world as the real inventor and discoverer of the practical art. He has had conferred upon him the Nobel prize. The Governments of Great Britain, of France, of Spain, of Belgium, of Russia, of Italy have honored him by reason of that invention. The only two great commercial countries that have persistently refused, so far as their governments are concerned, to recognize Marconi or his patents are the United States and Germany!"

The attitude of the Navy Department toward inventors and patentees was then illuminated by Governor Griggs, telling of the experience of the Marconi Company. "Its patents are supposed to be monopolies," he observed, "and they are given monopolies as incentives to reward invention and discovery; and in that respect we are proud of our monopoly.

"Very early—as early as 1904—the Navy Department began equipping naval vessels with piratical apparatus purchased from companies that made apparatus and sold it embodying the Marconi patents. The Marconi Company protested to the Navy Department against that practice and said it was not fair to a patentee to have the United States Government, which granted the patent, accept goods and buy them from a pirate. It was replied by the admiral, who at that time had charge of the bureau, that the Navy Department took no cognizance of patent rights, except so far as they had been adjudicated by some court. Whereupon the Marconi Company brought a suit against the deForest Wireless Co., and the Marconi patents were sustained as valid, and the deForest Co. was enjoined, and there was a complete judicial determination of the validity of the Marconi patents by Judge Townsend, who was a very able judge.

"Whereupon we meandered again down to the Navy Department and saw the admiral and said to him: 'Sir, we have brought suit against an infringer, and the Circuit Court of the Southern District of New York has declared our patent valid, and we now ask you to cease buying apparatus from these infringers.' And the admiral said: 'We can not recognize the decision of a subordinate court. We must have a decision of an appellate court.' 'Ah, but,' we said, 'deForest will not appeal. He acquiesces in the decision.' To which Admiral Manning replied, 'Well, that is your misfortune.'

"The Navy Department proceeded from that time to this, against our protest, ordering apparatus that embodied the patents of the Marconi Company, which had been adjudicated, and some of them subsequently adjudicated—some other patents—by the Circuit Court of Appeals. They went right on, in spite of decisions, and protests, and everything, ordering apparatus from piratical contractors.

"Well, several years ago, having got no relief whatever from this treatment by the Navy Department, we began suit against the Government in the Court of Claims to recover royalties for the apparatus which they had bought from pirates, the claims arising under the adjudicated patents; and what do you think the Government did? They not only denied our right to any royalty, but they denied the validity of the patents and required us again in the Court of Claims to go through another trial as to validity of patents which had been passed on by the Circuit Court of Appeals, although applications for certiorari to the Supreme Court were refused."

Mentioning the earlier discussion over the policy of having stations in South America controlled by the U. S. Government or private companies, Governor Griggs made the following point: "If in time of war in which the United States or The Argentine is a neutral, a private company is allowed to carry on communication with a belligerent country, it is not a breach of neutrality on the part of the country. But if a Government station in Argentina or in the United States carries on communication with a belligerent Government, it is a breach of neutrality under international law!"

Testimony by Marconi officials concluded with Governor Griggs' statement. Two full days were occupied by other wireless men, mainly in opposition. Aside from

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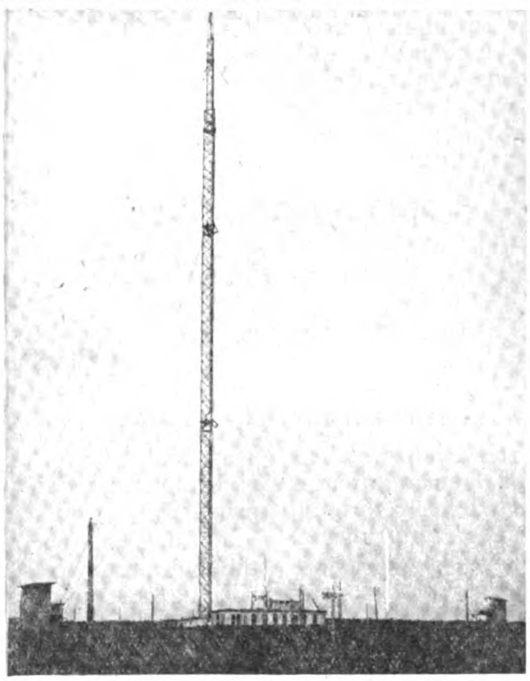
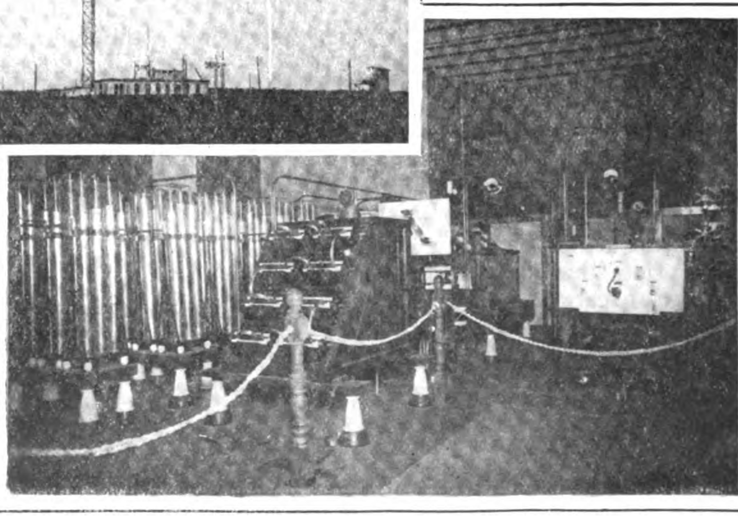


The Sayville Station



Multiplex Telegraphy and Telephony

The Use of Radio Frequency Currents

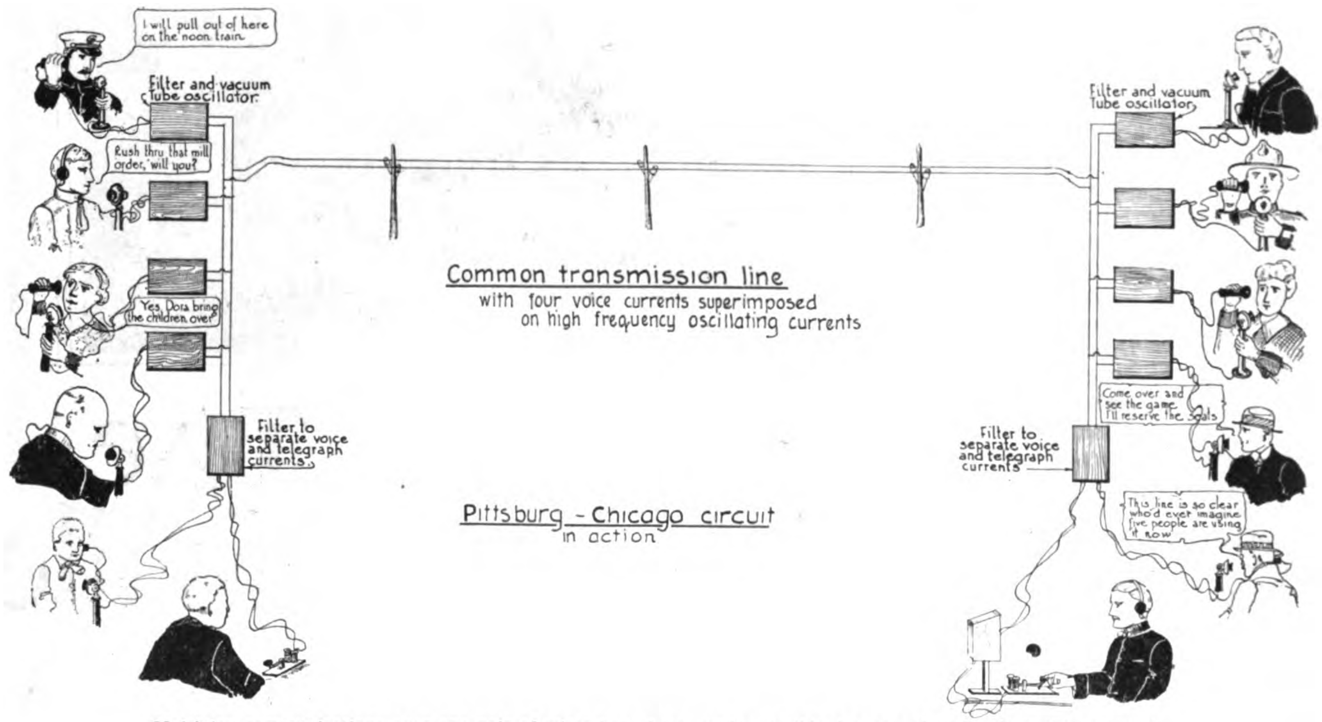
WHEN Prof. J. A. Fleming devised the two element valve for the detection of radio frequency oscillations and proved beyond all doubt its rectifying properties and moreover, when deForest and Weagant added the third electrode for further control of electron currents, they blazed the way for a series of developments which have well-nigh revolutionized both wireless and wire communication. The discoveries of Armstrong after a series of intensive experiments, in respect to regenerative amplification engaged the attention of physicists throughout the world. Numerous commercial applications of the vacuum tube followed with astounding rapidity. In fact, new inventions and further applications appeared in such numbers that it has been somewhat difficult even for the scientist to keep abreast of the times. For no sooner had one discovery been heralded forth than another appeared of possibly greater importance.

Telephone engineers were quick to foresee the possibilities of the vacuum tube in wire communication and to apply them in numerous ways to increase the efficiency of land line telephony. An air of mystery, however, has surrounded their experiments and the layman often is led to believe that the tube was perfected solely through their efforts. Nevertheless it was Fleming's fundamental discovery that made these developments possible, notwithstanding all arguments to the contrary.

It was the adoption of the three element electrode vacuum tube as a repeater and amplifier that made long distance wire telephony possible between New York and San Francisco; and it is because of the ease by which radio or audio frequency currents can be modulated by the vacuum tube that the modern wireless telephone has been developed to such a high degree of perfection. It is an outstanding fact that the art of wireless telegraphy is responsible for great advances in the wire communication, for many of the devices developed for radio use have been found equally applicable to wires. The tube now is being applied in miscellaneous ways in general electrical work.

The vacuum tube is susceptible to so many uses that each particular application of the tube should be the subject of a special article. The two electrode vacuum tube is now sold as a commercial article for the rectification of low frequency alternating currents. The three electrode vacuum tube is not only employed for the detection of damped and undamped electrical oscillations in radio but also is used as a generator of radio frequency currents at frequencies from one-half cycle to twenty million per second. Its use in cascade connection as a radio or audio frequency amplifier is well known to those engaged in radio engineering. Now-a-days, the use of five to eight tubes in cascade is common and not only are enormous amplifications obtained but the factor of selectivity, that is, discrimination between interfering wireless signals, has been remarkably increased.

Recent reports concerning the development of a novel system of wire communication whereby five telephone conversations and two telegraph messages were transmitted simultaneously over one pair of wires between Washington and Pittsburgh have arrested the attention of the newspaper reading public, but the layman is usually told that the apparatus is too complicated to be understood by the unscientific mind. This is true in a limited sense, but nevertheless the system mentioned in published reports is simply an application of well-known discoveries primarily engendered in wireless telegraph research.



Multiplex communications over one pair of wires have been made possible by use of radio frequency currents

A diagram portraying in a non-technical manner the multiplex wire system is shown in figure 1. But the burning question of the layman is, how can several telephone currents be made to pass over the same wires and enter specific receiving apparatus without interference. It would indeed present a difficult problem were it not for the well-known resonance phenomenon encountered in circuits employing the high frequency currents of wireless telegraphy. To illustrate: If we generate radio frequency currents around 50 to 60 thousand cycles per second and we wish to impress these currents upon other circuits, the maximum current flow in the last named circuits will only take place when they are tuned to exact resonance, that is, when their natural period of electrical oscillation is identical with that of the energy producing circuit. Moreover, if we generate currents of several radio frequencies say for example, 30,000, 40,000, 50,000 and 60,000 cycles and connect them to a common line, and we provide at the distance receiving station several circuits tuned to these four frequencies, we find that each particular frequency generated at the transmitter will automatically find its way into the receiving circuit tuned to that particular frequency and none other. The reason for this is that the circuit at the receiving station which is tuned to a particular frequency of oscillation offers the least impedance to that frequency and high impedance to all other frequencies.

Coming back to the simple wire telephone it is well known that the speech frequency currents generated in such circuits by the human voice are not only variable in amplitude, but in frequency as well. The frequencies usually lie between 200 and 2,000 per second. Imagine, then the absurdity of trying to transmit five telephone conversations each of which covered a range of several speech frequencies over the same circuit. Those familiar with the problems of telephoning will tell you that it would not be possible to weed out at the receiving station any one of these particular conversations. The question then arises, how is this done by means of the land line system so widely heralded.

We have mentioned the striking effects of resonance in radio frequency circuits and coupled with this it is well known that current frequencies above 20,000 cycles per second occur at rates to which the human ear is not

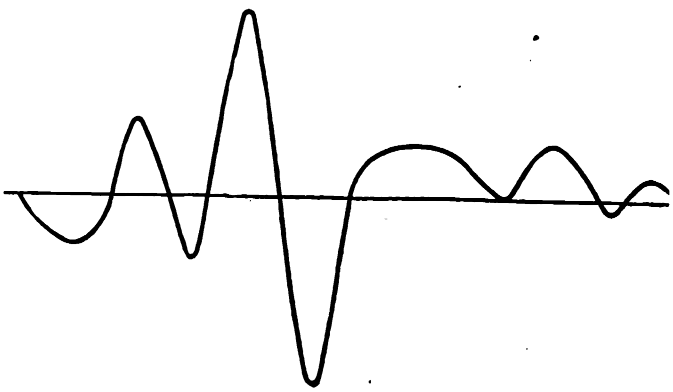


Figure 2—Oscillogram of voice-current transmitted over a telephone circuit

responsive. Consequently if a telephone receiver is employed to detect these currents, in radio or wire telephony, no sound is heard. But if we modulate the amplitude of such a high frequency current at speech frequencies by a microphone transmitter, the telephone diaphragm at the receiving station through the medium of an oscillation detector will move in accordance with these variations, reproducing the signal being transmitted.

A typical oscillogram of voice currents is shown in figure 2, the variation in amplitude and frequency being clearly indicated. The difficulty of weeding out several such currents at the receiving station is obvious. On the other hand, the unmodified radio frequency current shown in figure 3 has a definite wave form and if several frequencies are transmitted over one wire they can be weeded out at the receiving end of the line by resonant radio frequency circuits. If then, we modulate these radio frequency currents at speech frequencies by an ordinary telephone transmitter as in the oscillogram in figure 4 we obtain an audio frequency variation of the radio frequency current at the receiving station which, through the agency of the vacuum tube amplifier, appears in the head telephone as a speech frequency current. It is by this method that several telephonic conversations are carried on simultaneously without interference.

At the transmitter the grid and plate circuits of a vacuum tube are connected for the generation of radio frequency currents of any desired pre-determined frequency. Either the grid or plate circuit of the tube is connected to a microphone transmitter for speech frequency modulations of the line current. These modulated currents, whose frequency remains substantially constant, but whose amplitude varies as the frequency of the speech currents, are induced in the wire line and are weeded out at the receiving station by vacuum tube amplifiers, the grid circuits of which are made resonant to a particular radio frequency. Owing to the extreme sensitiveness of these amplifiers, very feeble line currents give good signals at the receiving station.

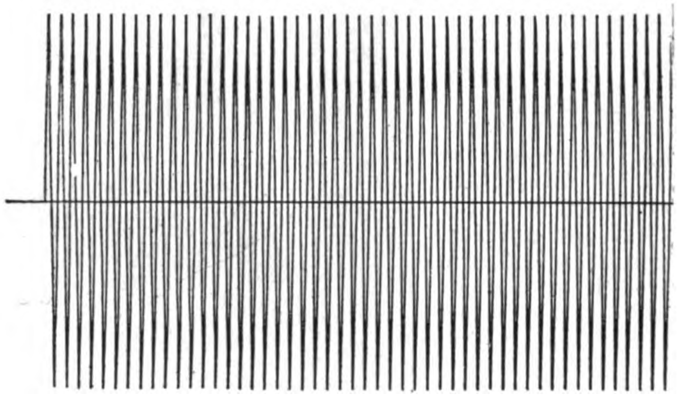


Figure 3—Oscillogram of a high-frequency current

No particular installation was made between Washington and Pittsburgh, but the toll line carrying these multiplex currents extends from the Tuxedo test station just outside of Baltimore, Md., to the Brushton station just outside the city of Pittsburgh. From Washington to Tuxedo and Pittsburgh to Brushton there are provided as many ordinary telephone circuits as are required for the ordinary and multiplex use of the toll lines between Tuxedo and Brushton—in this particular case five. These five circuits do not in any way differ from ordinary telephone circuits either from the standpoint of talking, signaling or operating. The Brushton and Tuxedo stations contain the vacuum tube generating apparatus and the current filters for the various radio frequencies.

Telegraphic currents sent over the wire do not affect this apparatus, for since these currents occur at an audio frequency and the telephone circuits are responsive to radio frequency currents only, no interference results. It has been possible for some time to take two adjacent metallic telephone circuits and to connect them to provide an additional phantom circuit. It is also possible to employ these four wires for a telegraph circuit without interference with the telephonic currents, but in the system cited two wires are employed for multiplex communication without interference. It should be understood that

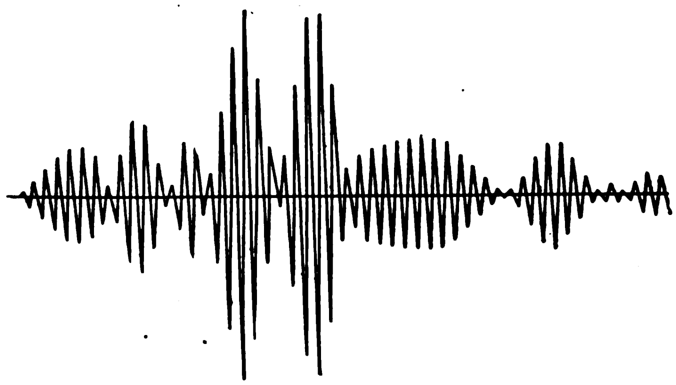


Figure 4—Oscillogram of a high-frequency current modified to transmit a voice-current

it is through the resonance phenomena accompanying high frequency alternating currents that such a system is possible and, moreover, it is the simplicity of the vacuum tube as a generator of high frequency currents and its sensitiveness as a repeater and an amplifier that makes this non-interfering common highway feasible.

It is safe to prophesy that the cable soon will employ this system of communication.

The Weagant Oscillation Valve

A Striking Improvement on the Original Fleming Oscillation Valve

Roy A. Weagant, chief engineer of the Marconi Wireless Telegraph Company

LITTLE is known of the exhaustive researches of Roy A. Weagant, Chief Engineer of the Marconi Wireless Telegraph Company of America, in connection with the design and practical application of the three-electrode oscillation valve. With the war ended it is now possible, however, to describe some features which should be of great interest to radio men. Among his numerous discoveries is a striking improvement on the original Fleming oscillation valve revealed in a recent U. S. patent. The fundamental construction of the new tube is indicated in figure 1, where a plate P and a filament F are enclosed in a vacuum chamber as usual. Mounted externally to the bulb is a metallic electrostatic control element, K, which is placed parallel to the electron stream. An essential characteristic of the tube is that the control element K is placed so that its field acts at right angles to the electron stream, for otherwise the valve becomes inoperative. It was the inability of other experimenters to recognize this all-important fact which caused their experiments to be unsuccessful. Other important factors contributing to stable operation are the spacing of the plate in respect to the filament, and the material of both.

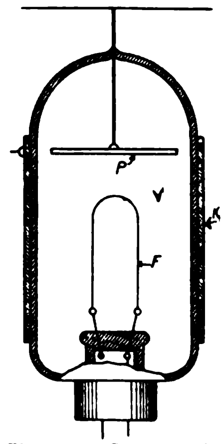


Figure 1—Cross section of the improved valve detector

Figure 2 shows an experimental type of the valve in which the plate P is a pointed piece of specially selected wire. In practice, the external element K may be plated on the glass, but it is not necessarily so attached. This tube has shown some remarkable operating characteristics, chief among them being its stability and sensitiveness as compared with previous types of bulbs. It may be employed in any of the well known circuits for cascade radio or audio frequency amplification, or regenerative amplification for damped or undamped wave reception.

A wiring diagram showing the use of the tube in a simple circuit is shown in figure 3 where the filament F as usual is heated by battery A-1 and the current regulated by the rheostat R-1. The plate circuit includes the battery, and telephone T shunted by a variable condenser C-4. The receiving transformer is indicated by the primary and secondary coils 1 and 2 respectively, with the loading inductance L-3, and the shunt condenser C-5.

In addition to the circuits generally employed in connection with three element oscillation valves, Mr. Weagant has developed the specialized circuits shown in figures 4, 5 and 6. The circuit in figure 4 can be made to generate oscillations in groups at frequencies above or below audibility and therefore can be employed for wireless reception by the beat phenomenon. In the circuit shown in figure 4 the vacuum of the tube is such that the application of 100 volts or less between the plate and filament will produce ionization. In later types of circuits a vacuum of a very high order is preferred.

An important addition to the figures 4, 5 and 6 is the use of a resistance in the plate circuit R-2 shunted by variable condenser C-3. When this resistance is of the order of that of the internal resistance of the tube, it enables the operator to obtain an adjustment so that minute electrical impulses impressed upon the tube cause a great increase in current through the telephone T. This resistance contributes materially, in tubes of low vacuum, in obtaining an adjustment whereby automatic interruption of the local plate current is secured, causing the valve to generate alternating currents in groups. The inductance 3 in figure 4 gives marked amplification of the incoming signals. By its use, the frequency of the plate circuit may be adjusted to correspond closely to that of the grid secondary circuit. Connected in this way, the valve generates sinusoidal oscillations with-

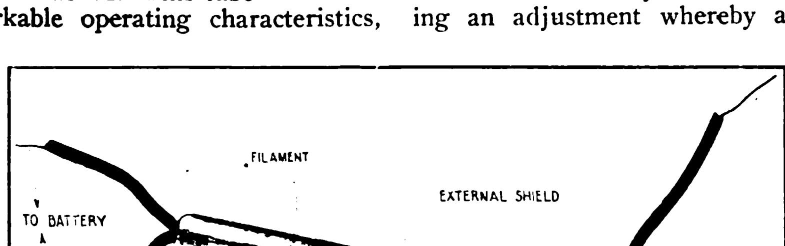


Figure 2—Experimental type of Weagant's oscillation valve

out depending upon ionization and the tube is therefore preferably highly exhausted. The more perfect the vacuum the better the results.

When the apparatus in these diagrams is employed for the reception of spark signals their circuits are adjusted just to the verge of oscillation, but for undamped waves, they are set into oscillation at frequencies slightly different from that of the incoming signal producing beat currents.

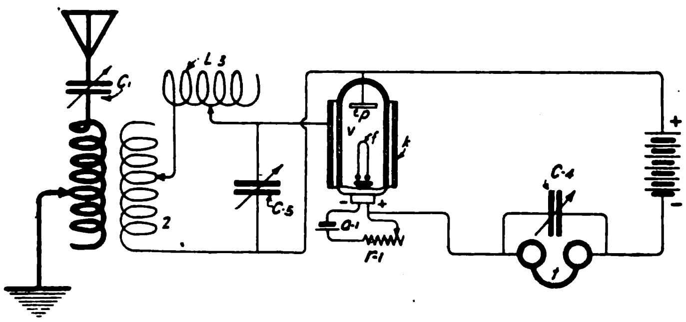


Figure 3—Simple circuit for the Weagant valve

An odd circuit devised by Weagant which is productive of good results is that shown in figure 5, where the antenna is coupled to the plate circuit rather than to the grid circuit. Coupling between the plate and secondary circuits is provided by the wire 10 tapped on to the coil 3. This circuit is applicable to the production of powerful oscillations for transmitting purposes. The modified circuit in figure 6 shows electrostatic coupling between the secondary and plate circuits through the medium of condensers.

Tubes of this type prove very efficient as generators of undamped oscillations for radio telegraphy or telephony.

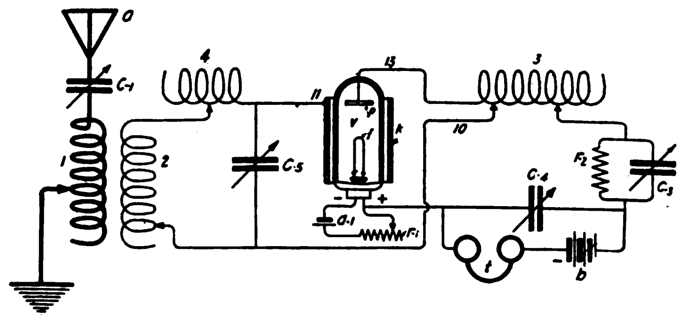


Figure 4—Circuit for damped or undamped wave reception

Tubes giving an output current of 50 watts have been constructed. They are found to operate continuously with great stability. A battery of such tubes may be connected in parallel with good results. Any of the circuits heretofore employed in connection with cascade amplification are thoroughly applicable to the improved valve with the external control element.

Very basic claims have been granted to the patentee. The specifications were filed April, 1915, and granted December 31, 1918. Extensive experiments were made previous to the filing of the application and it is therefore obvious that the work of Mr. Weagant antedates the experiments of all other investigators in this particular branch of radio. The scope of some of the claims may be understood from the following quotations:

"In a vacuum tube device, a vacuum chamber, two elements within said chamber, means for heating one of

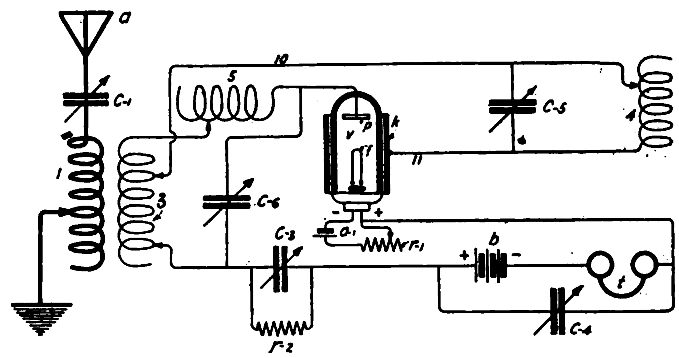


Figure 5—Circuit for transmitting or receiving purposes

said elements, means for producing an electron stream between said elements, an electrostatic control element outside said chamber, the field of force of the outside element being at an angle to the electron stream between the interior elements and the outside element being located near enough to the source or stream of electrons to usefully vary the space charge due to said stream.

"A radio frequency signaling device comprising a vacuum chamber containing two elements, means for heating one of said elements, and an electrostatic control element outside said chamber, the electrostatic field due to said control element being at an angle to the electron

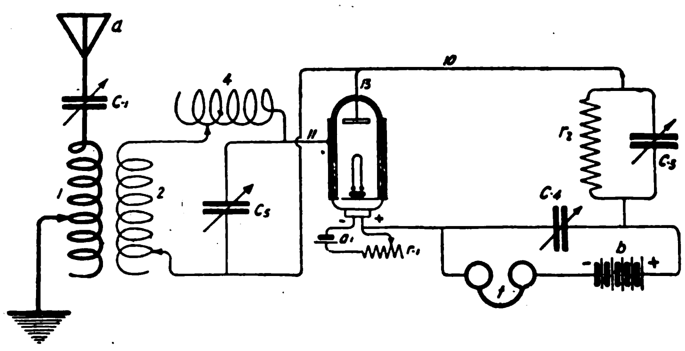


Figure 6—Simplified circuit for beat reception

stream within the vacuum chamber and thereby capable of producing useful variations therein.

"A radio frequency signaling device comprising a vacuum chamber containing means for producing a stream of electrons, and an electrostatic control element outside said chamber adapted to project a field of force into the space within the chamber at an angle to said stream of electrons."

Feature Article for the April Wireless Age

A Simple Four Valve Cascade Amplifier for Radio Reception

Practical Wireless Instruction

A Practical Course for Radio Operators

By Elmer E. Bucher

Director of Instruction, Marconi Institute

PART II—ARTICLE III

EDITOR'S NOTE—Part 1 of this series of lessons began in the May, 1917, issue of THE WIRELESS AGE. Successive installments were devoted to the fundamental actions of radio transmitting and receiving apparatus for the production and reception of damped oscillations.

Part 2, the present series, will deal with undamped wave generators, including bulb transmitters and receivers for the reception of undamped oscillations. The direction finder and other special appliances employed in radio telegraph work will be treated fundamentally. A discussion of the basic principles of wireless telephony will terminate the series.

The outstanding feature of the lessons has been the absence of cumbersome detail. The course will contain only the essentials required to obtain a government *first grade commercial license certificate* and to supply the knowledge necessary to become a first rate *radio mechanic.*

RADIO FREQUENCY CHANGERS

(1) In the two types of radio frequency alternators previously described—the Alexanderson and Goldschmidt machines—currents of the correct frequency for direct connection with the antenna circuit were generated within the machines, but in the system now to be described, a comparatively low frequency alternator is employed to generate the initial radio frequency current, the frequency being increased by means of **mono-inductive transformers** termed **radio frequency changers.**

(2) The principal advantage of the frequency changer system lies in the fact that since the initial frequency generated by the alternators is comparatively low, the generator armature may rotate at reduced speed, and the problem of design is accordingly simplified. Then by means of specially designed transformers, the frequency is increased to a suitable value for the various wave lengths employed in radiotelegraphy.

(3) The efficiency of the system decreases considerably as the number of steps is increased. But these transformers provide a fairly simple means for increasing the oscillation frequency, and permit a non-arcing control of the antenna currents—a desirable feature in high power transmitters.

(4) Various systems of frequency transformation have been devised, but it seems that the Joly-Arco or the Arco-Meissner systems are favored for commercial use, but they have not been widely adopted.

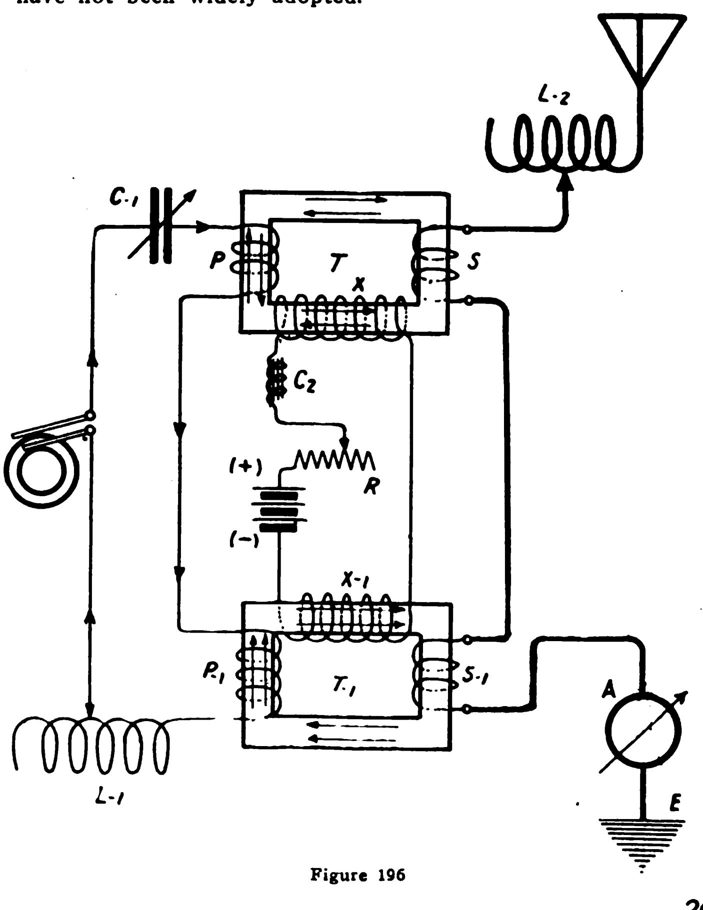


Figure 196

OBJECT OF THE DIAGRAM

To show the fundamental circuits of a single step radio frequency changer.

DESCRIPTION OF THE DRAWING

The radio frequency alternator to the left of the drawing generates at the frequency of 10,000 cycles per second. It is connected through the condenser C-1 and the inductance L-1 to the primaries P and P-1 of two radio frequency transformers T and T-1, respectively. Their secondaries S and S-1 are connected in series and in series with the antenna system comprising the loading inductance L-2, an aerial ammeter A and the earth connection E. Two DC excitation windings X and X-1 fed by a storage battery or DC generator are employed to saturate the cores of T and T-1. A regulating rheostat R enables close regulation of the core magnetism.

OPERATION

By proper disposition of the primaries P and P-1 and keeping in mind that the cores of T and T-1 are fully saturated by the DC winding, it is evident that **the transformer cores act inductively upon the secondary only when the current through their primaries flows in a certain direction.** For when the flux generated by the primary winding P-1, for a complete half cycle of the radio frequency current from the alternator, flows in the same direction as the flux supplied by the DC excitation winding, there is practically no increase in the core magnetism and consequently no effect upon the secondary winding S-1. But at the same time the flux generated by the primary winding P opposes the flux in the core T and a peaked reduction of magnetization takes place as will be shown in figure 201. **This reduction of flux followed by subsequent increase to the normal degree of saturation (which occurs upon the termination of the half cycle) induces a cycle of current in the secondary winding S.** For the next half cycle from the radio frequency alternator, transformer T-1 becomes active and transformer T inactive. **Therefore, for every complete cycle fed to the transformers by the radio frequency alternator, two complete cycles are induced in the antenna system.** The antenna frequency of a 10,000 cycle alternator will be 20,000 per second corresponding to the wave length of 15,000 meters.

SPECIAL REMARKS

(1) Each transformer in the frequency changing system comprises an annular or rectangular closed **iron yoke** composed of **thin laminated iron sheets** so constructed that each part is seamless and has the form of the complete yoke. The thickness of the sheet decreases with increase of frequency.

(2) The variation of flux generated by the alternator has a tendency to induce high voltages in the excitation windings fed by the DC dynamo. To reduce these E.M.F.'s to a safe value, the excitation coils are divided into groups connected in parallel. A DC excitation generator of low voltage is then employed.

(3) Maximum efficiency is secured from frequency changers when the effective number of ampere turns for the radio frequency winding is approximately equal to the ampere turns of the DC winding. The former should not exceed the latter by more than 20 per cent.

(4) Magnetic leakage must be reduced to a minimum, likewise the iron and copper losses. The windings must be uniformly placed over the whole length of the yokes and in case of very large powers, the iron yoke should be constructed of individual insulated packs of sheet metal with intervening air spaces. The transformer is then submerged in oil which is forced between the windings and the packs of sheet metal.

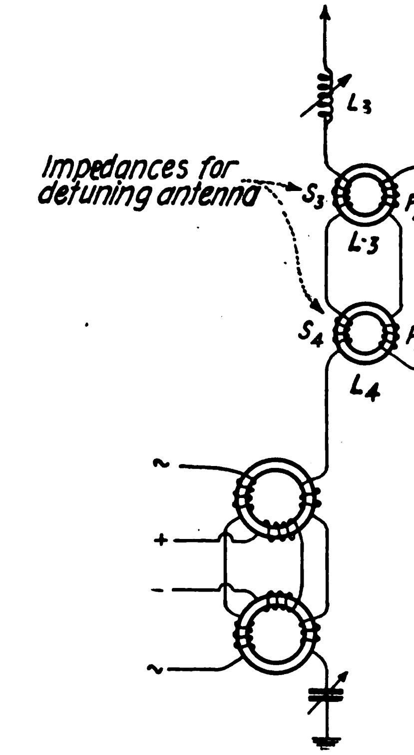


Figure 197—Method of controlling the antenna current, suggested by Arco and Meissner. One way impedances L-3 and L-4 have their secondaries connected in series with the antenna. Their primaries P-2 and P-4 are connected to the direct current source B which also includes the resistance R and the shunting key K. By proper adjustment of the DC magnetising current through P-2 and P-4, the self-induction of the windings S-3 and S-4 may be made to vary greatly simply by change of flux through the iron. Hence, the electrical constants of the antenna circuit can be so selected that when the key K is closed, the self-induction of S-3 and S-4 is reduced by such an amount as to place the complete antenna system in resonance with the last group of radio frequency changers. But one secondary winding is active in impeding the antenna current for a half cycle, that is, the winding S-3 impedes one half cycle and the winding S-4 the following half cycle.

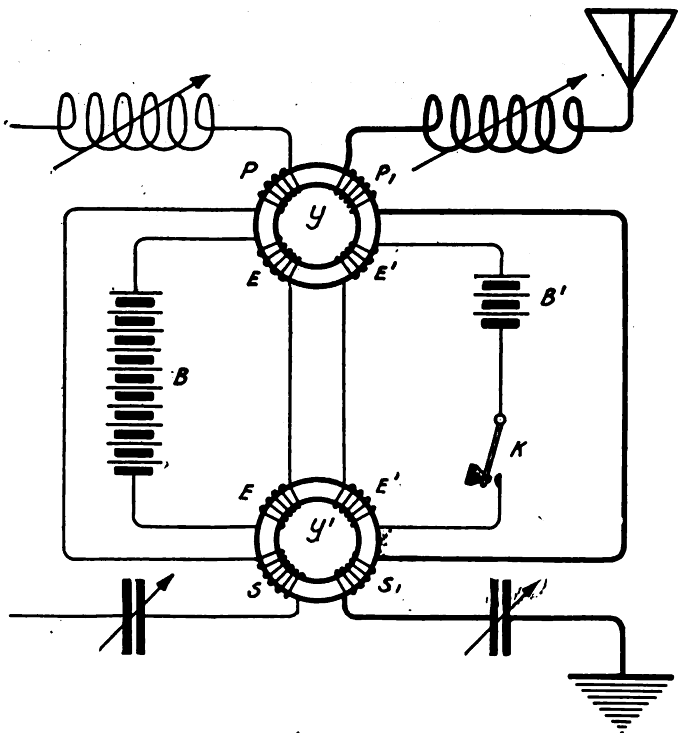


Figure 198—Divided control circuit of the Arco-Meissner system in which the cores of the last step of radio frequency changers are partially saturated by the DC excitation windings E, E, fed by the battery B. The coils E', E', provide the additional magnetising force required to saturate the core or to control the flux in the yokes Y and Y-1 in accordance with any particular set of requirements. The key, K, may be replaced by a magnetic interrupter for producing tone frequency signals or a battery of microphones for speech transmission may be placed in the same circuit to vary the antenna currents at speech frequencies.

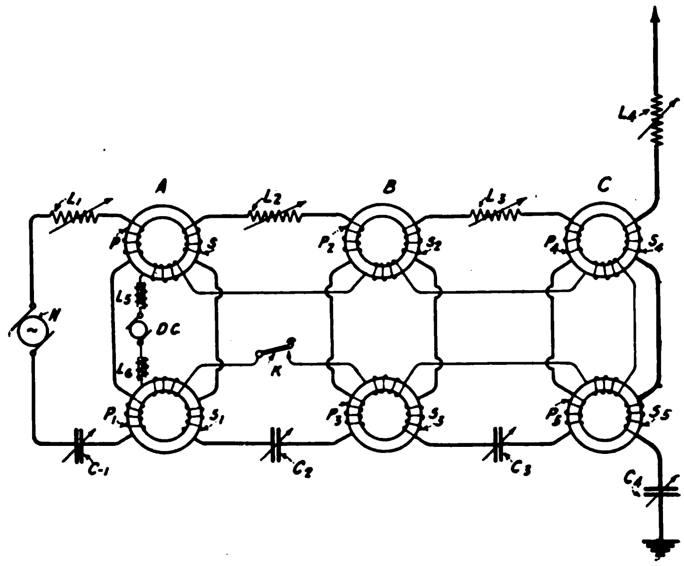


Figure 199

OBJECT OF THE DIAGRAM

To show the circuits of a three-step radio frequency changer system.

DESCRIPTION OF THE DRAWING

Three groups of **frequency transformers** A, B and C are connected in cascade. They are fed from a direct current source marked DC which through their excitation windings **saturate** the cores. The inductances L-5 and L-6 serve to prevent the flow of radio frequency currents back to the DC generator. The primaries of group A are connected to the radio frequency alternator N as usual. Secondaries S and S-1 of group A are connected to the primaries P-2 and P-3 of group B. Similarly, the secondaries of group B are connected to the primaries of group C. The secondaries of group C are connected to the antenna system.

The intermediate circuits of the transformers A, B and C are tuned to the requisite oscillation frequency by inductances L-2, L-3 and condensers C-2, C-3. A key K is inserted in the DC excitation circuit for signaling purposes.

OPERATION

If the frequency of the alternator N is 10,000 per second, a frequency of 20,000 will be developed in the secondary of group A which will be increased to 40,000 in the secondary of group B and to 80,000 in the secondary of group C. The antenna is carefully tuned to the latter frequency which corresponds to the wave length of 3,750 meters. The operation of this method is no different than that explained in connection with figure 196 except that three steps are connected in cascade. Resonance with the alternator frequency is obtained by the variable inductance L and variable condenser C-1, that is, the complete circuit N, L-1, P, P-1, C-1 is made resonant to the alternator frequency. Similarly the circuit S, L-2, P-2, P-3, C-2, S-1 is made resonant to frequency of 20,000 cycles, and the circuit S-2, L-3, P-4, P-5, C-3, S-3 to the frequency of 40,000 cycles. The antenna system is tuned to resonance with the last named frequency by the variable inductance L-4 and variable condenser C-4.

SPECIAL REMARKS

(1) To simplify the process of tuning, Arco and Meissner have shown a circuit wherein variable resistances are included in the radio frequency circuits to **decrease the sharpness of resonance.** After the resonance adjustments are roughly made the resistances are cut out until maximum resonance is secured.

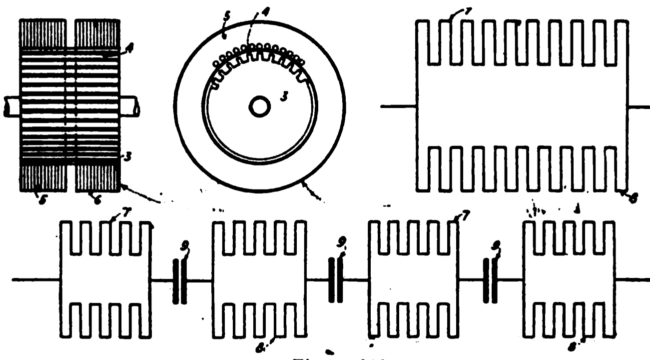


Figure 200

OBJECT OF THE DIAGRAM

To show the constructional details of the Arco-Meissner radio frequency alternator.

DESCRIPTION OF THE DRAWING

The rotor indicated at 3 consists of a **toothed wheel without windings** driven at a very high speed. The poles which are formed at the teeth are of equal polarity and the **generation of radio frequency currents** is secured by **undulations of flux** and not by a reversal which is the case of an ordinary alternator.

It has been found to contribute to the efficiency of the generator to divide the generator systematically in the middle at right angles to the rotor axis so that equal stator halves 5 and 6 are obtained.

As shown in the detail in the upper right hand corner, the windings of the two winding halves 7 and 8 are preferably arranged in parallel in order to reduce the self-induction of the generator and to keep the voltages developed by resonance within a safe value. In order to reduce further the difficulties of insulation due to high voltages, **each stator half in generators of high power is divided into an equal number of sections** and the two corresponding sections of the two armature halves are in each case arranged in parallel as a group as shown in the lower part of the drawing.

The resulting groups are preferably arranged in series with condensers 9 placed between each group. This arrangement reduces materially the equalizing currents which occur in the parallel arrangement of the armature halves due to **slight inequalities of the winding. By this design the voltage between the entire windings and the stator is no greater than the voltage between an individual partial winding and the stator.**

In generators of large power, means are provided for conducting cooling water through the iron of the stator.

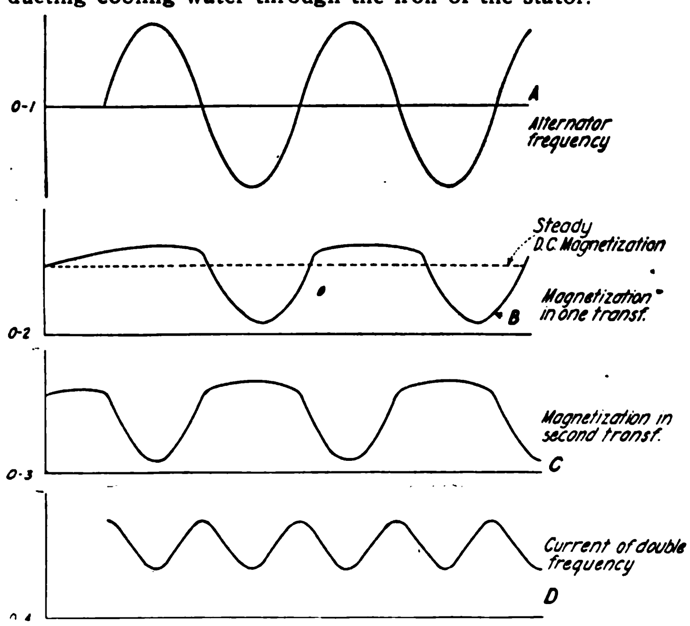


Figure 201—Series of curves showing graphically the phenomena involved in the induction of currents in the frequency changer system in figure 196. Graph O-1 indicates the alternator frequency and the dotted line in graph O-2 the steady DC magnetization in the cores. The curve B in graph O-2 shows the magnetization for a half cycle in one transformer and the curve C of the graph O-3 the magnetization in the second transformer. When the flux generated by the radio frequency current has the same direction as that in the DC excitation winding, the core magnetism is slightly increased, but when these fluxes oppose, a large reduction occurs which induces currents of double frequency in the secondary winding. This current is shown in the graph O-4.

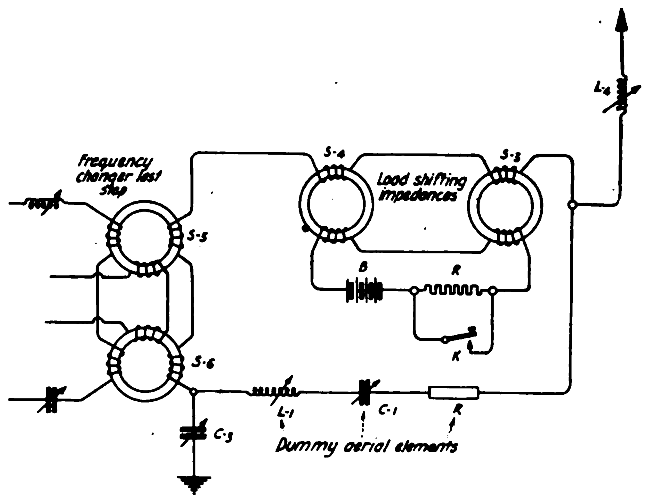


Figure 202

OBJECT OF THE DIAGRAM

To indicate the circuits of a load shifting device whereby the output of a radio frequency alternator is alternately shifted from the antenna circuit to a dummy aerial circuit during a signaling period.

PRINCIPLE

Detuning of the antenna circuit would, in the ordinary system, take the load off the radio frequency alternator whenever the signaling key is open. This may cause the alternator to increase its speed to such a value that it will be out of resonance with the antenna circuit, but if the load is shifted to an artificial antenna circuit during the non-radiating periods of the antenna circuit, the speed and output of the alternator remain constant.

DESCRIPTION OF THE DRAWING

The load shifting impedances are indicated at S-4 and S-3 which perform the same function as those indicated in figure 197. There is shunted around these impedances **an artificial aerial circuit,** including the inductance L-2, the variable condenser C-1 and the ballast resistance R.

OPERATION

The inductances and capacities of the antenna system and of the dummy aerial circuit are selected so that when the key K is closed, the **self-induction of S-4 and S-3 are reduced by an amount that will place the antenna system in resonance with the radio frequency changers.** Simultaneously the reduction of the self-induction of S-4 and S-3 detunes the artificial aerial circuit permitting the normal flow of antenna current. When the key K is raised, the reverse operation takes place, the load circuit being placed in resonance with the radio frequency changers and the antenna detuned.

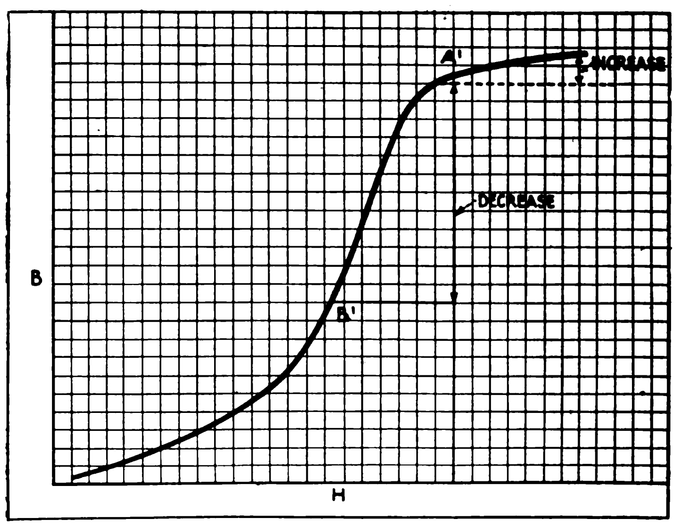


Figure 203—Characteristic magnetization curve of transformer core. H represents the ampere turns of the DC winding, and B the resulting flux through the core. Point A' called the "knee" of the curve, is approximately the point of saturation. It is clear from the curve that if the flux of an alternating current is superimposed upon DC flux (while the DC magnetization is adjusted to the point A'), one half cycle of the alternating flux will cause a slight increase in the total core flux and the next half cycle a marked decrease.

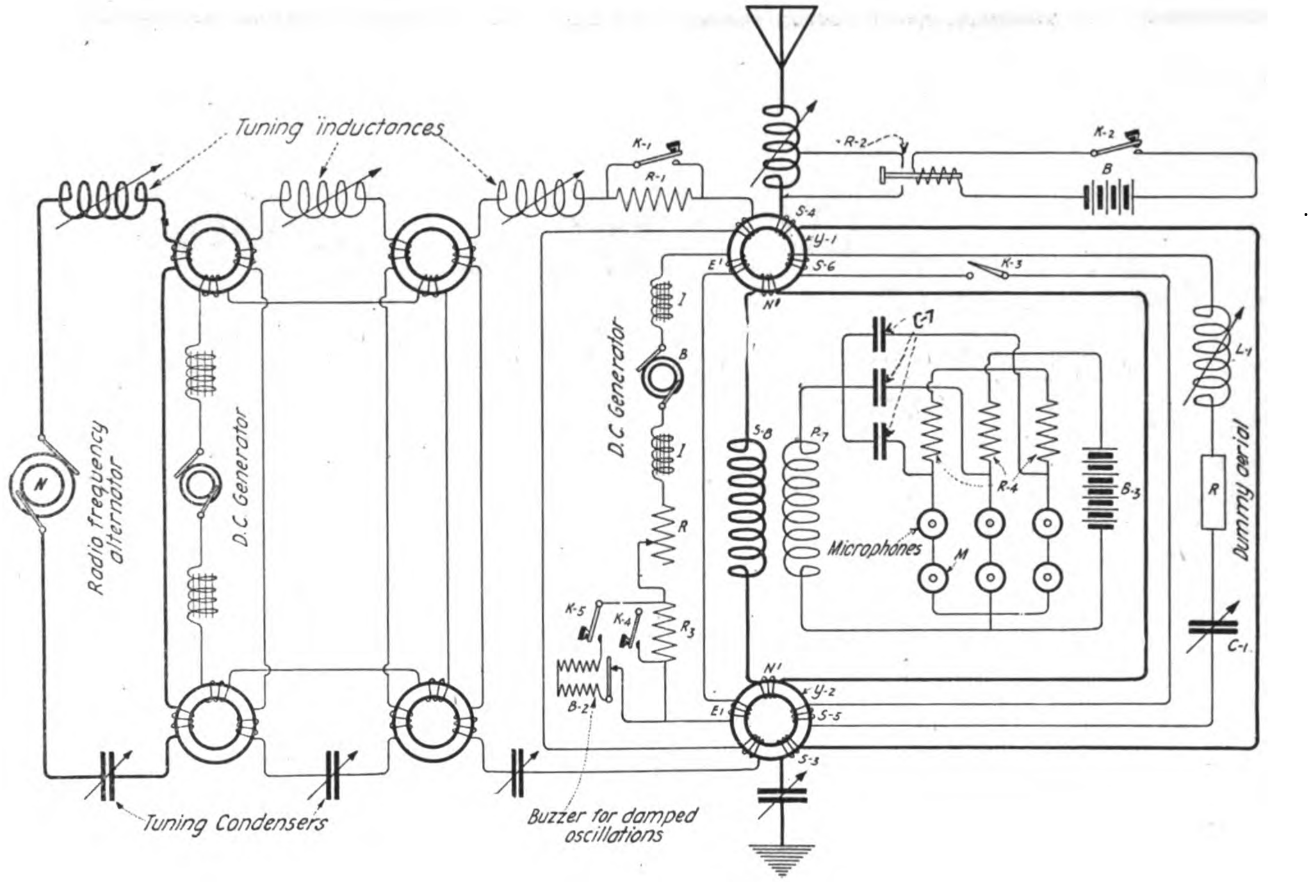


Figure 204

OBJECT OF THE DIAGRAM

To indicate the complete circuits of the radio frequency changer transmitting system for telegraphing by damped or undamped oscillations, or for wireless telephony.

DESCRIPTION OF THE DRAWING

The radio frequency alternator N is connected to the primary circuit of a three-stage radio frequency changer system, the last state being fitted with special circuits for **control of the antenna currents at speech frequencies, for the production of tone frequencies (damped oscillations), for telegraphy by undamped oscillations, and a special artificial aerial for maintaining a constant load on the generator.**

The cores of the first two groups of radio frequency changers are saturated by one DC generator and the cores of the last group by a second DC generator indicated at B which is protected from radio frequency currents by the iron core chokes I, I. A regulating resistance R is included in series to adjust the magnetism of the cores of the last group.

Several methods of signaling are provided, for example, **telegraphy by damped oscillations** may be accomplished by the key K-4 shunting resistance R-3, or for the **production of tone frequencies** the key K-5 and buzzer B-2 are employed. For **speech transmission** the microphones M coupled to the audio frequency transformer P-7, S-8 are employed to vary the magnetism of the cores of the last group. **Telegraphy by undamped oscillations** again may be accomplished by the key K-2 which operates the relay R-2 and in case of high powers the keys K-1 and K-2 are operated in unison to prevent the development of disastrous voltages in the circuits. An artificial aerial is also provided to maintain a constant load on the generator, that is, the key K-3 may be closed and when key K-4 is operated for signaling, the generator output is automatically shifted from the antenna to the artificial aerial. The artificial antenna circuit includes the key K-3, winding S-6, variable inductance L-1, the load R, variable condenser C-1 and the winding S-5.

OPERATION

As usual the frequency of the alternator N, through the three steps of frequency transformation, is increased four times, that is, if the alternator frequency is 10,000 per second, the antenna current will be 80,000 per second.

The alternator circuit and the intermediate circuits of the frequency changers are tuned by the variable condensers and inductances as heretofore explained.

In case of low powers, telegraphy by undamped oscillations may be effected by closing the key K-2 which operates the relay R-2, the latter shunting a portion of the aerial tuning inductance to place the antenna system out of resonance with the alternator. The key K-1 shunting resistance R-1 is worked in unison with the key K-2 to prevent the development of high voltages in the radio frequency changers. Thus, when the antenna is detuned the sudden insertion of the resistance R-1 prevents the phase shifting of the current and voltage from generating disastrous voltages.

For large power outputs the key K-4 may be employed to saturate and de-saturate the yokes of the last group of radio frequency changers. For the production of damped oscillations a buzzer B-2 in series with the key K-5 shunts R-3 and the resulting changes of flux through the yokes is sufficient to modulate the antenna currents at audio frequencies. The radiated energy is then of the proper characteristic for reception by oscillation detectors suitable to damped oscillations only.

For **speech transmission,** the microphones M are connected to their source B-3 and the resulting changes of current are made to act upon the primary P-7 through the condensers C-7. The speech currents induced in S-8 vary the magnetization of the core sufficiently to modulate greatly the output or antenna current. Two microphones are connected in series and three such sets are connected in parallel. Each microphone group is shunted by winding P-7 of the telephone transformer and each branch includes one of the condensers C-7. The operation of the microphone control is as follows: Whenever microphone resistance increases, the current through its series resistance remains nearly constant, but the current through the microphone diminishes. The excess current therefrom flows through the primary winding P-7 and the corresponding condenser.

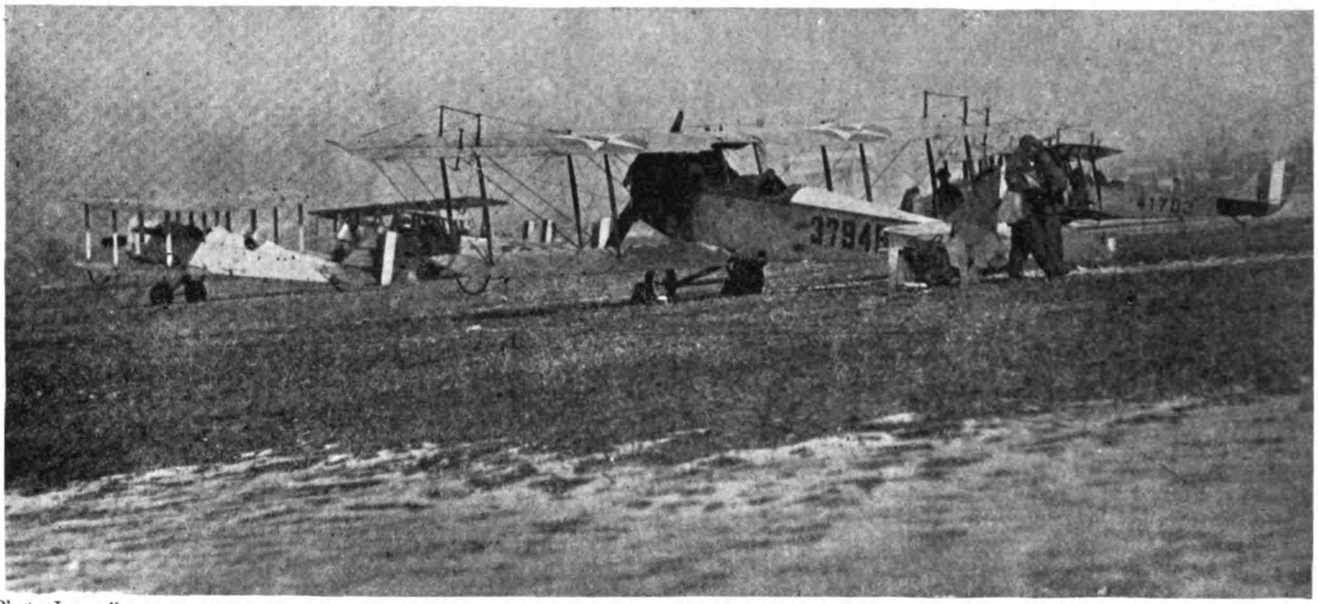


Photo Intern'l

Above: the finish of a coast to coast flight showing four U. S. Army airplanes which flew from San Diego, Cal., to Mineola, near New York City, for the purpose of mapping out a transcontinental aerial mail route; the distance covered was 4,200 miles in 53 flying hours

To the right: listeners of the British Navy using one of the inventions developed during the war which made possible the faculty of hearing the approach of submarines

Below: Capt. R. W. Schroeder, U. S. A., wearing the oxygen helmet necessary in making his altitude flight to 28,900 feet above sea level

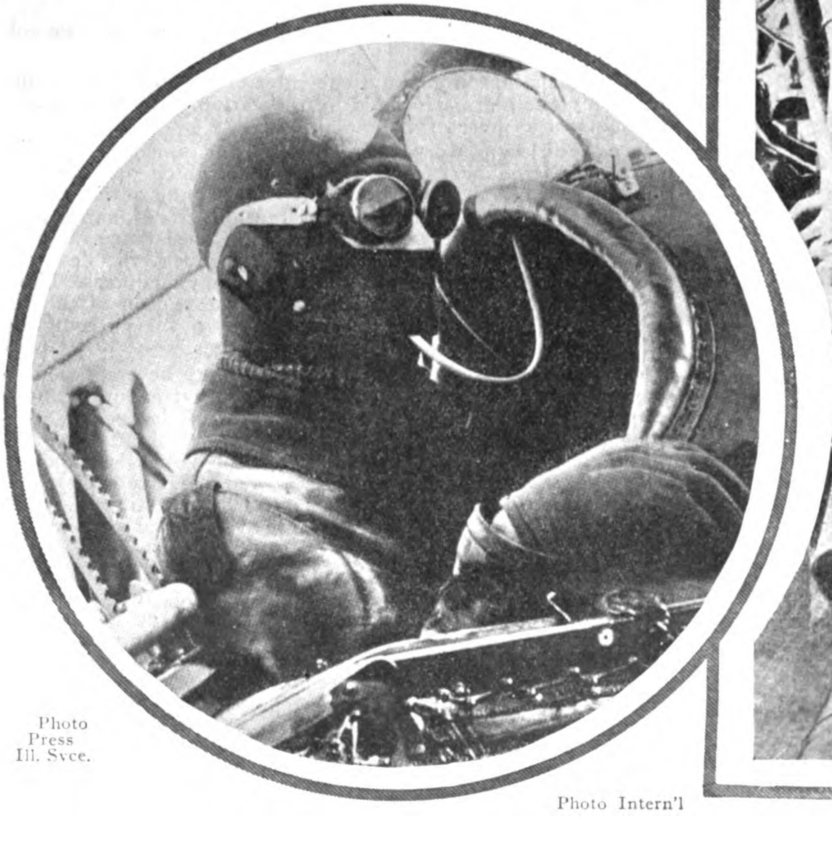


Photo Press Ill. Svce.

Photo Intern'l

The Monthly Service Bulletin of the
NATIONAL WIRELESS ASSOCIATION

Founded to promote the best interests of radio communication among wireless amateurs in America

The Amateurs' Services Have Been Invaluable To Our Country

I SEE no reason whatsoever why the Government should not permit amateur stations to re-open immediately.

In modern warfare wireless plays an important part on land, water and air. One can say that it forms the nucleus of efficient warfare. Therefore, when war was declared by the United States against Germany, and the army and navy was put on a war basis, very many positions, requiring a knowledge of wireless telegraphy were automatically opened.

To teach men the rudiments of wireless telegraphy would require time. So the United States turned her gaze upon the many amateurs in the wireless telegraph field and called upon them to help her out of the predicament. The amateurs responded nobly to the call. Many of them have given the supreme sacrifice. But they were glad to give it for they gave it for the United States—the land of liberty and justice.

To fail to recognize the right of amateurs, earned by bloodshed and death, to immediately have their stations opened would make many fellows feel that their country, the land of freedom, was not treating them fairly and living up to its name. And this would be a calamity.

Why not open up the amateur stations and show that our Government realizes that the boys of the "dots and dashes" did their bit and did it *nobly*.

JOHN KULIK—*New Jersey*.

A Reason for Re-opening Amateur Stations

WITHOUT the help of some thousands of radio enthusiasts the task of efficiently training the necessary personnel to man our ships and furnish the Signal Corps with proficient radio operators or electricians would have been an impossibility, particularly if we consider the demand for men and the lack of facilities for their immediate training.

I can state emphatically from my own experience that the former radio amateur was more easily trained into a proficient operator than his running partner, the telegraph operator.

The help which was so quickly forthcoming from the radio amateur should be sufficient to convince the Government that to permit amateur stations to re-open, will in itself, constitute an indirect expression of their appreciation of the amateur's good services.

HENRY E. BARTON—*New York*

Plan for Organization Indorsed

To the Editor:

Mr. Batcher's plan in the February issue for organizing the amateur interests by states is a splendid idea, in fact it seems to present a great similarity to the plan I have in mind for the organization of amateurs of the state.

My plan would be to divide the state in about four sections, each section to have its board of directors and jurisdiction in that vicinity only; to have also a state board of directors, allow each district to furnish the necessary officers for the board, as President, Sec'y.-Treas., Corresp. Sec'y., and Publicity Sec'y.

If the state has four districts, the necessary officers for the state board of direction can be alternately furnished by each district. The state to have a national representative, this member to be chosen by the state council from amateurs within the state. Of course, to begin with, the organization must be incorporated within its state, also must have sufficient funds and working capital for bulletins, etc.

It seems to me that too many local bodies would be as much of a failure as having one too large, but I think that most any state organized into four districts would make in a majority of cases, a local body with lots of pep and stamina; but it may look too large, if one stops to consider that a number of towns do not possess any amateurs whatever.

Our one big blow! Can we find our Philanthropist of the art of radio science? Of course, some of the expenses can be met by dues from the membership, the exact amount being governed by the class of membership held.

I certainly agree with Mr. Batcher that amateur bodies must be formed, so as to be perfected on the resumption of the amateur privilege.

L. N. WAY, *Michigan.*

Why Not Recognize Our Constitutional Rights?

EVERYONE who is personally familiar with radio in all its phases, knows many reasons which would justify the re-opening of amateur stations upon the conclusion of peace. Among these are the services rendered by the so-called "amateurs" in the war, the development of radio resulting from investigation conducted by amateurs, the supply of radio operators for national defence in the future, the wholesome effect upon boys and young men exercised by the study of the art, the employment of capital and labor manufacturing apparatus, and many others.

These reasons have been often cited, and as I remarked above, any one of them would more than justify again opening the amateur stations, but these reasons are all based upon the insecure argument of expediency, while there is another that is more basic and rests upon the secure foundation of principle; it is that we live under a government "Of the people, by the people, and for the people"—nothing less.

Now if our principles as a nation recognized "Government of the people, by the Government," or "Government of the people by the Navy," the permanent closing of amateur radio stations might be legal and proper, but as we live under a government "of the people, by the people, and for the people," it is not, and the stations must therefore be re-opened.

In war, drastic powers are necessarily delegated to the various departments of the Government, but in peace it is different, and we should not for one moment forget that the army and navy exist only to defend the people and enforce their will, and not to rule them and devise regulations for their conduct. This is the first principle of our country, and should be indelibly stamped in the heart of every American.

All this being true, the most important reason why the amateur radio stations should be re-opened is because the amateurs *want* them re-opened, and have a *right* to have them re-opened.

JOHN V. PURSSELL—*Washington, D. C.*

The Fire Underwriters' Rules Applied to Amateur Stations

AMATEUR wireless apparatus often is not installed in accordance with the Underwriters' rules and in a few cases the violations are so serious that it constitutes a fire hazard. As a rule, radio amateurs are willing to adopt any changes which are suggested to them that will better their stations if it is within their means, but the conditions necessary for safe and satisfactory service from their power wiring, are only vaguely understood. It is the purpose of this article to point out the advisability of modifying the installation to conform to the Underwriters' rules, and the method of doing so. If the suggestions are acted upon, the fire risk will be materially reduced.

In many amateur stations the circuits supplying current for the high voltage transformer of the experimental radio transmitter are given little or no attention, and consequently the majority of stations are not as perfect as they might be in this respect. The wiring is sometimes installed in a slipshod fashion from a miscellaneous assortment of material that is unsuited for the purpose. Improper insulation of conductors from each other and surrounding objects, insufficient carrying capacity of conductors, absence of proper protective devices and overloading of circuits are the main shortcomings. It is not uncommon to find wiring that could hardly be considered of sufficient current carrying capacity for battery current, supplying a 1 kw. transformer and a rotary gap besides. The service rendered by such poor construction is usually very unsatisfactory, causing excessive drop in voltage at the transformer terminals, blinking of lights and other annoyances, not to mention the fire hazard sometimes incurred.

In planning the reconstruction of his station, the progressive experimenter should give this subject due consideration and take steps to remedy any defects that may exist in the circuits of his power supply. Of course the chief consideration regarding the installation is that it shall comply as nearly as possible with the rules of the Fire Underwriters, and if these conditions are met even half way a comparatively safe and satisfactory condition will obtain.

If your transformer is of 1 kw. it would be well to first ascertain whether or not the house meter has sufficient capacity to carry the full load plus that of the rotary gap and about half the house lighting load simultaneously. This precaution may save an extended argument with the power company or perhaps the price of a new meter. It is the general practice to install only a 5 ampere meter in residences, since they can stand a 100 per cent overload. It is always good policy to notify the electric company of your new load, and if they do not believe it to be necessary to change the meter, it becomes their risk and if the meter is burnt out it is their loss. I mention this because I had to "kill" two meters before the local electric company consented to installing one of increased capacity. No doubt other experimenters have had their troubles in this respect.

If the transformer is on an upper floor of the house, some distance from the meter, it is usually the practice to tap into a convenient fixture or base board receptacle, or else run a short feed which is tapped onto the lighting circuit wires at some point in the room. This should not be done since it is forbidden by the Fire Underwriters. The wiring of the average house is seldom larger than No. 14 B. & S. and in the fixtures it is usually No. 16 or No. 18 B. & S. The voltage at the transformer terminals will be low, and all lamps on that circuit or on the same feeding wires will flicker badly. Choke coils and other paraphernalia are usually resorted to in an effort to prevent this, but they can never be of great value so long as the current is taken from the fixtures. Furthermore no lighting circuit is supposed to carry more than 660 watts, so it is evident that the only method sanctioned by the Underwriters is to run a separate pair of feed wires of proper size to carry the current without excessive drop in voltage, from the meter direct to the transformer terminals. There should be an individual fuse block for these feed wires mounted either at the meter or else in the radio room where it would perhaps be handiest to replace a blown fuse without going down to the cellar while you tell the other fellow to stand by. This usually is done by the light of a candle, as the house lights are out as well.

It will be found a good investment to run separate feeds, as you have done the right thing by the Underwriters, the lights will not flicker and the lights in the house will not go out every time you blow a fuse. This will give the home folks a vastly better opinion of "wireless." The size of these feeds will be governed by several factors; the current in amperes taken by this transformer, the distance of the transformer from the meter, and the loss in volts that is permissible in carrying the current this distance. The formula for finding the size of wire is:—

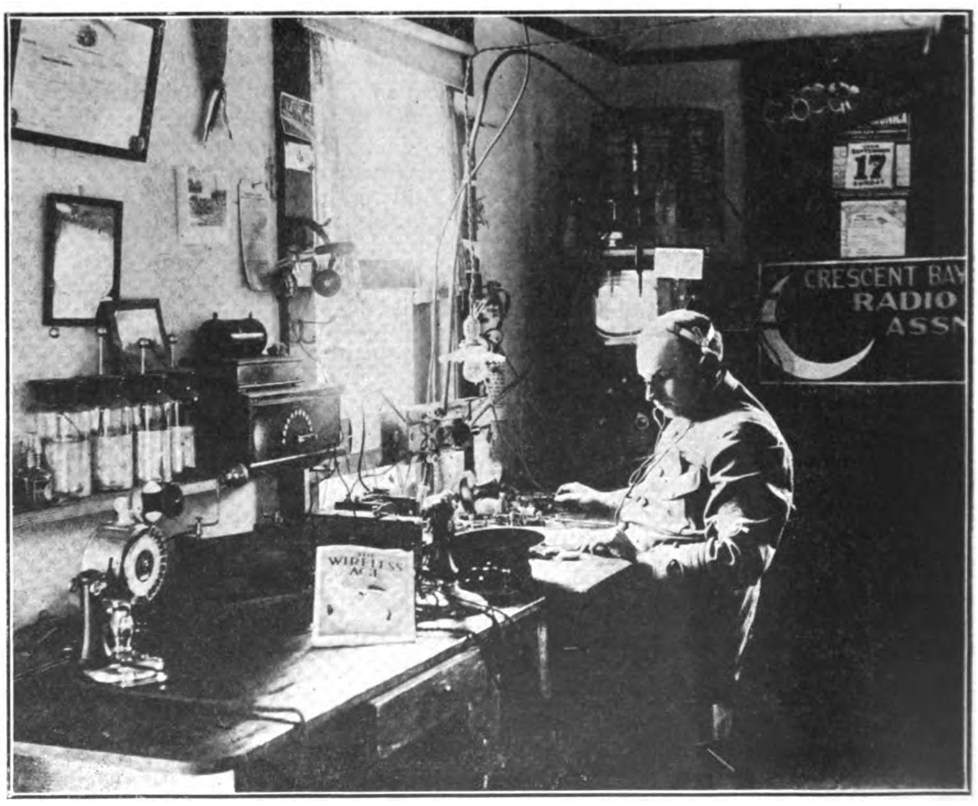
$$d^2 = \frac{10.8LI}{e}$$

and for finding the drop in volts is:

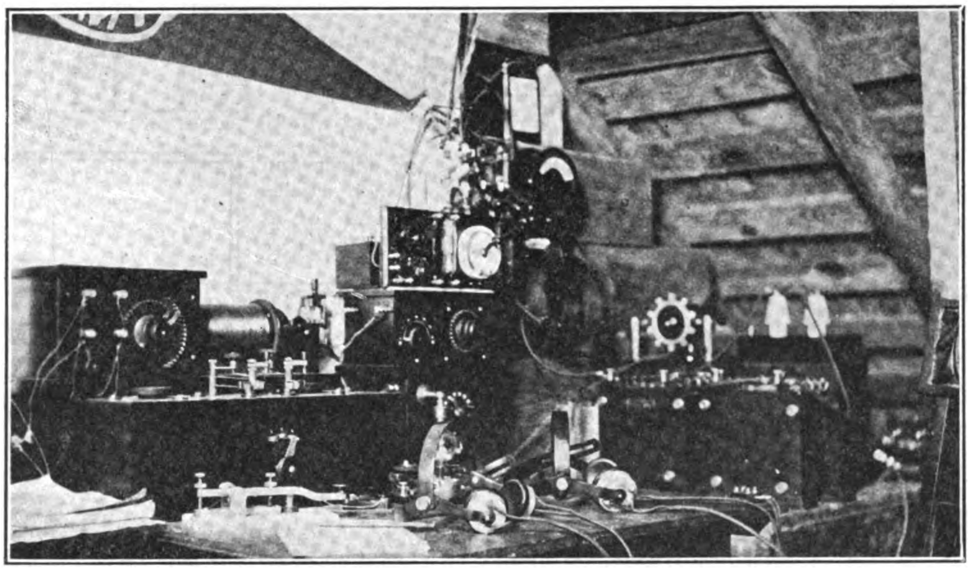
$$e = \frac{10.8\,L\,I}{d^2}$$

in which d^2 is the area of wire in circular mils. 10.8 is a constant, "L" is the length of circuit in feet, "I" is the current in amperes, and "e" is the drop in volts.

We have, for example, a transform-



Station of the Crescent Bay Radio Association at Santa Monica, Cal., where consideration has been given to fire regulations



This station located near the Mexican border and belonging to D. H. Graham of House, Texas, could probably be improved by a more rigid observance of fire rules

er rated at 1 kw. located on the second floor of the house, and the meter is in the basement. First determine the path your wires will follow between the two points, then determine the length of wire necessary to follow this path one way. Let us say this is 75 feet. This sum doubled is substituted for "L" in the formula. Assuming that the current drawn by the transformer when operated at maximum load is about 10.5 amperes and that we have a rotary gap motor which takes 1.5 amperes, then the total load will be 12 amperes and this is substituted for "I." Now we must determine the permissible drop in potential for the value "e." The voltage at meter terminals is usually about 115 volts, sometimes a few volts higher or lower. As it is very desirable to have the voltage at the transformer terminals as high as possible, only a very small drop should be tolerated, not more than 2 volts at any rate. Suppose we use 2 volts for the value of "e." Substituting these values and solving we have

$$d^2 = \frac{10.8 \times 150 \times 12}{2}$$

or $d^2 = 9.720$ circular mils. Referring to a table of wire dimensions we find that the size of wire which most nearly approaches our result is No. 10, and this should be used. Although this would satisfy conditions, it would be still better to keep the drop down to about 1 volt, and use a larger size of wire.

If it is desired to determine the drop in potential in an existing circuit the second formula may be used. A partial table of wire sizes covering those that are most likely to be used by the experimenter, together with those rules of the Fire Underwriters' from the 1919 code, class E, section 86, that deal with wireless telegraph apparatus, will be found at the end of this article.

In regard to the actual work of installing the feed lines; if you live in a town where it is necessary to have all electrical work done by licensed contractors, or if you do not feel capable of doing the work properly, it is best to have it done by an experienced wireman according to your specifications. If flexible armored cable is employed to protect the wires, it will conform to the Underwriters' rules and will be found very easy to install. It can be run either exposed or concealed under the floor and in partitions. The only thing that requires care is in stripping the armor to make connections, this being done by nicking it with a hack saw and bending back and forth until it breaks; then it can be slipped off. It is necessary to be very careful so that the wires or insulation will not be damaged. A condulet or other end fitting will be necessary at each end of the cable. Any wire supply store will gladly show you how to strip the cable and attach the fittings. The fuse block should be an ordinary two wire branch block for screw fuses, costing only a few cents. The new feeders should be tapped directly onto the wires from the meter that connect to the other fuse blocks for house lighting. While doing this the main switch should be opened so that these wires will be dead. All connections should be well soldered and taped. A ground wire of any kind of insulated wire of a size equal to that in the cable should be connected to the steel armor of the cable and then connected to a water pipe or other good ground. If these directions are closely followed, the radio experimenter of average ability should have no trouble in making a satisfactory installation, but he should make doubly sure that everything is O.K. by having an experienced man go over his work.

One other thing requiring attention is the provision of means to protect the house wiring from high potential surges or "kick back" from the transformer. There are a good many types of kick-back preventers; the electrolytic, needle gap, high resistance shunt of graphite rods, or large capacity condensers, etc. Probably the two best methods are the shunt condensers or the shunt resistance rods. Although the Underwriters' rules specify the condenser type of protection the high resistance shunt is used in commercial installations and is entirely satisfactory. In a future issue a full description will be given of a combined "kick-back" preventer and switch panel for experimental radio stations that is very neat and convenient and also not very difficult to construct. There are several types of this device on the market if one desires to purchase, instead of constructing it.

"Abstract from Regulations of the National Board of Fire Underwriters, Class E, Section 86, Wireless Telegraph Apparatus."

Note.—These rules do not apply to wireless telegraph apparatus installed on shipboard.

In setting up wireless telegraph apparatus (so called) all wiring pertaining thereto must conform to the general requirements of this code for the class of work installed and the following additional specifications:

a. Aerial supports to be constructed and installed in a strong and durable manner, and aerial conductors, with wires leading from same to ground switch, must be supported on approved insulators, and these conductors to be kept at a distance of not less than six inches from the building, except where entering same through approved non-combustible, non-absorptive insulators.

b. Aerial conductors to be permanently and effectively grounded at all times when station is not in operation by a conductor not smaller than No. 6 B. & S. gage copper wire run in as direct a line as possible to water pipe on the street side of all connections to said water pipe within the premises, or to some other equally satisfactory earth connection or to such other ground as may be allowed by special permission in writing.

c. Or the aerial to be permanently connected at all times to earth in the manner specified above, through a short-gap lightning arrester said arrester to have a gap of not over 0.015 inch between brass or copper plates not less than 2½ inches in length parallel to the gap and 1½ inches the other way, with a thickness of not less than one-eighth inch mounted upon non-combustible, non-absorptive insulating material of such dimensions as to give ample strength. Other approved arresters of equally low resistance and equally substantial construction may be used.

d. In cases where the aerial is grounded as specified in section b, the switch employed to join the aerial to the ground connection shall not be smaller than a standard 100 ampere knife switch.

e. Where supply is obtained direct from the street service the circuit must be installed in approved metal conduits or armored cable. In order to protect the supply system from high potential surges, there must be inserted in the circuit either a transformer having a ratio which will have a potential on the secondary leads not to exceed 550 volts, or two condensers in series across the line.

f. Transformers, voltage reducers or similar devices must be of approved type.

Wires for Interiors of Buildings
(National Code Standard)

B. & S. Gauge Number	Circular Mils	—Carrying Capacity— Rubber-covered Wires Amperes	Weather-proof Wires Amperes
18	1,624	3	5
16	2,583	6	8
14	4,107	12	16
12	6,530	17	23
10	10,380	24	32
8	16,510	33	46
6	26,250	46	65
5	33,100	54	77
4	41,740	65	92

J. A. WEVER, *Maryland.*

EXPERIMENTERS' WORLD

EXPERIMENTERS are urged to submit manuscripts covering the design and construction of all types of wireless apparatus for amateur use. Such articles will receive immediate consideration and those published will be paid for at regular space rates. The scope of this department is constantly enlarging.

Technical Advice to the Experimenter

By E. T. Jones.

THE sketch, figure 1, gives the details of a mechanism for changing the secondary inductance of a receiving tuner from one tap to the next, which at the same time causes the shunt secondary variable condenser to rotate throughout its range of capacities before another secondary coil is connected into the circuit. The whole adjustment is brought about by the rotation of a single control handle. This arrangement eliminates the necessity for using both hands in changing the inductance and capacity while tuning and leaves one hand free for writing down the message.

The objects of my design are brought about by arranging the strips of brass 1, 2, 3, 4 and 5 of the end-turn switch figure 2, so that when coil No. 2 is cut in, the condenser has revolved from zero to maximum capacity, and so on throughout the series of taps. The condenser is rotated by attaching a pulley to the shaft of the end-turn switch and a smaller pulley on the shaft of the condenser. By a partial turn of the control handle the secondary variable condenser is shifted through its entire scale. It is clear to the reader that a certain relation must exist between the diameter of the pulley on the condenser and that on the main shaft; also the taps on the secondary inductance must be of sufficient width to permit the variable condenser to rotate over its scale before the switch reaches the next contact point.

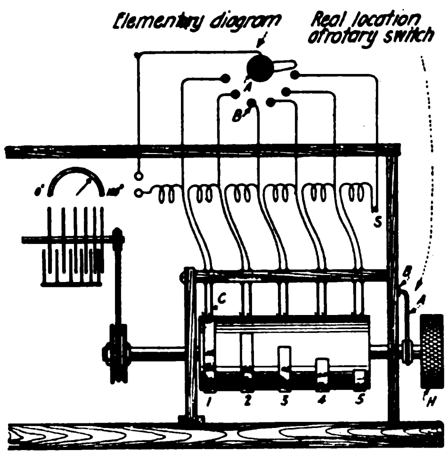


Figure 1—Detailed sketch of mechanism for changing the secondary inductance of a receiving tuner

The switch A, B, is of the rotary type and connects each coil in the circuit only when the last end is brought into the circuit by the end-turn switch. The rotary type of switch is necessary because the contact must be maintained while the switch is rotating and it should only make connection with the next strip in the circle when additional inductance is desired.

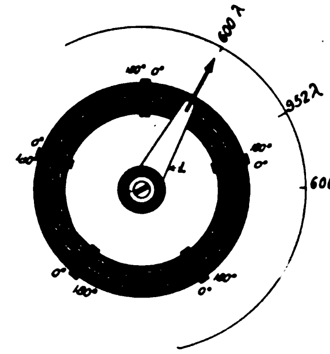


Figure 2—Rotary switch used to connect the coils

In figure 1 the location of the switch is indicated at the lower right hand part of the drawing and an elementary diagram of connections at the upper part showing how the coils are connected in the circuit.

The rotary switch to be used in conjunction with this aparatus is shown in figure 2 where a contact lever coil makes connection with copper segments 1, 2, 3, 4 and 5. These may be made of brass if desired.

The diameter of the switch must be chosen so that an individual segment will be long enough to permit the variable condenser to be rotated over its scale while the blade is on one tap.

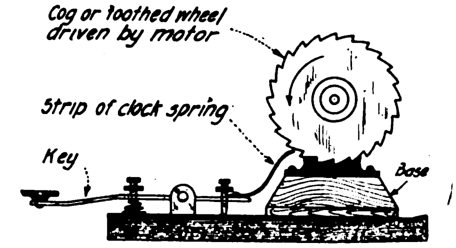


Figure 3—Mechanical code practice device

The experimenter will observe that as the inductance switch leaves one tap and makes connection with the second tap, the wave length at the first part of the scale of the second tap will be shorter than the maximum wave length of the preceding tap. But as the switch is moved on and the variable condenser is rotated over the scale, the longest wave will be considerably in excess of the wave obtained from the preceding coil.

As indicated in the drawing a wave length scale may be attached to the inductance switch, to indicate the wave length of the secondary circuit for various positions of the shunt variable condenser.

Code Practice Device

A very serviceable set for use in code practice is shown in figure 3. The object of it is to generate a buzzing signal without the use of a buzzer.

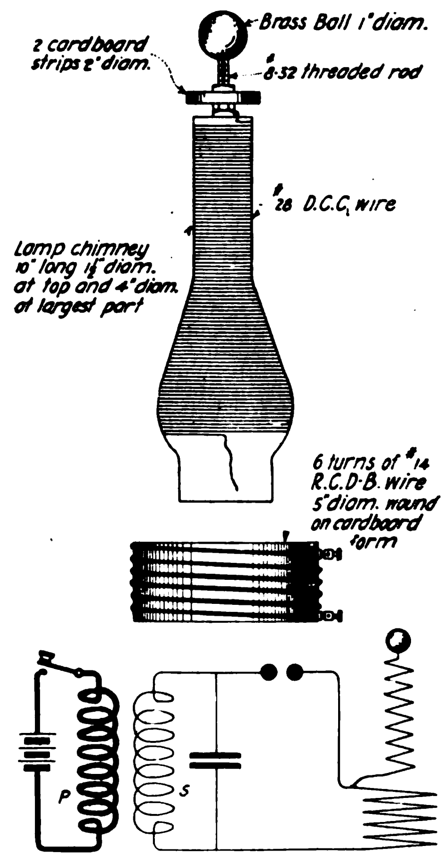


Figure 4—Diagram of detailed construction of the Oudin resonator

The telephone current is interrupted by a cog wheel which may be taken from an old clock.

No current is utilized other than that which turns the motor to which is attached a toothed or cogged wheel. The key is situated so that upon press-ing same it raises a strip of clock spring which barely touches the revolving cog wheel. This produces a very clear note when adjusted correctly. The motor should rotate away from the operator to protect his eyes from the flying filings which are liable to be thrown from the steel spring or the brass or iron cog wheel.

A very precise adjustment can be arrived at by making tight all screws on the key after adjustment, the

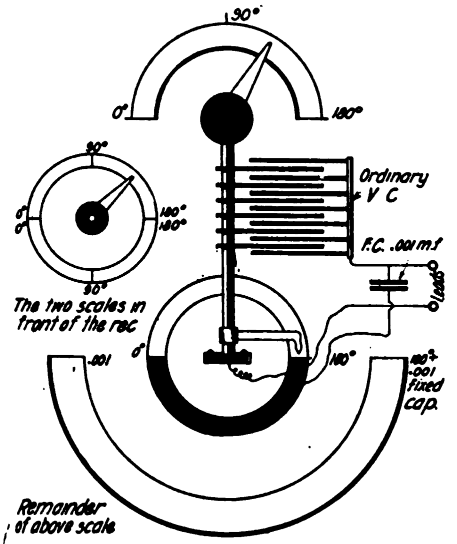


Figure 5—Sketch of a fixed condenser and variable condenser combined by means of a special switch to double the capacity

spring being arranged to barely touch the wheel in order to preserve its life. This, as a whole makes a very cheap practice set giving loud signals. A small Ajax motor and a cog wheel 4 inches in diameter by 1/8 inch thick, connected in series with four good dry cells, gives good results.

A pulsating note of a frequency depending upon the number of teeth on the wheel and the speed at which it rotates is obtained.

A Small Oudin Resonator

The Oudin resonator in figure 4 will give a good three inch spark with a 1/2 to 3/4 inch spark coil.

The secondary circuit is wound on a lamp chimney, making an excellent insulator. To place the wire, start from the end with the smallest diameter and wind upwards. It is impossible to wind from the other end owing to the slope of the chimney, but it is an easy matter to wind the opposite way. A globe ten inches long is covered with No. 28 D.C.C. wire closely wound (not spaced) 1/2 inch from the top and 2 1/2 inches from the bottom as shown. The primary is composed of 6 turns of No. 14 R.C.D. B. copper wire spaced about 1/2 inch apart, wound on a cardboard form 5 inches in diameter. The connections are shown just below the constructional drawing. This type of resonator will be found to be of exceptional interest and can be constructed at a small initial expense.

All kinds of high frequency phenomena can be demonstrated such as drawing sparks to your hand or to an iron instrument in your hand. Standing on an insulated form, matches can be lit from any part of your body by some one standing on the ground. Drop a piece of tinfoil inside the globe and a great quantity of ozone, a great germ killer and sure cure for colds, etc., will be generated and can be inhaled from the top of the globe.

Stand another small coil such as the primary or secondary of a "loose coupler" about 6 inches away from the resonator when in operation and without any connection whatsoever, a spark will appear at both ends of the winding, the forerunner of the wireless transmission of power. Hang a small light or lamp into the globe and a beautiful blue light will fill the globe. By bringing a piece of glass say 1/8 inch thick close to the ball and a piece of wire held in the hand close to the other side, the current will jump from the ball to the wire as if the glass were not there. The field for experimenting is great, and it is my personal opinion that if it ever becomes possible to intercept such waves that the whole world could be communicated with by the use of a small oudin coil. The frequency of the currents being generated are so great that they are absolutely inaudible—but who can tell what will take place in this wonderful new field in a space of ten years.

Means for Doubling the Capacity of a Variable Condenser

The combination of a fixed condenser, a variable condenser, and special switch, as in figure 5 will double its range of capacity.

It is clear from the diagram that when the ordinary condenser is at 180 degrees the maximum amount of capacity is in use, but if the condenser is brought back to zero and rotated toward the left instead of toward the right, a fixed condenser having the same amount of capacity as the variable condenser at maximum is connected in parallel. Therefore by rotating the condenser in the opposite direction, we can progressively double its capacity in the same manner as it is built up to its maximum capacity in the ordinary way. The scale on the outside of the condenser will be a complete circle instead of the usual half circle, or 180 degrees. An insulated circle is provided and half of it is made conductive by means of a strip of brass which cuts in the other fixed condenser. A switch arm protrudes from the shaft of the condenser and makes contact with the switch (brass semi-circle) cutting in the extra capacity.

This is a very convenient arrangement and is easily added to the ordinary receiver.

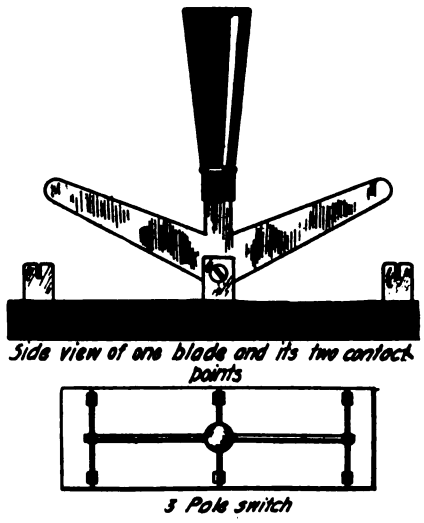


Figure 6—Sketch of switch used for starting small A. C. motors

Special Switch for Starting Small A. C. Motors

Ordinary types of switches furnished for this purpose are of the three pole double throw type, reactance coils being thrown in on one side in the motor line circuit and the other side cutting in the full line voltage. This is an awkward arrangement owing to the fact that one is liable to throw his arm across the line when pulling the switch from one position to the other in a hurry. For that reason, I have constructed the switch shown in figure 6. It works on the rocking principle, passing through an arc of about 25 degrees, thereby making it much easier to shift the connections.

The Vacuum Tube Generator for the Radio Laboratory

A VACUUM VALVE connected up as a high frequency generator and mounted with auxiliary instruments will be found a very useful piece of apparatus around an experimental radio laboratory. It may be employed in several ways such as calibrating wave meters, inductances, condensers, measuring the decrement of decrementers and high frequency resistance; also as a source of radio frequency oscillations for beat reception and in many other ways.

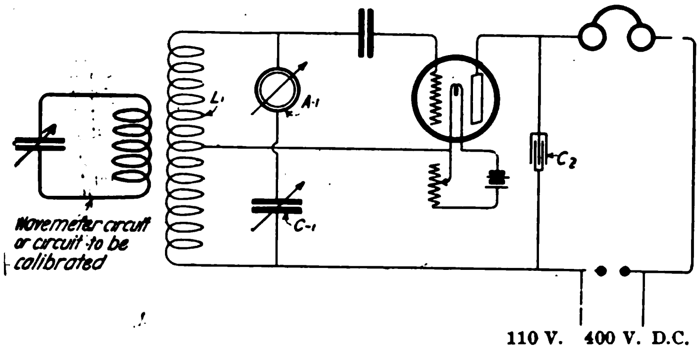


Figure 1—A simple circuit having a vacuum valve connected up as a high frequency generator

The amount of energy obtained from such a device will, of course, depend upon the size of the valve, its operating characteristics, and upon the E. M. F. of the plate battery. One hundred and ten to 250 volts D. C. can be safely applied to most bulbs, and in some cases more, without undue heating of the grid and plate, but it is best to consult the manufacturer of the tube for potentials above 250 volts.

Several circuits may be employed. That shown in figure 1 is very simple and will do the work of more complicated connections.

The size of the coil L_1 and condenser C_1 will depend upon the range of frequencies desired. It will be found that if a variable condenser C_1 having a maximum capacity of .0005 mfd. is used, the coil described below will be correct for a frequency of 120,000 cycles or above, which corresponds to the wave length of 2,500 meters at the maximum value. The coil should consist of a single layer of No. 26 S. C. C. wire wound on a tube 4 inches in diameter and 4 inches long. One hundred and seventy-five turns will be necessary, which will occupy a winding length of 3.5 inches. With a condenser C, having a capacity .005 mfd., 50 turns of the same wire, on the same sized cylinder with a winding length one inch long are needed. Three taps should be brought out from the coil, one at each end and one in the center.

The circuit should be calibrated against a standard wave meter. The distributed capacity of the coil, the effect of the leads and of the internal capacity of the bulb itself will change any theoretical determinations of the oscillation constant. A hot wire ammeter A_1 will indicate when the tube is oscillating properly. It should have a range of not over .5 amperes maximum except when large bulbs and high voltages are used. The condenser C_2 should have a capacity of 2 mfd. The telephone receivers and the grid condenser should both have a short circuiting switch or plug to cut them out of the circuit when they are not in use.

The whole apparatus should be mounted on one base or in a case with the inductance L_1 in such a position that it may be readily placed near another circuit.

To calibrate a wave meter with this apparatus place the inductance coil of the wave meter to be tested near the coil L_1 as indicated in the diagram, and set the condenser of this wave meter at some desired point. Note the reading of the ammeter A_1 in the oscillating circuit. By varying the condenser C-1 it will be found that as the condition of resonance between the two circuits is reached the current indicated by A_1 will fall off, often dropping to zero if the coupling between the two circuits is close. When the resonance point is passed the ammeter will again read the normal value. It is necessary to note the point on the condenser C_1 when the current in A_1 is at a minimum, and refer to the calibration curve for the circuit L_1, C_1 to find the wave length at this point. It is not necessary to have the two circuits coupled so tightly that the current in A_1, drops to zero, as a slight decrease is all that is necessary. Otherwise two waves will be in evidence if the coupling is too tight.

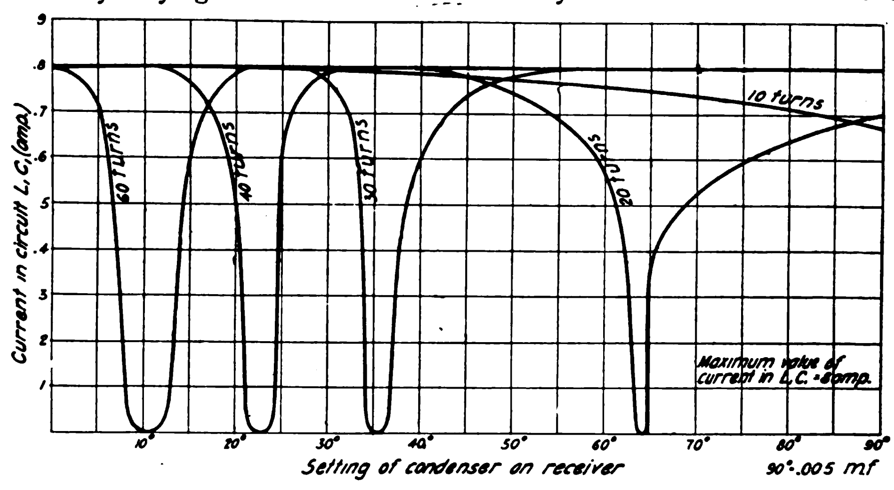


Figure 2—Graphic curves taken while calibrating a receiving set

The advantage of this method is that no connections need be made to the wave meter under test. It is a very rapid method of making a calibration. It is understood that with the standard condensers and inductances on hand the calibration of coils and condensers may be done in the same manner.

Curves taken while calibrating a receiving set are shown in figure 2. These show distinctly how the energy is "drained" from the valve circuit when resonance between the two circuits is reached. In these determinations the frequency of L_1C_1 was left constant and the condenser of the receiving set was varied, its values forming the abscissa on the curve sheet. Each curve represents one value of inductance on the receiving transformer.

There is another method in which a very interesting phenomena is made use of. It will be found that under certain conditions that a beat note will be heard in the telephones when the circuit L_1C_1 is nearly in resonance with the wave meter circuit. A shrill note is first heard as C_1 is rotated which drops to a low tone and then rises to inaudibility as the resonance point is passed. Anyone who is acquainted with beats will easily recognize the point when resonance occurs. It is necessary to have a correct value of the grid condenser, and sometimes a grid leak in order to have this action occur. An explanation of the theory of this action will be found in an article by Prof. L. A. Hazeltine, in the Proceedings of the Institute of Radio Engineers for April, 1918, on page 76.

The telephone receivers and the grid condenser are not needed for other tests and may be omitted, if desired.

Ralph R. Batcher, *New York.*

A Small Radiophone Transmitter for the Amateur Station

LOW powered radio telephone transmitters soon will be the order of the day, but few amateurs know just exactly how to get started in this branch of radio. The books "Radio Telephony" by Goldsmith and "Vacuum Tubes in Wireless Communication" by Bucher, are excellent for obtaining an understanding of the operating characteristics of continuous wave generators for speech transmission. This article aims only to give constructional details.

Directions for assembling a small radio telephone, which should have a transmitting range of at least six miles, follow. Prior to the war, a similar but cruder set was constructed, using but one ordinary vacuum tube with a speaking range of three miles.

In constructing a radio telephone, there are three primary obstacles which confront the experimenter. He must find:

(1) A very simple and easily understood hookup, containing inexpensive and easily procured instruments.

(2) A source of direct current of fairly high voltage.

(3.) A continuous wave generator.

The three element vacuum tube will be the only type considered. Figure 1 gives a hook-up which seems an adequate answer to problem (1).

If the amateur has access to a source of 110 volt AC and a sufficient amount of money to expend, he may either obtain a 500 volt DC motor generator or a Kenotron rectifier, patterned after the Fleming valve, and obtainable from the General Electric Company. Either the DC generator or the Kenotron with 500 volts AC, may be employed to supply the plate current. With such sources of current, quite a respectable transmitting range may be obtained. However, few amateurs will care to begin their radiophone experiments on such a large scale. The experimental set herein described uses from fifty to ninety volts of the large size tubular flashlight batteries or No. 6 dry cells. In wholesale lots the price is not as high as one might imagine from retail comparison. Under favorable circumstances a discount as high as 50 per cent may be had on quantity lots.

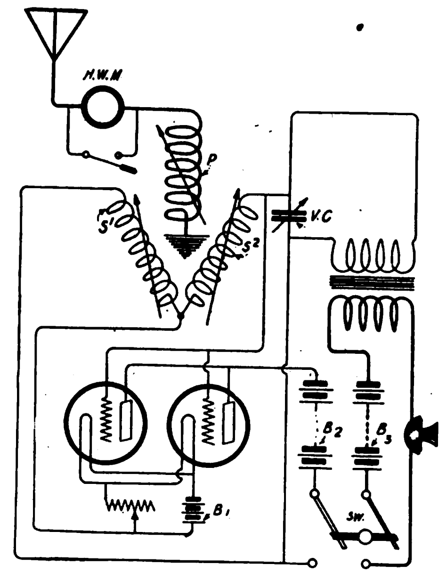


Figure 1—Hook-up of instruments for a small amateur radiophone transmitter

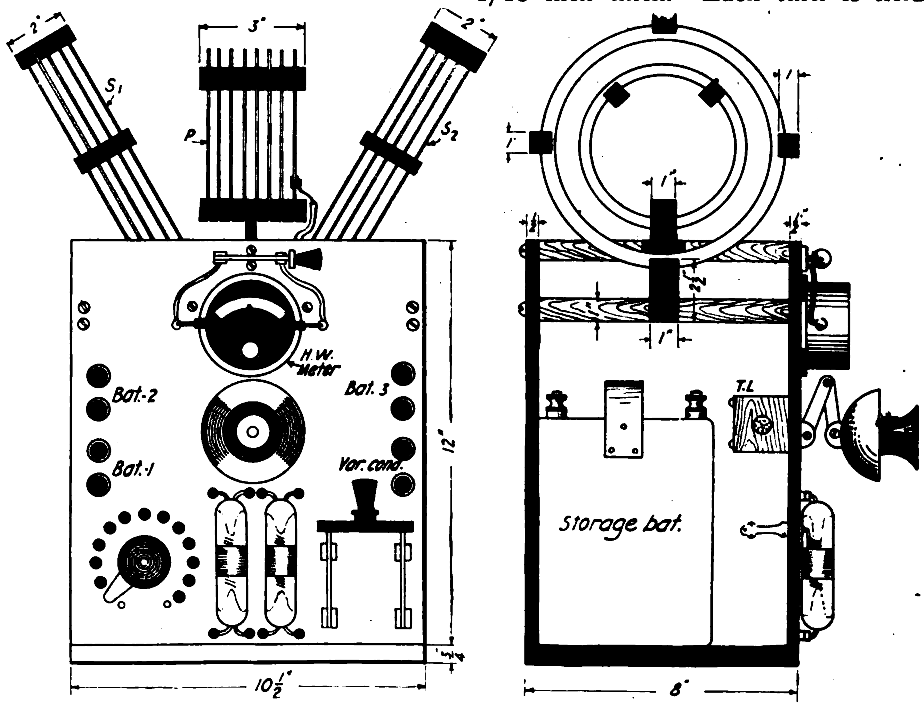


Figure 2—Front and side view of assembled radiophone transmitter

Problem 3 as in problem 2 resolves itself into a question of financial resources. The continuous wave generator in the outfit described here consists of two small, three element vacuum tubes such as tubular bulbs or electron relays with the members connected in parallel. Additional bulbs may be added to increase the range, which should be from two to six miles per bulb, depending on the tuning of the circuit and the efficiency of the antenna and ground.

After the experimenter has gained a working knowledge of radio telephony and has access to a source of high voltage, he should get possession of a "power bulb" such as the Pliotron or one of the Marconi bulbs. Large bulbs of this type, fed by 500 volts DC often given a speaking range of a hundred miles or more.

Figure 2 gives the front and side view of the assembled outfit. The front panel should be made of some good insulating material such as Bakelite. The base and back may be of hard wood treated with asphaltum varnish or a mixture of lamp-black and shellac as they are touched by no current carrying connections. On each side of the panel, about 9 inches up from base, two wooden strips 7 inches long should be placed between the back and front, to strengthen the construction. These are not shown in the side view as they would cover up the wooden, inch square strips which support the two secondaries. These hinge from the primary with these strips as axes.

Each of the two secondaries, S_1 and S_2, is composed of five turns of edgewise wound copper strip spiral 7½ inches in diameter, ½ inch wide and 1/16 inch thick. Each turn is held ⅜ inch apart from the adjoining turn by strips of Bakelite, 1 inch square and 2 inches long, except at the bottom. The coil is fastened to the axis upon which the secondary pivots by a piece of Bakelite shaped as in figure 3-A. The primary, P, is composed of copper, spiral wound edgewise as the secondaries and is 5 inches in diameter, 5/16 inch wide and 1/16 inch thick. Each adjoining turn is held ⅜ inch apart by Bakelite strips, ¾ inch square and 5 inches long, except at the bottom, where the primary is supported by a piece of Bakelite as in figure 3-B. This piece is to be fastened to a strip of wood, held between the front and back panels by wood-screws as in the side view of figure 2. The copper strip for the "oscillation transformer" may be purchased from wireless supply houses.

The transformer is designed considerably heavier than necessary for the current derived from the high voltage battery as suggested here, for the experimenter sooner or later may find himself in a position to use power bulbs and a commercial form of high voltage supply.

In most radiophone circuits a radiation indicator (such as a hot-wire ammeter) is essential, for successful operation depends mainly on careful tuning. The meter suggested is one of the small "junior" patterns. It should be short circuited by the switch at top of panel when not in use.

The battery B_3 in the transmitter circuit may be from six to ten volts of storage or No. 6 dry cells. The transmitter is taken from one of the common long-distance telephones. If it happens that the carbon grains become fused, replace them with larger grains. The induction coil I is nothing more than the ordinary telephone

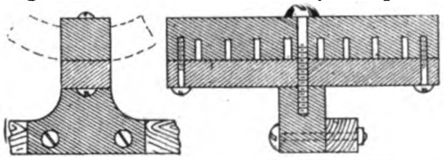


Figure 3A—Detail of fastening coils

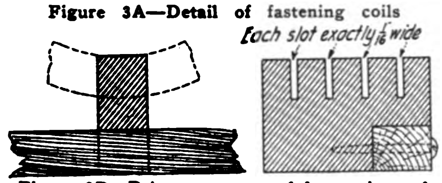


Figure 3B—Primary supported by a piece of Bakelite

transformer. A type that will operate from a ten volt dry battery may be purchased from any electrical supply house. Both the high voltage battery B_2 and battery B_3 are cut into the circuit by the switch at the bottom of the panel. One rated at 30 amperes, 250 volts is about the right size to use.

Battery B_1 is a six volt storage battery and is mounted behind the panel to prevent the outfit from overturning. The filament rheostat in the lower left hand corner of the panel is made in accordance with my article in the November 1918 Wireless Age. There are sixteen points of variation of one-half ohm each. A good radius for the switch points is 1½ inches.

Better results will be obtained if the bulbs are purchased from a reliable company which standardizes its products, that is, all bulbs are supposed to be alike.

The variable condenser VC is one of the 43 plate receiving type, filled with castor oil, or a good grade of motor oil to give a capacity of .005 mfd.

The design of the three coupling coils herein described permits a range of 180 to 350 meters with the average antenna. If permission can be obtained to use a longer wave length, either a loading coil or a longer aerial may be used, of which, the latter is preferable.

The variation for the high voltage battery is obtained by a clip and flexible lead at the battery box as it would be impractical to take a large number of leads up to the panel from the batteries.

It is of even more importance in radio telephony than in wireless telegraphy that the various leads and connections should be of litzendraht or stranded wire, and well soldered. No. 12 rubber covered stranded wire, is a practical size for the outfit described.

It would be a great benefit to experimenters if some genius for organizing would start a "National Amateur Radiophone Service League," modeled on the same general plan as some of our present relay organizations.

Think it over fellows, and send in your suggestions to The Wireless Age. Francis R. Pray—*Mass.*

Design of a Self-Cooled, Quenched Spark Gap

Assume that the amateur desires to construct a quenched spark set to fit a 1 kw. 500 cycle transmitting set, so that the gap will be self-cooling. Also assume an 11,300 volt transformer and a condenser capacity of .008

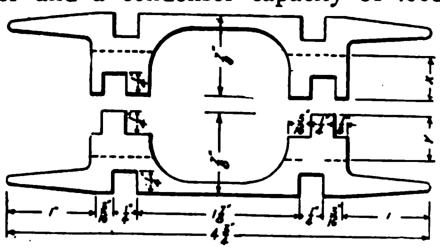


Figure 1—Showing design of spark gap

mfd., experience teaches that the gap current will be about 18 amperes. This is the root mean square and must be mutiplied by $\sqrt{2}$ or 1.4 to obtain the maximum value, namely 18x1.4=25.2 amperes. In the design of quenched spark gaps, one square inch of surface should be allowed for every 10 amperes of current. Gaps of smaller dimensions will cause arcing, and plates of excessive size will cause a ragged spark tone.

In the particular example cited, 25÷10 gives 2.5 square inches as the area of the gap, keeping in mind that diameter $= \sqrt{\frac{\text{area}}{.7854}}$; and in this example $\sqrt{\frac{2.5}{.7854}} = 1.8$ inches approximately. We must now allow 10 mils separation between the plates and a potential difference of 1,000 volts per gap; also we must allow .25 inches between the silver and the rim. If the rim is 3/16 of an inch in width, the total area of the rim will be approximately 1.4 square inches. We may now allow for the gap losses, 15 per cent. of the power, which in this case equals 150 watts; and since for a potential difference of 1,000 volts we must have 11 gaps, we must allow 150÷11=13.6 watts to be dissipated per gap. Then assuming .2 watts per square inch for a 50° C. rise of temperature for continuous working, we have 13.6÷.2=68 square inches, the surface required.

If we employ 2 cooling vanes per gap, then the approximate area will be equal to 68÷4 (the number of sides of two vanes)=17. The over-all diameter $= \sqrt{\frac{17}{.7854}} = 4.7$.

It is now assumed that the completed gap is mounted in a metal

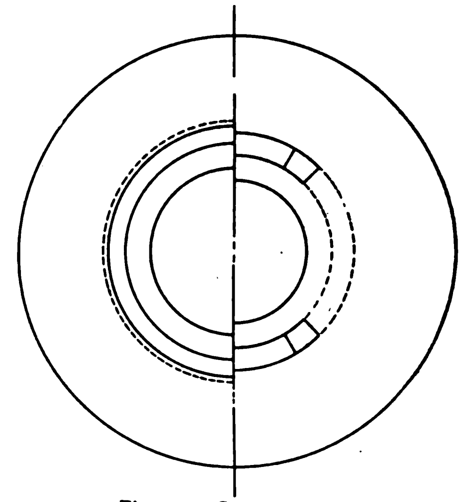


Figure 2—Gasket plates

frame and that the plates are pressed tightly together by means of a threaded bolt. We may then determine the leverage ratio with a 13 thread screw bolt and a 6 inch wrench; that is, ratio $= 2\pi$ 6x13 threads x 1 lb. = 489.84, or approximately 490. If we allow 150 lbs. per square inch to make up for the tightness required with mica gaskets, we have 150x1.4 (area of rim)=210 lbs. Figuring $\frac{210}{490}$ gives about ½ lb. pressure to be placed on the end of a 6 inch wrench.

The sections marked X and Y of figure 1 are cut away to a depth of ½ inch for a space slightly less than ¼ circumference of the circle, so that

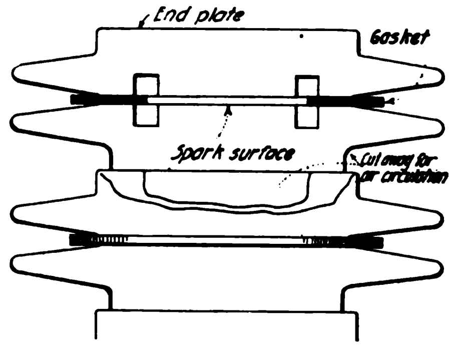


Figure 3—Spark surface of plate

when the gaps are put together the air can circulate through the main body of the gap.

Figure 2 shows the plates of the gasket and figure 3 the sparking surface of a particular plate. It also shows a portion cut away for air circulation. If the gap is to be used intermittently, allow .4 watt cooling surface for a 50°C. rise in temperature.

J. J. Holahan, *Virginia.*

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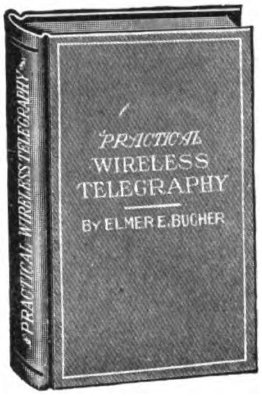

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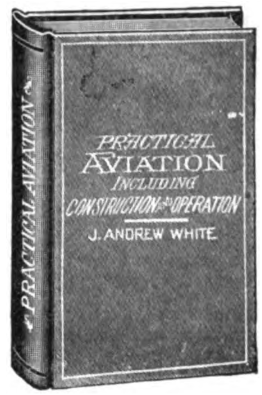

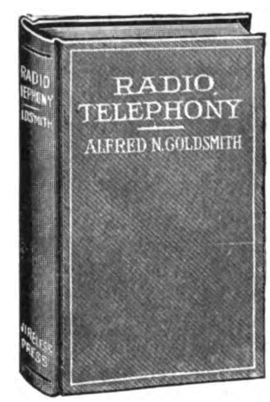

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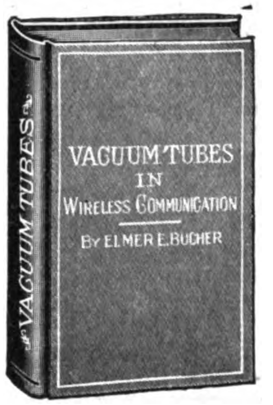

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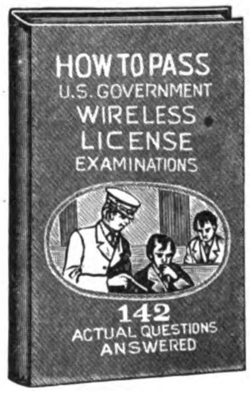

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Finding the Distance Between Wireless Stations

THERE is only one practical method of accurately finding the distance between any two points on the earth's surface, such as two wireless stations, and that is by means of spherical trigonometry. Recourse is had to this method in navigation, astronomy, and other scientific pursuits; also, maps are plotted from certain calculations obtained in this way. All maps based on Mercator's projection become increasingly inaccurate as the poles are approached, and hence are of no value in finding distances near the poles, or those which span any great part of the earth's circumference.

The actual details connected with the method herein described are usually taught in advanced trigonometry classes in colleges, but since only a few formulas are needed, along with a table of the various trigonometric functions, it is presented in the hope that those who have not had the advantage of such training, or else have forgotten the work, may avail themselves of the method. The use of the tables does

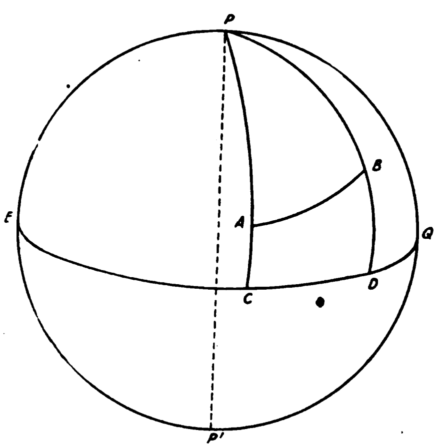


Figure 1—Diagram showing method of determining the distance between two wireless stations

not necessarily require a knowledge of trigonometry, but a working knowledge of common logarithms will greatly simplify the labor incident to these calculations.

The tables should give the values of the sine, cosine, tangent, and cotangent to within 10'. Greater accuracy is not required, as it is usually impossible to obtain the latitude and longitude with much more exactitude than this, and since 1' is only equal to 1.1516 miles, the error is inappreciable.

To apply this method, it is only necessary to know the latitude and longitude of each of the two places concerned, which can be found on any map, and by use of the formulas which will follow, the distance between them can readily be found. A brief discussion, however, will be of value to anyone making use of these formulas. In figure 1 is depicted the earth's globe, P and P' representing the poles, EQ the equator, and A and B any two points on the earth's surface whose separation it is desired to find. It is evident that AC is the latitude of A, BD the latitude of B. By substracting each of these values from 90 degrees we will obtain AP and BP respectively, the two known sides of the spherical triangle ABP. It is to be noted that these values are in degrees and minutes, as in the case of spherical triangles the sides are given as parts of an arc or a circumference.

Also, A has a given longitude, and B has a given longitude, and the difference between these two values will be the separation of A and B in degrees of longitude along the equator, or, the value of the angle APB. In case either A or B are on opposite sides of the prime meridian, or of the 180th meridian, a different procedure must be followed, as is explained later.

We have now determined the two sides AP and BP, and the included angle APB, of the spherical triangle ABP. For the sake of convenience, we shall refer to the angles shown by the capital letters which designate those extremities, as angles A, B and P. The sides of the triangle shall be referred to as AP, BP, and AB, the latter being the unknown side whose length we are to find.

The following formulas are then applicable, the first two being Napier's Analogies:

$$\text{Tangent } \tfrac{1}{2}(A+B) = \frac{\cos \frac{1}{2}(BP - AP)}{\cos \frac{1}{2}(BP + AP)} \cot \tfrac{1}{2} P$$

$$\text{Tangent } \tfrac{1}{2}(A-B) = \frac{\sin \frac{1}{2}(BP - AP)}{\sin \frac{1}{2}(BP + AP)} \cot \tfrac{1}{2} P$$

Also, $\tan \frac{1}{2}(A+B) + \tan \frac{1}{2}(A-B) =$ greater unknown angle, and $\tan \frac{1}{2}(A+B) - \tan \frac{1}{2}(A-B) =$ smaller unknown angle. Which angle is A and which is B can be found by applying the rule from geometry, that the greater angle is opposite the greater side, and vice versa.

Having found the unknown angles A and B of our triangle, we now apply the law of Sines in spherical triangles, namely:

$$\sin AB = \frac{\sin P}{\sin B} \sin AP$$

Looking up the value for the anti-sine of AB, gives the distance between these two points in degrees and minutes. This value (in degrees and decimals of a degree) is then multiplied by 69.117 to obtain the distance in statute miles.

Let us now examine the results of an actual calculation to fully fix in our mind the use of these formulas. Supposing it is desired to find the distance from Arlington, Va., to Kahuku, Hawaii. The latitude and longitude of the former are 38° 50′ N., 77° W., respectively; of the latter, 21° 40′ N., 158° W. Subtracting the two latitudes from 90°, we have 51° 10′, and 68° 20′ for the sides BP and AP of the triangle, respectively. Also, the angle P, being equal to the difference in longitude of the two places, is 158° — 77° = 81°. Applying the formulas:

$$\tan \tfrac{1}{2} (A + B) = \frac{\cos \tfrac{1}{2}\ 17° 10'}{\cos \tfrac{1}{2}\ 119° 30'} \cot \tfrac{1}{2}\ 81° = 2.298$$

$$\tan \tfrac{1}{2} (A - B) = \frac{\sin \tfrac{1}{2}\ 17° 10'}{\sin \tfrac{1}{2}\ 119° 30'} \cot \tfrac{1}{2}\ 81° = 0.2023$$

Looking up these values, we have, tan ½ (A + B) = tan 66° 30′, and tan ½ (A — B) = tan 11° 26′. Therefore, applying our rule for finding the unknown angles, and noting that the angle at Arlington is the larger of the two, we have:

$$\text{Angle } A = 66° 30' - 11° 26' = 55° 4'$$

and

$$\text{angle } B = 66° 30' + 11° 26' = 77° 56'$$

Also, we have

$$\sin AB = \frac{\sin 81°}{\sin 77° 56'} \sin 68° 20' = 0.9386$$

From which AB = 69° 50′, or 69.8°. This is then multiplied by 69.117, giving the value 4825 statute miles as the distance between Arlington and Kahuku.

It has been stated that in case the stations are located on opposite sides of the prime meridian, or of the 180th meridian, a different procedure is necessary for finding the angle P. In the first case just mentioned, the longitudes are added instead of substracted, in the second case both values are subtracted from 180° and the results added together. A little consideration will show the necessity of such methods.

In case the two points are almost of the same latitude, a simpler method will give the same results. It consists in finding the difference in longitude of the two places, and multiplying this by the value of a degree longitude in miles, at the mean latitude. For example, Funabashi, Japan, is at latitude 35° 40′ N., and Los Angeles, California, is at latitude 34° N. The mean latitude is 34° 50′, and at this latitude a degree is equal to 56.95 miles. Hence the distance is equal to 101.67° (the difference in longitude) times 56.95 = 5790 miles. Tables of this sort are called spheroidal tables, giving the length of a degree longitude at various values of latitude, in nautical and statute miles. The student is referred to the Year Book of Wireless Telegraphy for the complete values.

Hints for the Experimenter's Workshop

YOUR readers may be interested in the method, shown in figure 1, for making rods for zinc spark gaps. An iron pipe is sawed lengthwise as in

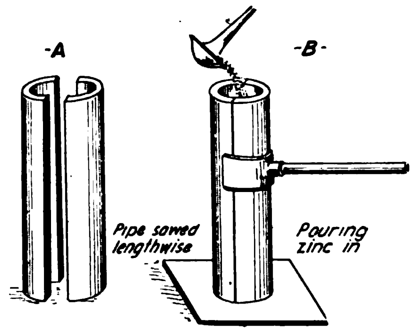


Figure 1—Showing method of constructing zinc spark gap rods

A to constitute the mould. The zinc cases of old dried batteries are melted and poured in as shown. In the same manner points for rotary gaps can be made. A threaded bolt should be moulded in place in the process so that the points can be screwed to the rotor.

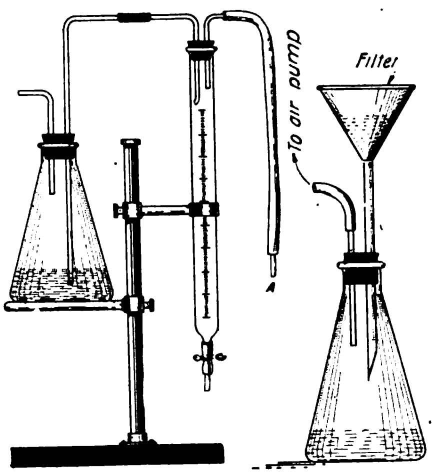


Figure 2—Design of an automatic burette Figure 3 — Rapid filtering device

In figure 2 is shown an automatic burette that the experimenter can construct with the apparatus at hand. The liquid used in the titration, etc., is put in the flask which is connected to the burette as shown. This is brought into the burette by suction applied at the mouthpiece A. The entire apparatus and the burette is easily filled.

An apparatus for rapid filtering is shown in figure 3. It is connected to a filter pump which is easily constructed by the amateur if necessary.

CAESAR KLAUS, *Illinois.*

Contest Winners for the March Issue

In response to the call in the December issue for manuscripts concerning the re-opening of amateur stations, prizes have been awarded to the writers of the following articles. The suggestion upon which the contest was based was:—AT THE FINAL CONCLUSION OF PEACE NEGOTIATIONS, WHAT DO YOU CONSIDER TO BE THE MOST IMPORTANT REASONS FOR IMMEDIATE OPENING OF AMATEUR WIRELESS STATIONS?

First Prize — Why the Amateur Should Be Allowed to Resume Operations

THE chief reason why the wireless amateur should be allowed to resume, after the war, is the fact that one naturally has the right to use the ether just as one has a right to breathe the air. Recently a power greater than his own compelled the amateur to relinquish the practice of his favorite art. But this power did not and could not take away his rights; it merely forced him to abandon the practice of them for a time. The wireless amateurs do not question the wisdom of this course. What the wireless amateur objects to is not regulation but annihilation. If anything is common property, it is the air and the ether. A man has the right to all the air he can use, but he has no right to control the rest of it; likewise no man or set of men has a right to appropriate the ether to his own exclusive use. All have a right to use it provided they have a due regard for the rights of others.

If it be said that the wireless amateur might pick up secret messages, I reply that no information of a confidential nature should be sent by radio except in code. In connection with this phase of the matter it is well to remember that if one were determined to get through a message for an improper purpose, one could do so, law or no law. A man cannot be prevented from buying wire and other materials. Now, it is well known that thousands of people can make all the parts of a wireless set. So if anybody wanted to do any surreptitious receiving, he could pack his instruments and a coil of wire in a suit case, go to some secluded spot, string the wire on trees, connect it up and listen to anything within range. The reception of messages by the evil-disposed cannot be prevented. No class of people has the moral right to take permanent charge of the ether simply because they wish to send information whose publicity would injure or embarrass them.

Station of J. Weiss, Port Washington, N. Y., an excellent type of high-grade equipment, which can be put to good use as soon as Government restrictions are removed

It is true that a very few amateur sending stations did interfere with other stations prior to the war, but this can easily be prevented. Let a few of these offenders be punished and the rest will reform in haste. The government has the whole matter in their own hands. If they fully prescribe the amateur's sending outfit, they will have full and effective control of him. In order to have effective control the government should prescribe not only the transformer input and wave length, but also the length and height of the aerial and the dimensions of the (sending) oscillation transformer. They should not allow an antenna that requires a condenser in series to be used; there would be danger that the condenser would get cut out! If fair play and good judgment rule, there is plenty of room in the surrounding ether for both the amateur and the commercial operator.

Then the more widespread the practice of the wireless art the greater will be the progress in it. The spirit of inquiry not only produces inventions but actually produces the inventor himself. He is the ultimate result of countless investigating minds.

simply do the work that comes to hand, and their sole desire is to maintain their position on the pay roll in increasing opulence. If the commercial wireless operators have no more of the spirit of inquiry than their brethren of the wires, let us thank heaven for the gift of the amateur and pray for his speedy return to the good work, for he loves the art of wireless for its own sake and is always striving to advance it.

So the matter seems to resolve itself into this: Everybody has the natural right to use the regions of space while he has a due regard for the rights of others. This being a self-evident fact,

An exhibit of the Atlanta Radio Club, indicating a high order of scientific training and practical work in the wireless field, developed by amateurs during the pre-war period

And has our government not had reason to rejoice that there was an army of wireless amateurs in the country when the war came? Suppose the amateur had never built his station or practised the art. In that case would there have been the interest in wireless when the war started that there was? Complete figures are not available, but it is certainly true that thousands of young men, on account of their previous experience as amateurs, fitted themselves in a few months for government work and rendered valiant service to the cause. Shall these young men, when they return, find that their government has condemned their former activities and forbidden their resumption.

The enthusiasm of the amateur should not be overlooked. I am not acquainted with any commercial wireless operators, but I know something about the wire telegraphers. I never knew one of them to make an effort to discover anything new in the art. They have no spirit of interest or curiosity. I have known good practical operators who could not connect up a simple set of instruments. They

we should not be required to prove it. The burden of proof is on those who think that the amateur should not invade the ether. We may well ask: What harm has the amateur done or what harm can he do under reasonable restrictions?

S. F. McCARTNEY—*Pennsylvania.*

Second Prize—Why Stop the Growth of an Art That Improves the Man?

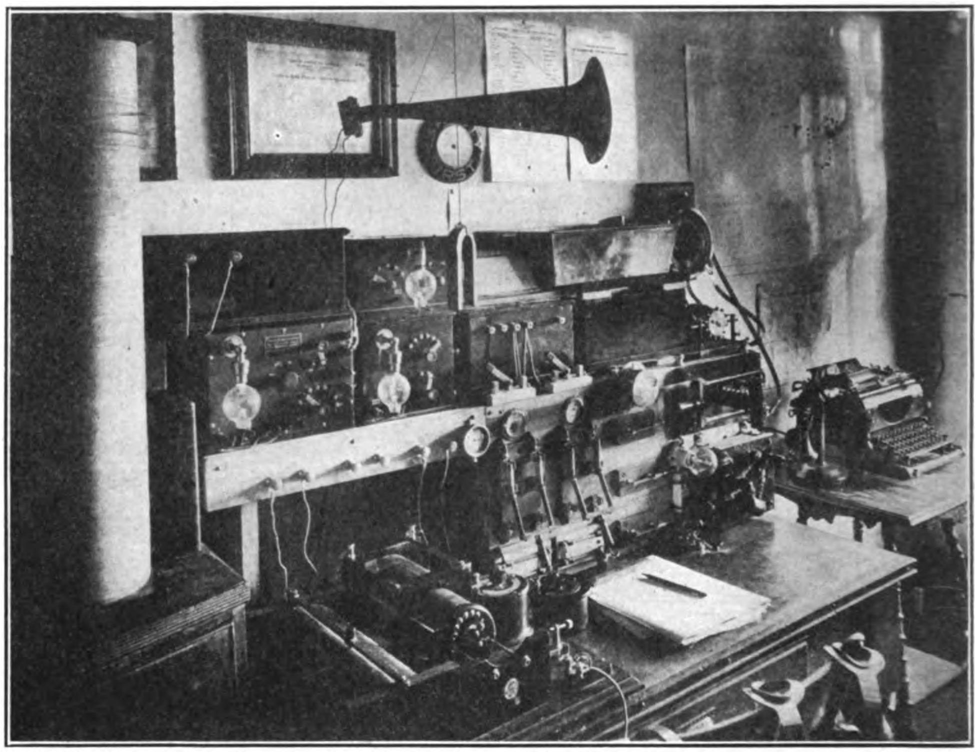
THE closing of the amateur wireless stations when we entered the war was a military necessity, and there is no reason why they should not be permitted to open just as soon as this military necessity ceases to exist. In fact a consideration of what amateurs have accomplished and what they may accomplish will disclose many reasons—logical ones, too—for permitting their opening just as soon as international conditions permit.

Only one objection can be raised against them and that is "interference." This is of two classes—one malicious, due to irresponsible, flighty amateurs; the other is just "interference" due to lack of scientific knowledge. Both disturb the sincere amateur as much as the commercial or Government stations and the sincere amateur is about 90 per cent of the field.

Malicious "interference" should be and can be punished by existing statutes and the amateur should and will give his aid to bring this about.

"Interference" is a problem recognized and appreciated by all amateurs as well as by radio engineers and is now well on the way to solution.

Amateurs are studying ways and means to overcome interference as well as how to work over long distances with a minimum of energy at the sending station and a maximum at the receiving station.



Amateur station of Chris M. Bowman of Pennsylvania. Scientific work of this nature should be encouraged—not destroyed—by the Government

Their problems are the same as those of the commercial and Government stations and instead of the solution being sought in one or two elaborately-equipped ideally-situated laboratories by an intellect skilled in research work for so much a year, the problem is being attacked by amateurs in thousands of laboratories, where each instrument is worked to its finest point and under thousands of conditions most of which are not ideal; the workers are not skilled in research work and are after immediate practical results.

Prior to the closing of the amateur radio stations their achievements in long distance transmission and receiving and continental relay work, in the better application of old principles and in the discovery of new ones, were noted almost daily. Their results are a matter of record and were gained only by hard work and sacrifice.

The stuff the amateurs are made of, their strength of character, their resourcefulness in an emergency and their ability to deliver the goods was proven in the conflict which has just been closed. "Sparks" as a rule braves danger and risks alone, silently and with no comeback, and not with a company of his fellows, amidst insane din and activity, as does his soldier and sailor brothers.

The foundation for this character and ability was laid years ago in an attic and in most cases under difficulties. An amateur radio operator is not an "operator" from choice but from necessity—he is not actuated by a desire to send a message but by a desire to know how and why the message can be sent at all.

This subject requires much careful investigation and thought; the application of his conclusions develops his manual dexterity. The cost of his instruments if purchased is almost prohibitive; but while they are very delicate and sensitive he may make them himself, from fairly cheap raw material and a few tools.

So we have a condition where a young, enthused mind controls its thoughts, analyzes, puts together, draws conclusions and expresses the results of those efforts in a device in which skill and care in manual effort is a great factor toward the desired result, and it is done for the sake of the work.

An amateur radio engineer is bound to be a better citizen than the average of his fellows because of this training and for this reason he should be given freedom to expand and grow, even if the advantages of the success of his efforts were not available—but they are and he is a tremendous force in the field.

Control his efforts by all means; it will help to make him a better man but no reason has yet been advanced for stopping his efforts, and there is no reason why amateur radio stations should not be permitted to open just as soon as the necessity for closing them ceases to exist. This necessity will have ceased to exist the instant after the treaty of peace has been signed.

F. L. LEMM—*New York.*

Third Prize—Shall Amateur Wireless Stations Be Re-opened?

THE end of the war has brought forth a great many problems that must be settled. One of them, and to a large number of Americans a very important one, is: Shall amateur wireless stations be re-opened at the final conclusion of peace negotiations?

A number of reasons for an affirmative answer can be pointed out.

We have just concluded, with our Allies, a war to "make the world safe for democracy." An important condition for keeping it so is a perfect understanding among the nations. This demands more reliable and better communication than we have had in the past, and here wireless telegraphy can play a role of no little importance.

As this is true of a number of nations, so it applies to a single nation. Added facilities for communication make for better union. This idea, in a large measure, was followed (in America) before we entered the war by wireless amateurs, although they perhaps did not realize it. As time went on, distant parts of the country were brought together by wireless, which brought about a general feeling of brotherhood — an indispensable factor in maintaining a democracy. This feeling of good-will and brotherhood existed invariably in a community having one or more amateur wireless stations. The permission to re-open these stations would be marked by a continuance and an increase of this good work.

In the first days of unpreparedness when our country entered the great war, and when the Army and Navy were in desperate need of young men who understood wireless telegraphy, the inherent patriotism of the amateurs was demonstrated beyond doubt. A great many volunteered, being willing to risk life and limb in the service of their country, whose free institutions permitted the operation of apparatus which had given them so much pleasure and education. And while it is not to be thought for a moment that they served for reward, it surely would be a mark of ingratitude for the Government to take from these fighters and those who helped to make it possible for them to fight, this mode of experimentation which is so beneficial and harmless when properly controlled. Such action would not be worthy of our nation.

There are instances on record of amateurs giving material aid to public officials. For example, an amateur helped prove that our neutrality was being violated by the Sayville wireless station. Once when a shore party from some Naval vessels was unable to establish communication with the ships, an amateur, upon request, did the needful thing. During the heavy floods of 1913 some communities would have been cut off from the world for days had it not been for amateur wireless stations. These instances and others prove that it would be wise to permit amateurs to continue their operations for the aid they could give in emergency or disaster.

Our rapidly growing Navy and Merchant Marine will require a large number of wireless operators. Formerly, even with the aid of the amateurs, the Government and the commercial companies could not obtain sufficient men. Now the need is greater and the difficulty will increase if there is not a large body of amateurs to draw from.

With a great many persons interested in wireless telegraphy the chances for invention and improvement are multiplied many times. Investigation and attempts at improvements are qualities characteristic of every earnest amateur. Beneficial results are bound to follow. For instance, Marconi was but a plodding, persistent amateur when he made his famous and priceless invention. Armstrong, whose amplifying circuits have done so much to extend the scope of wireless telegraphy, had scarcely attained his majority when his discovery was made. And Weagant, who was recently credited with overcoming the greatest enemy of wireless communication, began his task when but a young man. With these examples before us what may we expect in the future from amateur wireless experimenters?

All these reasons, and doubtless others exist, point to the wisdom of re-opening amateur wireless stations as soon as peace negotiations are on their way to final settlement.

ROSS MOORHEAD—*Ohio.*

Both Sides of the Government Ownership Question

(*Continued from page 21*)

the amateur arguments, which were reported in the February issue, several interesting statements were made which space does not permit dealing with here.

Captain Todd then appeared in rebuttal, arguing that the bill had nothing to do with patents or manufacturing in itself. He called for legislation which would further limit amateur operation, the concentration in one authority of coastal station operation, and issuance of licenses for all receiving stations.

Fulton Cutting, of Cutting & Washington, opposed the bill, stating that if it went through he would close out his company, not caring to be in a business where the U. S. Government would be the only customer. Lester L. Israel, radio engineer, gave reasons for his opposition that were an outspoken indictment of the showy and wasteful system in the Navy, as determined by his own experience during four years in the Navy Department. George McK. McClellan, representing the Honolulu Chamber of Commerce, said that Hawaiian business men strongly resented the Navy's bureaucratic administration and protested against the policy of the Government to continue its war control. Emil J. Simon, radio engineer, vigorously attacked the various provisions of the bill and used his own experience to demonstrate how young men could build up a substantial manufacturing business without fear of the Marconi "monopoly," which the Navy had attempted to prove practically existed.

Samuel E. Darby, patent attorney, representing the De Forest Radio Telephone & Telegraph Company, said that the company was "with the Government and in favor of the proposed bill." George S. Davis, general manager, radiotelegraph department, United Fruit Company, who preceded him, took the reverse attitude and showed by comparison that wireless was better for all concerned with the field open for all commercial interests.

The hearings closed with the introduction by Representative Lufkin of a letter of protest from an amateur of Essex, Mass.

As reported in the February issue, the committee, on January 16, by unanimous vote tabled the bill.

Queries Answered

Answers will be given in this department to questions of subscribers, covering the full range of wireless subjects, but only those which relate to the technical phases of the art and which are of general interest to readers will be published here. The subscriber's name and address must be given in all letters and only one side of the paper written on; where diagrams are necessary they must be on a separate sheet and drawn with India ink. Not more than five questions of one reader can be answered in the same issue. To receive attention these rules must be rigidly observed.

Positively no Questions Answered by Mail.

K. K. K., Elizabeth City, N. C.:

Ques. (1)—Is the regenerative beat receiver shown in figure 108 in the book "How to Conduct a Radio Club" more efficient than the modified Weagant circuit shown in figure 69 of the book "Vacuum Tubes in Wireless Communication"?

Ans. (1)—Practically identical results will be obtained from either circuit. The principle point of difference lies in the method of connecting the tuning elements of the plate circuit. In figure 108 the regenerative coupling coil is placed on the low voltage side of the secondary circuit. In figure 69, it is on the high voltage side. The circuits of figure 69 are less difficult to adjust than those in figure 108, for by proper design of the coils in figure 69 all the tuning necessary can be obtained by the loading coil L-1, secondary condenser C-1 and plate circuit condenser C-2, that is, these are the principal adjustments.

Ques. (2)—What would be the approximate range of wave lengths over which the apparatus shown in figure 108 of "How to Conduct a Radio Club," would work with coils L-3 and L-7, 20 inches in length, 6 inches in diameter, wound with No. 28 enameled wire; and if coils L-5 and L-6 were wound with No. 24 and No. 30 enameled wire respectively, the secondary coils being 7 inches in length, 4½ inches in diameter and the primary 7 inches in length, 4 inches in diameter?

Ans. (2)—The set should respond to wave lengths up to 8,000 meters and by shunting secondary L-7 with a variable condenser, still longer wave lengths may be obtained provided close coupling is employed at the coils L-2 and L-4.

* * *

H. C. K., Canton, Ohio:

Ques. (1)—In order to receive signals from both Naval and amateur stations would there be any marked advantage in erecting two separate aerials from the same support, one aerial to consist of two wires 350 feet long and the other of two wires 100 feet long? The wires in each aerial would be spaced three feet.

Ans. (1)—If the vacuum tube detector is employed in the receiver, an antenna short enough to receive amateur wave lengths would also work well on the longer wave lengths such as employed at high power stations. On the other hand, an aerial long enough for reception from high power stations would have too great a fundamental wave length for reception from amateur stations. Moreover, if separate aerials are employed, they should be placed a considerable distance apart, for otherwise, tuning on one aerial will effect the electrical constants of the other. However, this would not be so noticeable if the earth connection of one antenna is broken while the other is employed. For amateur reception a hundred foot aerial is preferable and with a good sensitive vacuum tube or a cascade tube amplifier you would obtain nearly as loud signals from high power stations on this aerial as from the longer one.

* * *

G. T. S., Chicago, Ill.:

Ques. (1)—Can I erect an aerial in my attic of a three-story building?

Ans. (1)—For receiving purposes it will work well, particularly if you use vacuum tube amplifiers to detect the signals. The efficiency will be somewhat lower for transmitting purposes, but fair results over short distances will be obtained.

Ques. (2)—Will lightning effect the house when the aerial is under the roof? It is my understanding that copper wire draws lightning.

Ans. (2)—The aerial would perhaps give better protection if it were outside of the roof because under the condition you mention, if the aerial was struck by lightning it would necessarily pass through the roof of your house to reach the aerial. However, it is rarely that one hears of amateur stations being struck by lightning and you therefore need have no fear on this point.