MANUAL OF THE

MARCONI INSTITUTE

FOR TRAINING IN
RADIO COMMUNICATION
AND ALLIED VOCATIONS

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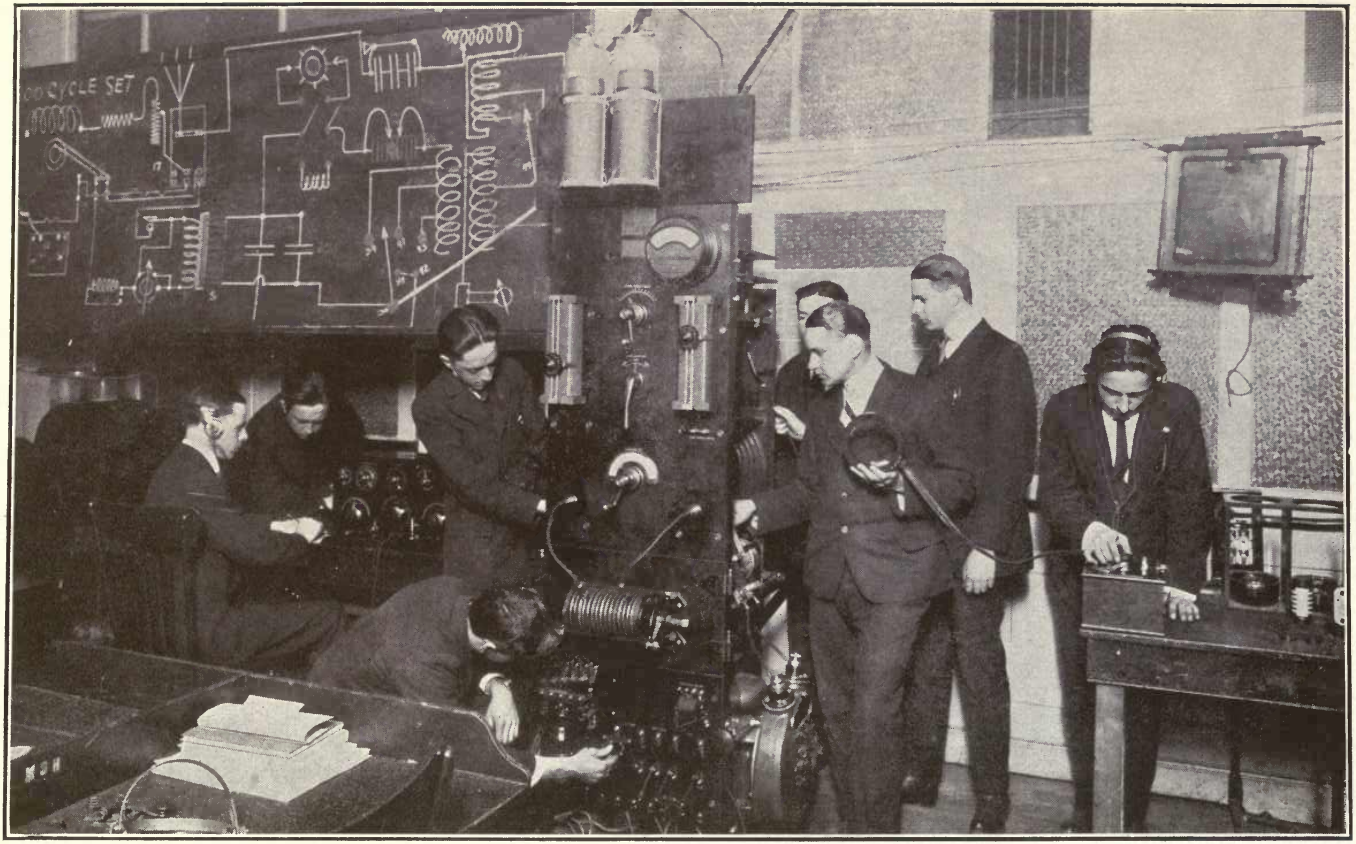


Laboratory instruction at the Marconi Institute, New York City

MARCONI INSTITUTE

A WAR-TIME MESSAGE

LOYAL citizens of the United States, in the present national crisis, are called upon as never before to cast aside all personal ambitions in the interest of world democracy. It matters not how promising a policy may have been laid out for future welfare. All selfish plans of the individual must temporarily be laid aside. For a time the services of Americans must be at the disposal of the Government. What we do we must do well.

Unlike previous wars, this one is a conflict of scientific forces with a definite ethical and broad humanitarian principle at stake, and the individual must not make the blunder of approaching the problem unprepared. Skilled workers are required in all branches of the Army and Navy. Men who possess no other qualifications than mere ability to perform manual labor are limited in their usefulness.

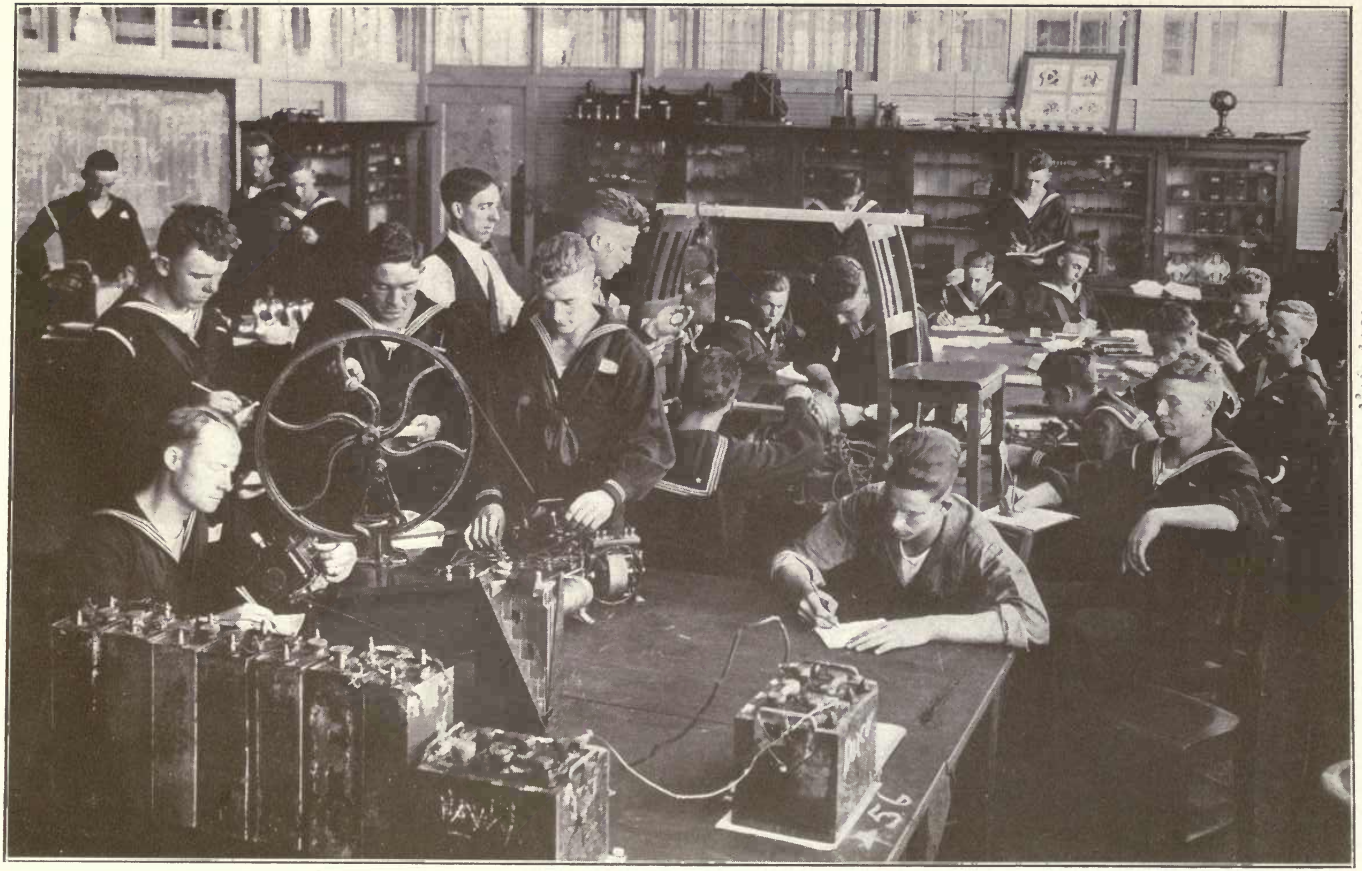
Foremost of all qualifications at this period is technical education. Whether in the interest of peace or of war, the man sought for is the one who understands the why and wherefore of things with which he deals in his everyday environment.

So important is the matter of supplying our Army and Navy with skilled workers, and keeping our workshops filled with technically trained men, that the *Scientific American* recently remarked editorially:

> If we are in for a long war then it is equally important from a military point of view to add to the brain power of the nation by increasing the attendance at universities, colleges, normal schools, and technical schools—now constituting a little more than one-half of one per cent. of the total population of productive age.... The hours of the classes and the length of the course should be arranged so as to give students better opportunities for "working their way" through college.... We must have more and more technically trained men whether for War or Peace—....more experts in every line.

The opportunities for well-trained and properly educated workers at the close of the war will be even greater. DR. KLAXTON, U. S. Commissioner of Education, states:

> When the War is over, whether within a few months or after many years, there will be such demands upon this coun-



Radio operators in training for service in the U. S. Navy at Dunwoody Institute

> try for men and women of scientific knowledge, technical skill, and general culture as have never come before to any country. The world must be rebuilt. This country must play a far more important part than it has in the past in agriculture, manufacturing, and commerce....Russia and China are awakening to new life and are on the eve of a great industrial development. They will ask of us steel, engines and cars for railroads, agricultural implements, and machinery for industrial plants. They will also ask for men to install these and to direct much of their development in every line.

The industrial progress and power of any nation depends absolutely upon the maintenance of rapid means of intercommunication. At the close of this war, no scientific development will expand commercially at a more rapid rate than the art of wireless communication. The war has given great impetus to the art, both from a commercial and a scientific standpoint. A far greater expansion will take place when hostilities cease.

Already the genius of our nation has bent its energies toward the perfection of needful improvements in radio, and as the result of this forced concentration discoveries of immeasurable importance have been made. Twenty-four hour wireless communication from continent to continent is now an assured fact. It will not be long before every outlying island, every vessel, every isolated settlement, will have a radio station as a link in a universal system of wireless intercommunication. This great expansion will require an army of skilled research engineers, inspectors, operators, and installers.

In view of this situation, a direct appeal is made to Americans: Will you serve your country in advancing a most remunerative and most fascinating profession, or will you stand by while others occupy the field? *All countries are calling for radio men. Your Government needs them now!*

The professional radiotelegraphist, to properly perform the simplest duties in the operation of wireless telegraph apparatus, must be a skilled man.

He must have a thorough education in the fundamental principles of electricity and magnetism; must understand the operation of dynamos and motors; must be familiar with the general theory of alternating currents and have an intimate knowledge of the radio frequency currents which are employed in wireless transmitting and receiving.

The United States Navy requires immediately several thousand

Radio men in training for Army service at Pratt Institute

skilled radiotelegraphists and the Army Signal Corps will require the services of more than 30,000 trained men.

The training is a big task. It can be brought to a successful conclusion only by educational institutions throughout the country opening up their facilities for instruction and co-operating fully with the Government.

THE INSTITUTE'S OFFER TO TECHNICAL SCHOOLS

THE Institute has engaged in the work of training radiotelegraphists for the past nine years, and during this period has graduated more than 3,000 men, ninety-nine per cent. of whom have been placed in commercial positions. Many are now in the Government service.

The directors of the Institute believe that for the present it can serve our country in no more effective and patriotic manner than by freely offering counsel and aid to radio schools now in operation, and to technical schools in process of forming radio classes to assist our Government.

The Institute stands ready to help all such schools in every possible way, particularly in outlining a definite classroom course for technical and code instruction. This is not an entirely new function of the Institute; it has acted in a similar advisory capacity to training schools throughout the world, particularly since the United States entered the war.

The Board of Managers invite all universities, colleges, or public schools throughout the country contemplating the training of radiotelegraphists on behalf of the United States Government, to freely present to them any problems which may arise in the forming of radio schools.

The outline prepared by the Institute gives a complete course of training and the approximate figures covering the expense of apparatus required and the cost of installation.

The need for well-trained men is urgent at this moment, and after the war the demands for professional radiotelegraphists will be such that it will be difficult to find men to fill the new positions created. Hence the outlined training course prepared equips the student for Government service now and places him in line for holding a responsible position when the war is ended.

Radio class of New York Police Department undergoing examination at Marconi Institute

Attention is directed to the technical literature, listed in this manual, compiled with the assistance of prominent American educators. The directors have instituted a special extension training service which will keep instructors and students in touch with the best current literature of the radio art.

This service is rendered without charge.

OPPORTUNITIES IN THE RADIO FIELD

THE great commercial development in wireless telegraphy which is bound to follow the world war has been referred to. The conclusions are definite and authoritative, for they are based on careful study of the trend of industrial development and exceptional opportunities to observe the operations of the commercial companies.

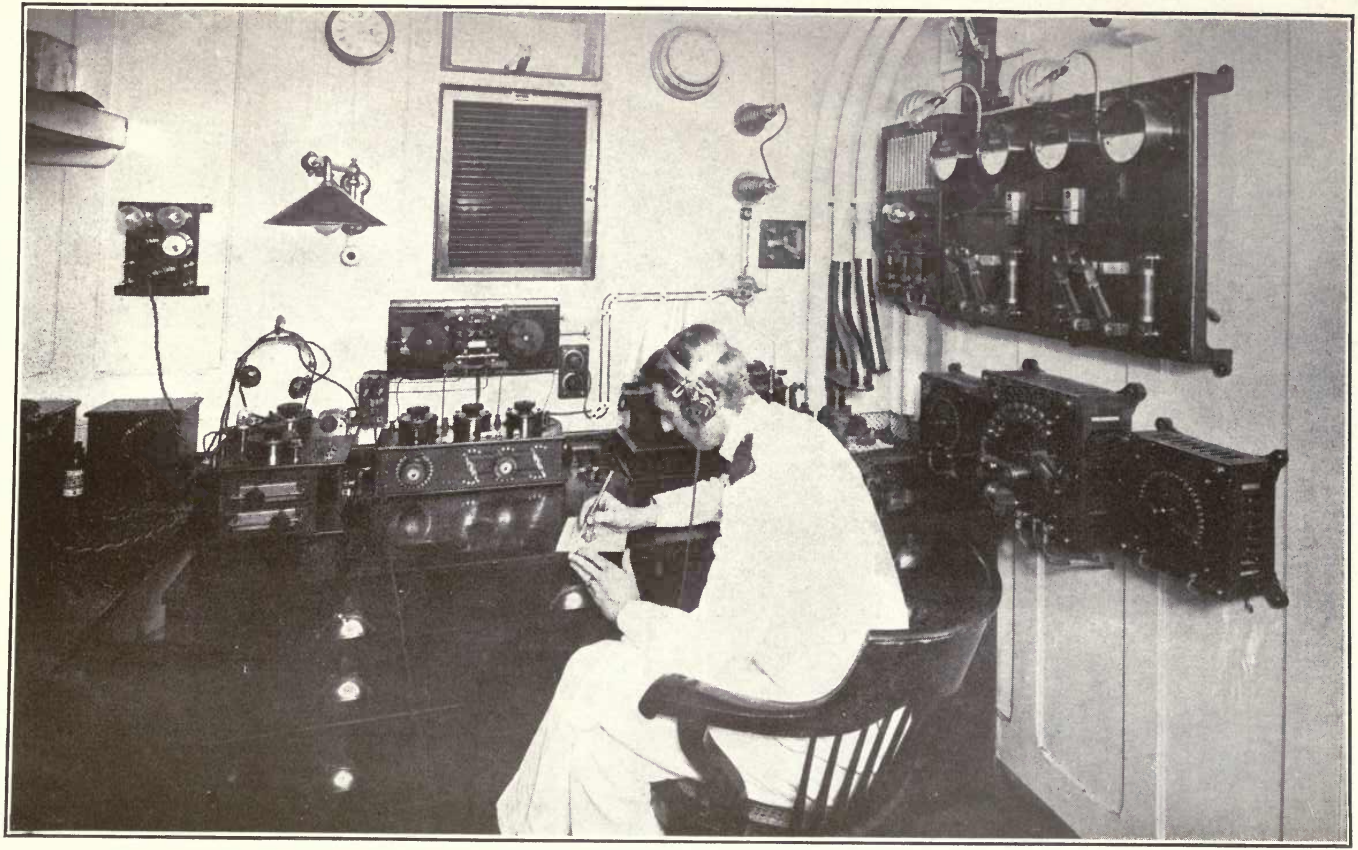
At the opening of the war in 1914, there were in the world approximately 700 land stations and 4,500 ship stations. These stations were engaged in public correspondence, Navy and Army communication, the service of lightships and lighthouses, and represent ownership by commercial companies, Governments, and individuals.

Vast extensions have taken place since the beginning of the world war. Definite figures are not permitted, but it may be said that wireless is employed almost exclusively for trench warfare communication, and for directing artillery fire from airplanes. It has proved invaluable to scout patrol boats, torpedo boat destroyers and the hundreds of other naval vessels. Millions of dollars in cargo and thousands of human lives have been saved through the elaborate system of radio communication which all nations have established.

Already wireless telegraphy is installed on several thousand vessels equipped by the affiliated Marconi Companies and others, and by the Army and Navy forces of every country in the civilized world. Continents have been connected together by a world-wide communication system, and although these stations are temporarily under Government control they will be opened for public service at the close of the war.

To the highly skilled employees required for this service must be added five thousand skilled operators needed in the next twelve months for the new American merchant marine to fulfill the program of the Federal Shipping Board.

It will not be long before radio men may be required in the fol-



Typical ship's radio cabin

lowing special fields for service which wireless telegraphy will be called upon to render:

(1) As an Auxiliary to Railroads:

Wireless telegraphy has been successfully employed by one of the foremost railroad systems in the United States and has rendered service in the despatch of trains when the wire systems were paralyzed by storms.

Communication has been established and maintained with moving trains.

Sections in the great West where it is difficult to maintain wires will employ radio.

(2) As an Auxiliary to Existing Wire Systems:

The interruptions to which wire lines are subject through heavy sleet and wind storms are well known. Thousands of dollars have been lost by business houses accustomed to rely upon telegraph communication for the transaction of business. Wireless systems have been perfected to the point where they can be relied upon for accurate service throughout the hours of the day. Radio gives a first class service independent of weather conditions.

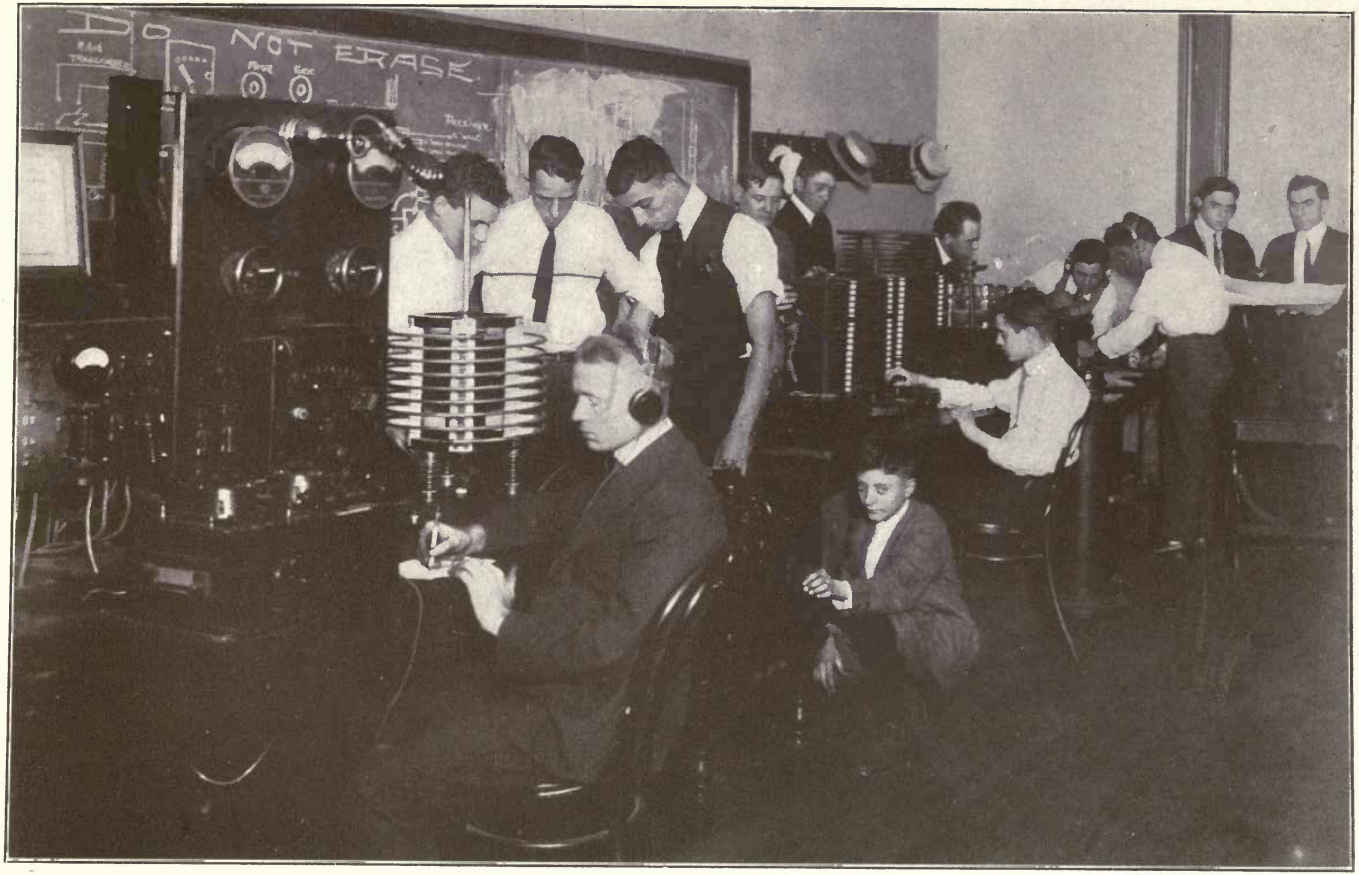
(3) The City Police Service:

For the police headquarters of every city of importance, connection by radio with other cities within a few hundred miles is essential. Outlying police stations within the larger cities must be joined by radio so as to form a complete system, independent of wire communication. Police ambulances and emergency wagons will be equipped with apparatus for communication with headquarters during riots, fires, and other disturbances.

No system can equal radio for the despatch of orders for apprehending criminals. Such messages could be broadcasted to several hundred cities simultaneously with one transmission.

(4) In Forestry Departments:

Nothing can equal radio as a system of communication for reporting forest fires. By means of large stations erected at strategic points in the forest reserves and by the use of smaller portable stations, fires can be quickly reported and the foresters mobilized for action.



A typical Y. M. C. A. Radio class at work in the Laboratory of the East Side Association Institute

(5) In Inland Water Systems:

The assured revival of water freight and passenger routes on the rivers and inland waters of the United States, will call for numerous stations in river and lake cities and on vessels.

(6) Time Service:

Accurate time service can be better furnished by wireless than by land lines. By means of a simple receiving station tuned to a central transmitter, time service can be supplied with greater accuracy than by wire, owing to the elimination of the lag in telegraph relays.

(7) Fishery Fleets:

These fleets will be more extensively equipped with radio apparatus than ever before. The advantages accruing to such fleets by the use of radio lie in the rapid despatch of information concerning the most favorable fishing grounds, market conditions and the weather.

(8) In South America, Africa, China, Russia and Other Countries in Which Wire Systems Are Not Extensive:

Otherwise impassable mountain ranges, jungles and widely separated cities in the above-mentioned countries will require complete systems of wireless communication, such as has been perfected in the Philippines. The number of stations and trained employees required to carry on this work and training will be such as to tax all existing facilities.

(9) In the Government Weather Bureau:

This department of the Government in all countries requires a very extensive wireless system for rapid transmission of weather reports and for collecting data.

(10) In Mining Regions:

As demonstrated in Alaska and in the Peruvian Andes, isolated communities will require a complete chain of wireless stations to keep in touch with one another. Particularly will such means of communication be required in event of local disturbances.

(11) Press Associations:

Wireless is especially adapted to this sort of work because a single transmitting station can dispatch newspaper reports simultaneously to several hundred receiving stations; in fact, to as many stations as may be necessary.

There is not the slightest doubt that the day is at hand when all continents will be completely joined together commercially by high-power wireless stations and a business will develop that will exceed the present total business of the cables of the world.

Wireless can perform this service with the accuracy of the cable and at a fraction of installation and maintenance expense.

An immense demand for radio men is assured for the immediate future. The supply of skilled workers in this field is always below the requirements of the day; the student's opportunities may be judged by the present conditions and the future possibilities as outlined.

TRAINING METHODS

NO one is qualified to manipulate wireless telegraph apparatus merely because he possesses knowledge of the Continental telegraph code. Further, the professional radio telegraphist must have, not merely a knowledge of the operation of equipment, but also sufficient fundamental knowledge to enable him to do installation work, to effect repairs, and to devise special means for solving any immediate problems which may arise. Such work cannot be performed without at least a preliminary technical preparation based on knowledge of elementary electricity and magnetism.

To standardize technical instruction in radio-telegraphy, the Institute presents the following outline, with subjects considered in the order of their importance. It is based upon the most successful practice followed in preparing thousands of students for entry into commercial service. It covers fully the basic principles underlying the operation of the transmitting and receiving apparatus in a complete radio system.

The subjects to be treated in theory and in practice are:

(1) *Primary and secondary cells.*

(2) *The theory of dynamos and motors.*

(3) *The special phenomena of alternating current circuits.*

(4) *The design, construction, and operation of motor-generators including the dynamotor, rotary converter, hand and automatic motor starters.*

(5) *The high voltage transformer.*

(6) *The high voltage condenser.*

(7) *High frequency oscillation circuits in radio telegraphy.*

(8) *Radiating circuits in radio telegraphy.*

(9) *Coupled transmitters.*

(10) *Wireless telegraph aerials or antenna.*

(11) *The principles of resonance and tuning.*

(12) *Fundamental receiving circuits.*

(13) *Practical wireless measurements.*

(14) *Undamped oscillation transmitters.*

(15) *Undamped oscillation receivers.*

To keep pace with the progress of the past few years, instructors are urged to teach students to recognize the present tendency towards the universal adoption of *compact panel transmitters*, and the special problems involved, owing to the close assembly of the apparatus.

Specially designed radio apparatus for airplanes and submarines should be explained in detail.

Modern regenerative beat receivers, in other words, the *oscillating vacuum valve circuits*, on account of their importance in long distance work, should be treated in general and in detail. Such instruction should bear only on modern apparatus of the types developed during the years 1916 and 1917.

All historical matter, in fact, everything not directly relevant to a practical understanding of a wireless telegraph set, should be subordinated. The call at this period is for men trained along modern lines.

Advanced code instruction at the Marconi Institute

Conducting a Technical Class

It is evident that students who come from all walks of commercial and private life, for radio instruction, will be of varying grades of intelligence; hence it is the duty of the instructor in charge to plan out a course suitable to the average intelligence of each class.

A course outlined for one set of students will not necessarily be applicable to the next or succeeding classes.

A good method to pursue in a class of different degrees of preparation, is to hold, for the first few days, general "quiz" questions. These permit the instructor to determine the calibre of his students and enable him to divide them into two groups.

Group (1) will contain those who have some knowledge of electricity and magnetism, and perhaps of wireless telegraphy.

Group (2) will consist of absolute beginners.

It has been demonstrated, notwithstanding certain students' opposition to the method, that the student graduate who has been well trained in the basic principles of the art progresses most rapidly in professional life.

It is urged that wherever possible, instructors teach first *the fundamentals* and then show the student the deviations, extensions and refinements of these principles in modern practice. The student will then be enabled to apply his general knowledge to any type of apparatus.

When the technical instruction is considered complete, the student should be given the opportunity to manipulate and adjust wireless telegraph apparatus. He should be supplied with a wave meter, and through the medium of a dummy serial, be permitted to tune the apparatus to resonance at the standard wave lengths. He should be taught to disassemble and re-assemble a wireless telegraph set, and afterwards to place it in first class working order.

All instruction of this nature should be conducted separately from the class and not more than twelve students should be permitted to enter a laboratory at one time, unless a large equipment and a considerable number of instructors are available to handle the work in groups.

Intermediate examinations during the course have been found to be of considerable value for they offer the student an opportunity to review his progress. They are an agreeable change from the every day routine. These examinations also give the instructor additional opportunity to judge the progress of the student.

The best results are secured where the instructor, from time to time, performs before his class exceptionally interesting experiments.

Text Books

The importance of an authoritative text book cannot be overestimated. A daily study assignment should be indicated for the student, but the instructor in charge must select only such material as will be of *practical* use.

One of the best methods for securing rapid progress, especially in a mixed class, is for the instructor to deliver occasional lectures covering advanced subjects. When in daily class work these subjects are reached, the student will immediately recall certain facts previously brought out by the lecturer, which will obviously facilitate his progress.

Buzzer Code Practice

The Continental Morse Telegraph code (commonly termed the International code) is universally employed in wireless telegraphy, and radio operators generally receive their training on a buzzer practice system which produces artificial radiotelegraphic signals. A diagram of such a circuit appears in Figure 1, where a number of head telephones are energized by a single buzzer.

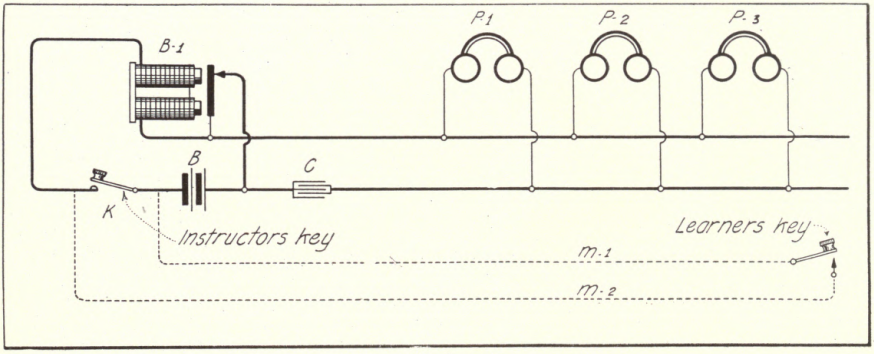


Figure 1

The essentials of this circuit are, a battery of primary cells *B*, a telegraph key *K*, a buzzer *B*-1, a two-microfarad condenser *C*, a number of head telephones *P*-1, *P*-2, *P*-3, etc.

With this arrangement the condenser *C* is periodically charged and discharged, and a faithful reproduction of the note of the vibrator is secured in the head telephones. If there are less than one hundred telephones in the circuit, it will be necessary to shunt the telephone circuit with a 400-ohm adjustable rheostat in order that the strength

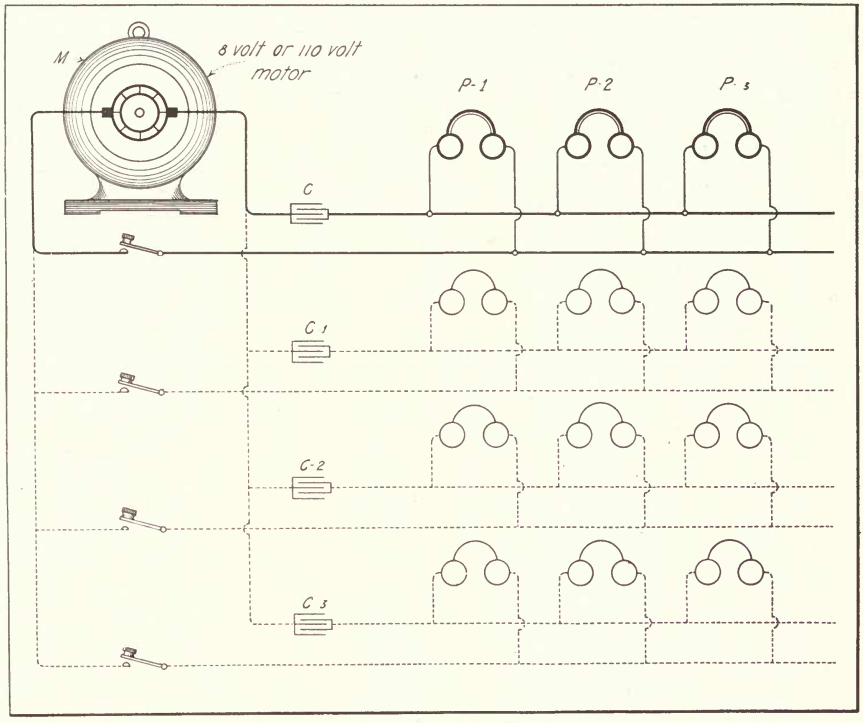


Figure 2

of the signals may be reduced to a degree consistent with everyday wireless practice.

The student at each position at the code practice table can be supplied with a telegraph key which is connected in shunt to the master key through the leads *M*-1, *M*-2, and thus one student at a time can transmit to the remainder of the class.

Although the apparatus described is much used for code instruction, difficulty is experienced in keeping the buzzer in constant operation and

in consequence, the circuit and apparatus shown in Figure 2, is strongly recommended.

Here a small motor *M* has shunted across its brushes a circuit consisting of the condenser *C* of two-microfarad capacity, head telephones *P*-1, *P*-2, *P*-3, etc., and a telegraph key. With this arrangement the condenser *C* receives a fluctuating charge, and if the motor rotates at a high speed, say 1,800 to 2,400 R.P.M., a faithful reproduction of wireless signals will be obtained with the great advantage that this apparatus will work day in and day out without trouble.

The type of motor employed is immaterial, whether it is operated by batteries or a 110-volt direct current circuit, but it is of considerable advantage to select a motor the brushes of which are mounted on a rocker arm so they can be shifted through a small arc. In this way the potential across the condenser can be increased or decreased and the strength of signals varied accordingly. The series-wound motor has been found to give the best results. A small motor operated from an 8-volt storage battery will easily actuate from three to four hundred telephones, and if a number of shunt circuits with special condensers such as *C*-1, *C*-2, and *C*-3 are taken off the brushes, several code practice circuits can be operated without interference or fluctuation of signals.

Division of Classes

It is recommended that code instruction classes be divided as follows:

Group 1—*to include beginners and those who are able to receive at speeds up to five words per minute.*

Group 2—*to include those who can receive at speeds from five to twelve words per minute.*

Group 3—*to include those capable of receiving twelve to eighteen words per minute.*

Group 4—*to include those capable of receiving eighteen to twenty-five words per minute.*

For the first day, absolute beginners should be given individual instruction; should be shown how to hold the telegraph key and how to carefully form their letters. Their work should be closely scrutinized for a period covering from three to five days, to insure the adoption of a uniform method of sending. Thereafter, they can be

placed with the first division (Group 1) and progressively advanced from one division to the other as they become proficient. When the student has passed the five-word-per-minute mark the instructor should transmit at a rate slightly in excess of the student's ability. This will tend to hasten the student's progress. If the instructor constantly transmits only at a speed equal to the ability of the student to receive, it is not likely that the student will advance rapidly.

Should the expense of head telephones prove prohibitive, an alternative device can be employed for code instruction. An automobile horn of the vibrator type operated by an 8-volt storage battery may be used to transmit to large groups of students at a time. This horn, mounted on the wall, can easily be heard throughout a large classroom. It has been employed by instructors with great success for teaching elementary students.

The procedure for training elementary students follows:

The instructor makes a particular letter of the telegraph code five or six times, and the students successively call out the letter sounded. In this way the art of reception is quickly learned.

Automatic Transmitters

Automatic transmitters for code instruction have been successful, the particular advantage being the uniformity of sending which the student unconsciously imitates and adopts in his own transmitting. Among the prominent automatic transmitters are the Wheatstone and the Omnigraph. Most practical mechanical code instruction can be obtained from the Marconi Wireless Telegraph Records, made by the Victor Talking Machine Company. These records are described on the last page of this Manual.

The Wheatstone automatic transmitter is particularly desirable in addition to the records, but it necessitates the services of one skilled in tape perforating.

Special types of Wheatstone perforators fitted with typewriter keyboards are now available and by a little practice anyone who is capable of operating a typewriter can perforate the tapes. Apparatus of this nature is costly, and is to be considered only by schools which have special funds available for the purpose.

Equipment for Technical Training

The laboratory of an advanced radio class should contain a modern 500 cycle quenched spark transmitter of the type used by commercial companies and the Government. This equipment should include a motor-generator, starting box, receiving tuner, head telephones, and a transmitting key. If an up-to-date set cannot be procured, any type of apparatus which possesses the fundamental parts of a complete transmitter and receiver will serve the purpose.

Owing to war conditions and the Government regulation of the sale of wireless apparatus, laboratory sets are difficult to procure, but the Marconi Institute, through its equipment department, will endeavor, if requested, to aid in securing suitable apparatus for schools interested in the inauguration of a wireless telegraph course.

Apparatus for Code Instruction

As explained in connection with the diagram of Figure 2, a single high speed direct current motor can be employed to operate several hundred head telephones, a number of shunt circuits being taken therefrom for several code practice divisions. Practically any type of direct current motor can be employed for this purpose.

Assuming a class of one hundred pupils the necessary electrical apparatus would be as follows:

One small high-speed D. C. motor, 100 head telephones, 50 transmitting keys, 1 2-microfarad condenser, 200 binding posts, wire for connections.

Assuming that, instead of a motor a buzzer equipment is employed, there should be at least one buzzer to each twenty-five students. The necessary apparatus for each group of twenty-five follows:

One 4-volt buzzer, 25 telephones, 12 transmitting keys, 50 binding posts, 1 2-microfarad condenser.

For a school with limited funds an automobile horn of the vibrator type will prove satisfactory, but it will be necessary to separate the several classes in partitioned rooms so that the sounds of several horns will not interfere.

Division of the Daily Routine

The day class for instruction in theory and code practice should convene at 10 A.M. until 12 noon, and from 1 to 4.30 P.M. Schools giving instruction in military tactics in addition to radio will, of course, lengthen their hours. A technical class session should be conducted from 10 A.M. to 11 A.M. and laboratory experiments from 11 to 12 M. Code instruction should be given from 1 to 4.30 P.M., with brief intermissions to afford students a respite.

It is customary in the classes of the Marconi Institute to include, once per week, a half hour or an hour lecture on radio traffic, but if such instruction is not required, the student should be shown, for instance, the geographical locations of prominent radio stations throughout the world. Such instruction will serve to renew interest and to destroy the dullness of daily routine.

QUALIFICATIONS OF STUDENTS

IN response to the appeal of the Federal Board for Vocational Education, for schools to undertake the training of drafted men in radio code and buzzer practice previous to their assignments to cantonments, a great number of universities, colleges, public schools, and high schools will establish special classes.

One of the first matters to be given attention is the qualifications of the applicant for admittance. Schools devoted primarily to training selected men under the plan of the Federal Board for Vocational Education, should accept none but those due for the second and following drafts and who can pass the required Government physical examination.

If the selected man has not yet been examined physically by his Examining Board, arrangements should be made with a local physician to do this work gratis. He should pass generally on the applicant's fitness for admittance to the Government Service.

Instructors of such classes should make every effort at the very start to weed out all men who do not possess the requisite education or other qualifications for the Government Service.

Schools to train men particularly for Government Service should exclude girls and women; persons under military age; persons not conscripted; persons conscripted but unable to pass the physical examination; persons exempted for any cause; and persons who are seeking only free training for commercial service.

It is evident that applicants for admission to these classes will be of mixed grades of intelligence. Consequently the instructors in charge should make every effort to segregate and apportion the men to proper classes directly upon entrance. There will be a constant change in students' personnel and it will be necessary to arrange the curriculum accordingly.

Time Required for Code Training

On an average it requires two hundred hours to train a first-class radiotelegraphist in code work, exclusive of technical instruction. Assume that a code class convenes for six sessions per week and that two hours per session be devoted to code practice, it will require from twelve to fourteen weeks to qualify an absolute beginner to pass a code test of twenty words per minute.

If the student is also to be taught technical wireless telegraphy, it will lengthen the course by about six weeks. Technical instruction during two sessions per week will be ample.

Obviously, greater difficulty will be experienced in dividing classes for technical instruction than for code instruction, but the instructor should have no difficulty in directing two classes simultaneously—one of beginners and one for more advanced students.

Obtaining Students

A list of conscripted men in each community can be secured from the local Examination Board or from the files of local newspapers. A circular should be sent to these conscripted men by the school authorities, asking them to appear for registration for the course. The circular should furnish all necessary information as to what it is proposed to offer them. Every effort should be made to obtain publicity through local newspapers and local commercial and civic organizations.

Instructors

Instructors for code classes can be obtained from among retired wireless operators or from commercial or railway telegraphists. Similarly, technical instructors can be secured from among retired wireless operators or those who have had active training in universities or colleges. The Marconi Institute has on file a list of men available

for such services, and will endeavor to supply qualified instructors in any locality. Code instructors are paid from $3.00 to $5.00 per evening and technical instructors $4.00 to $8.00 per evening.

Records

The records to be kept in the school are similar to those of any educational institution, but care should be taken to have them accurate in every respect, so that the Federal Board can supply the United States Army with complete information regarding the number of students attending. Blanks will be sent by the Federal Board to training institutions, from time to time, upon which this information can be recorded.

Opportunities in the Military Service

Naturally, conscripted men will want to know just what opportunities for advancement the Government has provided in event of their joining a local radio telegraph school. It can be stated authoritatively that the immediate need of the Army is fifteen thousand (15,000) radio and buzzer operators. Those possessing a considerable knowledge of radio telegraphy and assigned to cantonments will be in line for more rapid advancement in the Signal Corps. The greater their skill, the higher the appointment they will obtain.

Although assigned to a cantonment as a private, the drafted man, if selected as a radio or buzzer operator after the *vocational census* is taken, may advance to the rank of *corporal*, or *sergeant*, at a wage of from $36 to $51 monthly. If he has unusual qualifications and obtains rapid promotion in the cantonment, he may secure the position of *master signal electrician* with a wage of $81 per month.

Arrangements are now under way whereby the Signal Corps will give the student advanced instruction in the cantonment if he is unable to complete his course at a regular school. Promising young men who have shown ability in ordinary training schools will be eligible for selection for this special instruction.

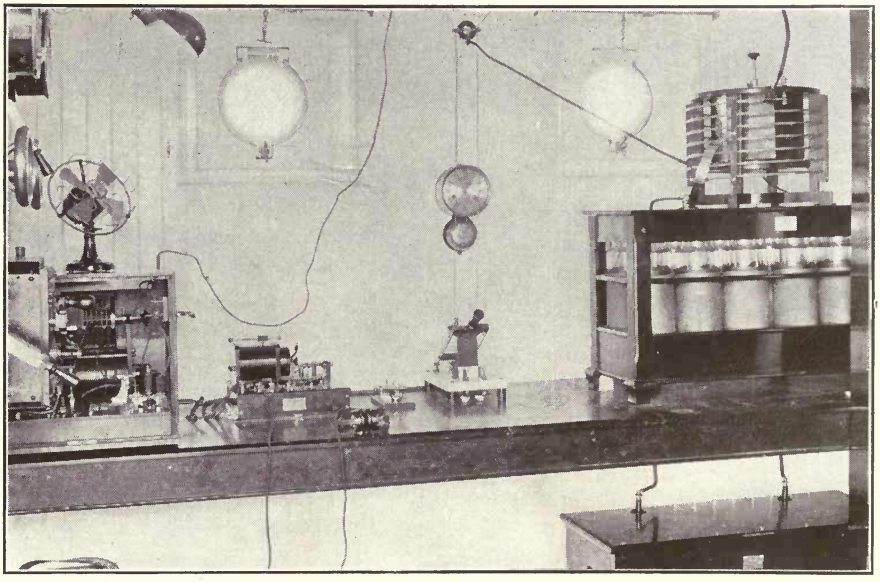
Day and Evening Classes

It is certain that an evening class will attract more students than a day class, because the man subject to conscription, if employed, will hold his position up to the time he is assigned to a cantonment.

Evening classes should convene not earlier than 7:30 P.M. and continue no longer than two and a half hours. It has been the experience of evening schools, backed by statistics, that longer evening sessions militate against efficiency rather than contribute to the student's progress.

It may be desirable in certain localities to hold classes convening from 5:00 P.M. to 7:30 P.M. to accommodate those who live far from schools and are unable, at the close of a day's work, to go home for supper and return to their classes.

The exact hours of an evening school should be adapted to the distance of travel and transportation facilities in a given locality.



A typical transmitting and receiving set of the type installed on ships under the U. S. Flag during the years 1907 to 1912. The photograph shows part of the transmitting apparatus, the receiving tuner, the aerial changeover switch, and a small induction coil auxiliary set.

COURSES OF INSTRUCTION AT THE MARCONI INSTITUTE

THE Marconi Institute was established in the year 1909, to train commercial wireless operators for ship and shore station service. The scope of this institution has gradually been extended to include more advanced work, to fit men to become radio inspectors, construction engineers, radio experts and experimental engineers.

Since America entered the war the doors of the Institute have been thrown open for training men in radio for all departments of the Government, in addition to the merchant marine service.

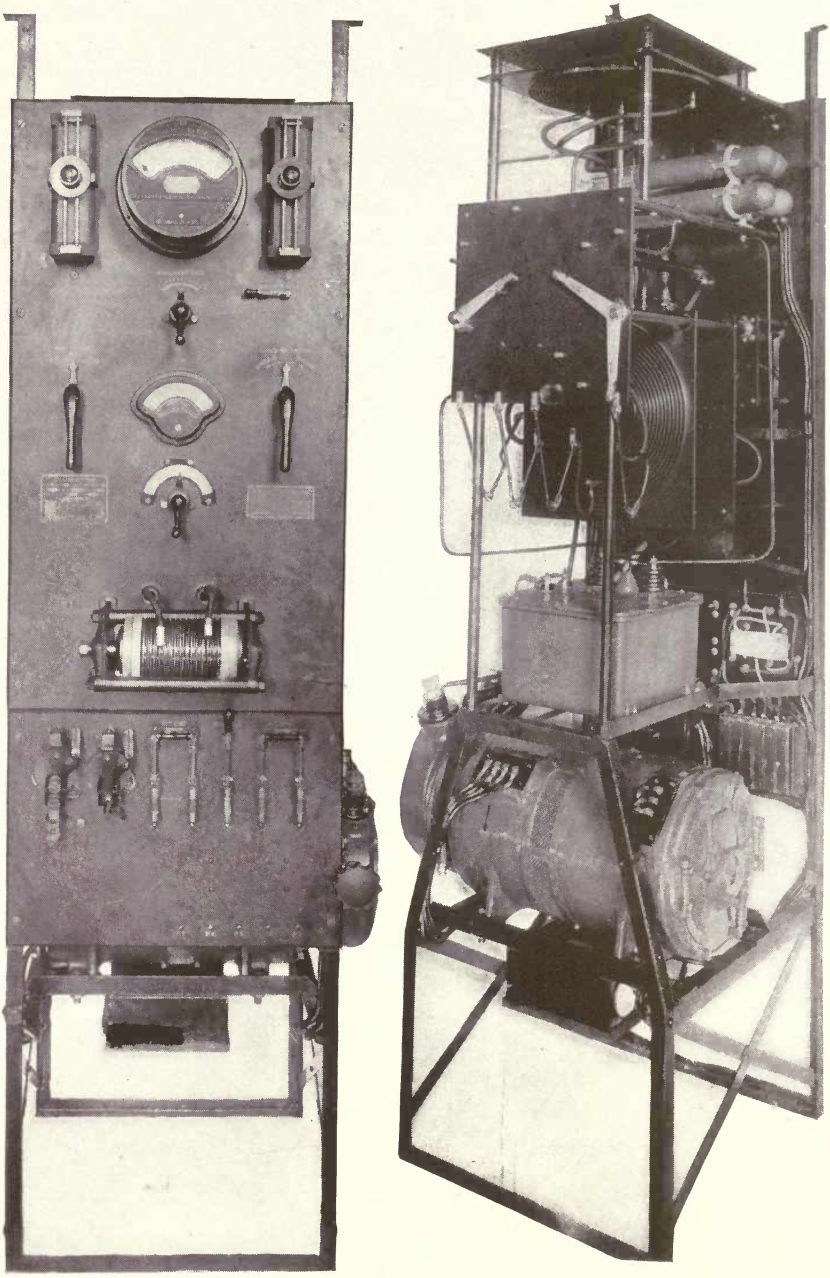
The Institute has already prepared many men for the aviation reserve, signal corps reserve, the artillery, enlisted naval men and men in similar service. The course of instruction has been especially adapted to meet the needs of the Federal service.

The Marconi Institute is equipped with an exceptionally complete outfit of wireless apparatus. By reason of its experience and equipment, it possesses unusual facilities for training advanced radio telegraphists for national and commercial service.

In addition to personal instruction given in classes, the Institute provides a complete and systematic course of training by means of text books, code practice apparatus, printed outline lectures and written examinations, which constitute a complete home study or reading course for those who are unable to attend proper training schools. It has selected and made available for individual study such wireless literature as is best adapted for instruction along modern lines. Not only has this Institute trained men for the particular services mentioned; it has also provided instruction for engineers from foreign countries, to fit them to undertake and maintain important installations in their home lands.

Classes of the Institute

The classes of the Marconi Institute are conducted at the following places: Headquarters—Edison Building, corner Elm and Duane Streets, New York City; Branches—Cleveland, Ohio, Rooms 361-70 Lenox Building, Euclid Avenue and East 9th Street; San Francisco, Cal., New Call Building, New Montgomery Street.



Front View Back View

MARCONI ½ K.W. 500 CYCLE TRANSMITTER

On certain vessels, a transmitter of 2 K.W. capacity is not required. Hence a special ½ K.W. transmitter was developed by the American Marconi Company for ship service. The photograph shows one of the latest types of panel sets of this power which in general is similar to the 2 K.W. 500 cycle set. The motor-generator is fitted with a special type of automatic starter and both the quenched and rotary spark discharges are employed. The apparatus is also constructed for rapid change of wave length, the standard waves of 300, 450 and 600 meters being provided for.

Hours

Both day and evening sessions are held.

The hours of the day class are from 10 A.M. to 12 noon and from 1 P.M. to 4:30 P.M., Saturdays from 9:30 A.M. to 12 noon. The evening classes hold sessions from 7:30 P.M. to 9:45 P.M., Monday to Friday, inclusive.

There will be established a third class, to convene at 3:30 P.M. and close at 7 P.M. This will provide instruction for men who are unable to attend at other hours during the day.

Under the present arrangement, technical instruction in the day class is given from 10 A.M. to 12 noon Monday to Friday; code instruction from 1 P.M. to 4:30 P.M. Monday to Friday, and Saturday from 9:30 A.M. to 12 noon, with the exception of a half-hour traffic class which is held on Wednesday from 3:30 P.M. to 4 P.M.

In the evening class technical instruction is given Monday and Thursday from 7:30 to 9:45 P.M. Tuesday, Wednesday and Friday are devoted to code and traffic instruction.

The Institute is closed on holidays.

Qualifications of Applicant.

An applicant for admission to the classes at the Marconi Institute must qualify as follows:

(1) *He must not be less than sixteen years of age.*

(2) *If he intends to enter the commercial or Government service he must be a citizen of the United States.*

(3) *He must possess at least a grammar school education.*

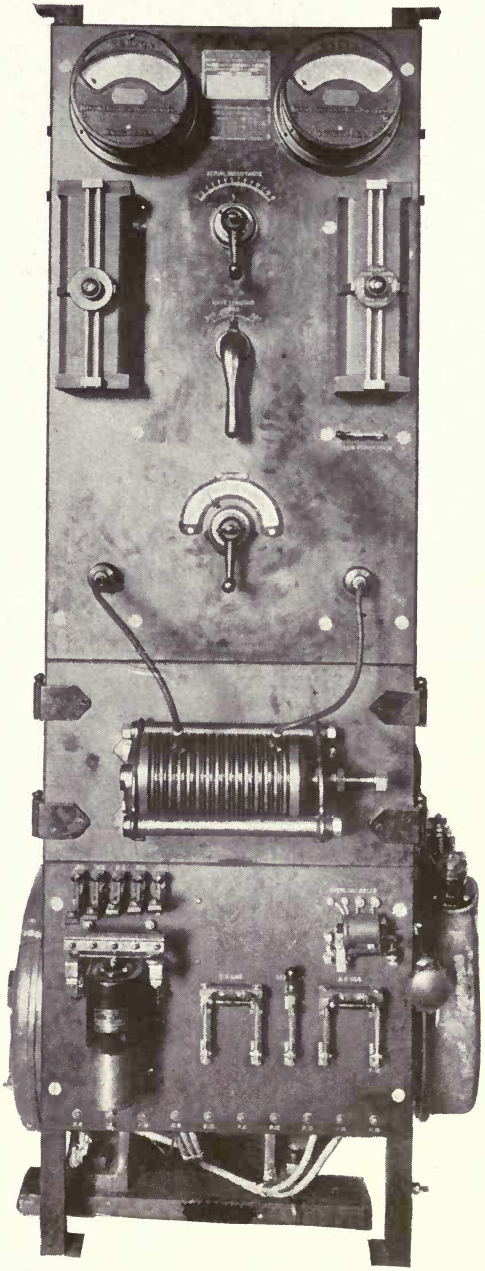
(4) *He must furnish satisfactory references.*

(5) *He must possess a birth certificate.*

(6) *If he has taken out naturalization papers he must present them for inspection.*

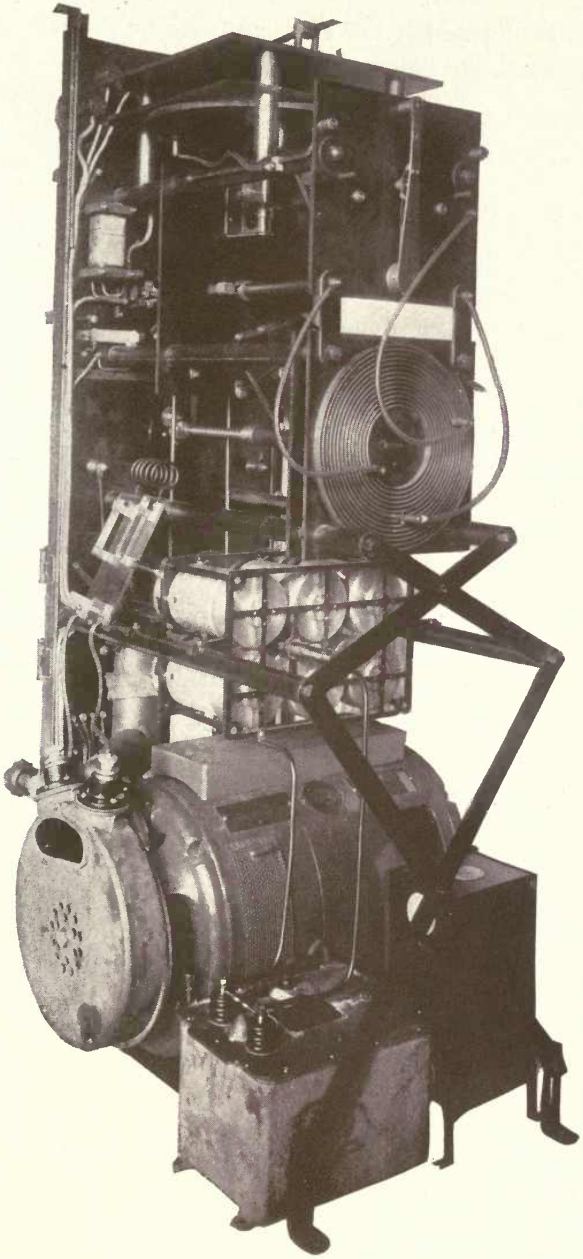
Telegraph Codes and Practice

Only the Continental Morse code is used in radio, but special instruction will be given in the American Morse code to those desiring it. The classroom is fitted with head telephones and apparatus which give a perfect reproduction of wireless telegraph signals. The operator's tables are so connected that the instructor in charge can send to the



FRONT VIEW

These photographs show the front and rear view of the 2 K.W. 500 cycle transmitter developed by the Marconi Wireless Telegraph Company of America. This transmitter is designed for three standard wave lengths—300, 450 and 600 meters—and is fitted with a special multiple point radio frequency switch whereby the wave length can be instantly changed from one to the other by the operation of a single



BACK VIEW

switch handle. The transmitter is supplied with both quenched and rotary spark dischargers, and the motor generator is fitted with an automatic motor starter for distant control. These sets have a daylight range of 500 to 600 miles and a night range up to 2,500 miles. The actual range of the transmitter, of course, varies with the type of oscillation detector employed at the receiving station. Hundreds of these transmitters are in daily use.

entire class simultaneously, or the class may be divided into sections, each section obtaining separate instruction.

The students' tables are equipped with transmitting keys enabling them to communicate with one another.

Call letters of prominent ship and shore stations are assigned to the various tables and traffic is dispatched after the method employed at commercial stations.

In addition, a Wheatstone automatic transmitter is in daily use. By means of this device messages which have previously been perforated on tape are automatically sent to the class at any desired speed. This apparatus is a duplicate of that employed at the high power transmitting stations for sending press and commercial messages to ships.

Radio Traffic

One of the special features of the Marconi Institute is its class devoted to instruction in the dispatch of wireless traffic. In times of peace, when trade routes and business are normal, correct methods of routing and handling traffic are highly important. The students of the Institute are taught not only the method of procedure in the dispatch of all kinds of traffic from ship to ship and from ship to shore, but they are given thorough training in accounting for tolls, the making up of final abstract, the trade routes of different steamship lines, and the special problems which the operator encounters in the transmission of messages through foreign stations. The instructors in this department are specially qualified through years of practical experience in actual service throughout the world.

Students are taught thoroughly the Regulations of the International Telegraphic Convention, and also the special Regulations issued by the Bureau of Navigation or the Naval Communication Service.

Laboratory Equipment

The Institute is supplied with the most advanced types of wireless telegraph apparatus developed by commercial wireless companies. The equipment consists, in part, of:

(1) *A 2-K.W., 500 cycle quenched gap panel transmitting set of the latest type, with all accessory apparatus for its commercial operation.*

(2) *A standard ½-K.W., 500 cycle transmitting set of the latest type.*

(3) *A ¼-K.W., 500 cycle cargo type transmitting apparatus.*

(4) *A 2-K.W. 240 cycle disc discharger transmitting set.*

(5) *A 1-K.W. non-synchronous rotary transmitting set with switch-board and all auxiliary appliances.*

(6) *Standard auxiliary or emergency transmitter for use on ships.*

(7) *A complete storage battery installation with switch-boards and all accessory apparatus for instruction in the maintenance and care of storage cells.*

(8) *Several of the latest types of receiving tuners employed in commercial service.*

(9) *A Marconi Direction Finder Set complete.*

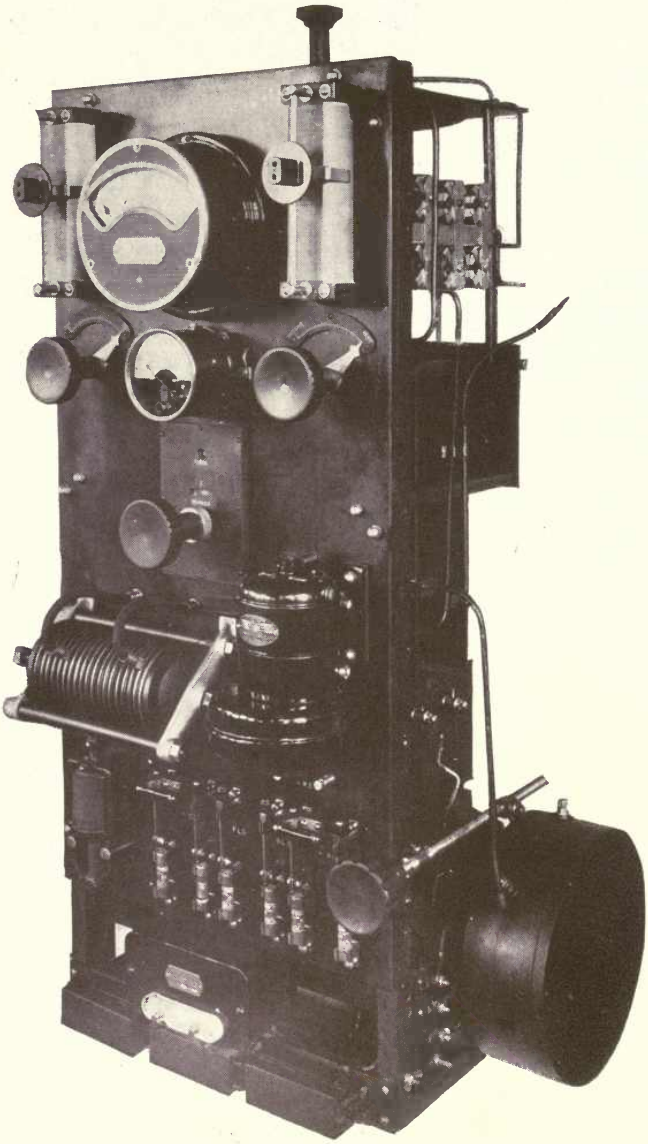
(10) *Numerous types of wavemeters, decremeters, and special parts of both transmitting and receiving apparatus for class instruction.*

Experimental apparatus is constructed by students as part of their course. Students who show special ability in conducting experiments are encouraged to make further investigations into radio telegraphic measurements, thereby fitting themselves for advanced work.

The Technical Course

The Institute's technical instruction begins with elementary principles of electricity and magnetism and continues through every department of electrical practice up to the radio frequency circuits of wireless telegraphy. The subjects treated are outlined in their order on page 17.

The Institute is under the supervision of men with years of practical and theoretical experience. Consequently, the instruction provided equips the student to take his place in the front ranks of commercial wireless.



The desirability of panel types of transmitters was early recognized in the art. The photograph shows the special ½ K. W. 120 cycle transmitting set designed by the American Marconi Company. This apparatus is complete in every respect and is supplied with both the quenched multiple plate and rotary spark discharger. The additional apparatus required to make a complete transmitting and receiving system is the receiving tuner, antenna changeover switch, and a telegraph key. Transmitters of this type are employed as the main power sets for cargo vessels or as an auxiliary set on vessels carrying transmitting apparatus of greater power.

Those who contemplate entering the service of a commercial company should not overlook this essential feature.

The Institute offers training, based on commercial practice in the years 1917 and 1918, through which the graduate is qualified to meet the requirements of present day practice. The latest developments in wireless telegraphy are taught, in advance of the general dissemination of this information to the public. The Institute's relations with large commercial companies enable it to offer instruction not available in other schools.

Time Required

The time required for the complete course depends largely upon the capability of the student. Generally speaking, the completion of a technical course requires two and a half months' daily instruction. The time required to complete the code course cannot be accurately estimated in advance. If the applicant is able to receive at a speed of ten words per minute at entrance, he should be qualified to pass the Government license examination at the end of two months. An absolute beginner will require from three to three and a half months code instruction.

The time required to qualify in the evening class is somewhat in excess of this; usually from four to five months in code instruction and from two and a half to three and a half months technical instruction. The Marconi Institute arranges the course for each new class, to suit the capabilities of the enrolled students.

An intensive training course is provided for those with special qualifications; this course is completed in six weeks.

Examination

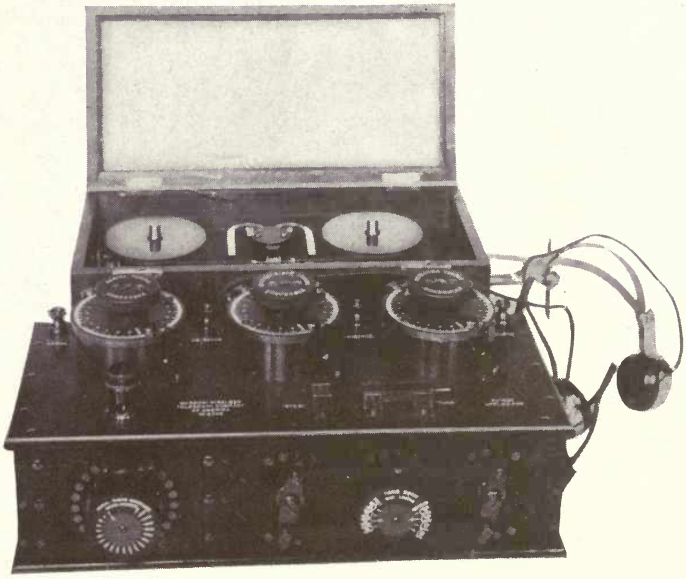
The final examinations of the Marconi Institute are suited to the particular branch of radio telegraphy which the student desires to enter. In the technical examination a passing mark of 75 per cent. is required and in the examination covering radio traffic a rating of not less than 80 per cent. is required. At the completion of the course a certificate is issued to the students upon which is recorded the number of hours he has attended, his rating both in the theory of radio and radio traffic, and his knowledge of American Morse and Continental telegraph codes.

Graduates of the code division must be able to transmit and receive

at a speed of twenty words a minute in the Continental Morse telegraph code.

Government Examination for Operators' Licenses

Commercial radio telegraphists must secure Government license certificates before they can be employed as wireless operators. Operators examinations are held at *custom houses* and *navy yards* throughout the United States. To inform applicants of the gradations of commercial wireless licenses and the qualifications expected from the students undergoing the examinations, the following general outline is appended.



The introduction of the Magnetic Detector by Marconi marked a step in the progress of commercial wireless telegraphy, for it permitted the use of a telephone as a current translator. Two advantages were thus derived: the receiving operator was enabled to distinguish between the interfering signals caused by the discharges of atmospheric electricity and those sent out by the transmitting station. Beyond this the telephone permitted a much higher speed of transmission and reception than the coherer.

The photograph shows the Magnetic Detector and its receiving tuner known as the Multiple Tuner, which has a range of wave length from 80 to 2,600 meters. With this apparatus signals are received aboard ship, in mid-ocean from the Marconi High Power stations at Cape Cod, Massachusetts, U. S. A., and at Poldhu, Cornwall in England.

GRADATION OF COMMERCIAL OPERATORS' LICENSES

GRADE	SPEED REQUIRED	TECHNICAL EXAM.
Commercial Extra 1st Grade....	30 words per minute American Morse. 25 words per minute International or Continental Code.	Wider in scope than examination for original first grade certificate. (Passing mark 80%).
Commercial 1st Grade	20 words per minute Continental Code (5 letters per word).	(a) Adjustment, operation and care of commercial apparatus. (b) Correction of faults. (c) Use and care of storage batteries and auxiliary apparatus.
Second Grade....	12 words per minute Continental Code (5 letters per word).	Same as examination for first grade but lessened scope.
Cargo Grade....	Approximately 5 words per minute Continental Code. (Sufficient to enable "watcher" to interpret S O S signals and call letters.)	Must be able to explain adjustment of receiving apparatus and draw simple fundamental wiring diagram of transmitter and receiver.

CREDITING OF GOVERNMENT LICENSE

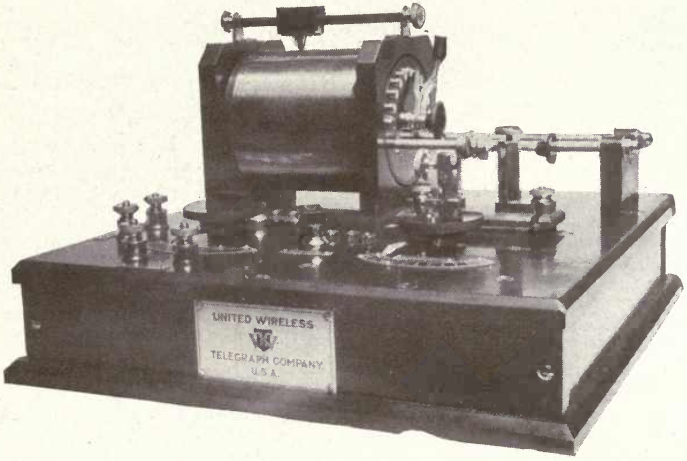
(75% constitutes passing mark for first grade certificate; 65% for second grade certificate).

	Points Awarded.
A—Experience	20
B—Diagram of Transmitting and Receiving Apparatus	10
C—Knowledge of Transmitting Apparatus	20
D—Knowledge of Receiving Apparatus	20
E—Knowledge of the Operation and Care of Storage Batteries	10
F—Knowledge of Motors and Generators	10
G—Knowledge of the International Regulations Governing Radio Communication and the U. S. Radio Laws and Regulations	10

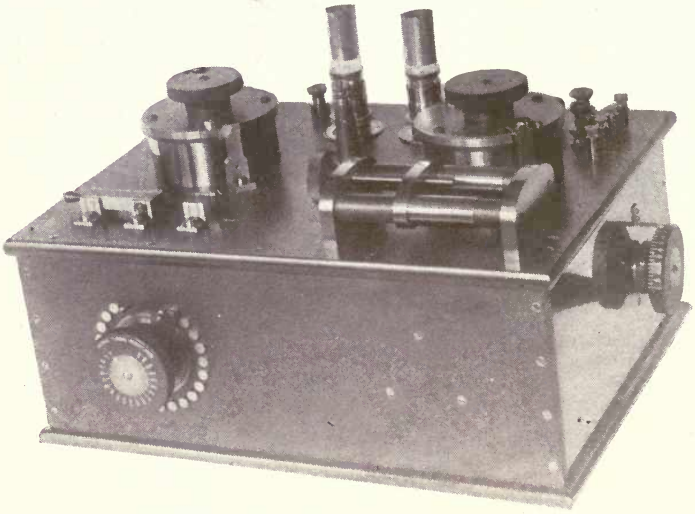
For Students From Out of Town

Young men from outlying cities may secure board and rooms at the Y. M. C. A.'s in Greater New York. Certain of these institutions have licensed employment bureaus which can frequently place students in day or evening positions, helping them to defray expenses while attending school. Good board and room can be secured in New York City at from $7.50 to $10.00 per week.

The Marconi Institute does not secure boarding places for its students, but has on file a list of places where the young men can be quartered during their period of instruction.



A special type of receiving apparatus was devised in the year 1907 to 1908 for use of both ship and shore stations. The photograph shows a type of inductively coupled receiver employed in ship installations under the United States Flag during the years 1908 to 1912. It is a complete receiving set constructed specially for use with the carborundum detector. The tuning apparatus consists of an inductively coupled receiving transformer, primary and secondary condensers, potentiometer, battery, and detector holder. It possesses a range of wave length from 200 to 3,000 meters.



Dr. J. Ambrose Fleming, of London, England, devised a very effective oscillation detector which he named the Oscillation Valve. He discovered that the electrons thrown off by the incandescent filament could be made to rectify the extremely high frequency oscillations employed in wireless telegraphy, changing them into minute pulsating direct currents suitable for operation of the head telephone. Also, on account of their mobility, these electrons permitted a very precise relaying action much similar to that obtained from a telegraph key.

The receiving tuner shown in the photograph was specially designed for use with the Fleming Oscillation Valve. It has a range of wave length from 300 to 1,650 meters and is widely used in ship installations.

THE INSTITUTE EXTENSION COURSE

THE Marconi Institute Extension Training Course and Service is a systematic, time-saving means of furnishing to students in the war camps, homes or local radio clubs, orderly and scientific training through literature prepared by the leading exponents of the art.

It is indispensable to experimenters or students who desire a thorough working knowledge of *wireless.* This service already has been subscribed to by 8,000 men.

It is planned primarily for those who are progressive and alert and who look ahead to the future.

Wonderful expansion in every department of scientific development and industrial application is assured. Students and experimenters who use the opportunities presented to them through the Institute Extension Course and Service, will never regret the time given to such study.

It is not essential that students have a college or technical education, but one thing is necessary: they must have a serious purpose and be willing to devote a reasonable portion of their spare time to study and practice.

The Organization

The Extension Training Course and Service is directed by successful business men and recognized expert instructors.

Persons Benefited

It brings to the student essential and reliable data that is not otherwise available in convenient form and at reasonable cost. It presents the best thought of the leaders in wireless work in America. It covers the essential subjects of which every radio student should be informed.

This Extension Service is designed especially for:

(1) *Persons who are already engaged in commercial and government wireless work.*

(2) *Students and experimenters who are looking forward to entering either commercial or military service.*

(3) *Individuals and the membership of local wireless associations attracted to the experimental wireless field by the fascination of the radio art.*

(4) *Instructors engaged in conducting radio classes.*

The Institute Service in outline:

(1) *It furnishes the subscriber, in the pages of THE WIRELESS AGE (the official monthly magazine of the*

Institute) and in specially prepared text books, a most complete and probably the best organized treatment of wireless principles and practice available for individual study.

(2) *It guides and stimulates the reading of the texts by a series of outline suggestive studies.*

(3) *It keeps the student in touch with the best current thought and practice through special periodic wireless extension lectures.*

(4) *It offers him opportunities for applying his knowledge in commercial service and prepares him to enter government service.*

(5) *It answers all personal inquiries in connection with his training course.*

To help meet the immense demand for trained men for the National Service, and to replace those called from the ranks of mercantile life, the Institute now provides in the pages of *The Wireless Age* a series of *Extension Training Courses* in the following branches, of which there is urgent need. The subjects treated are listed under each course.

AVIATION—Conducted by Henry Woodhouse, Governor of the Aero Club of America.

Principles and theory of flight—nomenclature, assembly, rigging—care and repair of aeroplanes—operation and care of aeronautical engines—principles of general and cross-country flying—reconnaissance, map reading, signaling and co-operation with military bodies—radio for aircraft and its uses—machine gunnery and bombing from aeroplanes.

SIGNAL CORPS WORK—Conducted by Major J. Andrew White, Chief Signal Officer, Junior American Guard.

Function and operations of the Signal Corps and its relation to the line of the army—drill instruction, mounted and dismounted, for telegraph companies, radio and outpost companies, and battalions of Signal Corps—signaling by telegraph, heliograph, night lantern and flags, radio and service buzzer—camp and field telephones and their uses—radio apparatus of the Signal Corps—scouting, patrolling and tactical employment of field lines.

WIRELESS TELEGRAPHY—Conducted by Elmer E. Bucher, Director of Instruction, Marconi Institute.

Code practise—elementary electricity and magnetism—primary and secondary batteries—electrical units and circuits—electromagnetism—electromagnetic induction—the dynamo, motor and motor-generator—transmitting and receiving apparatus—transformers—tuning—modern wireless sets—measurements—undamped oscillation transmitters and receivers—regenerative receiving circuits.

NAVIGATION—Conducted by Capt. F. E. Uttmark, Principal, Uttmark's Nautical Academy.

Compass work—details of Mercator's chart—coastwise and ocean chart sailing—keeping the log book—the taffrail and chip logs—dead reckoning—care and use of the sextant and chronometer—correcting

altitudes and declination—latitude by meridian observation of the sun—selection and use of logarithms—various kinds of time—longtitude by solar sights—deviation of compass by sun azimuths, and by terrestrial ranges.

These courses are conducted exactly as lecturers give them to their classes.

The printed diagrams and charts take the place of regular blackboard exercises, and the text, covering description, principles and application, progresses step by step through elementary instruction, apparatus and practical operation.

The cost of similar instruction in regular training schools would be:

Aviation	$75
Signal Corps Work	75
Wireless Telegraphy	65
Navigation	100
Total	$315

Furnished in *The Wireless Age* for $2.00.

Carefully selected standard texts on these subjects will be recommended to students who desire them, for more intensive study or references.

A membership period in the Marconi Institute Extension Training Course extends over one year. During that time each member should keep in close touch with the Institute and secure helpful guidance and co-operation.

Cost

The Institute Training Service for Schools and individuals comprises the following publications:

Wireless Age, yearly subscription	$2.00
Practical Wireless Telegraphy	1.50
How to Pass U. S. Government Wireless License Examination	.50
Radio Telephony	2.00
Military Signal Corps Manual	1.50
Victor Records for Code Practice (12 *lessons*)	5.00
**Key, Buzzer, Head Telephones and Condenser for Code Practice*	9.00

These items may be ordered *separately*, as required, or *in combination* at a discount of 10 per cent. on the magazine and text books, but not on the Records and Apparatus.

*Price subject to change.

TEXT BOOKS AND SPECIAL WIRELESS LITERATURE

After careful examination of available wireless literature the following texts for class and extension course study have been selected.

In addition, books for collateral reading, selected upon recommendation of the prominent educators throughout the United States, are listed.

For radio schools offering a general technical and code course, the following books, which are the official text books of the Marconi Institute should be used:

PRACTICAL WIRELESS TELEGRAPHY

By Elmer E. Bucher, Director of Instruction, Marconi Institute

This book is the last word in wireless text books. It furnishes information of utmost value in regard to the very latest styles of wireless sets now in use, and which has not appeared in print before.

PRACTICAL WIRELESS TELEGRAPHY is the first wireless text book to treat each topic separately and completely, furnishing a progressive study from first principles to expert practice. Starting with elementary data, it progresses, chapter by chapter, over the entire field of wireless—fundamentals, construction and practical operation.

Three chapters are devoted entirely to basic electrical principles. The motor-generator, the dynamotor and rotary converter are treated in detail. The nickel-iron and lead plate storage batteries, now supplied for emergency purposes with all commercial radio equipments are the subject of an entire chapter, a description of the apparatus associated with the charging of batteries and complete instructions for their care being furnished.

The radio transmitter is treated both in theory and in practice. The book contains complete diagrams, photographs and descriptions of modern commercial marine transmitters and instructions for the adjustment and operation of the apparatus. Receiving apparatus is treated in like manner, descriptions and working instructions being given for all types of up-to-date receiving sets, including the two and three-electrode valves.

A full chapter is devoted to practical radio measurements, showing in detail how to tune a transmitter and receiving set, how to measure inductance and capacity of radio telegraphic circuits, how to determine the strength of incoming signals and the method of plotting resonance curves. A complete explanation of ships' tuning records, Government tuning cards and everything pertaining to the adjustment of a wireless telegraph transmitter and receiver is published.

The emergency transmitters and auxiliary power apparatus of modern ship wireless sets are thoroughly described and illustrated. Descriptions in detail and principle of the Marconi direction finder are given and modern undamped wave transmitters and receivers are comprehensively told of.

The student, for the first time, is given a complete description of Marconi trans-oceanic stations, including their fundamental working principles, the details of the apparatus and the general plan of the great globe-girdling scheme of the Marconi system.

The 340 illustrations alone, specially drawn, form a complete diagrammatic study and impress upon the reader's mind a pictorial outline of the entire subject. Many of these illustrations reveal details of construction of the newest types of sets and apparatus never before published.

PRACTICAL WIRELESS TELEGRAPHY is a practical man's book from cover to cover and *up to the minute.*

Size 330 *pp., 6x9 inches. Price* $1.50 *net.*

TRAFFIC RULES AND REGULATIONS

We issued this compact volume for the MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA.

At the request of several radio schools, who believe it will be of the utmost value to their students now preparing for professional wireless service, we offer a limited number of copies for sale to persons who are deeply interested and who wish to master the details of practical wireless service.

It contains complete instructions covering every feature connected with the routing and handling of wireless traffic; an interpretation of the International Wireless Telegraph Convention rules as applied to commercial practice; conduct of wireless operators at sea and the method of accounting for traffic with affiliated companies.

CONTENTS — General Instructions—Traffic—Apparatus — Clerical Duties — International Radiotelegraphic Convention—International Telegraph Convention—U. S. Radio Law—Rates Through All Stations of the United States and Canada—Abstracting of Messages and Accounting of Ship and Shore Tolls—Map of Principal Trans-Oceanic Wireless Stations and Coast Stations of the World.

Cloth 12mo. Price $1.00 *net.*

HOW TO PASS U. S. GOVERNMENT WIRELESS LICENSE EXAMINATIONS

By Elmer E. Bucher

Prepared as a guide for radio operators training for the Government License Examination. Third Edition Largely Revised and Extended. One hundred and forty-two Questions and Answers.

CONTENTS—Explanation of Electrical Symbols—Definitions of Electrical Terms—Part I. Transmitting Apparatus—Part II. Motor Generators—Part III. Storage Batteries and the Auxiliary Set—Part IV. Antenna or Aerials—Part V. Receiving Apparatus — Part VI. Radio Laws and Regulations—Part VII. General Information Concerning Operator's License Examinations—Practical Equations for Radio Telegraphy—Equations for Ordinary Power Work.

Price 50*c net.*

MILITARY SIGNAL CORPS MANUAL

By Major J. Andrew White, Chief Signal Officer of the Junior American Guard

This manual, the first of its kind and the only complete work on the broad subject of army signaling, is indispensable to those responding to the call to the colors. Primarily prepared for Signal Corps men, it is a necessity for the proper understanding of their apparatus and the tactical employment of troops and equipment.

Officers of infantry and artillery will find the volume of great utility, a proper conception of the enormously enlarged Service of Information being indispensable to all commissioned men.

Its contents include administration and government of military units—tactics of the division on the march, at rest and in engagement—function and operations of the Signal Corps and its relation to the line of the army—drill instruction, mounted and dismounted, for telegraph companies, radio and outpost companies, and battalions of Signal Corps—signaling by telegraph, heliograph, night lantern and flags, radio and service buzzer—camp and field telephones and their uses—radio apparatus of the Signal Corps—scouting, patrolling and tactical employment of field lines.

Prepared with the full co-operation and approval of the Chief Signal Officer, U. S. Army.

550 *pages.* 260 *illustrations. Price* $1.50.

RADIO TELEPHONY

By Alfred N. Goldsmith, Ph. D.

Fellow of the Institute of Radio Engineers
Member of the American Institute of Electrical Engineers
Director of the Radio Telegraphic and Telephonic Laboratory of the College of the City of New York

This complete text on radio telephony is intended for radio engineers, radio electricians in the Navy, men in the Signal Corps and especially men in the Aviation Service who handle radio equipment. Amateurs and others who desire to be clearly informed concerning this newest and most interesting branch of electric communication will want this book.

It is written in clear style, and presupposes very little knowledge of radio. The text deals largely with the practical aspects of radio telephony and its future. It is copiously illustrated with wiring diagrams and previously unpublished photographs of "wireless telephone" apparatus.

IT IS THE ONLY BOOK TREATING THE SUBJECT OF RADIO TELEPHONY IN ALL ITS ASPECTS.

Among the unusual features of the book are a description of how radio telephony was carried on over a distance of more than 5,000 miles; an illustrated description of an airplane radio telephone set; an illustrated description of a large ship radiophone set; numerous illustrated sections on smaller ship "wireless telephone" transmitters; land station radio telephone sets of all sizes.

Another noteworthy feature is a description of the method of transmitting a radio telephone message to a ship at sea, or across continent or ocean, including the number of persons involved. This material is in dialogue form and so worded as to require no previous knowledge of the subject.

Among the topics treated are: the construction and operation of the Armstrong oscillating audion circuits; the construction and use of bulb amplifiers; the construction of the great alternators of the Alexanderson and Goldschmidt systems and how they are controlled, especially for radio telephony.

The book is very complete, practically every aspect of radio telephony being covered in detail. There are over 400 separate topics listed in a carefully prepared index.

8vo. 256 pages. 226 illustrations. Full cloth, stamped in gold. Price $2.00 *net.*

The following leaders of thought in the *Wireless* and *Electrical Engineering* fields in the United States co-operated in compiling a list of reference works for use as additional study texts and for collateral reading in connection with study courses in *Wireless telegraphy and telephony.*

ARKANSAS
BROWN, H. A. *Instructor in Electrical Engineering,* UNIVERSITY OF ARKANSAS.

CALIFORNIA
RYAN, HARRIS J. *Professor of Electrical Engineering,* LELAND STANFORD JR. UNIVERSITY.

HUND, AUGUST. *Assistant Professor of Electrical Engineering,* UNIVERSITY OF SOUTHERN CALIFORNIA.

COLORADO
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CREATION, GROWTH AND DEVELOPMENT OF THE MARCONI WORLD-WIDE SYSTEM

RADIO-SIGNALING, or the art of signaling by radiant waves, was originated, created, and developed by Marconi, and to him and the great companies bearing his name, formed to commercialize his genius, we owe the development of the art from small beginnings to world-wide achievement.

The transmission of intelligence through space, without any formal conducting medium, was practiced in ancient Egypt, and through past centuries by auditory and visual methods, including the beacon fire, the semaphore, the heliograph, and the cannonade. These methods had such obvious limitations, however, that they gave way to electrical transmission, upon the discovery of the electric telegraph.

The art of transmitting intelligence by electricity is in fact a group of arts, included broadly, under methods of wire transmission and methods of wireless transmission. Wireless telegraphy and radiotelegraphy have been considered, in the popular mind, as synonymous terms, but radiotelegraphy, or radio-signaling, is an art coming under the broad classification of wireless transmission. It involves communication by electric waves through the ether, and has nothing to do with the older methods of electric conduction through earth or water, or electromagnetic or electrostatic induction, in which the waves actually reach from one station to another and are not detached from the sending station and transmitted through space, as in radio-signaling.

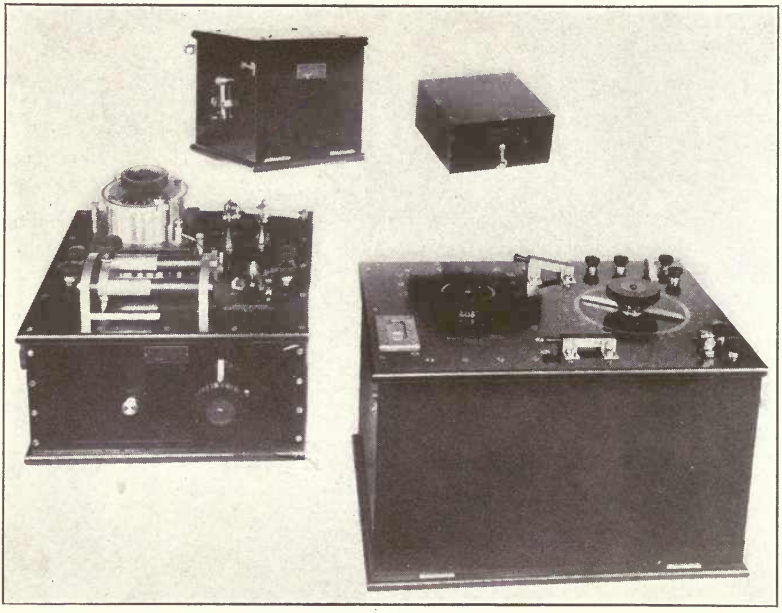
The conduction and induction methods had been tried without material success, due to inherent limitations, when Marconi created the new art of radiotelegraphy, one of the greatest inventions of all time, and afterward destined to become one of the greatest factors of modern civilization.

The first man to transmit intelligence electrically was Morse. He did it by utilizing certain well-known electrical appliances—the battery, the direct current, the magnet, connecting wires, and the key at the transmitter. That was the first one of this group of arts for transmitting intelligence electrically.

The second was the Bell invention of the telephone. Bell also utilized things that were known in electrical science, as the undulatory current, the magnet and diaphragms, and the connecting wires.

Morse, the father of electric telegraphy, originated an art which

was of enormous value. Bell, who originated the art of telephony, also created something of great value. The art of conduction through the earth or water, and signaling by means of electromagnetic or electrostatic induction, however, has not been of any considerable public benefit. But the art that Marconi created, the art of radio-signaling, was



Shows a type of receiving apparatus that has been especially useful in naval and war operations. These four pieces of apparatus constitute a complete Marconi Bellini-Tosi Direction Finder by which the receiving operator may locate the position of a wireless sending station. The apparatus shown has a range of wave lengths up to 600 meters and will locate the direction of the propagation of electrical waves with a notable degree of accuracy. Special types of this apparatus have been developed for use on wave lengths up to 10,000 meters, and with it signals have been received across the Atlantic ocean. The complete direction finder equipment consists of a radio ganiometer, a tuned buzzer detector, a divider, and complete receiving set with tuning appliances.

of enormous value to mankind, and stands as an art by itself, in the group relating to the transmission of intelligence by electricity.

Marconi's epoch-making achievement will be better understood by considering briefly the history of this group of arts to which his invention relates.

Prior Classes of Telegraphy

Extending over a period of fifty or sixty years prior to 1896, many of the most distinguished scientists and inventors of the world had endeavored to devise a system of communicating intelligence telegraphically from one point to another without the use of conducting wires.

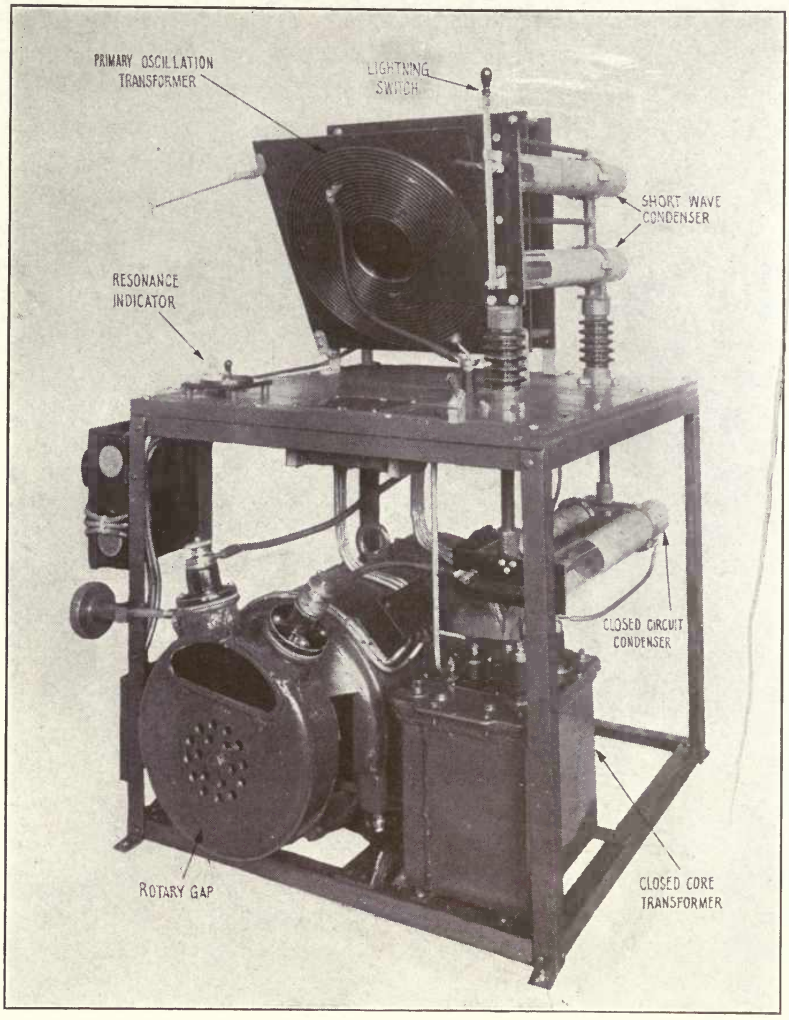
Such renowned scientists as Faraday, Morse, Lord Kelvin, Henry, and Sir William Preece, had endeavored to solve this problem by means of arrangements of apparatus adapted to utilize electric phenomena; these may be divided into three classes or methods.

First in order of time was the conduction system, the essential feature of which is that some other form of material conductor is substituted for wires. These substitutes were in all cases either the earth or bodies of water, since they are the only natural conductors that are sufficiently common and extensive for use. This method was preferably employed by means of wires which were stretched along both banks of a river and grounded at both ends, the length of wire on both sides of the river being greater than the distance by which the wires were separated from each other. If, then, a current was set up in one wire, a certain amount of this current would leak across the intervening space and produce current in the wire on the other side of the river. By means of a circuit maker and breaker signals were thus transmitted from one bank to the other.

It appears that Professor Morse discovered this method of communication as early as 1842, while giving a public demonstration in New York of the practicability of his wire telegraph. A passing vessel parted the wires, which he had stretched from Governor's Island to Castle Garden, and in his discomfiture he immediately devised a plan for avoiding such accidents in the future, by so arranging wires along the banks of the river as to cause the water itself to act as a conductor for the electric current.

Sir William Preece, the engineer of the British Postal Service, subsequently worked out more extensive methods of operation upon this principle, but the distance covered did not exceed two or three miles, and the large amount of wire required was a curious feature of this system of so-called "wireless telegraphy."

The second method originally employed by the scientists and inventors, known as the "inductive system," furnished a wider field of experiment. Of this there are two types; electromagnetic induction, and electrostatic induction. The electromagnetic induction method operated by the production of a magnetic field in one complete circuit, which induced a current in another complete circuit, by virtue of magnetic lines stretched or extending from the transmitting circuit to the receiving circuit. This method was also used by Sir William Preece in England, who was able to telegraph a short distance. This method



There has been an insistent demand in shipping circles for low power transmitters for use on cargo vessels. For these vessels transmitting apparatus was required which could be placed in the hands of operators who were not highly skilled in the technical operation of radio sets. The American Marconi Company developed a ¼ K. W. special cargo type of transmitting apparatus which met with universal favor. The transmitter shown in the photograph consists of a motorgenerator, high voltage transformer, high voltage condenser, oscillation transformer and short wave condenser. The motorgenerator is fitted with a hand-operated starter. This apparatus will permit communication over several hundred miles and is highly suitable for the special grade of service required on cargo vessels.

of wireless telegraphy was also applied to railroad telegraphy. Impulses produced in a wire extending along the track were communicated to a moving train carrying a circuit which was connected through the wheels to the rails at opposite ends of the car.

The third method, known as electrostatic induction, differs from the electromagnetic method in that it does not make use of a magnetic field but depends upon high voltage or pressure for the purpose of "charging the earth," so to speak. Professor Dolbear, of Tuft's College, in 1886, and Thomas A. Edison, in 1891, devised systems for signaling by the electrostatic method. These systems of wireless telegraphy by conduction and induction are of historical rather than practical value. Their utility was very limited and the cost of installation was even greatly in excess of the cost of wire telegraphy. They were obviously impracticable for commercial use because the messages or signals could only be transmitted a very short distance, owing to the fact that they all depended upon the electrical energy at the transmitting circuit stretching or extending to the receiving circuit. There was no detachment or radiation of the electrical energy from the transmitting source as in radiotelegraphy.

These, then, were the prior proposed methods of wireless telegraphy. The art of radiotelegraphy created by Marconi operated by virtue of new and different electric phenomena.

The Period of Speculation—Hertzian Waves

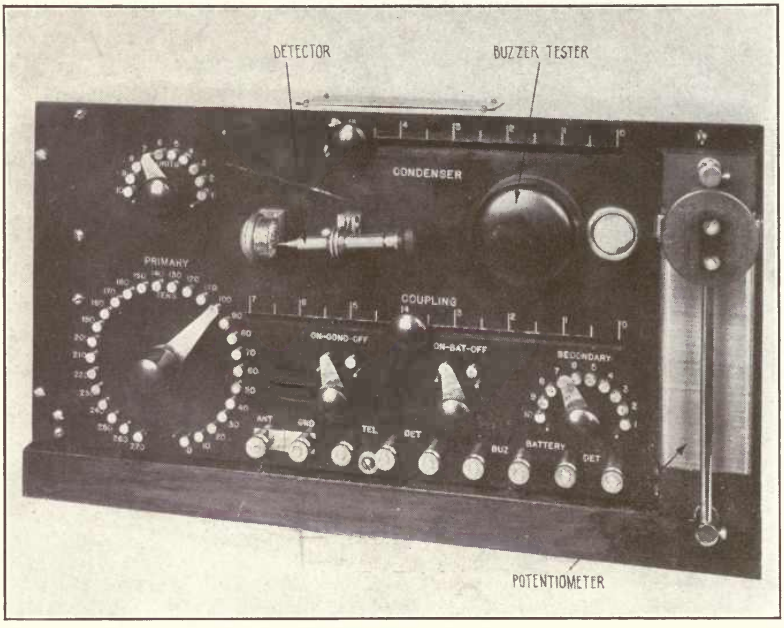
In 1863 the eminent physicist J. Clerk Maxwell, theoretically speculated that the medium known as "ether" should be able to transmit through it disturbances, with a velocity equal to that of light.

In 1887 these theoretical speculations of Maxwell were confirmed by the experiments of Hertz, who showed that electric oscillations which for many years had been known to exist in metal rods, were propagated out into space from these rods in the form of wave motion, when a very sudden electrical discharge took place between the rods. These Hertzian waves are propagated in the universally diffused but impalpable medium called by scientists "ether."

The waves or oscillations are electrical and optical in their nature, and have certain properties similar to "light" waves in that they can be reflected, refracted, and defracted, and travel at the same speed as "light" waves. Unlike an electric current (so called) the oscillations do not flow from the source of current over or through a conductor, but detach themselves or radiate from the place or instrument of produc-

tion, and travel through space as light does from the sun, or as sound does from a bell.

A device by which Maxwell's predictions were confirmed is known as the "Hertz Oscillator." It was then found that it was possible to detect the existence of these waves by employing a loop of wire, with the ends brought close together; if this little loop of wire had a certain relation to the direction along which the waves ought to be traveling,



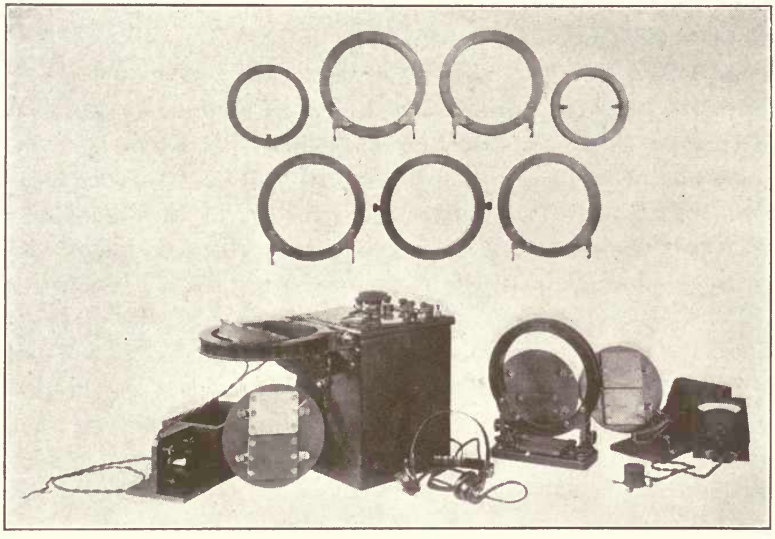
A special compact receiving set had to be designed for use with the ¼ K. W. transmitter. The photograph shows the type 112 receiving tuner of the American Marconi Company which contains full appliances for tuning and for adjustment of the receiving detector. This tuner has a range from 200 to 3,000 meters and is characterized by simplicity throughout.

minute sparks could be detected between the ends of the loops. This little loop of wire is called a "Hertz resonator."

These experimental researches aroused great interest in the scientific world. In 1889 Sir Oliver Lodge continued the experiments on a somewhat larger scale, and even connected the oscillator to a wire fence. In 1890 a distinguished French scientist, Edouard Branly, published an article describing a great variety of substances, which he had discovered to be sensitive to Hertz waves, that is by means of these substances he could detect the presence of these waves.

In the year 1892, following the publication of Branly's discoveries,

an eminent English scientist, Sir William Crookes, published his famous prophecy in the *Fortnightly Review* entitled "Some Possibilities of Electricity." Crookes referred to the before mentioned researches and predicted that eventually means would be discovered for transmitting signals in code. Crookes said that this was no mere dream of a visionary philosopher, but all the requisites needed to bring it within the grasp of daily life were well within the possibility of discovery, and were so reasonable and so clearly in the path of researches which were then



The photograph shows the station type of wave meter and decremeter developed by the American Marconi Company. This apparatus permits the transmitting and receiving apparatus to be calibrated in wave lengths and is useful for special radio frequency measurements such as the determination of the inductance and capacity of a circuit. It is also employed for measuring the logarithmic decrement of damping.

being actively prosecuted in every capital of Europe, that one might any day expect to hear that they had emerged from the realms of speculation into those of sober fact. This remarkable prophecy was completely fulfilled by Marconi, as we now know.

In the following year, 1893, Nicola Tesla delivered lectures before the Franklin Institute in Philadelphia and before the National Electric Light Association at St. Louis, on the subject of *High Frequency and High Potential Currents.* Tesla was not dealing with Hertzian waves, but after discussing and describing certain apparatus for high frequency illumination and power transmission, he referred to the possibility of the transmission of intelligible signals, or perhaps even

power, at any distance, without the use of wires. Tesla said that he knew that the great majority of scientific men would not believe that such results could be practically and immediately realized, but he was firmly convinced that it could be done and he hoped they would all live to see it done.

In 1894 Sir Oliver Lodge published a series of articles in the *London Electrician* on the work of Hertz, and described various forms of detectors or receivers which would render manifest the existence of Hertzian waves. Some of these detectors were discoveries of his own and others were repetitions of Branly's discoveries.

In 1895, a Russian scientist, Professor A. S. Popoff, in a lecture delivered and printed in the *Journal of the Russian Physical Chemical Society* repeated some of the experiments of Branly and Lodge, and also gave an account of some experiments of his own relative to certain substances which he had noted were detectors of the waves. In this article Popoff also described an experiment which he had made at a laboratory, in which he noted that if one of his detectors, consisting of a Branly tube containing filings, was connected to a lightning conductor at one end and to the ground at the other, with an electric bell and battery in circuit, the existence of a distant thunder storm in the Ural mountains could be noted. He concluded his paper by expressing the hope that with further improvements and the discovery of a source of vibrations possessing sufficient energy, his apparatus might be adapted to the transmission of signals at a distance.

The period from the middle of the nineteenth century until 1896 thus forms a period of speculation.

To recapitulate: Maxwell, in 1863, had speculated on the possibility of the production of electric waves which would detach themselves from the source of origin; Hertz, in 1887, had proved, experimentally, that Maxwell's theories were correct; Lodge, in 1889, repeated these experiments; Branly, in 1890, discovered that certain substances, in addition to Hertz's ring resonator, were detectors of electric waves; Crookes, in 1892, had dreamed of the possibility of wireless telegraphy by utilization of the waves. In 1893 Tesla was experimenting with older methods and was giving thought to the matter. Lodge, in 1894, had repeated the original experiments and some others of his own touching upon the form which these electric waves took when emanating from their source of origin. He also experimented upon substances which would detect these waves. Popoff, in 1895, had done the same and

noted that he could, by reason of certain substances, detect the existence of a distant thunder storm, and expressed the hope that wireless telegraphy would be accomplished. But no one had described or illustrated a system of wireless telegraph apparatus adapted for the transmission and reception of definite, intelligible signals by means of Hertzian waves.

Marconi's Discovery

In 1896 the lay and scientific world was astounded at the announcement that the hope of Popoff and the dream of Crookes had been fulfilled in the successful transmission, to a distance, of intelligible Morse signals through space by means of Hertz waves, without the use of connecting wires, and that a heretofore unknown Italian inventor by the name of Guglielmo Marconi had successfully discovered and invented means for accomplishing this astounding and wonderful result.

It was very evident that he, who first harnessed these peculiar manifestations and produced a system whereby they could be molded into definite and predetermined signals, found means of efficiently propagating them to a distance, and provided means for their intelligible reception at distant points, had made a most remarkable invention.

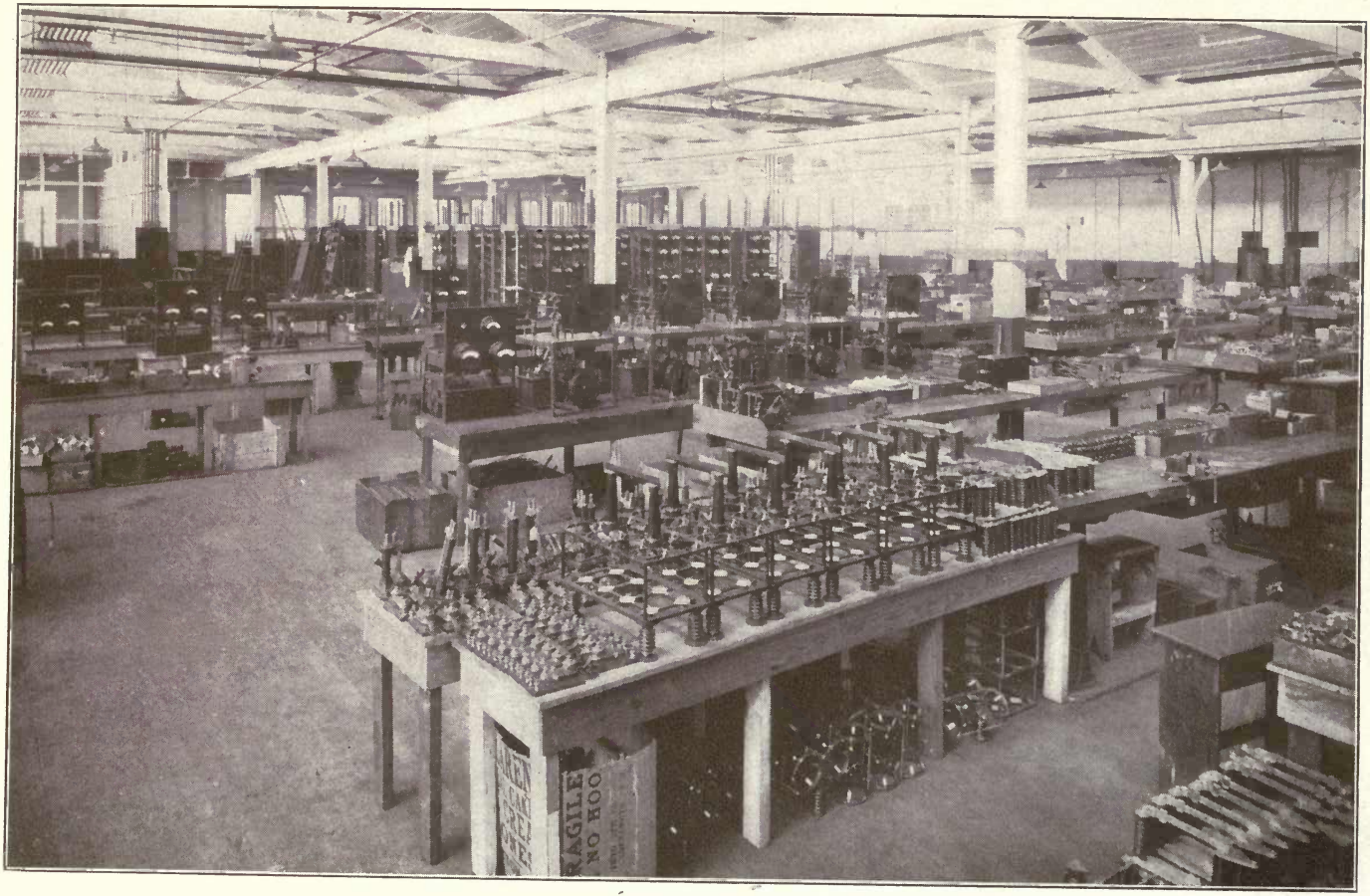
By what means, then, did Marconi attain such a marvelous achievement?

The system invented by Marconi consisted, essentially, of a signal apparatus at a sending or transmitting station, for controlling in a definite way the spark gap, and causing it to produce Hertzian waves of definite form, character and duration, and sparking apparatus subject to nice control and means for radiating and propagating the waves so produced through the ether to another distant station, known as the receiving station, where they were received and caused to manifest themselves through the medium of suitable apparatus, as telegraphic signals and messages.

The story of Marconi's early work, in 1894 and 1895, on his father's estate at Bologna is of intense interest, but for the sake of brevity will not be told here.

The Astounding Results Which Have Been Achieved by the Marconi Invention

The Government of Great Britain owns and operates all land telegraph systems, and early in 1896, Mr. Marconi demonstrated to the satisfaction of Sir William H. Preece, the Chief Engineer of the British Post Office, that his invention had then achieved what no other scientist



The Assembling and Testing Department of the American Marconi Co.'s factory at Aldene, N. J., U. S. A.

or physicist before him had been able to achieve, namely, the transmission of intelligible signals by means of Hertz waves, and to receive them as such, at a distance, without wires. Officers of the British Government were instructed to witness these demonstrations in London, which were so successful that the British Government invited Mr. Marconi to carry out further demonstrations before officers of the British Navy, the British Army, and the British Post office, at Salisbury Plain, some eighty miles from London, in September, 1896. At these demonstrations the British Government was satisfied that transmission over a distance of 1¾ miles was achieved.

The early history of the development of the invention from 1896 onward records ever increasing achievement in distance of transmission, until as early as 1910 a distance of over 6,000 miles was attained, from a station at Clifden, Ireland, to another station at Buenos Aires, in the Argentine Republic.

These new and astonishing results attained by Marconi made his an epoch-making invention.

After Marconi's demonstrations at Salisbury Plain in 1896, further demonstrations were carried out in 1897 before representatives of the British Post Office and the British Navy, when the distance was increased to four miles, and in the same year, before officers detailed by the British Navy, the British Army, and the British Post Office, as well as the British Board of Trade, to witness the demonstrations, communication was successfully established over a distance of nine miles across the Bristol Channel.

The success achieved by Mr. Marconi in this early work, done at the invitation of the British Government, attracted the attention of other Governments. Professor Slaby of Berlin witnessed these remarkable demonstrations and was shown the apparatus by means of which these marvelous results were achieved. At the conclusion of the demonstrations Professor Slaby went back to Germany and in an address described what he had seen as a great discovery.

Later, in 1897, Mr. Marconi demonstrated the new telegraph to the Italian Government, and at Spezia, Italy, he installed his apparatus on one land station and on some Italian warships. During these demonstrations, successful communication was established up to a distance of twelve miles and the official report by the Italian Navy Department, as a result of these demonstrations, contained a remarkable tribute to Marconi's wonderful invention.

A partial view of the machine shop in the factory of the Marconi Wireless Telegraph Co. of America at Aldene, N. J., U. S. A.

Still later, in 1897, Mr. Marconi returned to England and continued further demonstrations before the British Navy, Army and Post Office officials.

Early in 1898 stations were erected at "The Needles," Isle of Wight, and at Bournemouth on the mainland, and communication was established for a distance of over fourteen miles between these two places.

Also in 1898 the first commercial application of wireless telegraphy, for the purposes of journalism, was made. A Dublin (Ireland) daily newspaper—*The Daily Express*—fitted out an ocean-going tug with Marconi apparatus, and by means of that installation, and a similar installation at Kingston, Ireland, the Kingston yacht races, held in the Irish Channel that year, were reported by wireless telegraphy. A distance of twenty-five miles was attained, which, at that time, was a most remarkable achievement.

In 1899 communication was established, for the first time, by wireless telegraphy, between England and France, across the English Channel, the distance between these two stations being thirty-two miles.

In the fall of 1899 the first practical application of wireless telegraphy in the United States was made by Mr. Marconi himself, in carrying out an agreement with the *New York Herald* to report the International Yacht Races, held off Sandy Hook.

At the conclusion of these International Yacht Races, at the request of the United States Government, Mr. Marconi equipped the armored cruiser "New York," the battleship "Massachusetts" and the torpedo-boat "Porter" with wireless telegraph apparatus, and several officers were detailed to investigate his apparatus during tests conducted on these warships. The report of these tests which was contained in the *Proceedings of the United States Naval Institute*, stated that communication was effected between the warships over a distance of forty-five miles.

In 1900, in consequence of the successful tests during the naval maneuvers, the British Navy entered into a contract to equip thirty-two of its ships and stations with Marconi apparatus.

Marconi was improving his apparatus from time to time, in order to attain still greater results, and in 1901 the apparatus was installed in the United States on the Nantucket Lightship.

In December of 1901 he transmitted an intelligible signal across the

Atlantic, between Poldhu, Cornwall, England, and a station in Newfoundland.

The announcement in the public press that Mr. Marconi had successfully telegraphed across the Atlantic by wireless telegraphy, aroused the utmost astonishment and excitement. The Anglo-American Cable Company were apparently so disturbed that they started a suit against Marconi, asking for an injunction to prevent him from erecting a permanent station in Newfoundland, on the ground that they had the exclusive right for a term of years for all cable stations in Newfoundland.

A considerable number of articles appeared in the public press at this time and reported the first successful transmission of intelligence across the Atlantic.

In the next month Mr. Marconi was given a complimentary dinner by the American Institute of Electrical Engineers in New York, commemorative of his wonderful achievement in establishing transatlantic communication by means of wireless telegraphy. Such distinguished scientists as Steinmetz, Elihu Thomson, Alexander Graham Bell, and Dr. Pupin were present. Upon this occasion Mr. Marconi was accorded the highest scientific recognition of his marvelous achievement. Among the eminent scientists who sent congratulatory telegrams were Thomas A. Edison and Nicola Tesla.

Next, in February, 1902, Marconi performed extraordinary receiving experiments aboard the American Line steamship "Philadelphia," enroute from England to New York. At that time he received messages over a distance of 2,099 miles from the station at Poldhu, Cornwall. In July of the same year signals were received from Poldhu on the Italian battleship "Carlo Alberto" when lying at Kronstadt, at a distance of 1,600 miles from Poldhu.

Shortly afterward the long distance station at Cape Cod, Massachusetts, was equipped for transatlantic work and a station was erected at the expense of the Canadian Government, at Cape Breton, Canada. A transatlantic message was despatched from Cape Cod, Massachusetts, to Poldhu, England, on January 19, 1903, and in the same year the first International Conference on wireless telegraphy was held in Berlin for the formation of rules to govern the ship operation and shore radio stations in the principal countries.

Great stimulus was given to the commercial development of wireless telegraphy in the United States from the year 1903 onward. In 1907

the Marconi transatlantic stations at Clifden, Ireland, and Glace Bay, Nova Scotia, were opened and traffic was accepted for all points in England and Canada.

Great impetus was given to the use of wireless aboard ship, in the year 1909, by the collision of the steamship "Republic" with the steamship "Florida" off the coast of the United States. Assistance was called for through the wireless equipment on the "Republic" which was answered by vessels within range, and as a result the passengers and crew were saved before the vessel sank. This was by no means the first rescue made through the medium of wireless telegraphy, but it apparently made a greater impression on ship owners than any previous similar event.

Then came Marconi's record-breaking transmission of messages between Clifden, Ireland, and Buenos Aires, Argentine Republic, a distance of over 6,000 miles.

During the years 1910, 1911, and 1912, a world-wide development in the commercial application of wireless telegraphy took place. All vessels of any considerable tonnage throughout the civilized world were equipped with modern radio apparatus, and in addition shore stations were erected at the principal seaports. By means of a system of communication charts, prepared by the Marconi Company, it became possible for a vessel to establish communication, by relay, with a land station in any part of the world. Commercial ship-to-shore traffic increased enormously during this period, and as steamship owners realized the assurance of safety to vessels and cargo, and the possible saving of human life, which would result through the use of wireless telegraphy, an unprecedented demand for ship equipments followed.

Compulsory legislation was then enacted by the great nations, compelling the use of wireless apparatus on ships above a certain tonnage. Not only was the installation of apparatus required, but according to the regulations of the International Radio-Telegraphic Convention, to which the United States subscribed in the year 1912, the wave lengths employed in radiotelegraphy for ship use were restricted. It was required that the transmitting apparatus be adjusted to radiate a wave of different length, and standards were also adopted for the character of the radiated wave.

The next step of importance in the commercial application of wireless telegraphy was the completion of the Marconi Company's high power stations at Carnavon, Wales, and New Brunswick, New Jersey,

in 1914. Stations were also erected between Bolinas, California, and Kahuku, on the Island of Oahu, Hawaiian Islands. The California-Honolulu circuit was opened to public service in September, 1914.

About this time the German Telefunken Company erected a high power station at Sayville, Long Island, to communicate with a similar station at Nauen, Germany, and a high power station was erected by another company at Tuckerton, New Jersey, for communication with Hanover, Germany.

Practical tests of radiotelegraphy aboard trains were made in 1913 by Marconi, and in 1915 direct wireless telephonic conversation was effected between the United States Government station at Arlington, Virginia, and Honolulu, in the Hawaiian Islands. A little later wireless telephonic conversation was held between Arlington, Virginia, and Paris, France.

During the period 1912 to 1917, the United States Navy Department connected all its important naval bases by radio.

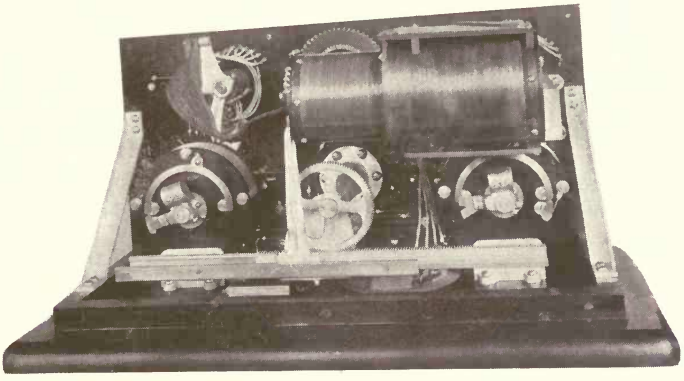
Progress in the year 1917 may not yet be recorded, for the greater part of the development during that period was on behalf of the various Governments engaged in war.

A special panel receiving set was also designed for use in ship work. The photograph shows the type 106 receiving tuner of the American Marconi Company which is complete in every detail. It has a range of wave length from 200 to 3,500 meters and is particularly suitable for ship traffic. The cabinet contains the component parts of an inductively coupled receiving transformer with all accessory apparatus necessary for tuning and adjusting. The tuner also includes a buzzer tester for preadjusting the crystal to its most sensitive condition.

SCIENTIFIC PROGRESS

IT is not practicable here to give a complete resume of the scientific progress in radio during the past seventeen years, but some of the more important developments will be briefly noted.

Marconi's original transmitter consisted of an induction coil, the secondary of which was connected to a spark discharge gap. One terminal of the gap was connected to a vertical insulated wire and the opposite terminal to earth. Marconi's early receiver consisted of a glass tube fitted with metal lugs on either end between which was placed a small quantity of metallic filings. This device, known as a "coherer," was connected in series with a telegraph relay and a battery. One terminal of the coherer was connected to the aerial wire and the other to earth.



This photograph shows the rear view of the type 106 receiving tuner, in which can be seen the primary and secondary coils of the oscillation transformer, the shunt secondary and the aerial condenser and the special rack and pinion for changing the coupling between the primary and secondary coils.

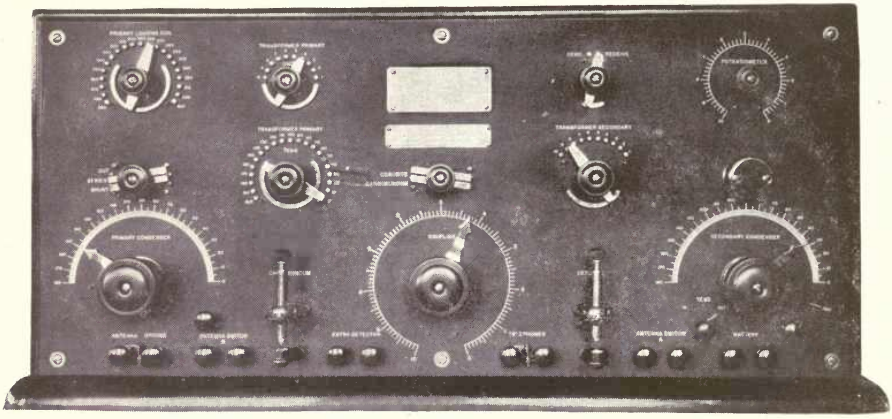
Under the influence of the electrical oscillations induced into the coherer circuits by the distant transmitter, the conductivity of the filings instantly increased, closing a battery circuit through the telegraph relay. A vibrating hammer device known as a de-coherer tapped the coherer at the termination of each signal and placed it in condition to become responsive to the next impressed group of oscillations.

Marconi next improved the transmitter provided for removing the spark gap from the antenna circuit, placing it in a local or closed circuit, which, on account of the increase of capacity over that of the aerial wires, generated more powerful oscillations. Then by means of

an oscillation transformer, these locally generated radio-frequency currents were transferred to the antenna or radiating wires.

This change in design resulted in more powerful radiation from the transmitter aerial with less damping of the oscillations, which reduced the interference between stations. Increased freedom from interference was also obtained at the receiver by coupling the coherer circuit to the aerial wires through a specially designed receiving transformer.

It is fully established that Marconi was the first to realize the necessity for complete resonance between the transmitter and the receiver. His original "four circuit tuning" patent covering this principle has become famous throughout the world, and its claims have been sustained in the major courts wherever contested. This patent was filed in England, April 26, 1900.



Marked improvement was made in receiving apparatus in the United States during the years 1912-1913. The component parts of a receiving set were mounted compactly in a cabinet and all control switches mounted on a panel directly in front of the operator where they were easily accessible.

The photograph shows the type 101 receiving tuner of the American Marconi Company which has a range of from 300 to 7,500 meters. It is fitted with a carborundum and cerusite detectors and further contains a complete set of tuning appliances for the primary and secondary circuits. This receiver is acknowledged by experts to be the most complete of its type.

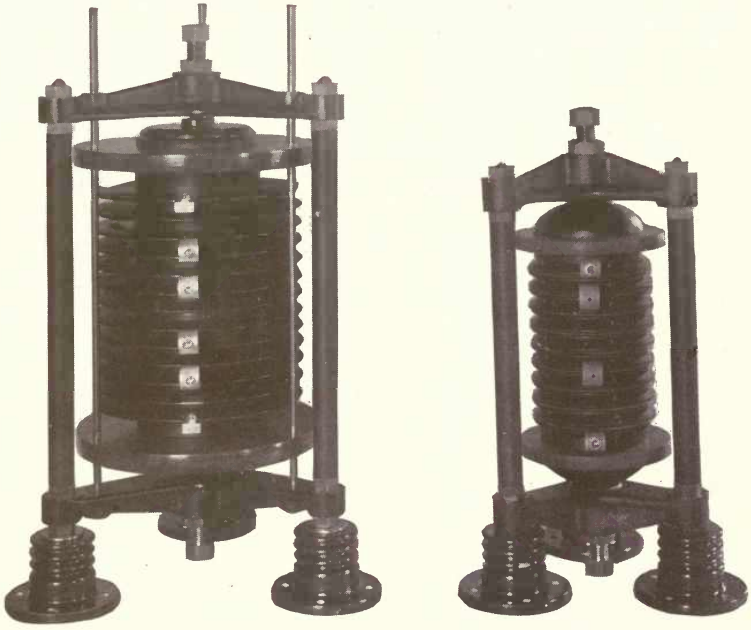
Sir Oliver Lodge made a number of investigations during Marconi's early work and he was instrumental in developing a special system in collaboration with Dr. Muirhead. Lodge filed one basic patent owned by the Marconi Co. on loaded aerials which proved valuable.

Another important invention of Marconi's was the perfection of the magnetic detector which depended for its operation upon the ability of high-frequency currents to demagnetize a moving band of iron under the influence of permanent magnets. This detector permit-

ted the use of a telephone receiver in place of the telegraph relay for recording signals, and it allowed practically unlimited speed of reception.

The use of the telephone receiver marked a distinct gain in the commercial progress of radiotelegraphy, because it permitted the operator to distinguish between radio signals sent out by a distant transmitter, and the interfering sounds of atmospheric electricity which differed in tone.

The induction coil as a source of high voltage current for the



The development of the Multiple Plate Spark Discharge Gap in the year 1908 increased the efficiency of low power spark transmitters to a marked degree. The gap proved eminently practical for ship use as it removed the great objection to open spark dischargers—the crashing noise which sometimes did not prove particularly pleasing to the passengers' ears.

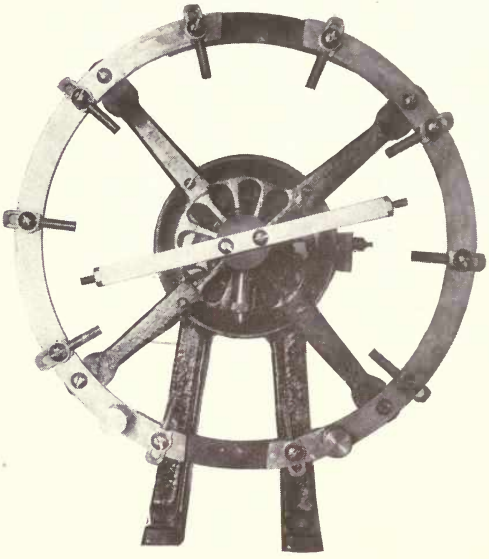
The photograph shows a 2 K. W. and 1 K. W. discharger of the early type. These were substituted in the closed oscillation circuit for the regular spark gap. In addition to the cooling afforded by the flanges of the copper plates, a blast of air from a fan or blower was constantly directed against the cooling flanges.

transmitter was early replaced by Marconi and other investigators with the high voltage alternating current transformer. Alternating current for the commercial operation of radio sets was introduced in the United States during the years 1901 and 1902.

Investigators were entering the field and endeavoring to discover

more sensitive means than the coherer for detecting radio currents. The electrolytic detector attributed to Fessenden in the United States and Schloemilch in Germany, was tried, but gave way to the crystal detector and valve detectors to be referred to.

The advantages of the high-frequency spark discharger were early recognized both in the United States and abroad, and during the years 1903 to 1905, transmitters operated by 125 and 133 cycle current were widely introduced in the United States.



The desirability of musical tones at the transmitter was early recognized in the art of wireless telegraphy because it permitted the receiving operator to distinguish between the discharges of atmospheric electricity and the signals sent out by a distant transmitter. Also it permitted greater ease of formation of the code characters. In order to produce a musical tone from 60 cycle transmitters, the non-synchronous rotary discharger shown in the photograph was designed. With this gap, 240 sparks per second were obtained from the transmitter supplied with 60 cycle alternating current. This gap also aided the quenching of the primary oscillations and thereby produced a radiated wave of greater purity.

The principal advantage of the high frequency spark lay in the fact that it enabled the receiving operator to distinguish radio signals from the interfering discharges of static or atmospheric electricity.

The year 1905 saw also the development of the synchronous rotary spark discharger for the transmitter.

The next great advance in respect to the receiving detectors of

wireless telegraphy was the discovery by Professor J. Ambrose Fleming, of the Marconi Co. in England in 1904, that if a metallic plate was sealed within the bulb of an incandescent lamp filament and the plate and filament were connected to the secondary of a receiving transformer, the device became a very sensitive detector of high frequency oscillations. The discovery of this fact proved to be the foundation work for a very valuable series of improvements during the years 1912 to 1917. The claims of Fleming's patent have been warmly contested in the courts; but in every case the inventor's claims were fully sustained.

A new form of oscillation detector owned by the Marconi Co. appeared in the year 1906. It was invented by General Dunwoody, U. S. A., who discovered that a crystal of carborundum acted very efficiently as a receiver for electric wave telegraphy and it was found later by Professor G. W. Pierce, of Harvard University, that these crystals possessed the property of rectification, i.e., they would convert a high frequency alternating current into a unidirectional pulsating current suitable for response in the telephone receiver. Further investigations by Greenleaf W. Pickard into the property of minerals and compounded crystals revealed that galena, silicon, molbdenite, iron pyrites and others possessed the property of rectification and were equally suitable as oscillation detectors for wireless telegraphy.

One form of oscillation detector introduced at this period was the so-called Perikon detector, a trade name given to a detector, consisting first of a crystal of zincite in contact with a crystal of chalcopyrite and later a crystal of zincite in contact with one of bornite.

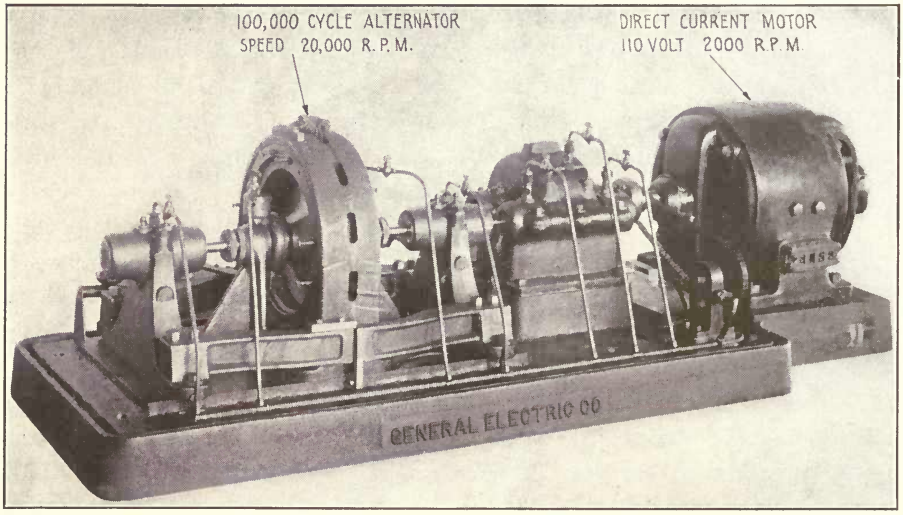
Dr. DeForest in 1906 placed a grid element between the filament and the plate of Fleming's original oscillation valve, and he named his product the "audion."

It should be kept in mind at this point that the trend in the early design of radio transmitters, particularly in the United States, was towards the use of sets of low power, but many attempts were made by the Marconi Company in England in 1902, and at South Wellfleet, in the United States, to employ very large powers of the order of 15 to 40 kilowatts. Many of these transmitters lacked the efficiency that was expected on the part of the designer and a rapid reversion took place in the United States (in 1906) to transmitters of lower power of the order of 2 kilowatts. These sets, however, were used almost exclusively for marine communication.

Marconi's Wireless Telegraph Company, Ltd., of England, attacked with great vigor the problem of designing high power trans-

mitters for long distance wireless communication. The first fruits of this series of experiments was the establishment of twenty-four-hour transatlantic wireless service between Glace Bay, N. S., and Clifden, Ireland in 1907.

For the first time in the history of the art Marconi employed at these stations high voltage direct current for charging a battery of condensers. This current was obtained from 6,000 storage cells connected in series, which in turn were charged by three 5,000-volt direct current generators connected in series. By the use of a high speed



An undamped wave generator of unusual mechanical electric construction has been developed by the General Electric Company. The machine shown in this photograph is known as the Alexanderson Radio Frequency Alternator, which generates direct from the armature winding current of frequencies up to 100,000 cycles per second. It may be noted that although the speed of the motor is but 2,000 revolutions per minute, the speed of the alternator through a special turbine wheel is increased to 20,000 revolutions per minute. So far, this machine has generally been employed for laboratory experiment, but larger generators of 50 and 75 K.W. have been designed which generate radio frequency currents up to 75,000 cycles per second. It has been proposed to employ these generators for long distance radio telegraphy and telephony.

rotary disc discharger perfect musical tones were secured suitable for telephonic reception.

Another innovation introduced during this period at the Glace Bay and Clifden stations, was the employment of air at atmospheric pressures as the di-electric medium for the high voltage condenser.

Early in the development of radio art, it was suggested that the use of undamped oscillation transmitters would materially increase the distances of transmission and permit a greater degree of selectivity at the receiver.

Valdemar Poulsen in 1903 produced improvements on Duddell's singing arc, perfecting it to the point where it could be employed to generate the extremely high frequency currents necessary for the generation of electromagnetic waves, but his early apparatus did not operate with the stability of Marconi's spark discharger and consequently it was not used commercially until its perfection by American engineers during the years 1908 to 1917. High powered arc transmitters of 30 to 100 kilowatts have been employed for trans-Atlantic and trans-Pacific communication. In fact, the United States Navy has in use at present arc generators of 350 kilowatts capacity.

Alexanderson, of the General Electric Company, during the years 1914-1915-1916, produced a 75 kilowatt machine which generated current at 50,000 cycles per second. This machine ran at reduced speed and thereby eliminated one of the most difficult problems encountered in the design of radio-frequency alternators.

Dr. Rudolf Goldschmidt, of Hanover, Germany, designed in 1910 a high frequency alternator which was a departure from machines of the Alexanderson type, the principal point of difference being that Goldschmidt's alternator generated current at frequencies up to 60,000 cycles per second from an armature which revolved at a speed of 3,000 R.P.M. With this machine successful communication was established between Tuckerton, N. J., U. S. A., and Eilvese, near Hanover, Germany, in 1913.

About the time that Goldschmidt was engaged on his alternator, Joly, and Count Arco of Berlin (1912) evolved a system for increasing externally to the generator the frequency of a comparatively low radio frequency alternator, and so successful were their first experiments that communication was established between Nauen, Germany, and Sayville, L. I., U. S. A.

During the period that the efforts of scientists were engaged upon the problem of undamped oscillations transmitters, progress was made in the spark discharge type of apparatus. It was found that by proper design of the spark gap, quenching effects were obtained which prevented the reaction of the antenna circuit upon the spark gap circuit. This interchange of energy ordinarily caused the radio transmitter to emit two waves, but the quenched type of spark dischargers permitted the antenna to oscillate at its own frequency resulting in the radiation of a single wave.

About the year 1908-1909, what is known as the multiple plate dis-

charger appeared in the radio field and it soon had universal application transmitters up to 10 kilowatts and later to 50 kilowatts.

R. H. Armstrong revealed that the vacuum valve detector possessed the property of repeating radio frequency oscillations into its local battery or telephone circuit, and hence by coupling this circuit back to the grid circuit, the incoming oscillations were magnified several hundred times. A most noteworthy increase in sensitiveness was obtained. Several other investigators, among whom may be mentioned Roy A. Weagant, chief engineer of the Marconi Wireless Telegraph Company of America, found that a three-element vacuum valve with proper accessories became a generator of high frequency oscillations and could be employed to produce the heterodyne effect first disclosed by Fessenden. These experimenters employed the vacuum valve as a combined oscillator, amplifier, and "beat" receiver, all these actions taking place simultaneously within the same bulb.

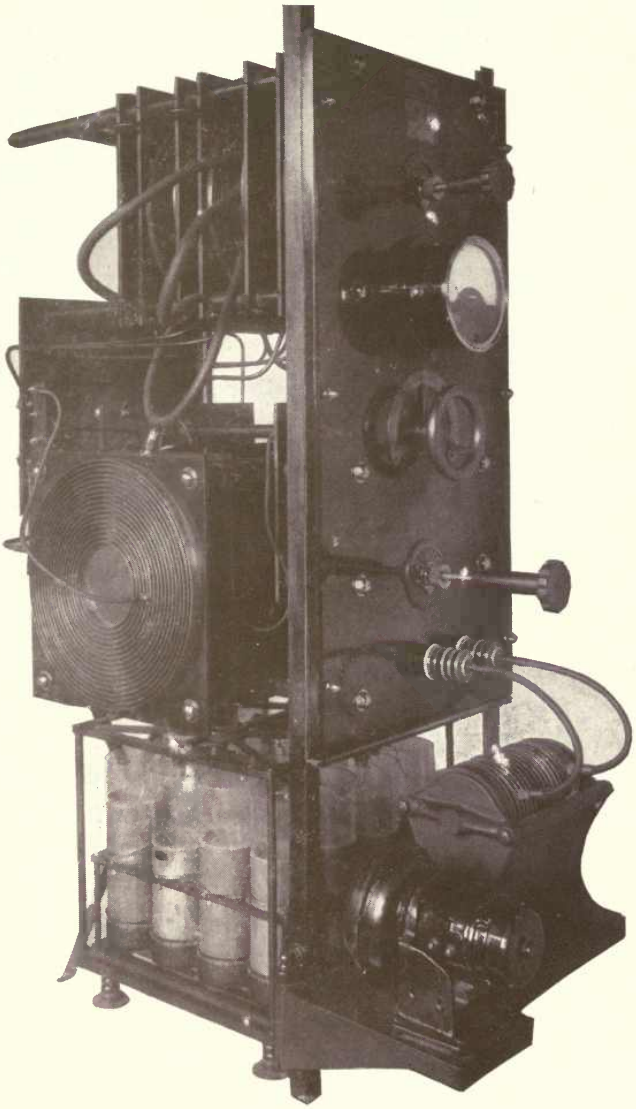
H. J. Round, of the Marconi Co. in England, who performed important experiments in this direction in 1913 and 1914, produced a vacuum valve oscillator of sufficient power output at radio frequencies to carry on radio telephonic and radio telegraphic communication over considerable distances.

Various methods of applying vacuum valve bulbs to radiotelegraphy have been perfected during the year 1916. These bulbs have been used in a battery as a source of radiofrequency current, as a means of amplifying the output of a radio-frequency alternator, and as a means of controlling the antenna current from such an alternator.

At the receiving station the vacuum valve is employed singly for regenerative amplification or in the cascade for radio-frequency or audio frequency amplification. They also have been extensively employed as repeaters on long distance wire telephone lines.

In the summer of 1916 Marconi installed at Carnarvon, Wales, his timed spark transmitter which generates continuous oscillations by overlapping wave trains in the antenna circuit. Very successful results were obtained, perfect communication having been established with the American Marconi Company's High Power Stations at Chatham, Massachusetts, and New Brunswick, New Jersey.

Inventions are now in process of perfection that will practically eliminate every obstacle that heretofore hindered twenty-four-hour long distance radio communication, and it is safe to predict at the close of the World war, a commercial expansion in the art will take place such as heretofore was not considered possible.



Very powerful types of transmitting apparatus are required for use aboard battle ships. The photograph shows a special 5 K. W. quenched spark transmitter developed by the American Marconi Company for naval use. This transmitter is designed for rapid change in wave lengths and also permits a wide variation of power.

THE INSTITUTE OF RADIO ENGINEERS

ORGANIZED IN 1912. INCORPORATED IN 1913.

The Institute of Radio Engineers is today the only American society of the radio engineering profession. Previous to its formation the two most influential organizations in this field of endeavor were The Society of Wireless Telegraph Engineers, organized in 1907, and The Wireless Institute, organized in 1909. Greater effectiveness was secured through their consolidation on May 13, 1912, into The Institute of Radio Engineers. Engineers, experimenters and professional operators are kept in touch with the technical progress of the radio art through its *Proceedings*.

This organization is under the direction of the foremost radio experts in the United States and its papers record the development of the radio art throughout the world.

The Proceedings of the Institute are under the editorial direction of Professor Alfred N. Goldsmith of the College of the City of New York.

Meetings of the Institute are held in New York monthly for the presentation and discussion of engineering papers. These papers are presented by members who have specialized in some division of the art and who desire to lay their results before the radio profession.

Sectional meetings of the Institute are held each month in Boston, Washington, and San Francisco.

The Institute membership consists of *Associates*, *Members*, and *Fellows*. Qualification for these classes of membership are in accordance with experience and achievement. Students of the art who seek for later professional advancement are advised by the directors of the Marconi Institute to place their application for admission as *Associates* at the commencement of their studies.

Particulars can be obtained from the secretary.

INSTITUTE OF RADIO ENGINEERS,

College of the City of New York, New York City.

NATIONAL WIRELESS ASSOCIATION

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

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It is estimated that previous to the United States entering the War there were at least 100,000 amateur wireless stations in active operation.

Realizing the necessity for co-operation among amateur experimenters, a National Association was formed in November, 1915, with objects which are summarized as follows:

(1) *To help existing radio clubs to establish more effective organizations conducted on standardized lines;*

(2) *To stimulate interest in the formation of radio clubs in communities where there are a few amateurs;*

(3) *To provide authoritative wireless literature for experimenters' use;*

(4) *To establish closer connection between amateur experimenters and military organizations;*

(5) *To organize all amateurs in the United States for the Government in time of war.*

(6) *To establish amateur wireless relay routes across the United States as an auxiliary in event of loss of wire communication;*

(7) *To protect the amateur purchasing equipment from unscrupulous manufacturers;*

(8) *To keep the field informed on current legislation.*

A Monthly Service Bulletin has been published, giving amateurs the latest list of calls of licensed stations throughout the United States, and summarizing the most recent scientific developments in the radio art. This bulletin was later transferred to the pages of *The Wireless Age*, through which the members are kept in close touch with the organization.

By co-operation with military organizations opportunity has been afforded to members to enter military encampments during the summers of 1916 and 1917, where they were taught military tactics and instructed in field radio signaling. The number instructed in camps for the two seasons is 1,126.

The Association's large membership is distributed throughout the United States, and is representative of the most advanced experimenters in the field. Several hundred are now in the Government service for war work.

Although the operations of the amateur experimenter have been temporarily curtailed, the organization is continued in the interest of more advanced work and study. The membership has been extended to include radio workers throughout the world.

Membership in the National Wireless Association is open to all radio workers who seek a means of keeping in touch with their fellow experimenters.

The Association supplies its members with:

(1) *Home training courses of study;*
(2) *Representative wireless literature of the day;*
(3) *Instructions for building the latest types of transmitting and receiving apparatus;*
(4) *Solutions of problems in the Bulletin and answers queries in the official organ and affords him opportunities to join commercial companies.*

Fees.—The initiation fee is $1, for which the amateur secures a certificate of membership, a membership button and an aerial pennant.

The annual dues are $2. For this members receive:

(1) *The Wireless Age for one year, which includes the Monthly Service Bulletin;*
(2) *The book, "How to Conduct a Radio Club";*
(3) *A question and answer volume, "How to Pass U. S. Government Wireless License Examinations";*
(4) *A discount of* 10 *per cent on any book listed in the Wireless Man's Bookshelf section.*

Those interested in improving the status of the amateur experimenter through connection with the foremost radio association in the United States, are invited to communicate with

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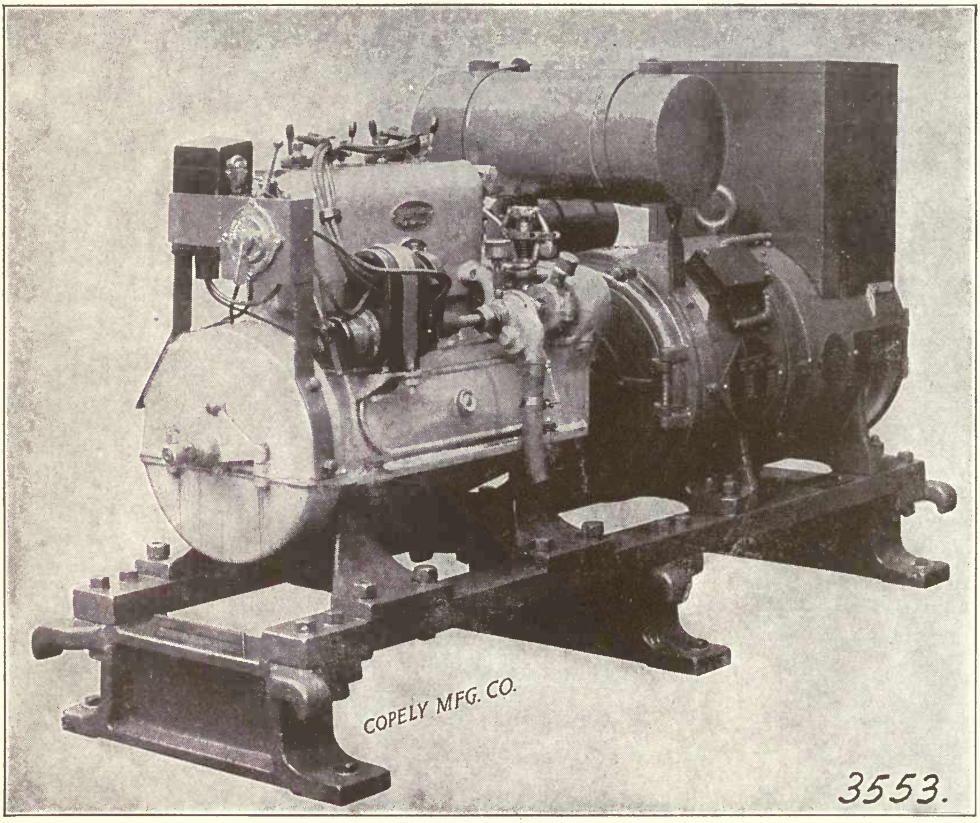

The Copely Power Unit is equivalent to an independent power plant, including the prime mover.

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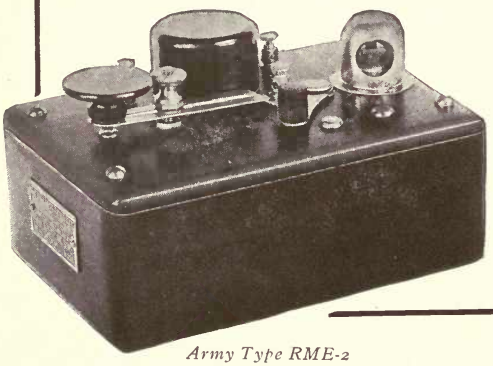

Army Type RME-2

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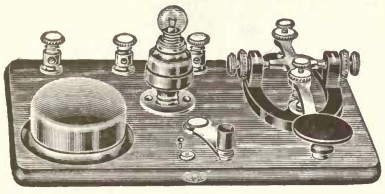
"COMBINATION"



This Practice Set consists of a regular telegraph key without circuit breaker, a special high pitch buzzer, miniature lamp socket, lamp, three binding posts, switch for transferring current from lamp to buzzer, all mounted on a polished hardwood base, and one RED SEAL Dry Battery with four feet of green silk covered flexible cord.

The efficiency of a wireless operator is gauged by his ability to read both sound and light signals and this practice set offers the means of acquiring proficiency in both, for the switch is used for connecting either the buzzer or the lamp into circuit.

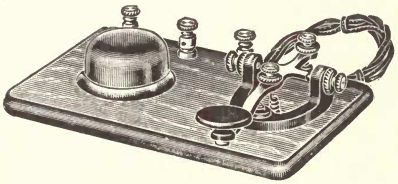
The set is of exceptional value to the beginner, as it may be used for individual code practice for operation on a two party line. After the beginner has mastered the code, the set may be used for his wireless outfit for setting the detector into its most sensitive adjustment. The key also may be used to control the spark coil.

The sound emitted by the buzzer simulates the tone of the signals of the most modern wireless stations perfectly.

This outfit is particularly recommended for schools and colleges teaching wireless telegraphy and Morse or Continental visual signaling, as it gives excellent service for class instruction in code work.

List No.		Price
52	MESCO Combination Practice Set	**$3.60**

"MESCO"



The main object of the Mesco Practice Set is to enable the beginner to learn the Morse and Continental Codes, which are easily mastered as the buzzer reproduces the sound of the signals of the most modern wireless stations perfectly.

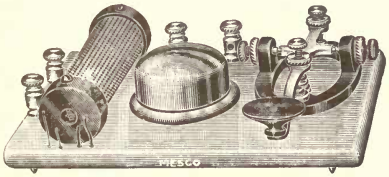
It comprises a regular telegraph key, without circuit breaker, a special high pitch buzzer, one cell RED SEAL Dry Battery, and four feet of green silk covered flexible cord.

The key and buzzer are mounted on a highly finished wood base; three nickel plated binding posts are also mounted on the base and so connected that the set may be used for individual code practice or for operation of a two party line, an excellent method of quickly learning the code. After the beginner has mastered the code, the set may be used in his wireless outfit for setting the detector in adjustment, and also the key may be used to control the spark coil.

Recommended for schools, as it gives excellent service for class instruction in code work. Full directions with each set.

List No.		Price
342	Wireless Practice Set, with Red Seal Dry Battery and Cord	**$2.70**
344	Wireless Practice Set only, no battery or Cord	**$2.55**

"STUDENT"



This set is similar to our No. 342 except that it has an 80 ohm telephone induction coil mounted on its base.

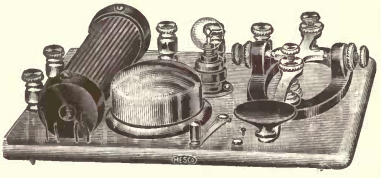
The induction coil allows the operator to use his standard radio head set, any number in parallel, which is generally of high resistance with maximum efficiency. With this coil the note is clear without discordance.

This set is particularly adapted for instruction purposes to classes of wireless students.

Diagram of connections with each instrument.

List No.		Price
53	Student Wireless Practice set	**$4.05**

"UNIVERSITY"



This outfit consists of a regular telegraph key without circuit breaker, a special high pitch buzzer, miniature incandescent lamp with socket, switch, five binding posts and one 150 ohm induction coil mounted on a polished wood base; one RED SEAL Dry Battery and four feet of green silk double conducting cord.

The induction coil permits the operator to use standard radio head sets (any number in parallel), which are generally of high resistance with maximum efficiency. With the coil in circuit the note emitted is clear and distinct without discordant tones.

This set enables the student to acquire both sound and sight signal instruction and is of special value to schools and colleges having a course in radio telegraphy on their curriculum. All metal parts are of brass, nickel plated, except the key base, which is of japanned iron. Diagram of connections with each instrument.

List No.		Price
54	University Practice Set	**$4.50**


7490-A


4500


4502


7379

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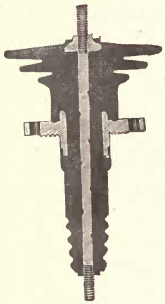
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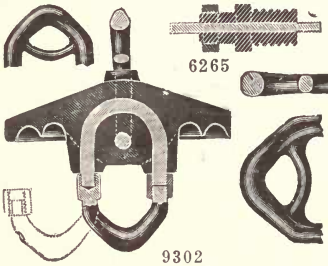
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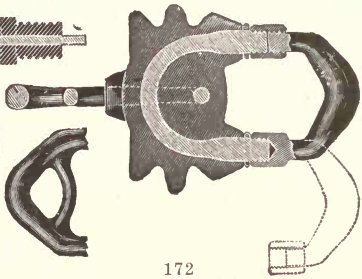
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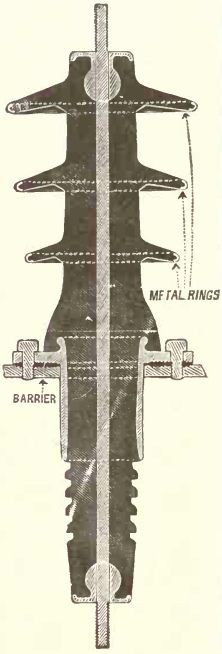

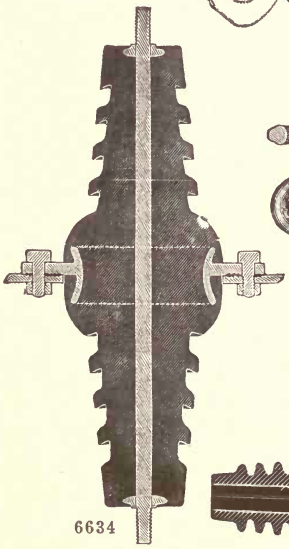
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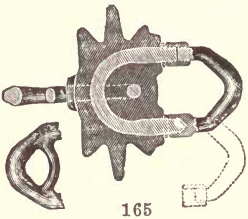
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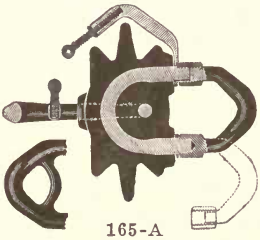
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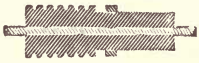
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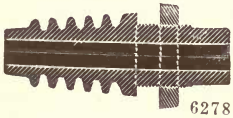
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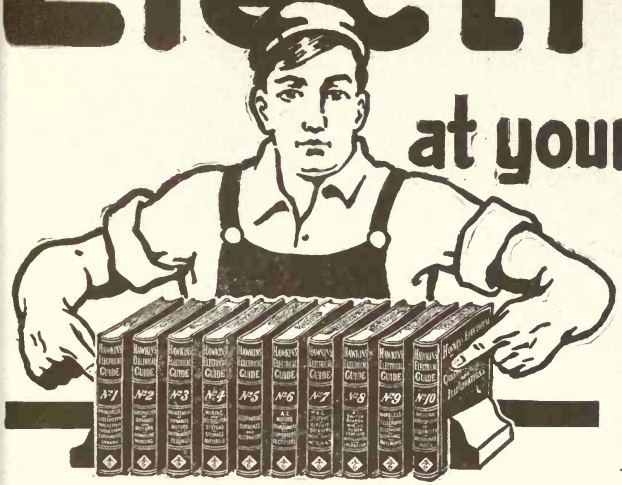

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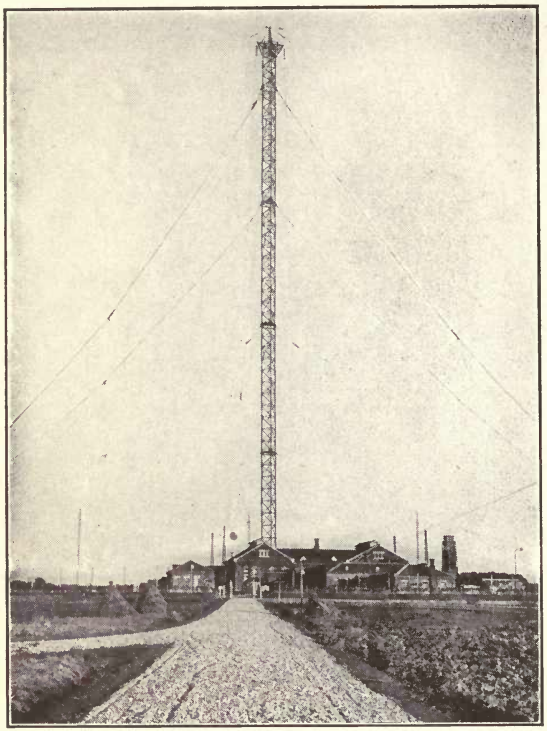

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