THE WIRELESS AGE

JANUARY, 1914

IN OUR OPINION

THIS is the day to begin looking forward to and planning what we purpose doing in the New Year that stretches alluringly before us.

You have no doubt summed up your work of Nineteen Thirteen.

Summing Up the Disappointments of the Past Year and Looking for the Reason

What a disheartening array of disappointments! This and that were not completed, you failed in the one thing you felt certain of success with, and, worst of all, not a single thing you managed to do to your full satisfaction attracted any notice. This old world of ours is a cold proposition. Each year you have started off with renewed vigor, fresh enthusiasm and a determination that was bound to get you somewhere. But it didn't.

Why?

Well, there was that absolutely brilliant inspiration that came in the night and kept you tossing about on your pillow, impatient for the dawn when you could commence working out the details. How you labored day after day, night after night, to get the whole thing perfect! It was a really big idea. And the more you investigated, the greater were its possibilities. At last you had everything just right.

Then came the sudden bump. Some one had done it before—it had been a success, too, but that was poor consolation. It had been done.

Or perhaps it was a lot of little things, nothing very important in the eyes of the world, but a mighty big help in carrying on its work. You are sure of that. You know, because you watched those ideas take form, and saw what a short cut they proved to be, what an amount of labor they saved. It was good work, well done. But nobody noticed.

Neither one fits your particular case? All right; we'll take it that you just plod along, hemmed in by routine, no opportunity to display any initiative; just a lot of old humdrum work that has to be done, petty stuff that takes up all your time and gets you nowhere.

Ever stop to think that it doesn't take up all your time? For instance, what do you do with your evenings?—what do you think about when you are dressing in the morning?—on the cars to and from your daily tasks? Suppose you reserved this time to plan a little ahead. Never mind the evenings. The man who spends them profitably is bound to go on up the ladder. But suppose you forgot about the exasperating routine and the lost individuality during those few moments devoted to dressing or while riding on the cars, and used them to figure out exactly what your work means. The mere fact that it has to be done shows that it is important. Maybe only as a cog in the powerful machine of commerce or a stitch in the great mantle of science that is being draped about the world—yet the greatest machine cannot run without each part being in place and a stitch dropped can unravel the most gorgeous banner. Now if your work was a little better the fabric would be stronger, the machine more efficient. And your work will be better if you know more about it.

THERE is a fellow just above you. What does he do? Could you do it? If he was promoted to-morrow could you fill his place? You think you could. In fact, you are sure of it. But do you know *more* about his work than he does?

On Adding an Extra Month to the Working Year

You should. That is, if you expect to take his place. When he goes a step higher, his successor will not make a very great impression unless he can do *better*. Those few minutes you ordinarily waste will prepare you.

It takes the average person twenty minutes to dress. Forty minutes more, twenty each way, are consumed in traveling to and from the office or shop. In all, one hour. Figuring three hundred working days in the year, this makes three hundred hours—or more than thirty-seven full working days!

Use this time profitably and there will be an extra month credited to your progress preparation in the year we have just ushered in.

Every so often we hear someone say that their particular line of endeavor holds no tangible reward. Which is a very foolish remark.

There is positively no manner of accomplishment that is not recognized, either by riches, gratitude or glory.

You have heard about the Nobel prize, a truly magnificent reward, for it stands for the gratitude of humanity and comprises both money and glory. A few years ago Mr. Marconi received this great honor. Why he was selected needs no further comment, for his gift to humanity is known far and wide. The prizes—there are more than one—are given each year. Chemistry, physics, medicine, peace and literature are the divisions. Do you realize that you can earn one? It does not matter who you are, or what you do; with the proper amount of concentration and energy and purpose you, or anybody, can attain this greatest of rewards.

Nobel was a Scandinavian, the inventor of nitroglycerine, or the dynamite that destroys life and property. He left to civilization his vast fortune that prizes might be given each year for the best work of the human mind.

The literature prize for the year just ended was given to a poet!

WHERE is the argument now that any particular line of endeavor lacks reward? For among all the thankless, ill-paid, little respected and less appreciated classes of work the making of verses

Honors Showered on a Comparative Unknown, Whose Message Came in a Strange Tongue

stands alone. The prose author has his troubles, but they pale into insignificance beside those of he who elects to spend his days and nights reaching for the expression of ideas, interminably polishing his phraseology—while the cartoonist looks on and makes him the laughing stock of the civilized world.

Remember that the Nobel prize stands for the best work of the human mind. In years gone by, many men you knew at least by reputation have received it. Now it goes to a poet, one whose writings you know little if anything of, whose name has not been seen in the magazines. He is a silent toiler, an earnest hard-working man who has labored steadily without thought of reward. But he had something to say, something that would do the human race good. And he learned how to say it.

Tagore is the man's name, Rabindrath Tagore, who wrote his poems in the Bangali language of India, a tongue you probably never heard. He has translated them into English, so that all of us might profit by his teachings. And the wisest among us will.

There is one story which contains a lesson applying directly to each one of us as we stand on the threshold of the New Year.

A MAN believed that somewhere could be found a magic touchstone that would change base metals into gold. He went along the shore of the ocean, with one hand picking up stone after stone—thousands, tens of thousands, hundreds of thousands of them. A chain of iron was about his neck, and as he picked up each stone he touched it with the chain. For when the magic stone appeared it would change the iron to gold.

An Indian Parable that Lights the Road to Success

Day after day, down through the long years, he continued the search until he became "a wandering madman seeking the touchstone, with matted locks, tawny and dust-laden body worn to a shadow, his lips tight pressed, like the shut-up doors of his heart, his burning eyes like the lamp of a glowworm seeking its mate."

One day a village boy asked the old man where he got that golden chain about his neck.

And the poor, tired and miserable old hunter looked down and saw that the iron had changed to gold. But he did not know when it had changed.

"It had grown into a habit to pick up pebbles and touch the chain and to throw them away without looking to see if a change had come; thus the madman found and lost the touchstone.

"The sun was sinking low in the west, the sky was of gold.

"The madman returned on his footsteps to seek anew the lost treasure, with his strength gone, his body bent and his heart in the dust, like a tree uprooted."

What a lesson for old and young in this fine parable of Tagore's!

EVERY day we see humans turn back, weary and hopeless, along the shore of life and time, vacantly seeking to recover the opportunity neglected and missed.

Pointing Out the Error of Doing Your Work Carelessly

And the story takes added strength in the fact that men at one time actually hunted for the touchstone, or "Philosopher's Stone," and believed it would change baser metals into gold. Chemistry began with the ancient alchemists' struggles to manufacture gold artificially. They did not discover how to do this, but they did learn how to change human thought and painstaking experiment into something more valuable—scientific knowledge.

This knowledge came in the effort to learn the truth. We know now that there is no Philosopher's Stone. But we have discovered great scientific truths, more beneficial to humanity than all the gold in the universe.

We have learned that work, not magic, changes the dross of iron of monotonous toil into the gold of opportunity and success.

Yet many of us are like the madman in the story. We go through life intent on the magic stone representing opportunity and success in commerce or scientific achievement and, reaching old age, find that we held it in our hands only to drop it without realizing what it was.

When Tagore's seeker began his search he did his work well. He believed in ultimate success and his mind was keen and alert. He felt that he would continue to do his work attentively. And he would seize the precious stone of opportunity when it came within his reach.

But as time went on he grew careless. He began to do his work mechanically; the oft-repeated process became monotonous and a function of the body as his mind relaxed its vigil. He was a dull machine grinding out his daily task when success came to his hand. So he lost it.

You can make no better resolution for the New Year, no better one through life, than an unswerving determination to keep watching as you work, never relaxing your vigilance.

Then, when you come to old age you will not have to face the truth from a younger man—that you had your chance, and didn't know it.

WE are starting this New Year with the business outlook none too cheerful, and men none too optimistic.

Yet the prospects for wireless workers were never brighter.

The Exceptional Opportunities in Wireless that Will Occur in the Next Twelve Months

The student at his desk has unprecedented opportunity to prepare himself for the great future that may be his. A few years ago, one might say a few months ago, wireless was more or less a mystery. Now colleges and preparatory schools are including wireless courses in the curriculum. In place of a few scattered text books mainly devoted to obsolete apparatus and general theory, there are a number of standard reference works, ranging from elementary instruction to weighty engineering treatises, and there are monthly magazines to keep step with the progress of the art.

The assiduous seeker after knowledge on wireless matters can now go deep into the subject, theoretically at least, and emerge from the institution of learning with a secure foundation for his practical application to the working problem of the day. Certainly no broader nor more promising field exists. Wireless telegraphy will soon connect the remotest corners of the earth with the great centers of population; wireless telephony will follow. And in view of man's conquest of the air—long looked upon as an absolute impossibility—who can doubt that some day will come the transmission of power by wireless?

Then our whole scheme of transportation and manufacture will be revolutionized. Men will have to direct the great forces, men who grew up in the wireless business. They will be the great human factors of their time, reaping reward beyond all dreams of avarice. Wireless transmission of power may or may not come in our generation. But if it does—will you be ready?

AND as the young student looks forward, using his imagination to spur him to greater effort and the shaping of his destiny, his elder brother, the practical worker in wireless to-day, can look upon his more tangible prospects for the year with justifiable enthusiasm.

What the New Developments Should Mean to the Commercial Wireless Man

The first links in the chain of powerful stations that will girdle the globe are receiving their finishing touches. Hundreds of men will be needed to operate and keep the massive machinery in the pink of condition, night and day. Good salaries, ideal living conditions and limitless opportunity for advancement await those who earn these appointments.

These stations represent a mere beginning. Each year wireless communication will come into more general use. Tens, hundreds, thousands, of stations will eventually dot the earth. Men will be needed to care for and operate them. Engineers will be required to design apparatus of ever-increasing efficiency.

Wireless engineering cannot be mastered in a day. The men on the big problems will have come up from the ranks. And they will be those who make brain and hand work together *all the time*.

The application of wireless to railroading is significant. In fact, all its present-day uses are but harbingers of what is to come. The surface has only beeen scratched; below lies a golden mine of opportunity for the technically inclined.

And you business men—are you wide awake to what this year will mean in commercial wireless? Have you figured out the increase in traffic when all these new stations are working?

A lot of business problems are going to arise. Some one will solve them. Perhaps the fellow at your elbow, at the next desk, will be the one to work out the short cut, or that quiet little man who has scarcely been noticed since he came into the department is going to offer a suggestion that will lift him out of drudgery and start him on up the ladder. Among the men around you there is one who some day will be pointed out as the great success.

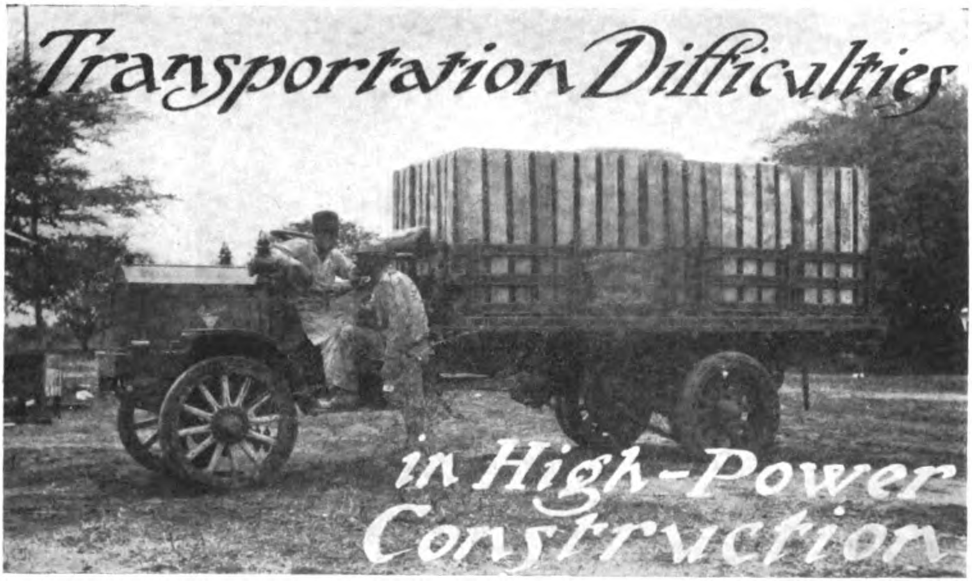
He has no more chance than you have right at this moment.

Jot this down on the calendar pad of your mental resolutions, to be referred to as you turn over the leaf for each new day:

> "Keep your brain active every minute of your waking hours so that you will recognize opportunity when it comes."

Which is in substance the lesson of the illuminating story told by Tagore, winner of the Nobel prize. It applies particularly to your work in the New Year, for there can be no question that Nineteen Fourteen will figure very prominently in the history of wireless telegraphy.

THE EDITOR.



AS VIEWED BY A MARCONI ENGINEER

NONE of the features to be taken into consideration when determining the site of a wireless telegraph station receive less thought, as a rule, than accessibility. This condition prevails perhaps because the factor of accessibility and the chief commercial factors are not in accord. It is needless to say that the latter factors carry the greater weight; yet, following the increased demand for power plants in wireless telegraphy, additional consideration is being given to easy access, with the result that the long distance installations now under construction for the American Marconi Company are more approachable than the majority of the larger ones erected in the past.

Why accessibility has increased in importance can be easily explained. Broadly speaking, accessibility means good railway transportation facilities—either steam or electric—for long distance freight haulage, and durable roads on which motor-driven or horse-drawn vehicles can convey materials to the sites. When the material necessary to build a wireless telegraph plant was measured by tens of tons, and the supplies required for maintenance were correspondingly small, speaking comparatively, the roads and their durability were not given great consideration. But since it has become necessary to reckon on tonnage of material to be hauled to one station site in three, and even four figures, transportation demands careful thought.

The Marconi station at Clifden, Ireland, is located on a site surrounded by soft peat bogs. A good macadam road, about five miles long, leads from the steam railroad to the edge of the bogs. From this point a road was built to connect with a railway about a mile in length, which extends over the bogs to the station buildings. All of the material used for the construction of the station and the supplies necessary to maintain it have been transported by means of this railway which has a road bed that is far from being firm.

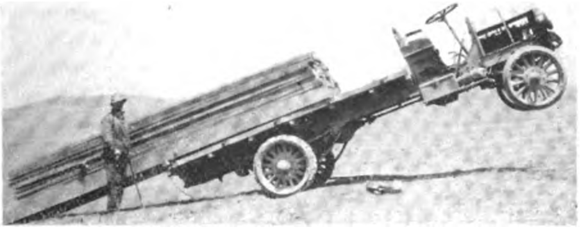
Ditches that have been dug on both sides of the railway are the cause of considerable inconvenience and some danger because of the fact that there is barely room to step off the tracks when a locomotive approaches, without falling into one of the ditches. Indeed, he who wishes to traverse the tracks, particularly at night, will do well to ascertain the location of the locomotive and the plans of the engine driver before he starts. For it is not a pleasant sensation to see the headlight of the locomotive rapidly draw near you and realize that your shouts cannot be heard by the man at the throttle. In a situation like this there remains little to do but decide between balancing yourself on what is practically the edge of nothing while the locomotive roars by, or jump blindly into one of the ditches.

An illustration of how little dependence can be placed in the track occurred when several heavy pieces of machinery were being transported from the road to the plant. On this occasion the rails built up the bluff, which is 100 feet in height, to the power house. The lighter weights were hauled up the incline without much difficulty, but the heavier pieces caused trouble. A boiler piece weighing eight tons was placed on a truck and started up the incline. After watching it enter the cut, we ran up the pathway to see that it arrived on top of the bluff without mishap. When we reached the summit of the incline we

The Kahuku station is made accessible by a steam railroad. The subsoil at the station is made up of porous coral rock, and there has been considerable trouble in putting down foundations.

sagged to such an extent that it was necessary to place timbers under the rails as supports in order to insure safe transit for the load.

That luck sometimes plays a part in transportation was shown during the construction of a station about half a mile from a wharf where the material was being unloaded. An inclined track had been found that the hoisting engine had stopped and that the load was within about ten yards of the top of the bluff. Inquiries showed that the negro in charge of the hoisting engine had neglected to keep up a full head of steam as he had been instructed to do. There was nothing to do, therefore, but hold the load on the brake until there was enough



A bucking auto of the West; the result of leaving the overhang out of load calculations.

Motor trucks, which were used to haul material, made such slow progress, because of the condition of the roads during the rain, that horse-drawn vehicles were requistioned to keep the field force supplied with material.

steam to work the hoisting engine. Then another difficulty arose. The engine could not be started while the drum was holding the load, and we were unable to remedy the trouble. After every one of our attempts the weight of the load pashed back the blocking until the latter was useless.

While we were trying to find a way out of our dilemma, the negro let the rope slip momentarily, and then started the engine. The load began to slip down the incline as the rope slackened, but when the engine was started the cable tightened with a jerk that made the boiler piece rock. In the slight pause that ensued before the issue was decided it seemed likely that the load would be tumbled off the car or the hoisting rope broken. With a grunt and a chug, however, the engine took hold and the load began its interrupted journey to the heights; and it did not stop again until it was safely landed upon level ground.

The same hoisting engine pulled the boiler piece on to its foundation in the power house, about a quarter of a mile away through the forest. The only trouble met with at that end of the haul was caused by a hitch in the signaling system between the men at the power house and the man in charge of the hauling engine. As a result, when the building was reached the load was carried too far and demolished some metal work in the structure before it could be stopped.

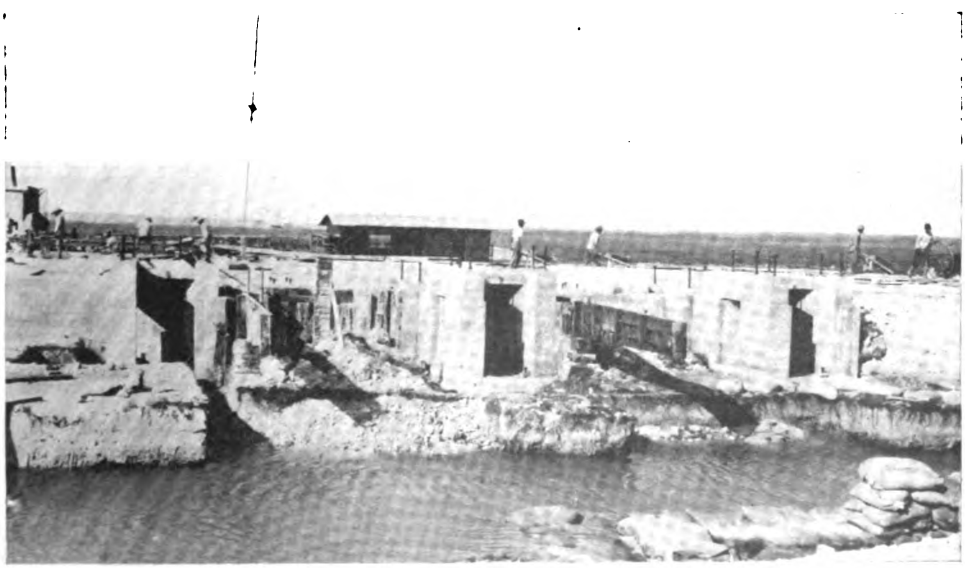
The largest wireless telegraph station at present under construction is located at Kahuku Point, on Oahu Island, one of the Hawaiian group. Wireless stations larger than this one, however, will be erected shortly in connection with the British Imperial Scheme, which will eventually connect with the Trans-Pacific stations. The Kahuku station is made accessible by a steam railroad. The subsoil at the station is made up of porous coral rock, and in consequence there has been considerable trouble in putting down foundations for the power house and masts. In order to control the flow of water which leaked into the foundation excavation for the condenser pit, a battery comprising three-inch, four-inch and six-inch pumps was put in operation. So great was the flow, however, that not until an eight-inch pump had been added to the battery could the foundation work be completed. In all of the excavations for the mast anchorage foundations, were built water tight wooden cribs into which was poured concrete. Different sections of the site have needed different treatment, but, generally speaking, the trouble has been due to the presence of water in the subsoil, a factor which will materially add to the ease of operating the station. Some details of this station and the plant at Koko Head appeared in a recent issue of THE WIRELESS AGE.

Of the two stations forming the California end of the Trans-Pacific circuit, that at Marshalls is the more accessible. A steam railroad passes along the front of the property, and there are good thoroughfares on two sides of the site. Bolinas, the site on which the power station is being erected, is more accessible by water than by railroad. The site is about four miles from the wharf and the road is poor. That section of the thoroughfare which passes through the village is good, but when the main highway is left it quickly changes into an ordinary farm trail. This type of a road is adequate for the comparatively light haulage normally required on farms, but as soon as the heavy loads for our construction work are transported over it the surface gives way and the thoroughfare becomes a series of bad ruts.

In wet weather the roads become soft and practically impassable for vehicles transporting material. Rain has been falling for weeks, but the roads are now being remade, and as soon as the weather moderates they will show the results of the work done. Motor trucks, which were used to haul material, made such slow progress because of the condition of the roads during the rain, that horse-drawn vehicles were requisitioned to keep the field force supplied with material.

The facilities for handling heavy material at Bolinas are not good and all the resources at our command were needed to transfer 275 transformers from the schooner to the truck and then to the site. In the future the heavier pieces will be sent by rail to Point Reyes and trucked along the main road via Bolinas to the site. The bridges and culverts along this road were not built to carry extremely heavy weights. Therefore, before hauling any very heavy pieces of freight, they must be tested and, if necessary, strengthened temporarily to enable them to carry the loads.

The Bolinas station will be supplied with energy from the Pacific Gas & Electric Company's power lines; an extension is now being built from its lines on the eastern side of Bolinas Bay. It was at first believed to be possible to run this extension out on a sand spit which forms the bar across the major



In order to control the flow of water which leaked into the foundation excavations at Kahuku a battery of pumps had to be put in operation.

portion of the entrance to the bay and spans the narrow channel on the west side of the harbor. But careful investigation showed that the stability of a line so located could not be guaranteed, and this plan was therefore abandoned. The extension is being carried around the head of the bay and thence as directly as possible to the power station.

As a result of purchasing the power the amount and weight of machinery to be installed in our plant are materially reduced. No generating plant with its numerous accessories is needed. In its place are motor-driven alternators which are merely frequency changers. That is to say, the motors of these sets take power at the frequency of the transmission line, while the alternators, driven by the motors, deliver power at a frequency more suitable for wireless work. Thus it will be seen that the weight of material to be hauled to the site will be less than in the case of the steam-driven plant at Kahuku.

The New Jersey stations are both accessible, the power plant at New Brunswick being the more approachable of the two. The Raritan Canal passes across the front of the property and the steam roads are within five miles of the site. The road surface near the site is very bad and was quite impassable for motor vehicles during the wet weather of October last. The bulk of the material, which comes by canal, is unloaded on the site and distributed as required. The New Brunswick station is supplied with energy by the Public Service Company, which has extended its power line from New Brunswick toward the site. The machine installed in our power house, therefore, will be merely a frequency changer set like that the Bolinas station.

The Belmar site is about four miles from a steam railroad. The highway is in satisfactory condition for about three miles. The last mile of the thoroughfare, however, is not all that could be desired. The haulage to the Belmar site has been accomplished entirely by teams of horses.

SANTA CLAUS VISITS THE HOME OF WIRELESS

In appreciation of their faithful service during the year, and with the object of bringing the organization still closer together, the members of the office staff of the Marconi Wireless Telegraph Company were guests at a Christmas party given in their honor on the afternoon of December 24.

All work was suspended at noon and

The Invitation

at two o'clock the eighty-odd members of the home office staff assembled in the fourth floor suite in the Woolworth building.

The rooms were decorated with bells and garlands, and a large table in the center was arranged to represent a snow field. A gigantic snowball gushed forth a mass of red ribbon streamers, each one leading to a small favor for each individual present. One by one the packages were opened and its accompanying jingle read aloud by a Santa Claus who knew respective weaknesses and hobbies well enough to send a shaft of wit home in each case.

The Engineering Measurements of Radio Telegraphy

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ARTICLE IV

In the article published in this issue the principles of distributed capacity are discussed in detail. Its effects are told of and a table is published for the purpose of calculation. The author takes up the subject of measurement of distributed capacity at radio frequencies and low voltage, and describes the theory of the practice.

II.—MEASUREMENTS OF DISTRIBUTED CAPACITY

12. *General Considerations.*—We have shown various methods of measuring capacities at radio or audio frequencies, and at high or low voltages. In all the cases treated, the device, the capacity of which was determined, was a condenser; that is, a device specially arranged to have electrostatic capacity and consisting essentially of (nearly) inductance-free conducting surfaces, insulated from each other. The capacity under these conditions is *localized* in the circuit, and the circuit has been assumed to contain no capacity such as was concentrated in condensers. This assumption is, in general, only approximately true, for the inductances used in these experiments contain what is known as *distributed capacity*. Since the notion of distributed capacity in some ways is less simple to grasp than that of ordinary or localized capacity, we shall discuss it in detail. Its effects, particularly in incorrectly designed receiving sets, are very marked, and may lead to greatly diminished efficiency of the set as a whole.

In Figure 17 a number of turns of an inductance is shown. If a varying current is passing through this coil, there will be a difference of potential between the ends, A and B, of the coil, quite independent of its ohmic resistance. Between turn 1 and each of the other turns a difference of potential will exist, and consequently *electrostatic* lines of force will pass from each point of turn 1 to every point of the coil which is at a different potential. It is to be noted that we are not referring to the *magnetic* lines of force which are interlinked with the entire coil. Some of the electrostatic lines of force between turns 1 and 2 are shown in Figure 17. We have then the interesting conditions that turns 1 and 2 are, in effect, plates of a condenser. Electrostatic energy is stored in the space between each portion of a turn and every

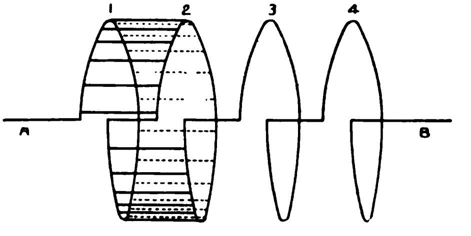


Fig. 17

part of every other turn; and, since such energy can be stored only in capacities, we have distributed capacity along the entire coil.

It is evident, therefore, that the coil can no longer be considered as a simple inductance, but must be treated as an inductance across the terminals of which a capacity (equal to the total distributed capacity) has been shunted. It might, at first sight, seem that this assumption that the distributed capacity may be regarded as equivalent to a single concentrated capacity across the terminals of the coil, is of doubtful validity; but it can be demonstrated that in circuits where the resistance is so small as not to affect the natural period of the circuit appreciably, the assumption referred to is justified. We may, therefore, consider the coil L (Figure 18), which has a distributed capacity C_d, as equivalent to a simple inductance L, across which is connected the localized capacity C_d, as shown in dotted lines.

The effects of this distributed capacity are as follows: To begin with, if the inductance of the coil be calculated by the usual formulae, and the coil be placed in an oscillating circuit with a known capacity, C, the period, instead of being, as usual

$$T = 2 \pi \sqrt{L C} \qquad (30)$$

is given by

$$T = 2 \pi \sqrt{L (C + C_d)} \qquad (31)$$

The distributed capacity of a coil may therefore be very objectionable, particularly if work is being done at short wave lengths where the permissible external (and adjustable) capacity, C, is already quite small.

Another point of difference between a coil having distributed capacity and a simple inductance is of importance. Even if no capacity be connected across its terminals, such a coil may vibrate electrically. It is, in fact, a so-called open oscillator, and behaves in this respect quite like the usual antenna of a radio station. If, in Figure 19, G is a generator of radio frequency alternating current, and L_1 an inductance which couples it electrically to the coil, L, having a distributed capacity C_d, it will be found that for some particular frequency of excitation the coil, L, will vibrate powerfully electrically. The particular frequency in question will be (if the coupling between L_1 and L is very loose), the natural frequency of L. The second circuit, L_3 C_3, will then indicate this frequency by means of a maximum reading of the indicator, I, provided that its capacity and inductance are properly adjusted. This last circuit will therefore serve as a "wave meter," or more strictly, a frequency meter.

If we consider more carefully the mode of electrical vibration of the inductance L, which possesses distributed capacity, we find it differs considerably from that

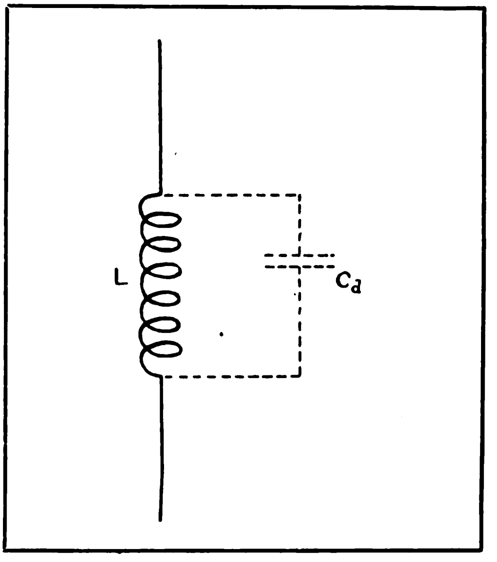


Fig. 18

in ordinary audio frequency alternating current circuits. In the latter, the value of current is the same at every point of the circuit at a given time. This is not the case for the open oscillator, L. At the left of Figure 19 is shown the curve of current distribution along L, the length of the short horizontal lines being proportional to the current at that particular level of the coil to which they correspond. The voltage or potential distribution along the coil is similarly shown in the second curve, to the right of the first. It will be seen that the potential is highest at the ends of the coil, but that the current is greatest at the middle. Remembering that the ordinary antenna corresponds roughly to one-half of such a coil, the ground connection being the analogue of the middle of the coil, it is immediately evident why the current in an antenna is greatest at the bottom, but the potential highest at the top. And a coil having distributed capacity resembles an antenna in another respect; it serves as a radiator of electromagnetic waves, and the greater the distributed capacity in proportion to the inductance, the more prominent does the radiation become.

It is possible to calculate the distributed capacity of an inductance from its dimensions. A convenient formula for practical purposes, and a quite accurate one, is given by Drude. It is the following:

$$C_d = 2 \alpha r \frac{2 + \frac{h^2}{r^2} + \frac{r^2}{h^2}}{10 + 4 \frac{h^2}{r^2} + 3 \frac{r^2}{h^2}} \qquad (32)$$

where h = length of the coil, 2r = diameter of the coil to the middle of the wire.

α = a factor dependent on value of h/2r, and given in the following table. The top headings are core material. In the case of the tubes, the ratio of thickness of tube to radius was 0.05. In all cases, the ratio of diameter of wire with insulation to diameter of wire alone was taken as 1.09. The following table has been specially calculated from Drude's data to adapt it to ready use in calculating distributed capacity:

h/2r	Ebonite	Air	Ebonite Tube	Glass Tube	Ash
6.	2.10	1.81	1.83	1.86	2.24
5.	1.92	1.64	1.64	1.76	2.05
4.	1.74	1.47	1.48	1.54	1.89
3.	1.66	1.37	1.40	1.46	1.82
2.	1.62	1.26	1.34	1.43	1.82
1.	1.54	1.12	1.28	1.37	1.81
0.8	1.54	1.10	1.26	1.37	1.81
0.6	1.52	1.07	1.22	1.34	1.79
0.4	1.36	0.943	1.10	1.24	1.62
0.2	1.00	0.69	0.855	1.06	1.19
0.1	0.72	0.498	0.615	0.828	0.91
0.05	0.41	0.282	0.383	0.50	0.50

To facilitate interpolation of values, the curves of Figure 20 have been drawn. In order to find the value of α for any coil, we calculate h/2r, that is, the ratio of the length of the coil to its diameter, and find the value of α corresponding to the ratio, and to the type of core employed. Formula (32) can then be directly employed.

The free period of a coil of inductance, L, and distributed capacity, C_d, can be directly calculated from the formula

$$T = 2 \pi \sqrt{L C_d} \qquad (33)$$

and its free wave length from

$$\lambda = 18.85 (10)^8 \sqrt{L C_d} \qquad (34)$$

with L expressed in henrys and C_d in farads.

Once the distributed capacity of a coil has been determined, and its natural wave length calculated, it is well never to use it in receiving sets intended to cover a range of wave lengths including the natural wave length of the coil. If this precaution is not observed, considerable energy will be absorbed in the free electrical vibration of the coil, and this energy is useless so far as receiving efficiency is concerned.

13. *Measurement of Distributed Capacity at Radio Frequencies and Low Voltage (by the Impulse-Excitation of Free-Period Method.)*

(*a*) *Theory.*—We shall suppose that the inductance of the coil in question is known for audio frequencies, either by direct measurement with an inductance bridge (as hereafter described), or by calculation, using the formulas given in Bulletin of the Bureau of Standards, Volume 8, Number 1. (Formulas and Tables for the Calculation of Mutual and Self-Induction, Revised.) We shall then determine the free period of the coil by exciting it impulsively, and calculate its distributed capacity by a simple formula derived from Formula (33).

It is assumed that the reader is aware

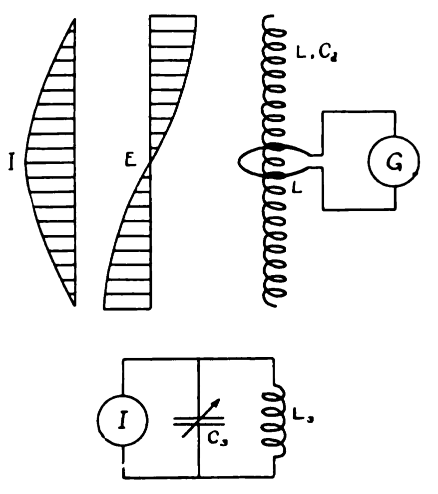


Fig. 19

that impulse excitation as used, for example, in the usual quenched spark sets, is a simple means of exciting a secondary circuit to vibrate in its own period and damping regardless (or nearly so) of the

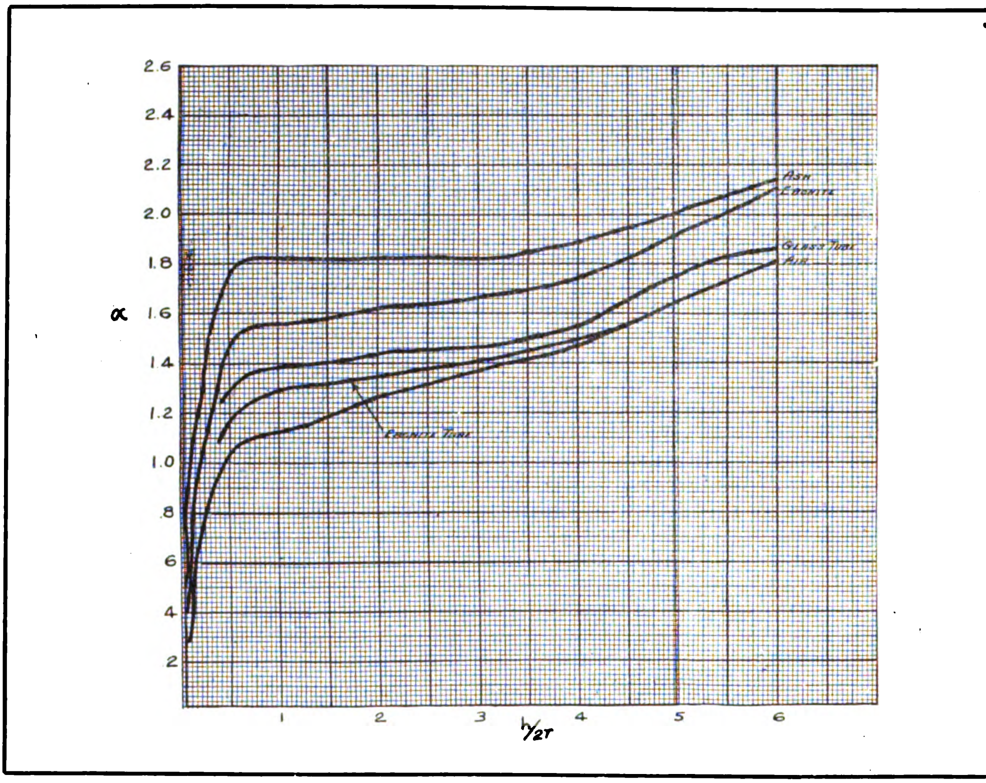


Fig. 20

period of the primary. In order that impulse excitation should be secured, the primary circuit should be highly damped and its coupling to the secondary not too close. We shall meet these requirements by making the primary circuit actually aperiodic, so that no free alternating currents can occur in it at all, but only individual highly damped pulses of current. We shall then couple it loosely to the secondary circuit, which is the inductance having distributed capacity, thus causing that coil to vibrate in its natural period. Suppose that the indicator I which is shunted across the capacity C_3 is of so high a resistance that its influence on the period of the circuit L_3C_3 is negligible. This is the case if its resistance is much larger than the quantity

$$\sqrt{(L_3/4C_3)}.$$

We may then take the period of this last circuit as

$$T_3 = 2\sqrt{L_3\,C_3}$$

and the period of the inductance itself as

$$T_2 = 2\sqrt{L\,C_d}$$

If the condenser C_3 is varied while L is in vibration till a maximum indication is obtained, $T_1 = T_3$, and therefore

$$C_d = \frac{L_3\,C_3}{L} \qquad (35)$$

which enables us immediately to calculate C_d.

It was mentioned that the primary circuit was to be made aperiodic. The condition for this is that, if R_1 is the resistance of the primary exciting circuit, C_1 its capacity, and L_1 its inductance, the resistance must be at least as great as the value of R_1 given by the equation

$$R_1 = 2\sqrt{\frac{L_1}{C_1}} \qquad (36)$$

R_1 may be made larger than this, but nothing is gained by so doing.

(*b*) *Arrangement and Description of Apparatus.*—A wiring diagram of the apparatus is given in Figure 21. A, B, and H are the terminals of a high pitch buzzer, F if the battery which operates the buzzer, and E is a regulating resistance for controlling the buzzer current. Connected across the gap of the contact point of the buzzer are L_1, R_1, and C_1, all in series. As indicated, L_1 is loosely coupled to the coil, L, which is the inductance having distributed capacity under measurement. L_3 and C_3 are the inductance and capacity (both known) of the wave meter circuit, D is a detector, and 7 strands of No. 32 enamel covered copper wire, the sets being all twisted together and the whole triple silk insulated, radius 8.045 cm., length of winding 31.7 cm. The wave meter circuit L_3 C_3 consisted of the inductance L_3, which was made up of 16.8 turns of No. 18 lamp cord wound on a core 8.7 cm. in diameter. Its inductance was 18,980 cm. The capacity C_3 was a small variable air condenser, maximum value being 0.00074 μf. The detector, D, was a usual crystal

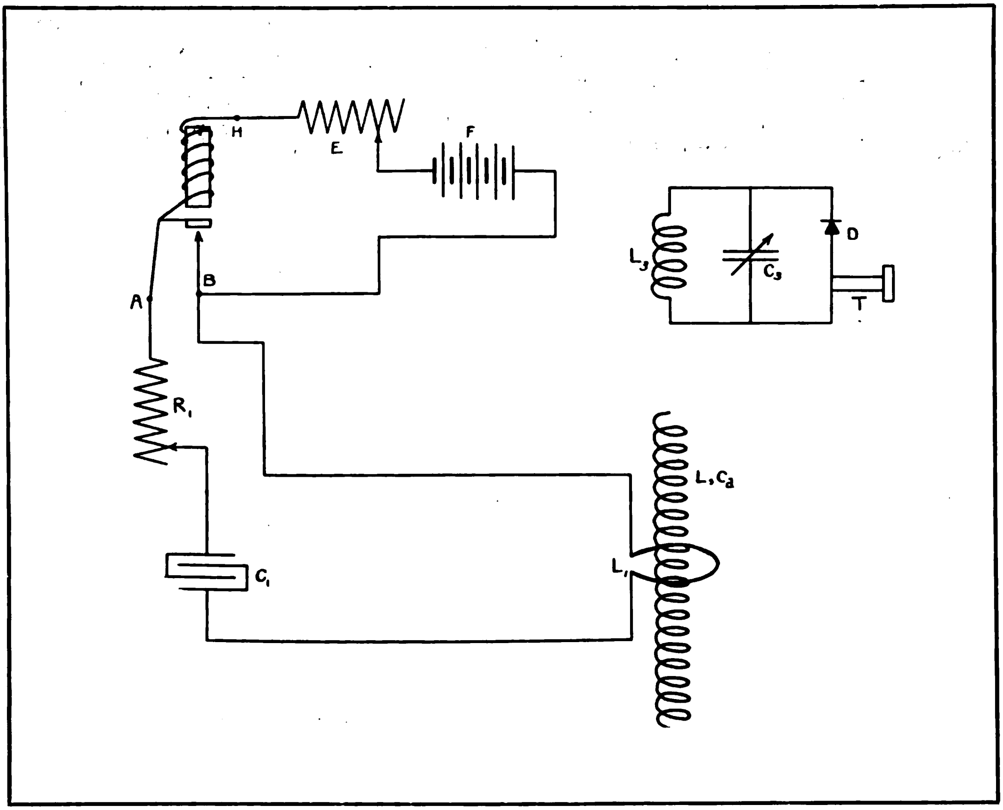


Fig. 21

T a telephone receiver. With the apparatus as actually used, F was a 10-volt storage battery, E was from 10 to 20 ohms, C_1 was a 2-microfarad No. 21-D Western Electric Condenser, L_1 a single turn or two turns of No. 18 lamp cord wound around L, and R_1 was between 10 and 100 ohms. L (in one case) was a coil of 157 turns of multiply stranded wire (so-called "litzendraht"), consisting of 7 sets of wire, each set made up of rectifier, and the telephone a 2,000-ohm double head band receiver.

The actual arrangement of the apparatus is shown in the photograph, Figure 22. To the left are seen the enclosed buzzer, and the resistances, E and R_1. The condenser, C_1, and a long coil, the distributed capacity of which is being measured, are in the middle. The two turns of the coupling inductance, L_1, are shown wound around L. To the right,

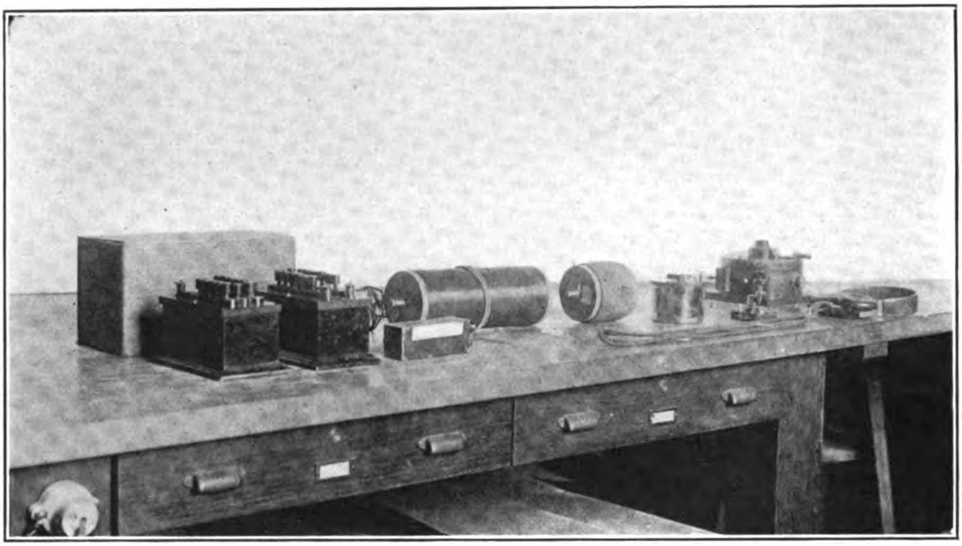


Fig. 22

L_3, C_3, D, and T are seen in order.

(*c*) *Procedure.*—An estimate of the magnitude of the distributed capacity C_d is made, and L_3 and C_3 are so chosen that it is possible to make

$$L_3 C_3 = L C_d$$

L_3 is then loosely coupled to L, and a number of readings of the resonance point of C_3 are taken. It is necessary to know the values of L and L_3, either by calculation of measurement. The condenser C_3 must also be calibrated.

(*d*) *Errors of the Method, Their Elimination; and Probable Accuracy.*—Unless L and L_3 are loosely coupled, the readings of the wave meter circuit are not dependable. Furthermore, it is essential that the resistance of D and T shall be high, as mentioned under theory.

As an example of the measurement, we consider the following: Coil of which the distributed capacity was being measured; "Litzendraht" coil, described under *b*.

L (as calculated by Nagaoka's Formula) = $16.55\ (10)^{-4}$ hy.

L (as measured on special apparatus at approximately 2,500 meters) = $16.7\ (10)^{-4}$ hy.

C_d (as calculated by Drude's Formula, number (32) above, assuming air core) = $5.85\ (10)^{-12}$ farad.

L_3 (in wave meter circuit) = $18.98\ (10)^{-4}$ hy.

C_3 (in wave meter circuit, when resonance is secured = 20 divisions) = $4.9\ (10)^{-10}$ farad.

C_d (as calculated from Formula (35) above) = $5.68\ (10)^{-12}$ farad.

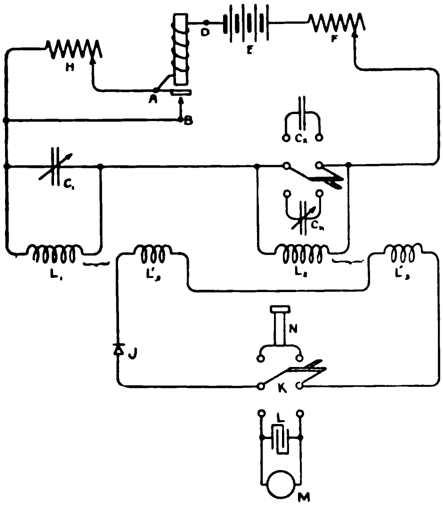
λ_f (fundamental free wave length of the coil as obtained from the calculated values of L and C_d) = 186. meters.

λ_f (fundamental free wave length of the coil as obtained from the measured values of L and C_d) = 183. meters.

It will be seen that the discrepancy in the value of $C_d = 2.9$ per cent, and that the discrepancy in the value of $\lambda_f = 1.6$ per cent.

The method which has been here outlined can readily be employed at high voltages. It becomes necessary to replace the buzzer excitation circuit by a quenched spark circuit, still further damped, if necessary, by insertion of the additional resistance R_1. Instead of the detector and telephone indicator, a hot wire ammeter in series with L_3 and C_3 may be employed instead. The theory is in no wise altered by these changes.

In the December issue of the WIRELESS AGE a connection was omitted from Figure 14, published to illustrate The Engineering Measurements of Radio Telegraphy. On the following page a corrected diagram of the figure is shown.



This is the fourth article by Dr. Goldsmith, in a series on the engineering measurements of radio telegraphy. The fifth will appear in an early issue.

DR. DeFOREST ON THE AUDION

At the November meeting of the Radio Institute at Fayweather Hall, Columbia University, an interesting lecture was delivered by Dr. Lee DeForest on the Audion—A Detector and Amplifier. The lecture was followed by a practical demonstration of the device.

The inventor gave a novel explanation of the operation of the audion, asserting that it did not obey the rectifying principle, but that the effect of the incoming oscillations from a transmitting station was to suddenly increase the resistance of the local circuit containing a high-voltage battery; this in turn, he said, caused a fluctuation of current that reproduced the radio signals in the head-phones.

After describing the steps preliminary to the discovery of the audion, Dr. De Forest showed in an elementary way the circuits of the audion as an amplifier. The instrument on exhibition consisted of four audions, each of which gave an increase of intensity of signals over the one preceding it; thus, amplications of 200 times the original strength of signals received in the first audion were obtained, according to the speaker.

In the practical demonstration of the apparatus the application of the devices to wire telephony was shown. A pair of ordinary wireless telegraph headphone receivers were connected to the audion amplifier. The first audion was then connected to a single magneto telephone receiver. The currents produced by the vibration of the single magneto receiver when near to the faintest sounds were sufficient to cause clear reproduction in the double headphone receivers. When a handkerchief was dropped on the single magneto telephone the feeble electric currents generated by the impingement of the sound waves upon the telephone diaphragm were sufficiently amplified by the audions to produce a considerable racket in the ear-pieces.

The single magneto telephone was then taken to a distant room and the audion amplifier connected to three loud-speaking telephones. Dr. DeForest's assistant in the distant room whispered into the magneto receiver and the electrical impulses thus produced were sufficiently amplified to be heard over the entire lecture hall.

It was stated that it is proposed to use the audion in connection with long distance wire telephony as an amplifier and that it might make transcontinental (New York to San Francisco) telephony possible.

A demonstration of the application of the audion in connection with wireless telegraphy was given. Radio signals coming from several wireless telegrah stations in the vicinity of New York had been recorded on the steel tape of the Poulsen telegraphone. The audion amplifier reproduced radio signals from the telegraphone records, which were so faint that they could not be heard on the telegraphone in the regular way. They were, however, sufficiently increased in intensity by the audion amplifier to make them audible. It was possible in this way to record the sound of the human breath on the telegraphone records and reproduce it quite distincly.

A new type of audion having double grids and double plates was shown. With this arrangement it is possible to light all three filaments from one storage cell, which, of course, is conducive to the simplicity of operation of the set.

How to Conduct a Radio Club

By E. E. BUTCHER

ARTICLE II

READERS of the series on How to Conduct a Radio Club will be interested to learn that the Bureau of Navigation, United States Department of Commerce, has concerned itself with the plan outlined relating to the formation of an organization, and suggested that the following be published:

"Radio station licenses can only be issued in the name of a club if it is incorporated in some State of the United States; otherwise the license must be in the name of some individual of the club who will be held responsible directly for its operation.

"Radio clubs having a club station should apply to the radio inspector of their district for the assignment of an official call signal which must be used for all radio communication."

In view of recent developments in radio telegraphic research the writer of these articles has decided to vary the practice generally employed relating to the order of publication; thus this article is written specifically for members of radio clubs already in existence, in the hope that it will spur them on to renewed efforts in investigating.

In it will be described two methods for the amplification of radio telegraph signals. As a rule, amateurs try to make the loudest noise possible when receiving signals from distant transmitting stations. At all radio stations, in fact, commercial or amateur, efforts are invariably made to obtain the greatest intensity of signals possible. Of the two methods presented for the amplification of signals, the second is not original with the writer, but was obtained as a result of his attendance at a lecture delivered recently at a meeting of the Institute of Radio Engineers. The first method was not brought out at the meeting, but suggested itself to the writer during the lecture.

Many amateurs are already familiar with the audion detector and the method of its application to wireless telegraphy, but there are some who are absolutely without knowledge relating to the device. For the benefit of the latter readers the audion will be explained in all of its details, accompanied by a diagram; a brief description of the construction and operation of the audion will also be given.

The audion detector is not a new apparatus, having been in use since about 1906. For some reason, however, it has not been employed generally in commercial service. This is probably due to the fact that, because of the battery current required, it is believed to be a device of considerable expense. The writer will show that this impression is erroneous.

In the equipment of every radio club should be included an audion detector. The apparatus, however, should be placed in charge of responsible members of the organization, for through careless usage it may easily be burned out.

The audion detector is shown in Fig. 1, and consists of a 4 to 6 volt lamp filament, F, a nickel-plated grid, G (which may also be a plate bored full of holes), and a plate, P, to which is connected one side of the local headphone circuit. The grid, G, is connected to one side of the closed oscillatory circuit of the receiving tuner and the filament, F, to the opposite side of the circuit. Either the B or A side of the filament may be connected to the lead D; the B side will generally give the best results.

The secondary of the receiving tuner is represented at L′, which is shunted by a variable condenser, VC. The variable condenser is of very small capacity; the maximum need not be more than .0001 mfds.—in fact, it may consist of two very small concentric brass tubes sliding over one another.

The members of radio clubs should

note specifically that the fixed condenser ordinarily used in the local oscillatory circuit of crystal detectors is entirely unnecessary in this circuit. This is an error found in many amateur audion circuits. The terminals of the coil, L', are directly connected to the filament and to the grid. If desired, however, a fixed condenser, PC, of the .005 mfds. may be shunted across the headphones as shown in the diagram. It is not absolutely necessary, but gives a slight increase of signals.

A rheostate (Rheo) of 10 ohms is connected in series with the lamp filament and is used to regulate the heat of the filament. It should be a rheostat capable of fine adjustment, for the heat of the filament must be closely regulated.

The type of tuner ordinarily employed by amateurs in radio work has not the right values of inductance for use in connection with the audion, nor is the capacity used in shunt with the secondary of the tuner of correct value. It is generally too large.

The audion is considered to be a voltage operated device, and it is best at all times to have the maximum potential from the receiving tuner act upon the bulb. This being the fact, inductance should predominate in the secondary tuner circuits, and the capacity used in shunt should be of a minimum value and within the range suggested.

The operation of the audion is as follows: The filament of the lamp, when heated by the storage battery, emits negative electricity and is said to be in a state of ionic discharge. When signals are received from a distant transmitting station the high frequency oscillations produced in the secondary of the receiving tuner may pass through the vacuous space between F and G in one direction, but are opposed in the opposite direction by the ionic discharge from the filament. In simple language, then, a collision takes place between the ions produced by the high frequency oscillations and those of the filament, which gives a decided increase of resistance in the vacuous space between F and plate P. This, in turn, causes a variation of current in the headphone circuit, making the diaphragms of the telephones vibrate.

The audion is therefore often referred to as a "trigger" device, for the reason that the high frequency oscillations produced in the receiving antenna do not energize the headphones direct, but are used to pull the "trigger," so to speak, of the local circuit containing the heavier battery current; hence the sensitiveness of the device. It is not unlike the operation of a telegraph relay where the feeble currents are used to operate a local circuit carrying heavier current.

A 4-volt 40-ampere hour storage battery is generally sufficient to operate the

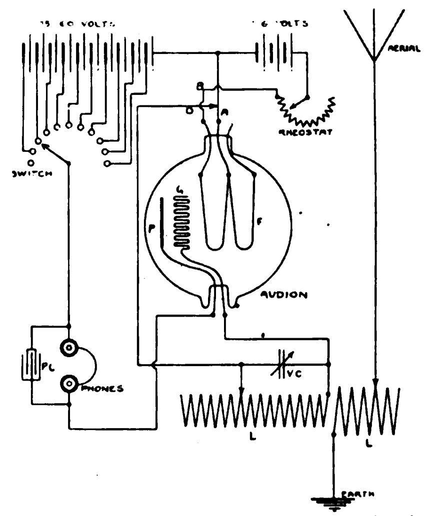


Fig. 1.—The audion detector and inductively coupled tuner; a detector which is noted for extreme sensitiveness.

filament of the audion, and will burn it on one charge of the battery for 100 hours. If the members of a radio club do not care to go to the expense of purchasing a storage battery they may use four dry cells of high amperage capacity similar to those employed for automobile ignition. The writer found that four cells of the HI-UP battery burned the filament for 75 hours before becoming exhausted.

From 35 to 60 volts is necessary in the headphone circuit, but the consumption of current in amperes is exceedingly small, and therefore batteries of the smallest possible size obtainable may be used; as a matter of fact, the writer employs the ordinary flashlight cells, which are exceeingly diminutive.

It will be understood, then, that the

cells are divided into two classes, the low voltage for the filament and the high voltage cells for the headphone circuit. After ten cells are included in the high voltage battery, a multiple point switch should be used to connect in three cells at a time from ten to maximum; for it is very important that the adjustment of the voltage in the headphone circuit be exact. At a matter of fact, no one can tell in advance the values of voltage to be used in either the high voltage battery or the filament, but after a little experimenting it will be found that a certain proportion between the two will give the best results.

It is well to bear in mind the necessity for having 60 volts in the headphone circuit, because there are some types of audions that require this amount of power.

The audion filament should never be burned in a vertical position; it should be used with the head of the bulb hanging down, for otherwise the filament might curl up and touch the grid, causing a short-circuit. Several wireless telegraphy amateur supply houses furnish miniature lamp stands, purposely constructed for the audion.

The audion has several peculiarities. When the filament of the audion is burning particularly bright and an abnormal amount of current is sent through the headphone circuit a blue glow takes place in the bulb, indicating that too much current is flowing across the vacuous space. The audion is then inoperative. It may be restored to sensitiveness again, either by reduction of the low voltage battery current to the filament or by reduction of the high voltage battery current through the headphone circuit. This action inside of the bulb is sometimes referred to by amateurs as a "spilling over." The audion may "spill over" when a high-powered station nearby to the amateur station is operating.

It requires considerable experience on the part of the amateur to properly manipulate the audion detector, and the best results can only be obtained through practice. It is, however, exceedingly sensitive, and, from official government tests, shows several times the sensitiveness of the ordinary electrolytic detector.

Particular care should be taken that at point E the negative end of the storage battery is connected to the positive end of the high voltage battery, for if the batteries are connected in opposition at that point the intensity of signals is considerably reduced.

For best results with the audion detector separate tuners should be employed for long and short wave lengths. Dimensions for tuners covering two ranges of wave length are as foldows:

Receiving tuner, 200 to 1,600 meters—loading coil (aerial tuning inductance) 5½ inches in length by 4⅛ inches outside diameter. Wound full with No. 20 S. C. C. wire; winding divides equally through a 10-point switch. Primary receiving transformer—wound on form 3¾ inches in diameter by 3 inches in length, with No. 20 wire; winding equally divided to the contact points of

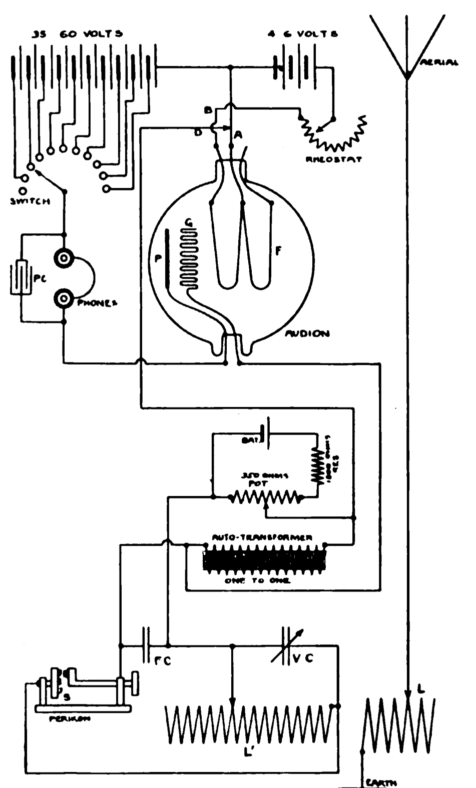


Fig. 2.—The audion as an amplifier of signals received with ordinarily inductively coupled tuner and perikon detector. With this arrangement the author claims amplifications of twenty times the strength received with the perikon alone.

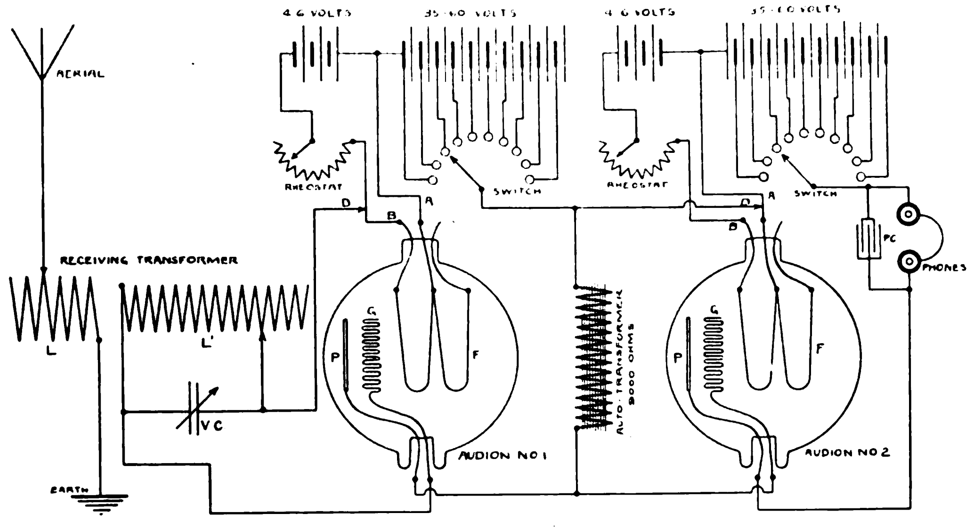


Fig. 3.—With this device it is claimed that messages may be copied from ships equipped with the standard types of apparatus up to a distance of 900 miles in daylight and 2,800 miles after dark. It is also possible to read signals which are otherwise undecipherable.

a 3-point switch. Secondary receiving transformer—Outside diameter tube 4⅛ inches, length 7 inches; wound with No. 22 S. C. C. wire; winding equally divided between the contact points of a 14-point switch.

Receiving tuner, 1,200 to 3,600 meters—loading coil (aerial tuning inductance), 7 inches in length by 4⅛ inches outside diameter; wound full with No. 20 S. C. C. wire; winding equally divided between points of a 20-point switch. Primary receiving transformer—3½ inches in diameter by 6 inches in length; wound full with No. 20 S. C. C. wire; winding divided into three taps. Secondary receiving transformer—wound on tube 12 inches in length, 4 inches in diameter; wound full with No. 28 S. C. C. wire; winding equally divided between contact points of a 12-point switch.

These tuners have been experimentally tried in connection with the audion and give excellent results. The dimensions may be slightly altered to suit the material on hand.

The expense attached to the purchase of an audion outfit is as follows:

1 audion detector	$3.50
1 10-ohm battery rheostat	.50
4 high-up dry cells	1.00
1 miniature lamp stand	.60
1 10-point wooden base multiple point switch	.30
*15 flashlight cells	2.10
	$8.00

*(*No. 503—Ever-Ready giving 60 volts.*)

The device, therefore, as will be seen, is not beyond the financial resources of the average radio club.

If the members of a radio club have on hand a perikon detector the audion may be used to amplify its signals.. As follows is the manner in which it should be employed:

The primary of the loose-coupler is represented at L, the secondary windings at L', the variable condenser in shunt by VC, the fixed condenser at FC, the perikon or silicon detector at S, the potentiometer at POT and the battery at BAT. When this loose-coupler is used with a perikon alone the headphones would ordinarily be connected around the fixed condenser; in this method there is shunted around the fixed condenser a one to one auto-transformer, the terminals of which are in turn connected to the audion detector. The one to one transformer is wound with about 3¾ pounds of No. 34 wire on a core 14 inches in length by 2 inches in diameter, and has a resistance of 8,000 ohms. The two ends of the auto-transformer are connected to the grid and filament of the audion detector, which otherwise is hooked up in the regular manner.

For best results the perikon detector should first be adjusted to maximum sensitiveness by connecting the telephones across the fixed condenser, FC, adjusting the values of the potentiometer, POT, until the loudest signals are obtained. The potentiometer, POT, may be of the values to be had in the ordinary potentiometer, 300 to 400 ohms, and should be connected in shunt to one cell of a dry battery. A fixed resistance of 1,800 ohms is connected in series with the 300-ohm potentiometer; thus a very small electromotive force may be applied to the perikon circuit and the best results obtained.

After the perikon detector has been adjusted to the highest sensitiveness the headphones should be removed from the fixed condenser and connected to the audion in the regular manner, as shown in Fig. 2.

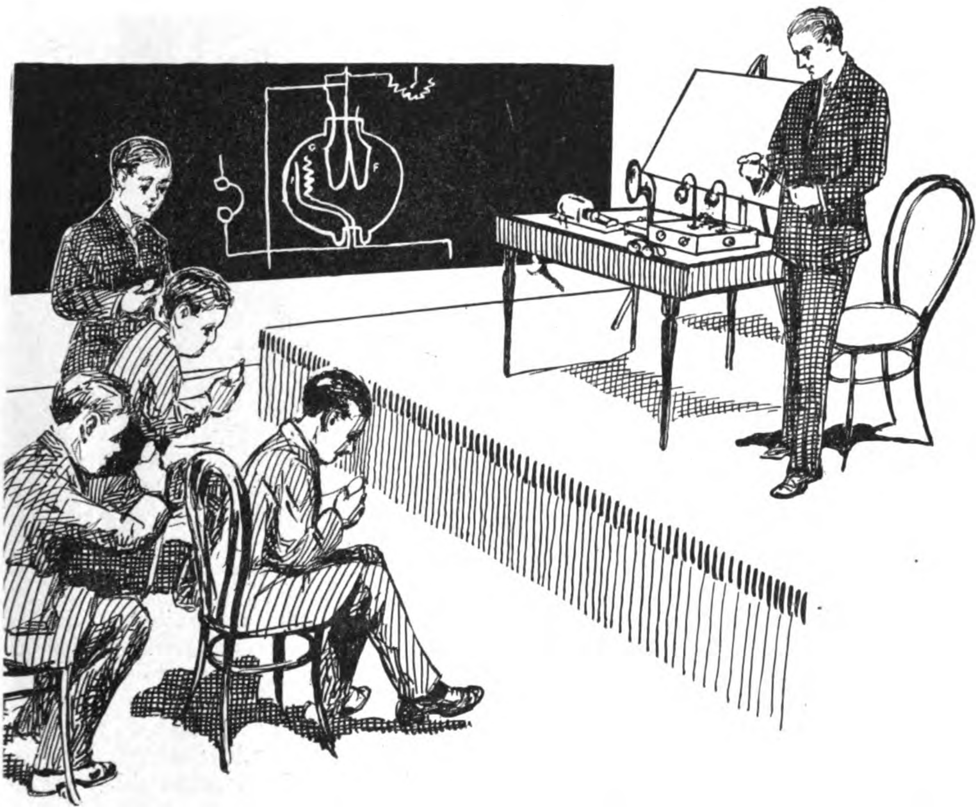
The one to one transformer is then connected in place of the headphones, as shown in Fig. 2.

The rheostat, R, in the low voltage battery circuit of the audion is now adjusted to give a certain degree of head to the filament, and the high voltage battery varied in intensity while some station is working. A point of adjustment will be found at which very loud signals will be obtained, much louder than are to be obtained with either the perikon or audion alone. Like all devices of this nature, it demands skill on the part of the amateur and an intimate knowledge of radiotelegraph receiving circuits; he should not be discouraged if the first tests are not successful.

The leads, H and H', connected respectively to the grid and filament of the audion, should be reversed and it will be found that the best signals are obtained one way or the other. This is best determined by experiment. If this arrangement is connected up exactly as shown, surprising results are in store for the amateur, but he must take particular care to keep the perikon and the audion in the most sensitive adjustment. During tests of this device the writer obtained amplifications of Arlington's time signals of 20 times the strength produced in the headphones with either the perikon or audion alone. A single audion may be employed to amplify the signals from any of the detectors like the silicon, perikon, carborundum, galena, and electrolytic, ordinarily used in wireless telegraphy.

Members of radio clubs will find it to their interest to purchase two or three audions and use them in series as amplifiers. It might be well to add that the audion as an amplifier is patented and may be used experimentally only.

A hook-up with two audions as they are used to amplify signals is shown in this article (Fig. 3). Observe that audion No. 1 is connected up in the regular manner with the exception of the headphones. In place of the headphones is placed one to one auto-transformer having a resistance of 9,000 ohms, with a core of the same dimensions as the one previously described. The core is wound with 4¼ pounds of No. 34 wire. Two leads are then tapped off from the one to one transformer and led to the grid and filament of the second audion. The second audion has its indi-



After the Audion is Properly Connected Up, and a Loud-Speaking Telephone Substituted, Those Present Will be Able to Set Their Watches by Arlington Time vidual high voltage battery and the telephones are connected to it in the regular manner.

Like all similar devices, familiarity with the apparatus is necessary, and it is impossible to advise in advance as to the adjustments of battery current or voltage in either audion. This can be determined by experiment. It is not difficult when one understands the adjustment of audions as used individually, but in all cases there is a proportionment of the high voltage battery to the degree of heat of the filament which gives the best result; when two audions are used as an amplifier, however, these adjustments may not be the same as when either audion is used singly and in the regular manner. As stated previously, this must be determined absolutely by experiment.

There are various types of ampliphones on the market to-day, but they will only increase the strength of signals which are already loud enough to be heard in the ordinary magneto telephone. The audion amplifier, however, will pick up and intensify signals when other types of crystal or electrolytic detectors fail to do so. When two audions are connected together the signals are so loud that stations which the amateur would ordinarily hear with fair intensity may be read at least 15 or 20 feet away from the headphones. Using this amplifier the writer has copied messages from 2 K. W. sets at sea in broad daylight at a distance of 900 miles with surprising clearness.

Members of radio clubs can give an interesting demonstration of the art of radiotelegraphy by purchasing a loud speaking telephone to be used in connection with the double amplifier. Then it will not be necessary for them to wear headphones in order to receive radio signals. Loud speaking telephones may be purchased from the large commercial telephone companies at reasonable prices. After the audion is properly connected up the loud speaking telephones should be substituted for the regular telephones, placed in the center of the room and the receiving tuner adjusted to the Arlington time signals. The ticks of the clock from the Arlington Radio Plant can be easily read twenty to thirty feet away from the headphones, and those present will be able to set their watches by Arlington time.

Using the amplifier described there is no reason why the members of any radio club within a range of 600 miles of Arlington should not be able to read the signals from ten to twenty-five feet from the loud speaking telephone, provided the club is equipped with an efficient antenna.

If any difficulty is experienced in securing results with the amplifier, it is undoubtedly due to the fact that the batteries (low and high voltage) are opposing one another in each individual audion or that the connections from the second audion to the one to one transformer are incorrect and need to be reversed.

If the radio club members desire a more elaborate arrangement they may place a third audion in the circuit, using another one to one transformer between the second and third audions. The third audion must have its individual lighting and high voltage batteries.

If all connections are properly made with the triple arrangement and the voltage is properly adjusted, amplifications 150 times the strength of signals to be had from the perikon or electrolytic detector can be obtained.

Amateur stations equipped with the more elaborate receiving antennae should be able during the winter months to receive signals from ships at a distance of 2,800 miles. It has often been noted that surprising results in tuning can be secured by the adjustment of either the battery voltage or the filament voltage of the second or third audion. As a matter of fact a slight adjustment of voltage will enable the experimenter to completely eliminate signals having different spark frequencies, although the various stations sending these signals may be operating on the same wave length.

(To be Continued)

RADIO CLUB OF AMERICA MEETS

The regular monthly meeting of the Radio Club of America was held on December 6 at eight o'clock in the evening at 327 West 107th street, New York. George Burghard, of 1 East Ninety-third street, secretary of the club, will answer inquiries relating to the organization.

The Lackawanna Tests

WIRELESS telegraphy, bearing a long list of triumphs wrested from the waters, has found new fields to conquer on land in conveying intelligence to speeding railroad trains. It is predicted that the new application of the art will revolutionize railroading, as it relates to the safety and convenience of travelers, for already passengers have experienced the novelty of reading news of the minute while they rode in cars thundering along at the rate of sixty miles an hour.

The value of a wireless installation was strikingly illustrated during a test on the Lackawanna Railroad train which left Hoboken at fifteen minutes after ten o'clock in the morning on November 24. The conductor of the train, known as the Lackawanna Limited, which was bound for Buffalo, became ill when thirty miles east of Scranton, Pa. Ordinarily it would have been necessary to stop the train and send a telegram asking for a relief conductor to be ready to take charge, or else wait for another conductor when the Scranton station was reached. The Lackawanna Limited is scheduled to run from Hoboken to Buffalo in nine hours and forty-three minutes, which means there is a constant fight against the loss of time.

On this occasion David Sarnoff, chief inspector of the Marconi Wireless Telegraph Company of America, was operating the wireless apparatus on the Limited train. The train was running at a speed of fifty miles an hour, but a wireless message telling of the conductor's illness and asking for a relief was dispatched to Scranton. The train arrived in Scranton about half an hour afterward and another conductor was on the station platform ready to step aboard.

When the Limited left Hoboken it was filled with passengers, and as it continued the conductor realized that he would need another coach. It was only necessary for him to notify the man at the wireless apparatus of what he wanted and a few minutes afterward a message was sent flashing over the mountains to Scranton, asking for another car to be held in readiness and added to the Limited when it arrived. The car was waiting when the train reached Scranton and no time was lost.

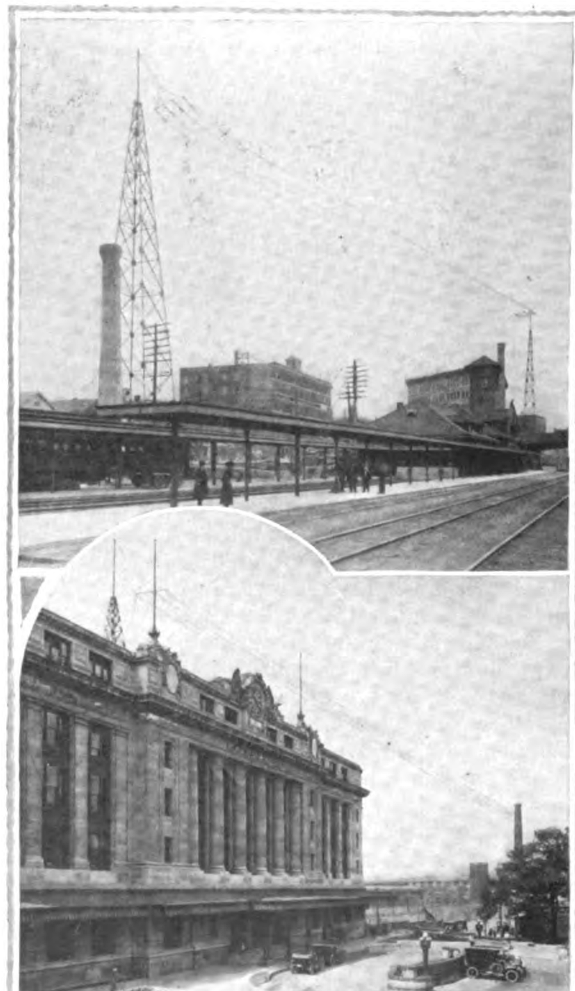
In charge of the wireless test on the train was L. B. Foley, Superintendent of Telegraph for the Lackawanna. He decided to get off at Scranton and return to New York on a train due in the former city two hours after his arrival. Mr. Sarnoff, however, remained on the train to continue the tests, and as the train Mr. Foley had planned to take —the Eastbound Limited—was due in Binghamton an hour before the arrival of the Lackawanna Limited, the Marconi employee decided to leave for New York on an express at midnight.

While in Scranton, however, Mr. Foley was informed that the Eastbound Limited was an hour behind time. A wireless message was therefore sent to Binghamton from Scranton and thence to Mr. Sarnoff on the Lackawanna Limited, informing him that he could make the connection with the Eastbound Limited at Binghamton. In consequence, he and Mr. Foley returned to New York on the same train.

Mr. Foley believes that when all trains have been equipped with wireless the absolute severing of all communication between trains and stations will be done away with. This will mean that disasters like the Dayton flood and the San Francisco earthquake will not cut off communication between the storm-devastated sections and the outside world. Wrecked or derailed trains will be able to notify stations about accidents as soon as they occur and word can be flashed to the nearest point outside the storm centers.

"Communication by wireless telegraph to and from fixed stations with moving trains is no longer an uncertainty," he said. "Railroads can now go ahead and install the service without any fear of failure. There are many fields for the wireless telegraph in railroad operation, in routine business, and emergencies when lives and property can be saved by its use.

"And the service can be put into operation without increasing the train crews. Regular trainmen can easily learn the telegraph alphabet or telegraph operators



The towers at Binghamton, showing the antennae suspended beside the railroad tracks.

The Scranton passenger station, with the aerial stretching to a nearby chimney.

on trains can perform the duties of trainmen. Later, it may be found necessary and profitable to place a telegraph operator on limited trains running long distances without stopping to handle commercial telegrams for the public. Telegraph offices on trains in the future may be of as much value to the public as branch offices in hotels and other places where people congregate in large numbers.

"In my opinion the wireless will revolutionize railroading. The time is coming, and it is not far distant, when the wireless telegraph on trains will make the safety and convenience of railroad traveling 100 per cent greater than they are to-day. And as a preventive of accidents I think the wireless will prove of the greatest value.

"In the Hudson tubes and subway, for example, the train dispatcher sits in his room, and by the flashing of lights knows where every train is. If two trains get dangerously close together he can send a signal that will almost instantly stop one or both of them. I believe that the same thing can be done on railroads with the wireless. The dispatcher can sit in front of a board on which the location of each train will be shown by wireless telegraph. If he sees trains getting too close together for safety, he can send a wireless message that will stop one of them any where—out in the country miles from a telegraph station.

"But of course all this is in the future. At present we are only experimenting. As far as they have gone, however, the experiments justify the predictions.

"Our doubt when we contemplated installing the wireless was about using the rails for grounding the electric current. There is a ground wire at every wireless station, but you can't have one from a moving train. So we tried sending our ground current to the rails. The scheme worked well and the first difficulty was overcome.

"And another problem was settled at the same time, that of supplying the electric current for the messages. We simply used the dynamos already in the train for lighting purposes. We had feared that they would not furnish sufficient current for the wireless, or if they did, that using it would weaken the lights. But we used all the electricity we needed and the lights were not perceptibly dimmed. I think it is certain that we can use the rails for ground wires and the ordinary lighting dynamos for our current. This was demonstrated.

"Our next problem is to get our instruments on the train absolutely in tune with those at Scranton and Binghamton. You see, on account of the tunnels and low bridges over the tracks we cannot have a high aerial on the train, but high aerials are necessary if messages are to be sent any great distance, so we built them high at the stations and work them with a low aerial on the train. This makes the transmitting of messages between the train and the stations more difficult, but I believe this difficulty can be overcome.

"We have sent and received messages so easily that we are convinced that the only thing required to perfect the service is a perfect adjustment of the instruments. We shall make an experimental trip every other day until this adjustment is satisfactory. Then the wireless service on the Lackawanna Limited will become a regular thing."

Setting signals by wireless is the next step, according to Mr. Foley. He said that if an operator wishes to set a signal for a moving train not in communication with him he can cause the semaphore blade of the signal post to rise or fall at his will by sounding the correct dots and dashes on his key.

"Signals can be set by wireless," he said, "as easily and as surely as they are now set by electricity conducted in wires.

"This means that if any mistakes are made in the orders issued to engineers and conductors at stations or in the case of any emergency in which a train must be stopped to avert an accident the station operator can signal the train as certainly as if he had direct wire communication with some one on board.

"Another valuable use to which the wireless-controlled signals can be put is the handling of freight trains on long runs. At present a through freight must make many stops between its starting point and destination, so that orders and instructions concerning right of way can be delivered to the conductors, but these frequent stops are a source of expense and delay which will be abolished by the wireless telegraph.

"Keeping freight trains in motion for long distances without stops will result in great economy of operation. Railroad operating officials know how expensive it is to start and stop heavy freight trains, the additional cost of fuel with the attendant pulling out of drawheads and the wear and tear of equipment being no inconsiderable items in themselves. With direct communication with a train and the ability to set and release signals by wireless, dispatchers can keep in touch with conductors and make the stops needless. The wireless permits the dispatcher to board every train and deliver his instructions as surely as if he handed them to the conductor in a sealed envelope.

"That the wireless service for ordinary operating purposes is no longer an experiment is proved by the fact that the Lackawanna has already depended upon it when wire communication was cut off. The railroad has used the wireless for handling train orders, and find it as accurate and reliable as the telegraph or telephone. Recently, when a severe sleet storm put all telephone and telegraph lines out of commission in the Mountain Division of the Lackawanna Railroad, all train orders were handled by wireless between Scranton and Binghamton, where the railroad's two fixed stations are. The signals were strong and distinct, and the messages were received and sent by the operators without difficulty. The wireless was the only means of communication between Scranton and Binghamton for two hours during which fifty-four orders were transmitted."

Commercial telegrams have already been sent from the Lackawanna Limited and a set of regular toll rates is now being prepared.

The wireless apparatus on the Limited has been installed in the forward part of the train. The aerial consists of a quadrangular closed loop on each car, supported at each corner by insulators on iron pipe attached to the corners of the car. They are raised eighteen inches above the roof of the car, this being the maximum space allowable on account of bridges and tunnels. Four cars are thus equipped, the connection between cars being by means of a plug and socket. The aerial on each car is sixty-five feet long and is composed of a twisted cable of seven No. 18 silicon bronze wires. The car aerials are brought together at a point about the center of the train and lead into the station, which is located in a small box-like compartment at one corner of the passenger cars.

The power for operating the train equipment is obtained from the generator storage battery and lighting outfit, and about 2 KW of energy is used for the wireless service. There is no appreciable effect upon the electric lights when the wireless is in operation.

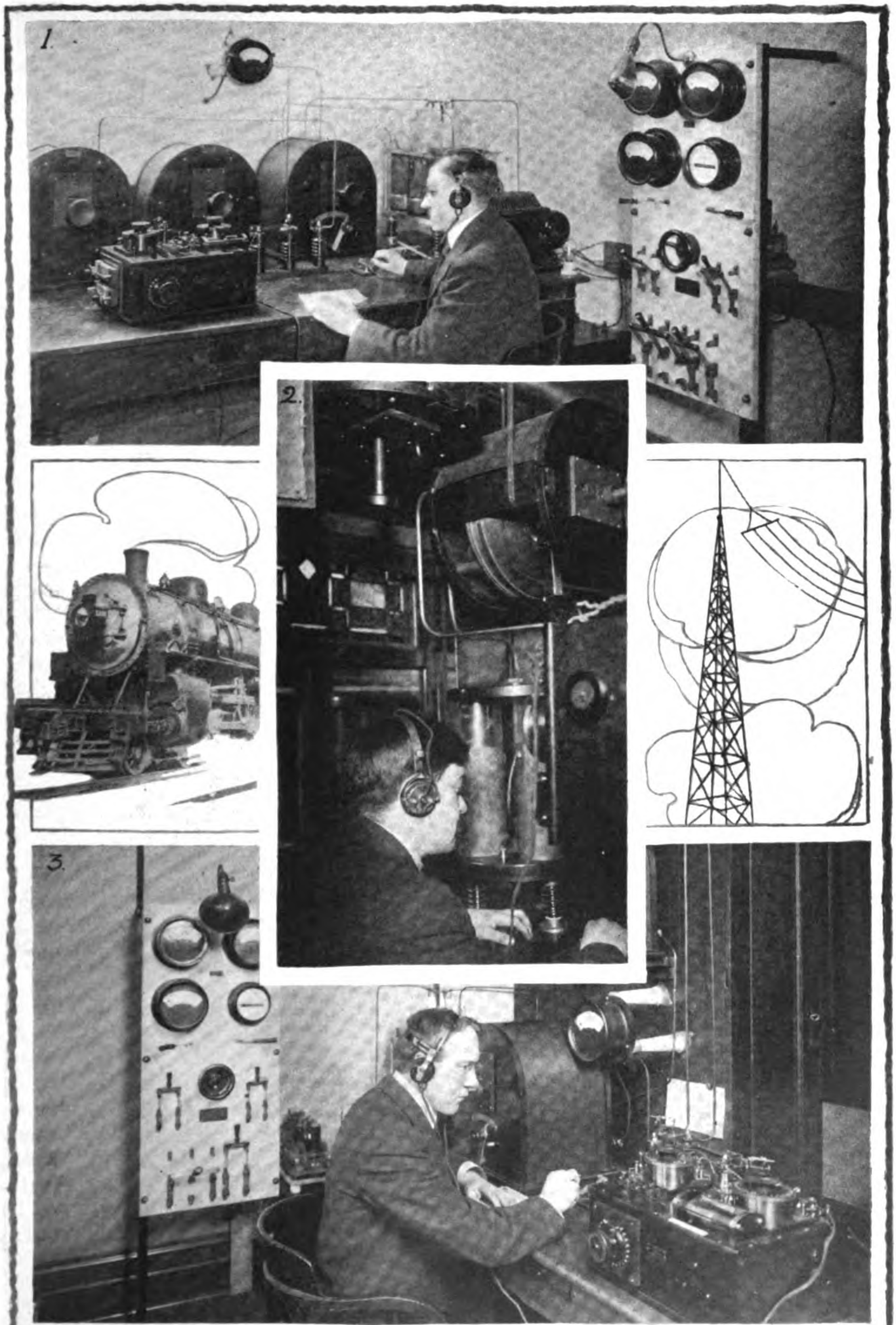
The radius of train operation at the present time is approximately fifty miles, but this range will be extended after the equipment has been tuned up.

The ground connection on the train is obtained through the steel trucks and wheels of the cars and rails.

The equipment on the train consists of a standard 1-KW Marconi set of modern design, especially adapted to this service. The motor-generator is automatically controlled, the operator simply throwing on and off a switch, as necessary. A special feature of the installation is the limited amount of space required for it. A photograph of the station accompanies this article.

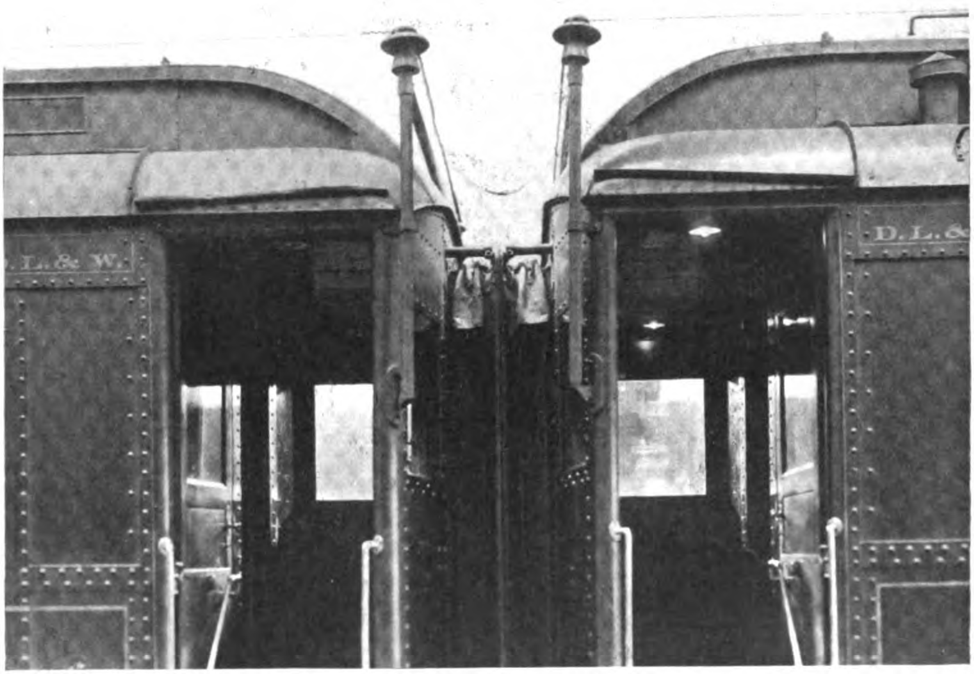
The distance between Scranton and Binghamton is about sixty-five miles, and in the experiments it was found possible to maintain communication from the train running at fifty-five miles an hour, part of the time direct from the train to the fixed station away from which the train was speeding, and when the train had proceeded to a point too far away for its short aerial to force signals through to this first station direct, the signals were delivered to the station by being picked up at the second station and relayed back. At no time during the tests was the train out of communication with both stations.

One of the most striking features in connection with train wireless was illustrated during one of the test trips, when news of the day was received while the train was demolishing distance between



(1) *The wireless room at the Binghamton railroad station.* (2) *Operator at the key of the train station.* (3) *J. J. Graf, Lackawanna electrical engineer in the Scranton station.*

Scranton and Binghamton at a mile-a-minute speed. Passengers were shown the latest dispatches from the United States and abroad, 250 words having been sent to the train by the Scranton Times. The sending of the dispatch recalled the fact that the daily news contained in the Ocean Wireless News, published on ocean steamships, was obtained by wireless and suggested the possibilities of a train wireless newspaper.



The aerial consists of a quadrangular closed loop on each car, supported at each corner by insulators on iron pipe attached to the corners of the car. They are raised eighteen inches above the roof of the car.

Railroad men, both in this country and abroad, have shown great interest in the tests. On December 17 Messrs. Logan and McDonald, of the telegraph department of the Pennsylvania Railroad, made a two days' inspection of the Lackawanna wireless system. They spent the first day watching the wireless work between Scranton and Binghamton. On the second day they were at Scranton when Mr. Sarnoff, of the Marconi Company, on the Limited, fifty miles east of Scranton, sent a wireless message to Mr. Logan, introducing himself. From that time until the train, which was west-bound, arrived in Scranton, communication between the Limited and the Pennsylvania men at Scranton was kept up. Then Logan and McDonald boarded the train at Scranton, the former taking the key in the wireless room. He sent messages to both Scranton and Binghamton.

Sarnoff, Logan and McDonald left the train at Binghamton and J. J. Graf, the Lackawanna's electrical engineer and operator on the Limited, sent a wireless from a point twenty-two miles west of Owego to the effect that the train was stalled because of trouble with the locomotive. The message was relayed to the chief train dispatcher at Scranton, and from that time until the locomotive had been temporarily repaired more than a dozen messages passed between the train and Binghamton. A new locomotive was ordered from Owego by the train dispatcher, and in twelve minutes it had been coupled onto the train.

Attention was called to the fact that if the accident had occurred in a storm that paralyzed the telephone and telegraph lines it would have been impossible to obtain another locomotive until the train reached Owego, and a considerable delay would have been experienced.

Mr. Graf sent out the following call recently while the Lackawanna Limited was forty miles from Buffalo and speeding toward that city: "Any radio station in Buffalo, adjust me." He repeated the call for twenty minutes and finally received a response: "Who are you?" This was followed by "What position are you in?" Graf replied, "Operator on board No. 3 Lackawanna Limited speeding toward your city."

The Buffalo operator, evidently believing that he was communicating with a wireless man on the Great Lakes, asked, "What longitude and latitude are you in?" Once more Graf flashed back an answer, and this time it was understood. The Buffalo operator, Jackson, of the Marconi Wireless Telegraph Company of America, sent his congratulations on the success of the train wireless and met the Limited when it arrived in Buffalo.

The possibilities of wireless applied to railroads multiply almost constantly. Soon after the installation had been made on the Lackawanna Limited, three tramps were discovered by Conductor Simrell riding on the tank of the locomotive, unobserved by the engine driver and the fireman. The Limited was between Scranton and Binghamton at the time and the conductor did not want to stop the train to put the men off. Therefore he reported his discovery to Mr. Foley and Operator Graf, who were in the wireless room.

The wireless apparatus was put in operation and a message sent to Binghamton informed M. F. Collins, a special division agent of the railroad in that city, of the fact that the Limited was carrying three men who were without tickets. When the train pulled into the outskirts of Binghamton and slowed up, Collins and his assistants took the three into custody. The tramps were greatly surprised when they were told of the means employed to capture them, and apparently took pride in the fact that they were among the first of their class to take a place in the history of train wireless.

The first Lackawanna train order was sent on October 23, from Scranton to Binghamton. It marked the first time in the history of the world that a train order was sent by wireless. But already wireless dispatching has become a daily occurrence, and as Mr. Foley says: "The total loss of communication between stations, caused by the prostration of poles and wires is a thing of the past."

THE SHARE MARKET

NEW YORK, December 22.

While Marconis hold at about the same level as last month, a good deal of stock market pessimism has been put to rout, and the scattered but heavy liquidation in leading, or what are termed standard stocks, came practically to an end with the close of the week. A sharp upward turn is now looked for in the general market, and Marconi issues will no doubt reflect the change in sentiment.

The sturdy resistance which Marconi shares showed to the adverse influences growing out of the anti-trust action against the American Telegraph & Telephone Company and the proposal for government ownership of telegraph and telephone lines indicated very definitely that the professional trader has ceased his depredations.

This opinion was confirmed this morning by a leading broker, who stated that the light trading was confined to purchasers of small allotments of Marconi stocks for investors. It was further added that Marconis were every day receiving wider recognition from the conservative investors and with currency matters adjusted in Washington and the new high-power stations opened, a gradual rise could be anticipated beginning with the first of the new year.

Bid and asked prices to-day: American, 3⅞—4⅛; Canadian, 2¼—2½; English common, 16—17; English preferred, 13½—15.

Starting the New Year Right

Whatever you do, do wisely and think of result.

⦿ ⦿ ⦿

Many things difficult to design prove easy of performance.

⦿ ⦿ ⦿

Facility of action comes by habit.

⦿ ⦿ ⦿

Apology is only egotism wrong side out.

⦿ ⦿ ⦿

Those who apply themselves too much to little things commonly become incapable of great ones.

⦿ ⦿ ⦿

There is no slipping uphill again, and no standing still, when once you've begun to slip down.

⦿ ⦿ ⦿

That which is everybody's business is nobody's business.

Character must be kept bright as well as clean.

⦿ ⦿ ⦿

Circumstances are beyond the control of man; but his conduct is in his own power.

⦿ ⦿ ⦿

Have the courage to face a difficulty, lest it kick you harder than you bargain for.

⦿ ⦿ ⦿

Industry pays debts, while despair increases them.

⦿ ⦿ ⦿

Diligence is the mother of good fortune.

⦿ ⦿ ⦿

A man in earnest finds means or, if he cannot find, creates them.

⦿ ⦿ ⦿

Nothing great was ever achieved without enthusiasm.

⦿ ⦿ ⦿

A great man is one who affects the mind of his generation.

⦿ ⦿ ⦿

The efficient man is always in haste and never in a hurry.

⦿ ⦿ ⦿

Nothing is too difficult; it is only we who are indolent.

⦿ ⦿ ⦿

Some people never make any mistakes because they never try to do anything that is worth doing.

With these thoughts in his mind, Rance struck another match. "K"— "K"—. He cudgeled his brain in a useless effort to identify the sender of the marconigram.

Little Bonanza

A Serial Fiction Story

By WILLIAM WALLACE COOK

Begun in November—On the steamship Ostentacia, bound westward across the Atlantic, is John Maglory, of Ragged Edge, Ariz., his adopted daughter, Bonanza Denbigh, and his nephew, Jefferson Rance. Maglory is developing for Bonanza a gold mine, which has shown so litle promise of yielding good returns that his attempt to sell it in London has met with no success. On the steamship he meets William Sidney, who buys an option on the sale of the mine. Rance, who has received a wireless message telling of a rich vein that has been uncovered in the mine, warns Maglory against Sidney. Maglory, however, is skeptical regarding the efficiency of wireless and pays no heed to Rance's statement that Sidney knows more than he appears to about the value of the property. Following an accidental meeting with Bonanza late at night, Rance has an encounter on the deck of the Ostentacia with Sidney, who draws a revolver. Johnnie Clendenning, wireless operator, witnessing the fight from the roof of the deck house, descends and stops it by disarming Sidney and restraining Rance.

CHAPTER V

SO far as Sidney was concerned, Clendenning, in taking the revolver, had checked for the time being his fighting spirit. Rance, however, might not have yielded to interference so easily had the compelling power of Bonanza's words failed to mainfest itself: "All the mines in the world could not make up to me the loss of an atom of my faith in you. Remember that!" And as the wireless man stood between him and Sidney, Rance remembered it.

"Man from the first cabin trying to take a pot shot at a man from the second!" came scathingly from Clendenning, "and the fellow aft doing his darndest to choke the chap with the six-gun! Pretty how-d'ye-do I must say! Shoo!"

He tossed the revolver over the side, where it glimmered a second in the moonshine and then carried its menace into the depths. "Go back where you belong, Mr. Sidney," advised the operator; "and you," addressing Rance, "better do the same. If you two will let the matter end here, so will I."

Rance drew back against the rail. Sidney started for the passage along the starboard side of the cabin, but paused and whirled.

"Your hand is on the table, Rance," said he, with forced calmness, "and so is mine. I have the winning cards, and you know it. I would have borne with your folly and reasoned with you. But you would not have it. Now take the consequences."

He lingered, perhaps expecting a retort and wondering why it did not come. Rance closed his teeth on the words at his tongue's end and, his eyes gleaming with suppressed anger, watched his enemy pass from sight.

"That's right," said Clendenning, expressing approval of Rance's silence. "Least said, soonest mended. Beautiful moon, eh? And the Atlantic's like a duck pond. Good night."

The wireless man moved off and vanished among the shadows. Rance remained by the rail, wondering what new developments might come of events unfolded by the last hour. His apprehensions had mostly to do with Bonanza. For himself, he did not care.

Sidney must have been convinced that his own position was impregnable. Rance firmly believed that trickery had been employed in the negotiations by which the option on the mine was obtained. But how could this be proved to the satisfaction of John Maglory?

Kennedy had been instructed to keep secret the operations at the Bonanza. These orders had come from Maglory himself. Rance had worked in the mine, however, and Kennedy, for a consideration, had agreed to keep him informed about the property. But from what source had Sidney secured his information?

Kennedy was shrewd, and had an eye

to the main chance. In spite of his shrewdness and vigilance, however, news of the "strike" at the Bonanza had found its way to Sidney.

Presently this one-sided fight, in which Sidney seemed already the winner, would shift to Southern Arizona. Rance yearned to push the calendar ahead, to take a leap through time and space and find himself at once in the vicinity of Lost Horse Cañon. There all was familiar to him, and he could battle for Bonnie's rights with weapons he knew how to use.

His last marconigram to Kennedy had told of the Sidney option, and it had promised the superintendent a dazzling bonus if he would discount the tales of the mine's success and turn that foot vein of hundred dollar rock into a limestone stringer. This was to be Rance's move in the attempt to checkmate Sidney. Kennedy would stand by, Rance felt positive.

Rance felt that he was helplessly drifting, that he could not do a man's work for Bonnie and the mine until his two feet were on the soil and in the surroundings he knew best. The outlook was dark indeed. He was on the decks of a liner, with many leagues of sea and land between him and Ragged Edge. His sole resource was the antennae of the wireless, which caught from the air and transmitted to Clendenning the dots and dashes which were to make or mar the fortunes of Bonanza Denbigh. And this resource was as available to Sidney as to Rance.

Reflections brought Rance nowhere, and with something of despair in his heart he bowed his head and started for his stateroom. Abruptly he halted.

Something lay on the deck. His eyes glimpsed it vaguely, and he would have passed on. Then, by one of those processes of the mind which now and again help fate to blunder and destiny to stumble, he was moved to investigate. Stooping, he picked up the object which had caught his attention.

It was a folded paper. He walked to the bench, seated himself and struck a match. He held in his hands a wireless message, originally transmitted to William Sidney. It was a code message, and the meaningless words danced vaguely before Rance's eyes.

The match flickered and died in a breath of air. Rance's fingers closed on the paper with a convulsive grip and his hand fell to his knee. In some way, that struggle at the rail had caused the message to drop from Sidney's pocket. He had passed on without discovering his loss; and the paper, cast up on the shores of chance, had come into Rance's possession.

All methods seem fair when you are fighting for the girl you love and her rights. In worsting a crook at his own game, one may not pick and choose the weapons that please him. With these thoughts in his mind Rance struck another match. His eyes, running over the words that might mean so much, yet promised so little, came to the letter "K," which was the sender's signature.

That one letter was a clue to the mysterious person in Ragged Edge who was keeping Sidney posted regarding the Bonanza Mine. "K"—"K"—Rance cudgeled his brain in a useless effort to identify the sender of the marconigram by the first letter of his last name.

Every American and Mexican, all up and down Lost Horse Cañon and in the Poco Tiempo district, Rance knew. And he had known every man in the workings until his uncle had ordered him away from the mine. Yet he could not think of one man, whose name might be abbreviated with the letter "K," who would pose as a spy for Sidney.

With an exclamation of disappointment, he folded the note. Then, once more, pure luck favored him. On the back of the sheet, written in red, were comprehensive words—undoubtedly a translation.

Here was a stroke of fortune which caused Rance to gasp. Again he read, from beginning to end; and, at the end, even that elusive "K," through some vagary of the translator, was followed by the letters which gave the informant's full name.

Another gasp, this time of consternation, was wrenched from the young man's lips. He went hot and cold, and his brain grew dizzy.

"Kennedy!" he whispered huskily. "Merciful powers, can it be Lafe? Has he sold out to Sidney, and is he against us—against Bonnie——"

A burly form rounded the corner of the deck-house, muttered wrathfully and planted itself squarely in front of Rance.

"Found you!" rasped a familiar voice. "By the jumping sand-hills, I'm having more luck than I expected! The night's well along, but I reckon you have an idea that Bonnie will come back? Oh, you low-down coyote! Now, Jeff Rance, you listen to me—and for the last time."

With a chill of apprehension racing through his nerves, Rance arose from the bench. But he faced his uncle squarely.

CHAPTER VI

A portentous silence followed the coming of John Maglory. The old man's face was shadowed by his hat-brim, but his eyes flashed angrily in the darkness. They looked the younger man over, up and down, apparently taking his measure in a new and contemptuous light.

Rance returned the stare as calmly as he could and waited for the storm to burst. He knew that it was coming.

"Man, man," came from Maglory, in a strangely repressed voice, "I knew you had hit the down-grade, that you had tossed most of the things that make life worth while into the discard, and that you had herded with tin-horns and crimps until you had become a crimp and a tin-horn yourself; but, so help me Gawd, I still had hopes that the Maglory part o' you would somehow and sometime strangle the Rance deviltry that tainted your blood. You're right. I'm an old fool; and I have been an old fool all along to harbor such notions. What I've heard to-night—what I've——"

His voice choked and died into silence. Maglory struck at his forehead with a clenched fist, then dropped his gripping fingers and worried at his throat. He staggered.

"Uncle!" cried the alarmed Rance, stepping forward with outstretched arm.

The other stiffened and drew back. Once more he grew firm on his feet and his eyes continued to blaze.

"Sheer off!" he ordered hoarsely. "You dog my heels like a coyote on the trail of a wounded buffalo. I can't even cross the water without having you camped on my trail, doing your little best to back-cap me at every turn. How long ago was it I told you to stop pesterin' Bonanza? D'you think I ain't man enough to look after the girl and keep her away from you? D'you allow you'll carry her off, in spite o' me? If orders don't count with you, I'll couple the orders with something else. Bonanza is pure gold, and you're only a mess of country rock and not worth your salt. You've been meeting her here o' nights, eh? What's her good name to you that you'll connive at such doings? I know—don't you dare deny it! I got it straight from Sidney, and straighter still from Bonnie, herself. That Rance streak of yalluh is about all there is left in your make-up, and——"

Rance flung himself forward. Maglory tossed up an arm to ward him off. Rance, with his face close, looked his uncle fearlessly in the eyes.

"You're wide of your trail, John Maglory!" he said, struggling to hold his temper in check. "If another had laid tongue to all that, something would have happened on this part of the boat. There's more Maglory than Rance in me—and you'll acknowledge it before we're done. I have met Bonnie here because it was necessary, that's all; and her good name is as safe in my hands as it is in yours. What's more, I'm not the devil you think I am. That is something you'll acknowledge before you're many weeks older."

"Well, look!" exclaimed Maglory fiercely. "Don't you ever let me see your face again, either on this boat or in Ragged Edge! I'm done with you, and Bonnie's done with you. Try to cross trails with me again, and I'll show you what I mean. That's my last word."

Breathing heavily, and swaying a little as he walked, he started to go away. Rance stopped him with a word.

"Wait! You've had your last word, now give me mine. Out of regard for Bonanza and the Bonanza Mine, John Maglory, you've got to listen. This man Sidney is no better than a thief. Through you he is robbing Bonanza blind! I have the proof!" and Rance lifted the hand that clutched Sidney's marconigram.

"You're a rainbow-chaser!" growled Maglory. "You haven't sense enough to wad a gun, and Bonnie is getting the brunt of all your tomfoolery. You——"

"Lafe Kennedy is in cahoots with Sidney," cut in Rance; "he——"

"He's in cahoots with you, I reckon, and he'll hear of that when I get back to Ragged Edge."

"Kennedy is working with Sidney to give you and Bonnie the worst of this mine deal. Here's a message to him from your superintendent—it's the one that caused Sidney to close that deal with you for the thirty-day option. Kennedy says that the Burton-Slocum Syndicate has got wind of the 'strike,' and that their agent is waiting for your arrival in Arizona to offer two hundred thousand for the property! That's Kennedy's tip to Sidney, and on the strength of it he has nailed that thirty-day option at fifty-thousand dollars—a clear steal of a hundred and fifty thousand from Bonanza! In the name of heaven, John Maglory, can't you wake up and see this thing as it is?"

Under this torrent of words, Maglory stood bewildered. Then he stirred suddenly.

"Lies, lies!" he cried angrily. "I'm doing the best I can for Bonnie. It's crooked talk you're giving me!"

"Bad as you think I am," continued Rance, "in your own heart you know I never lied to you."

"If that's Sidney's message, how'd you get it?"

"I picked it up, here on the deck!"

"Picked it out of his pocket, I'll bet, when he wasn't looking. That sort of work seems to be your stripe, since you headed down the wrong trail. That Burton-Slocum talk is moonshine! Wasn't I after 'em to buy, before I touched up the Poco Tiempo outfit?"

"That was before the 'strike' at the mine," insisted Rance, overlooking the hard words that were thrown at him in the desperate hope of carrying his point. "Of course they were not in the market, then; now the Bonanza Mine has been proved a winner, and they're wild to get hold of it and cut out their rivals, the Poco Tiempo crowd. The message came to Sidney by wireless, direct from——"

"Don't talk to me," snapped Maglory. "All lies, wireless lies!" and he tossed his hands contemptuously. "When I'm back in Ragged Edge I'll figure this all out first-hand; and about the first thing I do will be to get Kennedy's scalp, if he's really paying fast and loose with me. Thank goodness it won't be long, now, till I'm back on the old stampin' grounds with Bonnie. And if you show up there and try to cross trails with me," he finished, "there'll be fireworks. I'll not keep hands off of you, same as I've done up to now!"

He tramped away, and left Rance, discouraged and bitterly resentful, peering out over the heaving waste of waters.

(To be continued)

FIRST FINE UNDER NEW LAW

Collector of Customs Stone, of Baltimore, Md., recently fined Captain Ghakoenneman, of the North German Lloyd liner Frankfort, $100 for failing to maintain a radio wireless operator on duty at all hours while the vessel was en route from Philadelphia to Baltimore. The decision was the first under the new Federal Radio Inspection act, and if upheld by the Treasury Department will establish a precedent.

Collector Stone overruled the defense offered that the wireless law does not apply to foreign shipping and that the Collector lacked jurisdiction. He ruled that the law covered all shipping in American waters and likewise that he had power to hear the case. The evidence showed that the Frankfort did not have its wireless operator on duty during the full twenty-four hours.

INSTRUCTION TO BOY SCOUTS

By A. B. COLE

CHAPTER VI

The Transformer

AS we have previously stated, the main application of the transformer is in a permanent station, like the home or the armory. The following directions show how to build a ½ K. W. transformer, the transmitting range of which in connection with the other necessary apparatus and a good aerial, is from thirty to fifty miles over water or level land:

The transformer operates from an alternating current lighting circuit without any interrupter or choke coil. The standard voltage of most lighting circuits is 110 and the frequency is 60 cycles; consequently the design for this transformer is for circuits of this description.

The core is made of thin strips of soft iron which are shellacked or varnished to keep them from coming into electrical connection with each other. Two sizes of strips are used. Fig. 26 shows the method of forming the core. The first "layer" of the core consists of strips laid as shown at the left, and the second layer is illustrated at the right side of the drawing. One layer is placed over another until the core is completed. The third layer is the same as the first and the fourth the same as the second, and so on.

Strips A are 7¾ inches long and strips B are 5¼ inches long. Both sizes of strips are 1¾ inches wide. They should be cut from soft sheet iron, 1/32 inch or less in thickness. A sufficient number of strips should be used to give the core a cross section 1¾ inches square.

After the core has been formed as described, the legs, B, should be wrapped

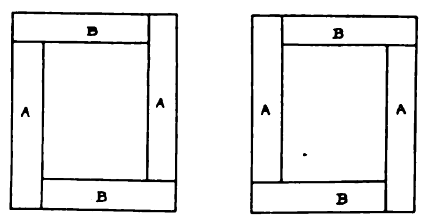


Fig. 26.—Transformer Core

with tape to hold the strips in place, and several layers of Empire cloth, 3½ inches wide, should be wound over this to give the total insulation over the core a thickness of about ¼ inch.

Two fiber separators, 5½ inches square and 3/16 inch thick, are made with a square hole in the center of each, 2¼ inches square, as shown in Fig. 27. These are to fit over one leg, B, and its insulation is to prevent the primary winding from coming in contact with any part of the core. In order to set these separators in place it will be necessary to swing one end of B away from one side, A.

After the separators are in place at

each end of leg, B, and the core is replaced in its original position, the primary may be wound over the insulation and between the separators in twelve even layers. No. 16 double cotton-covered magnet wire is used for this purpose and approximately four pounds will be required. A binding post set on each of the separators may be used to anchor the ends of the winding and as terminals for the primary.

The other leg, B, of the core is treated in much the same way as the first leg, by winding on two layers of tape and sufficient Empire cloth to give an insulation thickness of ¼ inch. Six fiber separators, 5¾ inches square by ⅛ inch thick, are made with a square hole in the center 2¼ inches square, as shown in Fig. 27, and two similar ones with a thickness of ⅜ of an inch. The thick separators are to prevent the end sections of the secondary from coming near the sides, A, of the core. The secondary consists of seven sections, formed on a winder constructed somewhat as shown in Fig. 23, except that the mandrel, P, should be square. Each section is ¼ inch thick and 5¼ inches square, although the corners will be somewhat rounded off. As soon as the winding of a section is finished, enough hot paraffine should be poured over it while on the winder to cause it to retain its shape when removed. As soon as this has cooled the section should

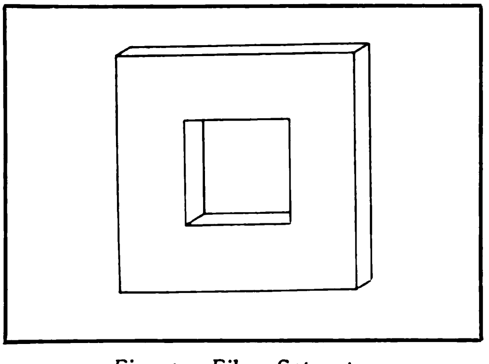


Fig. 27.—Fiber Separator

be held together by tapping where necessary, and it should then be boiled in paraffine until thoroughly saturated. It may then be removed and allowed to cool.

The sections are built of No. 34 single silk-covered magnet wire, and if convenient it is well to run the wire through hot paraffine as it is being wound on the form; this method will make handling a simpler matter. If the sections are carefully wound, about nine pounds of secondary wire will be needed.

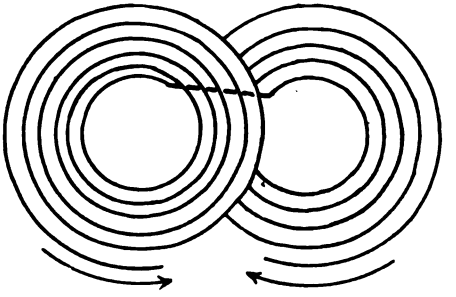


Fig. 28.—Two Sections Connected

The thin separators are to be placed between adjacent sections. In assembling the sections, after the first is in place, the second is swung around 180 degrees from the position of the first, so that, by following the path of the current around the wire, starting from the inner end, the direction of the second will be opposite to that of the first.

The third section is placed the same as the first, the fourth the same as the second, and so on, so that in alternate sections the current flow is in opposite directions. By arranging the sections in this way the inner ends of the first and second may be connected together under their separator, the outer ends of the second and third above their separator, and so on.

After the secondary winding is assembled and the leg, B, replaced, two pairs of wood cleats should be made, 11½ inches long by 1¾ inches wide by ¼ inch thick. One pair of these is placed on each side of the core, above and below the sides of the core at C (Fig. 29), and secured by two bolts, D, which do not touch the core itself. These cleats will hold the core in position. A leg, R, should be bent from sheet iron ½ inch wide for each side of the transformer.

The completed transformer may be placed in a wooden case if desired, and in this event the terminals of the primary and secondary will be connected to posts on the outside of the case. If no case is used, two hard rubber posts should be set up on cleats, C, for connection to the secondary terminals. These wires must not be allowed to approach either the core or the primary on account of the high voltage currents which they carry, and care should be used in handling them for the same reason.

This transformer will develop between ¼ and ½ K. W. if carefully made, and with a fair aerial will send over level land up to fifty miles.

Chapter VII

Aerials and Grounds

The aerial is of the same construction in general for all types of outfits, although a large set should naturally have a large aerial for the highest efficiency. The importance of having a good aerial for any station cannot be emphasized too strongly, for upon it the success of the station or equipment largely depends. The very best instruments are of little practical value unless the aerial is sufficiently high and long, but on the other hand, satisfactory results may be obtained with only a few instruments in connection with a properly designed aerial.

The purpose of the aerial is, primarily, to radiate the electro-magnetic or electric waves supplied to it by the transmitting instruments, and to bring into the station to the receiving instruments as large an amount of energy from passing waves as possible.

All buildings, trees and other objects between two stations will absorb and reflect electric waves to a certain extent. This is especially noticeable where many steel structures stand between the stations. Such objects act as aerials, and since they are all more or less perfectly grounded, they will absorb considerable energy from the waves. It is a simple matter to show this experimentally. A portable wireless outfit may be connected to a fence wire or the tin roof of a house or almost any other imperfectly grounded electrical conductor, and it will be possible to receive messages from considerable distances. This fact is of especial value in field work, but to obtain satisfactory results, the fence wires should not be in contact with the earth at any point.

High hills also detract from the energy transmitted between stations if they are between the stations or close to them. It will therefore be understood that the greatest distances can be covered over water, because the space between stations is unobstructed, and then, too, a good ground connection is available.

The prime reason for having a high aerial is that it may be above surrounding objects, so that the paths to and from other stations may be as clear as possible. Bearing this in mind, it can be seen that in some localities the aerial might be much lower than in others and still give good results; consequently it is impossible to say exactly how high it should be without a knowledge of local conditions. The aerials of commercial stations are generally between 100 and 500 feet above the earth, except on ship stations, when less height is necessary.

The height of the aerial is of more importance in transmitting than in receiving. It has been observed that a difference of two feet in the height will make a difference in the transmitting radius of the station.

The length of the aerial plays an important part in the radius of operation. A long aerial is more likely to be crossed by waves from another station than a short one. It has been found that the

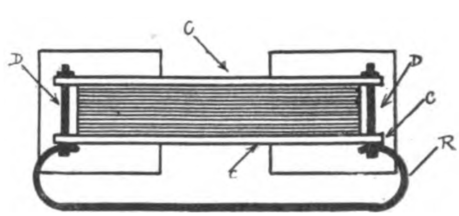


Fig. 29.—Use of Cleats on Core

greatest distances can be covered in transmitting if a comparatively long wave length is used. If the aerial is long, its natural wave length will be long and thus assist in transmission. In an amateur installation the aerial should not be too long, for it would be difficult to receive from other stations of similar equipment, due to the fact that its natural wave length would be too great. A length of 100 to 150 feet will give the best results in most cases.

The number of wires in the aerial will also affect the radius of the station, especially in regard to transmission. The greater the number of wires, the better the results will be. An aerial of many wires is a better radiator of electric waves because it has a greater surface and a greater capacity to absorb energy from the tranimitting instruments. An aerial of a certain number of wires will have a greater capacity if the wires are far apart than if the distance between them is small.

The aerial may be supported in any convenient manner, either on poles, houses or trees. The method depends largely upon its location. The size and shape should also be determined in some degree by local conditions. Any of the forms shown in this chapter will give good results.

The vertical aerial, which is used least of all, sends out and receives electric waves equally well in all directions. A horizontal aerial sends out waves best in the direction from which it points. An inclined aerial also has a directional effect, but less marked than the horizontal aerial. This effect should be considered when the direction of the aerial is being planned, so that messages can be sent and received with best results in the direction desired.

One of the best aerials for general purposes is the umbrella aerial illustrated in Fig. 33. The aerial wires, which are arranged in different directions, are insulated from each other, and lead into the building to porcelain base switches, so that one or any combination of wires can be used at will. The arrangement permits transmission and reception of messages equally well in any direction desired. This type of aerial gives very good results, but is limited to locations where considerable space can be devoted to it.

The types of aerials shown in Figs. 30-33 are all of the "straight-away" class, which are most generally employed. The "loop" type aerial is also used to a certain extent. One form of this aerial is illustrated in Fig. 34. The difference between these two classes of aerials is that in the "straight-away" class all the wires act as a single wire; in the "loop" aerial each wire is insulated from the others, and two wires, insulated from each other, are led from the ends of the aerial, so that it acts as a continuous circuit or loop.

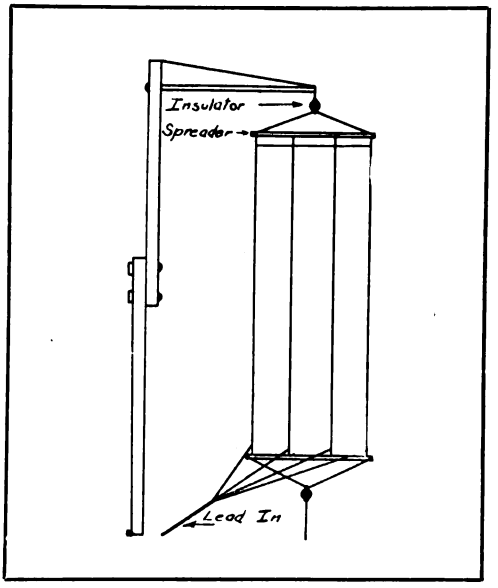


Fig. 30.—Vertical Aerial

Practically the only advantage of the loop type aerial over the straight-away class is that it permits a little closer tuning, but it has the disadvantage of requiring an anchor gap unless a special kind of aerial switch is used.

In some places it is impossible to build an aerial outside the building. In this case an indoor aerial may be used, and this will be quite satisfactory if it has sufficient length and capacity. A larger number of wires is required for an indoor aerial than for one built in the open, because the walls of the building will reflect and absorb a certain amount of the received and transmitted energy. A room having as great a length as possible should be selected; it should be as high above the ground as convenient. At least a dozen wires should be strung the length of the room and connected together in the same way as those of outdoor aerials. Porcelain knobs are entirely satisfactory as insulators in a dry place. It has been possible to transmit and receive over very fair distances with well designed indoor aerials.

All the wires of any outdoor aerial must be well insulated from any objects with which they might come in contact. The use of ordinary insulations on the wire, such as rubber, or weatherproof compounds, does not meet the requirements, since no ordinary insulation will stand the high voltages to which it will be subjected in an aerial. The proper method of insulating these high tension wires is to support them on insulators of glass, porcelain or special composition. Bare wires are generally employed, supported in this way.

Fig. 35 shows the type of glass insulator generally used in telegraph construction. This style may be used to support the leading in wires and may be convenient to use in other parts of the aerial.

The two wire porcelain cleat shown in Fig. 36 is acting as an aerial insulator in many amateur stations. It is quite satisfactory for receiving outfits and for transmitting sets of low power. A single cleat will serve the purpose where the spark coil of the station gives a one-inch spark or less. Where a larger coil is used, two or three cleats may be joined in series to form one insulator. The wire to be insulated is passed through one of the holes and the supporting wire passes through the other.

Porcelain knobs, of which one kind is illustrated in Fig. 36, are often used instead of cleats. The supporting wire passes through the hole and the aerial wire passes around the groove. Several knobs may be connected in series to give greater insulation if necessary.

A form of insulator which gives good results in small equipments is shown in Fig. 37. This consists of two porcelain knobs connected by a strip of wood on each side. A small bolt passes through the insulators and the wood strips as shown. This type of insulator is sometimes used also in the guy wires of the aerial. These guy wires should be broken by insulators at points about ten feet apart to prevent them from acting as aerials and conducting the oscillations to the earth.

The best aerial insulator is made of shellac and mica, molded under heavy pressure. These composition insulators are made in several styles, but those shown in Fig. 38 are representative. The ball type is suitable for small stations where a coil giving a two-inch spark or less or a transformer of 100 watts capacity is used. The corrugated type insulator is made in a five-inch and a ten-inch size. The former gives good results in stations employing coils up to three inches long and transformers up to ¼ K. W. output. The ten-inch size should be used for larger stations.

The composition insulator will stand any ordinary degree of heat or cold, is strong and of very high resistance and is practically unaffected by dilute acids or alkalies. It is used extensively by commercial wireless telegraph companies.

AERIAL WIRES.—All aerial wires should be of high conductivity if best

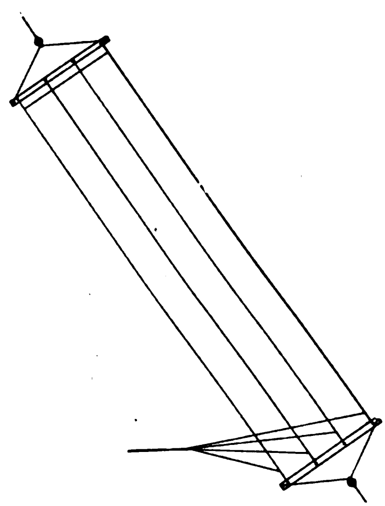


Fig. 31.—Inclined Aerial

results are desired. These should be not smaller than No. 14, and if larger so much the better. The wire in the aerials of commercial stations is generally composed of seven strands each, No. 20 gauge. Any wire through which currents of high frequency are flowing develops a resistance beyond that of ohmic resistance, generally known simply as "resistance." This additional resistance is known as "high frequency resistance" and its effect on the currents is called "skin effect." It has been found that

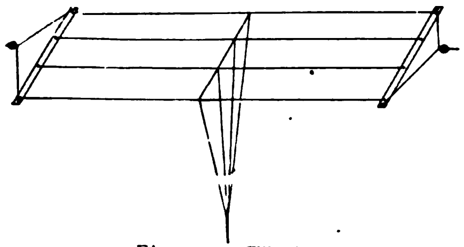


Fig. 32.—"T" Aerial

currents of constant intensity travel through the entire cross section of the conductor, but in the case of alternating currents of high frequencies, the tendency is for more to travel on the surface than in the center; this effect is more pronounced with increase of the frequency. For this reason it is desirable to use wires which have large diameters so that there is a low ohmic resistance and also a small resistance to the high frequency currents.

The wire or wires connecting the aerial with the instruments are known as the "lead in" wires. There should be as many wires leading from the aerial to the instruments as there are in the aerial itself. There is little advantage in having a large aerial if most of the energy from the sending apparatus is to be absorbed by the "lead in" wires before it reaches the aerial. The advantage in keeping the resistance of the aerial low and of having a lead in of many wires is

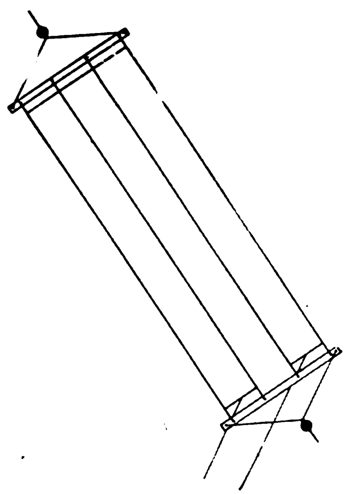


Fig. 34.—Inclined Loop Aerial

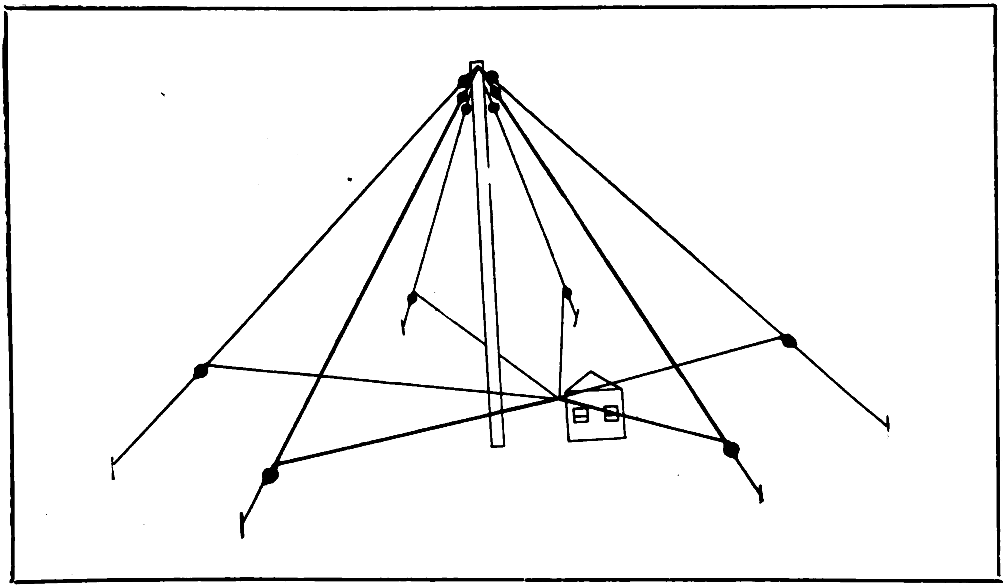


Fig. 33.—Umbrella Aerial

very apparent when transmission is attempted.

AERIAL WIRES.—The cheapest wire used in the construction of aerials is of galvanized iron. This wire is fairly

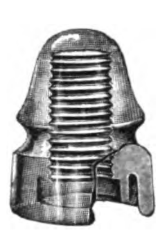


Fig. 35.—Glass Insulator

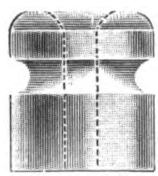


Fig. 36.—Porcelain Insulator

satisfactory, but has quite a high resistance, which is undesirable.

Aluminum wire is to be found in more aerials than any other wire. This is because the first cost is less and because aluminum is light. Aluminum wire is not to be recommended for this purpose, however, since the joints develop high resistance in the course of about six months, causing a material decrease in the intensity of received signals and also in the transmitting radius. This resistance is due to the formation of an oxide of aluminum around the wires, but may be prevented to a certain extent by covering all joints with tape.

One of the best wires for aerial construction is ordinary copper, either insulated with cotton or rubber or bare. In either case it must be supported on insulators. Copper wire has a high conductivity and will last several times as long as aluminum. Moreover, copper wires are easily soldered, causing joints to be good, both electrically and mechanically. This wire is suitable for all stations where the length of the aerial is not over 150 feet. Where longer wires are used, copper wire is likely to stretch after a time, since its tensile strength is not sufficient to support its weight on so long an aerial.

Where the aerial is to be a long one, a wire composed of some strong alloy should be used. Several different alloys are used for this purpose, among which phosphor bronze is well known. There is a certain amount of copper in all of them with some hardening material added. Joints between these wires can be soldered without difficulty. The commercial wireless telegraph companies generally use these wires in the form of stranded cables. A stranded wire has a greater surface than a solid wire of the same carrying capacity, and consequently has a less high frequency resistance.

GROUND CONNECTIONS.—The ground connection must be a good electrical connection with the earth if high efficiency and long distance operation are desired. The wire running between the instruments and the ground connection should be short and its diameter should be large. Copper wire should be employed for this purpose. It need not be insulated if it is short, but if it is ten feet in length or longer it should be supported on porcelain insulators.

If a city water or gas supply pipe is near the instruments, the simplest way to make a ground connection is to fasten the ground wire (the wire leading from instruments to the ground connection) to the pipe by means of a ground clamp, of the kind used by telephone companies. The pipe should first be scraped until the surface is bright and clean, to insure a good electrical connection between it and

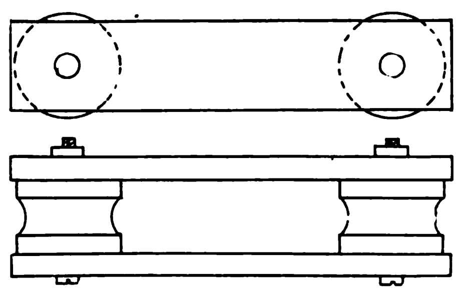


Fig. 37.—Composite Insulator

the ground clamp. The water pipe is to be preferred, although a gas pipe will serve the purpose. In either case it is always advisable to connect a wire to the pipes as they enter and leave the meter, so as to bridge it, since the contact between the meter and the pipes have considerable resistance.

In case one of these pipes is not available, the ground wire may be connected by means of a ground clamp to a piece of pipe driven into the earth in a damp place. This method is employed in field

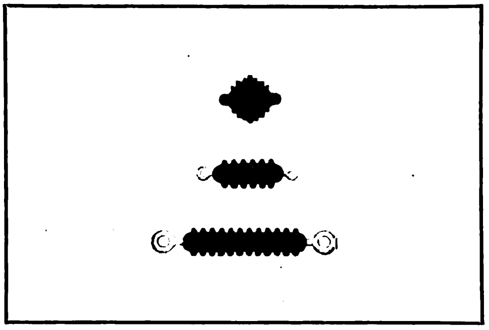


Fig. 38.—Composition Insulators

work. A pipe of this description should be five or six feet long. If holes are drilled in it and it is filled with water occasionally, a better ground connection will be afforded because the water will flow out slowly through the holes and moisten the earth around it.

LIGHTNING SWITCH.—In permanent stations, some suitable arrangement should be made to effectually connect the aerial to the earth at all times when the station is not actually in use. Fuses are of no value to protect the instruments from lightning, for by the time sufficient energy is developed in the aerial to melt the fuse, much damage will have been done to the apparatus.

The best device to use for this purpose is a single pole, double throw knife switch mounted on a non-absorbtive insulating base. Slate is not satisfactory for switches carrying high tension currents, as it is not a good insulator at these voltages. Porcelain is one of the best materials for the use of this switch.

The switch should be mounted outside the buildings at the point where the wires enter. It should be connected, as shown in Fig. 39, so that the aerial may be connected to either the instruments or to the ground, but not to both at the same time.

The purpose of the switch is to carry the small electrical charges which compose lightning when accumulated, to the earth before they can combine to form one large charge. A 25-ampere, 250-volt switch is satisfactory for small stations, but in some places the fire underwriters require a 600-volt, 100-ampere switch. The wire from this switch to the earth should be of copper, and should not be brought into the building; it should run directly to a pipe driven into the earth. If a 25-ampere switch is used, the ground wire should not be smaller than No. 10. Where the 100-ampere switch is installed, the ground wire should be No. 4 or larger. In either case the wire should be supported on porcelain insulators.

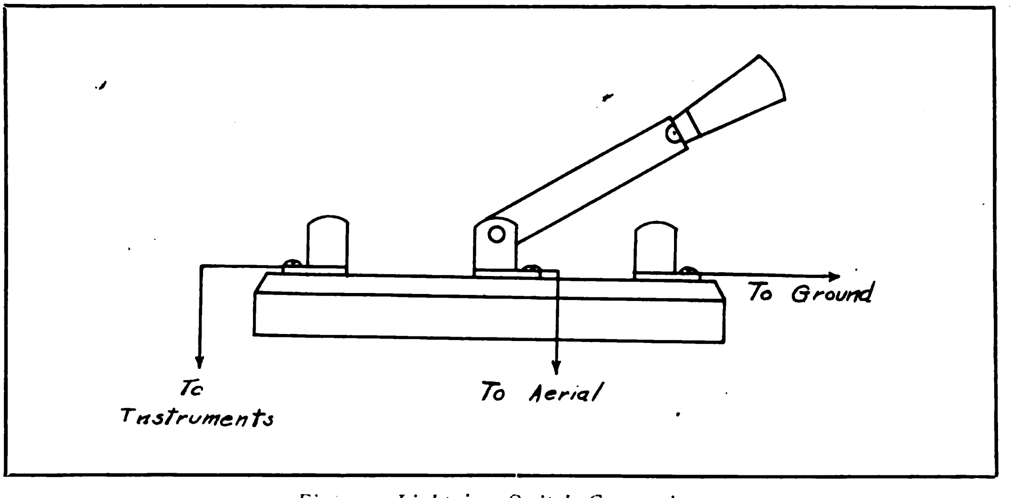


Fig. 39.—Lightning Switch Connections

This is the fourth installment of instruction for Boy Scouts. The fifth lesson by Mr. Cole will appear in an early issue.

From and For those who help themselves

Experimenters' Experiences.

FIRST PRIZE TEN DOLLARS

A Hot Wire Meter for Spark Coils and Transformers

The most important instrument conducive to a first class sending set which rardiates a high percentage of the energy expended in it, is a hot wire meter. Without this device the amateur can never be sure that he is getting all of the radiation possible out of his set. The methods of tuning up with a spark gap in the aerial or ground lead and of having a friend listen to the spark while adjustments are being made, are both very inaccurate. I have in this article described a hot wire meter that I have found to be very satisfactory with spark coils as well as transformers. Its chief merit lies in the fact that the pointer is under the influence of a spring at all times, thus insuring accurate results.. A few words will make the accompanying diagram clear:

A piece of No. 34 or 36 climax resistance wire, which may be purchased from any supply house, is stretched from a nail, F, to a screw eye, N. It is so fastened to the latter that the tension of the wire may be varied by screwing the eye in or out. In the middle is fastened a piece of silk thread, which runs up to a spring, S. A pointer (an aluminum strip will serve nicely) is mounted, as shown in the sketch, on a small knob (battery nut) to raise it off the base. The ratio of the short end, CK, to the rest of the pointer should not be less than 1 to 8 for accurate results. (Make CK equal to 3/8 of an inch and the rest 3 inches.) A scale is made out of cardboard and placed on the baseboard. It should be divided into the necessary equal divisions. With the pointer on zero, the other end is fastened to the silk thread at K. This may be done by taking a few turns around the end and then applying sealing wax or glue.

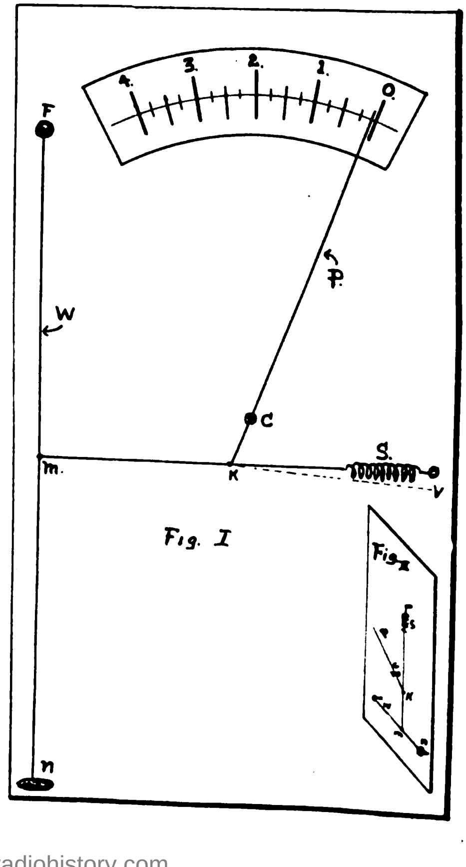


Fig. I

With the pointer in position at zero, it is evident that the line, MKS, should not be perfectly straight, but should tend to follow the exaggerated line MKV (dotted). As the pointer approaches the center of the scale, K will have to push down against the spring S. If this allowance is not made, the turn must be very slight; otherwise the same action will take place when the pointer passes the center of the scale. A side view is shown in Fig. 2.

The operation is extremely simple. When the current is passed through the climax wire, it heats up, due to the high resistance of the material. In heating it expands. The spring takes up all of the slack thus formed. It is this movement that works the pointer.

This meter will not, of course, measure the current in amperes. It will, however, readily show the relations between different adjustments or changes. The pointer can be kept on the zero mark by adjusting the screw eye, N. The spring must not be too strong, because the wire must work against it when it cools. With a moderate spring it will be found that the pointer will draw back to the exact starting point when the current is shut off. For spark coils up to 2 inches, No. 36 or 38 climax wire should be used; but with transformers (from a fourth K. W. up, No. 34 to 36 should be employed.

The instrument is placed in the aerial lead-in wire, with connections made to F and N. It is convenient to shunt a single pole knife switch around F and N so that, when through experimenting, the sending set may be used without disturbing the meter by simply closing the switch. It must, of course, be open while using the meter.

K. W. NICHOLSON, *California.*

SECOND PRIZE FIVE DOLLARS

The Use of Single-Wire Antennae in Receiving

Give an amateur 400 feet of antenna wire, and he will promptly put up a 4-strand aerial 100 feet long. With this he will hear WNT, WSE, WCA, WHB, WHE, NAH, the boats within, say, a hundred-mile radius, NAI, if he is lucky, and perhaps Arlington, Virginia, NAA. Then, some "freak night" in December or January, he will hear Cape Hatteras and get his name in the papers as a rising young radio expert. Some do better than this, but a great many never hear anybody beyond the city limit.

If you will take 400 feet of phosphor bronze cable, fasten one end of it either to a convenient apartment house, a tree, or anything which will stand the strain, and place the other end in your station, inserting insulators wherever necessary, you will have a single wire antenna with no poles, spreaders or guy wires. If you do not like the results you can always revert to the standard 4-strand aerial, but you won't care to. Neither will you be writing to the WIRELESS AGE to ask why your receiving range is not as great as it ought to be.

I believe that a long single wire always gives better results than a short aerial composed of a number of conductors in parallel. I am not arguing against the use of more strands than one in an antenna. A single wire 300 feet long will not bring in signals as well as two properly spaced wires 300 feet long, but it will do far better work than the same amount of wire used in a short multi-strand antenna. This is a fact which few amateurs seem to realize.

The best wire for any antenna is probably the standard 7-strand phosphor bronze stock. The cost of this wire is in most cases prohibitive. Aluminum wire is hardly suitable. I know of one strand of this wire which has been up four years and is still in use. The length is 400 feet. I believe, however, that this is an exceptional case and that aluminum should not be used. I have never used hard-drawn copper wire, for the reason that its tensile strength is hardly great enough to justify the risk.

The best wire at a moderate price is stranded copper clad steel cable, or duplex wire, which comes in 4 and 7 strands of No. 20 or No. 22. The 4-strand article can be used up to 250 feet; beyond that 7 strands are necessary. Do not use porcelain cleats as insulators. I can exhibit several which broke while in the air and released my antenna. In one case two cleats in tandem broke. The round split knobs are much better, for even if the insulator should crack, which is improbable, the wire will stay up. You can, of course, use electrose if you prefer it, especially if the antenna is to be used for transmitting.

Place your aerial at a good height and in a horizontal position if possible. A single wire is always more or less directive, even if it is parallel to the ground. A wire of this description, when tapped at or near one end, favors stations in the direction of a stone thrown from the free end towards the tapped end. Moving the lead into the middle does not help, for the range in a direction at right angles to the wire remains low. If the wire is higher at one end than at the other it becomes a so-called "compromise antenna," which is extremely favorable to stations in the direction of the lower end, particularly if the down-lead is taken off at this point, as is desirable.

I am at present using a 250-foot wire, 4 strands No. 22 copper clad, about 70 feet high at one end, and about 40 at the end from which I lead into my instruments. The latter end is made fast to a chimney, about 5 feet above a grounded roof. My set consists of a loading transformer, a loose-coupled tuner, galena detector, fixed condenser, and a pair of Brandes phones. No sliders are used, and the set is not well designed for distance work, because it is wound with enamel wire and has other faults. Enamel wire should not be used as inductance because of its effective capacity. In spite of these disadvantages, and others, my distance log shows the following:

Oct. 25, 3.15 A. M., S. S. KCV working WPD, Tampa, Fla. Did not hear WPD. KCV 500-cycle spk. clear. Distance to Tampa, 1,050. Atmospherics light.

Oct. 29, 11.20 P. M. New Orleans, La., WHK. Rotary spk. Signals fine. Distance, 1,200 over land. Atmospherics moderate, intermittent.

Oct. 31, 9.55 P. M. S. S. Tivives, AHW, wkg NAW, Guantanamo, Cuba. Did not hear NAW. Signals GHW fine, 500-cycle spk. GHW gave position, 26-28, 74-16. Heavy static. Distance fm. N. Y. about 1,080.

Nov. 1, 11.15 P. M. Heard Guantanamo, Cuba, NAW wkg S. S. Ancon. NAW 500-cycle spk. Signals weak. Ancon using rotary, good. Etatic very slight. Distance, 1,500.

Since then I have heard NAW and WPD several times. It will be observed that none of the stations heard use a large amount of power. I am about to construct a new set, designed especially for distance work, with which I should get better results.

The local stations, of course, come in very loud, especially Sayville, L. I., 40 miles away, which I have copied with the phones on the table 5 feet away.

I have known an amateur to send 8 miles with a 1-inch coil directly connected to a single wire. This, however, was done on a 600-meter wave some years ago, and on a wave too broad to be tolerated now. The single wire gives the better results because of the fact that under such conditions the wave length of the antenna is more suited to the wave length of distant transmitting stations than when using a 100-foot antenna having four wires. CARL DREHER.

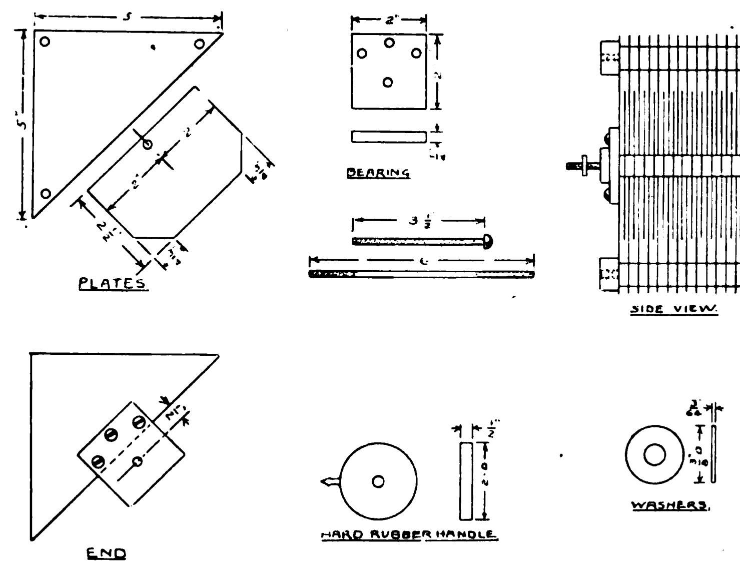
THIRD PRIZE THREE DOLLARS

A Variable Condenser of the Rotary Type

A good variable condenser of the rotary type is an instrument that many amateurs cannot build with the common tools he may have. I know how much trouble I had before I discovered several easy short cuts.

About 3 square feet of aluminum will be sufficient for a primary condenser. The most difficult part in the construction of a condenser is the cutting of the plates. A good steel ruler or metal strip, and a sharp, right-angled edged knife is all that is needed. Place the ruler on the aluminum to be cut and run the knife hard up and down its edge several times; then do the same on the other side, taking care that you keep the line already cut. The aluminum will then snap off easily, leaving a smooth, flat plate.

Cut off 9 squares on an edge, each 5 inches. Then cut it diagonally. These are the fixed plates. The movable plates are 4 by 2½ inches and are cut across



two ends. Seventeen will be needed. (See diagram under plates.)

Washers are the next in importance to be considered. Of course they cannot be made. Small brass washers can be obtained at any wholesale house dealing in brass. Two washers, each 3/64 of an inch in thickness, is what I used for separators, and I had no trouble with plates touching one another.

Bearings for the movable plates are made from two hard rubber blocks 2 x 2 x ¼ inches, drilled to the dimensions, and screwed to the two end plates (see diagram). The bottom block is countersunk so that the movable plates will move freely between the fixed plates.

A rough piece of hard rubber should be obtained from a wholesale hardware store. It may have dimensions 2 inches in diameter and ½ inch thick. Smooth all faces with emery cloth and polish with pumice stone. This gives it a shiny appearance. The sides may be made to have a milled appearance by cutting small slits with a file. A small piece of 5/32 brass rod is tapered to a point at one end and threaded at the other. This is screwed into the knob which has a hole drilled in the center, and countersunk so that a nut can slip into it.

Three bolts, long enough to hold the plates together, should be bought. The shaft for holding the movable plates is also cut to a sufficient length. Nuts on each end hold the plates together. The dimensions for the small articles are not given. These may be obtained from the stock the amateur always has on hand. A protractor serves for a good dial. The condenser can be placed in a box, or mounted in a cabinet set.

JOSEPH KAUFMAN, *Massachusetts.*

FOURTH PRIZE SUBSCRIPTION TO THE WIRELESS AGE

A Rotary Gap For Small Coils

For amateurs who use a 1-inch coil or over with an interrupter and who get a very low toned spark it will be interesting to know how to make a rotary that will give increased efficiency. This can be made for about $1.50.

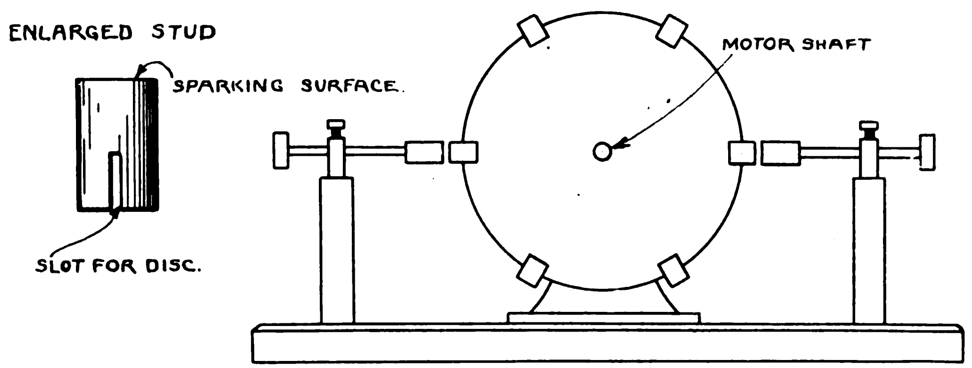
First get a small motor on the order of the Gem, Little Hustler, Little Giant, etc., and use six batteries with a rheostat in series, or a step-down transformer with a rectifier if A. C. current is used. Then procure a disk of tin or zinc about 3½ inches or 4 inches in diameter and mount it on the shaft of the motor. Make sure to place the exact center of the disk on the shaft. Divide the circumference of the disk into six equal parts, and at each of these points mount a zinc stud in the following manner.

Take a wet battery zinc and saw off six pieces about ¼ inch or ⅜ inch long and file the sparking surface smooth and slightly convex. In the center of these studs, on the opposite side of the sparking surface, cut a slit with a saw (as in diagram) about ⅛ of an inch deep that will fit over the disk. Solder these studs on at the points previously mentioned, being careful to have all the sparking surfaces exactly the same distance from the center. This is very important, as the rotary will break up if these are not exact.

Mount the motor on a suitable base, about 6 by 5 inches. Also mount two stationary studs as shown in the diagram. Adjust the stationary studs as closely as possible to the rotary studs without touching. Connect the gaps, using the stationary studs as though they were on a stationary gap. The rotary is now ready for use.

Start the motor up and when it is going at good speed press the key. The gap may be disappointing at first and you may not be able to clearly hear the note go up in the room, but if you listen in the phones with the detector set you will be able to distinguish the tone mixed with the sound of the interrupter. After regulating the gap any of your friends who are listening will hear only a clear high note with no breaks in it. The rotary will also send farther and come in louder and more distinctly.

H. B. HENGERER.



Increased Efficiency Rotary

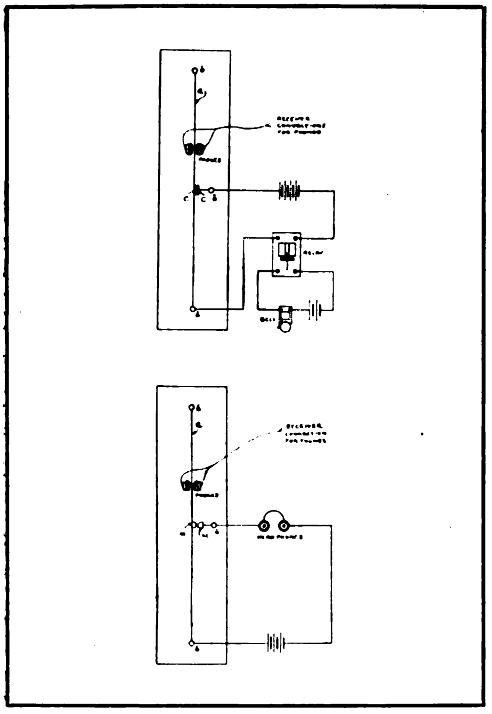
HONORABLE MENTION

A Device of Scientific Interest.

I enclose a sketch of a device which I believe to be of scientific interest. Referring to the sketch on the following page, the E string of a violin is stretched between binding posts B and B; on either side of the string is placed the magnets of an ordinary headphone receiver, P and H. C and C are two finely adjusted contacts which, when closed, send a battery current through the relay, ringing the electric bell in turn, as noted. The violin string, A, can be tuned to a certain pitch and consequently will respond to a certain spark frequency at the distant transmitting station. If the incoming signals produced in the head phones have the same period of vibration as the violin string, the string will vibrate energetically, closing the contracts C and C, and causing the bell to ring. A silicon detector can be used in place of contacts C and C.

MAURICE WINGLEMEYER, *Michigan.*

NOTE.—The device is certainly interesting. We believe, however, that considerable difficulty would be met with in attempting to operate the relay from contacts *C* and *C*. We suggest that contacts *C* and *C* be replaced by a carbon microphone (Fig. 2), in turn connected in series with a head phone and several cells of battery. This would not only make the device an amplifier, but would also effect an arrangement by which the receiving set could be tuned to a spark frequency of a distant transmitting



station. We suggest that amateurs make tests of the device and let us know the outcome of the experiments. If the distant transmitting station has a rotary spark gap giving 120 sparks per second, there will be 120 fluctuations of current per second in the head phones. If the *E* violin string is adjusted so that it has a natural vibration period of 120 per second it will give a maximum response to the string and consequently through the microphone.—*Contest Editor.*

STORY OF A COLLISION TOLD IN WIRELESS

The story of how wireless telegraphy was employed to tell of the collision between the freight steamship Pleiades and an unknown vessel about thirty miles from San Francisco, Cal., is contained in radio messages copied by K. W. Nicholson, of that city. The Pleiades, which left San Francisco on the night of November 8, was bound for Panama when the accident occurred. She reached San Francisco safely on the morning following the collision, escorted by the revenue cutter Unalaga. The messages are as follows:

8.25—Pleiades: S. O. S. S. O. S. S. O. S. S. O. S.

K. P. H. (Marconi station, San Francisco) K. with your position and state your trouble.

Pleiades: We are in sinking condition 15 miles south of lightship collision with an unknown ship in thick fog. Want help.

K. P. H.: R. B. K. To W. T. T. (Oil ship, Atlas): Do you hear Pleiades?

W. T. T.: Yes.

K. P. H.: Then stand by.

8.45—Atlas to Pleiades: To Captain Armstrong: Am on my way out and will stand by and render any assistance you need. What is your position?

Captain Smith.

9.10—K. P. H. to Atlas: Have you seen or heard him since your message?

Atlas: No.

(No answer can be obtained from the Pleiades to the calls of K. P. H.)

9.20—K. P. H. to Revenue Cutter Unalga: Go to assistance of Pleiades, about 15 miles south of lightship in sinking condition.

Captain Ulke.

9.40—Unalga to K. P. H.: To Captain Ulke, Custom House S. F.: Unalga standing through Golden Gate to assistance of Pleiades; thick fog.

9.45—Unalga to Atlas: Are you going out to Pleiades? Our whistle going all the time. Do you hear anything?

Atlas answers they hear the Unalga.

9.50—K. P. H. to Unalga: Notify Revenue Cutter McCulloch regarding sinking ship south of lightship. Both vessels are to proceed to assistance of Pleiades.

9.55—Unalga to McCulloch: Captain Reynolds requests that you proceed to scene of Pleiades 15 miles south of lightship.

(For the first time in forty minutes the Pleiades answers the incessant calls of the Atlas.)

10.05—Pleiades to Atlas: To Captain Smith, Atlas; 10 P. M.: Pleiades 10 miles S. E. by S. 1 m. m., 25 magnetic from lightship; do not require assistance.

Captain Armstrong.

10.10—Atlas to Pleiades: Message received, had fog out to main channel gas buoy. At present we can see about 3 miles.

10.15—Pleiades to K. P. H.: 10.10 P. M.—10 miles S. E. by S., 1 m. m., 25 magnetic from lightship; proceeding back. Number 2 hold full of water. Think we can make port without assistance. Will require a tug for docking.

Captain Armstrong.

10.45—Pleiades to K. P. H.: 10.45—Have just sighted the lightship. We are making for port at rate of 5 miles per hour.

103 PASSENGERS ESCAPE DEATH ON BURNING VESSEL

With seas running so high that it was seemingly impossible for small craft to live in them, 103 passengers of the Spanish steamship Balmes, threatened with destruction by flames, were taken from the burning vessel to the Pannonia, of the Cunard line, on November 14, after aid had been summoned by means of wireless telegraphy. The rescue, which occurred 600 miles east of Bermuda, added another stirring chapter to annals of the deep.

While Captain Ruiz, of the Balmes, and his men battled with the flames, Inocencio V. Michavila, chief Marconi wireless operator on the burning craft, began sending out the S O S call. Two hundred and eighty-seven miles north of the burning ship was the Pannonia, with Captain R. Capper in command. In the wireless cabin of the Cunarder was Senior Marconi Operator Stanley G. Rattee. He had been doing double duty because of the illness of his assistant, Edward Murphy, who was in the ship's hospital. The latter left his sick bed to go to the wireless cabin when the S O S call came. The Pannonia was at once turned about in her course and headed for the Spanish vessel.

Captain Capper told a graphic story of the rescue.

"I had preparations made for the reception of those whom we might be able to save," he said. "The hospital was made ready and food and hot drinks were at hand. At 7.20 o'clock that evening (Thursday) we came in sight of the Balmes. She was coming at us so straight that if she had not been well lighted we should have run her down.

"When about half a mile distant Captain Ruiz told me of the condition of the fire, declaring that his men were so exhausted that half of them were laid up, and he could not man boats to send his passengers to me. He said that the fire, which was in No. 2 hold, was in the cotton and that there were 200 hogsheads of rum on top of that, and that if the fire reached the rum there would be an explosion, which would mean the end of the Balmes, he said. There were fifty-eight in his crew, only half of whom were available to fight the fire and run the ship, the rest being laid up from fatigue and injuries.

"Finding that he could care for his passengers during the night, and it being needless to risk my men in the heavy seas, I lay by and at daybreak got off three boats. The sea had risen and was so high when my boats got away that they sank and rose twenty feet in the trough and crest, while the gale blew the spume into the faces of the crews. The Balmes had dropped a companion ladder over her side and my first boat, containing thirty-seven passengers, dropped away from her at 7.50 o'clock Friday morning. At 9.15 o'clock we had finished the task of transferring the passengesrs."

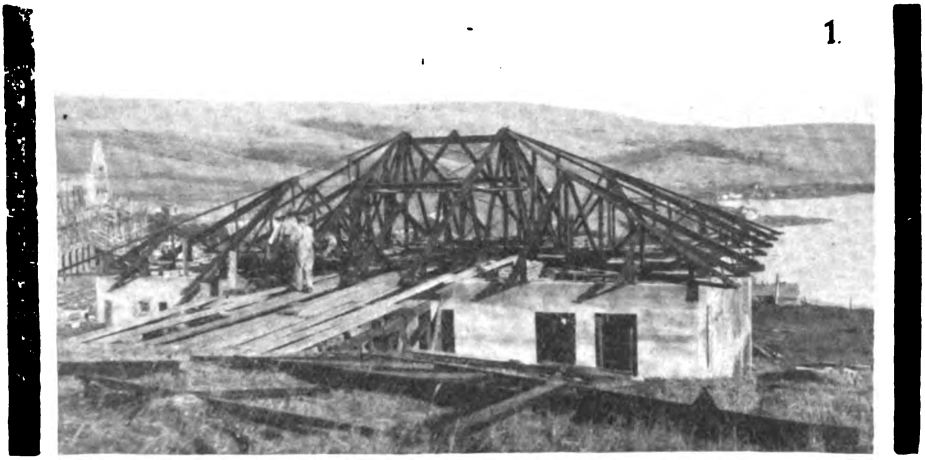
Passengers on the Balmes spoke highly of the devotion to duty displayed by Operator Michavila. He remained at his post for many hours without rest.

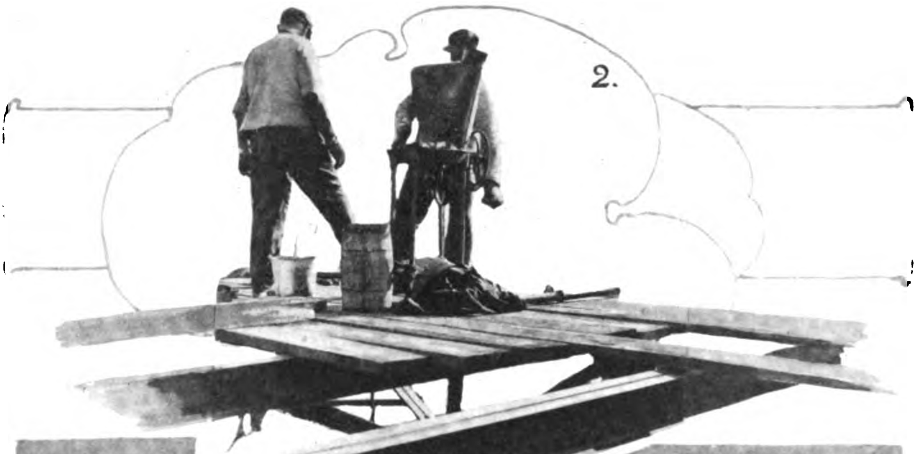
The Balmes, which was towed by the Pannonia to St. George, Bermuda, and beached, is owned by the Pinillos line, of Cadiz. She left Havana, Cuba, November 4, bound for Barcelona. The Pannonia was bound from Trieste to New York.

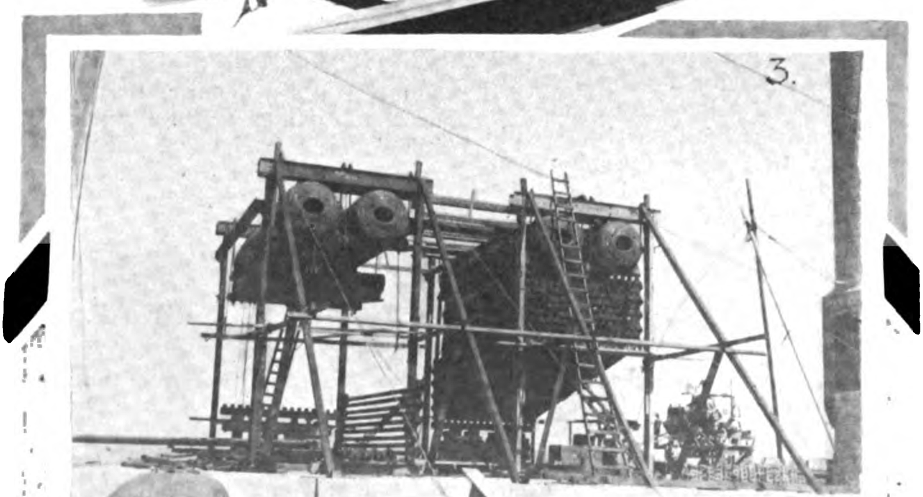
WASHINGTON GETS PARIS TIME

The naval observatory in Washington is now regularly receiving time signals from the observatory of Paris by wireless telegraphy between the Eiffel Tower and the naval radio tower at Arlington, Va. The scientific object is to measure by the velocity of the propagation of radio signals over the intervening distance the precise difference of longitude between Paris and Washington.

Photographic Glimpses of

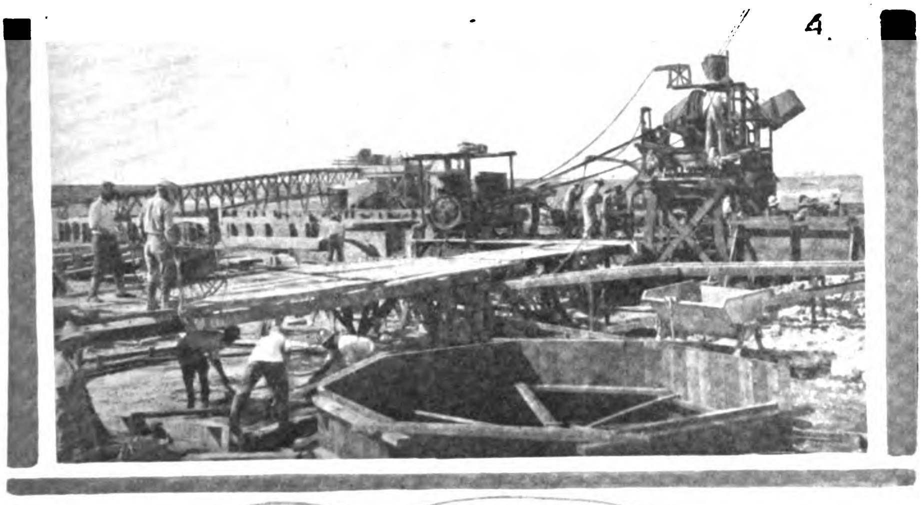


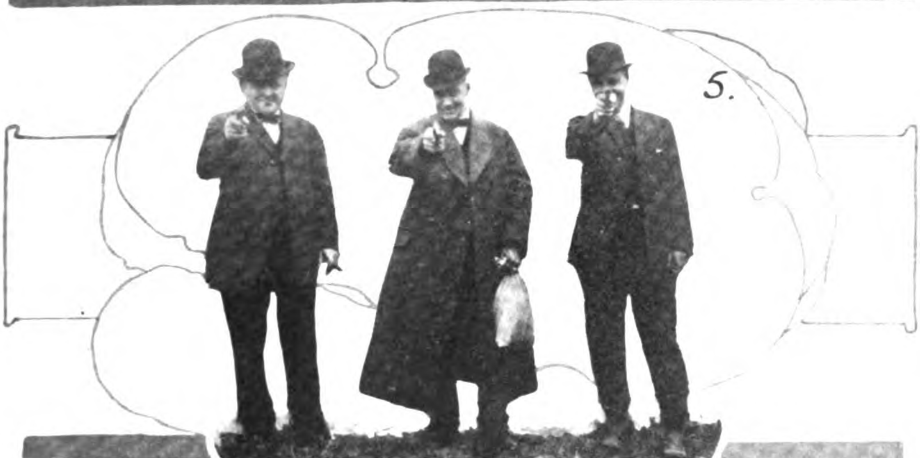


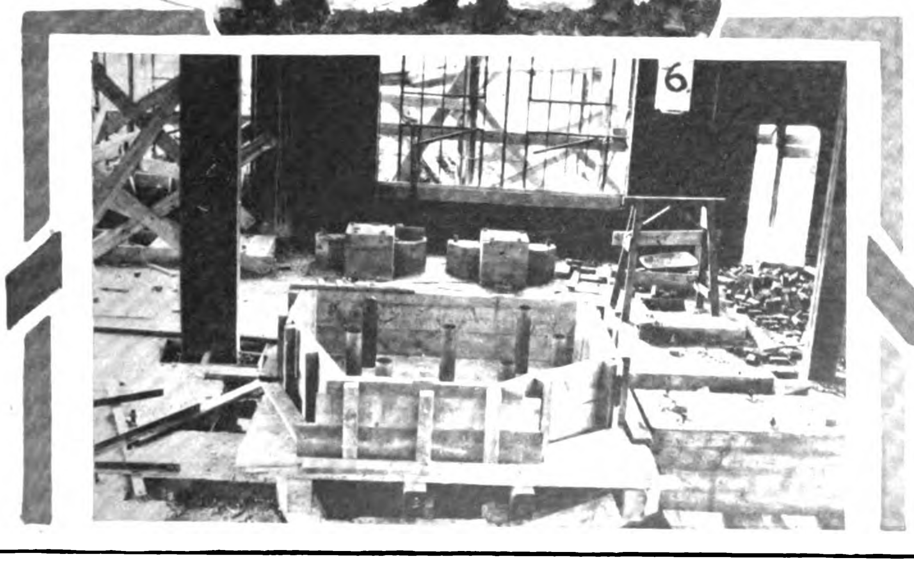


(1) *An interesting view of the structural steel detail of the roofs of the engineers' cottages, taken at the Marshalls, Cal., site.* (2) *Two of the riveters at their furnace atop the power house at New Brunswick, N. J.* (3) *Illustrating the method of installing the boilers at the Kahuku, Hawaii, transmitting site; a firebrick furnace is built underneath and*

the High Power Stations







(4) *The forms for the disc discharger foundation are seen in the foreground of this Hawaiian view; concrete is poured into them and the apparatus mounted on the solid block.* (5) *The armed escort which invariably accompanies the payroll, drawn twice each month;*

MIAMI STATION WORK BEGUN

Active work on the erection of the new Marconi station at Miami, Fla., will be commenced within the next few days, according to a report given out at the offices of the Marconi Company. J. C. Lewis, formerly manager at the Marconi South Wellfleet station, sailed on the Lenape on December 23 to take charge of the construction work.

The towers, of which there will be two 200 feet high, have been shipped, and the 5-kilowatt set to be installed will shortly follow. The towers are to be of the self-supporting type, and will be located close to the ocean front. Directly adjacent to a small lake will be erected a comfortable cottage for the operating staff, containing a living room, dining room, kitchen and three bedrooms.

It is expected that the station will be completed during January or early in February and will control a large share of the business which has been formerly routed through the government station at Key West. Besides breaking up the long stretch between Jacksonville and Key West, thereby greatly facilithating the handling of messages, it is expected that connection will be made between Nassau and the new Miami station to supplement ship to shore business.

SERVICE ITEMS

F. M. Sammis, chief engineer of the Marconi Wireless Telegraph Company of America, lectured on wireless telegraphy in Christ Church, East Orange, N. J., recently. Mr. Sammis illustrated his talk not only with lantern slides, but with wireless apparatus. After showing the operation of the apparatus by means of a sending and receiving device, he plucked several press dispatches out of the air.

* * *

Miss Elizabeth Sullivan and James O'Sullivan were married on November 26 in St. John's Cathedral, Brooklyn, N. Y. Mr. O'Sullivan is employed as an operator by the Marconi Wireless Telegraph Company of America at its station at Sagaponack, L. I.

VALUE OF WIRELESS IN GREAT LAKES STORM

The value of wireless has been demonstrated, according to the United States Department of Commerce, by the fact that none of the nineteen American vessels lost in the storm which swept the Great Lakes last November was equipped with wireless, whereas the vessels which had wireless received warning of the coming storm and sought safety. This information has come to the department from its radio inspectors at Chicago and Cleveland.

About fifty vessels are preparing to install wireless equipment, the inspectors report, as a result of the lesson. The Cleveland inspectors say that just before the storm three vessels cleared from Detroit, one with wireless, two without. The former, after attempting to warn the other two, returned to port and was saved, while those without wireless were lost.

WELSH STATION ON A MOUNTAIN

The Marconi wireless station in course of construction at Carnarvon, Wales, is nearing completion. Located on the side of the Cefndu Mountain, the station site is 800 feet above the sea level, and will communicate with the New Jersey station. The Welsh station is built at a height of 750 feet and the last row of masts, it is estimated, stands about 1,400 feet above the sea level.

DIRECTION FINDER FOR SENECA

Secretary of the Treasury McAdoo has given permission to the Marconi Wireless Telegraph Company of America to equip the derelict destroyer Seneca with a radio-goniometer or direction finder. By means of the apparatus it is possible to detect the direction from which wireless messages are sent.

SHORT DISTANCE SERVICE AT WELLFLEET TRANSFERRED

The short distance station of the Marconi Wireless Telegraph Company of America at Wellfleet, Mass., was discontinued on December 31. The station at Boston (call letter WBF) will be used in its place.

SEA SAFETY DELEGATES MEET

At the opening of the International Conference on Safety at Sea, which began in London on November 12, Sydney Buxton, president of the London Board of Trade, made an address, outlining the scope of the Conference. He indicated the questions to be discussed, one of which he expressed as follows:

"How can aid and assistance from another ship, or from the shore, be most quickly and effectively invoked and obtained? Under this head I especially have in mind wireless telegraphy—a question of vital importance. I should in this connection like, on your behalf as well as my own, to pay a tribute to the inventive genius who has rendered effective this great discovery."

The King sent a message to the delegates, telling them that he took a special interest in the subject of their discussions, and calling attention to the fact that he had personal experience of many of the matters to be considered. Sir Edward Grey afterward welcomed the delegates on behalf of Great Britain. Lord Mersey, principal British representative, was chosen as president of the conference.

At a luncheon given in honor of the delegates at the Foreign Office, M. Guernier, chief French delegate, made an address in which he referred to wireless as a rescuing agent for the shipwrecked. The delegates were entertained at dinner by the British government on November 18, Mr. Marconi being among those invited to meet the guests.

$20,500 TO REPAIR PHILIPPINE STATIONS

The Secretary of Commerce and Police has authorized the expenditure of $20,500 for the repair and improvement of wireless stations operated by the Bureau of Posts; 200-foot steel towers will be built at Zamboanga and Davao, a new power plant will be installed at Puerto Princesa, and a latticed steel mast 120 feet high erected at Cuyo. The Collector of Customs has drafted a law for the installation of wireless on all steamers carrying 150 persons or more in the inter-island trade.

COMMITTEE ON RESEARCH

Great Britain has appointed a committee to consider how far and by what methods the government should provide for research work in wireless telegraphy.

Lord Parker, of Waddington, is chairman of the committee which has among its members W. Duddell, president of the Institution of Electrical Engineers; R. T. Glazebrook, of the National Physical Laboratory; W. Slingo, engineer-in-chief to the Post Office; Joseph Larmor, secretary of the Royal Society, and Commander Loring.

DISSOLUTION OF LIQUIDATING COMPANY AUTHORIZED

Stockholders have authorized the immediate dissolution of the Wireless Liquidating Company. Instructions were given the directors to distribute, as far as possible, the stock of the Marconi Wireless Telegraph Company of America, held in the company's treasury, in specie. It was also voted that in case any stockholders, in the distribution of Marconi Wireless stock, shall become entitled to fractional shares, these fractions shall be transferred to a trustee, who shall issue scrip therefor, such scrip to be exchangeable for full shares whenever presented in sufficient quantities.

LIST OF STATIONS IN UNITED STATES

A list of the land and ship wireless stations of the United States has been printed by the Department of Commerce, Bureau of Navigation. The contents include a list of land stations arranged alphabetically by names, a list of all ship stations, and a list of all United States call signals arranged alphabetically, each followed by the name of the land or ship station to which the call has been assigned. In Part II is given a list of amateur stations licensed up to June 30, 1913, arranged according to radio districts, with the headquarters and territorial limits of each district.

OPERATORS' INSTRUCTION

CHAPTER VI

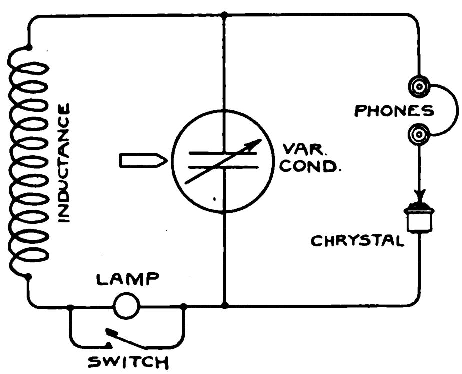
Wavemeters and the Adjustment of Wireless Telegraph Sets to Resonance—As stated previously in this series of aritcles, any circuit possessing inductance and capacity has a certain time period of vibration. In other words, it takes a certain length of time for an oscillation to complete itself in that circuit. Such a circuit is said to have a definite wave length.

Wavemeters—A wavemeter is a calibrated closed oscillatory circuit, the electrical length of which may be varied at will. It consists either of a variable condenser and a fixed inductance, or a variable inductance and a fixed condenser. Both, however, may be variable. It is self-evident that if either the inductance or the capacity of such a circuit is variable, the wave length is variable. Hence, if a pointer is attached to either the variable inductance or to the variable capacity, it can be made to move over a scale which is graduated directly in wave length.

It is customary to express wave lengths in meters rather than in feet. Common wave lengths used in ordinary ship wireless communication vary from 300 to 600 meters.

When a wavemeter is placed near to an oscillatory circuit it will absorb energy from it and maximum current will flow in the wave meter when it is in resonance with the circuit to be measured.

Marconi Wavemeter—The circuits of the Marconi wavemeter are represented in Figure 15. It consists of a variable condenser, to which is connected an inductance of fixed value. The inductance is attached to the condenser by means of a flexible cord so that it can be placed in any position desired, while the variable condenser is placed at some distance from the circuit to be measured. A carborundum crystal is connected in series with the head phones. Both are connected in shunt to the variable condenser.



MARCONI WAVEMETER.

Fig. 15

A small glow lamp is in series with the coil and condenser and is cut out by the switch.

The scale reading is placed directly on the variable condenser, which moves underneath a stationary pointer.

The scale reading of the condenser is graduated directly in wave lengths, or the data may be plotted in the form of a curve in terms of an empirical scale on the condenser. These calibrations are obtained by comparing the wavemeter to a standard oscillatory circuit or by calcuiation of the constants in the wavemeter itself.

The point of resonance on the wavemeter is located, either by the lamp or the crystal detector and headphones. If the lamp is used, it indicates maximum current flow in the wavemeter circuit; if the head phones and crystal are employed, maximum potential is indicated.

Tuning—In tuning a transmitting set to resonance, three readings are necessary.

1st—The wave length of the open circuit.

2d—The wave length of the closed circuit.

3d—The measurement of the radiated waves.

Open Circuit Readings—The wave length of the open circuit is secured as in Figure 16. The antennae are represented at A, an aerial tuning inductance at L_2, the secondary of the oscillation transformer at L_1. The primary of the oscillation circuit is designated at L. When taking these measurements, the closed oscillatory circuit is entirely disconnected from the primary of the oscillation transformer.

A small spark gap S is placed in series with the antennae and is energized by a small induction coil or transformer, the secondary of which is represented at F.

When the induction coil is set in operation, high frequency oscillations traverse the open circuit, the period of which may easily be determined by varying the capacity of the variable condenser of the wavemeter until the point of resonance is obtained as indicated by the loudest sound in the head phones.

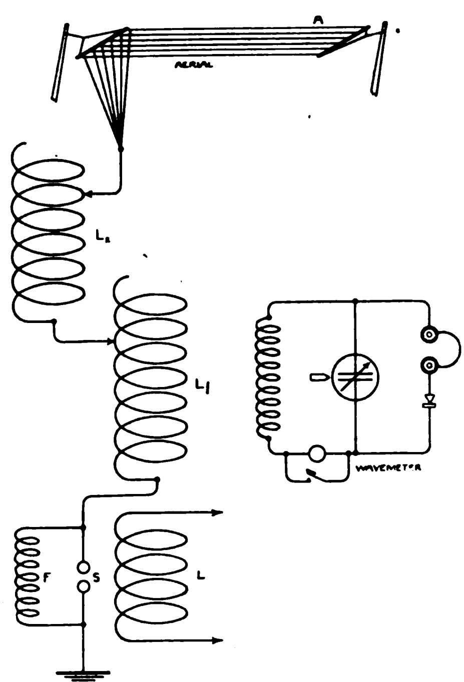
The wavemeter is now in resonance with the open circuit and the wave length is indicated directly by the pointer above the scale on the variable condenser, or may be obtained by reference to the curve sheet.

As the number of turns at L_1 are increased, it will be observed that the wave length of the open circuit is increased. Hence, if a definite wave length is to be arrived at and the number of turns in this helix are not sufficient, a separate coil of inductance will need to be added as indicated at L_2. If L_1 is an inductance of fixed value all the necessary changes will need to be made at L_2.

Closed Circuit Reading—The closed circuit readings are made as in Figure 17. The earth and antennae connections are removed from the helix, constituting the secondary of the oscillation transformer, and the spark gap of the power set, energized in the regular manner. Instead of using a detector this reading may be taken with a small lamp connected directly in series with the condenser and inductance coil of the wavemeter.

As the capacity of the wavemeter condenser is varied, the point of resonance between the wavemeter and the circuit being measured is indicated by the maximum glow of the lamp. This reading may also be taken by the crystal and headphones.

When taking the closed circuit reading care must be taken not to bring the wavemeter inductance too close to the closed circuit, as the oscillations induced in it may be so strong as to burn out the light or puncture the insulation of the inductance coil. Several trial readings should be taken until the proper distance is found.



WAVE LENGTH - OPEN CIRCUIT

Fig. 16

It will be observed that as the number of turns included in the primary of the oscillation transformer are increased, the wave length is increased.

The wave length can likewise be increased or decreased by variation of the condenser capacity.

The Coupled Circuits—After the two circuits have been independently adjusted to the same wave length the transmitting set is coupled up in the regular manner as shown in Figure 18.

The crystal detector of the wavemeter is again switched into the circuit and the inductance coil of the wavemeter held in the vicinity of the antennae.

When the transmitting key is depressed it will generally be found that two points of intensity are indicated on the wavemeter, showing that two wave lengths are being radiated.

This is due to the reaction of the magnetic fields of the closed and open circuits upon one another, causing the antennae to have two periods of vibration, one of which is shorter than the individual adjustment of the circuits, and the other longer.

Coupling—Two circuits placed in inductive relation to each other so that the magnetic lines of force of both interlink are said to be "coupled."

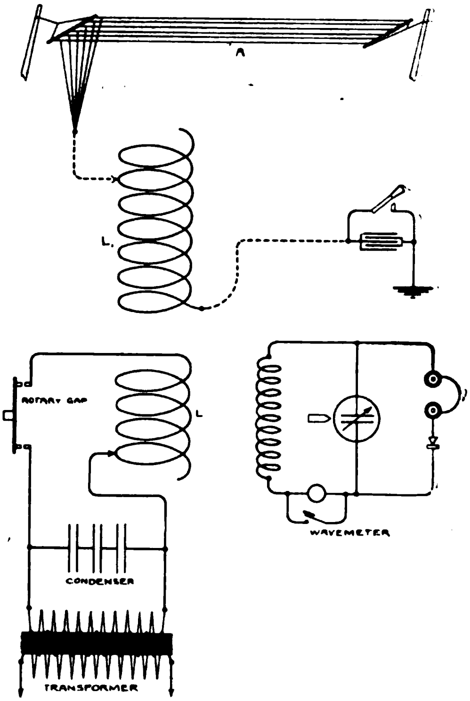
Since the production of two wave lengths is due to the reaction of these magnetic fields upon each other, because of the individual values of inductance in the two circuits altering, it is evident that as the coupling is reduced the two wave lengths will gradually approach a single radiation.

Referring to Figure 18: If the primary of the oscillation transformer is moved away from the secondary turns, the wavemeter will indicate that the two wave lengths are gradually approaching unity.

Degree of Coupling—The degree of coupling in the transmitting set is obtained as follows: Suppose the transmitting circuits were coupled together as in Figure 18: and the wavemeter indicated that two wave lengths were being radiated, one of 630 meters and the other of 570 meters, then the coupling would be:

$$\frac{630^2 - 570^2}{630^2 + 570^2} \times 100 = 9.9\%$$

When the percentage of coupling is low—5 per cent or less—the circuits are said to have "loose coupling."



WAVE LENGTH - CLOSED CIRCUIT

Fig. 17

When the degree of coupling is high, the set is said to have "tight" or "close coupling." There are no hard and fast lines to be observed; the term is merely relative.

Trial Readings—In the operation of any wavemeter several trial readings must be made in order to find the proper position where the wavemeter will be cut by the lines of force of the transmitting set.

When the correct position is found and the point of resonance on the wavemeter scale is located, the wavemeter may then be placed at a greater distance from the circuit, thereby decreasing the signals and allowing a more accurate reading to be obtained.

In making wave length tests, the operator will note that a few inches of inductance or a fraction of a turn in the closed circuit will make a great change in wave length, whereas in the open circuit it will require a considerable number of turns to create the same change. This is due to the fact that the capacity of the Leyden jars is decidedly greater than the capacity of the antennae.

Hot Wire Ammeter Tuning—It is also possible to tune a wireless telegraph transmitting set to resonance by means of a hot wire ammeter. This is shown diagrammatically in Figure 19, in which the hot wire ammeter has been purposely enlarged to give readers an idea of the internal mechanism described further on.

A hot wire ammeter is a device which measures the current flowing in a circuit by causing that current to flow through a resistance wire. In passing through this wire heat is produced which causes the wire to expand; the expansion in turn is made to work a pointer across a scale.

In adjusting a transmitting set to resonance by this method the hot wire ammeter is placed either in series with the earth lead or the antennæ lead.

The contact clip of the primary of the oscillation transformer, L, is set at some definite point, or the closed circuit may be adjusted to some definite wave length by means of a wavemeter.

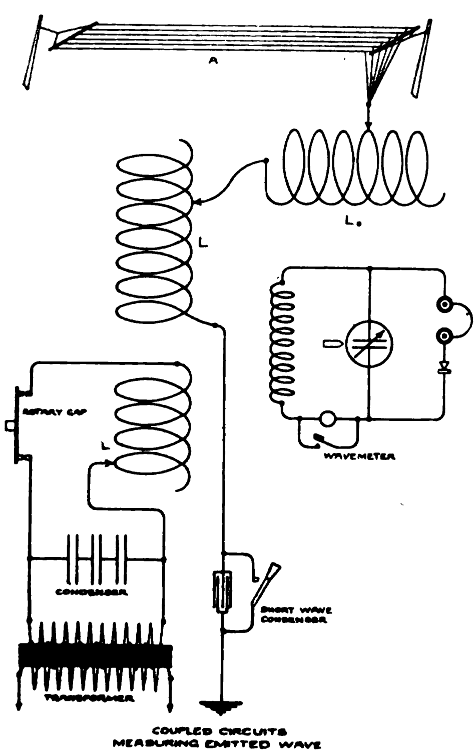


Fig. 18

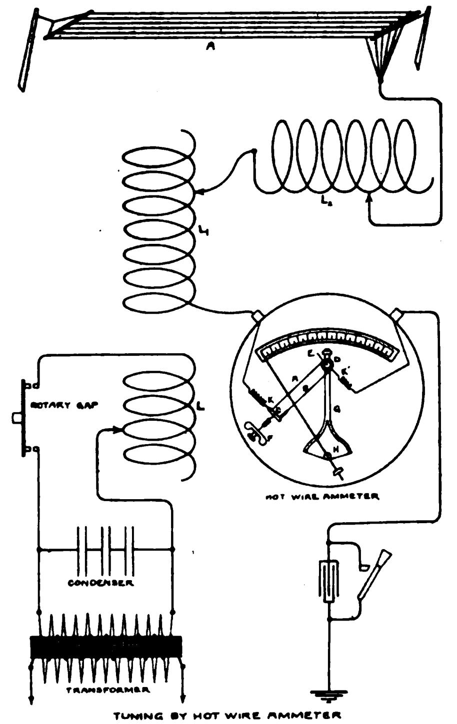


Fig. 19

The contact clip of the aerial tuning inductance is placed at some point, say the middle of the helix, and a trial reading taken.

The number of turns of the aerial tuning inductance are then increased or decreased until a maximum reading is obtained on the hot wire ammeter. This reading indicates that circuits have practically the same period of vibration and are said to be in resonance.

The reverse adjustment could be made in this circuit; that is to say, a certain amount of inductance could be included in the open circuit helix and the contact clip of the closed circuit varied until the highest reading is obtained.

The Hot Wire Ammeter—The mechanism of the Roller Smith hot wire ammeter is clearly indicated in Figure 19.

A wire, AB, of high resistance is

secured at one end to a plate, C, passed around a pulley, D, secured to a shaft, E, and its free end brought back again and mechanically, though not electrically, attached to the same plate, C. Plate C is kept under stress by the spring, F, which constantly tends to pull it in a direction at right angles with the axis of the shaft, E. To the shaft, E, is likewise secured an arm, G, bifurcated at one end and counterweighted at the other. Between the extremities of the bifurcated end and the arm, G, is another shaft, H, on which there is a small pulley to which is attached the needle, I, that gives the desired indication; a fine silk fibre is attached at one end to one of the arms of G, then passes around the pulley and the staff, H, and finally has its other extremity secured to the other arm.

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA.

TUNING RECORD

STATION S/S Monterey

DATE TUNED Sept 4, '13 TUNED BY F.A. Hart

CLOSED OSCILLATING CIRCUIT

WAVE LENGTH 600 METRES

PRIMARY OSCILLATION TRANSFORMER, No. OF TURNS 5 5/8

CONDENSERS { PLATES SERIES PARALLEL / 8 JARS SERIES PARALLEL

TYPE OF SPARK DISCHARGER Non-Synchronous

OPEN RADIATING CIRCUIT

WAVE LENGTH 600 METRES

SECONDARY OSCILLATION TRANSFORMER, No. OF TURNS 4 TYPE Outside

LOADING COIL, No. OF TURNS 14 RADIATION 6 AMPERES

NATURAL PERIOD OF ANTENNAE 365 METRES

DECREMENT PER COMPLETE OSCILLATION .106

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA.

TUNING RECORD

STATION S/S Monterey

DATE TUNED Sept 4 '13 TUNED BY F.A. Hart

CLOSED OSCILLATING CIRCUIT

WAVE LENGTH 300 METRES

PRIMARY OSCILLATION TRANSFORMER, No. OF TURNS 1 3/16

CONDENSERS { PLATES SERIES PARALLEL / 8 JARS SERIES PARALLEL

TYPE OF SPARK DISCHARGER Non-Synchronous

OPEN RADIATING CIRCUIT

WAVE LENGTH 300 METRES

SECONDARY OSCILLATION TRANSFORMER, No. OF TURNS 4 TYPE Outside

LOADING COIL, No. OF TURNS 6 RADIATION 2.7 AMPERES

NATURAL PERIOD OF ANTENNAE 365 METRES

DECREMENT PER COMPLETE OSCILLATION .11708

Fig. 20

The current to be measured flows through the wire A only, entering at K and leaving at K^1.

When A is heated by passage of the

current, it expands, making A's tension relatively less than that of B, and equilibrium can be restored only when the pulley, D, rotates sufficiently again to equalize the strain. The rotation of D carries G with it, and G in moving causes the silk fibre to rotate the shaft which carries the needle. The movement of the needle is then dependent upon the amount of expansion in A.

Tuning Records—When the inspector at the home port has tuned a ship installation to the standard 300 and 600 meters as required by the Berlin Convention, two tuning records are left aboard the ship for the convenience of the operator. These show the adjustments necessary in changing from one wave length to the other. Facsimiles of these cards are shown in Figure 20. In this particular case it should be noted that the antenna current is 6 amperes on the 600-meter wave and 2.7 amperes on the 300-meter wave. Likewise note the number of turns employed in the open and closed circuits under such adjustments.

It is understood that on the 600-meter adjustment the short wave condenser is shunted and thereby cut out of the circuit. However, on the 300-meter wave it is connected in series and generally calls for readjustment of the number of turns in use in the aerial tuning inductance.

Degree of Coupling—The degree of coupling or, in other words, the actual distance between the primary of the oscillation transformer and the secondary, varies with the wave length used, and for the particular adjustment in the two cases cited the actual distance by which the coils are to be separated is plainly marked on the rod supporting the movable coil.

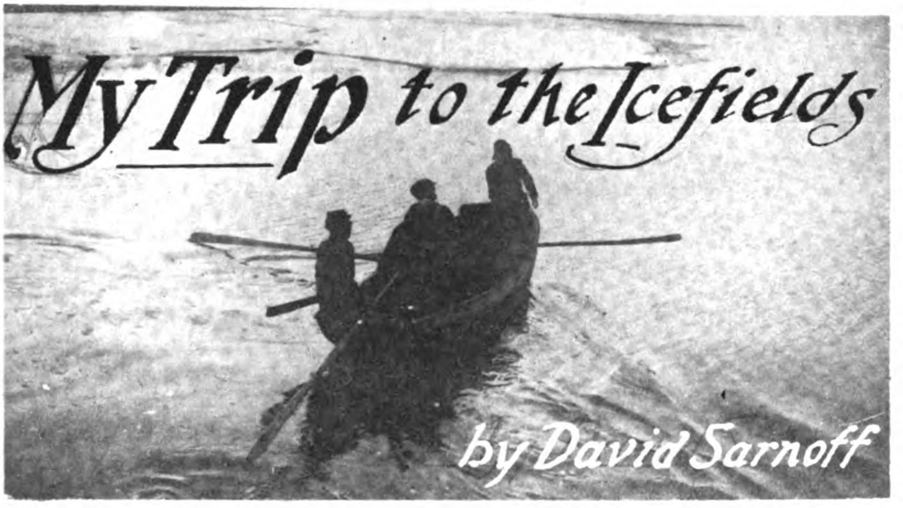
The operator should take great care in duplicating these readings absolutely, as a maximum degree of efficiency is thereby assured and the set complies fully with the U. S. Government Regulations covering coupling, damping, emitted waves, etc.

Data for Marconi Sets—Since there are various types of apparatus in use by the American Marconi Company, it is well for operators to become familiar with the capacity, voltage and frequency of each. A table is appended giving the necessary data:

Power	Frequency	Type	Pri. Volt.	Sec. Volt	Cond. Cap.	Type Condensers
1 K. W.	60 cycle	Marconi	110 V.	30000	.012 M. F.	12 copper pl. jars. 6 in parallel. 2 banks in series
2 K. W.	"	"	"	30000	.018 "	18 copper pl. jars. 9 in parallel. 2 banks in series.
1 K. W.	120 cycle	"	"	25000	.008 "	8 copper pl. jars. 4 in parallel. 2 banks in series.
2 K. W.	"	"	"	30000	.01 "	10 copper pl. jars. 5 in parallel. 2 banks in series.

The capacity of a copper-plated jar averages .003 M. F.
The capacity of a single plate of the oil condenser = .002 M. F.

(To be continued)



The Belle Isle Incident.

WE were within 75 to 100 miles of Belle Isle when word was received by wireless that the suffering undergone by the unfortunate operator Barrett had forced him to take most of his food through a tube. The ice was unusually heavy and the Beothic could make but little progress, and with the seal packs thinned out and little hunting to be done the crew became restless. Every now and then a group would form itself along the rail and voice a mild protest at the delay in returning homeward.

A change in diet which occurred about this time made the prospect of home still more alluring, for as provisions ran low our meals were principally composed of seal flippers. I had voted our former provender unspeakable, but when this ebony-hued product was placed before me my long-suffering digestive organs rebelled. I glanced at my companion, the doctor, and found a certain consolation in his woe-begone expression as he surveyed the limpid mass, squishing and gurgling in its bath of oil. An odor beggaring description and of unmatchable strength arose from the dish, and his amazement was beautiful to see when the various members of the crew actually attacked the proposition with what, from all appearances, might have been enjoyment. He looked up and saw me watching him, whereupon he executed a flank movement of the dissecting order and raised a very tiny piece of the flipper to his mouth. The consequences were all but fatal, but the doctor proved to be a good sport, and gulping down the mouthful, commenced expounding the merits of this class of food with all the zest of an epicure chancing upon a new discovery.

I had learned my lesson, however, from painful experience, and maintained a very passive and non-receptive attitude. But after a time, when he had joked me unmercifully on my perfectly justified reluctance, I threw all caution to the winds and proclaimed that I would "try anything—once."

And to the strict observance of the qualification may be attributed the fact that I am still among those present on this mundane sphere.

When I had washed away the taste of my first, last and only acquaintance with seal flipper in the guise of nourishment, I summoned sufficient courage to place before the captain the serious situation at Belle Isle. It looked like a matter of life and death with poor old Barrett, for the last wireless reports stated that he was steadily sinking, and unless the abscess was given proper medical attention he could not hold out much longer.

My efforts to have the ship turned toward Belle Isle were received with a kindly tolerance that held little encouragement. The ship was heavily laden, and should it be taken into the heavy ice floes it might become jammed and remain for weeks with all the men and cargo on board. The captain explained what this would mean in financial loss and brought out the danger to life and property in such an undertaking.

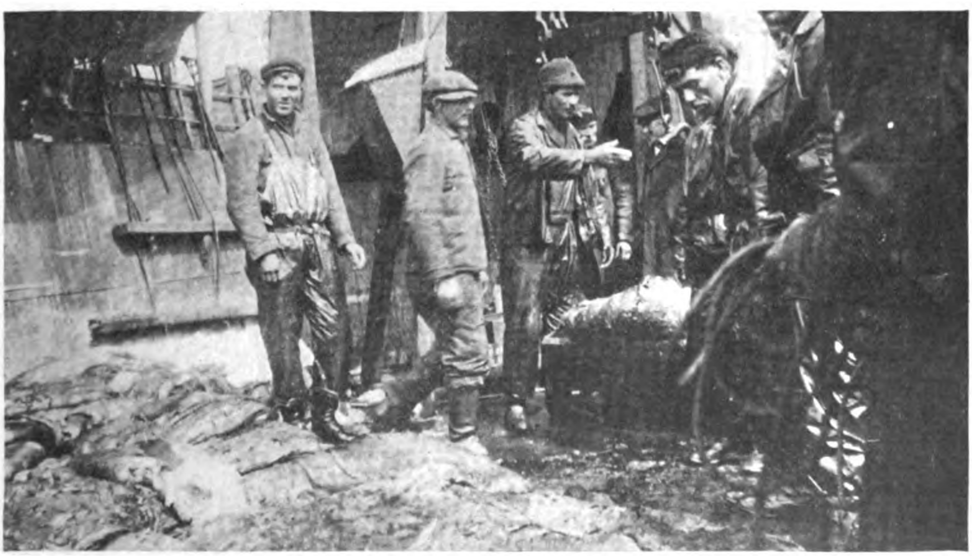
Dejectedly I sought the wireless room and sat down before the instruments, trying to find a way around the difficulty. Mechanically, through force of habit no doubt, I made the accustomed adjustments and was awakened from my reverie by the buzz of the cheery call of Jack Daw, Belle Isle's chief.

He was anxious to know what had been done toward securing assistance for his junior, and pressed me for details regarding the situation at my end.

His distress over the fate of his companion was pitiful. I simply could not tell him how unpromising things were. I cannot now recall exactly what I flashed across space to him; but I know it was a lie—a justifiable one, and one which I have never regretted, for when he heard that there was every possibility that our ship would come to Belle Isle his touch on the key fairly snapped with relief at the burden lifted from his mind.

Enthusiastic, hopeful messages, one on top of the other, buzzed into my head phones. He was sure everything would come out all right. When were we coming?—he wanted to tell Barrett the good news.

It was terrible! There I sat, staring the cold reality in the face, not one chance in a thousand that the captain would relent—and a man whose companion's life hung in the issue telling me across space how grateful he was to me for arranging his deliverance. Several times I started to interrupt and tell him the truth. But I could not bring myself to it. Then, when I had stood it as long as I could, I grasped at one despairing chance and broke in to tell him that everything was not yet settled, but it could all be fixed up if he would send a message addressed to the captain stating that his companion was suffering help-



My efforts to have the ship turned toward Belle Isle were received with a kindly tolerance that held little encouragement. The ship was heavily laden, and should it be taken into the heavy ice floes it might become jammed and remain for weeks with all the men and cargo on board.

lessly, that the end was near, and unless we hastened with medical assistance it would be too late.

I delivered this message to the captain, enlisting the doctor's aid in placing the case before him. We made a lengthy and strong appeal that from all indications reached the captain's heart. But he would not say definitely whether he would attempt the journey. It was evident that our plea had a marked effect, but the question lay with whether he would or could bring the vessel near enough to Belle Isle to permit a landing.

several days—in fact, would arrive there in six or seven hours.

With the wildest Indian warwhoop that ever broke up the tranquility of ambient atmosphere anywhere, I raced for the wireless cabin to dash off a message to Daw. Maybe he wasn't glad to hear that we were almost there!

And maybe I didn't feel like hugging the stolid old captain!

I know I meant to, but I don't believe I ever did, for during the next few hours I was about the busiest person that ever set foot on a ship. We made a syste-

The Belle Isle lighthouse and wireless station are situated nearly 500 *feet above sea level, on a mountain of ice and snow that takes on the appearance of an insurmountable glacier. When we finally reached the peak seven members of the party had dropped out.*

Several days elapsed. The suspense was maddening. We filled in the time with encouraging reports to Jack Daw, in which the doctor's prescriptions for the relief of the patient played a prominent part.

Then came a message that made the doctor wince. It looked as if blood poisoning was setting in.

Gravely the doctor carried this opinion to the captain, primed for a last despairing plea in the name of humanity. The intelligence was received stolidly, and with never a change in expression the captain told him that the vessel was headed toward Belle Isle, had been for

matic search from end to end of the vessel, gathering up everything that represented human comfort. Blankets, pillows and fur robes came first; then followed the collection of all manner of liquid refreshment carried "for medicinal purposes." There was little left, but what was on board we got, cheerfully contributed by the crew along with several pounds of tobacco for the game chief operator who had stood the long siege with the companion he refused to desert.

We came to a stop two miles from Belle Isle, and a party of ten—the doctor, the captain's son, seven members of the crew and myself—started across the ice toward the wireless station and the lighthouse appearing in the distance.

To reach our destination proved to be quite an undertaking, for the Belle Isle station is situated nearly 500 feet above sea level on a mountain of ice and snow that takes on the appearance of an insurmountable glacier. When we finally reached the peak seven members of the party had dropped out, and the survivors—the captain's son, the doctor and myself—were completely exhausted.

Jack Daw and the lighthouse keeper greeted us warmly, and when we had recovered from our exertions, escorted us to the little wireless house where lay the reason for our travel over miles of frozen ocean and wind-swept glacier. On a rickety old cot in the coldest and dreariest room I have ever entered, we found the object of our journey. I experienced a distinct shock as I looked down on him. His hair was matted and his hollow cheeks were covered with a stubble beard that sharply accentuated the ghastly pallor of his features. Emaciated almost beyond recognition from twenty days in bed, racked with intense pain every minute during that time, and forced to do with insufficient nourishment, he had wasted away to a shadow of a man, and one that any moment would pass into the Great Beyond.

When he saw us he broke down completely and great gulping sobs shook his frame as the tears coursed down his cheeks. We all volunteered a few cheery words and the doctor took him in hand, quieting him so effectively that within a few moments he was able to describe briefly his condition and answer questions relating to his ailment.

The doctor joined me a few minutes later and said that a very dangerous abscess had formed, and three of his teeth must be removed at once. While he was not a dentist himself, he was willing to undertake the operation with the instruments he had brought along, but he was rather reluctant about leaving the patient afterward without further aid at hand in case blood poisoning set in.

I laid the proposition before Barrett, telling him what was necessary to give him relief, and mentioning the danger of blood poisoning to a man in his sorry

An excellent likeness of Belle Isle's chief operator, Jack Daw (to the left), and the Beothic's ship surgeon (to the right). A snapshot taken shortly after the successful operation had been performed.

condition. I told him he must take his choice; either submit to the operation then and there and take his chances, or, if he wished, we would carry him back to the ship and take him to St. Johns.

He made his decision without the slightest hesitation. Under no circumstances would he leave his colleague, Jack Daw. That man had shown supreme loyalty and consideration and given him untiring care and attention, and he would never desert him where there was any alternative. If it was to be, he would end his days there rather than leave his companion.

So the operation was performed and the available remedies administered. It was a complete success, I am glad to say, and even before we left he had been relieved of his suffering and was sleeping peacefully.

As we prepared to depart we quite unexpectedly learned why Daw had been the only one to care for the sick man. Jack had told us that the only woman resident of Belle Isle was the wife of the lighthouse keeper, and we were curious to see the woman who in our opinion was deserving of a Carnegie medal for living in that desolate spot. Introductions, said Jack, would not be in order, for the husband, a short French Canadian, was a most inhuman sort and absolutely forbade his wife talking to any of the neighbors, which, of course, prevented her from administering to his companion. Nevertheless, our curiosity would not be denied, and we ventured out-of-doors in a raging wind that forced us to hold fast to the ropes placed around the houses. These ropes served to hold you on your balance, for walking is impossible, and sliding along the ice is the only method of locomotion. As we swept along in this manner toward the lighthouse the lady appeared at a window. She was a tall, striking brunette, one of the handsomest specimens of womanhood I have ever laid eyes on. She smiled a welcome and said something in French, which the doctor translated to mean an invitation to accept the hospitality of her home.

This we were willing and anxious to do, but our visit was short-lived, for hardly had we entered when the husband appeared and gruffly ordered us out, saying that he would not permit his wife to communicate with strangers. The woman was very angry, but evidently helpless, and considering discretion primarily, the doctor and I removed ourselves. The captain's son did not view the matter in the same light, however, and we had considerable difficulty in preventing him from ending the lady's tribulations by forcibly removing the cause.

This incident closed, we said our farewells and started on our return journey to the ship. A storm had come up in the interval and we experienced great difficulties and not a little hardship, but once aboard the humane object of the expedition and its entire success more than compensated for the discomfiture.

The doctor became quite a hero when we related to the men how he had conquered Barrett's malady and alleviated his suffering. Then, as the journey homeward progressed a full realization of the wonderful value of wireless in this case impressed itself on the minds of officers and crew. A human life was at stake and wireless had won. To wireless, too, could be credited the haul of 36,000 seals that lay in the hold, and these two subjects formed the principal topic of conversation that ended only with our return to St. Johns and the disbanding of the expedition.

The End

Elementary Engineering Mathematics

As Applied to Radio Telegraphy

By Wm. H. Priess

ARTICLE III

38. In the previous issue we considered the simple equation containing but one unknown quantity. This quantity was raised to the same power throughout the series of examples. The solution of two important problems of electrical design, and one of a general algebraic case, will familiarize the reader with the method of obtaining the solution. An equation is said to be solved when the unknown quantity with a coefficient and index of unity is placed on one side of the equation, while the known quantities or constants are placed on the opposite side. This is the usual form of equations for calculation of the dimensions of an electrical circuit.

Problems

39. The formula for the capacity of two parallel flat plates of equal area, separated by a dielectric is

$$C = \frac{KA}{36\pi d} \times 10^{-5}\ \mu\ \text{fs}$$

where A is the area of the dielectric covered by one of the plates in cms.$^{-2}$; d is the thickness of the dielectric in cms.; and K is a number found in electrical handbooks corresponding to the dielectric used, and known as the specific inductive capacity of the dielectric. It is a number which represents the ratio of the capacity of a condenser when its plates are separated by a certain dielectric employed to the capacity of the same condenser when air is the medium between the plates. Let it be required to find the area of the conducting surface of a condenser whose dielectric is flint glass of 0.2 cms. thickness and to have a capacity of 0.01 μ f. s. capacity. Multiplying both sides of equation (1) by $36\ \pi d \times 10^5$ and dividing both sides by K we get

$$A = \frac{c \times 36\pi d \times 10^{-5}}{K} \text{cms.} \qquad (2)$$

From hand books we find $K = 7$. Substituting the values, $K = 7$, $C = 0.01$, and $d = 0.2$

$$A = \frac{0.01 \times 36\pi 0.2 \times 10^{-5}}{7} \text{cms.}$$

$$A = 3230 \text{ cms.} \qquad (3)$$

This will be the equivalent of a plate 2.27 feet square. In order to make the condenser compact, let us use 12 glass plates. The area of metallic foil for each plate will then be 62 inches. The condenser will therefore require 13 pieces of foil, each having an area of 62 inches, and 12 glass plates large enough to prevent sparking from one sheet of foil to the other around the edges.

40. The relation between wave-length and the inductance and capacity of a circuit may be expressed.

$$\lambda = 59.6\sqrt{LC} \text{ meters} \qquad (1)$$

where λ is the wave length in meters, L is the inductance in cms., and C is the capacity in μ fs's. With the condenser calculated in the last problem (0.01 μ f. s.), let it be required to find the inductance necessary to give a circuit wave length of 200 meters. Squaring both sides of equation (1) we get

$$\lambda^2 = (59.6)^2 LC. \qquad (2)$$

Dividing both sides of (2) by $(59.6)^2$ c we get

$$\frac{\lambda^2}{(59.6)^2 C} = L \text{ cms.} \qquad (3)$$

Substituting the values C=0.01, L=200 in (3)

$$\frac{(200)^2}{(59.6)^2 \times 0.01} = 1060 \text{ cms. inductance} \quad (4)$$

The student should calculate the constants of the apparatus he possesses. The experience thus secured will be valuable for future experimental work.

41. To find x in the algebraic example

$$ax^2 = \frac{2(b - cx^2)}{3d} + 4 \quad (1)$$

multiply both sides by 3d

then, $$3adx^2 = 2(b - cx^2) + 12d \quad (2)$$

Transpose the x terms to the left hand side of the equation,

$$3adx^2 + 2cx^2 = 2b + 12d \quad (3)$$

Write the coefficients of the terms containing x in parenthesis;

$$(3ad + 2c)x^2 = 2b + 12d \quad (4)$$

Divide both sides by the coefficient of the x term,

$$x^2 = \frac{2b + 12d}{3ad + 2c} \quad (5)$$

Taking the square root of both sides to find the value of x,

$$x = \sqrt{\frac{2b + 12d}{3ad + 2c}}$$

42. To sum up: the simple equation is one containing but one unknown quantity, the latter being raised to the same power throughout the equation. The solution is accomplished when the unknown quantity appears alone on one side of the equation with a coefficient and an index of unity, and is equal to one or more related constants. The solution is reached by simultaneous operations performed on both sides of the equation in accordance with the axioms laid down in the foregoing article.

In general, five steps are taken for obtaining the solution;

(1) *Clear the equations of fractions.*

(2) *Perform the algebraic multiplications indicated.*

(3) *Transpose all terms containing the unknown quantity to one side of the equation, and all other terms to the other side.*

(4) *Group the coefficients of the unknown quantities and divide both sides of the equation by this coefficient group.*

(5) *If the unknown quantity appears as a power other than unity, perform the inverse operation indicated on both sides of the equation, to reduce it to unity.*

Simultaneous Equations of the First Degree

43. An equation containing two unknown quantities of the first degree is satisfied by an unlimited number of different values of one of the quantities, depending on the value given the other quantity.

$$x + y = a$$
$$x = a - y$$

For every value of y there is a corresponding value of x. But if we have *two independent* equations of the first degree in x and y, there can be but one pair of values which will *simultaneously* satisfy both equations.

A pair of independent equations are such that one equation cannot be made to reduce to the second equation, by simple addition, subtraction, multiplication or division of both sides of it by a quantity. The degree of an equation is the degree of the term, the sum of whose x and y indices is the greatest.

We shall consider the solution of *simultaneous, independent* equations of the *first degree.*

Methods of Solution

44. The procedure shall consist in the deduction of two simple equations—one in each of the unknown quantities; the solution of these simple equations may then be obtained from the previous discussion.

In the example

$$ax + by = c \quad (1)$$
$$dx + ey = h \quad (2)$$

If we multiply (1) by d, then (2) by a, and subtract (2) from (1), we get,

$$adx + dby = cd$$
$$adx + aey = ah$$

$$dby - aey = cd - ah \quad (3)$$

This process is known as elimination of an unknown quantity by cross multiplication of its coefficients and subtraction of equations. Equation (3) is a simple equation in terms of y. Solved for y it equals

$$y = \frac{cd - ah}{db - ae} \quad (4)$$

Substituting this value for y in equation (1) there follows the simple equation in x

$$ax + b\left(\frac{cd - ah}{db - ae}\right) = c \qquad (5)$$

Solving for x we have

$$x = \frac{c - b\left(\frac{cd - ah}{db - ae}\right)}{a} \qquad (6)$$

The values, x and y given by equations (6) and (4) respectively, are, therefore, the solutions of the simultaneous equations (1) and (2). Regarding this method (of elimination by addition and subtraction), no further explanation is required, as the operations, after careful consideration of the problem given, should be self-evident.

45. Another method of solution is to solve both equations for one of the unknown quantities, and then to equate the sides not containing this quantity. Put equation (1) in the last example in the form,

$$x = \frac{c - by}{a}, \qquad (1)$$

and the equation (2) of the last example in the form,

$$x = \frac{h - ey}{d}. \qquad (2)$$

Since the x's are equal (1) = (2).

$$\frac{c - by}{a} = \frac{h - ey}{d}. \qquad (3)$$

This is a simple equation in terms of y. Solved for y,

$$y = \frac{cd - ah}{bd - ae} \qquad (4)$$

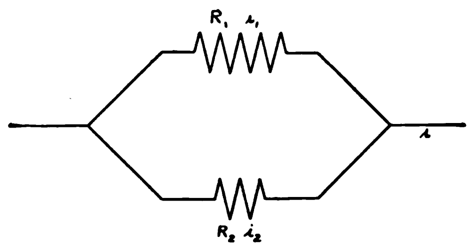
The value of y in equation (4) checks up with the value of y, found in the last example by means of elimination, cross-multiplication and subtraction. x is found, as in the previous solution, by substituting this value of y in one of the original equations. This process is known as *elimination* by *comparison*. It is labor saving and clear.

The Formation of Equations

46. Equations are the expression of a natural law. The process of forming an equation consists in writing down in algebraic form, the results of experience—dealing with the quantities whose values we wish to determine in terms of certain known quantities. All problems connected with finding the equivalent resistance, inductance or capacity, of parallel or series circuits fall into this class of equations. For instance, in parallel circuits containing resistance, the sum of the currents in the branches equals the current in the line. The voltage across each branch is the same. These two conditions lead to two equations, which permit solution of the problems when two of the values are implicated. The same applies in series circuits containing resistances; the current through each of the resistance elements is the same and equal to the current in the line; while the sum of the voltages across each resistance is equal to the voltage across the line. These two conditions likewise lead to two equations.

Examples

47. In a circuit consisting of two resistances in parallel, it is required to find the currents in each branch in terms of the resistances of the branches and the current in the line,



The voltage across each branch is the same and equal to the product of the current through the branch and its corresponding resistance. Therefore calling the currents in the first and second branches i_1 and i_2 respectively, and the resistance of the first and second branches R_1 and R_2 respectively, then

$$R_1 i_1 = R_2 i_2 \qquad (1)$$

The sum of the currents in the first and second branches is equal to the current i in the line.

$$i_1 + i_2 = i \qquad (2)$$

We now have two independent equations connecting i_1 and i_2 and may therefore solve for them from (1)

$$i_1 = \frac{R_2 i_2}{R_1} \qquad (3)$$

From (2)

$$i_1 = i - i_2 \qquad (4)$$

Equating (3) and (4)

$$\frac{R_2 i_2}{R_1} = i - i_2 \qquad (5)$$

Solving for i_2

$$i_2 = \frac{R_1 i}{R_1 + R_2} \qquad (6)$$

substituting this value for i_2 in equation (2)

$$i_1 + \frac{R_1 i}{R_1 + R_2} = i. \qquad (7)$$

solving for i_1

$$i_1 = \frac{R_2 i}{R_1 + R_2} \qquad (8)$$

Equations (6) and (8) are therefore the required answers.

48. The student of radio telegraphy should exercise his ingenuity to derive the audibility factor, when using a non-inductive shunt across the head telephones, in terms of the resistance of the shunt and the head telephones. This is done on the assumption that the sound in the telephones varies as the Ti^2 energy consumed, where T is either resistance and i the current through them. The audibility factor may be defined as the ratio of the energy consumed in the shunt and telephones (when the shunt is adjusted so that the sound in the phones is just readable or audible), to the energy consumed by the phones when the sound in them is just readable or audible. He should get as a result:

$$\text{Audibility factor} = \frac{T + S}{S} \; *$$

where T is the resistance of the phones and S, resistance of the shunt.

Simultaneous Equations of the First Degree in Three Unknowns

49. The first requirement for a definite solution is the statement of three equations connecting three unknown quantities. They may then be solved by one or the other of the methods illustrated in paragraphs 44 and 40. That is, a common letter is eliminated from two pairs of three equations. This leaves one pair of simultaneous equations containing two unknown quantities. This form has already been solved.

For example

$$ax + by + cz = d \qquad (1)$$
$$cx + fy + gz = h \qquad (2)$$
$$ix + jy + kz = l \qquad (3)$$

Eliminating x from (1) and (2)

$$(eb - af)y + (ec - ag)z = ed - ah \qquad (4)$$

Eliminating x from (2) and (3)

$$(if - ej)y + (ig - ke)z = ih - el \qquad (5)$$

Equations (4) and (5) are simultaneous equations and may be solved for y and z by methods shown in paragraphs 44 and 45. These values of y and z may then be substituted in one of the original equations to give the value of x.

Factors

50. The problems encountered in finding the factors of an expression resolves to that of finding the multipliers and multiplicands when the product is given. The solution of many equations depends largely upon their simplification and consequent reduction by means of factors. For this reason this important attribute of an algebraic expression is considered. We shall deduce the factors from known identities, and conclude by considering the factors and roots of a quadratic equation with one unknown quantity.

Factors from Multiplication Results

51. In paragraph 29 three repeatedly recurring cases were given. They are

$$(a + b)^2 = a^2 + 2ab + b^2 \qquad (1)$$
$$(a - b)^2 = a^2 - 2ab + b^2 \qquad (2)$$
$$(a + b)(a - b) = a^2 - b^2 \qquad (3)$$

When an expression takes the form of one of the right-hand numbers, it may be written down as product of the corresponding factors on the left-hand side, Methods, such as adding and subtracting a quantity, multiplying and dividing by and grouping of terms, serve to throw the average expression into one of these forms.

Examples

52. Factor the expression

$$x^2 + 8ab^2x + 16a^2b^4$$

* NOTE.—This is not strictly true. The standard method, in our opinion, would consist in using a box containing, say, 100 identical receivers. These receivers would be connected in parallel by split plugs to two silver-plated bars of large section. One of the receivers would then be permanently connected across the bars to serve as a test phone. Variations by unit steps from 1 ÷ 1 to 100 ÷ 1 in audibility factor could then be ascertained.

Grouping terms

$$x^2 + 2(4ab^2)x + (4ab^2)^2$$

From paragraph 51, equation (1)

$$= (x + 4ab^2)^2$$

53. Factor the expression

$$\frac{x^2}{2b} - 2a^2x + 2a4b$$

Multiply and divide the expression by 2b

$$\frac{1}{ab}(x^2 - 4a^2bx + 4a^4b^2)$$

Grouping terms

$$\frac{1}{2b}\left[x^2 - 2(2a^2b)x + (2a^2b^2)^2\right]$$

From paragraph 51, equation (2)

$$= \frac{1}{2b}(x - 2a^2b)^2$$

54. Factor the expression

$$9a^2x^2 - b^2 - 2bc - c^2$$

Multiplying and dividing by $9a^2$

$$= 9a^2\left(x^2 - \frac{b^2 + 2bc + c^2}{9a^2}\right).$$

The fractional term is a perfect square (paragraph 51, equation (1))

$$= 9a^2\left[x^2 - \left(\frac{b + c}{3a}\right)^2\right]$$

From paragraph 51, equation (3)

$$= 9a^2\left(x - \frac{b + c}{3a}\right)\left(x + \frac{b + c}{3a}\right)$$

Factors and Roots of a General Quadratic Equation

55. The form of the general quadratic equation is

$$ax^2 + bx + c = 0 \qquad (1)$$

adding and subtracting from the left-hand side $\frac{b^2}{4a^2}$ and multiplying and dividing through by a.

$$a\left[x^2 + \frac{b}{a}x + \left(\frac{b^2}{2a}\right) - \left(\frac{b^2}{4a^2} - \frac{c}{a}\right)\right] = 0 \qquad (2)$$

Factoring the first three terms and rearranging the last term

$$a\left[\left(x + \frac{b}{2a}\right)^2 - \left(\sqrt{\frac{b^2}{4a^2} - \frac{c}{a}}\right)^2\right] = 0 \qquad (3)$$

From paragraph 51, equation (3)

$$a\left[x + \frac{b}{2a} - \sqrt{\frac{b^2}{4a^2} - \frac{c}{a}}\right]$$

$$\left[x + \frac{b}{2a} + \sqrt{\frac{b^2}{4a^2} - \frac{c}{a}}\right] = 0 \qquad (4)$$

When

$$x = -\frac{b}{2a} \pm \sqrt{\frac{b^2}{4a^2} - \frac{c}{a}} \qquad (5)$$

The equation reduces to an identity, therefore, equation (5) is the solution of equation (1), while equation (4) is the equation of the factors of equation (1). These two equations are by far the most important formulæ we have reached, for by their aid any quadratic equation with one unknown quantity, and whose coefficients for x^2 and x are substituted in place of a and b respectively in (4) and (5), and whose constant term is substituted for C in equations (4) and (5), may be immediately written down as a product of three factors or as a solution with two roots.

56. When two circuits having the same frequency N are coupled, two waves of frequency N_1 and N_2 are produced, these two frequencies depend on the coupling coefficient K in the following manner:

$$K^2\frac{N_1^2 - N_2^2}{N^2} + 2K - \frac{N_1^2 - N_2^2}{N^2} = 0$$

It is required to find the coupling in terms of the natural frequency of the systems N and the frequency of the two waves N_1 and N_2. From equation (5), paragraph 55, we may immediately write the value of K in terms of N_1, N_2 and N where

$$a = \frac{N_1^2 - N_2^2}{N^2} \quad b = 2 \quad \text{and} \quad C = \frac{N_1^2 - N_2^2}{N^2}$$

$$K = \frac{-2}{\frac{2N_1^2 - N_2^2}{N^2}} \pm \sqrt{\frac{4}{\left(\frac{N_1^2 - N_2^2}{N^2}\right)^2} - \frac{\frac{n_1^2 - n_2^2}{n^2}}{-\frac{n_1^2 - n_2^2}{n^2}}}$$

which reduces to

$$K - \frac{n^2}{n_2^2 - n_1^2} \pm \sqrt{\frac{n^2}{n_1^2 - n_2^2} - 1}$$

52. Insight into the factors of an expression can only be gained by experience. Some additional forms are

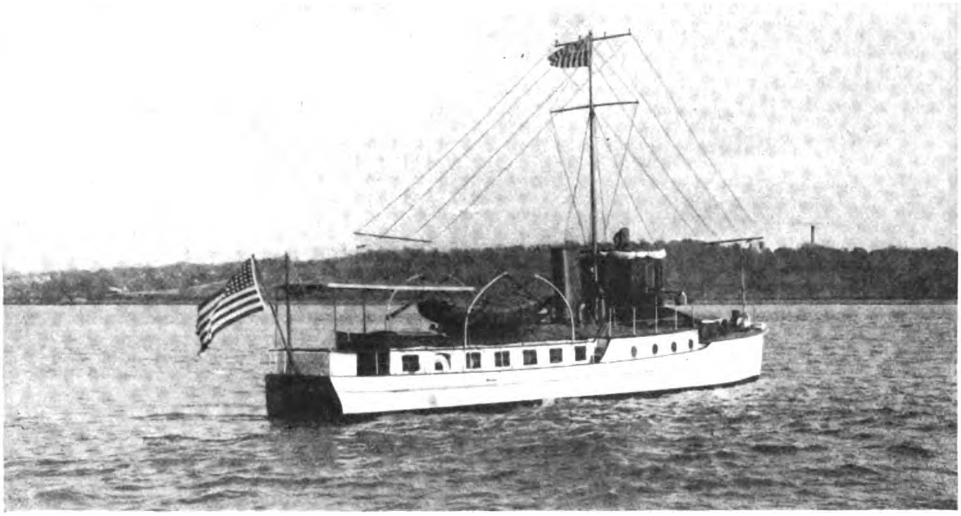
$$a^2 + b^2 + c^2 + 2ab + 2bc + 2ac = (a + b + c)(a + b + c) \qquad (1)$$

$$a^3 + b^3 = (a + b)(a^2 - ab + b^2) \qquad (2)$$

$$a^3 - b^3 = (a - b)(a^2 + ab + b^2) \qquad (3)$$

$$a^4 - b^4 = (a^2 - b^2)(a^2 + b^2) = (a - b)(a + b)(a^2 + b^2) \qquad (4)$$

This is the third in a series of articles on mathematics by Mr. Priess. The fourth will …



The Motor Boat Tarragon, which will Patrol the Atlantic Coast to Enforce the Wireless Laws

A New Ocean Policeman

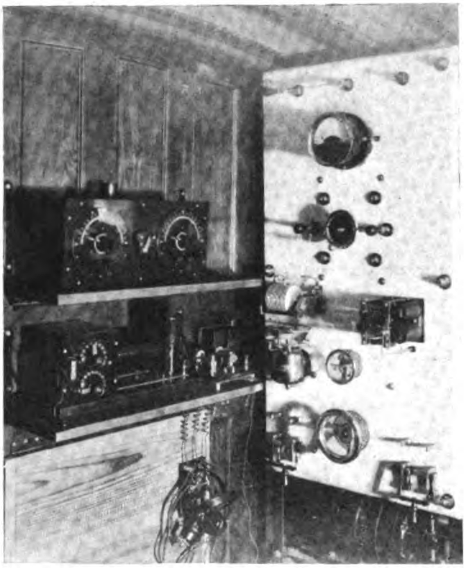
By V. Ford Greaves, U. S. Radio Engineer

THE United States motor boat Tarragon, of the Bureau of Navigation, Department of Commerce, has been equipped with an efficient wireless apparatus in charge of United States Radio Inspector Benjamin E. Wolf, and will enforce the radio laws of this country and the London International Radiotelegraphic Convention along the Atlantic coast. Particular attention will be paid to wave length and operating and traffic regulations, with a view to the reduction of interference.

Designed and assembled under the direction of Frederick A. Kolster, of the Bureau of Standards, the noteworthy features of the Tarragon's radio equipment are compactness and facility for quick change from one transmitting wave length to another. The transmitting apparatus and motor generator are mounted as a single unit on a panelboard, thirty-two inches wide by thirty inches high. The apparatus on the back of the board projects a maximum distance of eighteen inches. The motor generator is operated by twenty storage cells, which will operate the apparatus continuously on full load for about eight hours on one charge. The cells are charged by a small auxiliary gas engine connected to a thirty-five-volt, thirty-five-ampere generator. The transmitter is of the quenched gap type. A break system relay is provided, enabling the operator to be "brooken," or to overhear interference while transmitting.

At present the normal wave length of the Tarragon is 300 meters, and in addition to this, transmitting wave lengths of 200 and 450 meters are provided for. The change from one wave length to another is accomplished by a single throw of a six-point switch, which is mounted on the panelboard. This operation tunes both the oscillating and open circuits to resonance and, with a slight variation of coupling, maximum radiation is obtained. The wave length change device and the method of varying the coupling were devised by Mr. Kolster. The receiving apparatus is secured to a bulkhead, and the operating table, upon which is mounted the transmitting key, folds down when not in use. The complete installation occupies comparatively little space, even considering the comparatively small size of the Tarragon.

The installation is rated at one-quarter kilowatt, and on the 300-meter adjustment delivers a little more than three amperes in the antenna. The latter is necessarily of the inverted V type, due to the fact that only a single mast is available. The maximum height of the antenna above the water-line is about twenty-seven feet and its natural period is about sixty meters.



Wireless Apparatus on the Tarragon

A test of the apparatus was conducted recently while the Tarragon was in the vicinity of Norfolk, Va. During the trial she was able to hear distinctly the time signals and weather report from Arlington, and she was also able to hear the weather report as it was repeated by the Key West Naval station. The press messages from Sayville, L. I., were also copied and communication was established with the Norfolk Navy Yard station, thirty-five miles away.

The test showed that the equipment will have an approximate transmitting range at sea by night of 150 miles.

EFFORT TO ELIMINATE "STRAYS" AND "X'S"

Two commissions, one international and the other English in organization, soon will begin a series of investigations in the hope of being able to codify the various laws which are believed by scientists to govern wireless telegraphy. The English commission, which is known as the committee of the British Association, will devote its investigations to the qualitative phases of the problem, while the other organization, called the International Radio-Telegraphy Commission, will study the quantitative aspects of the question.

The British commission will endeavor to discover by extensive simultaneous observations at various parts of the earth those regularities of phenomena, commonly described as "natural laws." It is hoped that if these laws are once codified it will be possible to extend greatly the commercial possibilities of wireless by obtaining valuable information concerning the electrical conditions of the atmosphere, which have such a powerful effect on the working of wireless systems.

The International Commission will begin its work from a power station near Brussels, and from this station on a specified date certain signals will be sent out for the reception of investigators and national committees, which are being organized in every participating country. Certain technical measurements will be made by the transmitting experts at Brussels and by the receivers in various countries. The International Commission will compare the results of these observations, especially with regard to the effects of time, direction and distance on the strength and regularity of the received signals.

The object of the work of both expert bodies is the elimination of such obstacles as the "strays" or "X's" of the operator, and the difficulties of communication encountered near the periods of the sunrise and sunset and from atmospheric conditions generally.

WIRELESS ENGINEERING COURSE

By H. SHOEMAKER
Research Engineer of the Marconi Wireless Telegraph Company of America

CHAPTER XIII

THE reason why oscillations of different wave lengths are found in two coupled circuits under certain conditions is somewhat hard to explain. The writer will, however, endeavor to show in a simple manner why these two oscillations are found when the circuits are in certain inductive relation.

To begin with, a certain definite amount of energy is stored in the closed oscillating circuit (see Figure 52). If the energy is not removed from this circuit it will continue to oscillate until the energy is dissipated by the resistance of the spark gap and the conductors of the circuit. Any additions of resistance will decrease the number of oscillations, but will not affect the time period.

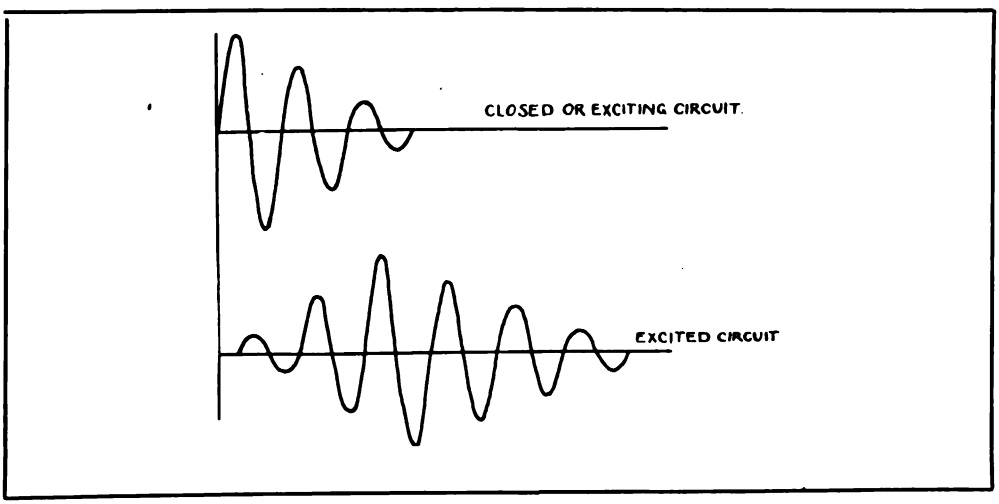


Fig. 53

The open or radiating circuit loses its energy by radiation as well as by resist-

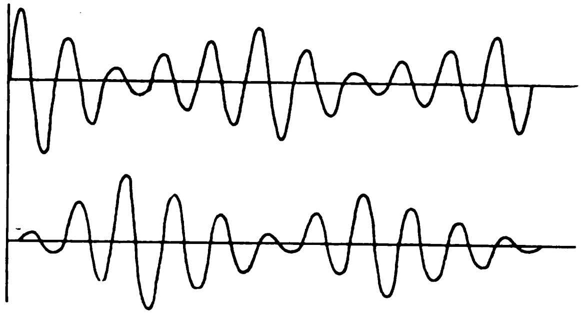


Fig. 54

ance, but does not lose it fast enough to make it aperiodic or non-oscillatory. In other words, the oscillations are persistent in the open circuit as well as in the closed circuit. This is due to the inductance of the circuit which stores the energy in magnetic form, and also gives the circuit inertia. A circuit of this description cannot be set in oscillation instantaneously, when acted on by another circuit. It requires a certain definite time for the oscillations to build up to a maximum and then die away. It is due to this inertia property of the circuits that two oscillations are set up in both circuits.

Figure 53 shows graphically how the oscillations in the closed circuit take place, and how they are generated in the radiating circuit. The closed circuit starts with a maximum amplitude because it has all the energy stored in its condenser; but the open circuit, being in inductive relation, has no energy to begin with, and as it has inertia it requires some time to take up the energy from the closed circuit. In fact it takes only a small portion of the energy at each oscillation. During this transfer of energy from the one circuit to the other the effective inductance of the circuits is changed, and this causes an alteration in the frequency of the oscillation. The extent of this change depends on the mutual inductance of the two circuits. The action referred to would account for a change of wave length, from the wave length of the circuits when operating separately; it would not, however, account for the two wave lengths found.

As the radiating circuit is also a persistent oscillator it will return its energy back to the closed circuit, if the spark gap of that circuit is still conducting, as is the case with some spark gaps. This retransfer of energy back to the closed circuit causes another change in the effective inductance, thus producing an oscillation of another wave length.

Figure 54 shows the relation of the oscillations in the two circuits, and how energy is transferred and retransferred from one circuit to another. When the coupling or inductive relation between the two circuits is small, the open circuit does not take the energy from the closed circuit at a rate high enough to cause it to build up, or absorb all the energy from the closed circuit; it only takes energy at a rate equal to that at which it loses it, and therefore the open circuit cannot return energy to the closed circuit and the oscillations take place as shown in Figure 53.

If the spark gap is so constructed that it loses in conductivity as soon as the energy has been transferred to the open circuit the closed circuit will not take energy back from the open circuit, and there will not be an effective change in the wave length of the oscillations. Spark gaps of this description are called quenched gaps. They are constructed of a number of parallel plates in series, separated by a few hundredths of an inch, and properly cooled. This construction causes the spark to be rapidly cooled, so that it loses its conductivity after a very few oscillations. With this type of spark gap it is necessary to have a close coupling, so that the energy of the closed circuit is rapidly taken up by the open circuit, which then continues to oscillate at its own period until it loses its energy by radiation and is dissipated by the resistance of the circuit. As the loss of energy by radiation has the same effect on the oscillations as the loss by resistance, it is called radiation resistance, to distinguish it from ohmic resistance.

In the last article it was shown how the period or wave length of the oscillations could be measured by means of a wavemeter.

Figure 55 is a diagram of the circuits of an instrument of this description. K is a variable condenser which has a pointer mounted on its movable element so as to indicate any change of capacity on a scale. L is an inductance which can be brought into inductive relation with other oscillation circuits. M is a hot wire, or other type of ammeter, which can measure high frequency currents. If L is brought into inductive relation with an oscillating circuit, and K is varied, a point in which M shows a maximum reading will be found. If the scale is graduated in wave lengths, this instrument will give the wave length of the oscillations taking place in the circuit. If a curve is plotted, showing current values on the ordinate and corresponding wave lengths on the abscissa, we can see exactly how the current varies in the wavemeter circuit. A curve of this description is called a resonance curve and is shown in Fig. 56.

When the wavemeter is used to measure the oscillations in a coupled circuit, where there are two frequencies, the curve will have two maximums, as shown in Figure 57.

By the use of the wavemeter it is also possible to measure the logarithmic decrement of the oscillations. This is accomplished by determining the current value in the wavemeter when adjusted for resonance with another circuit, and when the wavemeter is adjusted for a certain wave length off resonance. The ratio of these two current values, together with the amount of variation of the wavemeter circuit, can be used to determine the decrement of the oscillations.

It can be shown that:

$$\delta + \delta_1 = \pi \left(1 - \frac{\lambda}{\lambda_r}\right) \frac{a}{\sqrt{A^2 - a^2}} \qquad (16)$$

Where δ is the logarithmic decrement of the circuit to be measured, δ_1 is the logarithmic decrement of the wavemeter circuit.

$\pi = 3.1416$.

λ is the wave length corresponding to the current a, λ_r is the wave length for resonance and A is the current corresponding to λ_r.

If we write X for $\left(1 - \frac{\lambda}{\lambda_r}\right)$ and y for $\frac{a}{A}$ then we can put equation (16) in the form,

$$\delta + \delta_1 = 3.1416 \, X \frac{y}{\sqrt{1 - y^2}} = X \qquad (17)$$

X is then the sum of the decrements of the two circuits.

This formula only holds for values of X not exceeding .05.

To determine $\delta + \delta_1$ the wavemeter must be adjusted to resonance with the

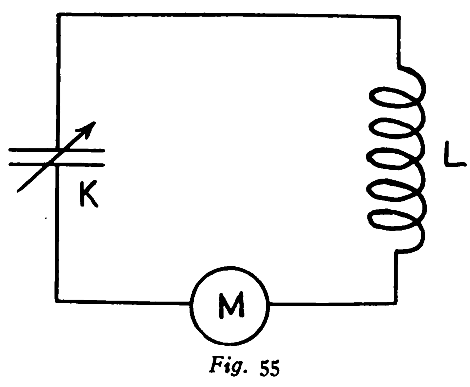


Fig. 55

circuit under measurement and the value of A determined. The variable condenser should then be varied so that the wave length of its circuit is decreased .05, or so that X = .05 and the corresponding value of a is determined. The value of y can then be found by dividing a by A.

These values are then substituted in

formula 17 and the value of X found. The value of δ_1 can be calculated by formula (5).

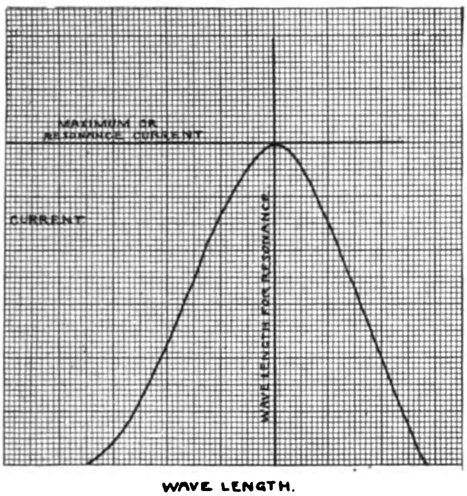


Fig. 56

$$\delta_1 = \frac{\pi}{2} R' \sqrt{\frac{C}{L}}$$

is the value of R′, the resistance, L the inductance, and C, the capacity of the wavemeter, is known.

δ could also be calculated by the same formula if it were possible to measure the resistance of the spark gap and the other element of the circuits. This is generally difficult to do in practice.

If resistance is introduced into the wavemeter circuit the total decrement is changed, and can be considered as composed of δ, δ_1, and δ_2, which is that due to additional resistance. Let this total decrement be expressed by X′, then,

$$\delta + \delta_1 + \delta_2 = X'$$

and,

$$X' = 3.1416\ X \frac{y}{\sqrt{1 - y^2}} \qquad (18)$$

Where $y = \frac{a'}{A'}$ and a′ is the current off resonance and A′ the current for resonance with the additional resistance in the wavemeter.

In taking this last set of measurements it is necessary to have all conditions the same as when taking the first set; that is, the current in the circuit under measurement and the inductive relation of the two circuits must remain constant, as X′ is determined by the ratio of the two maximum currents, A and A′.

It can be shown that,

$$A^2 \delta_1 (\delta + \delta_1) = A'^2 (\delta_1 + \delta_2)(\delta + \delta_1 + \delta_2)$$

Substituting X and X′ for their values.

$$A^2 \delta_1 X = A'^2 (\delta_1 + \delta_2) X' \qquad (19)$$

and

$$\delta_1 = \frac{X' \delta_2}{\left(\frac{A}{A'}\right)^2 X - X'}$$

and

$$\delta = X - \frac{X' \delta_2}{\left(\frac{A}{A'}\right)^2 X - X'} \qquad (20)$$

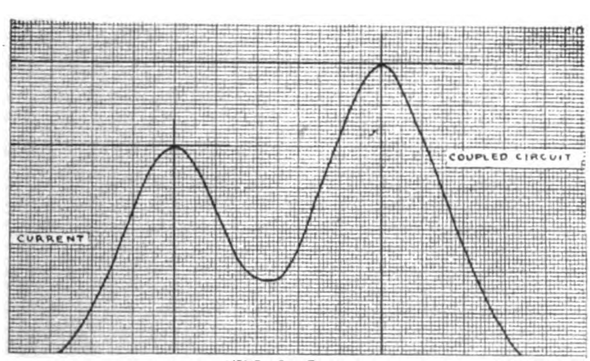


Fig. 57

When determining the logarithmic decrement by the above method it is good practice to take the average values of X and X' for different values of X from .01 to .05, as .01, .02, .03, .04 and .05.

(*To be Continued.*)

This course commenced in The Marconigraph, issue of December, 1912. *Copies of previous lessons may be secured. Address Technical Department,* THE WIRELESS AGE.

AUTOMATIC WIRELESS DEVICE

Leon Champeix has invented an apparatus for the automatic transmission and reception of wireless messages. It consists, in part, of a wax cylinder on which a graver writes Morse telegraphic symbols. A needle, which is connected by a lever to a key operating a wireless transmitter, goes over the signs made by the tool.

The wireless dispatch sent out in this way is received by a similar device, which is connected with the relay of the receiving installation. The graver, operated by the currents of the relay, records the message on another wax cylinder. The cylinders of each apparatus are operated by small electric motors. A horizontal shaft moves a sliding bridge by means of a comb and a helicoidal screw. The axis of the cylinder is connected by a belt to the motor and by gearing to the shaft. By operating a lever the bridge can be placed in its initial position.

A platform carried by the sliding bridge has upon it the graving and other tools. Attached to a bent lever pivoted to the platform is the graver. A silk cord connects the free end of the lever to the armature of an electromagnet. A current traversing the electromagnet attracts the armature and, by the intermediation of the cord and lever, the graver, which has a sapphire point, is plunged into the wax cylinder. A spring sends the graver and the armature back to their first positions when the current ceases.

In order to bring the reproducing needle into contact with the grooves of the cylinder, it is necessary to adjust the platform by screws that elevate and lower. The point of the needle enters the groove and passes over the various depressions made by the graver when the proper adjustment has been obtained. The needle is attached to the short arm of a lever pivoted to the platform and its movements are transmitted in enlarged form to the curved end of the long arms of the lever. The latter, by pressing on a fixed metallic piece, acts as a Morse key, making and breaking the current of the wireless transmitting device.

The obliterator is brought into contact with the cylinder in order to erase the record of the preceding message.

The original record of the message to be transmitted is made by operating the cylinder and graver manually by means of a special mechanism in the base of the apparatus.

PORTUGAL'S STATION PLANS

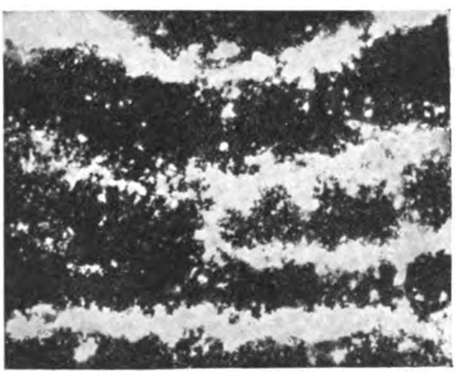
A system of wireless telegraph stations which will require several years of work to complete has been planned by the Portugese Government. The station at Libson, upon which work has already been begun, will be equipped with apparatus capable of communicating 2,200 miles by day and twice that distance at night, enabling it to keep constantly in touch with England, France and Spain. The station to be erected on the Cape Verde Islands will enable Lisbon to keep in communication with South America. The Azores Islands station will provide a link between Europe and Central America which is expected to prove of considerable value when the Panama Canal is opened to commercial traffic. The scheme embraces the erection of Marconi stations in the colonies of Angola, Mozambique, India, Macao and Timor in order to do away with heavy cable charges.

GERMAN STATION IN TOGOLAND

A wireless telegraph station with sufficient power to communicate with Berlin will be erected in Togoland, German West Africa, by the German Government.

APPARATUS TO PHOTOGRAPH WIRELESS WAVES

The basic foundation of an apparatus invented by Marcus A. Goodrich, of San Antonio, Tex., for photographing wireless waves, lies in the peculiarity of the selenium, which makes its electrical resistance vary according to the amount of light it is exposed to. Whether the light is from the visible part of the spectrum or whether it is from the invisible ends makes no difference, for selenium is sensitive to all known light, visible or invisible. In darkness, on the other hand, selenium has an electrical resistance so high as to make it practically a non-conductor of electricity. Once this is grasped the process is very simple, and is arranged as follows:



Photograph Obtained by Wireless Waves Camera

A selenium cell with a flat surface, consisting of 128 miniature cells, one quarter of an inch square, each insulated from the other, so that each little cell of the big compound cell receives and sends off its part of the current when exposed to the light independently of the other miniature cells. The selenium cell is put in the camera in place of the photographic plate, being arranged in the circuit with a set of batteries, so that no current can pass over it without first going through the selenium cell.

Back of this, in an opaque cabinet, is a platinum cell which, like the selenium cell, consists of 128 miniature platinum cells, each insulated from the other and arranged in the form of a very small screen made of extremely fine platinum wires. Each of these small platinum cells is arranged on a big compound cell in the same manner, size and position as the selenium cells on the large selenium cell.

The right sides of all the small platinum cells in the big compound platinum cell are connected directly with the set of batteries, so that each little platinum cell receives a part of the current independently of the other cells of the same size.

On the left-hand side of each small platinum cell is connected a wire running to the corresponding small selenium cell on the big compound selenium cell. Thus each small selenium cell is connected to the corresponding small platinum cell on the big compound platinum cell, so that passing through the small selenium cell the current will go direct to the small platinum cell which has the same position on the big compound platinum cell as the little selenium cell on the big compound selenium cell.

In the opaque cabinet with the platinum cell, and in a direct line and opposite to it, about ¾ of an inch away, is placed a highly sensitive photographic plate, backed by a small chamber filled with ice, to keep the emulsion of the plate from melting when exposed to the hot platinum glow.

Suppose a camera with the shutter open, supplemented with the apparatus described, is placed in position for operation on a dark night while a wireless installation is being worked. The wireless waves are constantly issuing from the aerial and the lens is gathering and placing them on the selenium cell in the same way that it would place them on a photographic plate. On the compound selenium cell the current is constantly on the verge of getting through the small selenium cells, but it is prevented from doing so to any considerable degree because the large cell is in perfect darkness. As soon as the lens concentrates the rays on the compound selenium cell in the form of a picture the current can pass through the cell and form a complete circuit. The positive current meeting the negative current in the platinum cell causes the cell to glow with a white heat in the shape and form and proportion as the wireless waves concentrated on the selenium cell by the photographic lens. The photographic plate being directly behind the platinum cell, gets the full benefit of the white-hot platinum glow, thereby, according to the inventor, impressing on the photographic plate the exact reproduction of the picture concentrated on the selenium cell by the lens. All that is needed is to develop the plate in the usual way and the photograph of the wireless waves is complete.

MORETTI'S WIRELESS PHONE

In the London Electrical Review is published an abstract of a high-frequency generator for wireless telephone work invented by Ricardo Moretti. The generator is a modification of the Duddell singing arc, but is distinguished from the latter and from Poulsen's generator by the fact that continuous wave trains are not obtained from Moretti's apparatus. The direct current arc is operated in series with a suitable ballast resistance, and is shunted by a capacity and inductance as shown in the accompanying diagram.

The positive electrode of the arc is hollow and is traversed by a continuous stream of water (or other cooling liquid). The water cools the electrode, and on entering the arc it is dissociated by the combined effect of heat and elec-

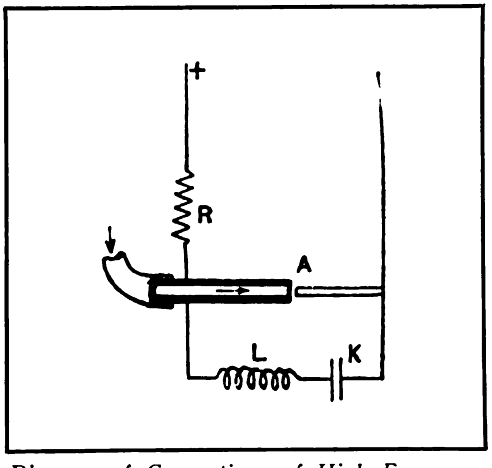


Diagram of Connections of High Frequency Generator

trolysis, and an extremely rapid series of explosions occurs in the arc, thus setting up energy surges, the frequency of which is said to be about 100 kilo-cycles per second. These discharges in the arc circuit set up oscillations in the circuit KL of frequency $F = 1/T = \frac{1}{2} \pi \sqrt{LK}$.

The frequency of the arc discharges is generally considerably lower than the natural frequency of the oscillating shunt circuit KL, so that damped wave trains are obtained—more or less closely following one another according to the frequency of the arc discharge. Hydrogen inclosure of the arc is not required. Using this generator, a hydraulic microphone and the usual arrangement of aerial, Moretti claims to have achieved satisfactory wireless telephonic communication from Centocelle (Rome) to Tripoli.

INVENTOR HAS FAITH IN WIRELESS

Dr. Robert Goldschmidt, wireless inventor, believes that wireless telegraphy has a bright future. Dr. Goldschmidt came to the United States to observe wireless experiments that are to be conducted at Arlington. These experiments will test long distance wireless telegraphy thoroughly and the Belgian inventor expects to acquire information that will be of use to him in his own work.

"I am the most optimistic of men where the wireless is concerned," he said. "We are only at the gateway, so to speak, of the development of this practical miracle."

The inventor has completed, at the request of the King of Belgium, the establishment of a wireless service in the Belgian Congo which has done away with the difficulties of communication in that immense colony.

"The King," said Dr. Goldschmidt, "was so interested in the necessity for linking together the towns and districts of his colony that he sent me to the Congo to establish a system. With my engineers I placed twelve wireless stations at Bànana, Boma, Leopoldville, Coquilhatville, Lisala, Basoko, Stanleyville, Lowa, Kindu, Kongolo, Kidindja and Elizabethville, twelve wireless links covering more than 2,000 miles of territory."

Queries Answered

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

B. M., Farmington, Ill.:

The normal wave length of your transmitting set is about 120 meters. The only proper method to figure the wave length of your aerial is by means of a wave meter. The receiving outfit which you describe will probably enable you to receive wave lengths up to 1,600 meters.

* * *

L. C. M., Brooklyn, N. Y.:

You would secure no increase in efficiency by placing a variable condenser across the circuits of the tuner described in your communication. One of the fixed condensers is supposed to be connected in series with the crystal detector, and the other in shunt with the head phones. A No. 14 earth lead is sufficient.

* * *

F. A. B., New York City, sends us a communication which we desire all our correspondents to read. He says:

"I noticed three years ago, while in the government service, a place on the Atlantic Ocean where wireless signals were so strong from all stations within several hundred miles that these stations seemed to be within very close range. It was so pronounced that no difference was noticed in the strength of signals from stations within 100 miles and those of 500 miles, and all appeared to be within 25 miles. I have never heard any one speak of this, and would like to know if it has been noticed by others. If my memory is correct this place is out of the regular courses of steamers. If you think worth while, please ascertain through your magazine and oblige."

Ans.—We should like to hear reports from others relating to this. We understand that this point of loud signals was located at the time that the United States fleet made its voyage around the world. The operators of the United Wireless Telegraph Company station at Atlantic City, N. J., received a communication from one of the operators on a battleship, saying that Atlantic City's signals could be read in daylight at a distance of 2,500 miles; in fact, all commercial stations in the vicinity of Atlantic City could be heard. This is rather singular when taking into account the power of these stations—2 kilowatts. We understand that this particular location was somewhere off the coast of Venezuela. We do not remember the communication in detail, but would like to hear from any one who is familiar with this particular incident.

* * *

E. H., St. Louis, Mo.:

An oscillation transformer to suit the needs of your 5-kilowatt transmitting set may be constructed as follows: It should consist of eight turns of copper tubing, ½ inch in diameter, wound on a form or insulating support, 12 inches in diameter. The turn should be separated 1 inch. The secondary of the receiving transformer may be made of the same material, but of smaller diameter, so that it will slide in and out of the primary. It need not be more than 9 inches in diameter.

* * *

W. K., Philadelphia, Pa.:

The wave length of your antennæ is approximately 235 meters.

Ques. (2) A loose coupler of the make you refer to has not sufficient value of inductance to allow tuning for Glace Bay. There is, therefore, no need for constructing a loading coil.

Ques. (3) The perikon detector gives far better results with a battery, provided you have a potentiometer of the proper proportions. You should have a potentiometer giving adjustments of voltage dowh to .01 volts.

* * *

H. M. A., Lindbrook, N. Y.:

You cannot use a rotary spark gap with a 1-inch coil. You do not require a condenser. The capacity of the antennæ is quite sufficient. The lead-in wire on the antennæ you describe should be taken off the nearest end.

* * *

C. C. K., Cleveland, Ohio:

The sketch of your receiving set is quite satisfactory. No doubt your receiving would improve if you employed four wires, each 50 feet long. You should be able to receive Arlington's time signals with little difficulty, as the wave length used is 2,500 meters.

* * *

R. M. P., Providence, R. I.:

You apparently have a misconception as to the meaning of the word "wave length." The dead-end effect in the tuner you describe would not be serious.

Information relating to the long and short-wave length tuners is published in this issue of

THE WIRELESS AGE, in the article on How to Form a Radio Club.

The same loose coupler would have the same wave length in the local circuit (detector circuit) regardless of the antennæ (provided loose coupling is used), but the wave length of the open circuit will vary with different antennæ.

Galena is said to be the most sensitive of the crystal detectors, and the audion most sensitive of the valve detectors.

* * *

J. C. R., Whitehall, N. Y.: Regarding query No. 1: You do not state the dimensions of your antennæ. It is probable that your set is out of resonance with the antennæ. This is likely to be the case if you are using an antennæ of amateur dimensions. You cannot employ 1 kilowatt in your transformer at a wave length of 200 meters.

You do not state how the plates in your condenser are connected. If they are all in parallel the combined capacity is about .02 mfds., which is far too great when using a rotary gap with a 60-cycle 1-kilowatt transformer.

(2) If you wish to purchase a device to cut down both the voltage and the amperage in the primary of the transformer you should purchase a step-down auto-transformer. Communicate with one of the electric companies, telling what you want.

(3) It is almost impossible to give you the dead-end losses of a standard loose coupler. Calculations of this description are not generally made. These losses need not be considered in the ordinary loose coupler having a wave length range of from 200 to 2,000 meters.

(4) You can obtain cardboard tubes for your windings from any concern handling fireworks.

* * *

A. R. M., Minot, N. Dak.:

Your query requesting data for a transformer to operate on 60 cycles, is fully answered on page 80 of the October issue of THE WIRELESS AGE.

(2) Divide the primary of the transformer into four equal divisions, if you wish, but you must have some means for controlling the power externally, such as reactance, etc., because, when you decrease the winding on the primary the current flow will increase.

(3) Not knowing the voltage of your transformer, we cannot give definite data on the condenser to suit the case, but assuming a voltage of 15,000 at the secondary, the capacity of the condenser should be .015 mfds. A condenser to have such capacity should consist of 8 glass plates, 14 x 14 inches, 1/8 inch in thickness, covered on both sides with tin foil, 12 x 12 inches. The entire 8 plates should be connected in parallel.

* * *

Amateur, Lynbrook, L. I.:

We are inclined to believe that the 1,000 feet of copper wire, fan shaped, will give a better earth connection than a chicken-iron wire, covering 300 square feet of earth.

(2) The secondary of the Blitzen receiving transformer has not sufficient inductance to receive Glace Bay signals. There would therefore be no need for constructing a loading coil.

(3) Regarding the valve and audion detector, we suggest that you purchase both and draw your own conclusions. The Fleming valve is exceedingly stable in its operation, and therefore of great value commercially.

(4) Write the engineering department of The Marconi Company for a catalogue of Amateur Apparatus.

(5) We are not familiar with either type of rotary gap to which you make reference, and therefore cannot answer the query.

* * *

J. H. W., Briarcliff Manor, N. J.:

There are a number of wireles telegraph experimenters carrying on their work in the vicinity of New York, making it impossible to advise. Perhaps the conversation you heard came from the wireless telephone station at the College of the City of New York.

* * *

C. A. S., Philadelphia, Pa., asks:

(1) My aerial is of the inverted L type, 4 wires, 135 feet long, space 1½ feet apart, 60 feet high, with a lead-in 25 feet long. What is the wave length?

Ans.—The wave length is approximately 338 meters.

Ques. (2) In the transmitting set what factor determines the amount of condenser capacity required?

Ans. (2) The capacity depends upon the voltage, frequency and the size of the outfit. The relation is given by the following formula:

$$C \text{ (in mfds.)} = \frac{W}{M \times V^2}.$$

Where M = cycle frequency.
V = kilovolts.
W = watts desired.

Ques. (3) What is the formula for obtaining the capacity of the condenser?

Ans. (3)

$$C \text{ (in micro-farads)} = \frac{2248 \times K \times A}{d \times 10^{10}}.$$

Where A = is the area of the smaller plate of the condenser.
d = thickness of the dielectric.
K = specific inductive capacity of the dielectric. (Varying from six to nine.)

Ques. (4) What do the abbreviations S, SG, CQ, XDH and others used in the preamble of messages stand for?

Ans. (4) CQ, according to the London Convention, is a call of inquiry, and is used by ships when desiring to know what radio stations are within their range.

S, SG, XDH are message prefixes used exclusively by The Marconi Company, and designate the type of message, to be sent as follows:
S—Paid message.
SG—Service message.
XDH—Relay dead-head message.

Ques. (5) Is there any book or pamphlet published by the government or any publishing company which contains the new commercial and amateur calls, with facts as to power, wave length, wireless abbreviations and instructions concerning the transmission of messages? If so, where may it be purchased and what is its price?

Ans. (5) A book giving the calls, call letters, etc., of the radio stations of the entire world, may be purchased from The International Bureau of Telegraphs, at Berne, Switzerland. A booklet may be obtained from the Superintendent of Documents at the Government Printing Office, Washington, D. C., giving the call letters of all land and ship stations belonging to the United States, including amateur stations. The price is $0.15.

* * *

G. T. L., Providence, R. I.:

Regarding query No. 1, relating to the advantage of a loose coupler over a 3-slide tuner: Neither has any advantage over the other, for the reason that a loose coupling can be obtained with a 3-slide tuner as well as with a loose coupler.

Ans. (2) Communicate with any of the advertisers in our publication selling amateur equipment, and you will no doubt find what you want.

* * *

O. E. C., Boston, Mass.:

Communicate with Marconi's Wireless Telegraph Company, Ltd., Strand, London, W. C. They may be able to put in touch with some one who can furnish you with a Lodge-Muirhead detector.

* * *

H. P. R., Cleveland, Ohio:

Ques. (1) Please tell me what way my aerial is directional. It hangs North and South, with the lead-in taken off the North end.

Ans. (1) Sends best toward the North; receives best from the North.

Ques. (2) Also will it decrease the efficiency of the aerial if the lead-in is taken off the middle?

Ans. (2) It is rather difficult to answer.

The arguments in your question No. 3 are fully answered in the December issue of THE WIRELESS AGE, page 254.

* * *

F. D. Columbus, Ohio:

The wave length of your antennæ is approximately 260 meters. The capacity of your antennæ is approximately .00027 mfds. It will therefore require a condenser in series having a capacity of .00039 mfds.

A condenser having this capacity may be made on a plate of glass having a thickness of ⅛ inch, coated with foil having dimensions of 5 x 6 inches.

* * *

H. V. R., Los Angeles, Cal., writes:

Within a radius of twenty miles of Poulsen Wireless Stations using continuous waves, I find it is possible to read their signals on an ordinary receiving set intended for receiving damped wave trains. With a wave length of 2,000 meters the frequency of the arc would be about 150,000 cycles per second, which is far beyond the limits of audibility. Please explain how it is possible to receive continuous oscillations of such high frequency using the regular receiving set with a detector?

Ans.—This is very interesting, and it may be possible that you are getting a "heterodyne" effect on your receiving apparatus. This may be due to the fact that there is another Poulsen station in your vicinity, the oscillations of which are of a slightly different frequency than the stations you hear; it is possible that the coincidence of the two frequencies causes the phenomena of beats, making the signals audible. This is the principle of the "heterodyne" receiver.

Do you hear the signals from these stations constantly or only occasionally? If you hear the signals constantly, our explanation is incorrect. When an arc transmitting set is in bad adjustment, there is produced a useless superimposed set of oscillations, which in the immediate vicinity of the antennæ may exhibit damped characteristics, and are therefore audible.

Ques. (2) All so-called synchronous spark sets have the same number of spark points as the number of field poles on the alternator.

Ques. (3) There is no advantage in a duplex loading coil over a single loading coil. Duplex coils are designed to be used in connection with tuners the maximum wave length of which is below that desired.

* * *

H. D. E., Collingswood, N. J.:

VBB is the Canadian Marconi Station at Soo Locks, Canada. VDG is the Canadian vessel S. S. Aberdeen.

* * *

H. P. M., Duluth, Minn.:

The signals coming over the top of a continuous whistle are caused by certain sets that have a reactance coil in shunt with the key (using quench spark sets). The spark discharges constantly across the gap, but not to its full value. When the key is pressed the current at the spark gap increases to its maximum value, enabling the signals to be read over the top of the "continuous whistle."

* * *

H. P. R., Cleveland, Ohio:

Please advise what instruments are necessary to get NAX, Colon, with a 5-wire aerial, 100 feet long, averaging 50 feet in height, the aerial being of the inverted "L" type and directional Southwest.

Ans.—We are in doubt whether you can hear Colon unless your aerial is situated on the roof of an apartment house or some high building. If so, it would be perfectly possible to hear Colon in the night-time during the winter months, particularly if you use the audion amplifier described in this issue of THE WIRELESS AGE.

* * *

G. H., Brooklyn, N. Y.:

Connect all the wires of the aerial together at one end, bringing in the lead-in wire from the opposite end.

The hook-up necessary to give the information asked for in your query No. 2 is shown on page 166 in the November issue of THE WIRELESS AGE. This cut also shows the position of the variable condenser. The remainder of your queries are adequately answered by the cut appearing in that issue.

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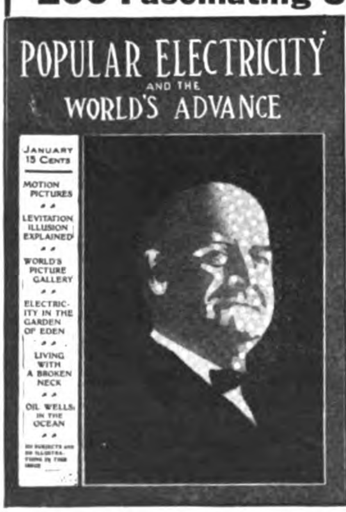

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