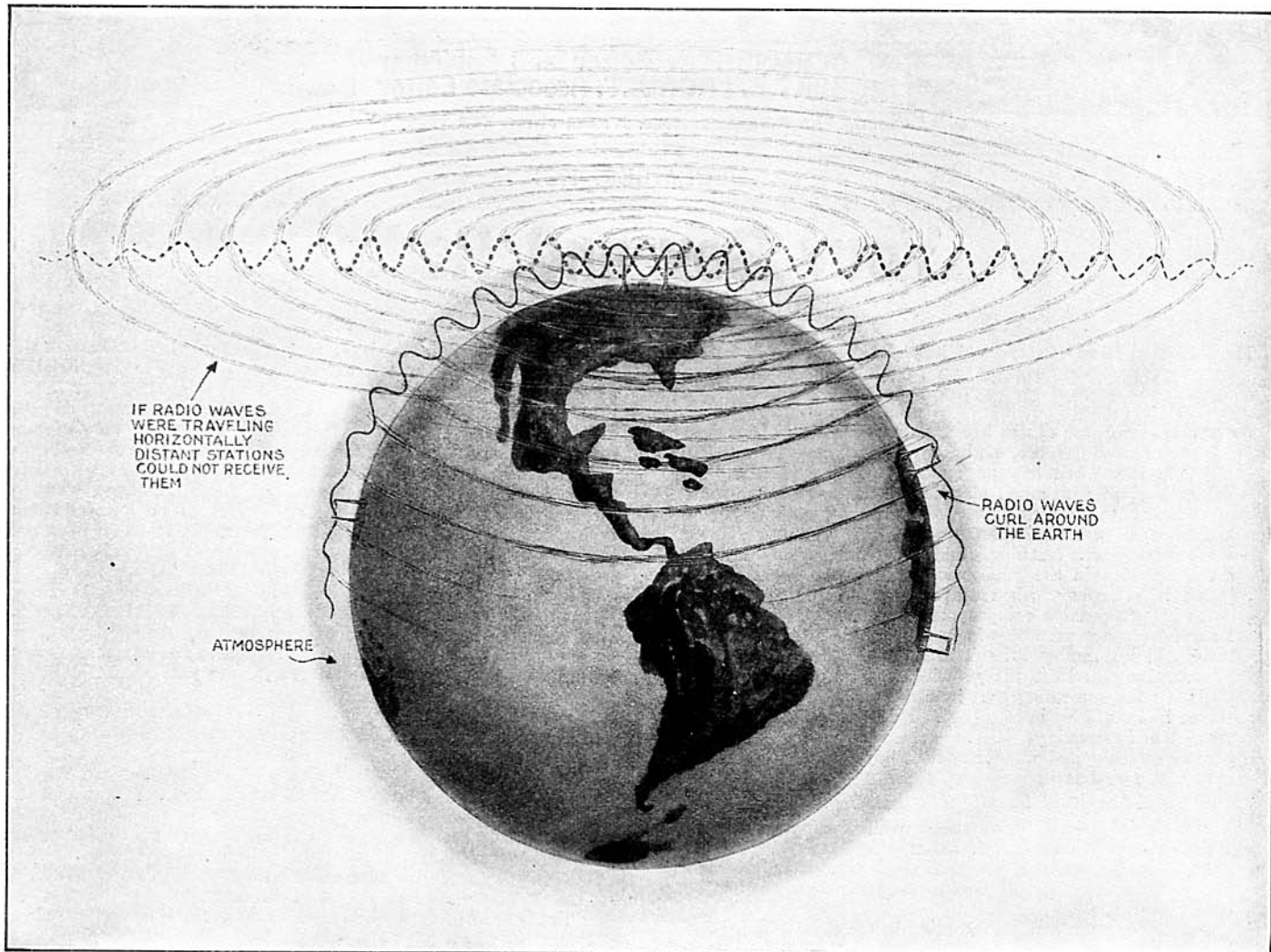


The Behavior of Radio Waves and the Heaviside Layer

By SIR OLIVER LODGE, D. Sc., LL.D., F.R.S.

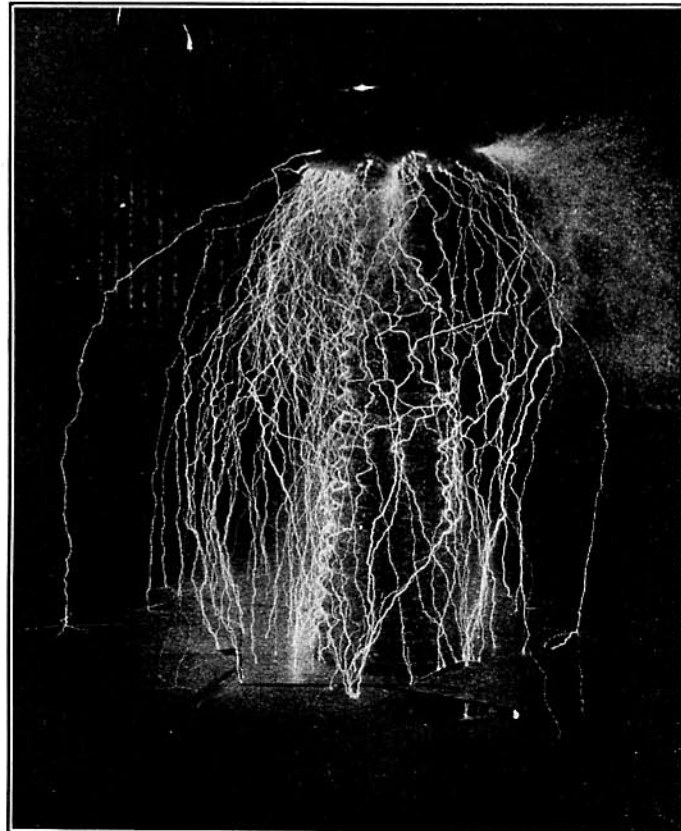


THE surprising fact that electric waves travel around the earth instead of spreading out in straight lines like the rays of ordinary light, has set a problem to mathematicians, which many have taken up and found to be of considerable difficulty. It is known that waves can be guided along conductors under certain conditions; in fact, that is how ordinary telegraph signals are conveyed, whether by land wire, or by cable: they travel through the insulator, but are guided by the conductor. Conductors are opaque to waves, they cannot be penetrated; at least the better the conductor the more opaque it is. But a conductor can reflect waves. If they establish a footing on its surface, they can creep, or rather flash along it, with great ease, leaving a little energy behind them if the conductor is imperfect, and becoming thereby somewhat distorted, but traveling almost free from distortion if the conduction is nearly perfect.

One way, therefore, of treating the problem of long-distance transmission mathematically is to imagine the earth a perfectly conducting sphere, and find out what would happen in that case. After solving this difficult problem, the data may then be modified so as to introduce a certain amount of resistance, making the earth an imperfectly conducting sphere, as if for instance it were totally covered by sea-water. A third attempt, hardly one tractable mathematically, can aim at distributing land and water into continents and oceans, and seeing what happens then. That, however, is one of the empirical problems that can only be approximated.

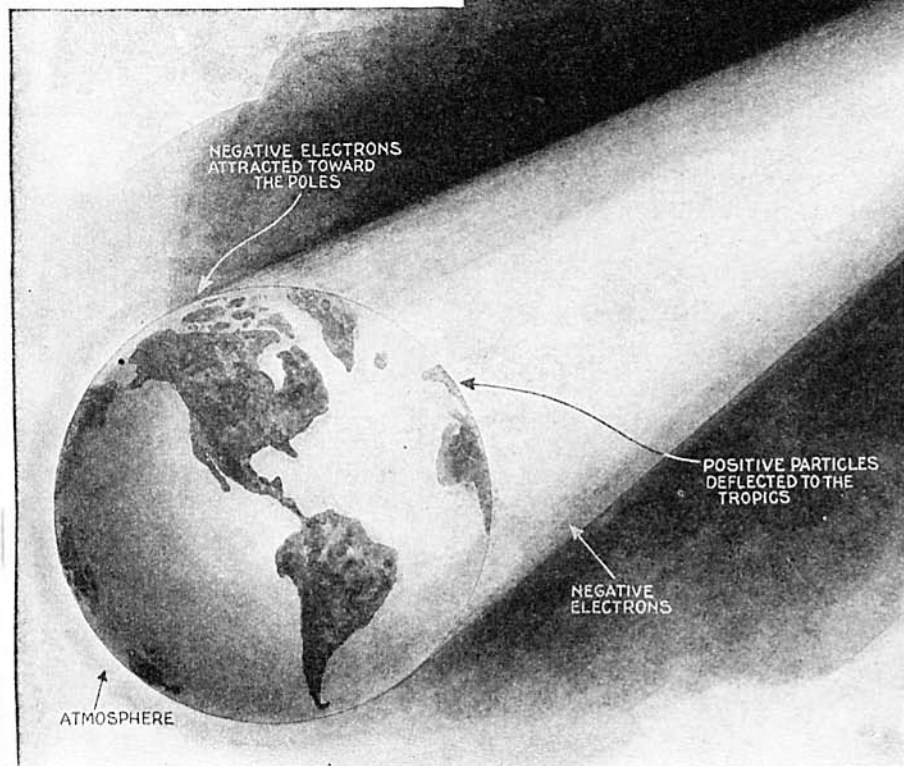
This graphic representation of wave propagation shows that if the energy of a radio wave were radiated horizontally, distant stations would not be able to receive the signals. The waves, according to scientists, are either reflected on the Heaviside layer or follow the curvature of the earth.

On the right the photograph of high frequency discharge shows that the currents of very high frequency do not follow the shortest path.



Another plan is to treat the subject optically, not electrically at all, and to think of waves curling round an obstacle by what is called diffraction. The laws of diffraction for small obstacles are pretty well known; and if the earth could be treated as a small body in comparison to the size of the waves—that is, if the waves were as big as the sun or the solar system,—then diffraction would be efficient; and there might be a focus or concentration of such waves at the

According to Arrhenius, the earth's magnetism separates the positive particles and the negative electrons from the sunlight, the electrons being attracted toward the poles and the positive particles to the equator.



antipodes. But that is a quite different notion from anything appropriate to radio telegraphy. Diffraction will not account for the curling round of ordinary ether waves. Nor is earth conduction very satisfactory.

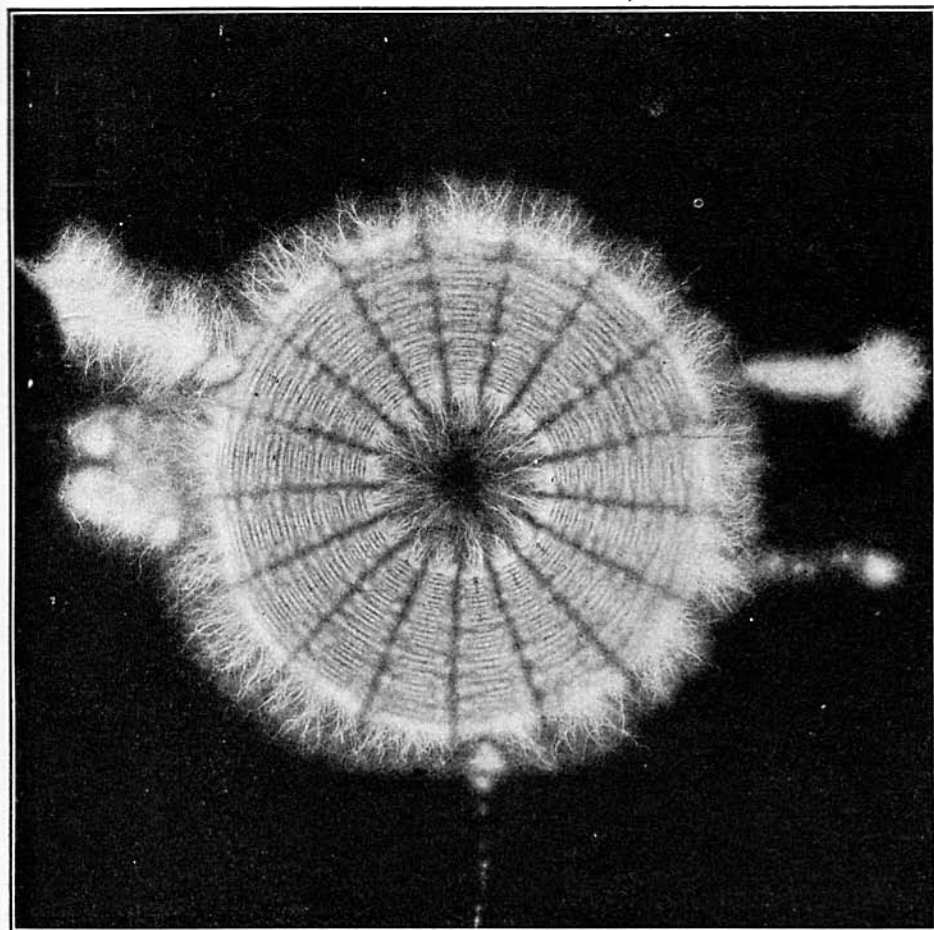
And yet the waves do curl round, and easily reach Europe. Whereas if they went in straight lines, they would be going far overhead, even for that distance. And now Mr. Marconi appears to find that even short waves, or comparatively short waves, travel enormous distances, under favorable conditions. What are those favorable conditions? If they were due to earth conduction, they would not be so likely to vary, as they do. The fact that they are capricious and dependent on sunlight and other causes, shows that the conditions must be partly regulated by the atmosphere. And as is well known, Mr. Oliver Heaviside attributed the curling-round of the waves to the influence of a good conducting layer in the atmosphere overhead, acting concurrently perhaps with the salt water below, so that the waves were enclosed in a stratum between two conducting surfaces, the air effect on the whole being more efficient than the earth conduction.

Everyone who has worked with vacuum tubes, with an air-pump, knows that at a certain stage of exhaustion, the residual air is conducting, or at least breaks down very easily, conveying a current and lighting up at very small voltage. Whereas, when the air is at high pressure, or very low pressure, great voltage is needed to drive a current through it. But at the best conducting vacuum, very small voltage suffices.

Now as we ascend through the atmosphere, we pass from ordinary atmospheric pressure to zero. Consequently a best conducting layer must exist. But a stratum of that kind is so gradual that it is unlikely to be able to serve as the layer postulated by Mr. Heaviside, even if it were sufficiently conducting. But it is well known that air can be made conducting by various means, notably by X-rays, and even by ultra-violet light; also by combustion, as by flames; and by various kinds of physical or chemical action, even by splashing water. These agents are said to ionize the air, that is, to eject electrons from atoms so that electric charges are free in the air for a time, and are able to conduct, as they do in metals, where for another reason they are extremely free.

The chief ionizing factor in the atmosphere is probably the solar rays. What we get down here of sunshine has been filtered by the atmosphere. But the upper layers of the air have to stand a bombardment of the unfiltered sunlight. By ascending a very high mountain or going up in a balloon, we may experience the sunlight only partially filtered. The result is that we get first bronzed and then blistered. There can be little doubt that the really unfiltered sun-

(Continued on page 1046)



This photograph shows the distribution of high frequency current in a spider-web coil. It spreads on the outside of the conductor, but follows it. The same thing probably happens around the earth.

XMAS GIFTS ON CREDIT

10 MONTHS TO PAY

**Sweet's
Diamond
Gift Book**

**Send for Your
Free Copy Today**

It shows a wonderful selection of Diamonds, Watches and Jewelry, Silverware, Ivory Ware, Toilet Articles and Novelties—all suitable for Christmas gifts. Make your selections today on our Easy Confidential Payment Plan—one-fifth after you receive and examine your purchase and the balance in ten easy monthly payments.



X2118—18K, white gold Spread-top ring. Blue white diamond, \$52.50.



X2119—Sparkling AAA quality diamond. 14K, Orange Blossom engraved betrothal ring, \$77.50.



X2120—18K, white gold Spread-top ring. Fine quality diamond, \$57.50.



X2121—Ladies' engraved 18K, Aquamarine ring, \$27.50.



X2122—14K, diamond set Gents' tooth ring, \$62.50.



X2123—Gents' 18K, white gold Spread-top Superior diamond \$97.50.



X2124—14K, white gold, 15 jewel hand engraved wrist watch. Sapphire crown, Nile ribbon, \$22.75.

OUR CHALLENGE If you do not find that our price on any diamond ring is at least 10% lower than that of any other concern, either cash or credit, we will gladly refund your payment in full, if you return the ring within two weeks. Send Today for your Diamond and Gift Book—IT'S FREE.

THE HOUSE OF QUALITY
AUTHORIZED CAPITAL \$1,000,000.

L.W. SWEET INC.

534-T

1660 BROADWAY, NEW YORK

or other prominent part of physiognomy of such persons.

If hangmen for such job are desired, I will be pleased to apply for such position, and can be secured at undersigned location at reduced salary.

Sensitively,
CHIN CHEW CHOW,
Shanghai, Ariz.

The Behavior of Radio Waves and the Heav- side Layer

(Continued from page 899)

light would be fatal both to animal and vegetable life. The radiation from so extremely hot a body as the sun is of a very violent character, having all the deleterious qualities of X-rays, and others in addition. So unfiltered sunlight constitutes a powerful ionizing agent. Also it appears that the sun itself shoots off free electrons, mingled probably with positive particles. These, according to Arrhenius, would be sorted out by the earth's magnetism, the positives falling mainly at the tropics, the negatives being deflected to the Poles, where they give rise to aurorae, the opposite charges ultimately recombining, with recognized atmospheric effects and earth currents and other disturbances.

Sunlight is one of the main causes, therefore, which may give us a fairly sharply bounded conducting stratum in the atmosphere; though it may be corrugated and otherwise distorted by heat effects. And this layer it is which has been treated as the main reflector or whispering gallery responsible for keeping the waves traveling around the curvature of the earth, and partially preventing their escape into space.

Dr. Eccles has dealt with the theory of an ionized atmosphere very thoroughly. And on the whole this Heavyside layer has been felt fairly competent for its work, though admittedly the whole subject demands extensive observation and record of experience, before the theory can be considered in any respect complete. Like all meteorological phenomena it is complicated by a multitude of causes and no one simple theory can adequately cover the ground.

In one of the interesting and instructive radio articles which Professor Howe contributes to the London paper "The Electrician" once a month, he comments (in the issue of June 13, page 720) on what he calls "the overworked Heavyside Layer" in the upper atmosphere, and on the criticism of it by Professor Guinchant of Bordeaux. This gentleman objects that the layer is not sufficiently conducting for low E.M.F.s, unless it is ionized; and he claims that the sun cannot ionize it, for two reasons: First, because a constant supply of electrons would soon overcharge the earth and deplete the sun; much as a thoroughly insulated filament in a vacuum tube could not continue to do its work properly. And secondly, because ultra-violet light can only ionize things when it encounters dust or solid particles. But I suggest that Professor Guinchant overlooks the exceedingly high frequency of some of the radiation likely to be emitted by a body at the temperature of the sun. Some of it would be X-rays, competent to ionize even oxygen atoms; and anyhow there is no doubt that the upper atmosphere is ionized; the Aurora is sufficient evidence of that.

The problem of the transmission of waves round the world is a most interesting and difficult one, and certainly the last word on it has not yet been said. But few acquainted with the facts can doubt that the atmosphere is largely responsible for the possibility. It must be the main deflector for world trans-

MODERN RADIO RECEPTION

**A New Book
by
Charles R. Leutz**

264 Pages, 150 Illustrations
Fully Bound

Partial List of Contents

Radiola Super-Heterodyne Diagram
Western Electric 4 B Receiver
Model C Super-Heterodyne
Model C 7 Super-Heterodyne
Long Distance Reception
Short Wave Reception
Long Wave Receivers
Plidynes and Super-Plidynes
Laboratory Equipment
Broadcast Transmitters
High Efficiency Amateur Transmitters
Model L Super-Heterodyne
and
Everything of importance relating to
Broadcast Reception.

Price

\$3.00 Postpaid

**Experimenters
Information Service**

Incorporated

476 Broadway
New York City

PATENTS WRITE for our Three Guide Books and "RECORD OF INVENTION" before disclosing inventions. Send model or sketch and description of your invention for Examination and Instructions. Electrical cases a specialty. Highest references, reasonable terms, prompt attention.

No charge for the above information.

VICTOR J. EVANS & CO.
919 NINTH ST., WASHINGTON, D. C.

NATIONAL CAPITAL VIEWS
Twenty-five beautiful Interesting Post Card Views of Washington, D. C. White House and Capitol Views included; twenty-five cents.
CAPITOL VIEWS
629 Second Street, N. W. Washington, D. C.



Far Better Reception Or your Money Back!

MAIL THE COUPON AT ONCE for a pair of these Marvelous, New, Karas Harmonik Audio Frequency Transformers. Put them in that new radio set you are building or put them in your old set in place of the transformers you are now using. Try them out—test them thoroughly for 60 days. IF YOU don't enthusiastically agree that they give you the most delightful radio reception you have ever heard send them back and we will return your money at once!

That's Our Special
Introductory Offer!

KARAS HARMONIK \$7.00

Those who are now using Karas Harmonik Transformers in their radio sets tell us if we could REALLY describe to all radio enthusiasts the exquisite pleasure of hearing this wonderful reception, they would all want Karas Harmoniks in their sets, at once. But there is only one way to fully realize the delightfully rich, round, full clear-as-a-bell tones of Karas Harmoniks, and that is to actually HEAR them! That is why we make this amazing trial offer.

We are stocking the dealers with Karas Harmoniks just as fast as we can. In the meantime we are making this "Proof By Trial" offer direct to those discriminating and particular folks who are keen to enjoy radio reception at its very best. If your dealer already has secured his allotment of Karas Harmoniks he is authorized to make you this offer.

We might give pages to telling you WHY Karas Harmonik Transformers give purer, sweeter, more natural music than any transformers ever built before. But it is far better to hear with your own ears and judge for yourself! So mail the coupon today. Please write very plainly. DO IT NOW!

Karas Electric Co.
4040 N. Rockwell St.,
Dept. 57-49
Chicago, Illinois

Send No Money With this Coupon

Karas Electric Co., 4040 N. Rockwell St., Dept. 57-49 Chicago

Please send me.....pair of Karas Harmonik All Stage Ratio Audio Frequency Transformers. I will pay the postman \$7 apiece, plus postage, on delivery. It is understood that I am privileged to return the transformers any time within 60 days if they do not prove entirely satisfactory to me, and my money will be refunded at once.

Name.....

Address.....

City.....

Dealer's Name.....

Dealer's Address.....

If you send cash with order we'll send transformers postpaid.

Insure your copy reaching you each month. Subscribe to RADIO NEWS — \$2.50 a year. Experimenter Publishing Co., 53 Park Pl., N.Y.C.

mission. If it is ever found that short waves are able to go around as well as long ones,—and some recent statements suggest that facts are trending in that direction; as then the whole question—I do not say it will have to be reopened, for it has never been closed—but the whole question will enter on a new phase.

The way in which natural conditions seem to assist long-distance radio communication, and as it were unexpectedly to lend a helping hand, is rather remarkable. It is generally said that the perfect adaptation of ways and means to ends, which we frequently encounter in the operations and processes of live things, must be due to their long-continued adaptation through the ages, and survival of the fittest. But that explanation cannot be applicable to a recent innovation like radio telegraphy; and it is interesting to find in the earth's atmosphere a favorable agent which indirectly promotes radio communication, even at enormous distances, and thus lends itself to the convenience of man, although the very recent inception and development of the process cannot have allowed any time for adaptation and survival.

A Marine Radio Operators' Association

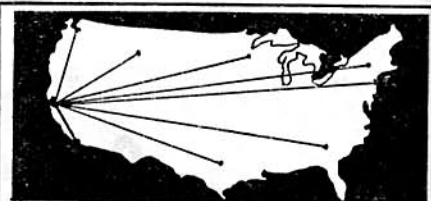
(Continued from page 953)

The mates and engineers have their associations, which are to be commended. However, in contrast to the radio operator, in some places they are over-organized with more than one association. Some of the mates or engineers belonging to more than one are oftentimes "on the fence" when certain issues develop. So it would be best for the operators to let their plight be an example and when they do unite, all belong in one organization.

When considering a Marine Radio Operators' Association, the following self-evident truths should receive some thought. Consider an increase of personal efficiency as a basis for the organization and stabilization of the profession; for betterment of the profession for present and future time. The profession can be bettered, and with a clean association as an agency, the present rights, position and remuneration can be maintained, thus granting basis for future augment. In Mr. Pyle's article, September issue, he states: "Very likely the operators on the lakes or on salt water doing the work mentioned, do it because if they protest they have no one to back them up!" When a steamship company cannot get an operator for a certain vessel they are bound to investigate the whys and wherefores and probably will, in a very short time, correct the existing condition in that particular case.

An association for the marine operator must issue an official organ to produce and give growth to the Fraternal spirit which must exist. The "I Tappa Kee" Fraternity is described briefly in this department in the September issue, in which article it is stated, "Were it not for the strong fraternal spirit of these men it would be difficult indeed to keep in touch with them." Due to shifting around or changing of runs, the operator has no opportunity for organizing personally and the bonds of the Association must be through letters and an official organ. The organ must be kept up and besides being instructive it must serve as the outlet for the human and personal element found in the profession.

It is evident that an honest, good, clean association for the Marine radio operators of this country could exist. Instead of "Why Not?" the question really is: "What is the most practical way to form such a 'Marine Radio Operators' Association'?"



ON ONE TUBE

BIG FREE BOOKLET tells the story. California users of CROSS COUNTRY CIRCUIT hear Atlantic Coast, Canada, Cuba, Mexico and Hawaii. Atlantic Coast users hear England to California. Our new plan makes this set easiest and cheapest to build. One hour puts in operation. One tuning control. No soldering. Any Novice can do it. BIG BOOKLET FREE or complete instructions for 25c stamps or coin.

WHAT USERS SAY

EAST—Am more than pleased with the parts ordered from you. The first night I hooked it up and received Omaha. Since then Minneapolis and Los Angeles. It works better without amplification than most sets with two stages. —Donalds, S. C.
WEST—I am sending you a list of some of the stations heard on one tube: WSB, WGY, KDKA every night. PWX, WWJ, WTAM, WLW every night. CFAC, CHCB. Not long ago I purchased another set of parts from you and first night got WGR, Buffalo, and KDKA. —Ione, Calif.

NORTH—Received coils OK today. If I have same results with these that I had with last will be wanting more. I am 1,500 miles from nearest station and have picked 56 to date. Chicago, Havana, Mobile, New Orleans and TWO IN ENGLAND. —Lunenburg, Canada.
BOX RN-117
Vesco Radio Shop OAKLAND, CALIF.

PATENTS

To the Man with an Idea

I offer a comprehensive, experienced, efficient service for his prompt, legal protection and the development of his proposition. Send sketch, or model and description, for advice as to cost, search through prior United States patents, etc. Preliminary advice gladly furnished without charge. My experience and familiarity with various arts frequently enable me to accurately advise clients as to probable patentability before they go to any expense. Booklet of valuable information and form for properly disclosing your idea free on request. Write today.

RICHARD B. OWEN
PATENT LAWYER

2 Owen Building, Washington, D. C.
2276A Woolworth Bldg., N. Y. City

Six Tools in One

\$1.25

A radio socket wrench that fits every round and hexagonal radio nut

Sockets ranging from 1/4" to 1/2"

How it works

Place socket of required size on end of shaft with slots not in line with lugs on shaft.

Buy it from your dealer or direct from us

THE PERRY-FAY COMPANY • Elyria, Ohio
Screw Machine Products