

# MAGIC TOUCH OF CALIFORNIA WIZARD OF ELECTRICITY HAS HARNESSSED SOUND WAVES AND LINKED CONTINENTS

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**Vacuum Bulb Invented by O. B. Moorhead  
Has Accomplished Miracles Undreamed of  
Even in Days of Aladdin and His Lamp**

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**Messages Carried by the Most Infinitesimal  
Vibrations of the Air Are Captured From  
All Corners of the Earth and Translated**

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## MOORHEAD INVENTIONS HAVE SOLVED RADIO PROBLEMS THAT LONG BAFFLED GENIUS OF EDISON AND MARCONI

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**Young Californian Is Given Credit for  
Improvements That Have Placed Radio  
Communication on New and Reliable Basis**

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**Inventor Wins Brilliant Success After  
Obstacles That Had Appeared  
Insurmountable to Many Predecessors**

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By **GEORGE J. DURAIN**

**T**HIS is the story of a California boy with a vision, of whom all Californians ought to be exceedingly proud.

It is the story of how a dream was conceived almost in the cradle, and how it was finally realized in the only way dreams can ever be realized, by hard work.

It is the story of achievement in the face of discouragement and difficulties, the story of how a comparatively unknown individual by dint of application and dogged persistence so solved certain great problems that had baffled the mightiest inventors of the age, that he succeeded where Edison, Marconi and De Forrest failed, and while hardly out of his teens thus made himself a world figure in the field of radio activity, with a future assured for all time.

Great men are outwardly like everybody else. They look like us and even speak like us, sometimes not as well as those of us accustomed to toot our own horns. We even pass them by in the street unnoticed.

The writer once sat on a bench on Riverside Drive, New York, near Grant's tomb. On one side of him was a small, stout little man with a white mustache, and on the other was an elderly, thin man with a careworn face but with iron determination written in his stern, gray eyes and set mouth. He was talking to a lady. The writer paid no attention to either man.

Suddenly, a white-haired individual with well-known features came along, and said to the first man on the bench, "Hello Dean."

The white-haired speaker was Mark Twain, and the man he was addressing was Dean Howells, the celebrated novelist. The third, thin man, with the careworn face turned out to be John D. Rockefeller.

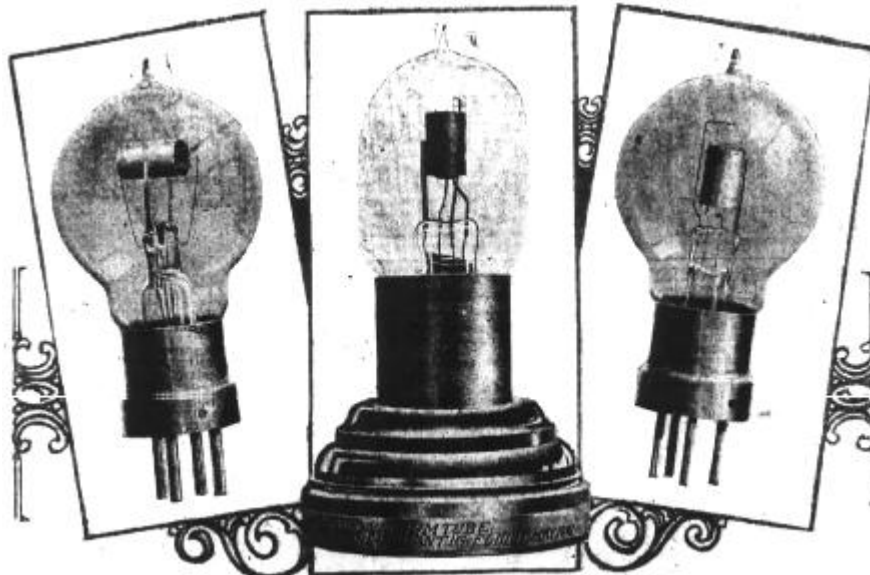
Hundreds passed these great men by without knowing who they were, or noticing them in any way.

This is why we, in San Francisco, pass by unnoticed men like Otis B. Moorhead, because he is young

and boyish, and in his talk does not appear to be in any way remarkable.

But if we were privileged to study him at his work, to talk to him of his dreams and visions, of the things he really loves, to examine what he has done and the methods he has followed, if we could see the high place he occupies among the great inventors in radio activity, the new science of the present inter-continental and, possibly in the not distant future, planetary communication, we will come to the irresistible conclusion that this young fellow San Franciscan of ours belongs in the class of the really great in that he has done some really great things.

**UPPER PICTURE SHOWS GIRLS AT THE DELICATE TASK OF WITHDRAWING residual gases from vacuum bulbs in the Moorhead laboratories. In the center are three of the famous Moorhead bulbs that have revolutionized radio-telegraphy. The bulb shown in the middle was used on the United States Navy seaplane NC-3 on its transatlantic flight, and later presented to Mr. Moorhead a s ouvenir.**



## **Little Instrument Can Perform Wonders**

Does the ordinary reader know that any man traveling in an automobile at a rapid rate can open a little receptacle not larger than a cigar box, take out a perfect telephone and communicate at once with his family or his office miles away without any wires of any kind?

Does the ordinary reader know that it is possible for a man lost near the North Pole, or stranded on a wreck in mid-Pacific, or marooned on a desert island of the South Seas, or abandoned in the depths of equatorial Africa, to take a little device out of his pocket and immediately hold converse with civilization thousands away?

These things are not vague dreams, not among the bare possibilities. Most of them have been done. They are twentieth century realities.

Today communication by wireless telegraph from San Francisco to Sydney, Australia or Manila, the Philippine islands, or to Cape Town, South Africa, are accomplished facts. Already it is possible to talk from New York to London without wires, and so perfect are these methods being made that before long people will be talking all over the world with the same ease with which they now converse with friends across the street.

And the man who has made these marvels realities, who has presented this rich gift to mankind, is not Edison nor Marconi, nor Bell, but a young San Franciscan, Otis B. Moorhead. Moorhead has gone the great wizards of wireless one better and has earned the right to be classed in the same exalted Pantheon.

### **Improvements Made in Detecting Methods**

For, as the reader will see, it is not so much the improvements in Marconi radio plants as to increased power in transmission that has brought about the revolution in wireless. Rather it is increased perfection in detecting small and feeble radio currents sent around the world, and formerly unnoticed because we had no sensitive devices to detect these imperceptible emanations.

It is improvements in detecting methods made by Moorhead that have given the tremendous strides now being made by wireless telegraphy and wireless telephony, that are making a real practical success, and not uncertain instruments as in past, great in possibilities, but lacking that essential perfection making them efficient, reliable and stable.

As a result of these improvements we may confidently assert that the old isolation of man on this planet has been completely broken down, and it is possible now to make arrangements for wireless communications to be held with any one wherever he may be in the wilds or deserts of nature.

### **California Inventor Is Unassuming Wizard**

Indeed we may further, in truth, say that Moorhead has given man the power to communicate with the planets of the interstellar spaces, provided that they be inhabited by thinking beings like ourselves and are capable of transmitting sound wave through the ether. For with Moorhead's valve any sound waves sent forth from the depths of space can be detected and interpreted, even though it may be so feeble as to amount to not more than the energy of a butterfly lighting softly on a rose.

How is this done? How can these faintly fluttering currents from afar, which before sped on their way to infinity unnoticed by mortal means, be picked up so that they may reveal their secret messages to man?

To explain this clearly so that all may understand and to give the proper credit to those contributing to this great step forward in civilization is the object of this article. And in reading this account of Moorhead's achievement remember that he is one of ourselves, a genius, whole-souled San Franciscan and true Californian, and withal just such a big lovable boy as you would imagine or want him to be,

modest and unassuming when talking of his own deeds, and genial and pleasant in his personal relations.

Yet none is more enthusiastic and gloriously alive with inspired enthusiasm than is this California wizard of electricity when speaking of the possibilities of wireless. For he has the true spirit of the pioneer. He has the vision and the radiant faith that moves mountains.

In studying the history of any of the epoch-making inventions which revolutionized both industry and the social life of the world during the last 100 years we find that there have been various claimants to the chief honors of having first devised these wonderful creations. The patent courts have been constantly full of rival claimants pitted against one another in infringement suits. This was true even of the aeroplane.

### **Tiniest Sound Wave Can Be Heard Now**

Thus are we, through this gifted young San Franciscan, brought so near to talking with the god's.

Moorhead has made it possible to detect the faintest sound of electric waves, waves so evanescent that they do not represent in actual power a small fraction of a millionth of an ampere.

This was the great defect of wireless telegraphy and wireless telephony up till very recently. And it was a fatal defect, forever interfering with real progress in radio science. The faint impulses given out by the most powerful radio stations thousands of miles away, could not be detected, and hence they were lost forever. Students knew these waves existed, but there was no known means of gathering them up and interpreting them. All the great minds of radio science were absorbed in this mighty problem, for the whole future of wireless depended absolutely upon progress in this direction.

Moorhead has made it possible to detect these minute, etherial wavelets, otherwise imperceptible, so that a human voice in the heart of the Arizona desert, or at the tip end of Greenland, can be heard with ease in San Francisco.

The fact is there is not a single great invention of the industrial era that any one man can claim to have absolutely produced in all its phases. This holds good for the steam engine, the locomotive, the steamboat, the telegraph, just as well as it holds for the automobile and radio communication. In the case of the steam engine we can trace historically a long line of contributing inventors going back as far as Hero of Alexandria, who in the second century before Christ actually produced mechanical revolving motion by means of steam.

### **Great Inventions Work of Many Minds**

This ought to be plain. It comes from the fact that when there is a great social need to be solved through an invention many minds will be found working on the problems involved, and applying the different scientific principles as far as they are known.

Consequently, it frequently happens that in a great invention one man in one land will devise so a certain indispensable element that advances the solution, and another inventor a thousand miles away will devise another and perhaps similar element which advances the invention a step further on toward ultimate success. All of these different but essential elements develop rival claimants. There may be two, three or a dozen different complicated and vexing problems presented by an invention which now one inventor succeeds in solving and now another.

Last comes the man who gives the final answer, who says the last word, who supplies the ultimate principle or device, and who in saying this last word makes the invention a comparatively perfect device for the purposes for which it is designed.

### **Moorhead Put Final Touch on Vacuum Bulb**

And it is just such a part that Moorhead has played in the evolution of the vacuum bulb, the main

instrumentality for long-distance wireless, the thing which is giving it its greatest commercial success. From now on Moorhead's fame cannot be disassociated from that of other great inventors responsible for this conquest of the air and its sound and light waves. The glory of his achievement will be all the more appreciated from the fact that he has put the final touch of perfection on the work of such master minds as Edison, De Forrest and Marconi.

A great deal of confusion prevails about the subject of the vacuum bulb, as regards both its operation, the part it plays in wireless telegraphy and telephony, and also as regards the proper credit which belongs to the various inventive minds that have contributed to its production.

The vacuum valve in radio activity is the agency which can either receive or transmit the mysterious waves of sound or ether, by which communication at a distance, without wires, is made possible.

The wonder of the Moorhead vacuum valve is that it performs many functions, acting as a detector, oscillator, rectifier, amplifier or transmitter. It can receive a message. It can transmit a message. It can intercept the message of another system.

### **Early Inventors Left Big Problem Unsolved**

Its own message is silent as the grave to the world other than to the receiver intended. This is because no other wireless system can pick up the wavelets that are as plain as day to the Moorhead vacuum valve.

Of course Marconi was the first by his apparatus with the coherer and the wire-rigged antennae that made possible the holding of long distance wireless. To accomplish this great feat was enough glory for any single human being.

But if wireless had stopped in its early stage with Marconi, De Forrest and Fleming, it would never have amounted to anything but a possibility. There were other steps necessary before it could emerge into the stage where it was mechanically perfect enough to be a commercial success.

As to the scientific principles behind radio telegraphy, Marconi himself did not discover them. Maxwell came first with his discovery of light waves, and next came Hertz with his oscillator, showing the way to the coherer.

The greatness of Marconi lies in the fact that he devised the first mechanical apparatus which successfully applied principles well known, and revealed by Maxwell, Hertz, Crookes and Sir Oliver Lodge.

It was an immortal day for the world when the flashlights of the great plant on Newfoundland met an answering spark on the coast of Ireland, and human thought in the twinkling of an eye leaped the continents and the seas. It meant the annihilation of space. How puny is the human voice! But from now on man had in his possession an agency to make that puny voice greater than the roar of the cataract, or the thunder of the storm, for now it was in time to be heard around the world.

When we come to the consideration of the vacuum valve, we can see that a number of the world's foremost inventors were responsible for its development, each one having contributed some important element.

### **Edison Experiment Gave the First Clue**

There is only one way to get at the truth, and that is to state the facts. The best way, therefore, to explain the part played by Moorhead in the development of wireless, so that there can be no dispute or challenge by anybody of the credit to which he is entitled, without at the same time disparaging the glory due to other men like Marconi and De Forrest, is to state the plain facts of the evolution of the vacuum bulb, to give, as it were, its natural history.

Using this scientific method of investigation we have the following prominent and indisputable facts about the development of the vacuum valve.

First: It was Thomas A. Edison who first discovered in his laboratory, shortly after he invented the carbon lamp, the phenomenon known as the "Edison effect." Edison, absorbed in another great problem, saw nothing but a laboratory phenomenon in his discovery, and passed it by as of no commercial value. Many others did the same.

What is an "Edison effect"? Divested of technicality, it is this: When a cold plate is introduced in an incandescent bulb and sealed inside, a current travels from the hot element to the cold plate.

Nothing was done with this important discovery of Edison until Professor Fleming of England, an electrical expert connected with the Marconi Company, made the additional discovery that the current would flow in one direction, and in doing so it would act as a rectifier.

### **De Forrest Succeeded In One Improvement**

Now one of the main unsolved problems of radio science was to provide a sensitive detector, and Professor Fleming discovered that the "Edison effect" could be applied as a detector. He obtained a patent, which was passed on to the Marconi Company.

Of course it is apparent that the more sensitive a detector, the longer the distance and the weaker the signals that can be heard. The first Fleming detector was considered a very sensitive detector in the early days of wireless.

Next came L. De Forrest, the great American inventor, co-discoverer and co-sharer with Marconi of the honor of first making wireless communication possible. De Forrest inserted another element in the vacuum bulb called the grid. The object of the grid is to control the current that flows between the hot and cold electrodes. This new device invented by De Forrest increased the sensitiveness of the detector by many hundreds of times over the old Fleming valve. This made possible the extension of wireless communication by many degrees.

But one of the main problems of radio communication was still unsolved, which to a large extent retarded radio development. For though all of the devices mentioned were excellent they were not stable. They could not be relied upon and were liable at any time to be rendered useless by the burning out of the filament. This was the universal condition of the vacuum valve made by the greatest inventors up to this period, and this instability made them useless at critical times. Not only were they unstable, but they were hard to manufacture, and not even the greatest mechanical firms of the world, such as the General Electric Company, could produce them in quantity.

### **Young Californian Revolutionizes Industry**

It is at this critical and important stage of the development of radio communication that our young Californian, Moorhead, enters with his most essential contributions. He took a defective valve and by his mechanical genius transformed it into an efficient valve. He took an unstable and unreliable valve, liable to burn out at any moment for no apparent cause, and made it stable and reliable at all times. He took a valve that not even the greatest experts and the brainiest inventors of the world could manufacture in quantities, and began to do this very thing, at a time when the safety of democracy and civilization depended largely on a large supply of vacuum valves for the airplanes of the allied armies.

It must also be remembered that all the wonderful advance made by radio telegraphy and radio telephony in the last few years has depended absolutely on, and been made through the instrumentality of the vacuum valve.

This splendid exhibition of creative mind on the part of our young California inventor beyond all doubt places him in the wizard class, alone with the great necromancers and Aladdin's who have given mankind those priceless gifts that enable them to speak to men in mid-ocean, to move mountains with ease, to ride the storm cloud like an archangel on the wing, to pass the human voice on to the unborn generations.

## **Success Resulted From Much Patient Effort**

Of course, Moorhead did not suddenly jump upon his discoveries that finally perfected the vacuum valve. His inventions were not made by accident. His splendid work in solving the most baffling problems of radio science is only another illustration of Carlyle's definition that genius is nothing but a capacity for infinite pains. It was only after long and arduous work that Moorhead succeeded in evolving the most perfect vacuum valve in existence.

After three or four years' hard study of the vacuum bulb during which he designed hundreds of them without ever building one, he finally designed a bulb which was theoretically perfect.

The first baffling problem he had to solve was to prevent the filament from burning out. This was the most serious, if not fatal, defect of the old bulb which soon rendered most of them useless. For in time of emergency to have your filament burn out was to render wireless useless. It was like the telephone or telegraph wires breaking down. Communication was off; the lines were dead.

Moorhead finally solved this vexing problem, that not even Edison or Marconi were able to overcome, by stream-lining the film. After this the filament no longer burned out and its life was indefinitely extended. It was now a stable and reliable bulb, and could be relied upon in an emergency.

A second great improvement of Moorhead was to obtain complete control of all the forces acting within the bulb. The grid and plate construction was revolutionized by him and changed to a cylindrical form, which enabled him to take advantage of all the forces acting within the bulb, so that receiving or transmitting could be managed with ease.

## **Commercial Success Is Finally Attained**

A third, and just as important, improvement of Moorhead's was in devising methods to remove the residual gases within the bulb after manufacture, which largely accounted for the previous instability. It was also these residual gases that decreased sensitiveness in detecting the faint waves impinging from space. These original devices for the evacuation of those retarding residual gases have largely contributed to the present perfection of the vacuum valve, and these are all Moorhead's own.

The effect of these three great improvements, on all of which Moorhead has obtained protecting patents, and the glory of which no one can deprive him, was to increase the sensibility, durability and all-round reliability and efficiency of the vacuum valve by many hundreds of times, so that from an inconstant factor it became that one thing necessary to commercial success, stable and reliable.

It was Moorhead, therefore, who put that final finishing touch on radio communication that made it, in a critical period of the world's history, capable of being used extensively in the Great War. Without his inventions such use would have been utterly impossible.

Of course the winning of the world war cannot be laid conclusively in any one factor. There were many elements essential to its success the lack of which would have been serious, if not fatal.

If this be so, there is no question that one of the essential factors contributing largely to the ultimate winning of the war was the superiority of communication upon land and sea by the allies. And the one element in the last year of the war, when this superiority was most manifest, that chiefly enabled this superiority to exist, was wireless transmission through the use of the Moorhead vacuum valves.

## **Invention Played Part In Winning the War**

The wireless telephone was the all-important medium through which the air scouts not only summoned quick aid but were able to dispatch reliable information of inestimable aid to the armed forces of the allies.

It was therefore largely through California ingenuity that the German airmen began to lose their

morale through the almost uncanny way by which the allied birdmen both conveyed and received word from their brothers in the air, and from main headquarters. No signals could take the place of this instantaneous and reliable telephonic communication by which the most important movements, the position of guns, the place of supplies and munitions, were immediately made known to the allied military commanders, so that the information could be acted upon at once.

One of the miracles of the war was to see an aeroplane of the allies shoot into space over the German lines, gather important information as to the disposition of troops at critical moments, and then suddenly fall a victim to superior numbers. Yet the valuable information, and the revelation of the plans of the enemy would still be in the hands of the allied generals. Nothing so mystified the Germans as to how this was done.

Again, German messages from German aeroplanes were picked up, intercepted here and there, and communicated almost instantaneously to the allied headquarters.

### **Britons Are First To Recognize Valve**

All these marvels were done through the genius of our young California inventor, for without the use of the devices of Moorhead they would have been impossible. The Germans could not detect the messages of the allies simply because they had no vacuum valves sensitive enough to intercept the minute waves of radio telephony.

The same large part played by wireless telephony on land was largely duplicated on the sea in the running down of the deadly submarines. Aeroplanes equipped with the Moorhead bulbs scoured the seas for the prowling marauders of the deep, and whenever the trace of a pirate was found they could immediately hold converse with some ship of war within range, and thus bring a destroyer or cruiser after the enemy and end its career with a depth bomb.

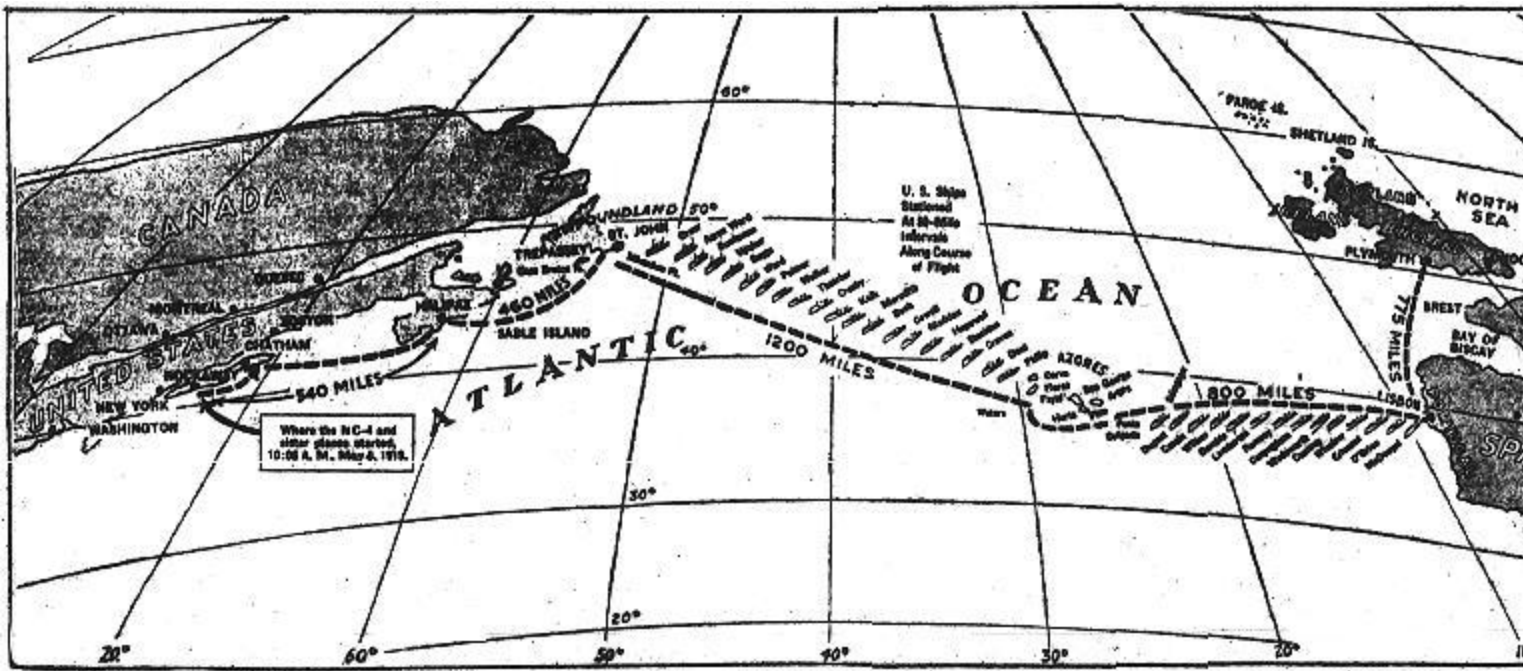
It was in this way that California inventive genius aided the allied navy and came to the assistance of Marshal Foch in those days when the fate of the world hung in the balance, in July, 1918, when he began his final and overwhelming march against the enemy and had to keep in constant and instant touch along his whole gigantic line.

It was the British Government, early in 1918, that first attested its faith in the Moorhead valve, after a thorough investigation and test by its experts, covering the whole field of radio activity, by placing an order amounting to considerably more than \$200,000 with the Moorhead Laboratories asking that bulbs be supplied with the utmost speed. After the completion of this contract other extensive orders came from the British Government, showing that the valve manufactured by Moorhead had not failed to continue its superiority over all others. In fact the highest officials of the British Government took occasion to officially compliment Moorhead on the superior quality of his work and the splendid practical results obtained from its extensive use.

### **Navy Used Invention on Its Record Flight**

**Below is a diagram of the U. S. Navy's record-breaking flight across the Atlantic which the Moorhead bulbs helped to make a success.**





Where the NC-4 and other planes started, 10:00 A. M., May 4, 1919.

U. S. Ships Stationed at 24-Hour Intervals Along Course of Flight

After the fame of the Moorhead valves had spread throughout the aeroplane world, the United States Navy began to take it up by giving orders for its seaplanes. The United States Government recognized the value of these valves by causing Moorhead devices to be installed in the Steamer George Washington for all wireless communication.

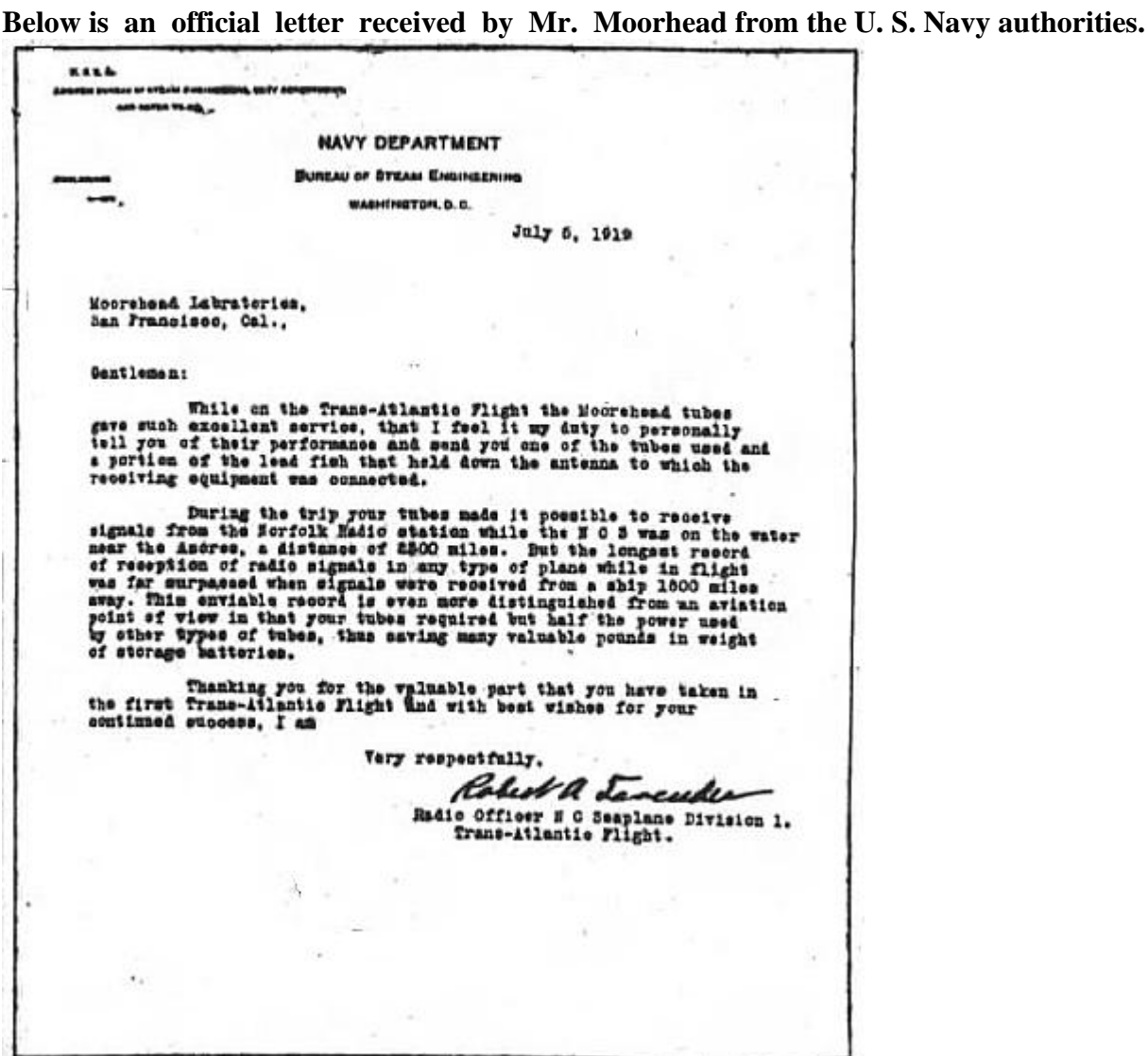
Probably the best example, or at least the most spectacular case of the success of the Moorhead valves at sea in radio telephony and telegraphy, was its

installation and use on the United States Navy seaplanes that made the first trip across the Atlantic.

One of the events that will thrill the sporting spirit of the ages to come was the magnificent feat of the daring aviators of the United States, who fulfilled the dream of our generation flying from shore to shore across the Atlantic.

And in this transatlantic flight the Moorhead valves were installed on the NC-3, NC-1 and NC-4, for the purpose of communicating from shore to shore, and to all the ships stationed on the route, as the accompanying illustration will show.

That the Moorhead vacuum valves played a valuable part in the success of the U. S. Navy in this monumental feat of first crossing the Atlantic and that Moorhead himself will participate in the perpetual glory of that success, is attested by an official communication from the radio commander of the seaplane division of the transatlantic flight.



### Next Problem Was Large-Scale Production

One of the proud possessions of Moorhead is the Moorhead valve, S. E. 1444, serial number U. S. 629, used on the seaplane NC-3 in the transatlantic flight in May, 1919. This bulb was taken from the seaplane, mounted by Commander Lavender and presented to Moorhead as a testimonial of appreciation on the part of the Navy officials for the part played by Moorhead valves in this great world event.

After having been the only man in the world who succeeded in creating a vacuum valve that met the requirements of the radio situation, in that for the first time wireless communication now had an agency

that was reliable, constant and stable, Moorhead was only half through his job. He had succeeded in making a practically perfect vacuum valve. Now the second part of the problem was to manufacture his perfect valve in quantities. His invention was of little avail unless it could be produced in numbers at short notice. The demand for it was tremendous. Thousands upon thousands of valves were needed immediately by aeroplanes of the allies and by the land and sea forces. And these had to be constructed at once and rapidly.

It is a question whether one ought to admire more the wonderful success of our young California genius in constructing a practically perfect vacuum bulb, where the greatest world inventors had failed, or whether we ought to give still greater credit and appreciation to the no less complex problems solved in the production of the bulb on a large scale to suit the requirements of the world war. One has only to watch the complicated process of the manufacture of a single valve and the almost endless operations of the most delicate kind necessary to complete it, involving the use by experts of a half hundred different machines in order to appreciate somewhat the tremendous task that confronted Moorhead.

### **Moorhead Laboratories A Wonderful Workshop**

If anyone doubts that O. B. Moorhead is not a master mechanic of the first rank all he has to do is to pay a visit to the Moorhead laboratories at 638-640 Mission Street. It is undoubtedly in this, one of the finest workshops of its kind in the world, that Moorhead gives us the secret of his success.

And that is thoroughness, persistence, application, and hard work, in connection with a clear idea of just what he wanted to accomplish. That is why the machine shop of Moorhead is the product of a master workman.

Many young men in school and college are asking what are the secrets of success. Here Moorhead gives them a sane practical answer. Concentration and work applied to the task in hand. Know what you want, and stay by it till you get it.

Besides being a dreamer, a man with big visions, Moorhead is intensely practical, and has the clearest ideas on the problems connected with his work. Only the closest study could have given him this lucidity of conception of electrical problems and conditions. Indeed, he has been at it ever since he was 8 years old, when his interest was first excited in wireless. Since that time there is not a book written on the subject that he has not digested, and not a problem unsolved that he has not studied and tried to answer. This is why Moorhead is a world figure in the radio field today, as well as being on the road to great riches.

### **Inventor Has Made an Art of Mechanics**

In going over the Moorhead laboratories the one conclusion forced upon the mind is that the inventor has made a fine art of mechanics. Everywhere is thoroughness, efficiency and maximum of production. So finished is the completed performance that the whole process gives one the sense of the beautiful.

Everything connected with the manufacture of the vacuum bulb is here undertaken, from the molding of the glass bulb to putting on the last finishing tip of brass. To give one an idea of the extreme delicacy and complexity of construction there is in the vacuum bulb, it may be stated that there are 2235 movements in the manufacture of each bulb.

And when one examines the complicated machines used in some of these operations, the brain reels at the attempt to calculate the nature of some of the fine achievements resulting therefrom. Glass tubes as fine as a hair yet perforated by a hole throughout, other glass so thin as to be almost breakable at the touch yet capable of withstanding great atmospheric pressure, wires so fine as to be almost invisible, yet capable of standing the strain of electric energy glowing with heat. The whole operation recalls nothing so much as the construction by the jeweler of the delicate mechanism of a fine watch. For each bulb must be made absolutely accurate to the one ten-thousandth of an inch.

## **Moorhead Designed All New Machines**

The production of a Moorhead bulb is therefore a marvel of exquisite workmanship. The writer has seen nothing, even in the famed Edison laboratories in New Jersey, to excel in these lines the highly original work of Moorhead in machine construction and operation.

The difficulty of Moorhead, when he had produced his vacuum valve, was that he was confronted with the fact that there were no machines in the world which could manufacture on a large scale the various parts, so that they could be standardized and put together rapidly, thereby making a commercial success possible. He, therefore, not only had to design his whole machine shop along original lines, but he also had to invent and perfect all the various machines necessary for performing the many difficult operations.

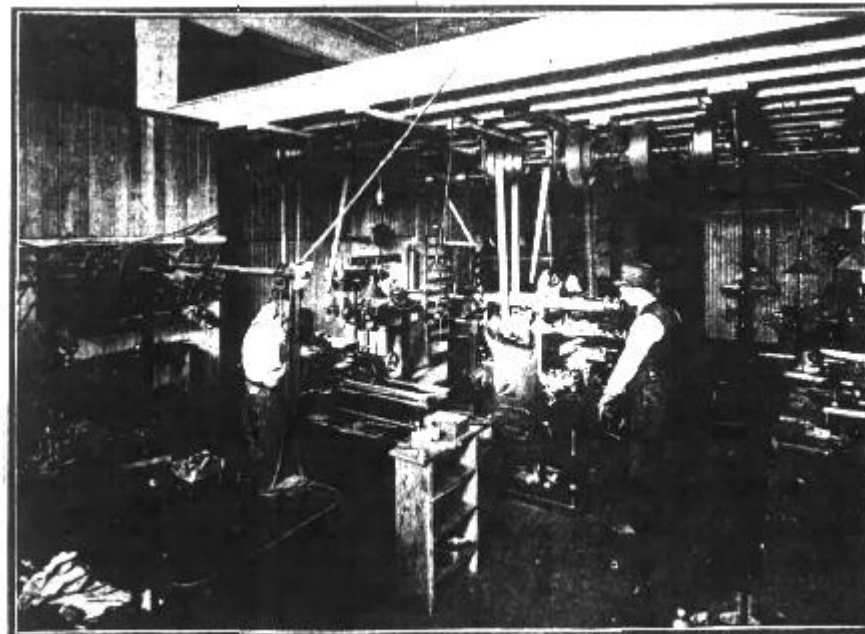
## **All Bulbs Tested Before Leaving Shop**

In addition to this he had to select and train the entire staff of the new shop, to teach them how to operate the new machines so that all could co-operate harmoniously in the production of the bulb by specializing on each of its parts. As there were 125 operatives this was some task.

Among the complicated machines that Moorhead had to either redesign or invent for the large scale production of his valve were the following: First, blowing of delicate glass by machinery, making the manufacture of glass bulbs in large quantities possible; second, machines for creating vacuums on a large scale had to be devised; third, welding low-pipes for platinum, copper and nickel wires had to be made suitable to the requirements of bulb construction; fourth, machines for crimping wires as fine as the finest leitz, yet flexible and strong, had to be invented; fifth, miniature spot welders had to be devised.

Besides all these producing machines there is a testing-room with still other original machines, where a staff of inspectors test every valve electrically. No bulb is ever permitted to go out below a certain standard. For this reason the Moorhead laboratories maintain the proud boast of absolute reliability, and that an imperfect Moorhead bulb is unknown in the commercial world.

**PAINSTAKING WORK AND THE UTMOST CARE ARE ESSENTIAL IN MAKING** the intricate little bulbs that are to catch the tiniest of sound waves. In the upper picture, girl handworkers are fashioning some of the delicate glass parts of the bulbs. Bottom picture shows a portion of the Moorhead Laboratories and some of the complex machines in operation.



In the production of the Moorhead valve one entire floor of the laboratories is devoted exclusively to the manufacture of glass bulbs. When blown in the rough the bulbs must have their stems shortened, and must be tubulated for pumping. The tubulating is performed in a machine having two heads, one of which fuses the glass where the pip is formed, this being blown out by small internal air pressure. In the meantime the tube is heated under another gas flame and the bulb is transferred to the carrier holding the tube and the two parts fused together. It is then taken to a ring of flame, which plays upon the stem, the surface metal falls by gravity, and the end of the stem is blown out and broken off, thus leaving a bell mouth for the operation of sealing in the elements.

**Much Delicate Work Required in Making**

In addition to these complicated operations three other machines are necessary for sealing the element support wires into their places, each machine having four heads. Three more machines with four heads seal the complicated elements into the valve.

The next operation is the sealing-in process, the glass members being placed in rotary annealers to eliminate cracking. The valves are then inspected, and after a thorough testing are passed to the pumps for evacuation of the residual gasses. Ten ovens are employed in this operation, each one being fitted with a Langmuir mercury vapor pump, each holding fifty valves at once. The operator knows exactly when the proper amount of exhaustion is reached, when the blue flame in the tube turns slowly to white. This indicates the presence of the X-ray, and the valves are then burned off.

On account of the degree of vacuum required and the frailty of the glass tube, it was in this operation that Mr. Moorhead encountered his most difficult problems. One of the chief causes of the instability of the old valves was the amount of residual gases which caused the essential filament to burn out quickly, thereby destroying its usefulness as a radio agent.

Obviously, therefore, the more perfect the vacuum, the more reliable and stable the bulb. It is this operation which constitutes one of Moorhead's chief triumphs in the manufacture of his bulb, thus prolonging the life of his bulb beyond anything known before. The life of the old bulb was thirty hours. The life of a Moorhead valve is 1000 hours of use.

Thus the Moorhead bulbs are not only the most efficient as regards detection of the lightest radio waves, but they are also the most reliable and longest lived.

### **Tungsten Filament Is Important Factor**

Moorhead so reduced the length of time required for the exhaustion of the bulbs, a very important factor in large scale production, that he is now able to turn out valves at the rate of 2000 a day from his exhaustion pumps, making possible a total production of 50,000 valves a month.

One of the main elements of the Moorhead valve is the tungsten filament, which is of exceedingly fine diameter, and must be accurate in respect to electrical resistance. This tungsten wire is first crimped in a motor-driven rolling mill, long lengths of wire being treated at one time. After the supporting wires have been sealed into their glass stem, they are cut off to exact length in a combined machine. The first operation of the lever shears off the surplus metal, the stem is then placed in another position and a small hook is formed in the short wire which supports the lower end of the filament.

Next comes the treatment of the grid, which consists of a spiral coil that is wound in two-foot lengths and is welded to the supporting wire in exact place by an electric spot welder.

The anode cylinders are then stamped out from nickel strips and rolled into form in a specially constructed mill having three power-driven rollers. They are then welded on to the supporting angle piece by an electric spot welder, one of the most delicate operations in the whole process of bulb manufacture, as the work requires great accuracy, and the material is awkward to handle.

After the centralization of these elements the next step is to place the top supporting wire for the filament under a drop hammer which flattens it at the bend, and gives it the requisite spring to take up the expansion of the tungsten filament when heated.

Following this is one of the most ingenious operations of the whole bulb manufacture, that of fixing the filament to the supporting wires. It is riveted in place in a machine with two heads, which gauges off the exact length of filament every time.

### **Bulbs Pass Through Many Operations**

After a number of minor operations, all of which are important, but which cannot be described here on account of space, the valve bases are finally cemented in place on a machine which is motor driven and

having six double heads. In the first carrier the valve is brought opposite a gas jet which dries out the cement, while the valve itself rotates, and upon touching a trigger the head rotates through half a revolution, the valve being brought to an air stream which cools it down.

After passing through the hands of the finishers and being finally tested, the vacuum valve is put in the hands of the packer, and is made ready for shipment in a patented cardboard box which has springs that give on each end, so that the safety of the bulb is assured.

It is the great multiplicity and exceeding accuracy of all these operations, each one of which had to be designed and perfected by Moorhead, which showed his marvelous mechanical genius, just as much as the invention of the vacuum bulb improvements showed his mastery of electrical science. Some of these machines, which you could almost put in your pocket, cost as much as \$600 and \$700.

It is precisely this perfection of workmanship, this high finish of design, this exquisite harmony of parts that makes the Moorhead valves so superior to all others on the market, making it the despair of all rivals, and the most sought-after radio device by all the leading Governments of the world.

The story of Moorhead would be incomplete without some account of the equally wonderful ability he has shown in the care of the financial and administrative, or business and commercial, side of the vacuum bulb.

### **Inventor Also Proves Good Business Man**

It is a proverb in the history of invention that most great inventors have proved bad business men, so that others have always realized on the fruits of their labors. The fact is that it often takes as much brains to exploit a great invention as it takes to devise it, and the two lines of endeavor are quite distinct and not always coincident in the same individual.

Moorhead is one of the first to tell you, for he is just as frank and open as a big, lovable boy, that while absorbed in the inventive and mechanical side of Moorhead Laboratories, his affairs got dreadfully tangled up, and that suddenly, owing to mistakes of confidence, he found his corporation in debt to the extent of over \$100,000 without credit anywhere, and yet with large governmental contracts to fulfill.

Compelled to turn his attention to the business end of his enterprise, he brought to bear upon his entangled affairs the same large intelligence that had been the cause of his splendid success on the inventive and mechanical side.

### **Heavy Deficit Wiped Out in One Year**

In this work of commercial rehabilitation he was fortunate in securing as his assistant, J. Henry Denning, who, as secretary of the corporation, has shown a zeal and administrative talent which Moorhead values highly.

Probably there is not a single business enterprise on the Pacific Coast that can show a more marvelous growth since Moorhead took personal direction of his own business affairs in November, 1918. From a tottering concern on the verge of insolvency with an overhead debt of considerably over \$100,000, Moorhead has placed the firm on the solid foundations as a going business, clear of all indebtedness, with fine revenues and with his product sold out practically for years in advance, thus making the stock of Moorhead Laboratories one of the most coveted on the market.

Within the short space of a year Moorhead has wiped out his heavy deficit, and has new contracts on hand which give his firm all the business it can handle. Inquiries for his product continue to pour in from all parts of the world, and it is absolutely impossible for him to accept any contracts except the large governmental orders coming in from England and the United States, and the Marconi and De Forrest companies.

So brilliant has been Moorhead's business generalship that the product of Moorhead Laboratories, large as it is, has been completely sold out for years in advance. He has just renovated and readjusted his

entire plant, and will soon be rushing it at full speed.

There is only one solution of this remarkable achievement. Back of it is the unquestioned superiority and necessity of the Moorhead vacuum valve in radio communication. Every growth and extension of radio activity means a growth and extension of Moorhead Laboratories. The bulb must be manufactured to fill an emergency world demand. Moorhead consequently sees very clearly that it will be imperative in the near future to construct a still larger plant than the one he now has in operation.

### **Many Flattering Offers Have Been Refused**

Not only that: so great is the growing demand for Moorhead valves with the ever-widening field of radio telegraphy and radio telephony, that cities from all over the United States have made offers for a plant, and some of them are now actually negotiating with the Moorhead corporation for the purpose of having plants erected in their districts.

The business management of the Moorhead Corporation is under the direct control of the inventor and his assistant. Large offers of financial assistance and support have been received from many quarters, but Moorhead feels that control and direction should be left in his own hands and has refused the most flattering offers. In recent months the corporation stock has become very attractive on the Stock Exchange, as investors feel that here is an enterprise in good hands with a brilliant future, bound to grow by leaps and bounds and to bring more than the usual returns.

As an inventor Moorhead says wireless is but in its infancy. Unquestionably it holds a great deal of the future in its hands. It will largely help to solve many of the great problems of the world. Already is a necessity in all places where wire cannot be strung. It is on ten thousand ships on the high seas. It cannot be done without in army and navy. It is indispensable in the new gunnery. It is a fixture of the airplane and there soon will be millions of birdmen on the wing. Upon wireless will largely depend the public opinion of the future and anything that will regulate and control that will cut a mighty large figure in human progress.

All industry depends upon transportation facilities, which link together the avenues of trade and serve as the medium of commercial interchange. The better and cheaper the transportation systems, railroads, steamships, canals, the better for the world's industries, the greater the resulting wealth and prosperity.

### **Interchange of Ideas Helps Harmonize World**

So, too, in the moral and intellectual worlds. The better the methods of communication of ideas, of the interchange of human thought, from country to country, the better is going to be the mutual tolerance and understanding, the clearer their conceptions of one another's points of view, the easier for them to get together in harmonious spirit of co-operation. The peace of the nations is therefore going to largely depend in the future on increased facilities in the interchange of news, thought and ideas between the different peoples, so that a real world opinion based upon fact and truth can be formulated as part of the daily life of the nations.

And it is wireless that holds the key to this necessary achievement. It is wireless that is going to provide that cheap means of communication across the continents and the seas, that will so much help to bring different countries together in a new international amity. This will lead to the creation of an entirely new world spirit, so that understanding on the basis of truth and justice can succeed mistrust on a basis of intrigue, jealousy and hate.

The future of the wireless is therefore immense. And it is the big men in radio science who are going to supply the new Archimedean levers that will move the world. It is they who are going to solve the baffling problems of wave interference and secrecy in radio telephony. It is the men with vision like our young California inventor, Moorhead, who have the grit and stamina, in the face of discouragement,



disappointment and difficulties, to stick by their dreams until they make them realities. It is these men who are going to devise the new agencies that will make international communication so cheap that to speak across the seas will be a commonplace of life, just as it is commonplace to call up our neighbor across the street.

While Moorhead has done great things for the world, he is going to do still greater things for us in the future. Remember, he is only 28 years old. He is working on plans now that promise big results. One of these concerns talking around the world. The other relates to the photographing of sound, so as to make the screen a complete picture of life, with the principals of the drama using living speech. Where Edison failed, he hopes to succeed.

Such men are in every high sense of the word real poets. They possess ethereal minds in that they are always dreaming of doing something for humanity. It is they who are moving with the angels. Out of their achievements come the big things that add to the life, happiness and prosperity of mankind, those new wonders that lift the races of men towards the stars.