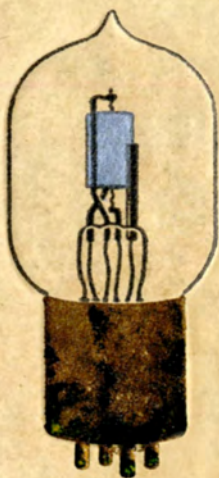
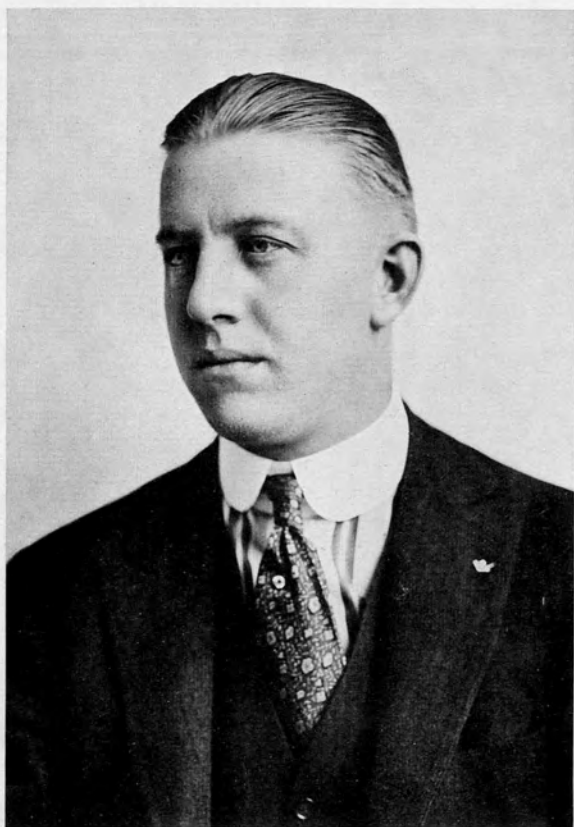


MOORHEAD



MOORHEAD
And His Valve





H.B. Moorhead
Presiding genius of Moorhead Laboratories.

MOORHEAD

"Around the world men's thoughts shall fly in the twinkling of an eye."

So wrote old Mother Shipton, a character in England centuries ago, and when men invented and used the telegraph and ocean cable it was thought her prophetic vision had been realized; but it remained for this day and generation to entirely realize the truth of the quotation, for with the marvelous Moorhead valve it is but the twinkling of an eye within which men's thoughts and words fly around the globe. Today communication by the wireless telegraph from San Francisco to Sydney, Australia; Cape Town, South Africa; and London, England, is an accomplished fact by use of the Moorhead valve, and, being limitless by process of multiplication, there is every reason to believe that even interplanetary communication would result if we could only receive a sound wave sent out by Mars or any other planet. Not only is this true in wireless telegraphy, but the results already obtained from experiments and laboratory work now being prosecuted justify the absolute conviction that Moorhead will soon be able to *talk* around the world by the same telephone method now used to communicate a distance of a few miles. Not only has Moorhead perfected devices for long-distance telegraphy and telephony, but for short, private communication his inventions have been equally successful, and even today one may have a telephone in an automobile, taking up no more space than a small cigar box and yet perfect in every respect, enabling one to talk with homes or places of business, both when the machine is stationary and when it is in motion.



MOORHEAD'S PERSONALITY.



Moorhead Valve, Type SE 1444. Standardized by the United States Government and used by all NC planes in first flight across the Atlantic.

The Apostle Paul wrote to Timothy, "Let no man despise thy youth," and it is remarkable in the history of the world that the most wonderful things have been accomplished by men young in years. Otis B. Moorhead is no exception to this rule. He was born in San Francisco in the nineties, and has not yet reached the age of thirty years, but the mere mention of the name Moorhead to any person connected with or interested in wireless telegraphy, or any field of radio activity, is sufficient to signify a man who stands at the very head and front of this remarkable profession.

Although so young in years, Mr. Moorhead has had very extensive experience in his business, and as a radio engineer for giving expert advice and deciphering intricate radio problems he is sought by the highest authorities, both in governmental and commercial fields.

At the age of eight years he was endeavoring to discover the mysteries and reasons actuating wireless application of all kinds. He took advantage of the inventions and experiences that had preceded him, and so amplified them that in his 'teens he occupied many responsible positions on ships as well as with land stations connected with wireless telegraphy, and during all of the time was pursuing his investigations and development work. He is an indefatigable worker, and in his private laboratories he may be found day and night, pursuing his studies and developing his investigations and ideas along



Moorhead's Electron Relay.



Moorhead Valve. Type R (receiving). Standard of British Government. Used by Allies during the Great War.

lines that lead to perfection. It was only natural that in the course of a short time he should occupy the very high place he now holds in the field of radio activity.

There are many devices originated for the purpose of accomplishing the results desired in wireless telegraphy and telephony, and Mr. Moorhead is more than willing to concede all honor to his contemporaries, as well as to those who preceded him in this great work, but his contemporaries also are more than willing and most cordially concede to Mr. Moorhead one of the very first places in the radio world.

Personally Mr. Moorhead is most engaging, genial and considerate, and so modest that until one engages him in conversation concerning the radio field one would never think he has accomplished such wonders and stands so high in his profession.

THE MOORHEAD VALVE

Soon after the wireless became a practical thing the stumbling block in receiving the faint impulses given out by powerful stations thousands of miles away became apparent, and the needs of the wireless service dictated that something should be done to overcome its shortcomings in that direction. Wireless communication has, at no time, been an intricate thing in its broadest principles or application. Men knew the principle, and even children applied it,



Moorhead Valve. Type B (transmitting). Standard of British Government. Used by Allies during the Great War.



Moorhead Laboratories.

Cutting platinum, nickel, copper, etc., in process of manufacturing the valve.

and the wireless neighborhood plant became quite a common thing, but devices that were perfected in the beginning fell far short of solving the problems necessary to be solved in perfecting wireless telegraphy and telephony. Moorhead solved them. He absorbed all that the others knew, and then applied himself to the study of known elements. After attempting the capture of the wave fluctuations in their faintest character he finally hit upon a principle which may be roughly compared to the principle of leverage. By the development of the ordinary incandescent bulb into a device for the detection of the wave fluctuation, through a small molybdenum spring surrounding the hot tungsten filament and encased in a pure nickel tube, and the creation of currents hitherto unused in this manner, the wave fluctuation of whatever intensity is accurately registered.

Put in other words, the principle of the thing is as follows: The very small current received from a distant transmitting station is made to control large currents in

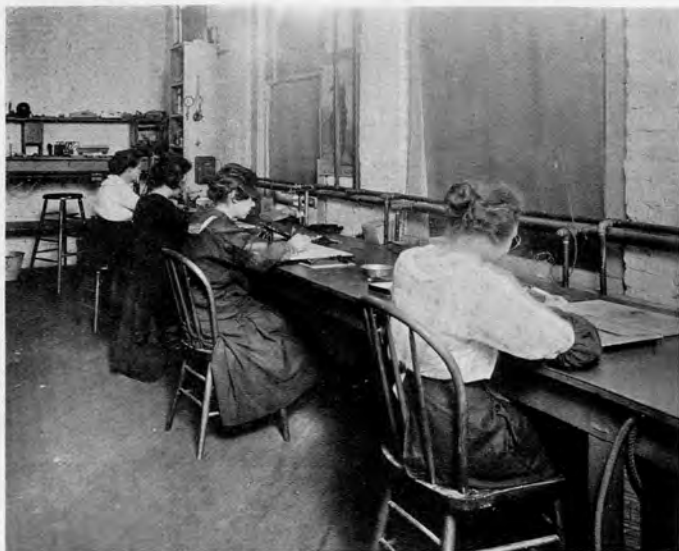
the receiving station. This feeble current is sometimes a small fraction of a millionth of an ampere, or less than the energy a house fly exerts when it flies across the room. The current generated in the valve is thousands of times greater than the received current, but it is controlled absolutely by the feeble current which comes from the distant station. The telephones that convert this current into sound are operated by the comparatively large current generated in the valve and its circuits, but this current is, in turn, controlled by the far-distant station, so that no matter how far the sending station is from the receiving station the most feeble currents will operate the receiving set when equipped with the Moorhead valve. Amplification of energy up to two million times its original intensity can be accomplished by using six valves in cascade.

And, in all the development of this wonderful instrument and its logical complement, the transmitter, the machinery necessary to the manufacture in quantities had to be devised. It was like invading an entirely new field. Miniature spot welders came into use; blowing of glass by machinery, making the manufacture of bulbs in large quantities possible; machines for creating a vacuum had to be devised; machines for crimping wires as fine as the finest human hair, welding blowpipes for platinum, copper and nickel wires, had to be invented; and a multitude of minutiae had to be conquered before anything like success in quantity production was arrived at. Then the operatives had to be educated in the operation of the several machines, as it was such a new enterprise that no one could be found familiar with the work.

While every radio engineer or person interested in wireless telegraphy or telephony is very familiar with the celebrated Moorhead valve, it is a subject almost unknown to the layman. The valve, however, has achieved such remarkable performances



*Moorhead Laboratories.
Shearing and forming machine.*



*Moorhead Laboratories.
Welding platinum, nickel, copper, etc.*

in the last few years that it is rightfully considered one of the most important devices of the wireless world. In the Great War it proved a most important factor for communication between the aircraft, battleships and land forces of the Allies, while it mystified the enemy when all of their messages and orders were intercepted and known long in advance by the Allies. In the history of the war as it shall finally be written there is no doubt that the Moorhead valve, manufactured in San Francisco, the invention of Otis B. Moorhead, will be acknowledged as one of the great factors contributing to the winning of the great conflict.



*Moorhead Laboratories.
Welding nickel and copper with oxy-acetylene*



*Moorhead Laboratories.
Stem Manufacturing Department.*

The Moorhead valve performs many functions, acting as a detector, oscillator, rectifier, amplifier or transmitter, as the case may be, according to how it is connected up in the electrical circuit.

A valve is so termed because it acts as a rectifier for alternating waves, and it takes the place of the crystal when employed for this purpose, and for the following reason: The three-element valve emits electrons from the heated filament to the anode and allows current to pass only in one direction from the anode, on which a positive charge is impressed to the heated cathode.

It will thus be seen that only



*Moorhead Laboratories.
Stem machine and operator.*



*Moorhead Laboratories.
Section of Assembling Department.*

the positive portions of the alternating wave which is connected with the anode can pass to the cathode. Between the anode and the cathode a third element, termed the grid, is interposed, having a single terminal, to which is connected one terminal of the outside circuit which is to be amplified or detected. This may be coupled up through the medium of a loose-coupled coil and a condenser so that the radio waves impress varying potentials upon the grid. When the valve acts as an amplifier the plate current passing from the anode to the cathode is intercepted by the grid and influenced by the varying potential thereon, and the slight variations in grid potential react on the plate current, which latter is connected through the telephone receiver, producing audible signals.

In wireless telephony one of these valves can be used as an oscillator producing a wave of radio frequency which acts as the medium for carrying the wave of audio frequency set up in another valve by means of one or

more valves in series according to the strength of the incoming signal.

Amplifying can be carried out to any desired degree, giving results which are perfectly true reproductions and free from those objections inherent with the use of metallic devices and conductors. Signals have been picked up in the war zone by means of wire loops laid on the surface of the ground, and have been transmitted over long distances by radio phone and to and from aeroplanes in flight, the whole apparatus being contained in a box not much larger than an ordinary cigar box.

The Moorhead valve has been standardized by the United States, the British and other principal governments of the world. While there are other valves manufactured, none of them has reached the efficiency or been able to produce the same results as the Moorhead valve. The Moorhead valve is as far superior to other valves as the perfected Baldwin locomotive is superior to Stephenson's first invention. The United States Government recognized the value of these valves when President Wilson made his trips to Europe, by causing Moorhead valves to be installed on the steamer *George Washington* for all wireless communication, and in the transatlantic flight of the U. S. seaplanes, the *NC-3*, *NC-1* and *NC-4*, Moorhead valves were used for the purpose of communication from shore to shore and to all the warships stationed on the route. The Chief Radio Officer of this expedition made the statement that he felt absolutely confident with the wireless equipment containing the Moorhead valve.

The British Government in 1918, representing the Allies, except the United States, attested their faith in the Moorhead valve by placing an order amounting to considerably more than \$200,000 with the Moorhead Laboratories, with a request that the valve be turned out just as fast as it was physically possible

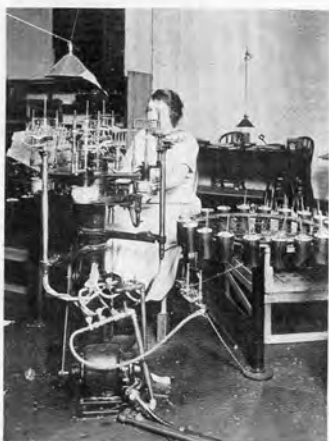


*Moorhead Laboratories.
The tubulating operation*



*Moorhead Laboratories.
Final inspection of assembled elements and attaching filament.*

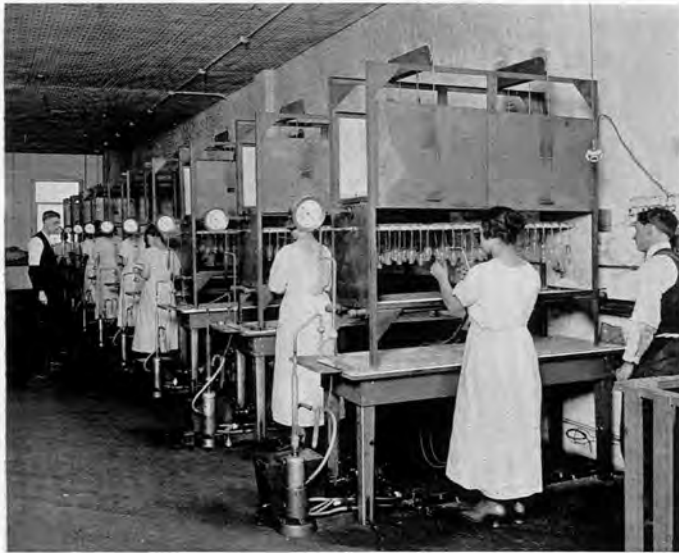
to do so. This contract has long been completed and in such a manner that his Britannic Majesty's Government officially complimented Moorhead on the quality of his work and results obtained in the use of the valve.



*Moorhead Laboratories.
Process of sealing.*

THE MOORHEAD LABORATORIES

As an outcome of the invention of the Moorhead valve there was established in San Francisco but a short time ago a plant known as the Moorhead Laboratories, occupying a three-story-and-basement brick building at 638-640 Mission Street, executive offices of the Company being located in the Call Building, San Francisco. This cor-



*Moorhead Laboratories.
Evacuating ovens and pumps in operation.*

poration was formed by Mr. Moorhead for the purpose of manufacturing the Moorhead valve, and is today the largest concern exclusively manufacturing vacuum valves in the world. In fact, it is the only concern manufacturing this valve or anything like it in any degree of perfection, for the reason that the Moorhead valve is protected by three lines of patents in all of the countries of the world, being licensed under the Fleming, or Marconi, patents and the De Forest patents with the right to the use of the word "*Audion*," as well as being protected by the inventions and perfections of its presiding genius, Mr. Moorhead.



*Moorhead Laboratories.
Inspecting for defects after sealing.*



Moorhead Laboratories

View showing portion of Glass Department with evacuating ovens in background.

Not the least interesting feature of the Moorhead valve is the mechanical construction thereof, and it became necessary in building up the laboratories to install and equip one of the finest machine shops in the world for the extremely fine precision work. Each valve requires two thousand two hundred and thirty-five movements in its manufacture. This is easy to understand when the fact is known that this minutely delicate instrument must be made accurate to the one ten-thousandth of an inch.

One of the great difficulties encountered by Mr. Moorhead and his staff in equipping the factory and manufacturing the valve for commercial purposes was to obtain machines of a nature and quality to produce satisfactory work. This made it imperative that Mr. Moorhead manufacture his own equipment. As a result, every machine used in the entire laboratory work is either the invention of Mr. Moorhead after days and nights of ceaseless labor and application, or, in some instances, he has

been able to adapt and adjust other machines to his uses.

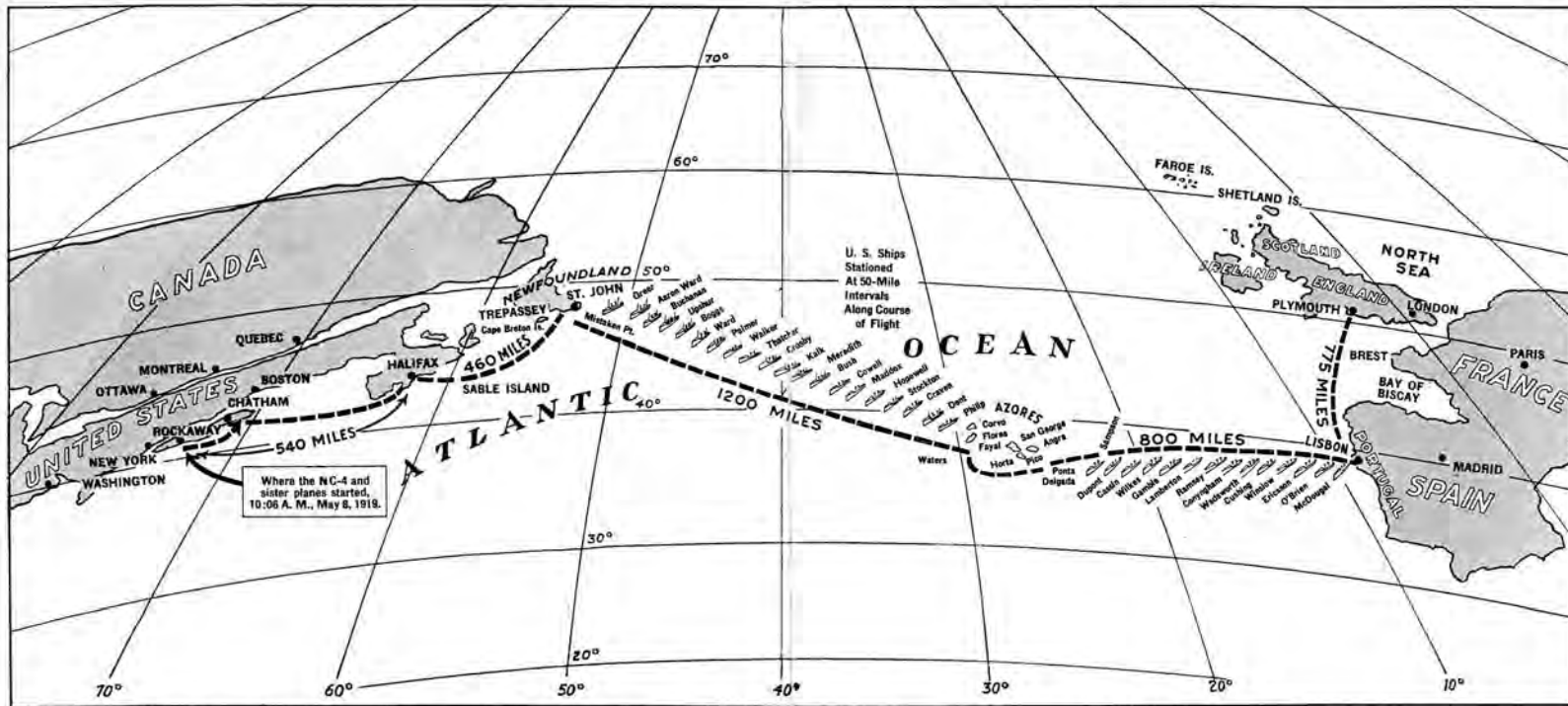
The great public interest manifested in the Laboratories and its work has made it absolutely necessary that visiting at the plant be extremely limited. During the war visiting was prohibited absolutely under the terms of the contract with the British Government; but to those who are interested in the wireless—and who is not?—an inspection of the plant will prove one of the most interesting experiences that can be had in any industrial establishment in San Francisco. The work involves all of the processes used in the manufacture of an ordinary incandescent light bulb, from the shaping of the globe to the adjustment and placement of the delicate filament within, and, in addition thereto, has interesting features of construction exceeding in delicacy the adjustment of the finest watch. Almost every mechanical operation is used, including the processes of stamping, riveting, punching, spinning, shaping, and electric spot welding of the most delicate nature. Every operation is accomplished by a miniature machine of special design for this particular work.

A staff of inspectors test every valve electrically, and periodical reports of a comprehensive nature are taken to insure that the product is maintained up to the standard of requirements. An imperfect Moorhead valve is unknown.

One floor of the factory is principally concerned with glass work; the bulbs in the rough must first have their stems shortened to the required length and 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 a 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 head having a ring of flames which play upon



*Moorhead Laboratories.
Evacuating oven and pump.*

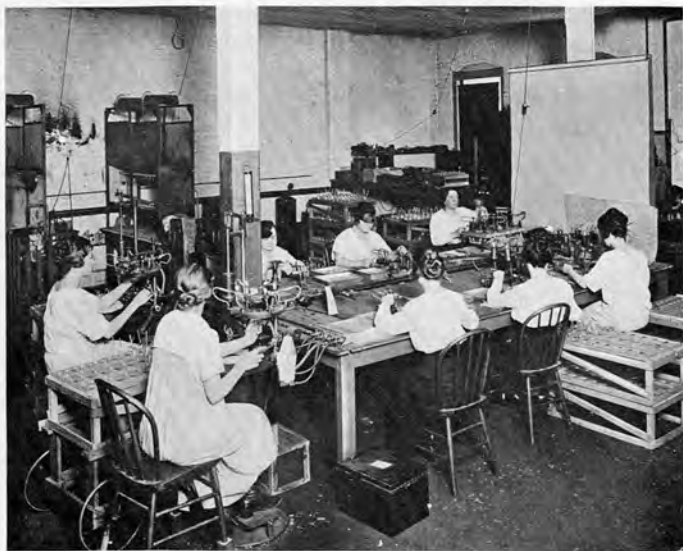


As the NC planes winged their flight from the New World to the Old, each plane was in constant communication with both Continents as well as all ships stationed along the route, with the aid of Moorhead's valve, Type SE 1444.

the stem, the surplus 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. Three machines are employed for sealing the element support wires into their stems, each machine having four heads, and three more machines each with four heads seal the completed elements into the valves. After each sealing-in process the glass members are immediately placed in rotary annealers to eliminate cracking. After inspection the valves then pass to the pumps for evacuation. In the Moorhead Laboratories ten ovens are employed for pumping, each one being fitted with a Lang-

muir mercury vapor pump, each holding fifty valves at once.

The evacuation of these valves was one of the principal difficulties Moorhead had to face, as the degree of vacuum requisite to insure a reasonable length of life is far in excess of anything that has been previously manufactured commercially. The reduction in the length of time which can be devoted to the pumping process is also an important factor in a commercial undertaking. This has been achieved in the Moorhead system of evacuation, and the rate of pumping exceeds two thousand valves a day at the present time.



*Moorhead Laboratories.
Glass band-workers.*

Some of the machines which have been produced in order to insure uniformity and accuracy in the manufacture of the elements deserve particular attention, by reason not only of their ingenuity but also of the novelty of purpose for which they are employed.

The tungsten filament, which is of exceedingly fine diameter, must be very accurate in respect to its electrical resistance, and it also has to withstand a considerable degree of overload in testing. The 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



*Moorhead Laboratories.
Repairing minor defects in audion.*



*Moorbead Laboratories.
Blue glow test after pumping.*

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. The end of the hook forms the locating point for future operations.

The grid consists of a spiral coil which is wound in two-foot lengths from a spool of nickel wire. Each grid is cut off to exact length and is welded to its supporting wire in exact place by an electric spot welder. The anode cylinders are first stamped out from nickel strips and rolled into



*Moorbead Laboratories.
Basing machine for cementing brass collars.*



*Moorhead Laboratories.
Etching and packing valves.*

form in a specially constructed mill having three power-driven rollers; they are then welded onto the supporting angle piece by an electric spot welder.

This system of spot welding has required a great deal of care in attaining its present state of perfection, as the work has to be done most accurately and the shapes and sizes of the material worked upon are very awkward.

After these elements have been centralized, the top supporting wire for the filament is placed under a drop hammer which flattens it at the bend and gives it the necessary amount of spring to take up the expansion of the tungsten filament when heated.

The system of fixing the filament to the supporting wires, though simple, is very ingenious. It is riveted in place in a machine with two heads which gauges off the exact length of filament every time. The surplus metal is cut away by hand.

After various intermediate operations the valve bases

are 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 and the valve is brought to an air stream which cools it down.

The remarkable uniformity of the product is evidence of the perfection of this system of manufacture.

The plant has been brought to such a state of efficiency that today it has a capacity of 50,000 valves per month. While the layman may not be able to understand the intricate details of the manufacture of this wonderful valve he can and does understand that by means of its wireless telephone and telegraph communication throughout the world for long and short distances is already an accomplished fact. The business man can understand what it means when he knows that the minimum price of a Moorhead valve is \$4.00 at the Laboratories.

A man with the genius and inventive ability of Mr. Moorhead would be universally assumed to have no ability as a business man, but here again Mr. Moorhead demonstrates his remarkable character.

When the Moorhead Laboratories corporation was first formed Mr. Moorhead did not assume any portion of the business affairs of the concern, but devoted himself strictly and entirely to the manufacturing or production department of the corporation. He subsequently discovered that he had been very unfortunate in his business associates, and that notwithstanding his success as an inventor, and the remarkable valve that he had been able to produce and supply to the world, his company was on the verge of bankruptcy, and he was unable to obtain credit or further conduct business under the same management. He then turned his attention to the business affairs of the corporation, and in



*Moorhead Laboratories.
Final meter test.*

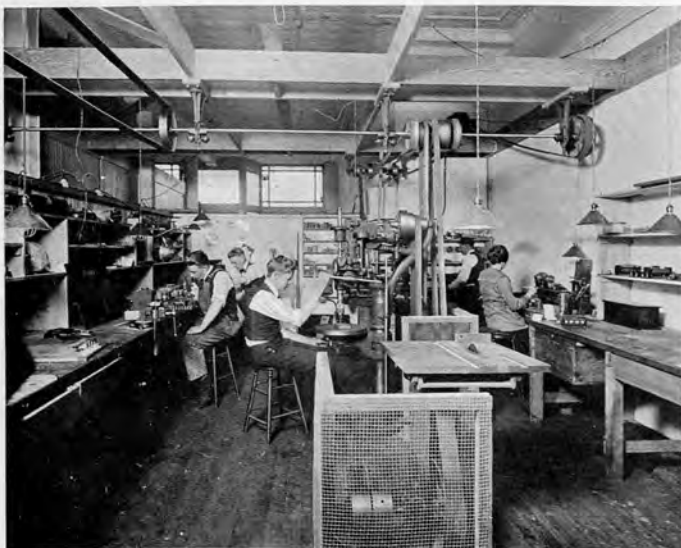


*Moorhead Laboratories.
Section of Drafting Department.*

association with Mr. J. Henry Denning, on the first of November, 1918, took entire charge of the business or commercial affairs of the corporation, in addition to the production or manufacturing department, with such splendid results that, although on the date above mentioned the Moorhead Laboratories was in debt considerably over \$100,000, without assets or credit of any kind except Mr. Moorhead's brain and integrity, within a short space of six months the entire debt of the corporation was wiped out. Today the credit of the corporation is first class in every respect, its assets are of great value and in the commercial field the Moorhead Laboratories have only been confronted with the difficulty of supplying the demand, as the entire product is sold out for years in advance. The corporation today is only able to manufacture and meet the demands of the United States Government and the Marconi Wireless Telegraph Company of America, which acts as the exclusive agent and distributor of the Moorhead



*Moorhead Laboratories.
Section of Testing and Experimenting Laboratory.
Section of Engineering and Experimental Department.
Experimenting, Glass Department*

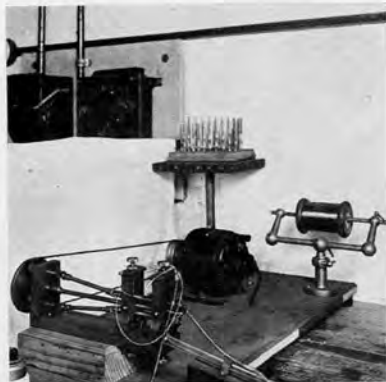


*Moorhead Laboratories.
Radio Machine Shop.*

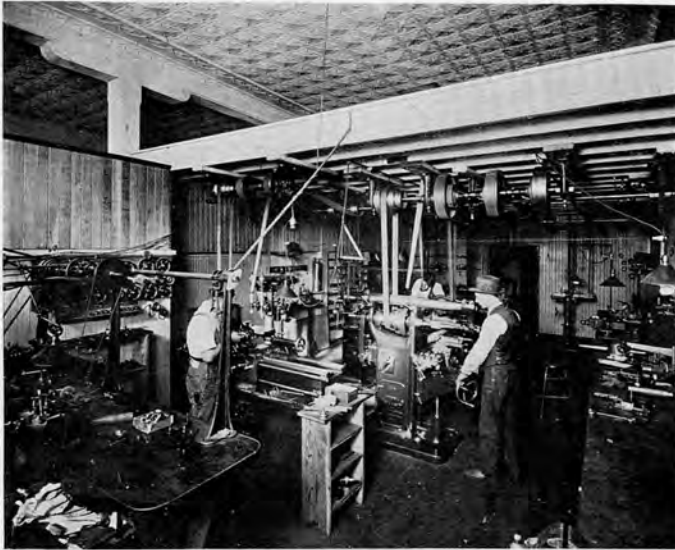
valve in the commercial and amateur fields, as well as to all foreign governments.

The plant at San Francisco has been conducted with such remarkable success since Mr. Moorhead added his business ability to his inventive genius that in the very

near future it will be absolutely necessary to construct a larger plant or plants to meet the great and growing demand for this remarkable valve. Cities all over the United States have made offers and are negotiating with the corporation for the purpose of having plants built in their respective communities. Thousands of dollars



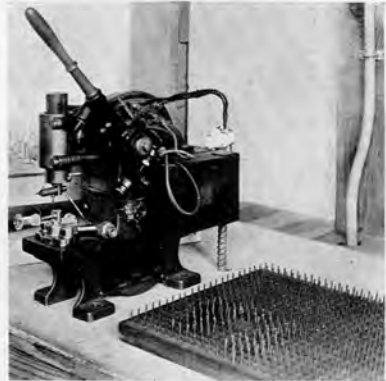
*Moorhead Laboratories.
Grid-winding machine.*



*Moorhead Laboratories.
Section of General Machine Shop.*

are paid at present each week in the form of wages to operatives. Many thousands more are paid out for material used in the manufacture of this valve, the principal materials being glass, brass, platinum, nickel, tungsten, copper and molybdenum. The manufacture of this valve is an enterprise which produces results of a most favorable nature in the business world in every respect.

While there are many who are seeking to become interested in the Moorhead Laboratories and its business affairs, Mr. Moorhead has steadfastly refused to consider all offers since he assumed the presidency of



*Moorhead Laboratories.
Spot welder.*



Moorhead Laboratories.

A unique carton. Invented by Mr. M. B. Wallace, of San Francisco, for the purpose of packing the Moorhead valve for shipment. The valve being encased and protected so that damage or loss is reduced to a minimum.

the corporation, no matter how attractive from a financial point of view. He has confined the commercial as well as the production department of the corporation exclusively to himself and his associate, Mr. Denning, as he considers the best results have been attained thereby. While there are many stockholders of the corporation, and Moorhead Laboratories stock has been a particular attraction on the stock exchange of San Francisco for a number of months, the Moorhead Laboratories have had no dealings therein or relation thereto, but have confined themselves strictly to the business of the manufacture of the Moorhead vacuum valve and the supplying of the demand therefor.

Otis B. Moorhead has too great and active a brain and is too great an inventive genius to confine himself to even this wonderful vacuum valve. In the future the world will hear of and acknowledge his inventive genius along other



*Moorhead Laboratories
Section of Shipping Department.*

lines of development in the wireless and radio world of activity, although his other inventions are at present in such a stage that he does not desire them to be specified or given to the public.

SAN FRANCISCO, U. S. A.
AUGUST, 1919.

N. E. E. S.
ADDRESS BUREAU OF STEAM ENGINEERING, NAVY DEPARTMENT,
AND REFER TO NO.

NAVY DEPARTMENT
BUREAU OF STEAM ENGINEERING
WASHINGTON, D. C.

ENCLOSURE
64-502

July 5, 1919

Moorehead Laboratories,
San Francisco, Cal.,

Gentlemen:

While on the Trans-Atlantic Flight the Moorehead tubes gave such excellent service, that I feel it my duty to personally tell you of their performance and send you one of the tubes used and a portion of the lead fish that held down the antenna to which the receiving equipment was connected.

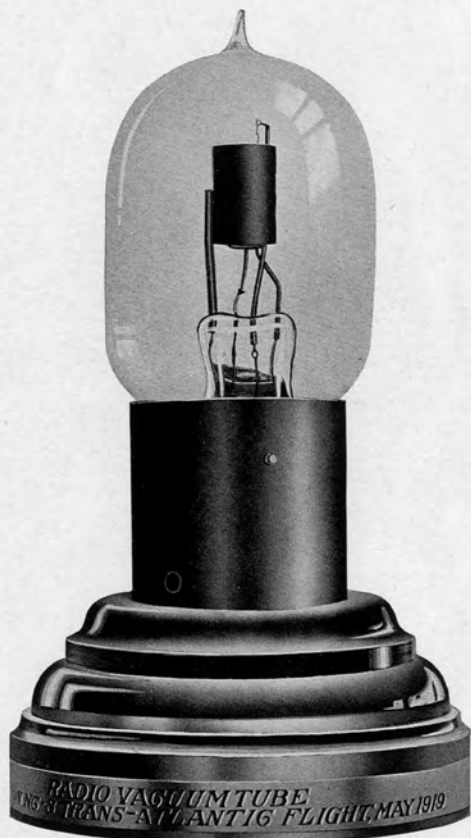
During the trip your tubes made it possible to receive signals from the Norfolk Radio station while the NCS was on the water near the Azores, a distance of 2500 miles. But the longest record of reception of radio signals in any type of plane while in flight was far surpassed when signals were received from a ship 1800 miles away. This enviable record is even more distinguished from an aviation point of view in that your tubes required but half the power used by other types of tubes, thus saving many valuable pounds in weight of storage batteries.

Thanking you for the valuable part that you have taken in the first Trans-Atlantic Flight and with best wishes for your continued success, I am,

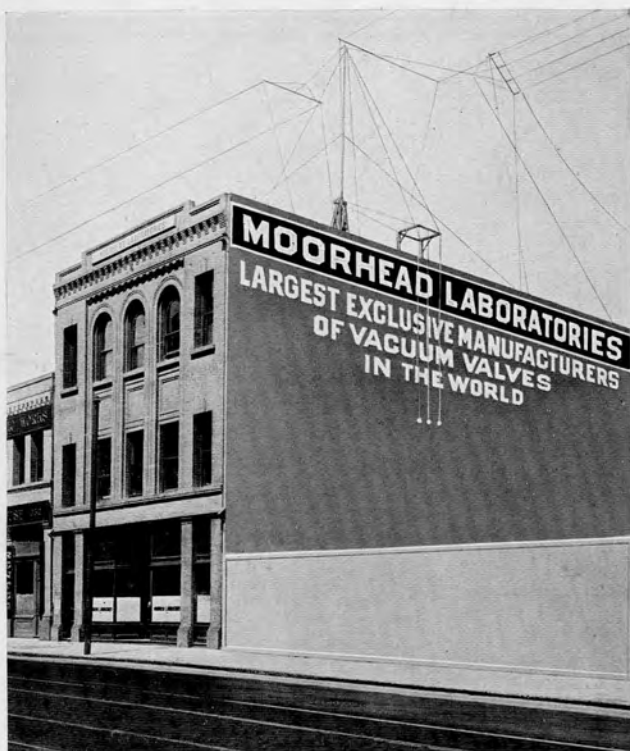
Very respectfully,

Robert A. Lavender
Radio Officer U. S. Seaplane Division 1,
Trans-Atlantic Flight.

Facsimile of letter from Radio Officer Robert A. Lavender to Mr. Moorehead after Transatlantic flight.



Moorhead valve SE 1444, serial number US 629, used on Seaplane NC-3 in Transatlantic flight May, 1919. Mounted and presented to Mr. Moorhead by Commander Lavender, Chief Radio Officer of the expedition.



MOORHEAD LABORATORIES, Inc.

O. B. MOORHEAD - - PRESIDENT
J. HENRY DENNING - SECRETARY

EXECUTIVE OFFICES - - 519 CALL BUILDING
LABORATORIES - - 638-640 MISSION STREET

SAN FRANCISCO, CALIFORNIA
U. S. A.

