No. 852,760. PATENTED MAY 7, 1907.

L. I. BLAKE.

RECEIVER FOR SYSTEMS OF SUBMARINE SIGNALING.

APPLICATION FILED JAN. 29, 1907.

2 SHEETS—SHEET 1.

Fig. 1

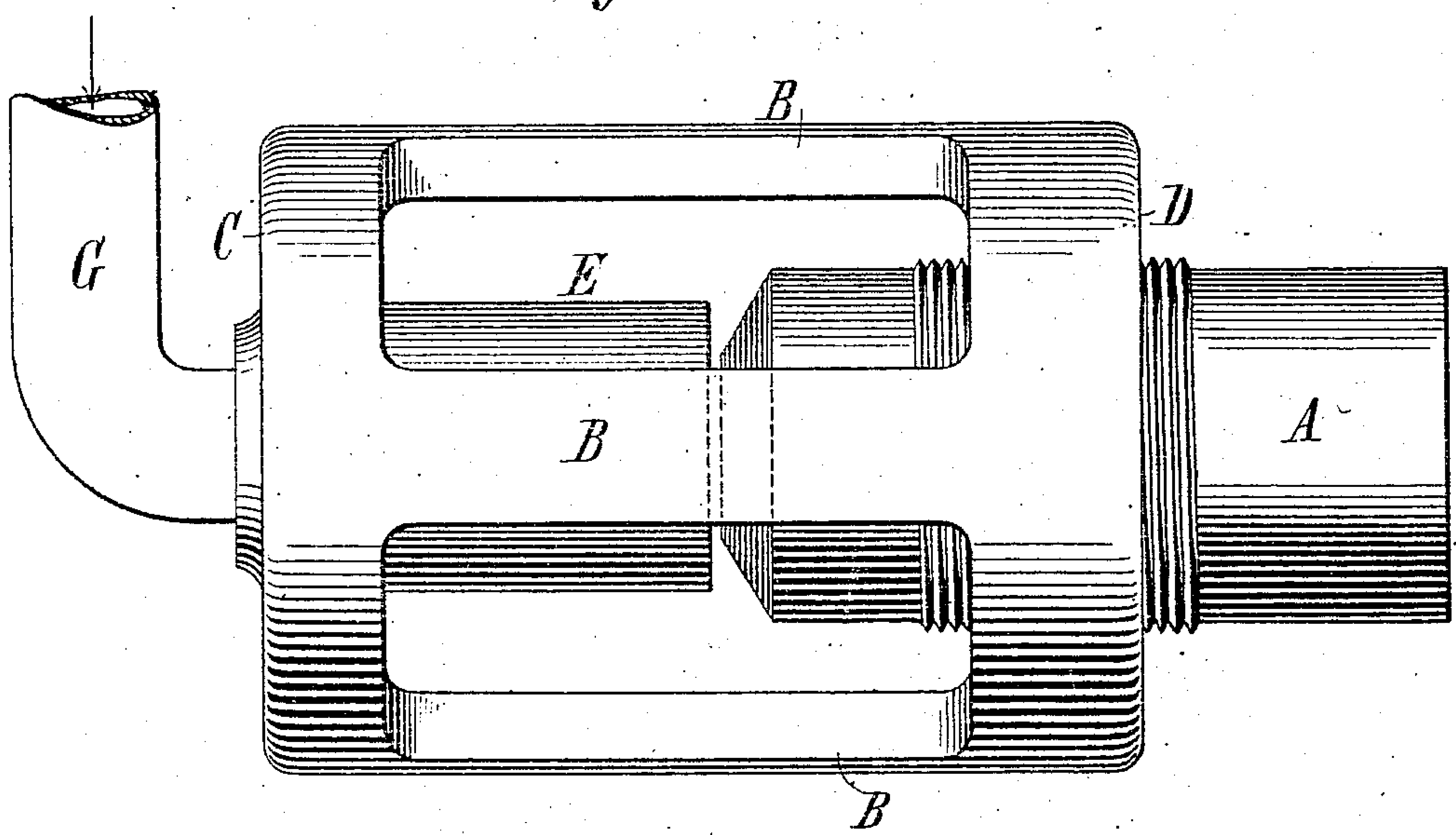
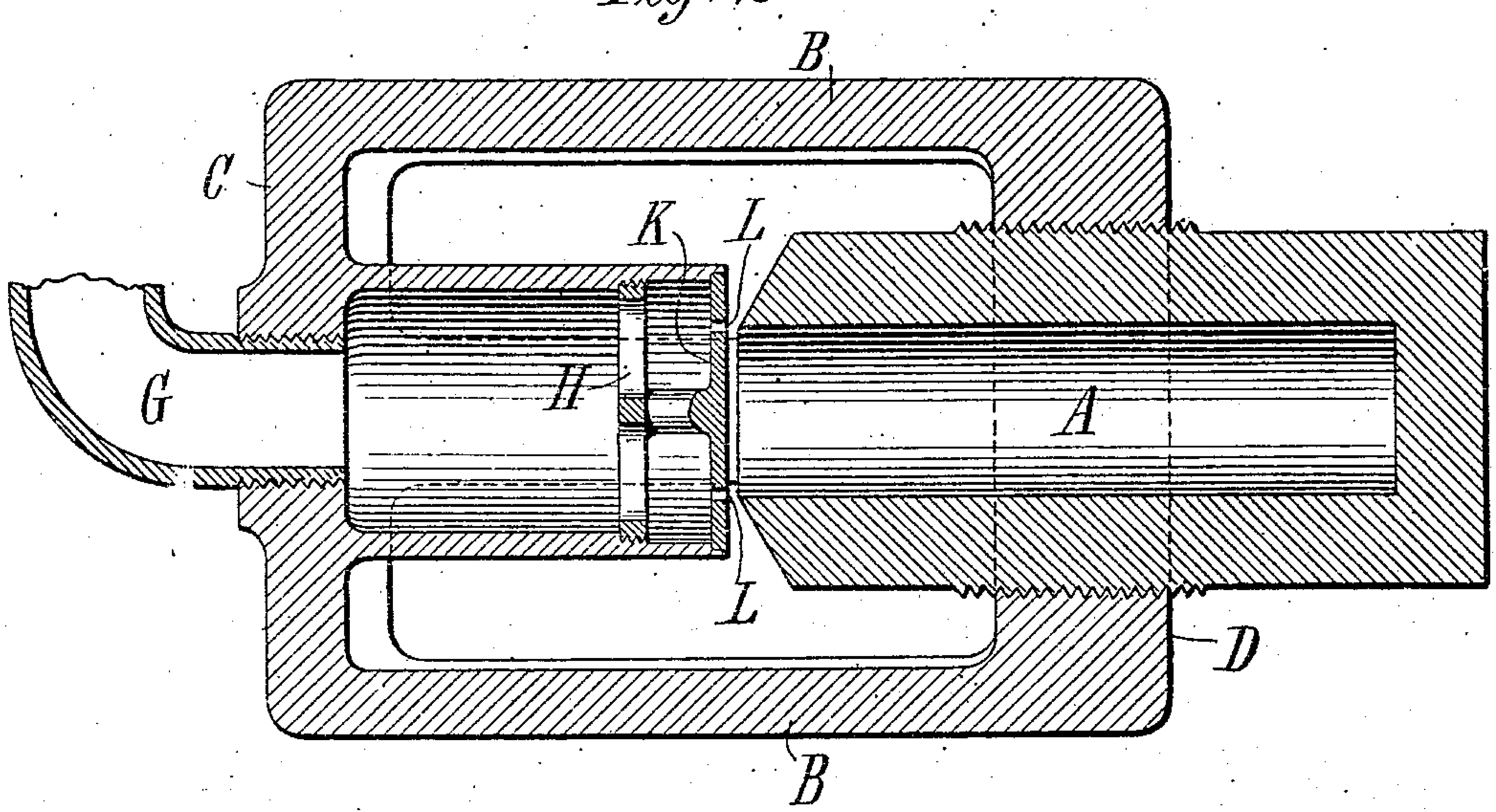


Fig. 2



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Examiner

Cross Reference

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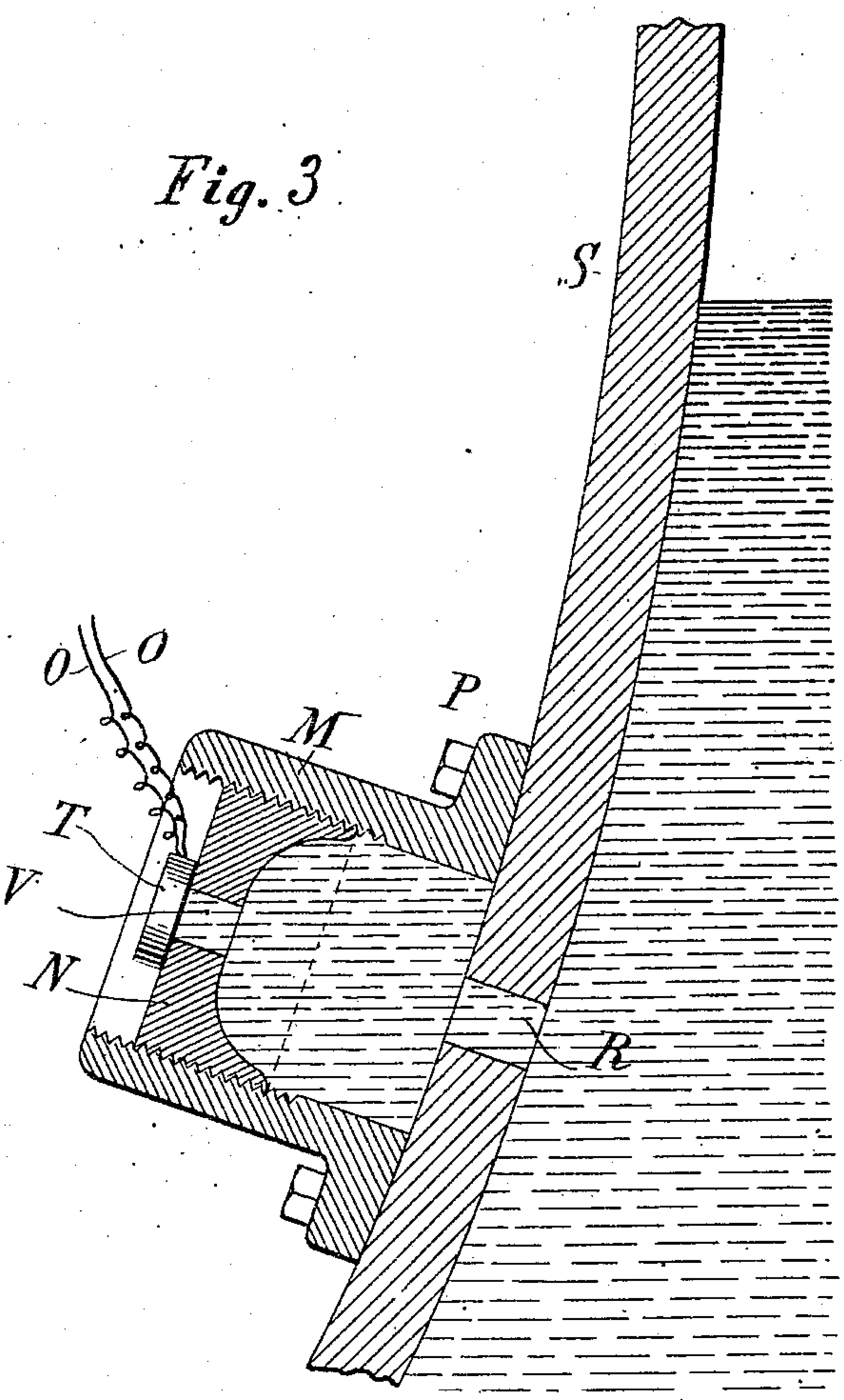
Fig. 3



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UNITED STATES PATENT OFFICE.

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RECEIVER FOR SYSTEMS OF SUBMARINE SIGNALING.

No. 852,760. Specification of Letters Patent. Patented May 7, 1907.

Application filed January 29, 1907. Serial No. 354,626.

To all whom it may concern:

Be it known that I, LUCIEN I. BLAKE, a citizen of the United States, residing at Boston, in the county of Suffolk and State of Massachusetts, have invented or discovered certain new and useful Improvements in Receivers for Systems of Submarine Signaling, of which the following is a specification, reference being had to the drawings accompanying and forming part of the same.

As an understanding of the nature of the invention upon which my present application is based, involves a knowledge of the phenomenon of resonance, the following statement of well recognized principles is apposite.

The fundamental principle of acoustic resonance is reflection. In any portion of a gaseous medium which is isolated,—by which term as used herein is meant wholly or partially confined by boundary walls of any suitable material differing in its physical properties from the inclosed medium,—a reflection occurs at the surfaces of the boundary walls, of any acoustic disturbance present in that medium. This reflected disturbance will travel back and forth between the walls or boundaries to produce a tone of definite pitch, dependent upon the volume and shape of the medium inclosed. The chamber or cavity formed by the boundary walls is called a resonance cavity. The method of exciting a given medium to resonance is immaterial. It may be effected by sound vibrations brought into it from an outside and remote source, or by vibrations originating within the cavity itself.

It is not necessary in any of the applications of the principle hereinafter described, or in general, that the cavity be entirely surrounded by reflecting walls, for an opening may be left in the latter through or at which vibrations may be imparted to the medium within the cavity, and another through which the regular periodic vibrations of the medium affected may be communicated to any other medium without the boundaries of the cavity. The function of the resonance cavity thus becomes a reinforcer of sound, whether received or produced.

In all aerial sound producers resonance chambers are the essential elements for giving intensity of sound. Their action is exemplified in the case of organ pipes and whistles. In these the column of air inclosed within the walls of the resonance chamber is set into regular periodic or harmonic vibration at the embouchure by either the so-called flute mouth-piece or a reed. When the length of the air column is great in comparison with its other dimensions, as in the case of a pipe, the pitch is controlled by the period of travel of the disturbance from end to end of the pipe, and this is called the free period of the pipe. In the flute mouth-piece form a thin jet of air or steam impinges upon the sharp edge of an opening into the chamber and the rhythmic effect of friction produces a vibrating reed of air or steam which is continually controlled in its rate of vibration by the regular periodic vibrations of the column of air in the pipe.

In the case of the reed mouth-piece the reed is set in vibration by the air or steam impinging upon its unconfined edge, and the air or steam column sustains and reinforces these vibrations, controlling their rate and consequently the pitch of the tone if the reed be not too stiff. In either case the free vibration of the column within the pipe or chamber is the essential source of sound.

In connection with the consideration of the action or effect of these resonance cavities, it is important to bear in mind the distinction between the free vibration of the inclosed medium and the forced vibrations which occur in consonant materials excited by any source of sound. In the phenomenon of resonance, one definite pitch is conspicuous or natural for each given set of conditions, while in the case of consonance, sounds of any pitch are reinforced. In the former the size and shape of the mass of confined medium control in determining the pitch, the character of the containing walls, within certain limits hereinafter more fully explained, being immaterial provided they are capable of reflecting the disturbances; while in the latter, the physical character of the consonant body is the controlling consideration, size and shape being immaterial.

I have discovered and practically demonstrated that under proper conditions a liquid medium may be readily brought into sonorous resonance with a tone of given pitch, and that an isolated portion of liquid medium possesses, according to its dimensions, a certain musical pitch of its own. If, under such conditions, harmonic vibrations be set up within a body of liquid the latter may be caused to strongly reinforce these vibrations and consequently intensify the sound produced by them. Such a liquid mass will also reinforce sounds delivered into it from a distance, whereby weak tones will be rendered more audible, so that it may, therefore, be utilized, like an aerial resonator, both for the production and reception of sounds. Availing myself of this discovery, I have employed liquid resonators in systems of submarine signaling with results of a highly useful and novel character.

The desirability of securing the advantages of resonance for intensifying sound, either produced for transmission or received from a distant source, in the art of submarine signaling, has been recognized by those skilled in the art. As an abstract proposition it is, in fact, self suggestive from analogous results in the application of the same broad principle in the case of wind instruments, whistles, and in general those devices in which a sound of given pitch is reinforced by a resonating body of air or gas. No useful or practical application of the principle to submarine signaling, however, has ever been made, so far as I am aware, and for the reason, which my discovery has now rendered apparent, that conditions essential to the attainment of the resonance of isolated bodies of liquid, have not been recognized or secured in any apparatus that has been designed or proposed for use either as producers or receivers of sound under water.

In all wind instruments and other devices in which the resonance of a confined or isolated body of air is utilized, the resonating medium is of such a highly compressible nature in comparison with the materials ordinarily constituting its boundaries, that the latter may be of almost any rigid material, such as wood, paper or very thin metal. If, however, the medium which it is desired to set into resonance be a liquid, which is practically incompressible as compared with any gas, the rhythmic changes of pressure within it which correspond to sound, exert exceedingly powerful total pressures over the boundary walls of the chamber or cavity containing the liquid, according to the laws of hydrostatics. Such pressures, as is well known, may bend and even burst walls of ordinary strength. Therefore, if liquid resonators be constructed without due regard to the effect upon the retaining walls of these variations of hydrostatic pressure, they present conditions which actually remove the elements upon which reflection depends, but the effect of which is negligible when the medium is an easily compressible gas, such as air. It is for this reason that a water column in an ordinary organ pipe does not produce resonance. This may be conclusively demonstrated by the following experiments: If a pipe 4 inches in cross sectional area and several feet long be made of hard metal, say $\frac{1}{8}$ of an inch thick, which would produce very much greater rigidity than would be required in any ordinary tone-producing instrument, and provided with an embouchure similar to that of an organ pipe, it may, if submerged in water, be operated to produce a tone by a jet of water in the same manner as an organ pipe is operated by air. It will be found, however, that the tone produced has a pitch wholly independent of the length of the pipe, thus showing that the water column is not set in resonance. The reason for this, as I have found, is that the rigidity of the walls is not sufficient to withstand the variations in hydrostatic pressure and thereby reflect the regular periodic or harmonic vibrations imparted to the mass of liquid within the pipe. If the walls of the pipe yield, then any change in the pressure originating at the embouchure of the inclosed liquid will be instantly relieved at that point, and therefore no change in pressure will be propagated through the pipe to undergo reflection, and thereby to produce resonance. In short, the liquid column remains quiescent at its normal pressure, and takes no part whatever in the production or reinforcement of sound. If the same pipe, however, be made of very hard and tough steel, with walls even more unyielding than the practically incompressible water surrounding them, it will be found to produce, when operated by a water jet in the same way, a tone of definite pitch that varies with the length of the pipe, thus proving that the liquid mass within the same is brought into resonance. To convey an idea of what is required in securing the proper character of inclosing walls for a liquid resonator, it may be stated that air is over twenty thousand times more compressible than water; and water over sixty times more compressible than hard steel, so that to secure the requisite rigidity of the walls in the case of a liquid resonator I have found it necessary to build them up by shrinking very tough steel tubes upon one another.

Applying the principle of the discovery that the boundary walls of the chamber or cavity for a liquid resonator must be of this special character in order to withstand the variations of hydrostatic pressure, and thereby produce the reflection characteristic of resonance, I have produced apparatus for use in systems of submarine signaling capable of intensifying sounds, both sent and received, and which possess all the advantages in submarine work which distinguish similar devices for aerial sound-producing and signaling purposes, and which have always been recognized and adopted as the most effective for fog signals, alarms and similar purposes.

In an application filed by me on January 8th, 1907, Serial No. 351,361, I have illustrated the application of the principle of resonance to both sound producers and sound receivers for submarine systems, but have confined the more specific claims to the former and to features of novelty that are common to both forms of instrument. In the present application the claims are directed to those features of novelty which more particularly distinguish the application of the principle to sound receivers. I have, however, as a more convenient illustration of the principle, shown in the accompanying drawings, the sound producer of the application referred to.

Referring now to the accompanying drawings, Figure 1 is a view in elevation of the sound producer, showing the means for operating the same. Fig. 2 is a longitudinal cross-section of the operative parts of the same. Fig. 3 is a sectional view of the sound receiver in which the invention upon which my present application is based, is embodied.

Referring to Figs. 1 and 2, A is a cylinder of steel. It is shown as closed at one end and with the other open end beveled on an angle of about 60 degrees to sharp edges. It is not necessary that the cylinder be closed, but, as will be understood, to secure the same free period of vibration of a column of liquid within it, an open cylinder must be of double the length. In practice I have found that for good results a cylinder designed for a given pitch and having a bore of 3 inches in diameter and 11 inches long should have walls $1\frac{1}{2}$ inches in thickness of very hard tough steel built up by shrinking several tubes, one over the other. B, B, are side bars connecting the heads C, D, of a rigid frame. In the head C is secured, or integral with it is cast, a chamber E, provided with an inlet, through which water is introduced by a pipe G from any suitable source capable of delivering it at a high pressure. Within the chamber E is a spider H carrying a plate K of slightly smaller diameter than an opening in the end of the chamber, and which therefore leaves an annular orifice L preferably of about $\frac{1}{32}$ of an inch in width. In the head D is a circular opening with threaded walls with which corresponding threads on the exterior of the cylinder A engage. By this means the cylinder is rigidly supported with its beveled edge in proper position relative to the annular orifice L and with the capability of adjustment with respect thereto. The cylinder A is adjusted to bring its edge in close proximity to the annular orifice L, and is submerged at any desired point where the sounds or signals are to be produced. Water under pressure, preferably from 125 to 200 pounds, is then supplied to the chamber E, and issuing therefrom in the form of an annular jet impinges upon the edges and beveled end of the cylinder A, with the result that the harmonic or regular periodic vibrations are set up in the column of water within the cylinder. These vibrations, owing to the unyielding character of the boundaries of the chamber or cavity in which the column of water is contained are reflected back and forth from the walls and the column is therefore set in sonorous resonance. Such an apparatus will produce a tone of definite pitch dependent upon the dimensions of the chamber or cavity within the cylinder A. I have found that sounds thus produced will be carried to great distances through water and may be detected and rendered audible by suitable sound receiving instruments the more readily because of their distinctive musical character. By interrupting or varying the pressure of the water supplied to the chamber E, or by deflecting the jet issuing from the orifice in said chamber, distinctive signals, according to any prearranged code, may be sent by this device.

In Fig. 3 which illustrates the device for receiving sound S represents a portion of the skin of a steel vessel, which is selected for purposes of illustration. To the inner surface of the skin is secured, as by means of bolts P passing through flanges at its end, a steel cylinder M of the same character as that described in connection with Figs. 1 and 2. The opposite or inner end of the cylinder M is closed by a head N of corresponding thickness, the edges of which are threaded to engage with threads in the inner surface of the cylinder. A small orifice V is formed in the head N and an ordinary microphonic transmitter T is secured over the same or placed at any point at which it will be operated by the resonance of the column of water contained in the cylinder M. Wires O, O, connect the microphone with an ordinary telephone receiver. A small opening R may be drilled through the ship's skin in order to permit access of the water into the cylinder M, but this is not necessary for reasons previously described, as sounds coming through the water would be transmitted through the wall of the ship to the water column in the cylinder M, even were no passage of communication present. The head N, by means of its threaded connection with the cylinder M, may be adjusted to vary the dimensions of the chamber within the cylinder, and thus control the pitch of the resonant cavity in order to tune it to any desired source of sound. In this device the column of water within the cylinder M will be set in resonant vibration by a given sound transmitted to it through the water and entering either through the ship's wall or the opening R.

The sound thus intensified operates the microphone, which produces in the telephone receiver an audible sound.

While I have described the invention by reference to a specific form of apparatus, it is evident that its construction may be greatly varied. In general, the sound receiver may be submerged at any selected station or placed in a tank attached to the walls of a vessel so that by means of the apparatus signals may be transmitted from the shore to a vessel, or conversely, or between vessels within the limits of practical transmission.

What I claim as my invention is:

1. A sound receiver for submarine signaling systems, comprising in combination a receptacle with walls capable of withstanding the variations of hydrostatic pressure accompanying regular periodic vibrations in a body of liquid contained therein, and reflecting the same to produce resonance, and a sensitive device adapted to be acted upon by such vibrations, as set forth.

2. A sound receiver for submarine signaling systems comprising in combination a receptacle secured to the side of a vessel and having walls capable of withstanding the variations of hydrostatic pressure accompanying regular periodic vibrations in a body of liquid contained therein, and a sensitive device in position to be affected by such vibrations, as set forth.

3. The combination of a liquid resonator consisting of a receptacle with rigid walls capable of reflecting regular periodic or harmonic vibrations set up in a body of liquid contained within the same, and a microphonic sensitive device, secured over an orifice in the end of the receptacle through which the vibrations are caused to act upon the sensitive device, as set forth.

4. The combination of a liquid resonator consisting of a receptacle with rigid walls capable of reflecting regular periodic or harmonic vibrations set up in a body of liquid contained within the same, and secured over an opening in the side of a vessel, and a microphonic sensitive device secured over an orifice in the end of the receptacle through which the vibrations are caused to act upon the sensitive device, as set forth.

5. A sound receiver for submarine signaling systems, comprising in combination a hollow cylinder with walls capable of withstanding the variations in hydrostatic pressure accompanying the vibrations imparted to a body of liquid contained therein and reflecting the same to produce resonance, a head adjustable in said cylinder to vary the dimensions of the chamber within the cylinder, and a sensitive device in position to be affected by the vibrations of the body of liquid, as set forth.

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