

Aug. 19, 1952

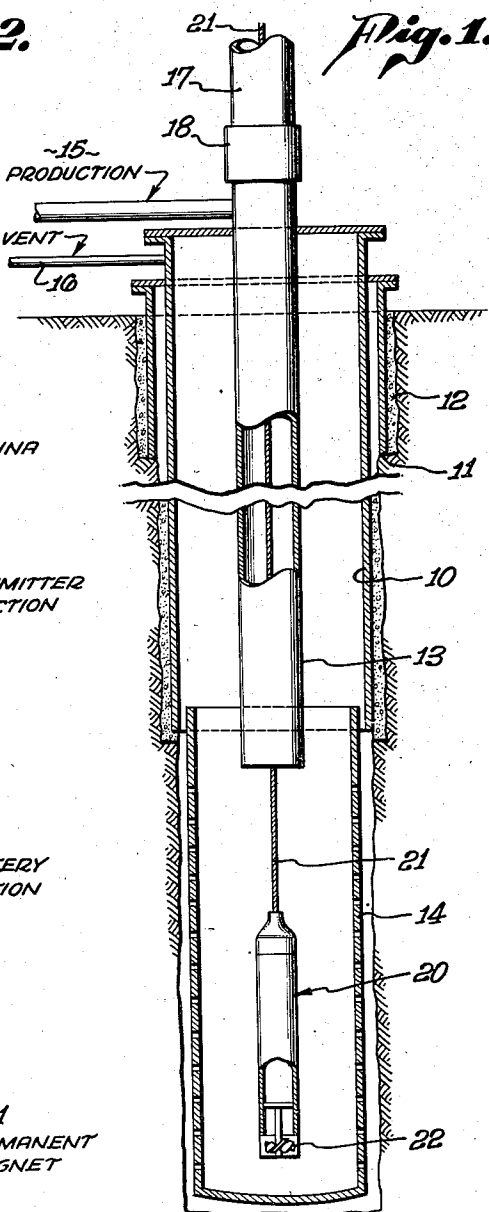
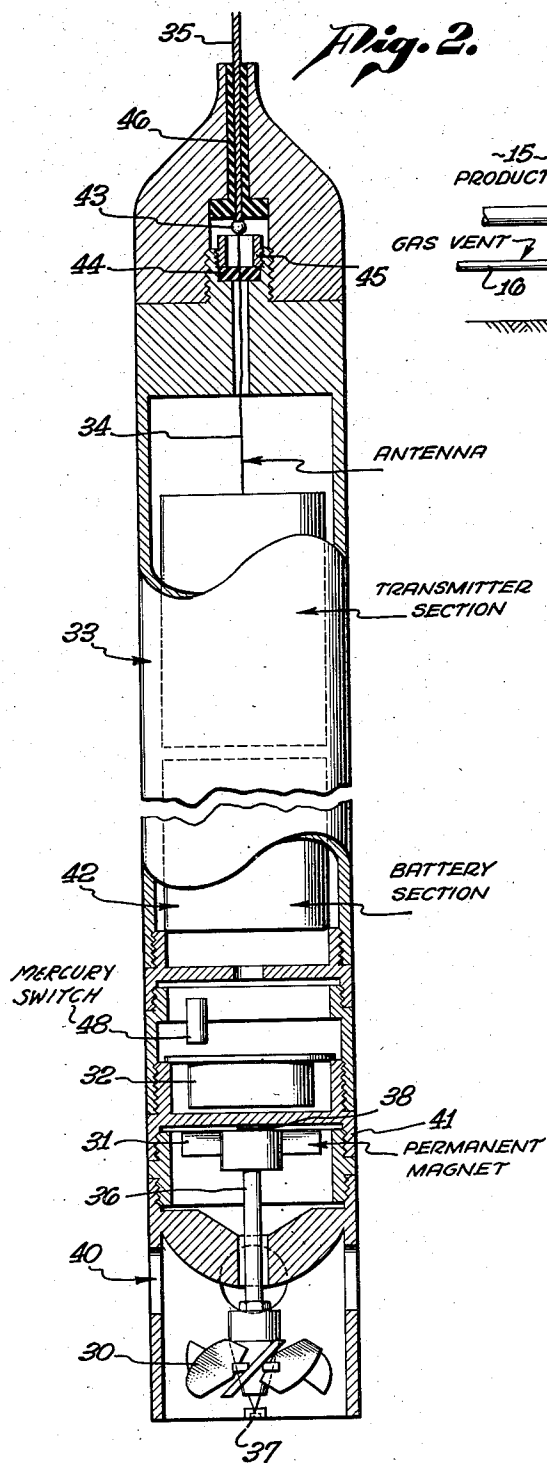
E. C. BABSON ET AL

2,607,221

FLOWMETER

Filed May 18, 1946

3 Sheets-Sheet 1



Edmund C. Babson
Richard R. Ormsby
Marshall C. Turner
INVENTORS.

BY *Ross J. Garofalo*
ATTORNEY

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3 Sheets-Sheet 2

Fig. 3.

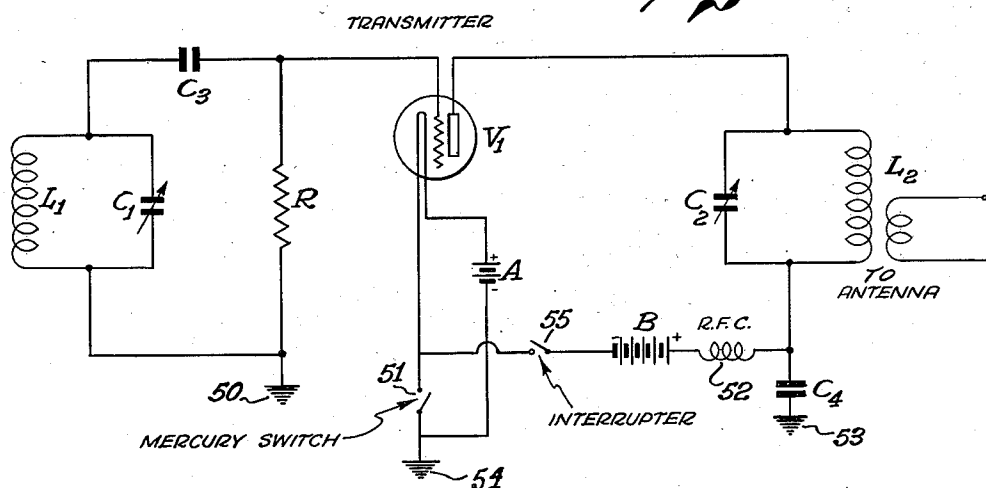


Fig. 4.

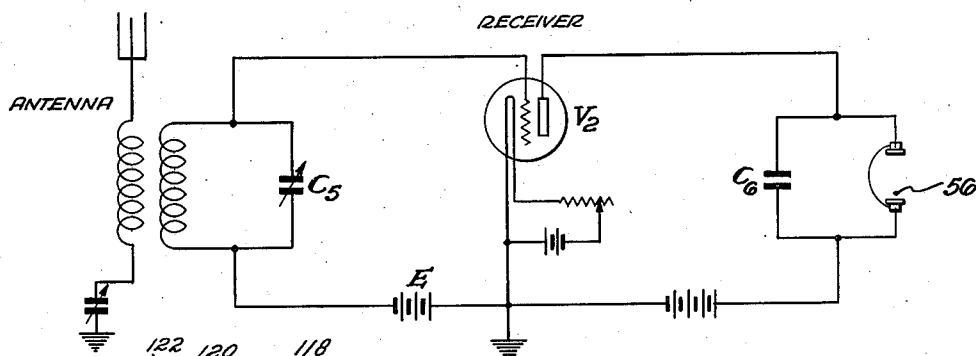
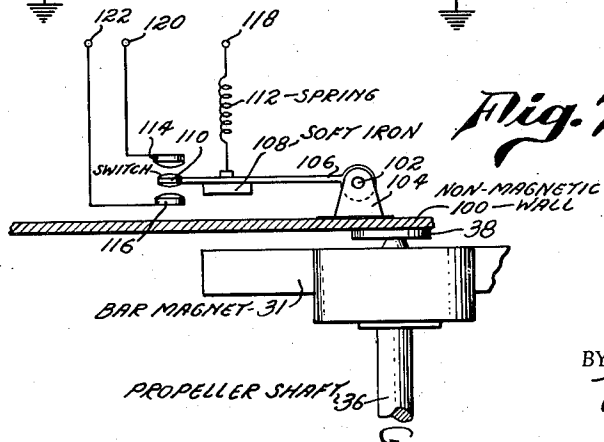


Fig. 7.



Edmund C. Babson
Richard P. Ormsby
Marshall C. Turner
INVENTORS

BY *Ross J. Garofalo*
ATTORNEY

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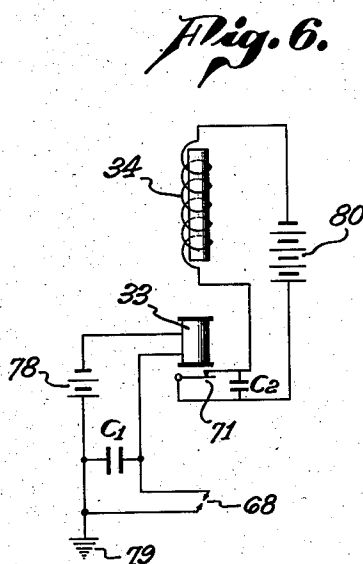
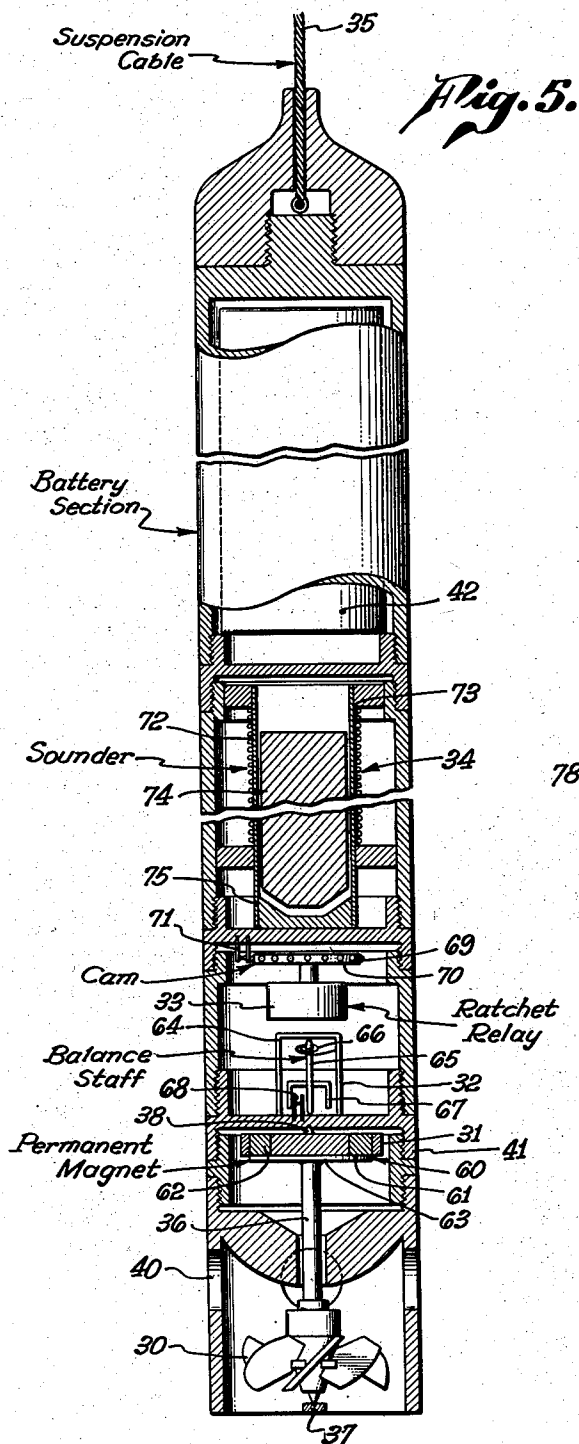
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3 Sheets-Sheet 3



EDMUND C. BABSON
 RICHARD R. ORMSBY
 MARSHALL C. TURNER,
 INVENTORS.

BY *Rose J. Garofalo*
 ATTORNEY

UNITED STATES PATENT OFFICE

2,607,221

FLOWMETER

Edmund C. Babson, Whittier, Richard R. Ormsby, Hermosa Beach, and Marshall C. Turner, La Habra, Calif., assignors to Union Oil Company of California, Los Angeles, Calif., a corporation of California

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8 Claims. (Cl. 73—155)

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This invention relates to apparatus for the location of the point of ingress or egress of fluids into or from the well bore of a producing well. Whereas, the greatest need for such an apparatus is probably in the production of oil the invention may be employed as hereinafter described in any producing well whether it be oil, water, gas, or the like for the measurement of flow differentials within the well bore.

In the production of oil there are numerous problems encountered concerning the flow of water or gas into the well or the flow of oil out of the well bore into the formation, for example, below the tubing string. This latter phenomenon is known by the term "thieving." Perhaps the greatest of these problems is the ingress of water into a well in excessive quantities which has the effect of materially reducing the efficiency of the well and the ultimate output attainable. Water may enter the oil well from strata overlying the oil bearing formation; such water being known as "top water"; from strata underlying the oil producing formation, or "bottom water"; from strata between two oil producing horizons, or "intermediate water"; or from the reservoir rock that yields the oil, or "edge water."

If water appears in the production of a well formerly free of water or if the percentage of water increases during the life of the well it is well known that it is desirable to take measures to determine its source and exclude it, if possible. It is not necessary to discuss herein the harmful effects of water in the producing formation of an oil well as these effects are well known to those skilled in the art.

Water may enter a producing well in a variety of ways. A casing used to cement off top water may corrode until it leaks, or a hole may be worked, punched or ripped in it by rubbing of drill pipe or tubing or by manipulation of tools used in repair work or clean-out operations. Water shut-offs may fail, even though originally successful. Canvas or rubber packers may rot, cement plugs may disintegrate or become cracked under stress or water may gradually find its way through or around the plug. Bottom water, originally under control, may gain admission to the well where bottom-hole pressures have diminished as a result of normal processes of production decline; or top-water, originally plugged off, may gain entrance to the well by disintegration or decay of the plugs used to exclude it. In fields where edge water under pressure is wholly responsible for expulsion of the oil, it is inevitable

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that water will gradually invade the reservoir rock as the oil is withdrawn, until eventually it takes possession of drainage channels to all of the wells. Wells near the edge of the productive area are first influenced, but gradually the water forces its way up the dip of the formation until wells at the very crest of the structure become "wet." Often, where a productive zone is composed of several distinct series of oil-yielding strata, water will advance more rapidly through or be found initially at higher structural positions in some strata than in others. Thus, "intermediate water" may appear in an area formerly free of water trouble, developing an increasing percentage of water, through some of the oil-yielding strata still continue to produce water-free oil.

Methods of combating such conditions including plugging, cementing through perforations, setting packers and the like. For such work, many special methods and appliances have been devised. However, before any remedial measures are undertaken, it is necessary to determine the source and the exact point of entry of the water finding its way into the well. It is to this end that the present invention is directed.

There are a great number of methods and types of apparatus known to the art which are employed to ascertain the point of water entry into an oil well.

Perhaps the simplest method comprises correlating the analysis of the water produced and the analysis of the core samples obtained during drilling. Such a method, however, has many obvious limitations, paramount among which is the inability to determine the point of entry of water not present during the drilling of the well. Several electrical instruments are available for this determination; one which measures the resistance of the well fluid to passage of direct-current electricity and another which operates on the principle of the generation of electromotive force by the well fluid which has been previously conditioned by the addition thereto of a solution of potassium bichromate with a small amount of sulfuric acid. Still another water-locating device utilizes variation of light intensity with a variation of well fluid composition to affect a sensitive photoelectric cell lowered into the well by insulated cables. All of these devices are limited by the fact that it is necessary to employ highly expensive means for lowering them into the well bore such as conduit, insulated wire, or the like; in some instances by the necessity of shutting off a flowing well in order to make

the determination, and further; in the fact that under the best conditions it is only possible to determine the point of entry of a contaminating fluid into a well while the detection of a "thief" structure, which has no effect upon the composition and thus the dielectric and other properties of the well fluid, is virtually impossible.

Analogous troubles occur in almost any type well in which a gaseous or liquid fluid is being produced. Thus, water is objectionable in a gas well, hydrocarbons are objectionable in a water well, etc.

It is therefore an object of the present invention to provide an improved apparatus for determining the point of entry of foreign substances into a well of any type.

More particularly, it is a principal object of the present invention to provide an apparatus whereby the location of water or gas ingress into an oil well may be determined.

It is yet another object of the present invention to provide apparatus for the determination of the point of thieving within a producing well so that adequate measures may be taken to seal up the strata of thief sand.

In its broader aspects, it is an object of our invention to provide a means of determining the relative velocity of fluid flow at various points in a producing well in such a manner that a velocity diagram of any portion of the well may be obtained.

Other objects and advantages of the present invention will be apparent to those skilled in the art.

Briefly, the invention contemplates attainment of these objects by the utilization of the change of fluid velocities within a well bore occurring as a consequence of the ingress to, or the egress from, the bore of fluids at various strata therein. From a correlation of these relative flow velocities with the composition of the fluid produced at the surface it is possible to ascertain with considerable accuracy not only the point of entry or exit of various components from the well bore but quantitative data as to the amount of such contamination at any given point. Our invention therefore includes an apparatus for determining the point of ingress or egress of fluids, the apparatus hereinafter being termed a "flow meter."

The present invention is accomplished by utilizing the flow within the well to rotate a propeller suspended therein at the lower end of the flow meter. The propeller, with the exception of supporting means, is mechanically independent of the rest of the flow meter and is separated therefrom by a magnetically permeable coupling. The rotation of this propeller, the rapidity of which is a function of the fluid flow velocity in the well bore, is utilized to actuate a mechanism whereby a signal is periodically transmitted to receiving means located at the surface. The period of this signal may be adjusted to any desired ratio with respect to the rate of rotation of the propeller. Thus there may be transmitted one or more signals for each rotation of the propeller or one signal for each two or more rotations of the propeller.

There are numerous methods by which these propeller rotations may be transformed into suitable signals transmittable to the surface. In general, however, it is preferred to effect this transformation in the instrument without requiring the propeller to accomplish any mechanical work other than that necessary to over-

come its moment of inertia. This is most conveniently done by locating at the top of the propeller shaft some form of permanent magnet which will be caused to rotate together with the propeller and in so rotating will operate an interrupter or similar electrical or magnetic device located immediately above the upper terminus of the propeller shaft and separated therefrom only by the magnetically permeable coupling above mentioned. The interrupter, or similar device, is made to actuate the signaling means which may for example employ the principles of radio transmission, sonic transmission, or the like, in order to transmit signals so induced by the rotation of the propeller to the well surface.

In accomplishing this transmission by short wave sending and receiving, the rotations of the propeller are caused to operate a magnetically actuated interrupter, situated immediately above the upper propeller shaft as above described, by means of a magnet attached and projecting transversely from the propeller shaft at a point adjacent to the magnetically permeable coupling. This interrupter in turn makes and breaks the circuit of a continuous wave transmitter located in the upper portion of the flow meter and more fully described hereinafter. This transmitter transmits a continuous wave signal generated by a self excited oscillator, crystal oscillator, or the like, at a frequency of, for example, about 11,000 kilocycles which is carried by means of an uninsulated wire from the upper end of the flow meter to the surface where the signal may be picked up by a conventional receiver. By this means two signals are received at the surface for each rotation of the propeller induced by the flow of fluid upwardly in the well past the flow meter.

A similar propeller construction may be utilized to induce the transmission of a sonic signal by causing the rotation of the magnet attached to the upper end of the propeller shaft to actuate an interrupter such as that previously described which in turn is used to actuate a ratchet relay. This ratchet relay is connected to a sounder as hereinafter more fully described. Preferably, however, in the utilization of sonic transmission we have found that better results may be obtained by picking up the rotations of the magnet by means of a conventional balance staff such as employed in watches, clocks, and the like, whereby the oscillating motion of the balance arms induced by the rotation of the magnet are caused to make and break contacts located in juxtaposition thereto. An electrical potential is impressed across these contacts by means of a battery and when the circuit is closed the flow of current may be caused to operate a ratchet relay which in turn is connected to a sounder.

The flow meter as described may be of any desired dimension but we have found it possible to manufacture one having a diameter of only $1\frac{3}{4}$ inches and an overall length of little more than three feet. However, any desired size may be employed and the power available to the signalling means will be a function of the battery space provided within the flow meter.

The method of utilizing the information acquired from the flow meter is simple and precise. For example, in a well producing 80% water and 20% oil by analysis, it may be found upon lowering the flow meter to the bottom thereof that there is no flow as evidenced by complete absence of signals which, as above indicated,

are transmitted only upon rotation of the propeller. The flow meter is gradually raised from the bottom of the well by means of the suspension wire, and at each point of oil entry the propeller will rotate a little more rapidly. If at some point within the well there is an inordinately large increase of signal reception, i. e., propeller rotation, it will be obvious that at this point water and not oil is entering the well as is apparent from the relative analysis of the well production. The exact location of this large water inlet may be determined by adjustment of the flow meter to determine the point at which the large increase in velocity occurs, at which point the length of wire suspension line is read and the exact location of water inlet is known. In a similar manner if thieving is occurring within the well it is possible, by the method of obtaining a velocity diagram of the producing horizon in the manner as above described, to determine the exact point therein at which the velocity of flow in the well bore is suddenly decreasing, indicating that at that point the loss is occurring. By means of this determination it is possible to effectively plug off the thieving formation.

The invention may be more clearly understood by reference to the accompanying drawings. Figure 1 shows a cross sectional view of a typical oil well. Figure 2 represents a vertical cross section of one modification of the apparatus of the present invention indicating the transmitting portion thereof only diagrammatically, and Figure 3 shows a wiring diagram of one type of transmitter which may be employed within the flowmeter shown in Figure 2. Figure 4 is of a wiring diagram of a simple receiver shown in its most elementary principles for purpose of convenience in the description. Figure 5 represents a vertical cross section of another modification of the apparatus of the present invention showing the utilization of a sonic transmitter in place of the short wave transmitter shown in Figure 2, and Figure 6 is a simplified wiring diagram of the sonic transmission system as shown in Figure 5. Figure 7 shows the details of the magnetic interrupter.

Referring to Figure 1, the characteristic features of a typical oil well, i. e., casing 10, retainer 11, the required cement seal off 12, tubing 13, and liner 14 are shown. Above the ground level the well is shown only schematically with production line 15 and the gas vent line 16. The lubricator 17 is shown connected to the upper end of tubing 13 by means of coupling 18. The function of a lubricator as a means of inserting a piece of equipment into a flowing well without interruption of production is well known by those skilled in the art. The lubricator comprises a cylinder through the upper end of which a wire line or other supporting means may be passed through a pressure seal gasket. Within the barrel of the lubricator sufficient space is provided in which the apparatus to be lowered within the well, such as the flowmeter of the present invention, may reside until it is lowered through the lower end of the lubricator into the well tubing. Thus the lubricator is attached to the upper end of the tubing, the pressure gasket at the upper end of the lubricator preventing loss of pressure from the well. In this manner the wire line or suspension means may be fed through this pressure gasket thus lowering the flowmeter into the well tubing. The flowmeter is illustrated diagrammatically by Figure 1 and is shown suspended by

the suspension wire 21 running through the well tubing and the lubricator attached to the top thereof. The flowmeter suspended by means of this wire may be raised or lowered within the well by any desired means such as a hoist, windlass, or the like, whereby the suspension wire is let out or withdrawn.

In the operation of the apparatus of the present invention the flowmeter may be lowered to the lower portion of the producing horizon as shown, at which point, if there be any flow of fluid, it will impart to the propeller 22 of the flowmeter 20, a definite rotary velocity, such velocity being a function of the vertical velocity of the fluid within the well, and further of the viscosity of that fluid. In the event there is no flow at the lower portion of the producing horizon there will be no rotation imparted to the propeller and consequently no signal transmission to the surface-located receiver. By the simple means of raising the flowmeter to different stages within the producing horizon relative velocity readings may be obtained by a correlation of the signal frequency received at the surface. In this manner, as pointed out above, a picture of the fluid flow either from the various stages of the producing zone or into the various stages thereof may be readily obtained by simple calibration and comparison of the relative velocities of flows at each stage.

The functioning of one modification of the flowmeter itself is described in relation to Figure 2 which illustrates the flowmeter diagrammatically without relation to its location in an oil well. The principle upon which this embodiment of the flowmeter operates is a transmission of a short wave signal to a surface receiver, the rapidity of which is related to the relative velocities of the fluid flow at the particular point within the well bore at which the flowmeter is located. In the flowmeter as shown in Figure 2 these velocities are transformed into the desired signal by the combination of propeller 30, magnet 31, interrupter 32, transmitter 33, antenna 34 and the uninsulated suspension wire 35.

Propeller 30 is suspended in the lower portion of the flowmeter, the propeller shaft 36 rotating on bearings 37 and 38. The rotation of the propeller is mechanically independent of the rest of the flowmeter and this rotation is induced by the flow of fluid through the bottom of the flowmeter past the propeller blades and out the vent holes 40. The permanent magnet 31 is attached to the upper portion of the propeller shaft 36 and is separated from the upper part of the flowmeter by means of the magnetically permeable bushing 41. This bushing may be made of any magnetically permeable material such as Monel metal, stainless steel, aluminum, plastics capable of withstanding the temperature in the well bore, or the like. The magnet is rotated by the propeller 30 below bushing 41 and actuates the interrupter 32 which may be a magnetically driven rotary switch above bushing 41 and adapted to follow the rotation of magnet 31 without mechanical connection therebetween. Interrupter 32 is so connected to the transmitter, as herein described, as to make the circuit therein and thus permit the transmission of two signals with each rotation of the propeller. The transmitter operated by means of batteries stored in the battery section 42 transmits a continuous wave signal by means of a self excited oscillator, crystal oscillator, with or without added radio frequency amplifiers, or the like.

The transmitter antenna 34 is connected to the uninsulated suspension wire by means of connector 43, the antenna and suspension wire being insulated from the flowmeter itself by means of the rubber packing 44, the packing gland 45 and the insulating rubber 46. The uninsulated suspension wire aids in the transmission of the signal to the surface receiver, which may be of any conventional design, located at the surface of the well. We have found that, although not necessary, it is preferable to employ a suspension wire having approximately twenty feet of insulation extending from the point of connection with the transmitter antenna. This small amount of insulation has the effect of increasing the intensity of the signal received at the surface.

The mercury switch 48 of Figure 2, although not a necessary part of the flowmeter, is a desirable one inasmuch as it may be conveniently connected to the transmitter circuit so that upon removing the flowmeter from the well and storing it in an upside down position the transmitter circuit is automatically broken thereby saving battery power.

As shown in Figure 2 the flowmeter is constructed in convenient sections whereby it may be completely disassembled for repairs, renewal of batteries, or the like, and thereafter may be conveniently reassembled.

Turning to Figure 3 one type of transmitter is shown which we have employed in the flowmeter as described in Figure 2. In the transmitter as shown, the oscillation of the plate current is induced by an oscillating grid voltage on the vacuum tube. Diagrammatically the oscillator comprises the inductance coil L_1 connected in parallel to the variable condenser C_1 . The circuit is completed by connection through condenser C_3 to the grid of vacuum tube V_1 together with grid resistance R and ground 50. The filament of the vacuum tube V_1 is connected to the source of power such as the A battery shown in the diagram and the circuit thereof is connected to the mercury switch as above described at a point 51. The mercury switch 51 is located with respect to the circuit as hereinafter described in such a manner that not only is the filament circuit controlled thereby but also the plate circuit. The transmission circuit comprises the plate of vacuum tube V_1 connected to a capacitance C_2 and inductance coil L_2 in parallel which are in turn connected in parallel to the battery B and the radio frequency choke 52. The transmission circuit is grounded through the condenser C_4 and ground 53 on one side of the battery B and also grounded together with the vacuum tube filament at ground 54.

The interrupter described in connection with Figure 2, is connected to this transmitting circuit at a point 55 in such a manner that the signal is generated only when the interrupter closes the circuit. It will be seen that whereas the mercury switch effectively opens or closes both the filament and the plate circuits the interrupter on the other hand operates only the plate circuit and thus while the flowmeter is in a vertical position with the propeller shaft at the lower end thereof the filament circuit is always closed and is independent of the interrupter. This is done to prevent lag in the heating of the filament which would be caused by so arranging the circuits that the interrupter also affected the opening and closing of the filament circuit.

Figure 4 illustrates a simple one-tube receiver and although a receiver is essential to the opera-

tion of the apparatus of the invention the type of receiver is not critical, the only requirement being that the receiver employed be capable of detecting the signals of the transmitter; that is, capable of receiving the wave lengths transmitted thereby.

In the receiver the voltage variations across the variable condenser C_5 are impressed upon the grid of the vacuum tube V_2 through the battery E. Variations of the grid voltage produce current variations in the plate circuit which are picked up by receiving means such as telephone receiver 56. The fixed condenser C_6 by-passes the high frequency fluctuation of the plate current and the receiver 56 receives the rectified current. The filament circuit is a characteristic one, substantially as described in Figure 3. It is again emphasized that the characteristics of the receiving means do not constitute a material part of the present invention and any type of receiver from the simplest to the most complicated may be employed providing it is capable of receiving and detecting the transmissions of the transmitter. Further, the signals so received may be automatically recorded as for example by connecting the receiver to a conventional oscillograph.

In Figure 5 there is shown a vertical cross section of another embodiment of our invention utilizing the same principle of fluid velocity within the well bore to transmit to the surface an indication of the point of ingress to or egress from the well of various fluids. In Figure 5 an indication of the fluid velocities is transformed into the desired signal by the combination of propeller 30, magnet 31, the balance staff assembly 32, the ratchet relay 33, the sounder 34, and the uninsulated suspension cable 35. As in Figure 2 the propeller 30 is suspended in the lower portion of the flowmeter, the propeller shaft 36 rotating on bearings 37 and 38. The rotation of the propeller is again mechanically independent of the rest of the flowmeter and this rotation is induced by the flow of fluid through the bottom of the flowmeter past the propeller blades and out the vent holes 40. The permanent magnet 31 is attached to the upper portion of the propeller shaft 36 and is separated from the upper part of the flowmeter by means of the magnetically permeable bushing 41. This bushing may be made as above indicated of any magnetically permeable material such as Monel metal, stainless steel, aluminum, plastics capable of withstanding the temperatures within the well bore or the like. The magnetic arrangement at the upper part of the propeller shaft 36 as shown in Figure 5 differs somewhat from the arrangement shown in Figure 2 and represents an alternative embodiment of this magnet actuator. The magnetic assembly 31 is composed of a non-magnetic disc 60 in which there is set two permanent magnets 61 and 62 joined to each other by means of the connecting bar 63 which is of a magnetically impermeable material such as iron, or the like.

The magnet as rotated by the propeller 30 actuates the balance staff assembly 32 which is so connected to the ratchet relay 33 as to make a circuit therein. The balance staff assembly consists of the yoke or supporting framework 64, the balance staff 65, the hair spring 66, the balance arms 67, and the contact points 68. The rotation of the magnet by the propeller causes the balance arms to oscillate, the complete rotation thereof being prevented by the hair spring 66. Upon each oscillation of the balance arms 67 the contact points 68 are engaged with each other

and in so engaging are caused to actuate the ratchet relay 33.

The ratchet relay 33 is connected to a cam 69 provided with numerous projections 70 thereon. These projections 70, when the cam 69 is rotated a step by means of the ratchet or staff relay 33, cause the contacts 71 to engage, which contacts are connected in a separate circuit to the sounder 34.

The sounder 34 comprises an electromagnetic coil 72 wound around a tubular core 73 in which there is free to ride a weight 74. In the rest position the weight 74 is supported by means of anvil 75. However, as the sounder circuit is closed by the operation of the ratchet relay, as above described, the magnetic force raises the weight 74 away from the anvil 75 where it is held until the relay is again actuated at which time the coil circuit of the sounder is opened and the weight is dropped on the anvil 75.

The effect of the dropping of this weight is to induce a sonic vibration in the suspension cable 35 which sonic impulse may be picked up or recorded at the surface by means of a strain gauge, a dynamometer or by any means of suitable amplification of the flux created. The method of detecting the disturbance created by the dropping of the weight 74 is not a limiting feature of the invention inasmuch as a number of methods of detecting sonic disturbances are familiar to those skilled in the art.

The electrical energy is supplied to the flowmeter by means of batteries contained within the flowmeter in battery section 42. By the utilization of batteries to supply the necessary power we are able to employ the flowmeter suspended on an uninsulated cable which is a decided advantage in that an insulated cable of the length required is not only comparatively expensive but is difficult to lower in a well bore without interfering with the flow of fluid within the well.

The operation of the flowmeter as shown in Figure 5 may be more clearly understood by reference to a simplified circuit diagram thereof as shown in Figure 6. In Figure 6 the contact points 68 are shown connected through battery 78 to the ratchet or step relay 33. This circuit is preferably provided with a condenser C₁ and is grounded at ground 79. The step relay by means of the cam 69 as shown in Figure 5 alternatively opens and closes the contact points 71 which are connected through battery 80 to the sounder 34. This circuit may also be provided with a condenser C₂.

Referring now more particularly to Figure 7, the details of the magnetic interrupter are shown. Non-magnetic wall 100 is a portion of element 41, shown in Figures 2 and 5. Rotating bar magnet 31 is shown supported on shaft 36 centered on bearing 38, also shown in Figures 2 and 5. Pivot 102 supported on mounting 104 carries arm 106 which is provided with iron armature 108 and movable contact 110. Spring 112 applies tension or compression to arm 106 holding movable contact 110 normally against either of stationary contacts 114 or 116, respectively. With tension applied to arm 106, an electrical circuit is made between terminals 118 and 120. Each rotation of bar magnet 31 exerts a downward force on armature 108 causing the contact between contacts 110 and 114 to be momentarily broken. Two such interruptions in the circuit named occur for each revolution of shaft 36. If desired, a circuit between terminals 118 and 122 may be employed, in which case two connections per revolution of shaft 36 result.

Whereas, particular apparatus has been described and illustrated for accomplishing the principles and purposes of our invention, it should be reiterated that the invention resides not only in the apparatus as described, or modifications thereof, but primarily in the principle of the utilization of velocity differences of fluid flow at various locations within a well bore as a means of determining the type of flow from the producing horizon into the well bore as well as, and of equal importance, the flow of fluid out of the well bore at a faulty structure within the producing horizon or at any point below the casing string. With these principles in mind, which principles comprise the primary teaching of our invention, many modifications in the apparatus as illustrated and described will be apparent to those skilled in the art without departing from these basic concepts of our invention. For example, if it becomes practical to suspend a flowmeter from the surface by means of an insulated wire or an insulated cable, then the necessity of radio transmission and reception or sonic transmission would be obviated, and a current could be run from the surface through an interrupter similar to the one described and back to the surface, again the circuit being opened and closed by means of an actuation of the interrupter in the same manner or in a similar manner as described above. However, one of the features of our invention which will have the greatest commercial interest is that it is not necessary to employ an insulated wire for we have found that the transmission to the surface of the short wave or sonic signals is suitably effected by an uninsulated wire. The use of an uninsulated wire has many advantages paramount among which being the tremendous differential in initial investment and the relative ease of feeding an uninsulated wire into a flowing well without loss of production or pressure.

Further, other means of picking up the fluid velocity variations may be employed in place of the propeller device as shown in Figure 2, although we have found that this device appears to be the simplest of construction and operation.

Also many variations in the transmitter hook up, as illustrated in Figure 3, may be employed. Perhaps the greatest possibility in this respect is the use of a crystal oscillator which is much more stable than a self-excited oscillator as shown in Figure 3, but is limited to the usage of a type of crystal which will withstand temperatures encountered at the bottom of a well bore, which temperatures may be in the neighborhood of 250° F. Whereas, the transmitter shown in the present invention transmits at a frequency of approximately 11,000 kilocycles, this transmission may be affected over a wide range of frequencies, such as from about 2,000 kilocycles to 300 megacycles or higher. The lower frequencies are limited by the distance through which the signal must be transmitted and the higher power requirements, and consequently larger equipment, than is necessary for higher frequency transmission.

Similarly many mechanical variations in the sonic transmission system, as illustrated in Figure 5, may occur to those skilled in the art. Thus, rather than the balance staff assembly as shown in the figure an interrupter similar to that shown in Figure 2 may be employed, or other means may be employed for transforming the rotation of the propeller to a sounding device similar to that shown in Figure 5. However, it

is preferable to effect this transformation without utilization of direct mechanical connection inasmuch as the propeller is not adapted, due to its size and the possible low viscosity of the fluid within which it is to be suspended, to accomplish an appreciable amount of work. It is the provision of a system whereby the necessity of the accomplishment of work is obviated that constitutes one of the advantages of the present invention, but it should be emphasized that many methods of transmitting this propeller rotation to a sounding device or short wave transmitter, or the like, are possible. Although a description of each of these modifications is not possible in the present disclosure any or all of these methods should be construed as being included in the scope of the invention.

Having located, for example, the point of entry or the point of escape of fluids from a well bore it is necessary, to complete the picture, to take remedial measures for the exclusion of the undesirable fluids or for the sealing up of formation faults. These remedial measures will depend upon the point of entry or of egress and the relationship of this location to the producing formation. Thus, in the exclusion of water from an oil well different methods will be employed dependent upon whether it is found that the water flow is of the nature of top water, edge water, bottom water or intermediate water. These methods are familiar to anyone schooled in the production art and the description thereof in the present application would be unnecessary and immaterial.

Whereas, the utilization of the apparatus has been described with relation to water entry into a well, and particularly into an oil well, it is equally applicable by means of the same principles to the determination of the point of gas entry into an oil well, of water entry into a gas well, or the like, and we do not intend to be limited to the usage of the herein disclosed method and apparatus to the one application of determining the point of entry of water into an oil well although perhaps this may be the widest application of the apparatus.

Having pointed out the principles of our invention and apparatus for accomplishing the ends sought and realizing that many modifications in this apparatus will occur to those skilled in the art without departing from the spirit and scope of the foregoing description or the following claims, we claim:

1. A flowmeter for determining the flow rate of fluids flowing in a bore hole drilled into the earth, which comprises an elongated fluid-tight shell, an uninsulated suspension cable mechanically attached to the upper end of said shell, a transverse fluid-tight relatively non-magnetic wall closing the lower end of said shell, a propeller housing dependent from the lower end of said shell below said transverse wall and having a lower open end for entrance of fluids and a plurality of peripherally disposed openings for fluid exit adjacent the upper end of said housing, a propeller shaft rotatably mounted on bearings within said housing substantially coaxial with the longitudinal axis of said shell, said shaft having a propeller secured adjacent its lower end and a bar magnet attached at its upper end and adapted to rotate in a circular path adjacent and below said non-magnetic wall on rotation of said shaft, a magnetically actuated electrical switch secured within said shell adjacent and above said non-magnetic wall at a point on said circular

path and adapted to be actuated by motion of said magnet, an electrically operated oscillating means adapted to produce oscillations within said shell, power supply means secured within said shell and electrically connected to said oscillating means, said magnetically actuated electrical switch being electrically connected to said oscillating means and adapted to interrupt the output thereof, and a connection between said oscillating means and said suspension cable adapted to the transmission of power therebetween.

2. An apparatus according to claim 1 wherein said oscillating means comprises a continuous wave transmitter, and said suspension cable is electrically insulated from said shell.

3. An apparatus according to claim 1 wherein said oscillating means comprises a sonic transmitter consisting of an electromagnetic coil containing a movable solenoid hammer, an anvil secured to said shell adjacent the lower end of said hammer, said solenoid hammer and anvil being physically disposed relative to each other so that said hammer rests on said anvil when said coil is unenergized and is lifted from said anvil when said coil is energized and adapted to drop onto said anvil on de-energization of said coil thereby imparting a sonic oscillation through said shell into said suspension cable to the earth's surface.

4. An apparatus according to claim 3 wherein said magnetically actuated electric switch is adapted to interrupt the electrical connection between said electromagnetic coil and said power supply means, and said magnetically actuated switch comprises a balance staff supported in a yoke attached to said shell disposed above and adjacent said non-magnetic wall, said staff being restricted in rotation by means of a hair spring attached between said staff and said yoke, an electrical contact point on said staff movable against a stationary electrical contact point upon restricted movement of said staff in response to movement of said magnet below said non-magnetic wall along said circular path.

5. A flowmeter comprising an elongated fluid-tight shell, an uninsulated suspension cable mechanically attached to the upper end of the shell and electrically insulated therefrom, a transverse fluid-tight relatively non-magnetic wall closing the lower end of said shell, a propeller housing dependent from the lower end of said shell below said wall and having a lower open end and a plurality of peripherally disposed openings adjacent the upper end thereof, a propeller shaft rotatably mounted within said housing substantially coaxial with the longitudinal axis of said shell, said shaft having a propeller secured adjacent its lower end and a magnet attached adjacent its upper end adjacent and below said non-magnetic wall, a continuous wave transmitter secured within said shell, power supply means secured within said shell and electrically connected to said transmitter, a magnetically actuated interrupter secured within said shell adjacent and above said non-magnetic wall and adapted to be actuated by rotation of said magnet, said interrupter further being electrically connected to said transmitter and adapted to interrupt the power output thereof, and an electrical connection between said transmitter and said suspension cable for the transmission of power therebetween, said connection being also insulated from said shell.

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6. A flowmeter according to claim 5 wherein said continuous wave transmitter comprises a self-excited oscillator.

7. A flowmeter according to claim 5 wherein said continuous wave transmitter comprises a crystal oscillator.

8. A flowmeter according to claim 5 wherein said continuous wave transmitter comprises an oscillator and at least one amplifier.

EDMUND C. BABSON.

RICHARD R. ORMSBY.

MARSHALL C. TURNER.

REFERENCES CITED

The following references are of record in the file of this patent:

Number	
369,595	
1,440,778	
1,700,642	5
2,018,030	
2,109,181	
2,283,429	
2,285,809	
2,287,786	10
2,325,927	
2,333,164	
2,334,920	
2,379,138	15

14**UNITED STATES PATENTS**

Name	Date
Dietzman et al.	Sept. 6, 1887
Foster	Jan. 2, 1923
Meindersma	Jan. 29, 1929
Martienssen	Oct. 22, 1935
Muldowney	Feb. 22, 1938
Ennis	May 19, 1942
Davis	June 9, 1942
Diamond et al.	June 30, 1942
Wilbur	Aug. 3, 1943
Fisher	Nov. 2, 1943
Gosline et al.	Nov. 23, 1943
Fitting, Jr. et al.	June 26, 1945

FOREIGN PATENTS

Number	Country	Date
323,198	Great Britain	Dec. 23, 1929