Feb. 11, 1941. E. L. KNOEDLER, JR 2,231,166

COMBUSTIBLE GAS INDICATOR

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Fig. 1.

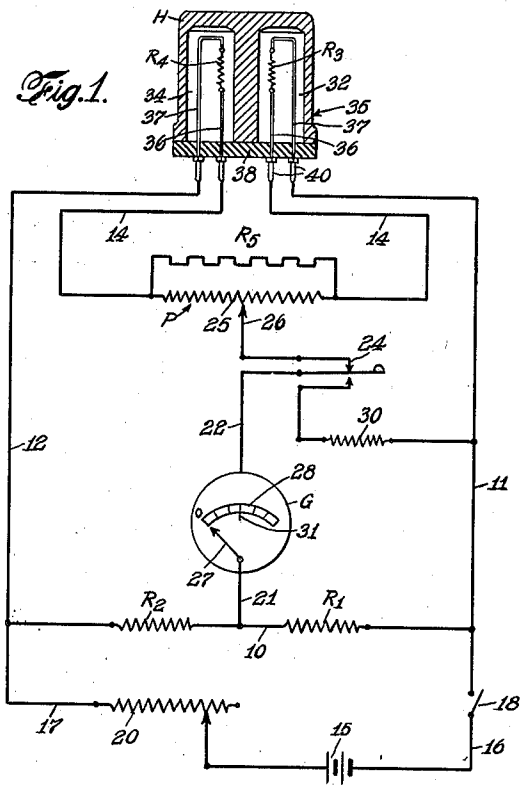


Fig. 2.

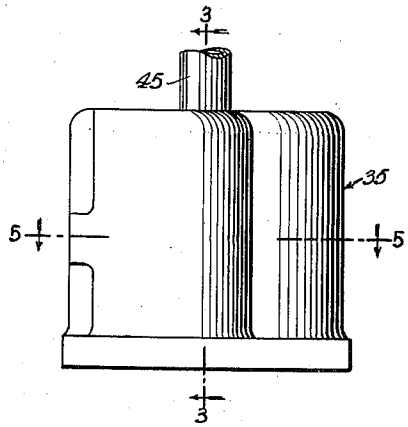
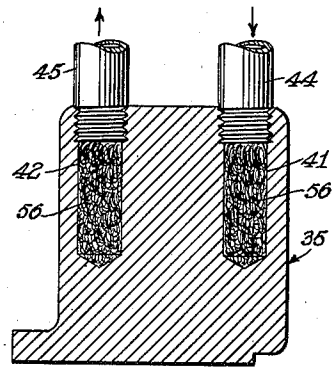


Fig. 3.



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Fig. 4

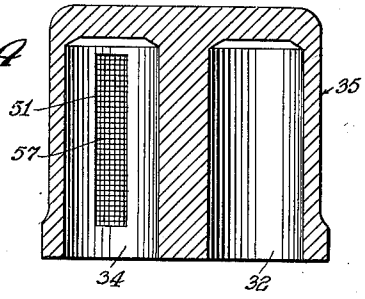


Fig. 4a

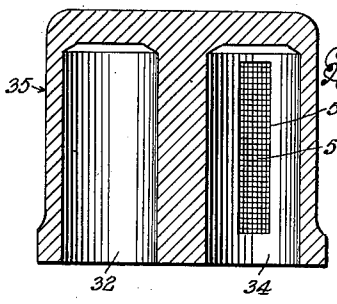


Fig. 5.

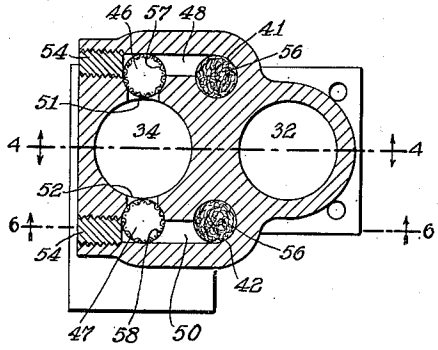


Fig. 6.

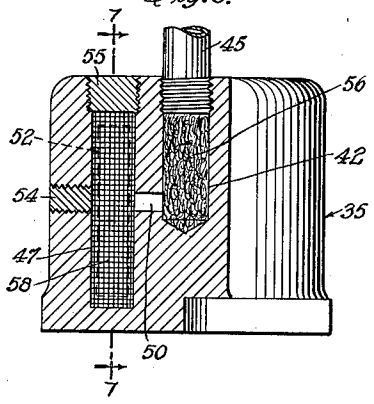
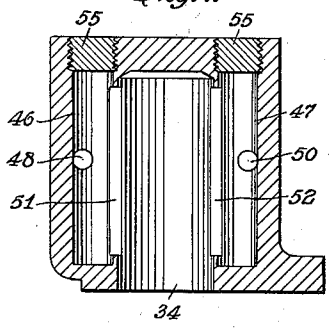


Fig. 7.



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UNITED STATES PATENT OFFICE

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COMBUSTIBLE GAS INDICATOR

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Application June 20, 1939, Serial No. 280,112

8 Claims. (Cl. 23—255)

This invention relates to combustible gas indicators, and is herein illustrated as embodied in an apparatus of the type wherein the gas to be analyzed is passed over one of a pair of heated filaments constituting portions of a Wheatstone bridge, one of which filaments (namely the one over which the gas to be analyzed is passed) being located within a combustion chamber through which the gas to be analyzed is caused to flow and the other being located within a sealed filament chamber and there maintained under stable ambient conditions.

In apparatus of the above type, wherein the gas to be analyzed is passed over one of the filaments by way of the combustion chamber, difficulty has heretofore been experienced in obtaining such a flow of gas as will consistently effect a prompt and reliable indication of the explosive nature of the gas undergoing examination. Additionally, difficulty has been encountered in apparatus of the type to which the present invention pertains in that the time required for purging the apparatus preparatory to the making of an analysis has been of such duration as to hamper or impede the work of the operator in his line of duty, as where he is required to make a series of analyses in rapid succession in the interest of the preservation of life and property.

Important objects of the present invention are to overcome the foregoing difficulties, and to that end improved means are provided for (*a*) effecting a flow of gas through the combustion chamber in such a manner that the apparatus will so respond as to expeditiously give an accurate indication of the combustible character of the gas undergoing examination, and for (*b*) effecting a flow of air through the combustion chamber in such manner that complete purging of the combustion chamber may be promptly accomplished.

Other objects and advantages of the invention will become apparent from the following description when taken in connection with the accompanying drawings, in which—

Fig. 1 is a diagram of an electric circuit which includes a pair of filaments constituting portions of a Wheatstone bridge, the filaments being shown as housed within a pair of chambers of a combustion chamber unit which is shown in section and which is constructed in accordance with the present invention;

Fig. 2 is a side elevation of the combustion chamber unit appearing in Fig. 1;

Fig. 3 is a transverse sectional view taken on line 3—3 of Fig. 2;

Fig. 4 is a composite view showing in section that half of the unit which appears above the section line 4—4 of Fig. 5; Fig. 4*a* is a view showing in section that half of the unit which appears below the section line 4—4 of Fig. 5;

Fig. 5 is a horizontal sectional view taken on line 5—5 of Fig. 2;

Fig. 6 is a sectional view taken on line 6—6 of Fig. 5, and

Fig. 7 is a sectional view taken on line 7—7 of Fig. 6.

In accordance with the present invention, an electrical circuit of the Wheatstone bridge type is employed, the circuit being characterized, as is well known, by the fact that it may be employed to indicate a change of electrical resistance in one of its parts.

In Fig. 1 a circuit of the above type is illustrated in the present embodiment of the invention as including resistances R_1, R_2, R_3 and R_4, the resistances R_3 and R_4 being in the form of, and sometimes hereinafter referred to as, filaments. The resistances R_1—R_2, R_1—R_3, R_2—R_4 and R_3—R_4 are respectively connected together by conductors 10, 11, 12 and 14 and to the conductors 11 and 12 there is connected a battery 15 by way of conductors 16 and 17, in the former of which there is disposed a switch 18 and in the latter of which there is disposed a variable resistance 20. The bridge circuit also includes a galvanometer G, connected on the one hand to the conductor 10 by a conductor 21 and, on the other hand, to the conductor 14 by way of a conductor 22 within which is disposed a normally closed switch 24 the function of which will hereinafter more clearly appear. In order that the circuit may be balanced as occasion may require to compensate, for example, for any gradual change in the electrical characteristics of the filaments R_3 and R_4, there is interposed in the conductor 14 a resistance 25 which, in conjunction with a wiper arm 26 interposed in the conductor 22, constitutes a potentiometer P about the resistance of which is shunted a fixed resistance R'. As to the potentiometer P, it will be understood that by moving its wiper arm 26 in one direction or the other, as required, along the resistance 25, the circuit assuming the switch 24 to be in its normally closed position, may be brought into a perfectly balanced condition, which condition is indicated when the pointer 27 of the galvanometer assumes a des-

ignated position, for example zero-position, on the galvanometer scale 28.

In order that the galvanometer G may be utilized in the capacity of a voltmeter as occasion requires, to test the voltage delivered to the circuit from the battery 15, the switch 24 may be moved from its normal closed-circuit position, shown in Fig. 1, so as to sever the direct electrical connection between the galvanometer G and potentiometer P and directly connect the galvanometer with the conductor 11 by way of a fixed resistance 30 having a relatively high resistance value as compared with that of the resistances R_1, R_2 and the maximum resistance value of the resistance 20. Preferably, the scale 28 of the galvanometer G is provided with indicia, such as an operating-voltage-graduation 31, with which the pointer 27 registers incident to the carrying out of a voltage-testing operation provided the prescribed operating voltage is then available, at the low potential side of the resistance 20, for use in the normal operation of the Wheatstone bridge. If, when carrying out the voltage-testing operation just described, the pointer indicates that the voltage delivered at the low potential side of the resistance 20 is either less than or greater than the prescribed operating voltage, the necessary compensation is effected by so adjusting the variable resistance 20 as to raise or lower the operating voltage to the value prescribed for use in the Wheatstone bridge.

According to the present invention the filaments R_3 and R_4 are housed respectively within chambers 32 and 34 formed in the metallic housing H of a combustion chamber unit 35, the chamber 32 being sealed to the atmosphere so as to maintain the filament R_3 under stable ambient conditions and the chamber 34, sometimes hereinafter referred to as a combustion chamber, being open to the atmosphere so that the filament R_4 may be subjected to a gas to be analyzed and so that the combustion chamber may be purged as conditions may require. Although the filaments R_3 and R_4 may be supported in any appropriate manner, I have illustrated them as being connected respectively to a pair of conductor posts 36 and 37 carried by a base 38 secured to the lower face of the combustion chamber unit 35 and provided with conventional prong-like connector elements 40 to which the conductor posts 36 and 37 are electrically connected and by which the filaments R_3 and R_4 may be (through the medium of a suitable socket, not shown) placed in the circuit of which the conductors 11, 14 and 12 constitute portions.

As shown most clearly in Figs. 3 and 5, the combustion chamber unit 35 is formed with inlet and outlet chambers 41 and 42 provided at their upper ends with inlet and outlet tubes 44 and 45 through the former of which gas or air, depending upon whether a testing operation or a purging operation is to be carried out, is directed into the gas chamber unit, and through the latter of which such gas or air is dispelled from the gas chamber unit by means of a suitable suction device (such as an aspirator bulb, not shown) connected to the outlet tube. The flow of gas or air from the inlet chamber 41 to the outlet chamber 42 is afforded by way of the combustion chamber 34 by reason of the fact that the combustion chamber unit is formed with a pair of distributing chambers 46 and 47 which, on the one hand, communicate with the inlet and outlet chambers 41 and 42 by way of a pair of ducts 48 and 50 and, on the other hand, communicate with the combustion chamber 34 by way of a pair of slot-like ports 51 and 52 which are substantially coextensive with the distributing chambers. The housing H may be so cored as to provide the filament chambers 32—34, inlet chambers 41—42 and distributor chambers 46—47, but in providing the ducts 48 and 50 the housing H is preferably drilled from one side thereof so that the drill-passages intersect the chambers 46—47 substantially midway of their ends and join the inlet and outlet chambers 41—42 at or near the bottom walls thereof. The drill-passages thus formed in providing the ducts 48 and 50 may be conveniently closed by inserting in their outer ends screw plugs 54 and likewise the distributor chambers 46 and 47 may be closed at their upper ends by inserting screw plugs 55.

In order to maintain a gentle and substantially uniform or constant flow of gas or air through the combustion chamber 34, under the action of the above-mentioned aspirator bulb, so as to insure an accurate indication of the combustible character of the gas undergoing examination, means are provided for baffling the gas or air and for uniformly distributing it to the combustion chamber 34 where it is subjected to the filament R_4. The baffling means just mentioned is herein illustrated as including a mass of metallic wool 56 (such as tungsten wool, i. e., thread-like elements of tungsten) confined within the inlet and outlet chambers 41 and 42 and as further including a pair of tubular baffles 57 and 58 located within the distributor chambers 46 and 47, the baffles being constructed from a suitable fine-mesh wire gauze and substantially conforming to the inner diameter of the respective distributor chambers. It will be appreciated that by reason of the presence of the metallic wool 56 and the metal gauze baffles 57 and 58 gas or air passing through the combustion chamber unit under the pulsating action of an aspirator bulb connected, as above mentioned, to the outlet tube 45, will be so controlled due to the impedance offered by the metallic wool 56 in conjunction with the baffles 57 and 58 as to pass gently and at a substantially uniform rate through the combustion chamber 34 so as to effect a stabilized ambient condition in the combustion chamber during a gas analyzing operation, which stabilized ambient condition obviates the possibility of sporadic movements or intensified fluctuations of the galvanometer pointer 27 so as to promote accuracy in the taking of galvanometer readings during the making of a gas analysis.

It is to be observed that stability of the ambient condition in the combustion chamber is further insured by reason of the fact that the baffles 57 and 58 so function in the capacity of distributors that the gas entering the combustion chamber from the distributor chamber 46 by way of the port 51 is caused to traverse the combustion chamber along a path substantially coextensive with the length of that chamber and at right angles to its axis in evenly distributed amounts, so that the filament, which is directly in the path of travel of the gas, is subjected at any instant to a gaseous condition which is identical with the gaseous condition then existing throughout the confines of the chamber. Inasmuch as the character of the gas in the immediate vicinity of the filament at any instant is identical with that of the gas then at all other localities in the combustion chamber, it follows that the galvanometer will so respond as to give an

accurate indication of the explosive character of the gas in its entirety.

The above-mentioned baffling means, already described, as including the masses of metallic wool **56** and the fine-mesh wire gauze baffles **57** and **58**, perform the additional function of insuring, as will be readily understood, against ignition of gas or gases without the combustion chamber unit **32** by the heated filament R_4 and/or the burning of any gas within the combustion chamber **34**.

Further considering the function of the baffles **57** and **58**, note is to be made of the fact that since they effect even distribution of the gas through the combustion chamber **34** transversely of its axis and substantially throughout its entire length, the filament R_4 is promptly subjected to gas to be analyzed upon initiating a gas analyzing operation, and this is especially true because of the fact that the filament is arranged in a relatively short path or line of gas flow between the inlet and outlet ports **51** and **52** leading to and from the combustion chamber through which the gas passes in a direct or straight-line manner. It will be appreciated, of course, that since the filament R_4 is promptly subjected to gas to be analyzed upon initiating a gas-analyzing operation, the galvanometer G is rendered quickly responsive so as to enable one to quickly take a galvanometer reading which, for the reasons already stated, is accurately indicative of the explosive character of the gas undergoing analysis.

The present invention not only enables one to quickly take a galvanometer reading which is accurately indicative of the combustible character of the gas undergoing examination, but also enables a complete purging of the combustion chamber to be promptly accomplished inasmuch as the purging medium (namely, pure air which traverses the combustion chamber unit **35** under the action of the above-mentioned aspirator bulb and along the already-described path of travel of gas to be analyzed) flows transversely through the combustion chamber **34** along substantially its entire length without provoking the formation of eddy currents or effects which would hinder or impede removal of gas from the combustion chamber and thus unduly prolong the purging operation.

Although it is believed that the operation of the apparatus herein illustrated as embodying the present invention will be readily understood from the foregoing description, it may be well to point out that when the apparatus is placed in use, a sample of gas to be analyzed is passed through the combustion chamber **34** (by way of the inlet tube **44**, inlet chamber **41**, duct **48**, distributor chamber **46**, inlet port **51**, outlet port **52**, distributor chamber **47**, duct **50**, outlet chamber **42** and outlet pipe **45**) under the action of an aspirator bulb, not shown. Under operating conditions, any burning of the gas entering the combustion chamber **34** will augment the normal heat inherent in the filament R_4 so that the resistance of that filament is increased with respect to the unaffected resistance of the filament R_3. Such increase in filament heat will electrically unbalance the Wheatstone bridge circuit and thus cause the galvanometer pointer **27** to indicate the combustible character of the gas undergoing examination. When it is desired to purge the combustion chamber **34**, pure air is passed through the combustion chamber, along the line of flow described in connection with the passage of gas through the combustion chamber, with the result that the apparatus is reconditioned for the carrying out of another gas-analyzing operation.

Although only one form of the invention is herein shown and described, it will be understood that various changes may be made without departing from the spirit of the invention or the scope of the following claims.

What is claimed is:

1. A combustion gas indicator comprising a Wheatstone bridge including a filament over which gas to be analyzed is passed and a combustion chamber unit having a combustion chamber within which said filament is housed and having a pair of distributing chambers communicating with said combustion chamber by way of a pair of slot-like ports substantially coextensive with that dimension of the combustion chamber which is perpendicular to the direction of passage of said gas, by way of one of which distributing chambers and its associated slot-like port gas is passed into the combustion chamber and by way of the other of which distributing chambers and its associated slot-like port gas is directed from said combustion chamber.

2. A combustion gas indicator comprising a Wheatston bridge including a filament over which gas to be analyzed is passed, a combustion chamber unit having a combustion chamber within which said filament is housed and having a pair of distributing chambers communicating with said combustion chamber by way of a pair of slot-like ports substantially coextensive with that dimension of the combustion chamber which is perpendicular to the direction of passage of said gas, by way of one of which distributing chambers and its associated slot-like port gas is passed into the combustion chamber and by way of the other of which distributing chambers and its associated slot-like port gas is directed from said combustion chamber, and baffling means housed within at least one of said distributing chambers and operable to effect a uniform rate of flow of gas through the combustion chamber transversely thereof in evenly distributed amounts.

3. A combustion gas indicator comprising a Wheatstone bridge including a filament over which gas to be analyzed is passed, a combustion chamber unit having a combustion chamber within which said filament is housed and having a pair of distributing chambers communicating with said combustion chamber by way of a pair of slot-like ports substantially coextensive with that dimension of the combustion chamber which is perpendicular to the direction of passage of said gas, by way of one of which distributing chambers and its associated slot-like port gas is passed into the combustion chamber and by way of the other of which distributing chambers and its associated slot-like port gas is directed from said combustion chamber, and baffling means housed within said distributing chambers and operable to effect a uniform rate of flow of gas through the combustion chamber transversely thereof in evenly distributed amounts.

4. A combustion gas indicator comprising a Wheatstone bridge including a filament over which gas to be analyzed is passed, a combustion chamber unit having a combustion chamber within which said filament is housed and having a pair of distributing chambers communicating with said combustion chamber by way of a pair of slot-like ports substantially coextensive with that dimension of the combustion chamber which is perpendicular to the direction of passage of

said gas, by way of one of which distributing chambers and its associated slot-like port gas is passed into the combustion chamber and by way of the other of which distributing chambers and its associated slot-like port gas is directed from said combustion chamber, and baffling means housed within at least one of said distributing chambers and operable to effect a uniform rate of flow of gas through the combustion chamber transversely thereof in evenly distributed amounts, said baffling means comprising a fine-mesh wire gauze element of tubular construction.

5. A combustion gas indicator comprising a Wheatstone bridge including a filament over which gas to be analyzed is passed, a combustion chamber unit having a combustion chamber within which said filament is housed and having a pair of distributing chambers communicating with said combustion chamber by way of a pair of slot-like ports substantially coextensive with that dimension of the combustion chamber which is perpendicular to the direction of passage of said gas, by way of one of which distributing chambers and its associated slot-like port gas is passed into the combustion chamber and by way of the other of which distributing chambers and its associated slot-like port gas is directed from said combustion chamber, and baffling means housed within said distributing chambers and operable to effect a uniform rate of flow of gas through the combustion chamber transversely thereof in evenly distributed amounts, said baffling means comprising a pair of fine-mesh wire gauze elements of tubular construction housed respectively in said distributing chambers.

6. A combustion gas indicator comprising a Wheatstone bridge including a filament over which gas to be analyzed is passed, a combustion chamber unit having an inlet chamber and an outlet chamber and having a combustion chamber within which said filament is housed and having a pair of distributing chambers communicating respectively with said inlet chamber and said outlet chamber and communicating with said combustion chamber by way of a pair of slot-like ports substantially coextensive with that dimension of said combustion chamber which is perpendicular to the direction of passage of said gas, by way of one of which distributing chambers and its associated slot-like port and its associated inlet chamber gas is passed into the combustion chamber and by way of the other of which distributing chambers and its associated slot-like port and its associated outlet chamber gas is directed from said combustion chamber, and baffling means housed within said inlet chamber and said outlet chamber and including masses of metallic wool and operable to confine combustion of gas to the interior of said combustion chamber unit.

7. A combustion gas indicator comprising a Wheatstone bridge including a filament over which gas to be analyzed is passed, a combustion chamber unit having an inlet chamber and an outlet chamber and having a combustion chamber within which said filament is housed and having a pair of distributing chambers communicating respectively with said inlet chamber and said outlet chamber and communicating with said combustion chamber by way of a pair of slot-like ports substantially coextensive with that dimension of said combustion chamber which is perpendicular to the direction of passage of said gas, by way of one of which distributing chambers and its associated slot-like port and its associated inlet chamber gas is passed into the combustion chamber and by way of the other of which distributing chambers and its associated slot-like port and its associated outlet chamber gas is directed from said combustion chamber, and baffling means housed within said combustion chamber unit operable to effect a uniform rate of flow of gas through the combustion chamber transversely thereof in evenly distributed amounts and comprising a fine-mesh wire gauze element of tubular construction housed within one of said distributing chambers and masses of metallic wool housed in said inlet chamber and said outlet chamber.

8. A combustion gas indicator comprising a Wheatstone bridge including a filament over which gas to be analyzed is passed, a combustion chamber unit having an inlet chamber and an outlet chamber and having a combustion chamber within which said filament is housed and having a pair of distributing chambers communicating respectively with said inlet chamber and said outlet chamber and communicating with said combustion chamber by way of a pair of slot-like ports substantially coextensive with that dimension of said combustion chamber which is perpendicular to the direction of passage of said gas, by way of one of which distributing chambers and its associated slot-like port and its associated inlet chamber gas is passed into the combustion chamber and by way of the other of which distributing chambers and its associated slot-like port and its associated outlet chamber gas is directed from said combustion chamber, and baffling means housed within said combustion chamber unit operable to effect a uniform rate of flow of gas through the combustion chamber transversely thereof in evenly distributed amounts and comprising a pair of fine-mesh wire gauze elements of tubular construction housed respectively in said distributing chambers and masses of metallic wool housed in said inlet and outlet chambers.

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