

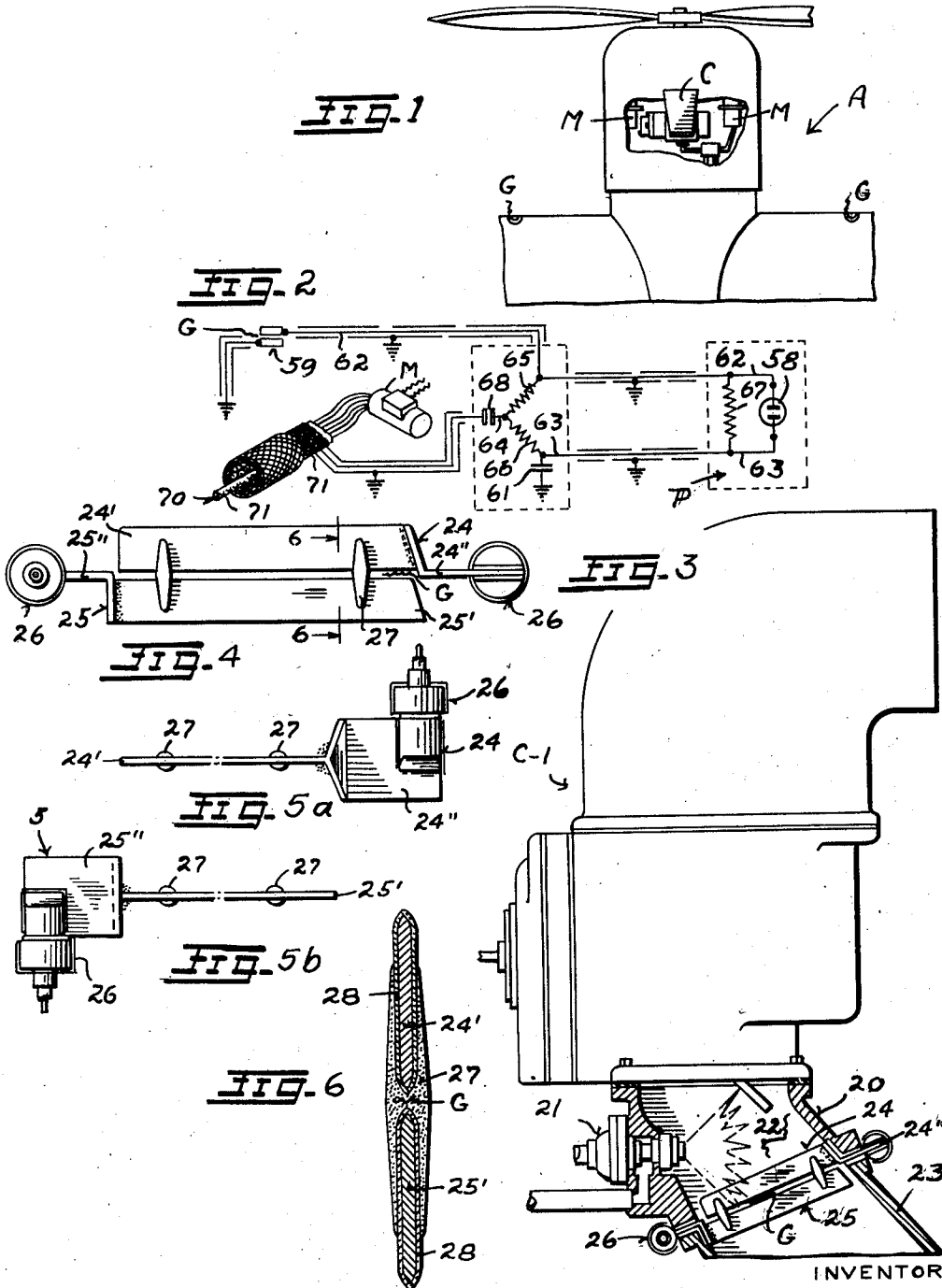
Jan. 14, 1958

J. E. LINDBERG, JR
ICING DETECTION DEVICE

2,820,196

Filed Dec. 10, 1951

3 Sheets-Sheet 1



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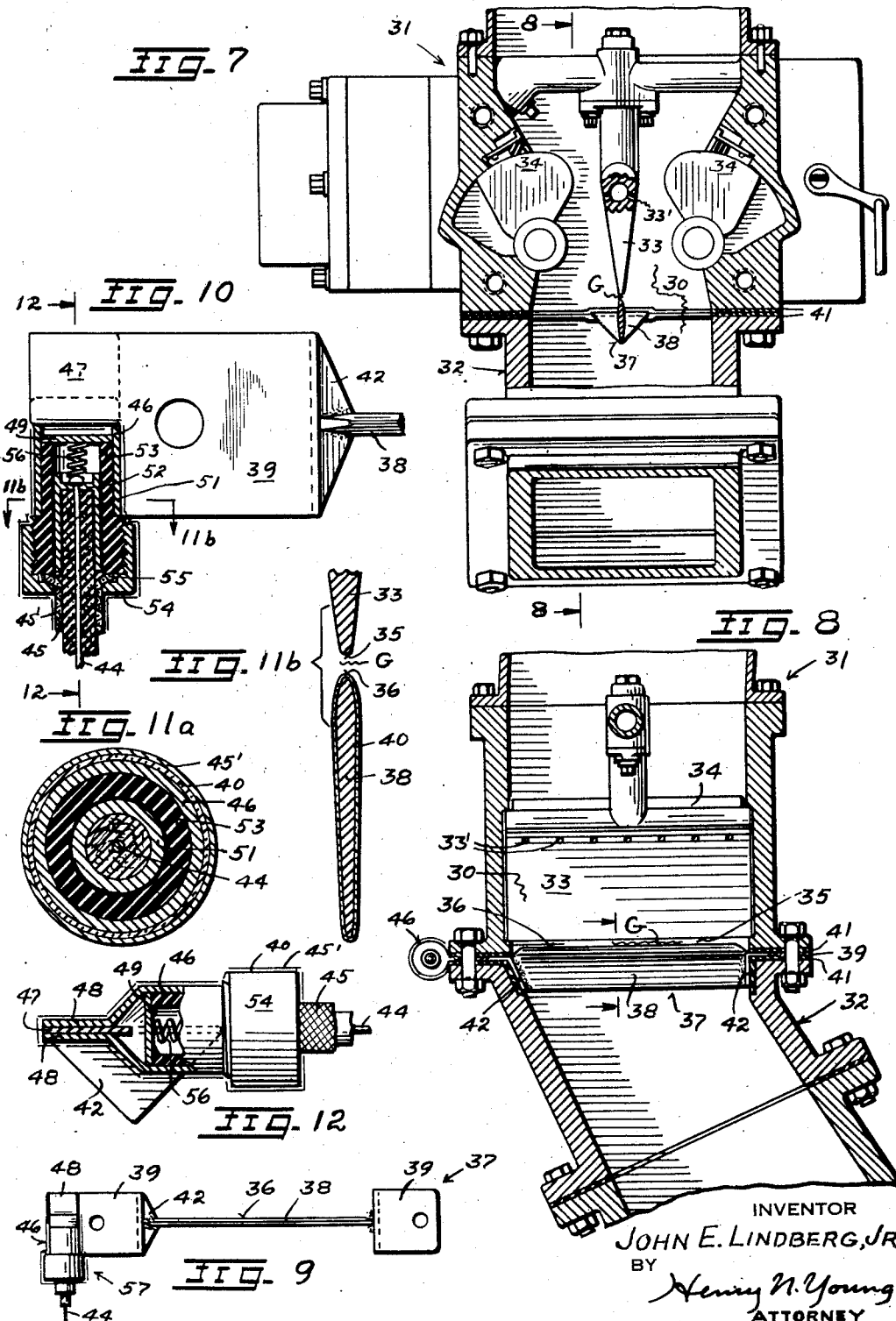
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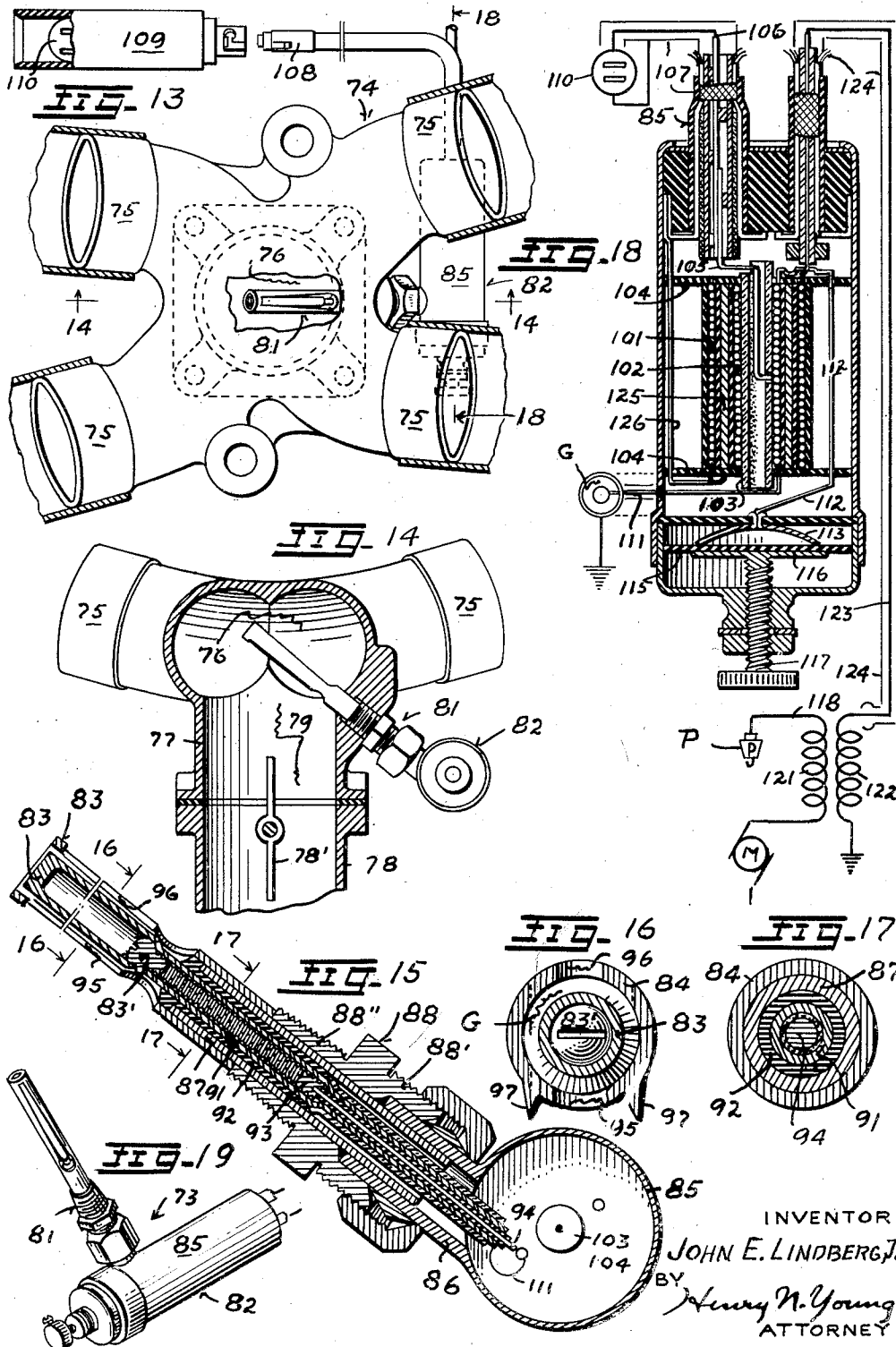
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ICING DETECTION DEVICE

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Application December 10, 1951, Serial No. 260,835

7 Claims. (Cl. 324—61)

The invention relates generally to a device for the detection and indication of a deposit of material at a particular location, and more specifically to the formation of ice in fuel induction systems of aircraft; the present application includes a continuation in part of my copending application Ser. No. 771,533, filed August 30, 1947, and which issued into Patent 2,577,779 on December 11, 1951.

An object of the invention is to provide particularly reliable and sensitive devices for indicating the formation of ice in the fuel induction systems of internal combustion engines whereby to permit safe engine operation with a full-cold carburetor setting and the accompanying highest engine efficiency and power.

A more specific object is to provide improved dielectric gap devices for disposal in gaseous streams as parts of icing-signal circuits.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be set forth or be apparent in the following description of typical embodiments of the invention, and in the accompanying drawings, in which,

Figure 1 is an enlarged fragmentary view of an airplane taken at a propelling motor thereof, a portion of the motor housing being broken away to generally show the engine carburetor and magnetos.

Figure 2 is a schematic diagram showing an indicator circuit and means for the detection of the formation of ice in an engine carburetor, as that of an airplane.

Figure 3 is a side view of a carburetor, an adapter portion of this carburetor being shown in section.

Figure 4 is an enlarged view of an electrode member of Figure 3.

Figures 5a and 5b are fragmentary plan views of different elements of the member of Figure 4.

Figure 6 is an enlarged transverse section at the line 6—6 in Figure 4, thicknesses being exaggerated.

Figure 7 is an enlarged side front view of a different type of engine carburetor and its associated adapter, the carburetor having its front side plate removed and the adapter being shown in section.

Figure 8 is a sectional view taken at the line 8—8 in Figure 7.

Figure 9 is a plan view of an electrode member of Figures 3 and 4.

Figure 10 is an enlarged fragmentary view of the electrode shown in Figure 9, a conductor connection therefor being shown in axial section.

Figure 11a is an enlarged fragmentary sectional view taken at the line 11b—11b in Figure 10, thickness being exaggerated.

Figure 11b is an enlarged fragmentary sectional view taken at the line in Figure 8, thickness being exaggerated.

Figure 12 is a partially sectional view taken at the line 12—12 in Figure 10.

Figure 13 is a plan view showing the application of another and particularly compact unitary embodiment of

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my ice-formation detection device to a fuel-intake manifold for a third type of internal combustion engine.

Figure 14 is a partial section taken at the line 14—14 in Figure 13.

5 Figure 15 is an enlarged sectional view of a portion of the structure of Figure 13 taken at the line 14—14 thereof.

Figures 16 and 17 are sections taken at the lines 16—16 and 17—17 in Figure 15.

10 Figure 18 is an enlarged sectional view taken at the line 18—18 in Figure 13 and showing the signal circuit of the applied unit.

Figure 19 is a fragmentary perspective view of the unit of Figure 13 at a reduced scale.

15 As disclosed, the device of my invention is applied for the detection of the formation of ice in the induction passage of an internal combustion engine and on the leading edges of the wings of an airplane A. Essentially, the device comprises the provision of a special gap between capacity electrodes provided in a signal circuit including a suitable indicator means which is actuable by a change in the dielectric conditions across said gap. In the present application of the device, the indicator means is arranged to be actuated by and upon a formation and/or deposit of ice in a gap G provided between capacity electrodes suitably provided at a circuit point in a zone normally containing only gaseous material including water vapor and where the formation of ice may be expected to first occur under icing conditions; for descriptive convenience, the gaps G are herein referred to as "dielectric gaps."

20 Figures 3 to 6 represent the showing of Figures 13 to 17 of my aforesaid prior application, and disclose a means for providing a dielectric gap G in connection with a down-draft carburetor C-1, such as a "Stromberg" injection carburetor, having the spray discharge of fuel taking place obliquely into an adapter 20 from a nozzle element 21 in such a manner that the evaporation of the fuel takes place adjacent the discharge end of the adapter passage 22. The lower end of the adapter 20 is arranged for bolted connection to the fuel intake nozzle 23 of the engine to be supplied with carbureted fuel, and electrode members 24 and 25 comprising uniform elongated and mutually coplanar flat condenser plates 24' and 25' providing a dielectric gap G between them arranged for mounting across the passage 22 and its continuation in the manifold at the juncture of the adapter and the intake nozzle 23.

25 As particularly shown, the respective electrode plates 24' and 25' are provided with terminal flanges 24'' and 25'' extending for their electrode-mounting gripping between the exposed adapter and nozzle ends, the flanges 24'' and 25'' being perpendicular to the plates 24' and 25' and preferably provided with suitable lead connections 26 at their free ends. In the present electrode structures 24 and 25, the end flanges 24'' and 25'' are provided by members having triangular connecting portions transverse to the plates 24' and 25' in fixed relation thereat to generally parallel the opposed faces of the adapter passage thereat, and these flanges have the plate portions 24' and 25' fixed integrally to them. The plates 24' and 25' are preferably of streamline cross-section to minimize frictional resistance to the flow of the fuel mixture in the passage 22.

30 Noting that the electrodes 24 and 25 respectively are each secured only at one side of the passage 22, and comprise relatively thin elements in mutually coplanar relation while providing a uniform gap G between their opposed edges, means are preferably provided to mutually secure the plates in such unitary relation as to avoid flutter of the plates in the stream of carbureted fuel, whereby the associated electrodes comprise a two-elec-

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trode unit. As illustrated, the plates 24' and 25' are connected with each other near their different ends with ribs 27 of suitable insulating material, and the complete two-electrode unit is preferably fully coated with a relatively thin ceramic, or porcelain, glazing coat 28 for preventing an electric leakage to or from the electrodes. It will be understood that the present electrode unit is adapted for inclusion in an ungrounded circuit, or in a grounded circuit by grounding one electrode.

Figures 7 to 12 disclose the provision of a dielectric gap G within a discharge passage 30 of a down-draft carburetor C-2, said passage being defined in part within a usual tubular adapter 32 through which the carbureted fuel is conveyed to the intake manifold of its engine. The present carburetor C-2 is of the type in which a wedge-shaped fuel discharge nozzle 33 is disposed between venturi throttle members 34 which are swingably adjustable about axes parallel to the nozzle plane to provide an adjustable air flow passage along the nozzle toward its apical edge 35, the fuel being supplied in said passages through usual ports 33' of the nozzle. The present generally disclosed carburetor is of the "Holly" aircraft type, and is bolted upon the adapter 32, the plane of connection of the carburetor and adapter being adjacent the straight nozzle edge 35.

In the present arrangement, the nozzle 33 is utilized as a plate or electrode defining one side of a dielectric gap G, and a member 37 provides the other electrode of the gap. The present member 37 includes a generally flat strip 38 of electrically conductive material for spanning the passage 30 in the plane of the nozzle 33 with its upper edge 36 in spaced parallel relation to the nozzle edge 35 to define the dielectric gap G between said edges. The connection between the carburetor and adapter may be utilized for mounting the member 37 in its operative position by providing the member with flat extensions 39 in the form of end flanges for gripped engagement between the opposed faces of the carburetor and adapter. The flanges 39 may be engaged between gasket members 41 of insulating material at the connection.

In the present structure of the member 37, the end flanges 39 are provided by members having inner end portions 42 triangular and down-turned to generally parallel the opposed faces of the adapter passage thereat, and have the electrode plate 38 fixed integrally to and between the portions 42 in a suitable manner. The plate element 38 is preferably of streamline cross-section with the edge 36 its leading edge whereby to minimize frictional resistance to the flow of the fuel mixture in the passage 30. Noting that the electrode member 37 provides one side of a dielectric gap G in a high-frequency indicator circuit and has a connection 26 at one flange 39, it is desirable that this member be particularly well insulated, and to the latter end, the member is preferably completely coated with a relatively thin glazed layer 40 of an insulating material having a highly capacitive dielectric constant; the provision of the coating 40, which corresponds to the electrode coating 28 of the first embodiment, is brought out in Figures 11a and 11b.

Understanding that the leads of a high-frequency circuit to include the gap G should also be insulated or shielded against electrical interference, as by a grounded tubular metal shield or shroud 45, the connection 26 for a lead 44 to the electrode member 37 is such as will maintain the desired insulation condition thereat. As particularly shown, a metallic member 46 is provided for mounting on an extension 47 of a flange 39, said extension comprising an integral continuation of the flange, but extending for only approximately one-half of its width. The member 46 is shaped as from a piece of tube which is flattened for a portion of its length and has its flattened portion cut off in the line of the cylinder of its unflattened portion to provide lips 48 for receiving the extension 47 between them, the member 46 being integrally fixed to the flange in a suitable manner, as by welding at the

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line of engagement of the members. Except for a limited central contact zone at the outer face of the disc 49, the disc and member 46 have the glazed insulating coating 40 of the rest of the member 37.

At the inner end of its tubular portion, the member is partitioned by a metallic disc 49 fixed therein and arranged to provide the contact point with the member 37 for the lead 44. For providing an electrical connection of the lead 44 with the disc 49, a cap-like metallic member 51 is mounted at the end of the lead to receive the insulation for the wire and has its closed end 52 perforated for receiving a bared end portion of the lead wire 44 therethrough for soldering in place thereat, said member being disposed slightly inwardly of the adjacent extremity of the cap. The cap member 51 is slidably engaged in a sleeve member 53 of insulating material having an inner portion thereof arranged for fixed insertion within the tubular portion of the member 46 to engage the disc 49 and having its extended portion externally threaded to mount a ring cap 54 arranged to receive the shroud 45 of the lead 44 through its opening.

In connecting the lead to the member 37, the shielding shroud 45 is turned outwardly adjacent the outer end of the cap member 51 to provide a radial flange 55 about the lead and its insulation thereat, and the flange 55 is arranged for clamped engagement between the opposed faces of the sleeve 53 and the ring cap 54 to fix the shroud and lead to the member 46. A compression contact spring 56 is seated between the disc 49 and the cap end 52, the screwing down of the cap 54 being arranged to compress the spring 56 in its place to provide a direct electrical connection between the disc and cap end; in this manner, a sealed-in connection 57 is provided between the lead 44 and the electrode member 47. Before the cap 54 is applied, the porcelain-coated extending portion of the electrode member 47 is preferably over-coated with metal, as by applying a metallizing spray thereto, to provide, in effect, an extension 45' of the shielding shroud 45 over the exposed portion of the member 37 when the ring cap 54 is operatively installed.

A dielectric gap G suitably provided, as in either of the previously described and illustrated manners, is arranged for its inclusion in a suitable capacity-change indicating and/or measuring circuit which may be energized by and upon the formation of ice in or across the gap to actuate a signal means of the circuit. By particular reference to Figure 2, a dielectric gap G is interposed in a circuit which is energized to light up a flow-discharge tube 58 when ice forms in or across said gap. In the present instance, the tube 58 has its terminals connected in a bridge circuit such that the tube is energized for its lighting only when the circuit conditions are suitably influenced by the formation of ice at the gap G in a more or less spanning relation thereto.

As particularly shown, an electrode of a gap G provided by an electrode assembly 59 and a plate of a condenser 61 are respectively connected to leads 62 and 63 of the tube 58, the numeral 59 being used to generically indicate any assembly providing a suitable dielectric gap G for installation and use in the described manner. Power for energizing the circuit is derived from a lead 64 connected with a suitable source of oscillating electromotive force and having branch connections with the tube leads 62 and 63 through resistances 65 and 66 respectively. A resistance 67 may be provided in parallel connection with the tube 58 for increasing the sensitivity of the tube as an indicator means. Oscillating power may be supplied to the power input lead 64 through a condenser 68 from a pick-up lead 69 deriving energy by induction from an ignition wire 70 which comprises one of a plurality of ignition wires which are periodically energized by a magneto M of the engine; for present pick-up purposes, the pick-up lead 69 may be connected with a tubular metallic shield 71 enclosing a portion of the wire 70.

In the circuit of Figure 2, the circuit portion including the indicator tube 58 and the resistance 67 is preferably provided at the instrument panel P of the aircraft for ready reference. On the other hand, the condensers 61 and 68 and the resistances 65 and 66 are preferably provided in a unitary assembly immediately adjacent the carburetor, whereby the leads thereto from the gap and power source may be as short as possible for providing the highest possible sensitivity and accuracy of indication. Radiation of energy to or from all leads of a circuit is preferably prevented by enclosing the leads in grounded shields as is generally indicated. While the gap assembly 59 and condenser 61 are both shown as being grounded, it will be understood that their grounding leads might be connected to provide an ungrounded bridge circuit including the tube 58.

Figures 13 to 19 inclusive disclose a unitary assembly 73 for providing an ice-detecting dielectric gap G and certain essential indicator circuit elements for association with the intake manifold 74 for a four-cylinder internal combustion engine of a type which is commonly used in smaller airplanes. The present manifold 74 comprises generally coplanar discharge nozzles 75 arranged for their connection to the different cylinders of an engine (not shown) for discharging the carbureted fuel from a central chamber 76 which receives the carbureted fuel through a receiving nozzle 77 which is attached to a carburetor discharge nozzle 78 provided with a usual throttle valve 78'; in the present instance, the nozzle 78 is assumed to be that of an updraft carburetor whereby the confined passage 79 of the connected nozzles 77 and 78 discharges axially upwardly into the manifold chamber 76. Noting that expansion of the received carbureted fuel takes place radially from the central portion of the chamber 76, this point is a critical one in the formation of ice in the fuel induction system of the associated engine, and the present form of my invention is particularly arranged for its installation to provide a dielectric gap G at or adjacent said point.

In the present embodiment of my invention, the unit 73 includes in an elongated assembly 81 which provides a dielectric gap, and an assembly 82 providing a transformer and a variable condenser of the signal system, said assemblies being in mutually fixed relation. The gap G of the assembly 81 is essentially provided by an elongated electrode 83 of cylindrical outline and a tubular electrode 84 coaxially receiving the electrode 83 and spaced from it to provide a space for the flow of gaseous fuel there-through for a possible deposit of ice in the dielectric gap thus provided to appropriately effect the indicator system of an installation. In the present unit 73, the elements of the assembly 82 are mounted in a tubular shell 85 having a tubular boss 86 extending more-or-less radially from it and providing a means by which the assembly 82 may be unitarily associated with the gap-providing electrodes 83 and 84 which are arranged for mounted disposal in the central portion of the manifold chamber 76 by reason of the engagement of the assembly 74 through a manifold wall in supported relation thereto.

A tubular member 87 extends from the uniform bore of the boss 86 in slidable engagement with it, and coaxially mounts the electrodes 83 and 84 in outwardly extending relation to it. The intermediate portion of the tube 87 is fixedly engaged in the bore of a fitting 88, and comprises an intermediate hexagonal portion for holding or turning engagement by a wrench, and externally threaded end portions 88' and 88''. The portion 88' is counterbored from its free end to slidably receive an outer end portion of the tubular boss 86 of the shell 85, and its exterior threadedly mounts a packing nut 89 which closely and slidably receives the boss 86 through the bore of its unthreaded end which is spaced from the opposed end of the fitting to provide space for suitable packing 90; in the present instance, the packing 90 comprises an externally

tapered ring of triangular cross-section axially thereof and arranged for its wedged compression between the head of the nut 69 and the opposed fitting end as a means for fixedly and removably attaching the tube 87 to the boss. The forward threaded portion 88'' of the fitting 88 is arranged for its threaded engagement in a hole provided through the side of the manifold 74 at a point which is generally between adjacent manifold nozzles 75, and with the axis of the tube 87 directed toward the geometric central point of the manifold chamber 76 and obliquely forwardly with respect to the flow line of the fuel stream into the manifold.

As shown, the tubular electrode 84 is fixedly mounted on the tube 87 by directly and fittedly receiving the tube portion which is forward of the fitting 88. The inner electrode 83 is mounted within the portion of the electrode member 84 which extends beyond the forward end of the tube 87 and is provided at the forward end of a tubular stem 91 which is fixed within a tubular insulation sleeve 92 fixedly engaging the forward part of the bore of the tube. Preferably, but not necessarily, the present electrode 83 has the form of a hollow cylinder and is provided at its inner end with a boss 83' which threadedly engages in the forward end of the stem 91 for mounting it thereon. A screw plug 93 engaged in the inner end of the stem 91 has a conductor rod 94 extending axially rearwardly therefrom in insulated relation to the stem 91 and to a point within the space of the shell 85 for its connection therein with an associated signal circuit, it being noted that the plug 93 and stem 91 and boss 83' are metallic for connecting the electrode 83 in the circuit; alternatively, the entire assembly 83-91-94 might be of a one-piece structure providing and mounting the electrode 83. The shell 85 and fitting 88 and tube 87 and shell 85 are also metallic whereby the tubular electrode 84 and shell 85 are both electrically connected with the manifold as a ground connection therefor. Aside from the specific arrangement disclosed, it will be understood that the mounting of the electrodes 83 and 84 is essentially such that the dielectric gap condenser provided thereby may be included in any suitable indicator circuit.

By particular reference to Figures 15 and 16, it will be noted that the portion of the tubular electrode 84 beyond the outer end of the mounting tube 87 is provided with longitudinal slots 95 and 96 at opposite sides thereof and extending from aligned radial holes 95' and 96'. The cylinder of the electrode 84 is of uniform cross-section, and the slot 95 beyond the hole 95' has its edges turned out as lips 97 to define a uniform and relatively wide side inlet to the annular space defined between the coaxial electrodes and providing the dielectric gap G of the assembly, it being noted that the electrodes define gap portions of uniform thickness between the opposed cylindrically curved face portions of the electrodes. The slot 96 of the electrode element 84 preferably tapers uniformly to its outer end from the hole 96' defining its inner end, is appreciably narrower at said hole than is the slot 95 and the hole 95', and provides a side outlet for the element. For a reason which will hereinafter appear, the outer end of the space defined between the electrodes is open to provide a gap outlet thereat.

It will now be particularly noted that the present dielectric gap provided by and between opposed faces of the electrodes 83 and 84 is preferably installed in a gaseous stream in which icing conditions may occur to have its inlet slot 95 disposed on the upstream side of the assembly, and also in such oblique relation to the stream that its free end is the furthest advanced in the stream. When the assembly is thus related to the stream, the gaseous fluid of the stream is arranged to enter the dielectric gap provided around the inner electrode 83 for its discharge from the outlet slot 96 and also to a lesser degree longitudinally from the gap. Recalling that gases are cooled at expansion points thereof, it will be under-

stood that some cooling of the gaseous fuel stream will occur where the stream passes the throttle valve 78' by reason of the relatively rapid expansion action produced thereat and in direct accordance with the degree of closing of the valve in the carburetor discharge nozzle 78, and it has been found that this type of expansion may congeal water vapor or water droplets in the stream into ice crystals which may adhere and collect on the nozzle passage side or be carried along by the gases of the stream together with any solid particles or droplets of other materials in the stream. At points in the stream where expansion may take place at slower rates, as at the carburetion point or at the primary distributing point in the fuel intake manifold, water vapor in the stream may be condensed into droplets which are so cold that they will promptly congeal into an ice coating when striking a cold enough surface. In view of the foregoing considerations, the present dielectric gap structure is particularly designed and intended to create thereat, in a stream in which it is placed, ice-coating conditions which are closely approached but not yet reached in the stream, and so effect the control of an icing signal before passage icing has actually occurred in the stream.

With specific reference to the action of a present dielectric gap unit in a gaseous stream in which icing conditions obtain or impend, it has been found that ice particles entering a gap G through the inlet 95 become wet enough, by reason of their impact against the inner electrode 83 and the compression and slowing of the stream portions flowing around the electrode 83 to the reduced outlet provided by the slot 96, for their retained deposit in the gap, it being understood that dry ice particles do not normally adhere to a surface struck by them. In reference to the packing of wet ice within the gap, it will be understood that this action is aided by the fact that the inlet opening 95 is bounded by the outwardly extending lips 97 which function somewhat as a funnel. The portion of the stream passing against and around the outside of the electrode 84 will have some aspiring effect upon the stream portion flowing through the gap unless the gap is closed by retained or deposited ice, this action resulting in a cooling of the electrode 84 adjacent the outlet. Any water droplets in a gaseous stream flowing against the exterior of the electrode 84 may congeal on either or both of the opposed gap faces if the electrodes are cold enough. It will thus be understood that a present dielectric gap assembly will, when placed at a critical ice-forming location, anticipate actual icing for actuating a signal and/or deicing means. If deicing, or ice prevention, is effected by preheating the stream, as by heating the air or other gas incorporated therein, the flow of a portion of the warmed stream against and/or into the outer electrode 84 may melt the signal-controlling ice in the gap, and the liquid thus produced will be blown from the assembly at the outlet slot 96 and from the gap opening at the outer ends of the electrodes, it being noted that the sloping disposition of the gap assembly is operative to prevent water drop accumulations thereon.

It will now be particularly noted that the shell 85 of the assembly 82 intermediately carries a transformer having a primary coil 101 coaxially enclosing a secondary coil 102 and a tubular core 103 on non-magnetic material carried by and between shell partitions 104 defining the ends of the coils. A conductor 105 extends from the mid-point of the secondary coil 102 and through the core 103 to an electrical connection in one casing end with a wire 106 enclosed in a metallic sheath 107, and the wire and sheath are arranged for connection with an electrically actuatable signal and/or deicing device provided at a more or less remote and convenient observation point, as at the instrument panel of an aircraft. As particularly illustrated, the wire 106 and sheath 107 terminate at a connector plug 108 for connecting them with a hooded socket carrying a neon glow lamp 110 comprising a sig-

nal means of the present icing detection circuit, and the sheath 107 is grounded to the metallic shell 85.

One end of the secondary coil 102 is connected by a wire 111 to the terminal end of the conductor 94 to the electrode 83, and the other end of the secondary coil 102 is connected by a wire 112 to a plate 113 of a variable condenser which is mounted in the opposite end of the shell 85 from the connections for the wire 109. As particularly shown, the condenser plate 113 is mounted on a fixed shell partition 114 and is cylindrically concave with its side edges slidably engaging the opposed face of a plate 115 which is engaged between the plate 113 and a metallic plate provided at the inner end of a positioning screw 117 which is threadedly engaged through the adjacent end of the shell 85 axially thereof. It will be understood that an appropriate turning of the screw 117 will decrease or increase the dielectric gap provided between the curved plate 113 and the screw-carried plate 116 whereby a particularly sensitive variable condenser is provided for its purpose.

Power for energizing the glow lamp and electric gap circuit is provided by induction from a wire 118 connecting an engine magneto M with an ignition plug P of the engine. As shown, a transformer 119 has its primary coil interposed in the wire 118, and the transformer secondary 122 is connected by a wire 123 entering the shell 85 from the same end as the wire 106 and connected to one end of the primary coil 101 of the transformer provided within the shell. A grounded conductor sheath 124 is provided about the wire 123 to prevent radio and other interference from the energized wire 123 while grounding the shell 85. For avoiding capacitance effects between the transformer coils, a grounded metallic sleeve 125 is interposed as an electrostatic shield between the coils in insulated relation thereto, and is connected to the shell 85 by a wire 126 which also grounds the primary coil 101 to the shell.

With reference to the present signal circuit, it will be understood that if the capacitances of the secondary circuit portions at opposite sides of the mid-point connection of the conductor 105—106 with the transformer secondary 102 are made equal by an appropriate adjustment of the variable condenser 113—116, said lamp connection point is at a zero potential with respect to ground, and the lamp 110 will not then be energized for its glowing as an indicator means. If, however, ice forms in the gap G, the resulting increase in capacitance in that portion of the secondary circuit to a sufficient value will provide a flashing current through the lamp for indicating the presence of ice in the gap. The present signal circuit is generally that of Figure 25 of my U. S. patent application Ser. No. 771,533 hereinbefore referred to.

While the present devices providing dielectric gaps for use in detecting icing conditions in a gaseous stream specifically discloses the use of a glow tube as an indicating means, it will be understood that an indicating or recording voltmeter might be substituted for a glow tube or be connected in parallel with the tube as an ice-formation indicator means. A suitable deicing device (not shown) would be provided for use in removing the ice whose presence is indicated by a present device, and may be automatically controlled by the indicating circuit. Furthermore, while the present dielectric gap device has been particularly disclosed as applied to the carburetor of an airplane, it will be understood that the principle and means and circuit may be applied in the indication and/or measuring of the presence or thickness of deposits or formations of other solid materials than ice from a moving fluid in a given passage or zone. Thus, the device might be applied in determining the moisture content of materials such as lumber or paper, or the degree of concentration or the specific gravity of materials introduced in a gap provided between suitably related gap-providing electrodes, or in the fuel delivery line of a jet propulsion engine, etc.

From the foregoing description taken in connection with the accompanying drawings, the advantages of the present device will be readily understood by those skilled in the art to which the invention appertains. While I have described the features and principles of operation of structures and arrangements which I now consider to constitute preferred embodiments of my invention, I desire to have it understood that the showing is primarily illustrative, and that such changes may be made, when desired, as fall within the scope of the following claims.

I claim:

1. In combination with a unidirectional stream of a gaseous mixture carrying water, a condenser structure mounted in said stream and comprising an elongated tubular electrode having its axis extending in and across the stream and freely receiving a second electrode in spaced relation to its bore and provided with intake and discharge openings at opposite sides thereof, the inlet opening of the tubular electrode being effectively larger than the discharge opening thereof whereby to retard the incident stream flow through the condenser for providing a cooling effect thereat.

2. An electro-static condenser having mutually insulated and spaced electrode elements extending outwardly from a surface and separated by an air gap whereby an ice formation in said gap will constitute a changed dielectric for said gap and vary the capacitance of the condenser in proportion to the extent of such ice formation, one of said elements being tubular and coaxially receiving the other element in spaced relation to its bore and being provided with respectively larger and smaller inlet and outlet openings at diametrically opposite sides thereof to provide for the flow of a gaseous mixture containing water transversely through the tubular electrode and around the other electrode, and means for mounting said condenser in a stream of the gaseous mixture to provide for the lateral flow of the gaseous mixture between the inlet and outlet openings of the first electrode and around the other electrode.

3. For disposal in a laterally closed passage subject to icing conditions and arranged for the delivery of a gaseous mixture carrying water therethrough, a condenser structure arranged for its mounting in said passage across the flow path of the mixture and comprising an elongated tubular electrode freely receiving an inner electrode in spaced relation to its bore and provided with intake and discharge openings at opposite sides thereof for alignment with the stream, the inlet opening of the tubular electrode being effectively larger than the discharge opening thereof and said openings of the tubular electrode being cooperative with the inner electrode to provide ice in the gap when the temperature of the stream portion flowing into the inlet opening is slightly above an ice-formation temperature for the water vapor therein.

4. An electrostatic condenser having mutually insulated and spaced electrode elements extending outwardly from said surface and separated by an air gap whereby an ice formation in said gap will constitute a changed dielectric for said gap and vary the capacitance of the condenser in proportion to the extent of such ice formation, one of said elements being tubular and coaxially receiving the other element in spaced relation to its bore and being provided with respectively larger and smaller inlet and outlet open-

ings at diametrically opposite sides thereof to provide for the flow of a gaseous mixture containing water circumferentially through the gap provided between the tubular electrode and around the other electrode and connecting said openings, and means for mounting said condenser in a stream of the gaseous mixture to provide for the pressure flow of the gaseous mixture between the inlet and outlet openings of the first electrode and through said gap for the formation of ice by reason of the variable pressure conditions along the gap and when the temperature of the entering stream portion is appropriate.

5. In combination with a unidirectional stream of a gaseous mixture carrying water, a condenser structure mounted in said stream and comprising an elongated tubular electrode having its axis extending in and across the stream and freely receiving a second electrode in spaced relation to its bore and provided with intake and discharge openings at opposite sides thereof, the inlet opening of the tubular electrode being effectively larger than the discharge opening thereof whereby to retard the stream flow through the condenser for effecting a deposited retention in the condenser passage of any ice particles present in the incident stream.

6. In combination with a unidirectional stream of a gaseous mixture carrying water, a condenser structure mounted in said stream and comprising an elongated tubular electrode having its axis extending in and across the stream and freely receiving a second electrode in spaced relation to its bore and provided with intake and discharge openings at opposite sides thereof, the inlet opening of the tubular electrode being effectively larger than the discharge opening thereof whereby to accelerate the stream flow through the condenser for providing a cooling effect thereat.

7. In combination with a unidirectional stream of a gaseous mixture carrying water, a condenser structure mounted in said stream and comprising an elongated tubular electrode having its axis extending in and across the stream and freely receiving a second electrode in spaced relation to its bore and provided with intake and discharge openings at opposite sides thereof, the inlet opening of the tubular electrode being effectively larger than the discharge opening thereof whereby to sequentially retard and accelerate the stream flow through the condenser passage for effecting a deposited retention in the passage of any ice particles present in the incident stream while providing an expansion cooling effect in the passage.

References Cited in the file of this patent

UNITED STATES PATENTS

1,882,316	Cleary	Oct. 11, 1932
2,133,483	Shaw et al.	Oct. 18, 1938
2,266,114	Bartlett	Dec. 16, 1941
2,349,992	Schrader	May 30, 1944
2,355,014	Schorn	Aug. 1, 1944
2,377,275	Smith	May 29, 1945
2,382,365	Carssow	Aug. 14, 1945
2,412,626	Malthaner	Dec. 17, 1946
2,457,085	Kliever	Dec. 21, 1948
2,557,311	Pond	June 19, 1951
2,577,779	Lindberg	Dec. 11, 1951