

Dec. 6, 1955

H. E. SHEETS ET AL

2,725,718

IGNITION SYSTEMS FOR JET MOTORS AND THE LIKE

Filed April 10, 1950

4 Sheets-Sheet 1

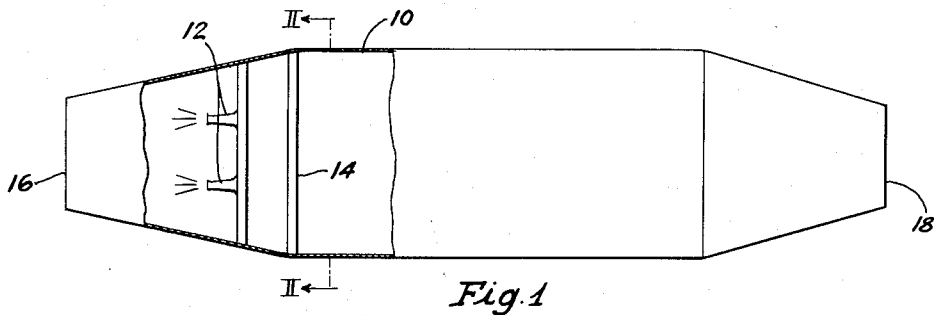


Fig. 1

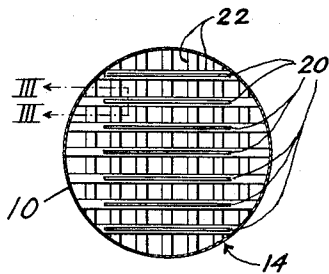


Fig. 2

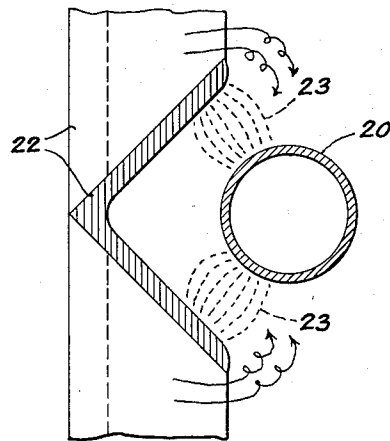


Fig. 3

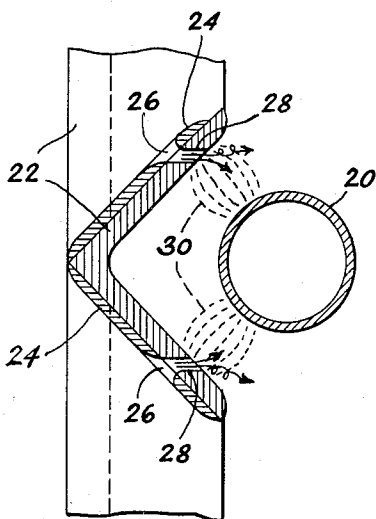


Fig. 4

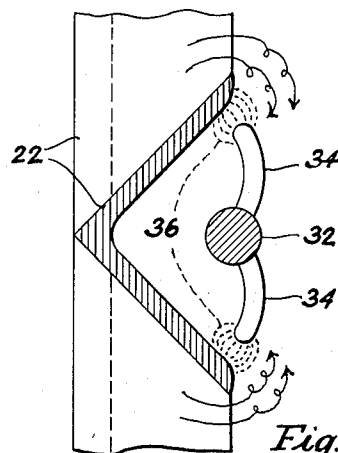


Fig. 5

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4 Sheets-Sheet 2

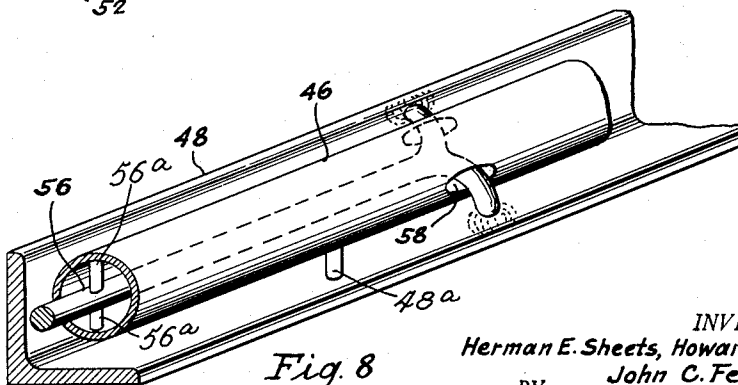
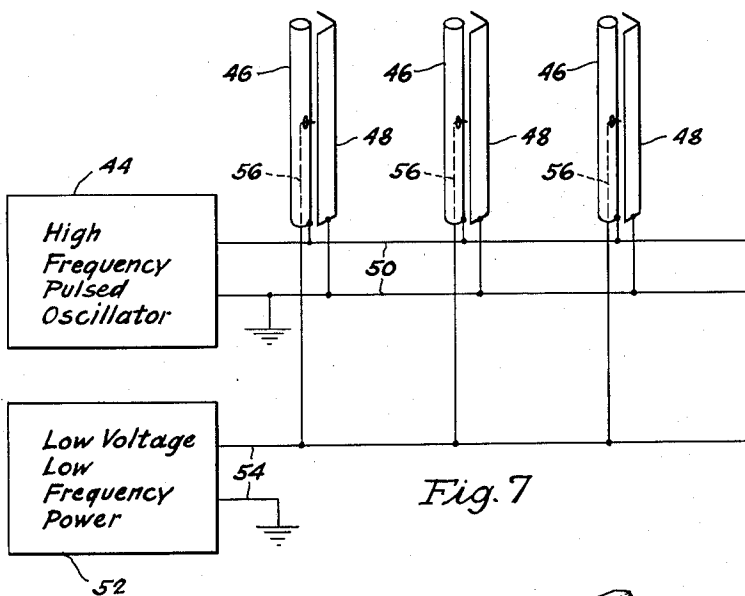
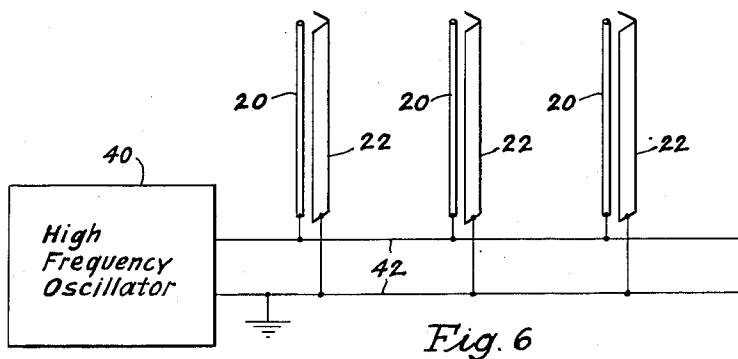


Fig. 8

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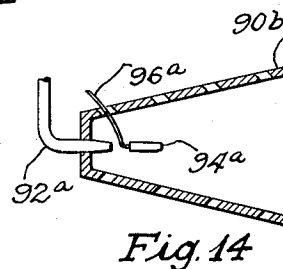
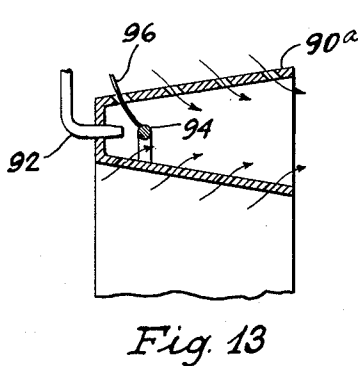
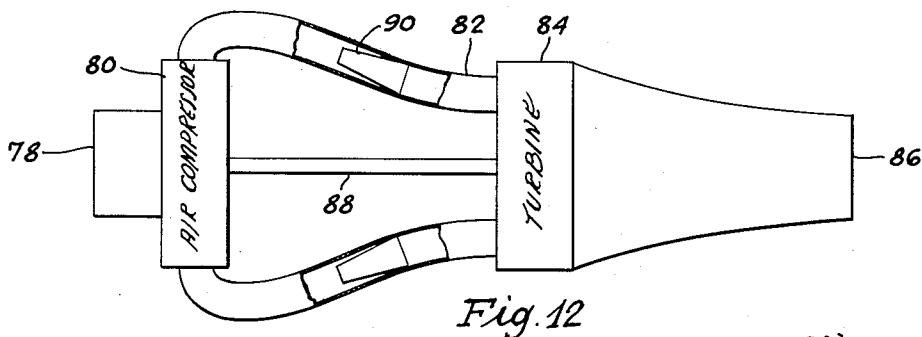
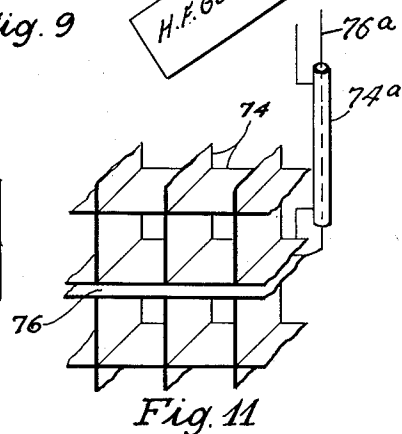
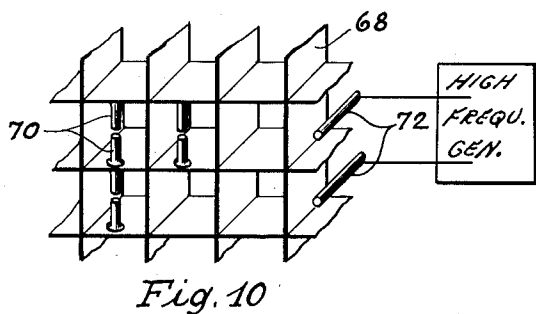
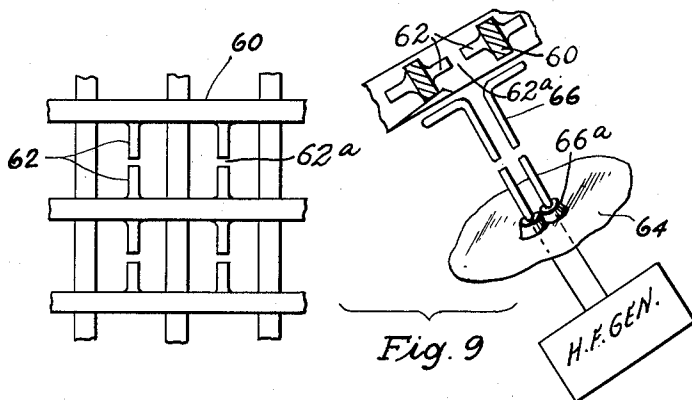
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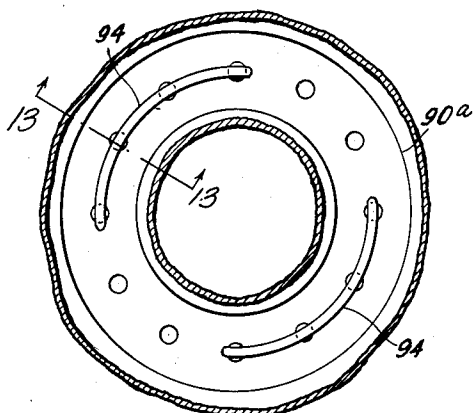


Fig. 15

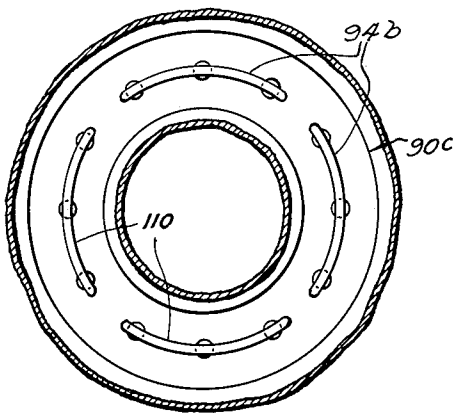


Fig. 16

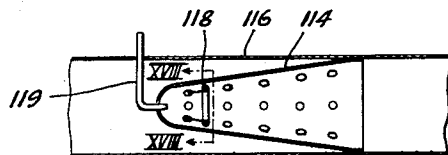


Fig. 17

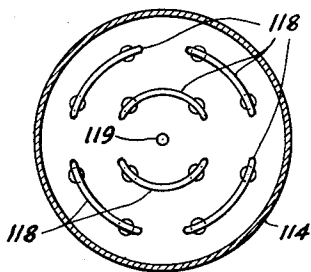


Fig. 18

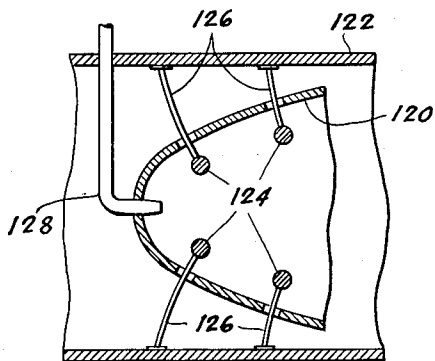


Fig. 19

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IGNITION SYSTEMS FOR JET MOTORS AND THE LIKE

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Application April 10, 1950, Serial No. 155,086

11 Claims. (Cl. 60—39.82)

This invention relates to apparatus for aiding high altitude burning and ignition, and, more particularly, is concerned with ignition systems for jet motors, for example ram jet and turbojet motors.

Some difficulty has been experienced in providing adequate ignition systems for jet motors, and particularly ignition systems which will function equally satisfactorily at sea level or at high altitudes. Known ignition systems employing high frequency sparks and fixed spark gaps operate inefficiently if at all at high or extremely high altitudes inasmuch as the resistance of the gap is reduced with resulting low power and lean spark effects. Efforts to overcome the foregoing difficulty have tended to noticeably increase the weight of the ignition system, or the cost thereof. Moreover, some efforts have been made to employ radio frequency energy to effect ignition, but such proposals are particularly subject to factors of weight and expense.

It is the general object of the invention to avoid and overcome the foregoing and other difficulties of and objections to known ignition systems for jet motors and the like by the provision of an improved system particularly adapted to high and extremely high altitude operation, and being characterized by relatively light weight, relatively low cost, and excellent efficiency.

Another object of the invention is to provide in conjunction with a flame arrester on a jet motor a series of electrodes distributed over the area of the flame arrester to provide a plurality of ignition points, usually in positions of relatively low velocity and high turbulence of the airflow thereover.

Another object of the invention is the provision of tuned radio frequency power circuits for effecting corona discharge and arcing between electrode means in a jet motor ignition system.

Another object of the invention is to provide the combination in a jet motor ignition system of a pulsating high frequency power source for effecting ionization of the air adjacent arcing electrodes followed by low frequency arcing at the points of ionization thereby noticeably reducing ignition system cost and weight.

Another object of the invention is to provide high frequency ignition systems wherein the transmission of radio frequency energy from the system is substantially damped and attenuated.

The foregoing objects of the invention, and other objects which will become apparent as the description proceeds, are achieved by the provision of an ignition system for jet motors and the like including a grounded flame arrester, a high frequency oscillator, an electrode positioned in tuned relation with the flame arrester, and means connecting the oscillator and the electrode to cause corona discharge or arcing between the electrode and the flame arrester. The electrode is usually positioned with respect to the flame arrester so that the corona discharge is in a region of low velocity but highly turbulent air flow. Also, the high frequency oscillator source is generally pulsating in character and the electrode in

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association with the flame arrester has a high impedance whereas the means connecting the oscillator and the electrode have a low impedance. Associated with the pulsating high frequency oscillator may be a low frequency power source including electric connector means for causing arcing between the electric connector means and the flame arrester in the regions of corona discharge of the high frequency oscillator.

Electric corona can best be described as occurring when the potential of a conductor in air is raised to such a value that the dielectric strength of the surrounding air is exceeded. Corona manifests itself by bluish tufts or streamers appearing on the conductor surface. This discharge is accompanied by a hissing sound, and by the odor of ozone. Corona is due to the ionization of the air. The ions are, depending on their charge, repelled from or attracted to the conductor at high velocity, producing other ions by collision. The ionized air is a high resistant conductor and increases the effective diameter of the metallic conductor.

For a better understanding of the invention, reference should be had to the accompanying drawings wherein:

Fig. 1 is a diagrammatic side elevation, partially broken away, of a ram jet motor incorporating the principles of the invention;

Fig. 2 is a transverse cross-sectional view taken on line II—II of Fig. 1, and illustrating the flame arrester and electrodes of the ram jet in side elevation;

Fig. 3 is an enlarged fragmentary cross-sectional view taken substantially on lines III—III of Fig. 2;

Fig. 4 is a view similar to Fig. 3 but illustrating a modification of the invention;

Fig. 5 is a view similar to Figures 3 and 4, but illustrating still another modification of the invention;

Fig. 6 is a schematic wiring diagram of the high frequency oscillator which may be incorporated with the apparatus illustrated in Figures 1 to 5;

Fig. 7 is a schematic wiring diagram of an ignition system including a high frequency power source and a low frequency power source;

Fig. 8 is an enlarged perspective view, partially broken away, illustrating the details of the electrode structure of the system illustrated in Fig. 7;

Fig. 9 is a broken-away perspective view of a flame arrester including gap discharge means employed in conjunction with a radio frequency energized transmitting element;

Fig. 10 is a perspective view, partially broken away, of a flame arrester incorporating a plurality of ducts energized by coaxial feed lines;

Fig. 11 is a view similar to Fig. 10, but illustrating a modified form of the invention in which the honeycomb of ducts of Fig. 10 is made in two parts which are spaced slightly apart;

Fig. 12 is a diagrammatic side elevational view, partially broken away, of a turbojet motor incorporating the features of the invention;

Fig. 13 is an enlarged sectional view, taken on line 13—13 of Fig. 15, of a part of a ring-type, conically shaped flame arrester adapted to be employed in a turbojet, and incorporating the features of the invention;

Fig. 14 is a view similar to Fig. 13, but illustrates a cup-type, cone-shaped flame arrester which is adapted to be incorporated in a turbojet motor;

Fig. 15 is a diagrammatic partially broken away view illustrating in front elevation the ring-type conically shaped flame arrester of Fig. 13;

Fig. 16 is a view similar to Fig. 15, but illustrating a somewhat different arrangement of the electrode means in association with the flame arrester;

Fig. 17 is a diagrammatic longitudinal sectional view illustrating the details of a cup-type cone-shaped flame

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arrester particularly adapted to be incorporated in one of the flow tubes positioned between the air compressor and the turbine of the turbojet motor;

Fig. 18 is a cross-sectional view, on enlarged scale, and taken substantially on line XVIII—XVIII of Fig. 17; and

Fig. 19 is an enlarged longitudinal sectional view of the bottom of the cup-type cone of Fig. 17.

Having reference to the drawings, the numeral 10 indicates generally the casing or shell of a ram jet motor including fuel nozzles 12 and a flame arrester 14. Air entry is, of course, at the end 16 of the casing, and the hot gases are exhausted at end 18 with jet effect.

Associated with the flame arrester 14, and as best illustrated in Figures 2 and 3, are a plurality of electrodes, for example in the form of tubes 20, each tube 20 being of substantially the same length and each tube being positioned in the downstream side of the grill work of angles 22 forming the flame arrester. The V's of the angles of the grill work point upstream of the airflow, and the result is, as best seen in Fig. 3, that the air flow by the edge of the angles is relatively turbulent, in the manner shown by the arrows, and of fairly low velocity, so that ignition effected at these points and near the corona or other discharge 23 effects the best possible combustion. As seen in Fig. 2, the tubes 20 extend behind the horizontal angles only, and cover a substantially square area of the flame arrester.

The modification of the invention illustrated in Fig. 4 is generally similar to that illustrated in Fig. 3, except that substantially flat guide plates 24 are provided on the upstream side of the angles 22 in advance of the tubes 20, with each guide plate 24 being formed with a bell-mouthed aperture 26 therethrough, the small and inner end of which terminates at an aperture or slot 28 through the angle 22 whereby air is directed at relatively low velocity and with high turbulence through the aperture or slot to a position between the angle 22 and its associated tube 20 in the region of the corona or other discharge between the tube and angle, such discharge being indicated by the lines 30.

The form of the invention illustrated in Fig. 5 is likewise similar to that of Fig. 3, except that the tube 20 has been replaced with a rod 32 to which are secured horns or spikes 34 at spaced points to concentrate a corona or other discharge at the points 36 adjacent the edges of the angle 22 and closely adjacent the low velocity and highly turbulent air flow illustrated by the arrows.

Fig. 6 illustrates schematically the manner of energizing the electrodes 20 or 32 of Figures 2 to 5. Fig. 6 includes a high frequency oscillator power source 40, one output lead of which is grounded, and with the angle irons 22 of the flame arrester 14 likewise being grounded. The other lead of the output of the high frequency oscillator is connected to the electrodes 20. It is to be understood that each electrode 20 together with its associated angle forms a tuned transmission line. The frequency used to drive the transmission lines, that is the output frequency of the high frequency oscillator 40 is such that a half wave length is greater than the diameter of the casing 10 of the ram jet. The ram jet casing thus becomes a section of a wave guide, and the wave guide is operated below cut-off so that radio frequency radiation from the tail pipe will be greatly attenuated. This is important for the reason that if radio frequency radiation is not substantially choked off, it may be possible to follow or detect the ram jet in the air because of the radio frequency radiations. In a typical example, when using a ram jet having a 20-inch diameter casing, a frequency of greater than 350 megacycles is employed.

Further in conjunction with Fig. 6, it is to be understood that each electrode 20 together with its associated angle preferably forms a one-quarter (or some multiple thereof) wave length transmission line, this line having a fairly high impedance, namely 150 ohms or more. All of the high impedance lines are connected in parallel and

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are coupled to a single low impedance coaxial line, 30 ohms approximately, this being the output line 42 from the high frequency oscillator 40.

Generally in the operation of the apparatus of Fig. 6, when employed in conjunction with the apparatus of Figures 1 to 5, the high frequency oscillator 40 operates in a pulsed manner. The result of the configuration described is that when breakdown, that is arcing or corona, occurs across or between one electrode 20 and its associated angle 22, the impedance reflected across the termination of the low impedance line is quite high, lowering the load on the oscillator 40. This action enables each transmission line 20—22 to have practically all the voltage available for breakdown, and provides automatic regulation of the distribution of power.

In Fig. 7 is illustrated substantially the schematic diagram of Fig. 6, except that a low frequency power source has been added. In Fig. 7, the high frequency pulse oscillator is indicated by the numeral 44, each electrode by the numeral 46, each angle iron by the numeral 48, and the low impedance feed line by the numeral 50. Associated with the structure described is a source of low voltage, relatively high amperage, and low frequency power 52, the output 54 thereof having one side grounded, and the other side connected to a rod 56. Each rod 56 extends up axially of a tube 46, out through a hole 58 in the side of the tube, and into arcing or gap proximity to the sides of the angle 48, all in the manner illustrated in Fig. 8. The rod 56 may be supported in spaced relation to the tube 46 by suitable spacing insulators 56a and the tube 46 may be held in suitable spaced relation to the angle 48 by suitable spacing insulators 48a as shown in Fig. 8. The rod 56 may be forked as shown at its end so that the rod ends will extend into proximity with both edges of the angle 48.

In the operation of the system as just described, the pulsating high frequency oscillator will be of a character to effect corona discharge between the tube 46 and the angle 48 to effect ionization of the air between the tube and angle. This ionization allows the low voltage, low frequency power source 52 to effect arcing between the ends of the rod 56 and the grounded angle 48 to thereby effect ignition and combustion. This system has the advantage that the bulk of the power for ignition is supplied at low frequency, with high frequency power being required only as a trigger, thus the weight and expense of high power, high frequency oscillator equipment is eliminated. In this system, the power to maintain the arc is supplied from a low frequency source 52, and because each transmission line provided by a tube 46 and its associated angle 48 is in turn effectively short-circuited at its end, as heretofore described, it presents a very high impedance to the coaxial feed line 50 and does not load it, making all the power from the high frequency oscillator 44 available for providing corona across another high impedance transmission line 46—48. It is to be noted that the point of greatest corona effect between the tube 46 and angle 48 will be concentrated at spaced points or at one point along the line, and it is at one of these points of corona concentration that the holes 58 are cut in the tube 46, and through which the ends of the rod 56 extend.

Turning now to Fig. 9, the numeral 60 indicates the flame arrester corresponding to the flame arrester 14 of Figs. 1 and 2, substantially as before, but each opening or square in the flame arrester is provided with a pair of studs 62 forming a spark or discharge gap 62a, and positioned on the casing 64 of the jet motor corresponding to the casing 10 of Fig. 1 is a horn or radio frequency discharge element 66 insulated therefrom by an insulator 66a which is adapted to be energized by a source of radio frequency power, the frequency being such as to be resonant with the squares or openings in the flame arrester. This will cause the gaps between the studs 62 to break down to effect ignition and combustion in the jet motor.

In Fig. 10 is illustrated a honeycomb of ducts 68 form-

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ing the flame arrester, the downstream ends of the ducts each being provided with a pair of studs 70 forming a discharge gap, and with the ducts being excited to their resonance frequencies by coaxial lines 72 to effect breakdown and ignition between the studs 70.

A modification of the structure of Fig. 10 is illustrated in Fig. 11, wherein the flame arrester is made as a series of honeycomb ducts 74, but with the flame arrester being split apart at 76 to provide a gap between the sections, and in this structure the whole mixing chamber is excited by radio frequency applied through conductors 74a, 76a to the respective sections of the arrester, each section acting as one cavity causing corona or arcing to form across the gap 76 to effect ignition.

In Fig. 12 is diagrammatically illustrated a turbojet motor including an air intake 78, an air compressor 80, conduit means 82 extending from the compressor to a turbine 84 connected in turn to a discharge jet 86, with the turbine 84 being connected by a shaft 88 to the air compressor 80. Positioned in the conduit means 82 are flame arrester means 90. It will be understood by those skilled in the art that the conduit means 82 may take the form of spaced annular cone-shaped members (Westinghouse type), or that the conduit means 82 may comprise a plurality of circumferentially spaced individual tubes (General Electric type). In Fig. 13 is illustrated at 90a a flame arrester of ring type, but of the conical cross-sectional form shown; this type of flame arrester being used with conduit means of the fully circular type. At the bottom of the flame arrester 90a is a fuel injection nozzle 92, and likewise positioned at the bottom of the flame arrester is an electrode 94 of tuned character similar to those heretofore described. The flame arrester 90a has a plurality of openings therein through which air will flow from the compressor in the manner shown in the arrows. The electrode 94 is adapted to be carried by support means 96 extending through one of these openings.

In Fig. 14 is illustrated a flame arrested 90b of the conical cup type, adapted to be employed with conduit means 82 in the form of individual conduits. In Fig. 14 the flame arrester 90b has a fuel injection nozzle 92a associated with the bottom of the cup, and an electrode 94a positioned likewise in the bottom of the cup and carried by support means 96a extending through one of the air openings in the side of the flame arrester cup. The electrode 94a may be of a character to excite the flame arrester cup at resonance frequency, or may be of the other tuned electrode types heretofore described.

Fig. 15 illustrates in elevation from the downstream side (with the sides of the ring broken away) the flame arrester 90a of Fig. 13. Note the position of the electrodes 94, each having a length of substantially a quadrant, and being substantially diametrically opposed.

Fig. 16 illustrates a modification of the structure of Fig. 15, and with four electrodes 94b being employed in conjunction with a ring type flame arrester 90c. The sides of the flame arrester 90c are broken away to simplify the illustration of the details of the electrode construction.

In Fig. 17 is diagrammatically indicated in longitudinal section at 114 a cone or cup type flame arrester employed in conjunction with a conduit 116, and with an electrode 118 and fuel injection nozzle 119 being associated with the bottom of the cup type flame arrester 114. A typical arrangement of the electrodes 118 is illustrated in the enlarged cross-sectional view of Fig. 18.

Fig. 19 illustrates a minor modification of the structure of Fig. 18, and is substantially in longitudinal vertical section, the modification including a cone-shaped flame arrester 120 employed in association with a conduit 122, and with electrodes 124 being positioned in the bottom of the flame arrester cone 120, these electrodes being carried on supports 126 extending through the flow openings in the flame arrester. A fuel injection nozzle 128 is

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adapted to introduce fuel into the flame arrester cone adjacent the electrodes 124.

By way of general observation, it can be said that the presence of corona improves ignition action, particularly at higher altitudes. Corona alone can achieve ignition, but a combination of corona plus sparking, as herein described, is advantageous.

From the foregoing, it will be recognized that the various objects of the invention have been achieved by the provision of relatively simple and foolproof apparatus for improving ignition and combustion of jet motors and the like, particularly when operating at high altitudes. The apparatus of the invention is adapted to employ a minimum of power, is long lived and substantially foolproof. The apparatus of the invention is adapted to operations either upon a ram jet or upon a turbojet type of jet motor.

While certain representative embodiments and details have been shown for the purpose of illustrating the invention, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit or scope of the invention.

We claim:

1. An ignition system for jet motors including a flame arrester, said arrester comprising a grill formed of angle irons having their angles pointing upstream, a plurality of uniform length tubes positioned parallel to each other, each tube being positioned downstream in the V of an angle, a high frequency oscillator, each tube and its associated angle forming a one-quarter wave length transmission line of fairly high impedance, at least 150 ohms, a low impedance line, less than 30 ohms, connecting the series of tubes and angles in parallel to the oscillator, and a substantially cylindrical casing around the flame arrester, the diameter of the casing being less than one-half wave length of the oscillator frequency whereby the casing will function as a wave guide operating below cutoff so that radio frequency radiation from the end of the casing is greatly attenuated.

2. An ignition system for jet motors including a flame arrester, said arrester comprising a grill formed of angle irons having their angles pointing upstream, a plurality of uniform length tubes positioned parallel to each other, each tube being positioned downstream in the V of an angle, a pulsating high frequency oscillator, each tube and its associated angle forming a one-quarter wave length transmission line of fairly high impedance, at least 150 ohms, a low impedance line, less than 30 ohms, connecting the series of tubes and angles in parallel to the oscillator, a substantially cylindrical casing around the flame arrester, the diameter of the casing being less than one-half wave length of the oscillator frequency whereby the casing will function as a wave guide operating below cutoff so that radio frequency radiation from the end of the casing is greatly attenuated, a source of low frequency power, a rod positioned inside each tube and connected to the low frequency power, each rod extending through a hole in the side wall of the tube and into arcing relationship with the angle at a point near the greatest corona discharge between the tube and angle.

3. An ignition system for jet motors including a flame arrester, said arrester comprising a grill formed of angle irons having their angles pointing upstream, a plurality of uniform length tubes positioned parallel to each other, each tube being positioned downstream in the V of an angle, a high frequency oscillator, each tube and its associated angle forming a one-quarter wave length transmission line of fairly high impedance, at least 150 ohms, and a low impedance line, less than 30 ohms, connecting the series of tubes and angles in parallel to the oscillator.

4. An ignition system for jet motors including a flame arrester, said arrester comprising a grill formed of angle irons having their angles pointing upstream, a plurality of uniform length tubes positioned parallel to each other, each tube being positioned downstream in the V of an angle, a high frequency oscillator, each tube and its asso-

ciated angle forming a one-quarter wave length transmission line of fairly high impedance, at least 150 ohms, and a low impedance line, less than 30 ohms, connecting the series of tubes and angles in parallel to the oscillator, a source of low frequency power, a rod positioned inside each tube and connected to the low frequency power, each rod extending through a hole in the side wall of the tube and into arcing relationship with the angle at a point near the greatest corona discharge between the tube and angle.

5. An ignition system for jet motors including a flame arrester, said arrester comprising a grill formed of angle irons having their angles pointing upstream, a plurality of uniform length tubes positioned parallel to each other, each tube being positioned downstream in the V of an angle, a high frequency oscillator, each tube and its associated angle forming a one-quarter wave length transmission line, and a line connecting the series of tubes and angles in parallel to the oscillator.

6. An ignition system for jet motors including a flame arrester, said arrester comprising a grill formed of angle irons having their angles pointing upstream, a plurality of uniform length tubes positioned parallel to each other, each tube being positioned downstream in the V of an angle, a high frequency oscillator, each tube and its associated angle forming a one-quarter wave length transmission line, and a line connecting the series of tubes and angles in parallel to the oscillator, a source of low frequency power, a rod positioned inside each tube and connected to the low frequency power, each rod extending through a hole in the side wall of the tube and into arcing relationship with the angle at a point near the greatest corona discharge between the tube and angle.

7. An ignition system for jet motors including a grounded flame arrester, said arrester comprising a grill formed of angle irons having their angles pointing upstream, a plurality of uniform length tubes positioned parallel to each other, each tube being positioned downstream in the V of an angle, a high frequency oscillator, each tube and its associated angle forming a one-quarter wave length transmission line, and a line connecting the series of tubes and angles in parallel to the oscillator, a source of low frequency power, a rod positioned inside each tube and connected to the low frequency power, each rod extending through a hole in the side wall of the tube and in arcing relationship with the angle at a point near the greatest corona discharge between the tube and angle, a source of low frequency power, and electric leads extending from the source of low frequency power into arcing relationship with each angle having an associated tube and at the point of greatest corona discharge between the tube and angle.

8. An ignition system for jet motors and the like including a substantially cylindrical casing, a flame arrester grounded to the casing, electrode means associated with the flame arrester, a pulsating high frequency oscillator for causing corona discharge between the flame arrester and the electrode means, one half wave length of the operating frequency of the oscillator being greater than the diameter of the casing so that the casing functions as a wave guide operating below cutoff, low frequency power means, and electrical means connecting the power means in arcing relation with the flame arrester adjacent a plurality of points of corona discharge between the flame arrester and the electrode means.

9. An ignition system for jet motors and the like including a flame arrester, electrode means associated with the flame arrester, a pulsating high frequency oscillator for causing corona discharge between the flame arrester and the electrode means, low frequency power means, and electrical means connecting the power means in arcing relation with the flame arrester adjacent a plurality of points of corona discharge between the flame arrester and the electrode means.

10. An ignition system for jet motors and the like including a substantially cylindrical casing, a flame arrester associated with the casing, electrode means associated with the flame arrester, and a pulsating high frequency oscillator for causing corona discharge between the flame arrester and the electrode means, one half wave length of the operating frequency of the oscillator being greater than the diameter of the casing so that the casing functions as a wave guide operating below cutoff.

11. An ignition system for jet motors and the like including a flame arrester, electrode means spaced from the flame arrester, a pulsating oscillator of such high frequency as to establish corona discharge between the flame arrester and the electrode means, a low frequency arc generating power means, and electrical means connecting said low frequency power means in arcing relation with the flame arrester in the region of such corona discharge between the flame arrester and said electrode means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,073,718	Vawter	Mar. 16, 1937
2,238,892	Fanger	Apr. 22, 1941
2,444,239	Aubert	June 29, 1948
2,482,505	Pierce	Sept. 20, 1949
2,508,420	Redding	May 23, 1950
2,544,299	Damon	Mar. 6, 1951