NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

NASA Goddard Space Flight Center

REPLY TO
ATTN OF: GP

TO: USI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for
Patent Matters

SUBJECT: Announcement of NASA-Owned U. S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code USI, the attached NASA-owned U. S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U. S. Patent No. : 3472080

Government or Corporate Employee : North American Aviation Inc. Santa Barb. Calif.

Supplementary Corporate Source (if applicable) : N/a

NASA Patent Case No. : NPO-10185-

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:

Yes ☑ No ☐

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of Column No. 1 of the Specification, following the words ". . . with respect to an invention of . . ."

Dorothy J. Jackson

Dorothy J. Jackson
Enclosure
Copy of Patent cited above

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Oct. 14, 1969 JAMES E. WEBB 3,472,080

ADMINISTRATOR OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPELLENT MASS DISTRIBUTION METERING APPARATUS

Filed April 24, 1968

N71-26339 40%

FIG. 1

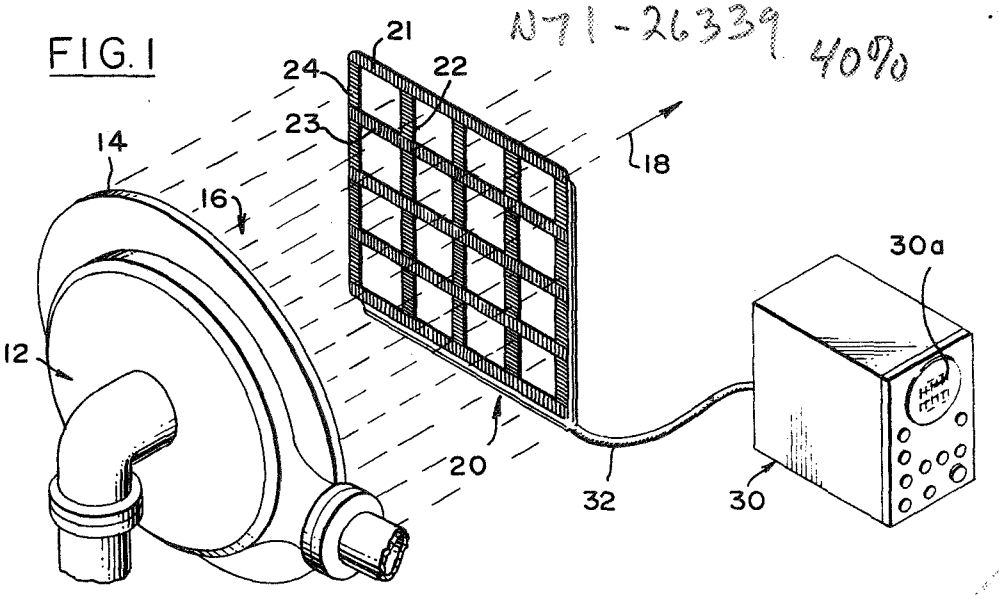
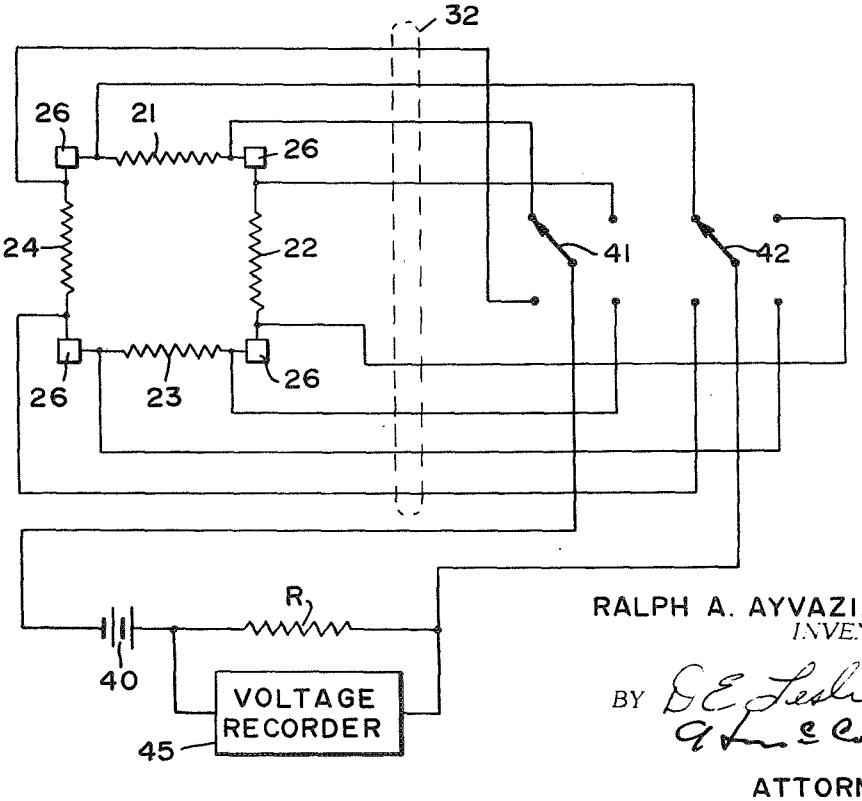


FIG. 2



RALPH A. AYVAZIAN
INVENTOR.

BY D E Leslie & Lee
ATTORNEYS

1622

United States Patent Office 3,472,080 Patented Oct. 14, 1969

3,472,080

PROPELLENT MASS DISTRIBUTION METERING APPARATUS

James E. Webb, Administrator of the National Aeronautics and Space Administration, with respect to an invention of Ralph A. Ayvazian, Canoga Park, Calif.

Filed Apr. 24, 1968, Ser. No. 723,805
Int. Cl. G01f 11/00, 23/00
U.S. Cl. 73—432 8 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus for metering or recording the spatial distribution of propellent matter, such as droplets or vapor in a stream which is ejected from an injector or nozzle. The apparatus consists of a grid with electrical high resistance screen elements, interconnected at insulating nodal member to form a preselected array or matrix. To meter or record the spatial mass distribution, the grid is placed in the stream's path and an external power supply and readout device are selectively connected across each resistance element to record changes in its electrical resistance as a function of droplets or vapor impinging thereon.

ORIGIN OF INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85–568 (72 Stat. 435; 42 USC 2457).

BACKGROUND OF THE INVENTION

Field of the invention

This invention generally relates to an electrical apparatus and, more particularly, to an electrical apparatus for metering or recording the spatial distribution of matter.

Description of the prior art

It is often desirable or necessary to determine the dispersion or spatial distribution of droplets or vapor which are ejected, as part of a high velocity stream, from an injector or nozzle. Such a determination is necessary, for example, in the development of injectors for liquid propellent engines, which operate properly only when a liquid fuel and a liquid oxidizer, ejected from separate nozzles or injectors, are uniformly mixed to produce a desired combustion. Performance of the nozzles or injectors is generally determined before actual hot firings by investigating the spatial distribution of matter ejected therethrough.

Herebefore, cumbersome and relatively inefficient techniques were employed to determine the spatial distribution of matter ejected from such devices. In one technique, which has been employed, a plurality of rain gauges are placed in the stream path. The matter trapped by the various gauges is separately analyzed and charted to provide a spatial distribution indication. Such a technique is quite slow and therefore, time consuming. Also, the rain gauges themselves disturb the spatial distribution of matter, so that the results are of limited accuracy. Therefore, the technique itself is of limited use, especially when precise information of the spatial distribution of matter is required.

OBJECTS AND SUMMARY OF THE INVENTION

It is a primary object of the present invention to provide a new improved apparatus for recording the spatial distribution of matter in high velocity streams as produced, for example, in a rocket engine liquid injector.

Another object of the present invention is the provision of a relatively simple electrical apparatus with which the spatial distribution of matter directed along selected paths is easily and accurately determinable.

A further object of the present invention is to provide an easily constructable and operable apparatus for the investigation of spatial distribution of droplets or vapor in high velocity streams.

Still a further object is the provision of a reliable, electrical apparatus for metering or recording, with a relatively high degree of accuracy, the spatial distribution of droplets or vapor in high velocity streams ejected from nozzles or orifices.

These and other objects are achieved by providing an apparatus which consists of a grid, composed of a plurality of electrical resistive elements, arranged in a fixed geometric planar pattern or array. The elements are carefully insulated from each other and from their support structure. An electrical lead is connected to each end of each element and to a grid scanning device, by means of which the resistance of each element can be monitored, recorded or measured. In the absence of droplets or vapor impinging on any of the elements, each element has substantially the same electical resistance.

To investigate the spatial distribution of droplets or vapor in high velocity streams, the grid is positioned in the stream, perpendicular to its path or direction. The spatial distribution is determined by sequentially measuring or scanning the resistance changes of the various elements, produced by the droplets or vapor impinging thereon.

The novel features of the invention are set forth with particularity in the appended claims. The invention will best be understood from the following description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is an isometric view of the apparatus of the present invention shown positioned in the path of a stream whose spatial mass distribution is to be determined; and

FIGURE 2 is a partial schematic diagram of the apparatus of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGURE 1, therein numeral **12** designates an injector, which is assumed to define a nozzle **14** through which streams of matter **16** are ejected in a direction or path designated by arrow **18**.

To monitor or record the spatial distribution of matter in the stream **16**, the apparatus of the present invention includes a planar multielement grid **20**, which is disposed in a plane perpendicular to the stream direction. The grid **20** consists of a plurality of preferably identical electrical resistive elements, which are arranged in a symmetrical geometric pattern. The number of elements which are used and the particular geometric pattern in which they are arranged depend on the size of the stream, i.e., the stream diameter and the desired resolution of the spatial distribution. In FIGURE 1, the grid **20** is shown consisting of twenty horizontally disposed and twenty vertically disposed resistive elements. Only the four elements of the grid's upper left-hand corner are designated by numerals **21–24**. An expanded view of the four elements is shown in FIGURE 2 to which reference is made herein.

Each grid element has a relatively high electrical resistance and is preferably of low cross-sectional area, so that a large number of elements can fit into a relatively small matrix. The element should preferably be in the form of a fine screen to define a maximum surface. This is desirable to produce maximum resistance change as

matter, such as droplets or vapor, comes in contact with the element. Fine Nichrome screen is one example of a material which can be used to form the various elements.

The elements are preferably insulated from each other with insulators **26** (see FIGURE 2) and from their support structure. Electrical leads connect each of the elements to a power supply and recorder unit, designated in FIGURE 1 by numeral **30**. The electrical leads which connect the various elements to unit **30** are represented in FIGURE 1 by a multilead cable **32**.

Briefly, the spatial distribution of matter in stream **16** is determined by the matter impinging on, or adjacent each element, as a function of the change in resistance thereof. It is apparent that the change in resistance may be sensed with any one of several techniques and with any desired degree of accuracy. Also, the manner in which the determined change in resistance is recorded or monitored would of course depend on the purpose of the investigation and the intended use of the results.

One simple example of an embodiment of the power supply and recorder unit **30** is shown in FIGURE 2. The unit includes a power supply, such as a battery **40**, connected in series with a resistor R. A pair of ganged multiposition switches **41** and **42** are used as commutators to sequentially connect the battery **40** and the resistor R across each of the elements. To scan all the forty elements of grid **20**, two, 40 position switches are required. For explanatory purposes, however, the two switches shown in FIGURE 2 are shown with only four positions, required to scan the four elements **21–24**.

Assuming that the voltage of battery **40** is V and the resistance of each element, in the absence of matter impinging thereon is R_E, the voltage across R as recorded by recorder **45** is

$$V_R = \frac{V}{R+R_E} \cdot R$$

Any change, generally an increase, in the voltage across R which is recorded when the switches **41** and **42** connect the resistor R and battery **40** across an element is directly related to the decrease in the element's resistance which is in turn a function of the matter flowing thereby. Thus, by recording the voltage across R as each element is scanned, a clear and accurate indication is provided of the spatial mass distribution in the stream of matter **16**.

The voltages recorded in recorder **45** may also be recorded on a tape for computer processing, or they may be used directly to control a display device, such as a cathode ray tube **30***a* (see FIGURE 1), which may be part of unit **30**. Indeed, the tube **30***a* may include a relatively long-persistance display surface, so that a complete visual display related to the spatial mass distribution in the stream may be produced thereon.

From the foregoing, it should be apparent that the apparatus of the present invention may be as simple or as complex as its specific use dictates. A grid of few elements may be sufficient to determine gross mass distribution, while a grid with a very large number of elements is justified to provide signals for a very critical evaluation of the mass distribution of the stream, produced by a complex nozzle or injector unit. Also, the manner in which the signals are processed and/or displayed would depend on their specific usage.

What is claimed is:

1. An apparatus for determining the distribution of particles in a stream of particles directed along a fixed axis, comprising:

a planar grid perpendicularly positioned with respect to said fixed axis, said grid comprising a plurality of grid elements arranged in a preselected pattern, each element exhibiting a selected substantially identical physical property; and

means connected to said grid elements for selectively measuring the physical property of each of said elements to detect changes therein as a function of the particles in said stream adjacent the grid element.

2. The apparatus as recited in claim **1** wherein each grid element has preselected electrical resistance at known environmental conditions.

3. The apparatus as recited in claim **1** wherein said means include commutating means successively coupled to a selected one of said elements to measure the physical property thereacross, and means for recording the measured physical property of each element.

4. The apparatus as recited in claim **3** wherein said means for recording include a two-dimensional display surface for simultaneously displaying thereon signals which are related to the measured physical properties of said grid elements, to thereby display the relative distribution of particles in said stream.

5. The apparatus as recited in claim **4** wherein each grid element has a selected fixed electrical resistance at known environmental conditions.

6. For use in combination with an injector, an apparatus for monitoring the mass distribution in a stream of matter of the type ejected from said injector at a discharge plane thereat comprising:

a multielement grid positioned parallel to the discharge plane of said injector and downstream thereof, each element exhibiting a selected physical property at known environmental conditions in the absence of said stream of matter; and

monitoring means coupled to said grid for selectively monitoring the physical property of each element as affected by the mass of matter streaming adjacent thereto.

7. The apparatus as recited in claim **6** wherein said grid consists of interconnected electrical resistive elements, and said monitoring means comprises means for monitoring the electrical resistance of each element as affected by the matter streaming thereby.

8. The apparatus as recited in claim **7** wherein said monitoring means include means for sequentially sampling the resistance across each element and for displaying a pattern corresponding to the resistances of the various elements.

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S. CLEMENT SWISHER, Primary Examiner

U.S. Cl. X.R.

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