United States Patent

Auer

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[54] **COSMIC DUST OR OTHER SIMILAR OUTER SPACE PARTICLES IMPACT LOCATION DETECTOR**

[72] Inventor: **Siegfried O. Auer**, Ludwigshafen-Rhein, Germany

[73] Assignee: **The United States of America as represented by the Administrator of the National Aeronautics and Space Administration**

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[52] **U.S. Cl.** ....**250/83.6 R**

[51] **Int. Cl.** **G01t 1/18**

[58] **Field of Search** ....250/83.6 R

[56] **References Cited**

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3,626,189 12/1971 Berg......................250/83.6 R

Primary Examiner—James W. Lawrence
Assistant Examiner—Davis L. Willis
Attorney—R. F. Kempf, E. Levy and J. R. Manning

[57] **ABSTRACT**

A system for detecting the impact position of cosmic dust and other similar outer space particles on a detector surface includes means for forming an ionized stream in response to impact of a particle thereon. The ionized stream is collected by one of a multiplicity of mutually insulated, metal electrode strips. There is provided a multiplicity of series connected capacitors, with taps between adjacent capacitors being connected to a different one of each of the strips. Each end terminal of the series circuit formed by the capacitors is connected to input terminals of amplifiers which drive circuitry to indicate the strip on which the particle impacted. To prevent the plasma stream from impinging on a strip other than the strip in closest proximity to the source of the stream, shield walls are provided along the edges of the strips.

13 Claims, 3 Drawing Figures

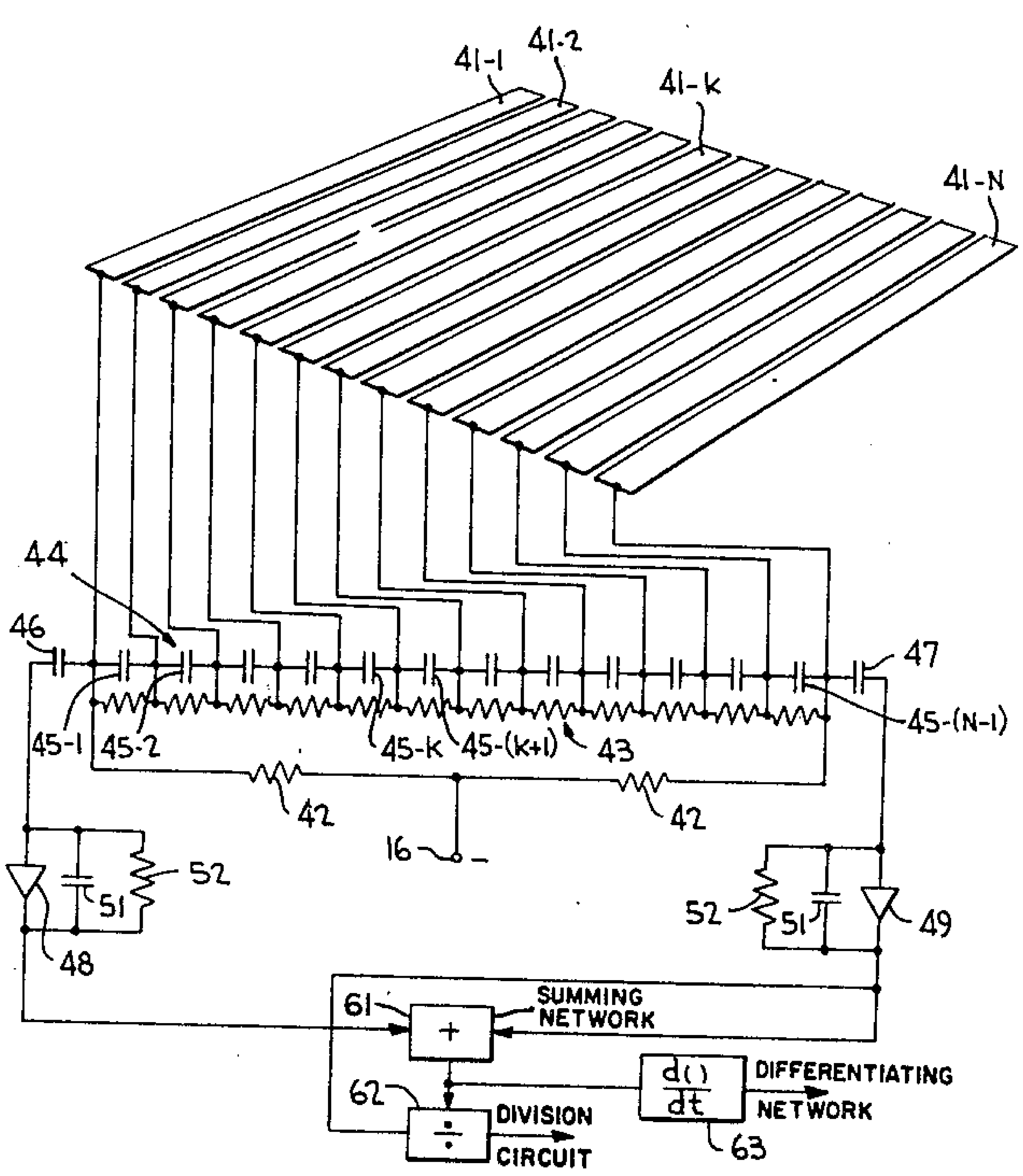


FIG. 2

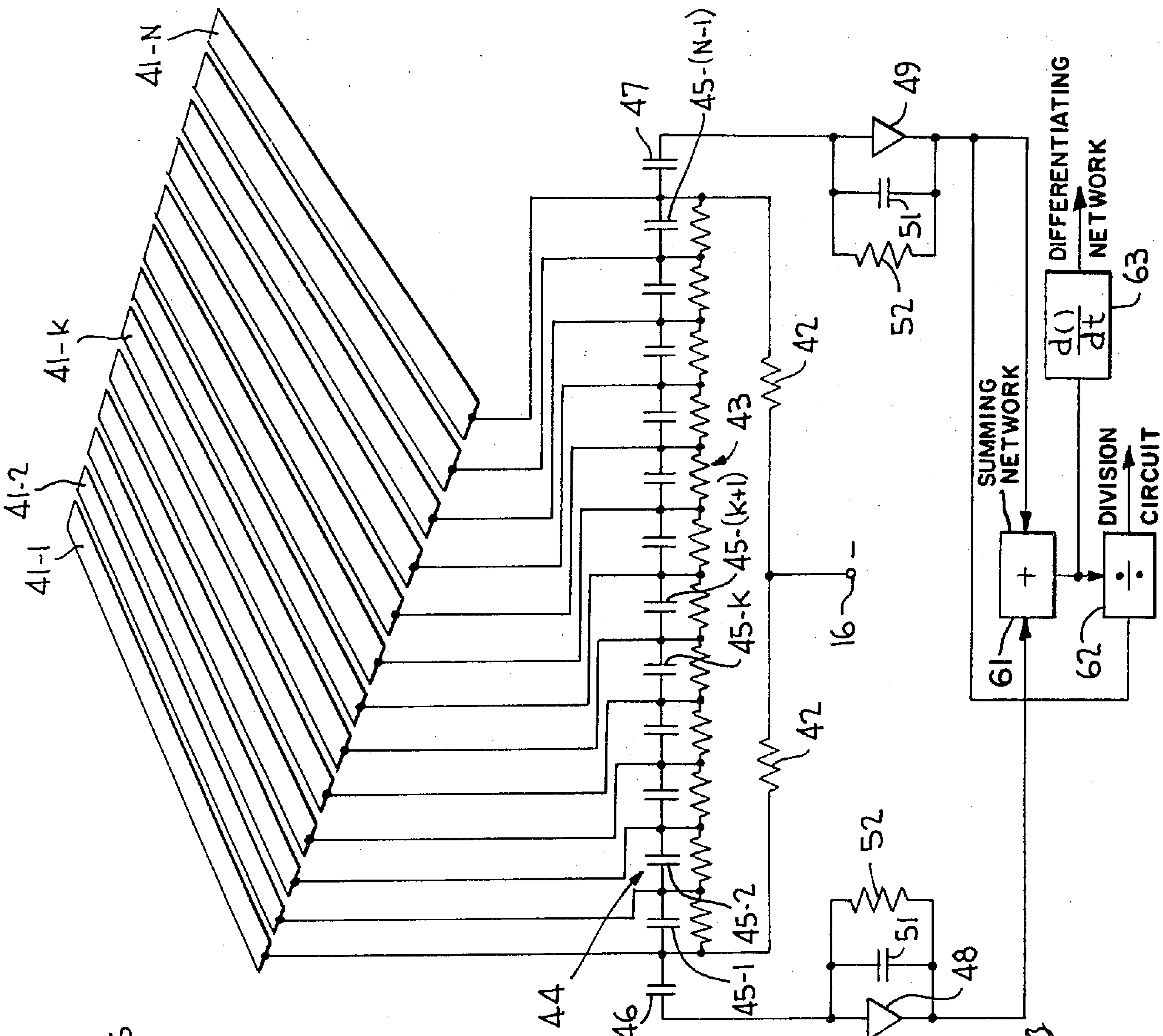


FIG. 1

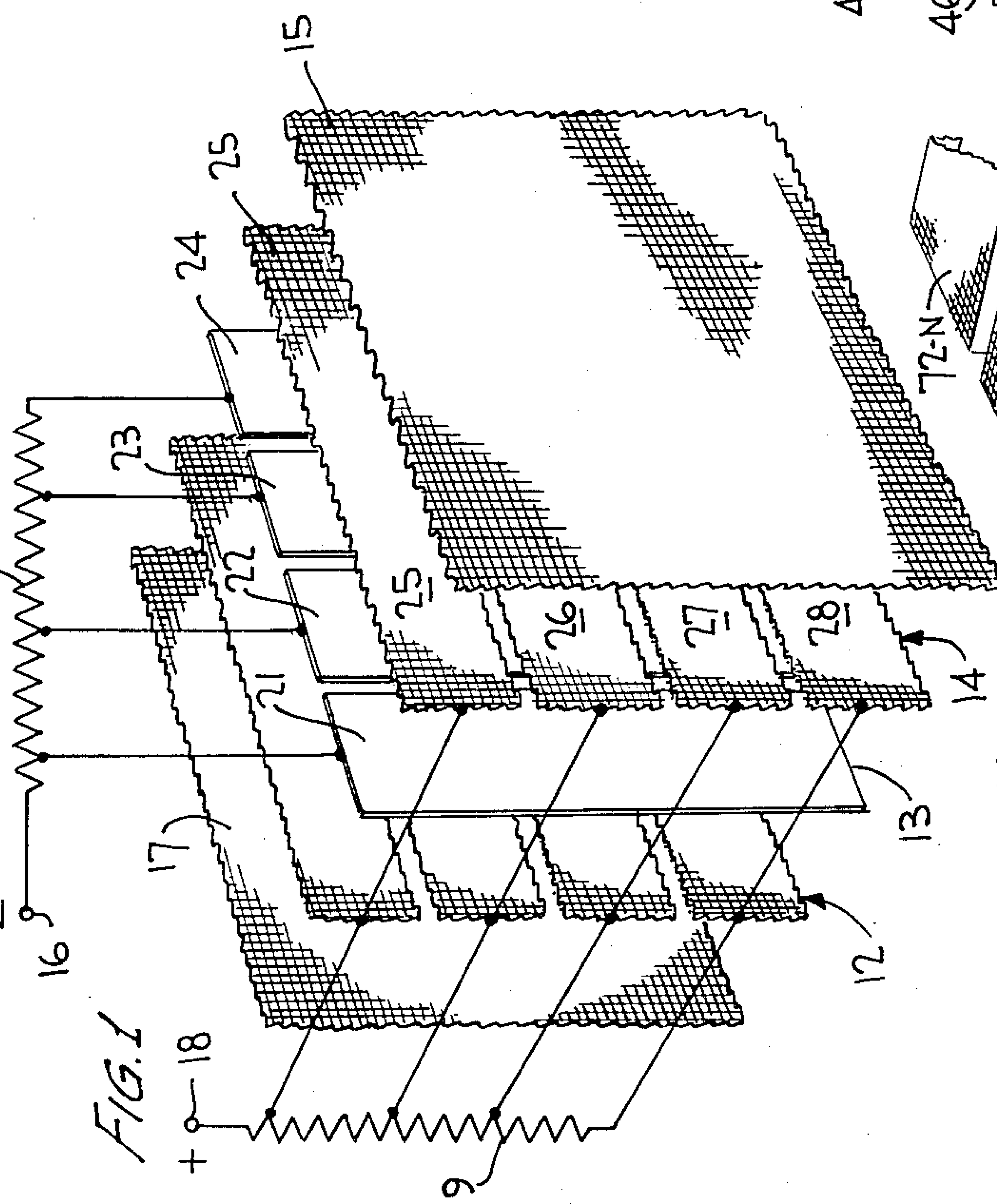
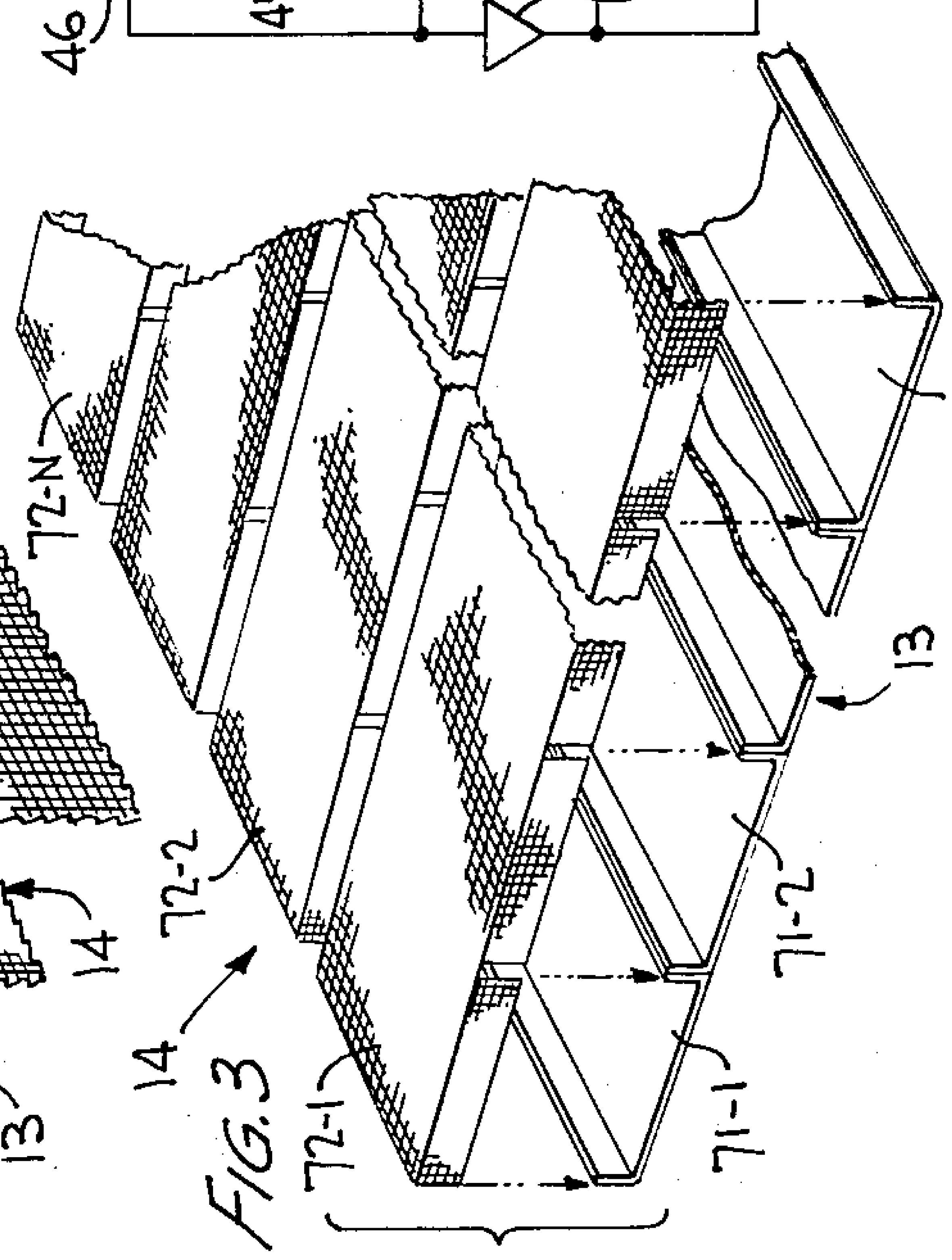


FIG. 3



INVENTOR,
SIEGFRIED O. AUER

BY

Earl Levy
ATTORNEYS

COSMIC DUST OR OTHER SIMILAR OUTER SPACE PARTICLES IMPACT LOCATION DETECTOR

ORIGIN OF INVENTION

The invention described herein may be manufactured and used by or for the United States Government without payment of any royalty thereon or therefor.

FIELD OF INVENTION

The present invention relates generally to cosmic dust and other similar outer space particle detection systems, and more particularly, to a new and improved system for detecting the impingement location of such particles on a detecting surface.

BACKGROUND OF THE INVENTION

In the copending application of Otto E. Berg, Ser. No. 789,044, filed Dec. 31, 1968, bearing the title "-Cosmic Dust Sensor," now U.S. Pat. No. 3,626,189, commonly assigned with the present invention, as well as in an article published in the Oct., 1969, "The Review of Scientific Instruments," pages 1333–1337, there is disclosed a device for detecting the impact position of cosmic dust and other similar outer space particles. The device disclosed therein includes a metal film electrode having a bias voltage applied thereto. In response to a particle impinging on the film, a plasma stream is generated. The direction of the plasma stream has a tendency to be aligned with the line of flight of the particle impinging on the electrode, although there is anisotropic spreading of the plasma stream to form a plasma spray. Electrical charges in the plasma stream are either returned to the film or collected by a grid electrode arrangement in proximity to the film. The grid is biased oppositely from the film so that charges of one polarity are collected by the film and charges of the other polarity are collected by the grid.

To determine the impact position of a particle on the detector including the film and grid, each of the film and grid electrodes is an array comprised of a multiplicity of electrode strips. The film and grid strips have parallel, longitudinally extending axes, with the strips of the grid and film mutually orthogonal to each other. By determining the strips in the grid and film arrays which collect charges in the plasma stream, it is possible to determine the position of particle impact.

The collected electrical charge in the plasma stream is generally so small that an amplifier is required to detect the extremely small signal level resulting from impingement of charges in the plasma stream on the film and grid strips. In the prior art device, a separate amplifier is employed for each strip in the film and grid arrays. To provide a device having a very high resolution, whereby the impact position of the particle can be restricted to areas on the order of 4 square millimeters, a prior art device having a detecting surface on the order of 10,000 mm^2 requires approximately 100 amplifiers. The use of such a large number of amplifiers in a cosmic dust or other similar particle detector, which must be included on a spacecraft in actual use, is disadvantageous because of reliability, power consumption and space requirements. If the resolution of the detector is decreased whereby there is employed a relatively small number of strips, such as four in each direction,

resolution is generally limited to an area of about 625 square millimeters.

It is important to provide the particle detecting system with the maximum possible resolution so that personnel examining the detector visually with a microscope can direct their attention to a minimum area. It generally requires one man hour to scan a 1 square centimeter area of the strip with a microscope, whereby a reduction by a factor of 2,500 can occur by increasing the resolution of the position detecting array from an area of one hundred square centimeters to an area of 4 square millimeters.

BRIEF DESCRIPTION OF THE INVENTION

In accordance with one aspect of the present invention, the same plasma forming principles utilized in the prior art device are employed to enable the position of cosmic dust or other similar particles to be determined. The position sensing apparatus, however, has considerably greater resolution than the prior art device, but requires only a pair of amplifiers to determine the location of impact in each direction, regardless of the number of strips employed. This result is achieved by providing a chain of series connected capacitors, with taps between adjacent capacitors connected to the strips of an array utilized for determining position in one direction. Terminals at each end of the chain are connected to the input terminals of first and second amplifiers, that derive outputs which are combined to derive the impact position indication. The output signal of each amplifier is indicative of the charge coupled by the strip receiving the plasma stream coupled to its input. Since the charge coupled to the input of each amplifier is indicative of the capacitance in the chain between the strip receiving the stream and the input of the amplifier, the amplifier output provides an indication of the strip receiving the plasma stream. The output signals of the two amplifiers are combined to derive a signal that is independent of the amplitude of the charge on a collecting strip and is dependent solely on the position of the strip in the array.

It has been found that a capacitive chain is highly advantageous because it has virtually no effect on the shape of an output pulse derived from an electrode strip. Also, capacitive coupling between the collecting strip and the inputs to the amplifiers enables the amplifiers to be simultaneously responsive to corresponding portions of a signal waveform derived by the collecting strip. If a tapped resistive network, functioning basically as a potentiometer, were employed in lieu of the capacitive chain, the impedance inserted between the collecting strip and the inputs to the amplifiers would frequently be great enough to prevent detection of a meaningful signal. In addition, resistive networks include distributed shunt capacity that materially degrades the shape of the leading edge of a signal derived from a collecting strip. It is important to preserve the leading edge of the collecting strip waveshape because the slope of the leading edge is an indication of particle speed since plasma temperature is a direct function of particle speed. In networks having significant shunt capacity, however, the leading edges of pulses applied to the inputs of the amplifiers are dependent upon the position of the collecting strip feeding the line because differing amounts of shunt capacity are provided in the network from different collecting electrodes.

It has been found through experimentation that the plasma stream does not precisely follow the same line of flight as a particle impinging on the plasma generating film. The average position of the plasma stream generally coincides with the line of flight of impinging particles, but there is anisotropic spray in the stream. In a high resolution array of strips, wherein each strip has a relatively narrow width, there is a fairly high probability of anisotropic spray in the plasma stream impinging on a strip that is not aligned with the line of flight of the particle which caused the plasma stream to be formed. If charge in the plasma spray impinges on a strip that is not in the particle line of flight, cross talk between adjacent strips arises so that the ability to determine particle impingement position on the film is decreased.

In accordance with a feature of the present invention, the problem of anisotropic plasma spray is essentially eliminated by employing charge shields as walls for the electrodes. The walls on the edges of the electrodes extend between the film and grid by an amount sufficient to prevent charge in the spray from reaching a grid strip other than the grid strip in closest proximity to the film strip from which the charge plasma spray originated. In addition, the shields provide a means to prevent charge in the plasma spray from returning to a film strip other than the film strip from which the plasma stream originated. The side walls of the different electrodes are electrically insulated from each other, whereby a multiplicity of electrically insulated cups are formed in the region between the film and grid arrays. Each cup forms a discrete area within a two-dimensional array to enable the position of an impinging particle easily to be ascertained.

OBJECTS OF THE INVENTION

It is, accordingly, an object of the present invention to provide a new and improved system for detecting the impingement position of cosmic dust or other similar outer space particles.

Another object of the invention is to provide a new and improved system for determining the impact position on a detector of cosmic dust or similar outer space particles, which system is highly reliable, requires minimum power, occupies a minimum amount of space, and yet has improved resolution.

Another object of the present invention is to provide a new and improved system for detecting impact position on a detector array of cosmic dust or other outer space particles, which system requires only a pair of amplifiers for determining position in each direction, regardless of the system resolution.

Another object of the invention is to provide a new and improved position impact detector for cosmic dust and other outer space particles, which system monitors the relative charge on taps in a chain of capacitors connected to sensing electrodes.

Another object of the invention is to provide a new and improved cosmic dust or outer space particle impact position detector wherein anisotropic spray in a plasma stream does not adversely affect the accuracy of impact position indicating signals.

Still another object of the invention is to provide a cosmic dust or similar outer space particle impact location detector wherein the leading edge of a pulse derived from a detecting electrode is preserved without requiring the use of a separate amplifier for each detecting electrode of the detector.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of several specific embodiments thereof, especially when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic, perspective, exploded view of one embodiment of the present invention;

FIG. 2 is a circuit diagram of the apparatus utilized for ascertaining particle impact position in accordance with the invention; and

FIG. 3 is an enlarged, perspective, exploded view of another preferred embodiment of the invention particularly designed to substantially eliminate cross talk between adjacent detecting areas.

DETAILED DESCRIPTION OF THE DRAWINGS

Reference is now made to FIG. 1 of the drawings wherein a cosmic dust or other similar outer space particle impact position detector is illustrated. The particle impact detector is generally located on the exterior of a spacecraft above the atmosphere of earth so that a greater probability of collecting cosmic dust and other similar particles results than can be attained within the atmosphere of earth.

The detector comprises five mutually insulated metal planar electrodes **11–15**, positioned in stacked relationship so that each lies in a different parallel plane. Electrodes **11, 12, 14** and **15** are formed of a metal grid or mesh so that cosmic dust or other similar outer space particles, as well as electric charges, can pass through them with a relatively low probability of being intercepted. Electrode **13** comprises a film, preferably formed of either copper, molybdenum or tantalum, which produces a relatively dense plasma stream in response to cosmic dust or a similar outer space particle impinging thereon. The plasma stream is produced by biasing electrode **13** with a d.c. voltage of predetermined polarity, such as derived from the negative d.c. source **16** and resistor chain **17**. Mesh electrodes **12** and **14**, positioned on opposite sides of film electrode **13**, are biased by a d.c. source having a polarity opposite from the biasing source for film electrode **13**, as derived from positive d.c. source **18** and resistor **19**. Mesh electrodes **11** and **15**, positioned on opposite sides of film electrode **13** and outside of grid electrodes **12** and **14**, are connected to a d.c. power supply having the same polarity as the supply for film electrode **13**, as derived from negative source **20**.

In operation, a cosmic dust particle or other similar outer space particle enters the array of electrodes **11–15** through mesh electrode **11** and passes through mesh electrode **12** to impinge on film **13**. In response to the particle impinging on film **13**, the film generates a plasma stream of electrons and positive ions. The plasma stream is directed along a path toward electrodes **14** and **15** that is substantially aligned with the flight path of the particle impinging on film **13**. Additional plasma, in the form of spray, is produced by film **13** in response to the particle impact on the film. This plasma spray is anisotropically directed, emerging from both faces of film **13** towards electrodes **12** and **14**.

Positively charged ions in the anisotropic spray and the plasma stream return to film **13** because of the attractive force between the positively charged ions and the negative d.c. voltage applied to the film by source **16**. Electrons in the plasma spray are collected by grid electrodes **12** and **14** because of the positive bias applied to these grids by source **18**. The positive bias applied to grid **14** is large enough to enable the grid to capture a significant portion of the electrons in the plasma stream generated by film **13**. Any electrons in the plasma spray having sufficient energy to pass through mesh electrodes **12** and **14** are repelled by the negative d.c. field applied to mesh electrodes **11** and **15** and return to and are captured by positively biased mesh electrodes **12** and **14**. A portion of the particle impinging on film **13** passes through the film to a second detector array (not shown), as described in the previously mentioned, copending application and article so that the velocity vector of the impinging particle can be determined.

To enable the impact position of a particle on film electrode **13** to be determined in one direction, the electrode is formed as a plurality of mutually insulated metal strips **21–24**, which have parallel, coplanar longitudinal axes. To enable the impingement position of the strips to be monitored in a second direction, extending at right angles to the first-named direction, mesh electrode **14** is formed as a plurality of metal strips **25–28**. Strips **25–28** are electrically insulated from each other and have parallel longitudinal, coplanar axes, extending orthogonally to the axes of strips **21–24**. While only four strips are illustrated as being included in electrodes **13** and **14**, it is to be understood that in an actual embodiment having high resolution, the number of strips in each electrode is considerably in excess of four, typically being on the order of **100**. The detailed description of FIG. **1** to this point is considered to be the prior art as disclosed in the copending application and previously mentioned article, except for the inclusion of a very large number of strips in electrodes **12**, **13** and **14**.

In accordance with one aspect of the present invention, there is provided a new and improved device for enabling the impingement position of the particle to be determined. The device for determining particle impact position in each direction is the same, so that a description of the apparatus utilized for determining particle impact position on film **13** suffices for the position locating apparatus utilized in conjunction with grid **14**.

Reference is now made to FIG. **2** of the drawings wherein film electrode **13** is illustrated as including a multiplicity, N, of metal, mutually insulated strips **41–1**, **41–2** . . . **41–*k*** . . . **41–N**. Bias voltage is applied to each of strips **41–1** through **41-N** N by the negative d.c. voltage at terminal **16** and resistive chain **17** that comprises resistors **42** and a multiplicity of series connected resistors **43**. A tap between each of the adjacent resistors **43** and taps at the end terminals of the series circuit including resistors **43** are connected to a different one of electrode strips **41–1** through **41–N**. An equal bias voltage is applied to each of the strips by the voltage at terminal **16** and resistive chain **17** since there is no d.c. load provided by the strips, except when a particle impinges on the strips, a relatively infrequent occurrence. Equal bias can be applied to each of the strips **41–1** through **41–N** with the use of a single resistor **42**; a pair of resistors **42** is connected to the opposite end terminals of resistors **43** solely for redundancy purposes.

To monitor the strip on which a particle impinges, a charge dividing mechanism is provided in accordance with the present invention. To establish the charge dividing mechanism, there is provided a string **44** of (N − 1) series connected capacitors, denominated as **45–1**, **45–2** ... **45–k** ... **45–(N − 1)**. One electrode of each of the capacitors in string **44** is connected to a corresponding one of strips **41–1** through **41–N** so that electrodes at either end of string **44** are connected to strips **41–1** and **41–N**, respectively, and taps between adjacent capacitors are connected to intermediate ones of strips **41–2** . . . **41–k**. The values of the capacitors in string **44** are selected to be considerably greater than the stray capacity between strips **41–1** through **41–N** and ground to stabilize the capacitance between the strips at a predetermined level. The values of the capacitors in string **44** can be selected on any basis, as long as this criterion is maintained. Frequently, however, for ease of fabrication and readout it is desired to select each of the capacitors in string **44** to have an equal value. Therefore, in further analysis of the present invention, it will be assumed that the value of each of the capacitors in string **44** has the same value, equal to C.

The end terminals at opposite ends of string **44** are connected through capacitors **46** and **47** to input terminals of operational amplifiers **48** and **49**, respectively. D.C. operational amplifiers **48** and **49** are provided to translate the relative amounts of charge at either end of string **44** into voltages commensurate with the charge levels. Capacitors **46** and **47**, preferably having the same value as the capacitors in string **44**, are connected between the end terminals of string **44** and amplifiers **48** and **49** to provide a voltage division effect to the inputs of the operational amplifiers if a voltage is developed on end strips **41–1** and **41–N**.

Each of amplifiers **48** and **49** is provided with a negative feedback path including the parallel combination of capacitor **51** and resistor **52**. The time constant of the feedback path for amplifiers **48** and **49**, denominated as R_fC_f, is much greater than the time required by strips **41–1** through **41–N** to collect charges in the plasma stream and spray; the time constant of a single resistor **43** and a single capacitor in string **44**, RC, is much greater than the time constant R_fC_f. Thereby, voltage waveforms developed at the output terminals of amplifiers **48** and **49** in response to one of the strips **41–1** through **41–N** collecting a charge have leading edges with substantially the same slope as the waveform developed on the collecting strip regardless of which strip collects the charge. The slope is commensurate with the velocity of a particle impinging on one of strips **41–1** through **41–N**, as described in an article appearing on pages 178-183 of Volume 4 (1968) of "Earth and Planetary Science Letters."

The relative amplitudes of the peak voltages of the waveforms derived from amplifiers **48** and **49** in response to one of strips **41–1** through **41–N** collecting a charge provide an indication of the strip on which charge was collected due to the charge division mechanism. The mechanism for achieving this result can be understood by assuming that a charge is deposited on one of the strips, for example, strip **41–*k***. In response to charge being deposited on strip **41–*k***, a voltage, U, is generated on strip **41–*k*** and is applied to the tap between capacitors **45–*k*** and **45–(*k* + 1)** that are connected to strip **41–*k***. The voltage applied by strip **41–*k*** to an electrode of capacitor **45–*k*** is applied through capacitors **45–1** through **45–*k*** and **46** to the input terminal of amplifier **48**, while the voltage applied by strip **41–k** to an electrode of capacitor **45–(*k* + 1)** is fed to the input terminals of amplifier **49** by capacitors **45–(*k* + 1)** through **45(N – 1)** and capacitor **47**. Since amplifiers **48** and **49** are polarity reversing operational amplifiers and the input voltages thereof can be assumed, for practical purposes, to be at a ground level for the a.c. voltage derived on strip **41–*k*** in response to charge being collected thereby and because of the much lower impedance of the capacitive elements to the a.c. signal than the impedance of the resistive elements in the network, the output voltages of amplifiers **48** and **49** can be written as:

$$e_{o_{48}} = -\frac{CU}{C_t k} \quad (1)$$

and

$$e_{o_{49}} = -\frac{CU}{C_t(N-k+1)} \quad (2)$$

Equations 1 and 2 are derived utilizing the well-known equation relating the output voltage of an operational amplifier network to the input voltage of the amplifier network, the input impedance of the amplifier network and the amplifier feedback impedance. The input capacitance between strip **41–*k*** and the input terminal of amplifier **48** through the k series capacitors between strip **41–*k*** and the input of the amplifier is:

$$C_{in_{48}} = C/k \quad 3.$$

while the series capacitance from strip **41–*k*** to the input terminal of amplifier **49** through the $(N-k+1)$ series capacitors between strip **41–k** and the input terminals of the amplifier is:

$$C_{in_{49}} = C/(N-k+1) \quad 4.$$

Substitution of Equations 3 and 4 for the input impedance into the well-known equation yields the results indicated by Equations 1 and 2.

Another manner for deriving the results given by Equations 1 and 2 is to assume that the inputs of amplifiers **48** and **49** are at ground potential so that parallel circuits exist between strip **41–*k*** and the inputs to the amplifiers. With such an assumption, the resulting capacitance between strip **41–*k*** and the common potential input of amplifiers **48** and **49** is the sum of the capacitances between strip **41–*k*** and the inputs to the two amplifiers, which can be expressed as:

$$C_T = C_{in_{48}} + C_{in_{49}} = C\left(\frac{1}{k} + \frac{1}{N-k+1}\right) \quad (5)$$

The voltage drop, U, between strip **41–*k*** and the input terminals of amplifiers **48** and **49** equals the total charge deposited on strip **41–*k***, Q, divided by the total capacitance, C_T, between strip **41–*k*** and the input terminals of amplifiers **48** and **49**, which can be expressed as:

$$U = \frac{Q}{C_T} = \frac{Q}{C} \cdot \frac{1}{\left(\frac{1}{k} + \frac{1}{N-k+1}\right)} \quad (6)$$

which simplifies to:

$$U = \frac{Q}{C_T} = \frac{Q}{C} \cdot \frac{k(N-k+1)}{(N+1)} \quad (7)$$

The fraction of the total charge, Q, collected by strip **41–*k*** that is coupled to the input terminal of amplifier **48** equals the voltage derived by strip **41–*k*** times the capacitance between strip **41–*k*** and the input of amplifier **48**, which can be expressed as:

$$Q_{48} = C_{in_{48}} \cdot U \quad (8)$$

$$= \frac{C}{k} \cdot \frac{Q}{C} \cdot \frac{k(N-k+1)}{(N+1)} \quad (9)$$

$$= Q \cdot \frac{(N-k+1)}{N+1} \quad (10)$$

Similarly, the fraction of the total charge on strip **41–*k*** that is coupled to the input terminals of amplifier **49** is expressed as:

$$Q_{49} = C_{in_{49}} \cdot U \quad (11)$$

$$= \frac{C}{N-k+1} \cdot \frac{Q}{C} \cdot \frac{k(N-k+1)}{N+1} \quad (12)$$

$$= \frac{Qk}{(N+1)} \quad (13)$$

The output voltages of amplifiers **48** and **49** equal the charge applied to the input terminals thereof divided by the feedback capacitance of each amplifier and can thereby be expressed as:

$$e_{o_{48}} = -\frac{Q(N-k+1)}{C_t(N+1)} \quad (14)$$

$$e_{o_{49}} = -\frac{Qk}{C_t(N+1)} \quad (15)$$

The negative sign in each of Equations 14 and 15 is provided because of the phase reversing properties of amplifiers **48** and **49**.

Comparison of Equations 1, 2, 14 and 15 reveals some striking similarities and differences. The denominator and numerator of Equations 2 and 14 both include the term $(N-k+1)$, while the denominator of Equation 1 and the numerator of Equation 14 include the term *k*. Each of Equations 14 and 15 includes the term Q/*N*+1, which replaces the term CU in Equations 1 and 2. Because Equations 1 and 2 deal basically with voltages, as expressed by U, while Equations 14 and 15 deal with charges, as expressed by *Q*, the portions of the numerator and denominator thereof including the term *k* are reversed. Reversal of the position of k in Equations 1, 2, 14 and 15 has no detrimental effect on properly designed apparatus to provide readout of the charge collecting strip. The same proper design of the apparatus for reading out the value of k enables the waveshape of the leading edge of the output waveform to be preserved.

To these ends, the output signals of amplifiers **48** and **49** are linearly combined in summing network **61**, having an output which is indicative of the charge on the charge collecting strip. The output of summing network **61** is nonlinearly combined with the output voltage of amplifier **49** in division network **62**. The output signal of division network **62**, commensurate with the output of amplifier **49** divided by the output of network **61**, is a variable amplitude voltage waveform having a peak value indicative of which one of strips collects charge. The output signal of division network **62** is also independent of the amplitude of the voltage derived from strip **41**–k and the amount of charge collected by strip **41**–k.

These advantageous results are seen by the following analyses, the first of which utilizes the results obtained from Equations 1 and 2 and the second of which employs results obtained from Equations 14 and 15. For the first analysis, the output voltage of summing network **61** can be written as:

$$e_{o_{48}}+e_{o_{49}}=-\frac{CU}{C_t k}-\frac{CU}{C_t(N-k+1)}=-\frac{CU}{C_t}\left(\frac{1}{k}+\frac{1}{N-k+1}\right)$$
$$=-\frac{CU}{C_t}\left[\frac{N+1}{k(N-k+1)}\right] \qquad (16)$$

Dividing the output signal of amplifier **49** by the sum signal derived from network **61** in division circuit **62** yields:

$$\frac{e_{o_{49}}}{e_{o_{48}}+e_{o_{49}}}=\frac{\dfrac{-CU}{C_t(N-k+1)}}{-\dfrac{CU}{C_t}\left[\dfrac{(N+1)}{k(N-k+1)}\right]}=\frac{k}{(N+1)} \qquad (17)$$

An examination of Equation 17 indicates that the output voltage of division circuit **62** equals the number k of the strip, **41**–k, which collects the charge divided by a predetermined constant, $N + 1$. The final result is completely independent of the magnitude of the voltage generated by charge collecting strip **41**–k.

The second analysis, leading to the same results, is obtained by adding the output voltages of amplifiers **48** and **49**, as expressed by Equations 14 and 15, as:

$$e_{o_{48}}+e_{o_{49}}=\frac{-Q(N-k+1)}{C_t(N+1)}-\frac{Qk}{C_t(N+1)}$$
$$=\frac{-Q(N-k+1+k)}{C_t(N+1)}=-\frac{Q}{C_t} \qquad (18)$$

Dividing Equation 15 by Equation 18, the operation performed in division network **62**, yields:

$$\frac{e_{o_{49}}}{e_{o_{48}}+e_{o_{49}}}=\frac{-\dfrac{Qk}{C_t(N+1)}}{-\dfrac{Q}{C_t}}=\frac{k}{(N+1)} \qquad (19)$$

Equations 17 and 19 yield the same result, fortifying the earlier statement that a properly designed network enables the output signals of amplifiers **48** and **49** to be combined to derive a signal solely indicative of the position of the charge collecting strip **41**–k.

To enable the velocity of a particle impinging on the detector array to be ascertained, the output voltage of summing network **61** is applied to differentiating network **63**. differentiating network **63** responds to the leading edge of the output voltage of the summing amplifier to derive a voltage indicative of particle velocity, as described in the previously mentioned article in "Earth and Planetary Science Letters."

Because of the relatively narrow width, approximately two millimeters, of each of the strips **41** in a high resolution device, there is a high probability of charge carrier spray impinging on a strip other than the strip directly aligned with the line of flight of an impinging particle. To solve this problem, another aspect of the present invention involves forming a two dimensional array of mutually isolated areas. The areas are formed by providing mechanical shields as side walls at the edges of the film and grid strips by cutting notches in the side walls of the grid strips and by placing the bases of the film strips against the upper edges of the side walls of the films. As illustrated in exploded form by FIG. **3**, each of the elongated strips **71–1** . . . **71**–N and **72–1** . . . **72**–N comprising film electrode **13** and mesh electrode **14** is formed as a channel having side walls extending at right angles to the base thereof. Typically, the height of the side wall of each of the channels is on the order of 20 percent of the width of the base of the channel to prevent plasma spray from being coupled into an area other than the area in the line of flight of a particle impinging on the detector array. The side walls of channels **71–1** . . . **71**–N and **72–1** . . . **72**–N are fabricated from the same material as the bases of the channels, whereby vias voltages applied to the strips establish electric fields for collecting charges and electrons in the spray crossing onto a strip other than the strip in the line of flight of an impinging particle. The exterior surfaces of the side walls of channels **71–1** . . . **71**–N and **72–1** . . . **72**–N are coated with a dielectric having a thickness typically on the order of one micron, so that adjacent channels can be placed in abutting relationship while maintaining insulation between them. The top surfaces of the upwardly extending side walls of channels **71–1** . . . **71**–N and bottom surfaces of the downwardly extending side walls of channels **72–1** . . . **72**–*N* are also coated with dielectric, so that the bases of grid strips **72–1** . . . **72**–N can be placed directly on the upper edges of films **71–1** . . . **71**–N, with notches in the side walls of the grid strips mating with the side walls of the films. The resulting structure forms a two-dimensional array including a multiplicity of individual cups, each of which forms a separate collecting area. Determining which of the cups receives charge is performed utilizing a pair of networks of the type described in conjunction with FIG. **2**, with one of the networks being provided for film strips **71–1** . . . **71**–N and the other network being connected to grid strips **72–1** . . . **72**–N.

While there have been described and illustrated several specific embodiments of the invention, it will be clear that variations in the details of the embodiments specifically illustrated and described may be made without departing from the true spirit and scope of the invention as defined in the appended claims.

I claim:

1. In a system for determining the impact position of cosmic dust or other similar outer space particles on a detector, means responsive to said particles impinging thereon for forming a plasma stream, a multiplicity of biased metal strips for collecting charge in the plasma stream, said strips being mutually insulated from each other, means for deriving a signal indicative of the strip on which the charge is derived, said deriving means including: a pair of amplifiers, means for capacitively coupling each of said strips to an input of each of said amplifiers, and means for combining output signals of said amplifiers.

2. The system of claim 1 wherein said capacitive coupling means comprises a multiplicity of capacitors series connected between the inputs of the amplifiers, different taps between adjacent ones of said capacitors being connected to different ones of said strips, one of said strips being connected to a different one of the taps.

3. The system of claim 1 wherein said deriving means includes means for generating the position indicating signal with an amplitude dependent on the location of the strip and independent of the charge on the strip collecting the impinging plasma stream charge.

4. The system of claim 3 wherein the generating means includes means for linearly combining the output signals of said amplifiers to derive another signal indicative of the amount of charge on the strip collecting the plasma stream, and means for nonlinearly combining the another signal with the output signal of one of the amplifiers to derive a signal independent of the amount of charge on the strip collecting the plasma stream.

5. The system of claim 1 wherein said strips are elongated and have substantially parallel longitudinal axes.

6. In a system for determining the impact position of cosmic dust or other similar outer space particles on a detector, means responsive to said particles impinging thereon for forming a plasma stream, a multiplicity of biased metal strips for collecting charge in the plasma stream, said strips being mutually insulated from each other, a multiplicity of series connected capacitors having taps between adjacent capacitors, different taps between said capacitors being connected to different ones of said strips, one of said strips being connected to a different one of said taps.

7. The system of claim 6 further including means connected to said capacitors for determining the capacitance between the strip on which the charge is derived and an end strip in the multiplicity of strips.

8. A detector for cosmic dust or other similar outer space particles comprising biased metal film means for deriving a plasma stream in response to one of said particles impinging thereon, said film means including a multiplicity of first metal strips having parallel longitudinal axes extending in a first direction, metal grid means biased with the opposite polarity from said film means for collecting charge in the plasma stream, said grid means including a multiplicity of second metal strips having parallel longitudinal axes extending in a second direction orthogonal to the first direction, means connected to said first strips for deriving a first signal in response to charge in the stream returning to the film, and means connected to said second strips for deriving a second signal in response to charge from the plasma stream being collected thereby, said first and second signals being respectively indicative of the impingement position of the particle on the grid means and film means, each of said signal deriving means including: a multiplicity of series connected capacitors having taps between adjacent capacitors, different taps between said capacitors being connected to different ones of said strips, one of said strips being connected to a different one of said taps.

9. In a system for determining the impact position of cosmic dust or other similar outer space particles on a detector, means responsive to said particles impinging thereon for forming a plasma stream, a multiplicity of biased metal strips for collecting charge in the plasma stream, said strips being mutually insulated from each other, said stream being anisotropically ejected from the plasma forming means and having a tendency to impinge on a plurality of strips, means for confining the plasma stream to only the strip in closest proximity to the portion of the plasma forming means from which the stream is ejected, and means for deriving a signal indicative of the strip on which the charge is derived, said deriving means including a pair of amplifiers, means for capacitively coupling each of said strips to an input of each of said amplifiers, and means for combining output signals of said amplifiers.

10. The system of claim 9 wherein said confining means includes metal side walls along the edge of each strip.

11. The system of claim 9 wherein the plasma forming means includes another multiplicity of mutually insulated strips running substantially at right angles to the collecting strips, means for biasing the multiplicity of strips with the opposite polarity from the bias applied to the collecting strips whereby a two-dimensional array of areas between the another strips and collecting strips is formed.

12. In a system for determining the impact position of cosmic dust or other similar outer space particles on a detector, means responsive to said particles impinging thereon for forming a plasma stream, a multiplicity of biased metal strips for collecting charge in the plasma stream, and strips being mutually insulated from each other, said stream being anisotropically ejected from the plasma forming means and having a tendency to impinge on a plurality of strips, means for confining the plasma stream to only the strip in closest proximity to the portion of the plasma forming means from which the stream is ejected, a multiplicity of series connected capacitors having taps between adjacent capacitors, different taps between said capacitors being connected to different ones of said strips, one of said strips being connected to a different one of said taps.

13. The system of claim 12 further including means connected to said capacitors for determining the capacitance between the strip on which the charge is derived and an end strip in the multiplicity of strips.

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