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

REPLY TO ATTN OF: GP

April 5, 1971

MEMORANDUM

TO: KSI/Scientific & Technical Information Division
Attn: 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 contained in the Code GP to Code USI memorandum on this subject, dated June 8, 1970, 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. : 3,437,818

Corporate Source : Lewis Research Center

Supplementary Corporate Source :

NASA Patent Case No.: XLE-04535

Gayle Parker

Enclosure:
Copy of Patent

N71-23354

April 8, 1969 R. D. SHATTUCK 3,437,818

PROTECTION OF SERIALLY CONNECTED SOLAR CELLS AGAINST OPEN CIRCUITS BY THE USE OF SHUNTING DIODE

Filed Oct. 19, 1966

N71-23354 40%

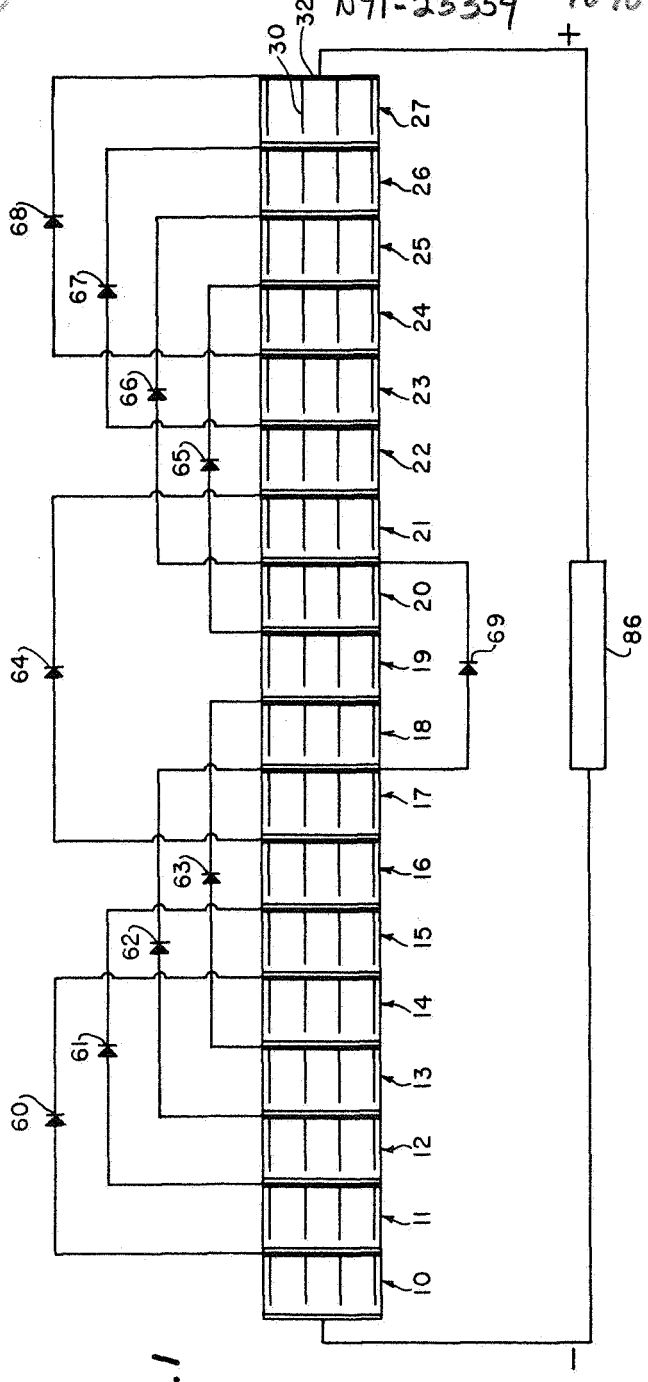

FIG. 1

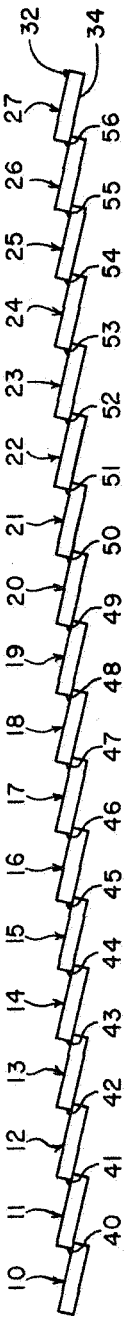

FIG. 2

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1397

United States Patent Office 3,437,818
Patented Apr. 8, 1969

3,437,818

PROTECTION OF SERIALLY CONNECTED SOLAR CELLS AGAINST OPEN CIRCUITS BY THE USE OF SHUNTING DIODE

Russell D. Shattuck, Bay Village, Ohio, assignor to the United States of America as represented by the Administrator of the National Aeronautics and Space Administration

Filed Oct. 19, 1966, Ser. No. 588,671
Int. Cl. H01j 39/12
U.S. Cl. 250—212 5 Claims

ABSTRACT OF THE DISCLOSURE

Maintaining current flow through an array of serially connected solar cells even though the array has some open connections. All junctions are shunted by at least one protecting diode, and each connection has at least one completely redundant shunting diode.

The invention described herein was made by an employee of the United States Government and may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to an improved serial connection for solar cells in an array. The invention is particularly concerned with maintaining current flow through the solar cells even though some open connections are in the array.

A power supply for equipment which is used in space frequently utilizes an array in which a number of solar cells are connected in series. Such an array presents a problem of open connections occurring between some of the cells.

Some protection may be obtained by connecting a diode across a cell-to-cell connection. The diode provides an alternate path for current flow to insure the operation of the series string when an open connection occurs between the cells. The difficulty resulting from such a connection is that because the most common solar cell failure is a contact break the protecting diode contacts may open at the same time a cell-to-cell contact fails.

These problems and difficulties have been solved by the present invention in which the diodes are staggered in such a manner that each diode is protecting more than one solar cell junction. This is accomplished by having each diode connected as a shunt across two, three, or more cells. In this manner every connection is shunted by at least one protecting diode, and the number of protecting diodes per solar cell connection may be increased. The number of protecting diodes is limited only by the magnitude of the allowable output degradation in the system because the failure of any one series cell connection would lead to a loss of output from all the cells being shunted by the particular diode involved.

It is, therefore, an object of the present invention to provide a solar cell array having improved electrical connections which maintain current flow even though some of the electrical contacts are broken.

Another object of the invention is to provide improved connections through which current flow is maintained in a series string of solar cells with a minimum loss of power where there are open connections between some of the cells in the series.

Still another object of the invention is to provide a solar cell array in which every connection between the cells is shunted by at least one protecting diode.

These and other objects of the invention will be apparent from the specification which follows and from the drawing in which like numerals are used throughout to identify like parts.

In the drawing:

FIG. 1 is a plan view of an array of solar cells connected in accordance with the present invention.

FIG. 2 is an elevation view of the array shown in FIG. 1.

Referring now to the drawing, there is shown in FIGS. 1 and 2 a group of solar cells **10–27** which may be of the P on N type. Each cell as a grid **30** which is secured to one of its faces. The grid **30** terminates at a P contact **32** across one end as best seen in FIG. 2. An N contact **34** covers the entire surface of each solar cell opposite the grid **30**.

The cells **10–27** are mounted in a straight line array by placing each P contact **32** in engagement with the N contact **34** of an adjacent cell and soldering the resulting joint. In this manner the cells **10–27** are connected in series at junctions **40–56** respectively. The array is used to supply current to a load **86** such as a battery which is charged by the array.

An open connection between any adjacent cells **10–27** at a junction **40–56** of the P and N contacts prevents passage of current directly through the array shown in FIGS. 1 and 2 because the cells are connected in series. If a diode is connected across each cell-to-cell connection the series strip is maintained in operation at a reduced power level because the diode provides an alternate path for the current. However, the protecting diode may not operate in its intended fashion because the most common solar cell failure is a contact failure, and the protecting diode contact fails at the same time the cell-to-cell contact is broken. By way of illustration, a diode connected between junctions **43** and **44** would form a shunt around the solar cell **14**. A break in either of these junctions would probably cause an interruption in this shunt. This is likewise true for any diode that forms a shunt between adjacent junctions around one of the solar cells in the array.

According to the present invention, diodes **60–69** are used to protect the junctions **40–56**. As seen in FIG. 1, each diode protects more than one junction. By way of example, the diode **60** forms a shunt across the junctions **40** and **44**. An open connection at any or all of junctions **41**, **42** and **43** would cause current to flow through the diode **60** between the solar cells **10** and **15**.

In a like manner, the diode **64** protects junctions **47**, **48**, **49** and **50** because an open connection at any of these junctions causes current to flow through this diode. The diode **68** forms a shunt between the junction **53** and the P contact **32** at the end of the strip.

As shown in FIG. 1 all the junctions **40** to **56** are shunted by at least one protecting diode. There is no cell-to-cell connection which does not have at least one completely redundant shunting diode, and some junctions have two spares. For example, an open connection at junction **43** would cause current to flow through diodes **60**, **61** and **62**. In a similar manner, an open connection at junction **54** would cause current to flow through diodes **66**, **67** and **68**. The diode **69** is connected between junctions **47** and **50** to form a second shunt with diode **64** for protecting the center junctions **48** and **49**.

While a preferred embodiment of the invention has been shown and described, it will be appreciated that various modifications may be made to the disclosed structure without departing from the spirit of the invention or the scope of the subjoined claims. For example, the improved connection can be used with a number of different types of solar cells as well as semiconductors where reliability is of paramount consideration.

What is claimed is:

1. In combination with a plurality of solar cells electrically connected in series at junctions between adjacent cells, the improvement comprising

a plurality of diodes for protecting the solar cells against open connections at the junctions, and

means for connecting each of said diodes as a shunt across at least two of the junctions between the cells thereby enabling current to flow through said diodes around an open connection at said two junctions.

2. Apparatus as claimed in claim 1 wherein the diodes are connected to the junctions in an overlapping manner so that each cell is protected by at least two diodes.

3. A space electrical power source comprising

a plurality of solar cells, each having a grid secured to one of its faces terminating at a first contact across one end thereof and a second contact on the other face,

said solar cells being mounted in a straight line array with each of said first contacts being in engagement with the second contact of an adjacent cell thereby forming a plurality of junctions between said solar cells,

means for forming a shunt around each of said junctions so that an open connection at said junction causes current to flow through said shunt thereby maintaining current flow through said array, and

a diode mounted in each of said shunts to prevent current flowing in the opposite direction through said junction.

4. A space power source as claimed in claim 3 wherein each diode shunts at least two junctions.

5. A space power source as claimed in claim 4 wherein the shunts are connected in an overlapping manner so that each cell is shunted by at least two diodes.

References Cited

UNITED STATES PATENTS

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U.S. Cl. X.R.

250—211