United States Patent [19]

Kostic et al.

[11] **3,784,823**

[45] **Jan. 8, 1974**

[54] **METHOD AND DEVICE FOR THE DETECTION OF FISSION PRODUCTS**

[75] Inventors: **Svetislav Kostic**, Paris; **Roger Le Meur**, Verrieres-le-Buisson, both of France

[73] Assignee: **Commissariat A L'Energie Atomique**, Paris, France

[22] Filed: **Jan. 19, 1972**

[21] Appl. No.: **218,861**

[30] **Foreign Application Priority Data**

Jan. 22, 1971 France 7102218

[52] **U.S. Cl. 250/83.6 FT**, 250/41.9 D, 250/106 SC

[51] **Int. Cl.** **G01j 1/18**

[58] **Field of Search** ..... 250/83.6 FT, 106 SC, 250/41.9 D, 41.9 ME, 49.5 A

[56] **References Cited**

UNITED STATES PATENTS

2,576,616	11/1951	Livingston et al.	250/83.6 FT
3,136,891	6/1964	Grafleaux et al.	250/83.6 FT
2,985,785	5/1961	Softky	250/83.6 FT
3,084,252	4/1963	Goupil et al.	250/83.6 FT

Primary Examiner—Harold A. Dixon

Attorney—Joseph M. Lane et al.

[57] **ABSTRACT**

The method consists in carrying out the electrical collection of fission products on both sides of very thin metallized discs of polyester insulating material which are placed at the center of a spherical chamber and in measuring the radioactivity with a set of two electron detectors mounted to detect activity of the discs in all directions.

The device for carrying out the method comprises a magazine constituted by a rotary circular ring provided with spaced openings each intended to accommodate a disc, a spherical ion-collection chamber, two parallel semiconductor detectors and a unit for conveying each disc from the magazine into an opening formed in a transfer plate. The disc is transferred by the plate to an ion-collection chamber, then passed between the two detectors in order to measure the activity and energy spectrum of the beta radiation of the collected ions then returned to the magazine.

14 Claims, 4 Drawing Figures

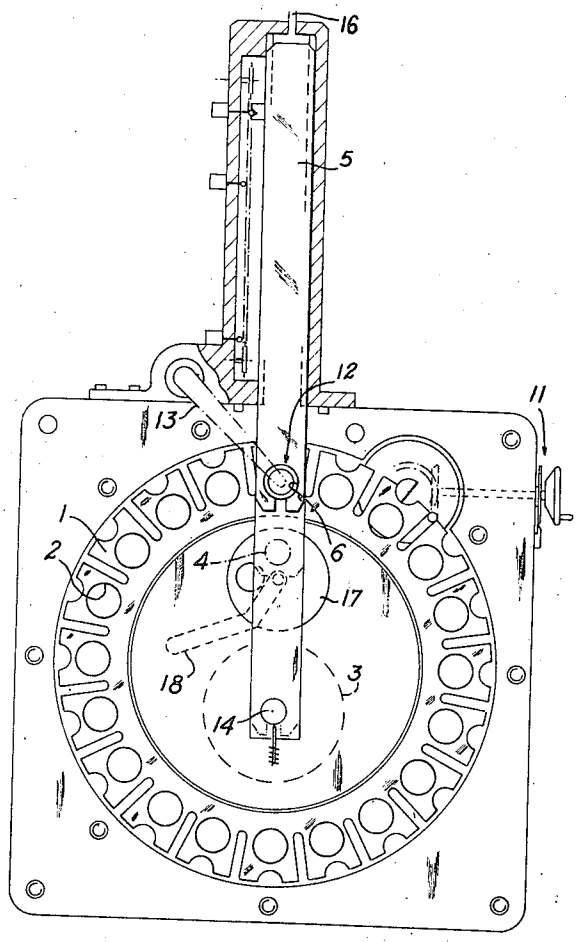
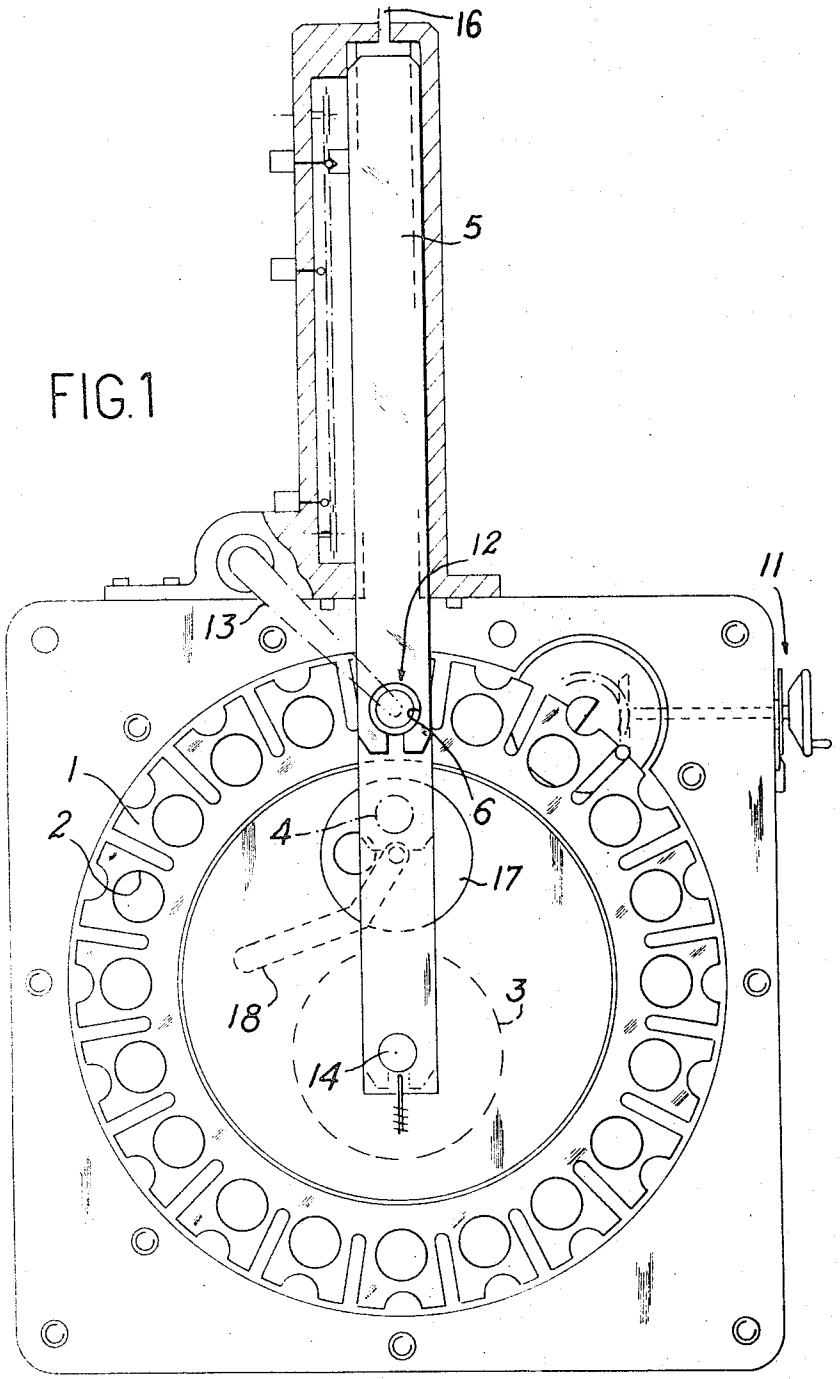


FIG.1



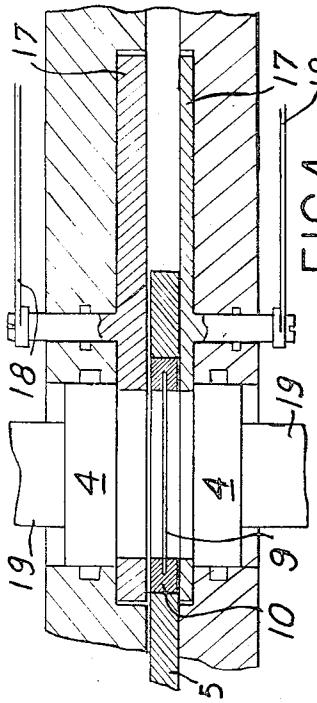


FIG.4

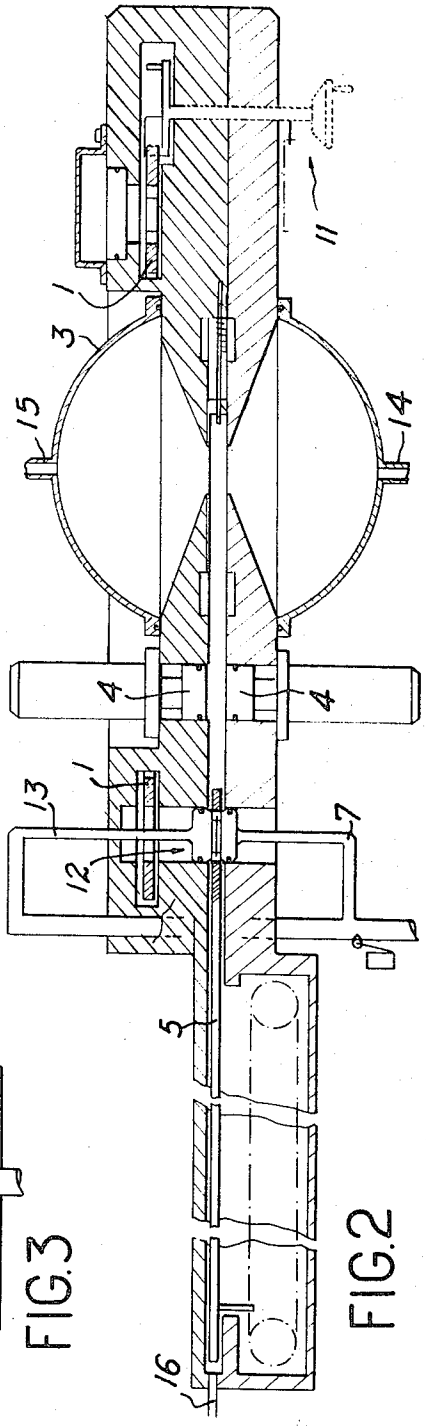


FIG.2

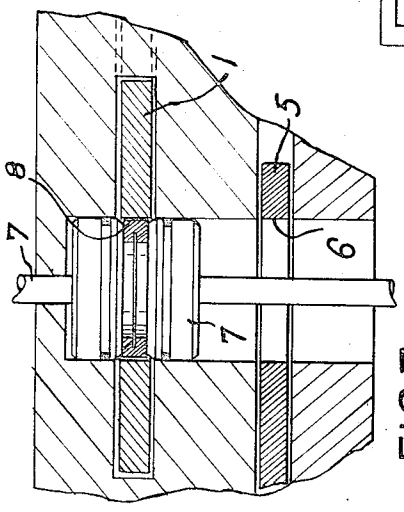


FIG.3

METHOD AND DEVICE FOR THE DETECTION OF FISSION PRODUCTS

This invention relates to a method of detection of fission products and a device for carrying out said method.

This device finds an advantageous application in the detection of fuel-can failures in nuclear reactors as a result of detection of fission products either in the coolant gas or in the gases extracted from the coolant fluid or in the blanket gas.

In order to monitor leakages in the jacket which surrounds the fissile material, it is necessary to detect the radioactivity of the short-lived fission products which are permitted by the jacket failure to pass into the coolant fluid in contact with said jacket. This radioactivity is measured by means of a detection device placed on the path of the gas which is sampled either from the cooling circuit or from the blanket gas. A number of different burst can detection devices are already known. In devices of this type, the fraction of gas which is employed for the detection is held within a suitable reservoir for a sufficient period of time to ensure the formation of radioactive ions derived from the fission products which are present in the gas ; these ions are then collected by precipitation by means of an electric field in selected zones on the surface of a conveying unit which may be either a drum or disc. After collection in a predetermined zone, this zone is brought by rotation of the conveying unit in front of a measuring apparatus consisting as a rule of a scintillator and a photomultiplier followed by an electronic counting device. The movement of the conveying unit is such that a further collection in a predetermined zone is possible only after a time interval which is sufficient to ensure that this zone is relatively decontaminated as a result of natural decay of the collected products. While a measurement is in progress, a sweeping neutral-gas stream can be injected between the detection unit and the conveying unit in order to reduce the undesirable influence of the active gases which may be present between these two units.

However, devices of this type do not permit fine β-ray spectrometry by reason of the lack of resolution of the scintillators and especially the magnitude of the backscattering phenomenon arising from the thickness of the conveying unit which is necessary to obtain good mechanical strength and which has the result of deforming the energy spectrum.

The device in accordance with the invention which makes it possible in particular to carry out burst-can detection operations of the kind referred-to above is primarily intended for the study of short-lived fission products by fine β-ray spectrometry.

Now β-ray spectrometry is usually made difficult by the fact that beta spectra are continuous whereas this is not the case with gamma spectra and also by reason of the fact that deformations occur as a result of disturbances such as backscattering, for example ; disadvantages of this kind arise in magnetic β-ray spectrometry which is the most common technique and which is attended by a further drawback in that it does not permit the possibiltiy of recording the entire spectrum in a single measurement.

The present invention utilizes beta spectrometry of fission products with electrical collection and makes it possible to obtain good resolution and a reduction of the backscattering effect.

More precisely, the invention is directed to a method of detection of fission products which consists in carrying out the electrical collection of fission products on both sides of very thin metallized discs of polyester insulating material which are placed at the center of a spherical chamber known as a 4π chamber and in measuring the radioactivity with a set of two electron detectors mounted to detect activity of the discs in all directions.

The invention also relates to a device for carrying out said method, wherein said device essentially comprises a magazine constituted by a rotary circular ring pierced by equal and uniformly spaced openings each intended to contain a very thin disc of polyester insulating material matallized on both faces, a spherical collection chamber, two identical electron detectors or semiconductors having a surface area at least equal to that of a disc and mounted in parallel relation at a very short distance from each other, a transfer plate provided with an opening which is capable of receiving each of said discs in succession, and a conveying unit in which is formed a chamber having the thickness of said discs and capable of coming to the level of said circular ring and to the level of said transfer plate, the arrangement being such that, by virtue of suitable coordination of the displacements of the transfer plate and the conveying unit, said unit causes one disc to pass from said magazine into the opening of the transfer plate, that said transfer plate displaces said disc to the center of the collection chamber in order to permit collection of the ions and then between the two detectors in order to permit measurement of the activity and energy spectrum of the beta radiation of the collected ions and then returns to its initial position, and that said conveying unit causes said disc to return into the magazine.

Further properties and advantages of this invention will become apparent from the following description of one form of construction of the device according to the invention, this description being given by way of explanation but without any intended limitation, reference being made to the accompanying drawings, in which:

FIG. 1 illustrates the complete device in accordance with the invention, looking at the level of its disc magazine ;

FIG. 2 illustrates the same device to a different scale, looking at right angles to FIG. 1 ;

FIG. 3 illustrates the conveying unit alone, to a larger scale than in FIG. 2 ;

FIG. 4 illustrates, to a larger scale than in FIG. 2 and in greater detail, the portion of the device according to the invention which comprises the two semiconductors.

The detection device as shown in these figures comprises essentially a magazine 1 constituted by a circular ring pierced by uniformly spaced openings 2 (which may be twenty in number, for example), said openings being each intended to contain a disc in accordance with the invention, a spherical collection chamber 3 (referred-to as a 4π chamber), two parallel silicon semiconductors 4, a transfer plate 5 provided with an opening 6 which is capable of receiving each disc in turn and of bringing them in accordance with a predetermined cycle into the collection chamber 3 and into the measuring chamber and a unit 7 for conveying the discs between the magazine 1 and the transfer plate 5,

there being formed in said unit a chamber 8 which is intended to receive each of said discs in turn.

Each disc (shown in FIG. 4) is constituted by a very thin leaf 9 of polyester insulating material (for example the product known by the name of "Mylar") which is metallized on both faces in order that the ions may be collected by both sides of the discs, said leaf being held in position by means of a retaining ring 10. The thickness of the leaf 9 is 13 microns, for example. These discs are electrically conductive by virtue of the metal spray-coating which constitutes the collection electrode and their thickness is intended to be as small as possible in order to remove any danger of a backscattering phenomenon which has the disadvantage of deforming the spectra.

The detectors 4 which are known as semiconductors have the shape of parallel circular plates. These detectors by reason of the fact that they each have a surface area at least equal to that of the discs, are capable of detecting the activity of these discs in all directions of the space.

The operation of the detection device according to the invention is as follows:

When actuating a crank-handle 11, the operator causes the magazine 1 to rotate in such a manner as to bring one of the discs (9, 10) of this magazine 1 into position 12, that is to say opposite to the transfer plate 5 which is then in the position of passage, that is to say in a position such that the opening 6 of said plate is located opposite to said position 12. The conveying unit 7 then takes up a position which, for the sake of convenience of terminology, will be referred-to hereinafter as the bottom position, assuming that FIG. 2 is oriented in such manner that the magazine 1 is located beneath the transfer plate 5. In this bottom position, the disc is maintained by the conveying unit 7 within the magazine 1 and imprisoned in the chamber 8.

Since the transfer plate 5 remains stationary, the operator then causes the conveying unit 7 to move upwards to the central position in which the chamber 8 coincides with the opening 6 of the transfer plate. The disc (9, 10) is then located within this opening 6.

The operator then moves the transfer plate 5 forward in such manner that the opening 6 of the said plate (and therefore the disc 9, 10) is located between the two semiconductors 4, there being then carried out in this location a measurement of the residual activity which this disc may possess if it is not an unused disc.

It should be noted that the conveying unit 7 is so designed that its arm 13 prevents the magazine 1 from rotating when the transfer plate 5 carries out a movement of displacement.

The operator then moves the transfer plate 5 forward in such manner that its opening 6 (and therefore the disc 9, 10) is located at the center of the spherical collection chamber 3. The disc is then brought to a negative potential with respect to said chamber 3.

The radioactive ions of the gas under study which penetrates through the openings 14, 15 of the chamber 3 are then collected on both faces of the disc, this collection being an electrical connection in 4π geometry (that is to say in all the directions of the space).

After this collection, the operater returns the disc between the semiconductors 4 where a measurement of the activity of collected ions is carried out, whereupon the transfer plate 5 is returned to the position of passage in such manner that the disc which has just been subjected to this measurement of activity is located opposite to the magazine 1. Finally, by actuating the conveying unit 7 and restoring this latter to the bottom position, the operator replaces the disc in the magazine 1 in position 12.

Provision can be made for continuous sweeping of the two semiconductors 4 with an inactive gas at a low flow rate, thus making it possible to reduce the background resulting from the activity of the gas under study ; in fact, said inactive gas which penetrates into the apparatus at 16 prevents the active gas which is collected in the 4π precipitator (reference 3) from coming between the semiconductors 4.

Metallizing on both faces of the disc has the advantage of producing the same attenuation of the radiation which reaches each of the detectors, with the result that these latter measure the same energy.

Since the device according to the invention is designed for beta spectrometry, the influence of gamma radiations, for example, is eliminated firstly by taking a measurement of the beta + gamma activity of the disc followed by a second measurement after having placed on each side of the disc two retractable screens 17 actuated by two arms 18 which stop the beta radiations.

It is also possible to make use of only one screen so as to carry out a beta + gamma measurement with one of the semiconductors 4 and a gamma measurement with the other semiconductor, these two measurements being then each carried out to detect activity of each side of the disc as if each side had collected radioactive ions in a 2π chamber.

The apparatus according to the invention is intended for the study of short-lived fission products by fine beta spectrometry. The electronic pulse-processing circuitry is not included in the figures which only show preamplifiers 19 at the level of the semiconductors 4.

The detector according to the invention has the advantage of practically eliminating backscattering by reason of the size and spacing of the two semiconductor detectors and by virtue of the fact that the discs are of extremely small thickness.

When a disc has been subjected to detection between the semiconductors 4, replacement of the disc may then be carried out either by returning the studied disc into the magazine 1 as explained earlier and by rotating said magazine in order to cause the following disc to come into position 12, or by extracting the studied disc by moving the conveying unit 7 upwards to the top position in which its chamber 8 and the disc contained therein are located outside the apparatus, then by inserting a fresh disc. This possibility of introducing discs into the apparatus makes it possible to calibrate the semiconductors by means of source discs (standard activity, standard energy) which can be placed directly beneath the semiconductors. The possibility of extraction of discs permits measurement of their activity in other devices such as a gamma spectrometer, for example.

It is readily apparent that this invention has been described in the foreqoing solely by way of explanation and not in any limiting sense and that any detail modifications could accordingly be made therein without departing from its scope.

We claim:

1. A device for the detection of fission products, said device comprising: a magazine established by a rotary circular ring having equal and uniformly spaced open-

ings each adapted to contain a very thin disc of insulating material metallized on both faces, a spherical collection chamber, two identical semiconductor electron detectors having a surface area at least equal to that of a disc and mounted in parallel relation at a very short distance from each other, a transfer plate provided with an opening capable of receiving each of said discs in succession, and a conveying unit defining a chamber having a thickness of said discs and movable between said circular ring and said transfer plate, whereby through suitable coordination of transfer plate and conveying unit displacement, one disc is caused to pass from said magazine into the opening of the transfer plate and displaced by said transfer plate to the center of the collection chamber so as to permit collection of the ions, then located between the two detectors in order to permit measurement of the activity and of the energy spectrum of the collected ions and is then returned to said conveying unit and to the magazine.

2. A device according to claim **1**, wherein the discs are each constituted by a polyester film such as "Mylar" which is metallized on both faces.

3. A device according to claim **1**, wherein said device comprises retractable screens which stop beta radiations and can be interposed between the semiconductors and the faces of the disc under study.

4. A device according to claim **1**, wherein said device comprises a duct for the introduction of inactive gas which is intended to sweep the two semiconductors.

5. A device according to claim **1**, wherein said device comprises a conveying unit which permits the discharge of contaminated discs and the introduction of fresh discs or of source discs for either activity or energy calibration.

6. A detector of fission products for use with a collection chamber containing a gas having radioactive ions derived from fission products present in the gas, the improvement comprising:

a plurality of very thin discrete discs suitable for collecting radioactive ions,

magazine means for holding said discs and for serially positioning said discs in a first position for movement from said magazine,

means for moving said discs individually from said first position to the collection chamber where radioactive ions are collected on opposite sides of said individual disc and for moving said individual disc from said collection chamber to a measuring station, and

detector means at said measuring station for measuring the activity of said collected radioactive ions in all directions.

7. The apparatus of claim **6** in which each of said discs comprises: a very thin leaf of insulating material which is metallized on opposite sides.

8. The apparatus of claim **7** in which said insulating material is a polyester such as Mylar.

9. The apparatus of claim **6** in which said magazine means comprises: means defining a plurality of uniformly spaced openings each capable of holding one of said discs and indexing means for serially positioning each of said discs in said first position.

10. The apparatus of claim **9** in which said means defining a plurality of openings is a rotatable ring and said indexing means is a crank mechanically coupled to said ring.

11. The apparatus of claim **6** in which said moving means comprises: conveying means for moving said individual disc from said first position to a transfer position, and transfer means for moving said individual disc from said transfer position to said collection chamber and then to said measuring station, from where said conveying means returns said individual disc to said magazine.

12. The apparatus of claim **11** in which said conveying means is movable to a third position whereby a contaminated disc may be discharged or a fresh disc inserted and moved to said transfer position without being positioned at said first position.

13. The apparatus of claim **12** in which said third position is outside the apparatus.

14. The apparatus of claim **7** in which said detector means comprises: two identical circular semiconductors each having a surface area at least equal to that of one of said discs.

* * * * *

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,784,823 Dated January 8, 1974

Inventor(s) Svetislav Kostic and Roger Le Meur

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

At column 2, line 17, "matallized" should be --metallized--;

At column 4, line 60, "foreqoing" should be --foregoing--; and

At column 6, line 39 (Claim 14, line 1), "claim 7" should be --claim 6--.

Signed and sealed this 23rd day of April 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,784,823 Dated January 8, 1974

Inventor(s) Svetislav Kostic and Roger Le Meur

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

At column 2, line 17, "matallized" should be --metallized--;

At column 4, line 60, "foreqoing" should be --foregoing--; and

At column 6, line 39 (Claim 14, line 1), "claim 7" should be --claim 6--.

Signed and sealed this 23rd day of April 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents