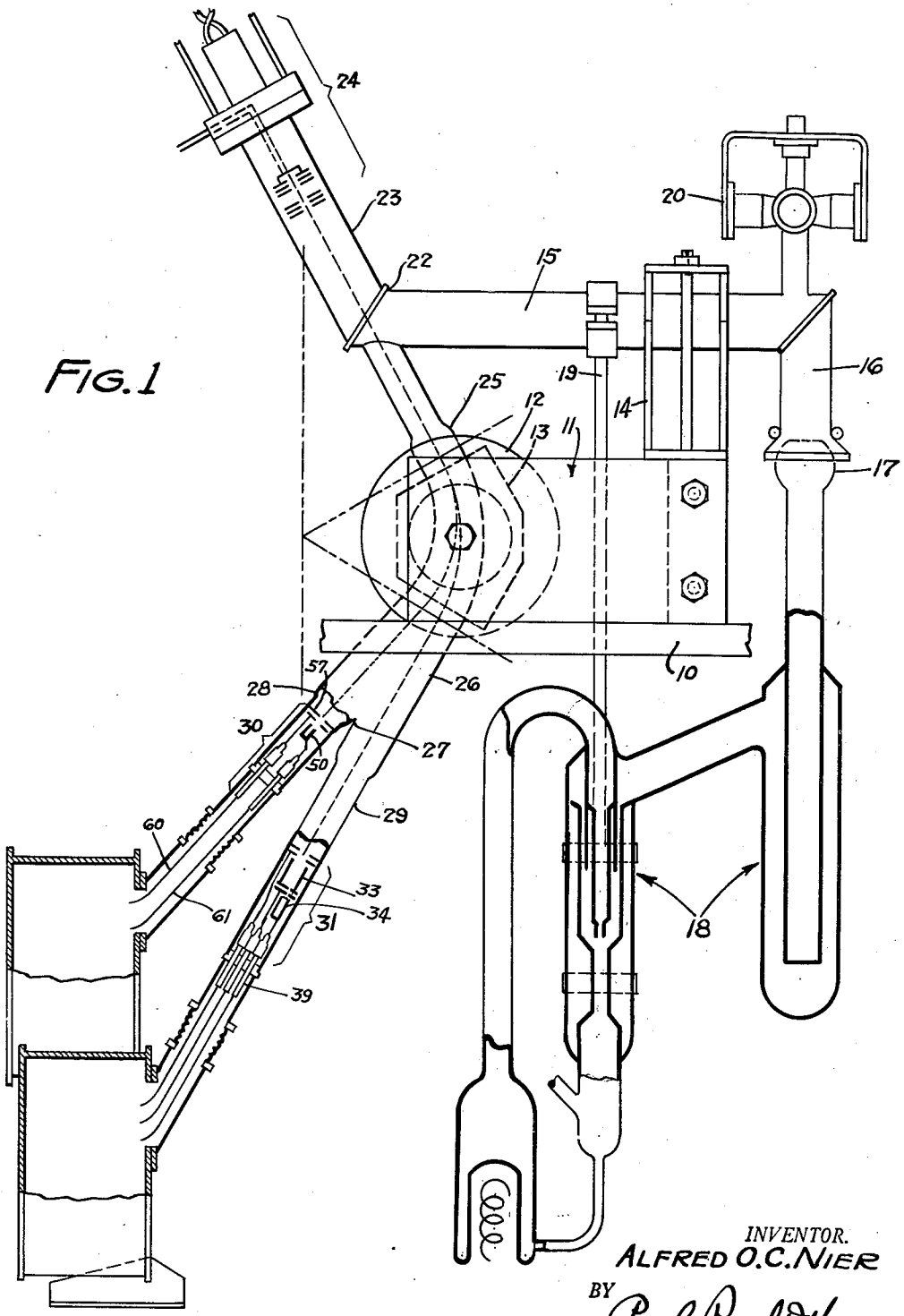
March 13, 1951 A. O. C. NIER 2,544,718

ION COLLECTOR FOR MASS SPECTROMETERS

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FIG. 1



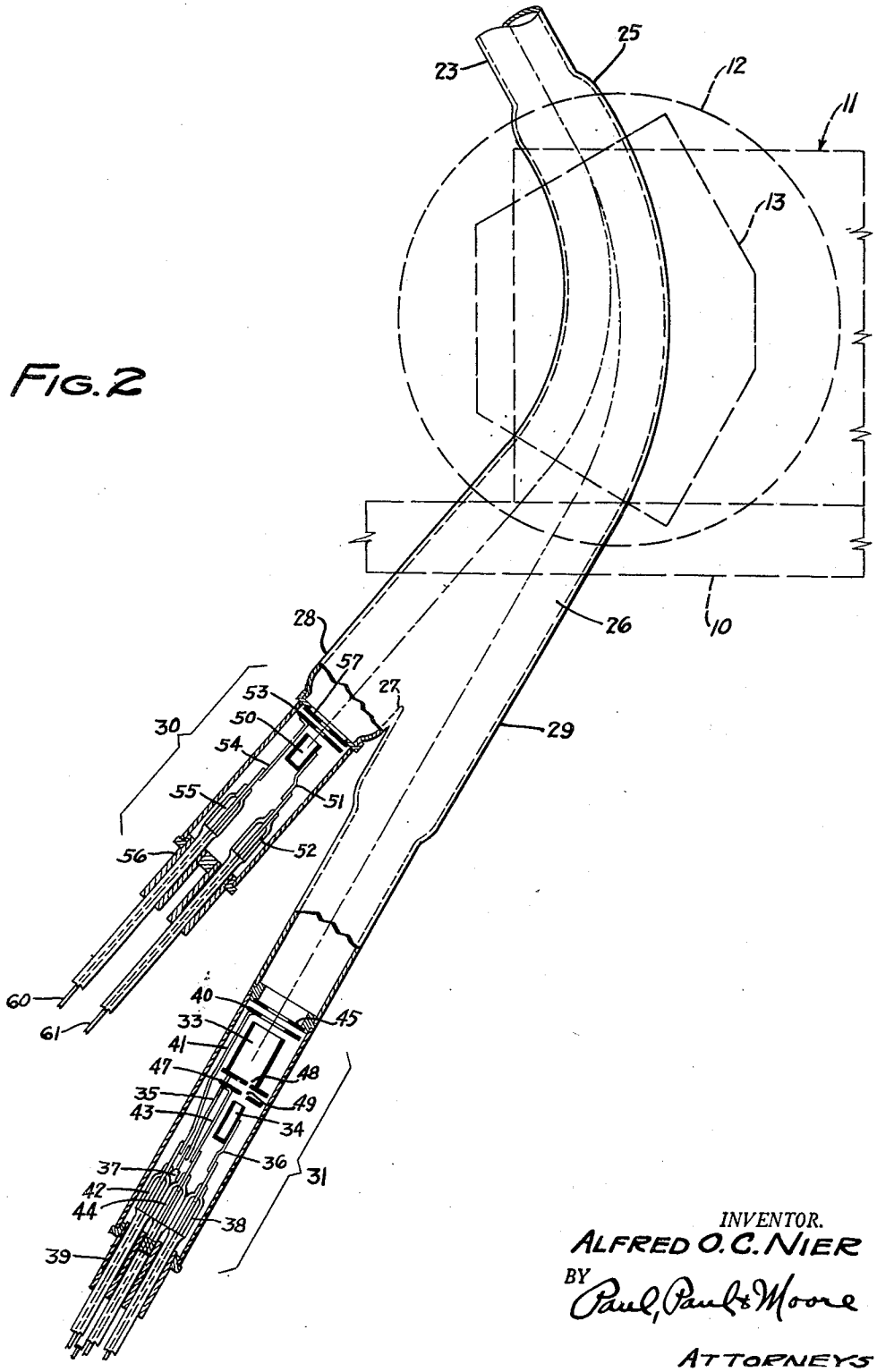
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FIG. 2



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ION COLLECTOR FOR MASS SPECTROMETERS

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Application July 30, 1948, Serial No. 41,493

3 Claims. (Cl. 250—41.9)

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This invention relates to mass spectrometers and particularly to improvements in ion collectors for mass spectrometers. Heretofore, in the operation of mass spectrometers it has been customary to provide an evacuated vessel having ion generating and beaming electrodes therein for generating a stream or beam of ions. The beam of ions is carried through the magnetic field of a deflecting magnet which causes the beam to be deflected, depending upon the mass of the ions. The ion beam passing out of the field then moves along a straight course determined by the degree of deflection and consequent course of travel of the beam of ions as they leave the field. The slightly varying mass of ions causes them to be deflected to varying degrees, and they are thus separated into slightly divergent paths after passing through the magnetic field. It has heretofore been the practice to collect said ions separately by causing the beam to impinge upon separated collecting surfaces of a duplex collecting electrode. The electrode has been provided with an aperture so that ions which are deflected a certain amount will fall through the aperture and then impinge upon another collection plate placed behind said aperture.

It has been found that difficulty is experienced in the operation of such mass spectrometers, due to the fact that after the spectrometer has been operated for some time the ions collected upon the electrodes do not wish to stay there and apparently build up some type of reluctance which causes other ions moving toward the electrode to be more readily dispersed therefrom, or to cause the ions to bounce off the electrode and be lost. The exact cause is not known, but it is known that the calibration of a spectrometer drifts during use.

It is an object of the invention to provide an improved mass spectrometer ion collector in which the ions may be collected in great number and for long periods of time without difficulty. It is also an object of the invention to provide an improved mass spectrometer collection electrode of cup or chimney shaped character wherein the ions are collected. It is likewise an object of the invention to provide an ion collecting electrode having a plurality of separated cup or chimney shaped ion collecting portions positioned slightly out of alignment and with the lower portion under a hole in the upper portion for separately collecting ions which are deflected to slightly different amounts by the magnetic field.

Other and further objects of the invention are those inherent in the apparatus herein illustrated, described and claimed.

The invention is illustrated with reference to the drawings in which

Figure 1 is a side elevational view, partly in section, of a mass spectrometer having ion collection electrodes in accordance with the apparatus of the present invention;

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Figure 2 is an enlarged view, partly in section of the electrode portion of the mass spectrometer of Figure 1, illustrating two types of electrodes made in accordance with the principles of the present invention.

Throughout the drawings corresponding numerals refer to the same parts.

The ion collectors of the present invention may be used in any type of mass spectrometers, but are illustrated herein as a part of a mass spectrometer which is novel in other respects, and forms the subject matter of my application entitled "Differential Collector Systems for Mass Spectrometers," Serial No. 41,687 filed of even date herewith, now abandoned. The particular mass spectrometer illustrated is, therefore, merely a respresentative environment in which the ion collectors of the present invention are illustrated.

Referring to the drawings the frame of the mass spectrometer is illustrated at 10 and serves to support the heavy magnet generally designated 11 which may be a permanent magnet or an electromagnet having magnet coils 12 and pole faces, as shown by the dotted line 13. From the frame of the electromagnet there is an upwardly extending bracket 14 which serves to support the cross tube 15 of the mass spectrometer evacuated vessel. The cross tube 15 is connected at its right end to the angle fitting 16 of the ball joint fitting 17 to which the upper end of the vacuum pump generally designated 18 is attached. From the tube 15 a brace rod 19 extends down between the pole magnetic circuit of the electromagnet 11 and is attached to and helps support the vacuum pump 18 which therefore hangs as a unit from the spectrometer tube and moves with it when the tube is adjusted with reference to magnet 11. This type of spectrometer tube and vacuum pump mounting is described and is claimed in my copending application Serial No. 783,434, filed October 31, 1947, to which reference is here made.

At 20 there is provided a Phillips gauge for determining the pressure within the evacuated vessel. The mass spectrometer tube proper is carried at the left end of the tube portion 15 which is connected at the junction 22 to the straight portion 23 of the mass spectrometer tube. The straight portion 23 of the mass spectrometer tube includes ion forming and beaming electrodes shown generally opposite the bracket 24 which are preferably constructed in accordance with my copending application Serial No. 783,433, filed October 31, 1947, now Patent No. 2,490,278, to which reference is here made, although any other suitable ion forming and beaming electrodes may be utilized as desired.

The straight portion 23 of the mass spectrometer tube extends downwardly and it is joined in the illustrated embodiment of the invention to a curved portion 25 of the mass spectrometer tube.

In the illustration the mass spectrometer tube is of the type having a branch portion 28 and a main portion 29, which forms the subject of my copending application entitled "Differential Collector Systems for Mass Spectrometers," heretofore referred to, but it is to be understood that the ion collection electrode of the present invention may be utilized in any mass spectrometer tube, regardless of whether it is the ordinary variety having only a main portion of the tube or of the type as illustrated herein having the main and branched portions of the tube.

After leaving the curved portion 25 of the tube the tube widens at 26 into the branched portion 28 and main portion 29 which separate from each other at the portion 27. Similar types of ion collecting electrodes are illustrated at 30 and 31 and are illustrated in detail in the enlarged views shown in Figure 2.

The main ion collecting tube is equipped with a duplex type ion collector shown opposite the bracket 31, which consists of a pair of ion collecting cups or chimneys 33 and 34 which are supported by posts 35 and 36, respectively, and connected through appropriate glass squash seals 37 and 38 to lead wires passing through the terminal head 39. Above the cup or chimney 33 there is an electrode 40 which is supported by the post 41 from squash 42 and between the bottom of the cup 33 and the top of the cup 34 there is another electrode 47 which is supported by the post 34 from the squash 44. Above the electrode 40 is an apertured electrode 45 supported from the side walls of the tube 29. Each of the electrodes 45 and 40 is apertured so that the beam of ions passing along the axis of the main branch 29 enters into the bore of cup or chimney 33, the open end of which is directed toward the oncoming stream of ions so as to collect the ions when they enter the cup or chimney 33. The cup 33 has a bottom which is apertured at 48 and through which ions of slightly different mass are adapted to pass. These ions fall through the aperture 49 of the plate 47 and thence fall into the cup or chimney 34 and are collected therein. It will be noted that cup or chimney 34 is entirely closed across the bottom.

Similarly, the ion collector 30 on the auxiliary or branch tube 28 is cup shaped, as illustrated at 50, and is supported by an appropriate post 51 from the squash 52. Above the cup 50 is an apertured plate 53 which is supported by the post 54 from the squash 55. The plate 53 and cup 50 are connected through two lead wires 60 and 61 through the connector terminal 56. Above the plate 53 is another plate 57 which is connected to the side wall of the tube 28. Both of the plates 57 and 53 are centrally apertured and the apertures are aligned so that ions falling down the axis of branch tube 28 will pass through the apertures in plates 57 and 53 and thence into the open end of cup 50 which is likewise directed so that its open end is toward the oncoming ions.

It has been found that the cups or chimneys 33, 34 and 50 assist greatly in reducing the electric field in the position where the ions hit and hence prevent any reflected ions from being drawn upwardly and out of the cup. Moreover, the cup or chimney shape subtends a very small solid angle. Hence, only a small proportion of any ions reflected actually leave through the opening but are instead caught upon the side walls of the cup or chimney, however designated, and serve to place their charge upon that element.

In this way difficulty previously experienced in operation of mass spectrometer tubes due to the drifting of the reading or due to the reluctance of ions to accumulate upon the collection electrodes has been completely overcome.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that I do not limit myself to the specific embodiments herein.

What I claim is:

1. In an isotope mass spectrometer having an evacuatable vessel presenting an ion path, means in said vessel for projecting a beam of ions along said path and magnetic means for deflecting the ions in said beam, the improvement comprising a plurality of electrodes for collecting ions after they are deflected, said electrodes comprising a plurality of open ended cups arranged so that the open ends of the cups are directed oppositely to the path of movement of the deflected ions, said cups being arranged so that their axes are slightly displaced and one of them displaced farther along the path of movement of the ions than is the other the cup electrode most remote from the source of said ion beam being provided with a closed bottom and the cup electrodes intermediate said remote cup electrode and said ion beam source each having a bottom provided with an aperture, each of said apertures being aligned with the open end of the cup electrode immediately disposed to the rear thereof and separate circuits to each cup.

2. In an isotope mass spectrometer having an evacuatable vessel presenting an ion path, means in said vessel for projecting a beam of ions along said path and magnetic means for deflecting the ions in said beam, the improvement comprising a plurality of plates positioned in overlying relation across the path of movement of the deflected ions, the plate most remote with respect to the oncoming stream of ions being continuous and the plates intermediate said remote plate and the oncoming stream of ions being provided with apertures for the passage of certain ions therethrough and a cylinder fastened to one of said intermediate plates around the aperture of said plate provided therein and forming with said plate a cup for trapping and collecting ions entering said cup, and circuit connections to said plates including that one forming the cup.

3. The apparatus of claim 2 further characterized in that at least two of said plates are provided with cylinders attached thereto and forming with said plates cups which have open ends directed toward the deflected ion stream, one of said cups being displaced axially in respect to the other and positioned beneath a hole in the bottom of the other cup.

ALFRED O. C. NIER.

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