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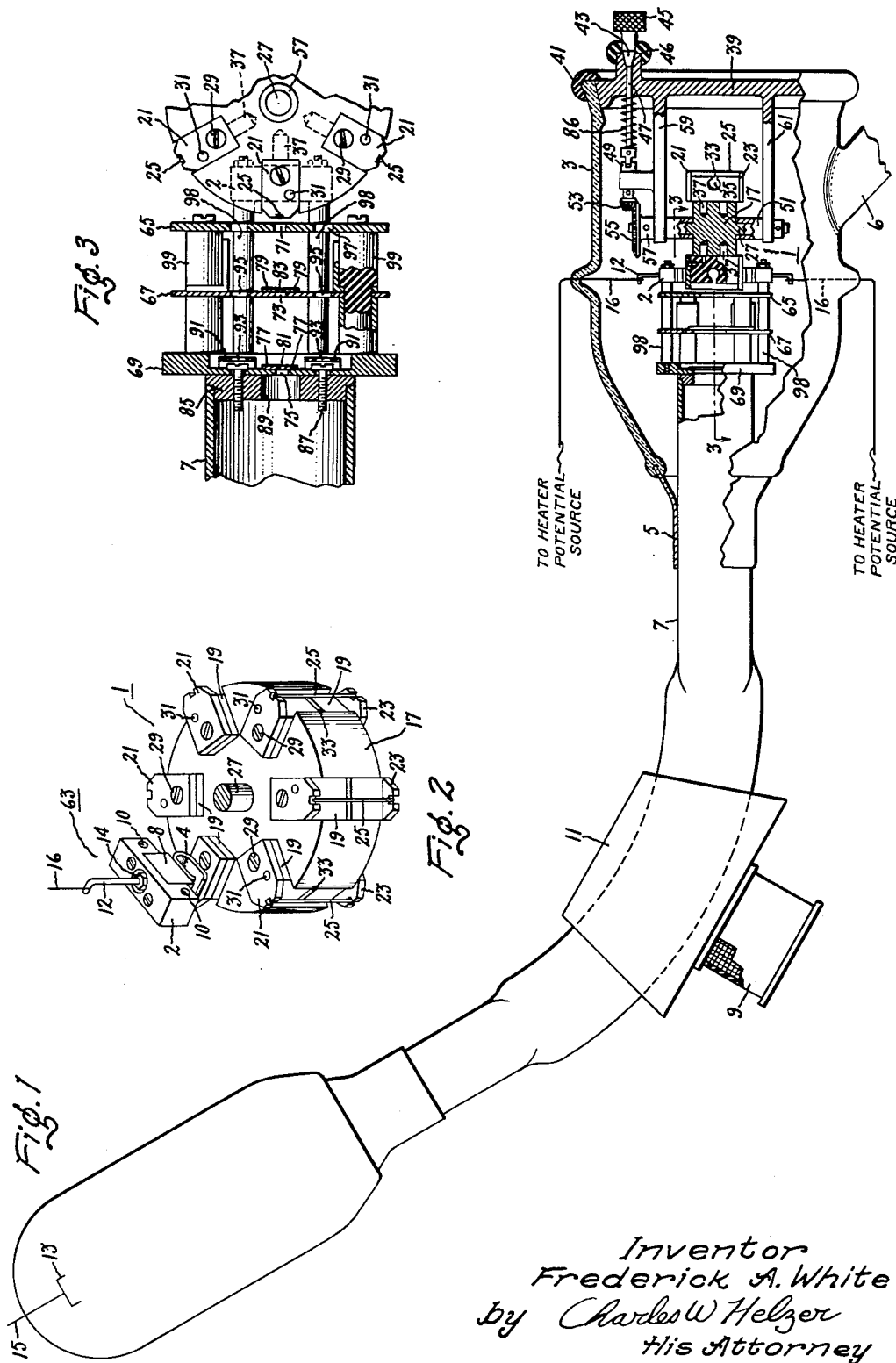
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MULTIPLE CARTRIDGE SOURCE FOR MASS SPECTROMETER

Filed Feb. 15, 1954

2 Sheets-Sheet 1



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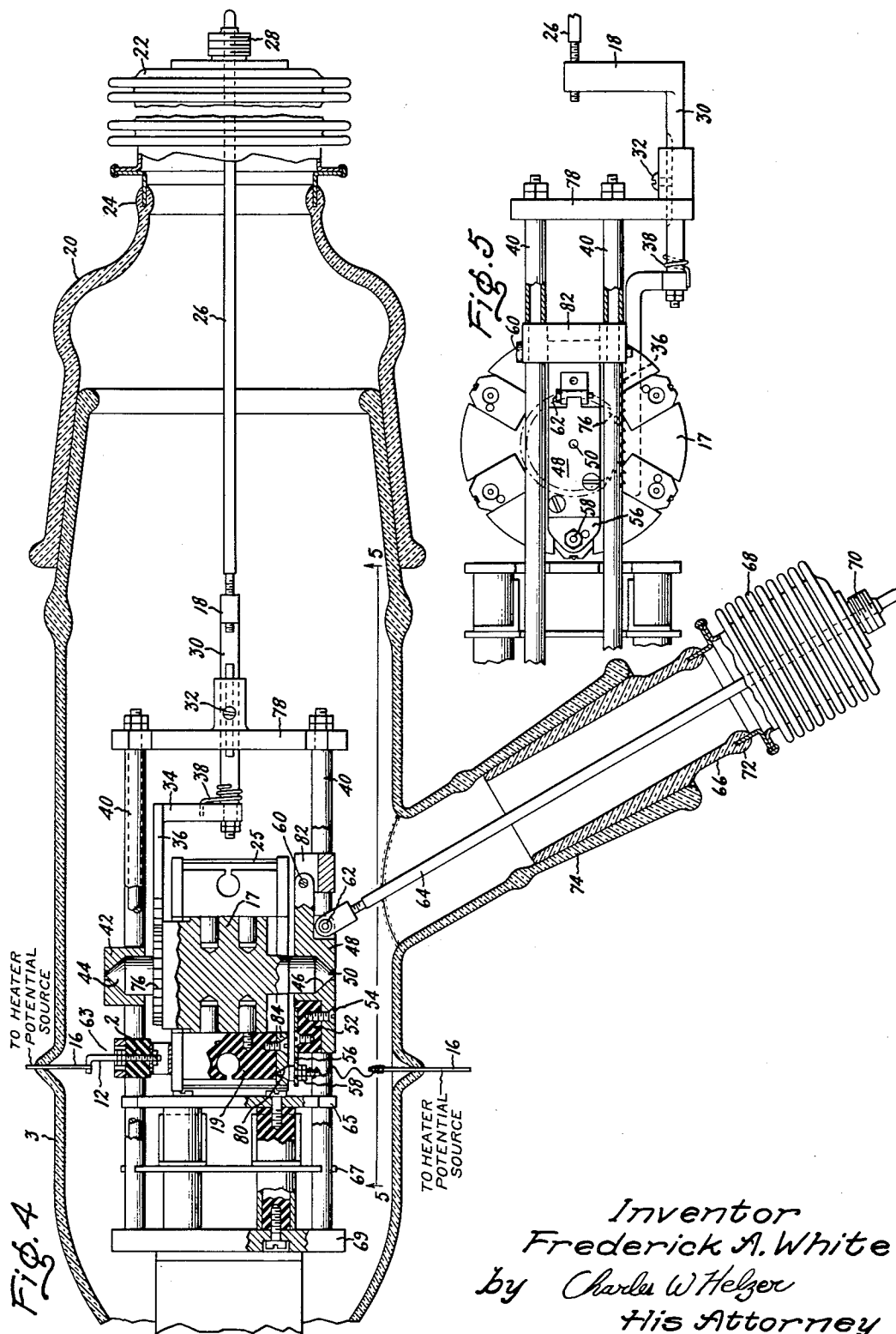
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MULTIPLE CARTRIDGE SOURCE FOR MASS SPECTROMETER

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19 Claims. (Cl. 250—41.9)

The present invention relates to mass spectrometers utilizing thermionic ion sources and particularly to a multiple cartridge source for such spectrometers.

In mass spectrometer procedures, a sample to be analyzed is ionized, the ions are segregated in accordance with their mass-to-charge ratio by inducing the spatial separation thereof, and the ions of a given mass-to-charge ratio are selectively discharged at a collector electrode. In determining isotope abundance ratios of uranium and other heavy metals, it is necessary to employ positive ions within the spectrometer. This has been achieved by utilizing a thermionic ion source wherein the compound under test was coated onto a heated element; however, such a thermionic ion source burns out in a relatively short interval of time, necessitating the opening of the spectrometer and the replacement of the source. Several hours of operating time are therefore lost due to the opening of the evacuated spectrometer, the welding of another heating element into place, the resealing of the instrument, and the evacuation process. The foregoing procedure must also take place when it is desired to substitute a different type of ion source. This procedure, in addition to delaying the production schedule, also utilizes for a considerable length of time the services of a highly skilled technician.

The principal object of the present invention is to provide an improved thermionic ion source for a mass spectrometer, which source can be changed with facility and dispatch.

A further object of this invention is to provide a multiple cartridge ion source which can be readily switched into position and having elements which can be easily replaced when necessary.

A still further object of the present invention is to provide a multiple ion source in which different types of filament samples can be tested, as desired, without any necessity for opening the mass spectrometer.

As will hereinafter appear, these objects of the present invention are accomplished by providing a thermionic ion source of novel design in a mass spectrometer. This thermionic ion source comprises a rotatable wheel around the circumference of which cartridges are removably plugged in, said cartridges bearing the coated filaments which will emit positive ions upon being heated. Various novel means are also provided for rotating the wheel so as to align any desired filament with slots in accelerating and focusing electrodes of a mass spectrometer.

For a better understanding of the invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings, like parts being indicated by like reference numerals, wherein:

Fig. 1 is a sectional view, partly in elevation, of a mass spectrometer embodying the features of the invention;

Fig. 2 is an enlarged perspective view of the multiple cartridge thermionic ion source of the invention and of a contact for applying a heater potential thereto;

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Fig. 3 is a sectional view, partly in elevation, taken along line 3—3 of Fig. 1;

Fig. 4 is a sectional view, partly in elevation, of an embodiment of the invention using a different means for rotating the multiple cartridge ion source than the one shown in Fig. 1; and

Fig. 5 is a view in elevation taken along line 5—5 of Fig. 4.

The mass spectrometer illustrated in Fig. 1 includes a multiple thermionic ion source assembly 1 enclosed within a glass envelope 3. The glass envelope 3 is bonded to a metal tube 5 by means of a suitable glass-to-metal seal, various types of which are well-known to the art, and tube 5 is in turn brazed to a metallic plate support 7 of a mass spectrometer. About the middle of the spectrometer, there are disposed pole pieces 11 of a magnetic field producing structure, indicated diagrammatically at 9, the spectrometer being curved in the vicinity of these pole pieces in order to conform to the curvature produced in the ion beam by the magnetic field. A suitable ion collector 13, which includes electrical connections 15 is diagrammatically shown in the end of the spectrometer remote from the ion source, by means of which the ion beam may be monitored and its intensity varied, and a pumping duct 6 is also provided, so that the spectrometer may be evacuated.

The multiple thermionic ion source assembly 1 is shown in perspective in Fig. 2. Referring now to this figure, there is shown a wheel 17, which wheel may be made of Duralumin, and around the circumference of wheel 17 are disposed six equally spaced cartridges which comprise blocks 19. Blocks 19 may be made of an insulating material such as Lavite. Mounted on the tops of blocks 19 are plates 21, while plates 23 are mounted on the bottoms of blocks 19, which plates may be made of an electrically conductive material such as molybdenum. A shaft 27 passes through the center of wheel 17 along the axis thereof. Coated filaments 25 are spot-welded between end plates 21 and 23 in grooves provided therein for this purpose, filaments 25 being parallel to the axis of the wheel 17. The assembled cartridges, comprising block 19, plates 21 and 23, and filaments 25, are removably plugged into wheel 17 by means of banana plugs 37, which plugs are shown most clearly in Figs. 1 and 3. The plates 21 and 23 are held upon blocks 19 by screws 29, dowel rods 31 being used to correctly position them, and each block 19 has a slot 33 therein, perpendicular to the filament adjacent thereto. These slots 33 open into holes 35 (see Fig. 1), which holes are also perpendicular to the axis of the filament associated therewith. The slot and hole arrangement, 33 and 35, is used to prevent the filament from being shorted out by a conductive film of sputtered metal sprayed across the face of block 19 when filaments 25 are heated.

Referring again to Fig. 1, it will be seen that glass envelope 3 has its end closed by a metal plate 39, the closing being vacuum-tight due to a glass-to-metal seal 41, a type of seal which is well-known to the art. Passing through a projection of wall 39 is a shaft 47, one end of which shaft is terminated by a tapered element 43 having a knurled knob 45 attached thereto and being seated within a tapered hole in the aforementioned projection of wall 39. A flexible seal 46, of a type that is well-known to the art, maintains the vacuum of the assembly at the point where one end of shaft 47 passes through wall 39, the other end of shaft 47 terminating in a clutch 49 leading to a bevel gear 53. A bevel gear 55 is in mesh with gear 53 and is mounted upon a sleeve 57, which sleeve surrounds shaft 27 of the wheel 17, but permits rotation of the wheel, and a sleeve 51 supports and surrounds the bottom portion of shaft 27 while also permitting rotation of wheel 17. Sleeves 51 and 57, as

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well as gear 53, are rotatably supported by projections 59 and 61 which form a part of wall 39. A spring 86 surrounds shaft 47 and maintains tapered element 43 tightly within wall 39; and, since clutch 49 has male and female portions, spring 86 also serves to engage these portions.

Referring now to Fig. 3, which is a view taken along line 3—3 of Fig. 1, there are shown three focusing and accelerating electrode plates 65, 67 and 69. These plates have slits 71, 73 and 75, respectively, therein, slits 73 and 75 being respectively limited by plates 79 and 77, which plates serve as beam centering electrodes, said plates, respectively, forming slits 83 and 81. All of the foregoing slits are lined up, as shown in this figure, with one of the heating filaments 25 mounted on one of the cartridges 19. Terminating one end of metallic plate support 7 is a wall 85 having a slit 89 therein which is lined up with the remaining slits. Plate 69 is screwed onto wall 85 by means of screws 87, and these screws are covered by plates 91 having holes 93 therein. Plates 67 and 65, respectively, have holes 95 and 97 therein, holes 93, 95 and 97 providing means whereby screws 87 may be tightened during the process of assembling plates 65, 67 and 69. Insulating spacers 99 are used to support and space the various plates 65, 67, and 69, from one another.

Referring again to Fig. 2, there is shown on top of one of the plates 21 a contact assembly 63 for applying heater potential to the filament aligned with the slits in plates 65, 67 and 69. Assembly 63 includes an element 2 made of metal and enclosing an insulator block 8, and a conductive U-shaped leaf spring 4 fastened to insulator 8 by means of an electrically conductive screw 14, which screw does not touch element 2. Attached to screw 14 is an electrically conductive rod 12 to which is attached a lead 16 going to the source of heater potential (not shown). A similar assembly 63 (not shown) as that described above is also disposed upon bottom plate 23 of the same filament upon which the top assembly is resting. Holes 10 are in element 2, and two pairs of rods 98 (see Figs. 1 and 3) are provided, two rods for each of the two contact assemblies 63, each pair of rods serving to hold its corresponding contact element firmly in position, the rods being supported by and threaded into plate 69 and element 2. Rods 98 pass through but do not touch plates 65 and 67. It should be noted that contact assemblies 63 are aligned with the ion stream passing through the slits in plates 65, 67 and 69.

In operation, knurled knob 45 is turned by hand, causing bevel gear 55 to rotate and turn wheel 17, until the desired one of the six filaments 25 is aligned with the slits in plates 65, 67 and 69. Only the aligned filament is heated by heater contact assemblies 63. If it is desired to change the sample being ionized, either because the first sample has burned out or else because it is desired to substitute a different type of sample, knob 45 is merely rotated until the next sample is aligned with the aforementioned slits. When the spectrometer must be opened to replace the six samples, the plug in feature of the cartridges upon which the samples are mounted results in a considerable saving in time and labor.

Referring now to Fig. 4, there is shown another apparatus for rotating the multiple thermionic ion source of the invention, and for locking it in position. In this figure, the glass envelope 3 is tapered and has its end terminated by a tapered glass envelope 20, the tapers insuring that envelopes 3 and 20 will form a vacuum-tight joint and also facilitating disassembly, although these elements could be sealed together. Envelope 20 is terminated by a metallic bellows 22 at joint 24, and passing through the bellows 22 is a shaft 26 having a knurled knob 28 threaded thereon immediately adjacent to the bellows. Shaft 26 is threaded into a connecting element 18, which in turn is connected to a shaft 30, which shaft has a keyway therein into which a screw 32 fits and prevents any rota-

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tional motion but permits longitudinal motion. Shaft 30 is attached to a ratchet rack element 36 by means of a shaft 34; and, as will be seen more clearly from Fig. 5, ratchet rack element 36 is meshed with ratchet pinion 76. Referring again to Fig. 4, it will be seen that ratchet pinion 76 is attached to a shaft 44 passing through the center of wheel 17, which wheel carries the filament-bearing cartridges previously discussed. Four spacer and insulating members 40 are provided, two of which support the top brush assembly 63 and also bear a tapered housing 42 which encloses but permits rotation of tapered shaft 44, all of the members 40 being screwed into plate 69. All of the members 40 screw into and support a plate 78, which plate serves to support shaft 30 and screw 32. A spring 38 is provided and is attached to shafts 30 and 34, which spring serves to maintain the ratchet rack and pinion in close contact; however, it permits the two elements to be ratcheted together when the shaft 30 is inserted during assembly. This spring permits free motion of shaft 30 in one direction only, the gear teeth preventing any motion in the opposite direction.

Also attached to the bottom pair of spacers and insulators 40 is an element 82 having a pivoted connection 60 to which is connected an element 48. Element 48 has a tapered hole 46 therein for receiving the bottom portion of shaft 50, which shaft forms a part of and passes through the center of wheel 17. Element 48 has an insulator element 52 attached thereto by screw 54, to which insulator element is attached a plate 56 bearing a contact element 58. Contact element 58 is tapered and fits into a tapered hole 80 in the bottom plate 84 of the cartridge 19 aligned with the slots in plates 65, 67 and 69, all of the cartridges having similar plates. Attached to element 48 by means of a pivot joint 62 is a shaft 64 passing through a glass envelope 74, which envelope forms a continuation of envelope 3 and has one end tapered to fit around the tapered end of a glass envelope 66 and form a vacuum-tight connection. This connection may also be sealed if it is so desired. The end of envelope 66 is terminated by a metallic bellows 68 which is sealed thereto at 72. The end of shaft 64 has a knurled knob 70 threaded thereon.

In operation, knurled knob 28 is turned compressing or expanding bellows 22 and thus permitting longitudinal movement of shaft 26. This movement of shaft 26 causes ratchet rack 36 to move ratchet pinion 76 and turn the wheel 17. When one of the filaments is aligned with slots in plates 65, 67 and 69, knurled knob 70 is rotated to cause longitudinal movement of shaft 64, which movement is permitted by bellows 68. By forcing element 48 up toward the wheel by means of shaft 64, the tapered hole 46 in element 48 is firmly pressed about the tapered end of shaft 50; and simultaneously, tapered contact 58 is pressed into the tapered hole 80 within bottom plates 84 of the aligned cartridge 19, thus insuring a firm electrical contact.

While there have been described what are presently considered preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention; and it is aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a mass spectrometer including means for focusing and directing ions, a multiple thermionic ion source comprising a rotatable wheel, a plurality of cartridges disposed around the circumference of said wheel, an equal plurality of specimen filaments each being mounted upon a respective one of said cartridges for emitting ions of the desired character when heated, means for rotating said wheel to bring any one of said filaments into alignment with said means for focusing and directing ions, and

means for applying a heater potential to the filament so aligned.

2. The multiple thermionic ion source of claim 1, wherein each of said cartridges has at least one plug thereon and said rotatable wheel has a plurality of holes disposed around its circumference and said cartridges are removably plugged into respective holes in said wheel.

3. The multiple thermionic ion source of claim 1, wherein each of said cartridges includes means for preventing the filament thereon from being shorted out due to the sputtering of the filament when heated.

4. In a mass spectrometer including slotted focusing electrode means for focusing and directing ions, a multiple thermionic ion source comprising a rotatable wheel, a plurality of cartridges insulated from said wheel and disposed around the circumference of said wheel, an equal plurality of specimen filaments each being mounted upon a respective one of said cartridges parallel to the axis of said wheel for emitting ions of the desired character when heated, the slots in said slotted focusing electrode means being parallel to the axis of said wheel, means for rotating said wheel to bring any one of said filaments into alignment with the slots in said slotted focusing electrode means, and means for applying a heater potential to the filament so aligned.

5. The multiple thermionic ion source of claim 4, wherein each of said cartridges has at least one plug thereon and said rotatable wheel has a plurality of holes disposed around its circumference and said cartridges are removably plugged into respective holes in said wheel.

6. The multiple thermionic ion source of claim 5, wherein each of said cartridges has a hole bored therein perpendicular to the axis of its respective filament and also has a slot therein communicating with said hole and opening into the side of the cartridge facing the filament, the slot in each of said cartridges being perpendicular to the axis of the filament.

7. In a mass spectrometer including slotted electrode means for focusing and directing ions, a multiple thermionic ion source comprising a rotatable wheel, a plurality of insulator blocks removably plugged into said wheel around its circumference, an equal plurality of pairs of electrically conductive plates, each pair of plates being mounted upon a respective one of said insulator blocks, one plate on bottom and the other on top of the block, an equal plurality of specimen filaments each being bonded to and disposed between a respective pair of said pairs of plates parallel to the axis of said wheel and each being spaced from a side of its corresponding block for emitting ions of the desired character when heated, each of said insulator blocks having a hole bored therein perpendicular to the axis of the filament thereon and also having a slot therein communicating with said hole and opening into the side of the block facing the filament, said slot being perpendicular to the axis of the filament, the slots in said slotted electrode means being parallel to the axis of said wheel, means for rotating said wheel so as to bring any one of said filaments into alignment with the slots in said slotted electrode means, and a pair of contact means respectively touching the top and bottom plates of each filament so aligned for applying a heater potential thereto.

8. The multiple thermionic ion source of claim 7, wherein said means for rotating said wheel comprises a pair of meshed gears, one of which is attached to a shaft passing through the axis of said wheel and the other of which is adapted to be rotated from outside of said mass spectrometer.

9. The multiple thermionic ion source of claim 8, further including means for locking the wheel at any desired position.

10. The multiple thermionic ion source of claim 7, wherein said means for rotating said wheel comprises a

meshed rack and pinion, the pinion being attached to a shaft passing through the center of said wheel and the rack being attached to a shaft which passes outside of said mass spectrometer through a vacuum-tight bellows to which it is attached so that movement of said bellows will rotate said wheel.

11. The multiple thermionic ion source of claim 10, further including a locking plate pivotally mounted within said mass spectrometer and having a tapered hole therein, the bottom end of the shaft passing through the axis of said wheel being tapered and fitting within the hole in said locking plate, the bottom one of said pair of contact means being insulated from and supported by said locking plate and comprising a tapered contact piece, each bottom plate attached to each of said filaments having a tapered hole therein for receiving said tapered contact piece, and shaft means passing outside of said mass spectrometer through a bellows to which it is attached for pivoting said locking plate upon movement of said bellows so as to lock said wheel in position by forcing said tapered hole of said locking plate firmly about the tapered end of the shaft of said wheel while forcing said tapered contact piece into firm contact with the hole in the bottom plate of the aligned filament.

12. A multiple thermionic ion source comprising a rotatable wheel, a plurality of cartridges disposed around the circumference of said wheel, and an equal plurality of specimen filaments each being mounted upon a respective one of said cartridges for emitting ions of the desired character when heated.

13. The multiple thermionic ion source of claim 12, further including means for rotating said wheel.

14. The multiple thermionic ion source of claim 12, wherein each of said cartridges includes means for preventing the filament thereon from being shorted out due to the sputtering of the filament when heated.

15. The multiple thermionic ion source of claim 12, wherein each of said cartridges has at least one plug thereon and said rotatable wheel has a plurality of holes disposed around its circumference and said cartridges are removably plugged into respective holes in said wheel.

16. The multiple thermionic ion source of claim 15, wherein said filaments are disposed parallel to the axis of said wheel, and wherein each of said cartridges has a hole bored therein perpendicular to the axis of the filament thereon and also has a slot therein communicating with said hole and opening into the side of the cartridge facing the filament, the slot in the cartridge being perpendicular to the axis of the filament thereon.

17. A multiple thermionic ion source comprising a rotatable wheel, a plurality of insulator blocks removably plugged into said wheel around its circumference, an equal plurality of pairs of electrically conductive plates, each pair of plates being mounted upon a respective one of said insulator blocks, one plate on bottom and the other on top of the block, and an equal plurality of specimen filaments each being bonded to and disposed between a respective pair of said pairs of plates parallel to the axis of said wheel and each being spaced from a side of its corresponding block for emitting ions of the desired character when heated, each of said insulator blocks having a hole bored therein perpendicular to the axis of the filament thereon and also having a slot therein communicating with said hole and opening into the side of the block facing the filament, said slot being perpendicular to the axis of the filament.

18. The multiple thermionic ion source of claim 17, further including means for rotating said wheel.

19. The multiple thermionic ion source of claim 18, further including means for locking said wheel at any desired position.