Aug. 30, 1960 R. L. KINDRED 2,951,155

MASS SPECTROMETER

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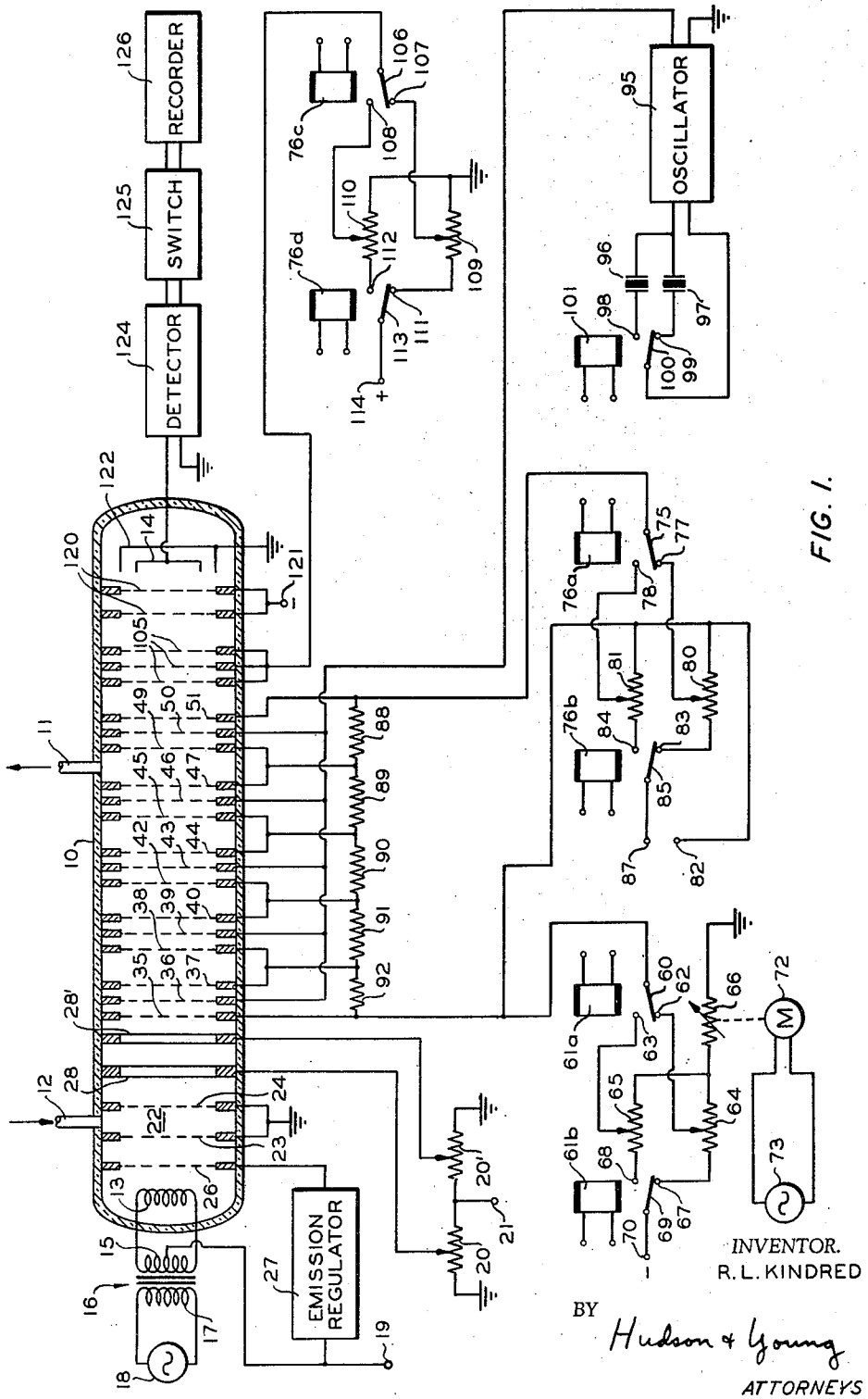


FIG. 1.

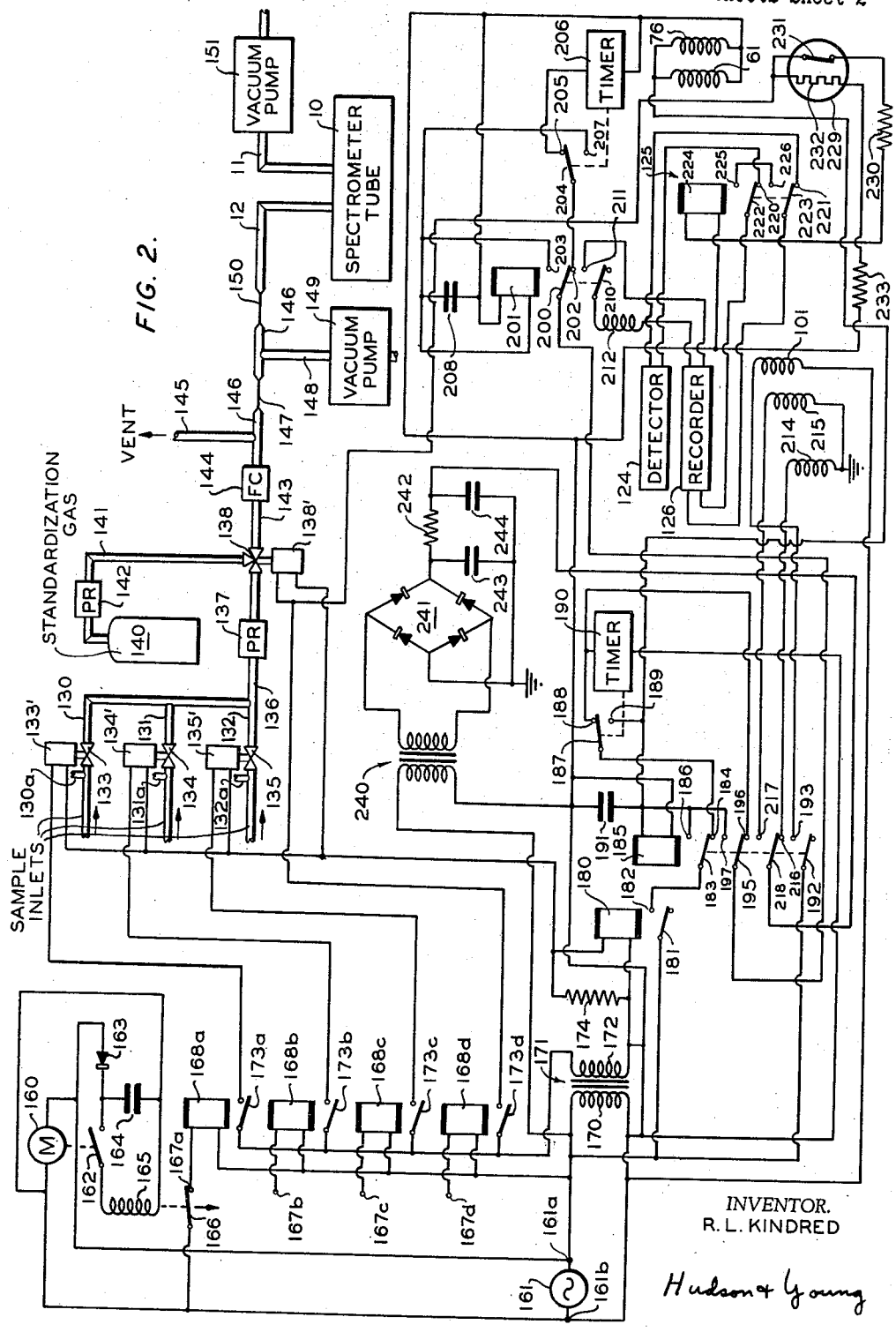
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MASS SPECTROMETER

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2 Sheets-Sheet 2

FIG. 2.



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MASS SPECTROMETER

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7 Claims. (Cl. 250—41.9)

This invention relates to a mass spectrometer which is adapted to measure a plurality of constituents of a sample mixture.

In recent years mass spectrometers have been developed from highly specialized academic research instruments for measuring the relative abundance of isotopes into analytical tools of extreme sensitivity and accuracy. At the present time, applications are being found for the use of mass spectrometers in process monitoring and control. Mass spectrometry comprises, in general, ionizing a sample of material under investigation and separating the resulting ions according to their masses to determine the relative abundance of ions of selected masses. The material to be analyzed usually is provided as a gas, which is bombarded by a stream of electrons to produce the desired ions. Although both positive and negative ions may be formed by such electrical bombardment, most mass spectrometers make use of only the positive ions. These positive ions are accelerated out of the region of the electron beam by means of negative potentials. Such potentials impart equal kinetic energies to ions having like charges such that ions of different masses have different velocities after passing through the electrical field and, consequently, have different momenta.

The presently known mass spectrometers can be classified in one of two general groups: the momentum selection types and the velocity or energy selection types. The momentum selection instruments sort the ions into beams of different masses by the use of magnetic and/or electrical deflecting fields. Ions of selected masses are allowed to impinge upon a collector plate to which is connected an indicating circuit. The velocity or energy selection instruments sort the ions according to the velocities or energies imparted to ions of selected masses by electrical accelerating fields. The present invention is particularly adapted to be employed with a mass spectrometer of the latter type, although it is not limited thereto.

In accordance with this invention, a sample system is provided to direct a plurality of fluid streams to be analyzed into the mass spectrometer tube in sequence. Means also are provided for introducing a standardization gas into the tube periodically to check the operation of the mass spectrometer itself. The flows of the several streams into the spectrometer tube are controlled automatically by a timing circuit. During the time that any given sample stream is flowing into the spectrometer, the operating potentials applied to the spectrometer tube are adjusted in sequence so that the tube is focused to detect the individual constituents of the fluid mixture to be analyzed. Means also are provided to adjust the accelerating potential so as to scan each of the mass peaks.

Accordingly, it is an object of this invention to provide an improved mass spectrometer which is adapted to measure a plurality of constituents of a mixture.

Another object is to provide a sample system for a mass spectrometer wherein a plurality of fluid streams

to be measured and a standardization gas are directed to the spectrometer tube periodically and and in sequence.

Other objects, advantages and features of the invention should become apparent from the following detailed description which is taken in conjunction with the accompanying drawing in which:

Figure 1 is a schematic representation of a mass spectrometer having a portion of the potential adjusting mechanism of this invention associated therewith.

Figure 2 is a schematic representation of the sample system and timing mechanisms which are employed in conjunction with the mass spectrometer tube of Figure 1.

Referring now to the drawing in detail and to Figure 1 in particular, there is shown a mass spectrometer tube **10** which comprises a gas impermeable envelope, the interior of which is maintained at a reduced pressure by a vacuum pump, not shown, which communicates with the interior of tube **10** through a conduit **11**. A sample of gas to be analyzed is directed into tube **10** through a conduit **12**. An electron emitting filament **13** is disposed in one end of tube **10** and an ion collector plate **14** is disposed in the second end of the tube. The end terminals of filament **13** are connected to the respective end terminals of the secondary winding **15** of a transformer **16**. The end terminals of the primary winding **17** of transformer **16** are connected to an alternating current source **18**. The center tap of the secondary winding **15** of transformer **16** is connected to a negative potential terminal **19**.

The gas sample supplied through conduit **12** is directed into an ionization chamber **22** in tube **10** which is defined by a pair of spaced grids **23** and **24** that are maintained at ground potential. Electrons emitted from filament **13** are accelerated into chamber **22** by the potential difference between filament **13** and grids **23** and **24**. A grid **26** is positioned between filament **13** and grid **23**. Grid **26** is connected to the output of an emission regulator circuit **27**, which can be of the type disclosed in the copending application of M. C. Burk, Serial No. 412,790, filed February 26, 1954, now U.S. Patent No. 2,792,500, granted May 14, 1957. The input of emission regulator **27** is connected to the center tap of transformer winding **15**. This emission regulator is provided for the purpose of applying a potential to grid **26** of magnitude such as to maintain a constant flow of electrons into ionization chamber **22**, irrespective of minor fluctuations in the electron emission from filament **13**. In this manner the rate at which gas molecules are ionized in chamber **22** by electron bombardment is a function of only the gas pressure in the chamber.

A first collimating electrode **28** is positioned on the second side of ionization chamber **22** and is connected to the contactor of a potentiometer **20**. One end terminal of potentiometer **20** is connected to a negative potential terminal **21**, the second end terminal of potentiometer **20** being grounded. A second collimating electrode **28'** is spaced from electrode **28**. Electrode **28'** is connected to the contactor of a potentiometer **20'**. The end terminals of potentiometer **20'** are connected to terminal **21** and ground, respectively.

The positive ions produced in ionization chamber **22** are accelerated by the negative potentials applied to electrodes **28** and **28'** so as to travel through the tube toward collector plate **14**. A first set of three equally spaced grids **35**, **36** and **37** are positioned in tube **10** between grid **28** and collector plate **14**. A second set of equally spaced grids **38**, **39** and **40** are positioned in spaced relation with the first set of grids; a third set of equally spaced grids **42**, **43**, and **44** are positioned in spaced relation with the second set of grids; a fourth set of

equally spaced grids 45, 46 and 47 are positioned in spaced relation with the third set of grids; and a fifth set of equally spaced grids 49, 50 and 51 are positioned in spaced relation with the fourth set of grids. The spacings s between grids 35 and 36, 36 and 37, 38 and 39, 39 and 40, 42 and 43, 43 and 44, 45 and 46, 46 and 47, 49 and 50, and 50 and 51 are equal. The spacings r between the centers of grids 37 and 38, 40 and 42, 44 and 45, and 47 and 49 can be represented by the expression:

$$r=2s\left(\frac{n}{0.742}-1\right)$$

where n is an integral number.

Grid 35 is connected to a switch 60 which is actuated by a relay 61*a*. Switch 60 engages a terminal 62 when relay 61*a* is de-energized and a terminal 63 when relay 61*a* is energized. Terminals 62 and 63 are connected to the contactors of respective potentiometers 64 and 65. The first end terminals of potentiometers 64 and 65 are connected to ground through a variable resistor 66. The second end terminals of potentiometers 64 and 65 are connected to respective terminals 67 and 68. A switch 69 engages terminal 67 when a relay 61*b* is de-energized and a terminal 68 when relay 61*b* is energized. Switch 69 is connected to a terminal 70 which is maintained at a potential which is negative with respect to ground. Variable resistor 66 is adjusted by a constant speed motor 72 which is energized by a current source 73. Motor 72 adjusts this resistor so that the resistance thereof continually increases, then is decreased, and repeats at a predetermined frequency.

Grid 51 is connected to a switch 75 which is actuated by a relay 76*a*. Switch 75 engages a terminal 77 when relay 76*a* is de-energized and a terminal 78 when relay 76*a* is energized. Terminals 77 and 78 are connected to the contactors of respective potentiometers 80 and 81. The first terminals of potentiometers 80 and 81 are connected to grid 35 and to a terminal 82. The second end terminals of potentiometers 80 and 81 are connected to respective terminals 83 and 84. A switch 85 engages terminal 83 when a relay 76*b* is de-energized and a terminal 84 when relay 76*b* is energized. Switch 85 is connected to a terminal 87. A source of direct potential, not shown, is connected between terminals 82 and 87 so that terminal 82 is negative with respect to terminal 87. Grid 51 is connected to grids 47 and 49 through a resistor 88; grids 47 and 49 are connected to grids 44 and 45 through a resistor 89; grids 44 and 45 are connected to grids 40 and 42 through a resistor 90; grids 40 and 42 are connected to grids 37 and 38 through a resistor 91; and grids 37 and 39 are connected to grid 35 through a resistor 92.

Grids 36, 39, 43, 46 and 50 are connected to one another and to the first output terminal of an oscillator 95, the second output terminal of which is connected to ground. The frequency of oscillator 95 is determined by a crystal 96 or 97 which is connected in the oscillator circuit. The first terminals of these crystals are connected to a common terminal and oscillator 95. The second terminals of crystals 96 and 97 are connected to respective terminals 98 and 99. A switch 100 engages terminal 99 when a relay 101 is de-energized and a terminal 98 when relay 101 is energized. Switch 100 is connected to the second terminal in oscillator 95 to complete the circuit with one of the crystals. If the masses of the different ions to be detected are nearly the same, only one output frequency from oscillator 95 normally is provided. The different frequencies are useful in focusing the tube when the masses of the ions are substantially different.

A plurality of closely spaced stopping grids 105 are positioned between grid 51 and collector plate 14. Grids 105 are connected to one another and to a switch 106 which is actuated by a relay 76*c*. Switch 106 engages a terminal 107 when relay 76*c* is de-energized and a terminal 108 when relay 76*c* is energized. Terminals 107 and 108 are connected to the contactors of respective potentiometers 109 and 110. The first end terminals of potentiometers 109 and 110 are connected to ground. The second end terminals of potentiometers 109 and 110 are connected to respective terminals 111 and 112. A switch 113 engages terminal 111 when a relay 76*d* is de-energized and a terminal 112 when relay 76*d* is energized. Switch 113 is connected to a terminal 114 which is maintained at a potential which is positive with respect to ground.

A plurality of suppressor grids 120 are positioned between grids 105 and collector plate 14. Grids 120 are connected to a terminal 121 which is maintained at a potential which is negative with respect to ground so that grids 120 suppress secondary electrons which may result from ions impinging upon metal parts of the tube. A grounded shield 122 is positioned adjacent collector plate 14.

Collector plate 14 is connected to the first input terminal of a detector circuit 124, the second input terminal of which is grounded. The output terminals of detector circuit 124 are connected through a switch network 125, which is described hereinafter, to a recorder 126.

The positive ions formed in chamber 22 are accelerated toward collector plate 14 by the negative potentials applied to grids 28 and 28'. During one half cycle of the output signal from oscillator 95, the electrical field between grids 35 and 36 is of such phase that the ions entering this field are accelerated. Ions which enter the field during a particular phase of this half cycle receive maximum energy. During the following half cycle of the signal from oscillator 95, the field between grids 36 and 37 is such that the ions are further accelerated. These ions then drift through the field-free space between grids 37 and 38. The masses of the individual ions determine their times of arrival at grid 38. The ions which arrive at grid 38 at the proper time are again accelerated a maximum amount by the field applied between grids 38 and 39, thereby receiving additional energy. The same accelerating procedure continues as the ions pass through the next ten grids. The positive potential applied to grids 105 is adjusted such that only those ions which receive a predetermined maximum energy are able to pass through grids 105 to impinge upon collector plate 14.

The ions impinging upon collector plate 14 cause current to flow in the input circuit of detector 124. This current is proportional in magnitude to the number of ions impinging upon the collector plate. The potential applied across the resistance network defined by resistors 88, 89, 90, 91 and 92 serves to decelerate the ions so that the velocity of the selected ions to which the spectrometer tube is tuned remain substantially constant, whereas the ions of other masses are decelerated in passing through the tube. For a more detailed description of the operation of the mass spectrometer tube thus far described, including oscillator 95, reference is made to U.S. Patent 2,761,974.

In order to describe the mass spectrometer of this invention, reference will be made to a particular system wherein three sample streams are directed to the spectrometer tube in sequence. It should be evident, however, that an additional number of sample streams can readily be provided. The gas samples to be analyzed are introduced into the system by means of conduits 130, 131 and 132 of Figure 2 which have respective solenoid operated valves 133, 134 and 135 therein. Vent conduits 130*a*, 131*a* and 132*a* communicate with respective conduits 130, 131 and 132 upstream from valves 133, 134 and 135. Conduits 130, 131 and 132 communicate with a common conduit 136 which has a pressure regulator 137 therein. Conduit 136 communicates with the first inlet of a three-

way solenoid operated valve 138. Standardization gas for the mass spectrometer is supplied by a tank 140, the outlet of which is connected by a conduit 141, which has a pressure regulator 142 therein, to the second inlet valve 138. The outlet of valve 138 communicates with a conduit 143 which has a flow controller 144 therein. A vent conduit 145 communicates with conduit 143 so that the sample to be analyzed flows continuously through conduit 143. A conduit 146, having a restricted passage 147 therein, communicates with conduit 143. A conduit 148 communicates between the second end restricted passage 147 and the inlet of a vacuum pump 149. A small volume of the sample thus flows through passage 147. A second restricted passage 150 communicates between conduit 146 and conduit 12. Conduit 11 is connected to the inlet of vacuum pump 151. A sample of the material to be analyzed is thus directed through spectrometer tube 10 from passage 150.

The solenoids 133', 134', 135' and 138' which actuate respective valves 133, 134, 135 and 138 are energized in sequence by a timing circuit. This timing circuit is controlled by a constant speed timing motor 160 which is connected across a source of alternating current 161. Motor 160 closes a switch 162 momentarily at periodic intervals. This can be accomplished, for example, by means of a cam connected to the drive shaft of motor 160. The first terminal of current source 161 is connected to the first terminal of a rectifier 163. The second terminal of rectifier 163 is connected through a capacitor 164 to the second terminal 161*b* of current source 161. A D.C. voltage thus appears across capacitor 164. This voltage is applied through switch 162 to a coil 165 of a stepping switch. When the coil 165 is energized, arm 166 of the stepping switch moves from one to the next contact 167*a*, 167*b*, 167*c*, 167*d* and 167*a*. Switch arm 166 is connected to terminal 161*b*. Terminals 167*a*, 167*b*, 167*c* and 167*d* are connected to terminal 161*a* through the coils of respetcive relays 168*a*, 168*b*, 168*c* and 168*d*. The primary winding 170 of a transformer 171 is connected across current source 161. The first terminal of the secondary winding 172 of transformer 171 is connected to switches 173*a*, 173*b*, 173*c* and 173*d* which are closed when respective relays 168*a*, 168*b*, 168*c* and 168*d* are energized. The stationary terminals of switches 173*a*, 173*b*, 173*c* and 173*d* are connected to the first terminals of respective solenoids 133', 134', 135' and 138'. The second terminals of solenoids 133', 134', 135' and 138' are connected through a resistor 174 to the second end terminal of transformer winding 172.

Each time switch 162 is closed by timing motor 160, switch cam 166 moves to the next terminal. This energizes relays 168*a*, 168*b*, 168*c* and 168*d* in sequence so that valves 133, 134, 135 and 138 are actuated in sequence. Conduit 136 communicates with conduit 143 except when solenoid 138' is energized. The three sample streams and the standardization gas are thus directed to the spectrometer tube in sequence.

The coil of relay 180 is connected in parallel with resistor 174. A switch 181 engages a terminal 182 when relay 180 is energized. Switch 181 is connected to terminal 161*a*, and terminal 182 is connected to a switch 183. Switch 183 engages a terminal 184 when a relay 185 is de-energized and a terminal 186 when relay 185 is energized. Terminal 184 is connected to a switch 187 which is adapted to engage either a terminal 188 or a terminal 189. Switch 187 normally engages terminal 188. Terminal 188 is connected to the first terminal of a timer 190. The second terminal of timer 190 is connected to terminal 161*b*. Timer 190 moves switch 187 into engagement with terminal 189 a predetermined time after being energized. Terminal 189 is connected to terminal 186 and to one terminal of the coil of relay 185. The second terminal of the coil of relay 185 is connected to terminal 161*b*. A capacitor 191 is connected in parallel with the coil of relay 185.

Relay 185 also actuates a second switch 192 which engages a terminal 193 when the relay is energized. Switch 192 is connected to terminal 161*a*, and terminal 193 is connected to terminal 161*b* through the coil of relay 101 of Figure 1 to terminal 161*b*. Relay 185 is provided with a third switch 195 which engages a terminal 196 when the relay is de-energized and a terminal 197 when the relay is energized. Terminal 197 is connected to terminal 186, and terminal 196 is connected to terminal 188. Switch 195 is connected to a switch 200 which is actuated by a relay 201. Switch 200 engages a terminal 202 when relay 201 is de-energized and a terminal 203 when the relay is energized. Terminal 202 is connected to a switch 204 which normally energizes a terminal 205. Terminal 205 is connected to the first terminal of a second timer 206 which moves switch 204 into engagement with a terminal 207 a predetermined time after the timer is energized. The second terminal of timer 206 is connected to terminal 161*b*. Terminals 203 and 207 are connected to the first terminal of the coil of relay 201, the second terminal of which is connected to terminal 161*b*. A capacitor 208 is connected in parallel to the coil of relay 201. The first terminal, of the coil of relays 61, which corresponds to relays 61*a* and 61*b* of Figure 1, is connected to terminal 161*b*. The second terminal of relay coil 61 is connected to terminals 186 and 197. A coil 76, which corresponds to relays 76*a*, 76*b*, 76*c* and 76*d* of Figure 1, is connected in parallel with coil 61.

It can be seen that relay 180 is energized each time one of the solenoid actuated valves in the sample lines is energized. The closure of switch 181 results in timer 190 being actuated. At the end of the predetermined time interval, timer 190 moves switch 187 into engagement with terminal 189. This energizes relay 185. Relays 101, 61 and 76 are energized at this time so that potentiometers 65, 81 and 110 are connected into the circuit of Figure 1 in place of potentiometers 64, 80 and 109. Crystal 96 is also connected into the circuit in place of crystal 97. The mass spectrometer initially is adjusted by means of potentiometers 64, 80 and 109 so that the instrument detects one of the constituents of the fluid mixture to be analyzed. Timer 190 serves to change the potentials applied to the spectrometer tube and the frequency of oscillator 95 so that the instrument detects a second constituent in the fluid sample to be analyzed.

Closure of switch 181 also energizes timer 206. At the end of a predetermined interval, timer 206 moves switch 204 into engagement with terminal 207. This energizes relay 201 to move a switch 210 into engagement with a terminal 211. Closure of switch 210 connects the coil 212 of the pen-drive motor in recorder 126 into the circuit. A record is thus made only after a predetermined time interval following the switching operation. This permits the mass spectrometer to become stabilized before a record of the constituent being analyzed is made.

The recorder can advantageously be provided with two separate recording pens to provide individual records of the two constituents to be measured. These two pens are actuated by respective solenoids 214 and 215 being energized. The first terminals of these two solenoids are connected to ground. The second terminals of solenoids 214 and 215 are connected to respective terminals 216 and 217 which are adapted to be engaged by a switch 218, the latter being actuated by relay 185. Power for relays 214 and 215 is obtained from a bridge rectifier 241 which is connected across the secondary winding of a transformer 240. The primary winding of transformer 240 is connected across current source 161. The output voltage of rectifier 241 is filtered by a circuit comprising a resistor 242 and capacitors 243 and 244. Solenoid 214 is thus energized during the first half of the analysis cycle and solenoid 215 is energized during the last half of the analysis cycle.

Switch network 125 is adapted to short the input ter-

minals of recorder **126** during a portion of the standardization cycle so that this cycle can readily be identified on the record. The two output terminals of detector **124** are connected to respective terminals **220** and **221** which are adaped to be engaged by respective switches **222** and **223** when a relay **224** is de-energized. Switches **222** and **223** are connected to the respective input terminals of recorder **126**. Switches **222** and **223** engage respective terminals **225** and **226** when relay **224** is energized. Terminals **225** and **226** are connected to one another to short recorder **126**. One terminal of the coil of relay **224** is connected to terminal **161***b*. The second terminal of this relay coil is connected through a resistor **230** and a switch **231** of a thermal time delay switch **229** to switch **173***d*. A heating element **232** and a resistor **233** are connected in series between switch **173***d* and terminal **161***b*. When relay **168***d* is energized to begin the standardization cycle, current is supplied to heating element **232**. After a predetermined interval, this heating serves to open thermal switch **231** so that relay **224** is de-energized. Prior to this time, the input terminals of record **126** are shorted.

As an example of the operation of the mass spectrometer of this invention, one instrument has been employed successfully in the analysis of converter recycle streams in the manufacture of ammonia. These streams generally contain approximately 60 percent hydrogen, 20 percent nitrogen, 10 percent methane, and 10 percent of other gases. The analyzer timer was set to pass each sample stream to the spectrometer tube for approximately six minutes, giving two half cycles of 3 minutes each. Timer **190** provides the two half cycles of 3 minutes each on each stream. Timer **206** is provided with a delay of 2 minutes to permit the analyzer to become stabilized after the switching. This gave approximately one minute each for the analysis of hydrogen and nitrogen in each sample stream. The potentials and frequencies applied to tube **10** were adjusted to permit detection of these constituents.

From the foregoing description it should be evident that there is provided in accordance with this invention an improved mass spectrometer which is adapted to analyze a plurality of sample stream periodically and to detect individual constituents of the streams. While the invention has been described in conjunction with the analysis of fluid streams to detect two constituents thereof, it should be evident that the switching system can be extended to the analysis of additional constituents in sample streams. Provision is also made in accordance with this invention for calibrating the analyzer periodically by means of a standardization gas of predetermined composition.

While the invention has been described in conjunction with a present preferred embodiment, it should be evident that it is not limited thereto.

What is claimed is:

1. A mass spectrometer comprising a gas impermeable envelope enclosing an ionization chamber, a collector plate spaced from said ionization chamber, a plurality of groups of grids spaced in a line between said ionization source and said plate, each of said groups comprising three grids in spaced relationship with one another, the spacings between adjacent grids being equal, the spacings between adjacent groups of said grids being substantially

$$2s\left(\frac{n}{0.742}-1\right)$$

where n is an integral number and s is the spacing between adjacent grids in each group, and an ion stopping grid positioned between said collector plate and said groups of grids; first and second sources of negative potential; first switching means to apply said first and second sources of negative potential selectively to the grid of said plurality of groups of grids closest to said ionization chamber; a potential dividing network; means to connect the end grids of said plurality of groups of grids to said network; third and fourth sources of direct potential; second switching means to apply said third and fourth sources of potential selectively across said network; fifth and sixth sources of positive potential; third switching means to apply said fifth and sixth sources of potential to said ion stopping grid; means to apply an alternating potential to the center grids of said groups of grids; detector circuit means connected to said collector plate; means to introduce a plurality of sample streams to be analyzed into said ionization chamber in sequence; and timing means to actuate said means to introduce and said switching means so as to apply said first, third and fifth sources of potential to the respective grids for a predetermined time and thereafter to apply said second, fourth and sixth sources of potential to the respective grids each time a different stream is passed to said ionization chamber.

2. The mass spectrometer of claim 1 further comprising means to vary progressively the amplitude of the source of negative potential which is applied to the grid of said plurality of groups of grids closest to said ionization chamber.

3. The mass spectrometer of claim 1 wherein said detector circuit means includes a recorder having two recording means therein to make two separate records, and further comprising means responsive to said timing means to energize one of said recording means when said first, third and fifth sources of potential are applied and to energize the other of said recording means when said second, fourth and sixth sources of potential are applied.

4. The mass spectrometer of claim 1 wherein said detector circuit means includes a recorder, and means to render said recorder inoperative for a predetermined interval after said first, third and fifth sources of potential are applied and to render said recorder inoperative for a predetermined interval after said second, fourth and sixth sources of potential are applied.

5. The mass spectrometer of claim 1 wherein said means to introduce a plurality of sample streams comprises a plurality of first conduit means having respective first control valves therein, second conduit means communicating at one end with said plurality of first conduit means downstream from said control valves, third conduit means communicating with the second end of said second conduit means to vent fluid, fourth conduit means having a first restriction therein, one end of said fourth conduit means communicating with the second end of said second conduit means, a first vacuum pump having the inlet thereof communicating with the second end of said fourth conduit means, fifth conduit means having a second restriction therein communicating between the second end of said fourth conduit means and the ionization chamber in said envelope, and a second vacuum pump having the inlet thereof communicating with the interior of said envelope.

6. A mass spectrometer comprising a gas impermeable envelope enclosing an ionization chamber, a collector plate spaced from said ionization chamber, a plurality of groups of first grids spaced in a line between said ionization chamber and said plate, each of said groups comprising three grids in spaced relationship with one another, the spacings between adjacent grids being equal, the spacings between adjacent groups of grids being substantially

$$2s\left(\frac{n}{0.742}-1\right)$$

where n is an integral number and s is the spacing between adjacent grids in each group, and an ion stopping grid positioned between said collector plate and said groups of grids; first and second sources of negative potential; first switching means to apply said first and second sources of negative potential selectively to the grid

of said plurality of groups of grids closest to said ionization chamber; a potential dividing network; means to connect the end grids of said plurality of groups of grids to said network; first and second sources of direct potential; second switching means to apply said first and second sources of direct potential selectively across said network; first and second sources of positive potential; third switching means to connect said first and second sources of positive potential to said ion stopping grid; means to apply an alternating potential to the center grids of said groups of grids comprising a source of alternating potential and means to vary the frequency of said source of alternating potential to establish first and second alternating signals of different frequencies; detector circuit means connected to said collector plate; and timing means to actuate said switching means to apply said first source of negative potential, said first source of direct potential, said first alternating signal, and said first source of positive potential to the respective grids for a predetermined time and thereafter to apply said second source of negative potential, said second source of direct potential, said second alternating signal, and said second source of positive potential to the respective grids.

7. A mass spectrometer comprising an ionization chamber; a collector plate spaced from said ionization chamber; a grid positioned between said ionization chamber and said collector plate; first and second sources of potential of polarity opposite the polarity of the ions to be measured; switching means to apply said first and second sources selectively to said grid to accelerate ions from said ionization chamber toward said collector plate; means to focus ions of a predetermined mass on said collector plate; detector circuit means connected to said collector plate; means to introduce a plurality of sample streams to be analyzed into said ionization chamber in sequence comprising a plurality of first conduit means

having respective first control valves therein, second conduit means communicating at one end with said first conduit means downstream from said control valves, third conduit means communicating with the second end of said second conduit means to vent fluid, fourth conduit means having a first restriction therein, one end of said fourth conduit means communicating with the second end of said second conduit means, a first vacuum pump having the inlet thereof communicating with the second end of said fourth conduit means, fifth conduit means having a second restriction therein communicating between the second end of said fourth conduit means and the ionization chamber in said envelope, and a second vacuum pump having the inlet thereof communicating with the interior of said envelope, and timing means to actuate said means to introduce and said switching means so as to apply said first source of potential to said grid for a predetermined time and thereafter to apply said second source of potential to said grid each time a different stream is passed to said ionization chamber.

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