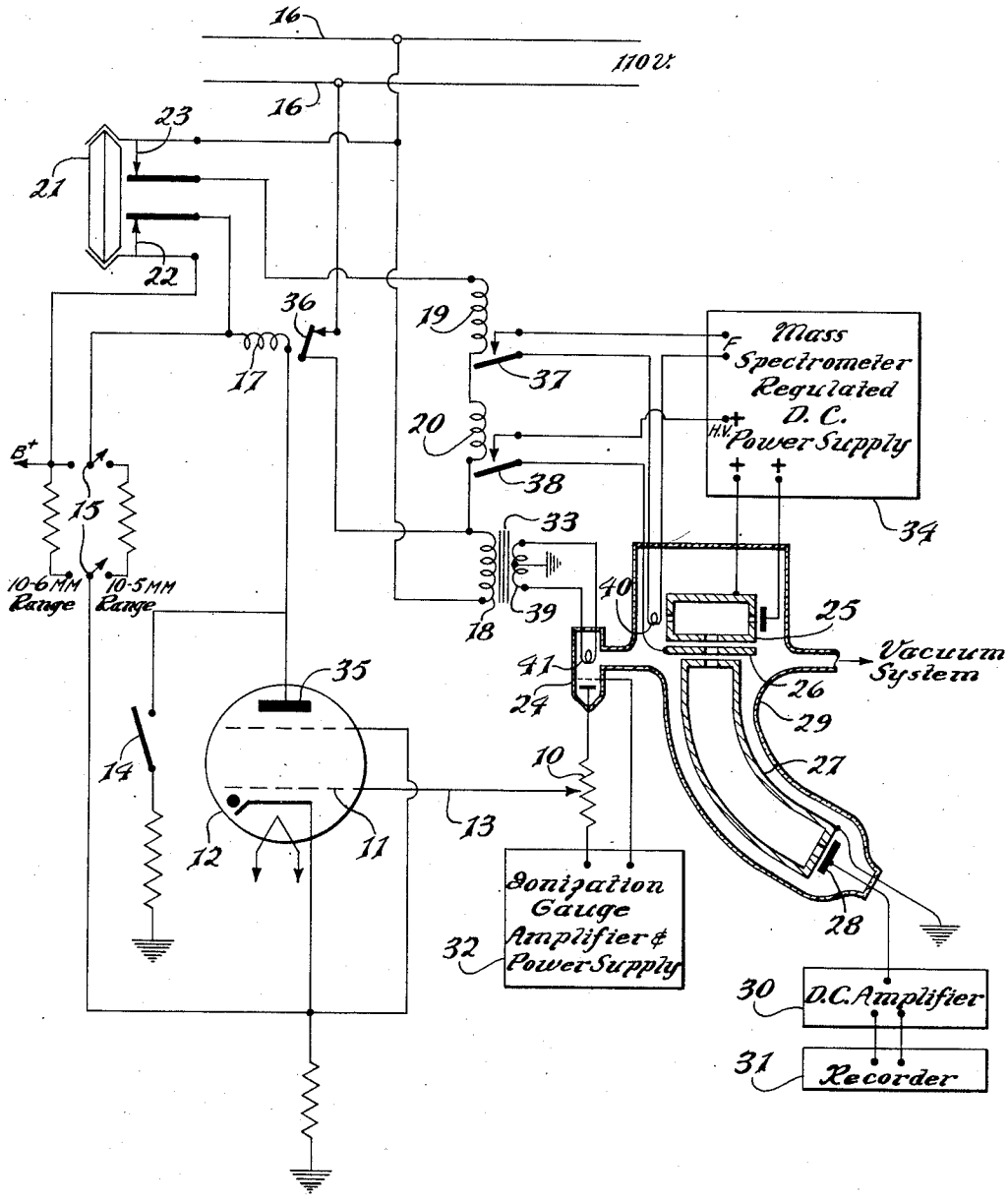
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MASS SPECTROMETER CONTROL

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MASS SPECTROMETER CONTROL

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This invention is concerned with mass spectrometers and their operation and provides improvements to the end that proper sensitivity is maintained by insuring against operation above an established critical pressure, and protection is provided for the elements within the mass spectrometer against excessive pressure increases.

As is known, a mass spectrometer is an apparatus for sorting ions which have different mass-to-charge ratios and therefore different specific masses, and is normally used for the qualitative or quantitative analysis of elements contained in mixtures, compounds, mixtures of compounds, or for the determination of the isotopic ratios which exist within most elements.

Protective devices found on mass spectrometers are normally designed to serve the purpose of protecting the mass spectrometer elements in the usual laboratory use of such instruments. When mass spectrometers are used in production control analysis, it is found that the normal protection devices are not adequate for such production control. The inadequacy results from the fact that the design of the protective devices is based entirely upon the critical pressures which may cause injury to the elements of the mass spectrometer and the associated pressure gauge, and not upon the pressure range at which the mass spectrometers should be operated to obtain a desired sensitivity. In production control analysis it is of major importance to maintain a relatively constant sensitivity so as to facilitate the interpretation of control analysis results. This relatively constant sensitivity can only be maintained if the mass spectrometer is operated below a predetermined pressure. The control circuit of the invention prevents operation at pressures higher than the predetermined pressure until a manual reset of sensitivity has been made by the operator and in addition provides protection against improper energization of the elements within a mass spectrometer. Such a manual reset is particularly desirable when production analysis makes it expedient to operate delicate instruments, such as mass spectrometers, with personnel who may not be particularly technically qualified to understand the operating characteristics of such instruments.

An object of my invention is to provide a means for maintaining a relatively constant sensitivity in a mass spectrometer by preventing operation above a predetermined pressure.

Another object of my invention is to provide an automatic lock-out, which, when the pressure exceeds the predetermined pressure, will prevent further mass spectrometer operation.

Still another object of my invention is to provide a manual reset of the automatic lock-out which is ineffective when the automatic lock-out is set to respond to changes from the desired sensitivity range, but which is effective when set to respond to changes from higher pressure ranges.

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These and other objects of my invention will be understood more thoroughly from the following description when read in conjunction with the accompanying drawing, the single figure of which is a schematic diagram of a control arrangement incorporating my invention.

With reference to the drawing, the mass spectrometer shown generally includes an ionization chamber 25, a high voltage accelerating electrode 26, an analyzing chamber 27, and an ion collector plate 28, used in conjunction with an ionization pressure gauge 24, all disposed within an envelope 29 which is highly evacuated by an associated high vacuum system, not shown. The current produced on the collector plate 28 is normally amplified by a direct current amplifier 30, whose output is recorded either visually or graphically by a suitable metering device 31. The ionization gauge 24 has an associated circuit 32 which provides power and indicates pressure. The mass spectrometer is provided power for the high voltage and filament circuits through a regulated power supply 34.

The control arrangement shown in the drawing comprises a gaseous discharge tube 12, such as a thyratron tube, having its control grid 11 connected by a lead 13 so as to be influenced by the voltage drop across a resistor 10 developed by a pressure representative current from an ion gauge 24. Voltage is applied to the plate 35 of the tube 12 through a first relay coil 17 and a contact switch 22. The pressure range response of the tube 12 is controlled by a two position double pole switch 15. When the switch 15 is in the 10^{-6} mm. pressure range position, one pole completes a circuit around the contact switch 22, thus providing another path through which the voltage is impressed upon the plate 35 of the tube 12 through the relay coil 17. The relay coil 17 has its armature 36 connected in series relationship with the primary 18 of an ion gauge transformer 33 between external 110 volt power lines 16. The armature 36 is also connected in series relationship with a second relay coil 19 and a third relay coil 20 having armatures 37 and 38, respectively, and a contact switch 23 between external 110 volt power lines 16. This arrangement makes it possible to energize the ion gauge primary 18 either independently of or simultaneously with the relay coils 19 and 20 by the action of the opening or closing, respectively, of the contact switch 23. The contact switches 22 and 23 are arranged to be actuated simultaneously by a push button 21. The purpose of this arrangement is to make it possible to operate an ion gauge filament 41, which is series connected to the secondary wind-

ing 39 of the ion gauge transformer 33, either independently of or simultaneously with a mass spectrometer filament 40, which is series connected to the armature 37 of the relay coil 19 and a D. C. power supply 34, and the high voltage accelerating electrode 26, which is series connected to the armature 38 of the relay coil 20 and the D. C. power supply 34.

The relay coil 17 may also be energized by means of a single pole single throw switch 14 through the contact switch 22 to a voltage source B+. This arrangement makes it possible to prevent the armature 36 operated by relay coil 17 from energizing the circuits connected in series with its armature 36 during the start-up period when the pressure within the mass spectrometer is too great to safely energize the ion gage filament 41.

In the operation of the above described arrangement, the signal from the ionization gauge 24 is transmitted through the resistor 10 to the ionization gauge amplifier 32, in a well known manner. The signal voltage produced across the resistor 10 is representative of the pressure within the ionization gauge 24, and therefore of the pressure within the connecting mass spectrometer envelope 29. The signal voltage across the resistor 10 increases in positive polarity with an increase in pressure within the envelope 29 and conversely a decrease in positive polarity results from a decrease in pressure. A portion of this signal voltage is impressed upon the grid 11 of the thyratron tube 12 through the lead 13. The ionization gauge 24, ionization gauge transformer 33, resistor 10, and the ionization gauge amplifier and power supply 32 are all parts of a conventional ionization gauge power source and amplifier system, and are not claimed as part of my invention.

Preceding the pumping-down of the mass spectrometer, the single pole single throw switch 14 is closed and the two position double pole switch 15 is in the 10^{-5} mm. pressure range position. The closed switch 14 energizes the relay coil 17 causing its armature 36 to open the circuits connecting the relay coils 19 and 20 and the ionization gauge transformer primary 18 between the 110 volt lines 16, thus allowing the relay coils 19 and 20, and said transformer primary 18 to remain de-energized. Since the relay coil 19 is not energized it allows its armature 37 to remain open thereby permitting the circuit between the mass spectrometer filament 40 and the D. C. power supply 34 to remain deenergized, while the de-energized relay coil 20 allows its armature 38 to remain open, thereby permitting the circuit between the accelerating electrode 26 and the D. C. power supply 34 to remain de-energized. De-energization of the ionization gauge transformer primary 18 prevents the energization of the ionization gauge filament 41.

The plate voltage is applied to the plate 35 of the thyratron tube 12 through the contact switch 22 and the relay coil 17. The cathode voltage of the tube 12, when the two position double pole switch 15 is in the 10^{-5} mm. pressure range position, is adjusted so that as long as the pressure within the mass spectrometer envelope 29 remains above 2×10^{-5} mm. of Hg, the signal voltage impressed on the grid 11 of the thyratron tube 12 through lead 13 will be of such magnitude as to cause the thyratron tube 12 to fire should the ionization gauge 24 be placed into operation. When the pressure is

in the neighborhood of 10^{-5} mm. of Hg, as read by a supplementary McLeod gauge or Pirani gauge, not shown, which is used in conjunction with the vacuum system, the pressure can be determined more precisely using the ionization gauge 24 by pressing a push button 21 which opens the contact switches 22 and 23 simultaneously. Opening the contact switch 22 de-energizes the relay coil 17 causing its armature 36 to close the circuit between the ionization gauge transformer primary 18 and the 110 volt power lines 16, thus energizing the ionization gauge filament 41 attached thereto, thereby resulting in the operation of the ionization gauge 24. Opening the contact switch 23 prevents the circuit between the relay coils 19 and 20 and the 110 volt power lines 16 from being closed by the action of the armature 36 when its relay coil 17 is de-energized. Since the relay coils 19 and 20 are not energized, their respective armatures 37 and 38 remain in the open position and the respective mass spectrometer filament and the accelerating electrode circuits attached thereto remain de-energized. Therefore, the push button 21, through its action of opening the contact switches 22 and 23 simultaneousy, allows the mass spectrometer operator to check the pressure reading, by means of the ionization gauge 24, several times before the pressure drops to the value of 2×10^{-5} mm. of Hg in order to determine if any vacuum difficulties are being encountered, and yet provides protection for the mass spectrometer elements. The closed switch 14 will again energize the relay coil 17 causing its armature 36 to open the circuits attached thereto when the contact switch 22 is closed so as to positively prevent the mass spectrometer circuits from becoming energized at a pressure which might prove detrimental to the elements contained within the mass spectrometer.

When the pressure is approximately 2×10^{-5} mm. of Hg, as determined by the ionization gauge 24, the single pole single throw switch 14 is opened. The grid 11 will control the operation of the thyratron tube 12 when the contact switch 22 is closed by the releasing of the push button 21. It is to be noted that, as previously explained, the releasing of the push button 21 closes both of the contact switches 22 and 23 simultaneously. If the pressure in the mass spectrometer is 2×10^{-5} mm. of Hg, or lower, the signal voltage produced at the resistor 10 will be such that it will not cause the thyratron tube 12 to fire, and the relay coil 17 will then remain de-energized and its armature 36 will remain closed, thereby maintaining the energization of the circuits attached thereto; such circuits being those connecting the relay coils 19 and 20, and the ionization gauge transformer primary 18 between the 110 volt power lines 16. Energizing the relay coil 19 causes its armature 37 to close the circuit between the D. C. power supply 34 and the mass spectrometer filament 40, and energizing the relay coil 20 causes its armature 38 to close the high voltage circuit between the D. C. power supply 34 and the accelerating electrode 26. The ionization gauge transformer primary 18 energizes the circuit containing the ion gauge filament 41, as previously explained.

In the event that an increase in pressure is experienced which is greater than the value of 2×10^{-5} mm. of Hg, the thyratron tube 12 will fire and energize relay coil 17 thereby causing its armature 36 to open the circuit to the relay coils 19 and 20, and the ionization gauge trans-

former primary 13. De-energizing the relay coils 19 and 20 causes their respective armatures 37 and 38 to open the circuits attached thereto, which protects the mass spectrometer filament 40 and the accelerating electrode 26 from injury due to excessive pressure within the envelope 29. Removal of the high voltage potential from the accelerating electrode 26 also provides protection for the D. C. power supply 34 against excessive drains which may develop during periods of excessive pressure within the envelope 29. When the pressure within the envelope 29 has again been reduced to 2×10^{-5} mm. of Hg, or lower, the mass spectrometer may be placed into operation by pressing the push button 21 which removes the plate voltage from the tube 12 thereby deionizing it.

When pressure in the envelope 29 has been reduced to a value of 2×10^{-6} mm. of Hg, or less, as indicated by the ionization gauge 24, such pressure being the maximum allowable value for a desired mass spectrometer sensitivity as required for normal operation, the two position double pole switch 15 is then placed in the 10^{-6} mm. pressure range position. The mass spectrometer is now ready for normal operation by the operational crew. With the switch 15 in the 10^{-6} mm. pressure range position, the lock-out feature of the control circuit becomes effective when the pressure in the envelope 29 increases above the value of 2×10^{-6} mm. of Hg. The lock-out feature results from the fact that the plate 35 of the thyratron tube 12 receives its plate potential by parallel paths, one such path connecting the plate 35 through the relay coil 17 and the upper pole of the switch 15 to the supply voltage while the other path connects the plate 35 through the relay coil 17 and the contact switch 22 to the supply voltage. Now if the pressure in the envelope 29 rises above the set value of 2×10^{-6} mm. of Hg, the thyratron tube 12 will fire and energize the relay coil 17 thereby causing its armature 36 to open the circuits attached thereto, such circuits causing the opening of additional circuits connecting the mass spectrometer filament 40 and the accelerating electrode 26 to the mass spectrometer D. C. power supply 34 in the manner previously explained. Due to the lock-out feature, the operator cannot reset the control circuit and place the mass spectrometer in operation in the desired pressure range of 10^{-6} mm. of Hg by pressing the push button 21 to de-ionize the thyratron tube 12 as long as the two position double pole switch 15 is in the 10^{-6} mm. pressure range position, because the contact switch 22 of the push button 21 is bypassed by the upper pole of the double pole switch 15 and therefore the plate potential of the thyratron tube 12 is maintained and the relay coil 17 remains energized until the double pole switch 15 is changed from the 10^{-6} mm. pressure range position.

It will be obvious to those skilled in the art that various changes may be made in this apparatus without departing from the spirit of the invention, and therefore the invention herein described is not limited to what is shown in the drawing and described in the specification, but only as indicated by the appended claims.

I claim:

1. In mass spectrometer operating means, an envelope enclosing spectrometer elements and an ionization pressure gauge, means for supplying

electrical energy to the spectrometer elements, means for energizing the pressure gauge, a gaseous discharge tube having at least a cathode, an anode and a control grid, means for impressing on the control grid a voltage corresponding to the pressure to which said gauge is subjected, switch means for selectively impressing upon the cathode two different biasing voltages of such values with respect to the control grid that the voltages required on the control grid to fire the tube correspond, respectively, to a pressure at which the elements of the spectrometer may safely be energized and to a lower pressure below which consistent operation of the spectrometer at the desired spectrometer sensitivity can be had, and a normally closed switch in the anode circuit of the tube and in parallel with said switch means when said switch means is in the position for consistent operation, whereby upon a pressure rise causing the tube to fire said switch means must be moved from consistent operation position in order to deionize the tube.

2. An analyzer system of the character decribed comprising a mass spectrometer, circuits for energizing said spectrometer, a control circuit responsive to pressures within the spectrometer above a predetermined magnitude for opening the energizing circuits and denergizing the spectrometer, manually operated means for interrupting the control circuit to energize the spectrometer, and means coupled in parallel with said manually operable means including a switch and circuit for altering the range of operation of said control circuit, said last means being connected to by-pass and serve as a lock-out for said manually operated means in response to the actuation of said switch to prevent interruption of the control circuit for a selected pressure range.

3. A system for the control of the energization of electrical elements in a mass spectrometer comprising an ionization pressure gauge in communication with the mass spectrometer, a source coupled to said pressure gauge for energizing it, a circuit for energizing the electrical elements of the mass spectrometer, means responsive to a predetermined pressure in said spectrometer for opening said circuit and maintaining it open, said last means including a gaseous discharge tube coupled to said pressure gauge and fired by signals therefrom at the predetermined pressure, and a relay in the output circuit of said tube and responsive to operation thereof for opening the energizing circuit to the mass spectrometer elements, means including a switch in the anode circuit of said tube for disabling it, and a lock in circuit including a second switch connected in parallel with said disabling means for maintaining the anode circuit and sustaining the operation of said tube.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,783,234	Firestone	Dec. 2, 1930
2,374,205	Hoskins	Apr. 24, 1945

OTHER REFERENCES

Henney: Electron Tubes in Industry, McGraw Hill, 1934, p. 180. (Copy in Div. 52.)