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(54) Mass spectrometers.

(57) A mass spectrometer has an ion source (1) capable of being operated to provide positive and negative ions. The output of the ion source is passed to an ion filter (2) whose output is fed to first and second particle multipliers (3, 4). The first and second particle multipliers (3, 4) produce output signals for positive and negative ions respectively. This mass spectrometer is usable to distinguish between the nitrogen and carbon monoxide constituents of a sample.

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"MASS SPECTROMETERS"

This invention relates to mass spectrometers.

A mass spectrometer normally consists of an ion source, an ion filter, and a particle multiplier. The material to be analysed is introduced into the ion source where it is ionized and ions are passed through the ion filter to the particle multiplier. The order in which the ions reach the output of the ion filter depends on their atomic weight. Thus in circumstances in which the atomic weights of the components of a sample differ it is possible to ascertain the percentage of each constituent in the sample. However, where the atomic weights of two components are identical or very similar, it is normally impossible to distinguish between those constituents using a small mass spectrometer.

There is now a requirement to measure the quantity of carbon monoxide in samples of cigarette smoke exhaled by a smoker or by a machine simulating a smoker. It is difficult to utilize a conventional mass spectrometer for this purpose as nitrogen is the largest constituent of air and is obviously present in cigarette smoke exhaled by a smoker or a machine simulating a smoker. Nitrogen has an atomic weight of 28 as does carbon monoxide and as the quantity of carbon monoxide is very much less than the quantity of nitrogen in any given sample, it is very difficult to measure the proportion of carbon monoxide using a mass spectrometer.

It is an object of this invention to provide a mass spectrometer which alleviates the limitation described in the preceding paragraph of known mass spectrometers.

According to this invention, there is provided a mass spectrometer comprising an ion source capable of being operated to provide positive and negative ions, an ion filter which receives the output of the ion source, and first and second particle multipliers which receive the output of the ion filter and which produce output signals for positive and negative ions respectively.

A mass spectrometer in accordance with this invention can be used to distinguish between the nitrogen and carbon monoxide constituents of a sample. This is because nitrogen cannot be caused to produce negative ions but will only produce positive ions whereas carbon monoxide will produce both positive and negative ions. The mass spectrometer for any given sample containing nitrogen and carbon monoxide is operated both to produce negative and positive ions and the output is recorded separately. A sample with a known percentage of carbon monoxide is separately introduced into the mass spectrometer and is used to calibrate the readings of the mass spectrometer for negative ions of an atomic weight of 28. The proportion of carbon monoxide within the sample under test is then subtracted from the overall proportion of constituents having an atomic weight of 28 to give the proportion of nitrogen within the sample.

The first and second particle multipliers may, for example, be conventional box and grid particle multipliers and may also be secondary emission glass tube electron multipliers usually known as CHANNELTRON multipliers.

In an embodiment of the invention using box and grid particle multipliers, the first particle multiplier may have a row of dynodes having increasing positive potentials beginning at a positive potential of +2kV or +3kV at the entrance of the particle multiplier and with the potential of the final dynode being +4kV or +6kV. The potential difference between two adjacent dynodes may, for example, be 0.1kV. The potential of the first dynode of the second particle multiplier, that is to say, the dynode at the entrance of the second particle multiplier may be -2kV or -3kV again with a potential difference of 0.1kV between two adjacent dynodes with the final dynode earthed.

The ion filter may, for example, be the ion filter which is disclosed in either of British Patent Specifications Nos. 1 367 638 or 1 379 514 (and 1 379 515). These ion filters have the characteristic as do all ion filters that they apply the same filtering action to positive and negative ions.

The ion source is alternately operated to produce positive and negative ions.

The ion source may be of conventional type having an electron source arranged to provide a beam of electrons through an ion box or cage with an electron collector at the other side of the ion cage. The ions thereby produced are selected by a focus plate and are passed into the ion filter. In order to make the ion source produce positive ions, the ion cage is held at a positive potential while the focus plate is held at a negative potential while in order to cause the ion source to produce negative ions, the ion cage is held at a negative potential with the focus plate at a

positive potential.

The ion source may be that disclosed in British Patent Specification No. 1 379 515 (and 1 379 514).

Two embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings of which Figures 1 and 2 are schematic side views of first, second and third embodiments respectively.

Referring to Figure 1, an ion source 1 produces alternately positive and negative ions in dependence on the potentials applied to it and these are passed through an ion filter 2 which has a similar effect on positive and negative ions. The output of the ion filter 2 is applied to first and second particle multipliers 3 and 4 respectively designed to respond to positive and negative terminals. These are box and grid type electron multipliers.

A gas inlet 10 is in register with the inlet of the ion source 1. Positive and negative ions will normally be alternately selected by applying a pulse signal alternating between a positive and negative levels to a control plate 11 at the input of the ion filter 2. The ion filter is as disclosed in British Patent Specification No. 1 367 638.

The particle multipliers 3 and 4 are of the box and grid type, are separated by a mumetal shield 12 to prevent interference, and have respective inlet focus plates 13 and 14. The particles multipliers 3 and 4 have respective output leads 15 and 16 which pass, with suitable insulation, through a flange 17, and are connected to respective connectors 18 and 19 in a connector box 20.

The signal on the lead 15 has to be passed through an isolation amplifier (not shown) because of the high positive potential on the final dynode of the particle multiplier 3.

The output signals of the particle multipliers 3 and 4 may be obtained separately or together and may be considered differentially, i.e. the output signal of one particle multiplier may be deducted from that of the other.

It has been found that charge exchange takes place between the neutral gas from the inlet proceeding along the axis of the ion source and the ion filter and the ions being focussed at the inlet to the ion filter. This causes the negative particle multiplier to produce an output when the ion source 1 is operated to give positive ions. Charge exchange is controlled by the voltage at the focus plate 11 at the inlet to the ion filter 2 and by varying the gas composition.

In the second embodiment shown in Figure 3, the first and second particle multipliers 3 and 4 are "CHANNELTRON" or secondary emission glass tube type particle multipliers.

It is also possible to use solid state type detectors which are a form of particle multiplier.

The illustrated ion source is one of a number described in the text book "Dynamic Mass Spectrometry in Volume 3 by Ball, Todd & Lawson (Editor D. Price) published by Heydn in 1972.

CLAIMS.

1. A mass spectrometer comprising an ion source (1), an ion filter (2) which receives the output of the ion source (1), and a particle multiplier which receives the output of the ion filter (2) and produces an output signal representative of the rate at which ions are leaving the ion filter (2), characterised in that the ion source (1) is capable of being operated to provide positive and negative ions and in that there are provided first and second particle multipliers (3, 4) which receive the output ion filter (2) and which produce output signals for positive and negative ions respectively.

2. A mass spectrometer according to claim 1 characterised in that the first and second particle multipliers (3, 4) are of the box and grid type.

3. A mass spectrometer according to claim 1 characterised in that the first and second particle multipliers (3, 4) are secondary emission glass tube electron multipliers.

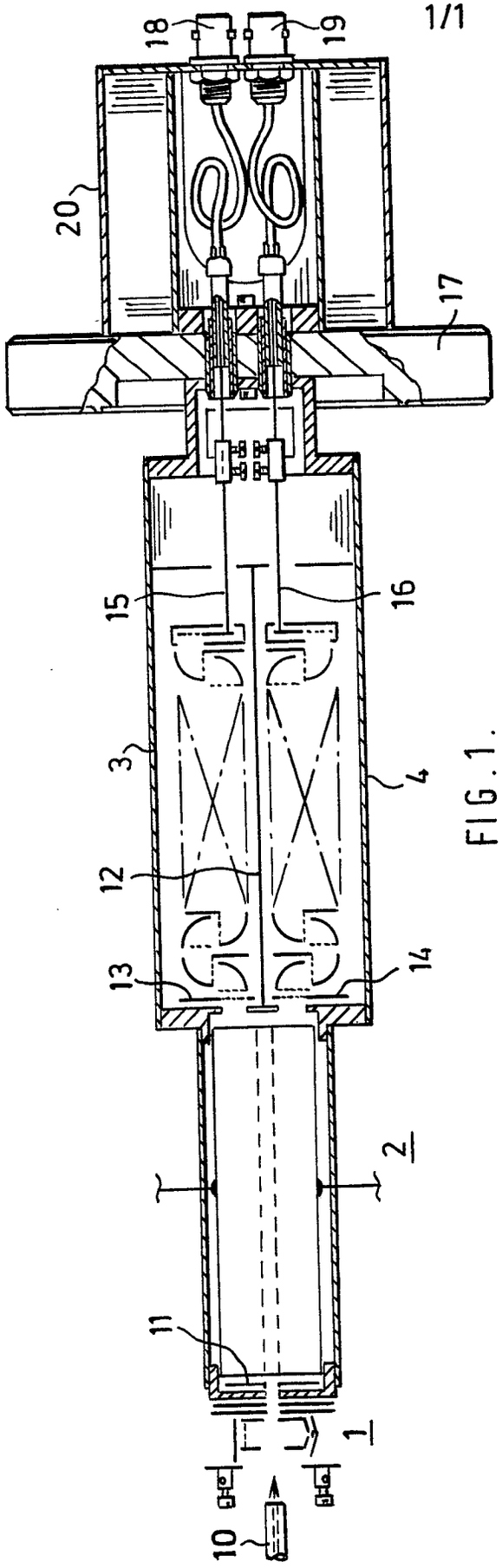

FIG.1.

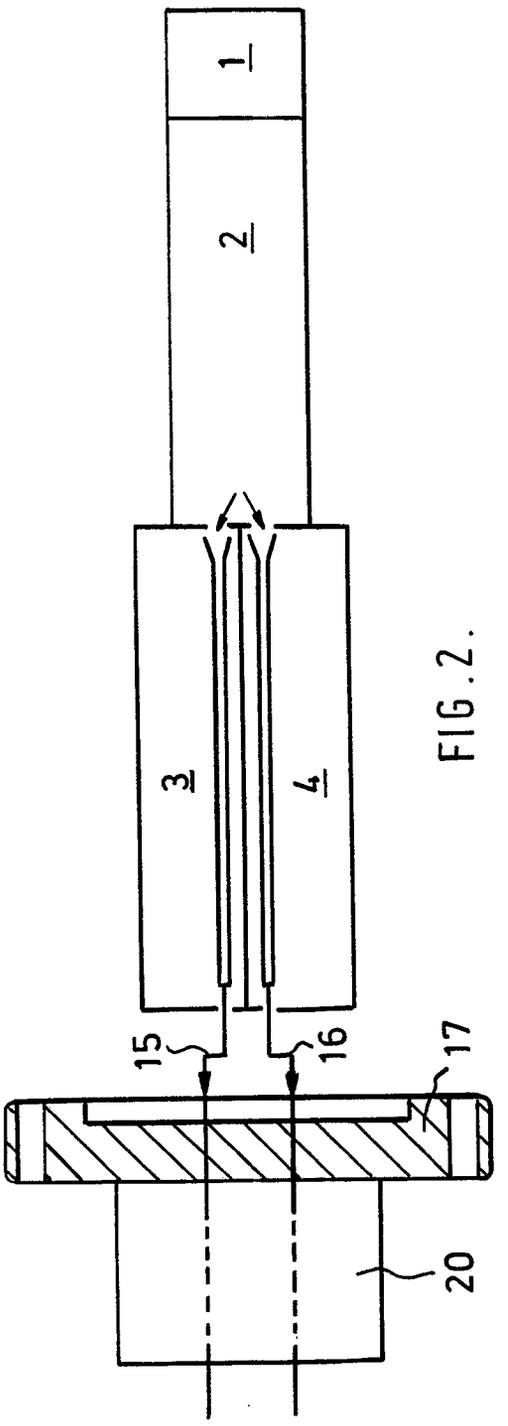

FIG.2.