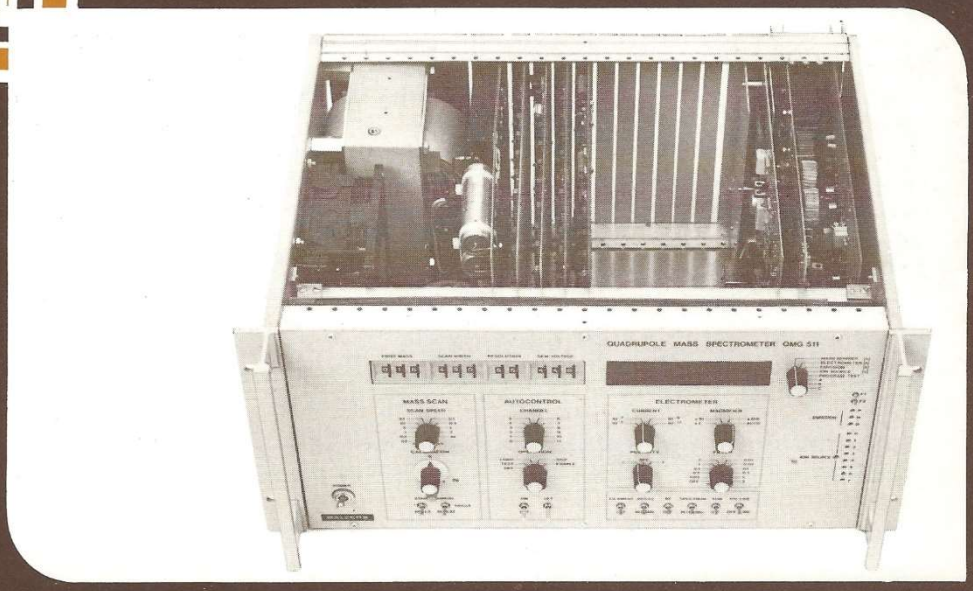
BALZERS Quadrupole Mass Spectrometer QMG 511



An instrument speaking the computer language!

For completely digitized units functioning in binary code the computer language is not a foreign language!

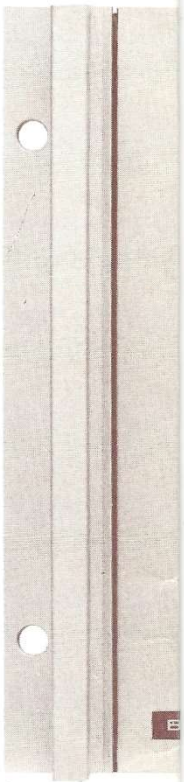
Customers from research and industry initiated the development of the new QMG 511!

The numerous customers (and those who want to become such) of BALZERS quadrupole mass spectrometers from the most differing branches of research and industry told us of their various requisites. Relying on this information regarding customer problems and also on the results of an extensive market research, the elements of a practical instrument could be determined. This was eigtheen months ago.

In the meantime, a team of physicists, chemists and computer specialists have been designing and developing a quadrupole mass spectrometer which, in addition to meeting almost all the requirements of users and because of its plug-in modular design, possesses such a flexibility and versatility for combination with other measuring systems that the future of the QMG 511 is still most promising.

The result arising from this elaborate and extensive development work, the quadrupole mass spectrometer system QMG 511, comprises:

- the completely digitized quadrupole mass spectrometer control unit, with its many possibilities for further extensions;
- the quartz-stabilized RF-generator;
- the extremely fast and sensitive electrometer amplifier with high dynamic working range;
- the high precision analyser equipped with a molybdenum mass filter system;
- a number of plug-in units to be used in many diversified application fields to increase the capabilities of the QMG 511 system.



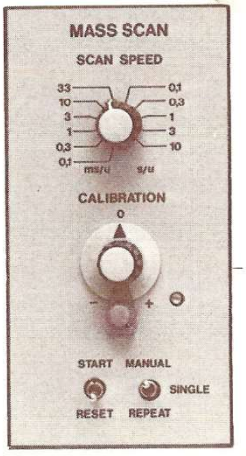
Quadrupole Control Unit

The quadrupole control unit is built in a compact 19" rack module. The basic chassis contains, in addition to the stabilized voltage supply unit, the plug-in units for the different function modules, all equipped with integrated circuits. The quadrupole control unit operates in the digital binary code (second complement) and is assembled wireless, as is nowadays common in the computer technique. A so-called "SpectroBus" ensures that all incoming and outgoing information is led through a common information channel. The operation controls of the QMG 511 differ from the usual quadrupole mass spectrometers inasmuch as the quadrupole function parameters are all electronically digitized. Consequently, this allows the "on-line" operation with a computer processor of both the control functions and data acquisition under real-time conditions, without loss of time and accuracy and with a minimum cost of interface. Moreover, in "off-line" operation, the digitized quadrupole control unit ensures the easy manual operation of the QMG 511 with extremely high accuracy and good reproducibility. The QMG 511 also contains a mass marker allowing the fast and easy determination of any mass number in the whole mass range. For convenient recording of the spectra, the QMG 511 can be connected directly to a strip chart recorder driven by a stepper motor system.

RF-Generator

The quartz-stabilized RF-generator with transistorized output is mounted directly near the quadrupole analyser. The distance between the quadrupole control unit and the RF-generator (standard 3 m) can be extended up to 10 m with a normal connection cable. A remote control of the QMG 511 can be provided for any required cable distance between analyser and control unit.

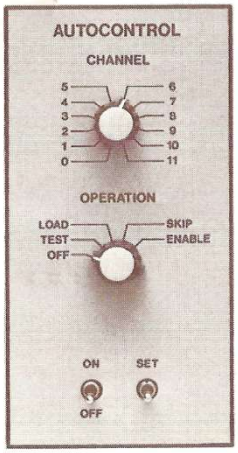
Mass scan



The function group MASS SCAN serves to control the mass scan. The following operation modes can be selected:

SCAN SPEED	11 scan speeds can be selected from 100 µsec to 10 sec per mass unit.
CALIBRATION	Allows the fine adjustment of the mass number
MANUAL	In this position, any point of the mass range can be selected with the FIRST MASS decade switch.
SINGLE	When the START switch is operated the mass range determined by the SCAN WIDTH is scanned starting from the FIRST MASS chosen.
REPEAT	The selected mass range is repeated continuously.

Autocontrol-the f



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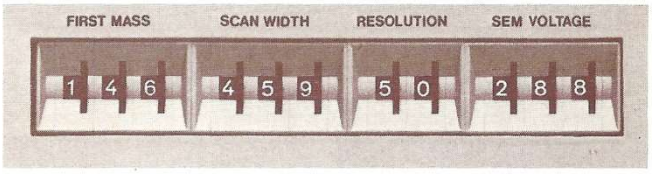
OPERATI

Digital setting with decade thumbwheel switch

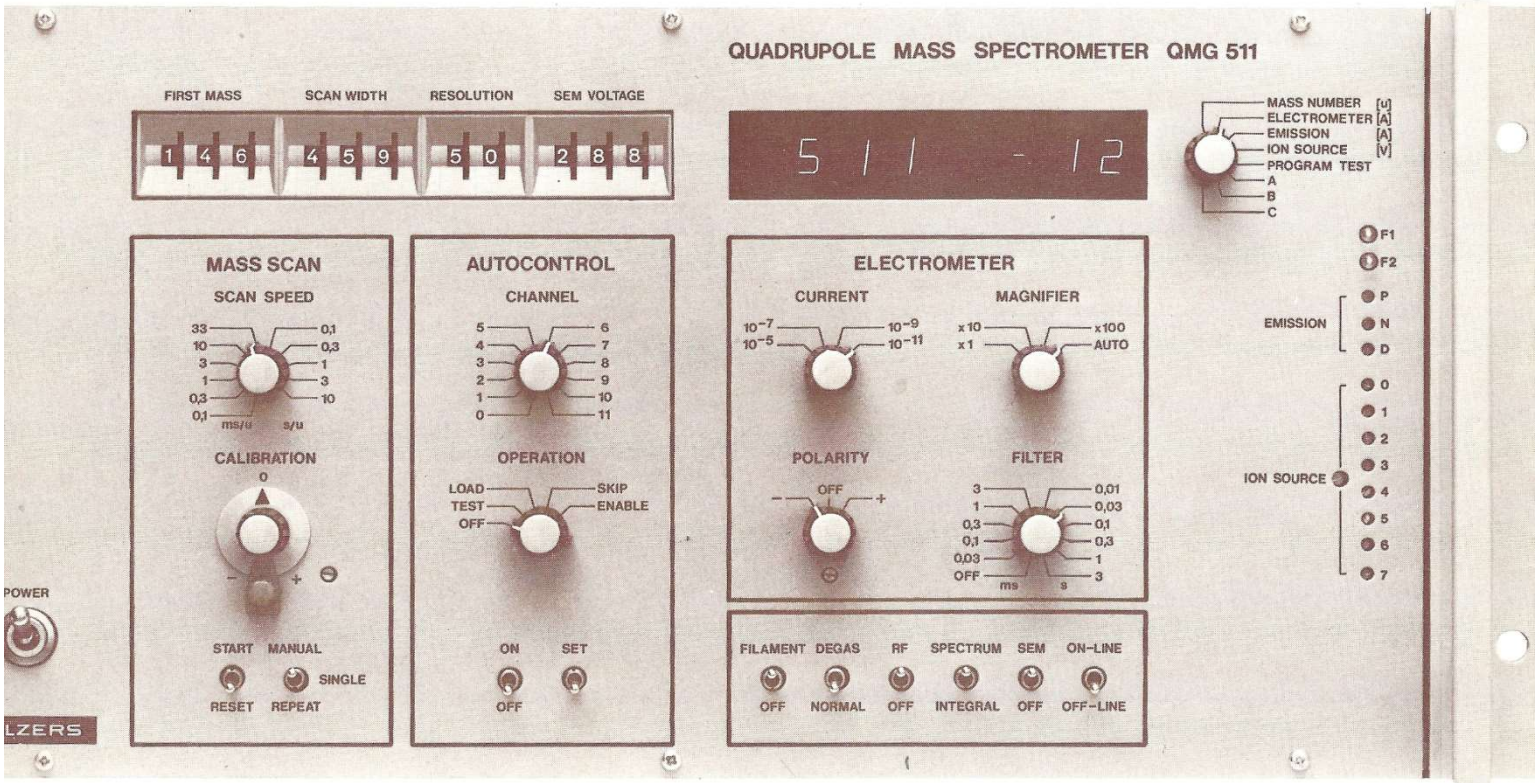


FIRST MASS — With the decade switch a given mass number can be set. The value chosen corresponds also to the first mass number of a mass scan (SINGLE or REPEAT).

SCAN WIDTH — With the decade switch the desired mass range is selected, which is to be scanned. This "SCAN WINDOW" can be moved as required with the FIRST MASS switch.

RESOLUTION — The resolution can be selected reproducibly with the decade switch.

SEM VOLTAGE — If the quadrupole control unit is equipped with the high voltage plug-in unit, the high voltage can be reproducibly set with the SEM decade switch. The set value (x 10) corresponds exactly to the high voltage applied to the multiplier.

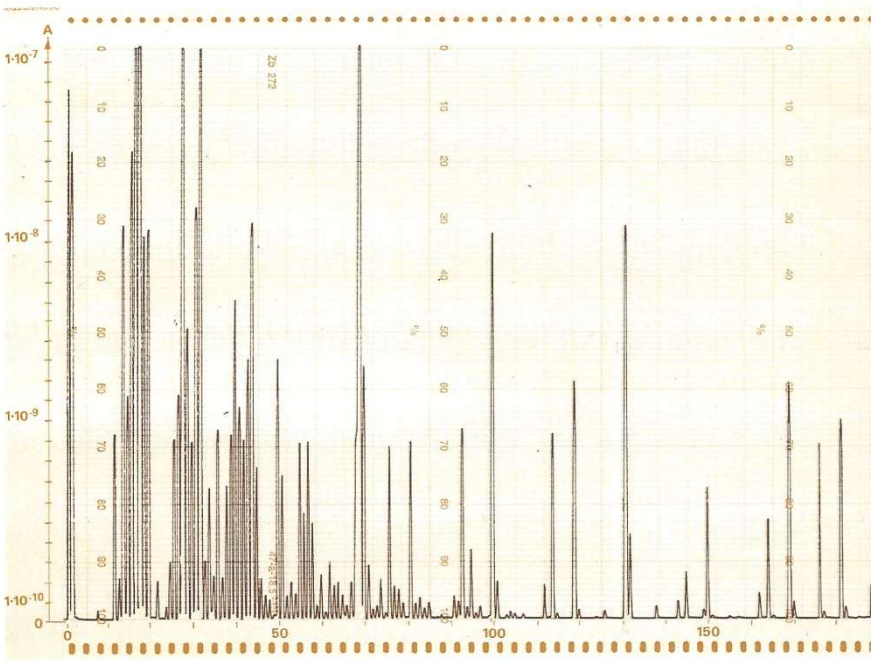


erfect programming system

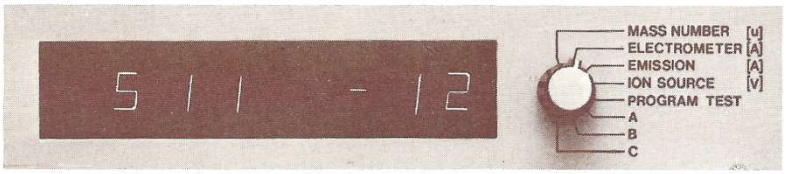
ontrols is operative when the plug-in unit, which is avail-
ın, is fitted. The autocontrol enables to store and control
ly different programmes including the parameters FIRST
CALIBRATION, SCAN WIDTH, RESOLUTION, SEM
SCAN SPEED, ELECTROMETER (CURRENT/MAGNI-
ILTER).

Independent programmes can be chosen and stored in the 12 available channels.

N In the position TEST, the values of the parameters chosen and stored in the various channels can be checked. In the position LOAD, the chosen values are set and stored with the switch SET. During measurements, certain channels can be suspended as required (SKIP) and again reactivated (ENABLE).



Digital display



Depending on the function selected the following parameters can be read on the digital voltmeter:

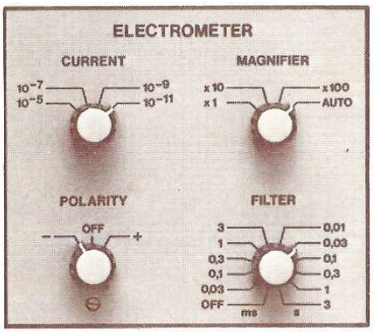
- the mass number
- the electrometer current with automatic indication of the exponent
- the emission current also with automatic indication of the exponent
- the voltage of the ion source with automatic indication of the relevant setting potentiometer
- the programme stored in the AUTOCONTROL

By allowing the representations of digital numbers with a mantissa and an exponent part, the floating point reading is possible. The following example illustrates this:

0.0000000996	→	$0.996 \cdot 10^{-7}$	→	is indicated as	·996	10^{-7}
0.0000001	→	$1.0 \cdot 10^{-7}$	→	is indicated as	·100	10^{-6}

Electrometer – an extremely sensitive and fast amplifier

The function group ELECTROMETER provides digital control of the electrometer directly from the quadrupole control unit. The electrometer with its very short rise times even in the sensitive ranges allows oscillographic recordings of mass spectra without the use of an additional secondary electron multiplier.



CURRENT The electrometer can be switched in 4 sensitivity ranges from 10^{-5} A to 10^{-11} A.

MAGNIFIER The 4 sensitivity ranges of the electrometer can be amplified x 1, x 10 and x 100. In the position AUTO, the magnification is switched automatically very quickly within the three decades. The output signal in this case is quasi-logarithmic, having the advantage of linearity within a decade and a defined zero level.

POLARITY With this converter step it is possible to change the polarity of the electrometer.

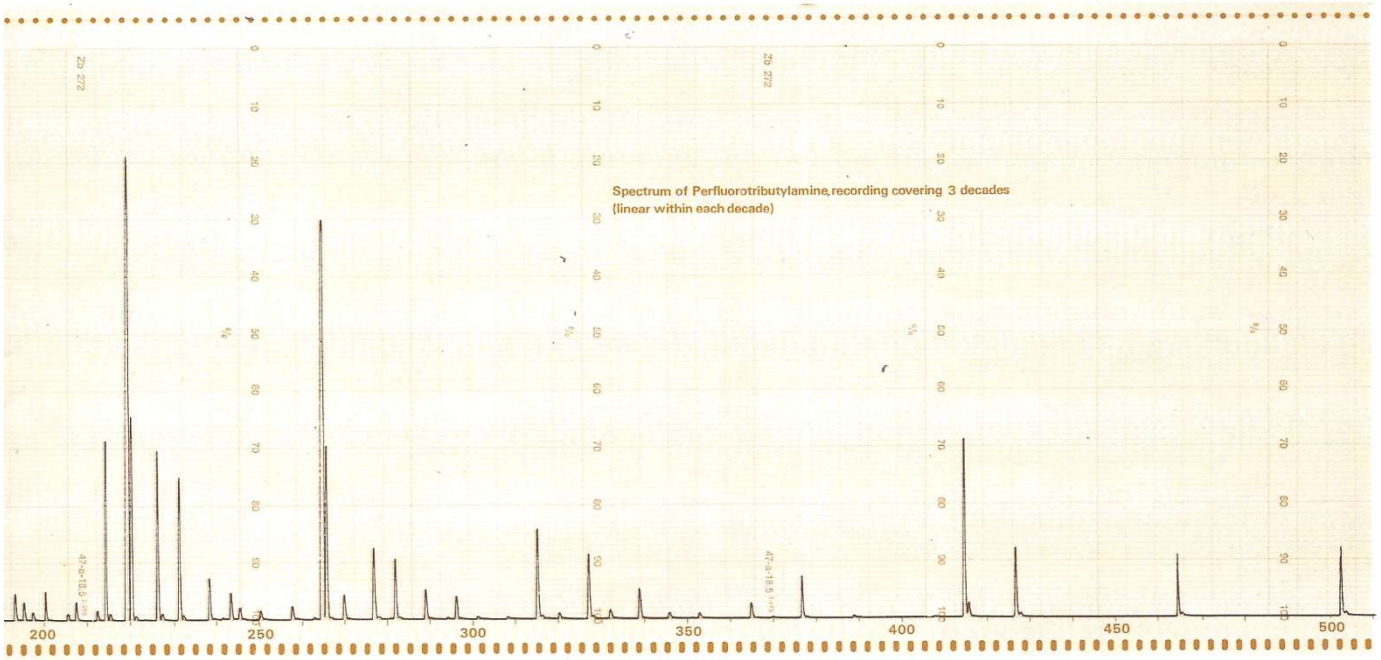
FILTER An 11 step low-pass filter with response times between 30 µsec and 3 sec allows to suppress noise and hum signal.

Options – plug-in units

- SEM high voltage supply
- Autocontrol

In preparation:

- Interface for a processor (computer)
- Peak identifier, to print out simultaneously the electrometer current and corresponding mass number of a mass peak
- Remote control; allows the remote operation of the QMG 511 over a cable distance of several hundred meters.



Spectrum of Perfluorotributylamine, recording covering 3 decades (linear within each decade)

Specifications and features

QMG 511-System

Mass range: 1 to 511, extension possible up to m = 1023

Resolution: constant line width Δ m = 1 at 10% of the peak height over the whole mass range ● At mass 500 variable resolution up to 2000 (full width half maximum, FWHM).

Sensitivity: for Argon, at 1 mA electron emission current, 95 V ionization voltage, measured with axial beam ion source with resolution Δ m = 1 (10%), analyser with Faraday cup $> 4 \cdot 10^{-4}$ A/Torr ● with axial SEM $> 10^3$ A/Torr ● with 90^o off-axis SEM $> 10^3$ A/Torr.

Lowest detectable partial pressure: measured with electrometer, analyser with Faraday cup $\sim 10^{-12}$ Torr ● with axial SEM $\sim 10^{-14}$ Torr ● with 90^o off-axis SEM $\sim 10^{-16}$ Torr.

Highest permissible total pressure: ion detection with Faraday cup $1 \cdot 10^{-4}$ Torr ● with multiplier SEV 117 / $1 \cdot 10^{-5}$ Torr.

Quadrupole Control Unit

Mass setting: single masses with FIRST MASS decade switch, fine calibration of m ± 2 with CALIBRATION rotary switch.

Mass scan speeds: from 100 μsec to 10 sec per mass unit, in 11 steps

Modes of operation: SPECTRUM measurement of normal mass spectra (e.g. determination of partial pressures) ● INTEGRAL measurement of integral spectra (e.g. determination of total pressure) ● MANUAL setting at any point of the mass range ● SINGLE single mass scan ● REPEAT repetitive mass scan ● The AUTOCONTROL programming unit enables storage of any chosen working programme. The following functions and parameters can be programmed: FIRST MASS, SCAN WIDTH, RESOLUTION, SEM VOLTAGE, SCAN SPEED, CALIBRATION, ELECTROMETER (CURRENT/MAGNIFIER/FILTER/POLARITY), filament emission (NORMAL/DEGAS), mode of operation (SPECTRUM/INTEGRAL).

Electrometer: 4 sensitivity ranges covering 3 decades each, current measurement possible between 10^{-5}A and 10^{-15} A. Within each range, the electrometer current signal can be amplified manually or automatically x 1, x 10, x 100 with MAGNIFIER ● 11 step low-pass filter with response times between 30 μsec and 3 sec.

Digital display: with 3-digit mantissa and 2-digit exponent ● function switch for display of mass number ● cathode emission current ● ion source voltage ● electrometer current ● programme-data stored in AUTOCONTROL.

Cathode emission: with automatic switching on second filament in ion source with two cathodes and automatic protection against excessive pressure rises ● Normal: 20 μA to 2 mA – Degas: 2 mA to 20 mA (both adjustable with precision potentiometer)

Ionisation voltage; ion source voltage, field axis voltage, 90^o ion deflection voltage, etc.: 7 stabilized voltage sources, short-circuit safe, continuously adjustable with precision potentiometer.

SEM high voltage supply: from 0 to 3550 V in steps of 10 V, adjustable by decade switch.

Mass marker: after each or every tenth mass.

Mass scan synchronized pulse-maker: adjustable number (max. 1024) per mass unit (for control of recorder with stepper motor drive system).

Outputs: mass scan synchronized pulse output **S** (with half pulse number **S/2**), 0 to 5 V pulse, TTL-compatible ● mass marker pulse output for each mass **M1** 0 to 2,5/5 V; for every tenth mass **M10**, 0 to 5 V, TTL-compatible (**M1** output is also suitable for the connection of UV-recorder oscillograph) ● **SWEEP,** saw-tooth voltage proportional to the mass number, 0 to 10 V, max. loading 1 mA ● 4 electrometer outputs **x 1, x 10, x 100, MAG** (according to switch position MAGNIFIER), 0 to 10 V, max. loading 1 mA.

Cable length: control unit to RF generator 3 m (can be extended up to 10 m) – Analyser to RF generator 0.5 m

Mains: voltage 184 to 260 V and 92 to 130 V, 470 VA – Frequency 47 to 63 cycles

Dimensions: 19" rack panel, 485 x 267 x 330 mm.

Quadrupole Analyser

Ion sources: open axial-beam ion source, filament material: rhenium, tungsten, thoriated iridium, lanthanum boride ● Cross beam ion source, filament material: rhenium, tungsten ● UHV grid ion source, filament material: tungsten ● Standard fitted with rhenium cathodes.

Mass filter system: length and diameter of the rods 200/8 mm – Material: molybdenum in aluminium oxyde ring casings.

Connection flange: NW 63 CF, with copper or Viton sealing (mass filter goes through opening of 50 mm diameter).

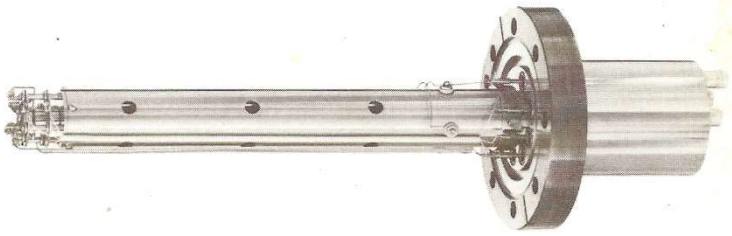
Penetration depth of the mass filter system: from flange connection, excluding ion source: option with Faraday cup 223 mm* ● with acial SEM 132 mm* ● with 90^o off-axis SEM 132 mm*
*) with axial-beam ion source + 26 mm – with cross-beam ion source + 20 mm)

Bakeability: with metal sealing up to 400 °C, with Viton sealing up to 150 °C.

SEV 117: Cu-Be-Dynoden, 17 steps, gain $> 10^8$ at 3.5 kV, bakeable up to 400 °C, in operation up to max. 200 °C.

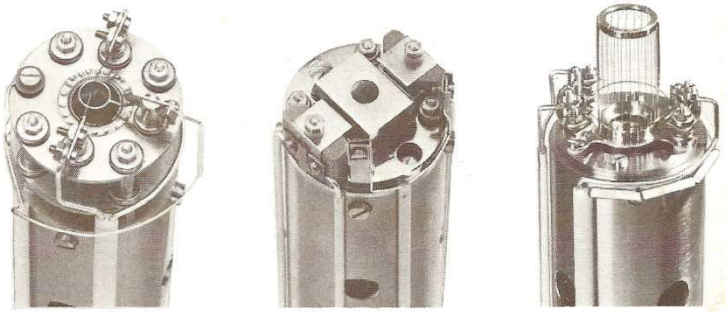
Quadrupole analyser

The new precision analyser comprises the ion source, the mass filter system and a Faraday cup or secondary electron multiplier (SEM).

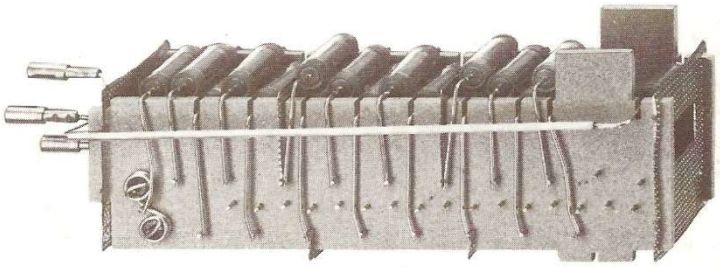


There are different types of ion sources available: the highly sensitive axial-beam ion source, the cross-beam ion source with two cathodes or the grid-extractor ion source with two cathodes for UHV-conditions. In any situation the appropriate ion source can be chosen for the measuring problem to be solved. The ion sources are interchangeable.

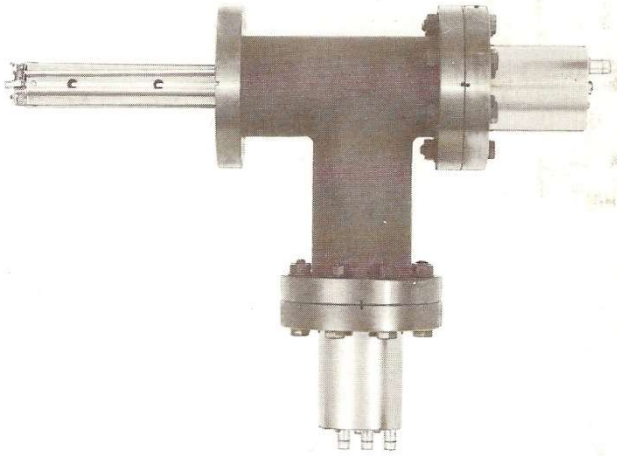
Molybdenum rod electrodes fixed in aluminium oxyde ceramic rings are standardly used in the new high precision mass filter system. The mechanical precision of the mass filter system is so high that the optimum calculated values for the resolution and transmission are achieved in practice.



The fast SEV 117 fitted with 17 Cu-Be-dynodes has a very high gain, low background noise level and is almost insensitive to air exposures. Thanks to these most favourable features extremely low partial pressures can be measured; even single ions can be detected, using a suitable ion counting system.



Quadrupole analysers with axially mounted secondary electron multipliers or perpendicular to the mass filter system axis are available. In the latter configuration, a very good signal-noise ratio is obtained, allowing partial pressure measurements of some 10^{-16} Torr and concentrations determinations in the ppb range.



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