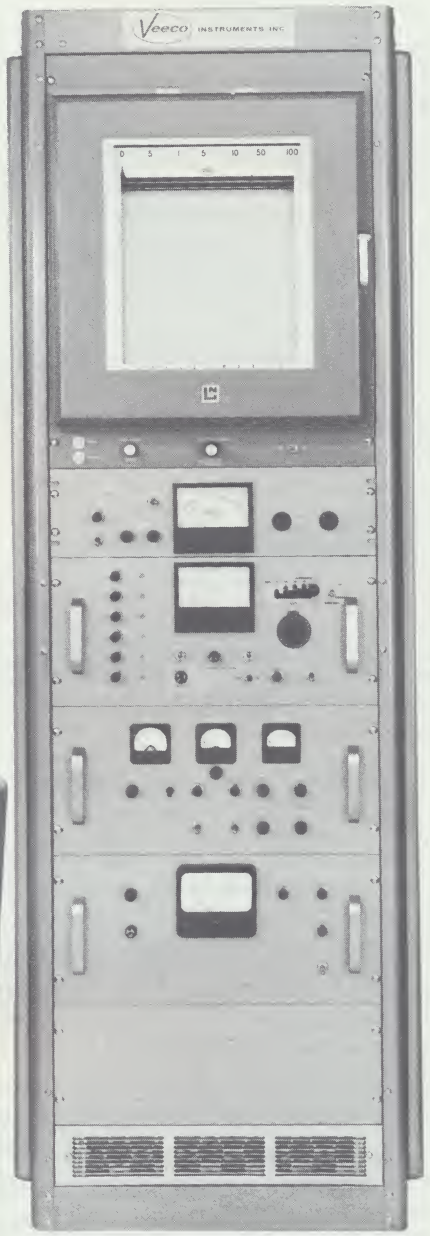
GA-4 Console



GA-4 Rack

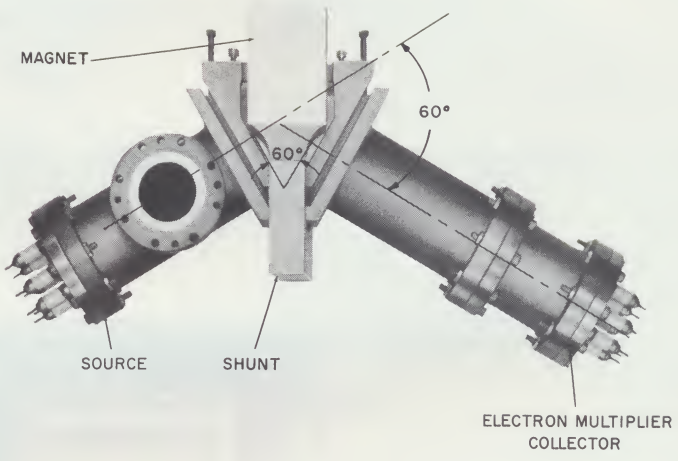
Veeco®

MODEL GA-4
RESIDUAL GAS ANALYZER

A Highly Versatile, High-Performance MASS SPECTROMETER GAS ANALYZER

RESIDUAL GAS ANALYZER SYSTEM

TYPE GA-4 AND GA-4R



VEETUBE

FEATURES AND ADVANTAGES

HIGHLIGHTS

- MINIMUM DETECTABLE PARTIAL PRESSURE — At least $1x10^{-13}$ torr of nitrogen.
- MASS RANGE — 2-300 a.m.u. The range is covered in two increments: 2-50 a.m.u. and 12-300 a.m.u. Mass I capability available.
- RESOLUTION — unit resolution at mass 100 as measured at 10% of peak height (see condensed specifications on page 17). Excellent adjacent peak separation to mass 150 (see page 15.)
- VERSATILE SLOW AND FAST MASS SCANS — extremely slow scans for detailed analyses, or fast scans for monitoring rapidly changing situations.
- SCANNING — automatic and manual; single peak monitoring possible; entire mass range or a selected section may be automatically or manually scanned.
- READ-OUT — choice of meter, recorder, oscilloscope, or all three.
- ANALYZER TUBE — repeatedly bakeable to 400°C, electron multiplier to 300°C.
- SOURCE AND COLLECTOR ASSEMBLIES — Field demountable flanged source and collector assemblies.
- FILAMENTS — Self-aligning, rugged tungsten filament is easily replaced in the field.

The VEECO GA-4 Residual Gas Analyzer is an integrated system for analyzing and recording the composition of residual gases in evacuated chambers. The system is comprised of an analyzer tube and a control console.

Analysis is effected by a mass spectrometer. The mass spectrometer analyzer tube is made to attach directly to the system under investigation. The tube is bakeable and suitable for ultra-high vacuum use. All necessary instrumentation, amplifier, and power supplies, and a strip chart recorder are contained in a mobile, desk-type control console. The GA-4 can be operated by non-specialists and maintained by laboratory or plant personnel.

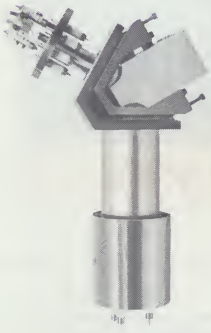
The GA-4 Residual Gas Analyzer is distinguished by its offer of high sensitivity, resolution, and range in a package having an extensive variety of options and special features.

MINIMUM DETECTABLE PARTIAL PRESSURE

The GA-4 can detect a partial pressure of $1x10^{-13}$ torr (nitrogen reference). This means that in a system with a total pressure of $5x10^{-8}$ torr (a pressure typical of many quality research and processing operations), the GA-4 can reveal constituents of the vacuum environment down to two parts per million (1/500,000th of those gases existing or remaining in the $5x10^{-8}$ torr vacuum), if the minor constituents are not of relatively high mass and in very close proximity to and therefore masked by a major constituent.

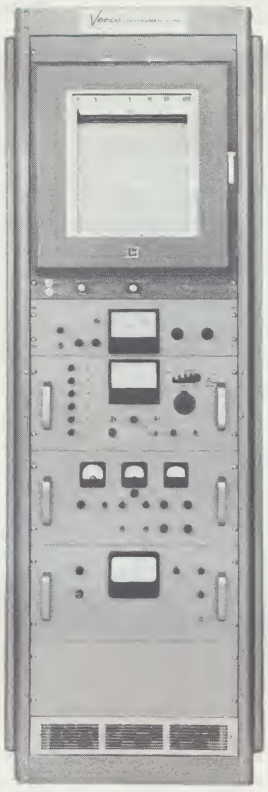
This figure takes into consideration the output sensitivity and the overall inherent noise limitation of any gas analyzer, not merely the noise level of the ion detector electronics. Veeco uses a signal-to-noise ratio of greater than one to define this capability.

Nude source tube is available on special order.



TUBE

CONSOLE



RACK MOUNT

RESOLUTION *(see also page 14)*

"Resolution" describes the ability of the instrument to separate adjacent mass peaks. However, since "Resolution" is defined in a different way by almost every instrument manufacturer, the most certain method for comparative evaluation is to study actual scans. GA-4 resolution is such that at mass 100, adjacent masses one unit apart are separated almost to the baseline (to 10% of the sum of the two adjacent peak heights).

Inspection of actual GA-4 scans will reveal that the GA-4 can "separate", in the sense of simple gross discrimination, two adjacent peaks up to about 150 a.m.u., and will "separate" (distinguish) masses two mass units apart high into the 200's, and often as high as 300 a.m.u. An improvement in resolution can be obtained with very little decrease in sensitivity by tuning the GA-4 on high masses (such as xenon) rather than low masses (nitrogen) as is usually done for convenience.

MASS RANGE

On the GA-4, a total useful mass range of 2 to 300 a.m.u. is covered in two increments —12 to 300 a.m.u. with the standard permanent magnet, and 2-50 a.m.u. with a furnished calibrated shunt on the magnet.

The shunt is very easily placed on the permanent magnet with a screw-adjust "let-down" and "drawup". No alignment or retuning is necessary when transferring from one range to another.

A saddle fixed in position on the VeeTube at the factory guarantees correct alignment of the magnet at all times. Should the magnet be removed, it can be replaced in half a minute, and requires no readjustment.

MULTIPLE SCAN MODES

The GA-4 affords a great deal of flexibility in its mode of readout, comparable to much more costly and sophisticated systems. The GA-4 has provisions for three modes.

The recorder mode uses a built-in chart recorder with 5, 10, 20, and 40 minute scans. This mode is useful for the great majority of analyses, and automatically provides a permanent record.

The scope mode, made possible by the electron multiplier, provides instant displays for fast evaluations of a system. It also permits study of fast-changing conditions in a system, such as during the short period of a thin-film evaporation.

The unique scope-recorder mode of the GA-4 permits use of a very slow external sweep (generally from an oscilloscope) to drive the mass sweep scans which are displayed on the chart recorder. This allows highly detailed study within a limited mass range, provides for great expansion in the high mass ranges, and fully realizes the maximum resolution capabilities of the instrument.

THREE-DECADE LINEAR SCALE

The chart recorder amplitude scale of the GA-4 is unique and exclusive with Veeco. It essentially presents three ranges at once on one extended scale. The advantages are several. There is no longer any need for continuous monitoring by the operator, so the scale need not be changed for every large peak. Successive time-consuming runs at different sensitivities are no longer necessary. Two peaks, one 4,000 times the amplitude of the other can stand side by side on the chart, both quantitatively readable.

MANY OPTIONS

Veeco provides the GA-4 to you in a variety of forms, and with a variety of options, to best suit your requirements. The GA-4 cabinet may be a unique desk-type mobile console, or it may be a standard equipment rack. The mass spectrometer tube may have a conventional source assembly, or it may have an exposed ("nude") assembly which is mounted directly in a vacuum system. The mass spectrometer tube may have a high-gain electron multiplier prior to the ion collector, or the electron multiplier may be omitted. These options permit you to select the combination that best fits your requirements and budget. In addition, other options and accessories are available on special quote.

The GA-4 is a complete system, ready to attach to your chamber or vacuum system and provide a gas analysis. It has the reliability associated with Veeco products, and each system is thoroughly performance-tested before leaving the plant. Each unit is shipped with an actual scan taken on a UHV system.

APPLICATIONS

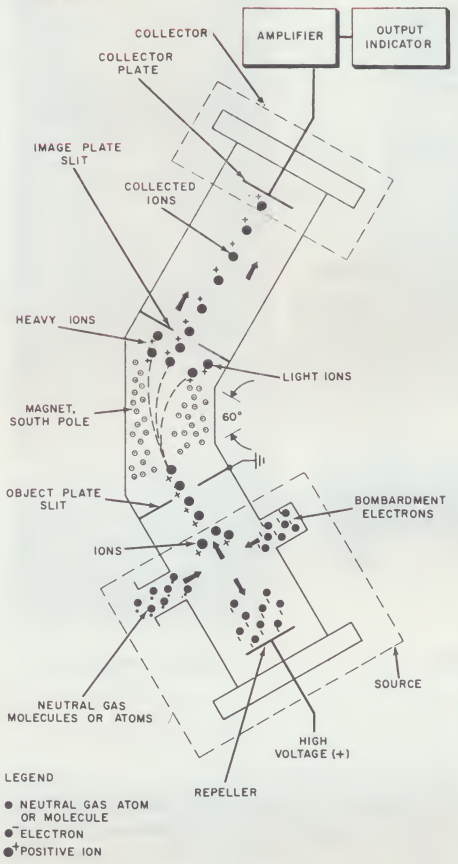
Typical areas of application for the GA-4 . . . in very-high and ultra-high vacuum environments . . . includes the following:

- Space simulation chamber studies.
- Material research studies in ultra-high vacuum.
- Vapor pressure studies
- Determining the limitations to the attainment of ultra-high vacuum.
- Leak detection.
- Thin film evaporation studies.
- Surface and film studies.
- Low pressure vacuum melting of ultra-pure metals.
- Thermal decomposition and vacuum degassing investigations.
- Electron tube exhaust and processing.
- Life testing of sealed off vacuum devices.
- Trace gas analyses.
- Trace contaminant analysis.
- Process monitoring.
- Isotope studies

The instrument is also suited for process control and for general gas analysis applications.

It is sometimes convenient to use several GA-4 mass spectrometer tubes at various points in a vacuum system or on several systems in a laboratory or plant. The GA-4 is well-adapted for this type of application since the mass spectrometer tube with its small, integral magnet, mounts conveniently and in any position, and the GA-4 console can be easily wheeled to appropriate locations to monitor the various mass spectrometer tubes.

THE MASS SPECTROMETER TUBE



The Veeco "VeeTube" used with the GA-4 is a 60° magnetic-sector type mass spectrometer tube, found to be most reliable and versatile for gas analysis.

The VeeTube is connected to the system to be analyzed at the source end of the VeeTube. The gas of the system diffuses into the source area, where ionization takes place by electron bombardment.

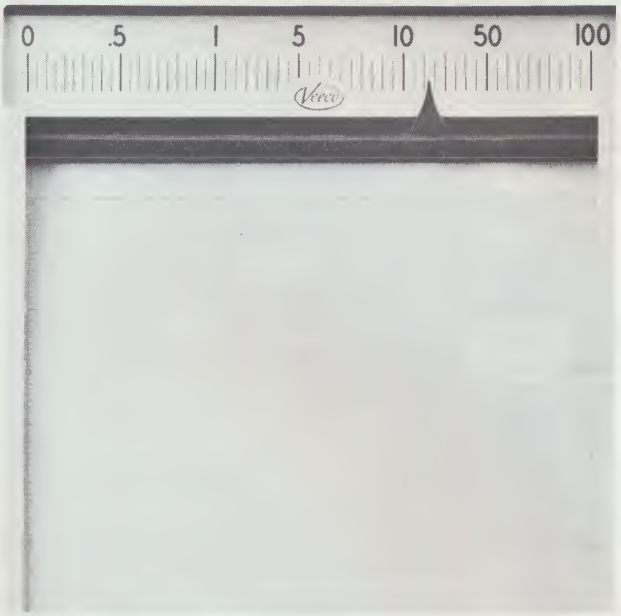
Electric fields focus the ions into a beam and accelerate them down the length of the tube. The magnetic field deflects the ions in proportion to their mass, charge, and velocity. By varying the energy of the ions (by the accelerating voltage at the source object plate), various masses can be "tuned in" and their abundance measured at the collector.

Veeco has been producing mass spectrometer tubes of this type for twenty years. The VeeTube is a well-engineered device of great reliability, and is simple and straightforward in its use. The VeeTube is the device that makes possible the high sensitivity and resolution of the GA-4. Reliability and flexibility is assured by such facets of design as stainless steel construction, Nicrobrazed joints, flange-mounted source, collector, and electron multiplier assemblies, beryllium copper (for great tolerance to atmospheric exposure) electron multiplier, conservative electron multiplier gain rating (10^6, normal capability is 5 times this), magnetic shielding, sturdy ceramic-to-metal feedthroughs for withstanding repeated bakeouts, small lightweight permanent magnet, and a saddle arrangement that is fixed in position at the factory to guarantee quick, correct self-alignment of the magnet at all times.

THE CONSOLE

1 PULLOUT DRAWER. The drawer contains controls and meters for adjusting filament emission, filament current, focusing potentials, as well as electron multiplier voltage. Once the instrument is set up, the drawer may be closed to avoid accidental misadjustment. All exposed front panel controls are non-critical, and control settings can be easily regained if accidentally changed. All operating controls for accessories to GA-4 are located on the front panel. All controls can be managed by relatively unskilled personnel.

2 CHART RECORDER. The special chart recorder includes a special scale potentiometer with decade taps to provide the unique three-decade linear scale. Each decade is linear and permits the recording and direct comparison of peaks having ratios as great as 4,000 to 1. The three-decade linear scale combines the visual advantages of a logarithmic scale with the accuracy and readability of a linear scale.

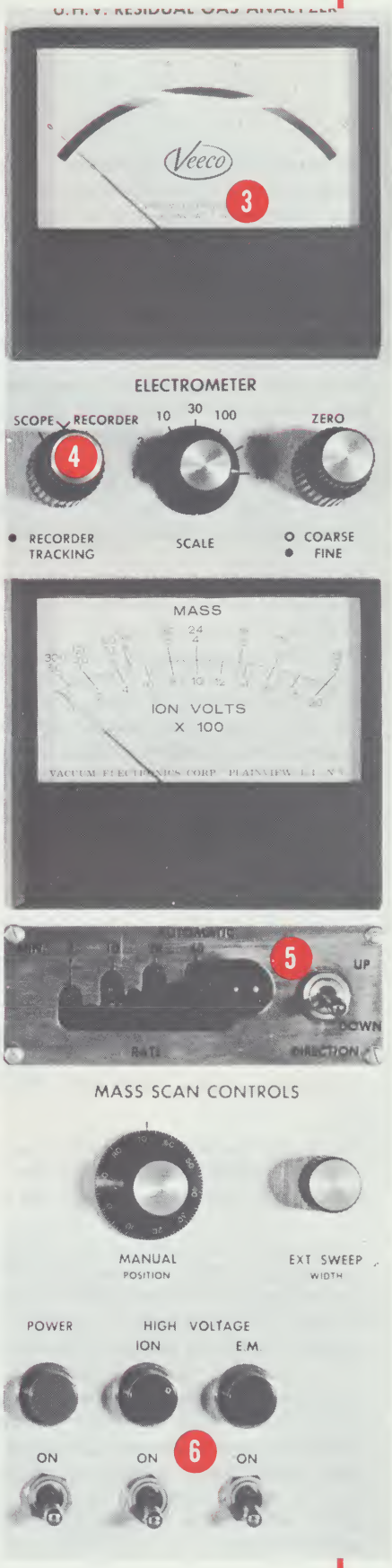


3 ELECTROMETER OUTPUT. The detected and amplified ion current is monitored on a front panel meter at the same time it controls the chart recorder pen or scope vertical deflection. Its use facilitates prescan adjustments, location of large peaks, single-peak monitoring, and calibration checks during scope scanning. The scale selector controls both the meter and the chart recorder. The easy-to-use zero control is used to set the position of the baseline on the chart recorder or scope.

4 MODES OF OPERATION. *Recorder Mode:* an integral part of the GA-4. *Scope Mode:* connections are provided for an oscilloscope. Once connected, the extent of sweep of the ion voltage is controlled by the external sweep knob, and can be instantly switched in or out by the Scope-Recorder switch. *Recorder-Oscilloscope Mode:* the output of the analyzer is traced on the recorder, with the scan derived from the scope sweep. This is principally of use in taking advantage of the extremely slow sweep which most modern oscilloscopes afford.

5 MASS SCANNING. Manual scanning, including single peak monitoring. Automatic at four speeds, 40, 20, 10, and 5 minutes for a complete mass range. Oscilloscope scanning is possible down to 10 milliseconds, best used for segments of the mass range. The extremely slow scan speeds afforded by the scope sweep can be used to expand segments of a mass range to obtain highly detailed presentations.

6 POWER SWITCHES. Power is controlled by three switches, a main power switch and two supplementary ones for the mass spectrometer tube ion source and electron multiplier.



NEW GA-4R RACK MOUNT

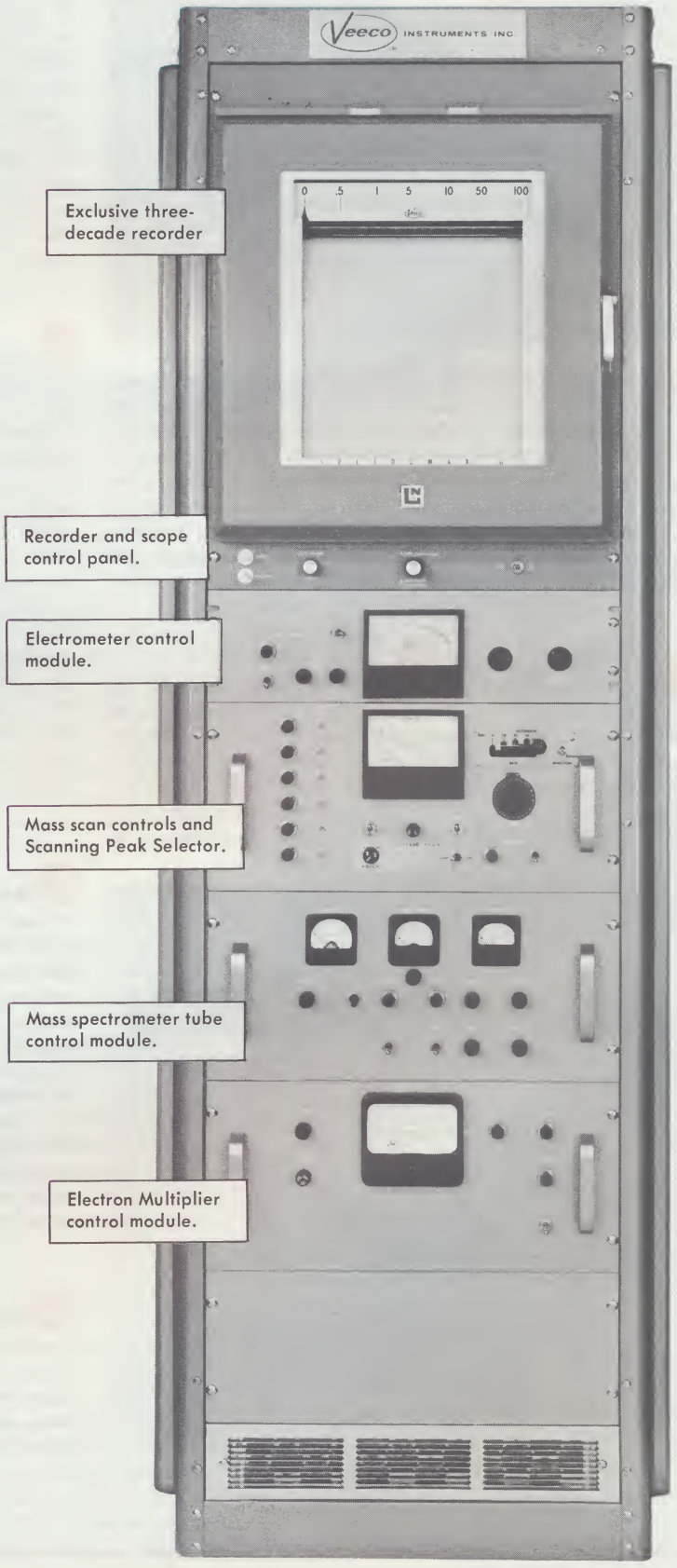
The same high performance and scanning features of the standard GA-4 console model are included in the GA-4R, plus additional features of convenience and versatility.

The GA-4R is unique in that it may easily be upgraded in the field, following purchase of a more economical version. For example, the most economical version of the GA-4R utilizes an ion collector in the mass spectrometer tube. An Electron Multiplier can be easily added to the system later in the field to obtain a 10^3 times improvement in Minimum Detectable Partial Pressure and an improvement in maximum scan speed. The three-decade-linear chart recorder may also be added at a later time.

The GA-4R is equipped with a variable ionization potential, helpful in analyzing complex scans.

Accessibility for maintenance is unmatched by any other analyzer in the field. The drawers on the GA-4R are mounted on slide-out guide bars, and may be removed for service simply by unplugging rear connections. For accessibility to the rear of all drawers, a full-height door is located on the back of the rack-mount chassis. The rack-mounted configuration has many other convenience features. Being rack-mounted the unit requires minimum floor space, so is ideal for a crowded laboratory. Because the drawers slide out, field upgrading is merely a matter of plugging in additional drawers. Thus, even the mounting of the GA-4R offers the *unmatched versatility* so characteristic of GA-4 performance and operation.

The GA-4R also offers a special option not presently available in the GA-4 console. A Scanning Peak Selector is available for automatic monitoring requirements.



SCANNING PEAK SELECTOR

This device permits automatic or manual sequencing to a series of pre-selected points in the mass range at which the GA-4 then scans over a selected range of masses.

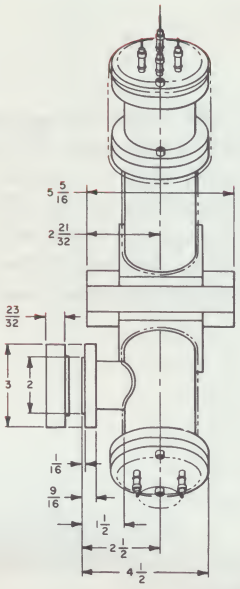
Six points in the 2-300 a.m.u. range can be selected for monitoring by the adjustment of six independent trimmer potentiometers. A motor-driven stepper automatically steps through the six preset points. The duration of time the stepper remains at each point is variable 0-60 seconds.

As the name implies, each selected peak can actually be scanned, thus assuring proper analysis. In addition, scan width and scan speed can be varied by separate controls. Scan width at each point to which the analyzer is indexed may be varied from zero for single peak monitoring, to a width sufficient to observe several masses in regions of special interest.

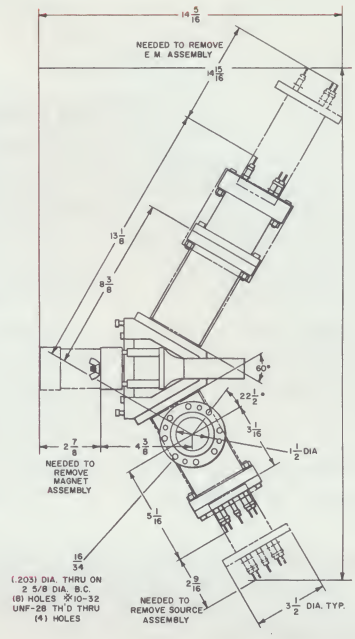
A manual mode permits sequencing only by pushbutton command. Additionally, use of the pushbuttons can override the automatic cycle at any time.

DIMENSIONS

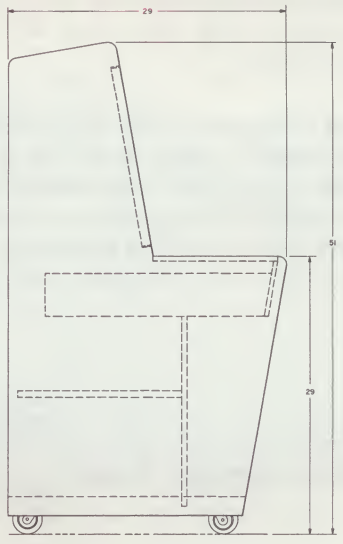
FOR TUBE, CONSOLE & RACK.

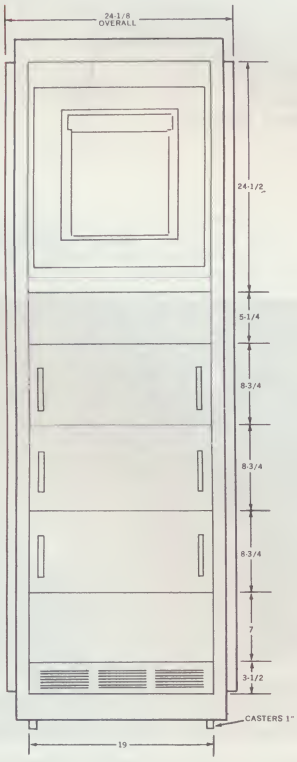


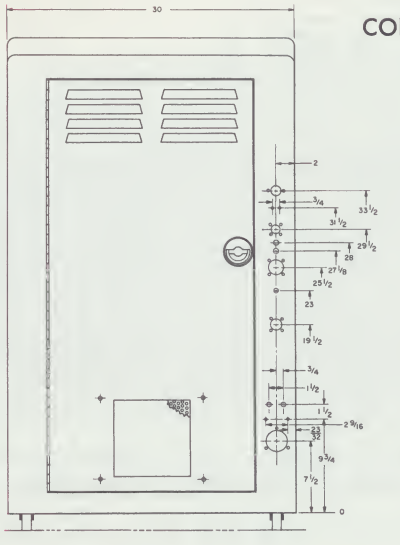
TUBE



RACK







CONSOLE

SCANNING CHOICES

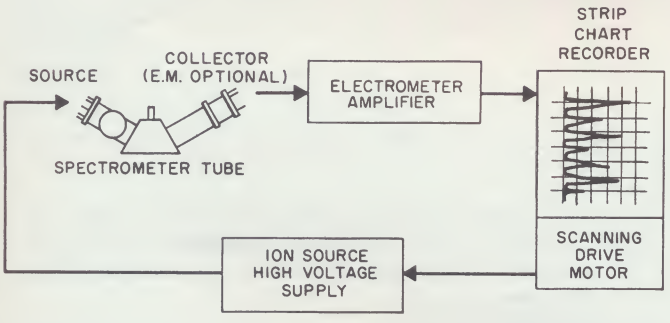
Part or all of a mass range can be scanned either manually, automatically or by means of an external sweep generator. The scan can go from low mass to high mass, or in the reverse direction, for both the manual and automatic scans. The modes of scanning are discussed below according to the method of scan display chosen. The choice of display is made by simple turn of a selector switch. In all cases, the mass being scanned at a given instant is identified on the scale of the "Mass" meter; the "peak" signal magnitude can be adjusted by means of the sensitivity switch, marked "Scale".

FOR GENERAL USE—

1. RECORDER DISPLAY

a) Manual Mode. All or part of a mass range can be covered by turning the "Manual Position" knob. (See photo cut-out). A single peak can also be monitored.

b) Automatic Mode. Any one of four scan speeds can be chosen by setting the "Automatic" selector rod to 5, 10, 20 or 40 minutes (for a complete mass range). If the "Manual Position" knob is initially set at other than the zero mass position, the scan will be over only the masses greater than that determined by the setting; or, if the scan is the reverse direction, over only the lesser masses.



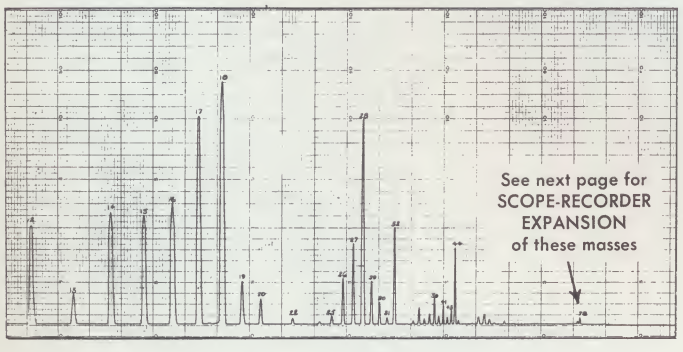
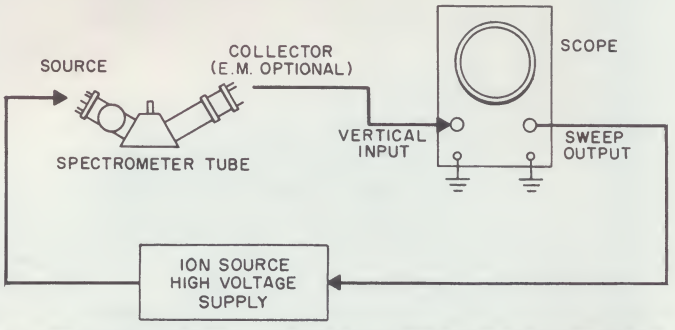


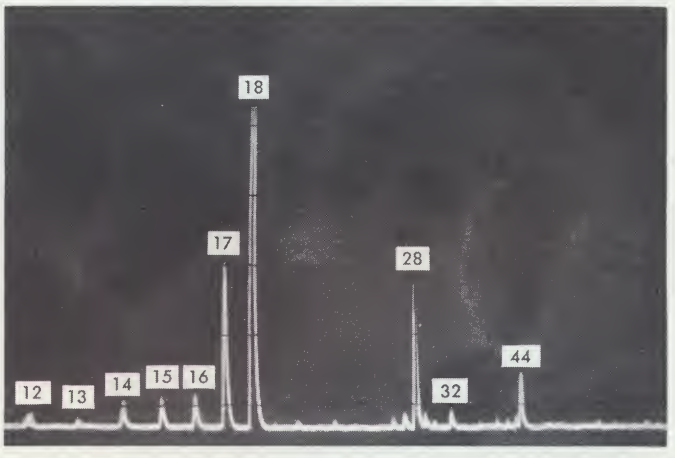
Chart recorder scan of Veeco "775" high vacuum evaporation system at 3 x 10^{-8} torr.

FOR VERY FAST SCANNING—

2. SCOPE DISPLAY

Connections are provided for attaching an oscilloscope to the GA-4. The scan speed is set by the oscilloscope sweep speed. If both the "Manual Position" and "Sweep" knobs are in their extreme clockwise position, the whole mass range is scanned. Any other setting of the "Manual Position" knob determines the low mass limit of the scan; the setting of the "External Sweep Width" knob *then* determines the upper mass limit. A 10 millisecond scan is feasible for a limited segment of a mass range; a tenth of a second suffices to cover the entire spectrum. No loss in sensitivity, resolution, etc. occurs. Faster speeds are possible with some sacrifice in performance.



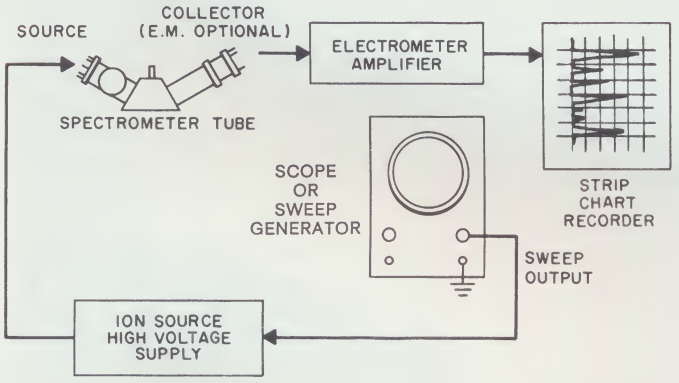


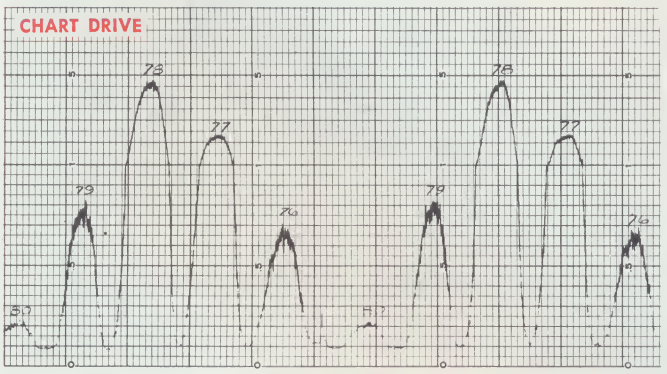
Fast scope scan (100 ms) of entire range shown on chart recorder scan at left (same vacuum system).

FOR SLOW DETAILED SCANNING—

3. SCOPE DRIVE/RECORDER DISPLAY

By setting the selector switch to the middle position, indicated by a forked line, the scan is displayed on the recorder, but the scan speed and mass range are determined by the scope and the control settings as described in "2" above. In this way, very slow scans (several hours) can be used to "blow up" a segment of the spectrum to clarify its structure. The Scope/Recorder mode is also extremely useful for recording repetitively a chosen mass range. Any suitable slow sweep generator may be used if an oscilloscope is not readily available.





Highly expanded scope-recorder scan of region near mass 78 (same vacuum system as chart and scope scans at left). Sensitivity is increased. Mass 78 is approximately 5 x 10^{-11} torr partial pressure. Scan is repeated; note good reproducibility.

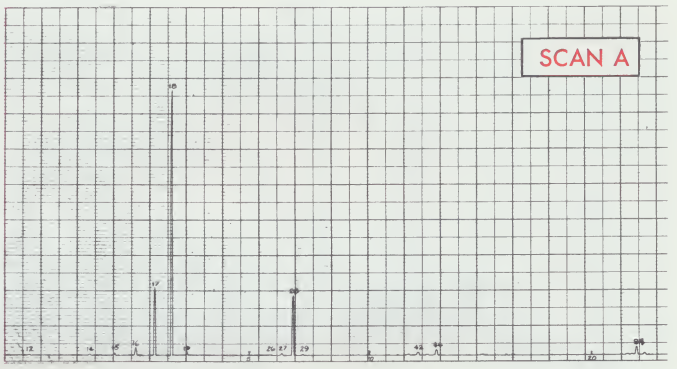
THREE-DECADE LINEAR CHART RECORDER

An outstanding feature of the GA-4 is the three-decade recorder, which virtually eliminates the need for manually attenuating the output display. With the Veeco recorder *three full linear decades* are displayed, and peaks changing from one decade to the next are automatically attenuated. Adjacent peaks with ratios of at least 4000 to 1 may be easily read. Thus, with the three-decade recorder you are assured of observing *all* peaks, not just the larger ones.

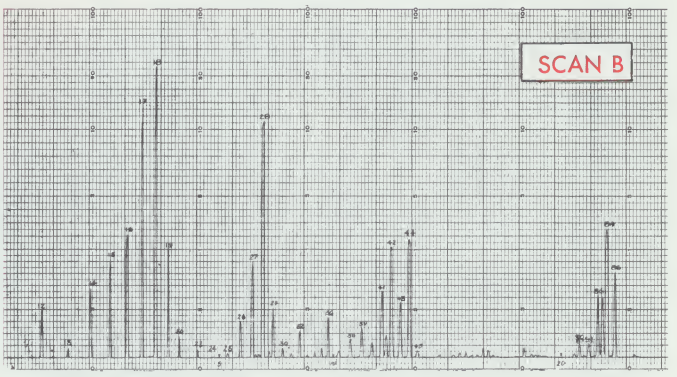
This makes qualitative and quantitative mass analysis and interpretation easier, more accurate, and more reliable, by insuring that no peak is missed completely or recorded at too low or too high a level to be precisely measured. For proper analysis, all peaks are important, not just the larger ones, since the smaller peaks are usually necessary for a proper identification of peaks and interpretation of the true condition of the system under study.

As an example, note the two unretouched scans shown below. Scan A was taken with a straight linear recorder; Scan B with the Veeco three-decade recorder. The scans were taken only a few minutes apart on the same system, using the same GA-4 tube and console. Krypton gas was added to assist mass identification.

Numbers *below* base line indicate points at which scan speed was changed (e.g., from 20 min/mass range to 10 min/mass range, at point 10).



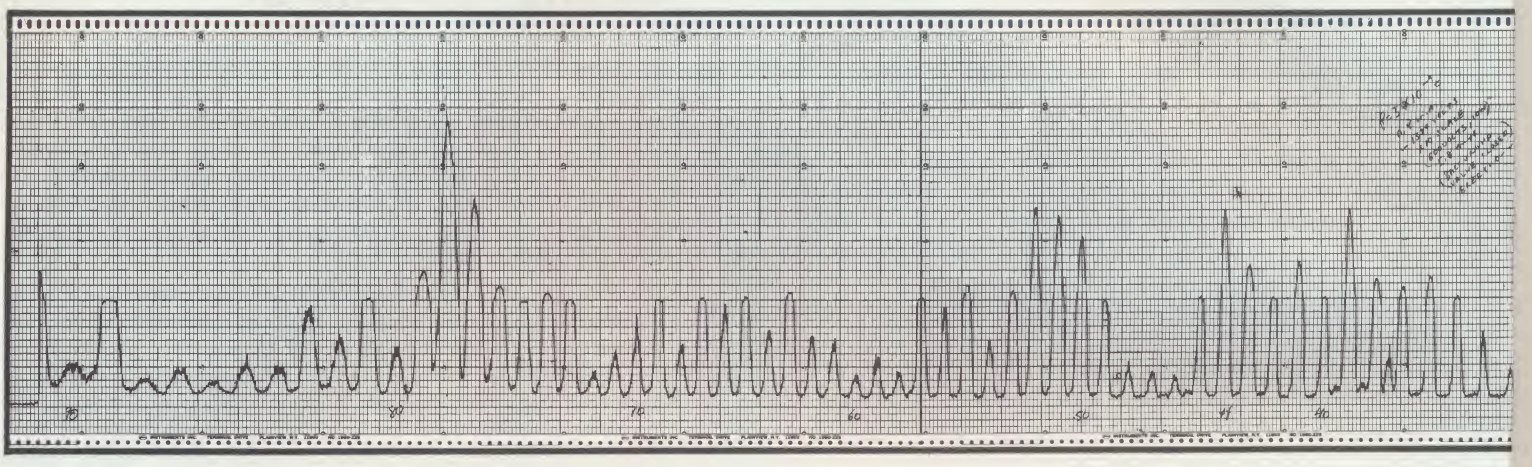
LINEAR SCAN of a given vacuum system shows only larger peaks, requires change of scale to see smaller constituents. If more sensitive scale is used, operator must stand by equipment and change scale to anticipate large peaks which would otherwise go off scale.



VEECO THREE-DECADE LINEAR SCAN of same system reveals many smaller peaks unobserved with linear scan above, permits much better appreciation of system condition and simplifies analysis of masses and mass patterns, all without changing scale during scan.

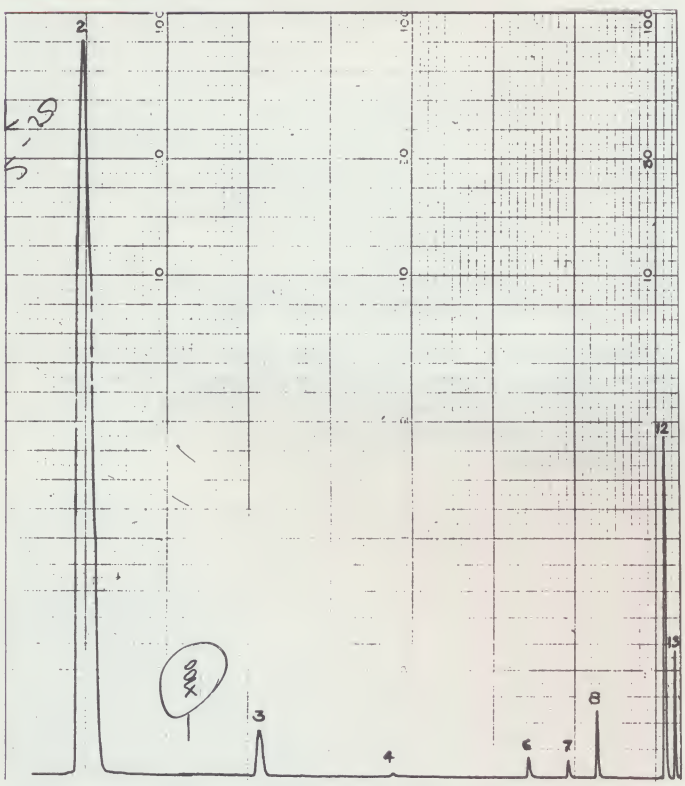
MASS RANGE

2-300 a.m.u.



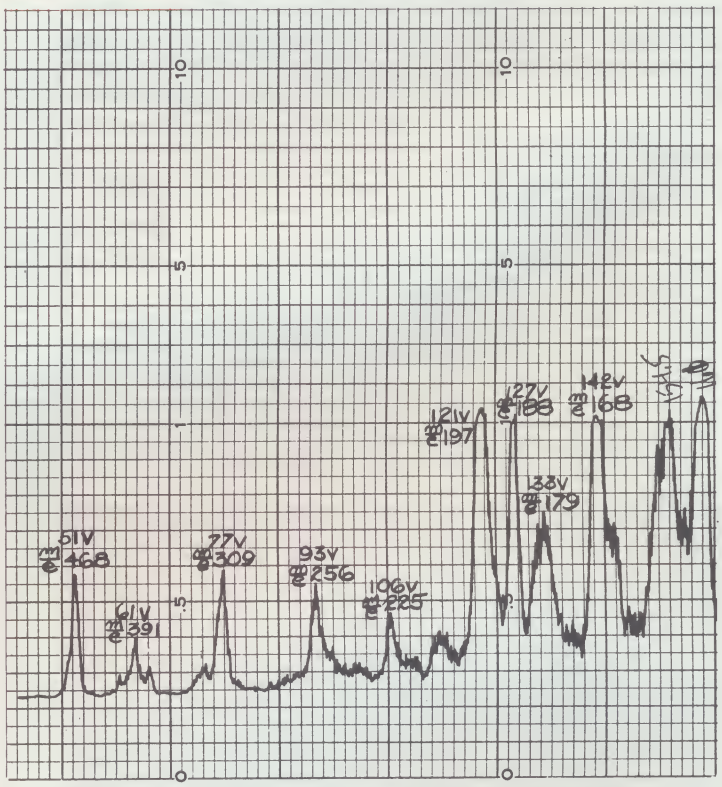
Scan taken on GA-4 using electromagnet scanning. High masses are automatically expanded, entire mass range is covered without shunts, mass range is greater, and mass one can be seen. 3×10^{-9} torr total pressure.

LOW MASSES

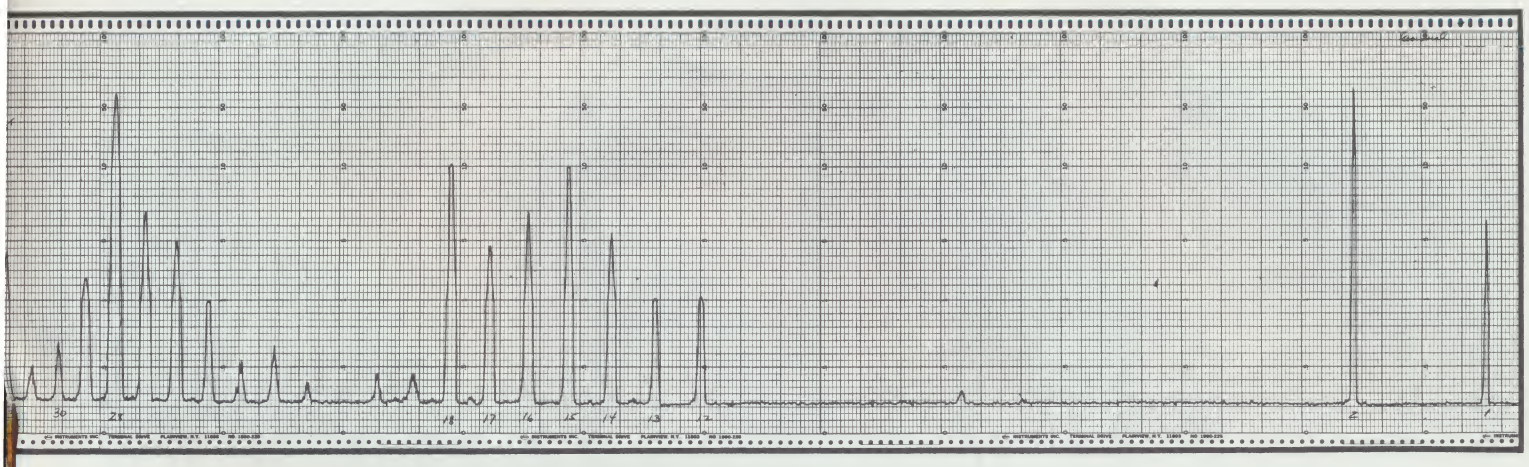


GA-4 scan of low mass range emphasizing 2-12 a.m.u. range. Note presence of mass 3 which is due to a hydrogen-deuterium molecule and the $H_2 + H^+$ ion-molecule reaction.

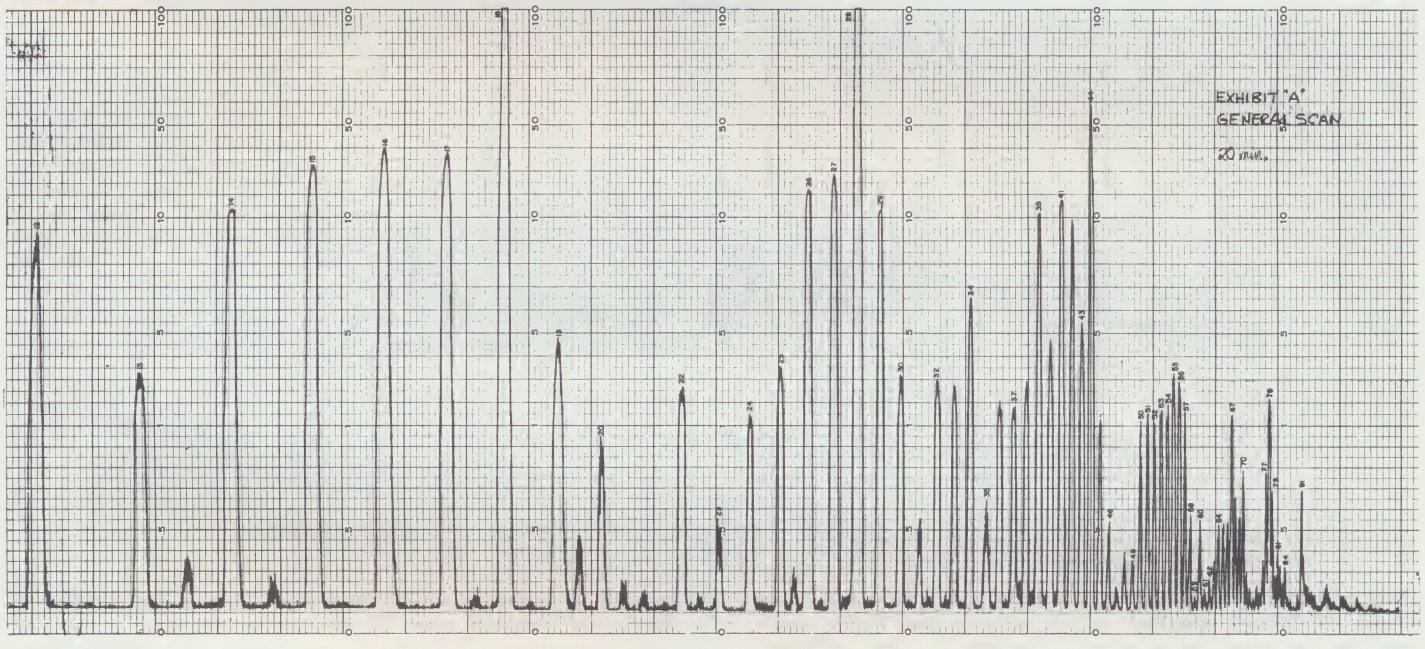
VERY HIGH MASSES



GA-4 scan at very high masses. High limit pot normally limits voltage at 80 volts, was adjusted to permit scan to 50 volts. Digital voltmeter used to read voltages from which masses were calculated.

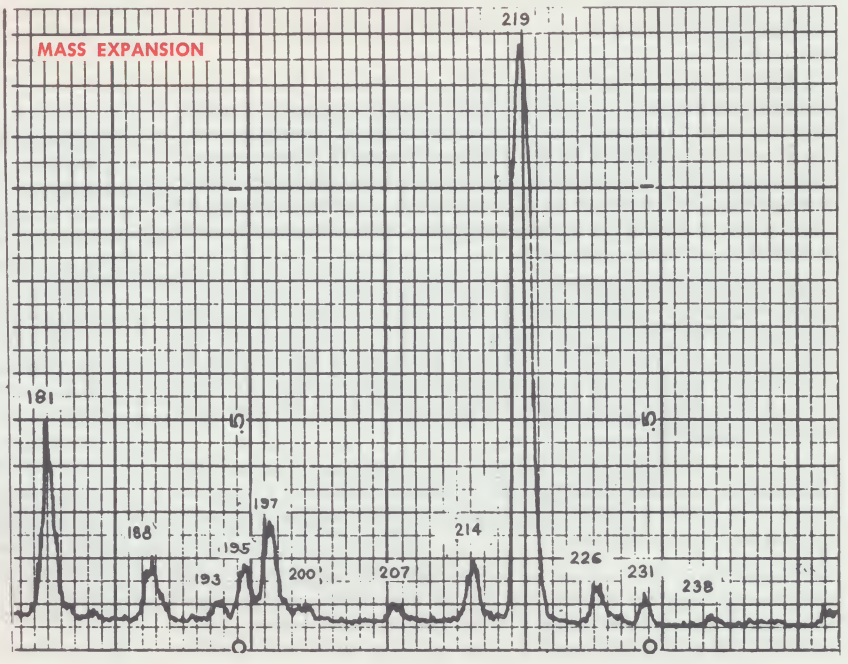


GENERAL SCAN



Above—general mass scan of a system in the 10^{-10} torr range. Note extraordinary resolution and clarity of lower masses, which are the most important for residual gas analysis. Note also the clarity of half-masses (doubly-ionized masses) which are essential for a reliable determination of actual compounds in a system.

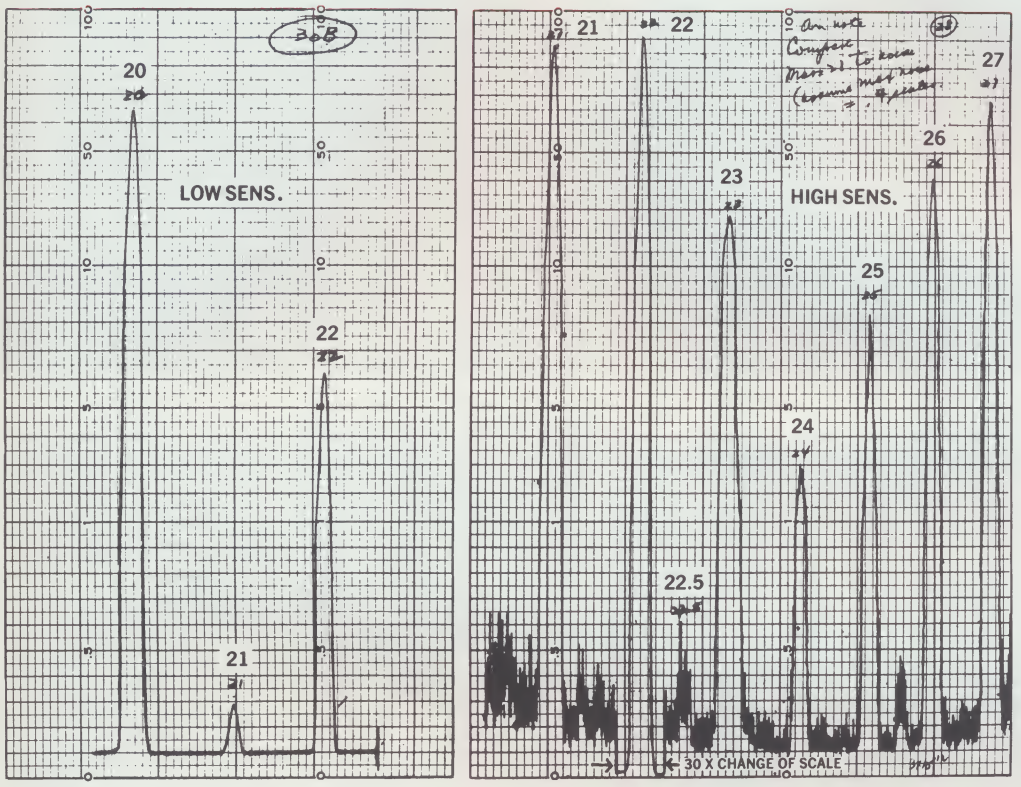
MASS EXPANSION



At right—Mass expansion of a selected mass region from general mass scan at top. Expansion is accomplished by Scope-Recorder Mode, in which very slow external sweep drives the mass sweep.

SENSITIVITY

EXPERIMENTAL DETERMINATION OF GA-4 MINIMUM DETECTABLE PARTIAL PRESSURE



The chart at left was taken after a 5×10^{-9} torr system was backfilled with neon to 1.1×10^{-8} torr. The pressure of neon gas introduced is therefore 6×10^{-9} torr ($11 \times 10^{-9} - 5 \times 10^{-9}$). Since it is known that the neon 21 isotope is present to 0.257%, its partial pressure is $0.00257 \times 6 \times 10^{-9} \approx 1.5 \times 10^{-11}$ torr.

Now on high sensitivity scan at right, note mass 21 scan again, now known to be 1.8×10^{-11} torr. (Note change of scale which makes mass 22 only appear to be same height as mass 21.) Simply by reading scale, an easily detectable peak at mass 22.5 (probably a doubly ionized CO_2 isotope) is seen to be about 4×10^{-14} torr.

SENSITIVITY AND MINIMUM PARTIAL PRESSURE

There is widespread confusion and misunderstanding regarding 1) sensitivity, 2) minimum detectable partial pressure, and 3) the proper definition and determination of each. The danger in this confusion is that some good-sounding "sensitivity" figures bear little relationship to the actual capability of the corresponding instruments in practical use.

The colloquial use of the term "sensitivity" is different from the strict scientific use, but the two are often incorrectly used interchangeably. Strictly speaking, sensitivity for a mass spectrometer is "amps per torr," and is a factor applicable to essentially any pressure in the range of the instrument (if linear), not just the minimum detectable pressure. In other words, it is the output meter deflection for a given pressure, the slope of the deflection vs pressure response curve. It is usually only of secondary interest to the user.

Minimum detectable partial pressure, on the other hand, is exactly what it says—the minimum partial pressure which the instrument can actually distinguish unambiguously from noise. This value is determined by two things: 1) the capability of the spectrometer tube to deliver and the amplifiers to read very low levels of ion current, and 2) the total system noise, which limits the practical realization of the basic tube and amplifier capabilities.

In most cases, the first requirement is rather easily met. Commercially available electrometer amplifiers are capable of detecting a signal of 2×10^{-15} amps (for 2%-of-full-scale deflection). This limitation is due to electrometer noise at this level.

Additional noise also originates in the electron multiplier. A single stray electron may be amplified by the 10^6 gain of the multiplier, and this noise is often a limiting factor in the detection of minimum partial pressures. As a practical matter, noise resulting from the multiplier can be held to about 2×10^{-12} amps output, which is equivalent to an input noise current of about 10 electrons per second.

Finally, the tube itself is subject to noise from beam scattering, which increases with increasing pressure, and from effects in the beam itself, which are proportional to the intensity of the beam. The tube does not usually contribute a significant amount of noise except at higher pressures (over 10^{-8} torr).

It is seen then, that *all* system noise must be taken into account when defining minimum detectable pressure, not just the noise of one component.

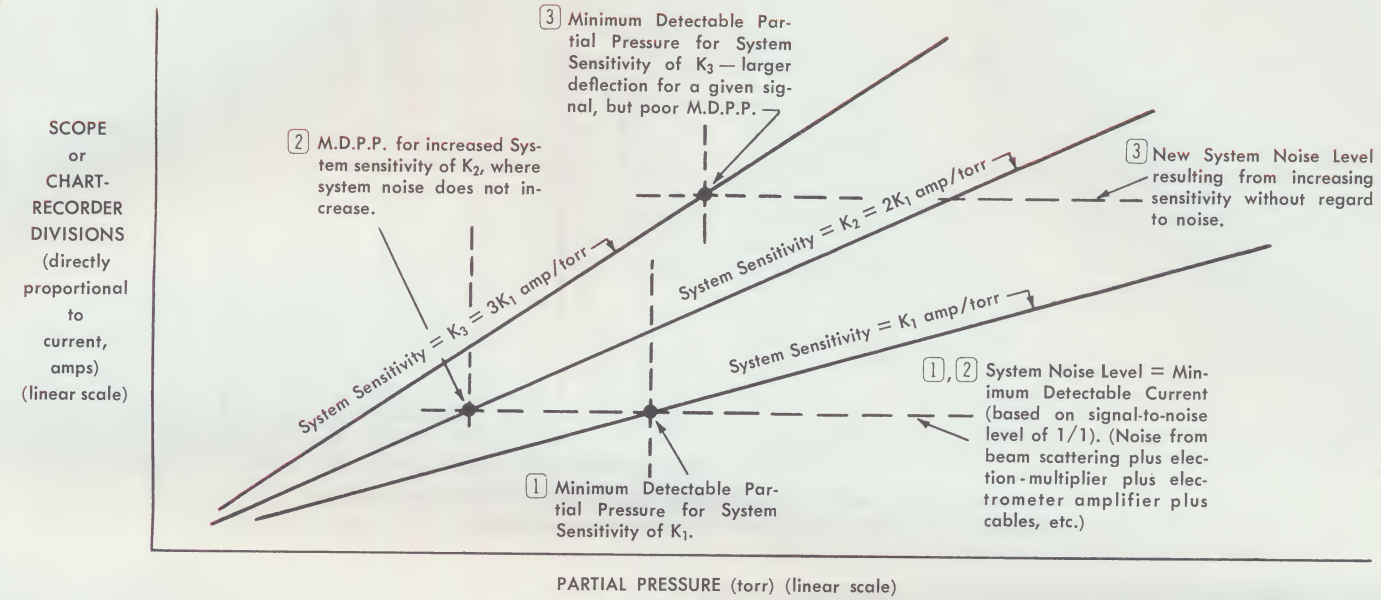
Both tube-multiplier and electrometer noise at the current state-of-the-art of commercial capability of these components makes it impossible to read partial pressures below approximately 10^{-14} torr. However, if noise averaging or cryogenic cooling (to reduce the emission of thermionic electrons from the multiplier's dynode surfaces) coupled with counting techniques is employed, then partial pressures of 10^{-15} to 10^{-16} torr become detectable.

In evaluating residual gas analyzers and mass spectrometers, it is therefore important to 1) determine exactly what is meant by "sensitivity" as used by the particular manufacturer, 2) check that the "minimum detectable partial pressure" takes into consideration the noise of the *entire system*, not just part of it.

Veeco follows the most stringent scientific practices in arriving at its specifications. As a consequence, they are conservative and reliable. For example, all sources of noise are taken into account. For the GA-4, minimum detectable partial pressure is the best available without requiring use of cryogenically refrigerated detectors or special counting techniques.

See diagrams at right for graphic illustration of these considerations.

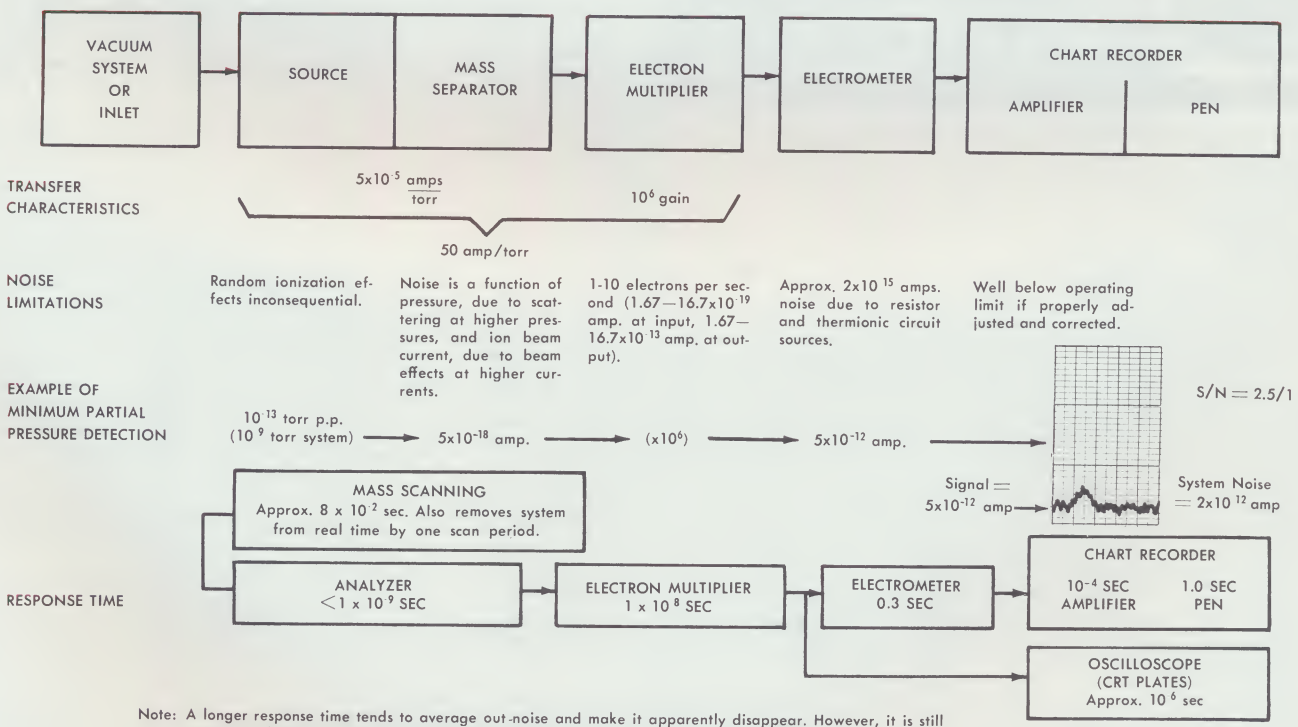
SENSITIVITY AND MINIMUM PARTIAL PRESSURE



RELATIONSHIP OF MINIMUM DETECTABLE PARTIAL PRESSURE TO SYSTEM SENSITIVITY

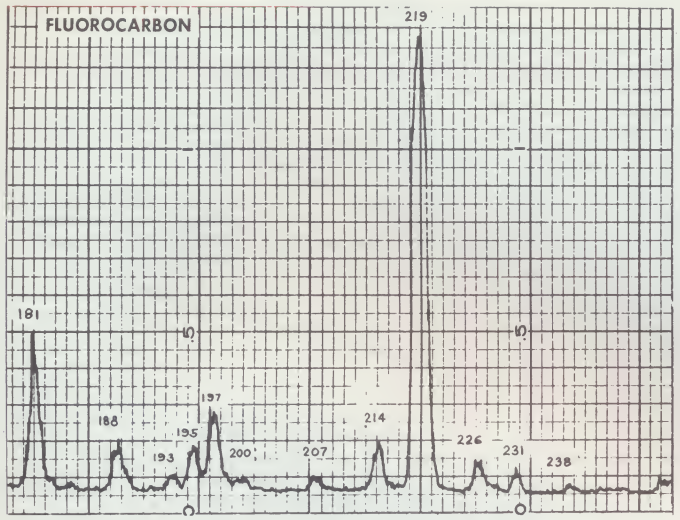
Note that "sensitivity" is for *total* system sensitivity, not sensitivity of just source or just electrometer amplifier. Note also that in actual practice, an increase in sensitivity by means of a change of source, electron multiplier, or electrometer amplifier design or operating voltages may also increase noise level, so that in some cases, minimum detectable partial pressure may actually suffer, and a "more sensitive" instrument may be less capable of detecting small partial pressures than another "less sensitive".

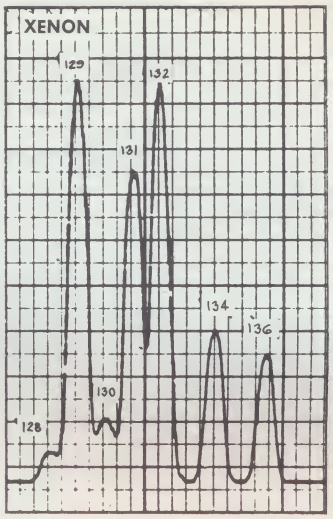
SYSTEM CONSIDERATIONS IN MINIMUM PARTIAL PRESSURE DETECTABILITY

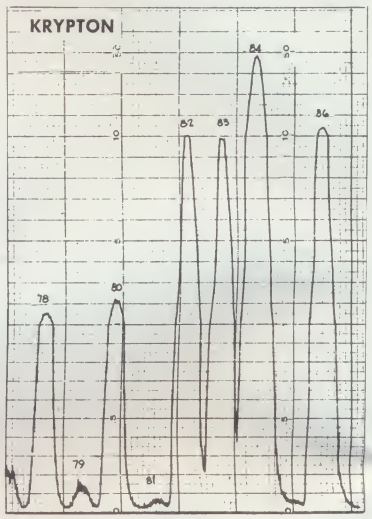


Note: A longer response time tends to average out noise and make it apparently disappear. However, it is still present and must be taken into consideration. This also conceals the true baseline, especially important on the most sensitive scale of the instrument, since it will cause error in amplitude measurements. Noise-averaging is useful in discerning very small signals near the noise level. However, it requires slower scanning speeds to avoid false broadening of mass peaks. The special Veeco electrometer used in the GA-4 has an exceptionally short response time, which permits fast chart recorder scanning without apparent loss in resolution.

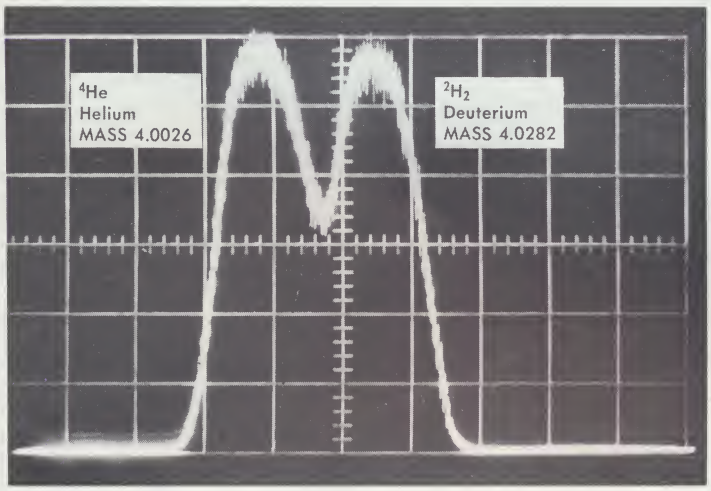
RESOLUTION

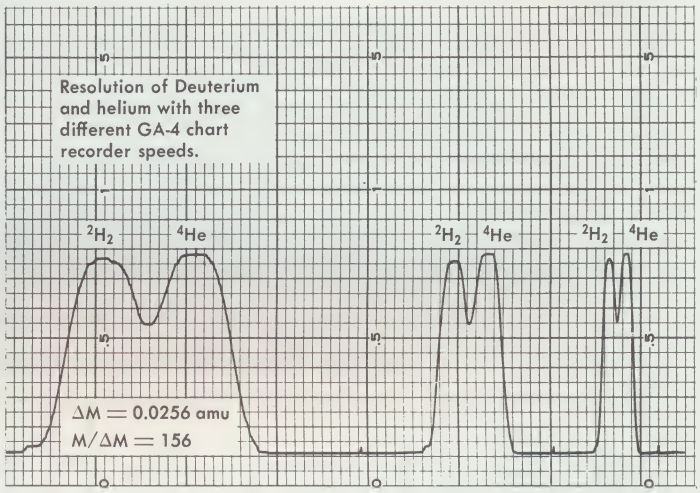






The fluorocarbon, xenon, and krypton scans above show the excellent resolution of the GA-4 and its ability to expand portions of its range.





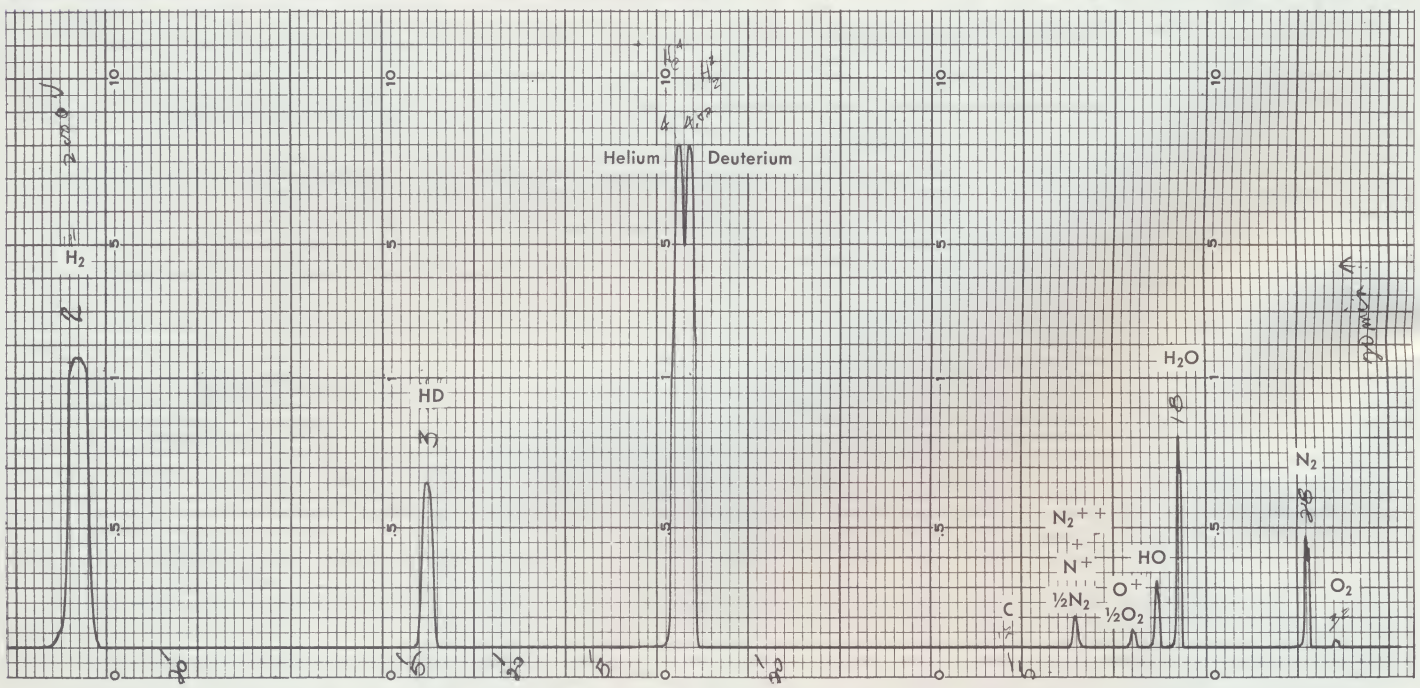
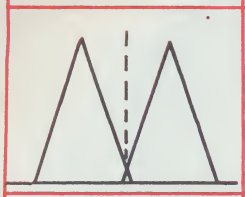
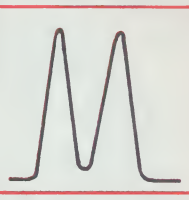
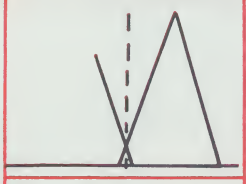
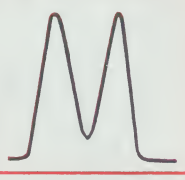
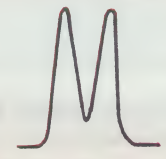
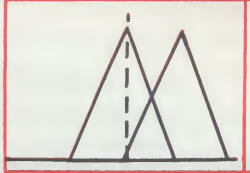
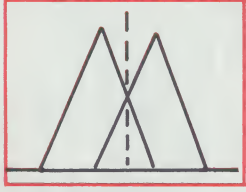


Chart recorder scans and scope scan above shows system into which equal parts deuterium and helium were inleted. Scans were made on standard GA-4 with no special tuning or other operations.

APPROXIMATE RESOLUTION OF GA-4 UNDER DIFFERENT RESOLUTION DEFINITIONS CURRENTLY IN USE

THEORETICAL	ACTUAL	DEFINITION	RESOLUTION
		Unity resolution at 1% of *two* peak heights.	75
		Unity resolution at 2% of *one* peak height.	75
		10% Valley based on *sum* of adjacent peaks (20% of one peak). (Veeco definition).	100
		1% Contribution to height of adjacent peak.	150
		The ratio M/ΔM where M is the atomic mass number at which a particular peak occurs and ΔM is the width expressed in atomic mass units of the peak at half amplitude.	approx. 150

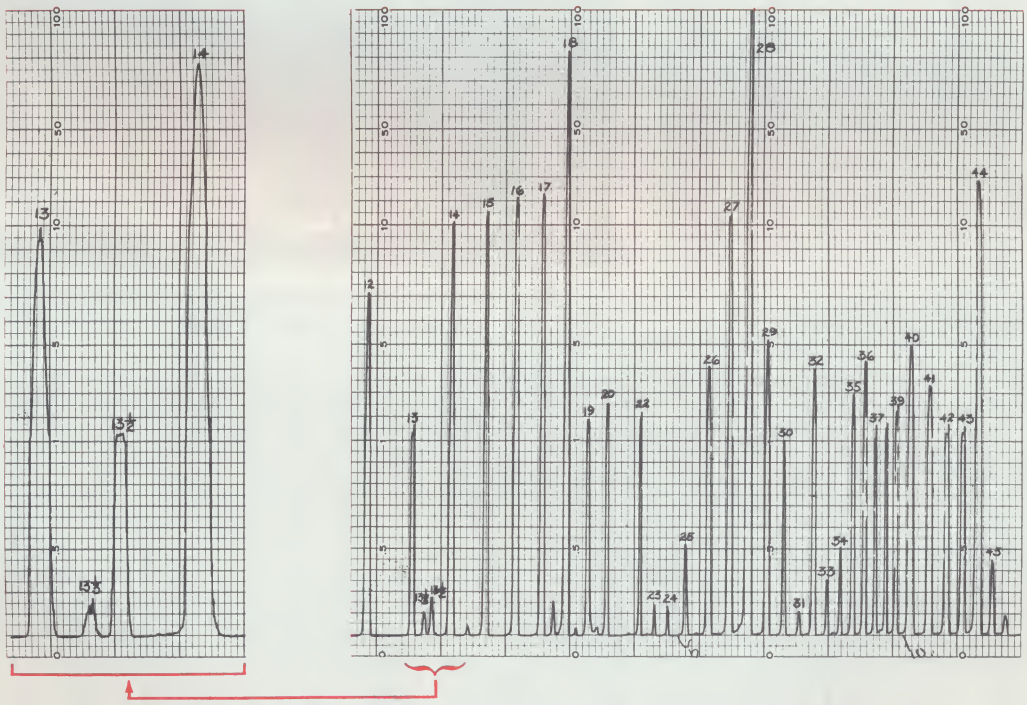
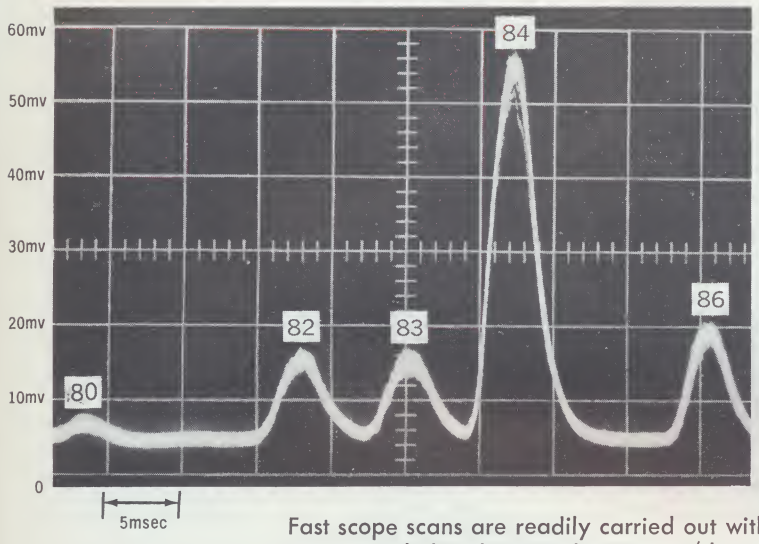
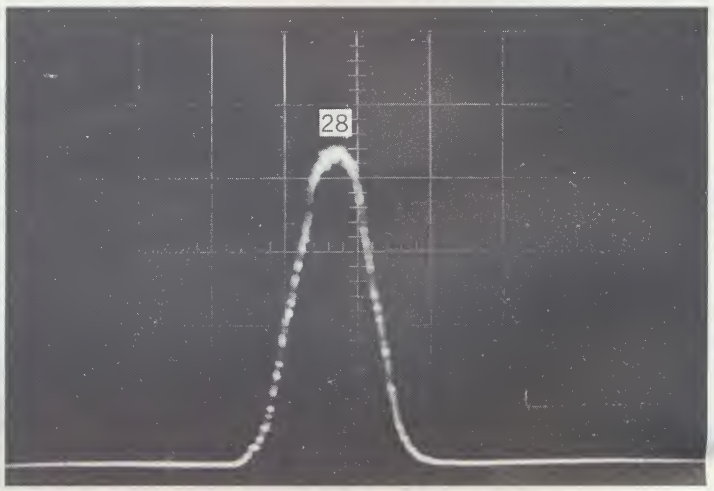


Illustration of excellent resolution of GA-4 in defining fractional masses, which is important in analysis of scans. Here, the GA-4 resolves triply-ionized argon (mass 13⅓) from a multiply-ionized hydrocarbon (mass 13½). Mass difference between these completely resolved peaks is 0.167 mass unit. Four peaks at left above are expansion of appropriate region of scan to right.

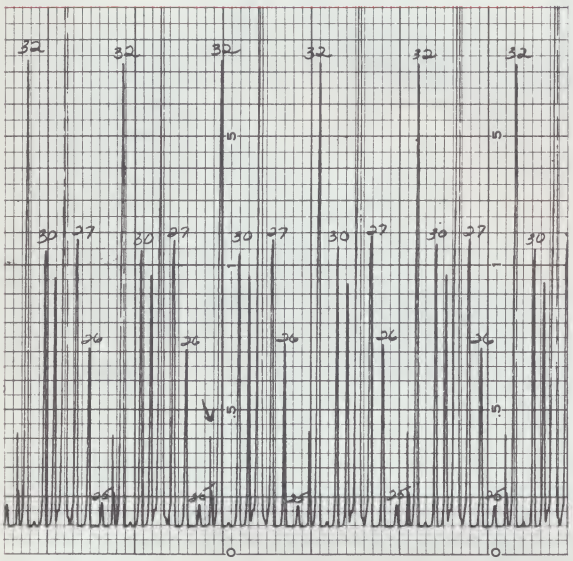
FAST SCOPE SCANS



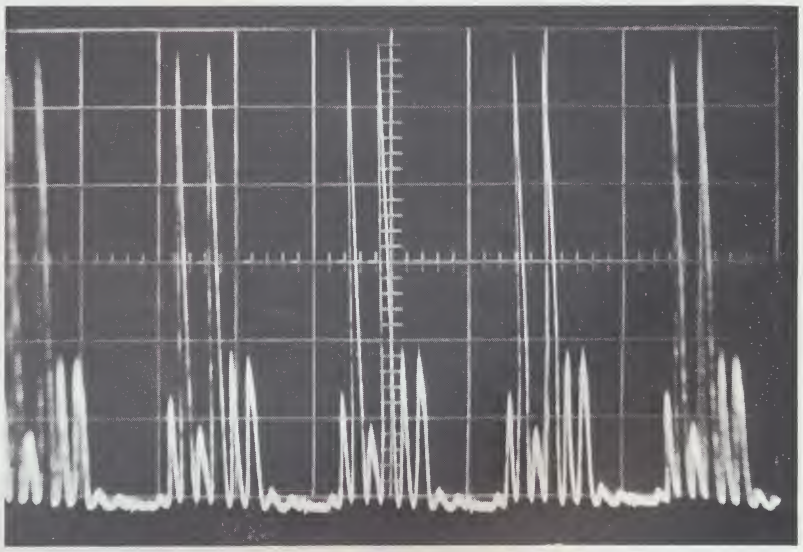


Fast scope scans are readily carried out with the GA-4. Left, five krypton isotope masses are expanded and scanned at 5 msec/div., at 10 mv/div. vertical sensitivity, in a 10^{-8} torr system. Right, mass 28 is expanded and scanned at 5 msec/div., 10 mv/div. sensitivity in a 10^{-9} torr system.

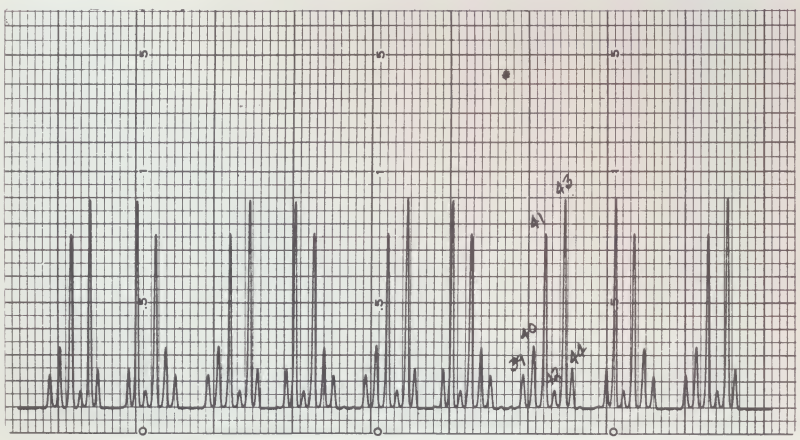
REPETITIVE SCANNING



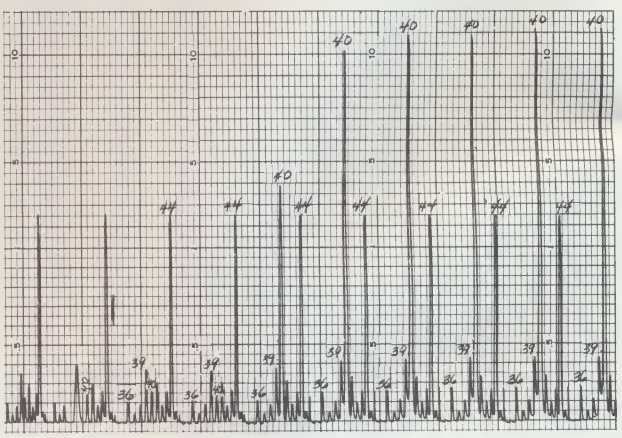
Repetitive scan over a mass range of approx. 25 to 32 a.m.u. Note excellent reproducibility.



Repetitive scanning left on oscilloscope of the same mass range as at below left, utilizing cyclic scan in GA-4R.



Mirror-image repetitive scanning of masses 39 to 44 a.m.u.



Repetitive scanning while argon (mass 40) was introduced into vacuum system.

SPECIFICATIONS

ANALYZER TUBE: 60° Nier type mass spectrometer tube, stainless steel construction with all permanent joints Nicrobrazed. Flange mounted, self-aligning bakeable source assembly; field replaceable filament is of tungsten ribbon, non-warping & self-aligning. Gold "O" rings used on all flanges. Choice of collector assembly—an election multiplier or electrometer for signal amplification, both flange-mounted. Choice of conventional or nude source (special order). Tube may be mounted in any position.

MASS RANGE: Total range of 2-300 a.m.u. is covered in two increments—2-50 a.m.u. and 12-300 a.m.u.

MAGNETS:

Magnets are mounted & supported directly on the analyzer tube permitting easy alignment & removal.

Standard—Permanent magnet, positioned against preset factory stops, manually shunted.

High mass range—4460 Gauss ..... 12-300 a.m.u.

Low mass range—with magnet shunted—
1830 Gauss ..... 2-50 a.m.u.

Option—Variable field strength electromagnet; range up to 500 a.m.u.

Other magnet configurations available on special order.

RESOLUTION: Definition: Two adjacent peaks are called resolved if the distance from the base line to the valley between them is equal to or less than 10% of the sum of their heights.

Specification:—Unit resolution is at mass 75 with 4460 gauss field.

MINIMUM DETECTABLE PARTIAL PRESSURE: $1x10^{-13}$ torr or better, partial pressure for N_2 when using the electron-multiplier collector. $1x10^{-10}$ torr or better, partial pressure for N_2 when using an electrometer ion collector.

PRESSURE RANGE: From UHV to 10^{-4} torr (total pressures) for electrometer ion collector and 10^{-5} torr for the electron multiplier collector.

SCANNING MODE: Manual mass scan and single peak monitoring, automatic scan, and very fast scanning with oscilloscope over a slow external sweep generator. Switching from one scanning mode to another is easily effected by means of a switch on the front panel.

SCANNING SPEED: 100 milliseconds to 40 minutes per 2-50 or 12-300 a.m.u. scan. 40, 20, 10 and 5 minutes for one full mass range. Recorder Oscilloscope: scanning speeds can be varied down to 0.1 seconds/scan for one entire mass range. Considerably faster scanning is possible over limited segments of a range. The Recorder-Oscilloscope mode of display permits very slow scans so that spectrum structure can be clarified.

READ OUT MODE: A recorder and/or an oscilloscope can be used. A switch on the front panel permits easy switching from one read-out mode to the other.

- **Recorder**—The standard GA-4 includes a specially designed potentiometer recorder. 100 millivolt full scale. The chart is divided into three *linear* ranges; 0-1, 1-10 and 10-100 millivolts. It is thus possible to directly record and compare peaks having amplitude ratios of 4,000 to 1.
- **Oscilloscope**—Provisions for oscilloscope hook-up are made on the terminal board on the rear of the console. An oscilloscope is not usually provided with the GA-4.

BAKEABILITY: Analyzer tube repeatedly bakeable to 400°C; electron multiplier repeatedly bakeable to 300°C. Heating Mantle is available for baking out tube without disturbing entire system. Separate section for electron multiplier. Up to 400°C; may be automatically controlled.

ELECTRON MULTIPLIER: The electron multiplier is an integral part of the collector assembly of the analyzer tube. Its power supply and controls are contained in the control console.

CONTROL CONSOLE: All controls, power supplies, amplifier, recorder and meters are contained in a Formica topped desk-type cabinet. Accelerating voltage, mass and output are indicated on front panel meters providing simplified mass identification. A recorder tracking potentiometer on the front panel is used to match the recorder and output meter. All controls are in a convenient location permitting operation from a seated position.

A pull-out drawer contains control and meters for adjustment or filament emission, filament current, ion focusing potentials as well as electron multiple voltage. The console is mounted on four (4) swivel, rubber casters.

Rack mounting is also available.

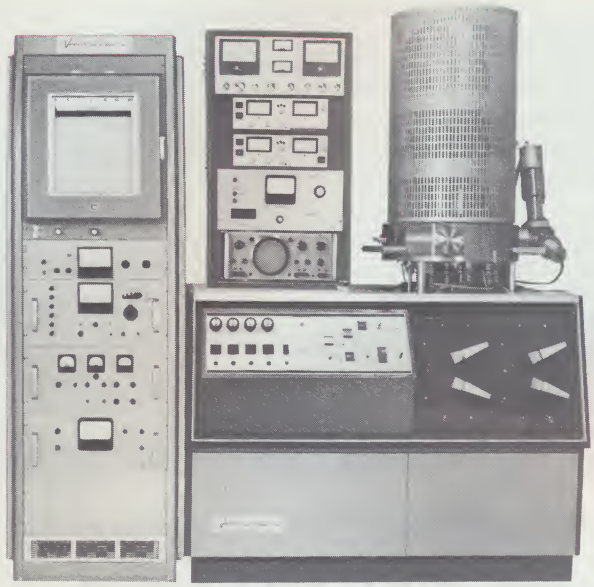
MOUNTING FLANGE:

Standard Tube: Choice of special Veeco gold O-ring flange or 2¾" conflat.

Nude Tube: Choice of special Veeco gold O-ring flange or 4½" conflat.

UTILITIES: 105-125 volts, 60 cps power; 50 cps system available as an option. 350 watts.

Specifications subject to change without notice.



Shown above is a complete laboratory set-up for thin film studies consisting of equipment available from Veeco. It consists of VE-775 Evaporator, GA-4 Gas Analyzer, VeB-6 Electron Beam Gun, and Thickness Monitor. Note use of stainless steel collar (available from Veeco) to mount mass spectrometer tube. The GA-4 is often used with such systems to insure constant system cleanliness and to analyze products generated by processes performed in bell jar. Typical scans (taken inside bell jar shown above) are on page 8.

MODEL VE-775 HIGH VACUUM EVAPORATOR

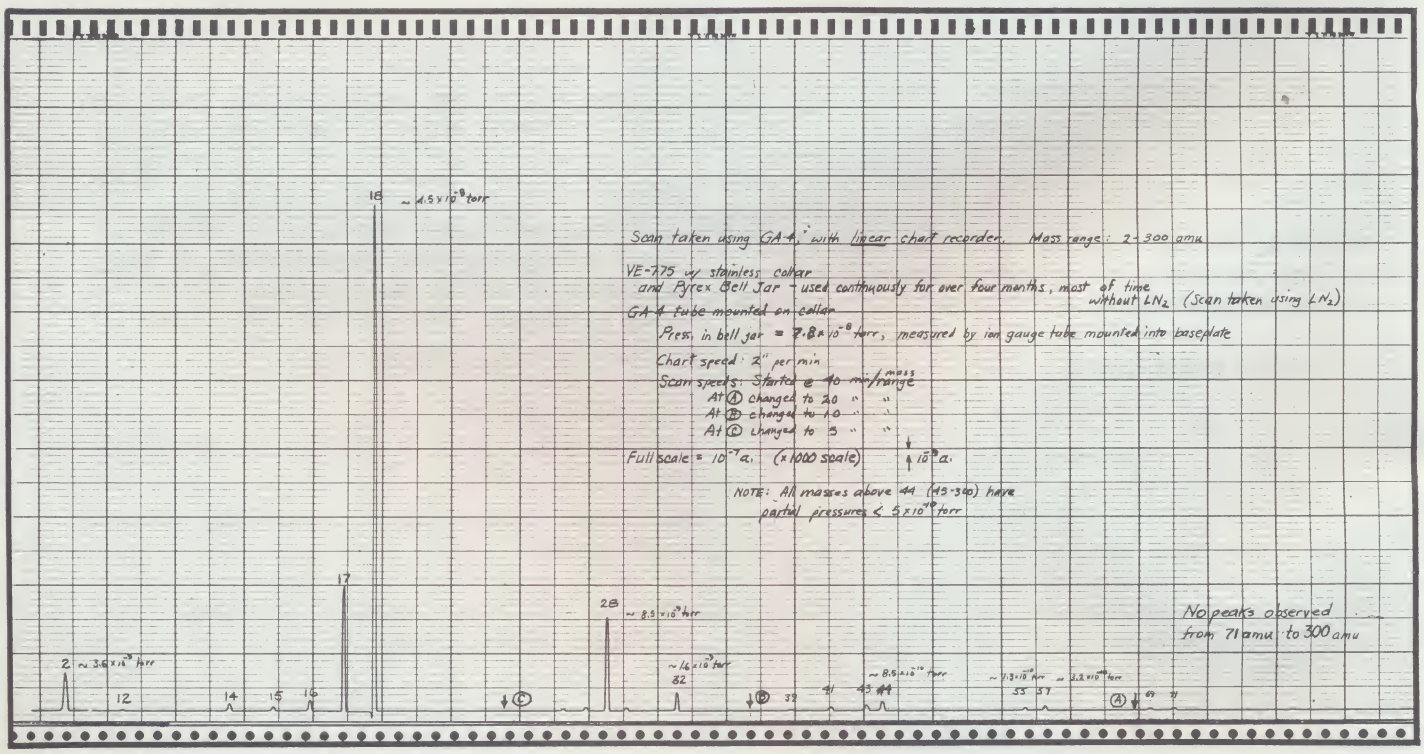
A fast, clean system to take maximum advantage of the GA-4 for evaporation analysis.

The Veeco "775" Series is a 7¾" high performance high vacuum system available in several packages—manual and automatic basic systems, pumping stations, and evaporators.

It is distinguished by the use of a total of three backdiffusion-reducing devices—a special double top cap, a high optically-dense chevron-type water baffle, and a high optically dense double reservoir chevron-type liquid nitrogen cold trap. As a consequence, it is the cleanest system commercially available.

In addition, the system is all stainless steel, and utilizes a forged stainless steel top-sealing gate valve. The system is very fast and attains 10^{-7} torr scale *in the bell jar* in five minutes after crossover to high vacuum. It typically reaches the 10^{-8} torr scale in about twenty minutes.

The "775" is widely used in the industry, especially for thin film work, where very high yields have been experienced in both research and production applications.



Above is an *unretouched* photograph of a GA-4 *linear* scan taken in a VE-775 bell jar. Note that although the majority of the time the unit was used without liquid nitrogen in the cold trap, the water-cooled baffle has kept the bell jar environment clean.

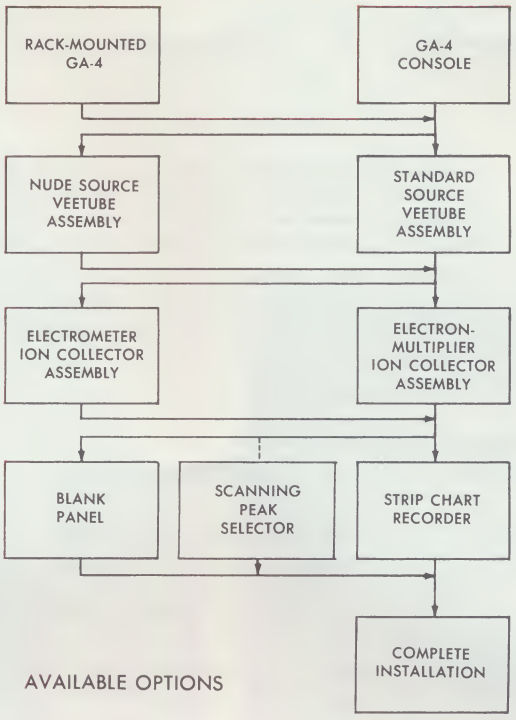
HOW TO ORDER

The chart at right shows the choices you have in ordering the standard GA-4. Make your choice of source, collector, housing, and recorder.

Call your Veeco field engineer listed on the back cover. He will answer any technical questions you have and will advise you on price and delivery.

Purchase includes installation, instruction in operation, and a complete operation and maintenance manual.

A variable field strength electromagnet is available on special order.



OTHER VEECO PRODUCTS

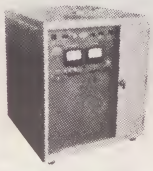
MS-12 LEAK DETECTORS
$5x10^{-12}$ sensitivity at full pumping speed; fastest, most sensitive avail; smallest

MS-90 LEAK DETECTORS
10^{-10} sensitivity constantly w/o attention; ultra-reliable workhorse.

775 SYSTEMS
6″ S.S. 500 l/s straight-thru w/unique high-eff. baffle & cold trap.

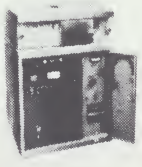
VR-775 STATION
Low-cost, manual, 10^{-8}, 500 l/s at port, S.S.

400/401 EVAPORATORS
Reliable, economical, $5x10^{-6}$ in bell jar in 3½ min., very clean

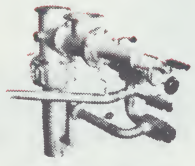


400/401 STATIONS
All S.S. 4″, clean, economical, automatic or manual.

200 (VS-9) STATIONS
Ultra-reliable ultra-versatile 2″; just plug it in and forget it.



UHV-2 STATION
$<10^{-9}$ torr, compact, all Nicrobrazed S.S., gold seals, oven.



400/401 SYSTEMS
Compact, reliable 4″, adapts to many jobs; manual or automatic.

200 (VS-9) SYSTEMS
Ultra-reliable versatile low-cost 2″; hundreds in use for years.

BASEPLATES
20″ & 26″ non-magnetic S.S., up to 27 & 49 holes, many feedthrus.

ELECTRON BEAM GUN
6 kw in ⅛″ spot, uniform across 2″ long beam, for evaporation.

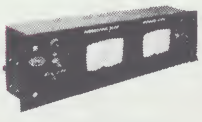
RGLL-7 ION GAUGE CONTROLLER
Log scale 10^{-3} to 10^{-10}, 8 control circuits, remote filament.

RGS-7 ION GAUGE CONTROL
Automatic decade switching, solid-state, no constant rezeroing.

TG-7, TG-2, TC CONTROLS
0-20 or 0-1000 μ (resp.); reliable, solid state.

RG-21X ION GAUGE CONTROL
Workhorse of the industry, hundreds in use, low-cost, reliable.

RG-31X TC/ION GAUGE CONTROL
Thermocouple control plus RG-21X above; 1 to $2x10^{-11}$ torr.

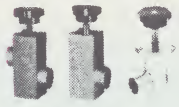


DG-2 DISCHARGE GAUGE CONTROL
10^{-2} to $5x10^{-6}$ torr; easy, low-cost to maintain, replace only liners.

RG-75 ION GAUGE TUBE
Iridium fil, non-burnout even at atmos, 10^{-10}, thousands in use.

TG-75 ION GAUGE TUBE
Two fil, switch to other when one fails; widely used.

BGT-75 ION GAUGE TUBE
Nude, S.S., 10^{-10}, 400°C, replaceable fils.



SR, FR: RT ANGLE
SL, FL: IN-LINE
SSV, RSS: RT ANGLE
Forged brass & S.S., ⅜″ to 3″, long stroke for high cond, Viton, Teflon, or lead seat, every valve leak-tested.

FP PNEUMATIC VALVES
Elec-contr; forged bellows; 100,000 cyc.

SV SOLENOID VALVES
Short, in-line no stem seal, 75,000 cycle.

EP-775 DIFFUSION PUMP
7¾″ port, 6″ ASA flange, 2000 l/s, S.S.

EP-4W DIFFUSION PUMP
4″, 400 l/s, S.S., reliable.

EP-2A, EP-2W DIFFUSION PUMP
90 l/s 2″, trouble-free, thousands in use, air & water cooled.

BAF-200, BAF-400 WATER BAFFLES
2″ & 4″, high cond., tilted cooled disc type, optically dense.

CT-200, CT-400 COLD TRAPS
2″ & 4″, reservoir type, 8-10 hrs, .8 l LN_2, brass or S.S.

C, CW QUICK-COUPLINGS
Also water-cooled types for bakeouts.

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