New Products: Instruments at the FASEB Show

The experimental biologist is becoming increasingly aware of the important part instrumentation plays in virtually every facet of biological research. This fact was evident at the exhibition of scientific instruments that accompanied the meetings of the Federation of American Societies for Experimental Biology (FASEB) in Atlantic City 10–14 April. The vast Convention Hall floor was covered by exhibits featuring equipment and materials from such basic necessities as laboratory clamps, glassware, and animal cages to precision analytical instruments, automatic systems for complete chemical analyses, and desk-top computers for handling and storing data. Wherever possible, I present opinions and comments concerning specific instruments obtained from scientists directly involved in their application.

Chromatography Levels Off

Having gone through a period of exponential growth during which new techniques and instruments appeared frequently, gas chromatography is now the accepted method for many separations and analyses in biomedical research. Innovations at the FASEB exhibition were very few. The trend in gas chromatography is toward the preparative chromatograph for the preparation of micro and macro amounts of high-purity compounds. Two approaches have been made. F&M Scientific provides the preparative capabilities of 4-inch (10-cm) outside-diameter columns in its Prep Master and Prep Master Jr.; the former is completely automatic and can handle liquid injections of from 12 to 125 ml; the latter, a low-cost, manual counterpart, handles up to 100 ml per injection. The other approach to column design is taken by Wilkins and Barber-Colman: the Wilkins Autoprep Mark II uses ¾-inch outside-diameter columns from 50 to 200 feet (15 to 60 m) long for its large-scale separations; for small-scale preparative chromatography from samples up to several hundred microliters, Barber-Colman has a series of similar-diameter columns 8, 12, or 16 feet long.

Several new instruments have joined the growing list of those designed for a single analytical task. F&M's new model 100 Permanent Gas Analyzer, a dual-column (silica gel–molecular sieve), dual-thermistor detector, dual-recorder instrument, sensitive to parts-per-million (ppm) concentrations, detects neon in room air (18 ppm) in a sample sized 250 μl; it gives qualitative and quantitative analyses of trace gases as well as of major constituents in a mixture of permanent gases, responds quantitatively to concentrations up to 100 percent, and is not damaged by any amount of oxygen. The redesigned model 185 Carbon-Nitrogen-Hydrogen Analyzer from FM features single-pass analyses, automatic sample injection, and 10-minute, simultaneous microdetermination of all three gases. An anesthetic-gas analyzer module from Barber-Colman features a temperature range to 100°C and combination of single, dual, or triple columns in series or parallel. Another special-purpose chromatograph, the FM model 450 Blood-Gas Analyzer, provides semiautomatic, simultaneous determinations of individual blood gases; about 0.3 ml of blood is required for duplicate analyses, from 12 to 15 analyses per hour are possible, and results are within the 2-percent relative range.

A most interesting innovation for general-purpose and research chromatography is the flow-programmer introduced by Perkin-Elmer as an alternative to temperature programming. This system increases carrier-gas flow during operation, hastening analyses of wide-boiling-range mixtures. It eliminates the problem of increasing decomposition of the liquid phase (bleeding) and the accompanying baseline shift as the temperature is raised..

A sophisticated system for yielding complete quantitative-qualitative data on multicomponent mixtures combines the quantitative advantages of gas chromatography with the qualitative capabilities of mass spectrometry for analyses of effluent fractions as small as as 0.1 μg. Perkin-Elmer is offering a system that combines its model 801 chromatograph with the Hitachi Perkin-Elmer RMU-6D Mass Spectrometer. A helium-diffusion separator is introduced between the column and the spectrometer to remove a large portion of the helium and thus increase sample concentration; because all compounds separated by the column are volatile enough for mass spectroscopy, the system can be used to identify compounds and fragments within the mass range of the spectrometer (mass:charge, $\leq$ 1800 for the RMU-6D).

Other forms of chromatography are still in the growth stage. Hydrogen-flame ionization detectors for liquid-liquid chromatography have been brought out by Barber-Colman and Glowall; both utilize a continuously moving chain to deliver the effluent from the column to a heated zone, where the solvent is driven off, and then to the flame. Thin-layer chromatography is being improved by introduction of various new supports such as Gelman's glass fiber–potassium silicate, glass fiber–alumina, and unimpregnated glass fiber.

Liquid Scintillation Spectrometers Impressive

An area growing rapidly and spectacularly is that of nuclear-radiation instrumentation; equipment for detecting, counting, and processing nuclear radiation occupied a significant portion of the exhibit area. The most impressive instruments were the liquid-scintillation spectrometers for counting low-energy beta particles. In addition to high sensitivity to the radiation of low-energy beta-emitting isotopes, the liquid-scintillation detector provides information about the energy of radioactive-decay events, making it possible to do counting with multiple isotopes having significant energy differences, and to improve the sample-to-background ratio by counting only certain portions of the energy spectrum.

In 1954, Packard Instrument Company introduced its Tri-Carb Spectrometer, the first and for a long time the only liquid-scintillation spectrometer available. This success and the increasing use of radioisotopes in all phases of biomedical research has recently prompted many companies to introduce liquid-scintillation counters. The resultant competition is great, and there is a choice of several high-quality, sophisticated instruments for fully automatic or manual counting of up to 200 samples (expandable to 400 on some counters) at prices up to about $15,000. Few instruments available to the biologist offer as much up-to-date technology and engineering sophistication as do these counters, while remaining within the financial reach of most.

The latest in solid-state circuitry is used to increase reliability and reduce bulk and heat dissipation; Nuclear-Chicago, in its model 6860, recently became the first to incorporate integrated digital microcircuits. Taking advantage of the speed, accuracy, and reliability of electronic computation, several companies offer special-purpose digital computers to provide continuous digital representation of count rate during the counting cycle. In the Beckman model 7066 counter, for example, the count-per-minute rate is computed every 1.2 seconds; total data-processing time including complete sample-changing and printout is 7 seconds. An advantage of electronic digital computation is its compatibility with various readout devices. Standard equipment on the Beckman counter (and available on most others) is typewriter printout which provides complete data for each sample on one line of 8.5-inch-wide copy suitable for notebook filing; sample number, counting time, channel identification, automatic external-standardization ratio, counts or count rate, and the 2σ statistical counting error are recorded. Other instruments offer punch-tape output, with typewriter and punch-card accessories. All the new automatic counters present pertinent data on easily read digital-display tubes on the front panel.

The serious problem of determining the effect of colored or chemical quenching substances in the sample has been approached by automatic external standardization. A sealed gamma-ray source automatically moves to a precisely reproducible position in the counting chamber after each sample count is recorded; with the source in position, a count is made on the standard, through the sample, to determine its internal quenching. If, because of geometrical configuration, this second count is volume-sensitive, the channels-ratio method is used to provide the required correction.

The new counters provide up to three channels of pulse-height analysis. Packard Instruments has patented its linear-amplifier technique which involves feeding the detector output simultaneously to three separate channels of pulse-height analysis; each channel, consisting of a precision attenuator, linear amplifier, two discriminator analyzers, and scaler, can be adjusted to cover the desired portion of the energy spectrum. Packard claims that linear amplification is inherently more precise and stable, permitting optimum, reproducible balance-point settings for three isotopes. Other manufacturers use logarithmic amplification, which compresses the entire energy spectrum into one range of pulse-height analysis, permitting counting of tritium, carbon-14, and phosphorous-32 at one high-voltage setting. Ansitron states that the ability to plot spectra of all isotopes on the same energy scale facilitates instrument set-up for single isotopes and for multiple-isotope counting. For convenience and reproducibility, Ansitron and Beckman offer preset, plug-in modules providing fixed discrimination channels for separating known isotopes; this assures precise duplication of settings for repetitive experiments, by eliminating the adjustment of upper and lower discrimination limits and gain control for each set of isotopes.

A unique feature of the Picker Liquimat Systems is the possibility of both beta- and gamma-emission counting with the same instrument; the counters provide one, two, or three energy channels for beta detection or one or two energy channels for gamma detection (or both) comparable with a 3-inch diameter by 3-inch well crystal. This permits a choice of channel utilization: (i) scaler *A* counts beta or gamma activity; (ii) scaler *B* counts beta and gamma activity, with different analyzer settings; and (iii) scaler *C* counts beta activity or handles external standardization.

The scientist buying instrumentation for liquid-scintillation counting is fortunate to be able to choose an instrument that meets his particular specifications and fits his budget. A complete spectrum of counters is available, from manual, low-capacity units with mechanical calculators to completely automatic, high-capacity instruments with the latest in electronic sophistication.

Spectrophotometry

Instruments for absorption spectrophotometry are being refined and improved; they generally cover a wider wavelength range than their predecessors and extend farther into the infrared and ultraviolet. Good examples are Perkin-Elmer models 450 and 621. The 450 covers the range from 165 mμ in the ultraviolet to 2700 mμ in the near infrared; it can resolve bands separated by 0.03 mμ at 175 mμ and has low stray light. Model 621 is an infrared instrument with a continuous scanning range of 2.5 to 50 μ; it features high resolution and variable recording speeds. Bausch and Lomb's new Spectronic 600 ultraviolet-visible instrument is a double-beam, double-grating, ratio-indicating unit with a range of 200 to 650 mμ (extendable to 800 mμ); scanning speeds are 10, 50, and 250 mμ per minute; bandwidths are 0.5 to 5 mμ. An infrared instrument for running spectra on gas-chromatography effluents, the new Beckman IR-102 Fast-Scan scans from 2.5 to 14.5 μ in 4 seconds.

A micro-sample spectrophotometer, Gilford model 300, performs precision absorbance spectrophotometry on samples of less than 0.5 ml over the wavelength range of 340 to 700 mμ. Absorbance range is 0.0 to 2.0 absorbance units (A); resolution is 0.001 A, and precision is $\pm$0.002 A. A rapid-sampling system using a self-contained vacuum pump allows measurement of as many as 50 or 60 samples per hour; price, $1695.

Of particular interest to biologists investigating the kinetics of rapid reactions, particularly in enzymes, is the new Durrum-Gibson Stopped-Flow Spectrophotometer. It is a complete system for rapidly mixing two liquid components and measuring the change in optical density as a function of time over the wavelength range of 235 to 800 mμ. With appropriate solutions and operating conditions, the instrument provides 99.5-percent mixing of two components in 2 msec, permitting observation of reaction half-times as short as 5 msec; price, $7900, without oscilloscope and constant-temperature circulator.

A most promising analytical method for determining trace amounts of metals in clinical and research applications is atomic-absorption spectroscopy, which can determine about 40 metallic and semimetallic elements in solution, with detection limits below 1 ppm and routine precisions better than 1 percent of amounts present. Depending on the instrument and solution, elements such as nickel, copper, and zinc can be read to 10^{-3} ppm. The method is dependable, fast, easy to use, and highly sensitive to an unusual range of elements. Several companies, notably Perkin-Elmer, Jarrell-Ash, and Aztec, offer large, elaborate instruments capable of high sensitivity, precision, and speed.

A new instrument, the Perkin-Elmer model 290, is a small, self-contained, low-cost instrument for analyzing a large number of samples for one or two elements each; measuring 25 by 15 by 12 inches high (64 by 59 by 31 cm), it can provide detection limits of less than 1 ppm for 30 elements in water solution, and makes successive determinations of an element in less than 15 seconds per sample on samples as small as 0.1 ml. Interchangeable 5-inch meter scales give linear readings directly in concentration, and multielement, hollow, cathode lamps simplify change of elements. The complete instrument (without recorder) costs $2900. Beckman has introduced an atomic-absorption accessory to be used with its DU, DU-2, and DB ultraviolet spectrophotometers.

Automated Chemical Analyses

Instrumentation for clinical application is designed to meet requirements that are often contrary to those for research. Research instruments are characterized by versatility and precision; they are used to analyze a relatively small number of samples of from 0.1 nlit. to several milliliters. On the other hand, clinical medicine requires its instruments to perform rapidly on a large number of samples a specific analysis with precision of a few percent; samples sized between 0.1 and 0.5 ml are ordinarily available.

The current trend in clinical instrumentation is to automation of the tedious wet-chemical procedures for analyzing blood serum. Technicon, for years the leader in automated clinical chemistry, had an impressive exhibit; it presented several new instruments and accessories, along with extensive improvements of older models.

The new Technicon Multi-Channel Analyzer can perform 12 simultaneous analyses on a single 2-ml blood-serum specimen in less than 10 minutes. Automatically, the sample is divided into portions which are separately processed, provided with the exact amount of diluent and reagent, and fed to the photometric output. Colorimetric determinations are made for chloride, CO_2, total protein, albumin, calcium, alkaline phosphatase, total bilirubin, blood-urea-nitrogen, glucose, and serum glutamic oxaloacetic transaminase (SGOT); flame-photometric readings are taken for sodium and potassium. Each component read colorimetrically has a separate cuvette; the cuvettes are scanned sequentially and the readings are recorded on a single recorder. An inconvenience of this analyzer—absence of sample identification from the recording—is eliminated by a new accessory: with coded plastic tags, decoded by microswitches, the accessory identifies the sample and types on an 8.5- by 11-inch sheet the batch number, sample number, and results of the analyses.

Another Technicon achievement is automation of blood typing. Installations for characterizing large numbers of specimens can now type automatically 60 samples per hour using blood samples as small as 1 ml. The eight-channel system performs simultaneous, parallel agglutination tests on plasma and red cells collected from anticoagulated blood. The tops (plasma) and bottoms (cells) of the specimens are automatically sampled and each phase is fed to four separate channels: three channels for typing and one for control. In each channel, the plasma (or cells) is mixed with reagent cells or antiserum and the mixture is passed through a decant-T. If agglutination occurs, the clumped cells are decanted to the waste bottle and the serum continues through the system. If there is no agglutination, the cells pass through the decant-T. Distilled water is then added to hemolyze any cells present, and the sample proceeds to the multichannel colorimeter. If the test in a particular channel is negative (no agglutination), hemoglobin from the lysed cells gives a colorimetric reading of full scale; a specimen reacting positively, having had its cells agglutinated and decanted, gives a colorimetric reading of zero. By using all eight channels to characterize one specimen, up to eight subgroups can be tested simultaneously. The Technicon system is also suitable for such research studies as differential agglutination.

Several companies have introduced methods for automatic time-rate analyses of enzymes. The kinetics of enzyme activity, important in biological systems, are measured by determining the rate of a reaction catalyzed by the enzyme. Bausch and Lomb exhibited its Spectrozyme II for determining the two transaminases (SGOT and serum glutamic pyruvic transaminase) and lactic dehydrogenase in as little as 0.25 ml of blood plasma or serum. A turntable with spaces for 40 sample tubes is suspended above a well-regulated constant-temperature bath; below, in the bath, are 40 corresponding reaction tubes. The sample is automatically sucked from the upper tube and delivered to the reaction tube along with the proper amount of diluent. A system of three syringes then automatically adds the required reagents and the reaction begins. The rate of the reaction is monitored photometrically by following the change in optical density at 340 mμ as diphosphopyridine nucleotide is reduced. The dual-beam optical system that observes the sample through the bath water is a null system utilizing a servo-controlled optical wedge; optical-density readings taken at 0, 50, and 100 seconds are printed digitally.

Another approach to the same problem has been taken by Perkin-Elmer which offers three accessories to the model 202 Ultraviolet-Visible Spectrophotometer. Measurement of absorbance as a function of time may be made at a fixed wavelength and controlled temperature, with automatic positioning of five samples in the time usually required for one sample; up to 15 samples in three batches can be run on one chart in 15 minutes. The American Instrument Co. is offering a similar system of accessories for its Fluoro-Microphotometer; they permit recording of fluorescence or absorption values as a function of time during enzyme-reaction-rate studies.

Data Processing Equipment

Biologists investigating complex physiological, biochemical, or biophysical phenomenon often accumulate raw data faster than they can process it; they are finding it practical to purchase automatic data-processing equipment to collect, process, display, and store their data as the cost of equipment continues to fall.

Several years ago, NIH financed development by the Massachusetts Institute of Technology of a small, general-purpose digital computer equipped with devices and logic particularly suited to biomedical research. The result, the LINC (laboratory instrument computer), was exhibited at FASEB by Digital Equipment Corp. This system, with built-in capabilities of data recording, analog-to-digital conversion, and experiment monitoring, control, and analysis, provides on-line, real-time, data processing; results of experiments are known immediately, so that modifications can be made and the study continued with a minimum of delay. The highly versatile input-output capabilities of the LINC allow it to be connected directly into a wide variety of research situations. Sixteen channels of analog data can be handled: eight of these are controlled by potentiometers on the control panel; eight are high-speed lines carrying analog data from eight different sources. The speed of the computer is due to the 8-μsec access time to the 2000-word magnetic-core memory; magnetic-tape units (standard equipment) expand the memory size and allow the contents of the core to be stored indefinitely. The price of about $40,000 includes the analog-to-digital conversion and multiplexing and the oscilloscope display.

An outstanding example of the general-purpose high-speed computers suggested for application in biomedical research is the Digital Equipment Corp. PDP-8, a desk-top system designed for scientific computation, system and control application, and in-line data collection and reduction. This system offers a 4096-word memory (expandable to 32,768 words) and a memory cycle time of 1.6 μsec. With paper-tape input and output, the unit sells for $18,000; analog-to-digital conversion and multiplexing, paper-tape capabilities, and oscilloscope display are extra. This machine is notable for its convenient size, solid-state design, high speed, and versatility; accessories are available.

Other Instrumentation

Perkin-Elmer exhibited the prototype of an electron-spin resonance (ESR) spectrometer designed to quantitatively measure free radicals in functional biochemical and biological systems. Incorporating the Townsend cavity design, the instrument is especially suitable for samples containing liquid water to 0.1 ml; tissue samples may be examined in their natural state rather than frozen or dried. Sensitivity is 10^{11} spins (1-second time constant); resolution, 100 mgauss over the sample volume. Information about the molecular structure and kinetic behavior of these systems is obtained from quantitative determinations of the spectroscopic splitting factor (g-value), line width, spacing, and intensity of hyperfine peaks in the ESR signal. The console measures 40 by 24 by 49 inches high; the magnet enclosure measures 23 by 24 by 24 inches high; price, under $30,000.

A biological oxygen monitor, Yellow Springs Instruments model 53, obtains complete Warburg-type oxygen-uptake or evolution curves in 5 to 15 minutes. A distinct advantage is ability to yield information only 60 seconds after insertion of the sample. The bath assembly contains four sample chambers stirred magnetically and regulated as to temperature by a Haake constant-temperature circulator. Two Clark polarographic-type electrodes inserted in lucite plungers are provided so that two chambers can be used while the others are being prepared. A 5-inch meter reads percentage-saturation in two ranges: full scale for air at 760 mm-Hg and full scale for O_2 at 760 mm-Hg. Output is provided for any 100-mv recorder; typical drift is 0.5 percent hr^{-1}; price $1225, without recorder.

Another product of Yellow Springs Instruments is its direct-reading radiometer, wavelength-independent from the ultraviolet to the near-infrared (YSI-Kettering Radiometer model 65). The sensing probe contains two thermistors which form two legs of a Wheatstone bridge. The sensing thermistor is attached to a coated silver target; the reference thermistor is shielded from radiation but is exposed to ambient temperature. Reading directly in ergs per square-centimeter–second and milliwatts per square-centimeter in seven ranges, 2.5×10^3 to 2.5×10^6 erg/cm^2 (0.25 to 250 mw/cm^2) full scale, the instrument is accurate within 5 percent of full scale and readable to 0.5 percent of range. The combination of metallic-layer target coating and quartz window provides wavelength-independent measurement from 200 to 3300 mμ. This bolometer is designed as a convenient tool for qualitative and quantitative measurement of radiation in photobiology and photochemistry.

A new linear quartz thermometer utilizes the temperature dependence of quartz-crystal resonators as the basis for accurate measurement of temperature. The Hewlett-Packard instrument measures temperatures ranging from —40° to +230°C, within 0.001°C, in 10 seconds. The unit consists of a quartz resonator located in the sensor probe, an oscillator, and a frequency counter which displays the measured temperature directly in numerical form on a digital readout. Of interest to biologists is the two-channel thermometer for measuring small temperature differences. Six-digit display permits difference measurements within 0.0001°C; each probe can also be read independently. Model DY-2801A (two-channel) provides selection of 0.01°, 0.001°, or 0.0001°C resolution with an absolute linearity of ±0.15°C over the entire range of —40° to +230°C (±0.02°C from 0° to +100°C).

A unique FASEB exhibit was the Tomos-Synthalyzer (RLM Research Corp.), a photo-optical instrument which permits three-dimensional synthesis and analysis of solids, concrete or abstract, from any coordinated set of two-dimensional data. The instrument is designed as a research and teaching tool for such diverse fields as pathology, histology, geology, and mathematics; the technique assists one to understand and visualize inner structures by providing observation and dissection of optically synthesized solids. The system consists in displaying sequentially, in their natural spatial relations, photographic records of a series of sections of an object in a cycle having a frequency such that a three-dimensional image is formed. With a biologic subject, for example, serial sections obtained by use of a microtome are photographed in natural sequence and orientation on successive frames of 16-mm film strip. The strip, rotated at high speed as a continuous loop, is projected with a high-frequency multiple-microflash tube (1 μsec flash) synchronized with the film travel. It is projected on the translucent edge of a drum composed of several spiral segments whose surfaces rise as the drum rotates. A complete film-sequence coincides with the travel of one spiral segment, and the flash-projected frames are frozen on successively higher levels of the segment. Because of the high frequency of the cycle and the viewer's retinal retention of image, he perceives a three-dimensional object composed of layers. Optical dissection may be achieved by removing vertical segments of the synthesis. The reconstructions may be permanently recorded on film for educational or illustrational purposes.

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Note

I thank R. L. Bowman, Donald Young, Paul Holland, Malcolm Bruce (all of NIH), and Arthur Karmen (Johns Hopkins University) for their assistance.

TEC 5 **Mini-Freezer** uses **thermoelectric cooling**. The unit employs a thermocouple module said to be capable of removing approximately 5 w of heat from the 85-ml container to which it is bonded. The container, cylindrical, 1.5 inches (3.8 cm) in diameter and 3 inches deep, is mounted in an insulated housing. Cooler operates on 115-v, 60-cy/sec power and consumes 18 w. Heat pumped away from the freezing compartment is transferred to a finned copper heat sink and dissipated by a small fan located in the base of the housing. Another model, TEC 5V, permits regulation of the degree of cooling by means of a control knob located on the front panel of the power supply, but is otherwise identical. Overall dimensions: cooler, 4.5 inches in diameter and 7.5 inches high; power supply, 6 by 8.5 by 8 inches. A cradle available as an accessory permits the device to be used in the horizontal position. The manufacturer's data indicate that 30 ml of 91-percent isopropyl alcohol is cooled from 65°F (18°C) to approximately 7°F (−14°C) in 30 minutes.—J.S. (Schoeffel Instrument Co., Dept. S438, 15 Douglas St., Westwood, N.J.)

Goniophotometer (GP 2) is a variable-angle unit that measures the gloss of diffusely as well as specularly reflective surfaces. Consists basically of an illuminating and a measuring collimator enclosed in a semicylindrical housing. The angle between the two collimators can be extended to 150 deg; the angle between the collimators and the specimen can be varied continuously over a range of 75 deg. Instrument may be operated either by placing it directly on the specimen, or by mounting it on its stand with measuring hole facing up or down. Collimators are independently adjustable through the 75-deg range. Angles of illumination and observation are read from vernier scales located on one dial in the face of the housing; readings can be estimated within 0.05 deg, according to the manufacturer. In operation, the specimen is lighted by a 6-v, 30-w, incandescent lamp focused through the illuminating collimator. Light reflected by the specimen is transmitted to a selenium barrier-type photoelectric cell by way of the measuring collimator. A built-in turret on each collimator adjusts the aperture angles of the two bundles of rays to a small, defined value. The aperture angle of the measuring collimator is adjustable to 2 or 7.5 deg. In the lighting collimator, stop adjustments correspond to aperture angles of 0.25, 0.5, and 1.0 deg. Three gray filters of approximately 0.1-, 1.0-, and 10-percent transmittance are supplied with the instrument. Also supplied are two calibrating standards: a white barium sulfate plate that approximates a perfectly diffuse reflector, and a polished black-glass plate representing maximum gloss with minimum diffuse reflectance.—J.S. (Carl Zeiss, Inc., Dept. S437, 444 Fifth Ave., New York, 10018)

Very-low-frequency **function generator** model SG-88 puts out wave forms that are limited in variety only by the requirement that the function from which each is derived is single-valued and repetitive. The functions are generated by means of interchangeable rotating discs that are scanned by a narrow light beam. Printed on each disc is an opaque pattern representing in polar coordinates the wave shape or function to be produced. The disc is driven by a servo-controlled motor through a four-speed gear box. Output frequency is continuously adjustable to from 0.005 to 50 cy/sec (nominal maximum). Acceleration of the disc on the two lower frequency ranges is said to be sufficient to permit effectively instantaneous start from any predetermined point on the wave form for single-stroke operation. Sweep capability is provided on the two upper frequency ranges, commencing at any preset frequency and proceeding logarithmically to the upper frequency limit of the range. Output voltage can be set to any value from +25 to −25 v. Built-in oscilloscope permits the wave form and the output level to be monitored. Five discs are supplied with the instrument. Three of them generate standard sine, square, and saw-tooth wave forms; the fourth generates white noise with a bandwidth ratio of 250:1, accommodated anywhere in the frequency range 0.005 cy/sec to 3 kcy/sec; the fifth (blank) enables the user to construct any other wave shape required.—J.S. (Houston Instrument Corp., Dept. S436, 4950 Terminal Ave., Bellaire, Texas 77401)

Critical-flow instrumentation, for analyzing gases, is available in a number of models designed for various ranges of concentration of water vapor and CO_2, and various accuracies, response times, and pressure and temperature conditions of the incoming gas. Model 103A analyzes air at entrance pressure between 9 and 20 lb/in. (abs.) (0.6 to 1.4 atm) and temperature from 35°F (2°C) to ambient. Accuracy claimed is a mixing ratio of ±1/10,000 for water or CO_2 in air; time to reach equilibrium is 15 seconds. Vacuum pump is supplied with models operated near atmospheric pressure to develop the overall pressure drop necessary to produce critical flow in the nozzles of the instrument. In operation, the gas to be analyzed is divided into two branches and is metered into the instrument through two critical-flow nozzles; as long as critical flow obtains in the nozzles, the flow in each branch is independent of any flow restrictions introduced into the stream. The component to be estimated is physically or chemically removed from one of the branches, thus reducing flow in that branch. After temperature equalization, the reduced flow is compared with the undisturbed flow in the other branch by means of a differential pressure measurement at the entrance of a second pair of critical-flow nozzles. A computer-derived tabulation relating the mixing ratio of the gases to the observed absolute pressure in the reference branch and the differential pressure between the two branches is supplied. A critical-flow instrument for determining the average molecular weight of a gas stream within 0.2 percent, with equilibrium time less than 2 seconds, will soon be available, according to the manufacturer.—J.S. (Lockheed Missiles and Space Co., Dept. S435, 16811 El Camino Real, Houston, Texas 77058)

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