Electronic Design

THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

VOL. 14, NO. 5

MARCH 1, 1966

Paris Show Report: Europeans form alliances in race to capture expanding microelectronics markets—Ferranti-Marconi and Westinghouse-Philips team up. ...British producing ME computer... French and Germans plan ICs for space and industry computers... Color TV slows down as system agreement lags (see p 17).

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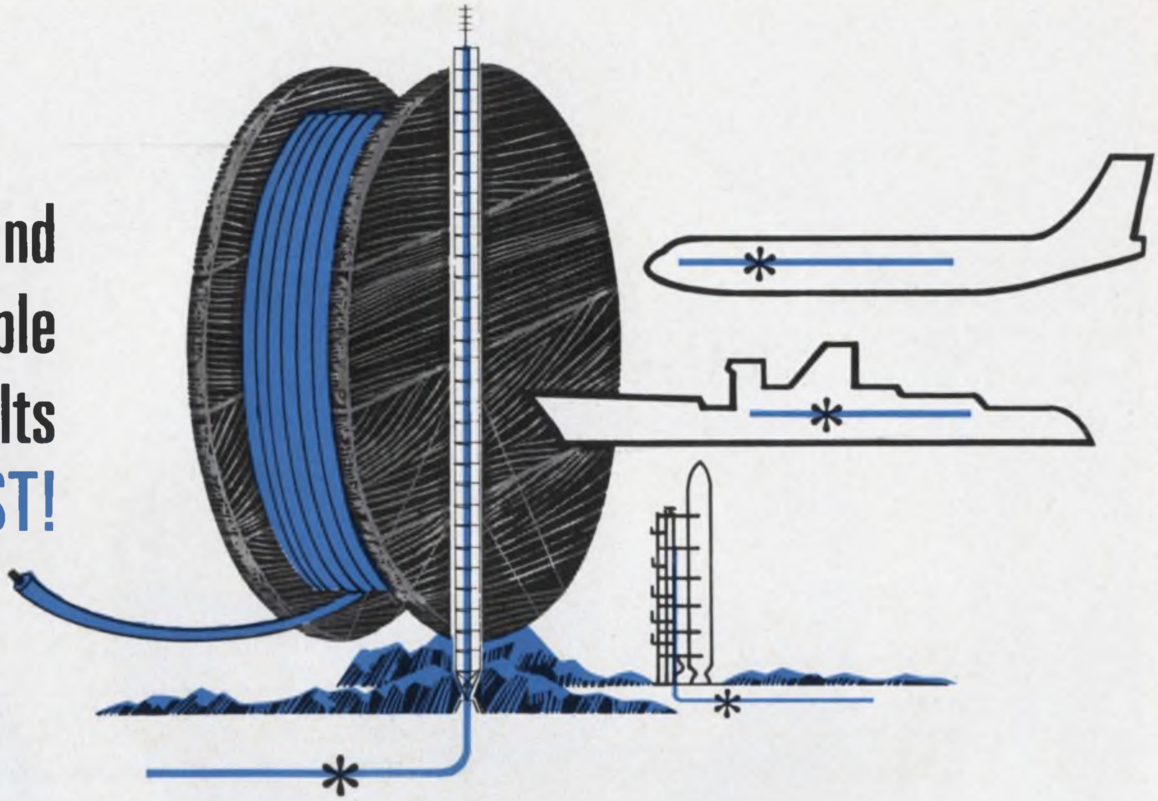

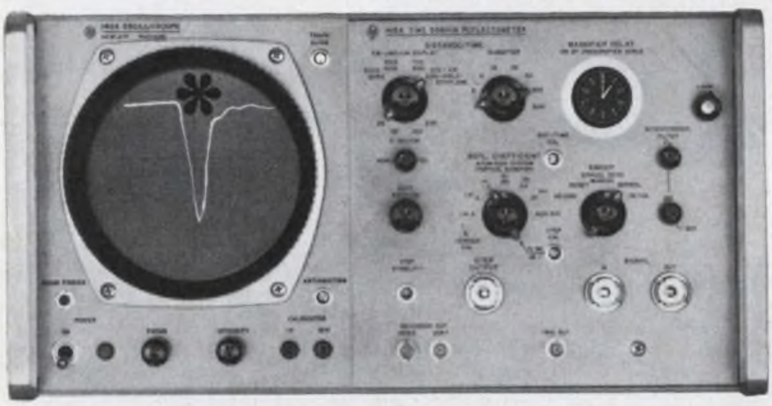

Use the hp 140A Oscilloscope and 1415A Time Domain Reflectometer Plug-in!

Quickly find and identify such problems as water in cables, crushed cables, damage caused by flex and bends in cables, transmission difficulties in buried or hard-to-reach cables, cables damaged by temperature extremes, and bad connectors joining cables.

With the 140A/1415A combination, you can instantly locate problems in cables up to 600 ft. (to 3000 ft. with Option 14), and you can identify their exact nature—opens, shorts, resistive or reactive discontinuities. You can separate, on the scope crt, discontinuities as close as one inch—making Time Domain Reflectometry (TDR) ideal for analyzing connectors and checking coax switches and attenuators.

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The 140A costs $575, the 1415A TDR Plug-in $1050. Besides accepting double-size special-purpose plug-ins, such as the 1415A, the 140A is useful as a general-purpose oscilloscope, accepting both vertical and horizontal plug-ins. Five vertical and two time base plug-ins provide maximum versatility. Performance includes sensitivities to 10 μv/cm, bandwidths to 20 MHz.

Contact your Hewlett-Packard field engineer for more information on the versatile 140A General-Purpose Scope . . . and especially on the 1415A Time Domain Reflectometer. A technical discussion of TDR techniques and their application is available, for the asking, in Application Note 67, "Cable Testing With Time Domain Reflectometry."

You can get a copy from your hp field engineer or by writing Hewlett-Packard, Palo Alto, California 94304, Telephone (415) 326-7000; Europe: 54 Route des Acacias, Geneva. *Prices f.o.b. factory.*

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ON READER-SERVICE CARD CIRCLE 3

VOL. 14, NO. 5

Electronic Design

THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

MARCH 1, 1966

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European firms team up against U.S in effort to compete in the fast-moving microelectronics market.

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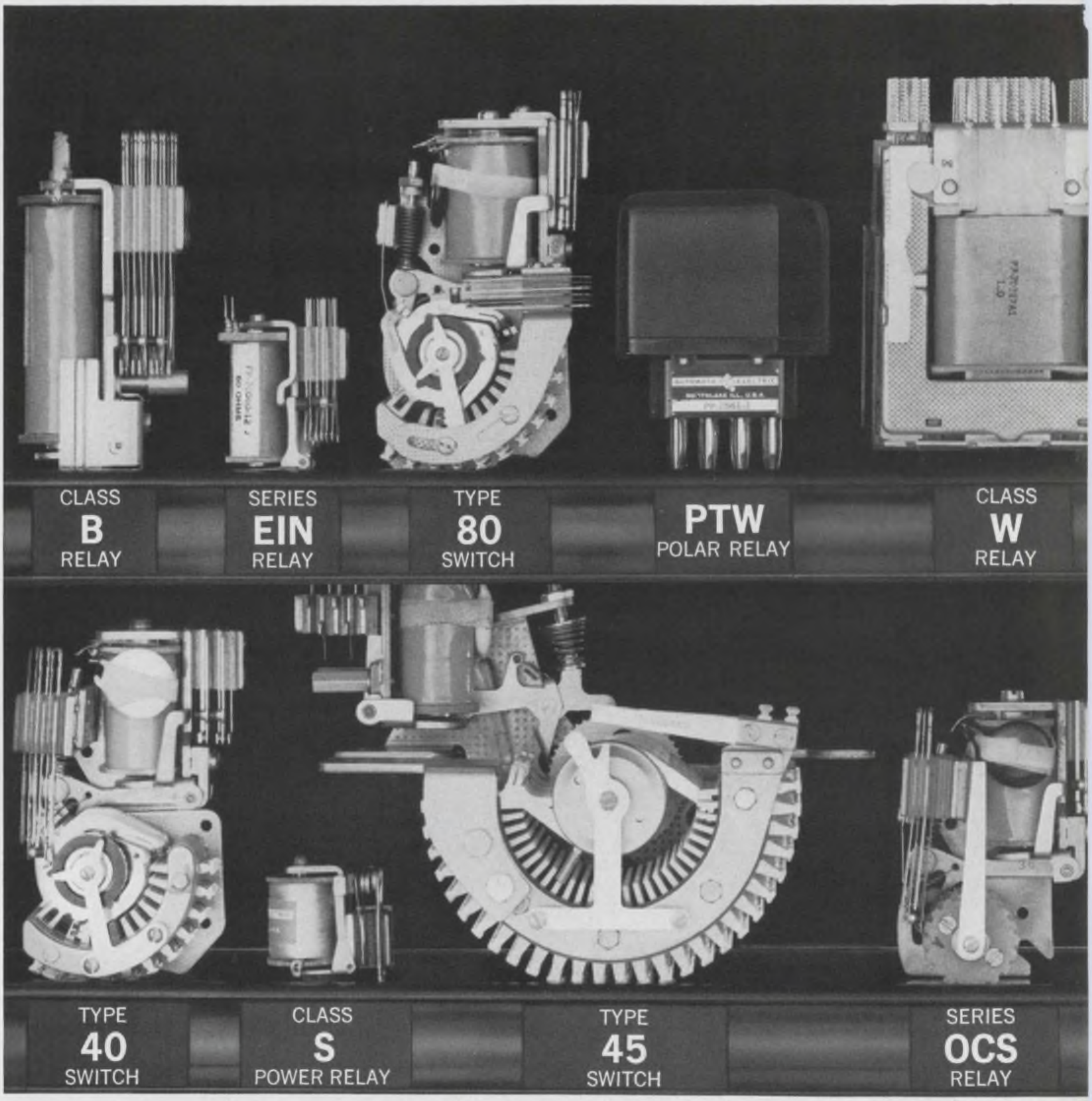
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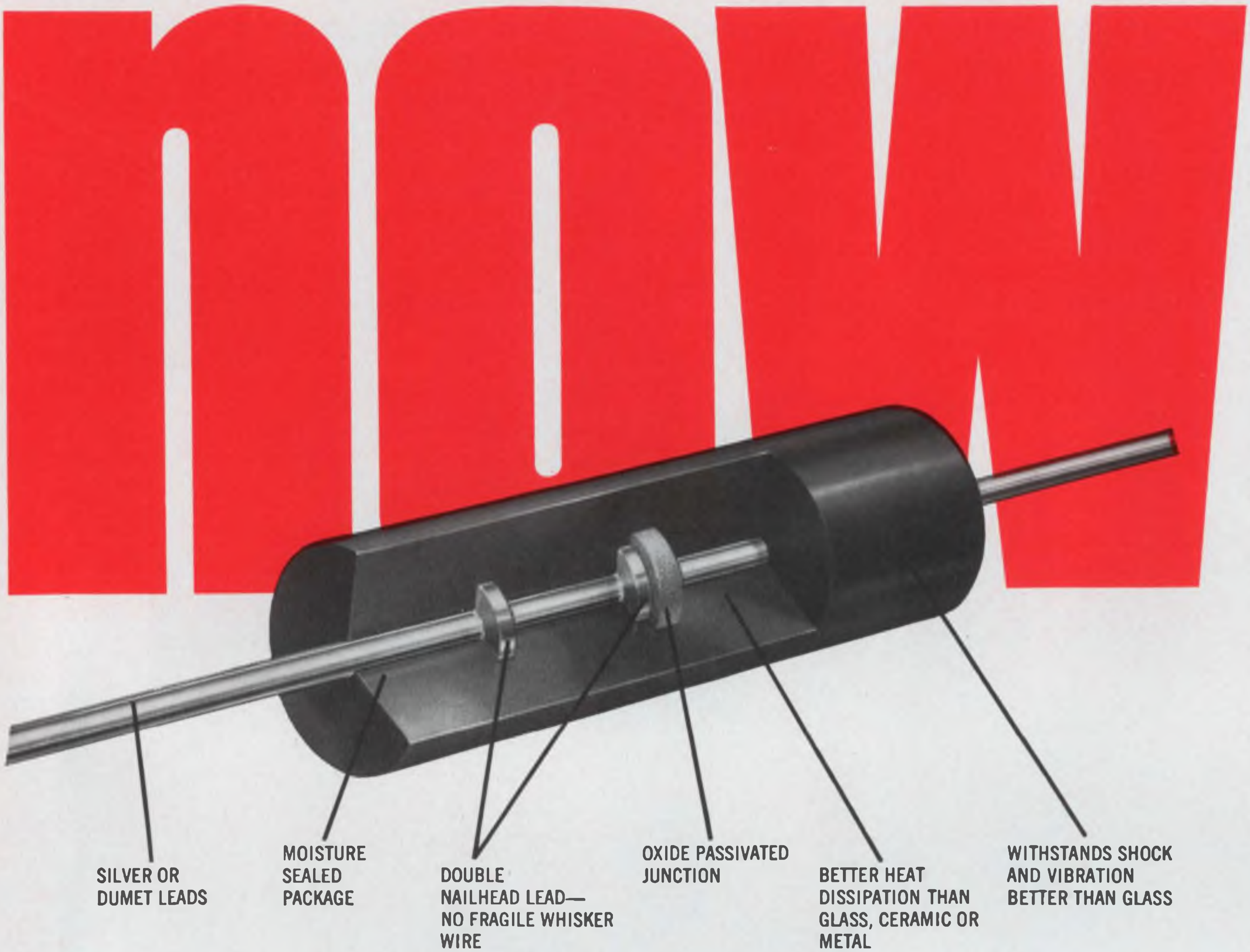

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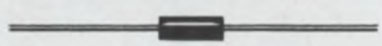

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MIL:	Designed to meet MIL-S-19500
WATTAGES:	Up to 1 watt @70°C
VOLTAGES:	6.8 to 200 volts
DIMENSIONS:	DO-7 (.265" long x .10" dia.)
TOLERANCES:	±5%, ±10%, ±20%
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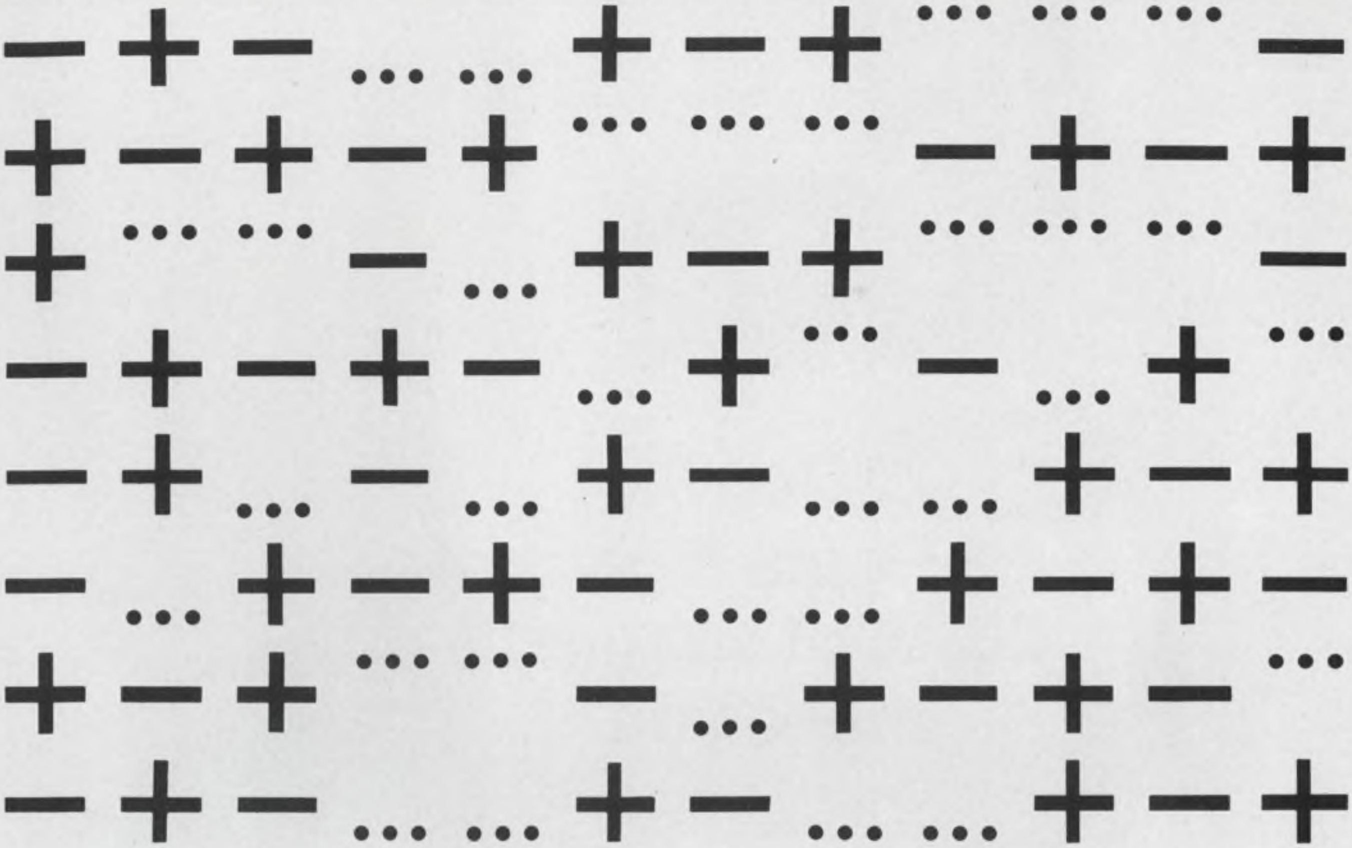


The Hoffman HCD-4 microminiature planar epitaxial passivated diode is designed for computer memory core driver and similar switching applications under 6 nanoseconds.

It features controlled forward conductance, with specified maximum limits on junction capacity and stored charge, to provide devices of uniform reproducible performance.

The conventional method of characterizing the switching speed of a diode by the measurement of the reverse recovery time is not used for fast switching diodes.

Hoffman uses a direct measurement of stored charge of the diode by integrating the reverse current of the diode. The stored charge represents an inherent characteristic of the diode and provides a single, unambiguous figure of merit which has minimal dependence on test conditions or jigs.

Repeatability of storage value measurement to within 5% can be made on direct reading low cost equipment.

For additional information regarding this product write Hoffman Electronics, Dept. A, El Monte, California.

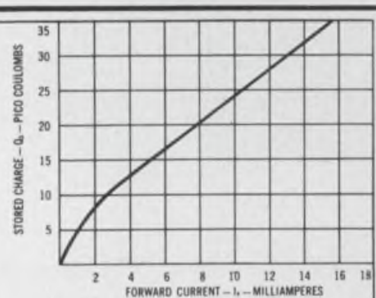
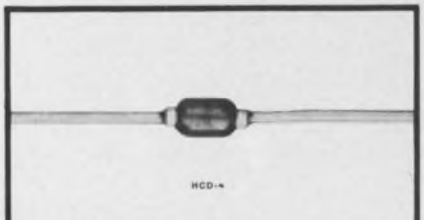


FIGURE 1 TYPICAL VARIATION OF STORED CHARGE WITH FORWARD CURRENT



MAXIMUM RATINGS

Power Dissipation: 500 Milliwatts (Derate 3.3mW/°C above 25°C)
Operating Temperature Range: −65°C to + 175°C
Storage Temperature Range: −65°C to + 200°C

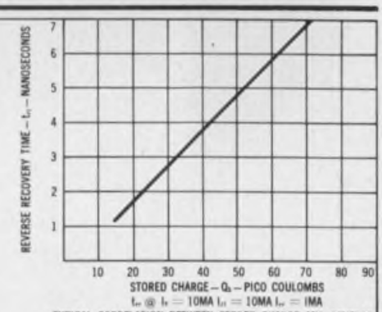
Electrical Specifications: 25°C unless otherwise specified

Parameter	Symbol	Min	Max.	Units
Forward Current (Note 1)				
I_F = 100 uA	V_{F1}	430	550	mV
I_F = 1 mA	V_{F2}	540	660	mV
I_F = 10 mA	V_{F3}	650	800	mV
I_F = 100 mA	V_{F4}	790	990	mV
I_F = 500 mA	V_{F5}	960	1350	mV
Breakdown Voltage I_R = 100 uA	B_{VR}	75		Volts
Reverse Current V_R = 50 Volts,	I_R		100	nA
V_R = 50 Volts T_A = 100°C	I_R		20	uA
Stored Charge (Note 2) I_F = 10 mA	Q_S		60	P Coul
Capacitance V_R = 1 Volt, f = 1 mc	C_D		2.0	pf

Note 1 — Test time at each forward test current 30-40 milliseconds.

Note 2 — Measured on B-Line Electronics Model QS-3 Stored Charge Meter.

Conditions: Pulse Amplitude = 5 Volts
Pulse Width = 50 nSec.
Rise Time = 4 nSec.
Source Impedance = 10 Ohms
Stored charge measurement accuracy ±4% of full scale.



t_rr @ I_F = 10MA I_rr = 10MA I_rr = 1MA

TYPICAL CORRELATION BETWEEN STORED CHARGE AND REVERSE RECOVERY TIME

FIGURE 2 (Q_s MEASURED IN B-LINE ELECTRONICS QS-3 STORED CHARGE METER AT I_F = 10 MA, t_rr MEASURED IN TEXTRONIX 291 DIODE TEST FIXTURE AT CONDITIONS INDICATED)

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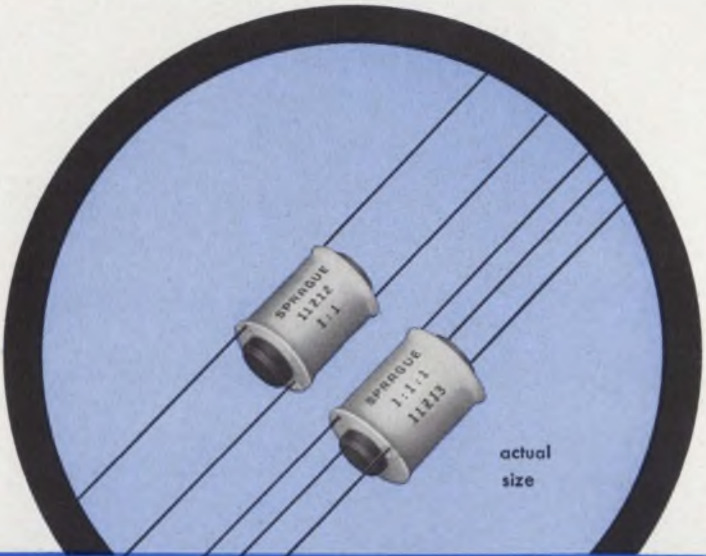

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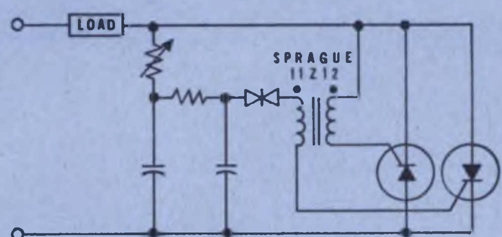
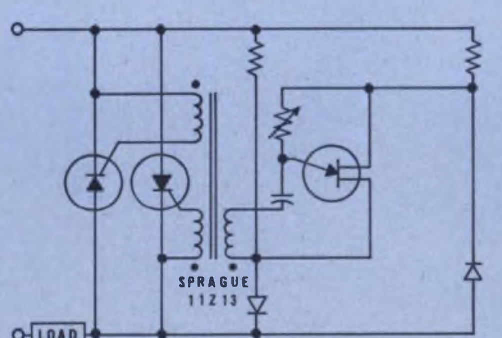


This breakdown-diode/transformer triggering circuit is a typical application for Type 11Z12 Trigate Pulse Transformers.



This unijunction-transistor/transformer triggering circuit is a typical application for Type 11Z13 Trigate Pulse Transformers.

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Dependable enough for industrial equipment, yet priced for high-volume commercial applications

Here's good news for designers of appliances; lighting controls; air-conditioning and heating controls; industrial controls. You can actually cut costs while upgrading your present method of SCR triggering!

Type 11Z Trigate* Pulse Transformers offer these unique features:

1. Balanced pulse characteristics and energy transfer from primary to secondary and tertiary windings.
2. Minimum saturation effect to allow operation where increased pulse widths are required.
3. Fast pulse rise time and increased current capability to prevent SCR *di/dt* failure.
4. Increased energy transfer efficiency.

Designed for operation over the temperature range of —10 C to +70 C, Trigate Pulse Transformers are available in 2-winding and 3-winding configurations for half-wave and full-wave applications. Both designs are rated for use with line voltages up to 240 VAC.

For complete information, write for Engineering Bulletin 40,003 to the Technical Literature Service, Sprague Electric Co., 347 Marshall St., North Adams, Mass. 01247.

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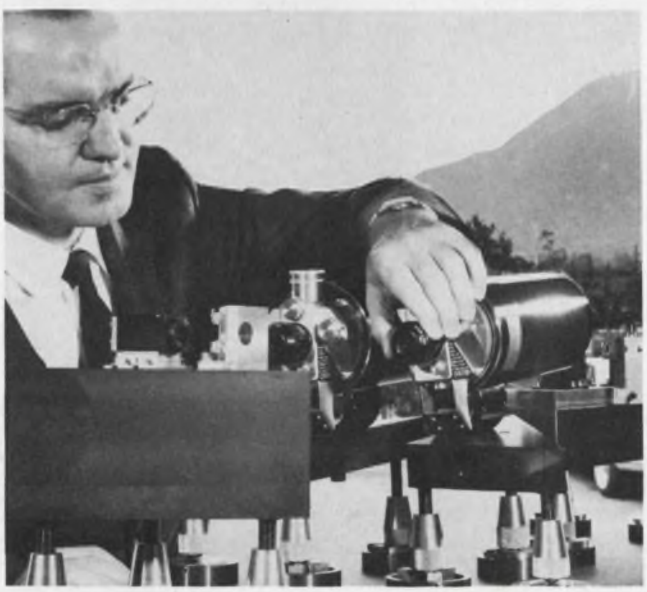
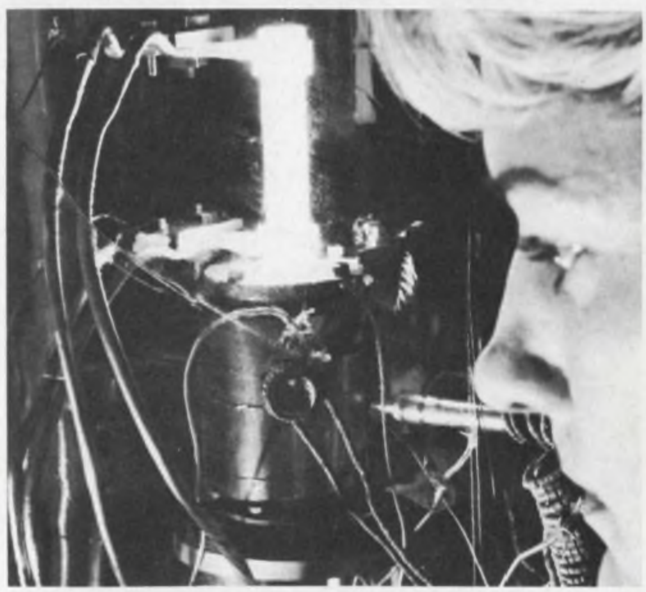
ED News

ICs dominate Paris Electronics Show PAGE 17
Practical heat pipe is developed PAGE 18
Improvements sought in deep-space data links PAGE 21
Cheap tools for budding physicists PAGE 26

All roads lead to Paris Electronics Show. 17

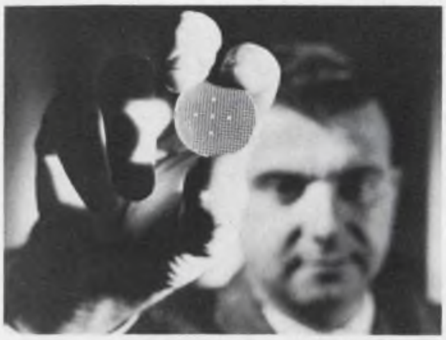


Laser communications. 21



Glow little "heat pipe." 18

IC mosaics



News Report

Ceramic insulation isolates IC elements

100 times greater voltage isolation between microcircuit elements results when they are embedded in a ceramic wafer, according to Arthur I. Stoller, of RCA Laboratories, Princeton, N. J., designer of the experimental process which accomplished this feat.

In this new mounting method the ceramic walls insulate the elements far better than the present method. Until now the rectangular elements had to be either "back biased"—adjacent element voltages matched so that no current flows between elements—or a large area of silicon dioxide was used as a separator. The former method hamstrings the IC designer while the latter method wastes much space.

The majority of communications circuits require higher voltages than precent IC arrays can handle. This new mounting method should eliminate these voltage restrictions that have prevented IC arrays from achieving widespread use in the communications field, according to C. Price Smith, director of the research project that developed this process.

The new process uses the same diffusion and interconnection techniques as previous IC arrays. And the ceramic mosaic is far more rugged than present IC array bases, according to Smith.

Apollo/Saturn IB to test hardware

The flight of the unmanned Apollo/Saturn IB, scheduled for late in February, is the first test in space of the craft that will send Americans to explore the moon.

Although this is not an orbital flight, the Apollo spacecraft is programmed to verify the performance of the launch vehicle and most of the major spacecraft systems during the approximately 39-minute flight. Almost 2000 measurements will be taken by the telemetry systems, making it the most highly instrumented space vehicle ever launched by NASA.

The launch will also result in other firsts for NASA. At 45,900 pounds, the Apollo spacecraft is the heaviest payload launched so far by the agency. And the combined Apollo/Saturn vehicle, standing 224 feet high and weighing more than 1,300,000 pounds at liftoff, is the largest space vehicle ever mated at Cape Kennedy.

As impressive as the Saturn IB launch vehicle is, it pales in comparison with the Saturn V, which will eventually hurl three men toward the moon. The Saturn V, with its 7.5 million pounds of thrust, will stand about twice the height of the Saturn IB.

IC prices cut by Signetics

Price reductions in some of its integrated circuit lines was announced recently by Signetics Corp. Cuts of 20 to 40 percent have been made in the SE100J MIL-range DTL series, the SE400J MIL-range low-power aerospace series and the SE500 MIL-range series of linear circuits, according to the company. In addition, reductions of from 33 to 50 percent have been made in the NE100J series.

In announcing the price cuts, Signetic officials said that they can be attributed to a rise in the production volume of these lines, most of which were introduced at WESCON, 1965. Said a company spokesman, "High production volume in MIL-range IC products not only makes it possible to reduce prices of the premium lines, but makes available a sufficient volume of narrower temperature range products to make the marketing of these devices feasible."

Consumer electronics soared in 1965

The output of consumer products by the electronics industry reached new peaks in 1965 with further gains forecast through 1970, according to the Electronic Industries Association's Marketing Services Department.

Color TV sets paced the field with a record number of 2.7 million sets sold, practically double the sales recorded in 1964. Sales of black-and-white TV continued strong, rising to 8.9 million sets during 1965. A heavy accent on portables and small-screen sizes in the black-and-white sales figures points up the trend toward families owning two or more TV sets.

In spite of the soaring popularity of television, the public demand for radios reached an all-time high of 41 million sets in 1965, with one out of every four radios produced being for automobile use. Tape recorder and phonograph sales were also up sharply over the 1964 figures.

The dollar volume of consumer electronic products also reached new heights in 1965. Factory sales totaled $3.3 billion, a whopping increase over the $1.5 billion recorded only ten years ago in 1955. The record dollar volume is even more remarkable in view of the steady decline in the prices of black-and-white TV sets and transistor radios. It is estimated that by 1970 the dollar volume will rise to $4.5 billion.

While TVs, radios and phonographs will account for the lion's share of the electronics consumer products market for the foreseeable future, manufacturers anticipate a steady rise in sales of both sound and video tape recorders and electronic organs.

Metric system coming closer?

A federal study on the feasibility of switching to the metric system of weights and measures may not be too far off. The House Committee on Science and Astronautics has approved, with amendments, legislation to authorize such a study.

Passed by the Senate last year, the legislation would direct the Secretary of Commerce to conduct a three-year program to appraise the desirability, practicability and cost of a general conversion to the metric system in the United States. The House version would authorize $500,000 for the first year of the study, with no budget limitations established for the final two years. Specifically, the Department of Commerce would:

- Conduct extensive comparative studies of the standards of weights and measures used in engineering, manufacturing, commercial and scientific areas and in educational institutions.
- Cooperate with other governmental agencies and private organizations in determining the advantages and disadvantages of a general conversion to the metric system.
- Cooperate with foreign governments in determining the advantages to the United States in international trade and commerce, and in military and other areas of international relations to be derived from such a conversion.

British version of our IEEE International Convention will open in London on March 23 and run through March 30. An all-time record number of over 600 manufacturers will be displaying products at the exhibition, which is sponsored by the Association of Supervising Electrical Engineers.

The world's most powerful circular electron synchrotron moved another step closer to completion with the awarding by Cornell University of a contract for the construction of a 55,000 square foot laboratory building to house the synchrotron's support equipment. The 10 BEV synchrotron is being built at a cost of $11,298,000 with National Science Foundation funds.

Price reductions on its entire line of solid-state low-noise preamplifiers have been announced by Applied Technology, Inc. of Palo Alto, Calif. The cuts range as high as 34 percent.

Dr. Edward M. Davis, Jr. has been named "1965's Outstanding Young Electrical Engineer" by Eta Kappa Nu, the national electrical engineering society. Dr. Davis, 33, is the assistant to the president of the IBM Data Processing Division in White Plains, N. Y.

The Foxboro Company has been awarded a contract for instrumentation to control what is reportedly the world's largest cement kiln at Dundee Cement Company's new $55 million plant in Clarksville, Mo. Foxboro will furnish electronic transmitting, recording and controlling instruments for the plant.

A conversion of its contract with Grumman Aircraft Engineering Corp. for development of the Lunar Excursion Module (LEM) has been announced by NASA. Under the new contract, Grumman will deliver 15 flight articles, 10 test articles and two mission simulators. This adds four flight articles to the contract. Total cost of the new contract, ending Dec. 1969, is $1.019 billion.

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Digital Thermometer/Temperature Controller 0.1°C accuracy* from -192.0°C to +999.9°C

features:

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- Direct reading
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The PAR Model DTS-1 offers a new order of reliability, convenience, and accuracy in laboratory and process control thermometry. The unit operates by comparing the resistance of a sensor element of platinum (the material whose characteristics define the International Temperature Scale) with an internally generated reference function which employs a unique resistance analog network** that precisely duplicates the temperature-versus-resistance change of platinum. This method allows an absolute accuracy* of 0.1°C to be achieved. A modified self-balancing Kelvin bridge eliminates sensor lead resistance errors, permitting precise remote temperature monitoring.

In addition to the direct visual readout, measured temperature information is available in binary coded or 10-line decimal form for printer or computer input as well as in pulse code modulated form for telemetry applications. For temperature control or strip-chart recording applications, an analog signal is provided which is proportional to the difference between the measured temperature and the desired temperature selected by front panel thumbwheel switches.

All circuits use solid state components except the comparator amplifier where two miniature nuvistor tubes are used to obtain high input impedance and the reference function generator where mercury-wetted relays are used. The entire Kelvin bridge, including the resistance analog network, is isothermally enclosed to assure a high degree of accuracy and good long-term stability. Rugged modular construction, utilizing printed circuit boards, contributes to reliable performance and extended service-free life.

Price: $3,950.00 (excluding probe). Write for Bulletin #118.

*Subject to operating range of actual sensor used.
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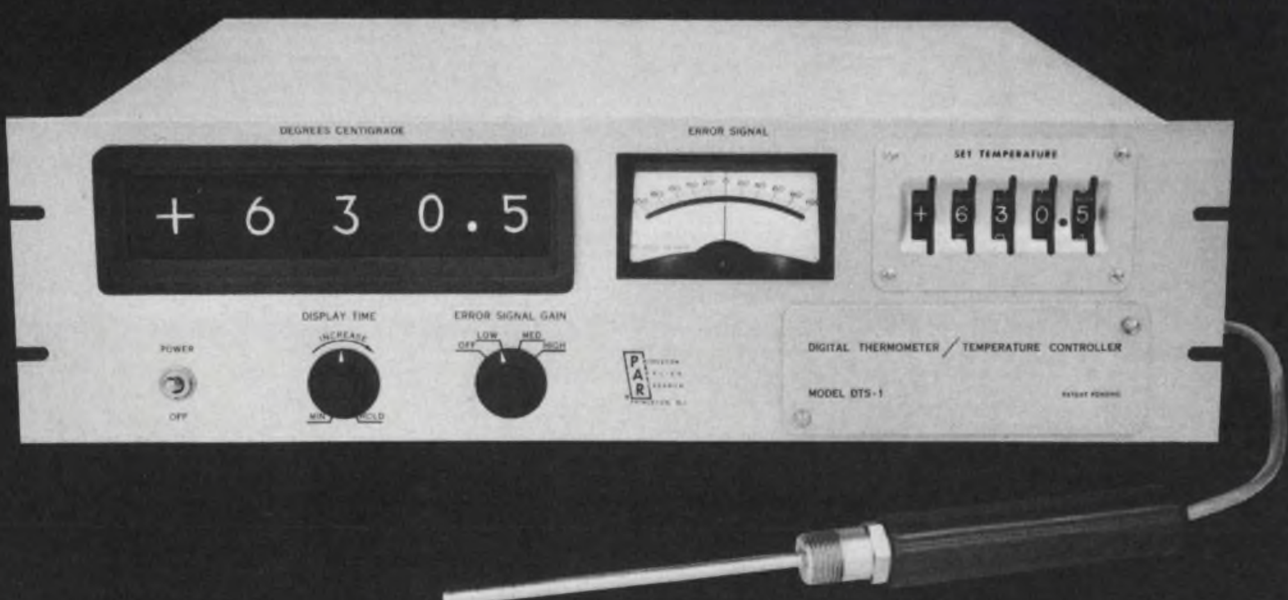


ON READER-SERVICE CARD CIRCLE 10

ICs dominate Paris electronics show

European manufacturers are teaming up to compete against U.S. concerns in the growing microelectronics market. Ferranti unveils an IC computer.

Howard Bierman
Editor

PARIS

With European integrated-circuit (IC) sales expected to soar from several million dollars last year to over $100 million by 1970, electronics manufacturers in Europe are banding together in a race to control the market. They want to avoid a repetition of the pattern established several years ago with transistors, when United States concerns captured the bulk of the sales.

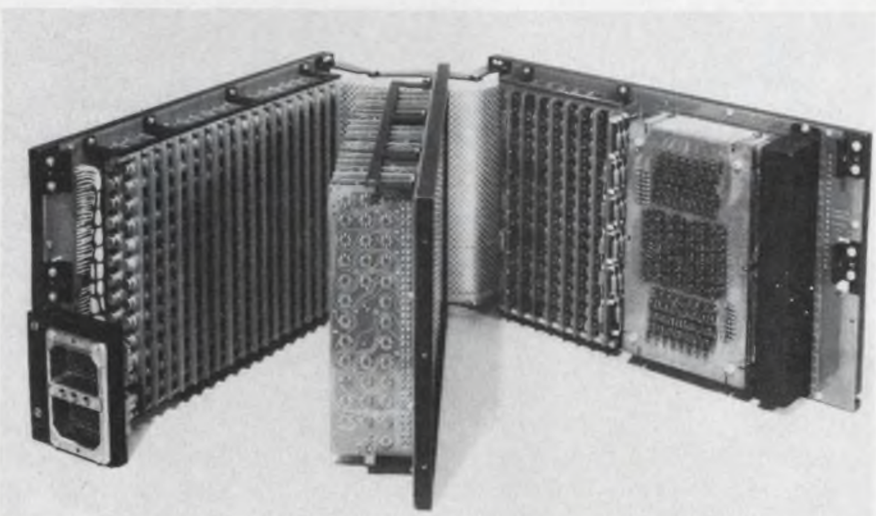
In Britain, Marconi and Ferranti announced a license agreement permitting Marconi to manufacture and sell Ferranti's Micronor silicon IC line. In France, two major semiconductor manufacturers, Cosem and Sesco, are completing an arrangement whereby each would concentrate on specific research efforts and then exchange technology. Finally the Molecular Electronics Div. of Westinghouse, through Westinghouse Electric International, has agreed to interchange licenses, patents and technological details with N. V. Philips Gloeilampfabrieken and North American Philips, Inc. These announcements were the main topic of discussion at the annual Salon International des Composants Electroniques, held here February 3-8.

European countries are faced with a difficult choice. Although not anxious to concentrate their purchases with U.S.-based electronics companies, they nevertheless want for their military and space programs the sophisticated devices that the Americans manufacture. European concerns are therefore rushing to set up production lines that can deliver comparable devices for prototype equipment.

At last year's components show, systems engineers showed considerable interest in microelectronic (ME) devices and were optimistic that hardware would soon be available. At this year's show, it was reported that the two major French computer manufacturers, IBM-France and GE-Ball, are relying heavily on ICs in their new designs. Although prototypes are being assembled with U. S. types, French companies reported they would be in a position to deliver quantity supplies of similar devices at competitive cost within the year.

German concerns, such as Siemens & Telefunken, are counting heavily on using ICs in industrial-control systems. Telefunken has been giving customers samples of its DTZL (diode-transistor-zener diode-logic line); the zener-protection feature is said to insure reliable performance despite sharp line-voltage surges, common in European factories. Telefunken is also seeking sales in military and space computer designs with a micropower DCTL line; however, a spokesman at its booth added wryly that sales of ICs seemed way off. Siemen's spokesman said that the company planned to offer a line of TTL devices for the industrial-control market within the next few months.

British reaction to the coming IC revolution appeared the most volatile. Current estimates by companies in Britain see a $50-million ME market by 1970. Marconi and Ferranti are determined to capture much of this. Ferranti has just invested more than $3 million in new production facilities to fabricate its Micronor line; Marconi is completing a 100,000-square-foot plant as a second source for the Micronor line.



1. **More than 9,000 ICs are used in Argus 400,** a Ferranti, Ltd, general-purpose microminiature computer. The processor, storage and input-output units are interconnected by a flexible printed-circuit assembly to facilitate servicing.

Ferranti's Argus 400 ME Computer

Details of Ferranti's recently completed Argus 400 microminiature computer, using Micronor ICs, were described at the show. The high-speed, general-purpose computer, slated for June delivery, uses approximately 8000 ICs in the central processor and more than 1000 in the remaining sections of the system.

In the central processor, the TO-5 packaged ME devices are soldered through six-layer printed-circuit boards, which are then connected to a multi-interconnection

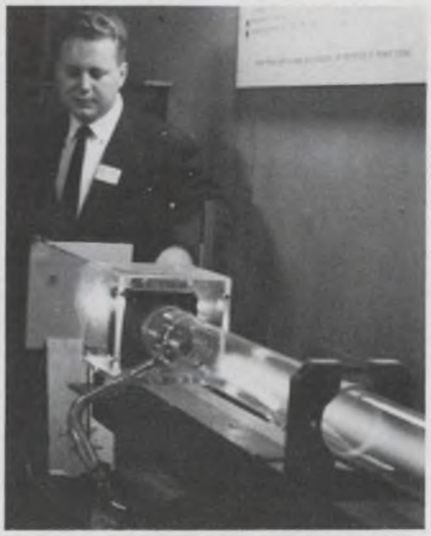
(Paris show, ***continued*****)**

circuit by miniature wrapped joints (see Fig. 1). The completed processor is housed in a 7-1/4-in.-by-12-in.-by-2-1/2-in. assembly.

The core-storage section includes six printed-circuit panels that contain 4096 storage cores; three panels of resistor-diode networks, and an interconnection board that includes timing circuits, driving circuits (ICs and conventional transistors), and thin-film sensing amplifiers. The complete storage section forms a 4096-word, 24-bit package in the same configuration as the central processor.

The processor, storage sections and input-output units are interconnected by wrapped joints to a flexible printed circuit, so that individual units are accessible when the outer case is removed. Ground planes formed on the printed-circuit boards, together with high operating threshold, offer a high degree of protection against induced transients.

The weight of the combined processor and storage section is only 16 pounds; the associated power unit weighs 13 pounds. The processor requires 20 watts; the first 4096-word core storage unit needs 30 watts (only 4 watts for each additional 4096-word storage unit), and 100 watts are required to deliver 80 watts output from the power section.



2. **CGE's 280-watt cw laser is demonstrated** by staff engineer M. Frappart. Laser demonstrations drew heavy attendance at the Paris Show.

Marconi revealed that close to 50,000 ICs would be used in 22 Myriad computers currently in production. Additional ICs will be used in the company's System 4 computer, similar in design to the RCA Spectra 70 line.

An attention-getting ME analog device, a VHF cascode circuit, was also announced by Marconi. The silicon device operates from dc to 200 MHz, with 17 dB gain and a 5-dB noise figure at 100 MHz. Marconi engineers say the TO-5 packaged device eliminates the time-consuming and costly neutralization techniques presently required in VHF wideband amplifiers.

Laser Activity Draws Crowds

Laser demonstrations at the show drew heavy attendance. The show management, in the interest of public safety, refused to allow exhibitors to set up operating lasers at the front of the booths.

Crowds jammed the rear quarters of E. Bradley, Ltd., and CGE (Campagnie Generale d'Electricite) to inspect the lasers. CGE showed a 280-watt cw type with an efficiency of 10 per cent (see Fig. 2). The active material was a mixture of carbon dioxide, helium and nitrogen. Emission, at a wavelength of 10.59 microns, was produced by exciting helium ions, which then excited the carbon dioxide. CGE reports it has sold close to 100 lasers this year for research and commercial use.

Color TV fades from show

A disappointing note at this year's show was the absence of color TV displays. At last year's show a number of companies exhibited color picture tubes, deflection components and even prototype receivers. There was optimism then that agreement on a color broadcasting scheme would be reached in Europe before the end of 1965.

This year, with agreement among the countries even further away than before, there was considerable gloom among consumer-goods suppliers about color-TV prospects for the next few years.

RCA 'pipes' heat into electricity

A highly efficient "heat pipe" for transferring energy from a heat source to a thermionic converter for direct conversion into electricity was unveiled recently by RCA.

The device is essentially a metal tube that conducts heat from one of its ends to the other with negligible loss. When used in conjunction with a thermionic converter, the heat pipe is expected to find application in space-vehicle power systems that employ nuclear reactors as the primary energy source.

Until now it has been necessary to design a thermionic converter as an integral part of the reactor. But with a heat pipe, the converter can be placed outside the reactor with no loss in efficiency.

1. Heat pipe (left) and thermionic converter (right) team up to convert thermal energy directly to electricity.

Lithium carries the heat

The heat pipe consists of a molybdenum tube containing molten lithium. When one end of the pipe is heated, the lithium at that end vaporizes, and in doing so, it absorbs a great amount of thermal energy.

The vapor is then transferred by

PERMANENT MAGNETS: Cast Alnico, Sintered Alnico and Ceramic Magnets (Arnox). **MAGNETIC CORES:** Silectron-C Cores and Distributed Gap Cores. Tape Wound Cores of Deltmax, Supermalloy, Permalloy, Supermendur and Silectron. **POWDER CORES:** MO-Permalloy Powder Cores, Iron Powder Cores and MSS Iron Powder Cores. **TRANSFORMER LAMINATIONS AND HARDWARE:** Nickel-Iron, Silicon-Steel Laminations, Transformer Cans and Hardware, Tube Shields. **SPECIAL MAGNETIC MATERIALS:** Vicalloy, Permendur and Vibralloy.

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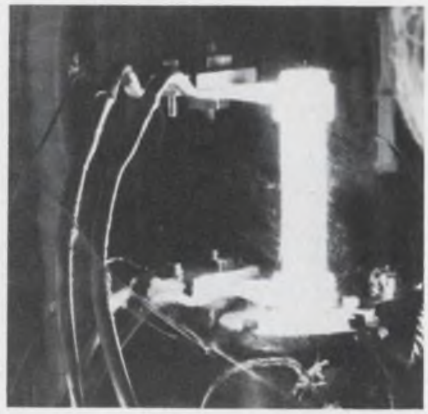
(**heat pipe,** *continued*)



2. Heat pipe glows white hot during test with thermionic converter.

thermodynamic action to the opposite end of the pipe, where it condenses and releases this energy with a negligible temperature drop. A capillary structure on the inner wall of the pipe, similar to a wick, returns the condensate to the other end of the tube, where the continuous cycle is repeated.

Initial work on the heat pipe principle was carried out by scientists at the Los Alamos Scientific Laboratory. RCA has continued this work at its Direct Energy Conversion Department under contract to the Air Force Systems Command.

Put a head on it

Ultrasonic transducers are replacing the physical jarring formerly employed to foam beer, driving off the unwanted air before the bottles are capped. The Electronic Assistance Corp.'s device is made of nickel due to the moist environment.

Far-out improvements sought in data links

Aerospace convention told of need for better components and techniques to achieve high-rate microwave and optical communications on deep-space missions.

Ralph Dobriner
West Coast Editor

LOS ANGELES

In the next decade communications equipment aboard deep-space probes may be required to transmit information back to earth at rates of 10^6 bits per second and higher. This compares with the 8-bit-per-second performance of the Mariner IV mission to Mars.

Several technical papers at the recent Winter Convention on Aerospace and Electronic Systems held here revealed that considerable component development in microwave and optical communications is still needed before the high data rates can be achieved.

Microwave needs outlined

Research goals for future microwave deep-space communication systems were described in a paper by Drs. W. T. Patton and A. B. Glenn of RCA, Inc., Moorestown, N. J. Assuming a 10^6 bits-per-second requirement for future spacecraft-to-earth data links, the authors cited the need for improvements in the following microwave areas:

■ **Phase and frequency stability** — Stability of better than 1 part in 10^{12} and phase-locked loop bandwidths of less than 1 Hz are needed. State-of-the-art frequency stability is adequate for high-data-rate noncoherent systems. However, for low-data-rate coherent systems, improved frequency stability is important to reduce both frequency acquisition time and doppler noise for orbit tracking. At the same time very low values of phase jitter (less than 15 deg rms) are required for a high probability of maintaining phase lock over long periods of time.

■ **Transmitter power**—The quality rather than the quantity of RF power needs improvement. The frequency stability and phase coherence of the transmitters must be better, particularly for relatively low-data-rate missions to the outer planets. Tube efficiencies must also be increased.

Techniques, such as beam focusing and the use of tapered helixes and multiple collectors should be considered, the RCA authors said. Solid-state amplifiers should be integrated with the solar cells, antenna and cooling structures to improve the over-all efficiency of the system and minimize the weight of these components.

According to the authors, a space-qualified traveling wave tube that can deliver 100 watts at 50% efficiency should be available by 1970. They noted that efficiencies as high as 57% have already been demonstrated in the laboratory. Current space-qualified TWTs deliver about 50 watts at about 2 GHz, with 40% efficiency.

■ **Low-noise receivers**—Improved maser materials and fabrication techniques, as well as better techniques for thermal isolation between components of the system, are needed.

More efficient and lighter closed-cycle cryogenic equipment and more efficient RF pump sources are also required. Multi-aperture receiving arrays will require many low-noise receivers at each station.

■ **Transmitting antenna gain**—A very lightweight spacecraft antenna that takes advantage of the relatively large surface tolerance compared with the ground receiv-

Table 1: Microwave Performance, Past and Future

PROGRAM	Index M (dB)	P_t (watts)	P_t (dB)	G_t (dB)	A_r (m²)	A_r (dB)	T_e (°K)	T_e (dB)	Freq. (MHz)
1959 Pioneer IV	−10.2	0.27	−5.7	2.5	290	24.6	1450	31.6	960
1962 Mariner II	+24	3	4.8	19	290	24.6	250	24	960
1965 Mariner IV	42	10	10	24	290	24.6	55	17.4	2290
1971 Voyager	70	50	17	34	1,770	32.5	25	14	2290
Future	90	10	10	45	63,000	48	20	13	
Future	90	100	20	40	20,000	43	20	13	

Table 2: Comparative Component Performance

Component	Type	Characteristic compared	Value
Lasers	Ar^{3+} (0.488μ) Nd^{3+} (1.06μ) CO_2 (10.6μ)	Photons/Mode-Sec (n_T)	10^{18} 10^{19} 10^{21}
Modulators†	Nitrobenzene KDP KTN	Max Trans/Mode	~1 ~10^{-1} ~¼ to ½
Optics	10 cm 100 cm 1000 cm	Transmission Mode	~1 <1 ~10^{-2}
Detectors	Si (0.488μ) PbS (1.06μ) (?) (10.6μ)	Quantum Efficiency	~½ ~½ *

Notes
†Adequate modulation bandwidth and modulation depth is assumed
*Heterodyne detection not yet demonstrated

(data links, ***continued*****)**

ing antenna is a primary goal. Also, RF-sensing and antenna beam-positioning techniques must be developed to handle beamwidths on the order of one degree or less. Single-channel RF error-sensing techniques should be developed to eliminate the cost and complexity of additional receiver channels for the sensing function, the authors noted. In addition there is a need for developing techniques for integrating the transmitting antenna, RF power source, prime power source and cooling structure, to improve the over-all reliability and reduce the combined weight of these components.

■ **Ground antenna system**—A large time-delay, collimated multi-aperture antenna system is sought, with noise contribution from the ground and low elevation angles on the order of 4°K. According to the authors, the techniques developed for this application must provide an average sidelobe level of about 80 db, with peak sidelobes or grating lobes on the order of 40 dB below the main beam. A 210-foot reflector, now being installed, represents nearly an order of magnitude increase in receiver aperture over the 85-foot reflector used for the Mariner IV mission. Future missions, the authors noted, will require an in-

Optical telescope, being adjusted by Dr. George Clark of Electro-Optical Systems, is used in experiments to measure the effect of atmospheric attenuation on laser beams. A pulsed neodymium laser output is beamed at mountain in background and signal attenuation is measured.

crease in effective receiver aperture of at least another order of magnitude. Envisioned is development of multi-aperture antenna systems that are 700 feet in diameter.

Performance index indicated

The microwave performance of three completed deep-space missions and the expected performance on future missions are summarized in Table 1, which was prepared by the RCA scientists.

The performance index, M, is considered to be the product of the effective radiated power in watts at the transmitter and the ratio of the receiver aperture area to the system noise temperature. The decibel values of M are the sum of the transmitter power, P_t, the spacecraft antenna gain, G_t, and the area of the receiving aperture, A_r, minus the receiving noise temperature, T_e. The performance index listed for future missions represents a data rate of 10^6 bits per second on a Mars mission. This is about five orders of magnitude above the performance of Mariner IV.

According to Dr. Patton, the improvements recommended above are expected to be achieved after five years of R&D and will probably take another five years to put into operation.

For high bps, go optical

For the very-high-data rates—10^7 to 10^9 bits-per-second—and especially for deep-space missions, it is generally accepted that optical communication systems, using the laser, will have to be considered. However, as discussed in a paper by George L. Clark, D. D. Erway, P. C. Fletcher and G. R. White of Electro-Optical Systems, Inc., Pasadena, Calif., many improvements in components and techniques are required before these systems can become practical.

According to Dr. Clark, a high-data-rate optical link will certainly be feasible between earth and the moon. He referred to the many favorable technical factors attributable to the fixed locations of both stations, though he expects the atmosphere to present a problem. Dr. Clark considers it far more difficult to set up a communication link between the earth and

(data links continued)

a deep-space probe at interplanetary distances. He observed that the earth station has all the bad effects of earth atmosphere, and the other station has all the difficulties of accurate tracking requirements plus limited size, weight and access.

A comparison of state-of-the-art lasers and components that make up optical communication systems is shown in Table 2, prepared by the authors.

The table shows that high-power gas lasers have the highest figure of merit, followed by solid-state crystal lasers and injection lasers. Although not as highly developed as sources, coherent optical detectors are nevertheless relatively far advanced.

Better materials and techniques to extend their capabilities to long wavelengths were forecast within the decade by Dr. Clark.

Modulators and optics lag

The third area of critical importance, that of propagation, modulation and control, is far behind in development, according to Dr. Clark.

The optical elements between the coherent source and coherent detector—including lenses, mirrors, modulators, phase shifters and turbulent atmosphere—must deliver the diffraction-limited output of the laser to the detector with the least possible loss of coherence.

Dr. Clark observed that at present these elements degrade communication systems by many orders of magnitude.

In Table 2 the concept of transmission per mode is used. The number of optical propagation modes in a beam is the ratio of the actual solid angle occupied by the beam to the diffraction limit.

Dr. Clark considers advances in pointing and beamwidth to be more important than increases in source power. In particular, he cited two functions in which diffraction limits are not even approached: modulation and penetration of the earth's atmosphere.

He pointed to the following areas in which coherence in optical communication systems is lost:

NEWS

(data links, *continued*)

■ **Electro-optical modulators**—At present all solid-state modulators introduce far more phase error, due to lack of optical quality, than phase control, in terms of the electrically variable phase induced in the wave. This means that the beams must be severely degraded to place the coded information on them.

■ **Earth's atmosphere**—A means of circumventing atmospheric fluctuations, through the use of low-frequency optical compensators in an adaptive array antenna, is needed to improve the data rate and characteristics of optical communication systems in which one station is earth-based.

In addition Dr. Clark cited the need for advances in detector materials and techniques for long wavelengths, for example, 10.6 microns.

He predicted that by 1975 a laser transmitter, operating in the 1-10 micron range, should be available. It would deliver up to 10 watts' output in a single mode. With suitable development, the unit would be able to meet the size, weight and reliability needs of space probes. Dr. Clark said that pointing accuracies of 0.2 second should be feasible corresponding to aperture diameters on the order of one meter at one micron. With an assumed detector quantum efficiency of 0.9 and an over-all transmission in the system of 0.4, the data rate would be about 90 million bits per second.

Accuracy is our policy

The path to international standards is tricky at times. We stumbled twice in our Feb. 15 issue.

On p. 17 the power-handling capability of Microwave Associates' all-diode duplexer should have been stated as 2 MW and 1 MW, instead of 2mW and 1 mW, respectively.

On p. 114 Fairchild's new microwave transistor was erroneously described as giving 200 MW output at 2 GHz. The correct figure should have been 200 mW.

New physics gives new physicists new tools.

Roger Kenneth Field
News Editor

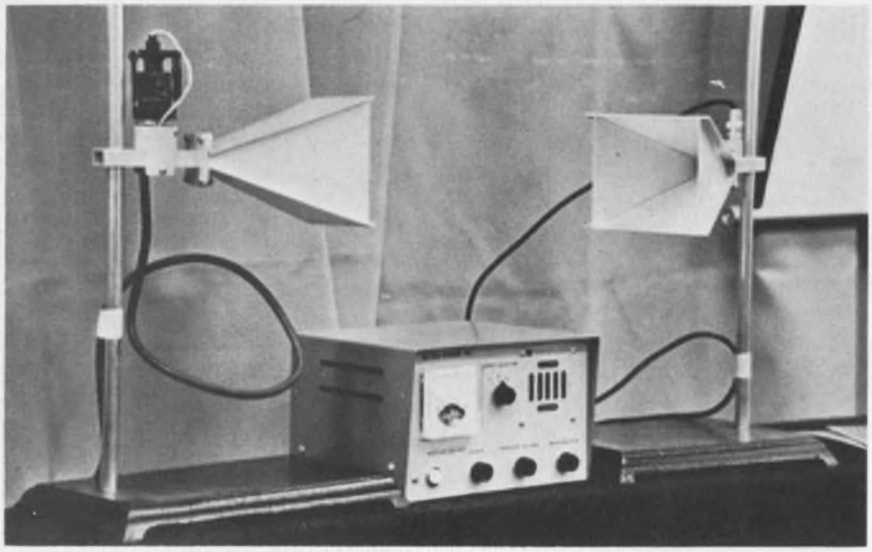
The new physics sweeps into the high schools of the country this year, and following the new broom is a whole new style of laboratory apparatus.

The new physics, like the new math, is a wholly coordinated and refreshingly intellectual approach to the teaching of a subject that has bamboozled students since Lucretius told his disciples about "The Nature of the Universe."

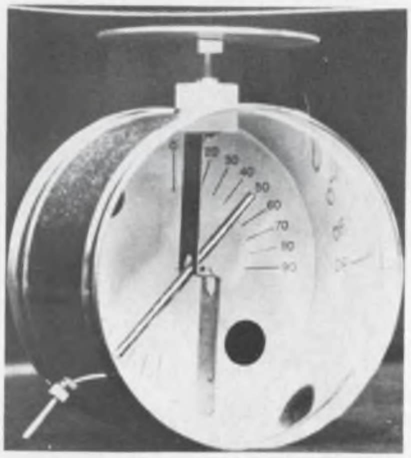
The apparatus is now so inexpensive that the budding young Nobel laureate can afford to own much of it himself. The emphasis of the new physics is to have the student duplicate famous experiments.

To keep production costs to a bare minimum, manufacturers must resort to using the cheapest possible materials. A list of "components" in this field includes such amusing entries as rubber bands, paper clips, drinking straws, coffee cans (see Fig. 2), colored water, balsa wood, fish tank pumps and strips of adhesive tape. It would also include, however, integrated flatpack arrays (Fig. 3) and klystron tubes (Fig. 1).

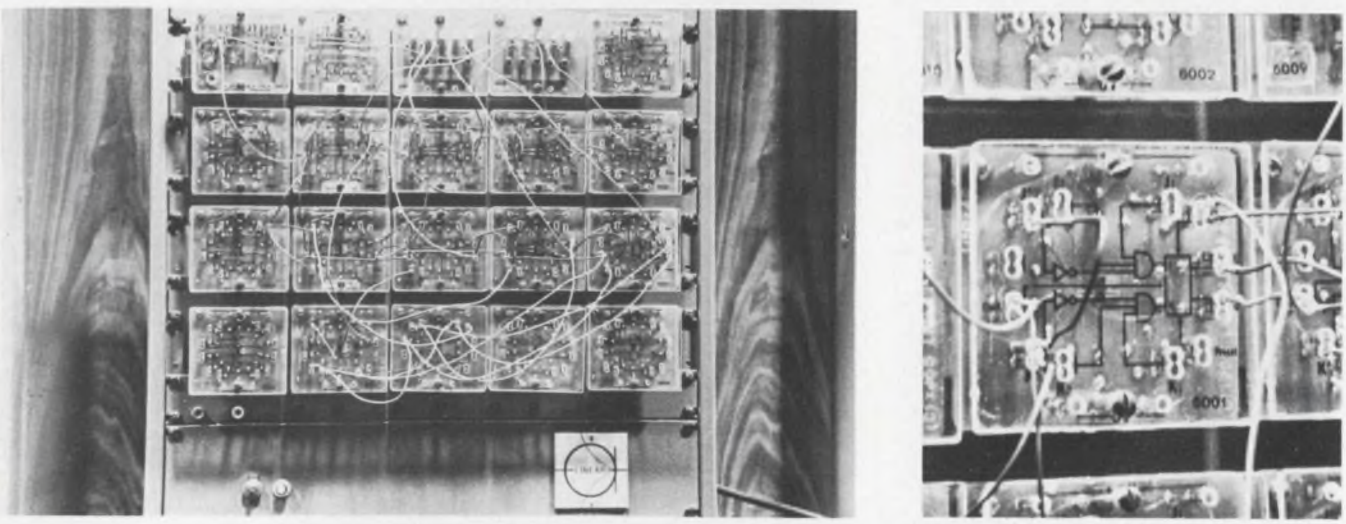
These electronic devices were displayed at the American Association of Science Teacher's Show in New York late last month.



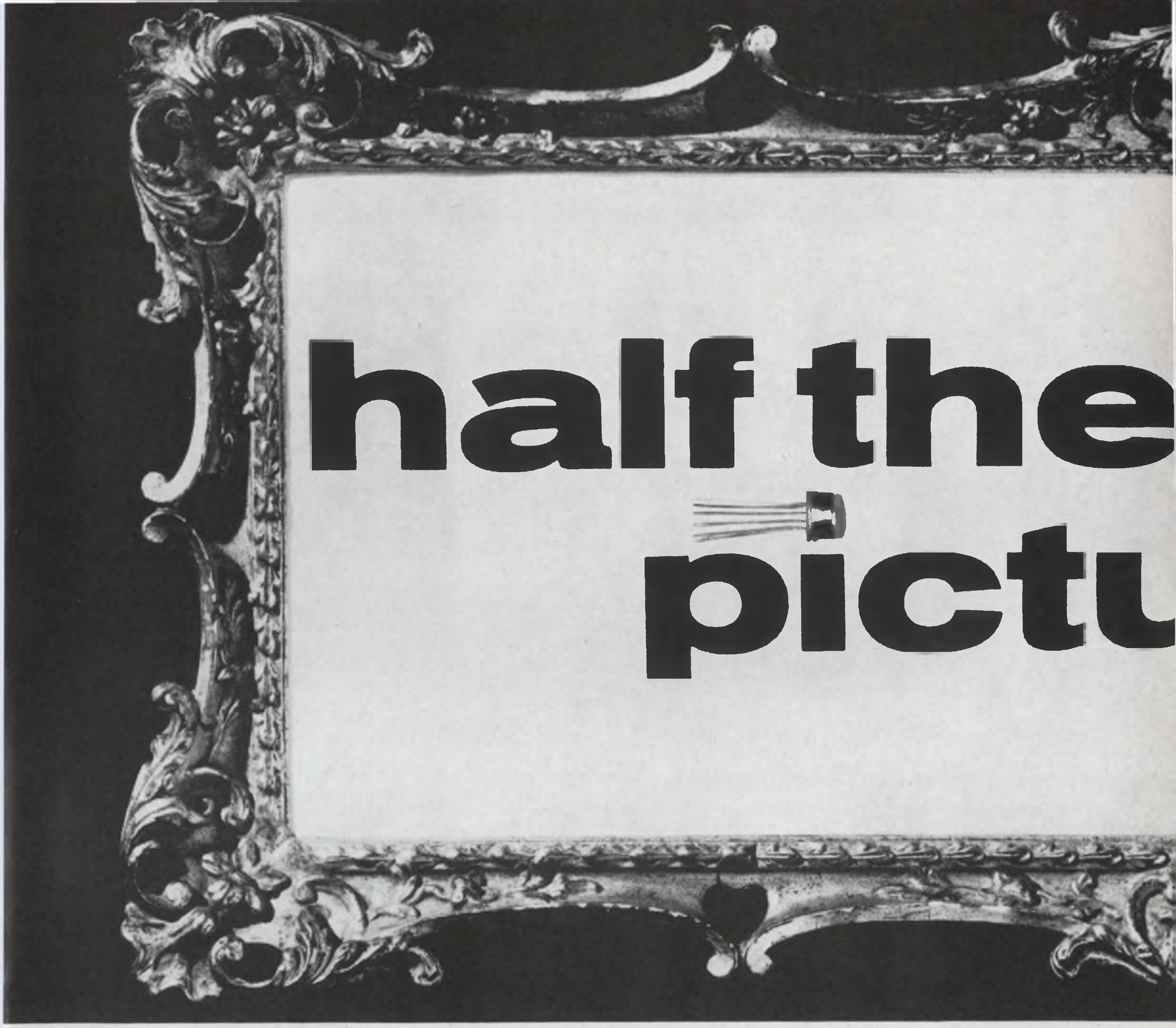
1. **Microwave experiment:** $190, by Macalaster Scientific Corp., Watertown, Mass., includes polarizing grid, and deflector.



2. **$3 electroscope** made from a Maxwell House coffee can, by Macalaster, uses an aluminized drinking straw for the pointer.



3. **"Log log lab"**—a digital logic patchboard system for classrooms: uses integrated circuits, from Linear Alpha, Inc., Evanston, Ill.



When you look at electronic components are you seeing only half the picture?

We're the last people to argue with component purchasers who put performance, price and delivery first — meeting these three basic requirements is what keeps us in business. But most engineers are also on the lookout for something more, and many of them find it at Mullard.

Take research and development for instance. Out of Mullard R&D have come outstanding devices such as the travelling wave tubes for the New York — San Francisco and Montreal — Vancouver microwave links. Production resources? Mullard plants are among the most efficient anywhere, with a reputation for the production of tight-tolerance devices to proved standards of reliability. As for circuit know-how, Mullard has the best equipped applications laboratories in Britain. And when it comes to technical services, you will find that Mullard provides the kind of comprehensive performance specs, survey documents and application reports that are just that much more useful.

If you want to get the *whole* picture, why not ask us to help you with some of your component problems?

ON READER-SERVICE CARD CIRCLE 213

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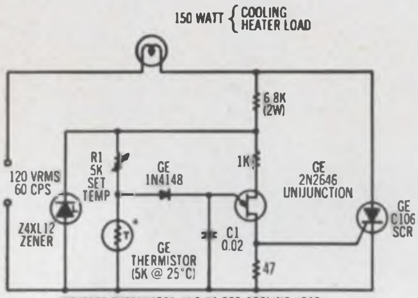

*REVERSE THERMISTOR AND R1 FOR COOLING LOAD
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heater so that the heat supplied the liquid bath load balances, exactly, the heat losses to the outside. Presto: the bath temperature must remain constant. Learn more about this profitable controller by circling Number 812 on the magazine Reader's Service Card.

■ NEW DESIGN TIPS—GET 'EM WHILE THEY'RE HOT! AT G-E IEEE SEMINARS!

Join us at the Barbizon Plaza on March 22nd for two vitally important G-E seminars. We've scheduled two excellent programs for you. On tap in the morning: *Innovations in Industrial Semiconductor Circuits.* And in the afternoon: *Semiconductor Control and Power Conversion Applications.*

Morning discussions will feature Rick Spofford on "Applications of the New Silicon Bilateral Switch and Silicon Unilateral Switch"; Bob Muth on "Digital Circuits with Visual Readouts"; and Dwight Jones on "Semiconductor Timers and Low Frequency Oscillators."

And the afternoon agenda will include presentations on "Ingredients for Today's Power Semiconductor" by Ed VonZastrow; "Economy Semiconductors for the Light Industrial, Appliance and Housewares Industry" by Denis Grafham; "Using Triacs and Light-resistive Leads" by Jim Galloway; "7500-volt 2-ma Power Supply" by Andy Adem; and "Low-cost Ultrasonic Inverter Using an SCR" by Neville Mapham.

Try to attend both if you can. Or if you'd like more information on either, circle Reader's Service Card Number 813 for details on the morning session and Number 814 the afternoon program story.

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Try substituting G.E.'s new microtab transistors. They're even smaller than they appear in this picture—a mere 0.07 by 0.07 by 0.085 inches. Yet you'll find they deliver exactly the same performance their larger, conventional-sized counterparts give you.

Think of the advantages they offer equipments such as hearing aids, miniature operational amplifiers, and very small instrumentation products. Try them in your latest hybrid circuit developments, or in your linear and analog circuits.

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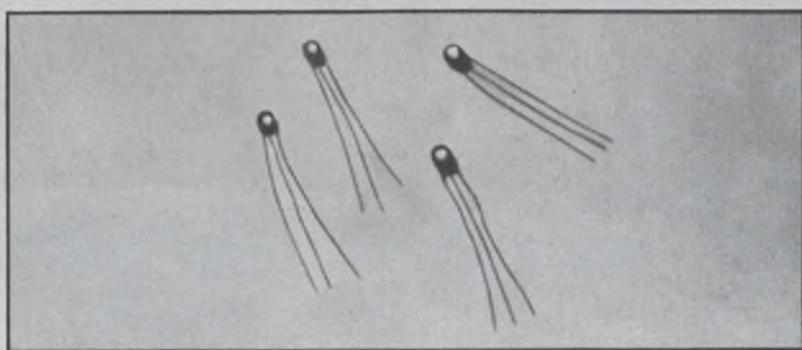

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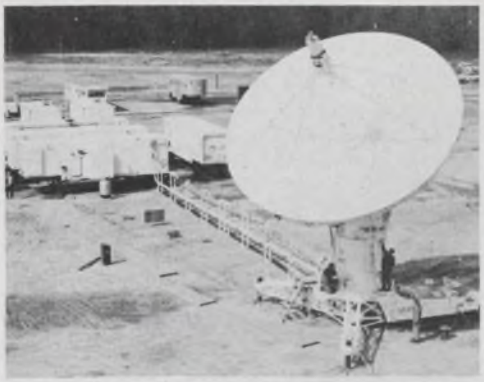
GENERAL ELECTRIC



Washington Report

S. DAVID PURSGLOVE, WASHINGTON EDITOR

U. S. to test its electronic defense

How effective are anti-radiation missiles? Can they really home on protective radar and knock it out in a war? The Army plans to find out. It is setting up a program to study U. S. electronic detection and identification systems and radar-controlled defensive weapons. How vulnerable would they be to enemy anti-radiation missiles, the weapons that modern war doctrine says will be launched as a first wave to activate the defensive radar, home on it and destroy it?

Most details of the Army program are classified. It is known that it will be supervised from Fort Monmouth, N. J. An Army-industry team will have until sometime next January to complete the first phase of the program—the development of a master plan and a computer program for conducting the study.

R&D slated for linear-induction motor

A commerce Department R&D official says that research funds will be provided for the linear-induction motor, viewed by some as a science-fiction approach to high-speed rail transportation. The research will be conducted under the High Speed Ground Transportation Research and Development Act of 1965. Exactly what route of several the researchers will follow has not been decided yet, because, as the official put it, "We aren't in the specifications stage yet on this project."

Among the directions in which the Commerce Department is known to be looking are those followed by Westinghouse Electric in its "electropult" idea, dating to its 1946 concept for electric launching of aircraft. Another direction is being pursued by General Motors' Santa Monica laboratory in California; it is looking at linear-induction motors for powering GM's Hovair vehicles.
The Teletrans Corporation, a Detroit firm, is building a test track with vehicles propelled by linear induction motors. A prototype has been in use over a year.

Commerce officials also indicate that the present "formative status" of the engineering research program for high-speed ground transportation holds significance for electronic designers. Feasible projects still are being sought for inclusion in the program, they said, and almost any probable proposal will be given a hearing. On this count, Dr. Robert A. Nelson, director of the Office of High Speed Ground Transportation, has said often that he tries to listen to all comers. He hopes somebody can weed out the pure crackpots, but he cannot afford to refuse an audience to the rational proponent of even a "way-out" idea. "This kind of idea may contain the kernel of an approach we need," he says.

Senators urge nuclear-transport program

Senators Warren G. Magnuson (Dem., Wash.) and John O. Pastore (Dem., R.I.) want to see the many Federal projects in nuclear propulsion for transportation systems brought together in a coordinated program. They have introduced a resolution that, ultimately, would have that effect. It provides for a study to determine the best way to encourage the use of nuclear transportation on land and sea and in the air.

Both Senators have long expressed annoyance at the initiation and cancellation of nuclear-propulsion programs in aircraft, ship and other fields, without regard by officials in one field for the state-of-the-art or the implications of their actions in another field. Some observers anticipate a push for a new "bureau of transportation energy" in the Atomic Energy Commission to coordinate and later manage ship and aircraft reactors and any railroad and highway-vehicle reactors that might be developed.

Civilian role for military R&D?

The White House is expected to call on military and space R&D companies by early summer to apply their systems approach to solve big non-technical problems. Administration science and technology advisers are said to be planning to point to a forthcoming report study by the National Institute of

Public Affairs. The study is evaluating "possible new technological approaches to problems of crime and delinquency, government information, transportation and waste management." The institute is examining the results of a California experiment in which aerospace companies applied the military R&D systems approach to define and partly solve major statewide problems. If the California results are found promising and point to applicability in other non-technical areas, the Administration is prepared to call in dozens of military and space R&D companies to combat everything from pollution control and transportation to poverty and foreign aid.

Most observers expect the institute report to be positive. Carl F. Stover, director of the institute, said before the study began: "The defense and space programs demonstrate that we can govern modern technology and employ it to execute gigantic tasks. They have given us better tools for analyzing complex problems . . . they have shown that industry's talents can be soundly used in carrying out public programs."

The California experiment, set up by Gov. Pat Brown, involved five aerospace concerns. Aerojet-General studied waste management. The Lockheed Missiles and Space Company analyzed state government information needs and proposed the beginnings of an automated information system. North American Aviation examined the state's future transportation needs and proposed several preliminary approaches to solutions of the problems it foresaw. The Space General Corporation utilized specially adapted computers to examine California's crime and delinquency problem, and it turned up several unforeseen factors. The System Development Corporation provided technical advice to the state on all of the studies.

The results of the California experiment already have been highly praised by state officials and by many Federal officials. There also have been skeptics who have cried, "Boondoggle!"

Federal highway bills pushed

The provision for a traffic safety research center in the National Traffic Safety Bill introduced by Sen. Vance Hartke (Dem., Ind.) has been spelled out. As Hartke sees it, the research center will have all the facilities necessary to study every aspect of traffic accidents; to determine causes and to design, develop and test systems and devices that suggest solutions. He wants to see the center equipped with the best possible library, laboratory and testing facilities.

Whether the Hartke bill will become part of President Johnson's over-all highway-safety program remains to be seen. The President's program calls for an outlay of $3 million in fiscal 1967 for research on the possible establishment of safety standards. The program envisions spending $20 million in fiscal 1968 to help states set up their own highway programs. And it includes $10 million more in the same year for federal R&D on all aspects of highway system safety.

Common grave for dying programs?

NASA and the Defense Department, largely at the urging of Congressmen who don't want to see the two agencies duplicate each other's manned space programs, have set up a joint group to coordinate NASA's post-Apollo applications program and the Air Force's manned orbiting laboratory (MOL). As reported in this column (E/D, Jan. 18), both programs are in trouble. MOL funds were supposed to soar in the new budget; the program got no increase, supporting a widespread belief that it will never get off the ground. The post-Apollo applications program, which would use man-on-the-moon techniques and hardware for unmanned scientific missions beyond the lunar landing, received only half the budget that NASA had asked the White House for. In fact, the post-Apollo program has never been officially authorized by congress.

The new agreement signed by NASA and DOD calls for the "expeditious coordination of their manned space flight programs." The agreement establishes a joint committee, known as the Manned Space Flight Policy Committee.

Within guidelines to be provided by the Secretary of Defense and the Administrator of NASA, the committee will "determine top-level policy for the manned space flight programs, ensure the coordinated planning of the two agencies' programs in this area, and resolve matters concerning the mutual participation in and support of the manned space flight programs which cannot be resolved at a lower level."

Following announcement of the NASA-DOD coordinating group, the coffee-talk at both agencies was somewhat as follows: "Does this mean the White House is going to save a little more money by picking a common funeral director to handle both corpses?"

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Letters

Federal action for highway safety irks some readers

Sir:

The editorial "Legalized Murder on the Highways" (ED, Dec. 20, 1965, p 23) asserts that the automobile manufacturers are guilty of murder and implies that the Federal Government should regulate or punish them.

This type of argument is at the center of nearly all the legislative activities of all the countries of the world. It should not be made or considered lightly.

The argument in its essential form is that the industrialist, the capitalist, is coercing (in your case murdering) his customers through his ability to produce and trade. But the Government, with its monopoly on compulsion and coercion, is capable of creating some vague societal excellence through its ever-increasing legislation, fines, taxes and jail sentences.

A cursory knowledge of political philosophy will tell you that the purpose of a government in a free society is to prevent the initiation of force. When government itself begins to use force on the citizenry—as in dictatorships and incipient dictatorships—it creates a living horror that no gang of murderers is capable of.

How much we dislike our unsatisfactory neighbors, steel prices, wheat prices, cars, medical costs, rent, etc., is trivial to the argument of whether or not the Government should "play a part"—which means whether or not the Government should initiate force for us against our neighbors.

The argument that capitalists and traders value the dollar sign, not human lives, is the stock-in-trade of every dictatorship on the globe. The dollar is a product of trade and capitalism. The results of dollars and capitalism vs. guns and statism on human lives is too obvious to be honestly disputed.

EDWARD S. DONN
Electrical Engineer
Phoenix, Ariz.

• *We did not intend to imply in our editorial that the Government should "punish" the automobile industry for deaths on the highways. But we certainly did suggest that regulation, such as that applied to airline operations, is in order. Because of the auto industry's long apathy, and the Federal Government's passive role, individual states are starting to take needed action. This is a poor situation, since rules will probably vary from state to state, causing much greater expense to the auto industry and its customers. The alternative is an intelligent and vigorous Federal program.*

We dislike losing freedom, too, but we're glad the Federal Aviation Agency makes our air travel safer. And we don't feel less free because of it. We'd be even gladder if cars were available with collapsible steering wheels, padded dash boards, low-glare surfaces, front and rear seat belts and other safety features.

Also, the use of electronic systems to aid traffic control is, with a few exceptions, rudimentary or nonexistent. Yet several techniques have proved useful in tests. A well-run federally sponsored R&D program could lead to greatly improved systems for state and local traffic authorities. Again, we believe in freedom, but we do stop for red lights and stop signs. We also pay taxes, and we like to see the money well spent.

Editor

Sir:

Re the editorial on highway safety:

You also fall for the holiday week-end syndrome of the National Safety Council. If you divide the total traffic deaths per year by 365, to obtain a figure of 120 per day, and multiply this by the number of days in the holiday (plus a little extra because NSC picks the worst parts of the first and last days), you will arrive at within 10 to 20% of the people killed during that holiday. Since this figure is so easily arrived at, one wonders about the sincerity of NSC in their misleading emphasis of the danger of holiday driving.

JOHN DARROW
Union Switch & Signal
Pittsburgh, Pa.

Sir:

While I am willing to concede the good intentions of the editorial "Legalized Murder on the Highway," among those contributing to the problem are the members of the public media who, on the basis of the opinion of one special pleader or accident, become experts on highway safety.

May I suggest that you secure some facts concerning it from sources other than lawyers or legislators. The National Safety Council, Cornell's Crash Injury Research, Harvard's Fatal Accident Investigations and Northwestern's Traffic Institute are only a few of those who have spent years researching the problem.

I doubt that you would pay much attention to a lawyer explaining the problems of electronics for space vehicles, and those of highway safety are just as complex.

It will avail little to point out how both your and Mr. Nader's statements are in complete variance with the facts of highway safety. The information is available, if either of you has any actual interest in this problem.

ROSS C. MERRITT
18 Great Hill Rd.
Ridgefield, Conn.

Sir:

Regarding your editorial in the December 20 issue of ELECTRONIC DESIGN (p 23) on "legalized murder," may I offer a few suggestions? Perhaps New Jersey needs to outlaw certain tires as being suicidally unsafe in the wet. Maybe Nevada could prohibit others for use at high speed and high temperatures. Certainly you can't drive across Baltimore in a snow alert without snow tires.

What makes you think that some Federal program of compulsory "safety devices" would be more effective in reducing highway slaughter than the mealy, creeping predictions and idiotic slogans of the National Safety Council?

Consider the car-and-driver system from the view of reliability, before you seriously suggest the insertion of any complex electronic gadgetry, in series or parallel, between me and my highly reliable four-wheeled black box. Let me point out some of our more outstanding electronic successes in the automotive/traffic field.

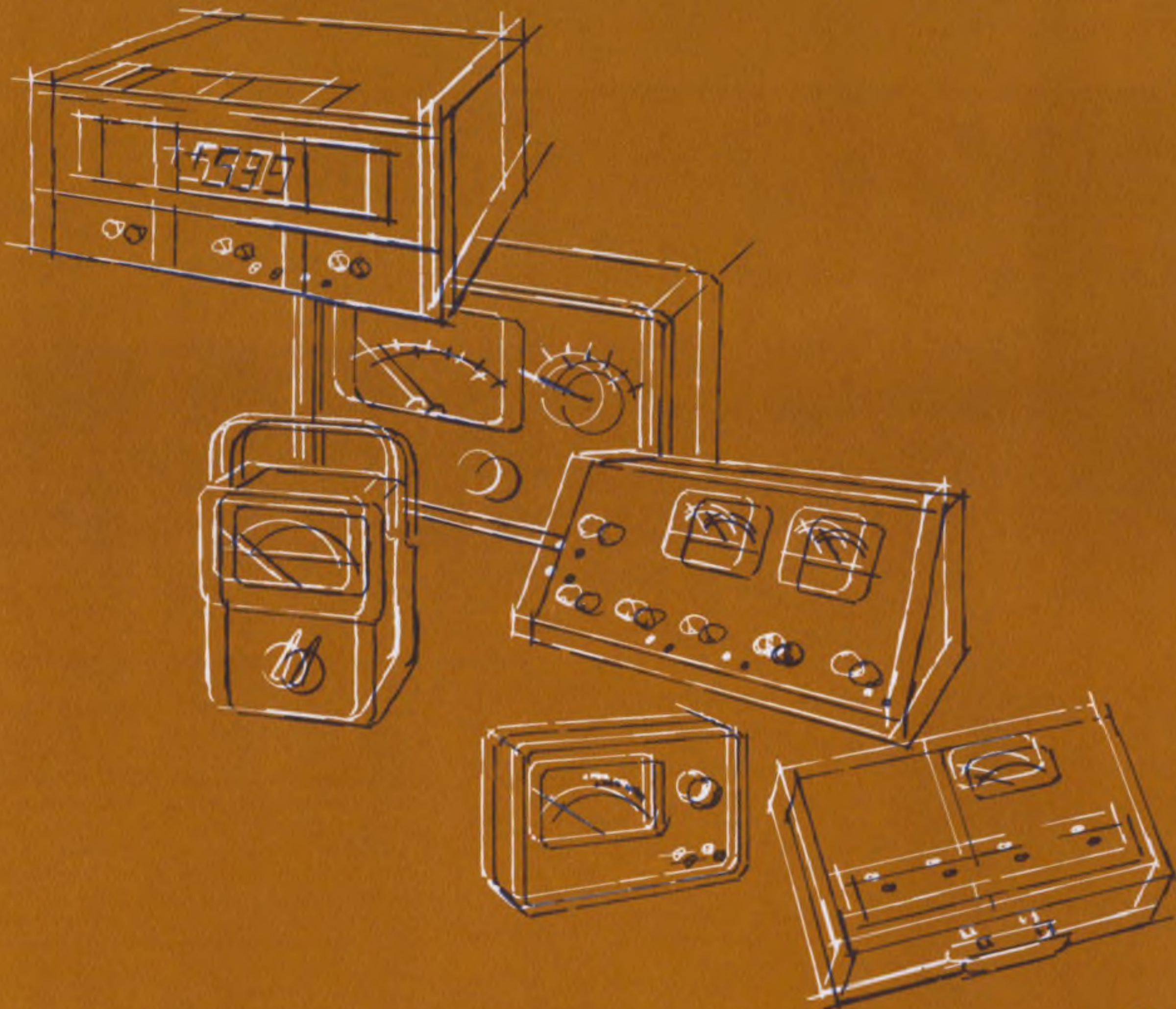
How does your headlight dimmer work? Did you have one of the early alternator/rectifier systems? The microwave traffic light actuator, which used to look at the tops of our cars (without seeing) at US Highway 441, had to be ripped out

CATALOG
NUMBER 056

Simpson

LAB-LINE

precision instrument group



SIMPSON ELECTRIC COMPANY

5200 West Kinzie Street, Chicago, Illinois 60644 • Phone (312) 379-1121

Simpson LAB-LINE TECHNICAL DATA

DIGITAL VOLTMETER

model 111

ACCURATE
0.1% of reading (See specifications)

WIDE RANGE
Reads from .001 to 999. volts DC (same AC voltages with Model 115 Converter)

FAST
Less than one second per reading

DECISIVE
Digital display eliminates reading errors

RELIABLE
Solid state circuitry means minimum maintenance

EASY READING
Unique, high-intensity, wide-angle display

BINARY OUTPUT
Available as an optional feature

TYPICAL APPLICATIONS

The Model 111 DVM is ideal for production testing applications because its use saves time and eliminates errors. An operator having no specialized training can obtain accurate readings right from the start and continue doing so, day after day. The digital display reduces operator fatigue since it requires no interpretation.

The Simpson Model 111 is also ideal for incoming inspection and quality control applications. In the laboratory—in educational and other applications where added accuracy would be of no advantage—the instrument provides all the benefits of digital readout at a substantial cost-saving, with respect to comparable equipment.

Model 111 can be used as an analog-to-digital converter. An optional binary output is available to operate digital printing equipment or remote displays. The Model 111 DVM is frequently used in conjunction with transducers as a readout system for widely-varied electrical, mechanical, environmental and chemical parameters.

DESCRIPTION

The Model 111 DVM is basically a null seeking-balancing system. It samples a portion of the unknown input voltage and compares it to an opposing voltage which is developed internally from a zener reference standard.

The internal reference voltage is divided into 1000 equal increments through a digital-to-analog converter. A 1-kc/s clock then increases the output of the converter in 1000 discreet steps (producing a staircase waveform). Simultaneously, a 7-bar incandescent readout display connected to the 1-2-4-2 bcd logic counter-decades counts each progressive step.

When the staircase voltage attains a level equal and opposite to the sampled portion of the unknown input voltage, a null is produced at a summing point. A photo-electric chopper converts the summing point voltage to AC for precise and stable null-detection. Detection of the null stops counting. The unknown voltage can then be read on the display.

Should the input voltage exceed the selected range, a null cannot be reached. In such case, the counters will continuously re-cycle, indicating that a higher range must be selected.

If the polarity switch is not correctly set, the internal reference voltage will not oppose the input signal. This is sensed by a diode network which triggers a "change-polarity" sign and causes the readout to indicate zero.

DIGITAL VOLTMETER, model 111

SPECIFICATIONS

ACCURACY: 0.1% of reading ±1 digit on upper ranges. On lowest range, 0.1% of full scale ±1 digit

REFERENCE SOURCE: High stability, temperature-compensated zener diode

RANGES: 0 to 0.999, 9.99, 99.9, and 999. volts DC

RANGING: Manual

OVER-VOLTAGE: If voltage is beyond capability of selected range, display will continuously re-cycle until proper range is selected

DECIMAL POINT: Tracks with range switch. May also be remotely programmed

POLARITY INDICATOR: If input polarity is incorrect, a "change polarity" sign automatically appears on readout

MAXIMUM TIME FOR READOUT: One second (proportional to voltage)

READOUT: Incorporates Model RLA High Intensity Readout, described elsewhere on this page

NUMBER OF DIGITS: Three

READOUT LAMPS: 1764-D 28-volt type, operated at 20 volts; rated average half-life is 100,000 hours

AUTOMATIC DISPLAY TIME: Adjustable from 200 milliseconds to 10 seconds. There is also a "hold" position

MANUAL READING: When display time is set on "hold," additional readings may be taken by depressing manual reset button

REMOTE READ COMMAND: Accessible on rear panel

INPUT IMPEDANCE: 11.1 megohms except on lowest range, which is 1.1 megohms

STABILITY: Rated accuracy is attained after 15-minute warm-up at ambient temperature of 25°C (77°F)

ACTIVE DEVICES: 99 transistors, 1 Nuvistor, 49 diodes (No relays)

AMBIENT TEMPERATURE RANGE: Internal cooling fan with air filter permits operation between 32° and 110°F at 0-90% relative humidity

PROBE: Contains 100,000-ohm isolating resistor. Connects to front panel-type BNC connector

POWER REQUIREMENT: 117/230 volts, 50-60 cps AC, 30 watts

SIZE AND WEIGHT: 5¼" high x 12¾" wide x 10½" deep—16 lbs.

PRICE: Model No. 111 (Cat. No. 12591) **$500**

OPTIONAL EQUIPMENT

DVM WITH BINARY OUTPUT CAPABILITY: Provides 1-2-4-2 bcd information for use with printing or data processing equipment or with remote displays.

Model No. 111-PR Catalog No. 12593
Price: **$550**

AC INPUT CONVERTER: (Available May, 1966) Adds AC capability throughout entire voltage range when used in conjunction with Model 111 or Model 111-PR. Overall accuracy is .25% from 20 to 20,000 cps. All-solid state circuitry.

Model No. 115 Catalog No. 12592
Price: **$250**

RACK MOUNT ADAPTER: For use with Models 111, 111-PR, or 115. Provides for mounting in standard 19¼" relay rack. Occupies 5¼" panel space.

Model No. RR-11 Catalog No. 01374
Price: **$15**

MODEL 111 COMPONENTS AVAILABLE FOR OTHER APPLICATIONS

These assemblies can be used in numerous applications to provide convenient and inexpensive digital readout or counting capabilities.

100,000-HOUR READOUT ASSEMBLY

High brightness 7-bar numerical display with wide-angle visibility can be read from as far as 20 feet under high ambient lighting. Each digit assembly has eight incandescent lamps (seven for the numerals, one for the decimal). The lamps are mounted on a rugged printed circuit board with Malco contacts. Lamps are type 1764-D, intended for operation at 20 volts at 33 MA per lamp for 100,000 hours rated average half-life.

Model No. RLA Catalog No. 01379 Price: **$12.50**

DECADE-COUNTER BOARD

40-kc counter board for in-line applications. Incorporates 15 transistors, 10 diodes, and the Model RLA Readout Assembly. Requires only +11 volts and —20 volts. Sixteen-volt output pulse will drive next DC-3 decade. Board plugs into Amphenol #143-018-01 connector.

Model No. DC-3 Catalog No. 01378
Price: **$50**

QUANTITY PRICES UPON REQUEST

SIMPSON ELECTRIC COMPANY

Simpson

LAB-LINE

TECHNICAL DATA

MULTI-RANGE DC SECONDARY STANDARDS

1700 series

Model 1700

Model 1701

Ever-Ready Leather Carrying Case

FIVE MODELS MEET EVERY NEED
Volts—Model 1700; Amperes—Model 1701; Milliamperes—Model 1702; Micro-amperes—Model 1703; Millivolts—Model 1704

MULTI-RANGE SIMPLICITY
Each meter has several ranges—does the work of several instruments.

ACCURACY
±0.5% of full scale

SIMPLE RANGE-CHANGE
Rotary switch provides five to ten ranges (except on Model 1701)

LOW COST PER RANGE
Exceptional economy due to innovations made possible by Simpson's extensive experience in the meter industry

EASY READOUT
Mirrored, 5½", hand-drawn scales provide superb readability, free from parallax errors

TYPICAL APPLICATIONS
These improved multi-range secondary standards are ideal for such applications as:

- General laboratory testing
- Production line testing
- Incoming inspection
- College, high school and trade school labs

MULTI-RANGE DC SECONDARY STANDARDS, 1700 series

DESCRIPTION

These standards are designed for long-term accuracy under maximum usage. Spring-loaded sapphire jewels and hardened pivots insure high shock resistance and minimum friction. A high damping factor, added to high torque, provides rapid response to input level variations and minimizes overshoot.

The combination of a self-shielded, deep-core movement and a steel case makes these instruments impervious to most external magnetic fields found in industry.

These standards use a knife-edge pointer, painted black on the side toward the user. The other sides are a natural aluminum color. This Simpson feature positively eliminates parallax (see Figure 1).

A large-diameter, ceramic rotary switch with solid silver contacts provides range-change in Models 1700, 1702, 1703 and 1704 so that only two binding posts are necessary. On the Model 1701 Ammeter a separate set of 3-way binding posts is provided for each range.

All 1700-series standards are temperature-compensated for operation from 15°C to 35°C.

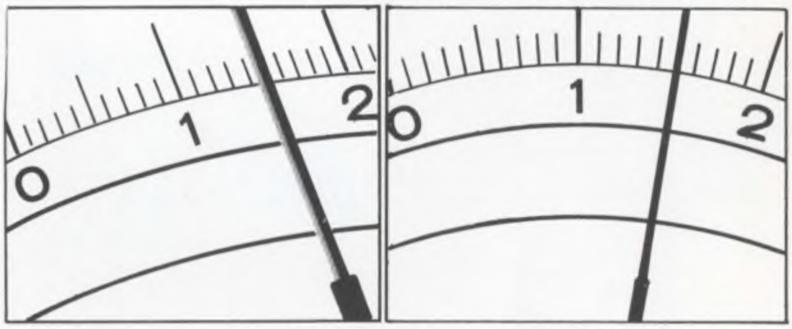


Fig. 1: When the aluminum underside of the pointer is visible (left), parallax is present because user is not looking at meter from correct angle. From the correct angle only the black topside of the pointer is visible (right) and user *knows* that parallax has been eliminated.

SPECIFICATIONS

FUNCTION	DC VOLTS	DC AMPS	DC MILLIAMPS	DC MICROAMPS	DC MILLIVOLTS
RANGES	0-1.5, 3, 7.5, 15, 30, 75, 150, 300, 750, 1500	0-0.75, 1.5, 3.0, 7.5, 15, 30, 75	0-1.5, 3, 7.5, 15, 30, 75, 150, 300, 750, 1500	0-75, 150, 300, 750, 1500	0-30, 75, 150, 300, 750, 1500
MODEL NUMBER	**1700**	**1701**	**1702**	**1703**	**1704†**
ACCURACY at 25°C††(•)	0.5% fs	0.5% fs	0.5% fs	0.5% fs	0.5% fs
MAXIMUM LOSS*	1 milliampere	45 mv	50 to 150 mv	.16 to .58 v	5 ma
SENSITIVITY	1000Ω/v	—	—	—	200Ω/v
SCALE LENGTH(•)	5.5"	5.5"	5.5"	5.5"	5.5"
ENCLOSURE	Steel case with etched aluminum panel, 11⅜" x 7⅜" x 3¼" deep‡				
NET WEIGHT	5½ lbs.	8 lbs.	5½ lbs.	5½ lbs.	5½ lbs.
CATALOG NUMBER	13300	13305	13310	13315	13316
PRICE	**$175**	**$170**	**$150**	**$155**	**$165**

†Model 1704 includes special 0.026-ohm test leads (•)

††Influence of external temperature change is 0.25% per 10°C (•)

‡All units above have case-to-circuit dielectric breakdown of at least 3 kv. RMS (•)

(•)Characteristics so marked are the key ones required by American Standards Association Electrical Indicating Instrument Specification C-39.1-1959. The 1700 series conforms to this specification.

Eveready leather carrying case: Catalog No. 9808, $19.95

Simpson

LAB-LINE

TECHNICAL DATA

LOW COST SECONDARY STANDARDS

models 9, 10, 880 • For AC, DC Voltage, Current, Power

MODEL 880

MODEL 9
IN ROLL-TOP CASE

MODEL 10

PORTABILITY

Convenient handle permits easy carrying. Rugged phenolic case withstands rough usage.

LOW COST

Simpson's extensive experience achieves significant economy while keeping quality high.

VERSATILITY

Available with the following ranges:

- 50 microamperes to 50 amperes, DC
- 50 milliamperes to 50 amperes, AC
- 50 volts to 600 volts, AC and DC
- 100 watts to 10 KW, AC and DC

MULTIPLE RANGES

Most-often-used range combinations are available in single instruments.

ACCURACY

0.5% of full scale on DC
1% of full scale on AC and AC/DC models
.25% when used as transfer standard at 60 cycles

TYPICAL APPLICATIONS

As general-purpose, economically priced secondary standards for the laboratory, production line, incoming inspection, quality control and field engineering. Also suitable for other applications which require precise measurement of electrical parameters.

DESCRIPTION

These portable precision instruments are available in a wide variety of ranges to suit almost any requirement.* Scales are hand drawn, individually calibrated, and easy to read. Parallax errors are eliminated by knife-edge pointers, painted black on one side and read against a mirror. All units are temperature-compensated. They have hand-polished, hardened steel pivots and spring-backed, jewelled bearings.

DC Instruments (Model 9)

Annular, self-shielded movements offer excellent linearity and freedom from errors caused by nearby magnetic fields. Shunts are milled from a single section of manganin for wide-range temperature stability. Multiple-range units have a binding post for selection of each range.

AC Instruments (Model 10)

All Model 10 portables use the Simpson magnetically damped repulsion-attraction iron vane movement. The movement, designed to provide essentially linear deflection through the upper 80% of the scale, has excellent damping and an extremely rapid response time. These characteristics make possible rapid, accurate readings. Model 10 portables are RMS-reading. They are within rated accuracy over the frequency range of 25-125 cps (except for the milliammeters and ammeter models which are 25-500 cps).

AC/DC Instruments (Model 880)

Dynamometer movements operate on both DC and low audio frequency AC with no loss in accuracy, permitting the use of Model 880 instruments as exceptionally low cost transfer standards. Wattmeter models of the 880 have separate binding posts for voltage and current. These units measure true wattage, compensated for power factor, and not simply volt-amperes. If the power being measured approaches full-scale wattage, either the voltage or the current can be limited so that their product will not exceed the specified maximum. Range is selected by a front panel switch.

*Special ranges can be provided to meet unusual requirements. Send us your specifications for a quotation.

SPECIFICATIONS

SPECIFICATIONS	MODEL 9	MODEL 10	MODEL 880
PARAMETERS	DC Voltage DC Current	AC Voltage AC Current	AC/DC Power AC/DC Voltage
ACCURACY*	0.5%	1%	1%
MOVEMENT	Self-shielded Annular	Iron Vane	Dynamometer
SCALE	4.03"; arc length, 100°	3.63"; arc length, 90°	3.63"; arc length, 90°
VOLTMETER SENSITIVITY	1000 Ω/V	100 Ω/V	52.5 Ω/V
SIZE, WEIGHT	5¼" x 3½" x 7"—approximately 2½ pounds		

*In horizontal position; temperature compensation per ASA Spec. C39.1-1964.

ORDER DATA

SINGLE RANGE UNITS

	RANGE	DC MODEL 9	CAT. NO.	AC MODEL 10	CAT. NO.
VOLTMETERS	50 V	$55.00	12900	$50.00	13060
	100 V	55.00	12910	50.00	13070
	150 V	55.00	12920	50.00	13080
	300 V	60.00	12930	55.00	13090
MICROAMMETERS	50 μA	77.00	12800		
	100 μA	73.00	12810		
	200 μA	70.00	12820		
MILLIAMMETERS	1 MA	63.00	12830		
	50 MA	55.00	12840	50.00	13030
	100 MA	55.00	12850	50.00	13040
	500 MA	55.00	12860	50.00	13050
AMMETERS	5 A	55.00	12740	50.00	12990
	15 A	55.00	12750	50.00	13000
	30 A	55.00	12760	50.00	13010
	50 A	55.00	12770	50.00	13020
	100 A	58.00	12780		
		AC/DC MODEL 880			
VOLTMETERS AC/DC	150 V	$65.00	13130		

MULTI-RANGE UNITS

	RANGE	DC MODEL 9	CAT. NO.	AC MODEL 10	CAT. NO.
VOLTMETERS	15-150 V	$60.00	12940		
	150-300 V	65.00	12950	$65.00	13100
	300-750 V	70.00	12960	65.00	13110
	15-150-300 V	70.00	12970		
	150-300-600 V	70.00	12980	65.00	13120
MILLIAMMETERS	10-100 MA	60.00	12870		
	25-250 MA	60.00	12880		
	100-500 MA	60.00	12890		
AMMETERS	2.5-5 A	60.00	12720		
	5-10 A	60.00	12710		
	2.5-10-25 A	65.00	12730		
	5-20-50 A	65.00	12792		
		AC/DC MODEL 880			
VOLTMETERS AC/DC	150-300 V	$75.00	13140		
	75-150-300 V	80.00	13150		
	150-300-600 V	80.00	13160		

POWER RANGES Single Current Range

WATTMETERS AC/DC Single Phase

MAXIMUM VOLTAGE* 150 V	MAXIMUM VOLTAGE* 300 V	MAXIMUM CURRENT*	AC/DC MODEL 880	CAT. NO.
100 Watts	200 Watts	1.5 A	$65.00	13170
200 Watts	400 Watts	3.0 A	65.00	13180
500 Watts	1000 Watts	7.5 A	65.00	13190
1000 Watts	2000 Watts	15 A	65.00	13200
2000 Watts	4000 Watts	30 A	70.00	13210
5000 Watts	10000 Watts	75 A	70.00	13220

POWER RANGES Double Current Range

MAXIMUM VOLTAGE* 150 V	MAXIMUM VOLTAGE* 300 V	MAXIMUM CURRENT*		AC/DC MODEL 880	CAT. NO.
		LOW SCALE	HIGH SCALE		
250-500 Watts	500-1000 Watts	3.75 A	7.5 A	$80.00	13230
500-1000 Watts	1000-2000 Watts	7.5 A	15.0 A	80.00	13240

*Maximum current and maximum voltage cannot be used simultaneously. Do not allow their product to exceed full scale of power range in use.

ACCESSORIES Roll-Top Safety Case for any model above—Catalog No. 6192—$9.95.

Simpson

LAB-LINE

TECHNICAL DATA

MULTI-RANGE PRECISION MILLIOHMMETER

model 1699

FULL-SCALE RANGES

.05 to 50 ohms

SENSITIVITY

0.001 ohms

ACCURACY

±1% of full scale on all ranges. Unaffected by contact or lead resistance

PORTABILITY

Self-powered. Completely self-contained, including resistance comparison standards

DISSIPATION IN SAMPLE

Less than 7.95 milliwatts

TYPICAL APPLICATIONS

The 1699 has many applications, all of which involve precision measurement of low resistance values. Among them are:

Switches and relays: Checking contact resistance rapidly during inspection and production. Model 1699 usually eliminates the need for a Kelvin bridge or other complicated laboratory equipment.

Printed circuits: Checking contact resistance of connectors and resistance of soldered connections.

Motor commutators, slip rings, coils (especially, the larger sizes). Current measurements on these items are easily made, but measurement of actual resistance is often important. Model 1699 offers an exceptionally convenient means of making this measurement.

Automotive cables, connectors, and starting motor leads.

Cable and wire: Checking resistance for quality-control purposes or to determine length of wire or cable.

Instruments: Measurement of shunt resistances and calibration of instruments.

Welding and other high-current equipment: Model 1699 simplifies heretofore-complicated resistance measurements.

Transformers, yokes, coils: For accurate DC resistance measurements.

Fuses: For non-destructive quality control testing.

Metallurgical studies concerned with electrical conductivity.

Computers: Checking resistance of grounding and bonding connections when installing equipment.

Physical science laboratory experiments.

MULTI-RANGE PRECISION MILLIOHMMETER, model 1699

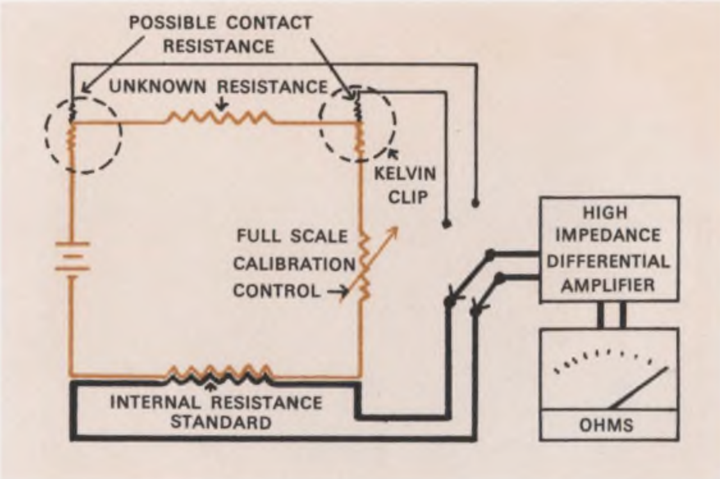


Fig. 1

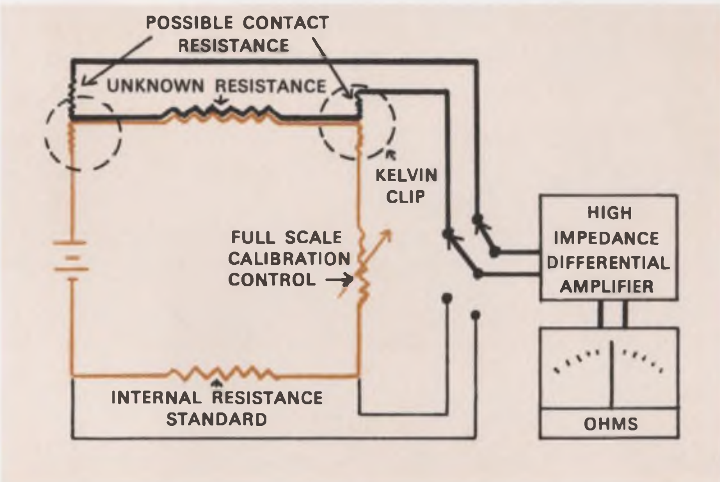


Fig. 2

DESCRIPTION

This instrument was designed to measure low values of resistance accurately, rapidly, and at low cost. It compensates for the shortcomings of the conventional ohmmeter in the area of low-resistance measurement, while retaining the ohmmeter's simplicity of operation.

The Model 1699 Milliohmmeter determines the value of an unknown resistance by comparing it with a known standard internal resistance.

In low resistance measurements, the contact resistance of the meter probes and the resistance of the test leads become significant sources of error. However, these errors can be avoided by using test leads terminating in Kelvin Clips. (In the Kelvin Clip the jaws are electrically insulated from each other so that half of each jaw becomes a separate electrical contact.) In the model 1699 these special clips function as part of a unique circuit which is divided into two distinct paths—the Current Path (shown in color in Fig. 1), and the Voltage Path (shown in black).

The unknown resistance is connected between the Kelvin Clips, thus completing the Current Path. The calibration control is then adjusted until the voltage drop being measured across an internal standard resistance causes the meter to indicate full scale. Since the unknown resistance and the internal resistance are in series, the current flow through each of them is equal. As expressed in Ohm's Law, the voltage drop across these resistances will be directly proportional to their respective ohmic values.

Therefore, (See Fig. 2), by measuring the voltage drop across the unknown resistance we can read its value in ohms, directly from the linearly-calibrated scale on the meter. For example, if the unknown resistance and the internal standard are of the same value, the meter will indicate full scale because its scale is calibrated with the standard. If the unknown resistance is half the value of the standard, the meter will indicate half scale.

The 1699 is calibrated by measuring voltage drop across a standard resistance. This adjustment is made with contact and lead resistance as integral parts of a series circuit referred to as the Current Path; therefore, contact and lead resistance are automatically compensated for during calibration. They will not affect the rated accuracy of the instrument.

Inasmuch as the input resistance of Model 1699's transistorized differential voltmeter circuit is very high, normal lead and contact resistance in the Voltage Path will represent less than .05% of the total resistance of the circuit. Accordingly, these factors will not affect the rated accuracy of the instrument.

SPECIFICATIONS

RESISTANCE RANGES								
Ohms:	0.05	0.1	0.25	0.5	1.0	5.0	10.0	50.0
MAXIMUM OUTPUT CURRENT								
Milliamperes:	460	231	97	47	26.5	5.0	2.7	0.5
MAXIMUM POWER DISSIPATION IN SAMPLE								
Milliwatts:	7.95	5.16	2.15	1.10	0.694	0.121	0.069	0.012

SENSITIVITY
0.001 ohms (Smallest scale division)

ACCURACY
±1% of full scale on all ranges

WARM-UP TIME
None

READOUT
Seven inch analog meter, single arc, 90° dial; mirrored, 100-division linear scale, knife-edge pointer

POWER REQUIREMENTS
Self-contained batteries only: one NEDA #11, life 700 hours; one NEDA #1604. min. life, 160 hrs.

TRANSISTOR COMPLEMENT
Two 2N2716 (matched pair)

ACCESSORIES FURNISHED
Wired-in, Kelvin-type clip leads; instruction manual; batteries

SIZE AND WEIGHT
11⅜" x 7⅜" x 3¼"—5 lbs., 10 ozs.

PRICES
Model 1699 (Cat. No. 13299) **$160.00**
Spare set of Kelvin Leads (Cat. No. 0140) **$5.50**

Simpson LAB-LINE TECHNICAL DATA

INSTRUMENT CALIBRATOR

model 2600

VERSATILITY

This calibrator can produce a variety of electrical parameters, most of which can be varied in amplitude continuously. The amplitude of the selected parameter is accurately indicated by front panel meters.

RANGES

AC/DC voltage, continuously variable from 0-1600 volts. Smallest voltage scale division: .01 volt

DC current, continuously variable: 0-16 amperes. Smallest current scale division: .01 microampere

Resistance: 1 ohm to 100 megohms, in steps, by powers of ten

DEPENDABILITY

Extraordinarily heavy electrical and mechanical construction assure stable operation during long, continuous use.

EASY READING

Two rugged 7-inch meters with easy-to-read, mirrored linear scales are mounted on the front panel, which inclines 30° for additional reading convenience.

RAPID OPERATION

All output ranges are available at one set of terminals.

TYPICAL APPLICATIONS

Trouble-shooting, incoming inspection, establishing or checking calibration and linearity of meter movements, meters and other measuring instruments by meter manufacturers, meter repair firms, and modification and calibration facilities. Instruments that can be calibrated with Model 2600 include DC analyzers, current shunts, galvanometers, microammeters, milliameters, millivoltmeters, VOM's, recorders, voltmeters and wattmeters: also, AC voltmeters and AC voltmeters having a potential transformer.

INSTRUMENT CALIBRATOR, model 2600

DESCRIPTION

The Model 2600 Instrument Calibrator is a unit of extremely rugged construction, designed for continuous commercial service in the laboratory or in industry. Its sturdiness and simplicity of operation permit its use where highly skilled operators are not readily available.

Model 2600 is enclosed in a strong steel cabinet. All control functions are engraved in a satin silver-finished aluminum overlay on the front panel. The panel is inclined 30° to the rear for ease in taking readings and the meters are calibrated at this angle for greater accuracy. Easy access to the interior of the unit is obtained by tilting the front panel forward on its hinges.

Front panel knobs control the following: output level, coarse; output level, fine; parameter; range; output polarity, short, open; resistance value.

All power for the calibrator can be supplied by the AC power line. No batteries or other accessories are required.

Factory calibration of Model 2600 is based on primary standards traceable to the National Bureau of Standards.

The meters of the Simpson Model 2600 Instrument Calibrator have 160 divisions for extra ease in reading.

SPECIFICATIONS

RANGES (continuously variable)

DC Microamperes:
0-1.6/4.0/8.0/16/40/80/160/400/800/1600
DC Milliamperes:
0-1.6/4.0/8.0/16/40/80/160/400/800/1600
Maximum output voltage = 6.0
DC Amperes: 0-16
Maximum out put voltage = 5.0
DC Volts:
0-1.6/4.0/8.0/16/40/80/160/400/800/1600
Maximum output current = 8 ma.
AC Volts:
0-1.6/4.0/8.0/16/40/80/160/400/800/1600
Maximum output current increases from 100 to 250 milliamperes as range increases
Ohms: 1/10/100/1k/10k/100k/1M/10M/100 Meg. (fixed values)
Maximum power dissipation = 1 watt

ACCURACIES

DC Ranges: ± 0.50% of full scale/@ 77°F
AC Ranges: ± 0.75% of full scale @ 77°F
Resistors: ± 1%, one ohm through 10 megohms.
± 2% at 100 megohms

CALIBRATION STANDARD

Each Model 2600 calibrated to primary standards traceable to National Bureau of Standards

AMBIENT TEMPERATURE

Instrument calibrated at 77°F.; correction chart supplied for range between 45°F. and 105°F.

DC OUTPUT RIPPLE

When operating from 60-cy. power line at maximum rated load: voltage and microamp. ranges, less than 0.25%; milliamp. ranges, less than1%.

POWER REQUIREMENTS

During Use of AC Ranges:
105-125 volts, 25-2000 cps (maximum), approx. 50 watts (Designed to permit instrument calibration at frequencies other than 60 cycles)
During Use of DC Ranges:
110-125 volts, 50-60 cps, approx. 50 watts. 16-amp. range requires 150 watts. When using 220-v., 50-60 cps power source, use external 220-v. to 117-volt transformer

READOUT

Method: Two 7-in. meters, one for AC ranges, one for DC ranges
Movement: Deep core, self-shielded, temperature-compensated
Scale: Mirrored, 5.9" long, linear, individually calibrated at 160 points
Arc: 0-400/800/1600 full scale

SIZE AND WEIGHT

15" x 31" x 15"—132 lbs.

OUTPUT TERMINATION

One pair of terminals for all ranges and one ground terminal

PRICE

Model 2600 (Cat. No. 13250) **$1700.00**

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and replaced by a treadle switch. How many of your friends had to reconnect hastily their conventional ignition when the collector junction turned to germanium vapor?

Ask your dealer how many turn-signal blinkers, radios, printed-circuit dash wires, and so on, he has to replace under warranty, in spite of the lack of sophistication in them.

When we come down from our lovely solid-state circuits to the grim penny-pinching world of the showroom, the customer simply won't pay the high price of electronic reliability; so to compel him borders on the ridiculous. Rather than wasting money on electronic "innovations in safety," the owner is far ahead to buy some 125-mph-rated tires, heavy duty or racing brakes, heavy duty or export suspension (off-the-shelf) safety belts and/or harness. If we could just make roll bars and big hairy door latches appeal to the ladies, they might not get flung and squashed with such appalling frequency.

Rather than wave the magic editorial wand for the Federal Wizard, you interested editors could be plunking for a Federal rating system, similar to the "truth in packaging" measures, on tires, brakes, etc. Brake fluid already has Federal minimum specs.

JON P. RAMER
Orlando, Fla.

Down with standards that are earth-bound!

Sir:

If we are to adopt a new system of units, let's do the job right. The only advantage of the metric system over the English system is that units are in convenient multiples of 10. However, it is just as arbitrary in its concept as the English system is—that is, it is based on arbitrary conditions on an arbitrary planet (earth).

Let's use a system that is not only consistently decimal (or binary, or octal) but one that is based on some universal standard.

Let's not use a system whose length dimension is essentially based on the length of an arc of this arbitrary planet. Let's not use one whose standard of mass is based on a sample of an arbitrary fluid. Let's not use a system whose temperature unit is based on the freezing and boiling points of that arbitrary fluid under arbitrarily chosen pressure conditions. Let's not use one whose time unit is based on the time of revolution of this arbitrary planet.

Let's look at some universal constants, such as hydrogen atoms (or protons), and the speed of light and derive some basic units from these:

A mass unit could be equal to the mass of a proton (at relative rest).

The frequency unit (and, inversely, the time unit) could be that of the frequency of the emission line resulting from the transition of a hydrogen atom from the energy state 2 to state 1 (ground state).

The length unit could be the distance that light would travel (in vacuum) during the time of the time unit suggested above.

Temperature is a derived unit, but could be based on the energy given up by a hydrogen atom in the transition mentioned above.

Many of these units would likely be too small or large for convenient engineering usage. Therefore they could be called the "abunits," and engineering units might be derived from them by multiplication with convenient powers of 10 (or 2, 8, etc.).

If we are going to take our place in galactic society, we are going to have to conform to facilitate communication and trade. The adoption of a universal set of units will help alleviate many future problems.

DAVID A. BEAN
Earth Rep for
APC (Aliens for Progress in Communications)
P. O. Box 4823
Chicago

. . . Early to rise keeps reader healthy and wise

Sir:

I was most interested to read the article "18 Ways to Save Time" in your issue of Nov. 8, 1965 (p 48), particularly item 17: "Get an early start." My personal experience shows that it pays handsome dividends.

Nothing is more exasperating and time-wasting than waiting for others; so why keep others waiting? This principle led me to start 30 to 45 minutes earlier each morning, and subsequently to walk to work, taking 30 minutes or so. This gives me such a feeling of mental and physical alertness that I can really get going as soon as I arrive, uninterrupted by day-to-day queries or telephone calls. In addition the time credit in the bank every day is invaluable.

V. O. STOKES
The Marconi Co., Ltd.
Marconi House
Chelmsford, Essex
England

ON READER-SERVICE CARD CIRCLE 19

Is electronics doing enough for puzzled astronomers?

Astronomers are grappling with a grand mystery that tops the best thriller yet to hit the best-seller list. Until recently they thought they had the universe pretty well figured out. Then, with shocking swiftness, their theories fell apart.

The upsetting data were provided by a combination of radio astronomy and spectrographic measurements of light-frequency shifts. Some radio sources that had been matched with visible objects, thought to be "stars" in our own Milky Way, turned out to have tremendous spectral shifts toward the red. These red shifts must be, according to accepted theory, doppler shifts caused by the fact that the universe is expanding and that objects far away from the earth are flying away from us at great speed. In 1929 Hubble postulated that the amount of red shift was proportional to the distance of an object from us.

The red shifts of these strange quasi-steller radio sources, or quasars, made them the farthest objects ever located! At such great distances as the Hubble theory suggested, they had to be huge galaxies rather than stars.

But some curious data have been obtained from measurements of these radio sources. Their energy output has to be at least 40 times greater than that of any known galaxies, if our distance estimates are correct. No process described by our present knowledge of physics could explain such tremendous energy emission. In addition the quasars seem to be "flickering." Measurements over a number of weeks show surprisingly large variations in energy output. If we consider the assumed size, and assume that no process could be transmitted throughout these galaxies faster than the speed of light, such variations are impossible.

Most theories of the universe have been patched up to fit the new data, but without firm conviction. Astronomers are frankly puzzled. The question is: Is electronics doing enough to help?

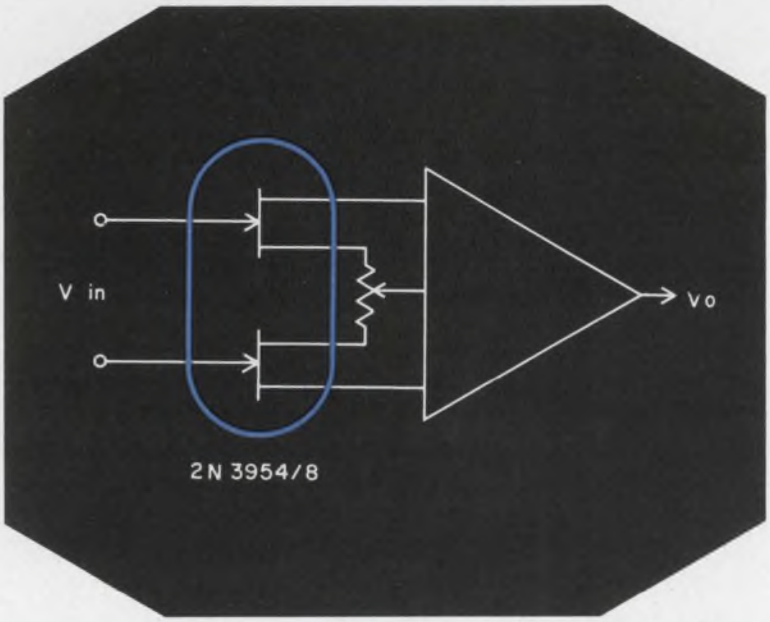
The most vital data are optical, involving telescopes and spectrographic film recording. Our best telescope, at Mount Palomar, is over 20 years old. The best method available now for obtaining the long integration time needed for red-shift measurements of low-level light sources is photographic recording. Image intensifier tubes have only recently been improved enough to be used for astronomy. Monitoring of absorption paths to eliminate the background noise problem of city light reflections is just being explored.

The astronomers need better techniques for these measurements. They would like to figure out better ways to measure blue shifts, if any exist. They would like to have long-integration-time detectors for the infrared and far infrared.

The modern physics laboratory is loaded with useful electronic instrumentation. The optical astronomical observatory has virtually none. Can't we do better?

Robert Haavind

DUAL FET's



CHECK THE SPECS!

SPECIFICATIONS

	2N3954	2N3955	2N3956	2N3957	2N3958	Units
Breakdown Voltage (min.)	50	50	50	50	50	V
Leakage Current (max.)	100	100	100	100	100	pA
Saturation Current (min./max.)	0.5/5.0	0.5/5.0	0.5/5.0	0.5/5.0	0.5/5.0	mA
Transconductance (min./max.)	1000/3000	1000/3000	1000/3000	1000/3000	1000/3000	μmhos
Pinch-off Voltage (min./max.)	1.0/4.5	1.0/4.5	1.0/4.5	1.0/4.5	1.0/4.5	V
ΔV_{GS1}-V_{GS2} (max.)	10	25	50	75	100	μV/°C

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ED Technology

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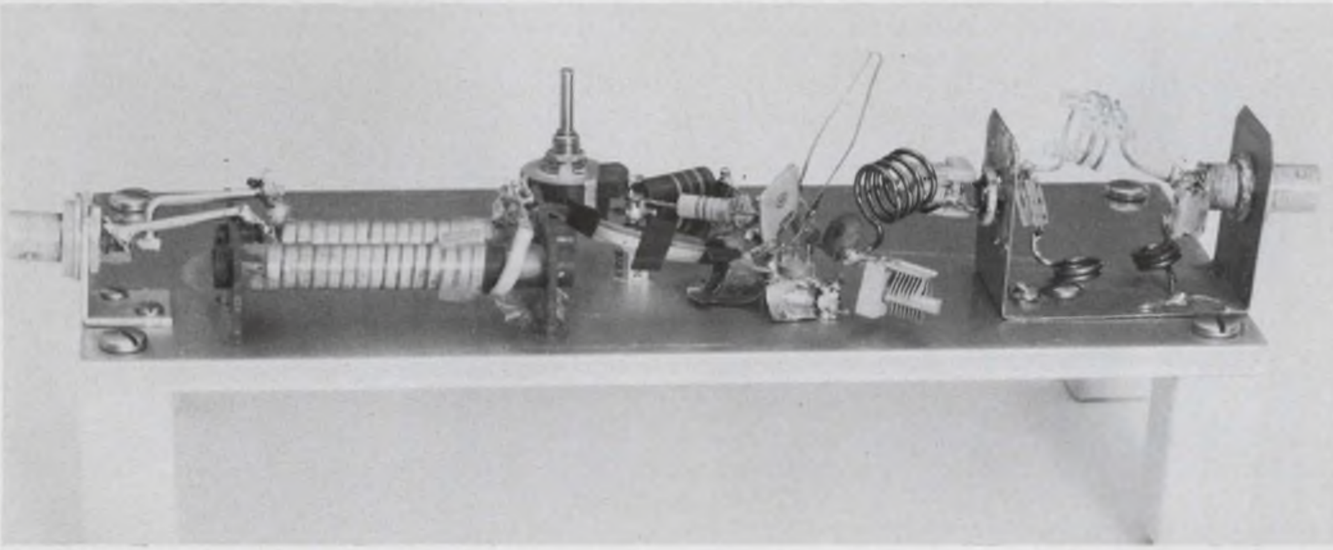
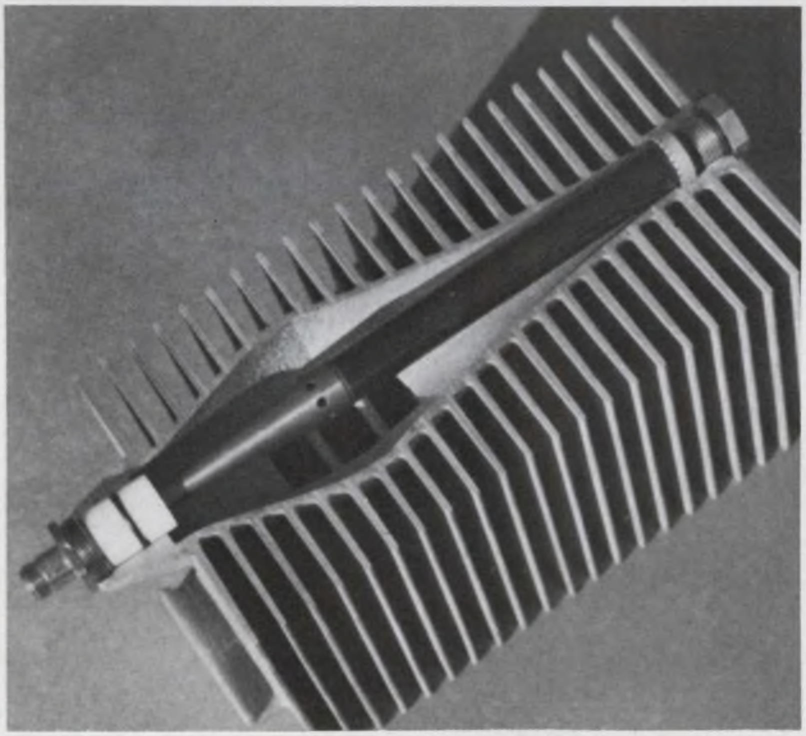
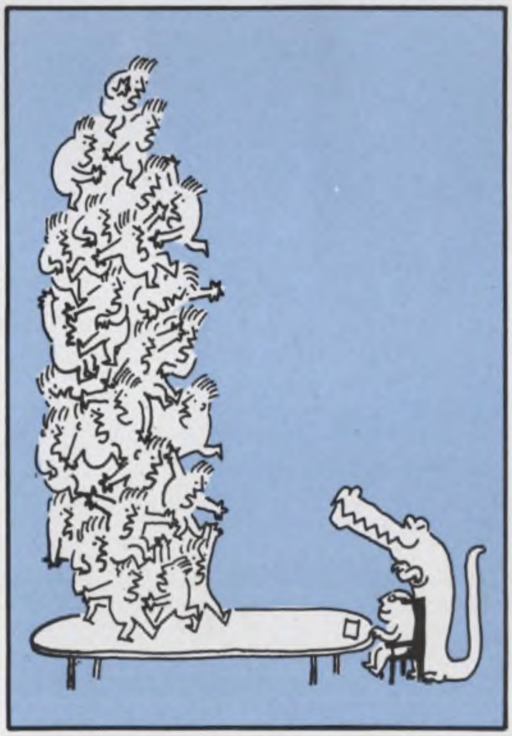
How to stay on the beam with deflection amplifiers PAGE 46
Reduce power drain by using IC gate-ring counters PAGE 52
How to select the right dummy load PAGE 60
Are your committee meetings worthwhile? PAGE 66



Squeeze your high-power amplifier into a small package 38



Pick the right dummy load 60



Orderly meetings are best 66

Amplifier has 85% efficiency while providing up to 10 watts power over a wide frequency band. A switching transistor is the key in the design.

The efficiency of transistorized power amplifiers for cw operations can go as high as 85%, if the design is right. What's more, the amplifier can maintain its broadband characteristic.

The design approach centers on a transistor, used in a switching mode, that gives very high collector efficiencies.

To illustrate the advantages of this design, consider the output power stages of conventional vhf communication equipment. The output powers are usually around 50 watts. If the efficiency of the cw power amplifiers is 60%, a bulky heat sink is needed to handle the dissipated power. If the efficiency is increased up to 80%, the dissipated power is halved.

A common requirement of communication systems, that the second harmonic be suppressed at the output, also helps achieve the high efficiency, since it lowers the bandwidth demands on the amplifier. The output circuit of the power amplifier has to cover a frequency range of less than 1:2 for each position of the range-selecting switch. This assumption is valid because the low-pass or bandpass filters used to suppress the second harmonic cover a frequency range of 1:1.8 to 1:1.5.

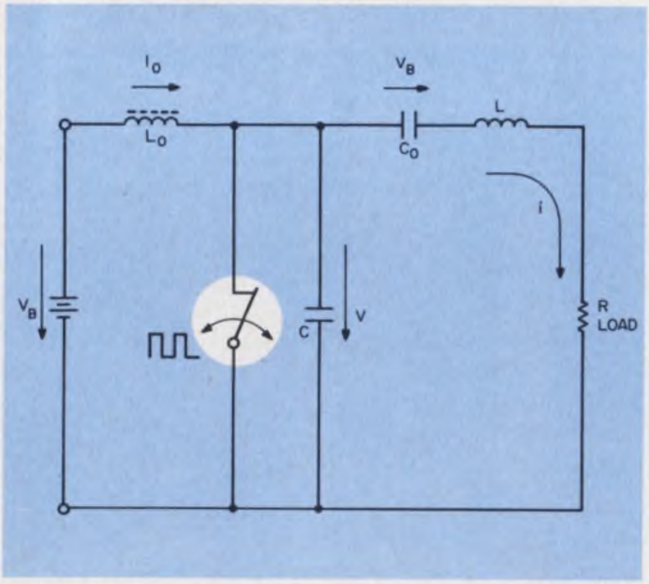
Dieter R. Lohrmann, Development Engineer, USAECOM, Ft. Monmouth, N. J.

The criterion for achieving high collector efficiency is this: The impedance, seen from the base and looking into the matched circuit, should not be a short-circuit for the second harmonic over the whole frequency band.

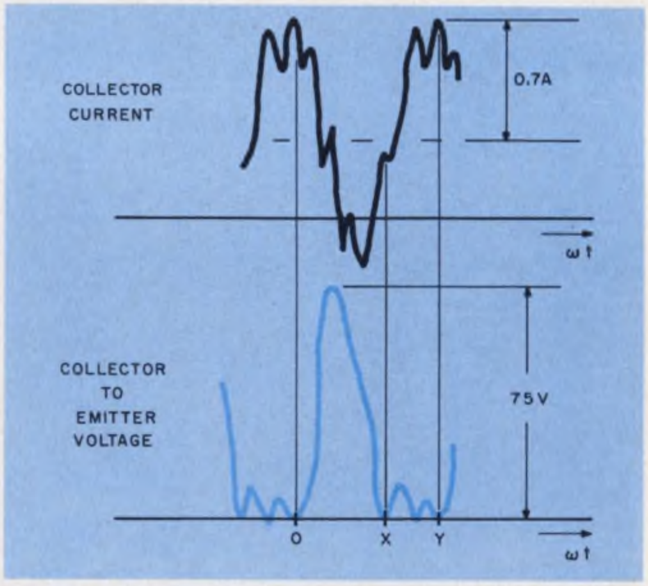
The simplified equivalent circuit of the collector shows the transistor as a switch, being opened and closed periodically (Fig. 1). The choke L_o feeds a current to the collector of the transistor. The collector-emitter capacity is C, which, for simplicity, is assumed to be independent of voltage.

The dc blocking capacitor, C_o, charges to the battery voltage. For simplicity, an inductor L, in series with the load resistor R, has been substituted for a low-pass filter.

To understand the operation of the circuit, let us assume that the switch has just been closed. After a sufficient amount of dc current I_o has



1. **Simplified equivalent circuit** of transistor's collector circuit. The ideal switch represents the transistor. It is operated by the signal fed to its base-emitter circuit by the dc current I_o. When the voltage across C crosses zero, the switch will be closed. The collector-emitter capacitance, C, is assumed to be independent of voltage. C_o, the dc blocking capacitor, charges to the battery voltage, V_B. The switch opens without any current.



2. **Traces of the collector voltage and collector current** indicate the open and closed periods. During the interval OX, the switch is open; during XY, it is closed. The collector current does not go to zero during the OFF period, because the collector capacitance is parallel to the switch. The transistor in the experiments is a type 2N3632, operated at 69 MHz. $I_C = 0.45$ A, $V_B = 25$ V. The output RF power is 9 watts with an input of 1 watt.

built up in L_o, the switch is opened. If the circuit of C, L and R is underdamped, the voltage across C will be a damped oscillation.

After the first half cycle, when the voltage crosses zero again, the switch is closed. This collector voltage, v, is traced in Fig. 2. During the interval OX the switch is open; during XY it is closed. The collector current, recorded in proper phase, is not zero during the switch-off cycle, because the collector's capacity is parallel to the switch. (Fig. 2)

It seems reasonable to assume that one of the reasons why this circuit yields high collector efficiencies is this one:

At the end of the OFF cycle the collector-emitter voltage returns to zero by itself, due to the transient. Hence the voltage will go down to zero, switching in the transistor, without need for any current. Thus only a little power will be dissipated in the switching slopes.

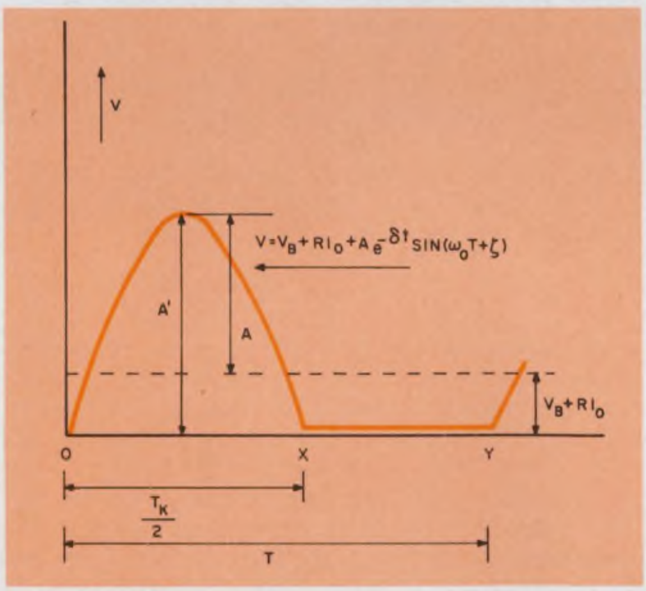
Linear equations described actions

Switching actions are usually described by a set of nonlinear differential equations. However, we can linearize them by using one set of linear equations for the ON interval and another for the OFF state.

The boundary conditions are provided by voltages and currents that must fit at the end of the preceding interval to those at the beginning of the next one. The equations for the open position (Fig. 3) are:

$$C \frac{dv}{dt} + i = I_o, \tag{1}$$

$$v = V_B + Ri + L\frac{di}{dt}, \; 0 \leq t \leq \frac{T_k}{2}, \tag{2}$$



3. **The basic switching action** results in a simplified mathematical model. One set of linear equations describes the OFF condition, another is used for the ON state. Voltages and currents are used as boundary conditions, to match the two intervals. The time between zero crossings of the collector voltage during the OFF period, T_k, is about equal to the period time of the transient in the collector voltage.

and for the switch closed:

$$v = 0, \tag{3}$$

$$V_B + L\frac{di}{dt} + Ri = 0, \; \frac{T_k}{2} \leq t \leq T. \tag{4}$$

These differential equations have very simple and well-known solutions. However, the equations for solving the boundary conditions become unwielding and nonlinear. Therefore we may use an approximate solution. The exact solution during the interval OA would be:

$$v = V_B + RI_o + Ae^{-\delta t} \sin(\omega_o t + \phi). \tag{5}$$

For this, the approximate form is:

$$v \approx A' \sin \omega_k t, \quad 0 \leq t \leq \frac{T_k}{2} \tag{6}$$

with $\omega_k = 2\pi/T_k$. Using Fourier analysis, we can show that the peak value of the fundamental voltage in the waveform is:

$$v = \frac{A'}{1+k} \cdot \text{Sa}\left[\frac{\pi}{2}\left(1 - \frac{1}{k}\right)\right]. \tag{7}$$

Here $k = T/T_k$ and $\text{Sa}\, x = \sin x/x$. T_k is the time between the points of zero crossings of the collector voltage during the OFF period. It is approximately equal to the period time of a transient in the collector voltage—that is, in the case of Fig. 1 it is:

$$T_k = \frac{2}{\sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}}. \tag{8}$$

The output power at fundamental frequency is:

$$P_{out} = \frac{v^2}{2} G_\omega, \tag{9}$$

where G_ω is the real part of parallel admittance that the load circuit exhibits to the collector at the fundamental frequency.

Thus, in the case of Fig. 1:

$$G_\omega = Re\left(\frac{1}{R + j\omega L}\right) = \frac{R}{R^2 + \omega^2 L^2}. \tag{10}$$

Now A' is still unkown, but it can be found from dc considerations. The choke in Fig. 1 cannot have a dc drop. Therefore the dc component of the waveform in Fig. 3 must be equal to the battery voltage, V_B. In other words:

$$V_B = \frac{1}{T}\int_0^T v\, dt = \frac{1}{T}\int_0^{T_k/2} A' \sin \omega_k t\, dt \cdot \tag{11}$$

This yields

$$A' = \pi V_B \left(\frac{T}{T_k}\right), \tag{12}$$

which is the peak collector voltage. If we put everything together, we have:

$$P_{out} = \frac{\pi^2}{2} \frac{V_B^2 k^2}{(1+k)^2} G_\omega \text{Si}^2 \left[\frac{\pi}{2}\left(1 - \frac{1}{k}\right)\right], \tag{13}$$

where:

P_{out} = RF output power.

V_B = battery voltage.

T = 1/(signal frequency).

T_k = twice the length of cutoff interval—that is, twice the time between the zero crossings of the collector voltage. It is about equal to the cycle-time of a transient in the collector circuit. In our example:

$$T_k \approx \frac{2\pi}{\sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}}.$$

k = T/T_k.

G_ω = the real part of the load circuit's admittance exhibited toward the collector at the fundamental frequency. The collector's capacity is part of the circuit.

A' = the peak voltage at the collector.

If we let $T = T_k$, we get:

$$P_{out} = \frac{\pi^2}{8} V_B^2 G_\omega, \quad (14)$$

and

$$A' = \pi V_B. \quad (15)$$

As can be seen from these formulas, A′ tends to increase as the frequency decreases.

For all these calculations we assumed that the output circuit is less than critically damped. This means, in the case of Fig. 1, that:

$$\frac{1}{LC} >> \frac{R}{4L^2}. \quad (16)$$

This condition is linked to the bandwidth of the load circuit, as shown in Fig. 4. The graph of the output power, P_{out}, over $V_B^2 G_\omega$ vs (signal frequency) (T_k), indicates a nonlinear dependence.

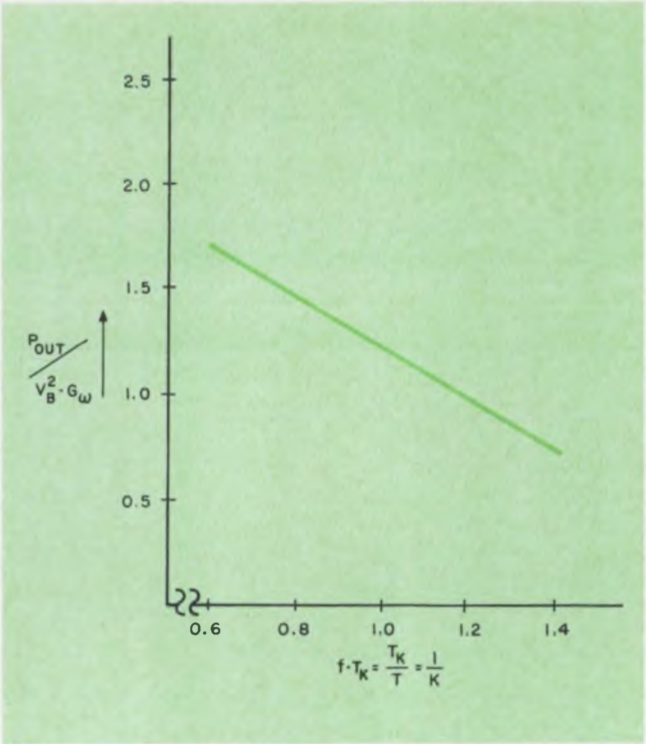
A filter (low pass) in the collector circuit slightly modifies the above equations. In principle, the same formulas apply. G_ω can be computed from the filter parameters. If Z_π/R = 0.85, then the eigenvalue of v will be $p_1 = (-0.168 + j0.895)(2\pi f_g)$, where f_g is the limiting frequency of the filter section—that is, the frequency at which the characteristic impedance turns imaginary. Hence $T_k = 0.895\ f_g$.

Practice modifies theories

Special requirements in an FM communication system demanded a power amplifier having about 10 watts output with a 10-dB amplification figure. It had to cover the frequency range of from 48 to 70 MHz with collector efficiencies up to 85%.

In the calculations thus far we neglected the following facts:

- The collector capacity of the transistor is dependent on voltage.
- There is strong coupling between the input and output circuits via the base-to-collector capacity, which is nonlinear. As a matter of fact, part of the input power might go directly to the output over this path.
- The switching will not happen instantaneously, and, most likely, *not* at exactly zero collector voltage.
- There are losses in the collector junction,



4. **The normalized output power** is a nonlinear function of the normalized frequency. The ordinate is V^2G_ω, and the abscissa is the signal frequency times T_k.

which must be represented by a nonlinear resistor.

- In the practical circuit we have a low-pass filter section in the collector circuit and not as simple a circuit as the one assumed in Fig. 1 for the calculation.

We got more accurate results by replacing V_B with $V_B - V_{CE\ sat}$, in Eqs. 13 and 14. The latter factor is the collector-emitter saturation voltage. This voltage is normally given by the manufacturer only for dc. For RF it seems to be on the order of 2 to 5 volts for a good transistor. So let us assume 3 volts, since a good guess is better than none.

The constant factor in Eq. 13 has been found to be 0.85, rather than $\pi^2/8$, in the practical circuit. Thus Eq. 14 becomes:

$$G_\omega = \frac{1}{R_\omega} = \frac{P_{out}}{0.85\ (V_B - V_{CE\ sat})^2}.$$

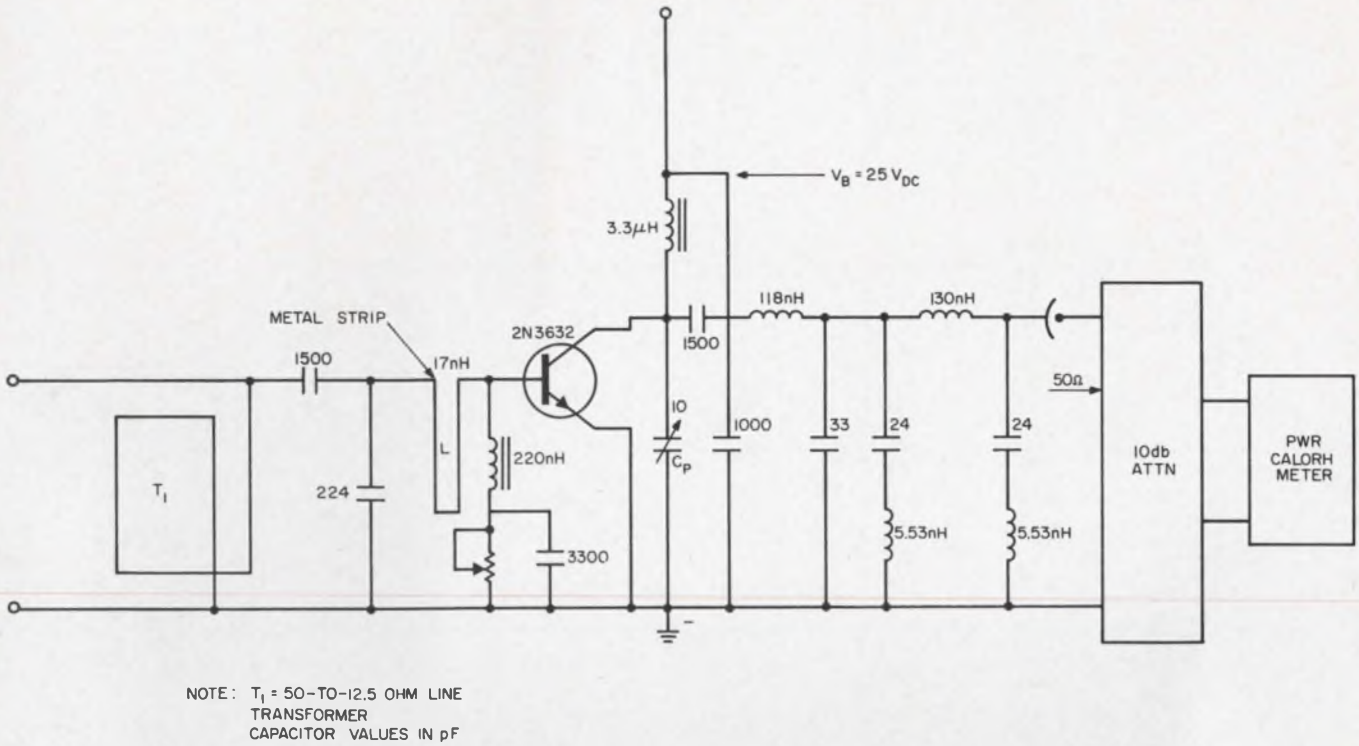
If P_{out} should be 10 watts at V_B = 25 V battery voltage, then G_ω = 24 mmho → 42 ohm is the load admittance the collector will have to see at the signal frequency. Once this R_ω is known, the first low-pass filter section can be designed. For the required amplifier, the frequency range desired was 50 to 75 MHz. Of course, the limiting frequency of the low-pass filter section must *not* be set to f_u = 75 MHz, since the mismatch is much too large at the limiting frequency.

It works well if one arranges:

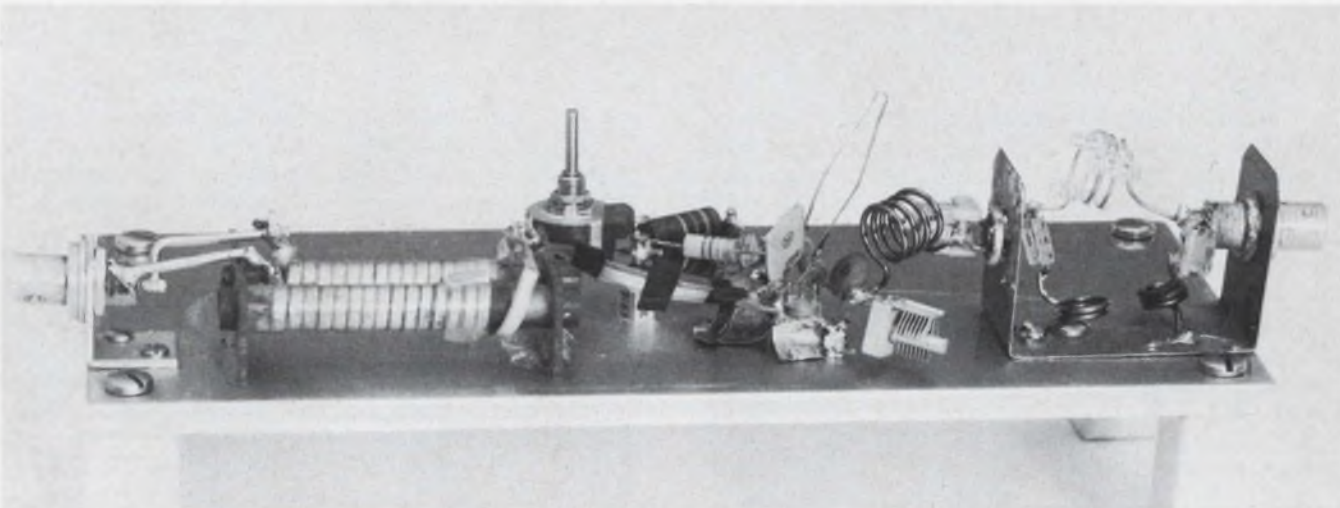
f_g = limiting frequency of low pass section = 1.5 f_u = 1.5 x 75 MHz.

The characteristic impedance of the low pass filter section is chosen as:

$$Z_\pi = 1.1 R_\omega = 1.1 \times 42\ \Omega = 46\ \Omega.$$



5. **Broadband power amplifier** covers the frequency range from 48 to 70 MHz and has about 10 watts output power with 10-dB gain even if the dc path in the base circuit is eliminated. (The calorimeter monitors the output power.) To lessen the danger of parametric oscillation, feeding chokes should have the lowest possible values.



6. **Breadboard model** of the circuit in Fig. 5 illustrates construction gimmicks. The inductance of 17 nH, in the input matching circuit, is made of a piece of metal strip folded like a hairpin. It can be adjusted very conveniently with a slug, soldered across the two legs. Mica capacitors satisfy the need for very low series lead inductances.

The input capacity of the section is known from filter theory:

$$C = \frac{1}{2\pi f_g Z_\pi} = 31 \text{ pF}.$$

On the collector side, one has to deduct the collector's capacity from the value.

Again from filter theory:

$$L = \frac{Z_\pi}{\pi f_g} = 130 \text{ nH}.$$

The peak voltage between the collector and the emitter is expected to be in the midband:

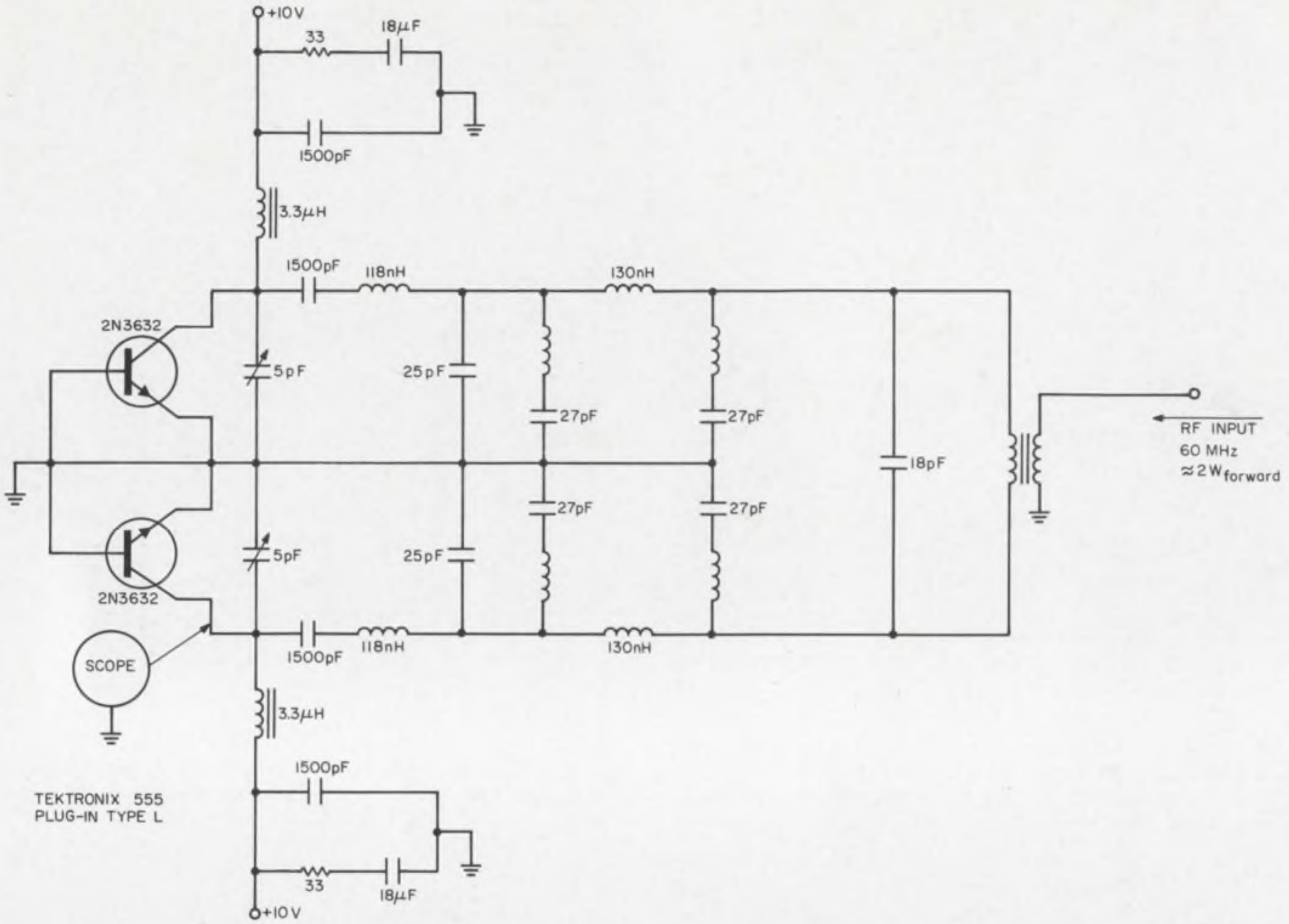
$$A' = \pi V_B = \pi 25 \text{ V} = 78 \text{ V},$$

which roughly agrees with measurements.

The pi filter section is followed by another one, to give additional harmonic suppression. It has an attenuation pole at a frequency that is twice that of the midband value.

Match input with transformers

To match the input, a broadband transmission line transformer T_1 is used (Fig. 5). It transforms from 50 down to 12.5 ohms, covering the entire range from 30 to 75 MHz. It is followed by



7. **Broadband push-pull amplifier** will brake out in parametric oscillations, even with its emitter and base leads grounded. (The oscilloscope picks up the parametric oscillations.) This proves the assumption that parametric oscillations are caused by a voltage-dependent capacitance in the collector and base circuit of the transistor, which gives rise to an undampening action. The capacitance acts like a varactor diode in a parametric amplifier.

a matching section made up of a 224-pF capacitor and an inductor of 17 nH. The capacitor must have very low series lead inductance. Therefore a mica capacitor of the button type was used. The inductor was made of a piece of metal strip folded like a hairpin. It can be adjusted very conveniently by soldering a slug across it (Fig. 6).

Under operational conditions, the equivalent input circuit for the transistor has been found to be a series resistor of about 5 ohms in the base lead, followed by a 1000-pF capacitor to ground.

Parallel to the 1000 pF capacitor is a resistor of about 10 ohms. About 200 pF of these 1000 are believed to be exhibited by the base-to-emitter junction. The remaining 800 pF is due to the Miller effect, caused by the collector's capacity. The circuit is valid between about 30 and 70 MHz.

The 224-pF capacitor, the 17-nH inductor and the equivalent input circuit of the transistor (5 ohms in series with about 1000 pF) form a broadband transformation network. It transforms the 5 ohms to 10 ohms and compensates for the 1000 pF.

The base is zero-biased. The biasing resistor is set to 100 ohms. At a 1-watt input driving power, the peak base-to-emitter reverse voltage is exceeded during the cutoff cycle, and reverse current is flowing. This reduces the dc current in the external base circuit. As a matter of fact, the transistor still gives 10 watts of output power if the dc path in the base circuit is eliminated. According to the manufacturer, the transistor is not damaged, provided that less than 25% of the permissible dc power for the base junction is dissipated by back conduction. The back conduction effect seems to increase the steepness of the switching slopes, thus improving the collector's efficiency.

The resistance in the base circuit was chosen as 100 ohms. for dc stability.

A 3.3-μH choke supplies the dc current to the collector. The collector circuit is formed by two low-pass pi filter sections that use the collector's capacity as part of the filter's input capacity. The trimmer in the collector line adjusts this output capacity. The second pi filter section has a pole at 141 MHz, to keep residual second harmonic power from being dissipated in the load.

A laboratory model, designed for 40 watts output power, is already being tested. The unit is similar to the one described below. It has the same high efficiency and a power gain of 10 dB.

Parametric oscillation is common problem

The tendency to break out in parametric oscillations seems to be a common problem to all high-efficiency switched power-amplifier stages.

It is caused by the voltage-dependent capacitance in the collector and base circuits of the transistor. This capacitance is periodically varied by the signal itself. Therefore it acts like the varactor diode in a parametric amplifier (also called reactance amplifier). It is well known that such an amplifier may exhibit negative resistance under certain conditions, undampening the circuits. The circuit starts oscillating at some other frequency if this undamping action becomes too large. Therefore care must be taken to prevent the collector from sensing circuit resonances outside the passband, presumably at lower frequencies, down to dc. As a consequence, feeding chokes should have values as low as possible. On the power supply line, there must not be any resonant circuits at low frequencies. They can be eliminated by a resistor in series with a capacitor across the line.

The largest change of capacity of the collector junction occurs near zero collector voltage. Therefore linear stages, which do not use that portion of the characteristic, are much less likely to oscillate because of this effect; switched stages should be more troublesome.

A small collector capacity is more favorable than a large one for a given power output. Switching transistors with low losses—that is, with high efficiency—are more sensitive than those having higher losses. A small series resistor in the collector line helps, but it reduces the collector efficiency.

To prove this hypothesis of parametric oscillations, we took a broadband push-pull amplifier and grounded all emitter and base leads with short, broad-ribbon leads (Fig. 7). Then we fed signal power into the output terminals of the amplifier. Fig. 8 shows the voltage waveforms at the collector. At a 0.4-watt input (the normal output power of the amplifier in normal operation is 25 watts) we still had a sine voltage at the collector (Fig. 8, top). But at 1.7-watts input, an oscillation of lower frequency suddenly appeared (Fig. 8, middle). At 2.7 watts the oscillation became noise-like (Fig. 8, bottom). Since these oscillations tend to kill the transistors, the experiment was made with a 10-volt battery. The dc current in the transistors was zero until the oscillations started; then it jumped up to about 0.5 A, though the bases were grounded.

The differential equations describing these effects are basically of the Mathieu and Hill types, and the solutions have stable and unstable regions. ■ ■

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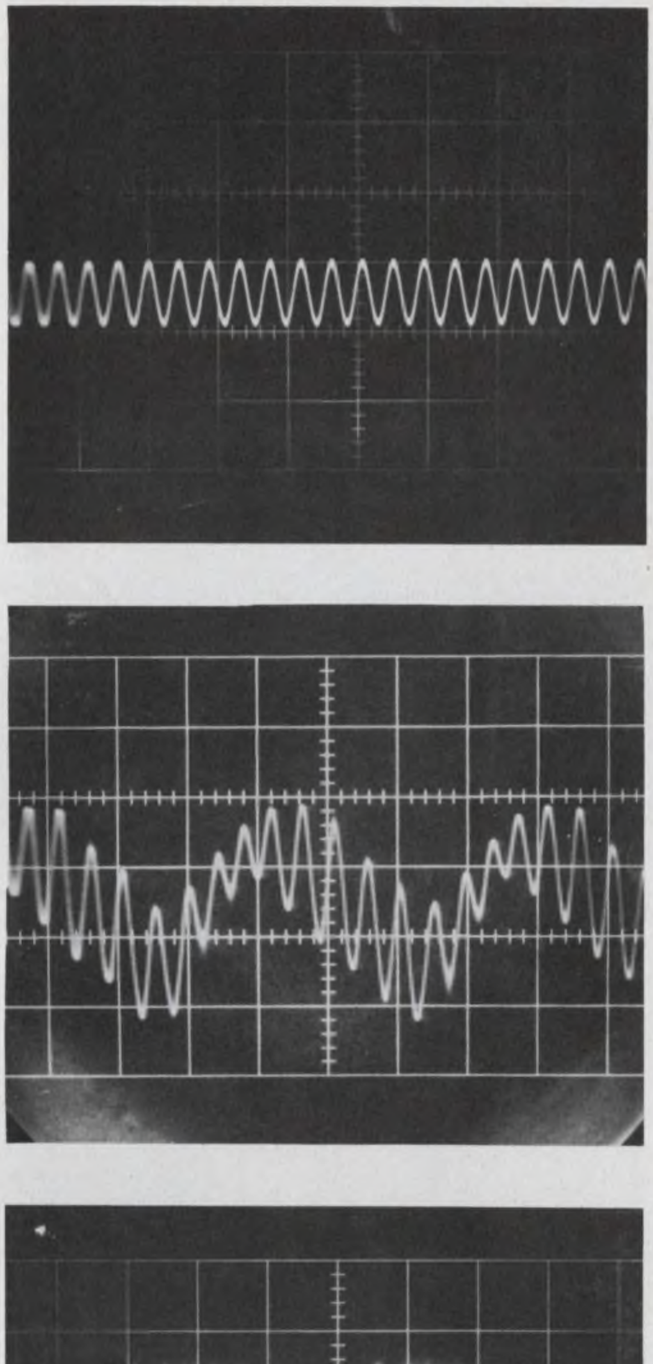

8. **Collector waveforms** show effects of increased input and the creation of parametric oscillation. At an input of 0.4 watt (top) the output is a sine voltage; at 1.7 watts (middle) a lower frequency oscillation appears, which becomes noise-like at a 2.7-watt input (bottom). The dc current jumped to 0.5 A from zero as oscillations started, despite the grounded bases.

Now–a wide choice of for industrial and consumer

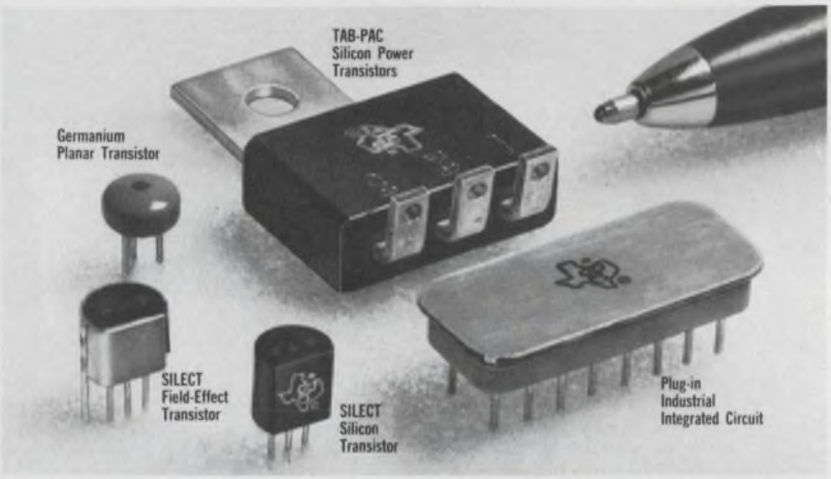

Figure 1. TI offers many economy semiconductors for industrial and commercial applications.

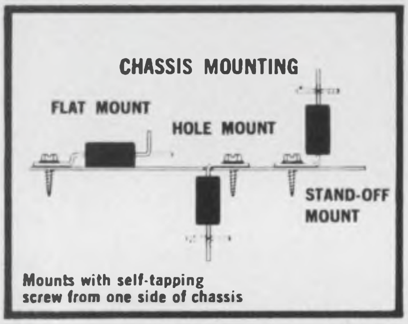

Figure 2. TAB-PAC silicon power transistors offer mounting flexibility as well as economy.

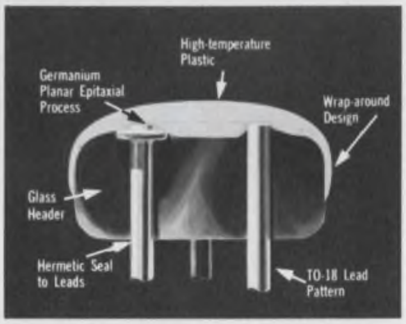

Figure 3. Note ruggedness of TIXM01-08 plastic encapsulated germanium planar transistors.

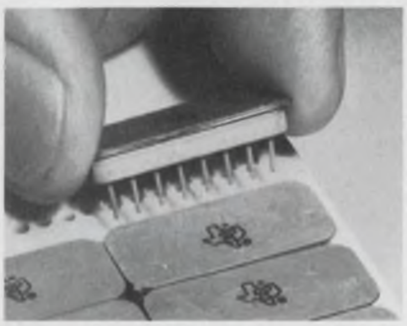

Figure 4. New plug-in flat packages for TI integrated circuits are easily handled and inserted into industrial-type PC boards.

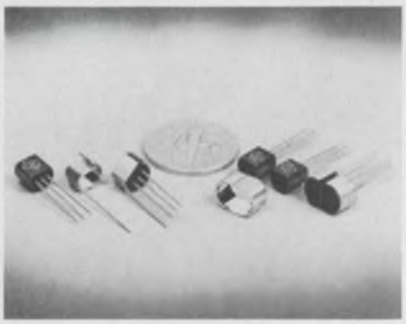

Figure 5. SILECT transistors and FET's are available with snap-on shield. Matched pairs may be factory-assembled with double clamps.

Reduce costs, simplify assembly with new plastic-encapsulated power transistors from TI

You save on both assembly and component costs when you use the new TAB-PAC™ silicon power transistor from TI. This new NPN planar device, typed TIP14, is designed especially for cost-critical industrial and consumer applications.

The low-profile, double-ended plastic package incorporates a mounting tab for simplified assembly. The transistor can be mounted on chassis or heat sink with a single self-tapping screw as shown in Figure 2.

Low saturation voltage ($V_{CE(sat)} = 0.1$ volt typical at 200 mA) provides high circuit efficiency with minimum internal losses.

High power dissipation (15 watts at 25°C case) and gain linearity over a wide current range (h_{FE} typically 35 at 50 mA and 30 at 1 amp) make the TIP14 ideal for use in amplifier applications. For more information circle 125 on the Reader Service Card.

Economy germanium planar transistors reduce costs and improve performance of TV, FM and industrial circuits

TIXM01-08 PNP epitaxial planar germanium economy transistors are designed for RF, oscillator, mixer and IF application in television and FM broadcast receivers and in industrial applications requiring low-noise, high-frequency amplifier devices.

Low noise (2.8 dB typical at 200 MHz), high gain (28 dB at 100 MHz), excellent forward AGC (>20.5 dB gain reduction through h_{fe} fall-off alone), low feedback capacitance (<1 pF), and low-cost plastic-and-glass package (shown in Figure 3) make these devices first choice for many applications.

TIXM01-04 transistors are for AM/FM, while TIXM05-08 are for TV. Circle 126 on Reader Service Card for data sheets.

Plug-in flat package for TI industrial integrated circuits reduces handling and assembly costs.

TI's new 16-pin plug-in flat package (shown in Figure 4) has been developed to reduce handling and assembly costs for industrial applications. The two rows of sturdy plug-in pins with 100-mil spacing facilitate automatic handling, assembly, and flow soldering to industrial-type PC boards. The hermetic package is designed for excellent reliability as well as for handling convenience and economy.

economy semiconductors solid-state designs

The new package is available at no additional cost for Series 74, 74 930, 1580, and most units in Series 73. Standard package for all series is the five-year-proved ¼" x ⅛" flat pack. Circle 127 on Reader Service Card for data sheets.

Broad line of SILECT™ silicon plastic-encapsulated transistors offers economy, reliability

For proven reliability in economy silicon transistors, look to TI's broad line of SILECT plastic-encapsulated devices.

Documented results of recent tests show demonstrable reliability advantages over alternative plastic silicon types. In the areas most critical in plastic transistors — moisture resistance and encapsulant stability — SILECT transistors excelled. Copies of this data are available.

PNP types offer the added advantage of TRI-REL™ redundant stabilization— an exclusive TI process insuring NPN reliability in PNP devices.

The table at right summarizes the characteristics presently available in SILECT transistors. With current capabilities ranging from 1 μA to 500 mA and frequency from 30 to 600 MHz, SILECT devices are well suited for a wide variety of industrial and consumer applications. Circle 128 on Reader Service Card for data sheets.

Get high performance at low cost with SILECT FET's from TI

Now you can improve sensitivity, reduce cross-modulation, reduce noise, and generally improve performance of much consumer and industrial equipment with SILECT field-effect transistors.

These low-cost, plastic-encapsulated, silicon junction units are available as N-channel (2N3819 and TIS34) and P-channel (2N3820) devices. Optional grounded or ungrounded snap-on clamps (shown in Figure 5) provide RF shielding and improved dissipation.

Applications include AM/FM tuners; mixers; low-, medium- and high-frequency amplifiers; and digital applications. Low-cost matched pairs for FET complementary circuits or differential amplifiers can be obtained by clamping matched units together as shown in Figure 5.

Electrical characteristics include extremely low leakage, high-frequency capability, superior cross-modulation, high transconductance, and low capacitance. Electrical characteristics of the three standard types available are shown in the lower table of Figure 6. Circle 129 on Reader Service card for data sheets.

***SILECT* SILICON TRANSISTORS**

Application	Polarity	Device	I_c Range	h_{FE} Min	BV_{CEO} MIN	f_T MIN
Low Level High Gain Small Signal Amplifier	NPN	2N3707 2N3708 2N3709 2N3710 2N3711	001-30 mA 001-30 mA 001-30 mA 001-30 mA 001-30 mA	100 45 45 90 180	30 V 30 V 30 V 30 V 30 V	30 MHz 30 MHz 30 MHz 30 MHz 30 MHz
Medium Power	NPN	2N3704 2N3705 2N3706	100 μA to 500 mA	100 50 30	30 V 30 V 20 V	100 MHz 100 MHz 100 MHz
Medium Power	PNP	2N3702 2N3703	100 μA to 200 mA	60 30	25 V 30 V	100 MHz 100 MHz
High Frequency Low Noise AM RF	NPN	2N3825	1 μA to 100 mA	20	15 V	200 MHz
High Frequency AM-FM IF	NPN	2N3826 2N3827	1 μA to 30 mA	40 100	45 V 45 V	200 MHz 200 MHz
High Frequency FM RF, IF UHF OSC	NPN	TI407 TI408 TI409 TIS18	1 μA to 30 mA	20 15 15 20	12 V 12 V 12 V 13 V	450 MHz 300 MHz 300 MHz 600 MHz
High Frequency TV last IF Citizens Band	NPN	2N3828	100 μA to 100 mA	30	40 V	360 MHz

***SILECT* FIELD-EFFECT TRANSISTORS**

Application	Polarity	Type	BV_{GSS} Min	$\|Y_{fs}\|$	C_{iss} Max	$V_{GS(off)}$
Industrial, Consumer, Small-Signal Low Noise, High Input Impedance	N	2N3819	25 V	2000 to 6500 μmho	8 pF	.5 to 7.5 V
VHF Amplifier and Mixer Applications	N	TIS34	30 V	3500 to 6500 μmho	6 pF	1 to 8 V
Industrial, Consumer, Small-Signal Low Noise, High Input Impedance	P	2N3820	20 V	800 to 5000 μmho	32 pF	.3 to 7.9 V

Figure 6. SILECT silicon transistors and FET's meet a wide range of industrial and consumer needs.

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Show off your display system to advantage by using magnetic deflection. It offers superior quality, small size, high reliability and design freedom.

Part 1 of a two-part article.

Should electrostatic or magnetic deflection be used in display systems?

When faced with this choice, don't automatically select electrostatic deflection for the more sophisticated systems. Magnetic designs may not be quite as good from the standpoint of speed and bandwidth, but they possess a number of other redeeming qualities. These make them strongly competitive with electrostatic deflection, even in complex display systems.

The more sophisticated displays, such as radar, sonar or computer editing, often require rapid-access symbol presentations, occasionally mixed with real-time data (such as radar video). The displays frequently employ large tubes with large deflection angles. These characteristics are well met by magnetic deflection, in several ways.

Magnetic-deflection is attractive

In the first place, the quality of the display itself is superior to that obtained with electrostatic deflection, because the magnetic field does not interfere with the beam-forming process. This yields brighter displays and clearer, more controllable spot sizes.

Magnetic deflection also permits considerable design freedom:

- Easier reference to ground of tube element potentials within the display are achieved, because of the nature of the magnetic-deflection field. This is particularly important when wideband intensity modulation is required.
- Power-supply requirements like ripple and regulation are less stringent—again, because the beam-forming field is independent of the magnetic-deflection field.
- Packaging advantages accrue. The length of the tube is relatively small, because larger deflection angles are inherent. This also simplifies the size and complexity of its electron-gun.
- A lower voltage power supply is needed to form the magnetic-deflection field than is required for electrostatic deflection. This permits the direct use of solid-state amplifiers, thus increasing the reliability and reducing the attendant power-dissipation requirements. Safety to personnel is also improved because of the lower voltages.

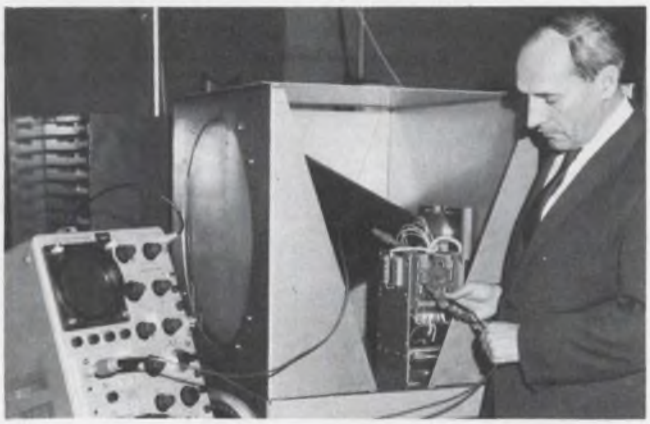
But magnetic deflection is not a panacea for display-system needs. One major drawback is the nonlinear relationship between the deflection current and the deflection of the spot (trace). If the cathode ray tube (CRT) had a spherical screen and a center of curvature that coincided exactly with the center of deflection, this would not be a problem. In practice, however, this is not the case, and a phenomenon called "pin-cushion distortion" results. However, it can be corrected.[1]

Finally, the speed and bandwidth characteristics of magnetic-deflection designs can be made to approach and even equal (when large tubes are involved) those obtained with the electrostatic method. The design methods for achieving this are comparatively esoteric.

Let us then examine the design criteria and the interrelationships between the deflection coil and amplifying elements.

Tracing CRT deflection needs

One of the most important parameters of a



The case for magnetic deflection: design problems are ironed out. Co-author Popodi checks the performance of his push-pull magnetic amplifier design. Used in display systems, it is much smaller than an electrostatic counterpart and offers considerably more design freedom. The attendant power needs are also less stringent.

A. E. Popodi and **R. M. Williams,** Design Engineers, Westinghouse Electric Corp., Defense and Space Center, Baltimore, Md. (Mr. Williams is now affiliated with Sanders Associates, Inc., Nashua, N. H.)

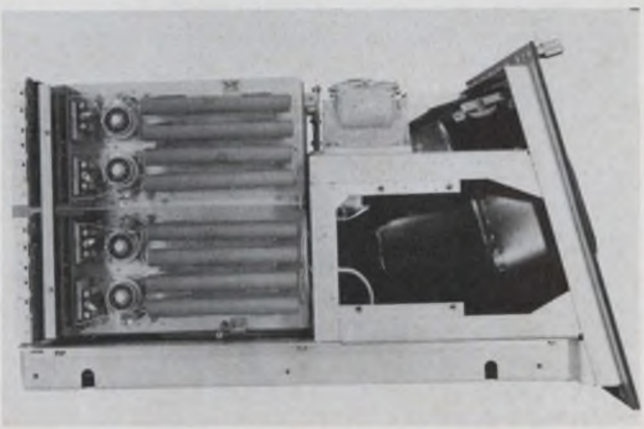
deflection design is its bandwidth. Bandwidth has a major influence on the two important deflection criteria—settling time and ramp delay. In magnetic deflection the response is limited primarily by the output driver-deflection yoke combination. In general, high bandwidth requires both high power-supply voltages and small yoke inductances. These, in turn, demand large deflection currents, which must be provided by the output stage. These stages usually consist of high-frequency power transistors. The key to attaining high bandwidths and small settling times is the transistor and, to a larger extent, the deflection-coil design.

For a display tube with a given deflection sensitivity, the engineer must select and optimize judiciously a number of circuit parameters. His aim is to fulfill specifications and maintain maximum reliability. These main design parameters are:

- Supply voltage of the output stage.
- Deflection current.
- Amplifier bandwidth and gain.
- Degree of negative feedback.
- Circuit configuration (single-ended or push-pull, grounded-emitter or grounded-collector) of the output stage.

These requirements are generally specified as a given settling time and ramp delay of the deflection current. In addition specifications for the dc-stability, resolution and linearity must also be satisfied.

Deflection amplifiers for modern display applications must be capable of two primary modes of operation. The first (Mode 1) is the linear deflection of the CRT beam (scanning) over a wide range of frequencies, generally coupled with small retrace times and minimum ramp delay or time lag. The second requirement (Mode 2) is the presentation of alphanumeric symbols that require the fast displacement of the CRT beam in any direction, with no accompanying positional correlation from one step to the next. In this case, minimum rise and settling times (amplifier recovery) are of prime importance. A figure of 10 μs settling time to within 0.1% of the final value, when proceeding across the full CRT screen diameter, is representative.



No longer on display . . .
Electrostatic deflection systems (such as the one shown above) are being hard-pressed by magnetic types in many display systems. Electrostatic types are larger, less-reliable, more complex and require higher power. Moreover, the frequency response of the magnetic types now approximate those of the electrostatic.

Spot the significant error

The changeover between the two modes occurs in most cases on a random basis. Depending on the particular display application, one of two amplifier parameters—accuracy or recovery time—will be more important. In general, absolute accuracy plays a lesser role than the relative error between the data presented in Modes 1 and 2. In radar language, a target should appear at the same screen location as its computer-positioned target symbol. There should be no significant difference in results when a given spot on the screen is reached by either of the two following methods: starting at the center of the tube (PPI-sweep) and approaching the spot with constant velocity (linear ramp), or starting at any screen location and reaching the spot by instantaneous displacement. In the latter case ramp delay, a function of amplifier bandwidth, is of prime importance.

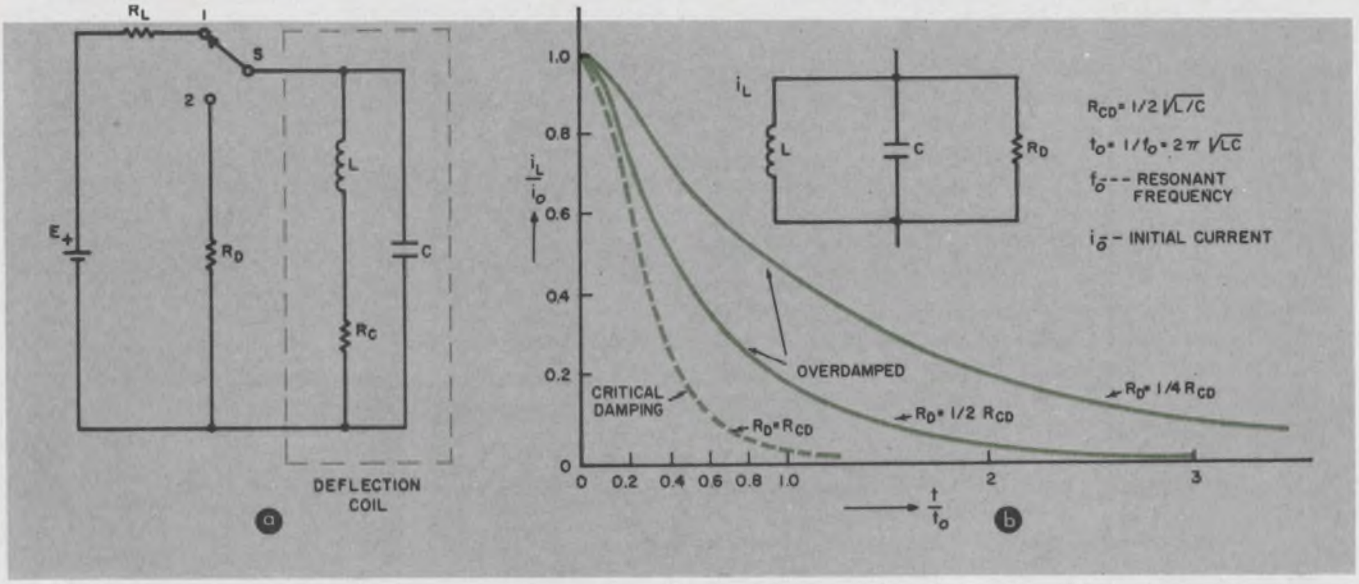
The total settling time of the CRT-spot depends on three factors: the deflection yoke inductance (L), the amplifier bandwidth and gain, and degradation effects. The yoke inductance determines the maximum obtainable current rise time, which is governed by the relationship $di/dt = E_s/L$, where E_s is the operating voltage of the output stage. The degradation of yoke characteristics is attributed to surrounding magnetic bodies, such as the magnetic shielding, armatures and the focus coils. Since it is not coil current but the actual magnetic flux that deflects the electron beam, great attention must be paid to maintaining a simple relationship between yoke current and flux.

The first design task is to choose the coil inductance on the basis of minimum power dissipation of the output stage. The next part of the design relates to the amplifier and its relationship with the deflection coil. Rise time and ramp delay for a single-pole feedback amplifier (second order system) will be calculated for single-ended and push-pull deflection systems, to illustrate this dependency. Finally a procedure to determine the total settling-time under actual overdrive conditions will be presented to demonstrate system performance.

To ease the analytical treatment, linear operation of the amplifier-yoke complex is assumed. Note that constant-frequency systems that feature a recovery of energy (such as television) do not apply to this discussion.

Deflection coil establishes di/dt

The deflection coil is part of the feedback loop, and, as such, its effect on amplifier performance is major. To determine the shortest obtainable rise and fall times of the deflection current, the equiv-



1. **Deflection coil is a key part** of the magnetic-deflection display system. Equivalent circuit (a) is used to determine coil current versus time relationships. In general, di/dt effects should be maximized, thus requiring that E_s be large and L and R_L small. Normalized plot of coil current as a function of damping resistor value demonstrates the current-time relationship for one critically damped and two overdamped conditions (b).

alent circuit of Fig. la is analyzed. The coil element consists of coil inductance L, winding resistance R_c and coil capacitance C.

If the switch S is in the charging position (1), coil current increases exponentially toward its final value, as given by supply voltage E_s and charging resistor R_L (resistor R_c is small and can be neglected). Charging resistor R_L is also small, thus permitting coil capacitance to be neglected. Current build-up in the coil is then described by:

$$E_s = iR_L + L\frac{di}{dt}; \qquad (1)$$

this may be rewritten as:

$$\frac{di}{dt} = \frac{E_s - iR_L}{L}. \qquad (2)$$

To maximize di/dt, E_s must be large and both L and R_L small. For solid-state drivers, the practical limit for E_s is the maximum collector-to-emitter breakdown voltage of the output transistor. Minimum values for R_L depend on both the ratio of feedback voltage to noise in the system and the requirement that it be non-inductive (or that its inductance be small when compared to L). Typical values for R_L in high-bandwidth applications (settling times of 10 o 20 μs) are from 0.1 to 10 ohms. Finally a practical limitation for the lowest coil inductance is the number of turns necessary to insure a uniform field distribution, especially in push-pull yokes. As the inductance decreases, the deflection current rises, and output transistor capabilities determine the minimum inductance. In high-bandwidth applications, coil inductances of 10 μh may be encountered.

If S is in the discharge position (2), the coil capacitance C cannot be neglected, and a coil damping resistor R_D must be added to avoid excessive ringing. The value of R_D must be near or possibly slightly larger than a critical value given by $R_{CD} = 1/2 \sqrt{L/C}$. This is because a small amount of overshoot produces faster settling time. Figure 1b shows the current decay for a critically damped case and for two overdamped cases.

The fastest possible current decay without overshoot is obtained if $R_D = R_{CD}$. At time $t = t_o$, where $f_o = 1/t_o = 1/2\pi\sqrt{LC}$ (the resonance frequency of the yoke), the current is approximately 1% of its final value. For this reason, L and C must be small for high bandwidth. The damping resistor in a practical circuit is established by the source impedance of the output. Thus it can be very low in the case of emitter-driven coil or relatively high with a collector configuration.

Easing the burden of yoke selection

In selecting a deflection yoke, it is assumed that the CRT has already been selected and that the fastest required spot displacement from center to edge is known. The type of yoke used depends on the particular display application. Several lines of yokes are available, depending on what aspect of performance is paramount. This can be the sensitivity, the linearity or the resolution.

To ease output-stage design, the engineer generally chooses the largest yoke inductance that, in conjunction with the amplifier, permits the attainment of a specified settling time. To find this inductance, the sensitivity constant of the particular yoke line must be determined. This is usually done by consulting data-sheet values for a sample yoke and sample tube, neither of which has to be final design values.

The energy required to magnetically deflect the electron beam of a CRT is given by

$$1/2\, L_1 I_1^2 = W_1 = \frac{E_{a1} \times \sin^2\theta_1}{k}. \qquad (3)$$

Combining and solving for k yields:

$$k = \frac{2E_{a1}\sin^2\theta_1}{L_1 I_1^2}, \qquad (4a)$$

where L_1 is the yoke inductance of the sample yoke (obtained from the data sheet), E_{a1} is the CRT anode voltage listed for the sample yoke, I_1 is the center-to-edge deflection current of the sample yoke, θ_1 is the center to edge deflection angle of the sample yoke and k is the sensitivity constant of the selected yoke line.

Because k depends only on the yoke geometry and construction, Eq. 4a can be rewritten:

$$k = \frac{2E_a \sin^2 \theta}{L I^2}, \qquad (4b)$$

where E_a is the actual CRT anode voltage in the particular application, I is the actual required deflection current for center-to-edge deflection, θ is the actual center-to-edge deflection angle, and L is the actual yoke inductance.

Voltage sets speed of spot shift

This equation describes the static relationship between inductance, deflection current, deflection angle and anode voltage. Under dynamic conditions, the fastest possible spot displacement is obtained when the full supply voltage (E_s) of the output stage is applied to the yoke. Neglecting coil series resistance, the current rises as per:

$$E_s = L\frac{di}{dt} = \frac{LI}{t} \qquad (5)$$

where E_s is the supply voltage of the output stage, L is the yoke inductance, I is the deflection current at the tube edge and t is the time allowed for spot displacement from center to edge. Substituting and solving for L, we get:

$$L = \frac{k}{2E_a}\left(\frac{E_s t}{\sin \theta}\right)^2. \qquad (6a)$$

In practice the coil current does not rise linearly, because the coil resistance R_c is not zero and there is a voltage loss in the feedback resistor R_L. Moreover the deflection amplifier is not ideal. Depending on amplifier design and damping conditions, overshoot may occur and therefore additional time is needed until a given settling level is reached. With good amplifier design (less than 5% overshoot), the total settling time is about twice the value used in Eq. 6a, if a settling to within 0.1% is desired. Therefore,

$$L_{(practical)} = \frac{k}{2E_a}\left(\frac{E_s t}{2 \sin \theta}\right)^2 \qquad (6b)$$

is a more realistic inductance expression.

The yoke inductance calculated from Eq. 6b is only a rough estimate of the final design value. The next step is to match the yoke to the amplifier and to determine the amplifier bandwidth required to obtain the specified settling time.

The deflection yoke is always the load of a limited-bandwidth deflection amplifier that often features a negative feedback arrangement. Basically there are two ways to connect the deflection yoke to the output stage. These are identified as the emitter and collector configurations.

Single-ended deflection used

In the emitter-follower configuration (Fig. 2), coil voltage is controlled by the output stage. Because large voltage excursions in both polarities ($+E_s$ and $-E_s$) are necessary for fast current rises, the preamplifier must be capable of supplying rather high base current drives. The preamplifier response, rather than the output stage response, is usually the bandwidth-limiting factor, because the former is more overtaxed. However, this does not present a great problem, because it is relatively easy to obtain high bandwidth at low-current levels with medium-power high-frequency transistors. One advantage of this connection is that the coil capacitance can be charged and discharged by the low-impedance emitter-followers; thus no damping resistor is required.

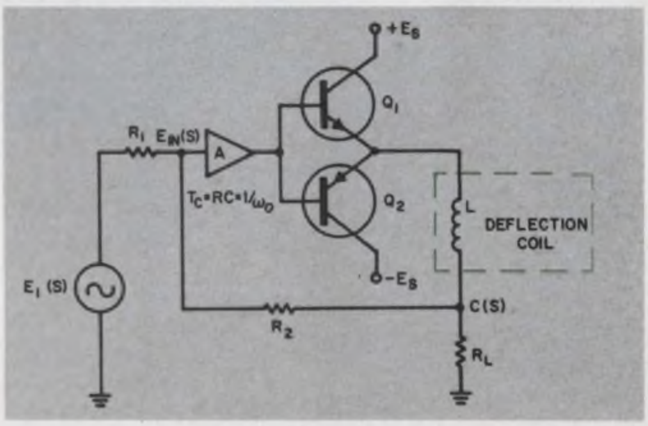
In a collector configuration, coil current is the controlled parameter. Here the preamplifier does not require large output voltage swings, because only the base of the output transistor must be driven. However, the large-power-transistor used has a high output capacitance (up to several hundred picofarads). This lies in parallel with the deflection coil and deteriorates the circuit time constant. Therefore, the gain-bandwidth product of the output stage becomes the limiting factor.

This is further complicated because the collector capacitance is not constant; it is voltage dependent. The damping resistor must therefore be selected for the largest possible capacitance—this entails an overdamping condition at all other values of C. In other words, a loss in current rise-time must be accepted.

The design characteristics and performance capabilities of a number of actual magnetic-deflection systems will appear in Part 2 of this article, in the next issue. ■ ■

Reference:

A. E. Popodi, "Linearity Correction of Magnetically-Deflected Cathode Ray Tubes," *Electrical Design News*, January, 1964.



2. **Single-ended and push-pull deflection stages often use** an emitter-follower configuration to connect the deflection yoke as an amplifier load. Note that a damping resistor (in shunt with the coil) is not required. This is because the emitter-follower stages both charge and discharge the coil capacitance directly.

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A473	550 Mc	230 mpf	—	34 db	36 db
A415	200 Mc	0.7 pf	—	—	30 db

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Why use IC gate-ring counters? Because they often use less power than other counter types do and at the same time require no more wafer area.

Part 2 of a two-part article. Part 1 (E|D, Feb. 15, 1966) described the types of gate-ring counters that can be built in integrated-circuit form.

The power dissipation of gate-ring counters is often less than that of other types. Moreover integrated-circuit gate-ring counters require no more wafer area than other commonly used types.

In deriving power-dissipation expressions, the engineer can ignore the dissipation in the pulse steering networks. This is because it is generally small, in comparison with the dissipation in the rest of the counter circuitry, to be of significance.

Power expressions for NAND counters

As Part I of this article has shown, NAND gate-ring counters can be built in integrated-circuit form using DTL gates. In such a counter the fan-out per gate varies with the number of gates in the counter. So for each gate (Fig. 1), the value of the fan-out parameter K (where $K = R_B R_L$) varies with the number of gates, for a given value of transistor β. This is because R_B must supply enough base current to the inverter transistor for it to sink all the available current from the fan-out stages. Therefore, as the number of gates in the counter increases, the fan-out per gate must increase and R_B must decrease. This in turn increases the static power dissipation per gate. Since the total power dissipation is dependent on the fan-out—and therefore K—the value of K for a given counter size can be determined and then used to derive a simple formula for the total static power dissipation of the counter.

If G is the number of gates in the counter, then $G-1$ is the fan-out required to satisfy the basic counter interconnection. Add to this the external fan-out requirements, N, and the total fan-out of each gate is $N+G-1$. Therefore, referring to Fig. 1, we see that the condition for static stability is:

$$\left(\frac{V_{CC}-V_{BE}-V_D}{R_B}\right)\beta = \frac{(V_{CC}-V_{SAT})}{R_L} + (N+G-1)\left(\frac{(V_{CC}-V_D-V_{SAT})}{R_B}\right)$$

where: V_{BE} = base emitter voltage of the transistor.

V_{SAT} = collector emitter voltage of the transistor when the transistor is ON, or conducting.

V_D = voltage drop of a forward biased diode.

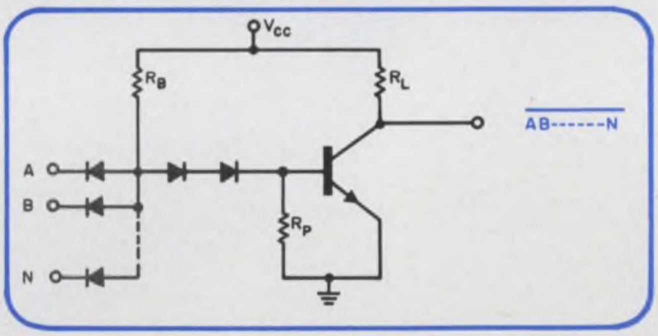
So, since $K = K_B/R_L$,

$$K = \frac{(V_{CC}-V_{BE}-V_D)\beta - (G+N-1)(V_{CC}-V_D-V_{SAT})}{V_{CC}-V_{SAT}}$$

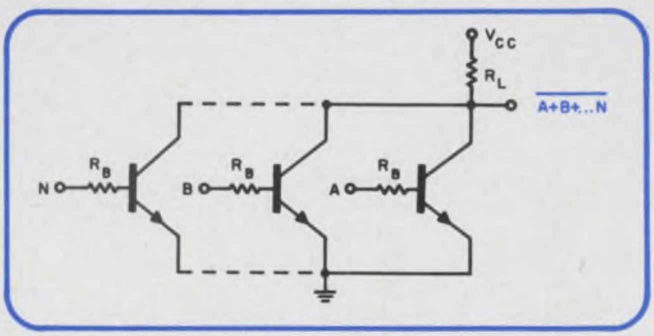
In deriving a simple expression for the power dissipation, P_d, we find that the power dissipated in R_p of the DTL gate and the power dissipated in the ON transistor from external fan-out are small—and are consequently ignored. Therefore,

$$P_d = \frac{(V_{CC}-V_D-V_{BE})}{R_B}V_{CC} + \frac{(V_{CC}-V_{SAT})}{R_L}V_{CC} + (G-1)\frac{(V_{CC}-V_D-V_{SAT})}{R_B}V_{CC}$$

which is the same as,

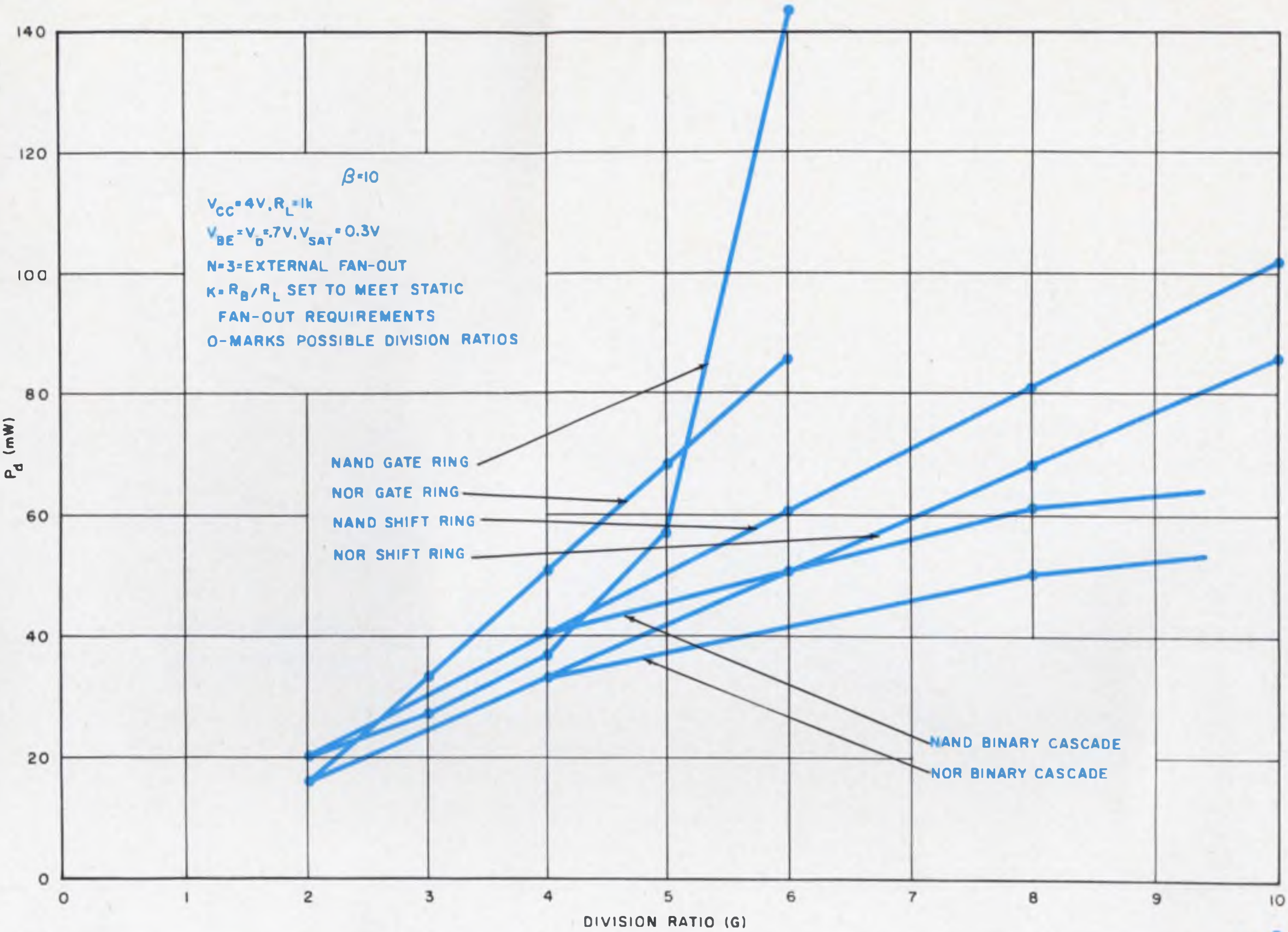


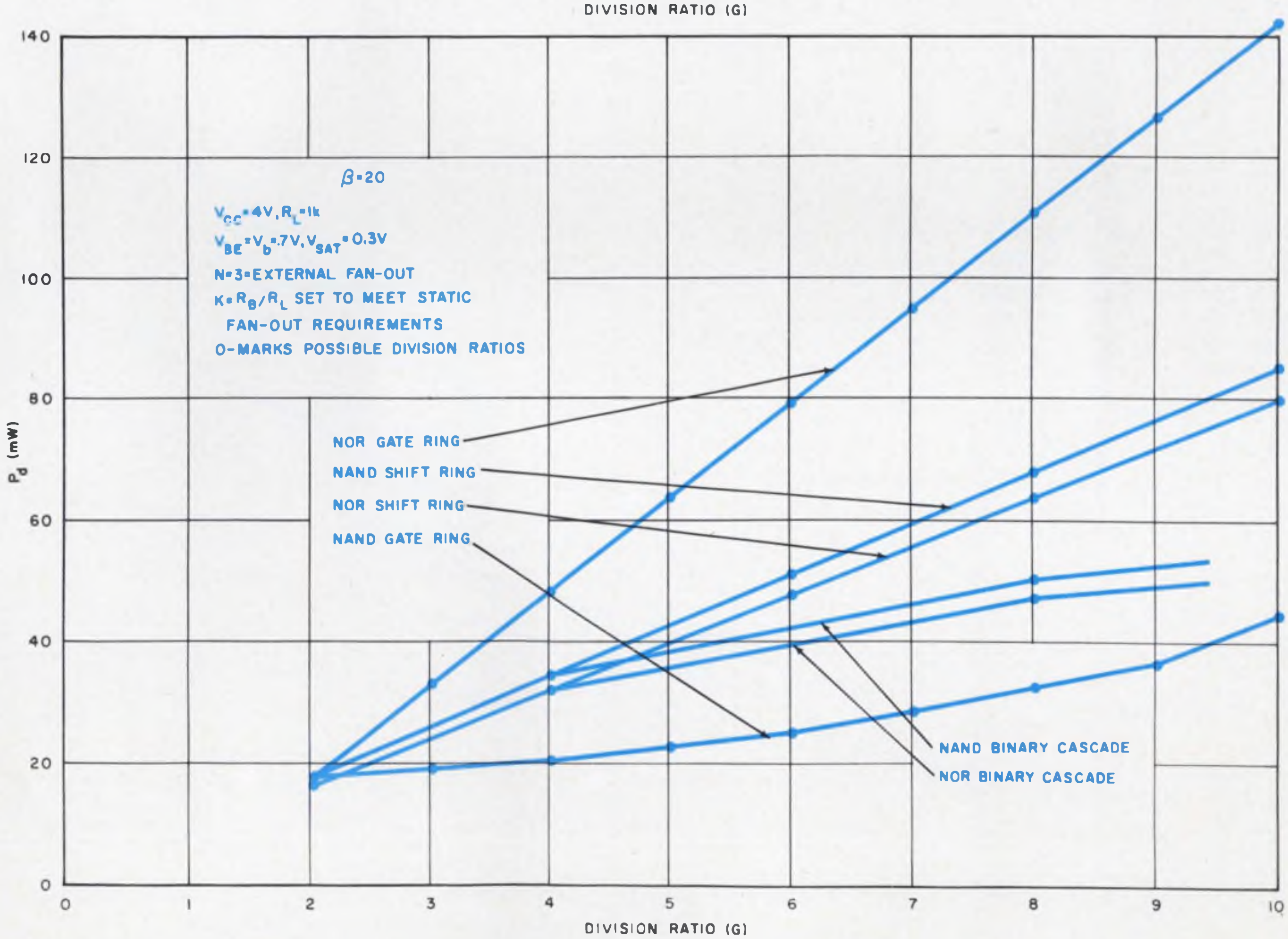
1. **DTL NAND-gate** can be used for integrated gate-ring counters.



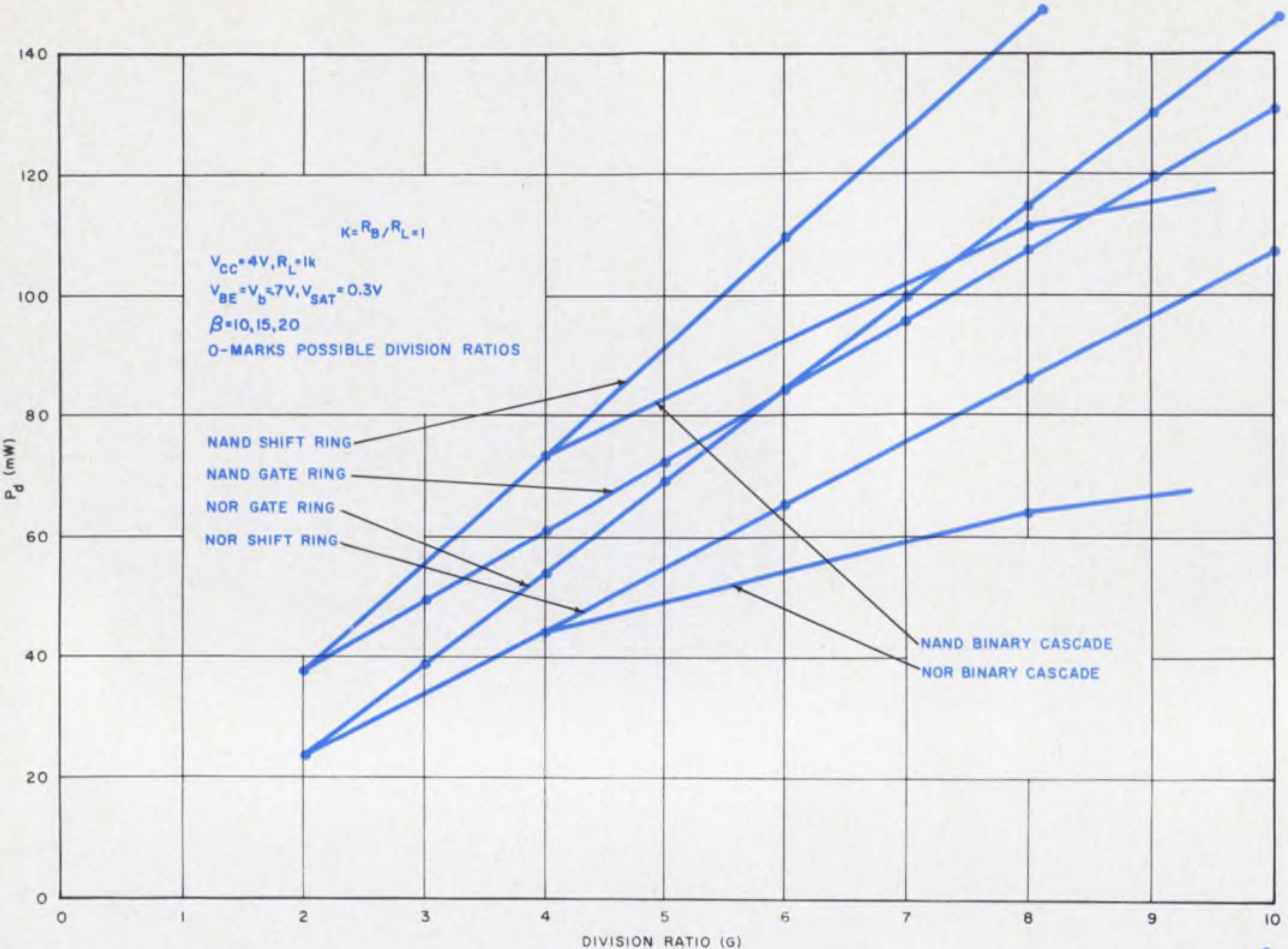
RTL NOR-gate is also realizable in integrated-circuit m.

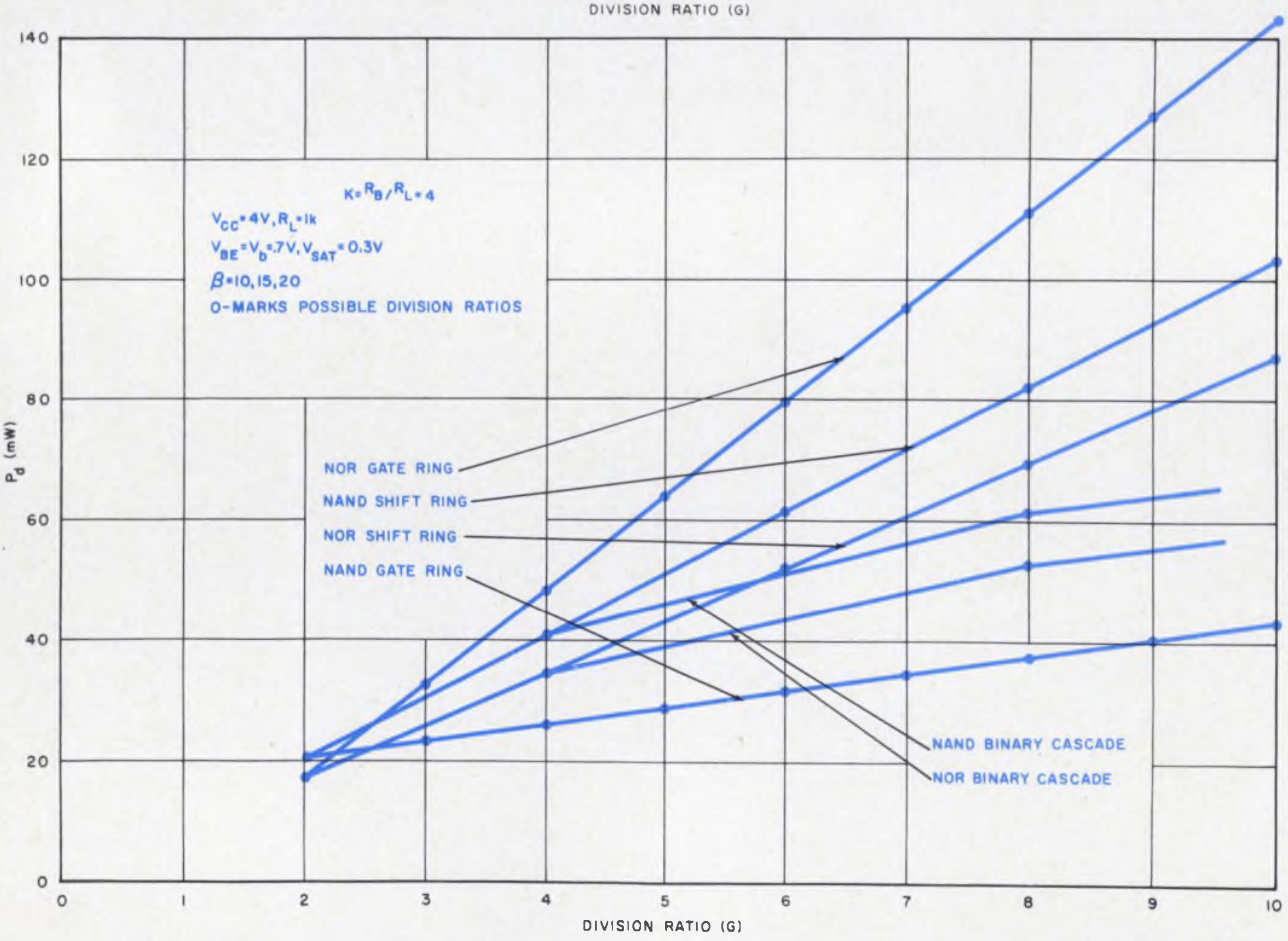
G. J. Veth, Applied Physics Laboratory, Johns Hopkins University, Silver Springs, Md.





3. **Static power dissipation vs counter length** is shown for various types of counters.





4. **Static power dissipation vs counter length** is shown for various types of counters when the value of K is fixed.

$$P_d = \frac{V_{CC}}{R_L}\left[\frac{(V_{CC} - V_D - V_{BE})}{K} + (V_{CC} - V_{SAT}) + \frac{(V_{CC} - V_D - V_{SAT})}{K}(G-1)\right]$$

Power expressions for NOR counters

As shown in Part I, integrated-circuit NOR gate-ring counters can be built using RTL gates. As with the NAND gate-ring counter, the required fan-out per gate for this type of counter varies with counter size. The total fan-out is the same as in a NAND gate-ring counter, being $(N + G - 1)$, where N is the external required fan-out and $G-1$ is the fan-out required by the interconnection of the gates.

To find first the value of K to satisfy the fan-out requirements (Fig. 2):

$(G-1)I_B + NI_B$ = required fan-out current

$$I_B = \frac{V_{OFF} - V_{BE}}{R_B}$$

where V_{OFF} is the output voltage of the OFF gate that is supplying the fan-out current.

$$V_{OFF} = V_{CC} - [(G-1)\,I_B + NI_B]\,R_L = I_B R_B + V_{BE}$$

$$I_c = \beta I_B = \frac{V_{CC} - V_{SAT}}{R_L}$$

Combining these two equations, we find K to be:

$$K = \frac{R_B}{R_L} = \frac{(V_{CC} - V_{BE})}{V_{CC} - V_{SAT}} - (N + G - 1)$$

In deriving a simple expression, we ignore the power dissipated by the load resistor of the OFF gate as it supplies current for external fan-out. Thus:

$$P_d = \frac{(V_{CC} - V_{SAT})}{R_L} V_{CC}(G-1) + \frac{(V_{CC} - V_{BE})}{R_L + R_B/G-1} V_{CC}$$

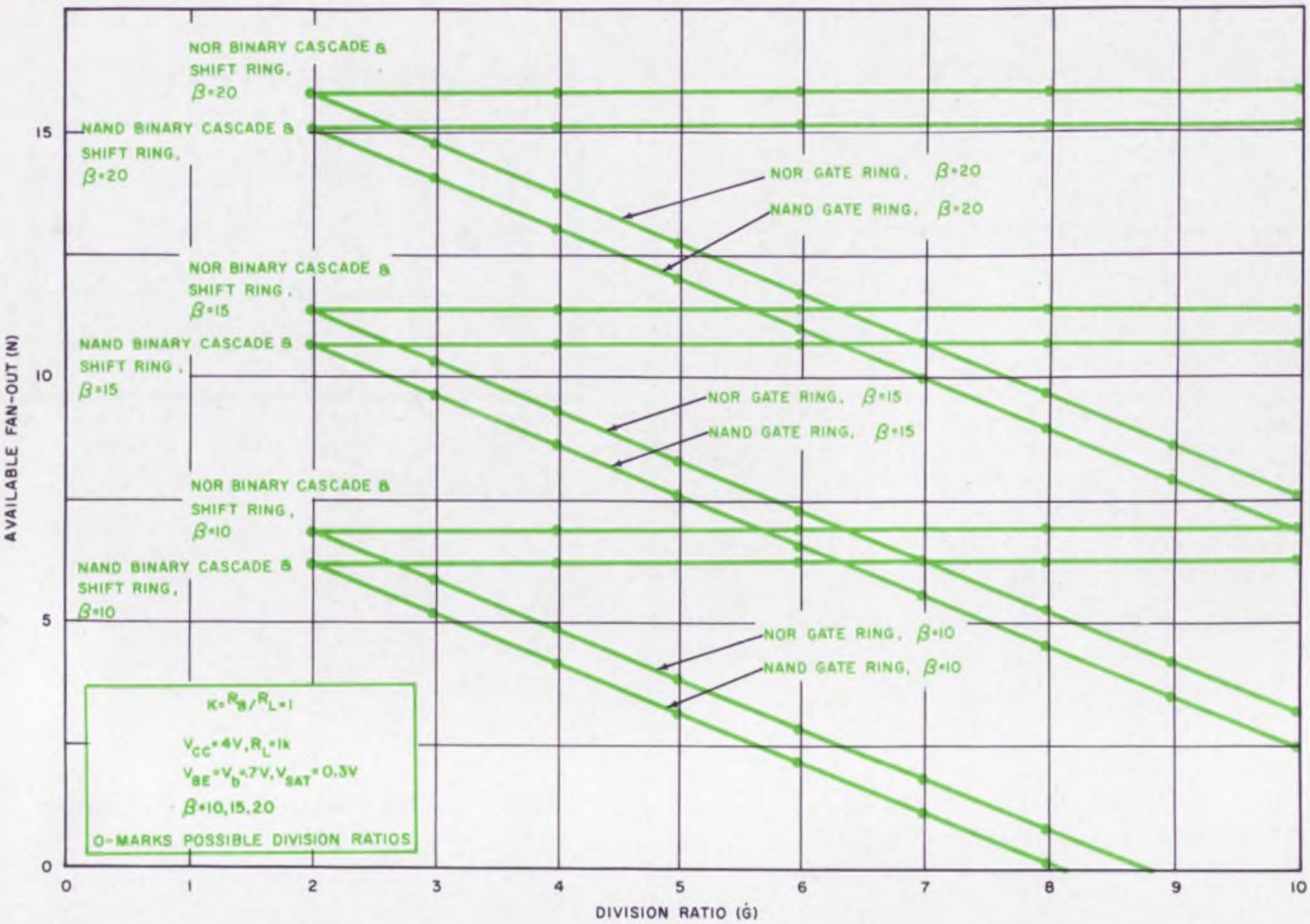
or,

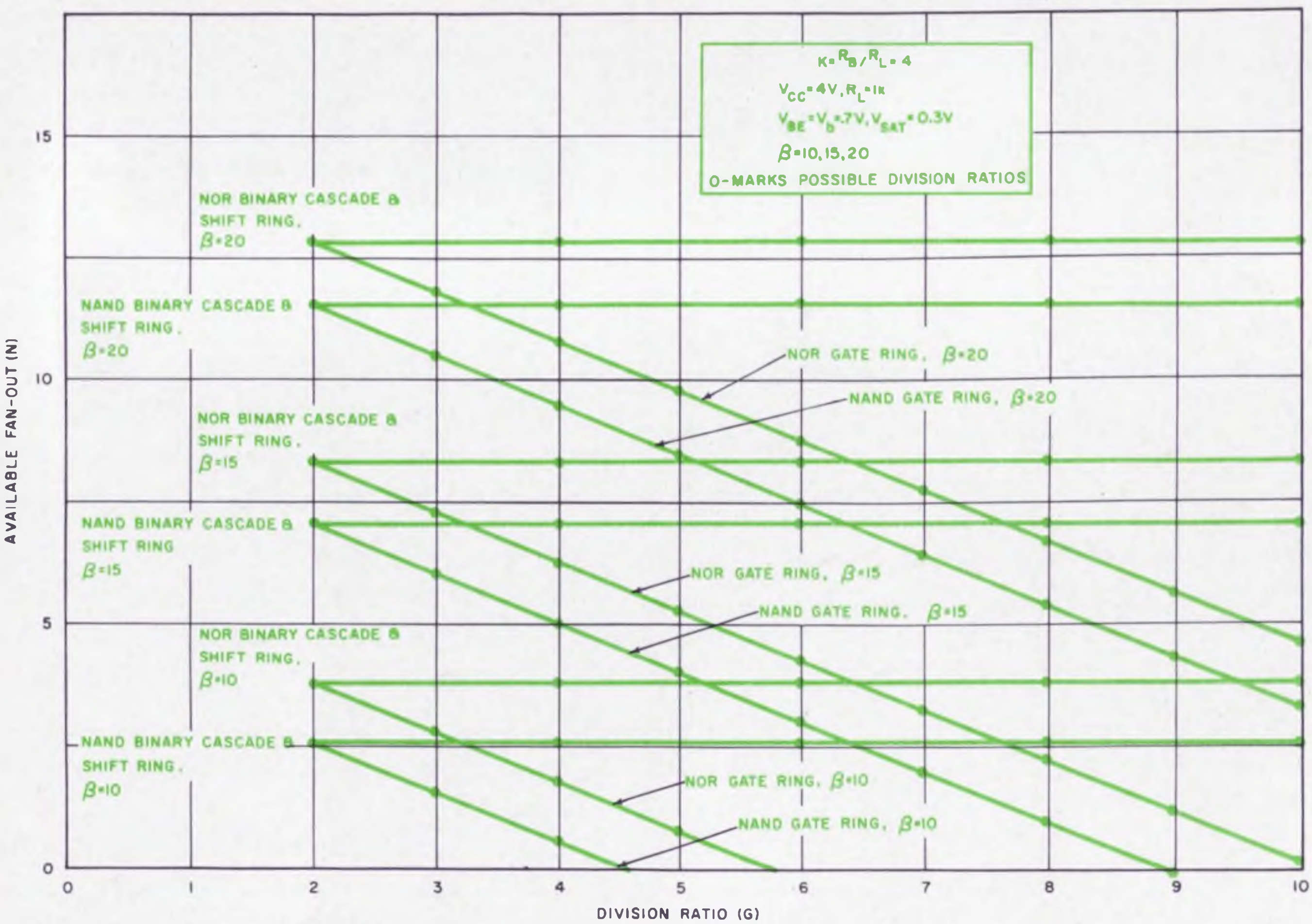
$$P_d = \frac{V_{CC}}{R_L}(G-1)\left[(V_{CC} - V_{SAT}) + \frac{V_{CC} - V_{BE}}{K + G - 1}\right]$$

Power expressions for binary-type counters

Serial dividers employing binary-counter stages and ring dividers using shift-register stages can be considered together, inasmuch as both can be built from the same basic circuit through proper interconnection. The circuit is essentially a shift register and is identical to the two-gate ring counter. Thus we can determine the static-power dissipation per stage for RTL and DTL implementation from the formulas just derived, by letting $G = 2$.

It should be noted that K does not vary with the counter length, as G is now a constant. However, K still varies with the external fan-out demands.





5. **Fan-out vs counter length** is shown for the fixed values of K used for Fig. 4; namely, K = 1 and K = 4.

Required area for integrated counters

Counter Length	Required Area		
	Gate Ring	Shift Ring	Binary Cascade
2	1	1	1
3	1.5		
4	2	2	2
5	2.5		
6	3	3	
7	3.5		
8	4	4	3
9	4.5		
10	5	5	

Therefore, from the previous formulas, we have:

$$K(DTL) = \frac{(V_{CC} - V_D - V_{BE}) - (N+1)(V_{CC} - V_D - V_{SAT})}{V_{CC} - V_{SAT}}$$

$$P_d/\text{Stage (DTL)} = \frac{V_{CC}}{R_L}\left[\frac{(V_{CC} - V_D - V_{BE})}{K} + (V_{CC} - V_{SAT}) + \frac{(V_{CC} - V_D - V_{SAT})}{K}\right]$$

and:

$$K(\text{RTL}) = \beta\frac{(V_{CC} - V_{BE})}{V_{CC} - V_{SAT}} - (N+1)$$

$$P_d/\text{Stage(RTL)} = \frac{V_{CC}}{R_L}\left[(V_{CC} - V_{SAT}) + \frac{V_{CC} - V_{BE}}{K+1}\right]$$

To determine the power of a cascade binary ring counter employing shift register stages, it is necessary to know only the relationship between the number of counter stages and the count cycle, or division ratio. The relationships for the simple cascade binary is:

$$\text{Count cycle} = 2^M,$$

where M is the number of binary stages. The relationship for the ring counter is:

$$\text{Count cycle} = 2M$$

where M is the number of shift register stages. These formulas have been solved for $V_{CC} = 4$ V, $R_L = 1$k, $V_{BE} = V_b = 0.7$ V, $V_{SAT} = 0.3$ V, and $N = 3$, and are presented in Fig. 3 for $B = 10$ and 20, respectively.

In obtaining these curves, we determined first the ratio $K = R_B/R_L$, which satisfied the static fan-out requirements. Then the power dissipation was calculated for this value of K. It can be seen from the curves that the NAND gate-ring counter allows division by any whole number and can have a lower power dissipation than the other counters. To obtain this lower power dissipation, though, the NAND gate-ring counter requires higher transistor betas than other counters do, especially as the length of the counter increases.

It is also interesting to compare the various counters discussed when the value of K is fixed. This has been done in Figs. 4 and 5. Figure 4 shows the static power dissipation vs counter length for two values of K, and Fig. 5 shows the available static fan-out for these same K values. To gain a power dissipation advantage with the use of a NAND gate-ring counter, K should be large, as can be seen, but if a large fan-out is required, K should be small or β large.

Size is no problem

Gate-ring counters should pose no fabrication problems in integrated-circuit form. The basic gates are already being realized in this form, and gate-ring counters with the required steering network components have also actually been realized, since flip-flop counters can be considered two-stage gate-ring counters.

The possibility of building entire gate-ring counters of reasonable lengths on a single chip is attractive. A comparison of the approximate wafer area required to build gate-ring, shift-ring and binary-cascade counters of given lengths in integrated form is given in the accompanying table. Since the gate-ring, shift-ring and two-stage binary-cascade counters are the same circuit, this circuit is assumed to require 1 unit of area. The lengths for the other counters are then given in multiples of this arbitrary unit of area.

To summarize:

Gate-ring counters can have important advantages over shift-ring and simple binary cascade counters. They are capable of counting by any whole number, they consume less power in many applications, and they require no more (or less) area in monolithic form. In addition they are quickly realized with the use of available integrated logic gates if conventional components are used in the steering networks, and, with minor modifications of available semiconductor gates, they can be constructed in fully integrated form.

Gate-ring counters have the disadvantage of requiring higher transistor betas for a given fan-out, or having lower available fan-out for a given beta. And, though not discussed here, gate-ring counters are subject to self-oscillations for certain combinations of circuit parameter values, especially as the length of the counter increases. ■ ■

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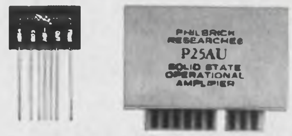

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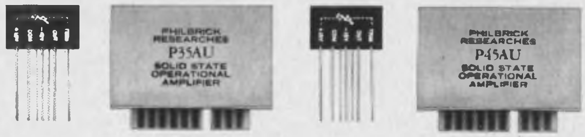
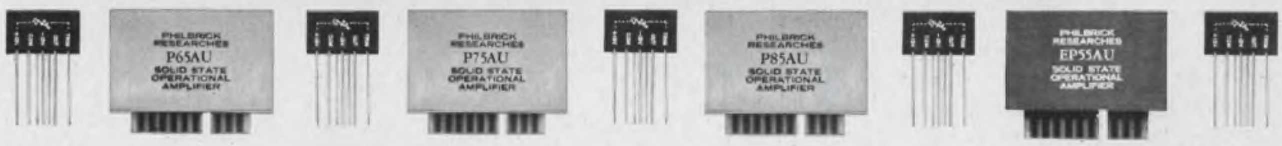


Operational

Amplifiers



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The ABC of dummy loads: A variety of choices are open to the designer, depending on the power, vswr and the availability of auxiliary equipment.

Before you select a coaxial termination, check these important parameters for dummy loads:

- Vswr.
- Power dissipation capability.
- Input connector.

Then examine the types that are available for your application. They can be conveniently grouped according to the way in which they dissipate heat:

- Dry terminations.
- Dielectric-cooled terminations.
- Water-cooled terminations.

In checking parameters, don't lose sight of your application. For example, vswr is a prime consideration in a directional-coupler application. In transmitter terminations, power dissipation is important. In high-power or peak-power applications, the choice of RF connectors should be carefully considered.

Let's examine these parameters one by one.

Theoretically a coaxial termination, or dummy load, should absorb all of the incident power on a transmission system without any reflection. The ability of a termination to perform this function is usually expressed either as its vswr or its reflection coefficient. (The reflection coefficient is the ratio of the reflected voltage to the incident voltage and, therefore, is always less than unity.) The vswr is the ratio of the maximum voltage to the minimum voltage appearing along the transmission line, and it is always greater than one. At frequencies approximately 400 MHz and above, the vswr is easily measured on a slotted line and is generally specified. At lower frequencies the reflection coefficient is often used.

The vswr is related to the reflection coefficient, ρ:

$$\text{vswr} = \frac{1 + |\rho|}{1 - |\rho|}. \qquad (1)$$

The reflection coefficient is related to the load impedance:

$$\rho = \frac{Z_L - Z_0}{Z_L + Z_0}. \qquad (2)$$

where Z_L = load impedance,
Z_0 = characteristic impedance of the coaxial system.

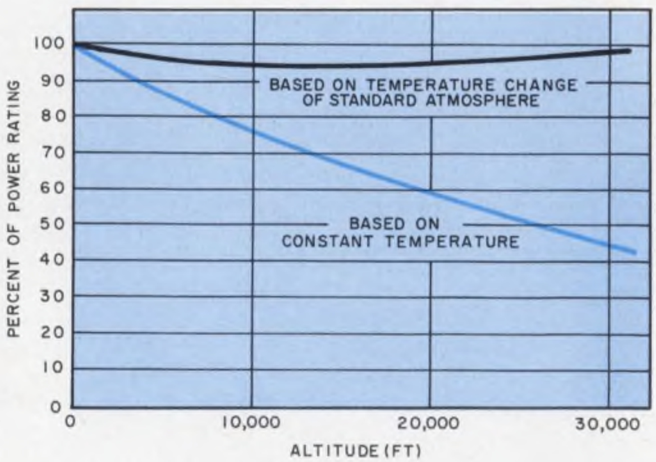
The reflection coefficient always has a phase angle, except when the load impedance is resistive. This time angle is ignored, and only the absolute value of reflection coefficient is used in the deter-

Goro R. Tahara, Development Engineer, Sierra Electronic Div., Philco, Menlo Park, Calif.

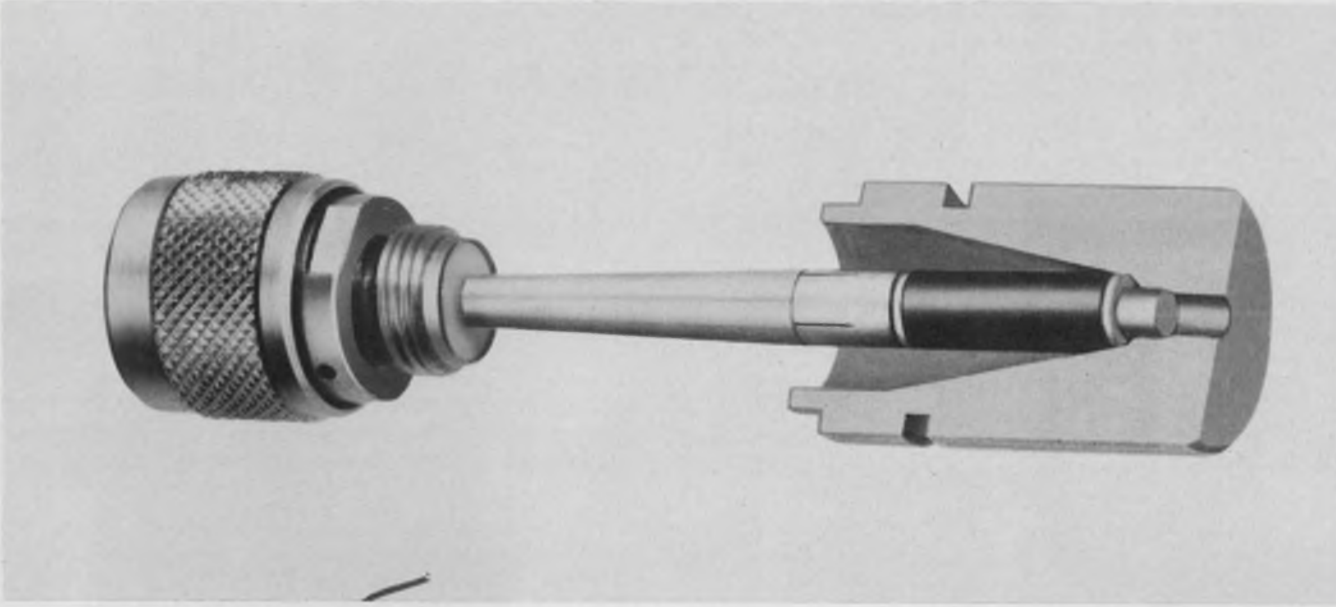
Facts and comments about connectors

Connector types	Peak voltage rating, volts	Equiv. peak power rating, kW	Comments
BNC	500	2.5	*Although rated to 10 GHz, Type TNC is not preferred above 3.0 GHz.
TNC	500	2.5	Rated to 10 GHz
UHF	500	2.5	Not recommended above 200 MHz
N	1000	10	Rated to 10 GHz
C	1000	10	*Although rated to 10 GHz, Type C is not preferred above 4.0 GHz
HN	5000	250	Rated to 4.0 GHz
LC	5000	250	Rated to 1 GHz

*Since the connectors are not rigidly mated in these bayonet type connectors, instability in vswr is observed at higher frequencies.



1. **Altitude-derating** curve indicates the drop in the power rating as the air pressure decreases with altitude and the temperature remains constant. If, on the other hand, the temperature decreases at about the same rate as the air pressure, the power-rating remains practically unchanged.



2. **Cross-section of dielectric-loaded termination** (Narda Model 375) shows how the dielectric is tapered for good match and maximum power dissipation. These dummy loads offer higher power ratings at higher frequencies than the resistor types. However, at low frequencies, dielectric materials usually have lower losses than resistors.

mination of vswr. Therefore the load impedance cannot be calculated from the vswr information, except in a purely resistive case (zero phase angle). In a resistive case, where $Z_L = R_L$:

$$\text{vswr} = \frac{R_L}{Z_0} \text{ or } \frac{Z_0}{R_L},$$

depending on which one of Z_0 and R_L is greater than unity.

Environment changes power rating

The maximum power rating of a coaxial termination is based on several criteria. In some cases complete failure of the termination is used as the limit for the full power rating. A more conservative rating would be based on a change in vswr characteristics or change in the power resistor.

When coaxial terminations are used in environments other than that of the laboratory, a power derating factor should be considered. Most manufacturers specify the maximum ambient temperature at which the termination can dissipate the full-rated power (+40°C is commonly used). The derating factor to be used above this temperature should be available from the manufacturer.

The most often neglected or misused consideration in power rating is the change due to altitude above sea level. The density of air decreases with altitude, causing a reduction of cooling efficiency. The change in viscosity tends to increase the convection of air, but it is insufficient to make up for the loss of density, if the temperature remains constant (Fig. 1). On the other hand, if the standard atmospheric temperature—as defined by international civil aviation organizations—is considered, the decrease in temperature with altitude effectively nullifies the derating caused by the decreasing density. The drop in temperature usually makes altitude derating negligible.

Find the right input connector

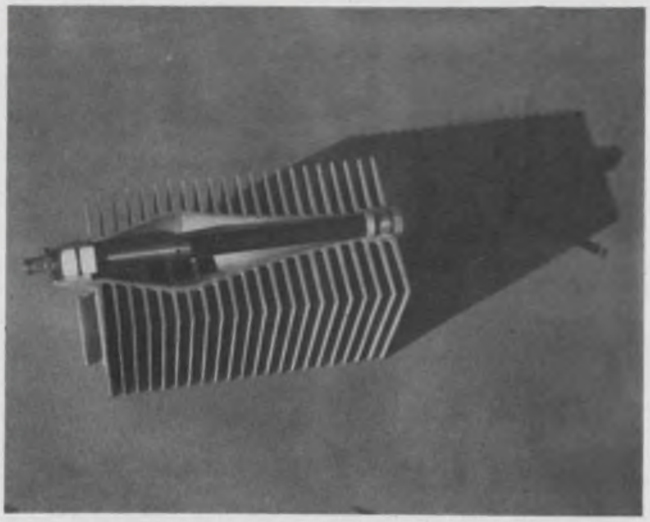
The input connector is an important part of the dummy load, since it has its own limitations of vswr, peak voltage rating and average power-handling capability. Some manufacturers are now offering medium and medium-large terminations, with interchangeable input connectors to accommodate various requirements. (For example, Sierra Twist-Off and Bird Electronic QC connectors). The characteristics of some of the more common connectors are listed in the table.

Information on the average power-handling capabilities of connectors is generally not available. In general, the coaxial cable's power rating is the limiting factor. The power ratings of coaxial cables vary with different manufacturers of cables and connectors.

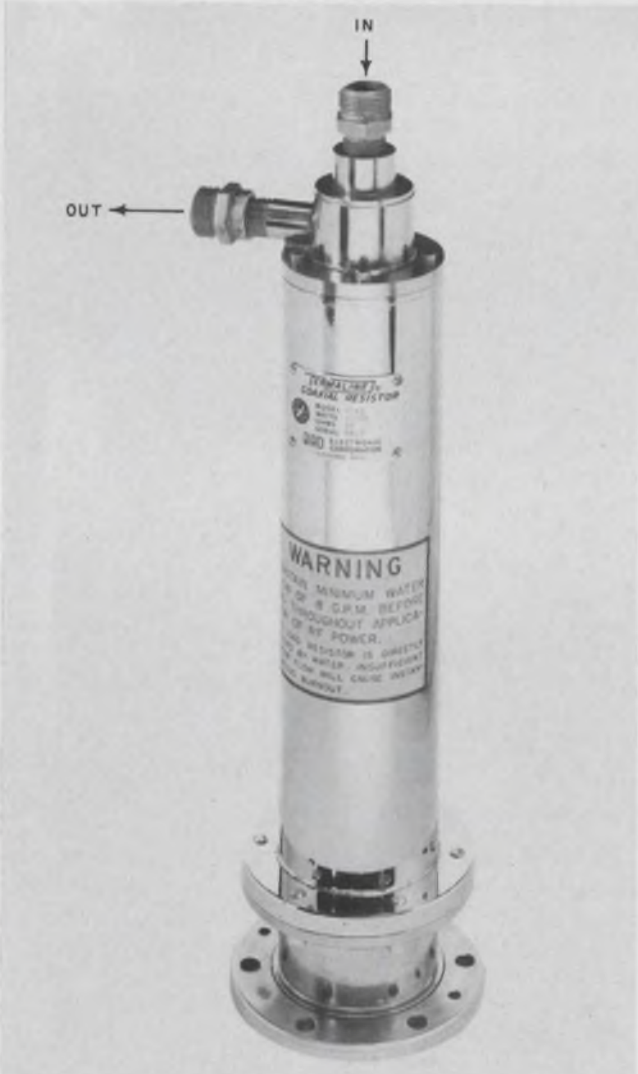
Now let's take a look at the three major types of dummy loads: dry, dielectric-filled and water-cooled.

Structures to get rid of heat

Low-power terminations are usually dry and have a resistor as the dissipating elements. The usual means of cooling is the free convection of air. The power resistor is cooled by convection air currents and by direct radiation to the outer conductor, which is also the body. The heat is conducted to the external wall of the body and fins and is dissipated by the free convection of air around the termination. Many companies manufacture these terminations for maximum power levels from 1 watt to 20 watts. Dry terminations up to 100 watts are now available that operate up to 4 to 5 GHz.



3. **Air-chamber,** cast as a part of a one-piece body, is large enough to handle expansion of dielectric coolant with temperature in this Sierra Model 160B-600. The tapered cone that surrounds the resistor matches the RF impedance.



4. **The power resistor** inside this dummy load (a film deposited on ceramic substrate) is cooled directly with water at a rate of about 8 gallons per minute. This termination (Bird TERMALINE® Model 8762) is rated 50 kW.

These are the advantages of dry terminations:

- They are reliable and rugged.
- They do not deteriorate in storage.
- The mounting position is usually not critical.
- They cover a wide frequency range—from dc into the gigacycle range.

The chief disadvantage of the dry termination is that it is available only in lower power units.

Instead of the resistor, a lossy dielectric may be used to dissipate the heat. The space between the center conductor and the outer wall is filled with a specially shaped dielectric material, which is lossy at high frequencies. Frequency coverage can be as low as 700 MHz and as high as 12.4 GHz. Power ratings extend to about 175 watts. The crossection of such a device is shown in Fig. 2. Low-power units do not offer any particular advantage over a termination that uses resistors. At higher power levels, they have these advantages, when compared with the resistor types:

- They offer better performance in the upper gigacycle frequency range, especially in the higher powered units.
- There is no air between the heat source (lossy dielectric) and the outer body. Therefore the efficiency of the heat transfer is greatly increased.

The disadvantages of dielectric units are as follows:

- They are not usable below 700 MHz.
- At lower frequencies they are physically long in comparison with resistor-based terminations.

Available lossy dielectric materials exhibit less loss per unit length at lower frequencies than at higher frequencies. Therefore, to obtain a given amount of attenuation at lower frequencies, a longer load is required. In actual practice the length of the load is primarily determined by the lowest frequency for which the termination is designed, since any higher frequency will encounter higher attenuation.

In the resistive type of termination, the loss is constant for all frequencies within the design limit. Since the physical size is not a function of frequency, a small unit can be made for low frequencies as well as for higher frequencies.

There is no direct relationship between frequency, length, power, and dielectric constant. They are factors that must be adjusted empirically to find the best combination for the design requirement.

Dielectric-filled terminations: how to keep fluid in

Dielectric coolants that transfer heat from the resistor to the body greatly improve heat-transfer efficiency. In this type of termination, the heat energy is removed from the resistor by the free convection of the coolant encased in the termination body. The heat absorbed by the coolant is transferred to the inner wall of the body. It is then conducted to the fins and dissipated into the air by free convection. The dielectric-filled terminations are generally available in the middle power ranges of 100 to 2500 watts.

The use of a dielectric coolant in a termination is not without disadvantages. There is the problem of keeping the coolant in and of providing for its expansion with rising temperatures.

A small flaw on the unit results in the loss of the dielectric coolant and in subsequent failure. A termination made of cast aluminum (Sierra Models 160-150 and 160-500) circumvents the problem. However, it also increases the manufacturing cost and results in a relatively expensive unit.

Some types use an air vent to release the internal pressure. This has the disadvantage of coolant spillage in transit or storage. Also, the exposure to air tends to contaminate the dielectric coolant.

Metal bellows are used in some terminations to permit coolant expansion. If properly designed and assembled, they permit the termination to be mounted in any position. A word of warning: Forced-air cooling should be used if the cooling fins are placed in a horizontal position, since natural free convection of air will be cut off. However, the bellows do increase the probability of dielectric leakage.

In dielectric-filled terminations the outer conductor is a tapered cone, surrounding the resistor, for RF impedance matching. Although holes are provided for the coolant flow to the body, the cone impedes the circulation of the dielectric coolant and reduces the heat-transfer efficiency.

The most recent dielectric-filled termination design (Fig. 3) incorporates cast-aluminum construction, in which the fins, body and internal RF matching cones are all in one piece. This construction assures reliability, ruggedness, high heat transfer efficiency and low manufacturing cost. The cost of this type of unit is generally less than that of a fabricated termination.

The air chamber may be cast as part of the one-piece body, and its size may accommodate all anticipated pressure changes. These terminations must be operated in a horizontal position, with the feet down.

Cooling fluids: three choices

One final consideration is the quality of the dielectric coolant. Different types of dielectric coolant are used in terminations.

Transformer oil is very economical, but it has a limited life, since oil tends to carbonize at the high operating temperatures of the power resistors. Carbon deposits on the resistive film gradually build up and cause hot spots, which eventually lead to resistor failure. The length of service of this coolant depends upon the operating temperature of the resistor. Some oils have an inhibitor to reduce the carbonization. This increases the life of the oil, but not significantly.

Silicone fluid has ideal properties for dielectric coolant, since it does not carbonize and can withstand high temperatures. This fluid is only used in high-quality terminations, since it is very expensive.

Synthetic fluids of fluorocarbon base are also used in some coaxial terminations. These fluids are generally not as expensive as silicone.

In general, the frequency ranges of dry terminations and dielectric-cooled ones are the same. The basis for comparison is usually the power rating.

Ways to increase power transfer

The power dissipation of a coaxial termination can be increased by a blower or fan to increase the flow of air through the fins. In general, forced air cooling on dry terminations is not very effective, since the large temperature drop occurs between the resistor and the body. The possible exception is in the lossy dielectric type of termination where material is in contact with the body.

The power rating of dielectric cooled terminations can be increased as much as two times, depending upon the termination operating temperature, the internal heat-transfer design, and the quantity and direction of the air flow. Some manufacturers offer a blower designed to fit their terminations. (For example, Sierra Model 160-1600AC and Bird Electronic Corp. Model BA-88).

The power dissipation can be further increased by cooling with water. Water-cooled loads are generally available in power ratings from 1 to 50 kW. There are two basic types of waterloads: indirectly cooled and directly cooled variations.

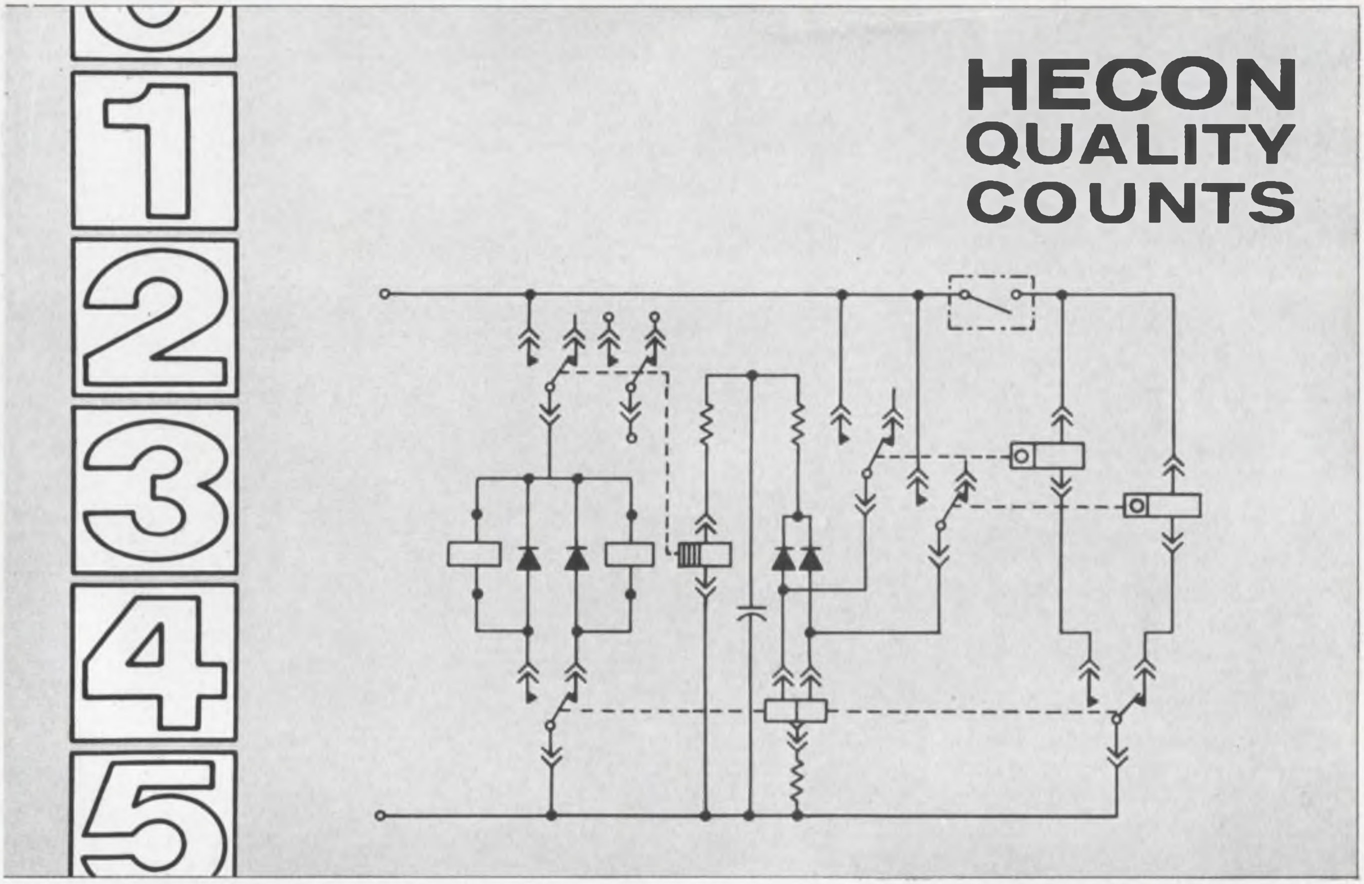
In the indirectly water-cooled loads, the termination resistor is cooled by a dielectric coolant (usually oil), which is circulated with a pump. The heat is transferred from the coolant to water by a heat exchanger. (An example is the Bird Model 502). In the direct-cooled termination the power resistor is cooled directly by the water. This method has higher heat transfer efficiency and results in a much smaller unit. For example, the Bird Electronic Model 8762 in Fig. 4 requires eight gallons of water per minute at 30°C. It operates up to 500 MHz, with a vswr of 1.1.

Water loads are also used in calorimetric applications where the rise in cooling water temperature is used to measure the input RF power accurately. In this application the heat loss to the environment must be kept at a minimum.

A look at the future

What will the future bring? There will be an increase in the variety of coaxial terminations of special design to meet the requirements of new applications. Small, lightweight dry terminations, handling power up to 100 watts, are already in the final stages of development. These are designed for missile and airborne equipment, where size, weight and reliability are prime factors.

Vswr performance is constantly being improved to meet more demanding applications, such as improved hybrids, couplers, etc. The power capabilities of dry terminations will continue to increase and the size of dielectric-filled terminations will shrink. Smaller loads are already being produced for use in miniaturized microwave systems. ■ ■



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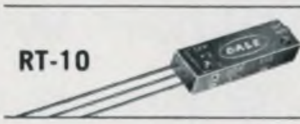
RT-10		Model 691 P.C. Pin Model 697 Flex. Leads
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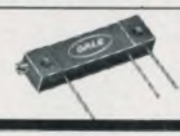
RT-12		Model 1680 P.C. Pin Model 1697 Flex. Leads
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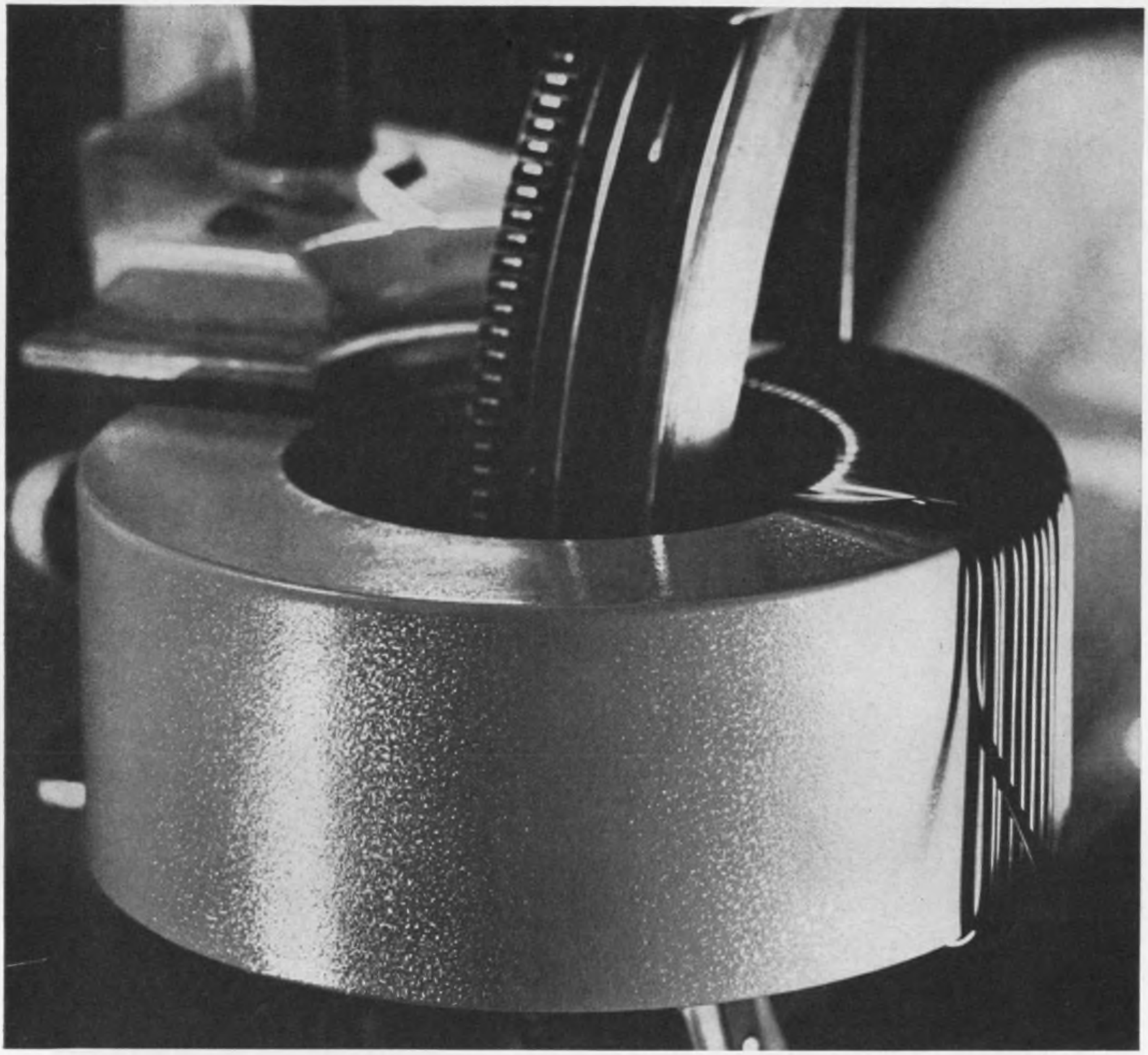

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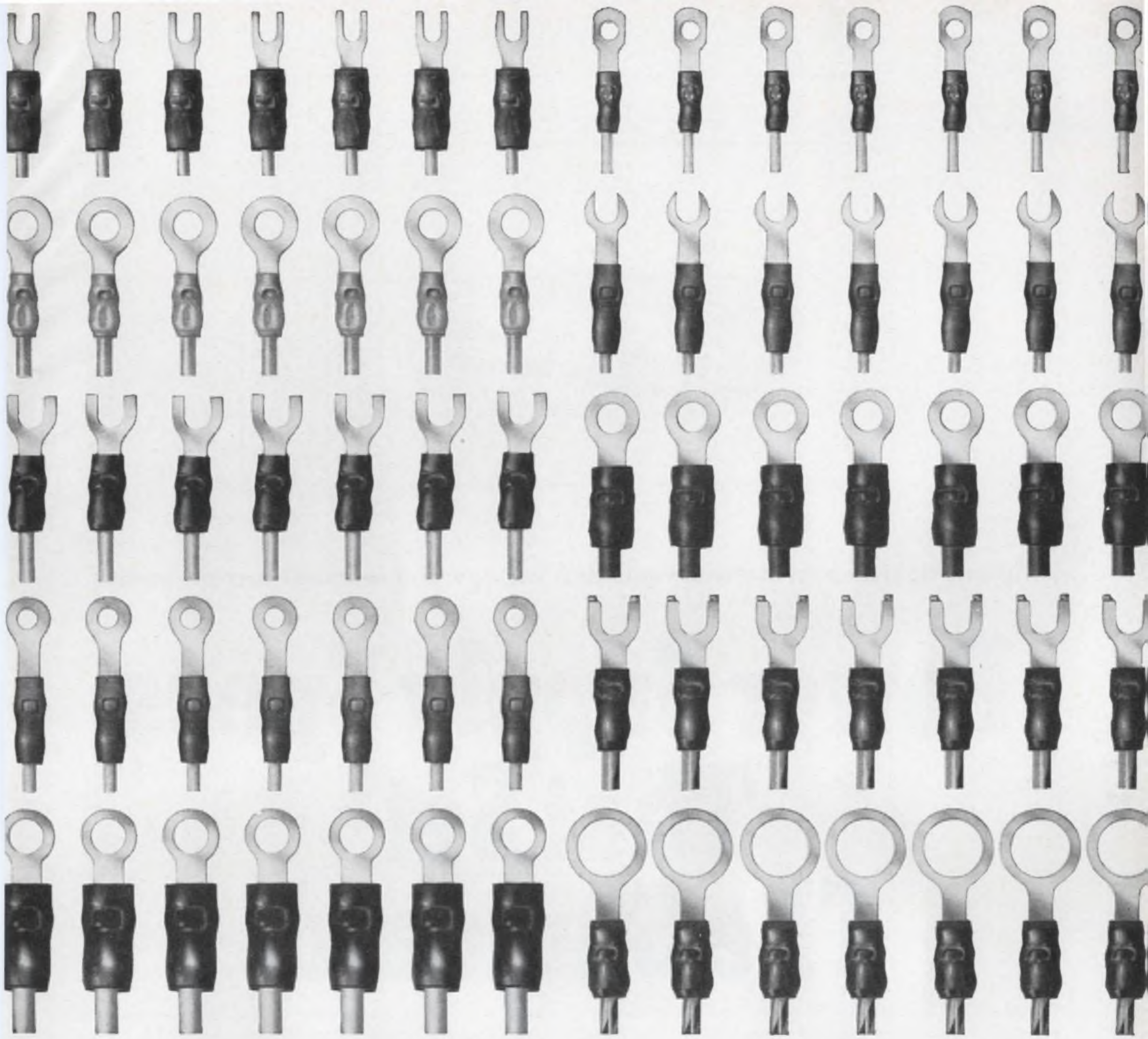

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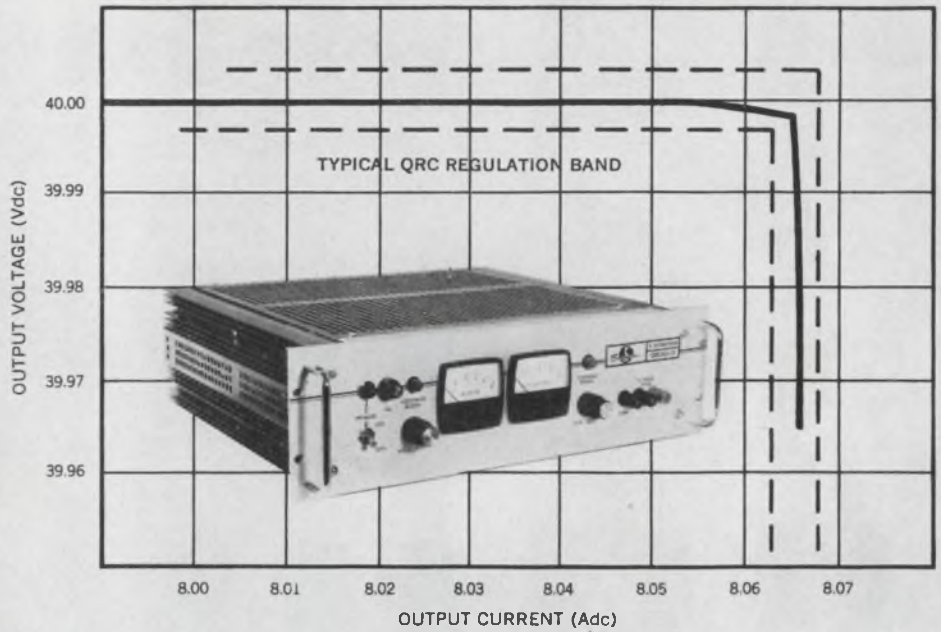

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QRC20-30	0-20	0-30	± .005% or ± 1 mv	1 mv	± .05% or ± 16 ma	8 ma	7	700.00
QRC40-4	0-40	0-4	± .005% or ± 1 mv	1 mv	± .05% or ± 2 ma	1 ma	5¼†	315.00
QRC40-8	0-40	0-8	± .005% or ± 1 mv	1 mv	± .05% or ± 4 ma	2 ma	3½	450.00
QRC40-15	0-40	0-15	± .005% or ± 1 mv	1 mv	± .05% or ± 8 ma	4 ma	5¼	575.00
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Committee meetings waste time—unless strict standards to control them are enforced. Here's some advice on how to make them useful.

As an engineer or manager, how much of your time do you spend at committee meetings? These meetings may be within your company, in professional societies, or in your everyday life. Most people spend more time this way than they would like to. Much of it is wasted time. What can you do about it?

Committee meetings can't be eliminated entirely; some are useful. But their number should be slashed drastically. Here's why:

One man working alone gets things done. Two working together may have an argument. But three or more make up a committee, and committees don't get things done; they should be used only for coordination and communication.

Here are some of the reasons why committee meetings are held, even though they shouldn't be. How many of them do you recognize?

1. To delay action or postpone decisions.

A manager may establish a committee to reconsider an idea. The objective, which may be hidden from the committee members, is to delay action or postpone the decision until a later date. But the pros and cons can be weighed only so many times. A decision must be made eventually. Why not now? The very nature of committees makes them slow and inept when speed is important.

2. To avoid or spread responsibility.

Instead of making a clear-cut decision, a person may establish a committee to make the decision for him. If the decision is wrong, nobody can pin the blame on any one person, especially if the committee members are all on the same level.

3. To mask individual incompetence.

A person assigned to a task, and lacking the ability to do it, often calls a committee meeting under the guise of seeking advice. He is really attempting to have the people on the committee do his job for him.

4. To provide an audience for the boss.

Many mangers like to have their egos bolstered by calling a meeting. With the spotlight on them, they then begin a monologue that is designed to prove they are managers.

5. To get together for a bull session.

Committee meetings that are scheduled on a regular basis can end up as bull sessions if the meetings are called simply to fulfill the schedule. Often there really is nothing to discuss.

6. To make unimportant decisions.

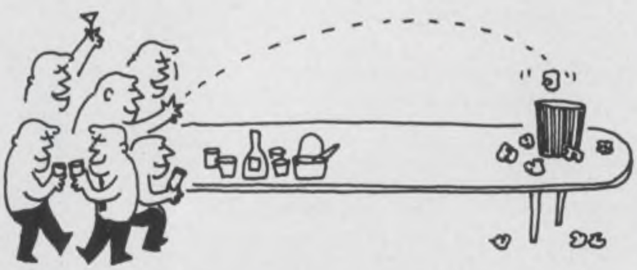
Committees sometimes meet to decide matters that are not worth a group decision in the first place. Like: decisions relating to the execution of different tasks, orders or plans.

7. To provide a "rubber stamp."

A committee meeting may be held to approve a decision after it has already been made and it is too late to do anything else about it.

8. To ease the pain of decisions.

Committee meetings offer opportunity for a compromise decision when such a decision is unwarranted. When a clear-cut decision is required, a committee involves a multiplicity of people, a diffusion of ideas and, ultimately, a compromise—which may be considerably less suitable than the decision sought.



Committee meetings that are scheduled on a regular basis can end up as bull sessions. . . .

Committees can be useful

But let's look at the other side of the coin. Committees are valuable in specific areas, but where their very structure makes them useful. Here are some valid reasons for calling committee meetings:

W. D. Rowe, Consultant, Sudbury, Mass.

1. To provide integrated group judgment.

In matters of extreme importance, a committee can provide broad depth of background and experience in evaluating decisions—for example, a properly run design review.

2. To promote coordination of inter-related efforts.

When a project extends beyond the responsibility of two or more people, it often is necessary to call meetings of the people involved to coordinate their efforts and understand the entire problem—for example, coordination among marketing, engineering and production personnel.

3. To obtain cross-fertilization of ideas.

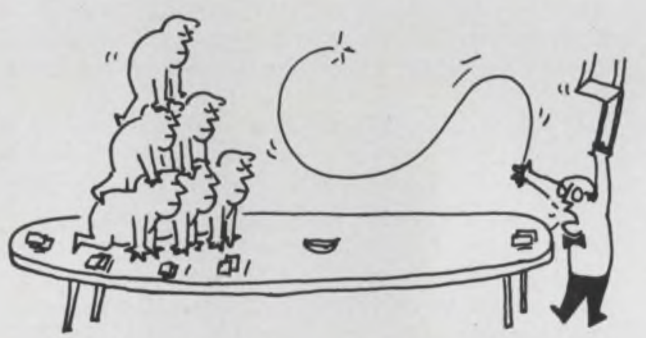
When attempting to find new approaches to a problem, brainstorming can be a useful device. However, it must be used properly—for example, in R&D planning sessions.

4. To enlist cooperation.

To secure action outside of your area of responsibility, it may be necessary to call a number of people together, so that you can explain what you are doing and invite their cooperation—for example, functional management action.

5. To communicate in parallel.

A meeting is useful when information must be imparted to a large number of people at the same time. This is more a seminar or lecture than a committee meeting. Its advantage over written communication is that feedback is instantaneous.



To secure action . . . it may be necessary to call a number of people together, so that you can explain what you are doing and invite their cooperation. . . .

How to hold a good meeting

Since you undoubtedly have to spend some time at commitee meetings, make sure that they are held properly: that they conserve time and manpower and accomplish the objectives in a reasonable manner. Here are essential steps:

▪ **Determine explicitly the purpose and the objectives of the committee meeting.** Are the objectives legitimate? Are they things that can be properly treated in a committee meeting? Or are they best accomplished by individuals working alone?

▪ **Organize the committee properly.** Define the duties and authority of the committee and its participants. Make sure everybody knows these objectives and is properly informed prior to the meeting. Limit the invitations to the meeting to those necessary to reach objectives.

▪ **Staff the committee properly.** Make sure the members are qualified people who give you the representation you require. Be certain they have accompanying decision-making authority. Support the committee with necessary staff assistants.

▪ **Establish committee procedures.** Set up the procedures in a way that insures bold and effective action. Formal procedures can be used when necessary.

▪ **Appoint the right chairman.** This is, perhaps, one of the most important considerations, since a good chairman can make a meeting run efficiently, can stir participation by the rest of the committee.

▪ **Know the participants.** Committees are made up of people with a variety of individual personalities. The action will result from the interplay of these personalities. Desirable traits must be encouraged; negative ones must be suppressed. Know the strong and weak points of the participants and play them accordingly.

▪ **Indoctrinate the members properly.** Make sure they know the rules (and why not give them a reprint of this article to read prior to getting down to business?).

▪ **Be prepared for the subject.** Too much committee time is taken up by detailed explanations of the subject. Be sure that all committee members are told in advance both what the subject is and what references are available—for example, memos, specifications or reports. Avoid restless waiting while one man—who has pleaded, "Too busy"—is brought up to date.

Commitee personalities

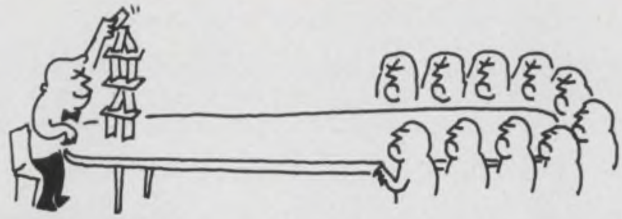
To help you recognize and control the personality types that committee meetings attract, check this list:

1. **The loud one**—Likes to hear himself talk and is most reluctant to quit. A chronic time waster, he should be squelched. It takes either a strong chairman with a formal set of rules, or a gag, to keep this type quiet.

2. **The detached observer**—Is secretly amused by the proceedings and the people participating in them. Since he doesn't really consider himself a participant, he doesn't help. So get rid of him by not inviting him.

3. **The wallflower**—Afraid to open his mouth or commit himself. He may have something to contribute, but nobody ever knows it. An adept committee chairman will encourage him to participate. Once given a little confidence, he may have something important to say.

4. **The take-charge guy**—Has to have his way or else. He's apt to think he'd make a better chair-



The detached observer is secretly amused by the proceedings and the people participating in them, since he doesn't really consider himself a participant. . . .

man than the appointed one, regardless of who the chairman is. He aims to dominate the meeting, regardless of the results or the wishes of others. Send him off with the "loud one" to a subcommittee, away from the rest of the members.

5. **The antagonist**—Against any idea, good or bad. He sometimes tries to sell himself as a "devil's advocate." He thinks he's a necessary adjunct to the committee. Nothing wrong with criticism, but let's make it constructive.

6. **The hedger**—Always wants to back off to some extent. Although no decision can satisfy everybody, this fellow always wants to try to modify it—in case it isn't right. Don't let him wreck the proceedings.

7. **The yes man**—Never disagrees. Since he never stands on his own, don't have him at the meeting, unless you are trying to pack it for a vote.

8. **The mediator or peacemaker**—Often serves a useful purpose when a stalemate is reached, but he may also dilute the impact of any decision that has to be made. He bears watching.

9. **The climber**—Talks to make an impression, even if his offering is worthless and he knows it. He'll usually delay proceedings by asking questions for which he already knows the answers, simply to impress everybody with how much he knows. Insult him by insinuating that he's stupid if he really doesn't know the answer to his question.

10. **The cynic**—Thinks the whole effort is a waste of time anyhow, so why bother? He is negative in the beginning and will be the same at the end; so place him and the "antagonist" in a separate subcommittee, where they can be miserable together—preferably in a remote location.

11. **The salesman**—Tries to sell his idea to the group, to the point of beating it to death. He just doesn't know when to stop. He requires preventative action by the chairman to keep him from defeating his own idea.

12. **The fanatic**—Has established his own doctrines and can't be budged from them, short of mayhem. When dealing with people, it helps to have an open mind. The fellow who doesn't is a real obstacle. The sole purpose of a committee meeting can often be to outvote or bring pressure to bear upon the fanatic.

Whether you're an engineer or manager, these guidelines will help you cut down wasted time. I know, because I've applied them. And now, if you'll excuse me, I'll quit writing. I have to attend a committee meeting, and. . . . ■ ■

NASA Tech Brief

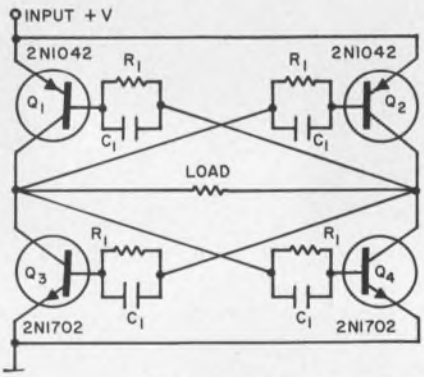
Simple oscillator for high power

Problem: Develop a compact square-wave oscillator that will operate with high efficiency at relatively high power levels.

Solution: A circuit that contains only simple resistor-capacitor combinations and solid-state devices.

It is a symmetrical bridge with a transistor in each arm. The base of each transistor is connected to a parallel resistor-capacitor combination. Each combination is connected to the collector of the diagonally opposite transistor.

The selection of transistors is the most important design consideration.



A smooth, balanced operation is provided by using a matched pair of *pnp* transistors, Q_1 and Q_2, and a matched pair of *npn* transistors, Q_3 and Q_4. In addition, these pairs should be complementary.

This oscillator circuit is simple and compact. It operates with high efficiency at relatively high power levels. Since the circuit employs only simple resistor-capacitor combinations and solid-state devices, its performance and reliability should be excellent.

For further information, contact: Technology Utilization Officer, Goddard Space Flight Center, Greenbelt, Maryland 20771 (B63-10554).

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COMMUNICATIONS Increase bandwidth and/or employ compaction techniques for expanded real-time bioastronautic, telemetry, and color TV data transmission...wideband data link using communication satellites.

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INFRARED Add new high-resolution spectrometers for launch and re-entry coverage...new IR systems to extend mid-range coverage.

RANGE SAFETY Study and develop areas of explosive hazard assessment, including instrumentation to cover chemical fuel explosions and nuclear fuel excursions.

INSTRUMENTATION & VEHICLE CONTROL Add a 64-man central control at the Cape to direct operation of the entire range...new real-time dual-system computer facility (including 2 CDC 3600's) for failure-proof high-speed data handling.

CORRELATION Reduce time correlation uncertainty across the range to less than 10 microseconds...standardize the timing signal format on the Eastern Test Range to be compatible with other national ranges.

FREQUENCY CONTROL & ANALYSIS Monitor and control all electromagnetic radiation within the missile test area with a Spectrum Surveillance System...expand automatic interference control, spectrum signature collection, and quality analysis.

METEOROLOGY Improve cloud height and growth indication instrumentation...develop a system to measure atmospheric electrical potential and cloud movement.

SHIP & AIRCRAFT INSTRUMENTATION Improve the instrumentation to meet more stringent telemetry, navigation, tracking, communications, and data handling requirements...phase into operation new and/or modified tracking ships and aircraft.

UNDERWATER SOUND Refine the techniques employed to establish impact location points of nosecones and instrumentation cassets.

BIOASTRONAUTICS Provide equipment to monitor and display physiological and environmental data to Air Force bioastronautic officers. Hook up this equipment into range computers and telemetry receiving sites.

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Projecting program requirements and developing the advanced tracking system concepts required, including instrumentation, facilities, and logistic support.

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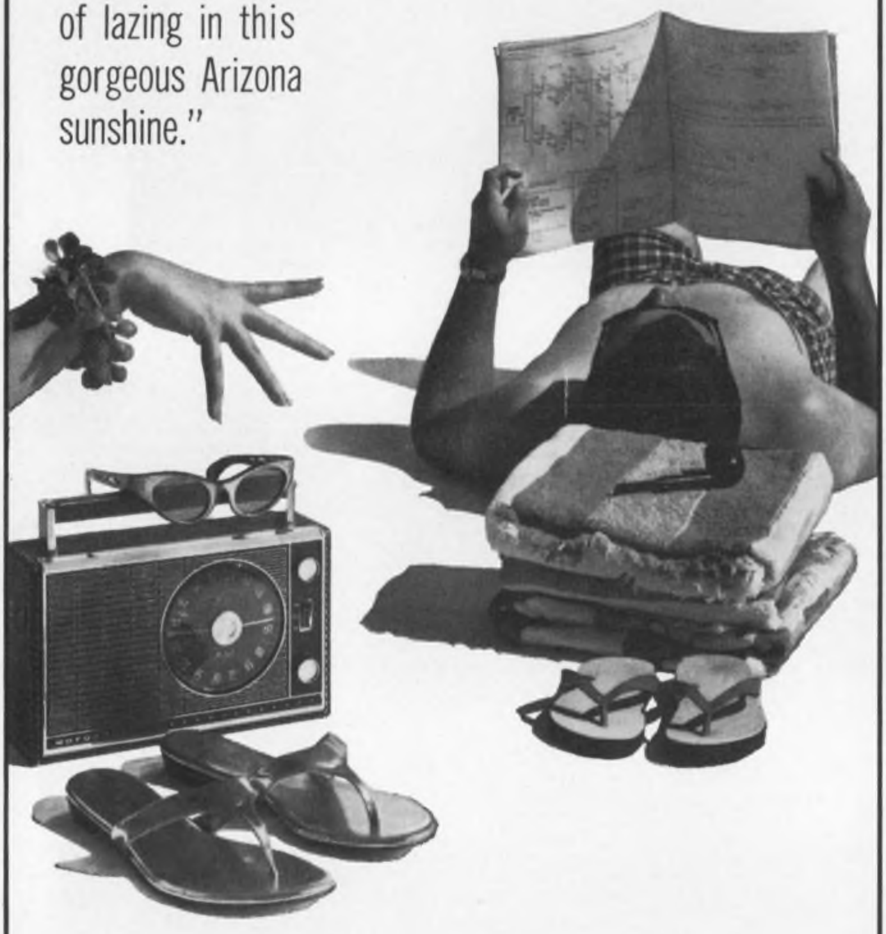


NASA TECH BRIEF

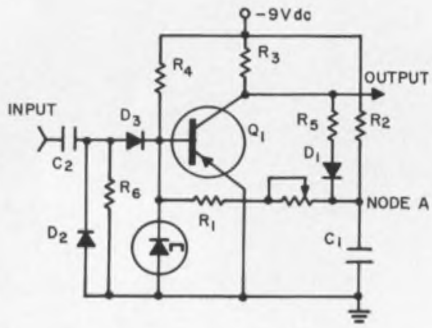
TD improves monostable circuit

Problem: Design a better monostable multivibrator (MSMV).

Solution: A monostable multivibrator that incorporates a tunnel diode in the circuit has a rise time below 0.2 μs, more constant quasi-stable time, and a 95% duty cycle.

In its stable state the tunnel diode conducts and the transistor Q_1 is saturated. If a positive trigger pulse is fed into the input, the tunnel diode switches OFF, which is a low-voltage state. This initiates a quasi-stable state. Its duration is controlled by the variable resistor and the choice of capacitor.

With D_1 back-biased and exhibiting a high impedance to node A, C_1 will begin to seek the steady-state voltage, where the low voltage resistance of the



tunnel diode is approximately 50 ohms. Node A can be considered a changing voltage source that supplies current to the tunnel diode—the current through R_1 is insufficient to switch the tunnel diode. When the sum of the two currents from node A and R_4 peaks, the tunnelling process is started and the tunnel diode switches to the ON state. The voltage across the diode causes Q_1 to switch to its saturated state, thus terminating the quasi-stable state of the multivibrator. Capacitor C_1 will then discharge, through the low impedance of the now forward-biased diode D_1 and saturated Q_1, completing the transition back to the steady-state condition.

For further information, contact: Technology Utilization Officer, Goddard Space Flight Center, Greenbelt, Maryland 20771 (B63-10603).

Ever come up with an elegant solution only to discover that nobody appreciated the thorniness of the problem let alone the subtleties of your approach to it?

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SENIOR ECM STUDY ENGINEER
To join a group engaged in the theoretical and practical evaluation of ECM systems problems. Will develop simple analytical models, bench and flight tests to verify models and study advanced radar and ECM systems and techniques. The most desirable background for this work would be 3-5 years in the development of radar hardware coupled with analytical experience in such phases as external parameters, system error, operations and use, or any aspect of system performance and trade-offs. ECM, Elint, or communications work will also be considered. Military experience highly desirable. BSEE or MSEE preferred.

SENIOR CIRCUIT DESIGN ENGINEER
Candidates should have 3 or more years in circuit design and analysis using vacuum tubes, transistors, and other solid state devices. Background should include extensive experience in the design and engineering of circuits of these types: digital and logic, video and pulse, RF and audio, power supplies and regulator circuits, etc., for military systems. Advanced degree desired.

SENIOR RECEIVER DESIGN ENGINEER
Require 5 or more years in the design and development of complex receivers for communications, radar and missile systems. These receivers are generally airborne, covering frequency ranges through UHF, and requiring the application of solid state devices. Must have specific experience designing sophisticated AFC, phase-lock loops, low noise front ends, stable local oscillators, IF strips, etc. Will supervise other engineers and technicians. BSEE or Physics with 5 or more years experience.

MECHANICAL ENGINEER—
Heat Transfer & Packaging. Desired background would include 5 or more years experience in military electronics involving high-density packaging of electronic equipment, design of components for severe shock and vibration, heat transfer as related to packaging, refrigerating and liquid coolants and applications of structural design. Assignment fields may include radar, missiles, ECM, ASW, communications systems or others. BSME required.

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Painted by Gloria Velasco, a junior at Los Alamos High School. Sixth in the series.

The Road to Discovery

Now in the design stage, the $55 million Los Alamos Meson Physics Facility (LAMPF) will serve as the world's first linear proton accelerator in the 800 MeV energy range. It will be capable of producing an average beam current of 1 milliampere, manifestly higher than that attained by any other machine of comparable output energy.

This 2,600-foot-long "meson factory" will open important avenues of basic and applied research. Such a meson producer will have many applications for studies in medium energy physics, particle physics, nuclear structure, biology, solid-state physics, radiation chemistry, and for neutrino experiments.

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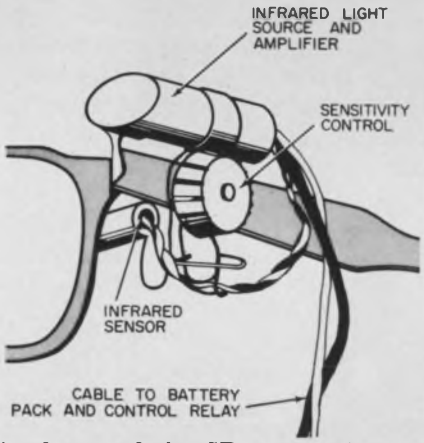
Sensor detects eyeball movement

Problem: Devise some means of extracting useful signals from the self-controlled movements of the human eye.

Solution: A small device combining an infrared (IR) source and sensor that can be attached to eyeglass frames or a headband. Operation of the device depends on the difference in IR absorption between the iris and the eyeball.

The device incorporates an IR source that consists of a battery-powered 6-volt or 10-volt lamp and high-pass infrared filter (to filter out visible light from the lamp), and a cadmium selenide IR sensor. A filter is also placed



in front of the IR sensor to exclude all ambient visible light. When the eye is looking straight ahead, all of the IR radiation from the source is incident on the area of the eyeball lying on one side of the iris and the radiation on this area is reflected to the sensor. This is the normal, or OFF, condition of the device. When the iris is turned toward the IR source, a high percentage of the radiation is absorbed by the iris and the external control relay connected to the sensor is actuated. An amplifier is used to amplify the generated current. A sensitivity control adjusts the threshold value for proper switching action under different ambient lighting conditions.

For further information, contact: Technology Utilization Officer, Marshall Space Flight Center, Huntsville, Alabama 35812 (B65-10079).

Dual MOS-FET simplifies FM multiplex decoder

The use of a dual, p-channel MOS-FET instead of diodes or bipolars greatly simplifies the design of an FM decoder. Demodulation of stereo FM composite multiplex signals is thereby achieved with fewer components and without elaborate filter networks.

Conventional multiplex decoders usually have a balanced demodulator network consisting of four diodes with a number of associated resistors and capacitors. Two diode (or two transistor) unbalanced demodulators are somewhat simpler, but they generate unwanted signals which feature large amplitudes. These signals require elaborate filters following the demodulators to "clean up" the detected waveforms.

A much simpler demodulator (Fig. 1a) uses a device containing two MOS-FET's on a single monolithic chip. Six connections are brought out of the device: common source and substrate terminals, and separate gate and drain terminals. Note that each device is symmetrical with respect to source and drain.

The demodulator operates on a time-share basis. Both sides function as switches to extract left and right information samples from the composite signal. Each switches at a 38 kHz rate. The left sample is passed when the negative one-half cycle of the 38 kHz reference voltage gates on side "A". The right sample is taken from the other side, "B", during the next half cycle when the out-of-phase 38 kHz reference signal supplies a negative voltage to its gate.

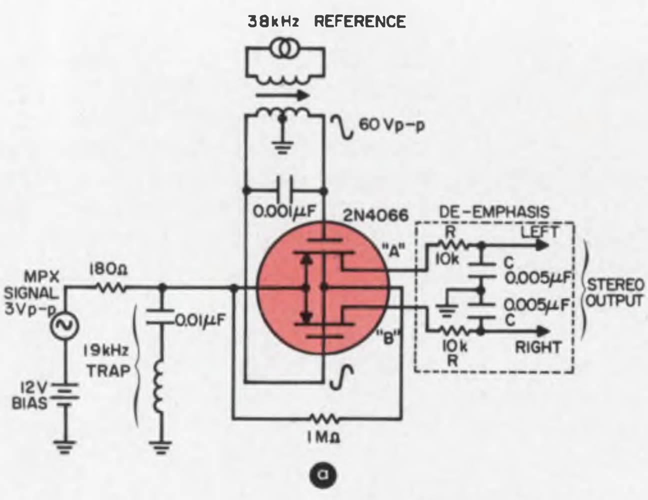
For this configuration, optimum switching operation is obtained when the substrate is near the potential of the sources (and drains). This is accomplished by resistively connecting the source and substrate. A direct connection is prohibited, because it would allow the multiplex signal to be coupled to the output via the source-substrate and drain-substrate diodes. This would disrupt the normal demodulator action.

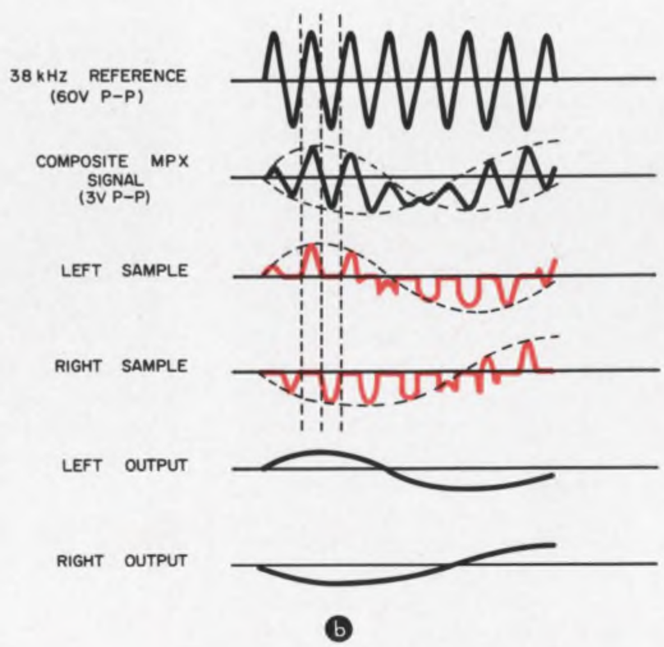
Properly phased samples fed through the R-C de-emphasis networks produce left and right stereo signals. The de-emphasis network is adequate for filtering out the 38 kHz switching transients, which in this case are small because no unbalance exists in the MOS-FET demodulation process. Note that no additional filtering is required.

The waveforms in Fig. 1b illustrate the operation of the demodulator. The composite multiplex signal, less the trapped out 19 kHz pilot, is fed into the common-source terminal of the dual MOS-FET. Sampling is controlled by the 38 kHz reference and produces left and right waveforms at the drain. These are de-emphasized and filtered by the R-C networks before the output.

The demodulator is disabled by turning off the 38 kHz reference signal. In this monophonic mode

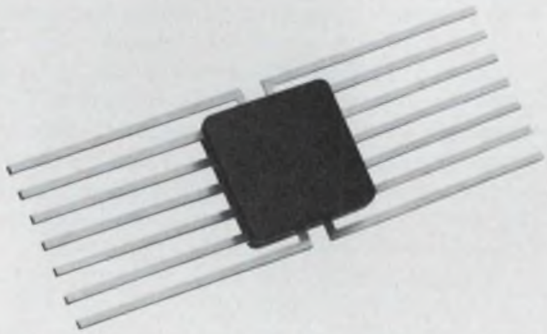
IDEAS FOR DESIGN: Submit your Idea for Design describing a new or important circuit or design technique, the clever use of a new component, or a cost-saving design tip to our Ideas for Design editor. If your idea is published, you will receive $20 and become eligible for an additional $30 (awarded for the Best of Issue Idea) and the grand prize of $1000 for the Idea of the Year.

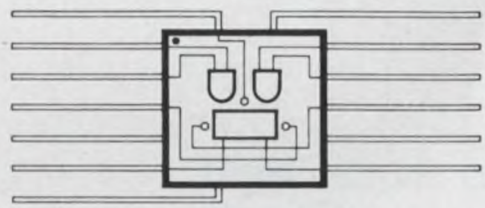




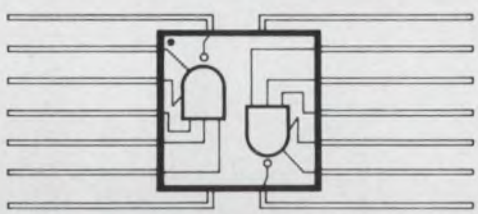
Dual p-channel MOS-FET simplifies the design of FM multiplex decoder (a). MOS device functions as a demodulator. R-C de-emphasis networks (dotted) filter out switching transients and produce left and right stereo signals. Key waveforms (b) illustrate demodulation process.

FAIRCHILD LOW POWER LOGIC

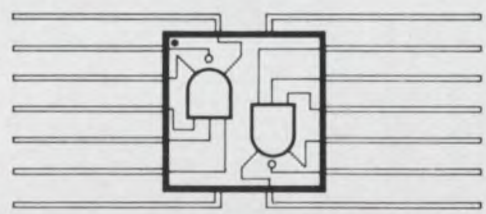




LPDTμL 9040



LPDTμL 9042



LPDTμL 9041

FEATURES:

Low Power drain	less than 1mW/gate (typ.) @ 50% duty cycle less than 4mW/clocked flip-flop
Single power supply requirement	5V optimum, 4.5V to 5.5V range
Guaranteed noise immunity	450mV min. at temperature extremes
Logic propagation delays	60nsec. typical
Binary clock rate	2.5Mc
Full temperature range	−55°C to +125°C

LPDTμL LOW POWER DIODE-TRANSISTOR MICROLOGIC™ CIRCUITS

Fairchild LPDTμL integrated circuits offer high performance in the low milliwatt range. High resistance values and small chip geometry hold down power consumption. The flip-flop element operates either in the R-S or J-K mode, with maximum dissipation of 6mW at a 2Mc toggle rate. Gates provide fan-out capability of 10 LPDTμL low power logic unit loads, or one standard Fairchild DTμL diode-transistor logic unit load. (Standard Fairchild DTμL logic circuits can be used to extend the fan-out capability still further). The circuits come in Fairchild's Cerpak flat package, and can be used in satellites, battery-operated field equipment, or other instruments where reliability and high performance must be achieved with limited power. Fairchild LPDTμL low power integrated circuits are available in evaluation quantities from distributors. For complete information write to:

FAIRCHILD SEMICONDUCTOR

FAIRCHILD SEMICONDUCTOR / A Division of Fairchild Camera and Instrument Corporation ■ 313 Fairchild Drive, Mountain View, California (415) 962-5011 ■ TWX: 910-379-6435
Micrologic is Fairchild's trademark for integrated circuits.

ON READER-SERVICE CARD CIRCLE 26

of operation both sides of the dual MOS-FET are on continuously, and the two de-emphasized outputs are identical.

Any switching-type demodulator (including the one just described) must be compensated to obtain optimum separation. This compensation may be accomplished by pre-emphasis of the 38 kHz subcarrier information on the composite signal prior to demodulation. An alternative method involves adding an out-of-phase portion of each channel into the opposite channel in a matrix that follows the de-emphasis network. The requirement for compensating a switching type demodulator must not be overlooked in the over-all design of an FM multiplex decoder. For the sake of simplicity, and because the methods are fairly well known, the compensation networks are not shown here.

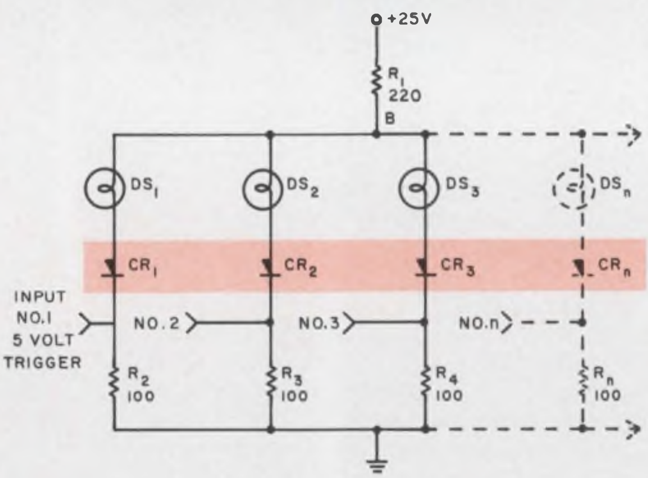
Larry Blaser, Senior Engineer, Fairchild Semiconductor, Mountain View, Calif.

VOTE FOR 110

Four-layer diodes form 'first one there' circuit

A circuit able to tell which input of a given number of inputs occurred first can easily be designed with four-layer diodes. It is especially useful for low-voltage applications.

Referring to the circuit (see diagram), we note that a negative pulse at any input energizes its respective indicator. At the same time it makes it



"First one there" circuit is easily designed with 4 layer diodes. Circuit tells which of "n" inputs occurred first.

impossible for any of the other indicators to actuate. Note that the device must be reset with the reset button after each operation.

Supply voltage V_{cc} set below the firing voltage of the four-layer diodes. The negative trigger required is the difference between V_{cc} and the firing voltage. R_1 is chosen so that the voltage drop at point *B* exceeds the trigger voltage when any branch is actuated. Then the voltage at *B* plus the trigger in any other branch cannot cause their respective diodes to conduct.

B. McClaskey, Engineer, Bendix Corp., Baltimore.

VOTE FOR 111

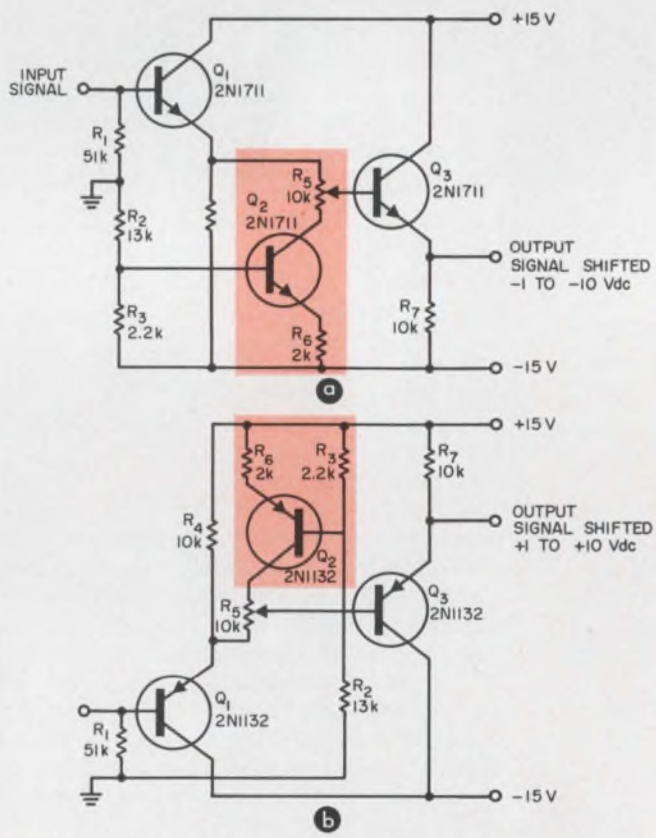
Circuit provides constant gain and variable dc offset

Up to 10 volts variable dc shift for slow ac waveforms may easily be provided by a three-stage transistor network. This property is especially useful in analog systems.

Shifts in the dc level of an analog signal are often required for dc amplifiers, CRT displays and squaring and threshold circuits. The circuit (Fig. 1a) shifts the *Q*-point of a slow 5.0 Vac peak-to-peak waveform and maintains unity gain.

It is superior to other methods. For example, signal coupling with a zener diode is impractical when a variable dc offset is required. In another technique where the conventional dc resistor is used, problems arise when low-frequency waveforms are encountered. Still another, using floating power supplies, is bulky and expensive and does not work well at high frequencies.

Circuit operation is as follows: A constant 10-volt potential is maintained across R_5, by the constant-current generator Q_2. Thus, the ampli-



Unity gain with a variable dc offset is provided by this three-stage network. Negative dc shifts of up to 10 volts are produced by (a) and positive shifts by the circuit in (b). Constant-current generator Q_2 keeps the ac amplitude at base of Q_3 constant, independent of pot settings.

tude of the ac signal at the base of Q_3 is constant, regardless of the potentiometer setting. This assumes negligible base current in Q_3 and a low output impedance from Q_1. The adjustment of potentiometer R_5 controls the dc offset of the signal.

Fig. 1b shows the same circuit modified for dc shifts that are positive with respect to the input dc level. In both circuits, CR_1 is used for temperature compensation.

Richard Peterson, Jr., Engineer, GM Defense Research Labs., Santa Barbara, Calif.

VOTE FOR 112

FET replaces vacuum tube in 1.0 MHz Miller oscillator

Because its typical input impedance is 1000 MΩ or greater, the FET can directly replace the vacuum tube in the Miller oscillator circuit. The FET's high input impedance in parallel with the crystal does not reduce the effective high-Q of the tuned circuit.

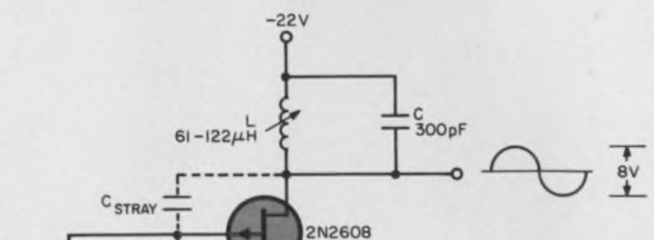
In this modified Miller circuit (see illustration), values of L and C are chosen to give resonance at a frequency slightly higher than the parallel resonant frequency of the crystal. The drain circuit must be inductive for oscillations to start, but since the amount of inductive reactance determines the amplitude of oscillations, care must be taken to prevent limiting. For this reason, and to allow some latitude for component tolerances, a variable inductor should be used in the drain.

Gate Resistor R_1 is a critical component. Its value must be high enough so that it does not reduce the effective high Q of the tuned circuit, and low enough so that temperature variations of I_{GSS} do not alter the FET bias point. Source Resistor R_2 determines the dc quiescent operating point of the FET. With R_2 = 2.2k, this operating point is typically 1.2 volts.

This circuit operates at a frequency of 1.0 MHz with an output voltage of 8 volts peak-to-peak. If a low output impedance is desired, a source-follower circuit is suggested for an output stage.

Charles MacDonald, Applications Engineer, Siliconix, Inc., Sunnyvale, Calif.

VOTE FOR 113



Miller oscillator uses a FET instead of a tube. High Z_{in} of FET does not reduce effective high-Q of tuned circuit.

GET SET...

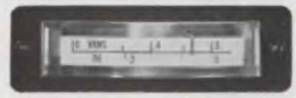
Kay 121-C
500 KHz to 1700 MHz

This solid-state instrument is an electronically swept VHF-UHF wide-sweep and marker generator which accepts a variety of UHF plug-ins to provide extended frequency ranges and sweep widths. With its plug-ins, the 121-C covers a range of 500 KHz to 1700 MHz, offers octave-wide sweeps at low UHF frequencies where most generators in this range are limited to narrow widths. Narrow sweep and wide sweep plug-ins cover special applications such as UHF-TV — full 440 to 920 MHz in a single wide sweep. A digital frequency dial provides smooth center frequency control and remarkable vernier adjustment for narrow sweep operation.

Performance characteristics include line-lock, cw, manual and variable sweep rates, and external input.

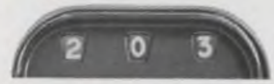
External modulation from dc up to more than 15 KHz, a built-in detector and switched attenuator are standard features.

Wide-Sweep



RF OUTPUT . . . *Set*

0.5 volt rms into 50 ohms
Flat: ± .25 db to 800 MHz
± .5 db to 1700 MHz



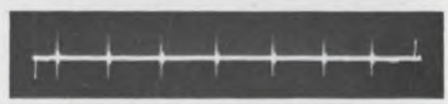
FREQUENCY . . . *Set*

digital frequency dial;
vernier control at all frequencies

SWEEP WIDTH . . . *Set*

5 KHz to 500 MHz
VHF: 50 KHz to 300 MHz
UHF: *P-121 — 124 Plug-ins

Marker Generator



harmonic (picket) birdie markers

single-freq. type birdie markers

***P-121:** 200 MHz to 1050 MHz
Sweep: 35 KHz to 350 MHz @ 800 MHz
5 KHz to 50 MHz @ 220 MHz

***P-122:** 900 to 1300 MHz
Sweep: 200 KHz to 400 MHz

***P-123:** 100 to 1000 MHz
Sweep: 5 KHz to any octave

***P-124:** 1300 to 1700 MHz
Sweep: 500 KHz to 400 MHz

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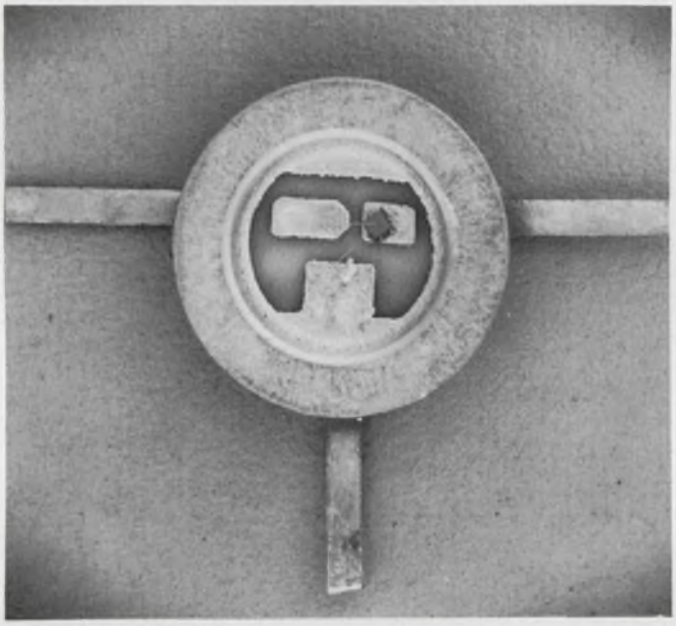
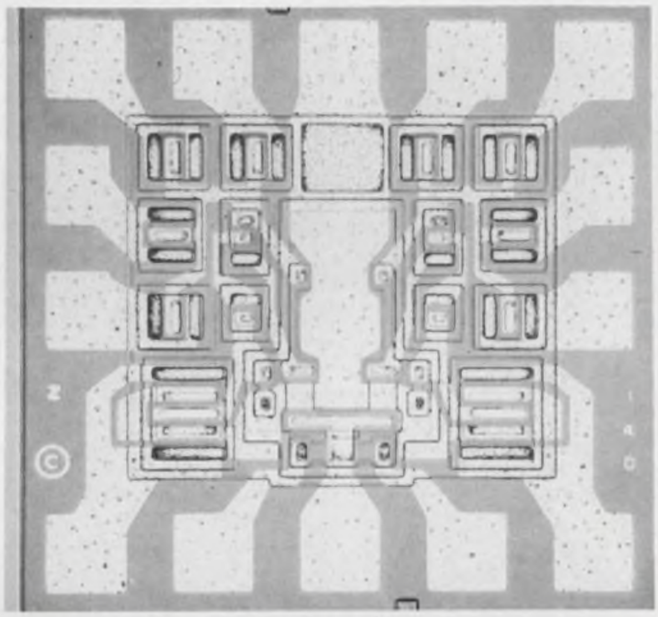
E|D Products

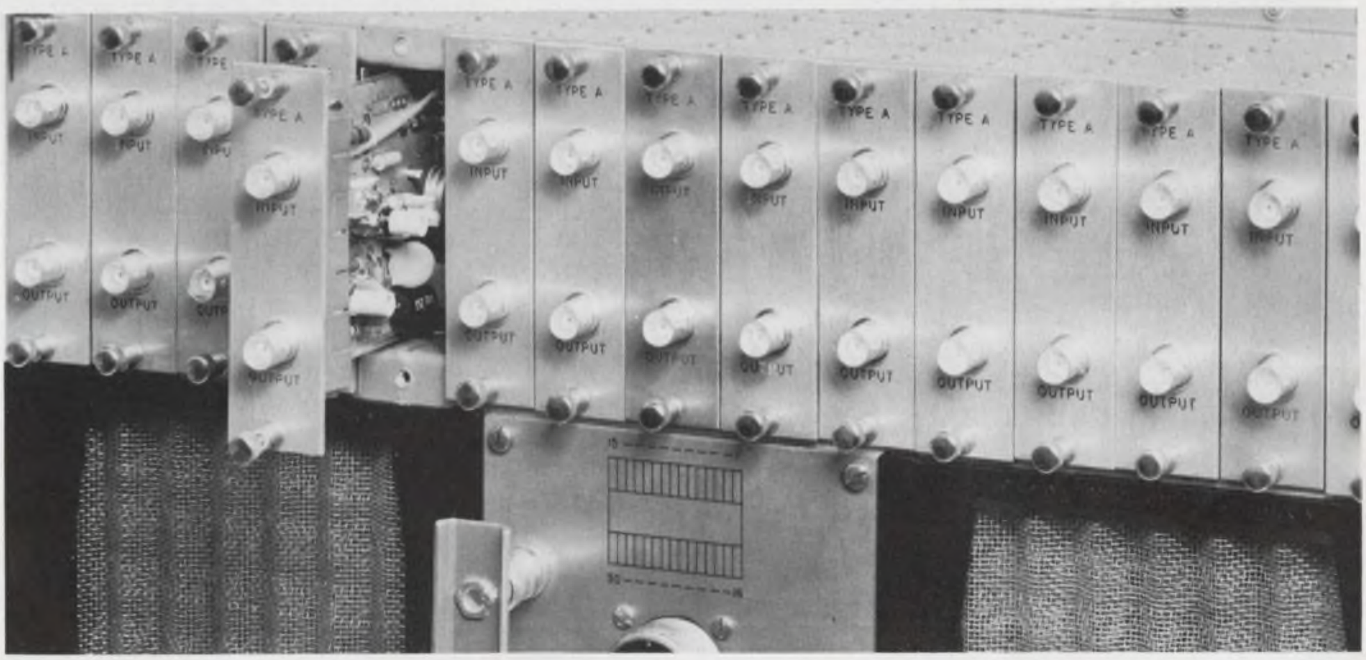
Chopper-stabilized amp at diff-op-amp prices PAGE 84
Automatic adjusting digital voltmeter PAGE 92
Germanium planar transistor beats TWT performance PAGE 88
High resistance chips for logic gates PAGE 96
Amplifier has an elephant's memory PAGE 98



Germanium planars outdo TWTs 88



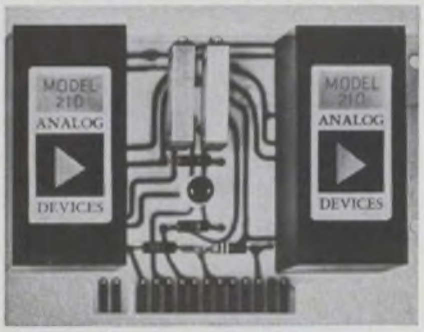
Half-Meg per chip resistance 96



System of delay-line amps has 120 dB per channel isolation 99

Low price—high gain, chopper stabilized amplifier

A chopper-stabilized amplifier priced with premium differential op-amps gives orders of magnitude better performance. Pricing of the 210 is below any comparable chopper-stabilized model.



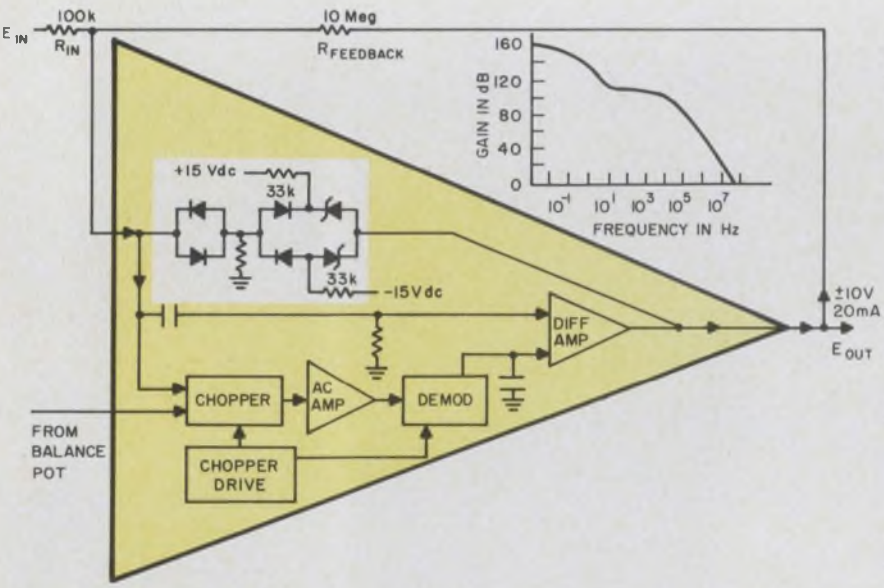
Specs include 20 MHz small-signal bandwidth, 100 V/μs slewing rate, 10^8 open-loop gain (160 dB), 3 μV peak-to-peak noise, 1 μV/°C and 2 pA/°C max drift, 50 μV and 50 pA maximum initial offset, and 10 μV and 10 pA equivalent offset for each 1% supply voltage change. Temperature range is −25 to +85°C. Input impedance is 500 K, output is ±10 V, 20 mA. A saturation protection circuit re-enables the amplifier 0.2 μs after overdriving, and the chopper-driver operates from the ±15 Vdc supply, obviating the need for 60 Hz excitation, a notorious noise source. The package is a 3-in^3 epoxy-encapsulated module which mounts directly onto printed circuits. Most competitive units are socket mounted, adding noise and insulation leakage.

An inherent susceptibility of chopper-stabilized operational amplifiers is input overdrive. Once overcharged (usually by several orders of magnitude), internal filter and coupling capacitors may require minutes to discharge. In the 210, a zener diode circuit "breaks down," paralleling the feedback impedance with a low resistance, and preventing the amplifier from reaching saturation. The network returns the amplifier to full operation within 0.2 μs of overdrive.

Initial offset specifications enable the user to dispense with the external offset potentiometer control in many applications.

P&A: $157 (1-9), $128 (100-249); 10 days (3 weeks for production quantities). Analog Devices, 221-5th St., Cambridge, Mass. Phone: (617) 491-1650.

Circle No. 254



Model 210 chopper stabilized amplifier has feedback network paralleled by zener protection circuit (called out). Very low offset levels make external balance pot unnecessary in many applications.

FET input op-amp

The model 132 differential operational amplifier uses matched input FETs for improved thermal tracking. Input offset current is very low as a result, providing exceptionally high input impedance and low values of voltage drift.

Specifications for the miniature unit include 200,000 typical voltage gain at dc (100,000 minimum), 10 MHz typical gain bandwidth product with 5 MHz specified as minimum and a 6 dB/octave gain roll-off rate.

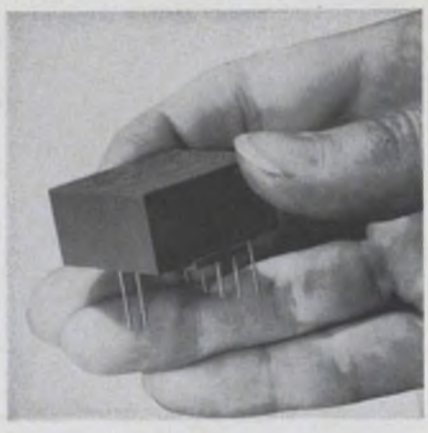
Input characteristics are 10 Megs input impedance in both differential and common modes; 50 μv peak-to-peak noise from dc to 100 kHz; ±10 V peak common-mode voltage, and common-mode rejection of 5,000:1 at dc and 2,000:1 at 400 Hz. The offset voltage can be externally adjusted to zero. Variations in offset voltage are according to a temperature coefficient of 20 μV/°C specified, 10 μV/°C typical. Input current is 0.1 nA at 25°C max, and doubles for every 10°C rise. Input difference current is 0.03 nA at 25°C, typically, and also doubles each 10°C increase.

The unit's output voltage swing is ±10 V peak, minimum. Output current is 4 mA minimum and frequency for maximum output is 150 kHz typical and 75 kHz minimum. Slewing rate is 5 V/μs minimum, with 10 V/μs being more typical.

The model 132 is 1.125 x 1.125 x 0.625-in. over-all, and requires a ±15 Vdc power source.

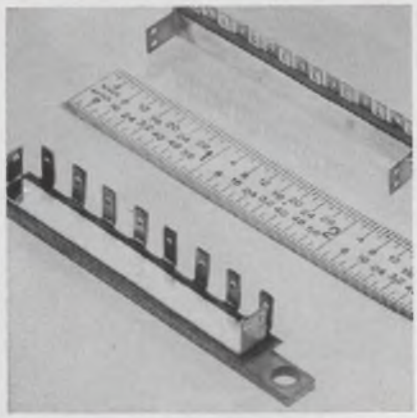
P&A: $95; 30 days for sizable orders. Zeltex Inc., 1000 Chalomar Rd., Concord, Calif. Phone: (415) 686-6660.

Circle No. 255



10,000 Megs minimum input impedance for the 132 op-amp—only $95!

Laminated bus bars



Conductors in thickness of 0.005 to 0.045-in. are available in a line of laminated bus bars that are said to reduce noise in power and signal distribution. Material and length and width of conductor levels and variable and ground levels and tabs can be incorporated to the customer's specifications. Each unit is incapsulated in Amron plastic insulation.

Eldre Components Inc., 1239 University Ave., Rochester, N. Y. Phone: (716) 244-2570.

Circle No. 256

High gain amplifier

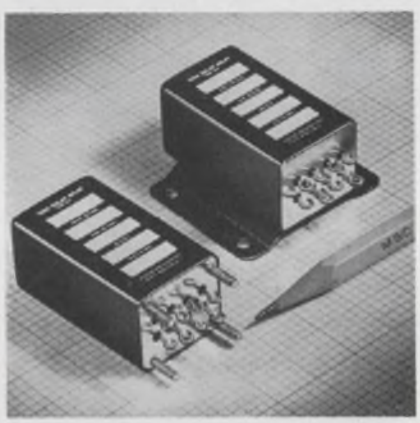
These dc differential operational amplifiers have low-frequency applications where high dc gain and good drift stability are primary requirements.

Models A, B and C of the 103 have 20 μV/°C, 10 μV/°C and 5 μV/°C voltage drift, respectively. Current drift of 0.2 na/°C and supply voltage drift of 15 μV/% are the same for all three.

P&A: $74, $84, $104-A,B,&C respectively; 3 weeks. Analog Devices, 221 Fifth St., Cambridge, Mass. Phone: (617) 491-1650.

Circle No. 257

Time delay relays



Series 700 time-delay relays feature ±5% accuracy in intervals as short as 0.050 seconds duration. Repeat accuracy is ±2%, and the unit has a 100,000 cycle life expectancy.

The relays contain solid-state timing networks. Available in factory pre-set or adjustable units they offer delay times from 0.050 to 90 seconds. Housings are available with studs or flange and tabs for panel or chassis mounting.

Master Specialties Co., 1640 Monrovia, Costa Mesa, Calif. Phone: (714) 642-2427.

Circle No. 258

Rigid-tube connector

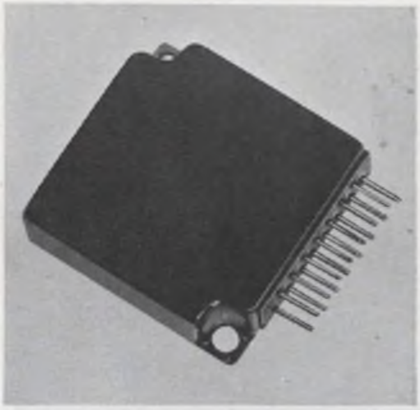
A new rigid-tube connector has been designed specifically for weight reduction and ease of installation. No tools are required for coupling. The connector can be used in such applications as hydraulic lines, cable-carrying tubes, electronic coolant transmission, and environmental low-pressure applications.

It is available in stainless steel, aluminum, and titanium. Sizes range from 1/4 to 6-in. inner diameter.

E. B. Wiggins, Dept. 30, 3424 E. Olympic, Los Angeles, Calif. Phone: (213) 269-918.

Circle No. 259

Power amplifier



A microelectronic power amplifier delivers up to 5 watts for servo control. Gain of the 0.4 cubic inch amplifier can be adjusted from 100 to 1000 by an appropriate external input resistor.

Power input for max output is 11 watts; signal frequency is 400 ± 20 Hz. The unit is constructed with low θ silicon power resistors in a thin film resistor substrate.

Solitron Devices, 256 Oak Tree Rd., Tappan, N. Y. Phone: (914) 359-5050.

Circle No. 260

Press-fit terminals

A new semi-assembled terminal is designated FT-2-SM-1163. A feed-through terminal with 0.06-in. solder posts, this unit is designed to mount on a 0.136-in. hole in a 0.047-in. thick chassis.

After installation in the chassis, a serrated shoulder expands the protruding minor diameter to "lock" the terminal in place. Teflon bushings insure reliability.

Sealectro Corp., 225 Hoyt St., Mamaroneck, N. Y. Phone: (914) 698-5600 *Circle No. 261*

Catheter tip transducer

The model CP-1 catheter tip pressure physiological transducer is designed for pressure measurement. Mounted at the tip of a 5F cardiac catheter, it can be used for long periods as flushing is not needed.

Excellent dynamic response enables this unit to register all heart sounds. Any common method of sterilization, including autoclaving, is acceptable.

P&A: $500; 60 days. Statham Instruments, Inc., 12401 W. Olympic Blvd., Los Angeles, Calif. Phone: (213) 272-0371. *Circle No. 262*

Miniature ignitron

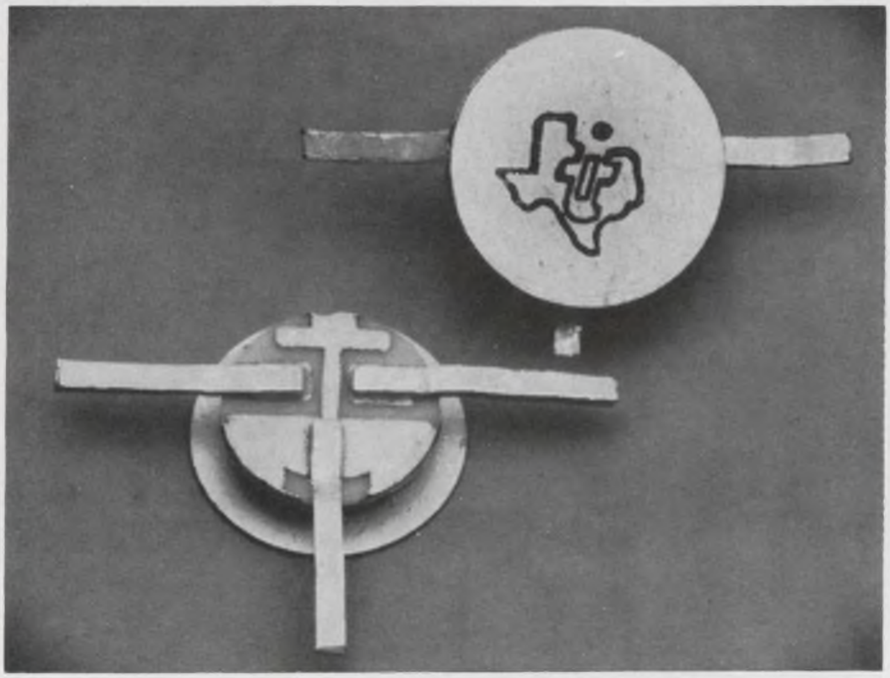
Miniaturized, size B ignitron NL-1031 is designed for resistance welding control equipment.

The unit is a water cooled, stainless steel jacketed, mercury pool ignitron with thermostat mounting plate. Two tubes connected in inverse parallel control 600 kVA in 380-600 V, 25-60 Hz power systems.

The photo compares the miniature and standard ignitrons.

Availability: stock. National Electronics, Geneva, Ill., Phone: (312) 232-4300.

Circle No. 263



Germanium planar transistor for MW has low noise figure

A new Alloy Diffused Planar Transistor in the 1-4 GHz frequency range features low noise figures. The TIXM103 features a typical noise figure of 3.8 dB at 1.5 GHz and 5.5 dB at 3 GHz when adjusted for optimum noise figure.

Planar construction techniques used on germanium material result in improvements similar to those seen in silicon planar transistors. A frequency limitation imposed on other Ge manufacturing techniques is that base and emitter must have large enough physical dimensions to allow connections for bonding wires to connect the stripes to the package terminals. Planarization, and the ability to use expanded contacts, gives stripe-size independence, as the bonding is made to the expanded contact rather than the stripe.

Some of the microwave features of the TIXM103 include: un-neutralized, stable, common-emitter gain of 9 dB per stage at 1.3 GHz is readily attained; insertion power gain of 5 dB into a 50 ohm line is practical; noise figure has been measured to deviate less than ±0.7 dB from its 25°C value from −55° to +85°C, and common emitter gain to deviate less than ±1 dB with the same temperature conditions. Other points include a readily attained system noise figure of 4.5 dB at 1.3 GHz, and 6.5 dB at 3 GHz. Noise figure does not degrade with age, as in TWTs, nor is warm-up time required. No gain drift will be encountered, as in parametric amplifiers, and no circulator is needed, as with tunnel-diodes.

The unit is produced in the TI-Line package with common-emitter configuration. Matched 50 ohm output and input impedances facilitate impedance matching. Leads are gold-plated silver for low lead loss and parasitics.

P&A: $82.50; stock. Texas Instruments, Semiconductor Div., 13500 N. Central Expway, Dallas, Texas. Phone: (214) 235-3111.

Circle No. 264

Planar stripline construction as seen without package cover.

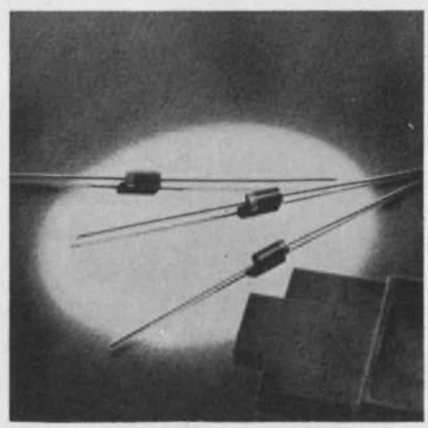
Flangeless rectifiers

A series of flangeless silicon rectifiers features hermetic glass-to-metal seal and a maximum continuous rating of 1.3 A at 50°C. Surge currents of 6 A and transient surges of 40 A can be sustained.

Operating ranges for the series 10C are from 100 to 1000 V at temperatures of −65° to +165°C. The printed-circuit design units are electro plated with tin.

International Rectifier, 233 Kansas, El Segundo, Calif. Phone: (213) 678-6281.

Circle No. 265



Fast recovery rectifiers

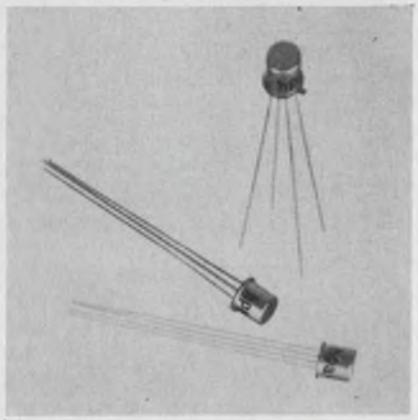
Silicon rectifiers with fast recovery and high current capability are offered in series 1N4942-1N4948.

Typical reverse recovery is 100 ns to 600 V and 250 ns to 1000 PIV; current capability is 1-A rectified at 55°C or 3-A with heat-sink per MIL-STD 750. Leakage current is 0.1 mA at rated PIV, 25°C. Solid silver leads have full area contacts, giving low thermal impedance.

Immediate availability. Semtech, 652 Mitchell Rd., Newbury Park, Calif. Phone: (213) 628-5392.

Circle No. 266

Photon-coupled isolator



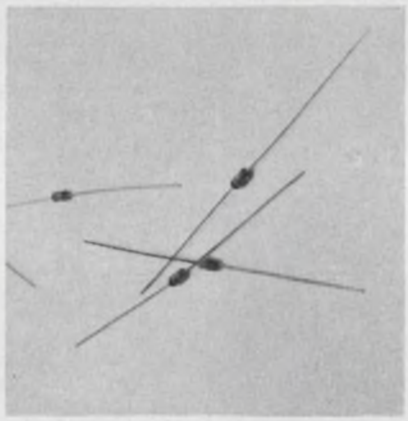
A new solid-state photon-coupled isolator, the hpa-4310 incorporates a gallium arsenide diode injection luminescent photon source and a silicon PIN diode photodetector.

Photon coupling between input and output is 2 pF and 10^{11} ohms. Working voltage is 200 V peak, max. Current transfer ratio is on the order of 0.001, dc to 10 MHz cutoff. Pulse rise is typically 50 ns.

Price: $55. hp associates, 620 Page Mill Rd., Palo Alto, Calif. Phone: (415) 321-8510.

Circle No. 267

Schottky-barrier mixers



High-reliability Schottky-barrier junction mixer diodes are intended for series mounting in strip transmission-line circuits.

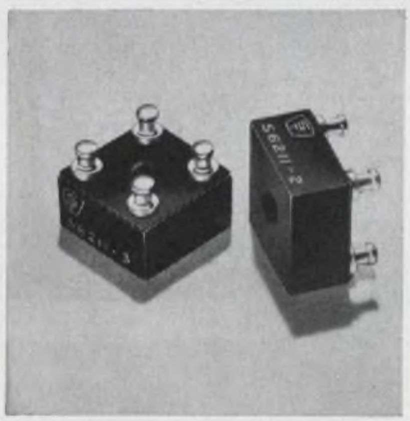
Specifications for the units are shown by model Ma-4855. Noise figure for the 4855 is 6.5 dB in L and S bands, and 8.5 dB in X-band. Cw burnout rating is 0.5 W.

These units meet the requirements of MIL-S-19500.

Microwave Assocs., South St., Burlington, Mass. Phone: (617) 272-3000.

Circle No. 268

Silicon rectifiers



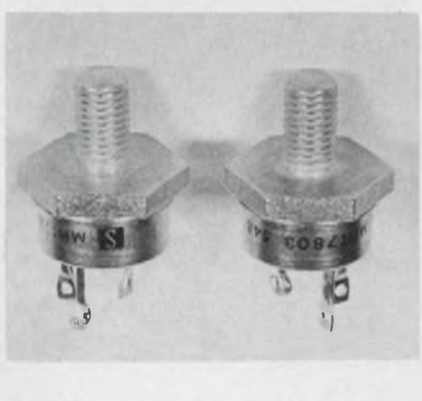
A line of full-wave bridge silicon rectifier assembles has avalanche characteristics as protection against reverse voltage transients.

These assemblies, S-6211, have PIVs of 200 to 800 volts. A 2 amp dc current rating is common and neither voltage nor current derating is required to 75°C. Turret terminals are silver plated brass.

Sarkes Tarzian, Semiconductor Div., 415 North College Ave., Bloomington, Ind. Phone: (812) 332-1435. TWX: (812) 332-5846.

Circle No. 269

HV power transistors



A line of high-voltage power transistors, MHT 7801 through MHT 7805, features sustaining voltages from 200V to 325V. These 10-amp planar *npn* transistors have a frequency response of 50 MHz, and a common-base output capacity of 150 picofarads. They are packaged in an 11/16-in. hex stud.

Price: $52.00 to $100.00 in 100 quantity. Solitron Devices, Inc., 1177 Blue Heron Rd., Riviera Beach, Fla. Phone: (305) 848-4311.

Circle No. 270

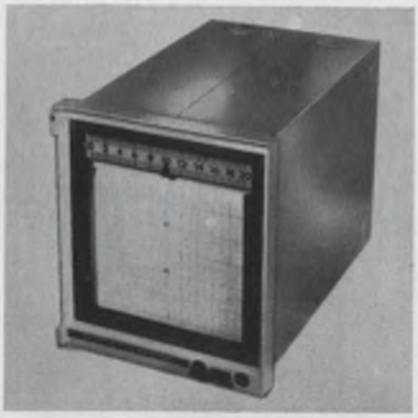


Chart recorder

Two series RD potentiometric strip chart-recorders can be mounted side-by-side in a 19-in. relay rack. A zener-diode constant-voltage reference power supply, and fully shielded measuring circuits, contribute to reliability.

Chart transports are interchangeable within 15 seconds, and also can be set at a 45° angle to serve as a writing platen during operation.

Barber-Colman, 1300 Rock, Rockford, Ill. Phone: (815) 968-6833. TWX: (815) 398-0341.

Circle No. 271

Proximity detector

The model 1000 magnetic field proximity system responds to a vector field rather than to area and mass. A relay in the control unit operates when the sensor detects a properly oriented magnetic field of about 2 oersteds. Operate distances range from source to 5 feet. The unit has continuously adjustable operate-release differentials from hold down to 1% of field.

Research Assocs., 555 E. Linden Ave., Linden, N. J. Phone: (201) 486-1154.

Circle No. 272

Digital differential voltmeter has only two null-adjustments

The model 353 digital voltmeter provides a faster approach to accurate dc voltage measurements. Laboratory accuracy can be obtained without the customary knob-twiddling and null-seeking. In this system the range knob is set to give an on-scale reading in the "normal" mode, then the first digit of the "normal" mode reading is manually dialed into the "expanded" mode—whereupon the system takes over. The measurement is automatically expanded to 4 digits with overranging to 5, and a further digit may be interpolated.

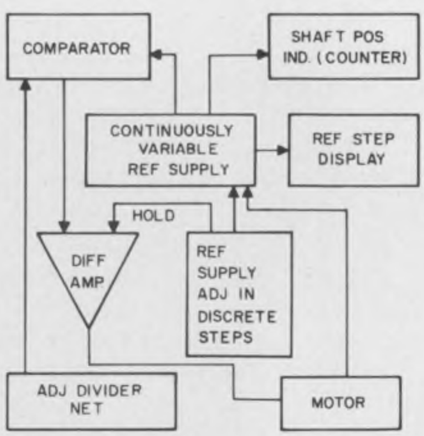
The system submerges the inherent electro-mechanical systems error by a factor of at least 10 to 1. A string of precision resistors in series with the potentiometer reduce that component's error producing importance. Not only does accuracy increase by at least 10 to 1, but so does the resolution.

The all solid-state instrument requires 115/230 V, 50-60 Hz. The input resistance is 10 Megs for all ranges in either mode, and the reference voltage is derived from a temperature compensated Zener diode to ±0.005% over a temperature range of 22°C ±10°C. The expandable voltage ranges are 1, 10, 100, and 1000 volts full-scale. The 0.1 volt full-scale range is not expandable, hence its accuracy is decreased by a factor of 10.

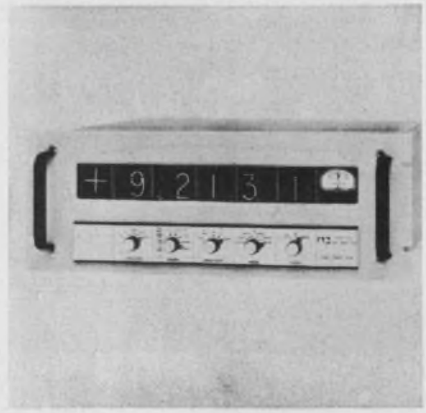
Features include a left-to-right readout, an automatic display of the terms "mV" or "V," and automatic placement of the decimal point. The motor is automatically disabled during the dial-setting for the "expand" mode, a red light indicates overrange or wrong polarity, and provision is made for a foot operated switch for "read" or "hold."

P&A: $490; June. Ballantine Labs., Boonton, N. J. Phone: (201) 334-1432. TWX: (510) 235-8329.

Circle No. 273



Input signal is range-selected and compared with the reference signal. Amplified error is fed to drive a potentiometer to correct the reference. The pot's resultant shaft-position gives the reading. A manually adjustable reference supply has discrete steps for major divisions. It can be read out on a display.



Digital voltmeter

The 5100 Series continuous balance digital voltmeter combines the wirewound resistance ratio and precision voltage reference methods of measurement. The special ratio bridge and proportional controlled reference minimize time and temperature influences. Accuracy is ±0.002% of reading ±0.002% of full scale for dc, ±0.05% of reading ±0.05% of full scale from 50 Hz to 20 kHz and ±0.25% of reading ±0.05% of full scale from 20-100 kHz, for ac voltage.

Ac voltages are converted to dc by full wave averaging rectification with 100 μV per digit resolution. Resistance is measured by a true ohmmeter principle, independent of the reference voltage or voltage calibration. The 4-wire input converter has the stability and accuracy of wire-wound resistors and provides 1 milliohm per digit resolution and six automatic ranges. Resistance accuracy for most ranges is ±0.003% of reading ±0.003% of full scale. Maximum dissipation in unknown resistance is 10 mW. An optional five-range converter has 1 mW maximum dissipation in unknown resistance.

Input impedance is potentiometric on lower ranges. Resolution of 10 μV per digit provides dynamic measurement range to 1000 V.

Internal plug-in modules provide auto-ranging multimeter and recorder output as well as other special functions. Isolated output in decimal or BCD format is available for digital data recording.

P&A: from $5295; 30 days. Auto Data, 4812 Kearny Mesa Rd., San Diego, Calif. Phone: (714) 279-3020. TWX: (714) 279-0268.

Circle No. 274

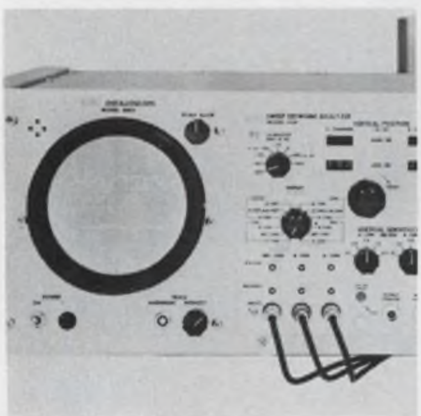
Rms reading meter

A volt-amp-watt meter features true rms readings. A "Transquare" solid-state transducer network has an output current proportional to the square of the instantaneous value of input voltage.

The ac, single-phase instrument has a current transformer to extend current and wattage ranges. Full-scale ranges are from 2.5 to 100 A, 25 W to 10 kW. Accuracy is ±0.5% to 1% full scale 30 Hz-15 kHz, power factor from unity to 50% lead and lag.

P&A: $2250; 8-10 weeks. Greibach, 315 North Ave., New Rochelle, N. Y. Phone: (914) 633-7900.

Circle No. 277



Power level/ratio meter

A 60 dB measurement range is provided by the 8000/7051 system for the measurement of gain, loss, absolute or relative power levels, vswr, and impedance magnitude. The instrument uses crystal detectors, compensated above the square-law region by internal circuitry. Accuracy is ±0.3 dB at +20 dBm and ±0.6 dB at −40 dBm.

P&A: $1250; 30 days. Alfred Electronics, 3176 Porter Drive, Palo Alto, Calif. Phone: (415) 326-6496.

Circle No. 275

Sweep generator

Model TH-200 wide-range sweep generator covers FM and VHF TV bands from 0.5 MHz to 230 MHz. The sweep width can be varied from 0.1 MHz to 230 MHz, and output is greater than 0.25 V rms. The unit accepts four plug-in single frequency or harmonic markers, has external marker input capability and an optional 0-70 dB turret attenuator.

P&A: $525; 3 wks. Texscan Corp., 51 S. Koweba Lane, Indianapolis, Ind. Phone: (317) 632-7351.

Circle No. 276

Microwave power meter

The model 431C microwave power meter gives direct readings. A knob automatically compensates the reading with a preset calibration. With the manufacturer's calibrated thermistor mounts and the 1% specified instrumentation accuracy, errors are considered in the readout, obviating calculations. All pertinent requirements of MIL-I-6181D are met.

P&A: $475; 8 weeks. Hewlett Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000.

Circle No. 278

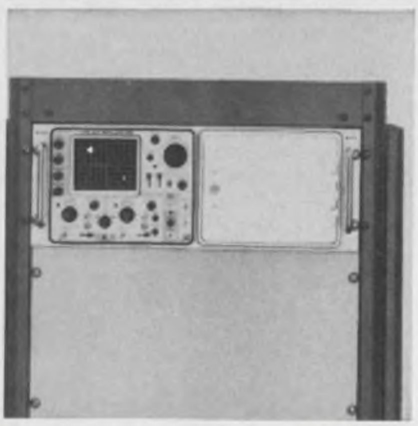
Solid-state vswr meter

The Model 813T measures vswr reflection coefficients or relative attenuation as well as bolometer current. It can also be used for audio frequency null measurements with the addition of an external bridge circuit. Sensitivity is 0.1 μV for full-scale at 40 Hz bandwidth and noise 5 dB below input. A selector switch allows operation at bands of 20, 40 or 400 Hz.

Price: $325. Microlab/FXR. Livingston, N. J. Phone: (201) 992-7700.

Circle No. 279

Rack-mount oscilloscope



The new Type R422 scope consists of an ac-powered oscilloscope and the necessary mounting facilities, including a hinged-door compartment for accessories. Bandwidth is dc to 15 MHz with a dual-trace sensitivity of 10 mV/division. The 4-in. rectangular CRT has 8.2-in.² display area with internal illuminated graticule.

P&A: $1400; first quarter of 1966. Tektronix, Inc., P. O. Box 500, Beaverton, Oregon. Phone: (503) 644-0161.

Circle No. 280

$200 ac/dc VOM

A new volt-ohmeter has solid-state circuitry, battery-power with an ac option, and a price under $200. It is a dc voltmeter, and an ac voltmeter for 10 Hz to 1 MHz with ±2% full-scale accuracy. Ranges are ±100 mV-±1000 Vdc, 10 mV-300 Vrms reading ac (1.11 times average), and 10 ohms center-scale to 10 Megs center-scale (±5%).

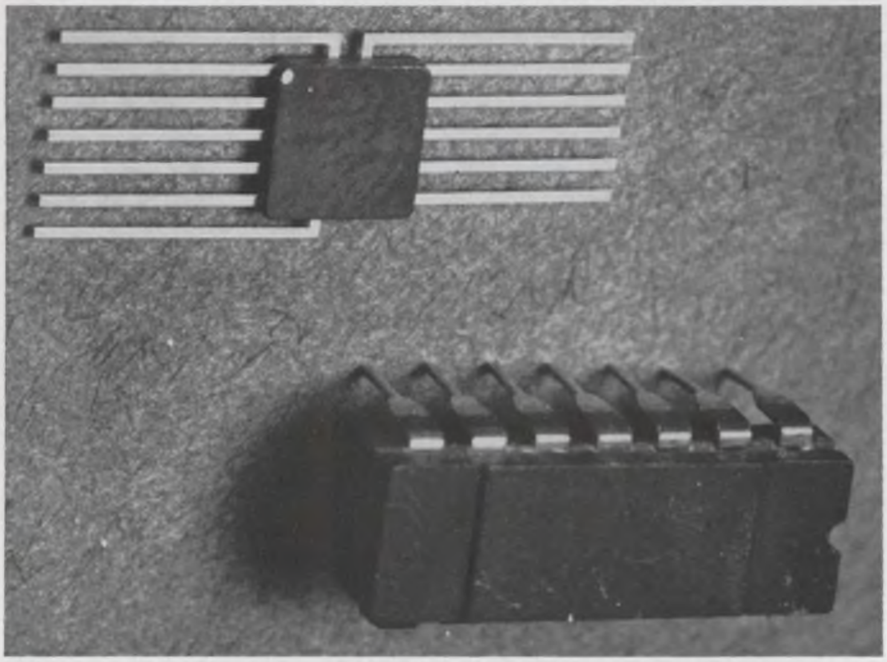
With 22.5V-dry cell power, "common" can be floated 500 Vdc off ground.

P&A: $195, ac option adds $25; stock. Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. *Circle No. 281*

Compact megohmmeter

Weight of the Model 2000 Meg-Chek is only 36 ounces. The instrument is housed in a welded steel case that measures only 5-3/4 x 4 x 2-3/4-in. Designed with push-button controls, it can measure resistances as high as 100 Meg at 500 Vdc. Power is taken from penlight cells housed within the unit and space is also provided for storage of two three-foot test leads.

P&A: $95; stock. Associated Research Inc., 3777 W. Belmont Ave., Chicago, Ill. Phone: (312) 307-4040 *Circle No. 282*



Integrated logic chips feature high-value resistors

This series of low-power logic chips includes a clocked flip-flop; a dual, 3 input NAND gate, and a dual, 3 input NAND gate with extender inputs (LPDTμL 9040 through 9042, respectively).

These circuits have typical power drains of less than 1 mW per gate (50% duty cycle) for the gate elements, and less than 4 mW for the flip-flop, over the full military temperature range of $-55°$ to $+125°C$. These low values were attained with typical values of resistors as high as 56 k planar epitaxial silicon devices, more than half-a-meg of resistance per chip.

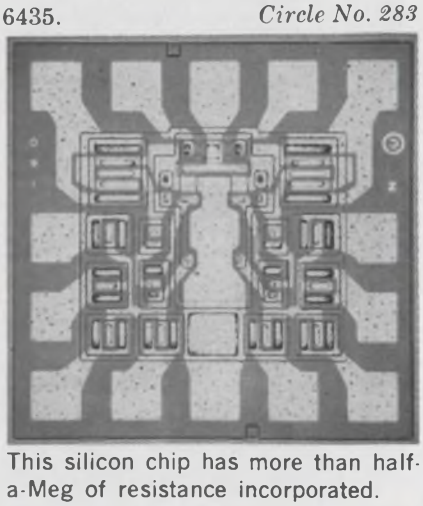
Propagation delays of 60 ns are average for the logic gates. Typical clock-rate for the flip-flop is 2.5 MHz. The optimum single supply voltage for all units is $+5$ V, range is $+4.5$ to $+5.5$ V. A fan-out of 10 LPDTμL or 1 standard DTμL is specified over the entire temperature and supply voltage range, and noise immunity is guaranteed at a minimum of 450 mV at the temperature extremes. Emitter-follower outputs provide good capacitive drive capabilities.

The 9040 is a direct-coupled, dual-rank flip-flop which may be used in counters, shift-registers, and storage applications. Direct set and clear inputs are provided, which override all other data inputs.

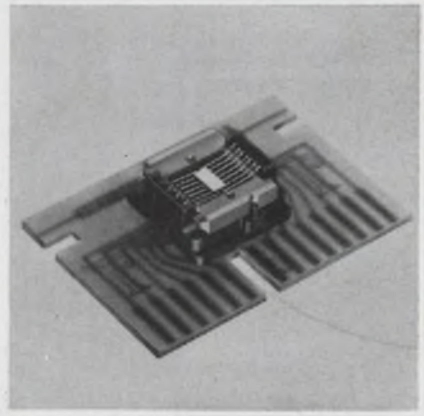
The 9041 and the 9042 are suitable for inverter applications and general logic-gate application. The 9042 has an extra input, allowing the user to increase the gate fan-in by adding on diode elements such as the DTμL 9933, a 4-input extender package.

All of the devices are available in the flat-pack configuration, or a new dual in-line package.

P&A: $24 (9040), $20 (9041 and 9042) in 100 lots; stock. Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. Phone: (415) 962-5011. TWX: (910) 379-6435. *Circle No. 283*



This silicon chip has more than half-a-Meg of resistance incorporated.



IC test socket

This integrated circuit test socket is designated Series 8104. It consists of a Mech-Pack connector soldered to a polarized printed circuit board. This permits testing of flat-packs in the T.I. Mech-Pack Carrier without the necessity of trimming the integrated circuit from the carrier.

The unit is available without a polarized edge connector.

P&A: $3.10 to $3.86, depending on quantity; 4-5 weeks. Augat Inc., 33 Perry Ave., Attleboro, Mass. Phone: (617) 222-2202.

Circle No. 284

VHF cascode microcircuit

A silicon planar integrated vhf cascode chip is available from England. Amplifier operation is possible at frequencies as high as 200 MHz with this circuit, type 316-04.

A unique circuit configuration provides extremely low internal feedback characteristics, thus allowing the elimination of neutralization techniques often necessary with vhf wideband-amplifier circuits.

Performance specifications for the microelectronic device include an operating frequency range of dc to 200 MHz with power gains of 17 dB at 100 MHz and 14 dB at 150 MHz. The circuit has a noise-figure of 5 dB at 100 MHz. Operational temperatures cover the $-55°$ to $+125°C$ military range, and maximum line-voltage is $+25$ Vdc. The unit is enclosed in a TO-5 header with an eight-pin configuration.

Available in production quantities from: Marconi Co. Ltd., Chelmsford, Essex, England. Phone: Chelmsford 3221—night phone: Chelmsford 57506.

Circle No. 285

Completely Automatic
CAPACITANCE BRIDGE

Just Insert a Capacitor... and Read the Answer

Direct Reading . . . C and D (or G) indicated with decimal point and correct unit of measurement.

Fast . . . measuring rates up to 2 per second . . . works with scanner-type inputs.

Accurate . . . ±0.1% of reading for C and G; 1% ±0.001 of reading for D.

Stable . . . a true bridge whose accuracy depends only on passive standards and fixed transformer ratios and is independent of generator voltage variations and phase-sensitive-detector errors. Three-terminal configuration permits accurate remote measurements.

BCD Output . . . BCD (1-2-4-2 code) for data processing and recording.

Wide Range

Frequency	120c/s	400c/s	1kc/s
Capacitance	0.0001μF to 1000μF 4 ranges	0.01pF to 100μF 7 ranges	0.01pF to 100μF 7 ranges
Conductance	1μ℧ to 1℧ 4 ranges	0.1n℧ to 1℧ 7 ranges	0.1n℧ to 1℧ 7 ranges

Dissipation Factor: 0.0001 to 1.0 in one range

Automatic Capacitance Bridge Assembly Type 1680-A . . . $4850 in U.S.A.

If you think a 1680 Automatic Capacitance Bridge can save you time and money and improve accuracy, why not write or call us for a demonstration?

RCA Aerospace Systems Division, Burlington, Massachusetts, has responded to the Department of Defense's challenge to industry to attain new levels of product quality by instituting a company-wide Zero Defects program. For example, in their Purchased Materials Inspection Department, new test equipment has been installed to upgrade measurement techniques and accuracy. A GR Type 1680 Automatic Capacitance Bridge and Type 1137 Data Printer are now used for incoming inspection of capacitors, whereas a manually balanced bridge was previously used. Capacitance measurements were not only tedious and time-consuming, but were also subject to a considerable amount of human error. With the installation of the Type 1680 Automatic Bridge, a thirty-percent saving in time has been realized; accuracy has been increased ten times; and data is automatically and permanently recorded.

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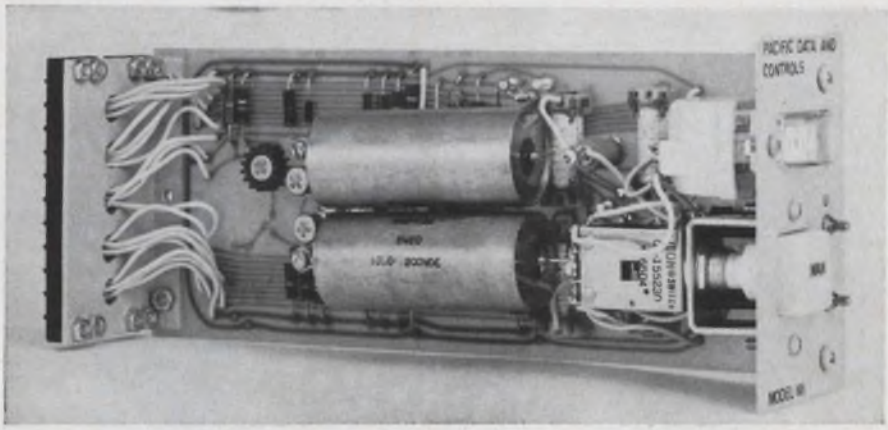
ON READER-SERVICE CARD CIRCLE 215



Sample-hold amplifier recalls analog inputs for hours.

Sample and Hold amplifier 101 memorizes its latest input values for hours after input is removed thus allowing manual control to be substituted without losing the original reference point, or preventing loss of data during loss-of-service. The 101 has a capacitance feedback amplifier arrangement performing the memory function at a cost considerably below competing devices.

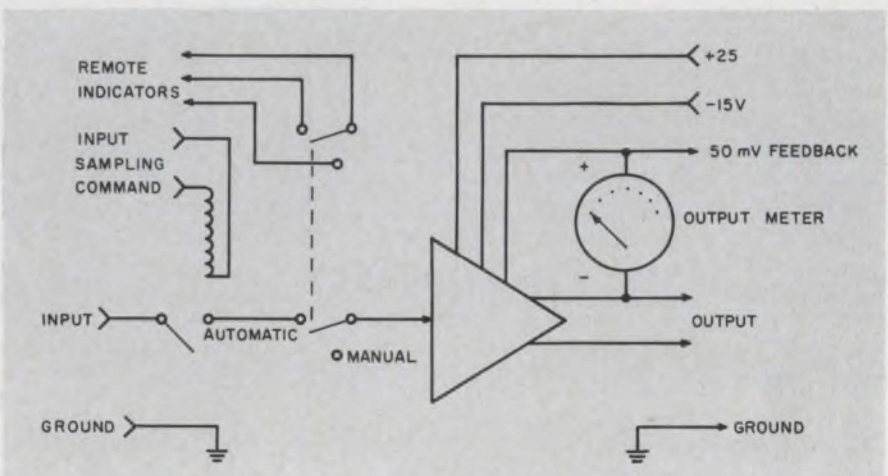
Two modes of operation are offered: low-level, floating hold amplifier adjustable from 2.5 V down to 50 mV input full-scale using an optionally available adjustable preamp; and single-ended sample-and-hold giving 2.5 V full-scale. Higher line voltages can be handled by using voltage divider networks. Provision is made for switching to manual from automatic with no discontinuity in signal level and returning to automatic with no discontinuity unless input signal has changed in the interim. Push-button switches and an output meter for the manual mode allow the signal level to be set to any point.

Output-currents are 1-5 mA into 3 kohm loads (floating) and 4-20 mA into 750 ohm loads (floating). The stability of the 101 is ±0.5% full-scale or 15°F temperature change up to 1 month, with power variations of ±10%, amplifier nonlinearity and hysteresis figured in.

Eight plug-in units can be mounted in a 3-1/2 x 19-in. rack. Compatible power supplies and preamplifier are available as matching modules. Battery power can be specified.

P&A: $300; stock. Pacific Data and Controls, 4606 Foster, Portland Ore. Phone: (503) 281-6401.

Circle No. 286



When input signal ceases, output remains at last level. Input restoration changes output only if signal has changed. Output meter and up/down controls are provided for the manual mode.

Delay-line amplifiers

Types A and B delay-line systems amplifiers for IF frequencies meet needs for wide dynamic range in the presence of high insertion-loss elements. Each channel requires a driver (type A) and a post amplifier (B). These amps have a 60 MHz center frequency, 30 MHz bandpass, and 25 ns pulse-response. Other frequencies can be ordered.

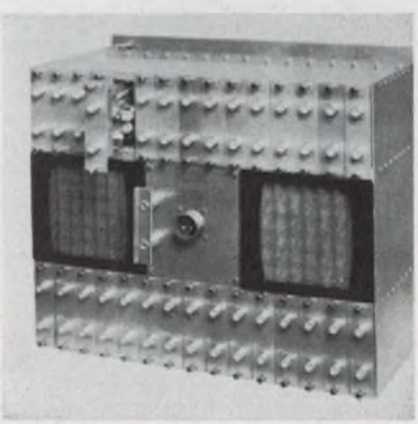
The type A amp provides 1-watt output for an element such as a delay-line. Type B maintains a low noise figure with a system dynamic range of 70 dB. Output for 1 dB compression is 250 mW and is variable over 15 dB without degrading amplitude or phase stability (± 0.25 dB and $2°$ rms). Gated units provide 60 dB min on/off ratio.

Available singly or in multi-channel systems, they are on printed-circuit glass-epoxy boards, RF connectors at the rear. A meter to show voltage and individual amplifier currents is in the systems package, as are blowers. Single units are conduction cooled. Isolation between channels is 120 dB min.

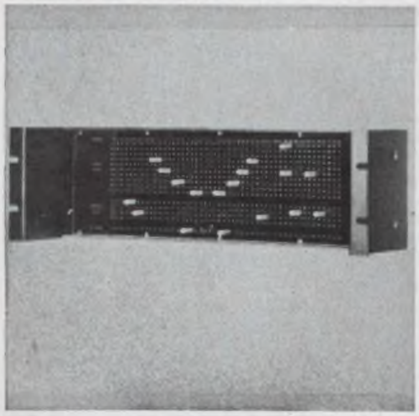
Specs include 30 dB min gain to 54 dB in type B, input Z of 50 ohms, and vswr of 1.25:1. Ripple is 0.5 dB, pulse rise- and fall-time (10-90%) is 25 ns. Over- and under-shoot with 0.1 μs pulse is under 10% for A, 5% for B. Max power is 1 W and 250 mW for A and B respectively. Dynamic ranges are 85 and 70 dB, noise-figure is 12 and 6 dB, and power requirements are 260 and 170 mA for A and B respectively. Linearity is within 0.5 dB.

P&A: about $550; stock. Aerospace Research, 130 Lincoln, Boston, Mass.

Circle No. 287



A 15-channel system (shown from rear) uses 15 'A' and 15 'B' amps.



Program boards

These program boards protect pins from damage by recessing them in their relay-rack housing. Pin positions are variable from a maximum of three inches, down to flush with the rack.

The boards are designed for mounting in a 19-in. rack, and are available for selective switching, or multiple but discrete spst or spdt in non-matrix form.

Sealectro Corp., 225 Hoyt Ave., Mamaroneck, N. Y. Phone: (914) 698-5600. TWX: (710) 566-1110.

Circle No. 288

Computing recorder

Computing recorders B24X and B34X perform arithmetic calculation and integration.

B24X two pen, and B34X three pen 10-inch graphic recorders can be associated with the XB arithmetic computer, the XD integrating computer, and the XA arithmetic and integrating computer unit.

P&A: B24X-$2500, B34X-$3100, XB-$390, XD-$890, XA-$1250; 45 days. Argonaut Assocs., P. O. Box K, Beaverton, Ore. Phone: (503) 292-3149.

Circle No. 289

Application Notes

Automation notes

Problem solutions across a broad range of industries are discussed, illustrated, and diagrammed. Examples of variable frequency power control of two-conveyor synchronization and material transfer are given. All systems application data are analyzed in the light of the manufacturer's co-ordinated speed control motor drive accessories. U.S. Electrical Motors.

Circle No. 251

Reliability design

A 33-page book consists of a discussion of reliability. What is it and how is it measured, designed, and obtained. Terms are defined and extensive use is made of tables, graphs, and nomographs. Avco-Electronics Div.

Circle No. 252

Ultrasonic delay lines

A 24-page reprint of a paper entitled "A Survey of Ultrasonic Delay Lines Operating Below 100 Mc/s" is available.

Types of delay lines in use are described, their limitations noted, and design considerations outlined. Attention is given to recently evolved dispersive lines suitable for radar pulse compression systems.

Wave diagrams, graphs, oscilloscope patterns, schematics, illustrative drawings, and photographs of devices assist the reader. Andersen Labs.

Circle No. 253

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Test Equipment Reference Data

ELECTRONIC DESIGN'S Test Equipment Reference Issue covers 12 important classes of test instruments. Included are complete up-to-date specifications for approximately 2500 off-the-shelf test instruments, arranged for quick and easy reference and comparison, and cross indexed by product category and manufacturer's name. Technical data prepared from the Directory of Technical Specification/Electronic Test Instruments, by Technical Information Corporation. Twelve application-oriented articles by industry experts complete the package. Price $5; check or money order must accompany order.

Hayden Publishing Company, Inc.
850 Third Avenue
New York, New York 10022

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Electronic Design

Advertising Representatives

New York 10022
Robert W. Gascoigne
Thomas P. Barth
George W. Fleck
John F. Gilbert, Jr.
Rick Brough
850 Third Avenue
(212) PLaza 1-5530
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Philadelphia 19066
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Yoshihiro Takemura
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March 21-25

IEEE International Convention (New York) Sponsor: IEEE; The IEEE, 345 East 47th St., New York, N. Y.

April 12-15

International Quantum Electronics Conference (Phoenix) Sponsors: AIP/IEEE; Dr. J. P. Gordon, Bell Telephone Laboratories, Murray Hill, N. J.

April 17-20

International Conference on Electron and Ion Beam Technology (New York) Sponsors: AIME and Electrochemical Society; Metallurgical Society of AIME, 345 East 47th St., New York, N. Y.

April 18-20

Symposium on Process Automation (Newport Beach, Calif.) Sponsors: Beckman Instruments, Consolidated Electrodynamics, Control Data, SDS Data Systems; Dr. William Biles, Shell Development Co., Houston, Tex.

April 20-22

1966 Intermag (International Conference on Magnetics) (Stuttgart, Germany) Sponsor: IEEE G-Mag; Dr. E. W. Pugh, IBM Corp., 1000 Westchester Ave., White Plains, N. Y.

April 25-28

Audio Engineering Society Convention (Los Angeles) Sponsor: Audio Engineering Society; John C. Baumann, Ampex Corp., 8467 Beverly Boulevard, Los Angeles, Calif.

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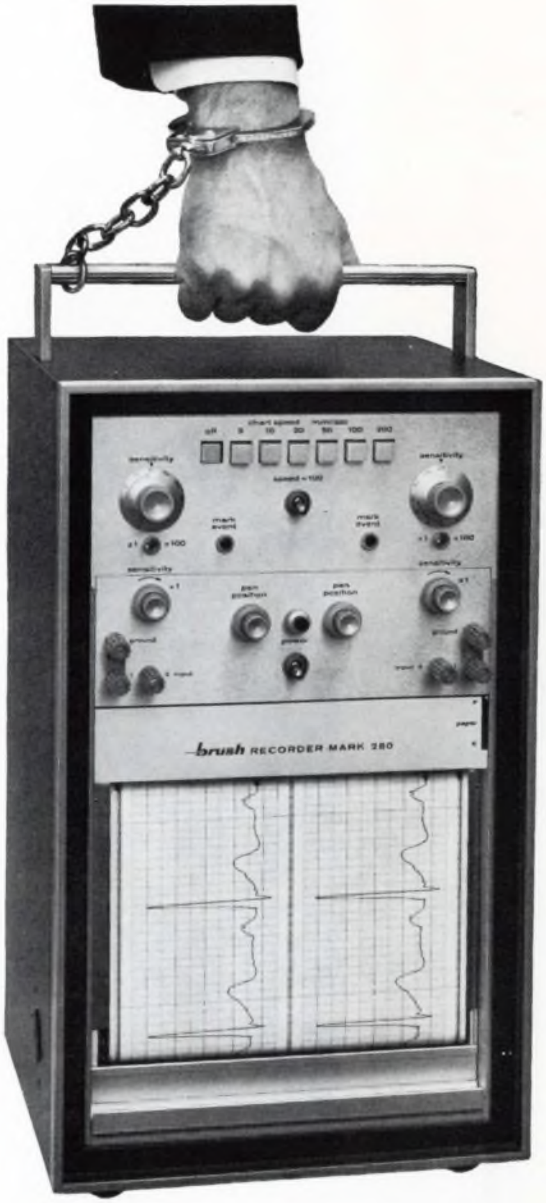

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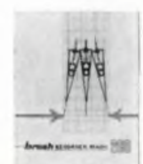

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