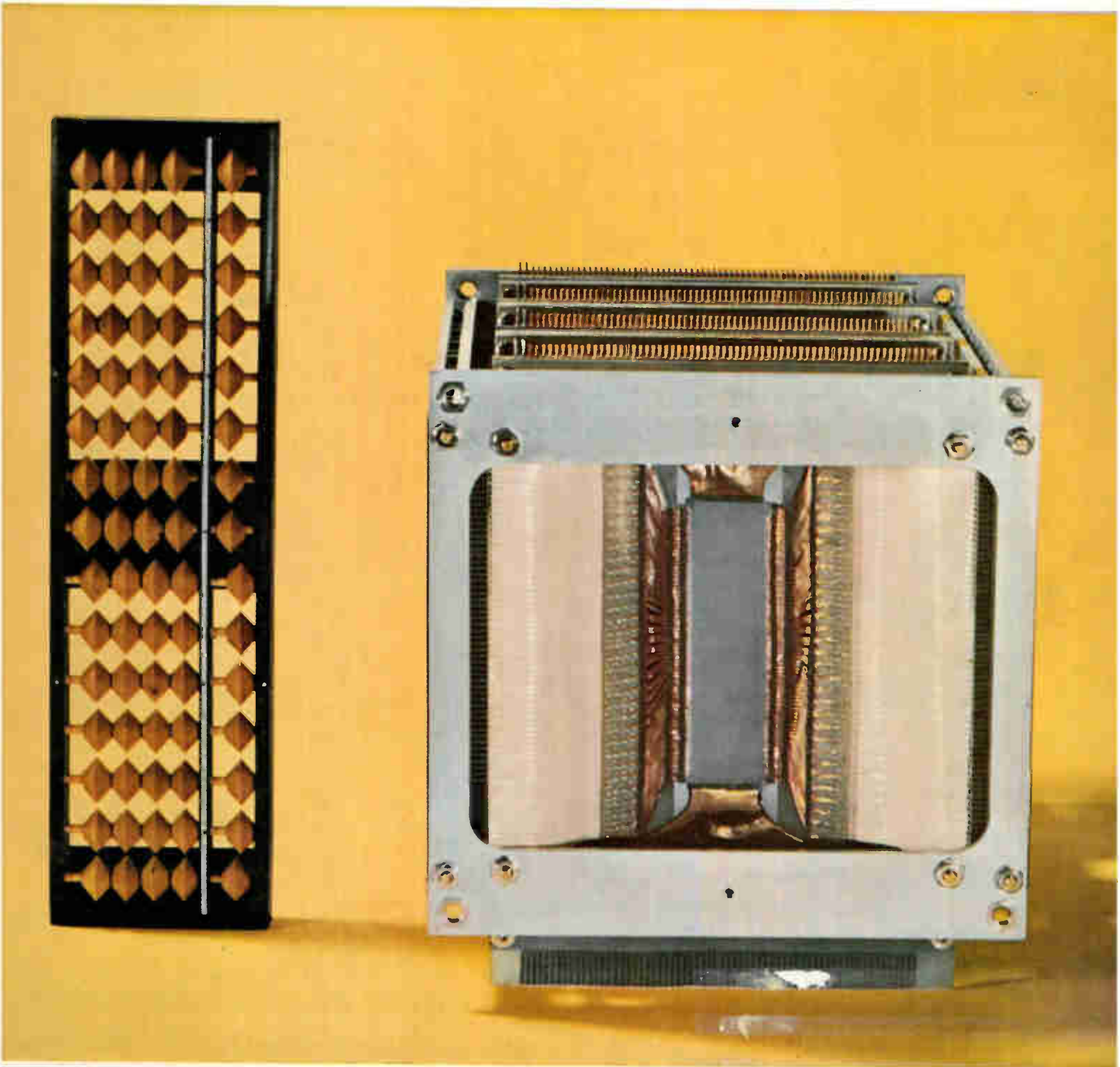
Electronics

SCR control in paper mills: page 42
Incremental recorder ends tape waste: page 48
New job for an interferometer: page 58

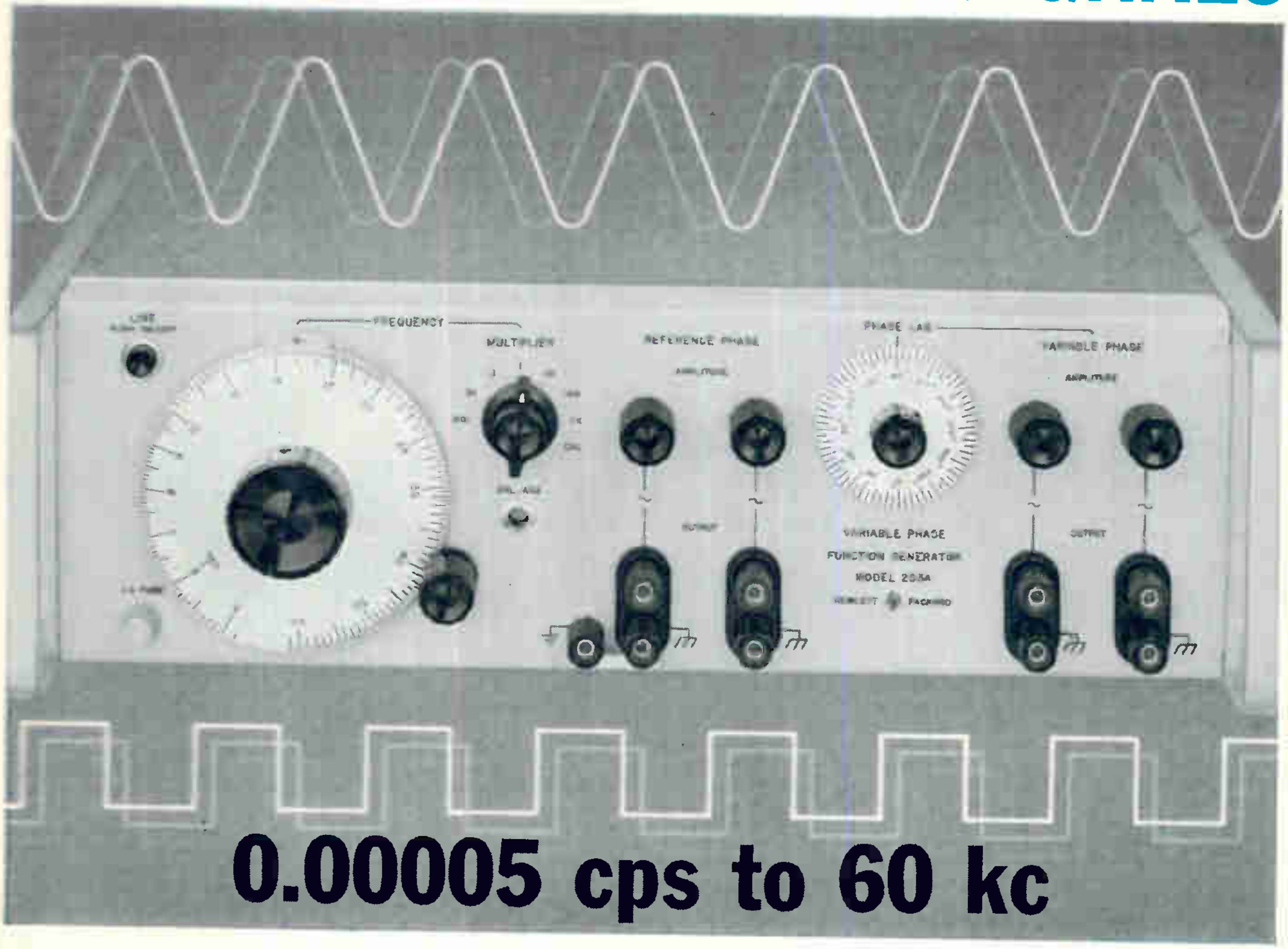
June 29, 1964
75 cents
A McGraw-Hill Publication

Below: first laminated ferrite sheet memory, page 64



Special | Magnetics in electronics: page 61

VARIABLE-PHASE TEST SIGNALS



Ideal for use in servo applications, analog computer work, phase shift measurements, physiological stimulators, vibration studies, subsonic and audio testing.

The 203A provides a reference sine and square wave, plus a variable-phase sine and square wave. Each pair of waveforms is continuously variable 0 to 360° with reference to the other. All four signals are 0-30 volts peak to peak.

Distortion is less than 0.06%, referenced to 1 kc on four test signals available simultaneously from the new hp 203A Function Generator. Frequency range is covered in seven decade ranges, vernier drive for precise adjustment. Two lower ranges (0.0005 and 0.00005 cps) optional at additional cost. Built-in circuit permits field calibration of frequency dial to line frequency.

The output system is floating with respect to ground and may be used to supply an output voltage with either terminal grounded or may be floated up to 500 volts dc above chassis ground. Output impedance 600 ohms on all outputs.

Check the additional specifications at right, then call your Hewlett-Packard field engineer for details on how the unprecedented capabilities of the 203A can help you in your specific task. Or write Hewlett-Packard Company, Palo Alto, California 94304, Telephone (415) 326-7000; Europe: 54 Route des Acacias, Geneva; Canada: 8270 Mayrand Street, Montreal.

SPECIFICATIONS

Frequency Dial Accuracy:	±1% of reading
Frequency Stability:	within ±1%, including warmup drift and line voltage ±10%
Maximum Output Voltage:	at least 30 v p-p open circuit, all waveforms
Output Power:	5 v into 600 ohms (40 mw), at least 40 db continuously variable attenuation, all outputs
Distortion:	total harmonic distortion hum and noise greater than 64 db below fundamental
Phase Dial Accuracy:	±5° sine wave, ±10° square wave
Square Wave Response:	symmetry within 1%, rise and fall time less than 200 nsec, top flat within ±0.5% from 10% to 90% of half period
Price:	$1200

Data subject to change without notice. Price f.o.b. factory.

HEWLETT PACKARD hp *An extra measure of quality*

Circle 1 on reader service card

NOW AVAILABLE FROM STOCK!

FM-AM SIGNAL GENERATOR

TYPE 202-H

RADIO FREQUENCY CHARACTERISTICS
- RF RANGE: 54-216 MC
- RF ACCURACY: $\pm$0.5%
- RF OUTPUT RANGE:
  - 0.1 μv to 0.2 volts*
  - *Across external 50 ohm load at panel jack
- ACCURACY:
  - $\pm$10%, 0.1 μv to 50 K μv
  - $\pm$20%, 50 K μv to 0.2 volts
- AUTO LEVEL SET:
  - Holds RF monitor meter to "red line" over band
- IMPEDANCE: 50 ohms
- VSWR: $<$1.2

AMPLITUDE MODULATION CHARACTERISTICS
- AM RANGE:
  - Internal: 0-50%
  - External: 0-100%
- AM ACCURACY:
  - $\pm$ 10% at 30% and 50% AM
- AM DISTORTION:
  - $<$5% at 30% $<$20% at 100%
  - $<$8% at 50%
- AM FIDELITY:
  - $\pm$1 db, 30 cps to 200 KC

FREQUENCY MODULATION CHARACTERISTICS
- FM RANGE:
  - Internal: 0-250 KC in 4 ranges
  - External: 0-250 KC in 4 ranges
- FM ACCURACY: $\pm$5% of full-scale*
  - *For sine-wave
- FM DISTORTION:
  - $<$0.5% at 75 KC (100 MC and 400 cps modulation only)
  - $<$1% at 75 KC (54-216 MC)
  - $<$10% at 240 KC (54-216 MC)
- FM FIDELITY:
  - $\pm$1 db, 5 cps to 200 KC
- SIGNAL-TO-NOISE RATIO:
  - $>$60 db below 10 KC

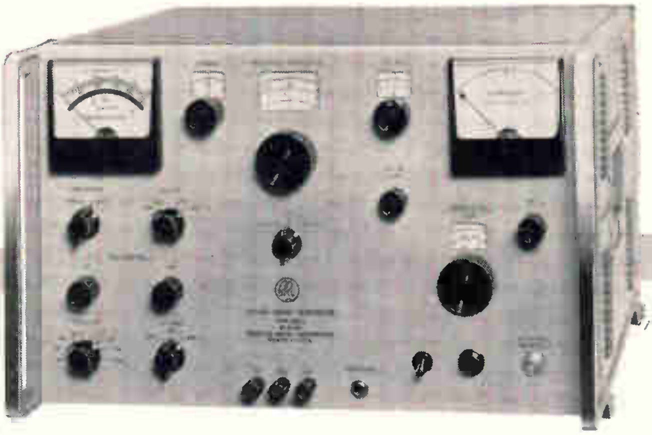
PULSE MODULATION CHARACTERISTICS
- PM SOURCE: External
- PM RISE TIME: $<$0.25 μsec
- PM DECAY TIME: $<$0.8 μsec

MODULATING OSCILLATOR CHARACTERISTICS
- OSC FREQUENCY:
  - 50 cps 7.5 KC 1000 cps 15 KC
  - 400 cps 10 KC 3000 cps 25 KC
- OSC ACCURACY: $\pm$5%
- OSC DISTORTION: $<$0.5%

PHYSICAL CHARACTERISTICS
- MOUNTING: Cabinet for bench use; readily adaptable for 19" rack
- FINISH: Gray engraved panel; green cabinet (other finishes available on special order)
- DIMENSIONS:
  - Height: 10⅜" Width: 16¾" Depth: 18⅜"

POWER REQUIREMENTS
- 202-H: 105-125/210-250 volts, 50-60 cps, 100 watts

PRICE — 202-H: $1365.00 F.O.B. Rockaway, N. J.



The Type 202-H FM-AM Signal Generator covers the frequency range from 54 to 216 MC and is designed for the testing and calibration of FM receiving systems in the areas of broadcast FM, VHF-TV, mobile, and general communications. The generator consists of a three-stage RF unit, together with a modulating oscillator and power supply, all housed in a single cabinet which may be adapted for rack mounting.

The RF unit consists of a variable oscillator, a reactance tube modulator, a doubler, and an output stage. The modulator is specially designed for minimum distortion and operated in conjunction with the electronic vernier to provide incremental changes in RF output frequency as small as 1 KC. The RF output is fed through a precision, waveguide-below-cutoff variable attenuator; automatic RF level set is incorporated which maintains "red line" on the RF monitor meter over the entire band. The entire RF unit is shock-mounted for minimum microphonism.

An internal audio oscillator provides a choice of eight frequencies which may be used for either FM or AM modulation. A modulation meter indicates either FM deviation or % AM and is calibrated for sine-wave modulation.

A completely solid-state power supply furnishes all necessary operating voltages and may be switched for inputs of either 105-125 or 210-250 volts, 50-60 cps.

Model 202-J is also available for the 215-260 MC telemetering band.

BOONTON RADIO COMPANY

A Division of Hewlett-Packard Company

GREEN POND ROAD, ROCKAWAY, NEW JERSEY

Tel. 627-6400 (Area Code 201) TWX: 201-627-3912 Cable Address: Boonraco

June 29, 1964
Volume 37, Number 19

Electronics

In this issue

Electronic review

Probing the news

Technical articles

Electronics

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Readers Comment

Electronics spying

On page 36 of your June 1 issue, I read that a book will soon be published, "The Invisible Government."

Please let me know the name and address of the publisher as I would like to order a copy.

John D. Askew
Atlanta, Ga.

▪ Authors David Wise and Thomas Ross discuss the electronic spy operations of the Central Intelligence Agency and the National Security Agency of the Defense Department. The book was published June 22 by Random House, Inc., 457 Madison Ave., N.Y. 22. Excerpts appeared in the June 16 issue of Look magazine.

Patents

I vigorously oppose the passage of bill H.R. 8190, increasing the cost of obtaining patents in the United States, and support B. F. Miessner's view [Electronics, March 13, p. 6] wholeheartedly.

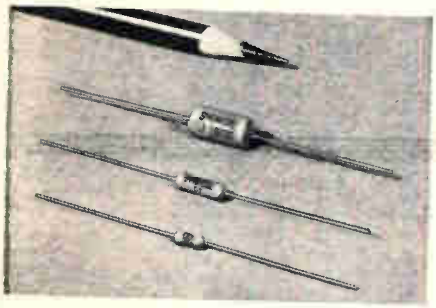
Your editorial comment on Mr. Miessner's letter proves to me that not only are patent fees excessive and the 17-year allowed life of a patent too short, but search and legal fees are completely out of line. Only the large corporations can afford to pay exorbitant fees. They stifle and starve the independent inventor to death. It is completely unrealistic to pretend that the minority of highly creative independent inventors existing today could possibly entertain or effectively promote successful lobbying to block this legislation.

A large corporation that spends millions annually on research and development is not about to make any mutually satisfactory financial deals with an impoverished but highly creative inventor; rather, it prefers to pick his brains or steal his ideas outright.

If Thomas A. Edison were an unknown and impoverished inventor living in these times, what chance would he have to develop? What large corporations will even consider hiring a creative genius

(Advertisement)

Dependable Construction, Size Reduction, Low Cost Are Features of Pacer® Filmite® 'E' Capacitors



MULTI-ADVANTAGE construction in a *low-cost* film capacitor has been achieved in Pacer® Filmite® 'E' Capacitors, which utilize a specially selected ultra-thin polyester film dielectric that permits dramatic size reductions.

Type 192P miniature Pacer Capacitors, designed and developed by the Sprague Electric Company, are one-third the size of conventional paper and paper-film tubulars, making them ideal for transistorized circuitry and other space-saving applications where small size *with dependability* is an important consideration.

Special End Cap Design

Metal end caps over extended foil sections assure best possible non-inductive capacitors, since all turns of the electrodes are positively contacted. The end caps also act as effective barriers against the entrance of moisture into the ends of the capacitor section. Type 192P Pacer Capacitors are further protected by a hard, durable, orange epoxy coating.

Unlike other epoxy coated units, Pacer Capacitors, with their special end-cap construction, assure the rigid fixed diameters needed for use with automatic insertion equipment. The metal end caps also provide a firm base to which the wire leads are welded.

Engineering Information Available

For complete technical data on Type 192P Pacer Capacitors write for Engineering Bulletin 2066 to Technical Literature Service, Sprague Electric Company, 35 Marshall Street, North Adams, Massachusetts.

4SC-153-53

6 Reasons Why SPRAGUE is a Major Resistor Supplier

FILMISTOR® PRECISION FILM RESISTORS

metal-film, molded case

Distinct limited temperature coefficients and low tolerances to meet exacting application requirements. Rugged end cap construction for long-term stability and reliability. Superior resistance to humidity and mechanical damage. Surpass MIL-R-10509D requirements. Send for Bulletin 7025B.

deposited-carbon, molded case

Approach precision wirewounds in reliability and stability, yet are smaller in size and have lower self-inductance. Low, controlled temperature coefficient. Dense molded case provides outstanding humidity protection. Send for Bulletin 7000A.

deposited-carbon, conformal coated

Full rated load operation at 70 C with no wattage derating. Assured uprated loads at lower operating temperatures. Ideal for circuitry where small size, humidity resistance, and close tolerance (±1%) are required. Send for Bulletin 7005A.

CIRCLE 270 ON READER SERVICE CARD

ACRASIL® PRECISION/POWER WIREWOUND RESISTORS

silicone-encapsulated

Combine the best features of both precision and power wirewound types. Resistance tolerances to ±0.05%. Unusually tough encapsulation protects against shock, vibration, moisture, fungus. Meet MIL-R-26C requirements. Smaller than conventional wirewounds, yet greater in stability. Send for Bulletin 7450.

CIRCLE 271 ON READER SERVICE CARD

BLUE JACKET® VITREOUS ENAMEL POWER WIREWOUND RESISTORS

All-welded end cap construction with special vitreous coating for long-term dependability. Axial-lead style for conventional wiring or on printed boards. Tab terminals for higher wattage applications. Meet MIL-R-26C requirements. Send for Bulletins 7400B, 7410D, 7411A.

CIRCLE 272 ON READER SERVICE CARD

KOOLOHM® CERAMIC-SHELL POWER WIREWOUND RESISTORS

Exclusive ceramic-insulated resistance wire permits "short-proof" multilayer windings for higher resistance values. Standard and non-inductive designs. Non-porous ceramic shell for moisture protection and electrical insulation. Axial-lead, axial-tab, and radial-tab styles. Send for Bulletins 7300B, 7305, 7310.

CIRCLE 273 ON READER SERVICE CARD

STACKOHM® POWER WIREWOUND RESISTORS

Flat silhouette permits stacking of resistor banks in close quarters. Aluminum thru-bar simplifies mounting and conducts heat from resistance element. Vitreous enamel protective coating. Meet MIL-R-26C performance requirements. Send for Bulletin 7430.

CIRCLE 275 ON READER SERVICE CARD

GLASS-JACKETED POWER WIREWOUND RESISTORS

Ferrule terminals soldered to metallized ends of glass casing for true hermetic seal. Virtually failure-proof, even in extremely corrosive industrial and salt atmosphere. Standard and non-inductive windings. External meter-multiplier types also available. Send for Bulletins 7350, 7420, 7421.

CIRCLE 274 ON READER SERVICE CARD

For complete technical data, write for engineering bulletins on the resistors in which you are interested to: Technical Literature Service, Sprague Electric Company, 35 Marshall Street, North Adams, Massachusetts.

4SR-166-63

SPRAGUE®

THE MARK OF RELIABILITY

without a degree? . . . much less allow him to retain ownership rights to all his creations? It is interesting to note that while they confiscate a man's creativity via the patent-assignment pre-employment forms, they nonetheless scream the loudest when the government considers owning any patents derived under research and development subsidies. Why the double standard? How many years is it going to take us to undo the damage perpetuated by bill H.R. 8190, which is sure to pass? Rest assured, we will reverse it.

B. McFarlane
San Jose, Calif.

Computer-designed antenna

Since my arrival in the fringe area north of New York, I have designed many log-periodic antennas for f-m and tv reception and built a few. Repetitious calculations (of limited accuracy) left me dissatisfied and bored. A program was written [see below] for the academic computer available (a GE-225) in no more time than for the normal calculations on one antenna.

Upper and lower operating frequencies were selected as two critical design features. Upper, rather than lower, frequency was usually over-designed because of the inherently superior propagation characteristics of the longer wavelengths. Implied in the selection of upper and lower frequencies is a desire to economize by truncating the antennas. The other major economic considerations are the length of the antenna boom and the number of elements. An increase in either increases both the gain and the cost.

With these four design parameters the program computes upper and lower half-wave lengths, total boom length to the "apex" (designed feed point for separation angle psi other than zero), design length of each element (one-fourth wavelength) and the distance from the smallest element to each other element. A designed construction space of one inch on each end of the boom was programed in.

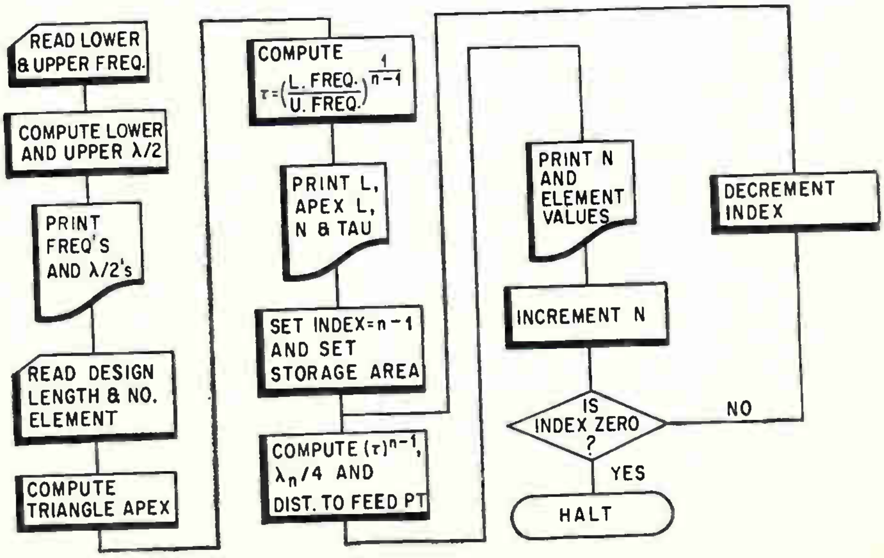
Irvin G. Kinnie, Jr.
Captain, Signal Corps
Dept. of Earth,
Space and Graphic Sciences
United States Military Academy
West Point, N.Y.

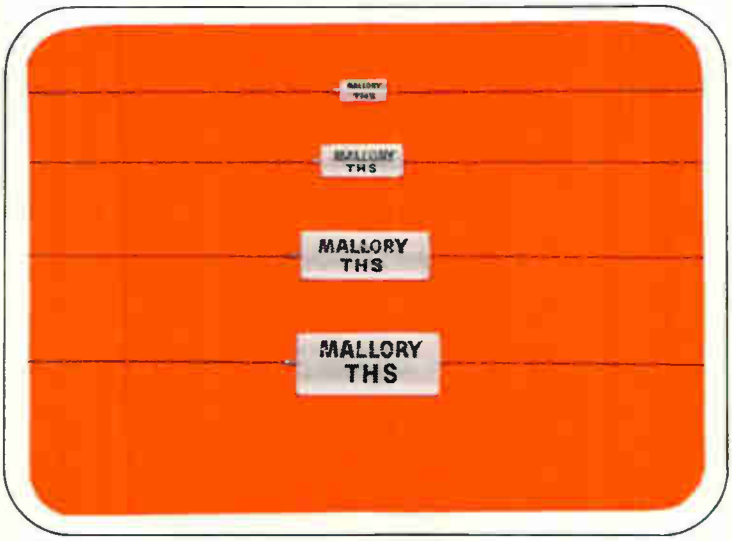
Bunker-Ramo saga

Regarding the final item in your June 1 Electronics Newsletter [p. 18], it is true that Thompson Ramo Wooldridge, Inc., sold its Columbus division to the Harvey-Wells Corp. [our client] in May. However, it sold only the closed-circuit television portion of its Dage division, and that was last July, not this year. The numerical-control facilities were retained by TRW and absorbed by Bunker-Ramo, as you stated in your newsletter item.

A final footnote is that Harvey-Wells stockholders met on June 19 to approve a change of name to The Dage Corp. The change will more closely identify the corporation with the activities of its Dage Television Co. division.

James W. Shorr
Daniel J. Edelman and Assoc., Inc.
Chicago





New solid tantalum capacitors for 200°C service

VOLTAGE DERATING CHART		
WVDC @ 25°C	WVDC @ 200°C Continuous Duty	WVDC @ 200°C 50% Duty Cycle*
6	2.4	4.8
10	4.0	9.0
15	6.0	12.0
20	8.0	16.0
25	10.0	20.0
35	14.0	28.0
50	20.0	40.0

*Based on a duty cycle of 2 hours on Voltage @ 200°C followed by 2 hours off voltage @ 25°C.

STANDARD CAPACITANCE AND VOLTAGE RATINGS
DC WORKING VOLTAGE AT 25°C

CASE SIZE*	6VDC	10VDC	15VDC	20VDC	25VDC	35VDC	50VDC
D—.125 L—.250	.0047 to 4.7MFD	.0047 to 3.3MFD	.0047 to 2.7MFD	.0047 to 1.5MFD	.0047 to 1.5MFD	.0047 to 1.0MFD	.0047 to .68MFD
D—.175 L—.438	6.8 to 33MFD	4.7 to 22MFD	3.9 to 15MFD	2.2 to 10MFD	2.2 to 6.8MFD	1.5 to 4.7MFD	1.0 to 3.3MFD
D—.279 L—.650	47 to 100MFD	33 to 68MFD	22 to 47MFD	15 to 33MFD	10 to 22MFD	6.8 to 15MFD	4.7 to 15MFD
D—.341 L—.750	150 to 220MFD	100 to 150MFD	68 to 100MFD	47 to 68MFD	33 to 47MFD	22 to 33MFD	

*uninsulated.

The first solid electrolyte tantalum capacitors to be rated for 200°C, the new Mallory Type THS line, was originally developed for use in oil well instruments which are subjected to high temperatures during deep-hole surveys. These miniature capacitors are hermetically sealed in tin-plated cases with gold-plated leads. Uniform high quality is assured by 100% screening tests at 200°C.

Four different case sizes are available from 0.125″ diameter by 0.250″ long, to 0.341″ diameter by 0.750″ long (uninsulated). Teflon* insulating sleeves can be supplied. Nominal values cover the range from 220 mfd, 6 VDC to 15 mfd, 50 VDC. For complete details, write or call Mallory Capacitor Company, Indianapolis, Indiana 46206—a division of P. R. Mallory & Co. Inc.

**Registered Du Pont Trademark*

MALLORY

WET SLUG, FOIL AND SOLID TANTALUM CAPACITORS

People

Louis T. Rader, president of the Univac division of the Sperry Rand Corp. since 1962, will return to General Electric Co. on July 1 as vice president and general manager of its industrial electronics division. This is the third time around for Rader at General Electric. Rader was with the company from 1937 to 1945—starting as a test engineer in the general engineering department—and again from 1947 through 1959. In 1953 he became general manager of GE's specialty control department, Waynesboro, Va. From 1945 to 1947 he was director of the department of electrical engineering at the Illinois Institute of Technology and a consultant to the Armour Research Foundation.

Rader received his doctorate in electrical engineering in 1938 from the California Institute of Technology. Two classmates were Simon Ramo and Dean Woolridge.

At General Electric, he replaces Harold A. Strickland, Jr., a non-engineer administrator. Rader's appointment indicates an effort by GE to place top-flight engineers in administrative positions and is seen by some as a move to coordinate more closely the company's far-flung—and occasionally competitive—electronics operations.

Lt. Col. Leonard M. Butsch Jr., chief of the bionics branch of the Air Force Avionics Laboratory, has retired from the Air Force. He was a driving force in the establishment of the Air Force's bionics facility. There he served as manager and research director in digital computers and bionics in the areas of computer logic, algebras for machine learning, self-organizing systems and systems research.

FACTS...

about today's most advanced solid state telegraph relays

RADIATION INCORPORATED

Are all solid-state relays alike?

No. Some are transistorized versions of mechanical units, while others are partially solid-state. Radiation Telegraph Relays are all solid-state. There are no moving parts.

Why invest in solid-state relays?

Because they eliminate routine maintenance, require no adjustments, and cut costly downtime and service calls.

How long will they operate under normal conditions?

Indefinitely.

APPLICATIONS . . .

Which mechanical relays can solid-state units replace?

All known types . . . except those rare applications where no solid-state device can be used.

How many kinds would I have to stock?

Only three: Radiation supplies polar, neutral and universal types.

Can I simply plug in your relays and expect them to work?

Yes. But because there are so many different wiring options, an adapter plug may be required to match your particular system.

How do you power Radiation Relays?

You don't. A unique circuit (patent applied for) allows the unit to operate on input current . . . the signal itself supplies the power.

TECHNICAL . . .

What are the features of Radiation Relays?

Non-polarized output contacts, high MTBF . . . 73,000 hours of actual field test without failure, high speed . . . up to 2400 bits/second, low distortion . . . less than 1% at 1000 bauds, and low leakage . . . less than $5\ \mu a$ at 130 volts. The units provide long operating life with extremely high reliability, and are designed with special protective circuitry.

What type of protective circuitry?

Thanks to a unique Radiation design, the units are highly resistant to spikes and overvoltages. Not only do they provide a cleaner telegraph signal, but they are also protected against destruction caused by abnormal line conditions.

Suppose a Radiation Relay is badly overloaded . . . how do I check it out?

We can supply our Model 7110 Solid-State Relay Tester. Incidentally, it comes with an adapter for use with electromechanical units, too.

What if the unit's actually damaged by abnormal conditions . . . do I have to throw it away?

Absolutely not! Due to modular construction Radiation Telegraph Relays are repairable.

QUALITY ASSURANCE . . .

Are your relays guaranteed?

They certainly are. Radiation warrants Neutral Model 9214 and Polar Model 9212 against all defects of performance for a year after shipment... providing they're used under normal conditions.

How can I prove the superiority of Radiation Solid-State Telegraph Relays?

Simply phone or write Product Sales Manager at Radiation Incorporated, Products Division, Dept. EL-06, Melbourne, Florida. We will supply technical information, and, if you wish, have a Field Engineer provide a relay to test on the line of your choice.

Why not call today? Prove to yourself that Radiation Relays assure higher circuit efficiency, lower cost operation and dependable service!

Circle 9 on reader service card

Meetings

Aerospace Reliability and Maintainability Annual Conference, SAE, ASME, AIAA; Statler Hilton Hotel, Washington, **June 29-July 1.**

National Society of Professional Engineers Annual Meeting, NSPE; Grove Park Inn, Asheville, N.C., **July 1-4.**

Rochester Conference on Data Acquisition and Processing in Medicine and Biology, University of Rochester, Rochester, N.Y., **July 13-15.**

Special Technical Conference on Nuclear Radiation Effects, IEEE PTG-NS, Radiation Effects Committee; University of Washington, Seattle, Wash., **July 20-24.**

Research Conference on Instrumentation Science, ISA; William Smith College, Geneva, N.Y., **Aug. 3-7.**

UAIDE Annual Meeting, Users of Information Display Equipment; International Hotel, Sepulveda and Century Blvds., Los Angeles, **Aug. 12-14.**

Symposium on Ultra Low Frequency Electromagnetic Fields, NBS Central Radio Propagation Lab. and National Center of Atmospheric Research; Boulder Laboratories, Boulder, Colo., **Aug. 17-20.**

Distributor-Manufacturer-Representative Conference, WESCON; Ambassador Hotel, Los Angeles, **Aug. 24.**

WESCON 1964, 6 Region IEEE and Western Electronic Manufacturers Assoc.; Los Angeles Sports Arena and Hollywood Park, Los Angeles, **Aug. 25-28.**

International Conference on Microwaves, Circuit Theory and Information Theory, Inst. Electrical Comm. Engrs. of Japan, Science Council of Japan and International Scientific Radio Union; Akasaka Prince Hotel, Tokyo, **Sept. 7-11.**

International Exhibition of Industrial Electronics, Swiss Industries Fair; Basel, Switzerland, **Sept. 7-11.**

International Convention on Military Electronics (MIL-E-CON-8), IEEE; Shoreham Hotel, Washington, **Sept. 14-16.**

Ceramic-To-Metal Session, American Ceramic Society, Philadelphia, **Sept. 17.**

Annual Northwest Computing Conference, Northwest Computing Association, University of Washington, Computing Center; University of Washington, Seattle, Wash., **Sept. 17-18.**

Engineering Management Annual Conference, IEEE-ASME; Pick-Carter Hotel, Cleveland, **Sept. 17-18.**

AIAA Military Aircraft Systems and Technology Meeting (Secret), AIAA, USAF, and BuWeps; NASA-Langley Research Center, Va., **Sept. 21-23.**

Third Canadian IEEE Communications Symposium, Canadian Region IEEE; Queen Elizabeth Hotel, Montreal, **Sept. 25-26.**

Physics of Failure in Electronics Annual Symposium, Rome Air Development Center, IIT Research Institute; IIT Research Institute, Chicago, **Sept. 29-Oct. 1.**

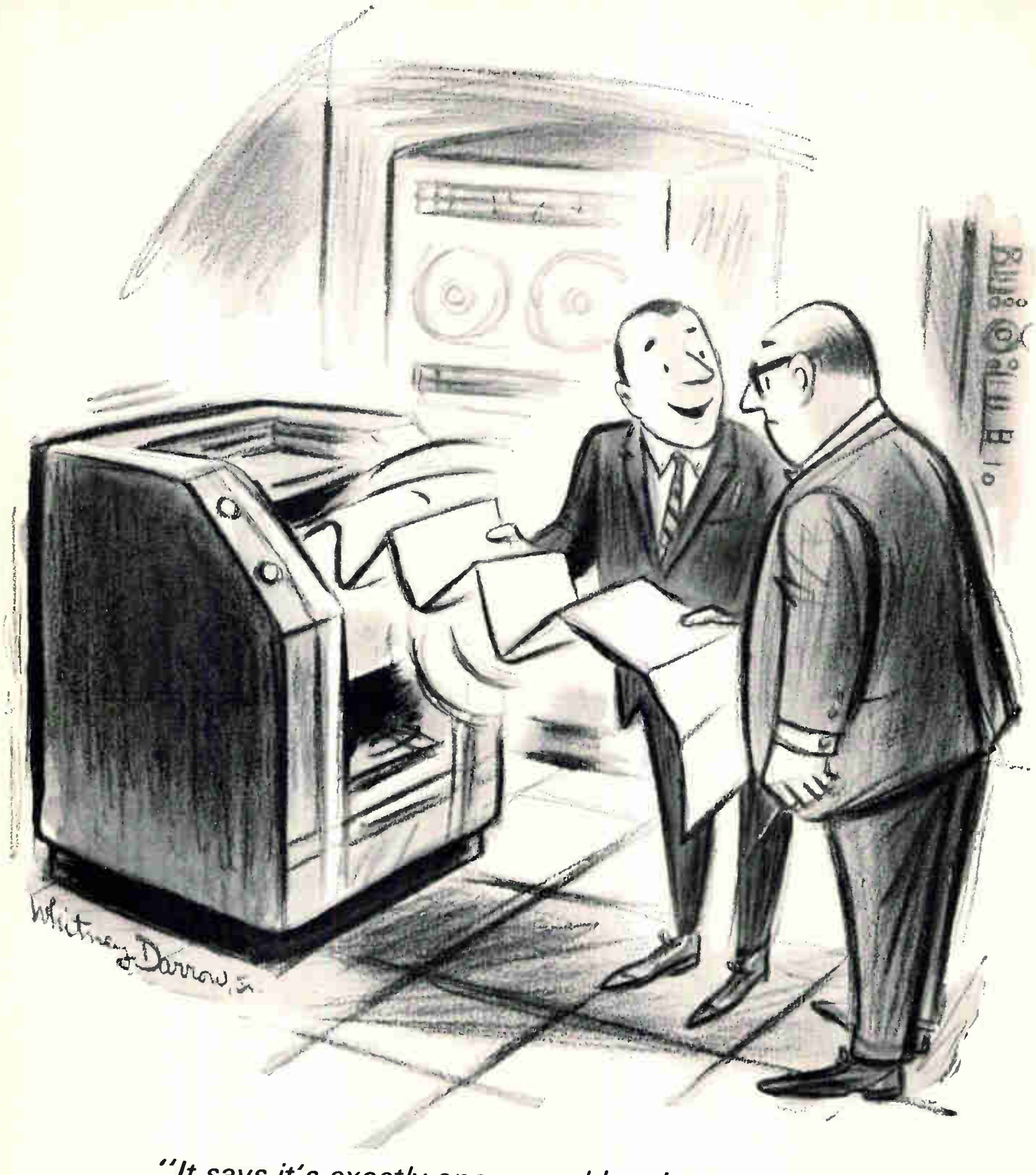
Physics and Nondestructive Testing Symposium, AF Materials Lab., Research and Technology Div., Aeronautical Systems Div., Wright Patterson AFB, Biltmore Hotel, Dayton, Ohio, **Sept. 29-Oct. 1.**

Society for Information Display National Symposium, SID; Shoreham Hotel, Washington, **Oct. 1-2.**

Call for papers

Optical and Electrooptical Information Processing Technology Symposium, Office of Naval Research, Association for Computing Machinery, PTG-EC/IEEE, Optical Society of America; Somerset Hotel, Boston, Nov. 9-10. **July 13** is deadline for submitting a reasonably extensive and detailed abstract to Barbara McKinney, Computer Associates, Inc., Lakeside Office Park, Wakefield, Mass. Topics include optical and electrooptical techniques for storage, logic, display and sensing; recent related device and circuit research; recent information processing research.

Protection Against Space Radiations Symposium, NASA, USAEC, USAF; Civic Auditorium, Gatlinberg, Tenn., Oct. 12-14. **August 14** is deadline for submitting 600-word summary to F. C. Maienschein, Oak Ridge National Laboratory, P. O. Box X, Oak Ridge, Tenn. 37831. Papers are invited in the areas of radiation environment in space, biological effects of space radiations, effects of space radiation on materials, and shielding against space radiations.



"It says it's exactly one year old and wants a new supply of tapes of MYLAR® for its birthday."

What a coincidence . . ."Mylar"* is having a birthday, too. It's ten years old. In the decade since it was first introduced as a base for recording tape, "Mylar" has consistently been the most used, most trusted tape base for all EDP applications. And why not? "Mylar" is strong (a tensile strength of 20,000 psi), stable (unaffected by temperature or humidity changes) and durable (can't dry out or become brittle with age). Celebrate the birthday of "Mylar" by giving yourself the gift of reliability. When reliability counts, count on "Mylar".

DU PONT
REG. U.S. PAT. OFF.
Better Things for Better Living . . . through Chemistry

only DU PONT makes
MYLAR®
POLYESTER FILM

*Du Pont's registered trademark for its polyester film.

Circle 11 on reader service card

NEVER BEFORE SO MUCH INSTRUMENT

DC standard
Differential voltmeter
High impedance electronic voltmeter
Power amplifier
Guarded for all modes of operation

TO PERFORM SO MANY TASKS SO WELL

Calibrate digital and differential VM's
Use as high voltage dc standard source
DC standard for transfer measurements
Standard cell comparisons
Low level null detector
Precision transducer, thermocouple measurements

AT SO GREAT A VALUE

Price: $2350

New concepts in circuitry make the new 740A DC Standard and Differential Voltmeter the most useful instrument of its type at a remarkably low cost!

This single instrument offers you all these features:

DC Standard: 0.01% accuracy. Floating and guarded output—positive or negative ground with remote sensing. Voltage ranges of 1, 10, 100 and 1000 at currents up to 50 ma (25 w max.). Stability greater than 0.002%/8 hrs., 0.003%/mo.; regulation better than 0.002% line or load. Front-panel current limiter (5 to 50 ma) for protection of test circuits. Temperature coefficient less than 2 ppm/°C. Six-digit resolution with 4 Nixie display tubes, plus individually calibrated taut band meter for remainder of reading—output voltage resolution better than 1 ppm on any range, directly readable on the front panel! Automatic decimal positioning. All solid state for rugged reliability.

Differential Voltmeter: Measures voltages zero to 1000 volts dc, seven ranges. Accuracy 0.01% ±1 μv, independent of null conditions. Greater than 1000 megohms input impedance on most ranges, independent of null. High impedance off null ideal for drift measurements. Temperature coefficient less than 2 ppm/°C. Six-digit resolution with 4 Nixie display tubes plus individually calibrated taut band meter... 5 ppm resolution. Isolated recorder output may be grounded. Floating and guarded input.

High Impedance Electronic Voltmeter: 1% accuracy end scale, 1 μv to 1000 v end scale. Floating and guarded input. Input impedance >1000 megohms on most ranges, never less than 10 megohms.

Amplifier: ±0.01% accuracy with up to 60 db gain—stability better than 0.001%, output up to 50 ma (25 w max.). As voltage amplifier, offering up to 120 db gain at recorder terminals—maximum 1 v output into 1 k ohm load.

Outstanding features of the 740A are exhibited in its performance as a dc standard. Resolution is 1 part per million. Stability is 0.002% per day, 0.003% per month. Repeatability is 0.001%. Temperature coefficient is less than 2 ppm/°C, 10° to 40°C. A unique method of continuously variable current limiting prevents transients from damaging external signals during overload, and a zero control permits compensation for thermal voltages due to external connectors.

Because of the guard which isolates the floating output, common mode rejection of the 740A exceeds 120 db at 60 cps. A standard cell is the only external equipment required for complete field calibration of the 740A, since an internal bridging arrangement is used to ratio match a proprietary hp set of binary coded decade resistive dividers on 1:1 basis, plus critical range resistors, on a 10:1 basis. Calibration takes only a few minutes. A front-panel overload indicator is lighted when the 740A is overloaded or in current limit.

Here is a new instrument so unusual in concept and performance that it must be seen to be appreciated. Why not call your Hewlett-Packard field engineer? He'll put one on your bench for you to try yourself. Or write direct for full data and specifications. Hewlett-Packard Company, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva; Canada: 8270 Mayrand St., Montreal. Data subject to change without notice. Price f.o.b. factory.

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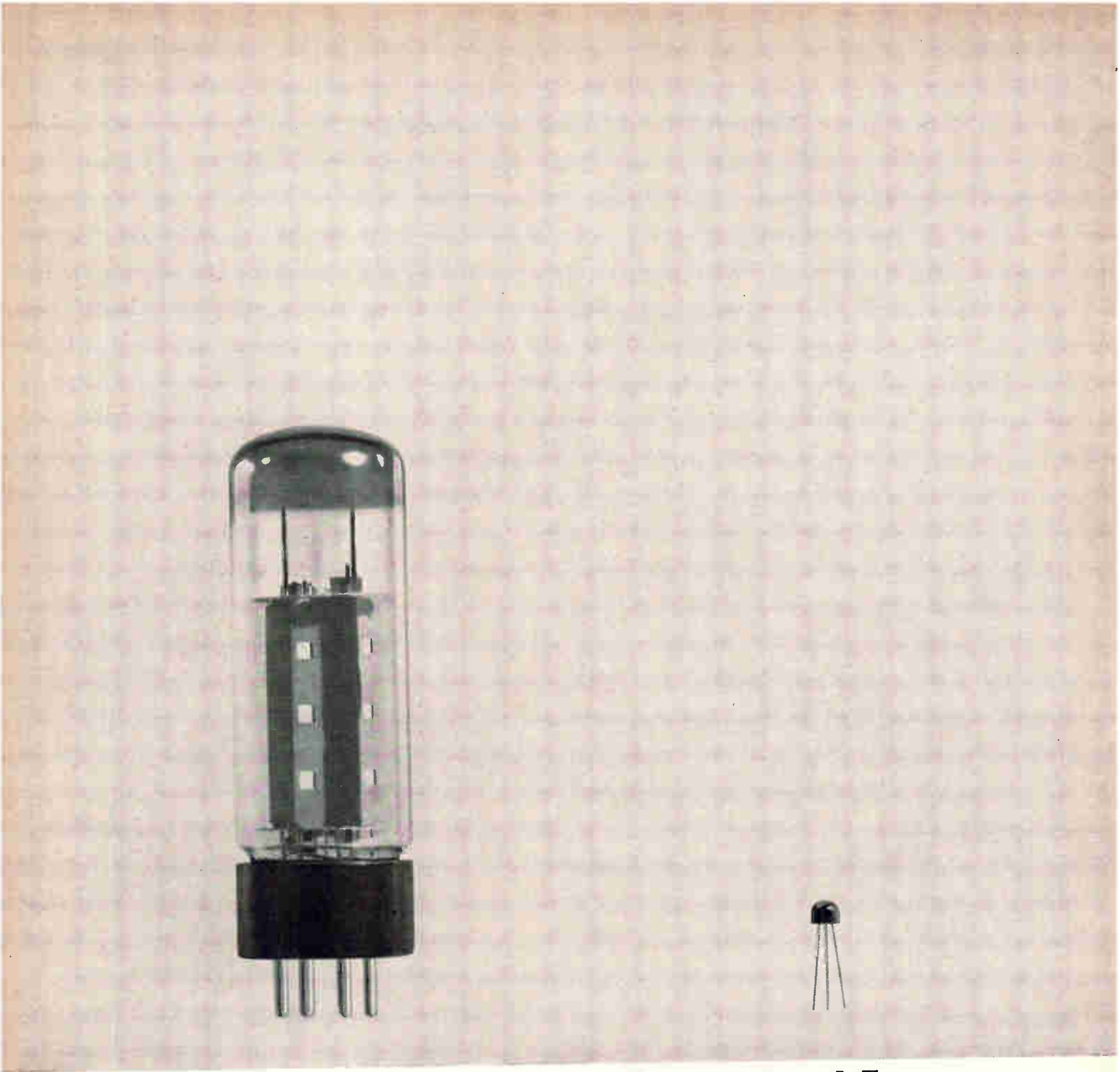

Editorial

Class of '64

This month, at colleges and universities all over America, new engineers are facing their futures with more apprehension and determination than any class in the last decade. To these tyros the future looks a lot different than it did to their recent predecessors. They haven't been courted and wooed like rich debutantes.

More engineers than ever are going on to graduate school. They are aware that the employment outlook is not as bright as it used to be, and that the technology is becoming even more complex. They are looking, wisely, into scientific fundamentals. In fact, the glamor field in college today is pure science. Engineering enrollments are skidding downward.

That's no cause for national alarm, even though the worrywarts were predicting dire consequences because of an engineer shortage just a few years ago. Now it is clear the United States doesn't need as many engineers as had been predicted. Companies are using their engineers more efficiently; there are fewer stockpiles of engineers; and the quantity needed declines as the number of electronics firms shrinks. One source of shrinkage is the increase of mergers and acquisitions among electronics companies (page 91).

More graduates in the Class of '64 are girding to compete for the good jobs, which have become scarcer. Fewer are going to specialize narrowly. Many have already seen the plight of their older colleagues who can no longer market military-oriented specialties. Others are eyeing commercial and industrial-oriented companies because these firms offer a more intriguing challenge: They call on a graduate's breadth of knowledge rather than on one or two narrowly slanted skills.

This year's graduates have learned that the smart operators are looking for broad-gage engineers who can do more than merely design circuits. In company after company, the personnel people are saying, "The man who sat at a board and fiddled with components to build a circuit has had it."

The future seems brightest now for the engineer, young or old, who can visualize the broader system picture. Companies now realize that their engineers must do more than design circuits; they have to understand the customer's application problems, have a feel for the advanced technology and for how and when it might be used in the company's products, and appreciate the limitations of manufacturing processes.

One point seems crystal clear to today's graduates. They have to do some serious long-range planning of their careers. They recognize that the golden era of employment opportunities in electronics engineering is over. They can't job-hop to follow a quick raise or to retaliate for a violation of protocol. The answer adopted by a lot of young men is to decide which part of the electronics field they personally like, then aggressively work their way into it.

Many graduates plan to continue their education informally, keeping up to date in the technology and broadening their know-how in research, product planning and manufacturing.

All this sounds like an impressively mature approach. In fact, a lot of working engineers might well borrow a few pages from the tyro's book. Too many 10-year men are in ruts; they don't read, attend technical meetings, or care about broadening their knowledge. With growth in the electronics industry slowing down, the alternative to personal improvement is simple: technological obsolescence and the possibility of permanent unemployment for the laggard.

If our reading of the June graduates' attitudes is accurate, the Class of '64 will carve out careers that will make their forerunners in electronics blink with admiration.

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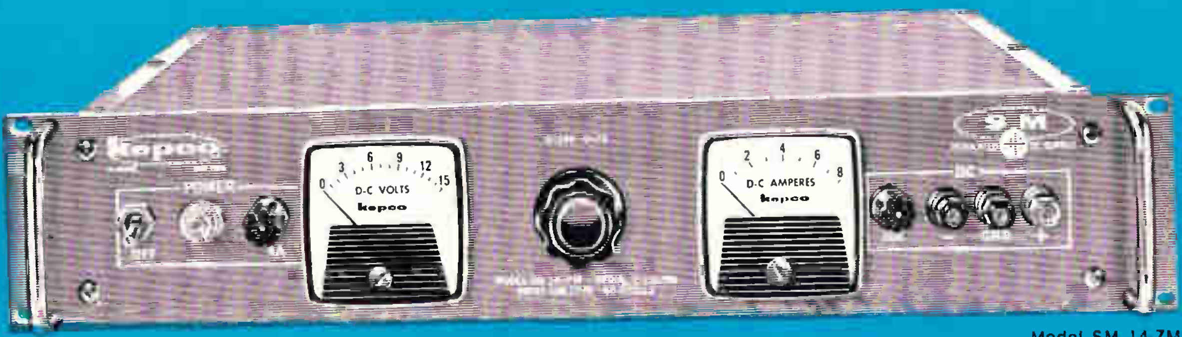

Model SM 14-7M

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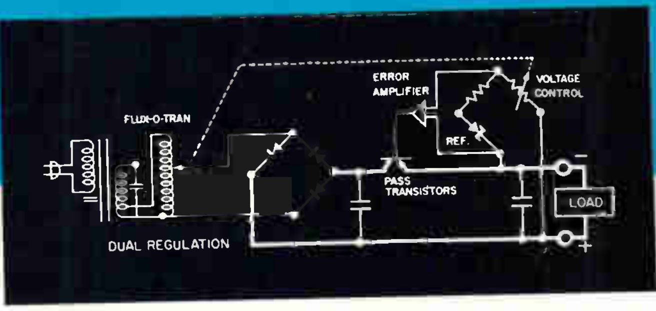

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SM Design Group features:

- **0.01% line and 0.05% load regulation**
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SM 14–30M	0–14	0–30	8¾	19	13⅞	10.5	690.00
SM 36–5M	0–36	0–5	3½	19	13⅞	4.0	375.00
SM 36–10M	0–36	0–10	5¼	19	13⅞	6.5	495.00
SM 36–15M	0–36	0–15	8¾	19	13⅞	10.5	595.00
SM 75–2M	0–75	0–2	3½	19	13⅞	4.0	395.00
SM 75–5M	0–75	0–5	5¼	19	13⅞	6.5	495.00
SM 75–8M	0–75	0–8	8¾	19	13⅞	10.0	595.00
SM 160–1M	0–160	0–1	3½	19	13⅞	3.5	395.00
SM 160–2M	0–160	0–2	5¼	19	13⅞	5.5	495.00
SM 160–4M	0–160	0–4	8¾	19	13⅞	10.5	595.00
SM 325–0.5M	0-165-325	0–0.5	3½	19	13⅞	3.5	415.00
SM 325–1M	0–325	0–1	5¼	19	13⅞	5.0	525.00
SM 325–2M	0–325	0–2	8¾	19	13⅞	11.0	635.00

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Electronics Newsletter

June 29, 1964

EIA paints a rosier picture

Charles F. Horne, who is retiring as the president of the Electronic Industries Association, soft-pedaled the effects of defense cutbacks on the industry, as he gave his annual report at the EIA Convention in Chicago on June 17.

While "discussions of cutbacks have cast a shadow over the industry's outlook for the immediate future," he said, "at present the electronics industry has no reason to be gloomy." The industry's diversity and rapid technical improvement give it a built-in advantage, Horne explained.

Omitted, however, from his speech was this encouraging comment in a printed version: "The impact of (defense) cuts on the electronics industry will probably be the lightest among all the major defense industries."

The association predicts 1964 sales will total a record $16 billion, compared to $15 billion last year, and that all major markets will be up. It expects the declining defense outlay to be offset by higher federal purchases in space, communications and other areas. EIA economists see government buying as relatively static for the next two years, possibly followed by a slight upturn as research and development advance the state of the art. Space electronics and satellite communications business will grow as military aviation electronics decline, EIA predicts.

Horne said industrial electronics will make the largest gain in 1964. Consumer products will make a "healthy rebound" chiefly because color-tv sales of "well over" a million sets should offset declines in monochrome tv sales.

EIA's predictions for 1964 sales are: government, $9.44 billion; consumer, $2.63 billion; industrial, $3.43 billion, and replacement parts, $0.62 billion. The comparable figures for 1963 are $8.94 billion, $2.53 billion, $3.06 billion, and $0.59 billion.

Succeeding Horne as president of the association is Harper Q. North, vice president of research and development for Thompson Ramo Wooldridge, Inc.

New cable speeds calls to Japan

An underwater cable linking Hawaii with Japan was opened June 18. **Overseas operators in Honolulu and North America can now dial any telephone in Japan directly,** and Tokyo operators can dial phones in Hawaii and North America. The new cable ties into the Hawaii-California cable and the British Commonwealth cable in the Pacific.

The $80-million cable has a capacity of 128 voice channels and **can carry data, telephotographs and other specialized services that were impossible with radio circuits.** Bandwidth is inadequate for television, however. The American Telephone and Telegraph Co., the Radio Corp. of America, the Hawaiian Telephone Co. and Kokusai Denshin Denwa, Ltd. jointly own the new system.

Bipartisan nod for solid-state tv

A portable television transmitter, all solid-state and weighing only 14 pounds, has been demonstrated to broadcasters by Microwave Associates, Inc. **It is said to be the first 2-gigacycle solid-state system with frequency stability that can be modulated with a signal approved by** the Federal Communications Commission. A companion receiver, also powered with dry batteries, weighs 23 pounds. The range of the picture and voice combination is about 20 miles.

The device will get its first test this summer at the national political conventions. According to Microwave president Dana Atchley, it could also be used for police surveillance, tunnel and highway control, and bank-to-bank or broker-to-broker links. **Key to the small size is a circuit design using semiconductor varactor diodes.** Frequency range of the units to be used at the national conventions is 1,990 to 2,100 megacycles. The transmitter has seven channels.

Viennese waltzes in f-m stereo

F-m stereo broadcasting will begin in Austria next month from a 99.9-megacycle f-m transmitter on the Kahlenberg, a mountain overlooking Vienna. **The system under test, like that of the United States, uses a 38-kilocycle subcarrier and a pilot frequency of 19 kilocycles.**

The European Broadcasting Union is still studying stereophonic broadcasting. Test results reported to the International Radio Consultative Committee have shown a preference for the pilot-tone system, **a modification of the U. S. system that would reduce the pre-emphasis time constant from 75 to 50 microseconds and eliminate the subsidiary communications authorization channel.** Pre-emphasis reduces inherent system noise and is used in most high-fidelity music transmission or reproduction. The subsidiary channel, when used here, provides for special commercial programs.

FCC studies relief of crowded bands

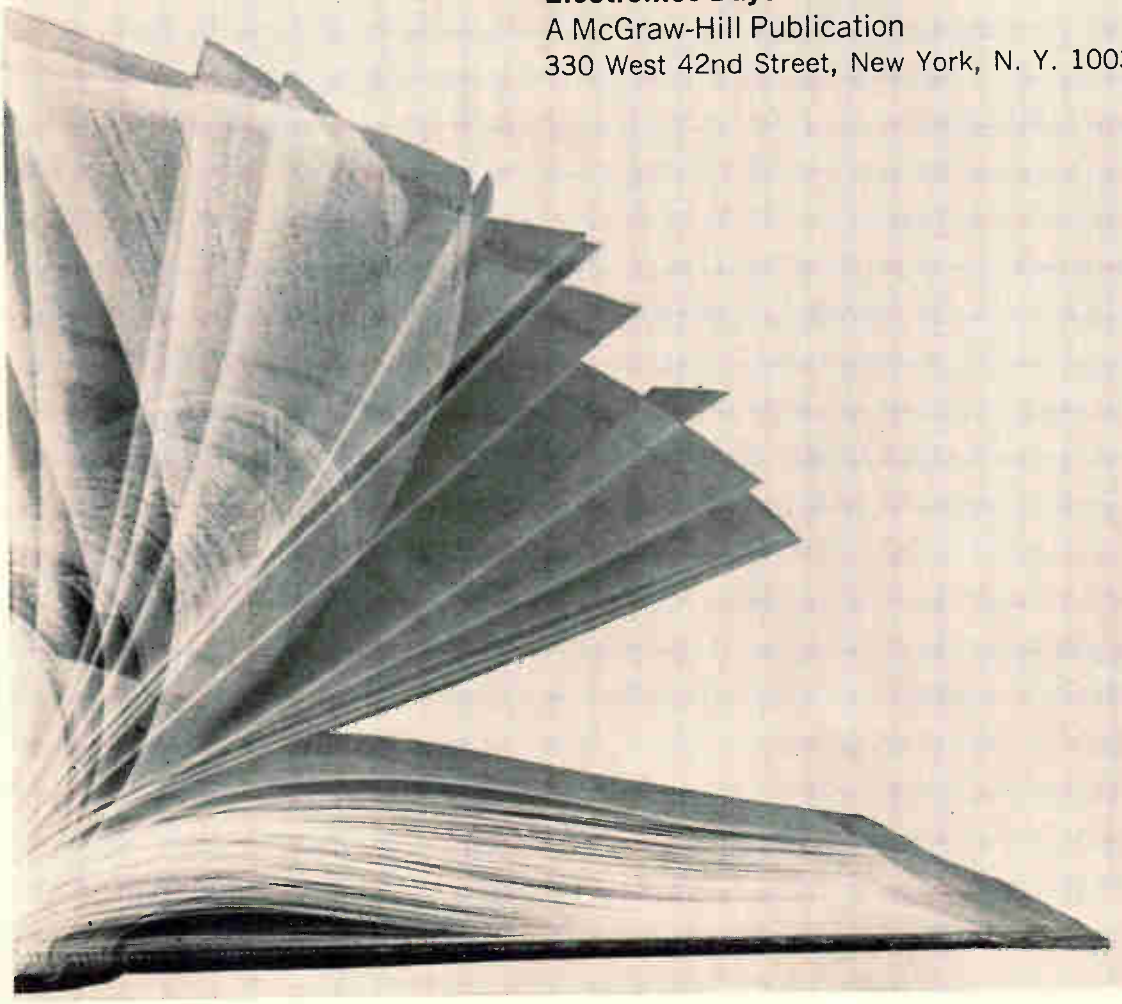
The Federal Communications Commission is sponsoring a three-pronged attack—operational, technical and administrative—on the problem of overcrowded mobile radio bands [Electronics, Apr. 20, 1964, p. 29]. About 150 persons recently attended an FCC-sponsored meeting of the Advisory Committee for Land Mobile Radio Services. From that group, a 25-member steering committee will be chosen, representing licensees, radio-equipment manufacturers, lawyers, engineering consultants, user groups and engineering associations. Other suggested **committees will work on various facets of the problem of mobile radio communications, including multiple-channel access systems, speech compression, and use of base stations by more than one licensee.**

"Spy" that came in from the water

A dead whale found floating in the waters off Sitka, Alaska, June 16 has been a big disappointment to the Central Intelligence Agency. The Soviet harpoon in the whale's back carried a radio transmitter and trailed a radar reflector on a line. CIA agents were all set to fly to Alaska to dissect the whale, but called the trip off—**obviously Russian whalers were just using the equipment to track dead whales.** CIA's last word was "we're interested in any Russian equipment, whatever it is."

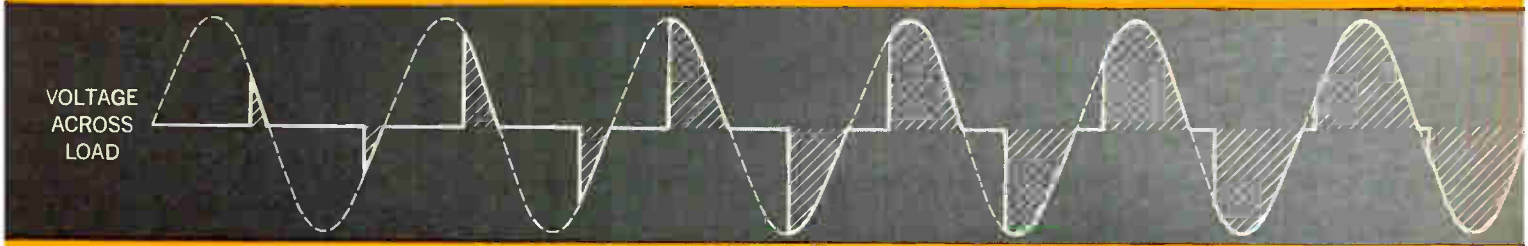
S-band winner

Confirming earlier reports [Electronics, June 15, 1964, p. 34], the Collins Radio Co. has been awarded a $20-million contract to build the unified S-band communications system for the Apollo program.



Here's a low cost, new approach to high power AC phase control which provides today's engineer with broader opportunities in creative circuit design

NOW, A NEW BiSWITCH THAT CONTROLS UP TO 2.5 KW



The newest member of Transitron's BiSwitch family, the 11/16″ stud-mounted TBS40AS, handles up to 20 amperes at 125 volts. It gives direct full-wave AC phase control of 2.5 KW. And no AC to DC converters or variacs are needed. It permits high power control circuitry that is simpler, more reliable and more economical than ever before possible.

All Transitron BiSwitches offer these same advantages in various power ranges. All are available in volume directly from inventory.

3 EASILY MOUNTED PACKAGES

TBS40AS

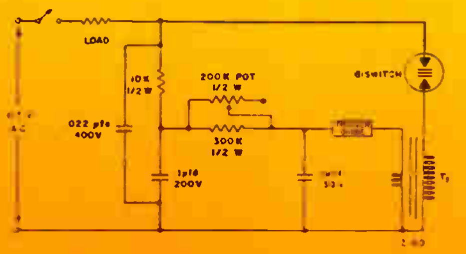
TBS10AS
TBS30AS

TBS20A
TBS20B

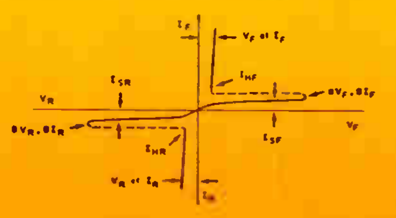
	RATINGS		
	Forward and Reverse Breakover Voltage		Maximum Current Rating 100°C. Temp.
	Min.	Max.	
TBS20A	200	400	5 amp
TBS20B	200	400	3 amp
TBS10AS	90	110	3 amp
TBS30AS	400	600	5 amp
TBS40AS	200	400	20 amp

All types have a maximum storage temperature range of —65° to 175°C.

Companion trigger diode available. ER900 is designed to function with all BiSwitches. Immediately available in volume.



Typical BiSwitch circuit application illustrates how the BiSwitch can be triggered. This basic circuitry may be used in a wide variety of applications.



V-I characteristics show that the BiSwitch blocks voltage in either direction and rapidly switches into conduction by exceeding the breakover voltage.

How can you use the BiSwitch?

In the relatively short time that Transitron's BiSwitch has been available, scores of manufacturers, in a cross-section of industry, have been sampling units. As a result, the BiSwitch is being designed now into many lighting and power products. Whole new areas of power control are being opened up because of the ability of this new solid state device to increase/decrease AC current over a full power range. With the inherent economy and compactness of the device, and with the new high power types now available, the range of applications is broadened tremendously: wall light dimmers, power tools, auditorium, stage, plant and office light controls, air conditioning, washers and dryers, portable heaters.

How can you build the BiSwitch into your products? Our design engineers welcome the opportunity to help you find out. For complete specifications on the BiSwitch family, write: BiSwitch, Transitron, 168 Albion Street, Wakefield, Massachusetts.

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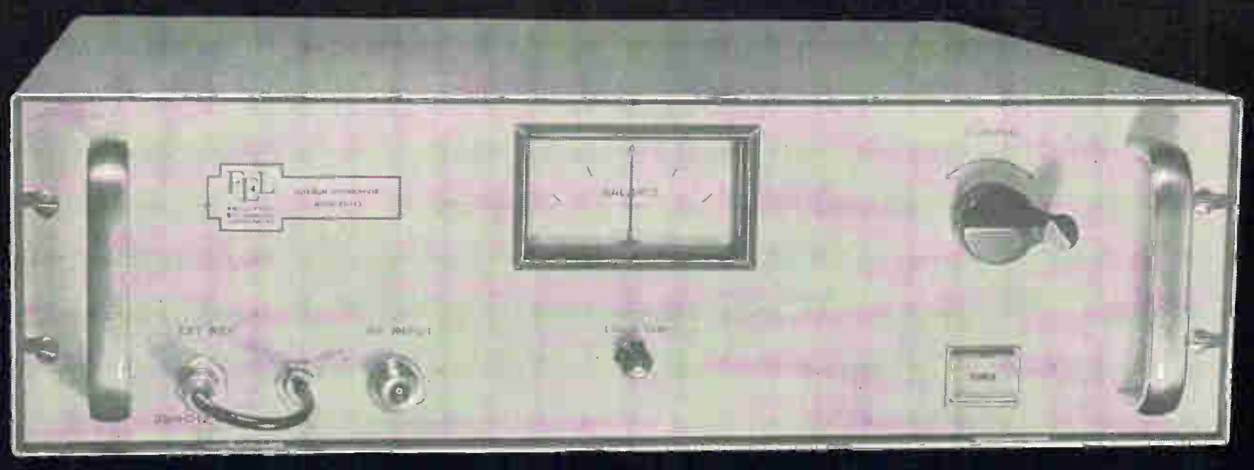


The First Continuously Tunable Solid State Klystron and BWO Synchronizer!

Here, from one of America's foremost creators of instruments for frequency measurement, comes the all-new KS-123—the first **continuously tunable** solid state Synchronizer.

The KS-123 phase locks oscillators within the range 1 Gc - 12.4 Gc to a crystal reference — thus achieving a short term stability of 1 part in 10^8 per second ... or 1 part in 10^6 per day at normal ambient temperature.

And the unit is **continuously tunable** from 2 Gc to 12.4 Gc!

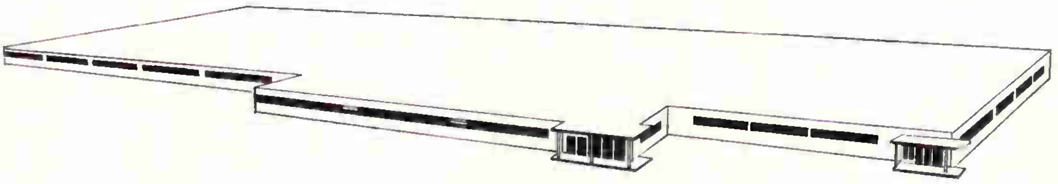
One control adjusts frequency and phase lock. Operation is accomplished with reflector or helix voltages to 5,000 VDC. And the KS-123 is usable as a precision transfer oscillator for frequency measurements to 100 Gc.

It is ideally suited for such applications as microwave frequency standards, doppler systems, MTI techniques, radio astronomy receivers and parametric amplifier pumps.

For complete information on the all-new KS-123, write or call today to **FREQUENCY ENGINEERING LABORATORIES, P. O. Box 527, Farmingdale, New Jersey, (201) 938-9221.**

SPECIFICATIONS

Frequency Range	2 Gc to 12.4 Gc (Usable below 2 Gc)
Tunability	Continuous over full range
Stability	1 part in 10^8 per second 1 part in 10^6 per day (at normal ambient temperature)
Input Power	0 dbm at X-band (greater sensitivity at lower frequencies)
RF Reference	Quartz Crystal
IF Reference	28 mc Crystal
Reflector or Helix Voltage	to 5000 V dc
External Reference (to replace internal reference source)	35 mc to 12.4 Gc (front panel connection)
Phase Detector Sensitivity	20 V dc per radian
Power Requirements	115 V, 60 cps, approx. 20 W
Dimensions	19 x 18 x 5¼ inches
Weight	Approx. 20 pounds
Price	$1,930. Continuously Tunable (Kly. & BWO) $1,750. Continuously Tunable (Kly. only) $1,375. Non-Tunable (Kly. only)



First in Frequency Control

A DIVISION OF HARVARD INDUSTRIES, INC.

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June 29, 1964

Electronics Review

Volume 37
Number 19

First automated freighter

Electronic control of the boiler rooms of iron-ore freighters on the Great Lakes may yet rescue their owners from the pounding they've been taking from foreign-ore carriers. The floundering fleet has gone from 256 ships in 1958 to only 178 still plying the Great Lakes.

The big steel companies have been using foreign ships to bring ore to East Coast ports. From there it goes by rail to the steel mills based on the Great Lakes. American carriers are completely bypassed.

Rescue ship? Early this month the picture brightened. The S. S. William G. Mather became the first U. S. freighter to be certified by the Coast Guard for operation without a fireman on watch.

The 39-year old Mather, a 592-foot-long, 13,400-gross-ton ore ship had been refitted with electronically controlled boiler and burner systems and was ready to show its stuff.

Owners of ore-carriers are hoping that electronic controls will result in reduced crews and lower operating costs. The performance of the Mather may determine how new freighters will be built and whether other old freighters will be automated.

No subsidy. There is no apparent federal subsidy for Great Lakes shipping. But, last December, the owner of the Mather, the Cleveland-Cliffs Iron Co. signed a contract calling for the U. S. Maritime Commission to fund the experiment in automated shipping.

The Bailey Meter Co., a subsidiary of Babcock & Wilcox Co. signed a subcontract to supply the analog boiler and digital burner control systems. The experiment worked.

A major reason for the Maritime Commission's willingness to sign the contract was the Babcock & Wilcox unitized plant concept—one boiler to one turbine to propel the ship. All other Great Lake freighters and ocean-going cargo ships use two boilers per turbine, and the problem of electronic control is more than doubled. The Mather has a unitized plant.

Certification. When the Coast Guard certified the Mather for operation without a fireman on watch, John S. Wilbur, senior vice president of Cleveland-Cliffs said this meant the Mather's standing watch would consist of only one man in the engine room to supervise the boiler control. Wilbur pointed out that a one-man watch on new ore-carriers would represent a saving of $30,000 per year and $1 million over a 35-year lifetime.

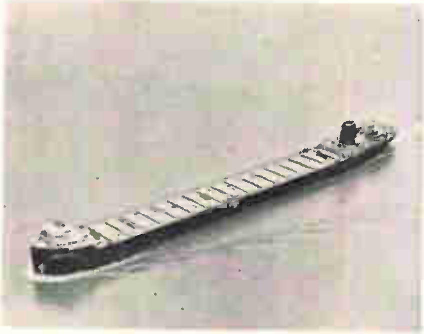
Electronic control. The boiler and burner system includes a two-element wide-range combustion system and a feedwater control system. The burners are monitored and controlled by a Bailey 760 digital control system.

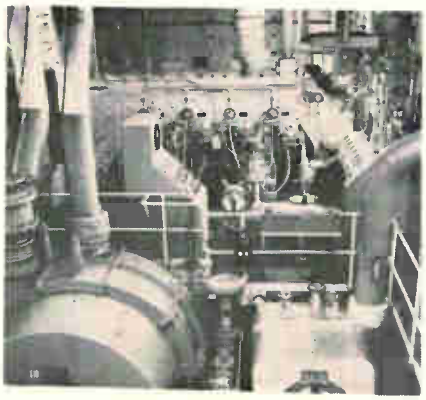
During normal operations only one adjustment is made by the watch engineer, that of turbine shaft-speed control. Analog, automatic pressure, temperature and liquid-level regulating devices carry out all the necessary control functions on the boiler.

The burner control automatically corrects any malfunction that might be dangerous—for example, a burner might go out while fuel oil was still flowing into the boiler. The system also controls start-up and shutdown of the four burners. The biggest advantage of automating the burner, in addition to saving money, is the safeguard against explosions.

Problems. There is still stormy weather ahead for the ore-freighters. Cleveland-Cliffs admit that without the funding from the Maritime Commission the system wouldn't have been installed. The cost of electronic control, pegged at $80,000 to $95,000 is too high for any Great Lakes shipowner. But, if further evaluation of the systems is favorable, Cleveland-Cliffs says it might automate the other nine ships in its fleet.

As things stand now, the big market for electronic control of freighters is still the trans-oceanic cargo ships. The first ocean-going cargo carriers using electronics are due out this fall.





S.S. Mather needs only one man in the engine room to supervise the boiler control.

Advanced technology

Devices that learn

The Astrionics division of the Aerojet-General Corp. has launched a large-scale effort to develop practical electrooptical adaptive machines that can learn and distinguish quickly between differing optical input patterns. One laboratory machine, known as the ADAPT I, uses a 25-cell mosaic as the input device and includes an automatic adjustment of "weighting" devices. It will be followed shortly by a more sophisticated model, with a substantially larger mosaic, that will make use of new solid-state adaptive elements.

The present mosaic consists of a five-by-five array of silicon light-sensitive cells. Follow-on models will likely have similar cells vacuum-deposited as integral units with the adaptive elements. Adaptive element packing densities are expected to be on the order of from 100 to 1,000 times greater than earlier elements such as wire-wound devices. Adaptive speed would be about 100 times faster than nonsolid-state devices.

High-vacuum technique. Fabrication of the new element—in essence a combined pre-processor and post-processor—will probably be accomplished in the company's automated high-vacuum (10^{-11} torr) chamber for deposition of thin films [Electronics, May 4, 1964, p. 36].

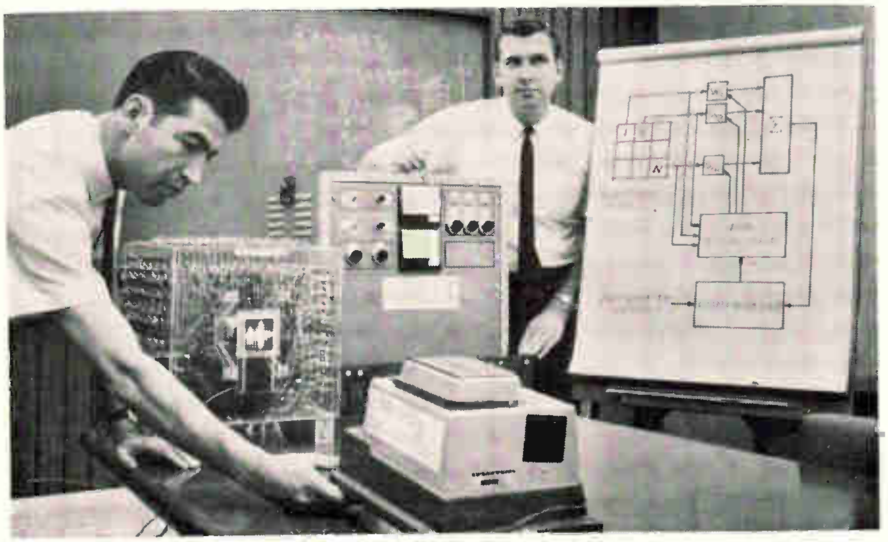
Khalil Seyrafi, project manager, says that theoretically 250,000 or more optical input devices might eventually be used in machines designed to track contrast patterns and high production capabilities would be essential.

He reports that another machine, using a conventional vidicon tv camera as its input device, is under development. It will be used to determine the maximum output of future mosaic machines. Scanning a 500-line raster, each with a resolution of approximately 500 points, this machine will simulate one having a 250,000-cell mosaic input.

Better memory. Seyrafi also states that the company's recently evolved easy-access non-destructive memory has a recollection time of 200 to 300 hours. Previous high-leakage elements had memory times of roughly twenty minutes.

The three major problems associated with all optical recognition machines now being developed are rotation, translation, and scaling (change in size) of the received image. A possible solution to the rotation problem, and one which Aerojet is examining, is the incorporation of concentrically mounted sensing cells within the mosaic.

EKG analysis. The family of machines which Aerojet foresees will be flexible, Seyrafi adds. The input source need not be optical. Any set of parallel signals can be used with a parallel system, and any sequenced or repeating signal can be used with a sequential system. Sonar recognition capabilities and electrocardiogram analysis are two possible applications.



Lab model of adaptive machine. Schematic shows hookup of detector mosaic (left), adaptive elements, job assigner and comparator (top to bottom, center) and summation unit. Comparator checks desired output against output from summation unit.

Words tell the story

Scientists from the Librascope Group of the General Precision Equipment Corp., Glendale, Calif. are trying to sell the National Aeronautics and Space Administration's Manned Spacecraft Center in Houston on a speech recognition and speech compression program which they have developed by listening to tapes of an astronaut's entire flight.

By analyzing the words used under certain patterns of stress, scientists hope to understand a man's reactions to the varying environmental conditions on a 14-day space flight.

The goal of the project, funded so far by Librascope and several study contracts, is to get information about an astronaut during a flight on a real-time basis. In this way, a medical officer on the ground could aid a pilot in trouble by administering drugs, talking to him, playing music, or directing a machine to take over his function while he sleeps.

'Wake up!' "We don't talk about it, but it's true, in an all-day flight a man might get sluggish and even die if those controlling his environment did not recognize it and order him to get up, exercise and be ready to reenter the atmosphere," says Dr. Merle Cross, a Librascope scientist on the project.

The computer used in the project examines a tape to classify the numbers of words, words used, intensity of use, grammar, endings and adjectives. This information is then combined with electrocardiogram and other body measurements obtained from vocal evidence.

While in Houston, the Librascope people will talk to Astronaut Walter Schirra, for his recollections of his own four-hour flight. Tapes from Schirra's flight were used in the initial work.

The real meaning? The new diagnostic technique might be used by the State Department to determine a speaker's state of mind during an anti-American tirade or to analyze the voices of important political figures like Nikita Khrushchev or Charles deGaulle.

Consumer electronics

Faithful sound

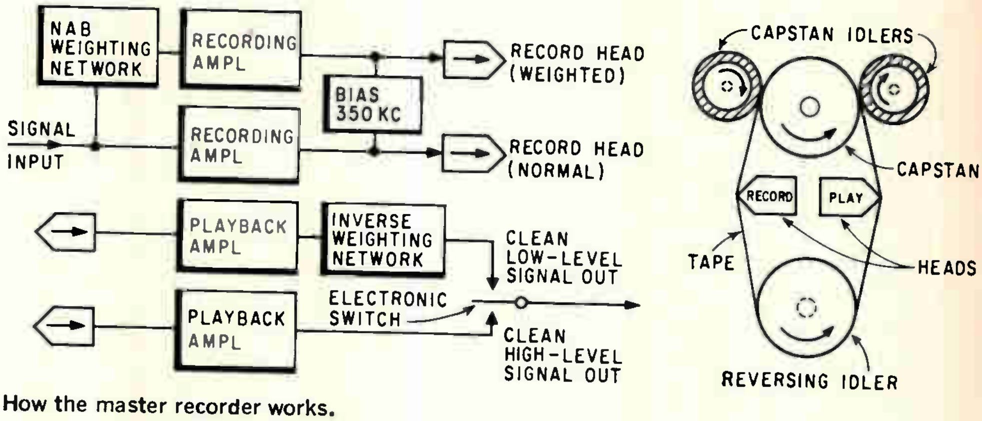
A recorder, designed by the Minnesota Mining and Manufacturing Co. has increased the dynamic range of high-fidelity recordings by at least 15 decibels, according to Kenneth Clunnis, supervising engineer of the company's audio master recording department. Records produced from the master recordings are capable of signal-to-noise ratio of 76 decibels with less than 3% harmonic distortion, he added.

The company has applied some of the techniques developed for nonconsumer tape recorders to master recording machines. The machines have remained basically unchanged for 15 years.

Track switching. The performance is recorded simultaneously on two tracks. On one track, signals are recorded conventionally. On the other, they are equalized according to the National Association of Broadcasters' standard weighting curve and attenuated 15 decibels. The weighting curve applies necessary cut or fill to the amplifier response, particularly on the high-frequency portions, so that high-frequency tape noise is given minimum amplification.

After recording, the tracks are played back for reproduction through one of two amplifiers. One amplifier has a conventional response. The response of the other is inverse to that of the specially weighted recording track. When a signal from the normal track reaches 1% harmonic distortion at any frequency, a switchover permits playback from the specially equalized track. In this way, recorded signals whose peak levels are high enough to cause distortion are avoided, permitting clean signals on the low-level channel to feed the output amplifier. That amplifier provides compensation that brings the signal back to the original average level.

The switching action is triggered by a self-contained analyzer that energizes a light source when it detects excess distortion. A photoresistor, connected in an electronic bridge, senses the light source. The addition of the light changes the value of resistance, unbalancing the bridge and actuating a relay that switches the playback amplifier to the other track. The switch from one track to the other takes place in about one millisecond—a speed sufficient to reproduce, without distortion, the sudden crashing of cymbals, playing of a piccolo, or screaming of a Beatle fan.



How the master recorder works.

Tape transport. The tape transport, derived from its counter-parts that were developed for digital instrumentation, has a large, low-rpm capstan, specially filtered and driven by a synchronous motor. The tape is fed to, and extracted from, a small loop at a constant velocity. Scrape flutter is minimized by keeping the free path of tape as short as possible as it passes over the recorder and playback heads. A tapered capstan permits tape tension sufficient to maintain contact between the tape and the heads, without other mechanical devices.

Computers

The groups

The Institute of Electrical and Electronics Engineers—quite a mouthful in itself—has taken a step toward reducing the verbiage in its subdivisions' titles. From now on, the Professional Technical Groups will be known simply as Groups, despite objections of some members that a "group" sounds smaller than a "chapter" and more like "a small number of girls from Vassar."

However, the remainder of the title should remove any confusion.

One of the units with a truncated name is the new IEEE Computer Group, formed recently by a merger of IEEE's Professional Technical Group on Electronic Computers with the American Institute of Electrical Engineer's Computing Devices Committee.

For simplicity's sake. Adding to the semantic confusion is the desire of the Computer Group to be known as a Society, specifically as the Society for Computer Sciences, which it will become if the group's new constitution, as yet unsubmitted, is approved by IEEE. But odds are against approval.

The new organization will combine the 10,000 members of the two dozen IEEE PTGEC chapters and the several hundred members of the AIEE CDC. . . . in the interest of simplicity, of course.

Fastest computer?

The LC-820, said to be the fastest computer ever built for aircraft and spacecraft, has been delivered to the Air Force by Litton Industries, Inc.

The computer can perform more than 30 million additions or subtractions a minute. It reportedly makes possible a completely integrated flight-control system for high-performance aircraft.

In space flight, it is designed to perform such tasks as boost cutoff, orbit injection, hypersonic air-data analysis, management of reentry energy and path control through the atmosphere. The computer also controls the inertial navigation platform during alignment and flight.

The LC-820, now scheduled for testing by the Air Force, attains its high computing speeds by using two separate random-access core memories with a total of 177,000 bits. Most of the memory is taken up by about 6,000 instructions that provide the sequence of operations for the computer. These are two-operation instructions, such as add-and-multiply or store-and-transfer. The program memory can be increased to 30,000 dual instructions.

Space electronics

No satellite for sailors

Potential users of navigational satellite systems gathered in New York at the June 16 meeting of the Institute of Navigation to consider whether such system designs met their needs. The answer, after a lively debate that ran overtime, was no.

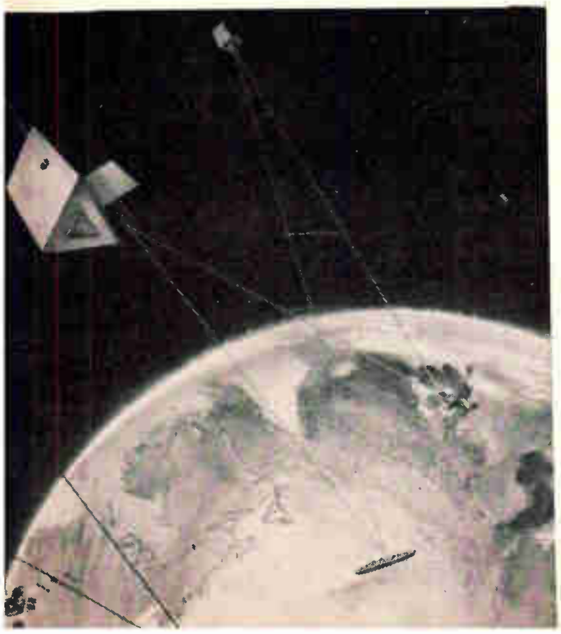
Guest panelists were joined by members of the institute in concluding that a navigational satellite system provided only marginal advantages and would cost too much.

Representatives from the Air Transport Association and the Federal Aviation Agency said that communications and air traffic control needs were more pressing than those of navigation. They argued that computers and doppler navigation gear do a satellite system's job for less money.

Different needs. The seafaring navigators in the Maritime Administration, Coast Guard, Defense Department and others were equally reluctant to endorse a $20-million to $30-million satellite system when a comparable earth-based system costs from $2 million to $5 million. The only advantage, said one speaker, would be to give all navigation information to all navigators—and the desirability of this was questionable. For one thing, foreign vessels might not be willing to report their locations to a United States authority. One panel member suggested that such a satellite system might lend itself to subscriber charges. On a pay-as-you-go basis, each navigational fix might cost 50¢.

The major disadvantage seemed to be the varied requirements. The Defense Department, for example, would require a jam-proof, passive system with ground stations on U.S. soil. Nonmilitary interests would prefer a cooperative system that would be available to everyone.

This system would use 24 satellites to help ships and aircraft pinpoint their positions. Proposed by General Electric Co., it is one being studied by the National Aeronautics and Space Administration.



Microelectronics

Improving the package

Producers of microcircuits are intensifying their search for cheaper reliable packaging. One official declares that market gains from now on will depend as much on improved packaging as on advances in circuitry.

There's disagreement on whether cheaper packaging, such as simply coating the circuit, can provide good enough hermetic seals for high-reliability military applications, but the industry seems in agreement that the seals will be practical for commercial purposes.

Target: computers. One company expects better packaging to bring nearly all integrated circuits into the $1 to $2 price range, where they will be economical enough for use in commercial computers. It expects to be selling circuits in production quantities for commercial computers by 1966.

The semiconductor division of the Fairchild Camera & Instrument Corp. is life-testing silicon monolithic circuits sealed in plastic. Fairchild thinks the method may cut its direct materials cost by 10 to 15 cents per circuit, and be satisfactory for small systems of the complexity of a desk calculator, for example.

Circuits in glass. An improved technique for packaging circuits in glass has been developed by the Signetics Corp. Signetics says it's now feasible to put as many as 20 circuits into a single package, probably shaped like present flatpacks [Electronics, Jan. 17, 1964, p. 52], and the company is putting the final touches on techniques that will permit tooling up for production. It expects to be able to produce circuits to military requirements by using a "whole new interconnection method" that eliminates the gold leads inside present packages, as well as some of the external connections. The technique, probably using metal film interconnections sealed into the glass, can be used either for individual circuits or for an entire subsystem such as a decoder or shift register.

The semiconductor division of the Hoffman Electronics Corp. is experimenting with glass packaging, not only for microcircuits but for solar cells and discrete semiconductor components such as silicon controlled rectifiers. The firm says its process involves depositing a thermomechanically compatible glass film on top of a silicon monolithic circuit passivated with silicon dioxide.

Epoxy, too. Systems people also are working on the problem at the Autonetics division of North Amer-

ABRIDGED DATA									
Code	Base	Heater		Delay Time at 20 C (sec)		Contact Ratings on make			
						a.c.		d.c.	
		V	A	Min	Max	V	A	V	A
DLS10	B4	4·0	1·5	30	90	250 1 000	5·0 0·2		
DLS15	B4	4·0	0·75						
DLS16	10-8	6·3	0·48	30	90	240 1 000	5·0 1·0		
DLS22	10-8	2·5	1·0						
S45C/1D	Small wafer octal	6·3	1·0	35	50	250	5·0	250	3·0
S102/1K	B7G								
VLS631		6·3	0·5	44	66	100	1·0	220	0·5
S102/1G	B7G/F								
S103/1K	B7G	27	0·115	36	54				
S104/1K	B7G	6·3	0·5	25	35				
S105/1K	B7G	27	0·115	20	30				
S106/1K	B7G	19	0·165	40	66	100	1·0	220	0·5
S107/1K	B7G	6·3	0·5	8	15				
S108/1K	B7G	24	0·13	36	46				
S109/1K	B7G	6·3	0·5	72	98				
S104/2K S204/2K	B7G	6·3	0·5	25	35	250	1·0	250	0·5
SS110/1D	Small wafer octal	6·3*	0·5*	90*	110*	100	1·0	220	0·5
	*per section								

Thermal Delay Switches

STC manufacture an extensive range of reliable and inexpensive switches which afford a choice of heater voltages, delay times and contact ratings, as shown in the table above. Recent additions to the STC range include type S45C/1D, a snap action single pole changeover switch and type SS110/1D which consists of two mechanically separate switches in a common envelope. Thermal delay switches are particularly suitable for delaying the application of h.t. voltage to electronic tubes which require a pre-heat time; they may be used also for switching 3-phase circuits from star to delta arrangements for induction motor starting and for automatically re-closing a circuit breaker after a temporary current surge has caused it to trip. These applications are fully described in booklet MS/117 available on request from Standard Telephones and Cables Limited, Valve Division, Brixham Road, Paignton, Devon. USA enquiries for price and delivery to ITT Components Division, P.O. Box 412, Clifton, N.J.

STANDARD TELEPHONES AND CABLES LIMITED
Subsidiary of International Telephone and Telegraph Corporation

ITT

Circle 27 on reader service card

ican Aviation, Inc., and at Litton Industries, Inc. Since September, Autonetics has been testing silicon integrated circuits that are passivated with silicon dioxide and then covered with an opaque epoxy. Satisfactory performance has been reported.

Litton's Guidance and Control Systems division has used thin-film circuits potted with epoxy in the ASN-44 inertial navigation unit. Litton engineers say that by "fiddling" with the vacuum deposition they have made capacitor dielectrics that are relatively insensitive to moisture. Moisture resistance in capacitors can also be increased by using nonhydroscopic dielectrics such as sapphire, they add.

Moisture and heat can damage circuits cased in plastic; that's why many people shy away from plastic. Others, however, are experimenting with plastic on top of some improved material for the initial passivation. Deposition of alumina borosilicate from the vapor phase is one technique being studied.

Military electronics

Integrated avionics

Action has been taken on one of the Navy's big avionics projects and is imminent on another. Three contractors have been selected to begin project definition phase studies on the Integrated Light Attack Avionics System (ILAAS) and a development contract is about to be awarded for the Integrated Helicopter Avionics System (IHAS).

First step. The three contractors for the attack plane system are the Remington Rand division of the Sperry Rand Corp., A.C. Spark Plug division of the General Motors Corp., and Autonetics division of North American Aviation, Inc. Each company will evolve a plan that defines precisely—for government and industry alike—what is wanted, how it is to be designed and built, how it will be used, what it will cost, and how the program is to be managed. Fixed milestones, goals and schedules will be drawn up.

The aim of the studies is to identify high risk areas, to come up with more realistic specifications, to reduce chances of a project's being cancelled once begun, and to lessen overruns and technical changes during the development-production cycle.

The studies will last about nine months and will lead to a development contract. If the equipment is ready in time, it may be used for VAL, the Navy's new light attack aircraft. If not, it will go in the Navy's follow-on to VAL, the VAX.

Helicopter system. The award for the development of an avionics system for helicopters will go to one of the three project definition phase contractors who finished their studies in March. These were Texas Instruments, Inc., Nortronics division of the Northrop Corp., and Teledyne Systems, Inc. The first completed IHAS will go into the Marines' attack/transport helicopter, the CH-53A.

The purpose of the multimillion dollar projects [Electronics, Feb. 28, 1964, p. 43] is to integrate all the avionics equipment. Acquired data will be fed into a computer, thus allowing the pilot and copilot to operate the whole system. Microelectronics, digital processing, and lightweight inertial navigation systems will be incorporated in the system to increase its effectiveness. High reliability and maintainability will be demanded.

Sensors for the helicopter system include communications, navigation, Identification Friend or Foe (IFF), terrain-following radar, and station keeping equipment that will enable a pilot to maintain relative position to the other planes in his formation. Sensors for the light attack plane system include those for the helicopter system plus a bomb-navigation radar.

Both the helicopter and attack plane systems will be studied by all the armed services when the equipment has been built.

And another one. A third avionics project that will get under way in five or six months is the Integrated Advanced Avionics for Aircraft (IAAA)—an effort that will derive from, and eventually be used in, the light attack plane system. The purpose of IAAA is to examine new technology to determine its usefulness to the phased integration program.

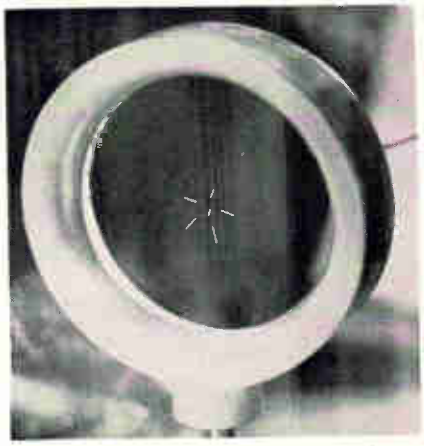
Components

Particle reference

An all-electronic guidance system with no moving mechanical parts may be the ultimate application of a technique developed at Martin Orlando Research Center. Scientists there have demonstrated that macroscopic charged particles—ranging from 2.5 to 250 microns in diameter—suspended by a low-voltage balancing field in an evacuated chamber can be used to measure deviations or linear displacements.

In a typical system, a small lamp illuminates the particles, and any change in their position is detected optically by photocells. The optical-error signals are amplified and applied to a servo system controlling the field, so as to maintain the particles at a null position. The nulling voltages serve as output signals for readout or control.

Ignores its surroundings. So far, the particle reference device shows virtual immunity to external en-



Oscillating particles in electrostatic field provide new inertial sensing technique.

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vironment. Stability is apparently unaffected by temperature, vacuum or pressure, or even by laboratory levels of nuclear radiation.

Martin researchers say the device shows particular promise as a three-axis accelerometer, capable of sensing acceleration along three axes simultaneously. Its excellent performance characteristics in this application are derived from the isolation of the proof mass from thermal, frictional and electrical aberrations encountered by more conventional sensors. Another major advantage is that the sensitivity can be adjusted over a wide range: from 0.1 volts per g to 30 volts per g, and the range extended to ± 100 g or more.

Other potential applications for the particle reference sensor are in gravimeters and gyros. In the latter, the charged particle is placed in a field that is so shaped as to cause the particle to rotate synchronously in a circular orbit with predetermined center radius and orbital velocity. The plane of the orbit is used as an angular reference, monitored by optical or electrostatic pickoffs to provide angular rate sensing.

Communications

Military message satellite

The military plans to experiment with its own communications satellite early next year. The program includes a mobile terminal now being prepared.

The Lincoln Experimental Satellite (LES) is being built for the Defense Department at the Lincoln Laboratory of the Massachusetts Institute of Technology. It's to be a relatively light, inexpensive, special-purpose device. If present plans work out, LES will be launched by a Titan III rocket, go into a quasi-synchronous equatorial orbit, and drift so slowly that it will be in sight of two ground stations for weeks at a time.

The X-band satellite will use a solid-state transponder and new switching techniques. A sensing device will determine the satellite's orientation with respect to the earth, and the sensor's output will enable two single-pole, four-throw diode switches to connect the appropriate antenna to the receiver and transmitter through a diplexer.

It will have a surface configuration of square and triangular panels. The squares will be studded with solar cells for power, and the triangles will hold clusters of horn antennas—a total of 32. LES will transmit right-hand circularly polarized signals at 7,750 megacycles and left-hand signals at 8,350 megacycles.

A rolling receiver. By the time LES is ready for launch, the Lincoln lab also expects to have a mobile terminal ready to transmit and receive via satellites. The trailer would contain closed-cycle cryogenics for masers and parametric amplifiers, and new solid-state equipment for modulation and signal processing. The terminal also is expected to be used in experiments with Project West Ford's tuned dipoles which are still in orbit.

Also due for completion early next year is Haystack, the lab's 120-foot antenna in Tyngsboro, Mass., believed to be the most precise large movable antenna ever built [Electronics, Nov. 9, 1962, p. 49]. Radiometry measurements on the antenna are scheduled to start early in July. Haystack is expected to cost the Air Force $15 million to $18 million, rather than the $10 million originally planned; its new target date for completion is 1½ years later than the original goal.

When LES, Haystack and the mobile terminals are ready, look for a dramatic demonstration of the armed forces' ability to contact units anywhere in the world.

Electronics abroad

Japanese exports

More new products from Japanese electronics companies will probably go on sales in the United States as a result of recent changes in Japanese export laws. Paradoxically, the changes stem from Japan's discontinuance of export subsidies to its manufacturers. This is expected to encourage manufacturers to increase their exports and to look to increased volume to offset lower per-unit profit.

The subsidies, in effect since August, 1953, were in violation of the General Agreement on Tariffs and Trade.

The subsidies were in the form of deductions on corporate income taxes. They allowed trading companies to deduct 1% of the value of export sales. Manufacturers could deduct 3% and plant exporters could deduct 5%.

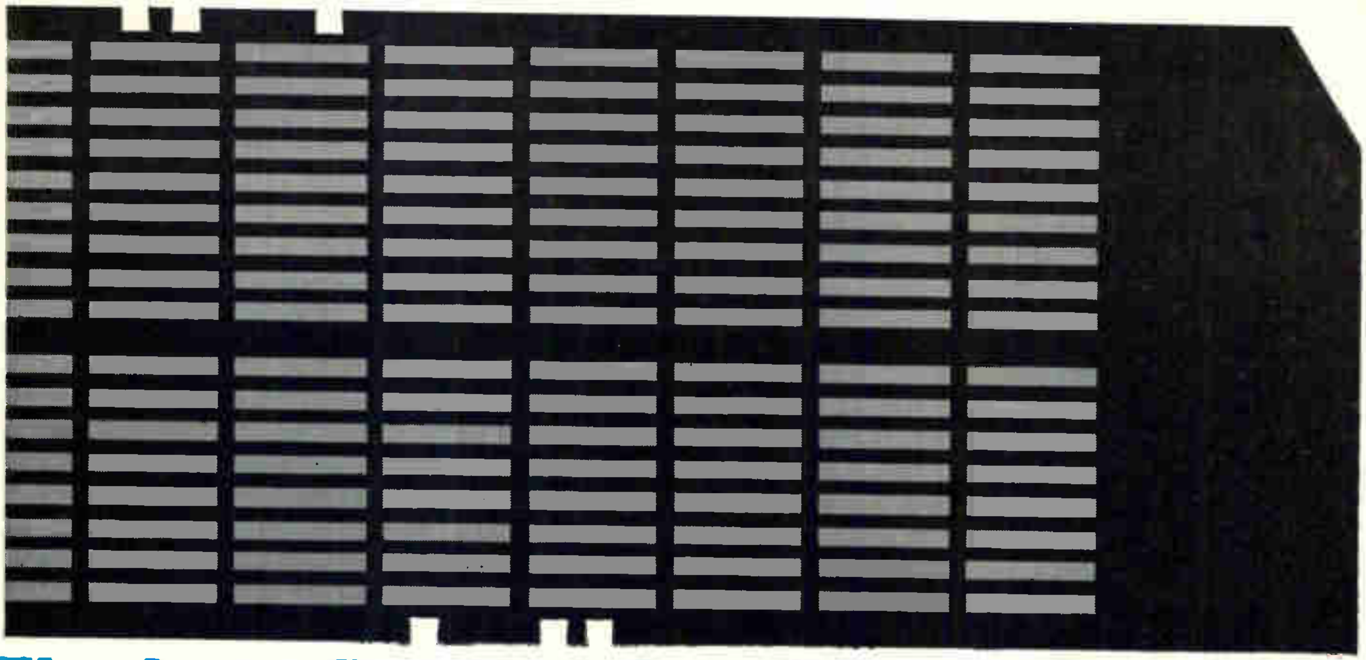
Sony's net slips. An example is the Sony Corp. During its fiscal half-year that ended April 30, there was one month in which it didn't receive export-subsidy tax deductions. During this period, Sony's sales increased 3.7% and profit before taxes rose by almost the same amount, but profit after taxes fell 1.5% because of a loss of the tax exemption for April, which would have been about $81,000.

Japanese manufacturers cannot divert products to the domestic market because it is not large enough. To get around the profit squeeze, many companies have been paring operating costs. One method has been to increase mechanization, which also boosts capacity, and compels them to push exports.

One downsmanship

Less than one week after Sony Corp. hailed its four-inch transistor television set as the smallest in the world, a three-inch set was shown in Japan by the Standard Radio Corp. Standard's set will make its American debut at the Music Show in Chicago at the end of this month. Sales here are scheduled to start the end of August.

About half of the initial production of 1,000 sets a month will be exported. The export version has a built-in uhf tuner. The export price has not been set but the domestic price will be about $110.



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These improvements, coupled with proven Moseley quality and precision, make the Model 7000A the most advanced X-Y recorder available today. Available, too, is the companion model 7030A, same as 7000A but accepts paper to 8½" x 11", without ac inputs. Model 7000A, $2575; Model 7030A, $1795. Call your Moseley / Hewlett-Packard field engineer or write: F. L. MOSELEY CO., 433 N. Fair Oaks Ave., Pasadena, Calif. 91102.

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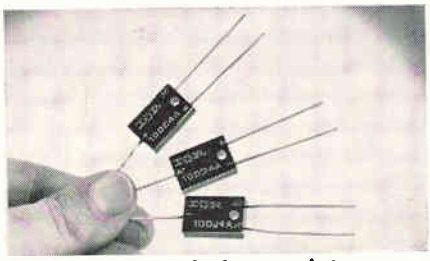
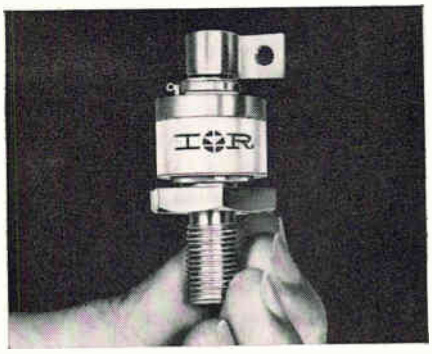
Troubled with voltage spikes in your ac or dc circuits? Install IR's 35 ampere (55 ampere RMS) epitaxial SCR's. They're designed to handle non-repetitive surges up to 700 amperes and have built-in protection against high transient voltages. This new series is rated for 600 to 1300 volts PRV. Write for Bulletin SR-361.

You'll be glad to learn we've got a variety of special parameter 16 ampere SCR devices for those problem-child circuits . . . 200 and 250 PRV units featuring maximum turn-off time of 12 microseconds, reverse recovery not exceeding 3 microseconds and gate recovery under 11.8 microseconds. 600, 700 and 800 volt PRV (2N690, 691, 692) SCR's have been added to that popular 2N681-689 series. Write for Bulletins SR-351 and SR-366.



Pack 'em in Like Sardines!

These 70 ampere SCR's feature flag terminals for closely packed circuitry. Although they measure less than 1¾" above the seating plane, they span a wide, wide voltage range. Diffused alloy SCR's range from 25 to 800 volts, epitaxial types from 600 to 1300. One epitaxial series provides specified maximum reverse avalanche voltage. We'll be glad to help you decide where they'll fit comfortably in your circuitry. Just ask!



To "Cram a Barrel of Power into a Thimble," Rely on IR High Voltage Technology

Each miniaturized device shown above replaces several rectifier devices in applications calling for positive or negative output, full wave center taps and OR gates. PRV ranges from 200 to 2000 volts, 350 to 2600 transient. Current ratings, at 50° C ambient, reach 1.8 ampere. They combine nicely in single-phase bridge or polyphase rectifier circuits.

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Our extremely compact, large output single-phase, full wave bridge rectifiers each perform functions that once required four individual diodes. Rated from 200 to 1000 volts PRV (350 to 1250 transient), they put out as much as 1.8 ampere average dc. Write for Bulletins SR-232-235.

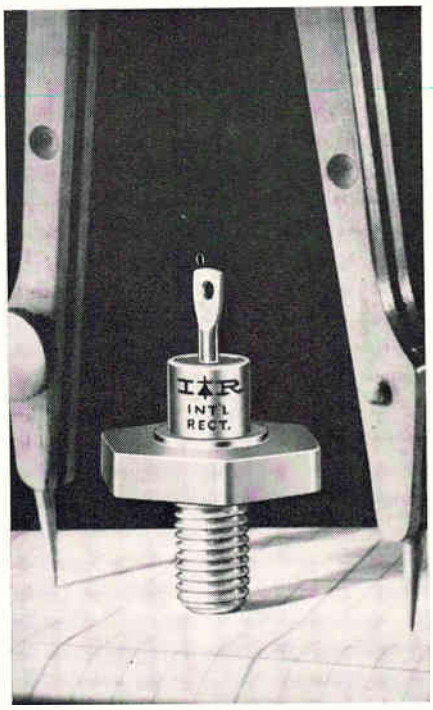
Want 8000 volts per inch? IR's compact encapsulated sticks offer a PRV range from 2 kv to 75 kv, with 0.2 to 1 ampere output. They measure only 0.5" to 1.0" square by 1" to 15" long! You'll find them mighty useful in radar pulse modulators, electrostatic precipitators and radio power supply units.

"What's Your SCR IQ??"

To find the answers to this and many other pertinent questions on controlled rectifiers, write for your copy of International Rectifier's SCR fact round-up, "What's Your SCR IQ??"

Reduce Installation Time and Labor Cost 30% with IR 50 watt Zeners

Especially designed for ruggedized military and industrial power equipment, IR 50 watt Zeners utilize the conventional stud mounting method, requiring only one mounting hole as compared to three positioned holes needed to mount the TO-3 package. In volume production, this means substantial labor savings—



without sacrificing high stability performance. Highly efficient heat transfer characteristics of the large hex base assure optimum performance over a —65°C to +175°C temperature range. Available in voltages from 6.8 to 100 volts in 5, 10 and 20% tolerance types, these JEDEC registered devices provide maximum Zener currents up to 6600 ma at 75° C stud temperatures.

Before you specify any Zener, check these IR features: Each unit is built to the same uncompromising high standards that have earned for IR the Signal Corps RIQAP Award since 1955 . . . low temperature coefficients assure maximum stability over entire temperature range . . . only IR Zeners offer 99.988% demonstrated industrial reliability! Write for Bulletin SR-274.

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Washington Newsletter

June 29, 1964

Hearings to show cutbacks' impact

Two Senate panels are opening hearings that seem designed to spur quicker, more specific action on problems created by automation, changing defense requirements, and other technological advances and economic change.

The Administration favors creation of a national commission to take a broad look at the problems. The Senate Labor Committee, after lengthy hearings, is ready to report out legislation along those lines.

But **two other committees' hearings are expected to show that defense cutbacks already are hitting certain states hard—states that carry a lot of weight in the presidential election year.**

The Small Business Committee is undertaking a series of case studies, starting with New Jersey on June 23. Its cochairman is Harrison A. Williams, New Jersey's Democratic Senator, who is up for reelection. More than 20,000 engineers, technicians and production workers in New Jersey defense plants—mainly in electronics, aircraft and shipbuilding—have lost their jobs in the past 16 months. Other states feeling the pinch are New York, California, Massachusetts, Colorado and Washington.

The Small Business Committee has coordinated its plans to avoid duplicating hearings held by the Commerce Committee, which is considering a bill by George McGovern (D., S. D.) to set up a national economic conversion commission. **Unlike the one favored by the Administration, this group would limit itself to defense conversion problems.** The Commerce Committee is headed by Warren G. Magnuson, of Washington, a state that depends on defense outlays.

Congress advised to cut excise taxes

There's strong **sentiment in Congress for elimination or reduction of excise taxes, including those on business machines, musical instruments, radio and television sets and their components.** The present 10% tax adds $275 million to the cost of instruments, radios and tv sets, and $70 million to that of business machines.

Manufacturers' and retail excises altogether bring in about $15 billion a year.

Tax experts testifying before the Ways and Means Committee have been almost unanimous in recommending an early end to excise taxes, particularly manufacturers' excises that become part of business costs. Republicans have been trying to push through reductions this year, but the **Democrats are insisting on further deliberation.** Industry witnesses will soon have a chance to testify before the Committee.

Five years to get a patent?

The three-year pendency of patents in electronics and other categories is in danger of slipping to five years unless the system is streamlined, says Commissioner Edward J. Brenner of the Patent Office.

On July 1, extensive shifts in manpower will be made to the new crisis areas from less demanding areas, along with efforts to double the 75,000 patents handled annually.

An ultimate pendency of 18 months on all patents and a reduction of the present backlog are among Brenner's goals.

There has been some pressure for easing the Patent Office's load by adopting some sort of deferred examination system on the pattern of some European countries, where extensive searches are not made unless a patent is challenged. The new policies are part of an effort to protect the prepatent searches that have traditionally been part of the U.S. patent system.

Value engineering plans are relaxed

The Defense Department has relaxed earlier proposals for requirements in contractors' value-engineering programs. The specification—MIL-V-3825—is shorter and less demanding than the draft that was sent out for industry comment earlier this year, and requires less reporting to the government.

The adopted version limits the requirements largely to cost-plus-fixed-fee contracts greater than $1 million, and exempts programs of research and exploratory development.

Activities covered by the new specification range from blueprints to fabrication and testing. It also assigns an important role to purchasing agents in its procurement standards.

The specification requires that VE techniques be applied when decisions are made as to whether to make, rather than buy, products. If the decision is to buy, the prime contractor must assist and monitor the subcontractor's VE efforts. When design and hardware are considered, purchasing representatives must be consulted.

The contractor is required to identify his VE organization, but not necessarily to hire specialists. He must be ready to report on how he is monitoring the VE program, but does not have to make the periodic reviews and reports that were required under the earlier draft.

Each VE study must contain accurate, reliable cost information. The contractor must even evaluate the government's own technical requirements to make sure they are realistic.

FAA fights slash in research fund

Najeeb Halaby, administrator of the Federal Aviation Agency, has made a strong pitch for Senate restoration of a 50% cut by the House in the agency's request for research-and-development funds. Prospects for his success are considered good. The test will come when the Appropriations Committee votes on the Multi-Agency Independent Offices Bill about July.

The FAA sought $42 million in R&D funds for the fiscal year starting July 1. About $24 million was for air traffic control and communication devices, the rest for navigation aids, visual airport aids, aeromedical research, and safety and weather programs. The House cut the request exactly in half, approving $21 million.

Halaby says the cut will have exactly the opposite effect from that intended by the House. Some House members are upset because the FAA hired a large number of traffic controllers to implement its program of continuous radar surveillance of nearly all air space above 18,000 feet over the United States. But unless the FAA receives enough money to develop techniques and hardware for a more automatic system, the administration declares it will have to hire more and more controllers to cope with increases in air traffic.

Without restoration of the $21 million, Halaby warns, the FAA will be able to start no new R&D programs and may even have to drop several existing contracts.

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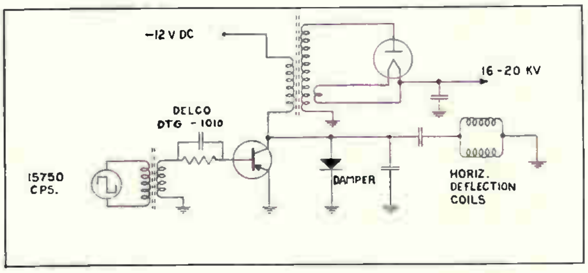

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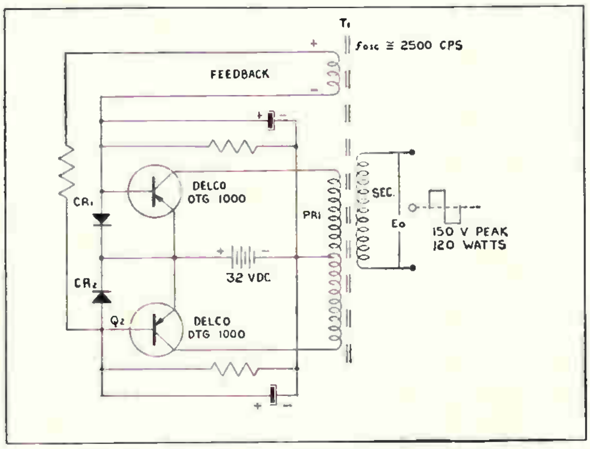

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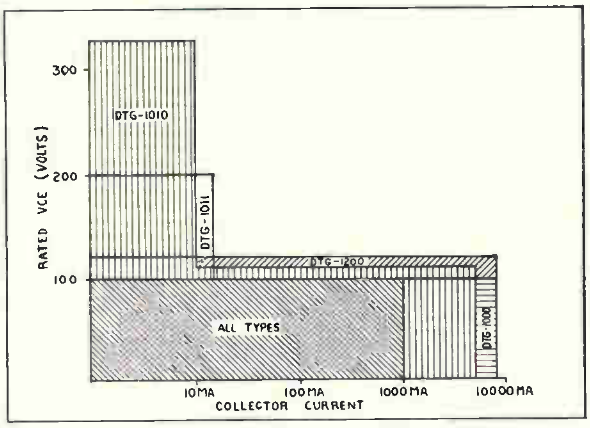

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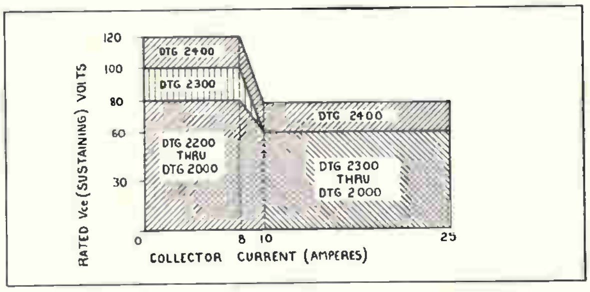

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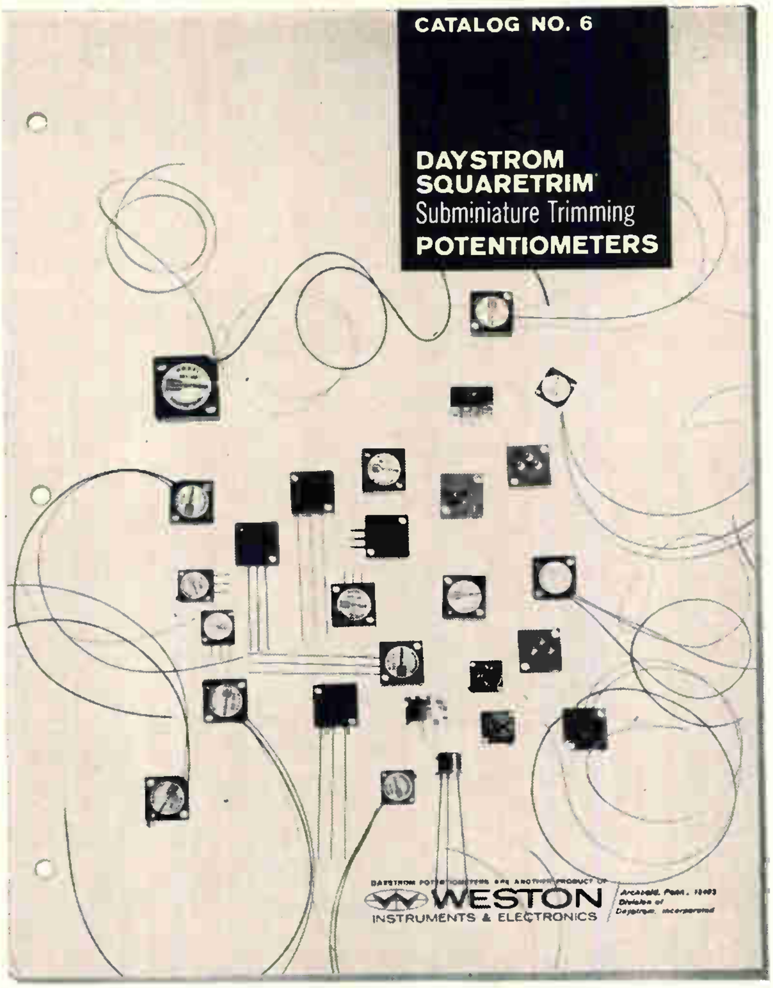

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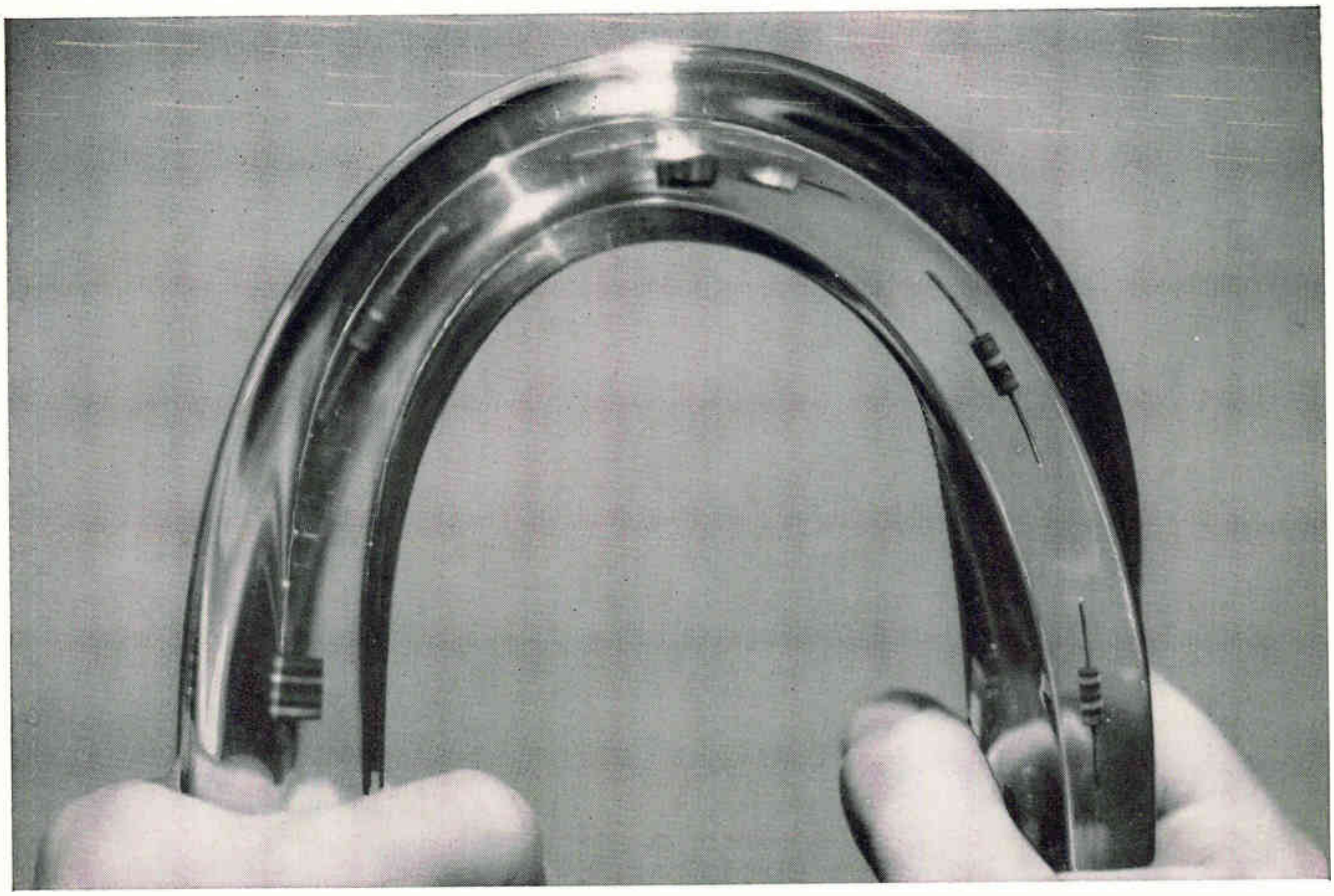

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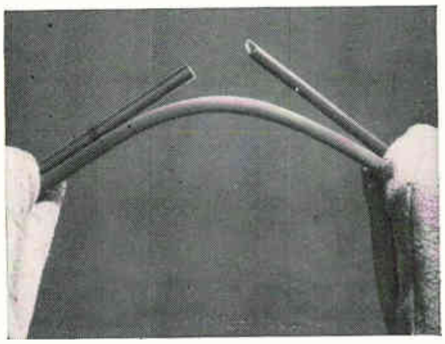

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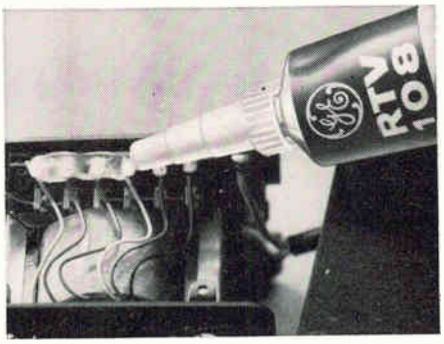

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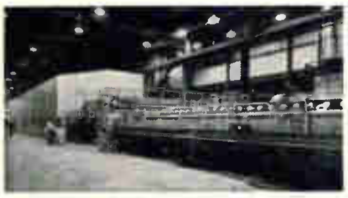
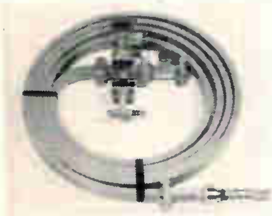
Highlights



SCR control in paper mills: page 42
Papermaking is a fine art that has adopted modern technology reluctantly. Now the silicon controlled rectifier promises to open the door for widespread use of electronic control. Scr's increase efficiency and reduce response time and maintenance costs.

Incremental digital recorder ends tape waste: page 48
If a computer has to handle an irregular flow of data, the efficiency of the whole system is improved with an incremental recorder. A high-speed stepping motor drives the capstan in this unit so the tape advances the same way a punched paper tape moves.



Interferometer analyzes microwave transmitter: page 58
A simple instrument, using optical techniques, takes the place of an expensive spectrum analyzer in measuring wavelengths. Although this approach has been applied so far only to K-band radar, the author believes it has no frequency limitation. The equipment needed is simple and readily available.

Special report on magnetics in electronics: page 61
Magnetic phenomena were recognized by ancient scientists. New ways to use this old knowledge, and the discovery of new effects, has turned a prosaic subject into a fascinating and practical area. The editors of Electronics, examine the use of magnetic effects in computers, power and control circuits, and microwave applications. They also report on new devices resulting from newly discovered effects, new materials and how to generate high magnetic fields.

Coming July 13

- The electronic splash in oceanography
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Industrial electronics

SCR control in paper mills

They increase drive-system efficiency
and response time, and cut maintenance costs

By Harry Dooley
English Electric Co., London

Water wheels, steam turbines, reciprocating steam engines and electric motors have all been used to drive papermaking machines. Until recently d-c motor drives have been powered by d-c generators or mercury arc rectifiers. Now the silicon controlled rectifier is providing the d-c motor power, an application becoming wide-spread.

The large gap between drive method and modern technology has now been bridged with a solid-state device. Using an scr designed controller on a papermaking machine offers many advantages over other methods now in wide use. Scr control provides increased efficiency, good power factor, lower maintenance cost, and smaller plant space requirements.

What's needed

A listing of paper machine drive requirements provides the background for a comparison of the effectiveness of scr control with other drive systems.

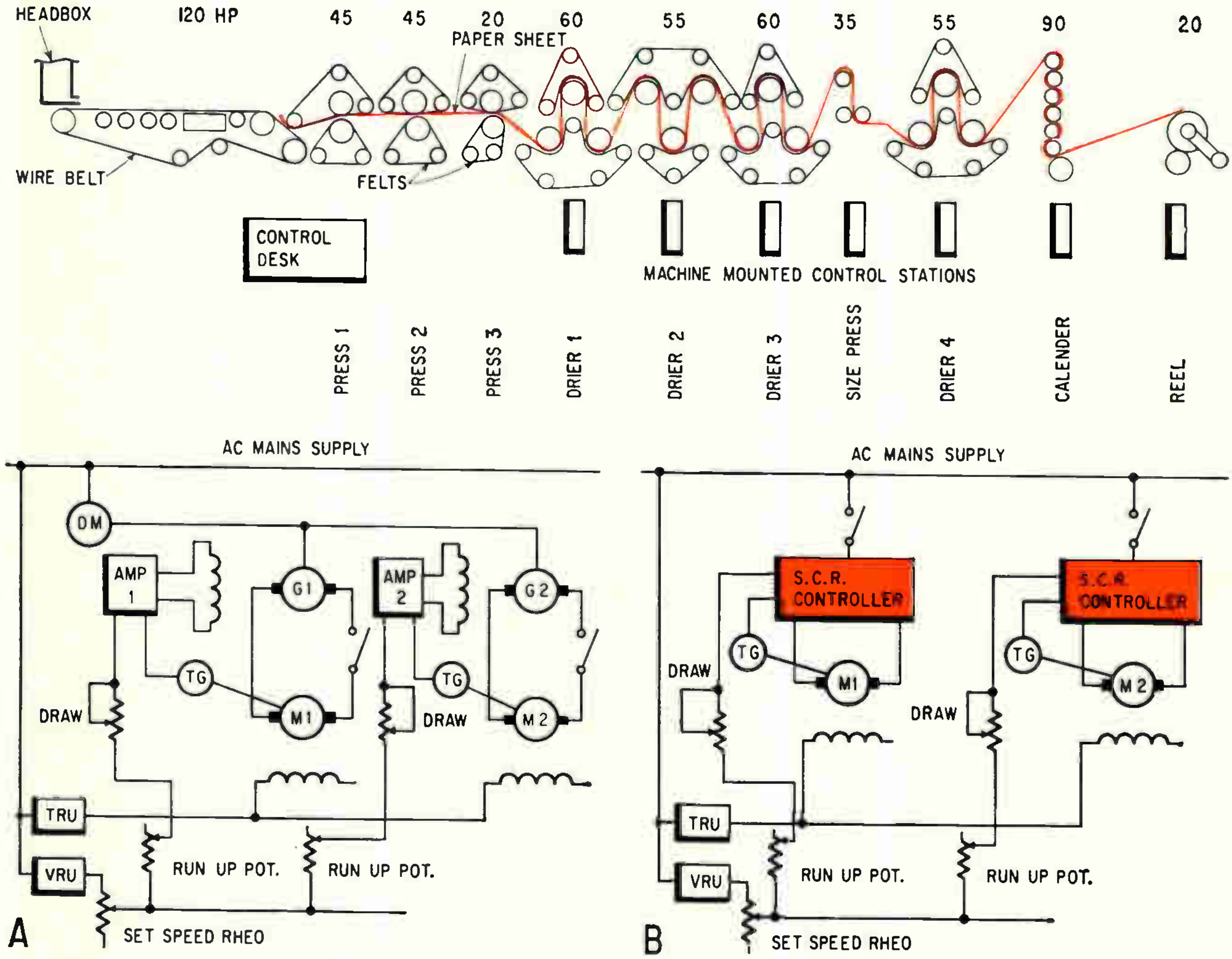
- A paper machine making 100 tons of paper per day, at $300 per ton, has a down-time cost of $1,250 per hour. Drive down time must be kept to a minimum.
- Because a paper machine runs continuously over a period of days, power factor and efficiency are very important.
- Most machines are used to make several grades of paper and must operate at various speeds, over a range as wide as 10 to 1.
- Paper machines are so large they are divided into sections, each with its own drive system. To keep paper quality consistent and to specification, over-all machine speed must be kept at one set value for long periods.
- To keep the correct amount of draw (tension) in the paper, good speed-holding between sections is essential.
- To keep from breaking the paper, which is made in a continuous sheet called a web, the control system must prevent load changes in a sectional drive from producing transient speed changes between sections.
- The ability to inch, or crawl, the individual sections without disturbing the others is necessary for cleaning and maintenance.

Control system

A paper-making machine is rated in terms of efficiency and power factor, speed-holding accuracy and speed of response. Variations in armature voltage, field current and load affect the speed of a d-c motor. An analog speed-control system measures the revolutions-per-minute of the motor with a tachogenerator. This tachometer generates a voltage proportional to speed, the voltage being compared with a set-speed reference voltage. Speed

The author

Harry Dooley received his electrical engineering degree from Nottingham University in the shire where Robin Hood once held sway. After specializing in aviation equipment design at the English Electric Co. several years, he transferred to their industrial department and now concentrates on problems in the paper industry.



Sketch of an 11-section paper machine at top shows the individual sectional drives that must be simultaneously controlled within tight speed limits to prevent breaking the continuous sheet of paper (color) as it goes from the head box to the wind-up reel. The multigenerator sectional drive system (A) is commonly called Ward Leonard control. In contrast (B) shows the simplicity of silicon-controlled rectifier control.

variations, due to field current or load variations, are corrected as the control system adjusts the armature voltage of the motor.

The gain of a typical control system must produce full control power when the difference (error) signal, between reference and reset voltages, is equivalent to 0.025% of full speed. This means that allowing for the effects of power supply and ambient temperature variations on the reference voltage and the tachogenerator, the set-speed can be held within 0.1 percent of the maximum speed at all times. Because of this control, changes in motor load and field current have such a small effect on the set-speed that they can be ignored.

Drive control schemes

The simplest way to run a paper machine is to drive a lineshaft with a large d-c motor and to couple the sections to the lineshaft through clutches and coned-pulleys. The coned-pulley design enables the speed of each section to be varied a few percent to give the required draw (tension) between sections. This method suffers from several disadvantages—the belt coupling the coned-pulleys slips and creeps and causes changes in draw. Also, if large amounts of power are to be transmitted, the coned-pulleys must be very large.

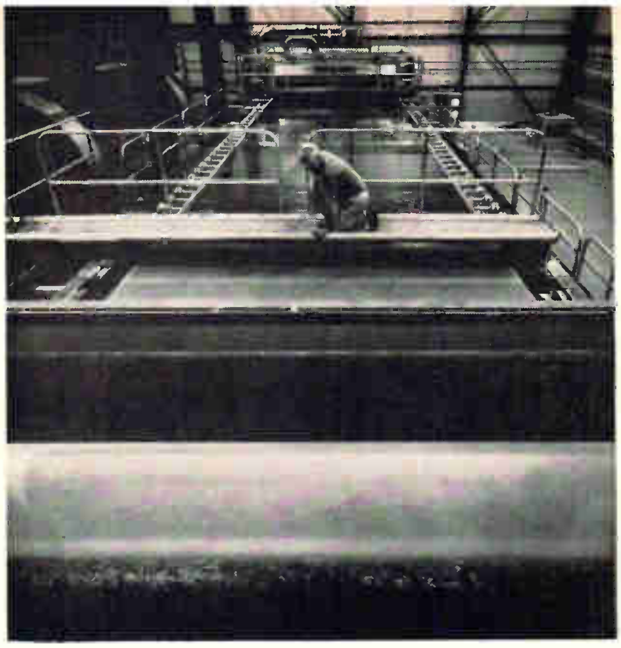
Most large, high-speed papermaking machines use sectional drives, each section driven by a separate d-c motor. One method of supplying power to the motors is from a common d-c generator. The speed of each section motor is regulated by controlling the field current of the motor. In the schematic on this page, A shows another method,

From forest to magazine

While the control method is new, the papermaking process is old. Once the logs have been ground into chips, the pulp is chemically treated and becomes a wet fibrous mass called stuff. This material is further refined and screened for grit, slivers and other impurities. The stuff is then fed from a huge tank called a headbox through a slice gate that controls the thickness of the material, onto a wire mesh belt. The belt allows excess water to drain off.

The stuff is now a semisolid sheet and is next fed onto a felt conveyor-belt running to the press section. Here the sheet is squeezed to force more moisture to drain. This continuous sheet, called the web, is next run through the driers and onto calendar rolls. These rolls give the paper a specified finish. The paper is then wound into huge rolls on a reel machine.

The scr control system described will be used on a papermaking machine 144 inches wide, running at a speed of 1,000 feet per minute.



the multigenerator scheme, where each section motor is supplied power by its own d-c generator. This is generally known as Ward Leonard control.

Although the common generator scheme seems to be very economical, because fewer machines are needed, it is only marginally so. To meet the drive requirements, starting facilities and an additional crawl generator must be added, plus much more control equipment.

Also, the section d-c motors need to be larger, to provide the required power with reduced field power. And, the performance of the common generator scheme is not as good as the multigenerator. At low speeds, when the armature voltage is low, greater field current changes are required to produce speed corrections than are required at high speeds.

Scr control

The multigenerator section (Ward Leonard) drive of A is most often used for modern high-speed papermaking machines, but the silicon-controlled rectifier is changing this picture. The need for another type of drive control system stems from the following disadvantages of the Ward Leonard scheme.

- Since the d-c motor power is obtained from the a-c mains, via an a-c motor and a d-c generator, the efficiency of the system is the product of the efficiencies of the three individual machines. The over-all efficiency for a complete paper machine would only be about 80%.
- The space required and floor-loading weight are high.
- A large number of rotating machines means frequent maintenance such as brush-changing and so on.

The scr-controlled sectional drive, as seen in B on page 43 has a much improved performance over the Ward Leonard drive.

An scr-controlled drive has a comparable overall efficiency of about 88%. Because the equipment is solid state it needs less space, is lighter in weight, and there is little maintenance. In addition, response time to control signals is faster.

Buck/boost

With a simple scr controller, the power factor falls in direct proportion to the output voltage. As an example, at ¼ speeds the power factor is about 0.25. With a Ward Leonard system the power factor at ¼ speed is about 0.7. But the power factor of scr controllers can be improved in several ways.

If the a-c input voltage is adjustable, the power factor can be kept at its maximum value, about 0.95, over the entire operating speed range—but this is now an expensive method. Another way would be to use capacitors, also costly.

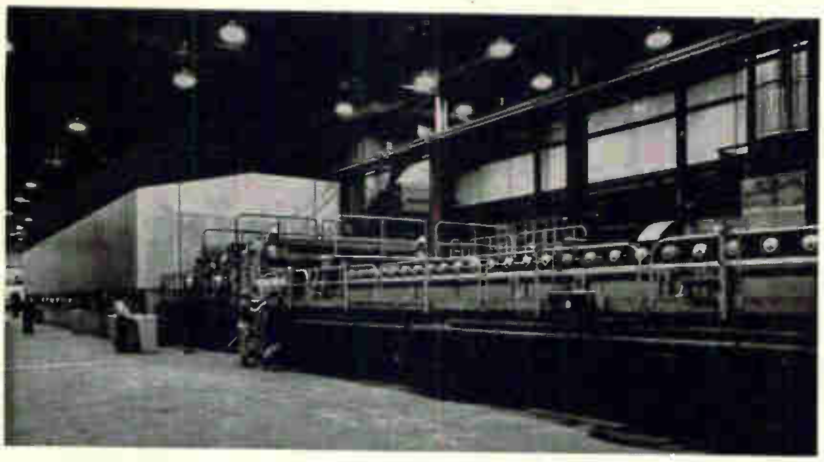
The most economical way, and one that uses the scr's ability to invert, is to connect an scr bridge in series with a rectifier bridge to form a buck/boost set-up as shown on page 45. The rectifier bridge gives a constant 45% of the maximum voltage; the scr bridge adds 55% (boosts) or subtracts 45% (bucks) to give a continuous d-c output voltage, controllable from 0 to 100%.

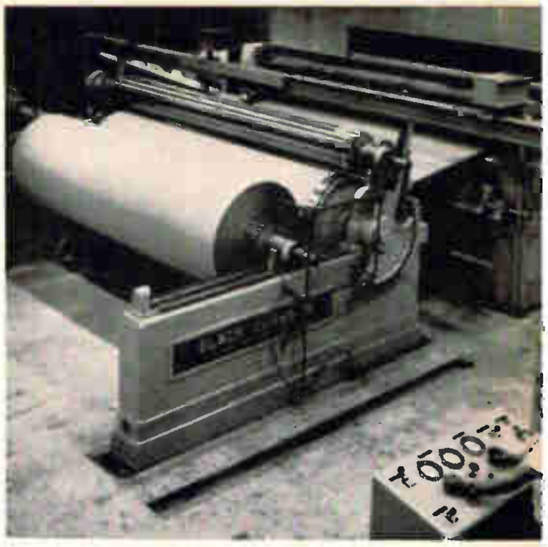
If, in addition, the transformer secondary windings are center-tapped and designed with tap-changing links, the power factor at ¼ speed can be increased to about 0.6.

Firing angle

The output voltage from an scr controller is varied by altering the firing angle, that is, the point in the positive half-cycle of the applied voltage when the scr is allowed to conduct.

The diagrams on the next page show a three-phase d-c voltage applied to three silicon controlled rectifiers. The first scr conducts as soon as the firing signal occurs. In A, the firing signal occurs near the beginning of the positive half-cycle of voltage and the firing angle α is zero. The current through the scr is in phase with the applied voltage. In B the firing signal is delayed, the firing angle being 60°. The mean d-c output voltage is reduced to 50% of the maximum value; the current is now out





At the Container Corp. of America's new Circleville, Ohio paper mill, the headbox (left) is the first stop for refined paper pulp. Avtron Mfg. Inc. digital speed equipment is used on the drive system. Driers (center) turn the wet semisolid mass into a dry continuous sheet of paper. Reel equipment winds the finished paper into rolls.

of phase with the applied voltage. In C the firing angle is 120°; the scr is now conducting for most of the time during the negative half-cycle.

The polarity of the output voltage is reversed but the current is still flowing in the same direction. The scr is now said to be inverting. This form of operation is only possible when the scr is in series with another voltage of such a value that the combined voltage across the scr remains positive. This condition is achieved with the buck/boost arrangement. In the inverting mode the scr is returning power to the supply.

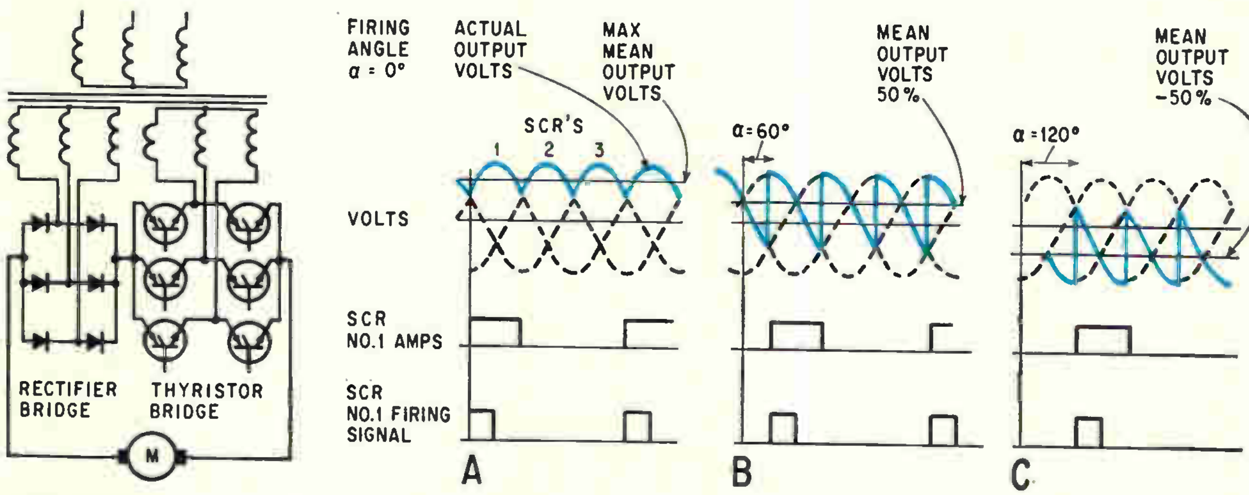
Triggering circuit

A triggering unit controls the scr conducting periods. The input to the triggering unit is the d-c error signal that has been amplified. The output is a voltage whose leading edge occurs at an electrical angle of delay, the cosine of which is directly proportional to the magnitude of the input signal. By varying the d-c input signal, the d-c output voltage from the scr controller can be varied from maximum positive through zero to maximum negative. The firing angle is varied from 0 to 170°

In order to prevent any malfunction due to an excessively large d-c input signal, a device known as an "end-stop" is included in the design.

The trigger circuit A on page 46 is a simplified diagram showing the principle of operation. One such circuit is required to control the firing point of each leg of the controller. The input, which is applied to the base of transistor Q_1, consists of a sinusoidal voltage from line 2, a d-c voltage from line 6, and the end-stop signal from line 1. The sinusoidal voltage applied at line 2 causes Q_1 to conduct whenever the base is made more negative than the emitter.

When Q_1 does conduct, the collector assumes the potential of the positive common line. When the base becomes equal to, or more positive than the emitter, Q_1 ceases to conduct and its collector potential rises sharply to that of the negative common line. This causes Q_2 to conduct and a pulse of current passes through the pulse transformer



Buck/Boost at left takes advantage of the scr's ability to invert. The double bridge gives a continuous d-c output voltage controllable from 0 to 100%. In (A) the firing signal affects the output voltage of scr controller.

through Q_2 to charge C_5. Positive feedback through C_4 and R_4 accelerates the change-over. When Q_1 resumes conduction, the collector becomes positive and shuts-off Q_2, since the emitter of Q_2 is negative, due to the charge on C_5, with respect to the positive common line. Any tendency to produce a negative spike in the transformer, due to the current ceasing, is prevented by diode D_5.

An illustration of how the firing angle varies with the d-c biasing input signal is given in B at right.

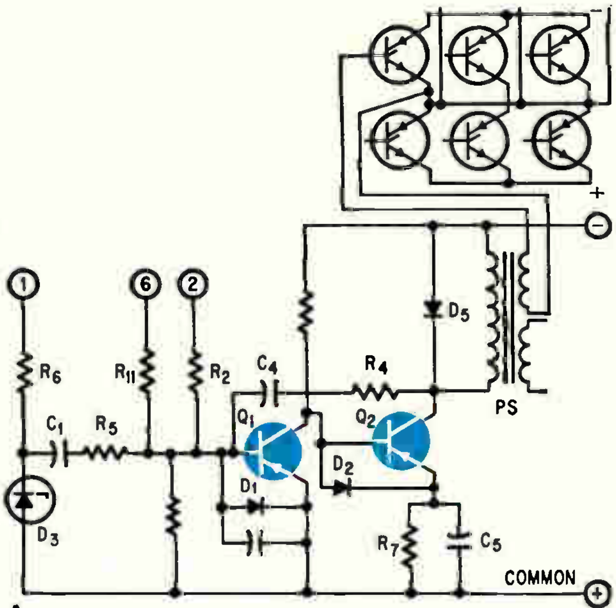
End-stop signal

In C the end-stop signal is derived from a sinewave signal, lagging 90°, that is clipped by zener diode D_3. It is essential that the correct phase relationship between the trigger unit and the voltage be applied to the scr's. It is also essential to trigger the silicon controlled rectifiers in the correct sequence.

The trigger unit's sinewave control-voltage is derived from a six-phase secondary winding on a transformer. A second six-phase secondary winding provides the sinewave end-stop signal. The three-phase primary winding is tapped. With these taps it is possible to obtain the correct phase relationship between the trigger unit and the scr voltage, provided phase displacement is not less than 30°.

This means that phase displacement can be corrected for 6- or 12-phase, bridge-connected scr circuits.

For 12- or 24-phase bridge-connected configurations, an auto-transformer is interposed between the primary winding of the trigger unit transformer and the voltage supply. The auto-transformer can be connected to correct 7½° phase changes. To start firing a bridge-connected scr system, two legs of the bridge must be triggered to complete the circuit. A pulse-doubling unit must be added between Q_2 and the pulsing transformer, as shown in D above, right. When Q_2 conducts, a current pulse is drawn through two adjacent pulsing transformers. The circuit is designed so that the two resulting pulses trigger two scr's and complete the circuit.



A

Trigger circuit, such as the one simplified in (A), is needed on each leg of the controller; (B) shows how the firing angle of the scr varies with the d-c input biasing

The pulses last for 1 millisecond. The pulsing transformer can be made to simultaneously trigger several scr's in one leg, by using several secondary windings. To ensure accurate load-sharing of parallel scr's they must be fed at exactly the same instant. The firing-pulse rate-of-rise must be fast, on the order of one to two microseconds.

High-speed paper machines

The equipment described above will be part of an installation for the C. Townsend Hook paper

Digital speed control

Looking into the future, there are two lines of development that are of particular interest to the paper industry. The first is digital speed control for much higher speed-holding accuracy. The second is the use of a-c induction motors, supplied with variable-frequency power from static inverters, to drive the machine sections.

Digital speed control consists of counting the revolutions of the motor and comparing them with the required revolutions obtained from a reference oscillator.

With a digital speed control system the speed reference is derived from a crystal oscillator having a frequency stability of 0.005% or better.

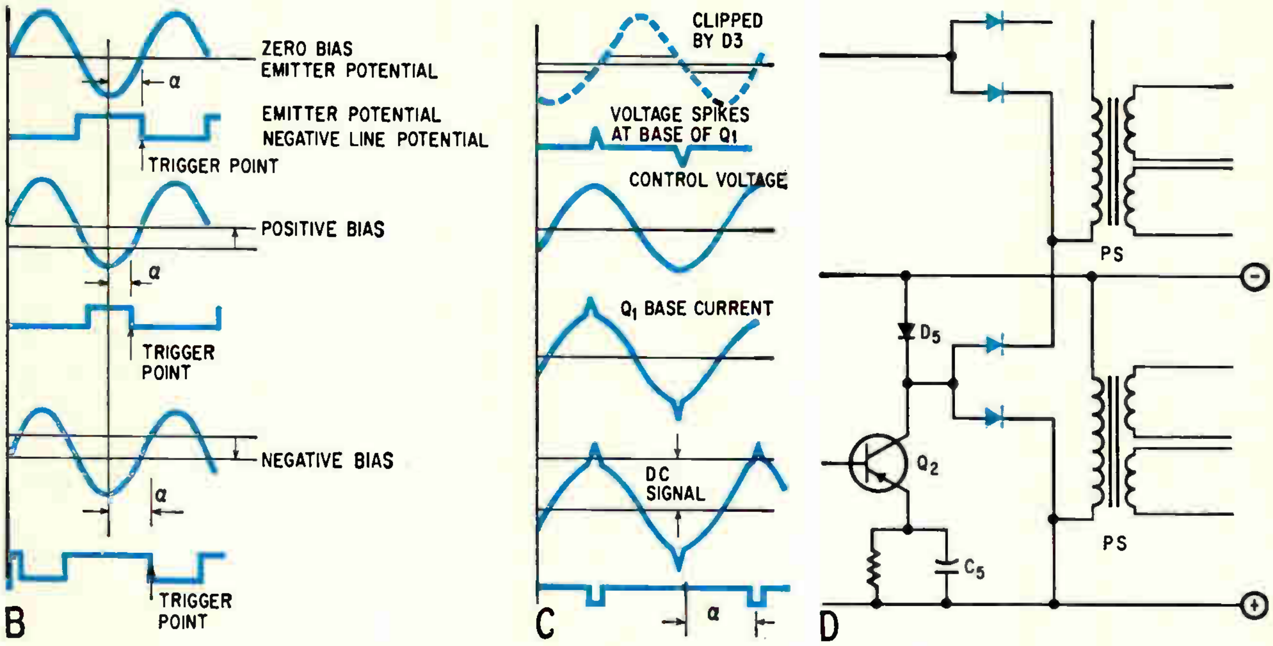
The resetting signal is obtained from a pulse-generating tachometer that can generate say 1,000 pulses per revolution and is driven by a section motor.

There are two ways in which digital speed control can be applied. The first method is to use it with conventional analog speed-control, when the reset-pulse count is compared with the reference-pulse count at say 10 second intervals. Any difference between reference and reset is then used to trim the motor speed. In this way, digital speed control corrects any drift in the analog speed control, due to temperature and supply variations every 10 seconds. The digital system is insensitive to what caused the drift.

The second method is to use the digital system by itself, comparing reference and reset signals pulse by pulse. This method is the most attractive and worth further development.

The digital system is more accurate than the analog system because the signal from the resetting pulse-tachometer does not suffer from variations due to temperature or any of the other problems associated with voltage generating tachometers.

A d-c motor under digital speed control using the pulse-by-pulse control technique has been shown in tests to hold a set-speed to within 0.01% continuously.



signal. The end-stop signal (C), clipped from a sinewave by diode D_3, prevents damage to the circuit from excessive d-c input signals. The pulse-doubling unit (D) is used to simultaneously trigger two legs of the scr bridge to complete the circuit and fire the scr control system.

mill at Snodland, Kent, England. The problems facing the system designer were spelled out at the beginning of this article.

The section motor horsepowers range from 20 to 120. Each motor, as shown in the diagram on page 43, is supplied from a separate scr controller. The motor fields are all energized from a common-transformer rectifier unit. Each scr controller is in a cabinet measuring 7 by 3 by 3 feet, that also houses all section control and protection equipment. Operator controls are located on a console for the master, wire and press sections, and also on individual, machine-mounted, control panels for the driers, size press, calendar and reel sections.

But, it is questionable whether speed-holding accuracy of this order is necessary on any paper machine. It has been suggested that digital speed control may only be justified on coating machine drives, where web breaks are so much more expensive in time and material.

The development of static variable-frequency inverters has been under way for some time. Units have already been supplied to the nuclear power industry to supply induction motors that are being used as variable-speed drives.

Inverters of large capacity are also available to supply power to groups of synchronous motors that are required to run in synchronism and to hold a set-speed accurately.

The real advantage as far as the paper machine drive is concerned is the replacement of costly d-c motors with induction motors that are inherently more rugged and require less maintenance.

At the present time however, the cost of the SCR inverters and associated control gear outweighs any saving which can be made on the machines.

All sections are speed controlled to a continuous steady-state within 0.1% of the maximum speed. In addition the reel and calendar sections can be put on adjustable-tension control by means of their individual control panels.

When the machine is to be started the operator first sets the required operating speed on the master section at the desk. This provides a common set-speed reference signal voltage for each section. Each section may now be crawled or run-up to the set-speed, by operating the appropriate section pushbutttton switches at the control stations. Each section can be stopped, crawled, run, or inched independently from the rest of the machine. Draw and slack take-up controls are provided at all section stations with additional tension controls at the calendar and reel. Facility for reverse-inch is also provided at the calender.

Each section is run-up to speed, at a controlled rate. A twice full-load current-limit control is included on each controller. This current-limit control gives ample starting torque, but run-up torque is limited by controlling run-up time. Run-up time control is less onerous on wire belt and drier and press felts than just current-limit, run-up control.

The speed control, current control and scr firing control equipment is the same for each controller. Potentiometers are included to adjust the gain and feedback to suit the particular requirements of any section. This equipment is mounted on hinged modules that can be inspected during operation and if necessary can be quickly replaced with a spare unit.

Each controller is fully protected. An indication and monitoring system is included to enable the maintenance electrician to check system components and locate any faults.

Incremental digital recorder puts more data on less tape

Ability to idle when there is no input allows it to store a year's information on 2,400 feet of tape

By Frank Beeler
Precision Instrument Co., Palo Alto, Calif.

An incremental digital recorder may solve most problems involved in recording an irregular flow of data economically and reliably. Magnetic tapes for digital computers or other data-processing equipment must have the recorded data uniformly spaced at specified packing densities. Standard bit-packing densities of 200 and 556 bits per inch have been widely adopted. But because much data occurs at random or nonstandard rates, it has been the practice to record this type of data in an intermediate storage, such as punched paper tape or punched cards. The tape or cards are later read at a uniform standard rate for recording on magnetic tape, for input to a computer or other data-processing machine.

The alternative is to keep a standard recorder operating, and waste many feet of tape between the irregular bursts of data; then convert the tape to a standard rate, leaving out the random intervals.

These inefficiencies in continuously running recorders led to the development of the incremental digital recorder. Instead of moving the tape across the magnetic heads at a constant speed, it advances the tape across the head step by step, or incrementally, in much the same manner as a punched paper-tape recorder.

Year's data on one reel

In addition to being able to accept asynchronous, or randomly occurring, data and record it in a uniform format on the tape, the incremental recorder remains in a standby condition between incoming signals, with the tape stationary. This characteristic allows the recording of data over long periods on a single reel of tape. For example, at the standard density of 200 bits per inch, data occurring at 10 characters per minute could be recorded continuously for more than a year on a single standard 2,400-foot reel of tape. Yet the same machine can record, in the same circuit, at rates up to 300 characters per second. In either case, the recorded tape can be used directly as the computer input without intermediate translation or change of medium. The drawing on page 49 shows this characteristic.

In configuration, the incremental recorder is almost identical to other recorders. Standard computer-quality tape, in standard widths and on standard reels, is passed over recording heads of standard track width, location and spacing.

Capstan turns on command

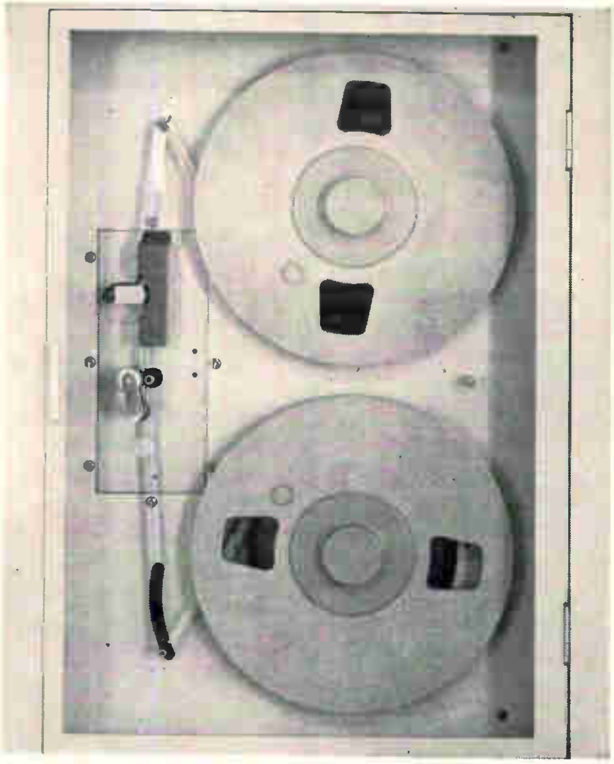
The tape is moved by pressing it against a rotating capstan with a pressure roller or similar device. Tape is fed from one reel and taken up on another reel by a servo-controlled reel-drive system that senses the demand of the capstan for tape.

The only basic difference lies in the manner in which the capstan rotates. Upon command, the capstan turns through a precise angular increment. Proper selection of the capstan diameter results in a precise length of tape being drawn over the head upon command.

Normally, the incoming data signal is used as the capstan step command. Because some inertia is inherent in the capstan driver, the signal will have been recorded on the magnetic tape before the tape starts to move. The quality of the recording is appreciably enhanced by the tape's being stationary when the record is made. At the end of the increment of capstan motion, the system remains motionless until the next command signal is received.

With proper tape restraint, there is no inherent lower limit to the rate of incrementing. The upper rate limit depends on the time required to accelerate the capstan from zero velocity to peak velocity and back to zero velocity. Therefore it is possible to record data, occurring at random time intervals, with uniform packing density on the tape at all rates below the upper limits.

The motor is capable of only a fixed number of steps—say 200—in each complete revolution. The capstan is an integral part of the motor shaft; therefore it steps one two-hundredth of a revolution each time it is pulsed. It cannot move through 201 or 199 steps in one complete revolution. If the capstan is precisely sized so as to move one inch of tape per revolution, the packing density must then be 200 bits per inch. The only remaining source of error is the accuracy with which each step is made. Any short step has to be compensated for by a long step within the same revolution of the motor shaft.



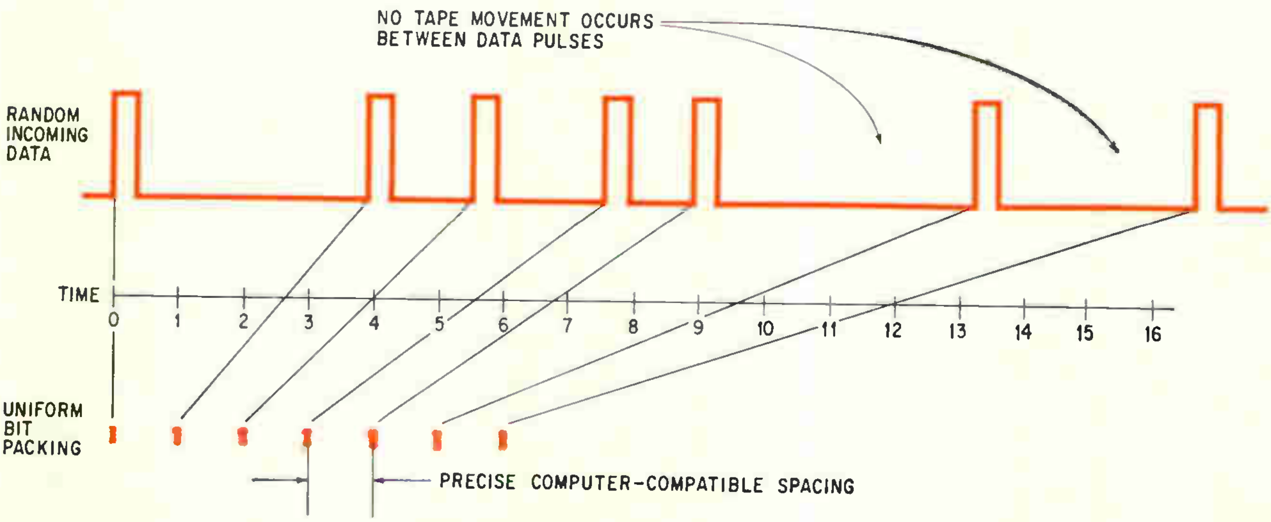
Incremental recorder, with cover removed from the capstan drive

Signal-step sequence

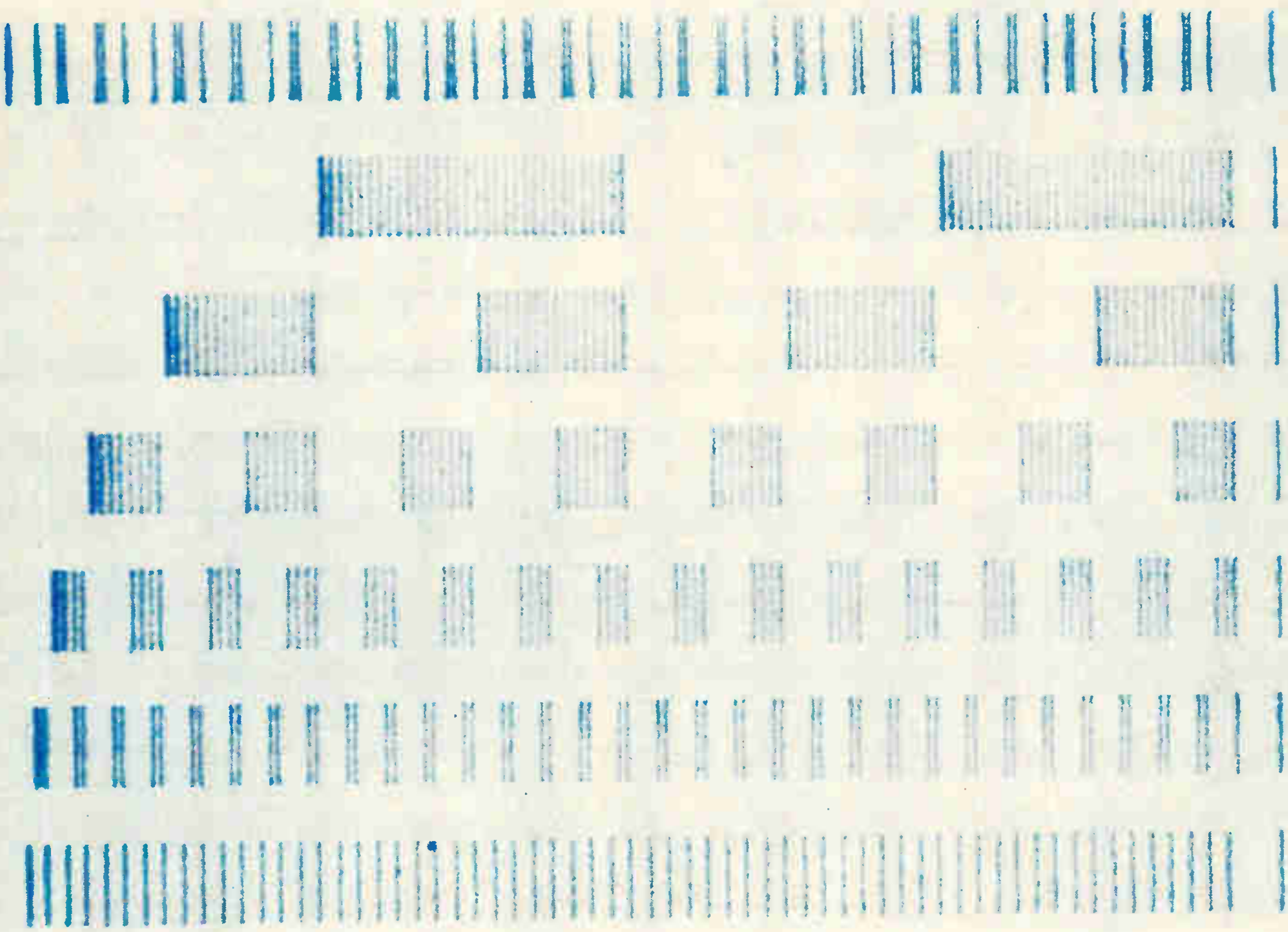
A typical signal-step sequence begins with the data input for each track being applied continuously to a NAND gate. Periodically a 12-volt write-command pulse is also applied to the gate. If the data input is a logical one (—12 volts), a pulse passes through the gate to the recording flip-flop for that track. This pulse causes the flip-flop to change state, thereby reversing the direction of current through the magnetic head and reversing the polarity of magnetization on the tape. In this way a one is written.

If the data input is a logical zero (ground level) at the time a write command occurs, no pulse passes through the NAND gate. The polarity of magnetization on the tape remains unchanged, and a zero is written on the tape.

The write command is also applied to the capstan drive, where it acts as a stepping pulse, causing the tape to move 1/200 inch, after which it stops to



Random incoming data (top), recorded as uniform bits (bottom) in standard computer language



Random signal output recorded in standard computer format. The lower six tracks contain, from left to right, the straight binary code for zero through 63, then zero through 62. A parity check bit is recorded in the top track when the total number of bits for a binary number in the six tracks below is even. The single pulse at the right end of each track is the standard IBM longitudinal redundancy check bit, added when the total number of bits in each block of track is odd. The tracks are 40 mils wide and 70 mils center-to-center. The recording was made at irregular intervals.

await the next command. Due to the mechanical inertia of the system, the data bits are recorded before the tape begins to move.

The capstan drive consists of a high-speed stepping motor actuated by a logical circuit with four stable states. Each time the logic circuit changes state in response to a stepping pulse, the motor rotates 1.8°. The motor shaft, ground to a circumference of exactly one inch, forms the capstan. As the capstan rotates 1.8°, the tape is moved a discrete 1/200 inch. After stepping 1.8°, the capstan is locked firmly in position by the stationary magnetic field in the motor.

Gaps generated internally

These incremental recorders are compatible with computers using seven-level binary codes and standard half-inch computer-quality magnetic tape. Standard interrecord and end-of-file gaps can be generated internally on command. The interrecord gap is a ¾-inch section of uniformly saturated tape (no data written on it), which separates groups of words written on the tape. The end-of-file gap is a 3.5-inch section of blank tape that separates groups of records, which are called files.

Both transverse and lateral parity checking can be performed internally or, at the user's option, externally. In transverse parity checking, the number of data bits across the width of the tap is counted as the tape is written, and an additional bit is written in the check track to make the total of bits either odd or even, in accordance with program requirements [photo above]. When the tape is read, the check bit is recomputed and compared with that written on the tape, and any discrepancy is signaled. Lateral parity checking is similar, except that the bits in each lengthwise track are counted and a check character is written at the end of each record. This character is spaced out a definite distance from the end of the record to prevent confusion with the data written in the record.

The latest in incremental recorders provides means for reading the previously recorded tape step by step. This is done in about the same way as the recording process, except that the tape is stopped with the read-head gap between the bits. On command, the bit is stepped past the head gap and the tape is stopped again between the next two bits.

A representative incremental write-read machine is shown in the drawing. The machine is prepared for recording by first loading and threading the tape. Pushing the load button starts the capstan motor. The tape advances several feet until a photosenstive device detects a reflective marker that was added previously to the tape; most computers require these markers, which identify the beginning and end of the recorded portion of the tape, and also prevent running out of tape.

Because of the geometry of the read-write heads, a "leader" of blank tape must be supplied for threading purposes, similar to the leader of blank film required by movie projectors. Therefore, after the reflective marker is sensed, the tape is advanced automatically 3.4 inches; the recorder is then ready to receive data.

Some applications

The abilities to record asynchronous digital data with uniform bit spacing at computer-compatible density, and to remain indefinitely in the standby condition without tape motion, suggest applications ranging from the recording of weather data and subsequent automated weather-map plotting to the recording of accounting data and later transmission to remove computer facilities.

The incremental recorder will accept digital data from a variety of sources including such devices as data-encoding typewriters, digital measuring instruments, analog-to-digital converters, paper-tape readers, and serial-to-parallel translators operating from teleprinter lines.

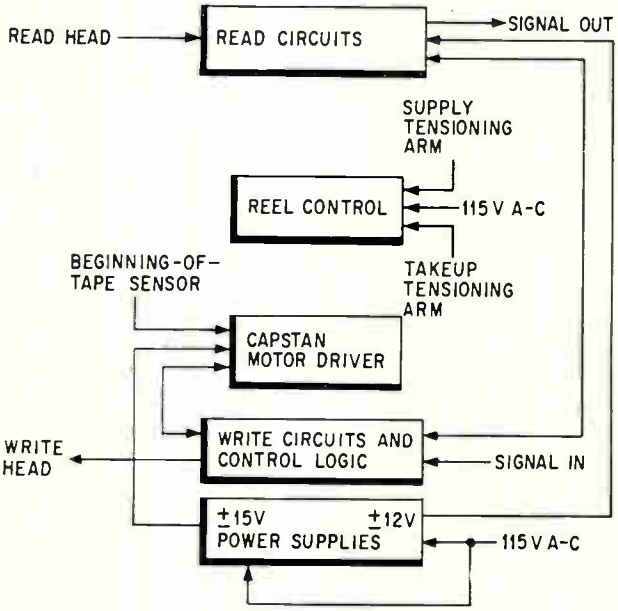
Direct recording on magnetic tape from manually operated keyboard machines such as typewriters, calculators and cash registers is another application.

One Navy installation, using a teleprinter network, accumulates weather data from all over the world and records it for computer processing. This installation has automated the drawing of weather maps by feeding the output of an incremental reader to a special plotter.

Another user had accumulated digital data in a very expensive experiment, but found it to be unusable because the bit-packing variations were too great to be accommodated by the computer. This data was recovered by recording the random output of the original tape using incremental techniques to produce a uniform bit-packing density.

Incremental recorders will accept digital data from a variety of sources, including:

- Data-encoding typewriters, such as Flexowriters, IBM typewriters and teleprinters.
- Digital measuring instruments such as electronic counters, digital frequency meters and time interval meters.
- Analog-to-digital converters such as digital voltmeters, shaft-position encoders, potentiometric recorders with shaft-position encoders, and special-purpose converters.
- Punched-paper tape readers.
- Input sources for paper-tape punches.
- On-line serial-to-parallel translators operating from teleprinter lines.



Typical read-write incremental recorder

Editor's note

Among other magnetic incremental tape recorders is a cartridge model by the Ampex Corp., using a stepping motor, that accepts data at speeds from 0 to 300 characters per second and plays back at 75 to 480 characters per second. The Data-Stor division of the Cook Electric Co. has a recorder that records up to 300 characters per second at 556 bits per inch, and up to 250 per second at 200 bits per inch. The capstan of the Data-Stor recorder is kept from moving by a brake that is released for each step and is reapplied by a photoelectric system, controlled by a slotted disk mounted on the capstan shaft. An incremental tape transport by the Potter Instrument Co. reads and writes at 300 characters per second. The write-only model uses a stepping motor; the read-write model uses "a new proprietary drive mechanism," which is a clutch and brake combination.

The author

Frank Beeler is Midwest regional manager of the Precision Instrument Co. Previously he was a senior engineer. He lives with his wife and eight children in Los Altos, Calif., but will soon move to the Midwest.

Circuit design

Designer's casebook

Designer's casebook is a regular feature in Electronics. Readers are invited to submit novel circuit ideas, packaging schemes, or other unusual solutions to design problems. Descriptions should be short. We'll pay $50 for each item published.

Transistor's stored charge controls pulse delay

By Ralph H. Blumenthal*
Frank E. Williams

Sperry Gyroscope Co., Great Neck, N.Y.

The storage charge phenomenon associated with saturated or bottomed transistors is used in this circuit to obtain a variable time delay. By appropriate choice of germanium transistors having low alpha-cutoff frequencies (typically 2 to 12 Mc), time delays from 0.58 to 4.65 microseconds are provided. In addition, automatic broadening or narrowing of the square input is obtained by appropriate setting of variable resistors.

Transistor Q_1 is initially biased to cutoff. The negative input voltage drives Q_1 into saturation. Transistor Q_2, which was initially saturated, is not immediately driven to cutoff because of its storage charge. With the removal of the input pulse, Q_1 returns to cutoff after a delay because of its storage charge. As Q_2 leaves the saturated operating mode, Q_3 is rapidly driven to cutoff by speed-up capacitor C_2. The output of Q_1 falls off, Q_2 proceeds to saturate again, and Q_3 is turned off. Transistor Q_4 reverses the polarity of the pulse and may be omitted when a pulse of opposite polarity to the input pulse is acceptable.

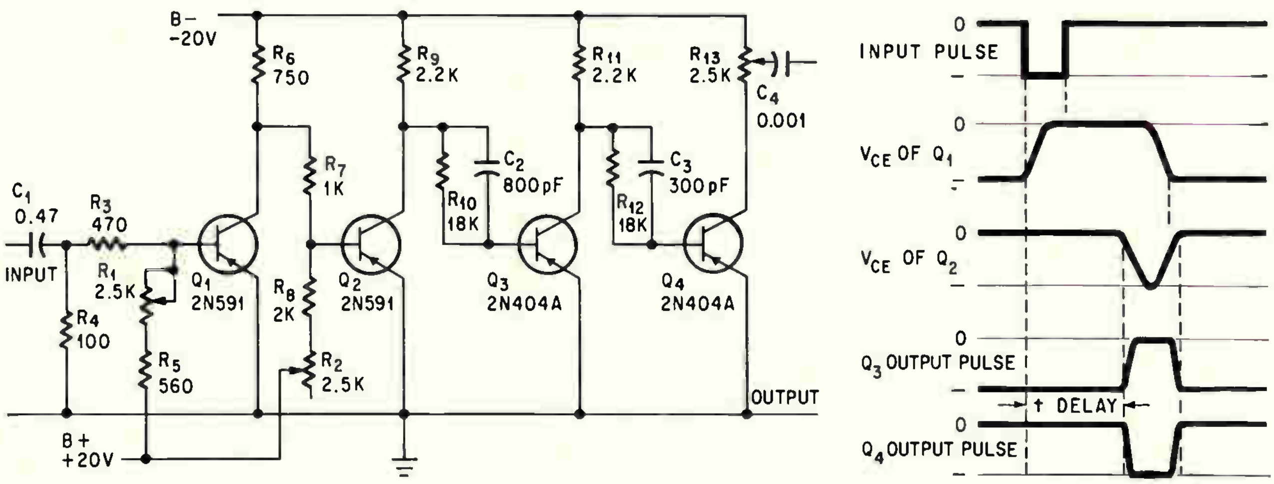
The pulse delay time is controlled by carbon potentiometer R_2 and the output pulse width by carbon potentiometer R_1. There is a narrow region of overlapping control with R_2 adjusted for a very long delay. Application of wider input pulses reduces the maximum obtainable delay when the output pulse width is equal to the input pulse width. Resistor R_{13} is used to adjust the output pulse amplitude.

Since constant output amplitude depends on a fixed input amplitude, regulation of the input pulse is necessary. Impedance matching at both the input and the output is also required.

The delay time range available is dependent upon the transistors used for Q_1 and Q_2 as the following operating data reveals:

Source impedance	100 ohms
Load impedance	10 megohms
Input voltage	—27 volts
Q_3, Q_4	2N404A
Input pulse width	1.5 μsec
Output pulse width	1.5 μsec
Output voltage	—20 volts max.

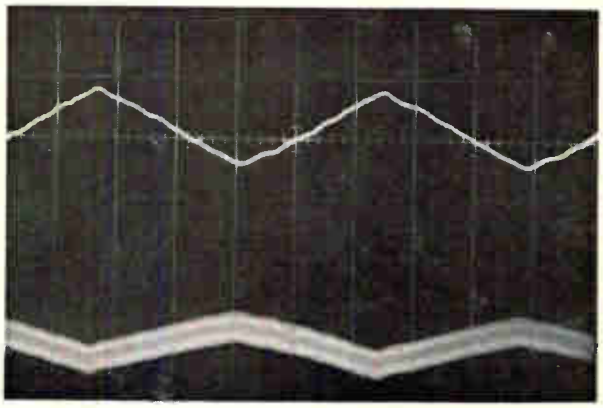
* Now with Grumman Aircraft Engineering Corp., Bethpage, N. Y.



Adjustment of R_1 and R_2 provided delay times of 1.1 to 3 microseconds for a 27-volt input pulse having a pulse width of 2.75 microseconds (left). Voltage waveforms (right).

Q_1 and Q_2 type	Delay range (μsec.)	Rise time (μsec.)
3907/2N404	0.58 to 0.75	0.20
2N414	0.55 to 0.83	0.20
2N591	1.5 to 3.7	0.20
2N109	1.65 to 4.65	0.20

The circuit performs reliably with pulse repetition rates from 50 to 5,000 pulses per second and has been successfully operated over an ambient temperature range from −55° to +55°C. The packaged circuit occupies about seven cubic inches and weighs only 14 ounces.



Output (top) and input (bottom) waveforms using TIX883 transistors. Approximate voltage gain is 40 db.

High-gain dc amplifier drives crt display

By F.J. Murphree and J.H. Hammond Jr.

U.S. Navy Mine Defense Laboratory, Panama City, Fla.

An amplifier with high voltage gain was needed to drive a horizontal deflection circuit for a cathode-ray tube display. The operating frequency was normally a 1-cps triangular wave but response to a low-power d-c input was also required. By using a field-effect transistor as the load for a field-effect transistor amplifier stage, d-c voltage gains as high as 35 to 45 db are obtained with a relatively low supply voltage.

In the circuit shown, Q_1 is the amplifier, Q_2 is the load for Q_1, and Q_3 is the output transistor. Bias resistors R_1 and R_2 are adjusted to obtain the desired operating point. An optimum operating point appears to be one that provides equal voltage drops across Q_1 and Q_2.

The maximum voltage gain obtainable with this amplifier circuit is approximately:

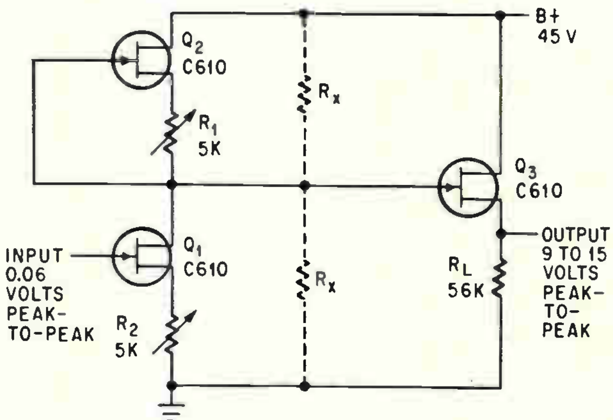
$G_v = g_m r_p/2$ or $\mu/2$

where g_m is the mutual conductance, r_p is the output impedance (similar to the dynamic plate resistance of vacuum tubes) and μ is the amplification factor for the field-effect transistor. For high voltage gains, field-effect transistors with high g_m and r_p should be used.

Either Crystalonics type C610 or Texas Instruments type TIX883 transistors were used in this circuit and the following results were obtained.

Input (p-p volts)	Transistor type	B (volts)	Voltage Gain (db)
0.06 triangular	C610	45	45
0.06 triangular	TIX883	28	40

The resistors labeled as R_x were not used in this

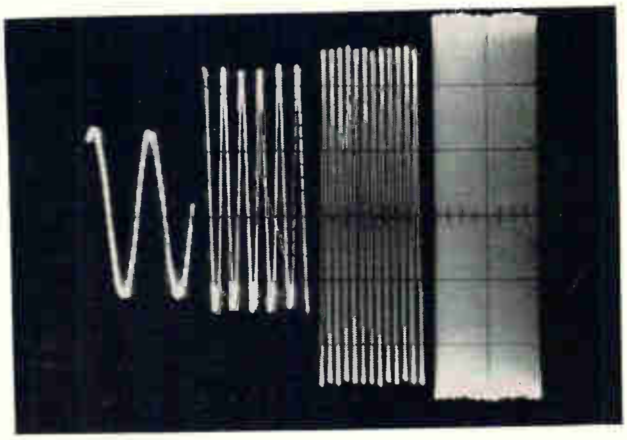


Three field-effect transistors produced voltage gains of 36 to 45 db.

circuit and the following results were obtained:

application. However, they may be employed to extend the high-frequency response of the circuit and reduce drift in the operating point at the expense of slightly reduced current gain. The value of R_x, when used, will vary from 50,000 ohms to one megohm depending on the output voltage and the operating frequency.

The top trace in the photograph of the waveforms is the amplifier output voltage. The x-scale is 5 volts per division. The bottom trace is the amplifier input voltage. The x-scale is 0.1 volt per division. The y-scale is 0.2 second per division. The output signal has been bypassed by a capacitor so that the high-frequency component seen on the input does not appear. The photograph was taken for a 0.06 volt peak-to-peak input and a 28-volt supply using TIX883 type transistors. The values of R_1 and R_2 were adjusted to yield an output swing of from 9 to 15 volts d-c.



Signals with equal signal-to-noise ratios have increasing amplitude with increasing bandwidth.

Instrumentation

Ten signals at a glance

Simultaneous display in multichannel instrumentation discloses hard-to-detect characteristics of a system

By J. E. Russell
Avco Corp., Tulsa Division, Tulsa, Okla.

You're a ground controller handling an experimental plane that seems to be in trouble on the landing approach of a test flight.

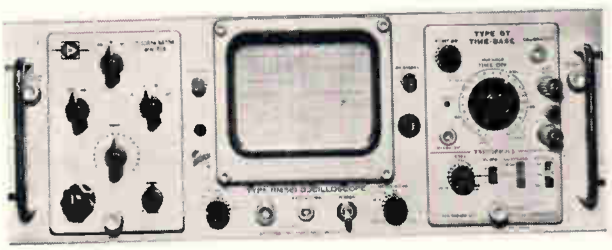
Your indicator panel shows that the plane's rate of descent is too fast. You flip the selector and are informed that engine rpm is rising alarmingly. Another twist of the knob reinforces your fear: air speed is increasing and a diving crash seems imminent.

Your duty is to declare an emergency, call out the crash crew and delay all approaching aircraft.

If you had enough time, you might take further readings of the telemetered flight signals. You might get a surprising picture: fuel supply increasing; cockpit temperature decreasing; engine pressure, aileron position and other parameters steady.

These later readings—if you had time to take them—would be inconsistent with conditions for an impending crash. Indeed, one of them would be inconsistent with any flight condition except in-flight refueling!

If time and temperament permitted, you might further observe that all the signals that spell disaster are fed from the same power supply. Your conclusion now is quite different: An instrument power supply has failed, but there's little danger of a crash.

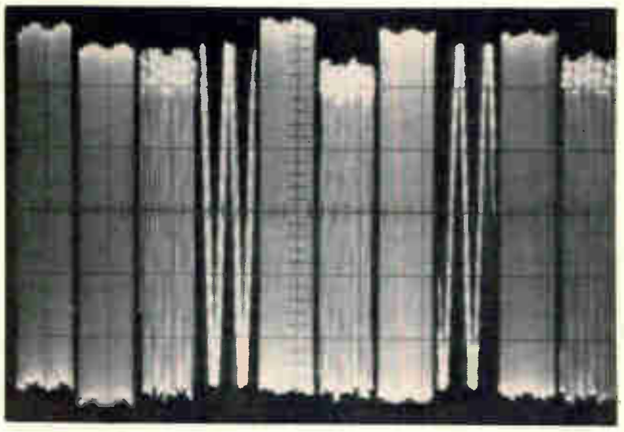


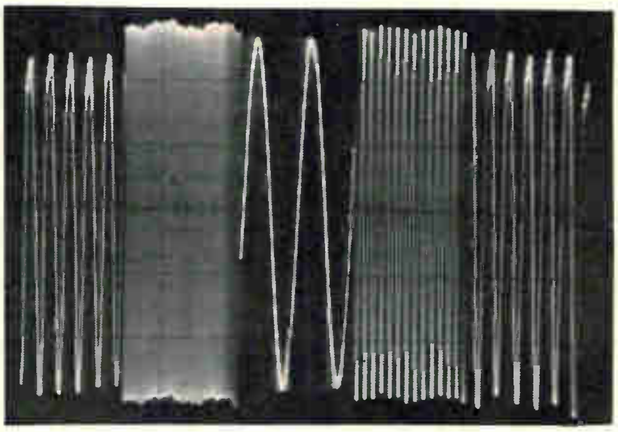
Front panel controls and adjustments of a segmented-sweep display circuit

10 signals on one screen

A new display system now gives the controller a complete picture of many variables simultaneously. The system, a segmented-sweep display for time-multiplexing many a-c signals, was designed specifically to monitor an fm/fm telemetry system having up to 18 f-m subcarriers. Circuit operation is shown in the block diagram on page 56.

In an instrumentation system with 10 or more channels, system characteristics are more important than any individual signal. For example, a large difference in noise between two channels may indicate a system malfunction even though





Segmented sweep display allows amplitudes of signals in separate channels to be compared and aligned for maximum transfer of information (left). Selected waveforms (right) can be examined in expanded sweep operation.

the noise in each individual channel is within specifications.

The conventional method of monitoring involves switching manually between channels and remembering or recording signal characteristics for comparison. But looking at one signal at a time is like driving a car and viewing the road with one eye through a mailing tube. Segmented-sweep viewing, in contrast, is like watching with both eyes, through a broad one-piece windshield.

Multichannel oscilloscopes also can be used for simultaneous monitoring, but this method is limited by high cost and complexity, and by the difficulty of an operator's handling more than about seven channels properly.

Equal signal-noise ratios

Each channel has a ±7.5% bandwidth, centered on the frequency of the channel subcarrier. White noise on a channel is also proportional to bandwidth. Channels with equal signal-to-noise ratios thus have increasing signal amplitude as the frequency increases as shown in the oscilloscope trace.

To improve system alignment, however, variable gains are used in the segmented-sweep display to bring all channels to the same amplitude for readout, as shown in the other oscilloscope traces. The subcarrier amplitude can be adjusted at the mixer amplifier and transmitter modulator, and in the receiver audio circuits. The system is then aligned or adjusted until all channels have equal signal-to-noise ratios.

With careful alignment, all data channels reach threshold simultaneously and produce maximum information efficiency for the data link. A carefully tuned link can often operate at twice the distance of an inadequately tuned link.

The required amplitudes of signals in the various channels can be calculated to meet bandwidth-noise requirements, but other factors make tuning necessary. If frequency distortion occurs in the link, or if transmitter deviation is not exactly proportional to the modulating frequency, the ratio of signal amplitudes in the data channels will be thrown off.

The amplitude ratios are also affected by amplitude variation in the subcarrier oscillators themselves, as the input signals vary from zero to maximum. Nonlinearities of the bandpass circuits in the receiver also affect the ratios.

Segmented display

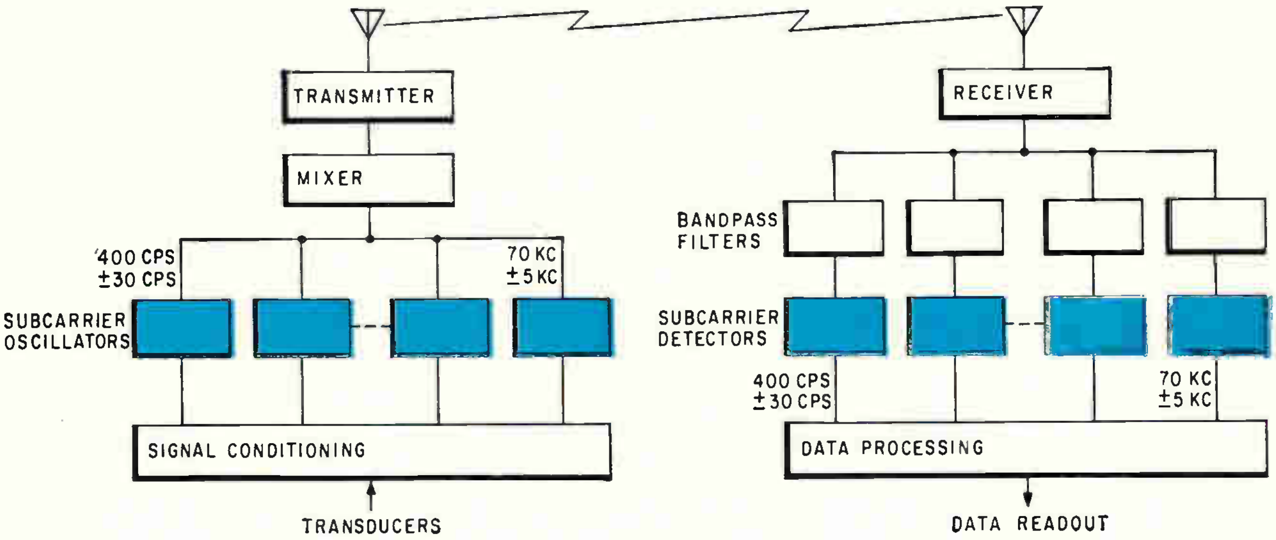
Electronic commutation is used to obtain the segmented-sweep display. For this application, a switching rate is selected that is lower than the lowest frequency signal to be monitored. At least four cycles of the lowest signal frequency (400 ± 30 cps in this case) should appear during the sample time of the commutator. The frequency response of the system is the response to the signal frequency as it is being fed through a particular gate during the time the signal is being displayed; frequency response in this application is independent of switching rate.

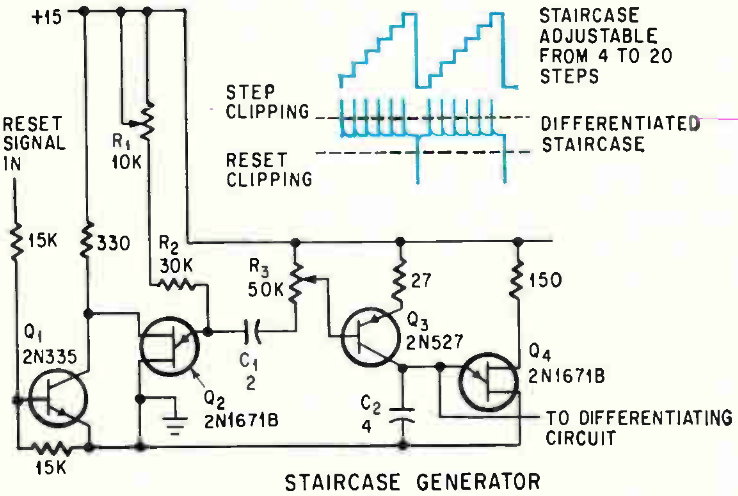
The d-c stability of the commutator is relatively unimportant because all information is a-c-coupled. Since the device is used with an oscilloscope, there are no extreme environmental problems. It isn't even necessary to maintain or restore the signal level through the system. All of this adds up to an extremely noncritical electronic commutator. The block diagram of the device is shown in the drawing on page 57.

The clock generator—the basic timing element in the system—provides pulses to the oscilloscope and ring counter. As each element of the counter is turned on by a pulse from the preceding element, it gates open the channels sequentially. It feeds the monitored signals through one at a time as the scope beam moves across the scope face. A reset pulse returns the scope beam to its starting point and sets the ring counter back to channel one.

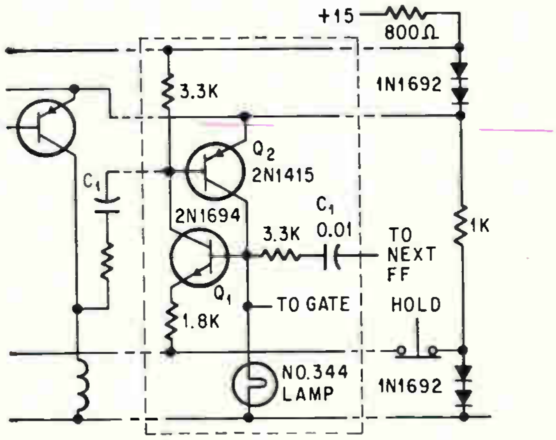
Staircase generator

In the staircase generator (page 56), transistor Q_2 is a free-running oscillator whose rate is established by the potentiometer R_1. This determines the dwell time for each channel. The oscillator generates negative pulses across the potentiometer





STAIRCASE GENERATOR



FLIP-FLIP RING COUNTER

Signals from transducers modulate subcarrier oscillators (top left). Center frequencies of channels range from 400 cps to 70 kc with ±7½% bandwidth. Signals from detectors in the receiver (top center) are fed to the segmented-sweep circuits for simultaneous monitoring.

Gates that feed the monitored signals to the oscilloscope (top right) are turned on sequentially by flip-flops. Staircase voltage builds up across C_2 (bottom left) as pulses from Q_2 turn Q_3 on momentarily. Waveform is differentiated and used to drive ring counter and to

R_3, and these in turn pulse on Q_3 to send current pulses into the capacitor C_2. The adjustment of R_3 determines the voltage amplitude of each step, or the number of steps to reach the firing point of Q_4. This is a front panel control and can vary the number of steps on the staircase from 4 to 20.

Transistor Q_1 allows the generator to be zeroed externally. Flatness of the steps is controlled primarily by the emitter resistor of Q_3, while the uniformity of the steps is a function of the ratio of the two capacitors and resistance R_3. The staircase output is differentiated, and positive and negative pulses are split to provide step and reset pulses to the ring counter.

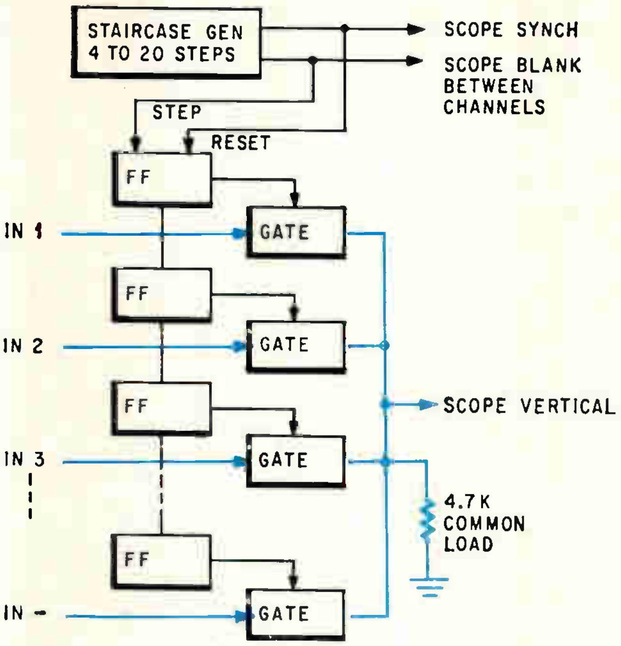
The step pulses also feed to the scope external blanking input to eliminate switching transients and to separate channels. The reset pulse also feeds the scope external synchronization.

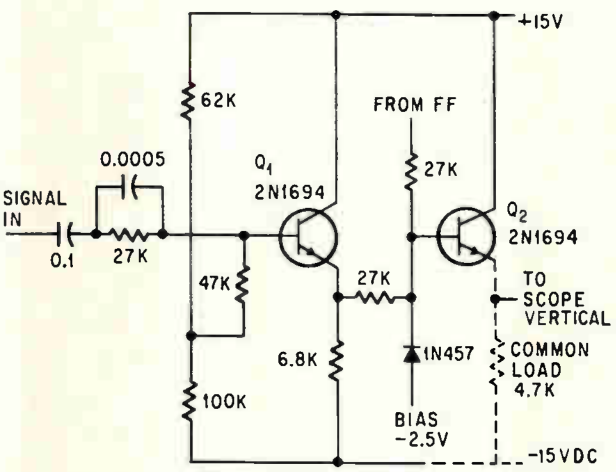
The author

J.E. Russell, a staff engineer at the Avco Corp.'s Tulsa division office in Tulsa, Okla., has been designing instrument systems and components for missiles, aircraft and space vehicles since 1951. He has patents on equipment for visual monitoring and phase-coherent detection.

Flip-flip ring counter

Each stage in the ring counter is a complemen-





DIODE GATE

synchronize the scope. Ring counter (bottom center) uses flip-flips (complementary circuits, with both transistors on or both off) to minimize power drain. Gate (bottom right) feeds signals to scope when its controlling flip-flip allows.

tary multivibrator circuit, here called a flip-flip in contrast with the conventional flip-flop. Both transistors in the flip-flip are either on or off. The advantage of the circuit is its low power drain since only one stage at a time is drawing full current.

Complementary transistors Q_1 and Q_2 (center sketch) are connected for bistable operation. The 3,300-ohm resistor to the base of Q_2, in combination with the lamp to the base of Q_1, hold both transistors off until a pulse from the preceding stage through C_1 turns them on. The stage stays on and feeds its associated gate until a strong pulse on line C removes the drive to Q_1 and causes the stage to turn off and feed a pulse to the next stage.

The counter is reset by a strong negative pulse at the base of Q_2 of the first stage of the ring.

The output is taken across the lamp (that indicates which channel is on) to drive a diode gate. The counter can be stepped manually for observing any channel continuously.

Diode gate

Transistor Q_1 (right sketch) provides input isolation. When the flip-flip signal is off (negative 12 volts) the diode is always forward-biased, regardless of input signal. This holds transistor Q_2 cutoff as long as any one gate is conducting through the common 4,700-ohm load.

When the control flip-flip is on (0 volts) the diode is reverse-biased and half of the signal on the emitter of Q_1 is applied to the base of Q_2. Voltage swing at the base of Q_2 is about -0.5 to -1.5 volts. Transistor Q_2 of whichever gate is on is thus the only one supplying current to the common load.

This inexpensive method of observing many signals simultaneously has been used with several telemetering ground stations. Results have exceeded expectations. Observation can be especially useful in diagnosing intermittent troubles.

Mechanical noise

Vibration can also produce noisy telemetry signals in a rocket or aircraft moving at supersonic speed through turbulent air. The telemetry signals can be considered normal for the conditions, and valid data about the vehicle can be obtained. However, if one or two channels become noisy during a smooth flight, these channels may be completely unusable in turbulent conditions.

Observing system operation one channel at a time, an operator would be lucky to see a single channel become noisy, and would have even greater difficulty comparing it with other channels. Even if the operator were both lucky and skillful, there would be no way to determine whether a single channel was becoming noisy intermittently as the vehicle entered turbulent air.

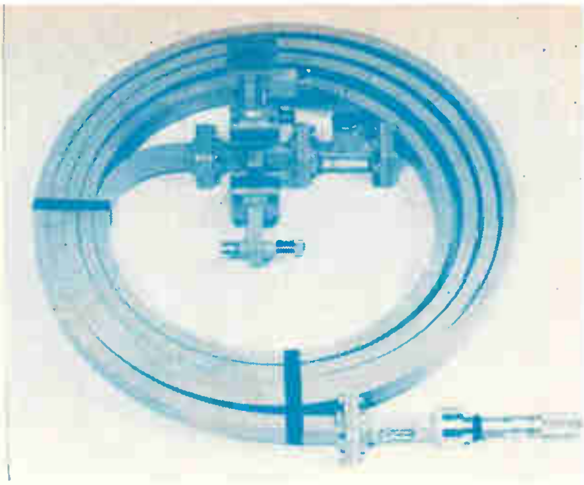
Simultaneous viewing would solve that problem.

Malfunctions of a vehicle or device can, in some cases, be deduced from variations of signals.

A satellite with a defective spin-control system, for example, will tumble in orbit. Radiation from the sun causes a variable local heating as the satellite turns, and this in turn can cause a periodic variation in all measurements. By observing all telemetered signals simultaneously, the system operator at a ground station will quickly note the systematic variation in the signals. This information can be used to determine the rate of tumble and the orientation of the satellite with respect to the sun, and this can lead to time-variant data corrections that would salvage information that might otherwise have to be discarded.

The segmented-sweep approach has already been built into a discriminator monitor by Dorsett Electronics, Inc., in Tulsa, Okla.

Interferometer analyzes microwave transmitter



Optical principles work at microwave frequencies too. Simple circuit uses off-the-shelf components

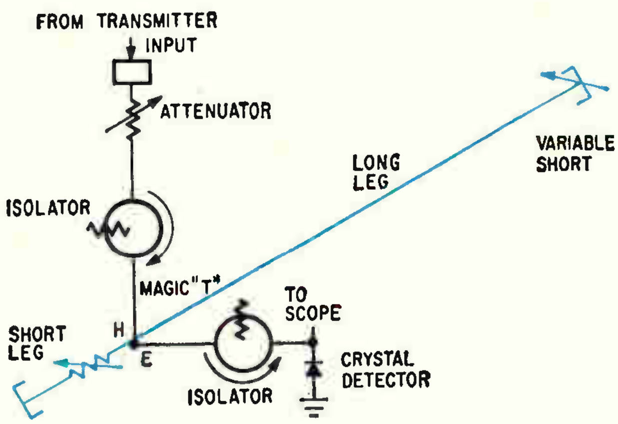
By Russell Robertson

GPL Division Aerospace Group, General Precision Inc., Pleasantville, N.Y.

The phenomena observed when radio frequency fades or when a passing airplane causes television flutter, are interference effects—the signal arrives at the receiver over two or more paths of different lengths. The resulting phase differential between the signal components can result either in reinforcement or cancellation at the receiver. Interferometry has long been used in optics. Now it is the basis of a remarkably simple instrument for the analysis of a microwave transmitter.

The equipment required for the interferometer is simple and readily available. The results compare favorably with those obtained through the use of the more expensive spectrum analyzers.

The technique has already been applied to a pulsed K_e-band radar set recently developed at the GPL Division Aerospace Group of General Precision, Inc. but is not limited to K_e-band equipment (about 13,325 Gc).



Signals arrive at the diode detector after having travelled different path lengths via the short and long legs of the interferometer. The interference produced as the signals either cancel or reinforce each other leads to highly informative readout signal.

Microwave tests

Included in the usual equipment for microwave tests is a calibrated wavemeter cavity placed in the line ahead of a power-measuring thermistor. As the wavemeter is varied, the power meter indicator dips at the source or transmitter frequency.

The single dip, however, suggests a continuous wave signal when in fact the energy may be pulsed or otherwise modulated. When the signal is modulated the resulting sidebands may be of great interest in evaluating the transmitter. Usually the distribution of the frequencies in the signal must be obtained with spectrum analyzers, which are available to cover the K_e-band. But their cost is high and, since the K_e-band is little used as yet, few shops are equipped with spectrum analyzers.

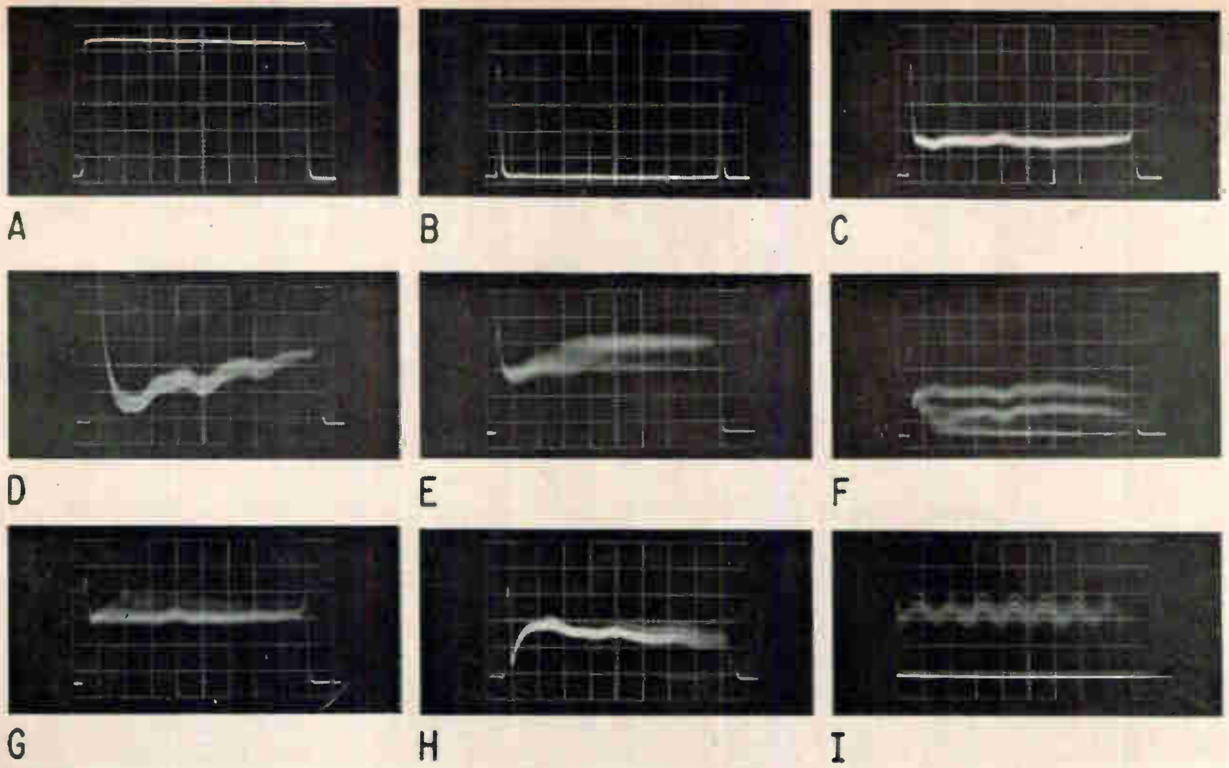
The interferometer

As shown in the sketch, left, a sample of the transmitter output (obtained from a directional coupler) is applied through an uncalibrated variable attenuator to one of the two inputs of a hybrid junction or magic tee. The input attenuator can be adjusted to protect the detector diode from burnout by excess input power.

The hybrid junction divides the input, half going into the short leg and half into the long leg. The characteristic of a hybrid junction that is significant in interferometry is that the inputs to the E and H junctions have a high degree of isolation from each other. Thus, practically none of the signal goes directly to the detector.

The short leg, terminated in a fixed short circuit, receives one half the input power. This is reflected by the short and returned to the hybrid junction, where it emerges from the output and arrives at the detector.

Simultaneously, the other half of the input sig-



Waveforms from interferometer reveal much about the transmitter. Trace A is typical signal from the detector showing one transmitter pulse. Signal is reduced to minimum ampliitude at B by balancing the circuit. Trace C is a signal from an acceptable MA 239 magnetron. Sloping line in D indicates a change in frequency during the pulse. Change of oscillation mode in mid-pulse is revealed in E. Trace F displays multi-mode oscillation producing two pulses with different frequencies. Noise, trace G, and random moding at H can arise from several causes. Power supply ripple produces I trace.

nal propagates along the long leg which, by comparison, represents a very long path. At the terminating short circuit, the signal also is reflected back to the hybrid junction and then to the detector. Because of the difference in path lengths, it arrives many cycles later than the other component. The relative phase of the two components depends upon the length of the long stub.

If an adjustable short circuit is installed at the end of the long leg to control its length, the signal from the long leg can be adjusted until the two returning signals are exactly 180° out of phase with each other. However, perfect cancellation is possible only if both components have equal amplitude. Because of attenuation in the long stub an uncalibrated variable attenuator is installed in the short leg to compensate for transmission loss in the long leg.

The isolators shown in the sketch permit energy to flow only in the direction of the arrows, thus preventing multiple reflections.

Operation is simple

The waveguide input is connected to the transmitter directional coupler. The interferometer diode detector (loaded with about 150 ohms) is connected to an oscilloscope. For diode protection the input attenuator is set for maximum attenuation. The attenuator in the short leg should initially be set to minimum attenuation.

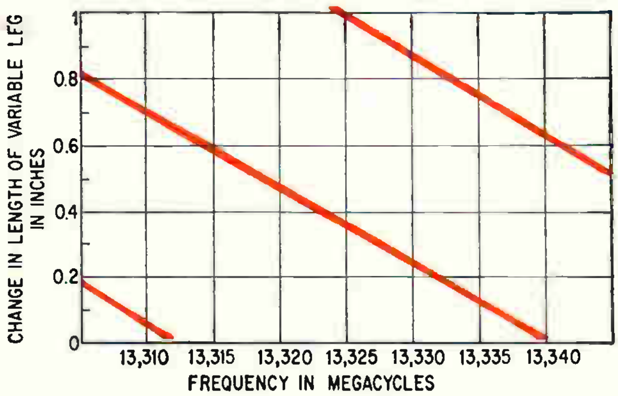
When the transmitter is put into operation, the detected microwave signal should appear on the oscilloscope as shown in trace A in the waveform photographs. (It may be necessary to reduce the input attenuation.) The oscilloscope should be externally synchronized with the driver or modulator pulse. The time base should be set to present one complete transmitter pulse (0.5 microsecond per cm in this case) and the gain set for about 0.1 v per cm dc. While observing the transmitter pulse, the position of the short circuit at the end of the long leg is adjusted until the scope display is at minimum amplitude.

Next, the attenuation in the short leg is adjusted, again for minimum amplitude of the signal. By varying both the short-circuit position and the short leg attenuator, the amplitude of the display pulse can be reduced to nearly zero, as in trace B. Input attenuation can be reduced to increase the sensitivity of the presentation as interferometer balance is approached.

When balancing the interferometer, obviously a perfect null is possible only if the signal consists of a single frequency. If other frequencies are present, some output will always appear at the detector. After the best null is obtained, the attenuator in the short leg requires no further adjustment. However, the adjustable short circuit in the long leg provides a means to analyze the spectrum of the transmitter output.

Interpretation

A display of frequency as a function of time is available on the oscilloscope. This is the great advantage of the microwave interferometer over a conventional wavemeter. With this instrument, the frequency spectrum of the transmitter output can be observed for the duration of the pulse. A con-



Calibration curve of change in length of long leg versus frequency shows that instrument balances at more than one frequency for a given length. The ambiguity, however, can be resolved.

K_e-band interferometer parts

1	one-inch variable short	Microwave Associates	MA-568
1	Hybrid junction		MA-638
1	Crystal holder		MA-595
2	20db variable attenuators		MA-578
2	20db Isolators		MA-187
1	Fixed short	De Mornay-Bonardi	DBF960
1	Crystal detector		IN78
1	13 ft length (coiled) waveguide Micro-Delay Div.		WR62013

tinuous-wave input produces a constant output, which is zero volts at the null point or which can be adjusted by unbalancing the interferometer slightly (changing the position of the variable short) to some other finite value in the linear region of the detector characteristic.

A pulse input produces a spike at the leading and trailing edges of the displayed pulse. Between the two spikes the display will appear as a straight line for a constant input pulse frequency. This is illustrated in the 4.2 microsecond pulse shown in trace C taken from the output of MA 239 magnetron operating normally.

When the transmitter frequency changes slightly during the transmission of the pulse, the display takes the form of a sloping line, illustrated by D. The instrument affords a convenient method of measuring the amount of frequency modulation present by measuring the slope of the line. This is done by adjusting the short circuit in the long leg until the high point of the sloping line is positioned at any convenient reference point on the display, say one of the lines on the crt graticule, and noting the wavemeter dial reading. The short circuit is then adjusted to position the low point of the line in the same position, and the wavemeter dial again noted. The difference between the readings, when referred to the wavemeter calibration chart yields the amount of frequency modulation.

Noise in the output of the transmitter results in a broadening of the trace—or "grass." The width of the trace and thus the amplitude of the noise can be measured by the method described above for measuring frequency modulation. How much of this noise is a-m and how much f-m cannot readily be determined, however.

Changes in oscillation modes of the magnetron appear as shown by E and F. A mode change during the pulse appears as a step change in the presentation. If the mode change produces several pulses at several frequencies, multiple lines appear as in F.

Another very informative presentation is made available if the sweep speed of the oscilloscope is reduced until a few cycles of primary power frequency are displayed.

What may at first appear to be noise, trace G, or random "moding," trace H, may actually be a variation of the transmitter output at the primary power frequency or at twice the primary power frequency, depending upon whether the variation is the result of modulation by the filament voltage or full-wave ripple on the high voltage. Trace I show such ripple on the high-voltage magnetron output.

Calibration

The position of the short circuit in the long leg is repeatable with great precision because the adjusting knob is a one-inch micrometer head. The calibration curve shown above is a graph of frequency as a function of change of length of the long leg. Note that for each frequency, the instrument can be balanced at more than one position. These positions are one half wavelength apart. Also, for each dial reading there is more than one frequency at which the instrument will balance. The difference in frequency between two nulls can be found by dividing the operating frequency by the difference in length—expressed in quarter-wavelengths—of the two legs.

Construction

All parts required for a K_e-band interferometer are available off the shelf. The parts actually used are shown in the table and photograph but equivalent items are available from other manufacturers.

The parts are assembled as shown in the schematic diagram (make sure that the direction of the isolators is correct). Nuts and screws can be sealed to discourage disassembly since such tampering can ruin the calibration.

The use of the interferometer in routine microwave maintenance is new, and its application to other measurements has not been fully explored.

The author

Russell Robertson has worked on doppler radar navigation systems and their associated test equipment since joining the customer service department of the GPL Division Aerospace Group in 1959. He specializes in preparing technical information for customer application.

Special report

Magnetics

its applications in electronics

By the editors of Electronics

- The challenge of magnetics
- Computer magnetics
- Power and control circuit magnetics
- Microwave magnetics
- Magnetic effects
- Generating high magnetic fields

After a long period of relative obscurity, magnetics is emerging to play an increasingly important role in the electronics industry

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The challenge of magnetics

The long-dormant field of magnetics is stirring. New techniques, new materials, improved magnetic devices and components are finding applications in every area of electronics

Unless he's in the computer industry, the average American electronics engineer is likely to have only a rudimentary knowledge of magnetics. When building equipment he frequently overlooks new magnetic techniques and devices that might have been cheaper and more reliable than the semiconductors and vacuum tubes he uses.

For example, improvements in magnetic materials are opening up a host of new applications for that old standby, the magnetic amplifier. Today magnetic amplifiers are finding important uses in space electronics. They can be designed to occupy one cubic inch and outperform units that occupied 10 cubic inches a decade ago.

In computers, new forms of magnetic memories and logic are starting to challenge the standard ferrite-core memory and semiconductor logic circuits. In the field of microwaves, intense materials research is leading to new microwave devices like yttrium-iron-garnet preselectors and tuners in military reconnaissance receivers.

With the availability of new semiconductors a variety of hitherto exotic magnetic effects—Hall, Nernst, Ettingshausen to mention only a few—are being harnessed to broaden the family of electronic devices. For instance, the Ettingshausen effect has been used in experimental coolers that hold promise for cooling individual electronic components to lower temperatures than are now feasible. A new class of magnetic compounds whose magnetic properties are affected by temperature is also being studied. They may be useful in bistable circuit elements as well as sensors and regulators.

Today's research in magnetic effects presages the devices of tomorrow. To help understand the challenge offered by the almost untapped potential of magnetics, some recent theoretical developments are briefly examined.

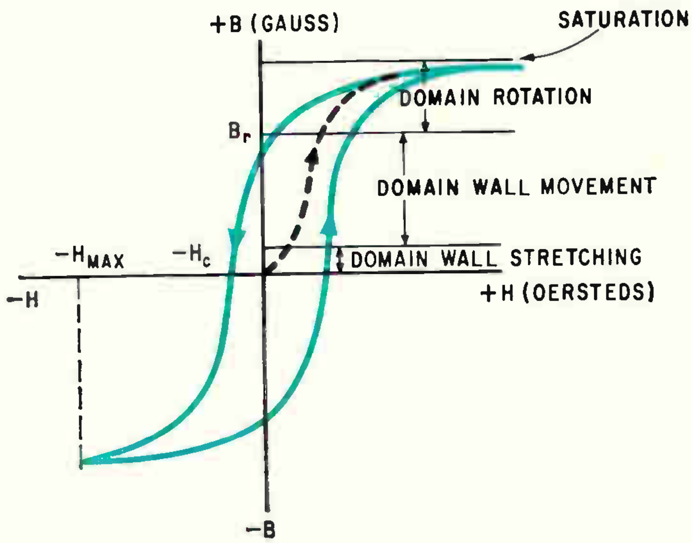
Domains

A ferromagnetic material is composed of domains—regions in which the magnetic moments of groups of atoms are held parallel by electrostatic forces in the material. Ferromagnetic materials, like iron, are those that have high permeabilities and exhibit magnetic hysteresis effects.

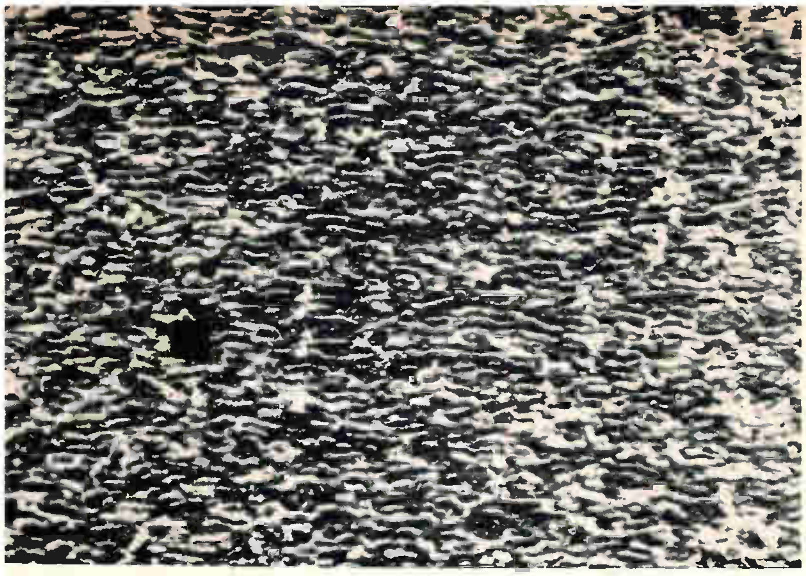
Adjacent domains are separated by boundaries called domain walls. These boundaries are similar to grain boundaries between the different crystals in a polycrystalline semiconductor except that they move easily. Domain walls are of practical significance because their behavior largely determines the useful engineering properties of magnetic materials.

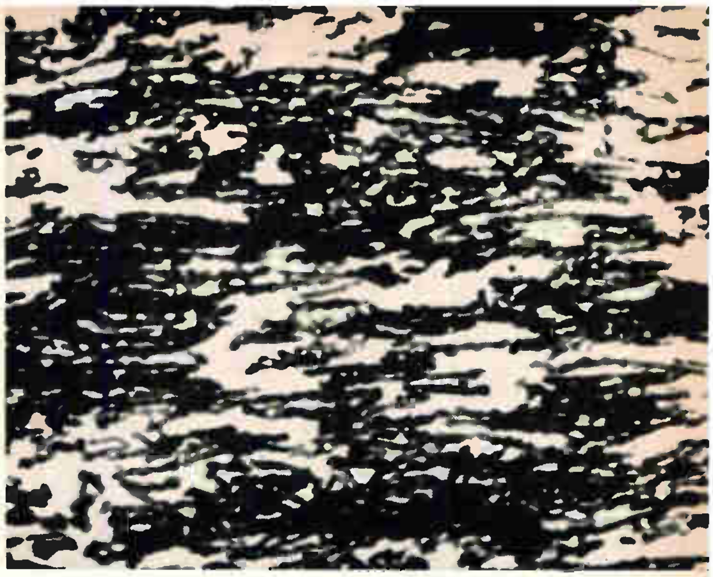
In the unmagnetized condition, the domains are randomly oriented and there is no magnetic field outside the material. When a magnetizing force, H, is applied, it changes the balance of internal energies so that the domain walls move in a way that results in the material becoming magnetized. This motion can be described by three distinct processes occurring in different regions of the familiar hysteresis loop. The hysteresis loop plots magnetic flux density (B) versus magnetizing force (H), see below. The quotient of B/H is the permeability, μ, which is unity for nonferromagnetic materials.

First the domain boundaries are stretched elastically around imperfections in the material. This causes a slight magnetization that is reversible; that is, the domain boundaries will return to their original position if the field is removed. Second, as the intensity of the applied field is increased, domain boundaries break away from the imperfections and move through the material. This move-



Hysteresis loop plots flux density (B) as magnetizing force (H) is applied, withdrawn, reversed, withdrawn and applied again.





Metallurgical structure of Alnico, left, contains elongated single-domain regions developed by aging the alloy in a magnetic field, whereas Lodex, a synthetic structure, contains iron-cobalt particles made individually and then aligned and compacted into a magnet. Photos by F.E. Luborsky, General Electric Research Laboratories.

ment is accompanied by a sharp increase in irreversible magnetization. Finally, the fully grown domains rotate their directions of magnetization until they are aligned with the applied field. This brings the material to the point of saturation, where no additional magnetizing force will increase magnetization.

If the magnetizing force, H, is now removed, the resultant magnetization will decrease to a value B_r known as the residual induction. If H is then reversed and increased in the negative direction, the resultant magnetization is reduced to zero. At this point, the value of the demagnetizing force is $-H_c$, known as the coercive force. Increasing H to $-H_{max}$ changes the sign of the magnetization, B, and the remainder of the hysteresis loop is obtained by repeating the process starting with $-H_{max}$.

This simplified picture can be used to illustrate the importance of controlling domain boundary movement. For efficient transformer materials or thin films for computer switching where the aim is to get a large change in magnetization by applying only a small magnetizing force, the domain boundaries must be made to move easily in response to low fields. Such materials, which have a low coercive force, are called "soft". Permanent magnets require high-coercive force ("hard") materials so that it will be difficult to move walls.

The single domain

One obvious approach to impeding the motion of domain walls it to introduce structural inhomogeneities in the material. This was done with early permanent magnets. A more effective approach, however, is to eliminate these boundaries altogether. This results in materials with higher coercive forces and is done by preparing particles smaller than the width of a normal boundary.

When the particle size is reduced to this point (in iron it's normally less than 0.1 micron). the domain walls disappear because of energy considerations that need not be detailed here. The result is a single domain. The rotation of this single domain until it is aligned with the applied field (the third phase of the process described) accounts for the whole hysteresis loop.

This is the concept of the single domain, or fine-particle, magnet that has emerged in the last decade as the modern high-coercive-force permanent magnet, where magnetization can take place only by rotating the magnetic moments of individual atoms. Because greater energies are involved, this is a much more difficult process than simply moving domain boundaries.

The coercive force of a fine-particle magnet is determined by forces that resist the rotation of the domain. These resisting forces are called anisotropy forces and are accounted for by one of the following mechanisms:

1. Crystal anisotropy—the tendency of magnetization to lie in a preferred, or "easy" crystalographic plane.
2. Strain anisotropy—the tendency of magnetization to lie in the direction of elastic strain.
3. Shape anisotropy—the tendency of magnetization to lie along the length of an elongated particle.
4. Exchange anisotropy—due to the coupling of the atomic spin system between a ferromagnetic material and one, called anti-ferromagnetic, in which the magnetic moments of neighboring atoms are anti-parallel.

Materials

All the new high-coercive force materials derive their magnetic properties from single-domain particles whose coercive force is developed by bringing one or more of the above mechanisms into play through metallurgy. The most widely used magnet is the aluminum-nickel-cobalt-iron alloy series known as Alnico whose coercive force (approximately 700 oersteds) is developed from the shape anisotropy produced by elongated precipitates. A newer fine-particle magnet, based on shape anisotropy, is a synthetic structure called Lodex. It consists of elongated particles of iron-cobalt and has an H_c of about 900 oersteds. By obtaining more perfectly shaped elongated particles it may be possible to obtain even better properties than current Alnico or Lodex magnets. For example, H_c's of 10,000 oersteds might be possible in iron.

Barium ferrite, another synthetic structure, depends on crystal anisotropy for its coercive force of approximately 2,000 oersteds. This high coercive force has made it useful in such applications as television-focusing structures, while its light weight makes it attractive for instrument movements. No commercial developments have yet come from strain or exchange anisotropy.

Soft magnetic materials

In a similar manner, domain theory has led to the development of soft magnetic materials. Here the aim is to minimize the different anisotropies. For example, stresses inherent in thin films cause high coercive forces. These are minimized by annealing, by matching mechanical properties of the substrate to the film through evaporation at an angle normal to the substrate, or by forming the film at temperatures where the stresses are minimized. Crystal anisotropy can also be minimized by using alloys such as 80% nickel—20% iron that have no crystal anisotropy.

Metallurgists and physicists are striving to improve magnetic materials by making use of these anisotropies in presently known materials and by looking for new alloys and compounds with better or different inherent properties.

Among the latter, considerable research is being devoted to superconducting magnets, rare earth materials and first-order transition materials, which are described in the last two sections of this report.

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Other magnetics move in on the standard ferrite core

High-speed, high-capacity capabilities of newer memories plus expected economical fabrication may push the ferrite core out of under-one-microsecond memory systems

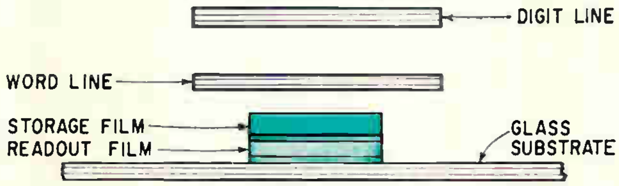
The ferrite core is still the preferred storage element in high-speed memory systems when a very rapid read-write cycle time ranging from 0.5 to 15 microseconds is desired. But computer manufacturers are actively developing other possible storage media. The leading magnetic candidates are shown in the table on page 68.

Since the practical limit for a small-capacity ferrite core is slightly under 0.4 microsecond, memory elements with 0.2-microsecond or faster cycle-time capability—such as thin magnetic film—are considered the most likely to make the first significant break into the ferrite core's domain—provided they can also make the grade economically.

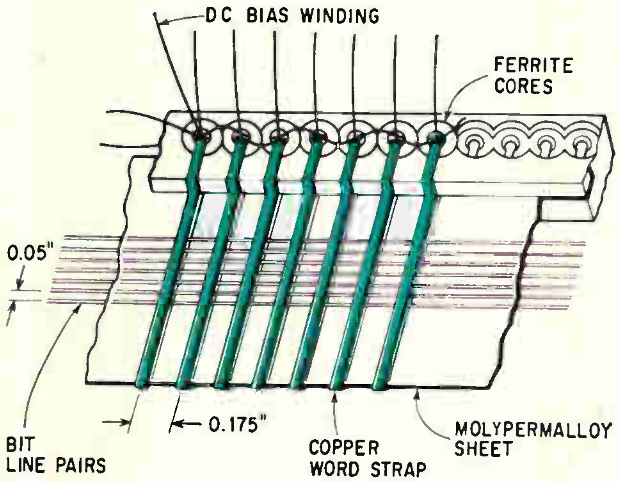
Low cost is one of the virtues of the ferrite-core memory element. In a standard memory using ferrite cores, the cost of electronic components is approximately equal to that of the magnetic core arrays but magnetic cores outnumber the semiconductor switching elements by 200 to 1. The development of automatic testing facilities plus more than a decade of molding experience have lowered the fabrication cost of ferrite cores and produced elements of extremely high uniformity.

Thin magnetic film

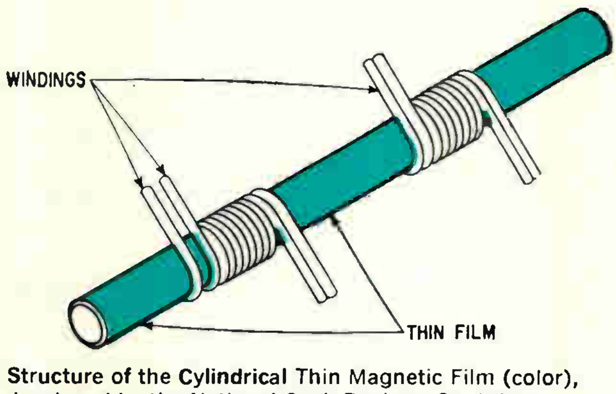
Nevertheless, prospects in high-speed applications look good for thin magnetic film. The Burroughs Corp., for example, says that thin magnetic film appears more feasible than core memories from both economical and technical standpoints where cycle times of shorter than one microsecond are desired. Researchers of the Lincoln Laboratory of the Massachusetts Institute of Technology believe that a cost reduction of almost two orders of magnitude over core memories will be achieved with magnetic films in the under-one-microsecond category. The Radio Corp. of America puts on the



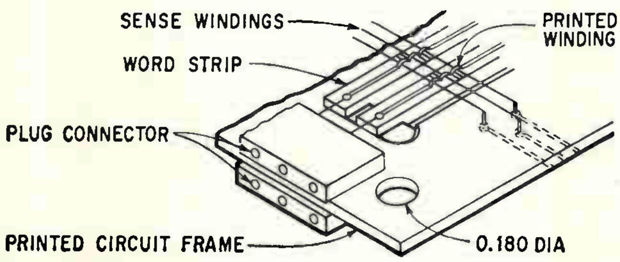
Cross-sectional representation of the Bicore thin-film memory. Spacing is exaggerated.



Section of a single plane in a piggyback twistor memory. The copper word straps (color) are at right angles to the bit line; each strap defines a word location.



Structure of the Cylindrical Thin Magnetic Film (color), developed by the National Cash Register Co. It has a 1,025-bit capacity and a 100-nanosecond cycle time.



N7100 Microferrite array by the Radio Corp. of America. This 3,840-bit memory has a 400-nanosecond cycle time.

damper, by pointing out that for the important class of large memories of medium speeds—one to two microsecond cycle time—the thin-film approach to integrated batch fabrication is more expensive than fabrication based on automatic handling of individual cores.

Thin magnetic films are made from Permalloy, an alloy of nickel and iron having a square hysteresis loop, which provides the storage ability. They have already compiled an impressive list of successful use in memory systems. The FX-1 (3,328 bits with 370-nanosecond cycle time) and the TX-2 Computers at Lincoln Laboratory, the UNIVAC 1107, the 166,000-bit 700-nanosecond UNIVAC ADD (Aerospace Digital Development) and the Burroughs D825 are some of the better known examples. Last year, Fabri-Tek Inc. announced its thin-film memory system—the FFM-202. The FFM-202 is available with four planes providing a total of 18,432 bits with a cycle time of 300 nanoseconds.

Experimental success with a 200-nanosecond cycle time (with 1024 bits) was reported as early as 1961 by the National Cash Register Co. Continuous thin-film cylinders were used. By 1962 IBM had achieved cycle times under 200 nanoseconds using rectangular films with 18,432-bit capacities. That same year, the continuous thin-film approach was successfully demonstrated in England when a 4,096-word 1,000-nanosecond-cycle-time system was introduced by International Computers and Tabulators Ltd.

The head start of the toroidal ferrite core and the fast cycle time attained by thin magnetic film have not slowed investigation of a wide variety of other magnetic memory elements.

Ferrite memories

In the ferrite category, the field includes the apertured plate molded with an array of holes: the Biax—apertures at right angles in the ferrite element; the Flute—molded tiny magnetic ferrite tubes over a mesh of fine wires; the Transfluxor—a memory element with holes of unequal diameters which define the magnetic paths, the laminated ferrite sheet, and the 10-mil (inside diameter) microferrite memory. The original version of the ferrite bead, a memory device formed by direct fusing of the ferrite powder onto a set of drive and sense wires, is no longer in the picture because of its comparative high cost as well as technological problems.

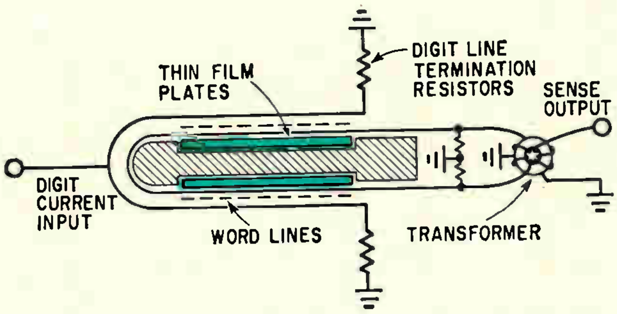
Other approaches

In the metals, besides the various thin magnetic film approaches including the Bicore (two thin films per memory element) and cylindrical thin film, there is the etched sheet, the permanent magnet and piggyback twistors and the woven screen.

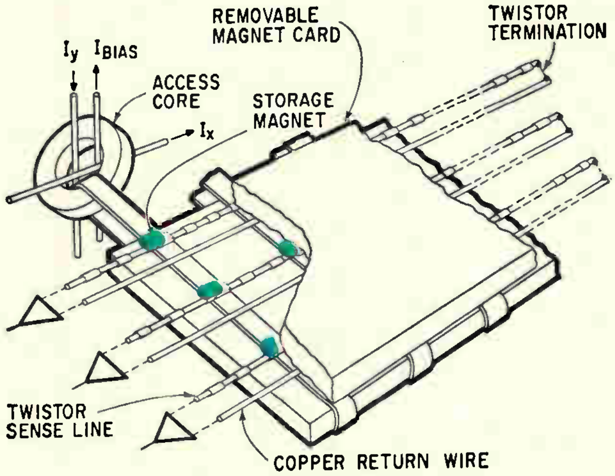
Another promising candidate is the ferrite-metal waffle-iron memory. It consists of a base plate made of a high permeability ferrite into which a grid of slots is cut. This forms an array of rectangular posts which give the appearance of a miniature waffle iron. Also being investigated is the Cubic, actually a form of the waffle-iron memory except that the selection and sense wires follow straight lines instead of weaving around the posts. Bell Telephone Labs now has an experimental waffle-iron memory with a 30,000-bit capacity and 0.4 microsecond cycle time. The highest capacity previously attained was 8,000 bits.

An 8,000-bit memory with 0.4 microsecond cycle time had been announced by Bell last year. In England, Standard Telephone and Cables, Ltd., is experimenting with a 6,000-bit waffle-iron memory which has an access time of 0.1 microsecond.

While the ferrite core is holding down first place in the memory derby and thin magentic film is currently the number-one runner-up, it looks as if one of the newcomers—the laminated ferrite sheet—has moved into third place.



Internal arrangement of Texas Instruments Inc.'s MS-13 thin-film memory plates (color), word, sense and digit lines.



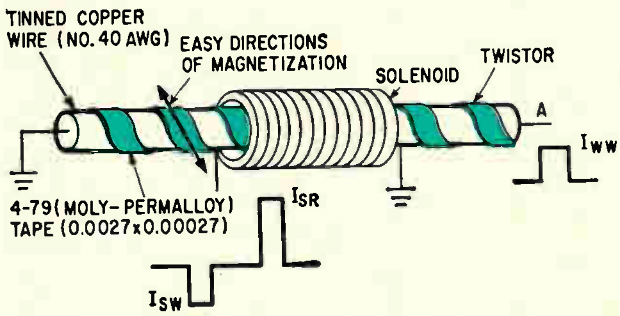
The permanent magnet twistor memory plane. With this memory system, information is stored on arrays of permanent magnets (color) contained on removable cards.

Laminated ferrite sheet

The laminated ferrite sheet, announced last fall at the Joint Computer Conference, could well be the sleeper in the field of memories. When driven with currents of several hundred milliamperes the laminated ferrites have cycle times as fast as 100 nanosecond. When driven by currents as low as a few tens of milliamperes they have cycle times of about one microsecond. As a result, they simultaneously provide a single device that meets both high-speed and large-capacity, low-cost memory requirements.

The only laminated ferrite arrays fabricated thus far have 16,384-bit capacities with over-all array dimensions of 2.8 × 0.75 × 0.005 inches (cover photo). The array consists of 256 parallel X-direction windings and 64 parallel Y-direction windings. Both sets of embedded windings are electrically insulated from each other. Each crossover point between an X-conductor and a Y-conductor is a storage location.

RCA is very optimistic about the future of the laminated ferrite. Jan A. Rajchman, director of the RCA Computer Research Laboratory at Princeton, N.J., believes the laminated ferrite sheet has the brightest future of the various memories under development. Since Rajchman is one of the principal developers of the ferrite core memory system—the standard storage device in modern high-speed computers—his view is a strong endorsement of the laminated ferrite.



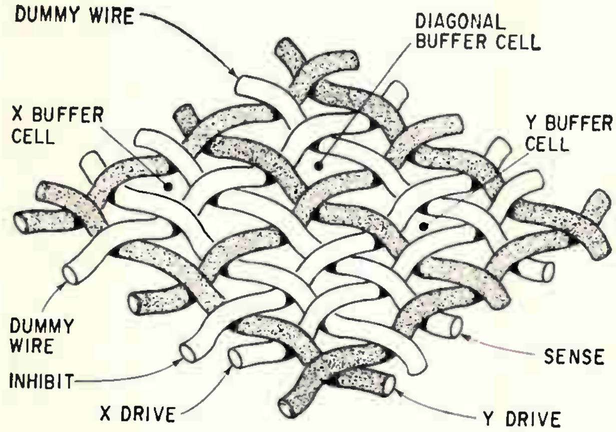
The permanent magnet twistor is composed of a length of twistor (color) and a solenoid concentric with the twistor. The twistor consists of a copper wire on which a ribbon of square-loop magnetic material is wound, helical fashion.

Twistors

Just recently announced, but already very highly regarded at the Bell Telephone Laboratories, is the piggyback twistor.

The piggyback twistor uses two thin narrow tapes—one to store information, the other to sense the stored information—spirally wrapped around a fine copper conductor. Because the tapes are wrapped one on top of the other, it is called piggyback. The twistor was developed at Bell Telephone Laboratories by W. A. Baker and announced only three months ago. The memory has 4,096 words, each storing 54 bits of information. Each word consists of a copper strap wrapped around a flat cable containing 54 twistor wire pairs. A binary digit (bit) is stored at the intersection of each word strap and twistor pair.

The piggyback twistor eliminates the need for the card-changeable technique used with permanent magnet twistor. In a permanent magnet-twistor memory system, small bar magnets are bonded to thin aluminum cards. The cards must be precisely positioned in the twistor memory so that each bar magnet is located exactly at the intersection of a twistor pair and a copper strap. The



A typical four-wire single-turn woven-screen memory cell.

information content is changed by removing the magnet card and inserting a modified card in its place. Since the piggyback twistor memory can be written into automatically by current pulses, it allows considerably faster changing of information. Thus far, experimental piggyback twistor memories have been built with up to 300,000 bits and a read-cycle time of about five microseconds. Bell is currently working on a 800,000-bit memory with a five microsecond read-time.

The permanent magnet twistor memory, developed in 1957, is currently in use in Bell system equipment, including Bell's No. 1 Electronic Switching System, which contains nearly six million bits in a 65,536 word, 90 bit-per-word array. This memory is divided into 16 modules of 4,096 words each. To minimize time out-of-service for program changes, a magazine loader which simultaneously inserts 128 magnet cards is used. Inserting or removing the cards with the loader takes about one minute. The read-cycle time is five microseconds. More than 300 memories using permanent magnet twistors have been built since 1961.

Flute memory

The Flute is a very recent arrival. IBM is currently evaluating a 1,000-bit one-microsecond experimental Flute memory array. The company is enthusiastic about the adaptability of the Flute to batch fabrication, but needs more time for comprehensive investigation. A 15,000-bit array has also been constructed and larger-bit capacity memories are on the drawing board.

Each Flute array includes spare elements so that faulty elements can be disconnected and spare tubes wired in as replacements. IBM expects that this technique will provide extremely high yields.

Woven-screen

Based on tests conducted for 2,500-bit and a 4,000-bit experimental woven-screen planes, Thompson Ramo Wooldridge Inc. believes this approach is feasible and has proposed a 10^8-bit, 10-microsecond read-access time, woven-screen memory system. The difficulty experienced in uniformly plating large woven planes appears to be under control and the substitution of cloth looms for the wire looms originally used, has improved the weaving quality. Woven-screen experimental memories have been operated successfully at temperatures to 195°C, and from an environmental standpoint are superior to ferrite-core memories. This approach also offers low-production costs in fabricating large-capacity memory systems. There are still several problems in the weaving process to be worked out in order to avoid damage to the screen-surface characteristics.

Biax

During March, 1964, the Aeronautronic Division of the Philco Corp., Newport Beach, Calif., delivered its first prototype 10-megacycle memory system—1024 48-bit words—using Biax memory elements. This was the third achievement by Aeronautronic in the development of Biax memory systems (a 1-Mc system was introduced in 1961; a 2-Mc system was brought out last year).

Transfluxor

The transfluxor is losing ground to some of the newer approaches. It was used in the first electroluminescent display array back in 1957 and has also been used in a variety of specialized applications, including experimental content-addressable memories. Its use in all-magnetic logic circuits (the circuits contained only transfluxors and wire) aroused considerable interest.

Superconductive memories

Many companies have been investigating superconductive phenomena. Superconductive techniques offer electronic memories with capacities in billions of bits. Sharply defined thresholds between superconductive and normal states allow switching and the persistent supercurrents are an excellent form of storage.

Some of the superconductive memories already investigated have been the Crowe Cell—a film sheet with a hole bridged by a narrow strip, the continuous sheet, the persistor and the persistatron.

Last year, supported in part by the Rome Air Development Center, Rome, N. Y., RCA built and operated a 16,384-bit superconductive memory plane. The entire memory plane together with accessing cryotron circuitry was contained on a 2-inch by 2-inch substrate.

To address the superconductive memory, a network of cryotrons steers the drive currents to the selected lines. The usefulness of the cryotron results from the ability of a superconductive strip to establish a normal resistive path when a sufficiently high current is passed on a superimposed strip. In the selecting networks, the cryotrons are arranged in trees. At every branch one of the cryotrons is resistive and the other superconductive, according to the value of the corresponding binary address bit. The currents are steered to the desired memory through the only completed superconductive path.

Magnetic circuits

The advantages of magnetic systems include their low cost per bit, reliability, low standby power and, for military and space applications, radiation resistance. Now, with the low-coercive-force and square-loop materials, and better techniques, magnetic systems look more promising than they did a few years ago.

The trend in magnetic elements is toward bipolar devices, where information is represented by a plus one or a minus one; unipolar devices represent information by a pulse or no pulse, require 10- to 20-percent drive-current margins and have a relatively small gain per transfer.

In bipolar devices the margins are excellent: drive currents can be varied over a ratio of five to one, and an energy gain greater than 30 can be obtained in one sequence of clock pulses. The smallest unipolar element requires 15 times the energy of similar bipolar elements, and has a small margin.

At present the cost of magnetic shift registers operating under 500 kilocycles is less than with semiconductor integrated circuits. It may become even lower for one type, depending on the success of efforts in building a programed wiring-machine at one research laboratory for wiring magnetic elements. One semiconductor company has projected a long-term cost for a 20-bit shift register, operating at less than 500 Kc, at a cost of 50 cents to a dollar per bit.

At last year's Intermag Conference, E. E. Newhall of Bell Labs described work on storing, amplifying and rewriting into memory with bipolar ferrites. These balanced-flux elements are used for memory, storage and logic, and achieves energy gain without biasing; the circuits consist of nothing but magnetic material and wire. A 14-bit shift register was constructed, and operated at up to 200-Kc bit rates.

At the 1964 Intermag Conference, Newhall dis-

Comparison of various memories

Memory type	General status	Market (Present or anticipated): Commercial	Military	Telephone	Mode	Fastest speed achieved: Capacity (Bits)	Read-write cycle time (μsec)	Highest capacity achieved: Capacity (Bits)	Read-write cycle time (μsec)
Ferrites									
Apertured plate	In production			●	DRO	4.1×10^3	1.25	2×10^5	5.5
Biax	In production	●	●		EANDRO or DRO	5×10^6	.1		
Flute	Research program	●			DRO	10^4	1	10^4	1
Laminated ferrite	In development	●	●		DRO	10^4	.2	3×10^4	.4
Microferrite	In production	●	●		DRO	3.8×10^3	.4		
Standard core	In production	●	●	●	DRO	10^4	.5	1.9×10^7	8
Transfluxor	In production	●	●	●	EANDRO or DRO	10^4	1		
Metals									
Bicore	In production	●	●		EANDRO			2×10^5	3*
Cylindrical film	In production	●	●	●	EANDRO			10^6	
Etched sheet	In development		●		DRO	2×10^3	1	2×10^3	1
Permanent magnet twistor	In production		●	●	MANDRO**	2×10^5	2.5*	6×10^6	5*
Piggyback twistor	In development			●	EANDRO or DRO			8×10^5	6*
Plated rod	In production	●			DRO				
Thin-film sheet	In production	●	●	●	EANDRO or DRO	5×10^3	.25	2×10^5	1
Woven screen	Experimental	●	●	●	DRO			8×10^3	
Ferrite-metal									
Waffle Iron	In development			●	DRO	8×10^3	.4		
Superconductive									
Continuous sheet	Experimental	●	●	●	DRO	10^2	1	1.6×10^4	10
Cryogenic	Research programs	●	●		EANDRO or DRO				

* Read-only time ** Cord changeable

DRO—Destructive Readout. The contents of this memory are destroyed during the readout process. Information is subsequently reinserted by a write pulse.

MANDRO—Mechanically Alterable Nondestructive Readout. With this type of memory, readout does not depend on destroying the stored state of the interrogated elements. The memory is interrogated with a read pulse and an input address. Information is entered, stored, and altered by a mechanical operation.

EANDRO—Electrically Alterable Nondestructible Readout. This type of memory also leaves the information in the memory element but changes in information are made by electrical rather than mechanical means.

cussed a converging switch for a data processing system and a small memory for use in a magnetic system, both built of bipolar elements. The converging switch is for supplying data from a variety of input devices to a group of data processors; the experimental switch has a capacity of 128 words of 26 bits each, with an access time of about one microsecond. At the same meeting W.D. Farmer of Bell Labs described the sensing of a bipolar magnetic memory. The problem is in controlling the address input to memory, which is the final interface to cross before being able to build a fairly general all-magnetic digital control system. As to the problem of the external interface, such as controlling a relay or a motor, a silicon controlled rectifier or similar device might solve it.

Smaller, better magnetic amplifiers for power and control circuits

The old, heavy 60-cps magnetic amplifier is on the way out but a more compact, higher-frequency version is coming in, particularly in space electronics.

Electronics engineers who've kept abreast of recent developments in magnetics know that the magnetic amplifier (magamp) has changed and, in newer forms, is making a strong comeback. Designers of electronic power and control circuits are putting the modern magamp's capabilities to effective use instead of depending exclusively on the semiconductor.

It's true the old heavy 60- and 400-cycle magamp (which consisted of saturable iron-core reactors with selenium rectifiers in the load circuit) is frequently being displaced by semiconductors in many of its traditional applications such as providing push-pull power drive for a servomotor. But a host of applications is opening up for the newer forms of magamps. These use improved saturable reactors (see panel) of square hysteresis loop materials in combination with transistors, silicon-controlled rectifiers and turnoff SCRs, either at higher frequencies or shorter excitation pulses. This cuts reactor size and cost considerably and provides a much higher speed of response than was possible with the older devices.

For example, magamps can be designed today that occupy one cubic inch and outperform units that occupied 10 cubic inches a decade ago. Today's amplifiers are operated regularly at five kilocycles and sometimes at 10-kc line frequencies. Response times can be near a millisecond. Applications include inverters, power amplifiers, radar pulse modulators, oscillators, and voltage-to-frequency converters, as well as the more familiar regulator and control applications.

What magamps can do

Magamp features are summarized in the panel. Basically, magamps are unsurpassed for low-frequency applications where limited frequency response is acceptable and extreme demands are placed on reliability, ruggedness and resistance to radiation and high temperatures. Magamps make outstanding d-c amplifiers for transducer and control applications because they have temperature stabilities greater than one microvolt per degree C compared to several microvolts per degree C. for silicon transistor amplifiers unless over-all d-c feedback and careful design is employed.

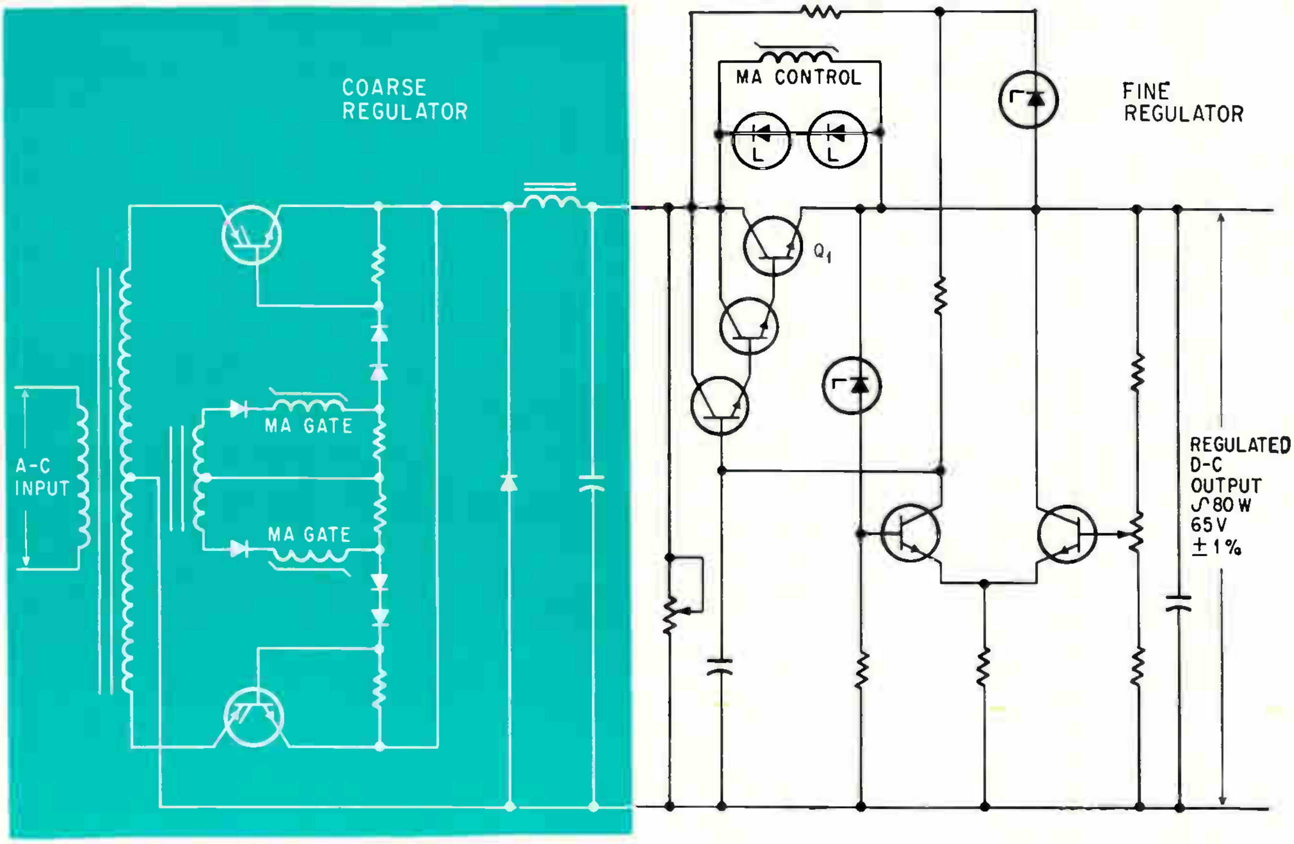
Commenting that his magamps can work at inputs of 10^{-8} ampere or lower, H. E. Harris, president of Harel Inc., says "while magamps make miserable a-c amplifiers, we can state categorically that we can always make a lower drift d-c magamp than the best transistor type (assuming no choppers are used) especially if the amplifier is to operate over a wide temperature range."

Where response time is not important, current gains better than 100 per stage can be obtained. Moreover, it is easier to add stages in d-c magamps than in transistor amplifiers because operating voltage levels are not pyramided.

The Instrument Systems Corp., for example, has developed a three-stage 60-cycle magamp whose power gain for a two-kilowatt output is 160 billion. Input voltage is 250 microvolts, input impedance is about five ohms and the output can go to 50 kilowatts. The quarter-cubic-foot amplifier is used with sensors like strain gages and temperature sensors to regulate power devices like furnaces to less than 1° C.

Space electronics

The reduction in weight and the improvement in performance points to a surprisingly bright future for magamps in space electronics. In d-c power supplies for space it can be more economical to use magamps and power transistors, a rough rule of thumb being that the equivalent all-transistor circuit takes three times the number of components.



Two-stage voltage regulator built by the Electro Devices Laboratory of the Sperry Gyroscope Co. illustrates improvement over traditional regulators where all power was handled by heavy magamps. Here magamp size is reduced about 80% by using it only to control the firing of the SCR in order to reduce input voltage swing. Chopped d-c from the coarse regulator stage is filtered and applied to fine regulator which gives a smoothed d-c output. Any deviations are sensed by the fine regulator which varies the output of Q_1 to restore original output voltage. Coarse regulator adjusts itself to keep voltage across Q_1 constant.

Saturable reactors and magamps

A saturable reactor in its most common form consists of two toroids. A gate, or output, winding is wound around each toroid and connected to an a-c supply so that the toroids produce a series impedance.

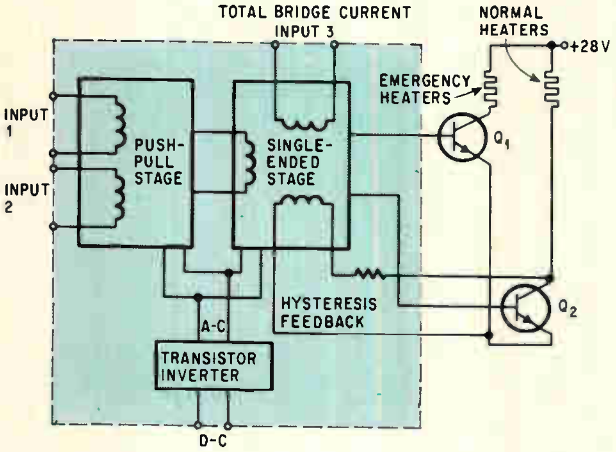
A control, or input, winding is wound around the pair of toroids. When d-c is applied to this winding it changes the degree of saturation of the cores, thereby changing the impedance in the a-c winding. When the cores are saturated (permeability near unity), the impedance in the a-c circuit drops abruptly and the reactor is said to fire. This action causes 100 to 1,000 times more current to flow in the load than before saturation. Precise control of the saturation point and, hence, the firing point is made possible by using materials with square hysteresis loops.

A saturable reactor becomes a magamp simply by putting a diode in each gate winding. The cores now function as first open and then closed switches on alternating half-cycles of the supply voltage. Now it is possible to get considerably more power gain (approximately 1,000 times) than in a saturable reactor alone because a much smaller input current will drive the reactor to saturation. The reason is that during each half cycle when a diode is blocking current flow, the power output circuit is open and the control signal drives the flux in the reactor freely. In the saturable reactor, on the other hand, there is transformer coupling between the power and control circuits and more current is required to drive to saturation.

Several control windings can be used to compare different signals or, when the amplifier is used as a regulator, to introduce different feedback signals.

Materials

The trend is toward tape-wound cores because the tapes are thinner than cut laminations and, therefore, provide less core losses and faster response. Widely used up to about 2 kc are the 50% nickel-iron alloys. These offer the rectangular (square loop) B-H characteristics that are necessary to obtain a sharp break between the saturated and unsaturated states. For higher frequencies 79% nickel—17% iron—4% molybdenum alloys can be



Apollo alarm amplifier occupies approximately one cubic inch (Marin Controls, Inc.).

An extreme example of this is provided in the temperature control system for the Polaris accelerometers. A 1.8-cubic-inch magamp plus a power transistor controls a 15-watt heater to ±0.1° F. over 10-90 percent of the 15-watt range. An equivalent transistor circuit would require 36 transistors. The system was designed by the Massachusetts Institute of Technology's Instrumentation lab and the Magnetic Controls Co.

Inertial components in the Apollo inertial guidance and navigation system require tight temperature control over a wide range of temperature, shock and vibration. In addition, they must meet general system requirements of high reliability, high efficiency, light weight and low volume. MIT found that approximately three times the number of components would have been required to duplicate the performance of magnetic amplifiers with transistor amplifiers in the following applications: a blower-speed control, a temperature-control amplifier, heater-current sensor, temperature-telemetry amplifier, and a temperature alarm and backup control amplifier.[1]

The Apollo alarm amplifier (see the schematic at left) is a good example of new magamp capabilities. It is a two-stage amplifier that operates off a 3.2-kc square wave and weighs only 1.6 ounces. The amplifier acts as a threshold device for any one of three isolated inputs that represent critical conditions in the external circuit, such as temperature. If any input is out of tolerance, an alarm condition is effected by turning off transistor Q_2 and turning on Q_1. When the out-of-tolerance condition is corrected, the unit reverts to normal where Q_2 conducts. Total power required is on the order of one volt-ampere while the output controls a transistor capable of handling nearly 60 watts. A key feature of this, and other new magamp designs, is the inclusion of the inverter so that only d-c is required for the amplifier. In the past the necessity of going from d-c battery primary power to a-c caused considerable difficulty in small-size applications like missiles and spacecraft.

Time ratio control

Fast-response power amplifiers and regulators that use combinations of semiconductor switching devices, and saturable reactors need an efficient way of controlling power from portable d-c sources such as batteries and thermoelectric generators. Time ratio control (TRC) is gaining wide use for this. It is often used to regulate voltage to a d-c to a-c inverter as, for example, on a battery-run submarine where several hundred kilowatts may be run off a battery and one must first regulate the d-c inverter input in order to get well-regulated a-c out of the inverter.

The SCR-saturable reactor amplifier is an application where TRC has proved particularly advantageous. This is a high-gain, fast-response amplifier that can deliver up to 300 kw at frequencies between 0.1 and 1 kc. TRC controls the voltage deliv-

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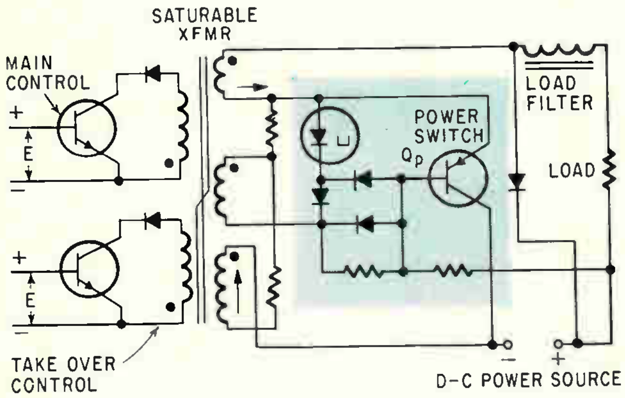
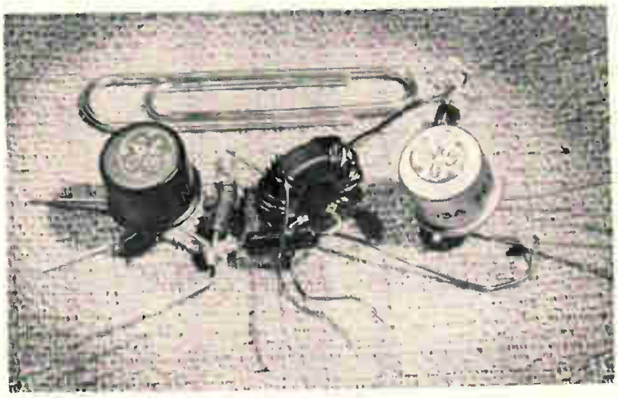
obtained in thickness down to ⅛ mil. While they have lower saturation flux density than the 50% nickel-iron alloys, they are capable of higher frequency operation.

Both materials are available under a variety of trade names from several manufacturers. Although more than one manufacturer may offer the same trade-name material, this is no guarantee that the chemical properties will be identical—users are advised to discuss their specific requirements (such as core loss at the required frequency) with several manufacturers and obtain the material that comes closest to meeting their requirements.

Magamp features

- **Operation at low-level d-c.** It is possible to operate on inputs as low as 10^{-14} watt and easily obtain equivalent input circuit drifts of 10^{-15} watt over ambient temperature variations of, typically, 100° C. with ±10% line voltage changes.
- **Ruggedness.** Magamps can operate at several hundred degrees centigrade, hundreds of g's of shock and virtually unlimited vibration.
- **Electrical isolation.** Since the a-c windings and the control windings are electrically isolated, it is easy to use inputs having different reference voltages. It is also easy to "float" a complete magamp stage so the output can be connected, without decoupling, to some circuit not referenced to ground.
- **Noise immunity.** Since the magamp is inherently a low-impedance device (input impedance is about 200 to 1,000 ohms) it can be hundreds of feet from, say, a d-c bridge temperature sensor without serious pickup problems.
- **Overload.** High tolerance to overcurrent and overload conditions can be included in the design with little additional cost.
- **Power handling.** Large amounts of a-c power (100 kva, 50 ka or 15 kv) can be handled with relatively little internal power consumption or standby power.





High-frequency time ratio control circuit, developed at the General Electric Co.'s Advanced Technology Laboratories, allows reducing size of components to those shown in the photo.

ered to the amplifier load by varying the time the SCR is turned on and off.

Frequently the SCR is turned on by a gate pulse from a constant-frequency supply and turned off by either an auxiliary SCR or a saturable reactor. This turning-off operation, called commutation, can be made more efficient and economical at frequencies below one kc by combining the SCR and the reactor as in the circuit (below).[2] This circuit commutates SCR_1 even when the load current drops to zero. Briefly, it operates as follows: initially, capacitor C_C is charged to the supply voltage. Then SCR_1 is turned on by a constant-frequency oscillator, applying voltage across the load through filter L_F — D_F. After SCR_1 has been on for the desired period, a second oscillator turns on SCR_C. Then C_C and L_C oscillate for 180°, at which point the voltage across C_C is reversed, SCR_C turns off and SR_C saturates. Commutating current now flows through D_1 and the voltage across SCR_1 is reversed so SCR_1 turns off. Should the load current ever drop to zero, the voltage across C_C will be restored by energy stored in L_1.

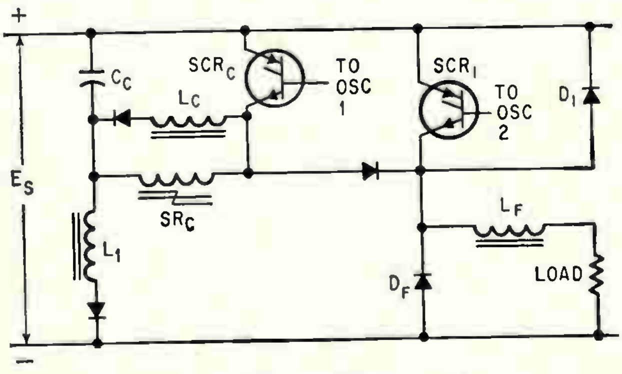
In order to cut the size of filter components further and also get an amplifier with faster response, it is necessary to go to higher frequencies. Fast response is desired in regulators for such applications as power supplies for laser pumps. A transistor-magnetic power amplifier has been built, in which a TRC chopping rate of 50 kc is obtained with high-speed power transistors and tunnel diodes. The amplifier can deliver up to 1 kw.[3] In this amplifier a saturable transformer the size of a TO-5 can (see photo) provides multiple inputs that have negligible capacitive coupling between them, thereby allowing take-over control from current or temperature limit circuits. The inputs are isolated so the takeover controls can operate when changes in voltage between the inputs, or the inputs and the power source, are as high as 1,000 volts per second.

The tunnel-diode control circuit permits switching the base current of Q_p in 0.02 microsecond so that (if it's a 2N1907) it can switch the load current in 0.1 microsecond or less.

The principles of this circuit have been used in a 50-kc bridge-type chopper for a new d-c to a-c inverter.[4] This inverter provides sine-wave power at 400 cps without using the normal 400 cps filter or transformer. This cuts size and weight to about one-third that of the inverters used in most aircraft and space applications. Efficiency is also good—85% or 90% at 100 watts and 50% power factor.

Looking to the future it may be possible to eliminate commutating circuits by using turn-off SCRs, which, unlike ordinary SCRs, can be turned off simply by applying a negative voltage to the gate. Wide usage of this technique, however, would require economical devices in the 100 to 500-ampere range. These are probably a long way off because of semiconductor fabrication problems.

At present, turn-off SCRs are available only in the 5-10 ampere range, but at voltages up to 400 volts. Thus, in this current range and above 100 volts (where transistors are uneconomical) they are being used in place of the cheaper SCRs where size and weight are prime considerations.



Time ratio control circuit uses SCR-saturable reactor commutating circuit.

Pulse generation

High-power pulse generation is another field where magnetics is receiving attention, particularly in the line-type modulator. Here a thyratron discharges a pulse-forming network through a step-up pulse transformer, thereby generating a high-voltage pulse for a klystron or magnetron. These circuits are primarily for military radar but could be applied to laser, sonar and commercial applications of pulsed radar such as aircraft beacons and navigational altimeters. There are several design problems associated with their successful use, however.

A crucial problem is specifying parts. The circuit must be optimized for rise time, pulse duration and, frequently, tight ripple requirements. Designers at the Electro Devices Laboratory of the Sperry Gyroscope Co. warn against buying the components separately and expecting them to work with a specific magnetron.

Factors such as leakage inductance and capacitance of the pulse transformer, and stray network and load capacitance can create wide variations (50% from nominal) in magnetron current pulsewidth, and peak amplitude.

In addition there are problems of voltage risetime and magnetron stability that must be considered. Magnetrons are subject to arcing even under normal operating conditions. This arcing creates open and short circuit loads to the pulse transformer and modulator. The transformer can be hit by voltages two or three times higher than normal operating levels, and sufficient insulation must be provided to ensure long life. Thus, Sperry suggests that all components be bought as a package to ensure compatibility.

A key trend in modulator design is that of solid-state switching—replacing the thyratron with an SCR. Where switching voltage or power levels exceed the rating of present SCRs it is necessary to use several series-parallel combinations. However this adds to circuit complexity.

The technical advances that have produced magnetic materials that saturate sharply and have essentially rectangular hysteresis loops, have led to another approach that allows using single SCRs within their present ratings. This is the magnetic modulator, in which the SCR switches low currents and saturable transformers handle the high currents. This approach should give higher reliability and efficiency than vacuum tube modulators, as well as savings in power, space and weight. Power is especially important—for example a 1258 thyratron requires 15 watts of heater power while in some radar applications this is the power spec for the whole system.

The schematic (shown below) is a simplified diagram of a semiconductor-magnetic modulator. Briefly, it operates as follows: a starter trigger pulse turns on SCR$_1$ allowing capacitor C to be charged to about 600 v. When the main radar timing pulse turns on SCR$_2$, the energy stored in the capacitor is transferred to the pulse forming network (in less than 10 microseconds) through step-up transformer T$_1$ and the primary of pulse transformer T$_2$. This allows the network to be charged to about 10,000 volts which is then discharged into the load by the saturation of T$_1$.

A modulator of this type is being considered by the Jet Propulsion Laboratory for a future high-altitude radar experiment where high performance, low weight, short operating intervals and high reliability are prime requirements.

Multivibrators

Magnetic multivibrators[5] are finding applications in such areas as precision oscillators, frequency dividers and voltage-to-frequency converters. The latter application has been used by the National Aeronautics and Space Administration's Goddard Space Flight Center for pulse frequency modulation (pfm) telemetry systems in several satellites. The multivibrator is in the payload and converts the d-c output of a sensor, such as an accelerometer, to a frequency which is then telemetered to the ground station.

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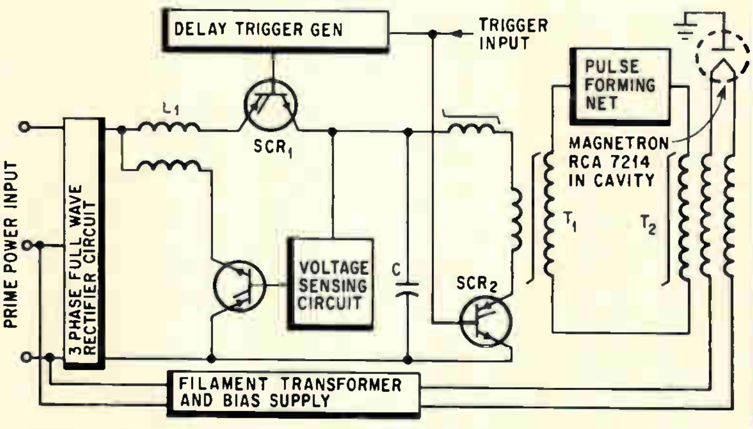


Radar modulator under study at the Jet Propulsion Laboratory will weigh about 10 pounds and occupy about 500 cubic inches.

RADAR MODULATOR CHARACTERISTICS	
PEAK MODULATOR POWER	400 KW
PEAK R-F POWER	100 KW
DUTY CYCLE	0.003
PULSE DURATION	10 MICROSECONDS
OUTPUT PULSE TIME JITTER	50 nS MAX
OUTPUT VOLTAGE	20 KV
POWER REQUIREMENTS	50 VOLTS D-C, 40 AMPERES MAX
OUTPUT CURRENT PULSE RIPPLE	10%
OUTPUT VOLTAGE PULSE RISETIME	1.5 MICROSECONDS

Microwave magnetics

Intense study of ferrimagnetic materials has produced a number of completely new microwave devices. New techniques are improving microwave tube performance

New and improved magnetic materials are responsible for the rapid development of microwave devices and components. The latest and most promising of the ferrimagnetic materials or ferrites is yttrium iron garnet. Available in single crystal as well as polycrystalline form it is being put to use in many new applications.

Research in microwave magnetics has also centered around new configurations of focusing structures for klystrons and traveling wave tubes as well as new techniques and applications of magnetic materials for noise reduction and improved performance of these devices.

What are ferrites?

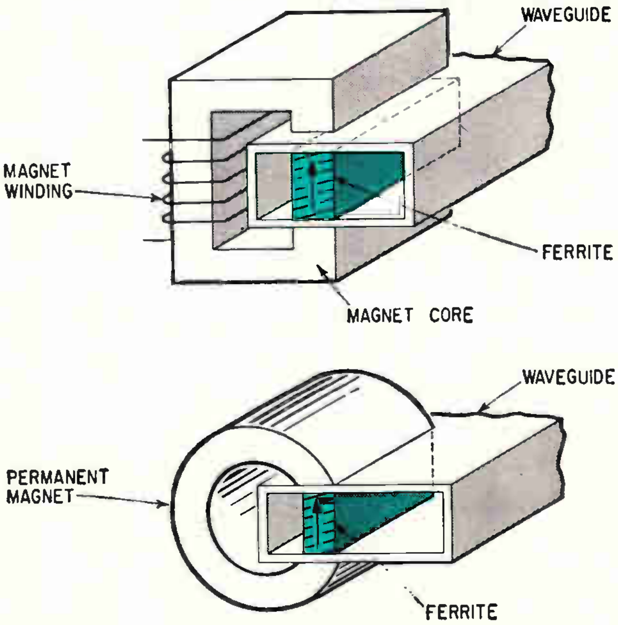
A ferrite is a chemical compound with high resistivity, high permeability and a relatively narrow hysteresis loop. More specifically, it is a powdered, compressed magnetic material consisting chiefly or iron oxide combined with one or more other metals. Physical properties of ferrites are similar to those of ceramics. The manufacture of ferrites and ceramics is similar.

Permeability (ratio of magnetic induction to corresponding magnetizing force) may run as high as 5,000 or more. Direct-current resistivities of ferrites correspond roughly to those of semiconductors, and are about a million times more than those of the conducting metals. This combination of high permeability and high resistivity gives ferrites a unique place in microwave electronics.

High resistivity makes eddy current losses at high r-f frequencies negligible in ferrite materials. Early work, over half a century ago, indicated great promise for these materials as transformer and inductor cores. But development of production techniques was slow. Most of the progress in the field of ferrites took place after 1930 when further studies of the materials indicated a frequency-dependent spin resonance loss, a characteristic that makes ferrites particularly suited for application to microwave devices.

As energy at microwave frequencies is applied, the characteristics of a ferrite material change depending upon the frequency of the energy applied and upon the polarization of the material. Permeability of the ferrite material reaches a maximum at a point called ferromagnetic resonance. This point appears at different applied frequencies in different material formulations, depending also upon the intensity of an applied transverse d-c magnetic field. While the frequency at which ferromagnetic resonance occurs in any material depends upon the intensity of the external magnetic field, some materials are known to have an inherent internal magnetic field which enables a resonance point to be reached without an external field. Details of the theory of ferromagnetic resonance may be found in any text dealing with the properties of electron spin and electron spin resonance.

Nonreciprocal properties of ferrites are the key to successful development of microwave devices. This one-way action permits wave polarization, or attenuation of energy, in only one direction. A linearly polarized wave will have its direction of polarization rotated when it passes through a mag-



Methods of applying a biasing magnetic field to ferrites. Intensity of the field of the electromagnet (top) may be varied to achieve a tunable ferromagnetic resonance.

netized ferrite plug in the waveguide. A device using this principle is the classic Faraday rotator whose development has contributed most to the understanding of the behavior of ferromagnetic materials.

As an attenuator, the ferrite absorbs power depending upon the applied magnetic field. Maximum absorption is at the point of ferromagnetic resonance.

Three basic types

Three main classifications of ferrites are generally recognized:

1. Spinel-type material named after the crystal structure of the mineral spinel, which is regarded as cubic.
2. Hexagonal crystal structure which is considered to resemble stacks of spinel structures.
3. Garnet-type ferrites which are pure rare earths and were discovered about 1956. Yttrium iron garnet (YIG) is the most prominent of these.

Spinel-type material is the oldest, and thus the most commonly used. It finds application in medium power devices such as phase shifters and isolators.

The Westinghouse Electric Corp. has used ferrites in electronically controlled microwave phase shifters. These shifters are called latching switches and are used in phased array radars. In this device, the biasing magnetic field is established by passing a current through a wire imbedded in the ferrite. The resulting circular magnetic field causes the ferrite to become permanently magnetized in one of two stable states. Once latched, no holding power is required. The large solenoid or magnet typical of the conventional ferrite phase shifters has been eliminated.

Hexagonal ferrite materials have not been used at lower frequencies and are generally associated with devices in the millimeter range, usually two mm and higher. These materials already have a large internal magnetic field because of their crystal structure and are used for compact, lightweight devices.

Ferromagnetic resonance isolators using ferrites with hexagonal crystal structure for the 50 to 75 Gc and 60 to 90 Gc bands have been developed at the Sperry Microwave Electronics Co. The material was incorporated into a dielectrically-loaded ferrite isolator configuration and has resulted in a compact, temperature-stable isolator that requires no external magnetic field. In typical narrow band operation, more than 15 db of reverse attenuation was obtained with less than 1 db of forward loss. Work is continuing to reduce this forward loss. One ferrite unit, covering the 84 to 89 Gc range, is about one and a half inches long and weighs about one ounce.

Narrow linewidth

Garnet materials, especially yttrium iron garnet, are the newest of the ferrites and are characterized by a relatively narrow ferromagnetic resonance linewidth. Ferromagnetic linewidth is the width of the resonance absorption peak, measured between the points at which power absorption is half its resonant value.

This narrow linewidth is important in the design of practical devices. If the resonance linewidth is very broad it may be nearly impossible to design a device to operate in a minimum loss region below resonance. Narrow linewidth makes it possible to transmit through the material with very low loss. This is important in the design of tunable filters.

In the design of practical isolators, linewidth determines the lowest frequency of operation and the front-to-back ratio. In this case, front-to-back ratio is the ratio of attenuation in one direction to attenuation in the other.

Conventional ferrites have linewidths of up to 1,000 oersteds, but garnet materials have linewidths of as low as one oersted. Narrow linewidth means high Q, and now engineers may create new devices.

Think YIG

Thus, single crystal and polycrystalline YIG are probably the most important new materials to be developed within the last few years. But researchers in the field say that much more study is necessary to fully understand the properties of YIG.

Most of the work in YIG device development is concentrated in a small group of firms. One of the leaders in this area is the Watkins-Johnson Co. which has developed a number of practical YIG devices. Three major properties of the Watkins-Johnson YIG resonators are their magnetic tunability, nonlinear characteristics and nonreciprocity. The YIG resonator differs from a mechanical resonator in that its resonant frequency is independent of its size, and is a function of the d-c field used to bias the YIG sphere to its resonance point. The YIG sphere is typically very small, usually about 0.05 inches in diameter.

Three good applications

Electronically tunable bandpass filters are the most obvious application of YIG resonators. The device is very simple—an input and an output transmission line are coupled to a YIG sphere so that coupling exists when the sphere is resonant and not when the sphere is anti-resonant. YIG filters are available at frequencies up to 18 Gc. Some of the newer materials now under study, such as yttrium-gallium iron garnet, may allow operation down into uhf. The usable range of a material is determined by its saturation and magnetization. Elements may be introduced into the material to change its characteristics.

Band-reject filters are made by placing a YIG sphere between the inner and outer conductor of a coaxial line. At resonance, the sphere becomes a large reflector, permitting little power transfer between input and output. High ratios of rejection to bandwidth may be obtained by cascading stages. A three-stage band-rejection filter could have three times the rejection in db as a single stage, and with twice the bandwidth.

Nonlinear characteristics of YIG resonators are applied to the devices when used as limiters. The large signal behavior of ferrites is complicated—limiting depends upon the mode of operation. Limiters may also filter, depending upon the material used and the frequency. Development of practical YIG limiters has been very slow because until recently, engineers haven't understood fully the physics of YIG. Varactor limiters have been used up to the present. A common application of limiters is to prevent burnout of receiver detectors that are in close proximity to a high-power r-f source.

Nonreciprocity is a characteristic that has not yet been used to any great extent in YIG devices. For certain system applications, it is possible to build isolators, circulators and phase shifters. Through the use of nonreciprocal techniques, multiple devices such as channelizing filters may be built. These have a single input and multiple outputs. Filters with multiple pass bands or rejection bands may also be built. Nonreciprocal YIG filters may be constructed in waveguide, but the problem is more complex in coaxial line or stripline.

Bell Telephone Laboratories at Murray Hill, N. J. has devised wideband circulators using polycrystalline YIG. Losses are quite low and the devices have high isolation and the ability to get controlled impedance characteristics.

Using YIG devices

Electronic tuning offers some exciting possibilities for YIG devices. The new generation of military receivers for reconnaissance work will use YIG preselectors and tuning devices [Electronics, April 20, 1964, page 78]. Electronic tuning of a wide-range tunnel diode oscillator has been demonstrated by Watkins-Johnson. This technique shows promise in frequencies as high as 100 Gc.

A two-port electronically variable delay line, using pure spin wave propagation in a single crystal YIG, has been built by Frank Olson of the Microwave Electronics Corp. A signal transmitted through a YIG rod could be delayed from zero to several milliseconds at frequencies from 1 Gc to 10 Gc.

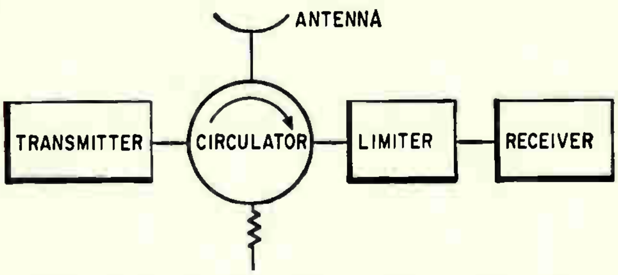
According to Olson, three forms of delay have been observed using YIG in the microwave frequency range. These are: 1) acoustic-wave propagation with essentially fixed delay, 2) spin wave/acoustic-wave propagation which is variable (by changing the d-c magnetic field) from one to several microseconds, and 3) spin wave propagation giving delay which is continuously variable from zero to

Ferro or ferri?

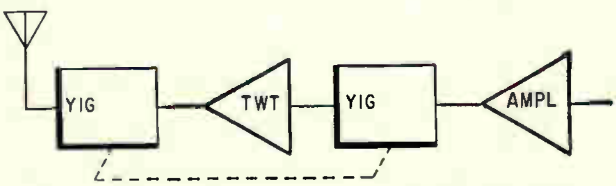
In ferromagnetic materials, the magnetic moments of neighboring ions are aligned paralled to each other and all in the same direction. Iron, steel and nickel are examples of these materials.

Ferrimagnetic materials are characterized by the antiparallel alignment of their magnetic moments, but they are of different magnitude, with a resulting vector in one direction. The ferrite materials, including the garnets are in this class.

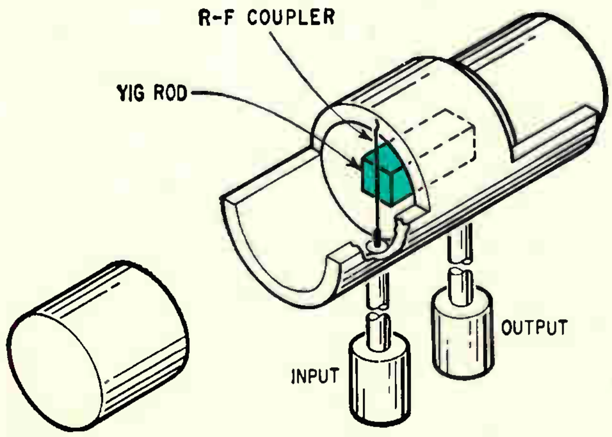
Confusion arises because the resonance effect in both ferromagnetic and ferrimagnetic materials is called ferromagnetic resonance. Ferromagnetic resonance is the condition that exists when all the magnetic moments in the material are excited in phase, that is, at the natural frequency of the system. To achieve resonance, a transverse magnetic field is applied to the material which causes the moments to line up. Applying an r-f field at right angles to the magnetic field causes the moments to precess. When the magnetic moments are precessing uniformly but not in phase, spin waves exist within the ferrimagnetic solid.



Common application of a microwave limiter to prevent damage to the receiver from excessive transmitter leakage power. Ferrite circulator is a combination of the Faraday rotator with two hybrid tees. It provides a common antenna transmit-receive system.



Use of two ganged yttrium iron garnet filters as receiver tuning elements. A more exotic application might be to tune a parametric amplifier idler with a YIG resonator.



Structure for generation and propagation of magnetic waves in a YIG crystal to provide variable delay. Magnetic field is applied parallel to the rod axis.

several microseconds. The first two schemes require precisely polished end surfaces of the YIG rod, while the third method is a transmission device and is not affected by end conditions.

Attention has been given this type of propagation through ferrite materials because of its applicability to delay lines. However, there is loss involved in all the previously mentioned methods.

Recent experiments at Bell Laboratories have shown a means of amplifying acoustic waves to reduce loss. Amplification was observed over the frequency range of 500 to 800 Mc. There is a continuing effort to decrease losses and increase operating frequency. It may be possible to go into X band. The limitation has been in the size of YIG crystal; the largest size available at present is about one-half inch long and 100 mils in diameter.

YIG technology looks simple but isn't. YIG is hard to reproduce, the degree of polish is difficult to achieve, and the orientation of a YIG device in a circuit is tricky. Material formulation needs a great deal of work and much study is necessary to get rid of spurious responses in the devices. Increased attention will be given to lowering production costs and improving performance.

Focusing structures

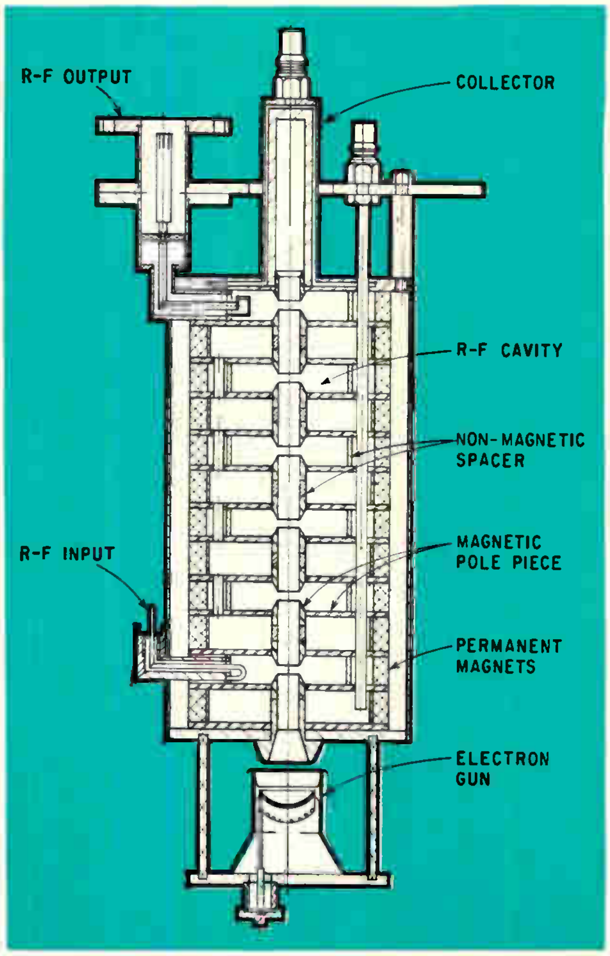
Prominent microwave developments involving magnetics include devices and circuit methods as well as new materials.

Focus coils are used to produce the magnetic fields necessary to focus electron beams in klystrons and traveling-wave tubes. Several new methods of focusing have been developed to reduce weight and size and to improve performance.

Eitel-McCullough, Inc. has a pulse amplifier klystron using a method of periodic permanent magnet focusing. PPM focusing has been applied to traveling-wave tubes for about ten years, but this is its first application to klystrons. It has not been used before because it wasn't possible to get close enough to the beam without getting tangled up in the circuit and the cavities. But this design combines the cavity requirements with the pole piece arrangement necessary for periodic permanent magnet focusing.

Applicability of PPM to klystrons is not universal. The scheme will work for pulsed tubes, but must be designed with the tube. It is less attractive for cw tubes because spacings are tighter and there may be problems getting strong enough magnetic fields. The magnetic material in this Eimac klystron, a 75 Kw peak power tube operating at 2586 Mc, is Alnico 8. Ceramic could have also been used. While there is no appreciable difference in performance of the tube, the structure results in lower cost and lighter weight.

Another focusing configuration applied to traveling-wave tubes was developed at the Radio Corp. of America Laboratories, Princeton, N. J. It is a method of arranging the permanent magnet structure to peak the focusing magnetic field just before and after its reversals. Over-all, the results show



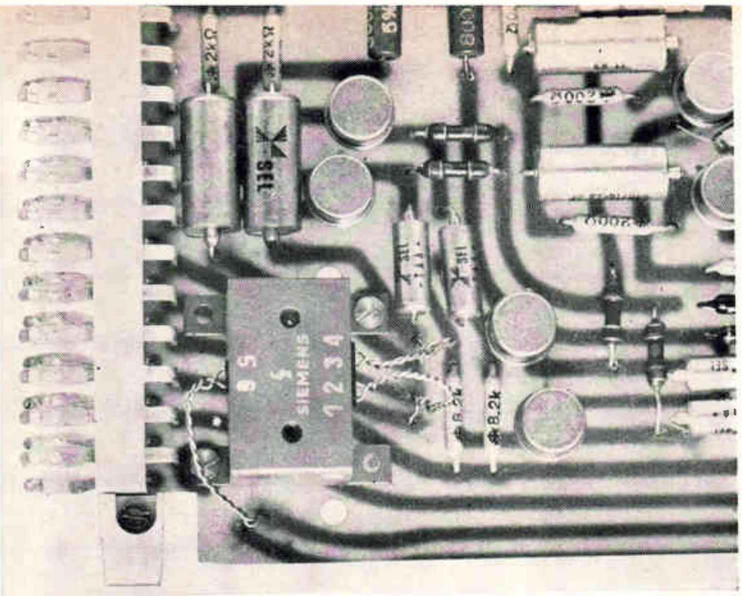
Construction of Eitel-McCullough Inc.'s periodic permanent magnetic focusing structure for a klystron. Magnets form an integral part of the tuning cavities.

higher gain, and increase in power of about 10, and a significant improvement in reliability because of fewer vacuum joints. The method works better at higher frequencies, generally above 30 Gc.

Applying a very high magnetic field in the cathode region of a traveling-wave tube has been found to substantially reduce noise, according to the RCA engineers. The method improves performance of low-noise traveling-wave tubes to the point where they are less noisy than parametric amplifiers. At a frequency of 2.6 Gc, a noise figure as low as 1 db was obtained. There are some side effects present that are still under study.

What next?

Studies leading to a better understanding of ferrite materials and their characteristics will continue. New circuits will be studied. In the tube area, superconducting solenoids and easy ways to operate them at the low temperatures required will be investigated. There is a need for smaller and more efficient structures for millimeter tubes. Stripline systems in which ferrite components are integrated will be developed but further study of the dielectrics is necessary. All of these investigations are certain to result in faster-switching ferrite devices.



Hall-effect chopper element used in a high-gain amplifier to replace electromechanical component. Unit (rectangular with two mounting holes) is distributed by the Instrument Systems Corp.

New devices from magnetic effects

Improved semiconductor materials are spurring research into little-known magnetic effects. Practical applications and improved components are in sight

Magnetic effects used to be an assortment of obscure curiosities, mentioned in physics texts in small italics and taught only to graduate physics students. Besides having strange names, the effects were insignificant. Their detection and measurement was something of a feat in itself.

With the availability of new materials, especially semiconductors, and of new instrumentation, the magnetic effects have suddenly gained importance. A new family of electronic devices that may soon change circuit designers' thinking is being born. For example, Hall-effect devices are becoming widely accepted in Europe where they are replacing more conventional components in many practical applications.

The resurgence of interest in magnetic effects is due to new semiconductor materials. These have very low carrier concentrations, compared to metallic conductors, and thus attain much greater carrier velocities in order to carry the same electric currents. The Lorentz force, which is the cause of most magnetic effects, is strongly dependent on carrier velocity. As a result, magnetic effects in semiconductors are several orders of magnitude greater than in metals, and large enough to be useful at the voltage levels of today's circuits.

The traditional magnetic effects—Hall, Nernst, Ettingshausen—are leading the way to new applications. Still other effects of magnetic fields are receiving researchers' attention: the Kerr magneto-optical effect, Faraday rotation, the Zeeman effect, electron paramagnetic resonance, magnetoresistance, cyclotron resonance and first-order magnetic transitions. The refinement of measuring techniques, availability of high magnetic fields and progress in solid-state materials research have placed these effects within sight of practical applications both as research tools and as components of electronic equipment.

Hall effect

Probably the best known of the magnetic effects, the Hall effect is certainly the one most exploited to date in terms of components and circuits.

The Hall effect is a majority-carrier mechanism that depends only on the bulk properties of the material, and thus is entirely independent of surface effects, junction-leakage currents and junction-threshold voltage. For this reason, Hall devices have high stability, reliability and reproducibility as compared with semiconductor components of the junction type.

The Hall equation, in simple form, is

$$V_H = \frac{R_H}{t}(I_c \times B)$$

where V_H is the generated Hall voltage, t the thickness of the material, R_H the Hall coefficient of the material, I_c the current density and B the magnetic field. To prevent excessive heating of the material, the resistance of the element is usually made as low as possible.

Indium arsenide is the most suitable of presently available materials for practical Hall devices. Indium antimonide is also used; both materials have very high electron mobilities, 23,000 and 75,000 cm^2/volt-second respectively.

Practical Hall devices today come in many shapes and sizes. The two basic kinds are thin-film and bulk devices; the thin films can be cut and shaped for a variety of critical applications, while the bulk devices have the advantages of greater mobility, lower over-all resistance, lower noise figure and greater output efficiency.

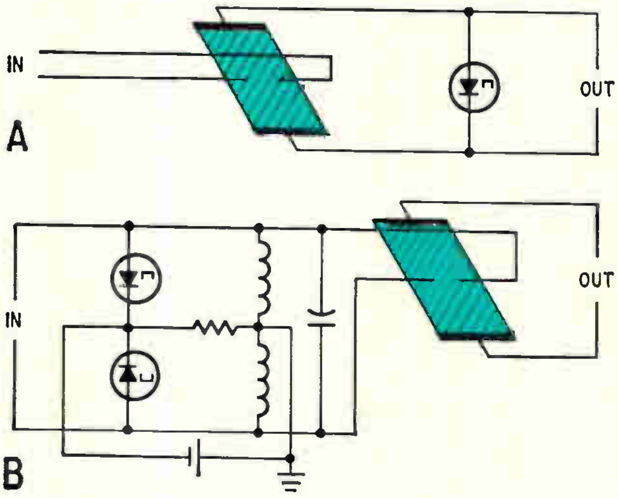
One company, F. W. Bell Inc., manufactures thin-film Hall devices as thin as 0.006 inch, and axial bulk elements with diameters down to 0.063 inch. Under an applied field of 10 kilogauss, the output Hall voltage is typically a hundred millivolts to two volts. Currents through Hall devices are of the order of a few tenths of an ampere for bulk devices, or a few tenths of milliamperes for thin-film devices. Hall device prices range from about $5 to several hundred dollars; prices are gradually decreasing.

Hall-effect applications

One of the simplest Hall-device applications is detecting magnetic fields and measuring absolute flux density. For this purpose, Hall probes are made in both transverse and axial models. Using iron shapes to concentrate the flux, Hall probes can measure fields—both a-c and d-c—in the milligauss range, and determine the polarity of d-c fields. A variety of Hall-probe flux meters calibrated in gauss is available off-the-shelf.

Related to the use as a gaussmeter are Hall device applications for magnetic field plotting and gradient measurements. Going one step further, clip-on ammeters based on the Hall effect are available. They have the advantage of taking virtually no power from the measured circuit. Used in conjunction with small magnets, Hall devices have been applied to measuring linear displacement, angular displacement, as proximity sensors and digital speed sensors. In Europe this principle, developed mainly by Siemens & Schuckert of West Germany, has found industrial applications such as automatic-conveyor dispatching, motor air-gap flux control, pneumatic-tube-conveyor control and automatic elevator leveling.

Another Hall device that is becoming popular is the Hall-effect multiplier. Since the Hall voltage



Amplifier circuits using a Hall-effect isolator and tunnel diodes, developed by Varian Associates. Circuit at top (A) has high voltage and power gain. Greater dynamic range is obtained with antiparallel push-pull amplifier circuit (B).

Glossary

Hall effect: the generation of a transverse potential difference across a conductor carrying a longitudinal electric current in a magnetic field at right angles to it.

Ettingshausen effect: the generation of a transverse temperature difference across a conductor carrying a longitudinal electric current in a magnetic field at right angles to it.

Nernst effect: the generation of a transverse potential difference across a conductor carrying a longitudinal thermal current in a magnetic field at right angles to it.

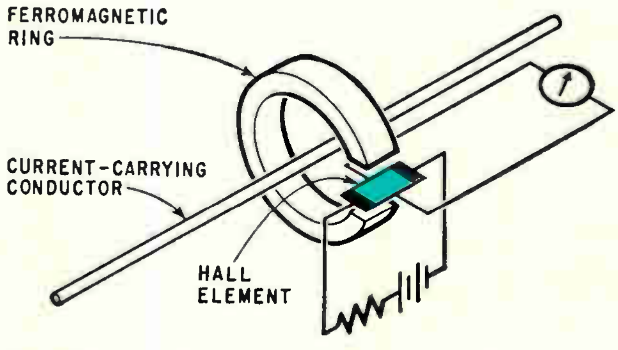
Lorentz force: the force exerted by an electric field and a magnetic field on a moving electric charge.

Kerr magneto-optical effect: an elliptical polarization of plane-polarized light resulting when the light is perpendicular to a magnetic field. For simplicity, it may be considered as a rotation of the plane of polarization, the rotation being proportional to the magnetic field.

Faraday effect: rotation of the plane of polarization of an electromagnetic wave in the presence of a longitudinal magnetic field. Its amount is determined by the Verdet constant of the material.

Magnetoresistance: the change in electrical resistance of a material due to (and proportional to) an applied magnetic field.

Zeeman effect: the splitting of an atomic or molecular energy level into several levels by a magnetic field; observed as a widening or splitting of a spectral line.



Noncontact current probe using a ferromagnetic ring and a Hall element is much more sensitive than conventional clip-on meters, takes far less power from circuit.

output is proportional to the product of the device current and the transverse magnetic field, multiplication comes naturally. In a cathode-ray-tube polar display system recently developed at the Microwave Device Division of Sylvania Electric Products, Inc., Mountainview, Calif., Hall multipliers were used in the X and Y deflection circuits, achieving radial accuracy of display of ±2% of the display radius and angular accuracy of ±2.5%, with no moving parts.

The multiplier principle is further elaborated in applications such as modulators, analog multipliers, power transducers, variable attenuators, frequency doublers and square-law detectors.

At the Bendix Corp., an experimental d-c resolver unit using the Hall effect has been built. Work has also been done on Hall-effect-based magnetic tape readers. Varian Associates is working on the theory of Hall-effect isolators for use in tunnel-diode amplifiers.

Today's research in Hall devices is directed toward improving their maximum efficiency and dynamic range, mostly by better ways of assembling the Hall-element-magnet combination, and to improving their temperature characteristics by applying appropriate compensation techniques.

Magnetoresistance

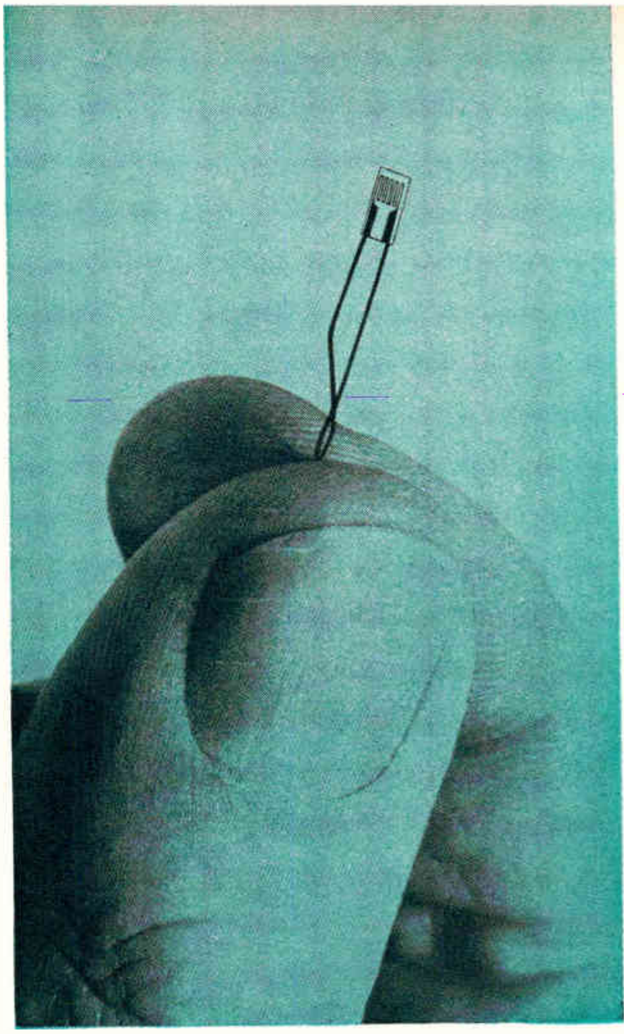
An effect closely related to the Hall effect is magnetoresistance, which has also come under recent study and application.

One company, American Aerospace Controls Inc., has recently marketed a magnetoresistive circuit element, named the MistoR. Unlike the Hall devices, this unit has two instead of four terminals. Its resistance, normally of the order of 1,000 to 5,000 ohms, changes by 4% per 1,000 gauss of applied field in the range from 1,000 to 50,000 gauss, with about one percent linearity. The materials used in magnetoresistive devices include indium antimonide, bismuth and metals; selection is made on the basis of temperature characteristics.

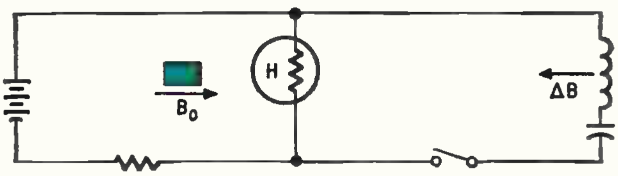
Applications include solid-state a-c to d-c converters, current modulators, computer functions and sensing.

In many applications, Hall devices and magnetoresistors are almost interchangeable. Magnetoresistors have the advantage of offering signals of the order of a volt, while Hall voltages tend to be in the millivolt range. Similarly, Hall elements have resistance levels measured in ohms, while magnetoresistors operate in the kilohm range. Since the output of a magnetoresistor is sufficient to fire a silicon-controlled rectifier, problems of switching without metallic contacts can be solved with the aid of a permanent magnet and a balanced Wheatstone bridge using magnetoresistors in two of its arms. Proportional control arrangements can be used to control machinery.

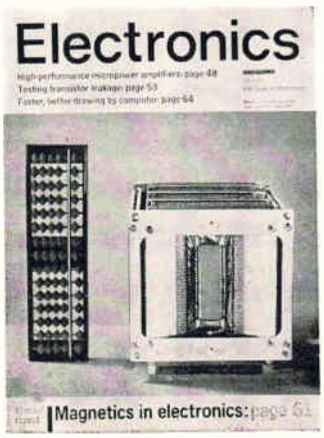
Another intriguing magnetoresistance application is the magnetoresistor-electromagnet package, used to provide electrical isolation between input (control) and variable output, somewhat in the same



Magnetoresistive circuit element, the MistoR by American Aerospace Controls, Inc, comes in a number of standard nominal resistance values, responds to fields from 1,000 to 30,000 gauss.

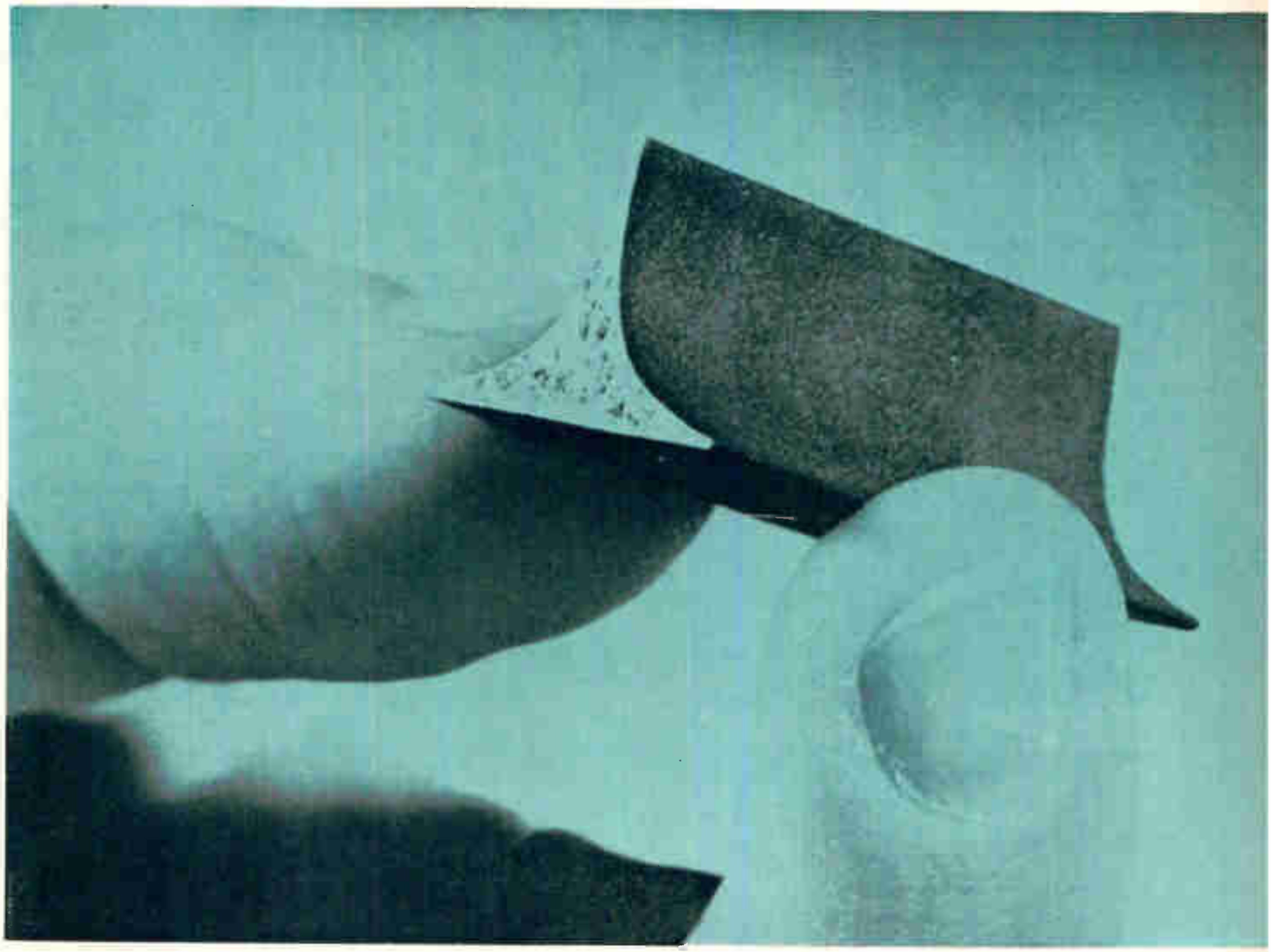


Oscillator circuit using an indium-antimonide magnetoresistor was developed at the Institut fuer Hochstfrequenztechnik in Stuttgart, Germany. A similar circuit was operated at 210 cps, with an open-circuit a-c output of 540 mv. If capacitor is short-circuited, circuit acts as a feedback amplifier. Permanent magnet provides bias B_0.



The cover

The RCA experimental stack contains four laminated ferrite-sheet memories. One of the laminated sheets equivalent to 16,384 ferrite cores is visible at the center of the stack. The stack provides a 1,024 word, 64 bit-per-word memory and operates at less than 500 nsec. cycle time; the finger-operated abacus is somewhat slower.



Exponentially shaped bismuth crystal acts as a Nernst-Ettingshausen refrigerator, with an infinite number of stages, to cool from a hot junction or surface temperature of 302°K to a cold junction or surface temperature of 201°K. Element was made at MIT's Lincoln Laboratory.

manner as the Raysistor lamp-photocell signal-coupling unit, but with higher response speed and practical frequencies to many hundreds of kilocycles.

Combinations of magnetoresistors with permanent and electrical magnets are suitable for applications such as modulators, mixers, multipliers, dividers, square-rooters, wave analyzers, detectors, wattmeters, phase and frequency discriminators.

Nernst-Ettingshausen effects

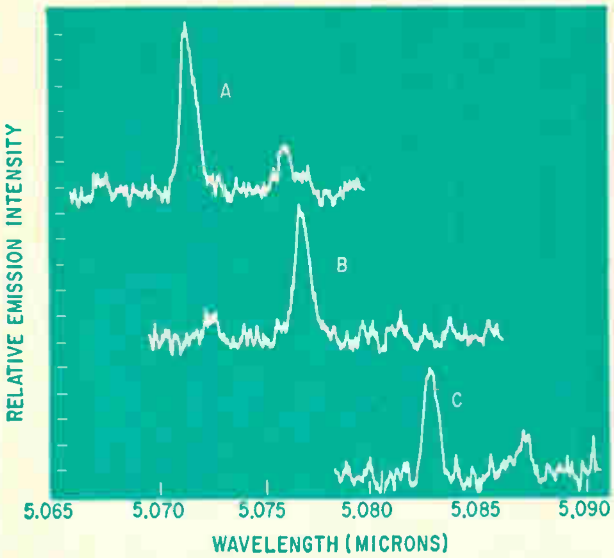
The Nernst-Ettingshausen effect is a thermomagnetic one, analogous to the better-known thermoelectric Peltier-Seebeck effect, but requiring a magnetic field for its operation. Though smaller in magnitude than thermoelectricity, it has the advantage of being a bulk phenomenon independent of bimetal junctions.

This makes the Ettingshausen effect attractive for potential cooling devices. Again, semiconductor materials show promise here. Bismuth-antimony and other bismuth alloys are being studied [Electronics Sept. 6, 1963, p. 84]. Since no junctions are needed within the unit, staging of Ettingshausen cooler elements can be accomplished by shaping a single piece of material, and the effect of infinite staging can be obtained with an exponentially tapered crystal.

Present-day Ettingshausen coolers are small and experimental. When they go commercial, they may be suitable for cooling individual electronic components. They function most efficiently below 200° K, at which point the thermoelectric (Peltier) coolers become inefficient. This suggests using a combination of the two kinds of elements to achieve cooling from room temperature down to temperatures below 150° K.

Direct-energy conversion

The other exciting possibility suggested by the Nernst-Ettingshausen effect is direct conversion of heat into electricity. Such a power generator would



Magnetic tuning of a c-w indium-antimonide diode laser by the Massachusetts Institute of Technology's Lincoln Laboratory shows spectral change of emission with change in magnetic field. For spectrum A, the applied field was 52 kilogauss. It was reduced in steps of 530 gauss to obtain spectra B and C.

require only a properly shaped piece of active material, attached to a heat sink at one end and to a cold sink at the other, and a magnetic field.

Magnetic effects on lasers

In research on semiconductor diode lasers—such as the indium-antimonide laser—it has been found that magnetic fields affect the laser emission threshold and the emission frequency.

The first effect is a lowering of the effective threshold current necessary to obtain stimulated emission. A high magnetic field quantizes the energy levels of electrons in the conduction band and of holes in the valence band of the material. These bands, which are continuous at zero magnetic field, become grouped into sets of discrete energy states. The quantized magnetic levels enhance the stimulated emission of a diode laser. In the future, high magnetic fields may make it possible to get laser action from semiconductor materials that would not normally permit it.

By rearranging the energy levels within the laser material, magnetic fields can emphasize different modes of emission. In recent experiments at the Massachusetts Institute of Technology's Lincoln Laboratory, fields up to 100,000 gauss made it possible to "tune" the laser frequency over a range of 8%, or between 4.6 and 5.0 microns in wavelength. In another experiment, MIT researchers have changed the laser emission wavelength in steps of 50 angstrom units from one cavity mode to an adjacent one. They did this by applying incremental steps of magnetic field of less than 600 gauss.

The use of magnetic fields to modulate the output of diode lasers is under investigation at the Research Laboratories of the Radio Corp. of America, under Air Force sponsorship. RCA hopes to produce pulse repetition rates in the megacycle range, with short pulse rise-times of the order of 20 nanoseconds.

RCA laboratories have also achieved magnetic laser tuning via the Zeeman effect of rare-earth-doped CaF_2 lasers over a range of 150 Gc, and magnetic modulation of these lasers with half-megacycle bandwidth.

The Zeeman effect can be used to modulate a ruby crystal laser by a magnetic field either directly or by controlling the Zeeman splitting of a resonant ruby absorber external to the laser cavity. This has been done at the General Dynamics/Electronics laboratory in Rochester, N. Y.

A material of interest in this direction is europium selenide, currently under investigation at the Thomas J. Watson Laboratory of International Business Machines Corp., Yorktown Heights, N. Y. Transparent to red light, europium selenide is also ferromagnetic at low temperatures such as 7° K. This means the material has a very high Verdet constant, which measures its ability to rotate the plane of polarization of light passing through it (Faraday rotation), when subjected to a magnetic field. Recently produced in single cubic crystals suitable for splitting into thin layers, this material holds promise for direct magnetic modulation of laser beams in communication and radar applications.

First-order magnetic transitions

A class of magnetic phenomena that has only recently come to attention is first-order magnetic transitions. The term is a thermodynamic one and denotes a transition in which the first derivative of the material's free energy with respect to temperature, pressure and magnetic field undergoes a discontinuous change.

Several such changes are possible in magnetics, all having to do with the magnetic spin state of the material. There are two classes of such magnetic phenomena: order-order transitions between differently ordered magnetic spin states, and order-disorder transitions involving changes from a disordered to an ordered magnetic spin state. All the changes are based on exchange interactions of energy between neighboring atoms and their magnetic moments.

In magnetic terms, the transitions take place between the ferrimagnetic, antiferromagnetic, spiral and paramagnetic states of a material. Specific materials are identified with specific transitions.

These transitions are accompanied by volume, pressure or temperature changes. Sometimes the volume change is considerable, suggesting practical applications such as sonar transducers. Such first-order-transition volume transducers, according to the General Electric Co.'s Research Laboratories, would be several orders of magnitude more effective than presently available devices (such as piezoelectric transducers).

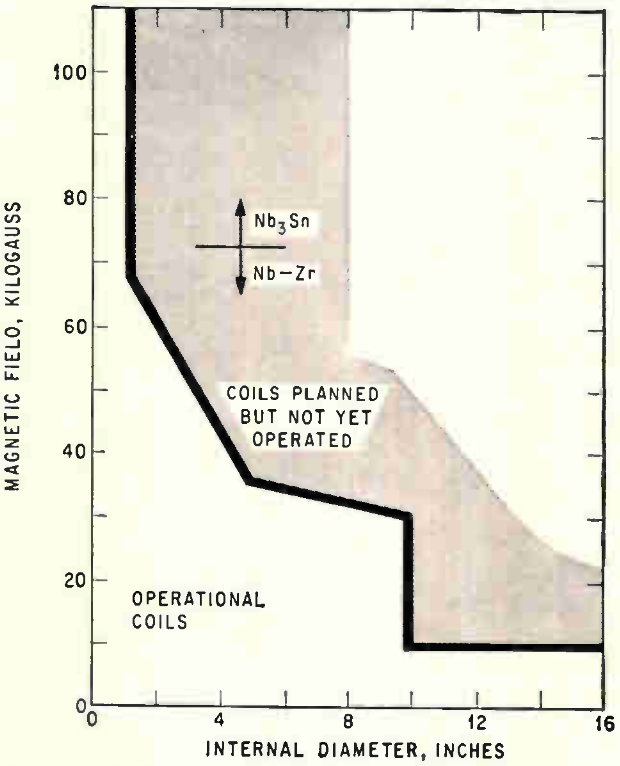
First-order transitions are known to occur in a selected list of materials, many of which are now under study. Among these are iron-rhodium, which displays a first-order transition from the antiferromagnetic state to the ferrimagnetic state at a critical temperature of 350 deg K, and manganese arsenide, with a ferrimagnetic-paramagnetic transition at 318° K.

A new class of metallic compounds of chromium, manganese and antimony that undergoes a remarkable change from an antiferromagnetic to a ferrimagnetic state with increasing temperature is the chromium-manganese antimonides, under investigation in the Dupont Co.'s Central Research Department. The discontinuity in magnetic behavior is accompanied by an abrupt change in electrical resistivity by about 27% in the case of $Mn_{1.9}Cr_{0.1}Sb$.

Potential applications are thermal regulators and sensors, thermostats, temperature, pressure and magnetic field sensing and telemetering devices, analog devices, energy interconverters and bistable circuit elements. Experimental versions of thermostats built by Dupont on this principle have shown excellent stability.

Generating high magnetic fields

Superconducting solenoids will do the job more efficiently than conventional electromagnets—and they're already on the market



Superconducting solenoids built today and projected in the near future are shown on this approximate graph from the AVCO Corp. of magnetic field against working internal diameter.

The 100,000-gauss superconducting magnet, predicted in 1913 by Kammerlingh Onnes, discoverer of superconductivity, is now a reality. The achievement of the 100,000-gauss figure was a milestone in (but not the end of) a "numbers race" of several years' standing. Now that it has been achieved, researchers say their work is likely to concentrate on producing fields of greater physical dimensions, of longer duration and with high uniformity—although work toward a 200,000-gauss supermagnet will continue.

The bulk of research in superconducting magnets has to do with development of new materials and of better fabricating techniques. Best materials for high-field coils today are niobium, zirconium, tin and titanium, in various alloys and compounds. Of these niobium stannide, Nb_3Sn, has the highest critical temperature known—18.3° K—but is very brittle. The problem is how to develop a ductile, flexible and strong wire with the desirable properties of high critical field and high critical temperature.

The techniques of conductor preparation are at the heart of successful high-field-solenoid design. At the Westinghouse Electric Corp. Research Laboratories, a 100,000-gauss field was produced early this year with a coil wound with a niobium-titanium ductile alloy, covered with a niobium-zirconium layer. At the General Electric Co.'s Research Lab-

107,000-gauss superconducting magnet developed at the Radio Corp. of America's research center uses 15,370 turns of Nb_3Sn thin-film ribbon in a compound structure (coil within coil within coil), stores 20,500 joules of energy at full field strength.

oratories, Martin and Benz have made a 101,000-gauss field using a coil of Nb_3Sn conductor made by plating niobium wire with tin and then heating it to produce the compound.

The Radio Corp. of America built its 107,000-gauss, 26-lb supermagnet with Hastelloy stainless-steel tape, coated with a thin film of Nb_3Sn and copper-plated over-all. RCA is now building a one-foot-internal-diameter, 150,000-gauss solenoid with the same material for the National Aeronautics and Space Administration's space propulsion research.

Hard superconductors

The new high-field electromagnets all depend on the properties of compounds and alloys called the "hard" or type II superconductors. Unlike the pure superconducting metals, these materials can tolerate higher magnetic fields before going resistive. Nb_3Sn has been estimated to have a critical field of about 188,000 gauss, depending on its structure.

Several companies are already marketing superconducting magnets, mostly of niobium-zirconium, with field strengths ranging to 70,000 gauss, and working volumes of several cubic inches. All operate in liquid-helium baths at 4.2° K. (—452° F.). Most are intended for research applications.

Superconducting magnets have a great advantage over normal magnets in that they consume no ohmic power in operation. This eliminates the need for bulky power supplies and for means of removing heat from the windings (once operating temperature has been established). Because they can carry very high current densities (about 10^5 amp/sq. cm. at 100,000 gauss for Nb_3Sn), they are physically very small compared to conventional copper coils. They can be brought up to full power with a car battery, and once the field is established, require no power source whatever.

Potential applications

Among the applications being investigated—in addition to the replacement of conventional magnets—are the storage of energy in the magnetic field (e.g. for pumping lasers), in magnetohydrodynamic power generators, plasma research, bubble chambers, and the shielding of space vehicles against radiation produced by solar flares.

Parallel with progress in superconducting magnets is the development of small, light and cheap closed-cycle refrigeration systems accessible to the average user. There is also development going on in auxiliary equipment such as superconducting flux pumps [Electronics, April 6, 1964].

Superconductivity

At a few degrees above absolute zero, certain metals completely lose their electrical resistance. To prove this, researchers at the Massachusetts Institute of Technology induced an electric current in a superconducting ring of lead; it continued without attenuation for over a year. However, superconductors become resistive again when they are subjected to a magnetic field over a certain value (critical magnetic field) or when heated above a certain temperature (critical temperature). The quest is for superconducting magnets that will not destroy their own superconductivity by the field they generate, and, for convenience, super-magnets that can run at the highest possible temperatures, with the maximum possible field.

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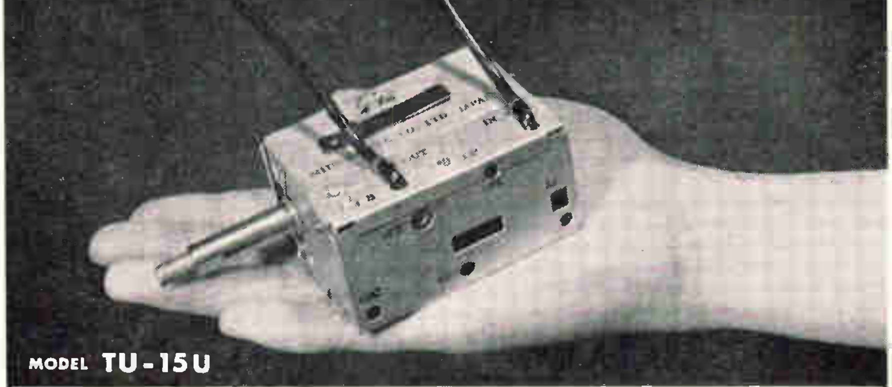

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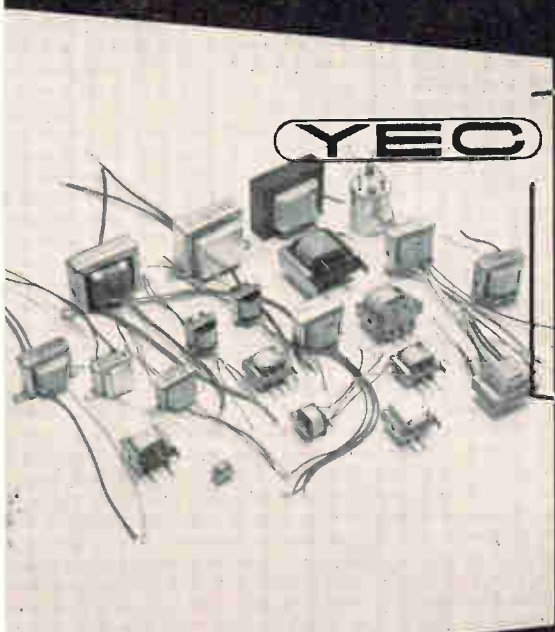

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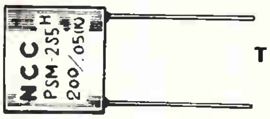

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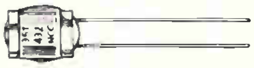

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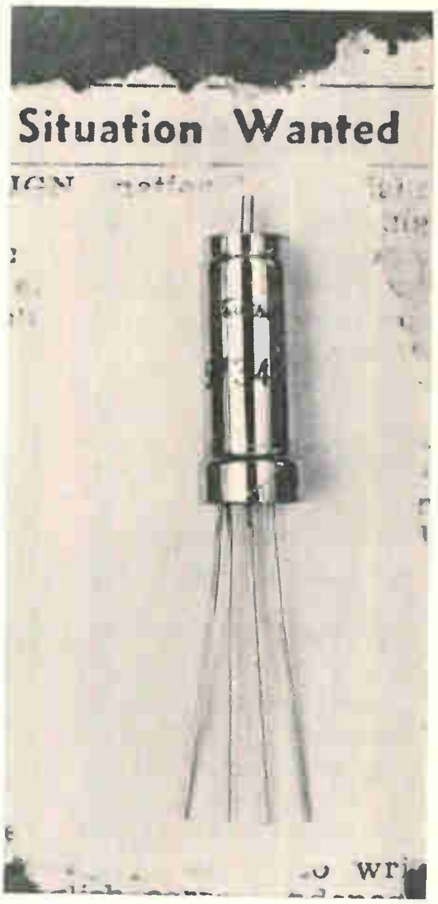

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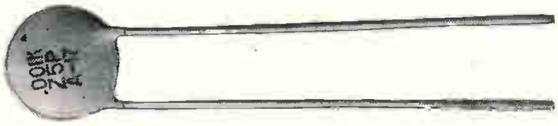

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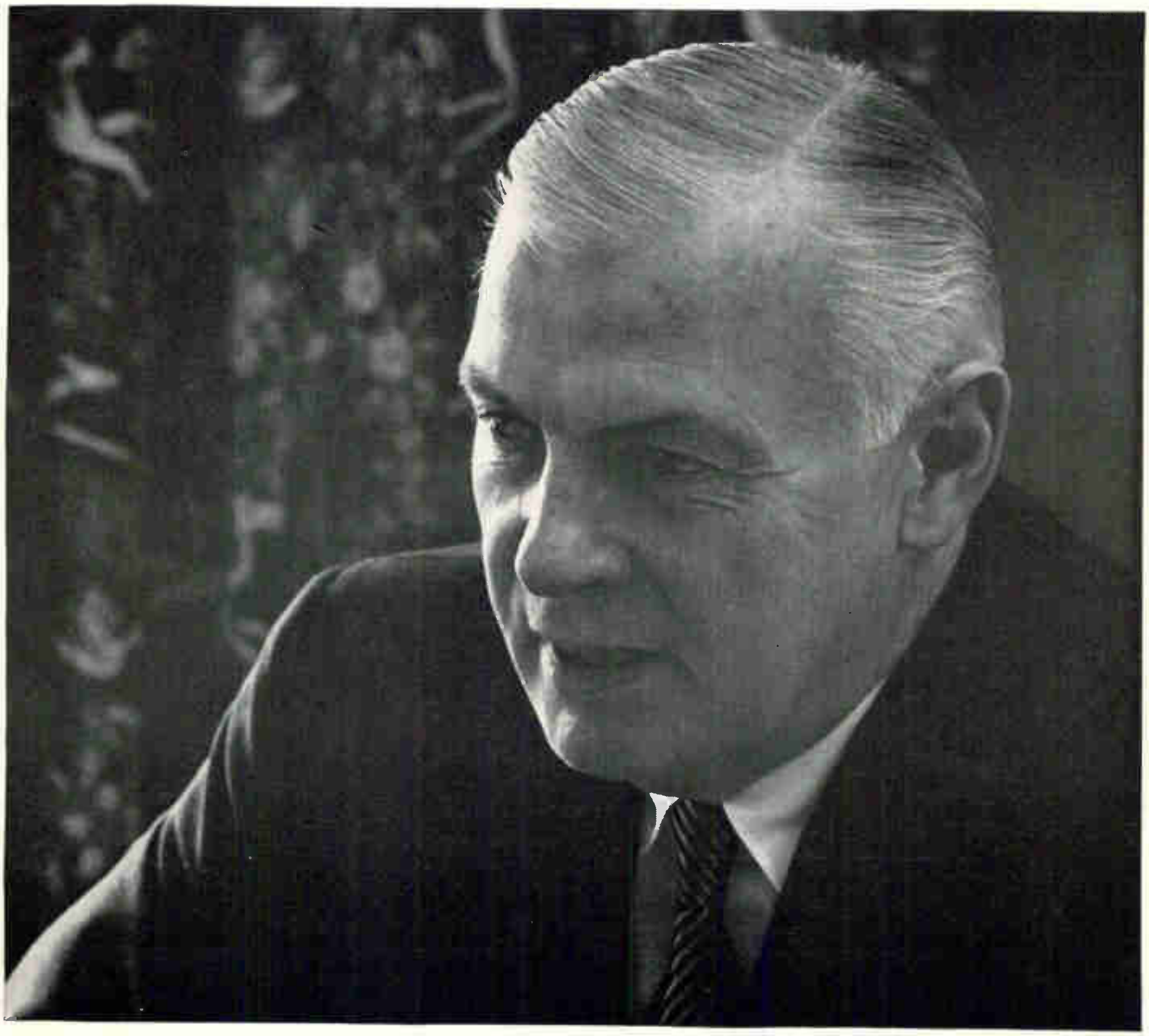

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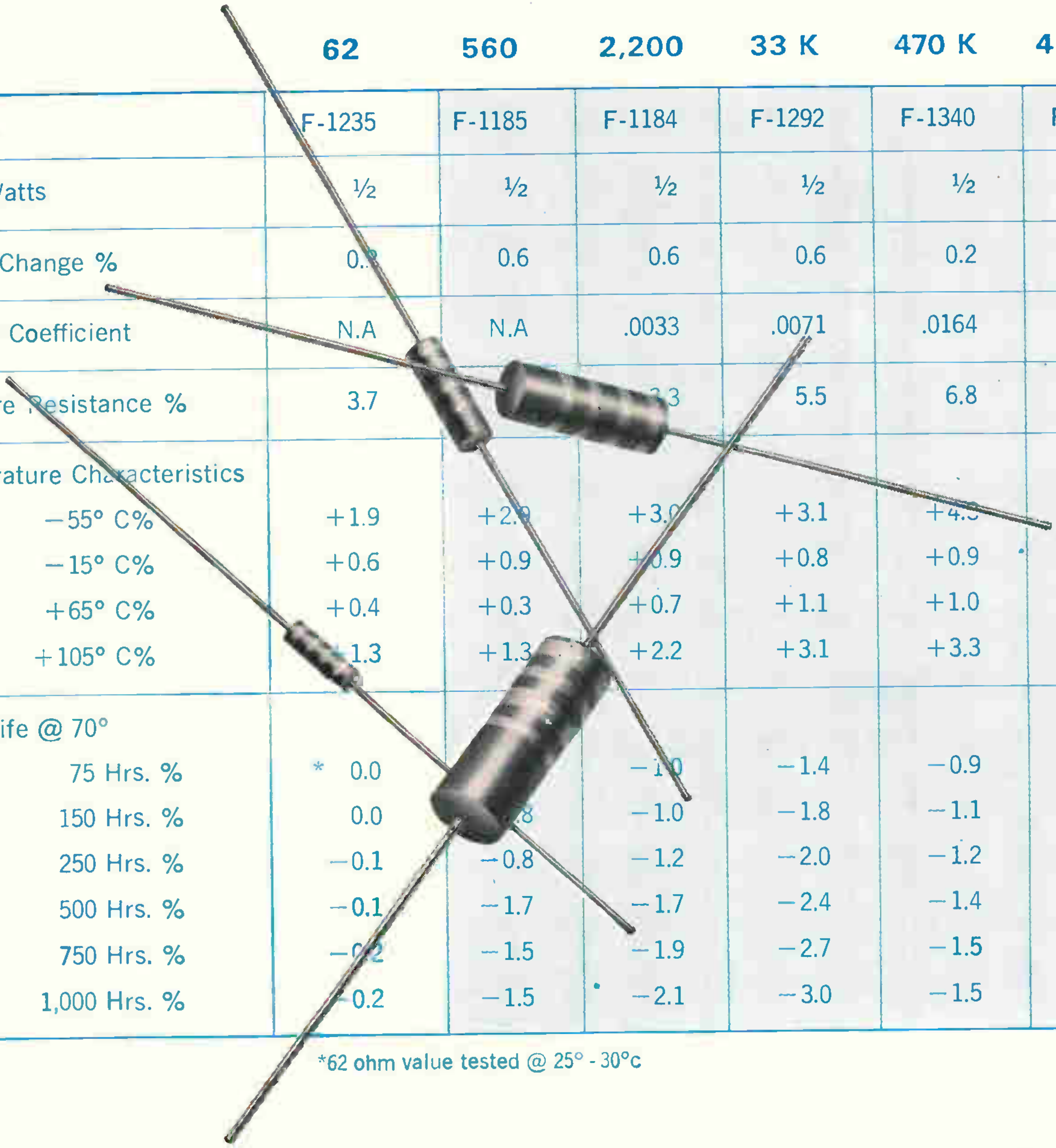

	62	560	2,200	33 K	470 K	4.37 M
Lot No.	F-1235	F-1185	F-1184	F-1292	F-1340	F-1419
Size - Watts	½	½	½	½	½	½
Solder Change %	[illegible]	0.6	0.6	0.6	0.2	0.5
Voltage Coefficient	N.A	N.A	.0033	.0071	.0164	.0166
Moisture Resistance %	3.7	[illegible]	[illegible]	5.5	6.8	8.3
Temperature Characteristics						
−55° C%	+1.9	+2.9	+3.0	+3.1	[illegible]	+7.1
−15° C%	+0.6	+0.9	+0.9	+0.8	+0.9	+2.2
+65° C%	+0.4	+0.3	+0.7	+1.1	+1.0	+0.4
+105° C%	+1.3	+1.3	+2.2	+3.1	+3.3	+1.9
Load Life @ 70°						
75 Hrs. %	* 0.0	[illegible]	−1.0	−1.4	−0.9	−0.6
150 Hrs. %	0.0	[illegible]	−1.0	−1.8	−1.1	−0.7
250 Hrs. %	−0.1	−0.8	−1.2	−2.0	−1.2	−0.7
500 Hrs. %	−0.1	−1.7	−1.7	−2.4	−1.4	−1.2
750 Hrs. %	−0.2	−1.5	−1.9	−2.7	−1.5	−0.8
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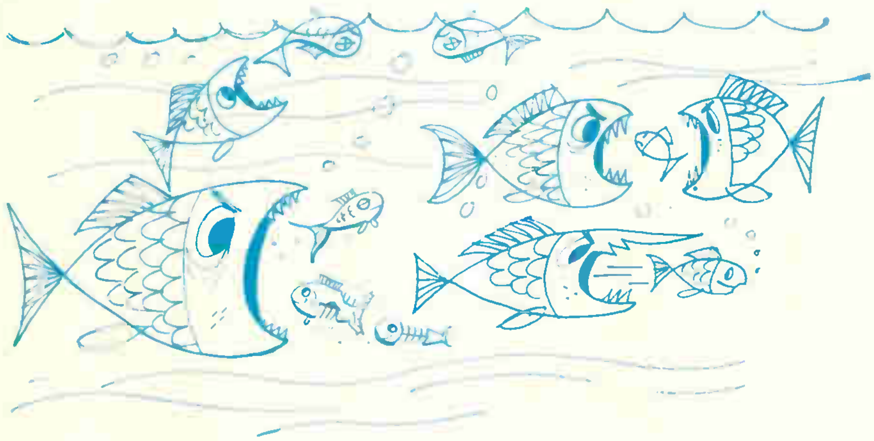


Companies

The merger-go-round

Defense cutbacks speed acquisitions in electronics field past 3-a-week

By Leon H. Dulberger
Staff Writer

Mergers and acquisitions are increasing rapidly in the electronics industry. At the last unofficial estimate they were proceeding at better than a three-a-week clip, with every indication that the pace will quicken before it slows down.

Nearly all of the activity can be traced, directly or indirectly, to the slump in military orders. But the patterns of mergers are many and varied.

Large, weapons-oriented companies are seeking ways to diversify into civilian markets. The fastest way is to acquire an existing commercial business.

Smaller, more specialized suppliers of defense hardware and research burgeoned during the military and space boom of the late 1950s and early 1960s. Now many of them are fighting for survival by trying to swap autonomy for working capital. They're hoping to be acquired, or merged with, more profitable concerns.

Commercial and industrial companies, relatively unhurt by the military cutbacks, see the situation as an opportunity to expand speedily and economically in a field that is becoming more and more competitive. Many of them are moving to acquire firms unable to cope with the slump in defense spending, or nonmilitary firms whose product lines complement their own.

Sometimes, military electronics companies bidding for commercial electronics firms encounter unexpected competition from outside the industry. Chemical companies, including the Union Carbide Corp., have shown strong interest in electronics, partly to offset an anticipated plateau in the chemical industry's growth.

Buyers for sale?

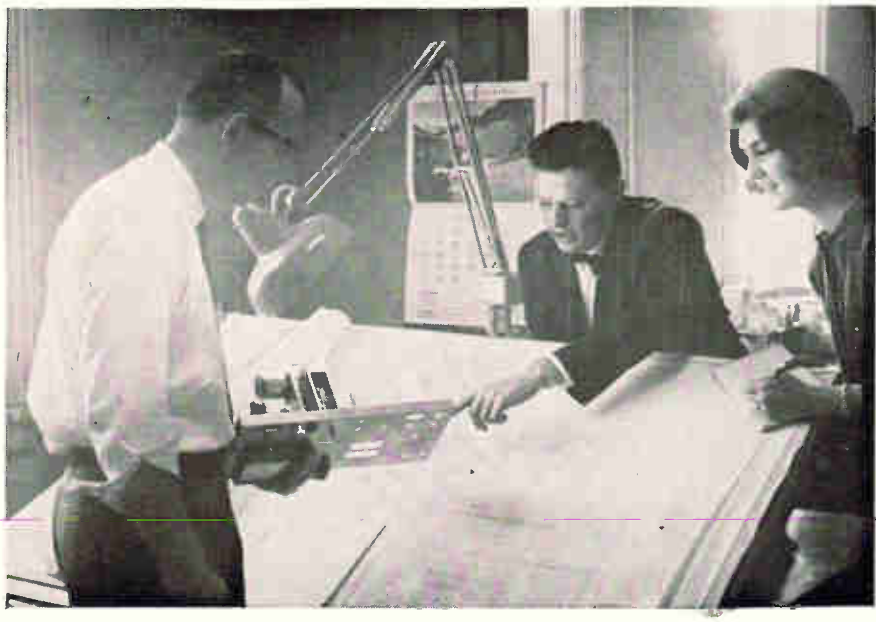
As a result of these situations, and others, some companies have found themselves in the dual roles of prospective buyer and potential seller in merger transactions.

Industrial Instruments, Inc., a New Jersey concern that derives 85% of its income from nonmilitary sales, announced the acquisition in April of two smaller firms, the Precise Measurements Co. and Kalpa Scientific Laboratories, Inc. Yet Bernard Dreskin, president, says Industrial Instruments "receives an inquiry at least several times a week from firms inviting merger talks." He adds that the 25-year-old producer of process control, scientific and industrial equipment has no plans to accept any of these offers.

For some, too late. According to Richard E. Richter of the Shelton Securities Corp., a company that arranges mergers, "Aerospace firms see the handwriting on the wall and are eager to take over commercial electronics companies." Conversely, Richter adds, "Small electronics firms selling military-only products are suddenly eager to be acquired by stronger companies—though it's already too late for some that held out too long."

One arranger of mergers complains, "I've an electronics firm that made money in the military electronics business for 9 out of the 10 years of its existence, and it's a fair-size firm. Now we're having the darndest time trying to sell it, with no takers yet."

Why failures? According to Dun and Bradstreet, Inc., failures in the electronics manufacturing industry rose from 41 in 1958 to 92 in 1962, with 82 reported last year and 20 in the first quarter of 1964. The failure statistics do not include discontinuance of operation without loss to creditors, nor transfers of



Interference analyzer, the first product developed at Fairchild Camera & Instrument Corp.'s new subsidiary, Electro-Metrics Corp. The newly acquired company was formed by 11 executives and engineers who left Empire Devices, Inc., when it was bought by the Singer Co.

company ownerships.

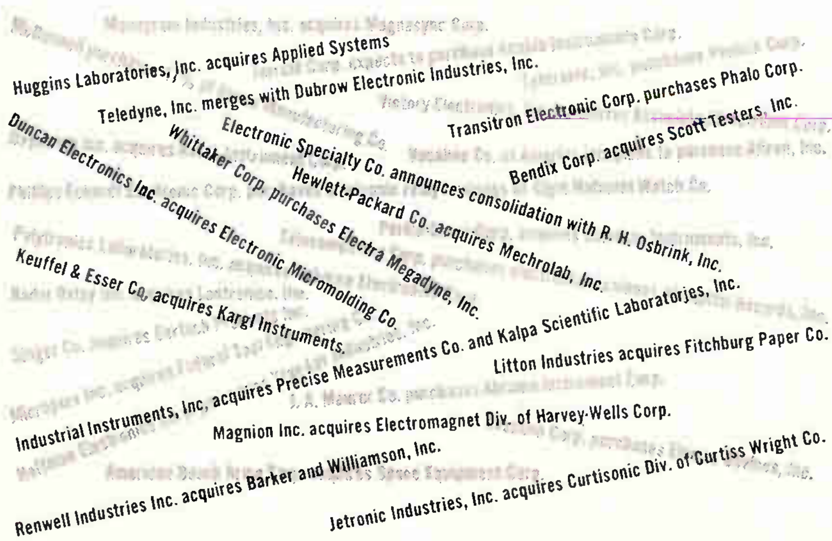
Why do electronics companies fail? Shrinking defense markets is the big factor. But another reason is the fault of the companies themselves.

"Poor management is common in many of the electronics firms that were formed by engineers," says Casper M. Bower, a management consultant. "They've been guilty of such things as poor marketing, poor production techniques, ineffective quality control and immaturity with respect to financial administration. They've done badly in the last few years.

"Now that there are strong demands for efficient military-space manufacturing operations," Bower continues, "risk capital is not readily available to these firms. Since they've gone through their money, they're anxious to accept merger offers as a way to get fresh capital."

Bower cites a company that developed a thermoelectric module to achieve cooling without mechanical motion. "They made no plans to effectively market the item, nor to realistically determine the demand for it," he relates. "They sold samples to engineers at various companies, who were fascinated with the device. The company executives failed to realize that engineers tend to purchase devices that challenge their imagination.

"This provided the new company with a profitable first year or so, but the volume repeat orders, which they thought would follow, never materialized. The market they anticipated is still some time away, experts hold, and the company's enthusiastic marketing assumptions were based upon illusionary projections of first-year sales."



Investors' role

Another push toward mergers may be coming from small-business investment companies, such as the Electronics Capital Corp. These firms may be encouraging mergers for companies in which they have holdings. "The near-disappearance of equity market financing—public money—for the marginal producers of electronics equipment has left the SBICs unable to transform their investments into sizable capital gains," Bower explains.

W. Hardie Shepard, of the venture capital firm of Payson and Trask, stresses another factor leading to mergers. "The government's increasing desire to deal with electronics firms that have full systems capabilities is adding impetus to the merger trend in the industry," he says. He adds, however, that "shrinkage of military markets and the need to replenish capital squandered in the 1950s accounts for the major current of mergers in the electronics industry."

Commenting on growth in nonmilitary segments of the industry, Shepard looks to computers as a promising field, with process control, medical and educational electronics also likely to gain at a slower rate.

Return to 'go'. In one case, the desire to enter the nonmilitary electronics field after years in military electronics has created an interesting cycle. On June 6, the Hoffman Electronics Corp. acquired the television and radio manufacturing firm of Trav-Ler Industries, Inc. Trav-Ler's products range from color tv through stereophonic sound systems. The purchase puts Hoffman back in the television business it deserted for military-space work four years ago. Without Trav-Ler, Hoffman devotes about 90% of its effort to the military-space markets.

The new Electro-Metrics Corp., a subsidiary of the Fairchild Camera & Instrument Corp., dramatizes the present interest in acquisitions in the electronics industry. Electro-Metrics is an indirect result of the Singer Co's acquisition last June of Empire Devices, Inc., a maker of equipment for measuring radio-frequency interference. Singer, anxious to make up for declining sales of sewing machines, created the Singer Metrics division and embarked on a series of acquisitions of electronics firms.

When Singer took over Empire Devices last September and moved it from Amsterdam, N. Y., to Bridgeport, Conn., 11 key employees declined to relocate. They included the chief engineer and the sales manager. They believed in their ability to create a product line, and formed Electro-Sensitive Products, Inc., to develop and market equipment for analyzing electromagnetic interference.

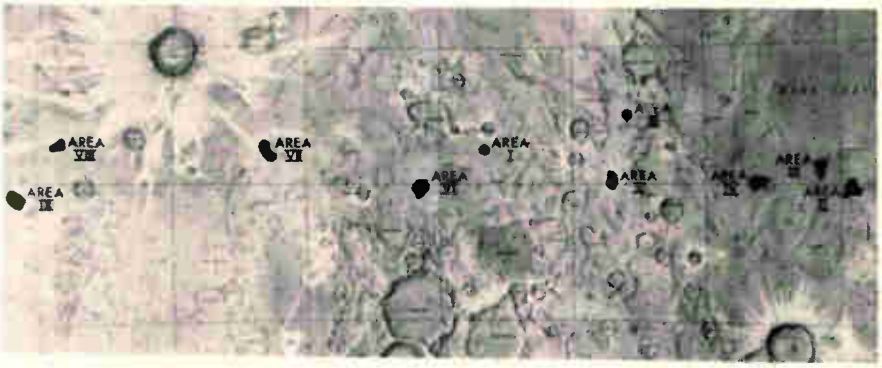
Fairchild, already interested in the electromagnetic - interference market, heard of the new firm and acquired it. The firm was renamed Electro-Metrics, and was allowed to remain in Amsterdam. A largely autonomous operating framework was provided for the company, whose executives were allowed to retain a financial interest.

Healthy helpmates. Many military electronics companies are eyeing instrumentation and process-control firms. Perkin-Elmer Corp., a maker of scientific instruments and electro-optical equipment, says it is often approached for merger talks. despite the fact that only four months age it acquired Coleman Instruments, Inc., a maker of laboratory analytical instruments and electronicoptical components. Since Perkin-Elmer has no requirements for fresh cash, it prefers to remain autonomous.

Process-control companies have a long history of operating agreements with aerospace-electronics firms. Though they are assiduously wooed by the aerospace companies, they do not appear anxious to tie their future in with them. In the opinion of a management consultant in the electronics industry, the process-control firms would gain little from changing their status from that of helpmate. However, the consultant notes that in some cases existing operating agreements could lead to mergers.

Bids from abroad. In the course of arranging mergers, Richter is investigating the increasing possibilities of cross-investment by overseas electronics concerns into United States companies.

A recent case in point is the takeover of a controlling interest in the Dignitronics Corp., Kulka Smith Electronics Corp., Dialight Corp. and Ohmite Manufacturing Corp. by the Consolidated Electronics Industries Corp., whose effective working control is held by Philips Gloelampenfabrieken, N. V., of the Netherlands.



Portion of target area on the moon shows some possible landing sites.

Space electronics

26 steps to the moon

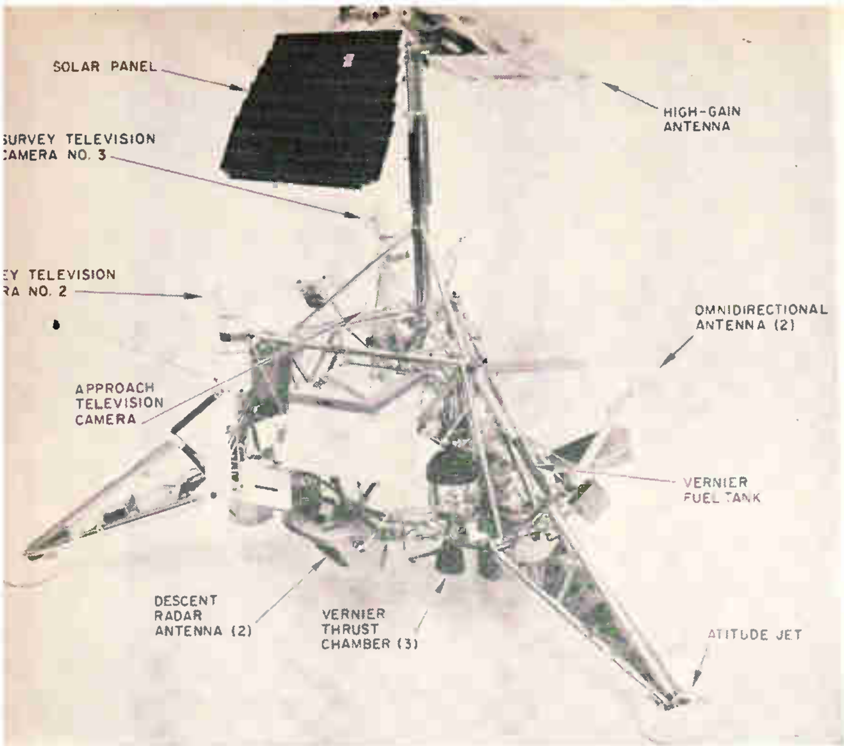
Before an American sets foot there, unmanned vehicles will gather a lot of data

By Joel A. Strasser

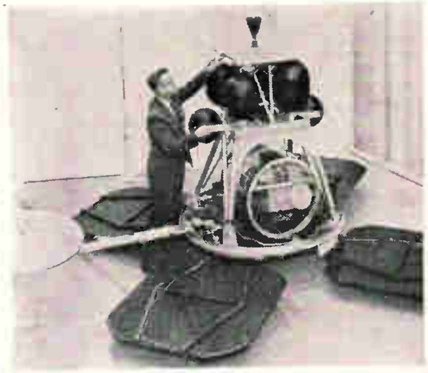
Space Electronics Editor

When we land our man on the moon, will he and his vehicle sink into its surface and be swallowed up? Will the lunar terrain be smooth enough for a soft landing and rigid enough to support the weight of a lunar excursion module and its crew? Exactly where should the first manned Apollo vehicle land? How far from his spacecraft can an astronaut wander? Will he clobbered by meteorites or bombarded by radiation from solar flares? Nobody knows.

The National Aeronautics and Space Administration must have answers to these questions before it can send a manned flight to the moon. The Ranger failures [Electronics Jan. 24, p.14 and Apr. 20, 1964, p.30] were disappointing but NASA still has 26 more chances to get the information it needs. There will be three more Ranger shots, five Lunar Orbiter missions, 17 Surveyor flights and possibly one



Surveyors will make the first soft landings on the moon. Stereoscopic pictures will be obtained with two television cameras.



Lunar orbiter will take closeups of large areas of the moon's surface in the search for a good landing site for Apollo. Five flights are planned in 1966.

manned Apollo reconnaissance flight.

I. Scouting the moon

This stepped series of programs should give NASA a detailed topographic and "geologic" map of the moon, and other information necessary for a decision on the best landing spots. NASA isn't going to gamble. It is counting on the Ranger, Lunar Orbiter and Surveyor missions to do specific reconnaissance jobs. They may make it possible for the manned flights to come off on schedule.

Ranger has fulfilled one important function—experience in building and sending a spacecraft to the moon. The last Ranger flight, for example, proved that the guidance system worked. Ranger 6 was only 20 miles off course when it crashed.

There will be another try later this summer for the television pictures that Ranger 6 failed to take. To strengthen the possibility of success, a series of design changes has been incorporated into Ranger 7. The television pictures Ranger 7 is to take before impact are needed for a general idea of the lunar terrain and as an aid in defining the needs of subsequent programs. NASA is counting on the three remaining Rangers, each equipped with six cameras, to gather data through 1965. The Jet Propulsion Laboratory of the California Institute of Technology is the contractor for the Ranger project.

A closer look. Ranger probes are to provide high-resolution spot pictures of the lunar surface. The Lunar Orbiter, while circling 28 miles above the moon's surface, will photograph an area bounded by $\pm 10°$ lunar latitude and $\pm 60°$ lunar longitude. Within this area, 40,000 square kilometers coverage is specified with a resolution of eight meters. For 8,000 square kilometers of coverage, a resolution of one meter is specified. The aerial photographs, similar to those taken by reconnaissance planes above the earth, will be used for mapping the moon to find potential landing areas. Five Lunar Orbiters are scheduled for launch, beginning in 1966. NASA's Langley Research Center is managing the program, and the Boeing Co. is the contractor [Electronics, June 15, 1964, p.124].

The Orbiter will probably photograph the far side of the moon too, even though there are no plans to land Apollo there. This will be done to satisfy the curiosity of United States scientists and to build a photo file for use in possible future explorations. The Soviet Union took relatively crude, long-range pictures of the moon several years ago [Electronics, May 26, 1961].

The Lunar Orbiter will not send television pictures from the far side of the moon because direct transmission would be blocked by the moon itself. The spacecraft will make photographs and store them. Later, when the craft is in direct line of sight with the earth, the photographs will be scanned by video equipment and relayed to the ground station.

Readout system. Various parts of the Lunar Orbiter's camera systems have been carried on reconnaissance aircraft. The photographs are taken on 70-millimeter aerial photographic film that is radiation-resistant. The film is processed and stored on a spool.

Later, a readout system is activated and the film is read by passing it back through the activated readout system. The light source for film scanning is a line-scan tube that has its phosphor on a revolving drum. The transmitted light from the successive passes over the film is funneled into a photomultiplier with the aid of collecting optics. The signal is then conditioned by a video amplifier that makes the signal compatible with the spacecraft's communications demodulator.

The spacecraft's communications system will operate in the S band, transmitting 10 watts of video data through a directional antenna, and 0.5 watts of other data through a low-gain antenna. Nonvideo data

includes information on lunar gravity, and measurements of micrometeorids and high-energy particles.

On the ground, the video signal is received and the displayed video image is recorded on a continuously moving strip of 35-mm film. The 35-mm film strips are sent to a central facility where a printer regenerates the original photographs made by the Lunar Orbiter.

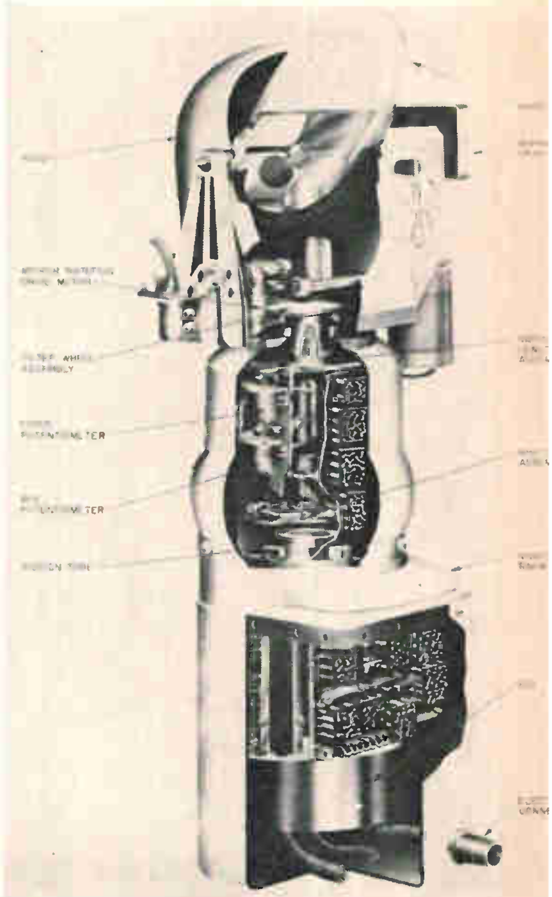
II. Soft landing

When the Lunar Orbiter photographs are evaluated and the most likely landing sites selected, the Surveyor spacecraft will move in. Surveyors will actually squat down on the moon—NASA calls this a soft landing—to take on-the-scene television pictures in three dimensions. Surveyors will sample the soil and gather other data needed for precise information on the potential landing areas. They will gather information about the moon's surface structure and composition, lunar tremors if any, and radioactivity and meteoric conditions. If all goes well Surveyor will find out, for example, how flat the landing plain is, how solid the surface, how steep the crater walls and how craggy the mountains.

Another chore for Surveyor will be to check out some of the landing procedures that the Apollo Lunar Excursion Module will use. Surveyor's landing radar [Electronics, Feb. 7, 1964, p. 70] and velocity-sensing systems will be similar to the Lunar Excursion Modeule's. Both sets of landing systems are being built by the Ryan Aeronuatical Co.

Seventeen Surveyors are planned, and the first soft landings are scheduled for 1965. Only the first seven missions have been clearly defined; flights one through four will be practice trips to check performance and the operational readiness of the craft, and the next three Surveyors will carry the scientific experiments to probe the composition of the lunar surface. The missions of the remaining 10 Surveyors will be determined by what the earlier flights discover.

Designs of the last 10 Surveyors will be frozen when information is in from the Ranger, Lunar Orbiter and the first seven Surveyor flights. The later vehicles will be heavier and more sophisticated than their predecessors. The later Surveyors may carry roving vehicles that would be turned loose on the moon to pick up more data. The Jet Propulsion Lab is managing the Surveyor program for NASA, and the Hughes Aircraft Co. is building the spacecraft.

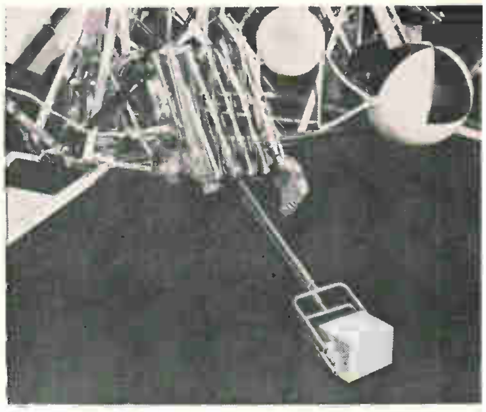


Surveyor's television cameras can observe 360° in azimuth, and 20° above and 45° below the horizontal plane of the spacecraft.

Television systems. All seven of the earlier Surveyors will carry two kinds of television systems. One will be an approach system to monitor the landing; the other will be a survey system to do the exploring after the landing.

The approach tv system, which points down constantly, will provide pictures of the landing site. It will also be able to distinguish at least eight gray levels at a highlight luminance of 800 foot-lamberts. An iris adjustment, made prior to launch, will set the system at the optimum sensitivity for expected lunar-scene luminance from 50 to 2,600 foot-lamberts.

Surveyor flights five, six and seven will have two television survey systems. Two cameras will



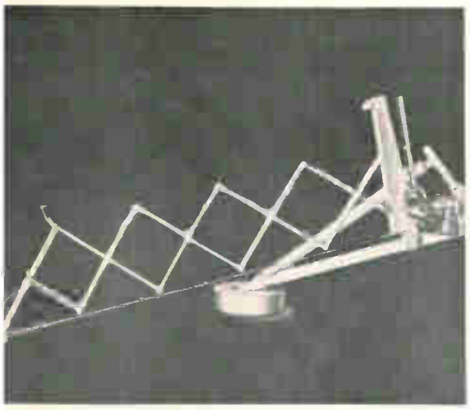
Surveyor will carry a mechanized arm that can reach out five feet to scoop up samples of the lunar surface.

operate together for stereoscopic viewing of the lunar surface and singly for monitoring the operation of surface-sample experiments. The cameras will have both wide- and narrow-angle modes, and will be capable of observing 360° in azimuth, and 20° above and 45° below the horizontal plane of the spacecraft. Each camera has a lens of variable focal length, adjustable from 25 to 100 mm, and an automatic iris, adjustable from f/4 to f/22. On command from the earth, colored or polarized filters can be inserted into the optical path.

III. Mapping the Moon

Stereoscopic observations will permit accurate photogrammetric measurements of lunar slopes and location of surface objects. The maximum limit for accurate mapping is a radius of about 24 meters, with an anticipated minimum of 12 to 15 meters from the spacecraft with measurements accurate to ±5%. Topographic maps of the moon can be prepared with this information. The tv survey cameras will also serve as dust sensors as they observe the spacecraft and its surroundings.

Some mysteries of the lunar surface may be solved with the aid of some extremely interesting contraptions. An instrumented mechanical arm, called a surface sampler, will reach out five feet to study the dust believed to cover the moon. An accelerometer mounted on the scoop measures deceleration during picking actions, to indicate the solidity of the dust. One transducer will measure vertical forces while another measures retroactive forces. The data pro-



vided will aid in preparing lunar topographic maps.

An alpha-scattering experiment will analyze the chemical composition of the lunar surface. Particles scattered from the sample in the target area are measured by semiconductor detectors, and the resulting pulses are amplified, analyzed and telemetered to earth where their energy spectrum is reconstructed.

Moonquakes. A seismograph experiment will determine whether moonquakes are present, the effect of daily temperature changes on surface materials, meteorite impacts and the structure of the surface. Micrometeorite instrumentation will measure the flux, momentum and gross trajectory of particles on the lunar surface near the spacecraft. Twenty-four sensors will study the characteristics of the lunar touchdown and the effects of the landing on each of Surveyor's landing legs.

Last look. As a final step before a lunar landing is attempted, a manned Apollo vehicle may be placed in orbit around the moon. It would take still, television and motion pictures of the surface. Right now, the manned reconnaissance flight is not an approved program. The decision depends upon how successful our unmanned explorers are. NASA says the decision could be made as late as six months before a manned lunar landing.

The Apollo reconnaissance mission will be a manned version of the Lunar Orbiter. And the first Apollo lunar landing will be a manned version of the Surveyor mission.

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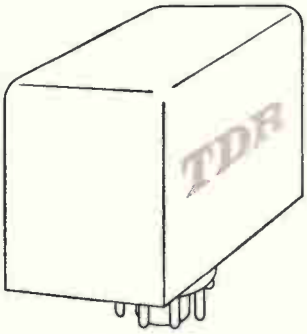

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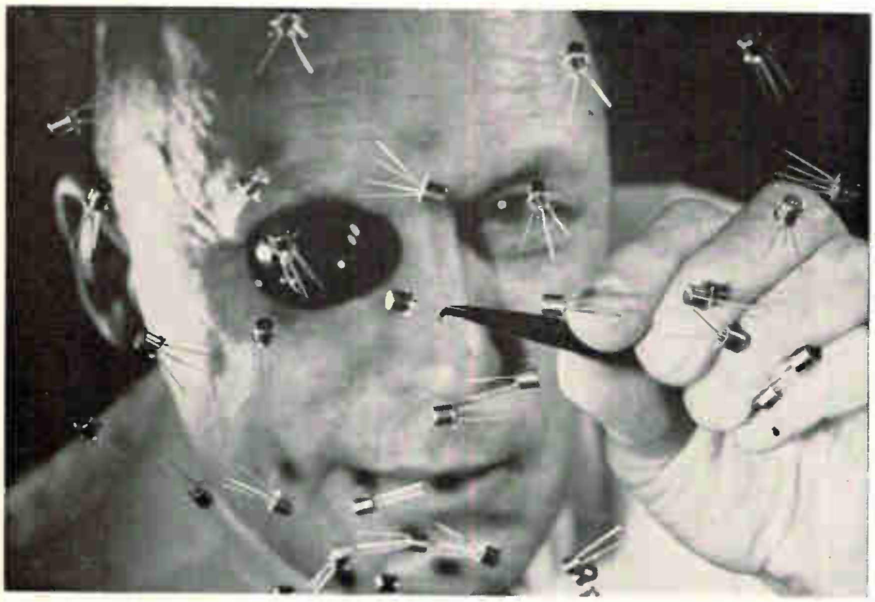
Silicon controlled switches resist transients

Planar, four-lead devices can withstand more than one million volts per microsecond, and are low in cost



A new family of four-lead, silicon controlled switches (scs's) are voltage-transient-proof. According to the manufacturer, it is the first planar four-lead device of this type. The additional lead gives the switch built-in immunity to voltage transients because it increases the ability to withstand high rates of rise of forward-blocking voltage. The device can withstand more than one million volts per μsec.

The extra lead also adds design flexibility. Each of the leads is connected to a separate semiconductor layer. In effect, the new scs becomes an integrated circuit consisting of a complementary pnp and npn transistor in a positive feedback arrangement. It also behaves much like a scr.

As an example, one scs and three resistors comprise a latching Nixie tube driver. A 10-element device of this type would require 10 scs's and 30 resistors. A conventional transistor counterpart of this circuit would require 20 h-v transistors plus associated passive elements.

The new device functions as a latching-type digital switch for both a-c and d-c applications up to 100 v and 200 ma. All four layers are completely oxide-passivated, contributing to high reliability. Another major feature is the high sensitivity of the new switches. For example, types 3N81 and 3N82 have a gate trigger current rating of 1 μa.

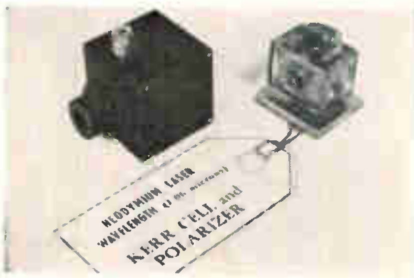
These scs's are designed to be used as drivers for gas tubes, neon tubes and incandescent lamps in alpha-numeric displays. As drivers for a broad variety of relays and solenoids, the new switches are said to offer an inexpensive way to latch, with higher sensitivity and a greater variety of applications than other pnpn-type devices. Separate control over both center junctions of these four-level pnpn units helps eliminate premature turn-on caused by rate effects inherent in other semiconductor switches, according to the manufacturer.

Other uses include low-speed logic, delays, gates, counters, machine-tool controls, process controls, computers, calculators, test equipment, low-level scr and complementary scr circuits.

JEDEC-registered types from 3N81 to 3N86 are available. The 3N81 and 3N82 are designed to be used in temperatures from −65° to +150°C. Prices in thousand-lot quantities range from $1.15 for the type 3N84 to $2.95 for the 3N82. The company attributes the low cost to the fact that the switch is double rather than triple-diffused.
General Electric Co., Semiconductor Products Dept., Syracuse, N. Y.
Circle 301 reader service card

Kerr cells control neodymium lasers

Size 16 and 25 Kerr cells are designed for use with neodymium lasers which have a wavelength of 1.06 microns. The cells are filled with deuterated nitrobenzene which has extremely low losses at the neodymium wavelength of 1.06 microns, thereby increasing laser



system efficiency and power output. The size 16 is for use with ¼ or ⅜ in. laser rods; the size 25, for ½ or ¾ in. The Kerr cells are available individually or as a complete Kerr shutter assembly including Kerr cell, Glan-Kappa polarizer and enclosure. The Kerr shutter assembly is commonly used in giant pulse laser applications.
Kappa Scientific Corp., 49 S. Baldwin Ave., Sierra Madre, Calif. [302]

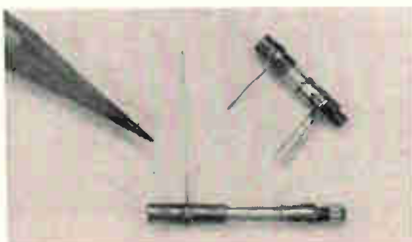
Microminiature relay requires low coil power

A grid-spaced microminiature relay, featuring all-welded construction, including enclosure to header seal, has been designed to require only 40 mw for double-pole units and 25 mw for the single-pole version. The company says low coil power consumption highly qualifies the relay for aerospace applications. It can also be used for applications that restrict coil operating power but require performance equal to or better than relays with 250 mw or more sensitivity. Ambient temperature range is between −65°C and +125°C with weight at 0.95 oz maximum, not including mounting brackets or studs. The relays have a minimum rated life of 100,000 operations at rated load or 10 million mechanical operations. Operating time stands at 10 millisec max, including bounce, while release time lists at 5 millisec, including bounce.

General Electric Co., 392 S. Stratford Rd., Winston-Salem, N. C. [311]

Backlash eliminated in glass trimmer

The temperature characteristic of this glass trimmer capacitor, 0 to 50 ppm per degree centigrade, is comparable with more expensive quartz



units. The precision capacitor is of 0.15-in. diameter and is designed for either panel or printed-circuit board mounting. The torque mechanism eliminates backlash and prevents electrode movement under conditions of shock and vibration without recourse to springs or tension rings. For easier tuning, the adjust screw does not emerge from the tuning well. The trimmer is available in five sizes; the smallest, with an over-all length of 0.48 in., has a range of 0.5 to 2.5 pf; the largest, 1.6 in. long, has a range of 0.5 to 16 pf. Engineering evaluation units are available at $10 each.

Statidyne Co., 22 Lynn Place, Valley Stream, N.Y. [312]

Power transformer rated at 2 watts

Encased in diallyl phthalate, this rugged unit can develop voltages of 5 to 150 v. a-c with a power rating of 2 w. Model 2E is especially suited for aerospace and industrial applications where small size and dependability are prime factors. It is 0.87 by 0.74 by 0.78 in. high, is built to meet MIL-T-27A specifications, and is capable of operating at a maximum of 105°C. The unit will also meet the environmental requirements of MIL-E-5272C. Price is $14.40 each.

Abbott Transistor Laboratories, Inc., 3055 Buckingham Rd., Los Angeles 16. [313]

Solderless coax plug saves assembly time

This coaxial cable plug can operate at frequencies up to 500 Mc and is suitable for circuits requiring maximum voltage of 500 v. The A-MP uhf plug is terminated with

newly developed hand and power crimping tools which reduce assembly time considerably over conventional soldering methods. The procedure consists of a one-stroke self-bottoming crimp which simultaneously terminates the braid and the center conductor. Not only does this controlled crimping process create high resistance to braid pull-out, but the square-style crimp of the center conductor also assures high retention and maximum conductivity. The plug can be used in maritime, aeronautical, domestic and other applications involving guidance or communications equipment.
AMP Inc., Harrisburg, Pa. [314]

Nickel-cadmium cell offers safety-vent seal

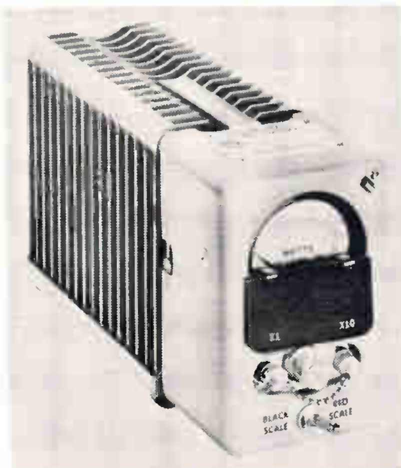
A rechargeable, nickel-cadmium battery cell with pressure-sensitive seal has been developed that is slightly longer than the ordinary penlight (AA) battery cell. Its small size and constant discharge voltage make it ideal for multi-cell battery applications. Model S-140 features a safety vent which protects the cell from damage if internal pressure should build up due to malfunction of charging equipment. Even if such action should occur, causing the cell to vent, the cell is still usable and will continue to operate for many charge and discharge cycles. The S-140 has a nominal voltage output of 1.25 v. The average discharge capacity to 1.0 v is 530 ma hours at the 1-hr rate and 575 ma hours at the 5-hr rate. The recommended charge rate is 60 ma for 14 hours. The cell weighs 0.9 oz and actual size is $\frac{13}{32}$ by 1.92 in.
Sonotone Corp., Elmsford, N.Y. [315]

New Instruments

Video power amplifier for crt manufacturers

This video power amplifier provides 150 v p-p output at low impedance and with a bandwidth to 10 Mc. Originally designed for the extreme test requirements of the cathode-ray tube manufacturer, the widely applicable amplifier features a hybrid transistor circuit, and incorporates a phase reversal switch. Price is under $300.

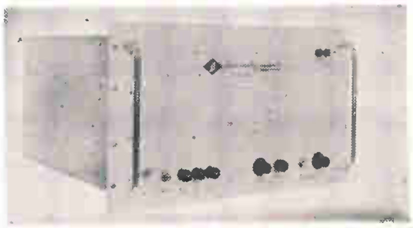
American Electronic Controls Co., 2459 Susquehanna Road, Roslyn, Pa. [351]



Absorption wattmeter reads r-f power directly

The Termaline model 6154 is a portable absorption wattmeter for accurate non-radiating termination and measurement of r-f power in 50-ohm coaxial systems. Designed for c-w, a-m, f-m and tv modulation envelopes in the frequency range of 25 to 1,000 Mc with a maximum vswr of 1.1, it reads r-f watts directly without calibration adjustments or charts. Combining the usefulness of two instruments in one package, model 6154 has four power ranges in place of the usual two: 5/15/50/150 w full scale. Weight of the wattmeter and detachable meter housing is 8 lb, and price is $265.

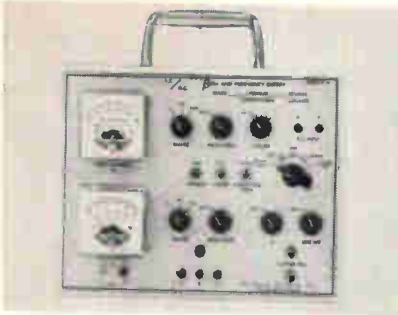
Bird Electronic Corp., 30303 Aurora Rd., Cleveland, O. 44139. [352]



High power d-c supply simulates transients

This instrument was designed to supply power for check-out and qualification tests of electronic equipment used in space programs. Model PM1217 is a variable-voltage high-power regulated power supply that has provisions for the simulation of d-c line transients by the superposition of an internally generated rectangular pulse onto its d-c output. The pulses are generated by a newly developed power pulser. The controlled transient output consists of a rectangular pulse of 44 ± 6 v amplitude added to the d-c output. Pulse width is 7.5 μsec; rise time into full load is 1 μsec; and fall time is 2 μsec max. Repetition rate is 1.75 ± 0.25 pps. Available as options are amplitude control, adjustable repetition rate to 10 pps, and adjustable pulse width. The d-c output is variable from 20 to 30 v d-c with a resolution of at least 20 mv, and can be loaded from 0 to 35 amp d-c. Regulation for line and load is ± 10 mv. Ripple is 10 mv peak-to-peak, and 8-hr stability is ±20 mv.

Pioneer Magnetics Inc., 1745 Berkeley St., Santa Monica, Calif. 90404. [353]



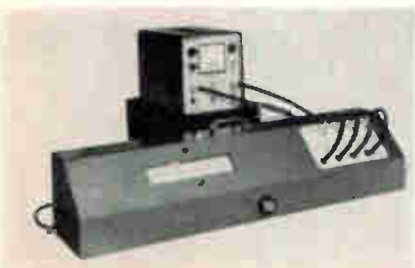
Battery-powered unit tests semiconductors

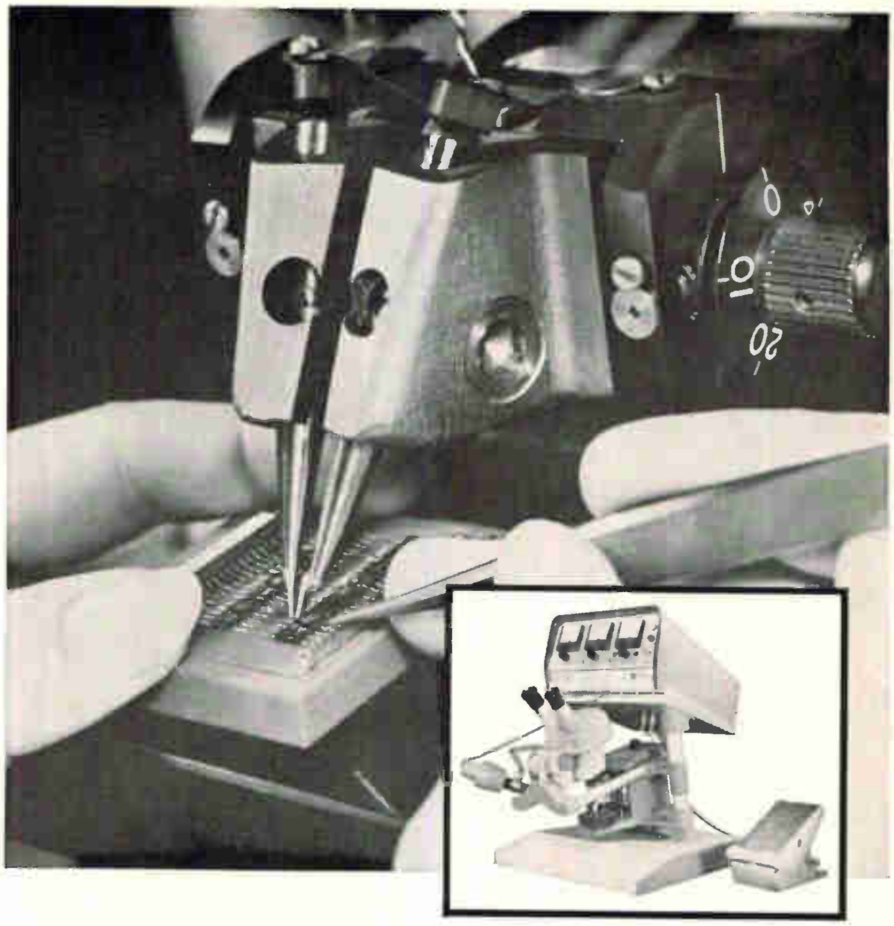
A portable, battery-powered test unit has been developed for determining voltage and current characteristics of semiconductors. It measures the forward conduction and reverse leakage of diodes and transistor junctions simultaneously. It also determines current at maximum beta, and permissible current range for linear amplification. Model 2115 has provisions for external a-c inputs for determining a-c beta and frequency cut-off and half-power points. The external input provisions also permit the determination of gain and frequency characteristics of transistor amplifiers. The instrument incorporates a meter reset capability that permits returning the pointer to zero for subtracting collector-emitter leakage, for expanding the meter-range sensitivity, or for making transistor gain measurements in-circuit. The price is $475.

Electronic Systems, Inc., P.O. Box 22166, Houston. 77027. [354]

Phase detector /shifter has high accuracy

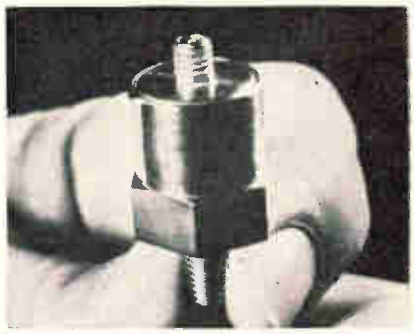
New instrumentation, which embodies the principle of amplitude insensitive phase comparison, comprises a null detector, PD-201 and a precision phase shifter, PS-201A. It operates in one band-pass range





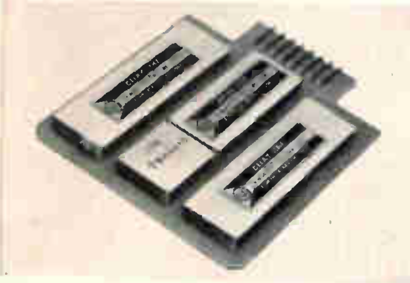
New Instruments

of 100 Mc to 1 Gc. The final measurement accuracy of PD-201 is 0.1° or ±1% of total delay, whichever is greater, when used with the PS-201 or PS-201A phase shifter. Characteristic impedance of the system is 50 ohms nominal. Vswr is 1.1 to 1 which, together with the detector's high sensitivity, permits the vswr of the test piece to be lowered by appropriate padding to obtain accurate small-angle measurements. One channel may present an amplitude unbalance up to 20 db or more without adverse effect to the system readout. Readout scale is calibrated in increments of 0.005 nsec. The null meter, with center scale zero, provides a positive reference point with minimum parallax. The new system is designed to measure phase shift in r-f amplifiers, i-f strips, wideband amplifiers, narrowband filters, networks and delay lines.
Teltronics, Inc., 23-27 Main St., Nashua, N. H. [355]



Accelerometer has low transverse response

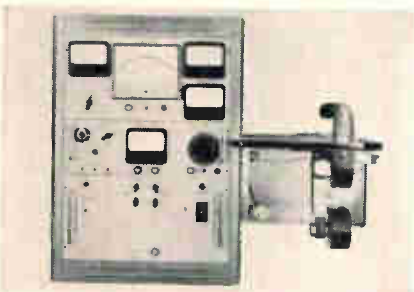
An accelerometer with a shear seismic element has been developed for use where high resonant frequency and ultralow transverse sensitivity are desired. Model BA-45501 measures shock and vibration in missiles, rockets, static and silo test firings. The shear accelerometer is especially useful as a secondary standard since it has an extremely flat frequency response up to 10 kc. Resonant frequency is greater than 50 kc with transverse response less than 1%.
Gulton Industries, Inc., 212 Durham Ave., Metuchen, N.J. [356]



Modular delay lines mount on p-c boards

Lumped-constant delay lines in modular form are available for p-c board mounting. Delays may be chosen for 50, 100, 250, 500 or 750 nsec, 1.0, 1.45, 2.90 or 4.35 μsec. Any of these lines may be had in 50, 150 or 500 ohms impedances. Delay-to-rise time ratios selected determine the case length, and are as follows: 4:1, 1.25 in.; 8:1, 2.20 in.; and 12:1, 3.45 in. Other case dimensions are 0.31 in. high by 1.0 in. wide. Price of the D647 series depends on the delay and rise time selected. The D647-113 is typical. With a 500-nsec delay, 125-nsec rise time and an impedance of 150 ohms, it is priced at $18 each in small quantities.

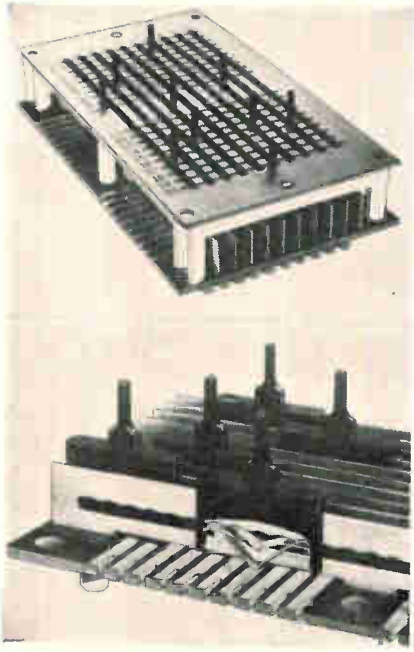
Computer Devices Corp., 6 West 18th St., Huntington Station, N.Y. [371]



Adjustable output from pulse modulator

This hard tube pulse modulator provides negative pulses of up to 10 kv peak amplitude, 18 amperes peak current at 0.002 duty cycle. Pulse repetition rate is adjustable from 200 cps to 60 kc. Pulse width is adjustable from 0.08 μsec to 7.0 μsec. Rise time is adjustable from 40 nsec to 0.3 μsec. The h-v power supply contained in the unit is adjustable from 0 to 11 kv and is regulated to within 1%, line and load. Besides the usual metering facilities, a peak voltage meter is provided, as well as voltage and current probes. Model 211 sells for $6,200.

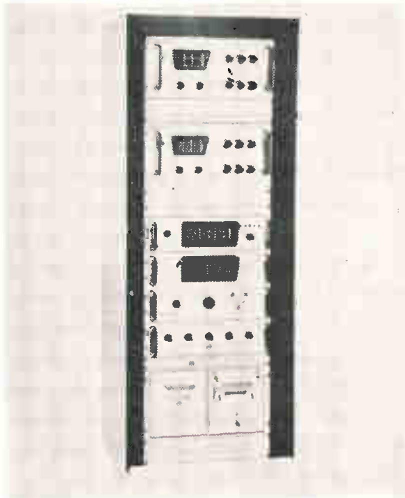
E.F.E. Laboratories, Inc., Horsham Valley Industrial Center, Horsham, Pennsylvania. [372]



Switch module acts as programmer-selector

A manual programmer-selector switch module, C10-01A, contains 10 select stations, each with 20 slider contact positions, to provide 200 switching combinations within a single, compact 2 in. by 3½in. by 6 in. unit. Each module has 20 p-c contact strips and 10 dual-purpose, transverse rails which carry the beryllium copper contact and positive detent for circuit selection. Separate springs perform detenting action and carry current. Rectangular coordinates simplify selection. The module is suited for programing, circuit design and sequencing automatic equipment. Circuit current-carrying capacity is 1 amp 15 v d-c, 150 ma, 125 v a-c make and break, or 3 amp 125 v a-c/d-c current-carrying only. Printed circuit is nickel-rhodium plated on copper-clad phenolic. Price of the C10-01A module is $20.50.

Cherry Electrical Products Corp., P.O. Box 438, Department F, Highland Park, Ill. [373]

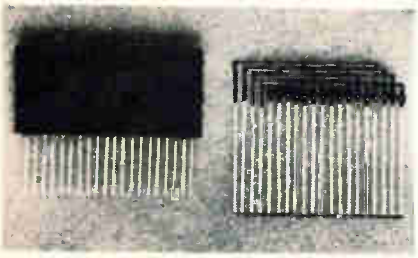


Resistance test system scans automatically

An automatic tester has been designed for the development, quality control and manufacturing of fixed or variable resistance components, investigating electrical resistance properties of materials, for testing reliability or environment and for reading the outputs of variable-resistance transducers. The 24297 resistance test system can automatically scan up to 800 external resistances at accurately clocked intervals from several minutes up to 1,000 hours. Resistances are measured to an accuracy of $\pm$ (0.01% of reading + 0.001% of full scale) from 0.1 ohm to 1 megohm with a solid-state 5-digit digital ohmmeter. The resistance measurement, identification number and time are recorded in numerical form on a data printer, and auxiliary outputs are available to operate into computers, tape or card punches and digital comparators.

Non-Linear Systems, Inc., Del Mar Airport, Del Mar, Calif. [374]

New Semiconductors

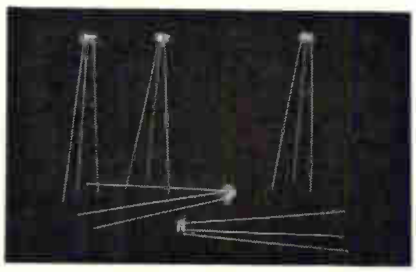


Tiny diodes in varied packages

Silicon core-memory diodes and assemblies have been announced. They have ratings to 1500 ma and 500 v, and recover within 2 nsec. Units are intended for use in lightweight, compact, high-speed converters and inverters, in addition to conventional computer core drivers. They may be obtained with round leads or ribbon leads. Body sizes start with 0.050 in. by 0.100 in. (with ribbon leads). A variety of package configurations is available, including many conventional off-the-shelf miniature connector assemblies. Unit prices range from $2 at the 100-quantity level.
Micro Semiconductor Corp., 11250 Playa Court, Culver City, Calif. [331]

Silicon rectifier withstands humidity

A miniature silicon rectifier has been developed for a variety of high-density, low-current circuits. The device promises long life and reliable operation because of a new glass package and passivated junction. The package withstands stringent humidity tests and electrically insulates the rectifier from surrounding components. Type A13A/Z2 can continuously handle 1 amp. It can withstand surges up to 30-amp peak surge forward current. Forward voltage drop is 1 v max and reverse current is 10 μa. Effective thermal resistance from junction to tiepoints is 70°C per w. The rectifier is available in prv ratings from 50 to 600 v. Price for a 200-v unit is 40 cents in lots of 100-999.
General Electric Co., Rectifier Components Dept., Auburn, N.Y. [332]



Chopper transistors feature low offset

New pnp silicon switching transistors, designated 2N3217-18-19, are designed for low-level chopper applications. They feature very low offset voltage, high emitter breakdown voltage, and low leakage current. Pairs matched in offset voltage to 50 μv from -25°C to $+100$°C are available. As a result of the expitaxial junction process, the devices combine the high voltage advantages of alloy junction devices with the ruggedness, stability and reliability of planar units. They are bed-mounted and oxide-passivated by a process which eliminates "purple plague" and results in extreme ruggedness and parameter stability. Respective parameters for the 2N3217, -18 and -19 are as follows: min BV_{CBO} & BV_{EBO} are 15, 25 and 40 v; min BV_{CEO} are 10, 20 and 35 v; max offset voltages are 1.0, 2.0 and 3.0 mv; and max I_{CBO} & I_{EBO} are 1.0 nanoamp for all three.
Crystalonics, Inc., 147 Sherman St., Cambridge 40, Mass. [333]

New Production Equipment

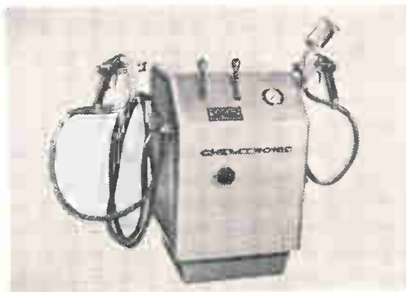
Drill fixture expedites p-c board production

An optical drill fixture has been designed to provide accurate placement of holes in printed-circuit boards for R&D and prototype runs. The unit projects a magnified view of the work surface on a vertical screen. Cross-hairs on the screen are aligned with the center point of a drill bit mounted vertically below the work table. Centering a hole-locating mark on the cross-hairs automatically centers the locating mark over the drill. A large area of the circuit board is shown, keeping the operator oriented and able to move rapidly from one locating mark to another. A hand clamp holds the board in position while a foot switch operates the self-activating motor which automatically raises the drill as it turns. The drill fixture comes complete with its own motor, drill head and projector. Only 32 in. high, 16 in. deep, and 8 in. wide, it fits on any work bench or table. A 6½-in. throat clearance and ½-in. vertical clearance allows boards to be ganged. Drill sizes are available up to 3/32 in.

Acme Scientific Co., 1450 Randolph St., Chicago, Ill. [421]

Vapor spray system applies photo-resist

Through new techniques in the use of the Chemtronic vapor spray system, photo-resist coatings are claimed to be applied with a quality and uniformity not obtainable heretofore. Resolution of the circuit pattern to 10 micron lines now is obtained as standard. The system applies photo-resist with a control of coating thickness from 1/10 mil on up. This is accomplished within tolerances of ±1/100 mil. Other problems in the application of photo-resist, such as filling of through-holes, contamination of compressed air with moisture or oil, pin holes, orange-peel and sag have all been eliminated. The system provides a truly contamination-free coating, assuring reliability as well as fidelity in reproduction of the circuit pattern. The technique also measurably cuts cost of material and application. Heart of the Chemtronic system is a super-dry vapor called Chemsine, used as the atomizing agent. This vapor, with a molecular weight three times that of air, flashes off immediately be-



yond the spray nozzle. Only the photo-resist reaches the plate. The system is simple and entirely self-contained, requiring no compressed air. All units are equipped to operate with two guns, completely independent of each other.

Zicon Corp., 63 E. Sandford Blvd., Mt. Vernon, N.Y. [422]

Seamwelder seals thin metals

Precision automatic production of thin-metal, hermetically seam-welded parts from any flat geometric pattern is achieved by the Profiler-200. The equipment is designed for electronic flat-circuitry, transducers, transformers, filters or relays. Thickness capacity ranges from 0.001 to 0.010 in., like or unlike, to each other or to heavier parts. High hermetic integrity is achieved with negligible reject

rates. There is no heat damage, no operator fatigue or hazard. Unskilled personnel are quickly and easily trained to perform the automatic sealing operation.
Nyborg Engineering Co., 553 Dawson Dr., Camarillo, Calif. [423]

Fluid dispenser for micro-modular work

The Micro Air Dispenser provides air-operated, controlled applications of all types and viscosities of adhesives, sealants, coatings, lubricants, potting and encapsulating compounds. Dispensing a dot, a line or a continuous flow, the system is designed to meet the requirements of micro-modular electronics production. It incorporates

compactness and light weight, effortless operation, positive on-off with no material drip, and disposable low-cost syringe which eliminates clean-up.
Techcon Systems, Inc., 13206 South Western Ave., Gardena, Calif. [424]

New Microwave

Impedance converters span d-c to 2 Gc

Two new microwave impedance converters have been announced. Type MC-102A is intended for use between a 50-ohm and a 75-ohm system; type MC-102B, for use between a 50-ohm and a 95-ohm system. Since both types employ only precision resistive elements, the bandwidth can be extended from d-c up to several thousand Mc. The resistive elements are connected as an L-section matching network. The construction is entirely coaxial, with the shunting elements to ground and a rod resistor as interconnector. Operating frequency is from d-c to 2 Gc. Vswr is from less than 1.2 up to 1 Gc and less than 1.3 up to 2 Gc. Maximum dissipation is 1 w average, 10 w peak. Type MC-102A has 50 ohms at the side with type N male connector and 75 ohms at the side with BNC female connector. The MC-102B has 50 ohms at the side with Type N male connector and 95 ohms at the side with BNC female connector.
Ad-Yu Electronics, Inc., 249 Terhune Ave., Passaic, N.J. [391]

Sweep oscillator generates high power

In the frequency range from 950 Mc to 2.3 Gc, the PRD L720 sweep oscillator generates 1 w (+30 dbm) of swept r-f power with a minimum power variation of ±1 db. Input power consumption is less than one-third that of equivalent tube models resulting in extended equipment life and reliability. Use of all-solid-state circuits contributes to reduced warm-up time and frequency drift. A complete variety of sweep modes and modulation schemes are available in the instrument to insure an extensive measurement versatility. Weighing approximately 40 lb, the unit measures 7 in. high by 17 in. wide by 15 in. deep.
PRD Electronics, Inc., 202 Tillary St., Brooklyn, N.Y. 11201. [392]

Modulated detector receives c-w signals

Combination of an ultra-high-speed diode modulator with a sensitive diode detector has resulted in the model X510 modulated detector, a very sensitive X-band microwave receiver. The unit is ideal for detecting: low-level c-w signals from tunnel-diode oscillators and varactor multiplier chains, spurious oscillations, radiation from aircraft and ground radars, and electromagnetic interference (rfi). A conventional vswr meter is readily converted into a high-sensitivity c-w receiver by driving the modulator portion of the model X510 with a 1,000-cps signal and feeding the detector output to the vswr meter. Modulation up to 200 Mc permits the use of low-noise, high-gain, i-f amplifiers and receivers. The detector output can be optimized by use of a standard X-band sliding short (not provided). Model X510 insures improved transmitter stability by modulating the received signal without disturbing the transmitter. Antenna-range instrumentation can be simplified and improved by placing a c-w transmitter at one end of the range and using the X510 modulated detector at the receiving end.
Somerset Radiation Laboratory, Inc., P.O. Box 201, Edison, Pa. 18919. [393]

New Literature

Environmental test facilities. American Electronic Laboratories, Inc., Richardson Road, Colmar, Pa., offers a six-page brochure listing the company facilities for either standard or special environmental and measurements testing. Circle **451** on reader service card

Deflection yokes. Syntronic Instruments, Inc., 100 Industrial Road, Addison, Ill., has issued a 2-page catalog on high-resolution, push-pull and single-ended, 1-in. vidicon deflection yokes in both magnetic and electrostatic focus types for commercial, military and space applications. **[452]**

Module breadboard kit. Packard Bell Computer, 2700 S. Fairview St., Santa Ana, Calif. 92704. Descriptive data sheet SP-163 discusses the MBK1 breadboard kit and its uses in designing, testing and checking out for digital-circuit and systems engineering and for logic instruction. **[453]**

Microwave swept measurements. Sperry Microwave Electronics Co., P.O. Box 1828, Clearwater, Fla. Microwave swept measurements are discussed in 28-page Microline Application Note No. 2 **[454]**

Hardware. USECO division of Litton Industries, 13536 Saticoy St., Van Nuys, Calif. A 1964 engineering standards manual gives complete specifications for terminals, terminal headers, terminal boards, encapsulation cups and electronic hardware. **[455]**

Magnetic heads. Magnusonics Industries Inc., 68 Toledo St., Farmingdale, N.Y. A brochure provides complete specifications and descriptions of a line of heads for magnetic tape transports and tape instrumentation systems. **[456]**

Mil specs for fixed capacitors. Cornell-Dubilier Electronics, 50 Paris St., Newark, N.J. 07101, has now produced its guide to military specifications for fixed capacitors in a convenient pocket-size booklet. **[457]**

Waveguide switches. DeMornay-Bonardi, Division of Datapulse Inc., 780 So. Arroyo Parkway, Pasadena, Calif. A line of square and delta configuration solenoid-driven waveguide switches for 7.05 to 18.0 Gc is described in a 4-page bulletin. **[458]**

Magnetic tape for instrumentation. Ampex Corp., 401 Broadway, Redwood City, Calif., has available a 12-page bulletin on magnetic tape for instrumentation recording. **[459]**

Ultrasonics. Magnaflux Corp., 7300 W. Lawrence Ave., Chicago, Ill. 60656, has prepared a broad-coverage 4-page folder surveying the techniques and uses of both the resonance and pulse ultrasonics. **[460]**

Analog-digital conversion. Digital Equipment Corp., 146 Main St., Maynard, Mass. A 74-page analog-to-digital conversion handbook covers all phases of conversion from concepts to calibration. **[461]**

Field-effect transistors. Amelco Semiconductor, 1300 Terra Bella Ave., Mountain View, Calif., has available a technical bulletin entitled "A Pico-Ampere Electrometer Circuit Using Field Effect Transistors." **[462]**

Precision welding equipment. The Sippican Corp., Barnabas Road, Marion, Mass. 02738, has published an illustrated catalog describing power supplies and weld heads for miniature electronics fabrication. **[463]**

Equivalency charts. Microtran Co., Inc., 145 E. Mineola Ave., Valley Stream, N.Y. A plastic pocket protector which contains decimal-to-fraction, Fahrenheit-to-Centigrade equivalency and dbm-to-power conversion charts imprinted on the back, is available by writing on company letterhead.

Sweep/signal generators. Telonic Industries, Inc., 60 N. First Ave., Beech Grove, Ind. A catalog provides descriptions and specifications of sweep signal generators and accessory equipment covering audio to 3 Gc. **[464]**

Relay testing console. Babcock Relays, Div. of Babcock Electronics Corp., 3501 Harbor Blvd., Costa Mesa, Calif. A brochure introduces the new 36-channel dry-circuit relay tester. **[465]**

Adaptive data communication modems. Collins Radio Co., 19700 San Joaquin Road, Newport Beach, Calif. 92663, has issued a series of bulletins on a new line of adaptive data communication modems that offer data rates up to twice those previously available. **[466]**

D-c differential voltmeter. Keithley Instruments, Inc., 12415 Euclid Ave., Cleveland, Ohio 44106. An engineering note describes and illustrates model 662 d-c differential voltmeter that features a 0.1% limit of error with 0.005% stability. **[467]**

Code generator and comparator. Republic Aviation Corp., Farmingdale, L.I., N.Y., has published a bulletin on its quasi-random code generator and code comparator, a test set for checking the operation and accuracy of digital data transmission systems. **[468]**

Semiconductors. Amperex Electronic Corp., Hicksville, L.I. A 48-page catalog contains much new material of interest to engineers, in addition to all the basic specifications of the company's full line of transistors, diodes and photosensitive devices. **[469]**

New Books

Semiconductor structure

Imperfections and Active Centres in Semiconductors. R.G. Rhodes, Pergamon Press, distributed by the Macmillan Co., New York, 1964, 373 pp., $12.50.

This is volume six in the generally excellent series of monographs on semiconductors edited by H. K. Henisch. The title of this newest volume is somewhat misleading since it is much more restrictive in its subject matter than is implied by the title. The book is concerned entirely with germanium and silicon, and as there is no discussion of compound semiconductors, all the work that has been done on point defects arising from chemical substitution and non-stoichiometry in compounds is omitted. This includes a wealth of interesting work falling within the scope of imperfections and active centers in semiconductors. Furthermore, in the treatment of germanium and silicon a very heavy emphasis has been placed on certain subjects at the expense of other topics that might well have been discussed more extensively.

Approximately one-third of the book is devoted to an excellent discussion of dislocations, where the pertinence to semiconductors is primarily in the usual metallurgical sense rather than in relation to the electrical properties. There are also extensive sections on radiation effects in germanium and silicon, and on etch pits. A number of topics, such as diffusion, the interaction of imperfections, precipitation and thermal acceptors, are also treated, but by no means in the same amount of detail as the above three subjects, and some interesting work in these areas has been omitted.

Many readers will regard these omitted topics as being so important to a book proposing to cover the general subject of imperfections in semiconductors that they will be disappointed by the relatively brief treatment. Crystal growth is included, but the discussion deals entirely with conventional methods of growth from the melt and there is no mention whatsoever of such important modern methods as epitaxial growth. The electrical properties of crystalline imperfections are treated very briefly, and those of chemical impurities not at all.

The book is considered to be primarily of potential interest to semiconductor metallurgists. Chemists, physicists and device engineers, except insofar as they want to pursue the three topics dealt with in detail in this volume, will probably find little to interest them.

The level of sophistication of this book is moderate, and the average reader familiar with the properties of semiconductors will have little trouble handling the text. The layout is good, the figures are well executed, the type is easy to read and the book appears to have been proof-read quite carefully. A moderately extensive bibliography and an index are included at the end of the volume.

N.B. Hannay
Bell Telephone Laboratories, Inc.
Murray Hill, N.J.

Communications digest

Digest of technical papers; 1964 International Symposium on Global Communications. Lewis Winner, editor, New York, 1964, 104 pp., $5. Available from H.G. Sparks, Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia.

The symposium theme, intermarriage of computers and communications, is reflected in the variety of papers, from undersea broadband cable systems to very-low-frequency transmitter power requirements. Involvement of the computer is described in terms of computer interconnection and special device control of command-control communications networks. Satellite systems, industrial applications and economic factors are also covered.

Nicely balanced between the economics of printed conference proceedings and cheaply reduced copies of papers furnished by the authors (or their companies) is the preprinted digest. A further advantage of the well-prepared digest is its compact size and optimal content in an age of too many technical papers.

With wisdom, the sponsors of Globecom VI have shoe-horned the essential details of about 100 technical papers, talks and special reports into about as many pages of small but readable type together with necessary drawings.

Alexander A. McKenzie
Communications Editor

Systems analysis

Analysis of Linear Time-Invariant Systems. William M. Brown, McGraw-Hill Book Co., New York, 1964, 339 pp., $11.75

Written as a senior-graduate text, this book aims to "develop in considerable depth operational analysis and its applications to the study of linear time-invariant systems." Emphasis is on system evaluation and optimization, rather than on detailed design work.

The first part deals with sinusoidal steady-state operation and introduces two-sided Laplace transforms in considerable detail, including the fundamental theorems and an assortment of specific applications. The basis of operational analysis is developed in the next chapter.

Part two, on applications and extensions of the theory developed in the first part, deals with a variety of related topics such as system response time, bandpass systems, Z-transforms, power spectrums, optimum linear systems, and mathematical models of radar and communications systems developed with linear time-invariant operations.

The final chapter of the book is a presentation of Fourier transform mathematics, which provides the proofs for the necessary basic theorems.

In addition to its use as a textbook, the volume is a helpful introduction to operational analysis for the practicing systems engineer. A knowledge of calculus and basic differential equations are required of the reader. In addition to numerical examples, there are problems provided in each chapter, and mathematical reference data and bibliography at the end of the book.

George V. Novotny
Advanced Technology Editor

Technical Abstracts

Colored crystal memory

Feasibility experiments on an optical memory system.* A.N. Carson. Carson Laboratories, Bristol, Conn.

The use of colored crystals of alkali-halide compounds is suggested for information storage, using a property of these crystals that permits two stable states separated by the transfer of an electron. The transfer can be accomplished with optical excitation. The process is also known as thermally-assisted bleaching since the crystal, on absorbing an optical quantum, then becomes transparent to its wavelength. Transition to the new state is made stable by a second beam of light. By using intersecting light beams, it is possible to achieve a high-density three-dimensional storage pattern within a single crystal. Readout is effected either by transparence or by spontaneous or stimulated fluorescent emission.

The storage capacity of the proposed memory is of the order of 16×10^{12} per cubic inch using binary digits, or considerably larger than the estimated storage capacity of the human brain. A difficulty lies in the fact that to date such memories would have to be run at cryogenic temperatures to preserve the stored information.

Suggested applications, besides straight memory use, include switching, logical operations and matched filter-maze learning. Experimental results are also given.

Tactual perception

A computer-aided instrumentation system for studies in tactual perception.* James C. Bliss and Hewitt D. Crane. Stanford Research Institute, Menlo Park, Calif.

The authors describe their initial efforts at developing a tactual language and displays for vehicle control. Using this concept, they suggest that data such as position coordinates, pressures, temperatures and fuel consumption, as well as direct language, could be transmitted to an operator by airjet stimulation of the surface of his fingers. Another possibility being evaluated is the use of a computer as a library source of material for the blind.

Although research in hearing an vision has a long history, the sens of touch seems to be relatively nc glected. One reason has been th lack of a stimulator that is simpl and effective enough so that larg arrays of them could be assemble and easily controlled. Now a simpl airjet stimulator has been deve oped for use with a small digit computer that can automaticall program a large array of stimul tors.

An electromagnetic valve, sui able for construction in a relativel large array, was developed for ta tile stimulation. When the coil energized, it pulls on an iron slu opening an air valve. Because the low inertia and short strok of the slug, these valves can ope ate at up to 200 cycles per secon A 12-by-8 array of these electr magnetic airjet stimulators h been built inside a pressurized bo with the 96 stimulators occupyir an area of 6⅞ by 4⅜ inches. Sma tubing brings the airjets to a t plate, where a variety of interj spacings can be obtained. T height of the tubes above the pla can be adjusted to accommoda different body curvatures. A 160- computer, made by the Contr Data Corp., is used in real time store stimulus patterns, scan the according to various tempor modes, output the scanned pa terns, record and tabulate the su ject's responses, and analyze t data.

To minimize the learning tin for a tactual alphabet, the prese plan is to use letter forms as simil to the visual forms as possible. T first subject was trained throu a complete alphabet on which scored almost perfectly with lette presented for about 50 millisecon each. The entire learning a letter-design process took about hours of computer time. If t many stimulators are on at on confusion results; therefore t letters used are in a rather a stracted, open form.

Future steps will include stud ing alternate letter design, wo and sentence presentation and i munity to tactual noise.

In a concurrent study, a moving sign-board of display is being used, with common letter forms faithfully presented, to help evaluate the usefulness of a tactual system for the blind. After four hours of training, a blind seventh-grade student was making almost perfect scores at about 15 words a minute.

To test the notion that apparent position and apparent motion effects might be combined to give an apparent motion line moving within, rather than on, the body surface, apparent motion stimuli were simultaneously presented to two sides of a hand or finger. The effect was indeed an enhanced perception of a broadened line traveling through the center of the finger. Such a technique may well strengthen and enlarge the scope of tactual perceptions.

*Presented at the National Aerospace Electronics Conference, May 11-13, Dayton, Ohio.

Solid-state modulator

A novel solid-state modulator for millimeter waves. A. Saeki, Y. Horiguchi and H. Tsuru, Nippon Electric Co., Kawasaki, Japan

A new modulation technique combines a crystal-diode modulator with a ferrite gyrator so that the diode's impedance variation, caused by the modulating signal, controls the operation of the gyrator.

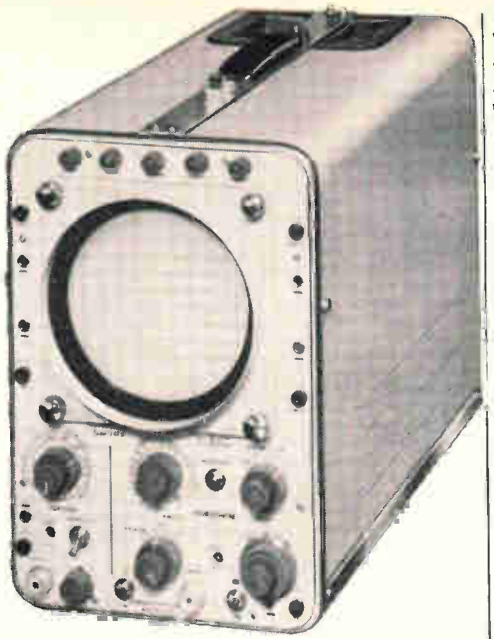
This modulator operates at higher speed than a ferrite modulator, and has a higher switching ratio than the crystal-diode modulator of the conventional transmission type.

The rise and decay times of the modulator are less than two nanoseconds. The switching time is limited by the pulse response of the diode. The crystal is n-type germanium and the ferrite is manganese-magnesium with a saturation magnetization of 2,000 gauss, a line width of 300 oersteds, a dielectric constant of 14, and a loss tangent of 2×10^{-3} at 9 Gc.

This device has obvious applications for pulse modulators in millimeter-wave communications and for tr switches in millimeter radar systems.

Presented at the International Symposium of the Professional Technical Group on Microwave Theory and Technique, May 19-21, Kennedy International Airport, N.Y.

NEW ! HIGH SENSITIVITY



GENERAL PURPOSE

247A

The type 247-A oscilloscope fully qualifies as a universal instrument because its performances and the size (13 cm (5") dia.) of its C.R. Tube authorize accurate measurements and tests in all fields of low-frequency instrumentation. Also, because of its simplicity of operation, the 247-A is ideally suited for practical laboratory work of an educational nature.

TECHNICAL SPECIFICATIONS

Vertical amplifier

1 channel; Frequency range: DC to 1 Mc/s (–3 dB)
Sensitivity: 50 mV/cm

AC: 10 c/s sinewave or 50 c/s square-wave to 100 Kc/s (–3 dB)
Sensitivity: 5 mV/cm

Calibrated attenuator: step-adjustable from 5 mV to 20 V/cm in 12 positions
Sequence: 1 – 2 – 5 – 10 etc...

Attenuator vernier ratio 1/3
Constant input impedance: 1 M Ω 47 pF

Sweep

Free-running – triggered - single sweep
Duration: 1 s/cm to 0.5 μs/cm in 20 calibrated positions
Vernier: 1:3 ratio -
x 5 magnification expanding
sweep durations from 3 s/cm to 0.1 μs/cm

Sync

5 positions: single-sweep, HF, LF, TV-line, TV-frame
Polarity: + or – internal or external
selection of triggering level

Horizontal Amplifier

Frequency range: 0 to 500 Kc/s (–3 dB)
Sensitivity: 1 V/cm or 10 V/cm (switch-selected)
Vernier: 0 to 1
Constant input impedance: 1 M Ω and 47 pF

Cathode-ray Tube

5 ADP 2 or equivalent type
Screen: 13 cm (5") dia.
Deflection factors:
X: 30 V/cm (approx.)
Y: 20 V/cm (approx.)

Direct drive of H and V plates
Acceleration voltage: 3 Kv

MECHANICAL FEATURES

Light alloy chassis, readily-detachable panel for easy access to circuits.

1) **Tube complement**
9/ECF80 – 2 NM2L or equivalent types

2) **Power supply**
105 115 - 127 - 220 - 240 V – 50 or 60 c/s

3) **Dimensions**
Width: 20.5 cm – (8")
Depth: 38.5 cm – (15")
Height: 31 cm – (12")
Weight: 14 kg – (30 lbs)

OTHER INSTRUMENTS

Oscilloscopes

204 A – High speed and fast rise oscilloscope
241 A – 242 A – 243 A, Multi-function osc. with plug-in préamplifiers.
255 B – Portable oscilloscope
245 A – High performance portable oscilloscope
246 A – High sensitivity low-frequency oscilloscope
248 A – Maintenance oscilloscope.

Sweep frequency Generators

411 A – Laboratory sweep frequency generator
410 B – TV - FM sweep frequency generator
476 A – Radio sweep frequency generator

Signal Generators

405 A – Low frequency RC signal gen. (30 c/s–300 Kc/s)
428 A – HF constant amplitude signal generator (100 Kc/s–30Mc/s)
458 – Pulse generator (5 c/s - 50 Kc/s).

TV pattern generators

465 C – Portable electronic pattern generator
464 A – Test – pattern generator

Regulated power supplies

117 A – Transistorised regulated power supply
114 A – Regulated power supply

Cameras

1000 A – oscilloscope camera with Polaroid
1001 B – oscilloscope recorder

INTER-PLANS

RIBET-DESJARDINS

MEASURE & CONTROL DEPARTMENT, 13-17, rue Périer MONTROUGE/PARIS TEL : ALESIA 24-40
CANADIAN BRANCH : RIBET-DESJARDINS (CANADA) Room 114, 5757 Decelles Avenue - MONTREAL

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Professional, high quality instrument . . . specifically designed for electronic engineers and technicians . . . made to our rigid specs by Pickett & Eckel. Has special scales for solving reactance and resonance frequency problems. Accurately and quickly locates decimal points. Carries widely used formulas and conversion factors not found on any other slide rule. Comes complete with top-grain leather carrying case, illustrated instruction manual, 90 day consultation service — all for just $14.95. Carries lifetime **guarantee against defects in material and workmanship.**

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June 29, 1964

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7	36	65	94	123	152	181	210	239	268	297	326	355	384	413	442	471	500	959
8	37	66	95	124	153	182	211	240	269	298	327	356	385	414	443	472	501	960
9	38	67	96	125	154	183	212	241	270	299	328	357	386	415	444	473	502	961
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11	40	69	98	127	156	185	214	243	272	301	330	359	388	417	446	475	504	963
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15	44	73	102	131	160	189	218	247	276	305	334	363	392	421	450	479	508	967
16	45	74	103	132	161	190	219	248	277	306	335	364	393	422	451	480	509	968
17	46	75	104	133	162	191	220	249	278	307	336	365	394	423	452	481	510	969
18	47	76	105	134	163	192	221	250	279	308	337	366	395	424	453	482	511	970
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