June 1, 1962

electronics

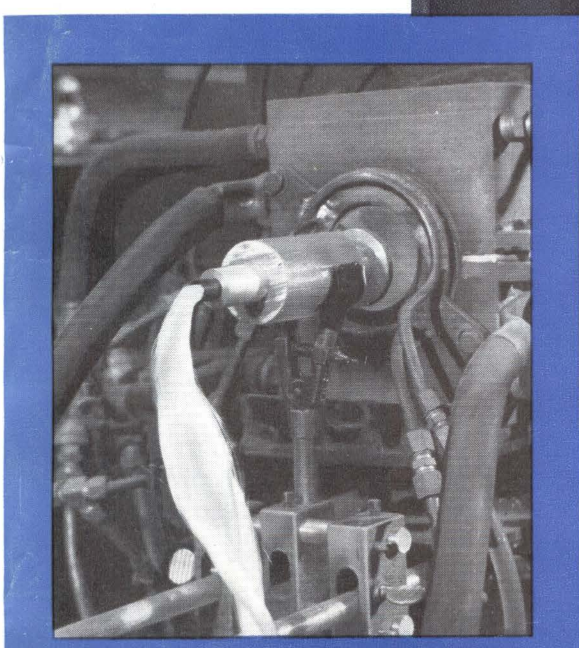
A McGraw-Hill Publication 75 Cents

FIBER OPTICS

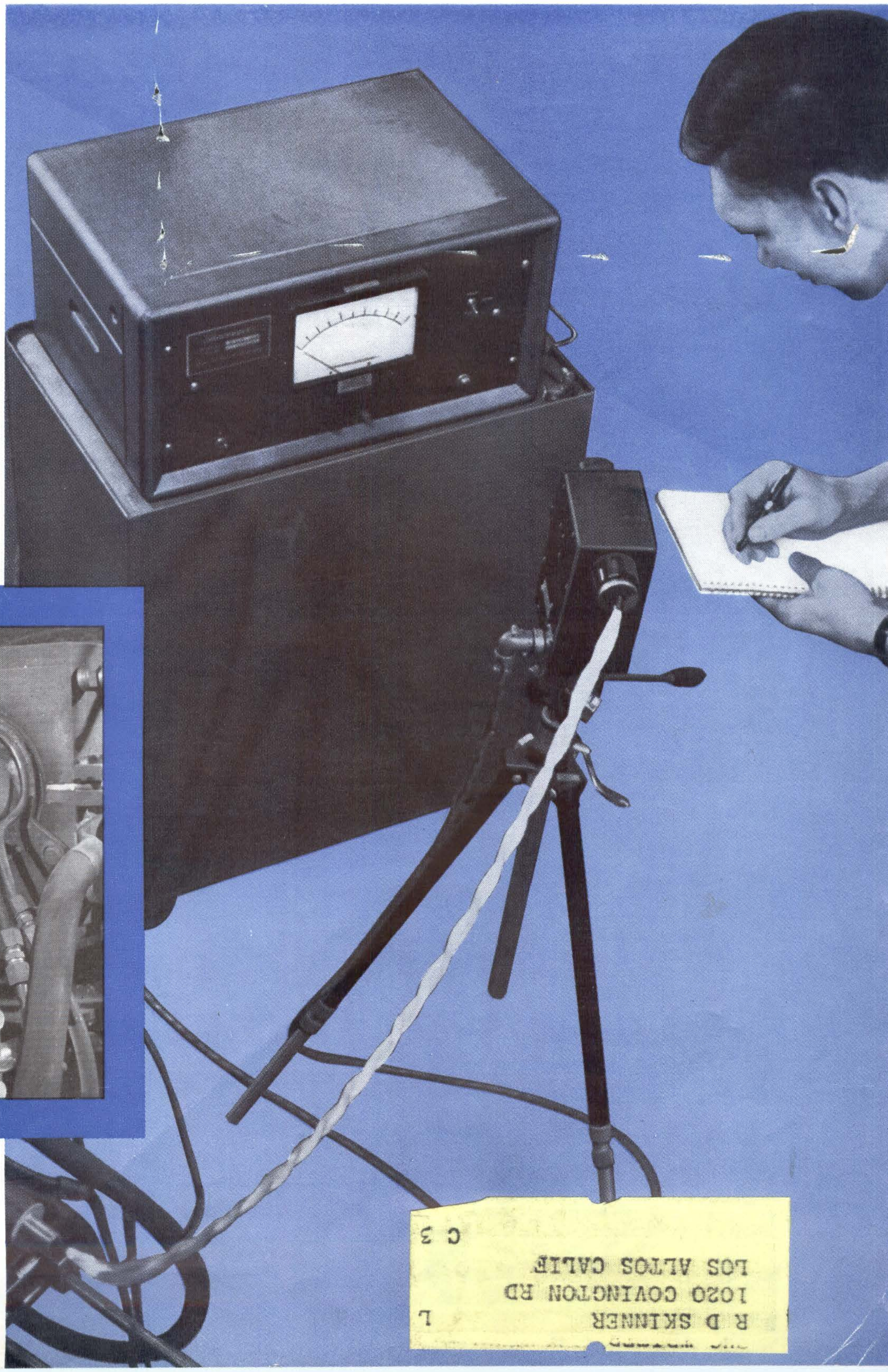
Versatile tool with electronic applications, p 37

Also in this issue:

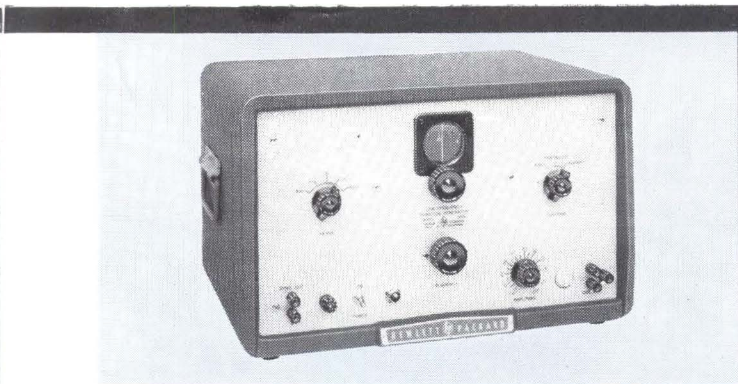
- *Extending Tunnel Diode Frequency, p 43*
- *Magnetometer for Space Applications, p 48*



Pyrometer using fiber optics for remote reading

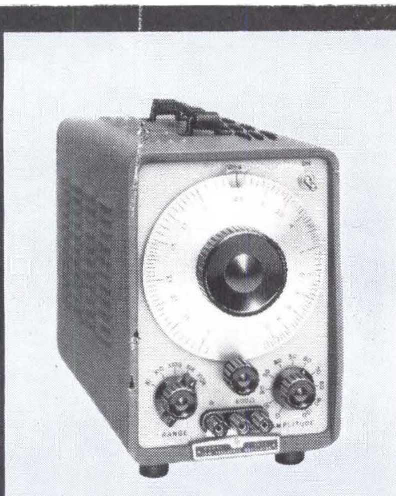


you need from hp



hp 202A Function Generator, 0.008 to 1,200 cps.

Source of transient-free sine, square and triangular waves, frequency continuously variable through 5 bands for electrically simulating mechanical, physical, medical phenomena. Stability within 1%, distortion less than 1% up to 100 cps. Sine, square or triangular waves selectable by front panel switch. Output 28 mw or 30 v p-p/4,000 ohms. hp 202A (cabinet), $550.00; hp 202AR (rack mount), $535.00.

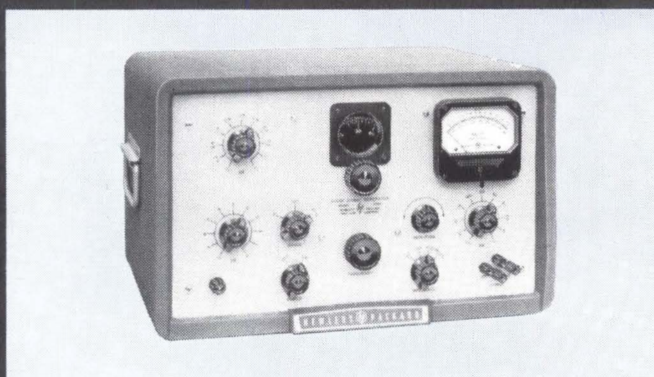


hp 202C Low Frequency Oscillator, 1 cps to 100 KC.

Especially convenient for measurements in the subsonic, audio and ultrasonic regions such as vibration, electro-cardiograph, electro-encephalograph. Distortion less than 0.5%, hum voltage less than 0.1%, short recovery time. Output 10 v/600 ohms. hp 202C (cabinet), $300.00; hp 202CR (rack mount), $305.00.

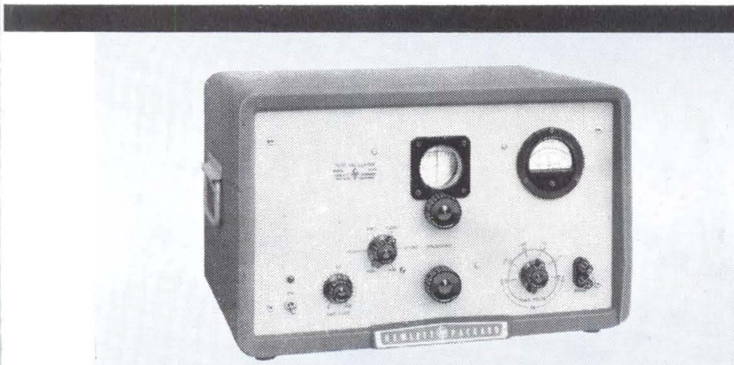
hp 205AG Audio Signal Generator, 20 cps to 20 KC.

Six basic instruments combined in one for high power audio tests, gain measurements. Two voltmeters measure input and output of the device under test. Output 5 watts, adjustable. Output impedance selected by front panel switch. hp 205AG (cabinet), $600.00; hp 205AGR (rack mount), $585.00.



hp 206A Low Distortion Audio Signal Generator, 20 cps to 20 KC.

Distortion less than 0.1% makes the hp 206A ideal for use in testing of FM broadcasting units and high fidelity audio systems. Metered output, variable in 0.1 db steps, +15 dbm into 50, 150, 600 ohms. hp 206A (cabinet) $900.00; hp 206AR (rack mount), $885.00.



hp 650A Test Oscillator, 10 cps to 10 MC.

Metered output flat within 1 db full range. Voltage range is 0.00003 to 3 v. 600 ohm impedance, voltage divider furnished for 6 ohm impedance. Distortion less than 1% to 100 KC. hp 650A (cabinet), $550.00; hp 650AR (rack mount), $535.00.

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Hewlett-Packard pioneered and developed the resistance-capacity oscillator, available today in these versatile instruments.

A feature of the R-C oscillator circuit is its automatically varied negative feedback which provides low distortion, excellent frequency response and amplitude stability. R-C oscillators are extremely simple to operate and, because of their high stability and wide frequency range, require no tedious resetting or adjustment during operation. They are lightweight, portable, compact in size. Dependable operation is assured by clean, simple circuitry and painstaking construction from quality components.

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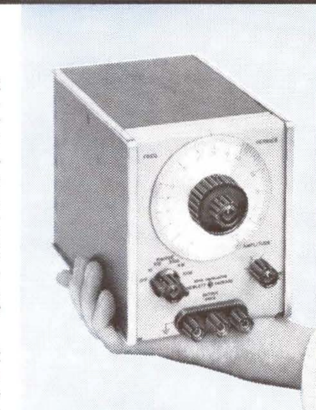
hp 204B Portable Oscillator, 5 cps to 500 KC.



Use it on the bench, carry it anywhere. This solid state portable oscillator offers battery or optional ac operation, is small and lightweight, gives you highly stable signals from 5 cps to 500 KC. Internal heat is small, warmup drift is negligible. Output is fully floating, isolated from both power line ground and chassis. The 204B will drive balanced and unbalanced loads and loads referenced either above or below ground.

hp 204B maintains excellent frequency stability even with rapidly changing loads. Frequency stability over the entire 5 cps to 500 KC range is better than $\pm 0.03\%/°C$ from 0° to 55°C. Output is flat within $\pm 3\%$ at all settings of dial and range switch. Distortion less than 1%, hum and noise less than 0.05%. Output 10 mw (2.5 v rms) into 600 ohms; 5 v rms open circuit. hp 204B, with batteries, $275.00. AC operation optional, $25.00 extra.

hp 200AB Audio Oscillator, 20 cps to 40 KC.

Ideal for amplifier testing, modulating signal generators, testing transmitter modulator response. Covers its range in four overlapping bands. Simple operation, just three controls. No zero setting required. High stability, with accurate tuning circuits. Output 1 watt (24.5 v) into a 600 ohm load. hp 200AB (cabinet), $165.00; hp 200ABR (rack mount) $170.00.

hp 200CD Wide Range Oscillator, 5 cps to 600 KC.

Subsonic to radio frequencies covered in five overlapping decade bands. Used for testing servo and vibration systems, medical and geophysical equipment, audio amplifiers, video frequency circuits, etc. 85 dial divisions for reading convenience. Distortion rating less than 0.5% below 500 KC. Output 160 mw (10 v/600 ohms); 20 v open circuit. hp 200CD (cabinet), $195.00; hp 200CDR (rack mount), $200.00.

hp 201C Audio Oscillator, 20 cps to 20 KC.

Especially designed for testing amplifiers, speakers, cross-over networks, this high power oscillator offers an output of 3 watts or 42.5 v into 600 ohms over its full frequency range. Response is 1 db full range. Attenuator adjusts output 0 to 40 db in 10 db steps, provides either low impedance or constant 600 ohm impedance. hp 201C (cabinet), $250.00; hp 201CR (rack mount), $255.00.

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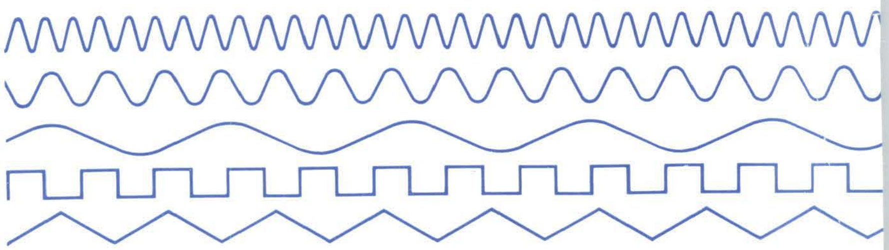

0.008 cps to 10 MC!

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Turn the page

June 1, 1962

electronics

A McGraw-Hill Publication *75 Cents*

W. W. MacDONALD, Editor

FLEXIBLE GLASS bundle transmits thermal radiation to automatic two-color pyrometer. The system, built by Armour Research Foundation for measuring temperatures of rocket nose cones during reentry, *will use fiber optic bundles to monitor outer skin of missile, send signals on uneven heating to correct reentry attitude. See p 37* COVER

NAECON Shows Gains in Molecular Circuits. Computers are now being built with integrated circuits. The list of circuits made as one unit continues to grow. *IRE president predicts a billion-dollar molecular circuits market in the 1970's* 18

MILLIMETER-WAVE DEVICES. Reports at National Aerospace Electronics Conference indicate that millimeter-wave devices have not only passed the feasibility stage but that they are getting ahead of applications. *Among the laser papers: setup to modulate and demodulate laser beam* 19

NAVY'S RDT&E BUDGET FOR 1963 Totals $1,474 Billion. To meet the threat of enemy submarines carrying long-range missiles, Navy is stepping up antisubmarine warfare R&D. *Here is a fact-packed summary of projects that will generate military electronics developments during the next few years* 26

GERMAN ELECTRONICS Industry Spotty. Though the experts said it would be a major growth industry, output is dropping. One reason is growing competition from U. S. and British imports. *German manufacturers hope industrial electronics will perk up sales* 28

THERMOPLASTIC RECORDING Tapes Radar Data. Direct recording from video signals promises high-density, high-resolution technique. *Analog and wideband recording methods are being worked on* 30

FIBER OPTICS for Electronic Engineers. The wedding of electronic and optical techniques has produced many important and versatile system developments. Fiber optics now promises to widen the scope of electro-optical applications. *This new technique is attractive in data processing, display devices, image handling, and lasers.* By G. V. Novotny 37

EXTENDING TUNNEL DIODE OPERATING FREQUENCY. By proper matching of the microwave impedance of the external circuit to the negative impedance of an S-band tunnel diode, successful operation was achieved at X-band. *The method can extend use of commercially available diodes into the millimeter wave region.* By K. Ishii and C. C. Hoffins, Marquette University 43

VOLTAGE-VARIABLE BANDWIDTH FILTER. Two-tube circuit has voltage-controlled, continuously-variable bandwidth between 200 Kc and 15 Mc centered at 30 Mc, introduces near-zero insertion loss. *Device extends range of a military radar system by varying the bandwidth as a function of signal strength.*
By R. B. Hirsch, RHG Electronics Laboratory 46

Contents continued

electronics

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CONTENTS continued

TRANSISTOR Q-MULTIPLIER and Oscillator. Simple circuit uses only one inductor to achieve high Q multiplication. It is relatively independent of transistor parameters, thus stability depends only on tank circuit elements. *High-Q filters can be designed with ordinary coils.* By J. R. Woodbury, Stanford Research Institute 53

FLUX-GATE MAGNETOMETER Uses Toroidal Core. For space experiments a magnetometer must be highly sensitive, small and light, consume little power. This new circuit uses an ordinary toroidal core with switching transistors to meet this requirement. *Device overcomes undesirable "memory effects" of conventional circuits.* By W. A. Geyger, Naval Ordnance Laboratory 48

DEPARTMENTS

Crosstalk. *Spreading Confusion* 3

Comment. *All-Channel Tv Receiver. The Earadio* 4

Electronics Newsletter. *EIA Convention* 7

Washington Outlook. *Tariff Bill Gets Escape Clause. Renegotiation Act Staying Put* 12

Meetings Ahead. *Space Phenomena and Measurements Symposium* 32

Research and Development. *Optics Generates Multidimensional Functions* 60

Components and Materials. *Avalanche Breakdown of Silicon Rectifiers. Extending Range of Controlled Rectifiers* 68

Production Techniques. *Welding School Improves Circuit Reliability* 78

New Products Design and Application. *Clock-Compensated Oscillator* 88

Literature of the Week 104

Books. *Electromagnetics. Radio Electronics Transmission Fundamentals* 106

People and Plants. *Space-General Consolidates in El Monte* 108

Index to Advertisers 119

Publisher's Page. *The Dangerous Years* 122

CROSSTALK

SPREADING CONFUSION. Part of the basic training of every engineer of any caliber is blowing fuses. He should be proficient in fuse-blowing by the time he is 14 or 15.

Next in his training, the young engineer is confronted with the ridiculous contradictions of transmission lines. They permit themselves to be joined with large chunks of metal, under the guise of supporting brackets maybe, but definitely without any undue protest or blown fuses. It is a grave source of doubt to the young engineer and he can't always be mollified by explanations about nodes and antinodes and analogies with vibrating strings.

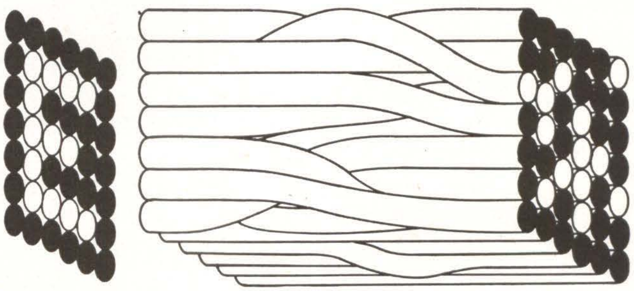
Later, the would-be engineer comes across waveguidery. This sorts the men from the boys. He emerges from this contact determined to be a dentist, or he will plod on, come what may, to the bitter end.

And now, the witchcraft is compounded. Not only can you pump electricity down pipes, but visible light, that former touchstone of scientific incorruptibility, has fallen too. No longer is the shortest distance between points A and B the path that a beam of light would travel between them: the weakening of fundamental principles has spread. Now light will go around corners, travel in circles and perform just about any convolution that fiber optics demands of it. This upsetting of optical first principles would have Issac Newton working nights rewriting *Optiks*.

George Novotny, an ELECTRONICS' editor with a taste for the fallen-from-grace story, has penetrated the Frankensteinian laboratories and has come up with a six-page revelation. Among the other facts that he tells us in this issue about the degradation of visible light is that a tube of fiber optics can have individual fibers so small that waveguide-like transmission ensues instead of continual reflection from the fiber walls. This means that you could pull out the core of the individual fibers, leaving just about nothing, and the performance of the whole pipe is improved.

As if trying to grasp all the consequences of the wave-versus-corpuscular theories wasn't enough!

In fact, the unusual behavior of light in a pipe even puzzled the discoverer (in 1870), the British physicist, John Tyndall. Shining light into a tank of water, he saw the light carried by a thin stream issuing from a hole in the side of the tank. It was then thought that this was a way of making light travel in curves, instead of straight lines. Today we know better. While the pipe may be curved, the light—so far at least—still travels in straight lines, bouncing down the inside of the pipe.



Once understood, light pipes caught on. But it was a long time before the more complex possibilities of fiber optics took hold, although a patent for a "bundle of light pipes" was granted in 1930.

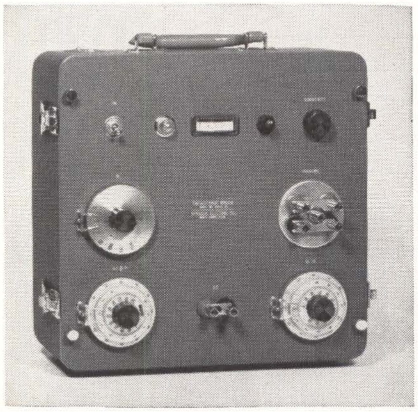
The illustration above is rated an early example of fiber optics trickery, dating all the way back to 1953. The principle of scrambling letters by mixing up the fiber bundle was used then in a secret message coder devised for the Dutch navy.

In the actual coder, thousands of fine fibers convert the message into a random scattering of dots. The scrambled message can be read by simply reversing the bundle, but a spy would need to know the alphabet and type used and perform a random analysis on a computer.

Today, our military plan to use fiber optics to couple the stages of night-warfare image intensifiers so sensitive that individual photons can be seen striking the screen. In medicine, thin fiber probes take color movies of patients' viscera. Video processing, data display, scanning, image concentration or expansion are among the many other important uses now emerging.

These applications depend upon using a bundle of many fibers to manipulate light. For the future, fiber optics experts see the field going far beyond flexible fiber bundles, opening possibilities for optical computers, fiber lasers and long-distance communications at optical frequencies using fibers as waveguides.

When that day comes, our young friend—the embryo engineer—will really have something to ponder over.



COMMENT

Lasers and Peace

In the *Comment* column of May 18 (p 4), Clarence Stephans of the Newark College of Engineering prefaced his advertisement for a series of engineering seminars with the remark that recent articles on lasers have played up their death-ray possibilities, and have neglected to mention the applications of lasers in manufacturing.

If Mr. Stephans is referring to the ELECTRONICS series on lasers [p 39, Oct. 27; p 40, Nov. 3; p 81, Nov. 10; p 54, Nov. 24], then he didn't read it as closely as I did. Checking it again just now, I find only two references to the laser as a death ray, both of them in the Nov. 10 issue, a total of four sentences, in the middle of two dozen pages on the use of lasers in land and space communication, medical applications, space exploration, computer memories, and basic optical research.

Mr. Stephens takes to task "recent articles in business periodicals" because they fail to mention laser "effectiveness to industry for metal removal." I believe that the only connection so far of the laser with metal removal has been to drill microscopic holes in razor blades, as a demonstration. What is so effective about a punctured razor blade?

R. L. SMITH
New York, New York

Our thanks to reader Smith for setting the record straight regarding military versus other uses of lasers. We've also reported that high-intensity optical beams have a future, too, in metalworking (p 21, March 2, and p 8, March 23, for example), for cutting, welding and other operations requiring clean, high-intensity heat. Those punctured razor blades merely indicate possibilities.

All-Channel TV Receiver

Regarding the Federal Communications Commission's all-channel television receiver legislation: it may not be too late to also consider some modern engineering refinements—at very long last—such as the following:

(1) Shielding against local r-f from other services than tv.

(2) High-pass filtering integral with vhf and uhf inputs.

These two items should do much to reduce the mental anguish caused by tv interference, and further educational tv—should they be applied to all receiving equipment offered to the public.

If placed on the drawing-board in time, these two very simple sound engineering practices could be applied for pennies.

DAVID H. ATKINS
Los Angeles, California

The Earadio

Your comment on the letter by R. A. Purifoy in the April 20 issue (*Comment,* p 4) told him that his idea for a locket-sized electronic music box is not yet possible, according to the present state of the art of miniaturization.

This is undoubtedly true; aside from the electronics involved, it would take a long piece of recording tape to play a musical number at a speed that would allow decent reproduction. And making the device cartridge-loading, as Mr. Purifoy suggests, would increase the size.

Why not take advantage of present hardware and techniques and make a radio receiver to fit in the ear? I recently saw an advertisement for a hearing aid that would fit in the ear, so why not a radio?

Despite your deploring the fact that many of today's young people keep an ear glued to a transistor radio, nothing will keep them from it, not even a law like the French regulation you mentioned, which forbids playing a radio in the street or subway.

The teenage market is a vast one, and an inexpensive "earadio" could be worth a fortune to the manufacturer who gets there first.

K. MORI
New York, New York

Earadio or electronic music-box locket, it still amounts to mass hypnotism, and puts the listener in such a trance that he is barely sure of where he is.

Life must surely be difficult for a teenager if he can't go for a walk without having to resort to an earfulsome radio to escape from it all, into the dream world of "oooh-baby, c'mon 'n twist!"

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Now it is possible to have the advantages of the most reliable stud-mounted diodes with the convenience and economy of press-fit assembly.

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RELIABILITY. Tung-Sol 30 amp press-fit silicon rectifiers are available as types 1N3659-1N3665, with ratings and characteristics as indicated below. The only press-fit diodes with welded cases and ceramic-to-metal seals to minimize leakage and resist thermal shock. Environmental testing through thousands of operational thermal cycles verifies stability of characteristics. Also available are lower current rectifiers in the same construction, types 1N3491-1N3495.

Electrically these units are the equivalent of the best available stud mounted diodes with comparable ratings. Write for complete technical information. Tung-Sol Electric Inc., Newark 4, N. J. TWK: NK193

	1N3659	1N3660	1N3661	1N3662	1N3663	1N3664	1N3665	Unit
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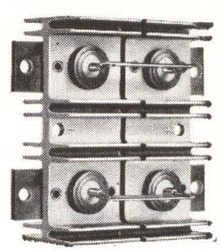
Repetitive Peak Reverse Voltage......	50	100	200	300	400	500	600	V
Max. Rectified Output Current @ 100°C. case.......	30	30	30	30	30	30	30	A
@ 150°C. case.......	25	25	25	25	25	25	25	A
Max. Peak one-cycle Surge Current 60 cps..	400	400	400	400	400	400	400	A
Max. Full Load Reverse Current, Full Cycle average, 150°C. case.	5.0	4.5	4.0	3.5	3.0	2.5	2.0	mA
Max. Operating Temperature Range.......	−65°C. to + 175°C.							

INTEGRATED CIRCUITS. Tung-Sol supplies modular rectifier assemblies which embody the many practical features of the press-fit diodes. Typical is the single phase bridge assembly shown; from a package measuring only 1 9/16" x 3 1/4" x 3 1/2", outputs to 55 amperes are possible.



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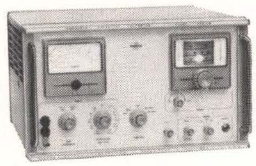

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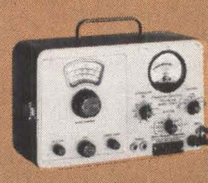

Solid State Model 127 A-Y
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Frequency range: 2 KC to 350 KC
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ELECTRONICS NEWSLETTER

At EIA: Failure and Truce for Semiconductors

CHICAGO—H. M. Evans, chairman of the Electronic Industries Association's credit committee, told EIA's 38th annual convention last week that failures in the industry have reached a 28-year high. In the year ending April 30, 56 manufacturers and 38 distributors closed shop.

Evans mostly blamed inadequate management. Most new components manufacturers, particularly in solid state, he said, were launched by engineers who may not have sufficient business and sales experience. Component firms led the list of failing manufacturers.

Industry sources at the meeting generally thought that the shakeout in solid state would continue apace and that failures would remain high in 1962.

However, while increasing use of distributors may cause local price cutting, the feeling was that transistor and diode prices have finally "bottomed out." One sales executive said the only radical price drops would be in new components such as integrated circuits.

George W. Keown, EIA tube and semiconductor division chairman, blamed 1961 sales decreases in those components on increasing cost-consciousness by government and industrial purchasers. In 1960-1961, transistor unit sales rose from 128 million to 191 million, but volume dropped from $301 million to $300 million.

West Sees Nine Percent Sales Gain During 1962

LOS ANGELES—Latest Western Electronic Manufacturers Association survey projects 1962 sales for the 11 western states at $3.3 billion, a gain of nine percent over 1961 and one-fourth estimated national sales.

Predictions for 1962 by area are: greater Los Angeles, $1.8 billion; northern California, $730 million; San Diego and Arizona, each $185 million; Pacific northwest, $175 million, and the rest of the west, $147 million.

Western electronics employment is expected to rise 17,000 to 230,000. William Miller, WEMA president, said this is a 40 percent increase in three years. The number of graduate engineers has risen from 17,500 in 1957 to 38,500 today. Southern California has 60 percent of total employes, 137,000.

Horne Succeeds Davis As President of EIA

CHICAGO—Charles F. Horne, president of General Dynamics' Pomona and Electronics division and a GD senior vice president, was elected to succeed L. Berkley Davis, of General Electric, as EIA president. A retired rear admiral, Horne served as a communications and electronics officer.

Parametric Oscillation at Optical Frequencies Seen

THEORETICAL calculations made by a group at MIT under C. F. Townes indicate that parametric oscillation at optical frequencies can be achieved.

Electromagnetic radiation at half-frequency will appear if a nonlinearly polarizable material is driven at an optical frequency. If gain is sufficient to sustain oscillation, the subharmonic component's power approaches that of the fundamental. If a high-power, far-infrared laser pumps the material, output in the near-infrared region is substantial.

Such a laser is now under construction, say MIT scientists, for further experiments in nonlinear effects at optical frequencies.

Two Bills Move Up

WASHINGTON—The Senate Commerce Committee last week approved two bills previously passed by the House of Representatives (p 12, May 11):

One is the all-channel tv receivers law which would require tv sets to receive 70 uhf as well as the vhf channels. The other is the act providing for establishment of a satellite communications system

Hydrofoil Subchaser Gets Special Computer, Radar

COMPUTING and attack-plotting system for the Navy's hydrofoil subchaser has been delivered by General Precision's Librascope division. The system will show the crew where the craft is, where the target is and at what point the craft should launch its torpedoes. It can also automatically track a target.

The subchaser, being built by Boeing, will go more than 40 knots when raised on its hydrofoils. Sonar bearings to a submarine will be taken when the craft is down in the water.

Raytheon last week announced it has received a contract to develop the subchaser's radar system. It will use a bright display and image storage to provide the history of a target track. A similar Raytheon scope presentation is being used by the Coast Guard in an experimental harbor navigation system (ELECTRONICS, p 76 and cover, May 18).

Highways in the Sky For Sound Waves, Too

ATMOSPHERIC physicist with the Army Missile Support Agency told the Acoustical Society of America meeting in New York last week that sonic waveguides exist at altitudes to 30 miles and between 30 and 80 miles.

Abnormally high temperatures tremendously increase speed and duration of sound in the ducts, according to Marvin Diamond. Sound travels swiftly eastward in winter, westward in summer, bends toward earth at different points, depending on the time of the year.

Diamond thinks it possible to establish recording stations to detect and analyze sound coming from great distances. The ducts were discovered by rocket probes. It was recently reported that r-f ducts also exist in the atmosphere (p 8, May 11).

Navy Sets Up Navigation Satellite Ground Units

NAVY has established a group to operate its navigation satellite system. The unit, to be headquartered at Point Mugu, Calif., will have a computer center, a satellite tracking station, and will maintain ground and satellite equipment. Tracking stations will also be located at Minneapolis, Winter Harbor, Me., and Wahiawa, Hawaii.

British Showing Their Microminiature Circuits

LONDON—Among the new and experimental products to be displayed this week at the International Instruments, Electronics and Automation Exhibition were:

Thin-film deposited circuits under development for the Ministry of Aviation; 15-stage shift register with 34 transistors, 90 diodes, 162 resistors and 64 capacitors, in a matchbox-size assembly, by Mullard; experimental solid circuits and integrated tunnel diode memory elements, by Standard Telephones and Cables; dice-sized, six-transistor recording modules for rockets, by McMichael Radio; 10-pound, battery-operated tv camera, by EMI Electronics.

Four-Sensor Detector Sorts Seven Weathers

RAIN, DRIZZLE, hail, sleet, snow, freezing rain or freezing drizzle are identified and measured with a four-sensor weather detector system developed by Thompson Ramo Wooldridge. The kind of precipitation is indicated by the output from all sensors and from temperature and other data.

In one sensor, light reflection from particles is focused on a photodiode, indicating reflectivity of particles and how often they are falling. In another sensor, the change in a tuning fork's frequency indicates ice accumulation.

An array of piezoelectric crystals in an impact sensor tells how big the particles are. The fourth sensor also uses crystals, arranged to detect how much a particle bounces.

Sporadic-E Experiment Goes Up on Schedule

LANGMUIR PROBE experiment to measure daytime sporadic-E (p 18, May 25) was launched as scheduled last Friday. The probe, designed by Geophysics Corporation of America, was among a payload of 213 pounds on an Aerobee rocket fired from NASA's Wallops Station, Va. Three Goddard Space Flight Center Experiments were also carried. The rocket went up 152 miles.

Hope to Get 10-Year Life in Space Radio

SYLVANIA has received a $380,000 Air Force contract to develop a feasibility model of a communications set for second-generation satellites and spacecraft. The company indicated it could build a system able to operate continuously for 10 or more years.

The model will contain a solid-state multichannel transmitter and receiver. Narrow-beam phased-array antennas will be used for communications signal acquisition and tracking, to prevent mechanical movements causing satellite tumbling and to guard against hostile interception of transmissions.

Lear Stockholders Vote For Merger with Siegler

LEAR, INC., shareholders last week approved the merger of Lear and the Siegler Corp. Siegler stockholders were to vote yesterday. Their merger would give the new company, Lear-Siegler, Inc., annual sales of more than $200 million. The company would be headquartered in Los Angeles. Plants are located in seven states, West Germany and Switzerland.

In Brief . . .

FEDERAL AVIATION AGENCY has begun awarding research contracts for a supersonic transport plane. Among $2.66 million in initial contracts announced last week was $111,250 to Cornell Aeronautical Lab to study feasibility of self-adaptive control systems.

ENGINEERS JOINT COUNCIL is issuing a report, "The Nation's Engineering Research Needs, 1965-1985," based on a two-year study.

CONTRACTORS for the Navy's radio station in Australia (p 7, May 25) will be Deco Electronics, Continental Electronics Mfg. Co. and Holmes and Narver.

GREECE is getting a 500-mile, 17-hop microwave radio net. It will be installed by Standard Telephones and Cables, London, for about $3 million.

TWO COMPANIES announced purchases of components firms. P. R. Mallory is buying Tyco Semiconductor Co. Sprague Electric has acquired Sky-Borne Electronics.

ADVANCED TECHNOLOGY LABS will design and produce infrared horizon scanners for Gemini, the two-man spacecraft.

LIMITED WAR electronic command and control system requirements will be studied by Martin under a $225,000 contract.

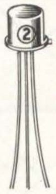
SYSTEMS CONTRACTS include one for a Titan II missile procedures trainer, to ACF, and one for $1 million of communications-identification-navigation systems for F-105 fighter-bombers, to Collins Radio.

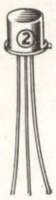
NASA has awarded Documentation Inc. a $1.2 million contract to provide a space and aeronautical sciences information center serving NASA and its contractors. The edp center will be in Bethesda, Md.

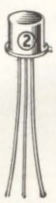
MARCONI, of England, will supply the Norwegian Air Force with a two microwave radar links for $1.4 million.

New From Sprague!

ECDC® Type XT-300 LOGIC TRANSISTOR







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CHARACTERISTICS	2N779A	2N964	XT-300
BV_{CES} @ $I_C = 100\ \mu A$	15 V min.	15 V min.	**25** V min.
BV_{CEO} @ $I_C = 1 mA$	**12** V min.	6 V min.	**12** V min.
I_{CBO} @ $V_{CB} = 6V$	**3** μA max.	**3** μA max.	**3** μA max.
h_{FE} @ $I_C = 50$ mA, $V_{CE} = 1V$	**40** min.	**40** min.	**40** min.
V_{CE} (SAT) @ $I_C = 50$ mA, $I_B = 5$ mA	**.18** V min.	.35 V min.	**.18** V min.
V_{BE} @ $I_C = 50$ mA, $I_B = 5$ mA	**.6** V max.	.75 V max.	**.6** V max.
f_T @ $I_C = 20$ mA, $V_{CE} = 1V$	200 mc min.	**300** mc min.	**300** mc min.
t (on) @ $I_C = 10$ mA, $R_L = 300$ ohms, $I_{B_1} = 1$ mA, V_{BE} (off) $= 1.25$ V	60 nsec max.	**50** nsec max.	**50** nsec max.
t (off) @ $I_C = 10$ mA, $R_L = 300$ ohms, $I_{B_1} = 1$ mA, $I_{B_2} = .25$ mA	120 nsec max.	**85** nsec max.	**85** nsec max.

For complete information, write Product Marketing Section, Transistor Division, Sprague Electric Company, Concord, New Hampshire.

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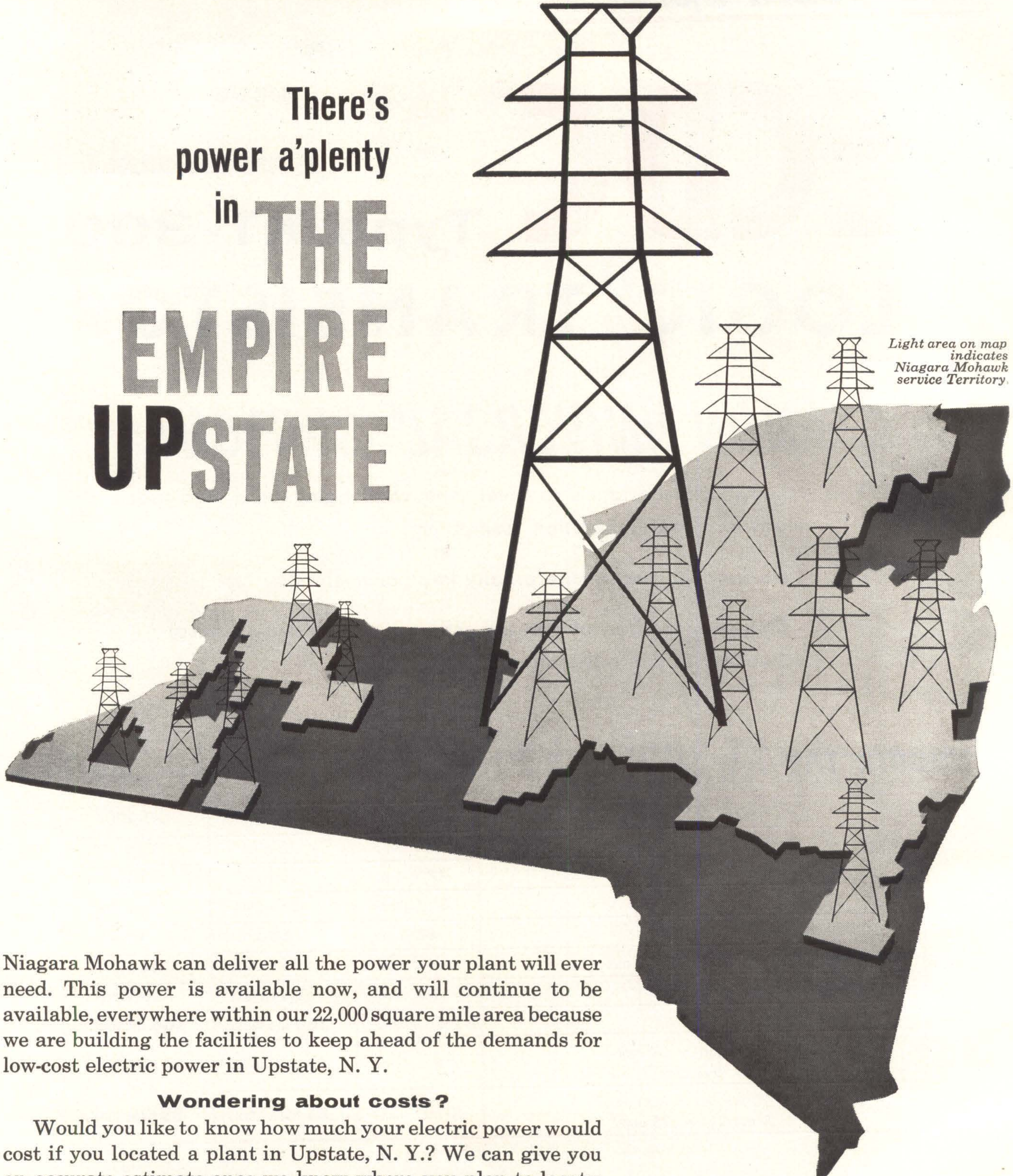

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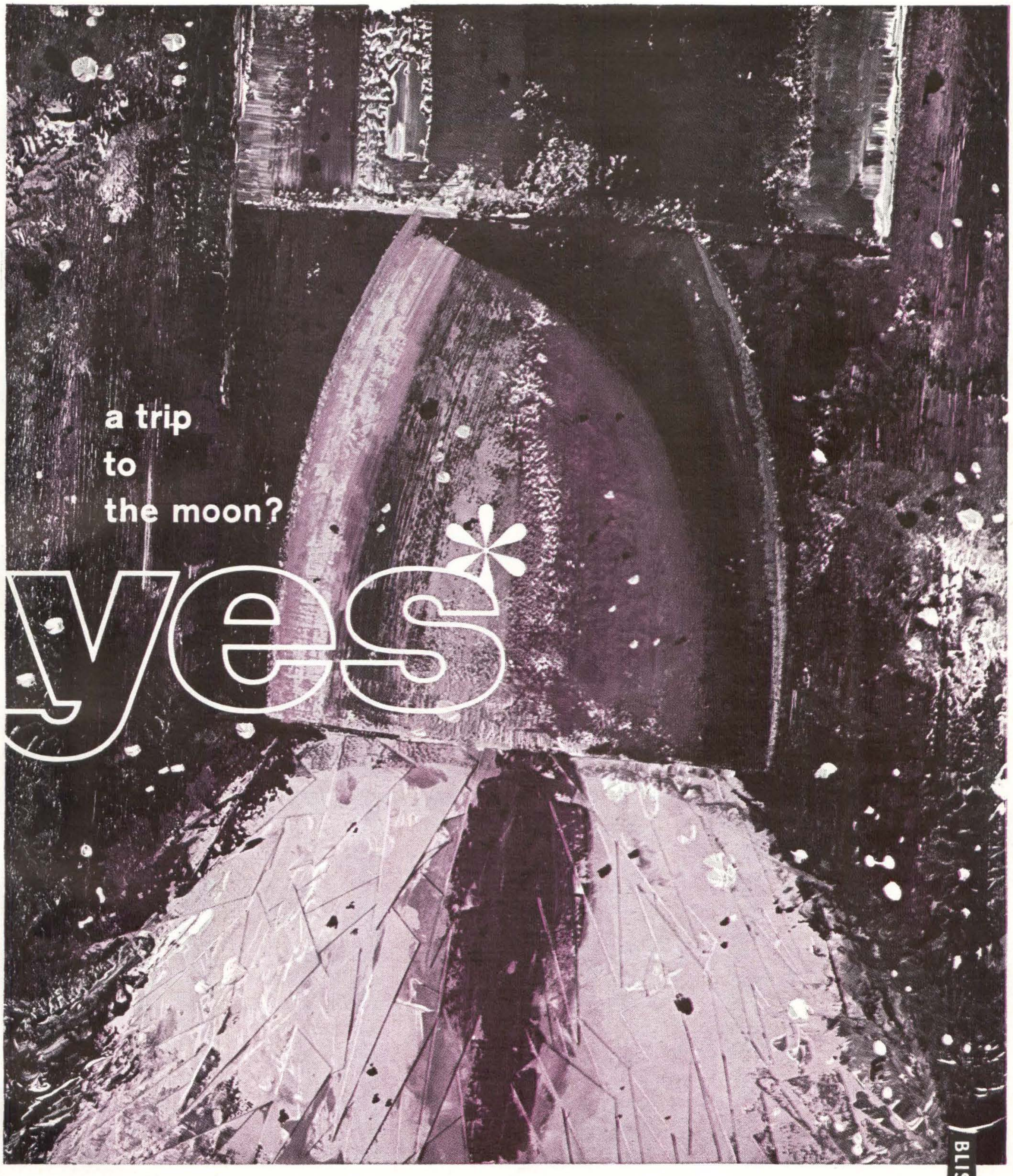
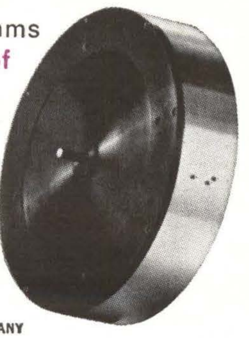


Gamewell made a Master Pot with these characteristics: resistance, 31,500 ohms (nominal); total angle, 359.5°; resolution, .000055 (or approximately 1 minute of arc); linearity, ±.01° zero based; cam corrected; O.D., 8″; thickness, 2″; shaft, 1/4″; alignment boss, 1″ x 1/16″; and an anodized aluminum finish. This extremely accurate precision potentiometer demonstrates our ability to manufacture pots to meet the most demanding specifications — such as might be necessary on a trip to the moon. Write and tell us about your *special* pot problems. Chances are they can be solved by Gamewell's YES service — ***Y**our **E**ngineered **S**pecials service.



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CIRCLE 11 ON READER SERVICE CARD

WASHINGTON OUTLOOK

TARIFF BILL GETS ESCAPE CLAUSE

HOUSE WAYS AND MEANS COMMITTEE put an escape clause into the trade expansion bill before passing it last week. The President would no longer be the sole judge of whether a company or an industry gets tariff protection. As the bill goes to the House floor, the President would receive a recommendation from the Tariff Commission. If he rejected the recommendation, Congress could override him by a two-thirds vote. Companies would have to show real damage from imports to an entire operation, not just one product.

The language giving the President power to negotiate tariff cuts of 50 to 100 percent for products on the "zero list" was left practically intact. However, the committee deleted reliance on standard international trade classifications to list these products (world trade controlled 80 percent by the U.S. and European Common Market) and there is no written-in method of determining them. Companies would have more time to find out what products may face 100 percent tariff cuts in deals with the EEC.

CENTAUR SNAGS ADVENT

DEPARTMENT OF DEFENSE is expected to decide within a few weeks whether to make changes in Project Advent, Army's communications satellite system. The Centaur liquid-hydrogen-fueled rocket that was supposed to put Advent into orbit next year is almost two years behind schedule. Advent's weight may be cut so it can be launched by an Atlas-Agena-B combination, able to loft 600 to 700 pounds into synchronous orbit. Advent's exact weight is classified, but it has pyramided to over 1,000 pounds. Pentagon technical personnel say advanced electronics could scale it down. Another alternative is to wait a couple of years for the Air Force's Titan III booster.

EXCESS PROFITS STAY PUT

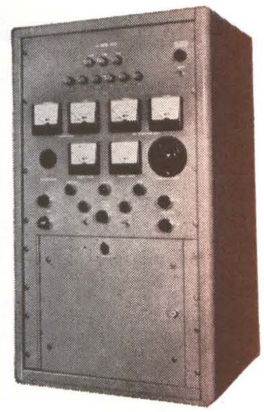
RENEGOTIATION ACT RENEWAL for four years is shaping up as a cut-and-dried matter. The House Ways and Means Committee has given industry five weeks to submit written comments on the administrations recommendation to extend the law. There are no plans now for hearings. The law, expiring June 30, provides for government recovery of "excessive profits" on defense contracts.

Industry has asked that incentive contract profits be exempted or granted special consideration. New Pentagon procurement policies will favor such contracts to boost contractor performance.

Some defense officials privately support an amendment on incentive profits, but the administration has officially rejected the idea, and it has little if any congressional support.

LIMIT RESEARCH REFUNDS

PRESIDENT KENNEDY asked House and Senate leaders to reverse a restriction on overhead or indirect costs reimbursable to universities under government research grants. A 15-percent restriction is in the House-passed Defense Appropriations Act and in pending appropriations for AEC, NASA and National Science Foundation. If the House won't go along Senate pressure for a more liberal policy is expected to peg the restriction at about 20 percent. Universities and administration science advisors say the restriction would force university subsidy of government basic research.



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Model Number	Peak Power Output	Pulse Width (μsec)	Maximum Duty Cycle	Pulse Freq. (pps)	Droop %/μsec	Rise Time (μsec)	Price
10003	−4.5KV at 2A	0.25 to 2.2	0.002	200–4000	1%	0.1	$2,450
10004	−4.5KV at 4A	0.25 to 5.0	0.001	100–2500	2%	0.1	$2,925
10005	−9KV at 4A	0.25 to 5.0	0.001	100–2500	1%	0.1	$3,850
10010	−16KV at 16A	0.25 to 5.0	0.001	100–2500	2%	0.1	$5,875
11020	−18KV at 20A	0.5, 1.0 & 2.0	0.001	200–2000	5%	0.1	$5,560
11040	−33KV at 33A	0.5, 1.0 & 2.0	0.001	200–2000	5%	0.1	$9,650

TWT SUPPLY

DC Output:	−2 to −12 KV DC at 75 ma.
Regulation:	0.5% max. for 95 to 135 V line variation, 0.5% max. from no load to full load.
Grid Pulse:	0 to 600 V peak, 0.25 to 2.5 microseconds pulse width, 0.1 microsecond max. rise time. Internal repetition rate generator variable from 400 to 4000 pps, or by external trigger input. Maximum duty cycle 0.005.
D.C. Bias:	0 to 250 V at 15 ma.
D.C. Filament:	0 to 10 V at 5 A.

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Silicon power transistors in a TO-37 package

Delco's unique new family of silicon NPN power transistors combines the benefits of miniaturization (TO-37) and light weight with the ability to withstand continuous junction temperatures of up to 175°C while operating at these absolute maximum ratings: collector diode voltage Vcb 100 volts; emitter diode voltage Vebo, 4 volts; collector current, 1 amp.; base current, .2 amp. This entire 2N2340 family is particularly useful where moderate power handling capabilities are required in a miniature package. The units have just two mounting holes and may be mounted with leads up, down or sideways on either side of the heat sink. Available in either single or matched units, they're characterized by low saturation voltage and high switching speeds. The transistors in this family are especially well suited for military or industrial applications in regulated power supplies, square wave oscillators, servo amplifiers and core driver circuitry. For complete engineering data, or applications assistance, write or call our nearest Sales Office or your nearest Delco Radio Semiconductor Distributor.

Number	IC Max.	Vcbo	Vceo	Sat. V @ IC Max.	Gain Min.—Max. @ IC	fae @ 250 ma IC (typical)
2N2340	1A	50V	40V	4V @ .75A	10— 40 @ .75A	900 kc
2N2341	1A	50V	40V	4V @ .75A	40—100 @ .75A	550 kc
2N2342	1A	100V	60V	3V @ .75A	10— 40 @ .75A	900 kc
2N2343	1A	100V	40V	2.5V @ .75A	40—100 @ .75A	550 kc

Thermal resistance of 8°C/watt max. Typical Alpha cutoff of 15 Mc

Rise Time of .2μ seconds—.75A, IB = 40 ma (Vce = 12V), Fall Time of .5μ seconds (IC = 0 Veb = 2v Reb = 37Ω)

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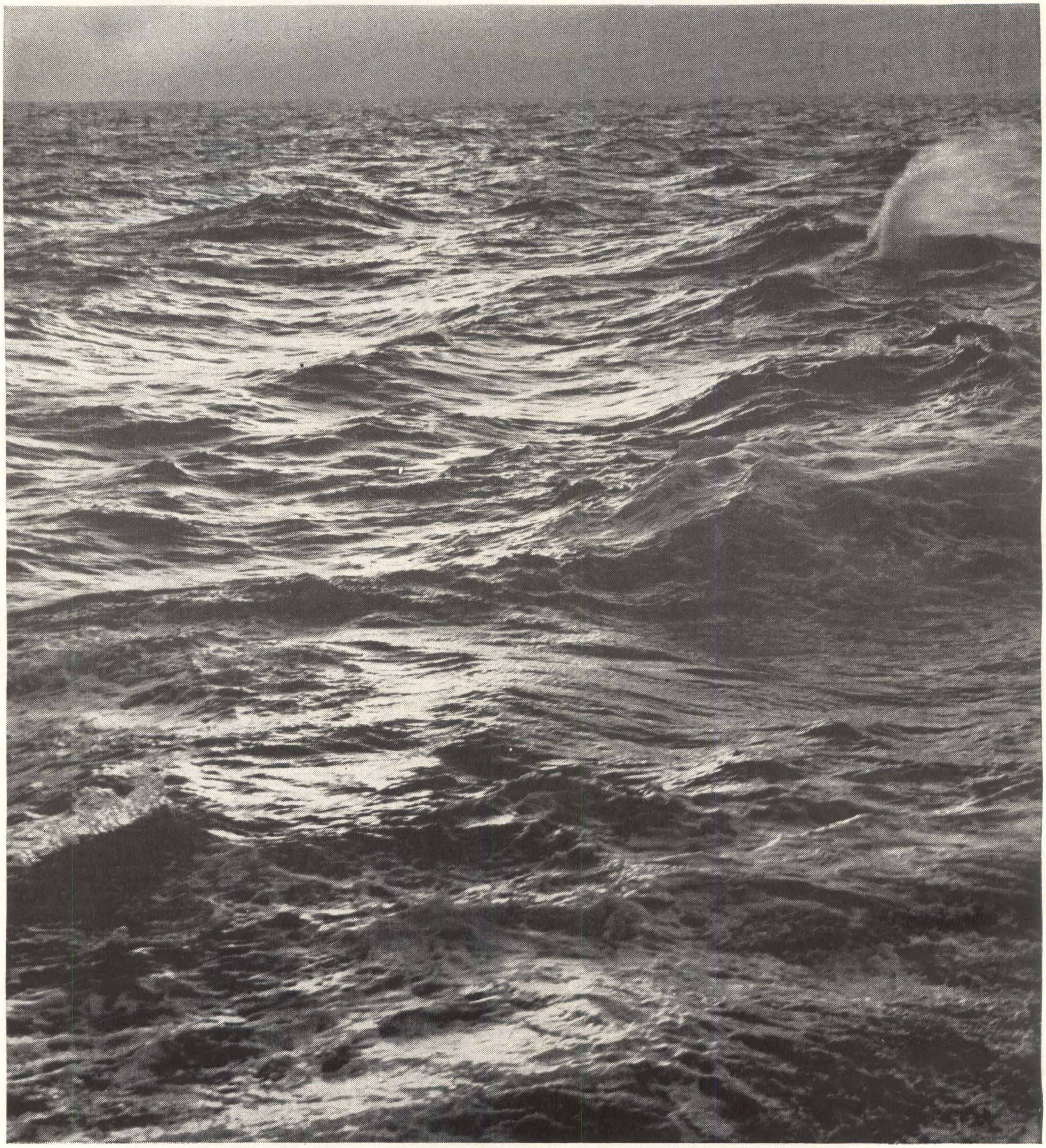

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You're looking at more than a horizon. It's a future, yours and America's. Out there is Europe and Latin America and Asia and Africa. But in 1960, of all U.S. manufacturers, less than 5% saw these foreign shores for what they are worth: a 19-billion-dollar export market, a vast source of foreign trade.

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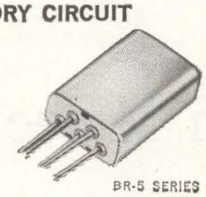
NEW BR-5 RELAY COMPLEMENTS OTHER BABCOCK SERIES

The new BR-5 is smallest of the precision relays that Babcock manufactures. Despite its small size, it features the same rugged dependability and operating versatility that distinguish all Babcock products.

Most airborne, undersea or ground support requirements can be satisfied by Babcock's standard line of relays, while other requirements are met by special variations. The following relay series show typical performance characteristics of Babcock's standard product line.

BR-5 MICRO/MICROMINIATURE DRY CIRCUIT TO 1 AMP SERIES

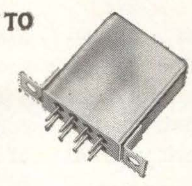
Contact Rating: 1 amp res. @ 32V DC, .050 Ω max. • **Contact Arrangement:** SPDT • **Vibration:** 30g, 40 to 3000 cps; 0.4″ DA, 10-40 cps • **Shock:** 125g, 11 millisec. • **Life:** 100,000 operations min. @ 1 amp, 125°C. • **Military Specification:** meets MIL-R-5757D.



BR-5 SERIES

BR-7 SUBMINIATURE DRY CIRCUIT TO POWER SWITCHING SERIES

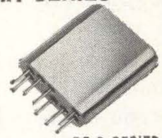
Contact Rating: 2, 5 and 10 amp res. @ 28V DC or 110V AC, 400 cps • **Contact Arrangement:** SPDT, DPDT • **Min. Pull-in Power:** 80 mw/pole, derated to 50 mw • **Header Styles:** plug-in terminals, solder hooks, 3″ printed circuit leads.



BR-7 SERIES

BR-8 MICROMINIATURE CRYSTAL CAN SERIES

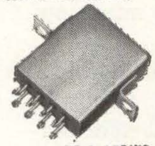
Contact Rating: 2 amp res. @ 32V DC or 115V AC, 400 cps; 1 amp inductive @ 32V DC • **Contact Arrangement:** SPDT or DPDT • **Dry Circuit:** 1μa @ 1 mv, 100 Ω max. contact resistance • **Size:** .360″ x .790″ x .870″ high (current sensitive, 1.190″ high).



BR-8 SERIES

BR-9 SUBMINIATURE MAGNETIC LATCHING SERIES

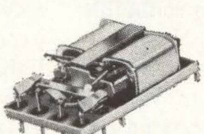
Contact Rating: 5 and 10 amp res. @ 28V DC or 110V AC, 400 cps • **Contact Arrangement:** DPDT • **Header Styles:** 10 pin or 8 pin polarized • **Holding Coils:** separate or series operation.



BR-9 SERIES

BR-12 MICROMINIATURE ULTRASENSITIVE SERIES

Relay Types: standard, high sensitivity, max. sensitivity and centepede "lie down" printed circuit versions • **Contact Rating:** 2 and 3 amp res. @ 32V DC or 115V AC, 400 cps; 1 amp inductive @ 32V DC (max. sensitivity unit 2 amp res. @ 28V DC) • **Contact Arrangement:** SPDT or DPDT • **Coil Power** (max. sensitivity unit): 25 mw SPDT, 40 mw DPDT.

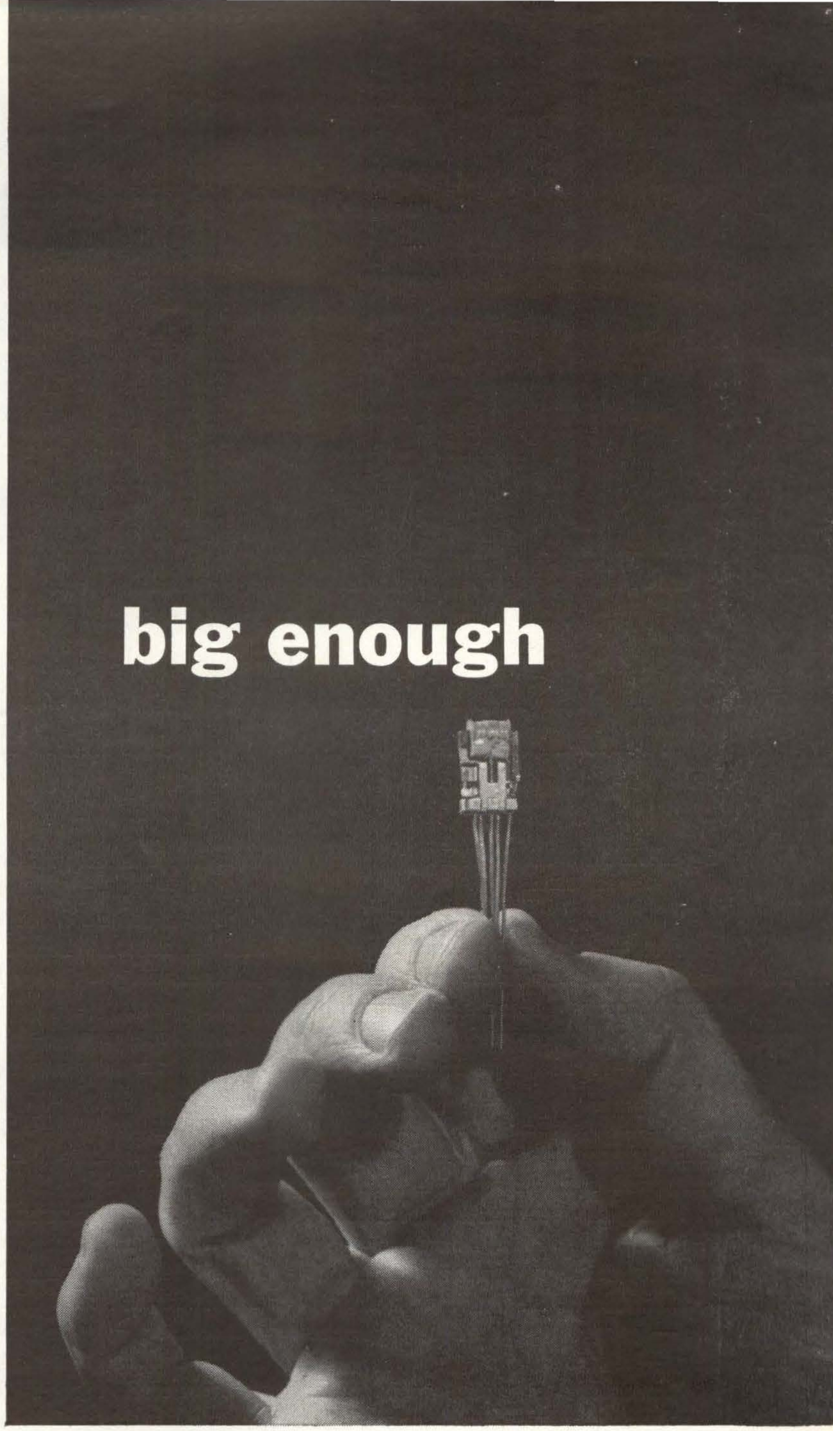


BR-12 SERIES
BR-12P SHOWN

BR-14 SUBMINIATURE FOUR POLE, DOUBLE THROW SERIES

Contact Rating: (@ 28V DC or 115V, 400 cps): 10 amp res., 3.5 amp inductive; 7.5 amp res., 2.5 amp inductive; 5 amp res., 2 amp inductive • **Contact Arrangement:** 4PDT (4 form C) • **Size:** 1.000″ x 1.075″ x 1.300″ • **Weight:** 3.0 oz. max.

BR-14 SERIES



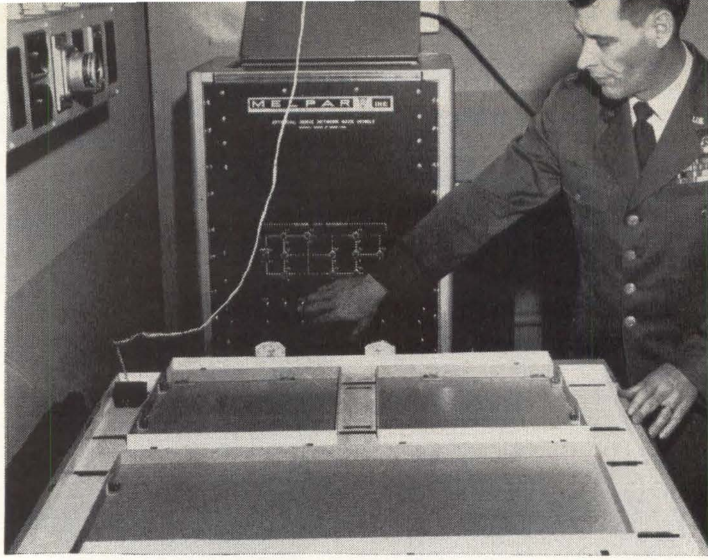
Dry circuit to 1 amp switching in a rugged 1/10th oz. hermetically sealed relay

Babcock's dependable new BR-5 SPDT relay easily handles any load to 1 full amp at 32V DC. The transistor can-sized package is only as large as it needs to be, measuring 0.2″ x 0.4″ x 0.6″. A special magnetic circuit is responsible for its high sensitivity, generally a limiting factor in relay miniaturization. Exceptionally rugged, the BR-5 is built to withstand 125g shock and 30g vibration at 3000 cps. Selective utilization of materials enables −65°C to +125°C operation, ideal for missile and space probe environments. Available in various mounting styles with printed circuit leads. Interested designers should contact their Babcock representative or write direct for Bulletin BR 617.

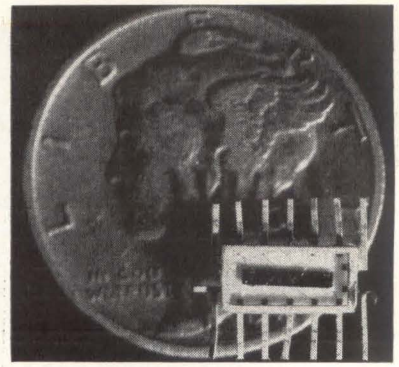
Babcock Relays

A Division of Babcock Electronics Corporation
1645 Babcock Avenue, Costa Mesa, Calif.

CIRCLE 17 ON READER SERVICE CARD



Air Force demonstrates Arton learning network developed by Melpar



Quarter-inch is the widest dimension of molecular amplifier reported by Autonetics, division of North American Aviation

NAECON Shows Gains in Molecular Circuits

By CLETUS M. WILEY
Midwest Editor

DAYTON—During the next 10 years, molecular electronics will spark a revolution in electronics comparable to that caused by transistors during the last decade, Patrick Haggerty, IRE president, told National Aerospace Electronics Conference.

He predicted that integrated circuits will account for $1 billion of a $20 billion electronics market by the 1970's. Suppliers must prepare to meet these needs, many already existing, because they will be satisfied—by new companies, if necessary—he indicated.

Conference reports made clear that progress in molecular and integrated circuits has reached the point where they may be used to build entire systems.

A molecular computer assembled in half the man hours required for its conventional component equivalent was demonstrated by H. Cragon, of Texas Instruments. Molecular flip-flops helped reduce memory size to seven cubic inches and power dissipation to 15 w.

Martin-Denver announced availability of a production digital computer using Fairchild Semiconductor's Micrologic integrated circuits. The computer was designed for missile launch control and remote electronic systems checkout.

William DeBoice, of Autonetics, announced development of a molecular differential amplifier which bypasses the need for transformers and capacitors. Texas Instruments is developing a silicon block version of the prototype.

A molecular high-frequency oscillator mixer that can be adapted for biomedical implantations was discussed by P. R. Amlinger, of Westinghouse Electric. A fundamental crystal used in a Pierce-type oscillator circuit eliminated need for frequency-stabilizing capacitors in the 27-Mc oscillator. The mixer operates at 0.5 to 10 Mc.

Another Westinghouse development, a diode transistor AND gate fabricated in a monolithic semiconductor functional block, was reported by J. Zubek. Characteristics can be designed for reproducible batch processing, he said. Near uniform temperatures makes it unnecessary to compensate for voltage drops across diodes and transistors.

J. Payton, Litton Systems, described a nondestructive, random-access, tunnel-diode memory switching in 1 to 50 nsec and highly immune to radiation. Speed was increased by eliminating a requirement for timing pulses. Nondestructive read eliminated the write-back or restore cycle and clear-write cycle time was reduced by having word clearing simultaneous with write-in. The usual requirement for buffer register and associated delays was removed by a direct-coupled read amplifier.

Higher packing density of optical components helped reduce the size of a bulk storage memory discussed by D. H. Blauvelt and W. W. Lee, of Bendix. Information is stored as clear or opaque areas in a glass cylinder drum. Fiber optics and a photodetector handle readout.

Among bionics reports was one by a psychologist, Mildred Mitchell, on a laminar adaptive device made of semiconductor, insulating, photoemissive and storage materials, being developed for the Air Force Aeronautical Systems Division. Controlling component and circuit formation by reward and punishment techniques will permit autonomous adaptation and problem solving, she said. The approach is expected to cut size and improve reliability of learning equipment.

E. B. Carne, of Melpar, discussed an Arton maze runner delivered to the Air Force (ELECTRONICS, p 39, Feb. 9). It has 10 decision elements, learns a trial course in a half hour. Complex problems require eight to 10 trials for solution.

A coding system that presents an image in terms of basic areas or blocks improves channel compression, said Richard Schaphorst, of Philco. A 10-to-1 reduction in time bandwidth is expected from equipment designed for a data link with a bandwidth of 10 Kc.

100-Gc Devices Now Ready for Systems

By MICHAEL F. WOLFF
Senior Associate Editor

DAYTON—Two high-interest regions of the frequency spectrum—the millimetric and the visible—came under scrutiny at the National Aerospace Electronics Conference.

Summarizing the millimeter wave session, J. F. Hull, of Litton Industries, said devices are past the feasibility stage and ahead of applications. He asked that more attention be paid to applications because of the importance of millimeter waves in such areas as secure communications and anti-jam radar.

A progress report on linear beam tubes was given by M. R. Currie, of Hughes Research Labs. He thought these tubes would be dominant at millimeter wavelengths.

Systems applications to 100 Gc can be satisfied now by backward-wave oscillators in the 10 to 20-watt, c-w, range with 5 to 10 percent efficiencies, and forward-wave amplifiers and oscillators producing tens of watts with efficiencies of 25 to 30 percent. Currie predicted 200 to 400-watt, c-w, at 5 mm in the near future and said tens of watts should be possible at 1 mm.

Currie described a class of solid-beam interaction structures based on arrays of quarter-wave resonant bars that could be used in either forward or backward-wave tubes or extended-interaction klystrons. Primary emphasis was on fabrication feasibility rather than optimum electrical performance.

Structures described included a modified easitron circuit useful in bwos, a second easitron modification for forward-wave oscillators, a combination of the two structures known as the interdigital line suitable for forward-wave amplifiers, and the Millman or vane-line structure which has been employed in bwos. For low-voltage space harmonic operation these structures exhibit typical tuning ranges of less than 10 percent, less than 4 percent, greater than 10 percent, and 15 percent, respectively.

Prospects for the Ubitron as a high-power millimeter-wave amplifier were discussed by R. M. Phillips, of GE. The Ubitron is a traveling-wave amplifier based on the interaction between a magnetically undulated electron beam and the TE_{01} waveguide mode. Phillips said 1 Mw had been obtained at 6 percent efficiency from a 14 to 20-Gc model. Magnetic circuits are being developed to scale the Ubitron to millimeter wavelengths where it is expected to have peak-power capabilities similar to that of a 1-cm traveling-wave tube.

H. R. Johnson described bwo, traveling-wave amplifier and electrically tunable filter work presently underway at Watkins-Johnson. He reported obtaining 100 Kw peak and 100 w average power from a bwo at 100 Gc.

Results of a one-year-old program to develop transverse-wave tubes for the millimeter region were discussed by J. Feinstein, of SFD Laboratories. He said 3 to 5 w had been obtained from a bwo tuned over 65 to 72 Gc and that this type of tube could be highly efficient.

Generating millimeter waves by extending traveling-wave tube techniques was reported on by G. R. White, of Sperry Electronic Tube division. He said a two-tube amplifier chain to give 50 Kw peak power output, and a traveling-wave tube mixer were being developed for 5.5 mm. These components could be used in a space radar transmitter.

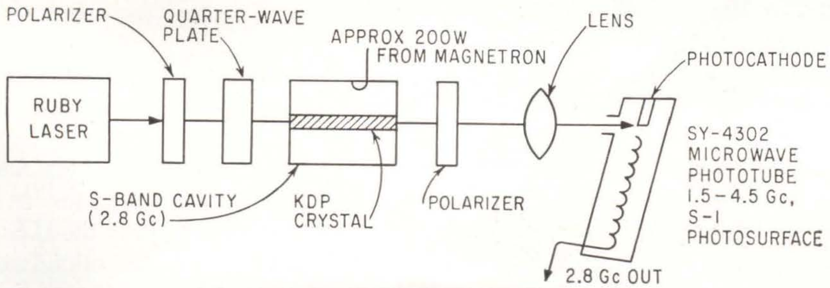
Laser Sessions

Two sessions on lasers heard several workers agree that materials were still the major problem in laser research. Little optimism was expressed for one potential solution to materials problems—the use of liquids.

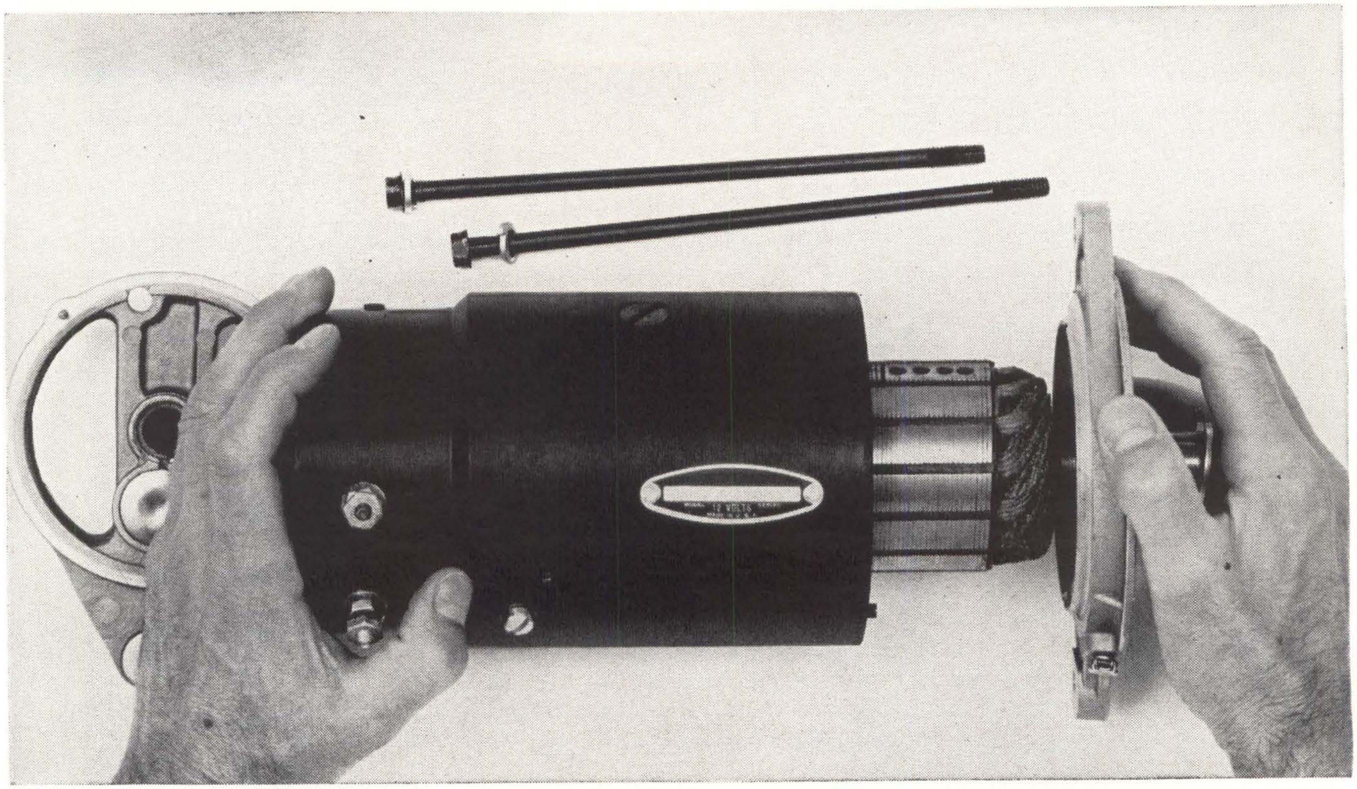
Few doping ions fluoresce in solution and quantum efficiencies may not be high, T. H. Maiman, of Quantatron, said. He thought that the number of liquids that would work would be restricted. D. S. Bayley reported that a number of liquids were being investigated at General Precision without, so far, any lasing observed. Plans are to try to observe fluorescence in some liquid compound of neodymium.

A. E. Siegman, of Stanford University, reported what he believed to be the first direct modulation and demodulation of light at microwave frequencies. With the system illustrated, he obtained 100-percent amplitude modulation at 2.8 Gc, with a 5-Mc bandwidth.

Siegman felt the best modulation techniques were those performed outside the laser. Particularly promising seem to be traveling-wave systems with KDP (potassium dihydrogen phosphate) or other crystals distributed along various types of slow-wave circuits. He predicted bandwidths of a few gigacycles with modulating powers of 100 watts or less would be obtained soon. Other modulation methods meriting attention include Faraday rotation in garnets or thin magnetic films, and changing the absorption of a semiconductor outside its absorption edge by injecting free electrons.



Stanford University experiment for 2.8-Gc modulation and demodulation of laser beam



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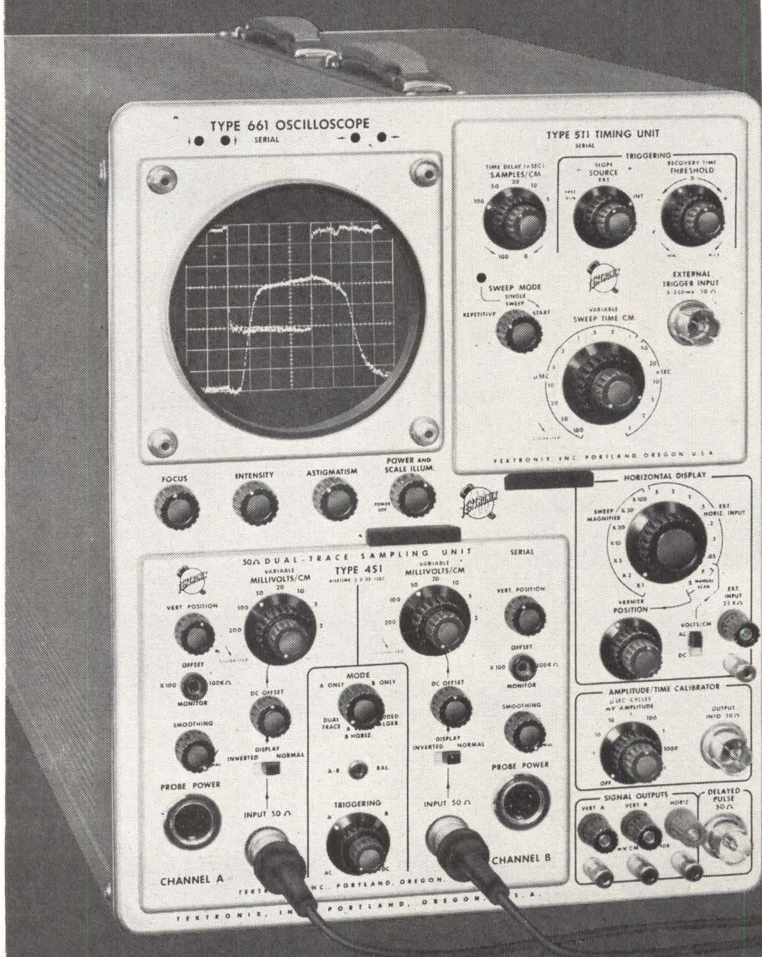

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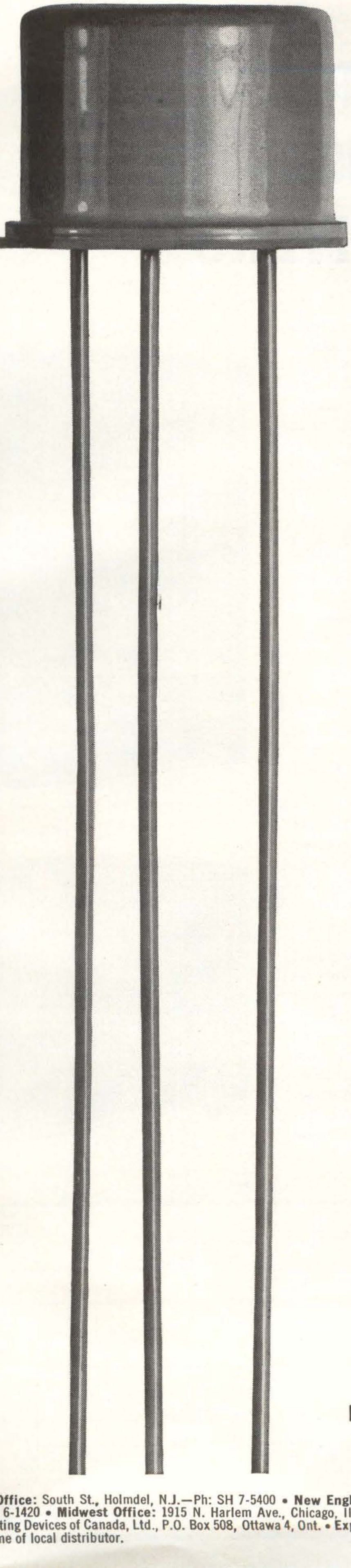

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2N398,A	105	200	500	100	20	5
2N464-2N467	15-40	100	150	100	14-90	1
2N650-52,A	45	500	200	100	30&45&80	10
2N1008,A,B*	20-60	300	400	100	40-150	10
2N1009	40	300	400	100	40-150	10
2N1176,A,B	15-60	300	300	100	20	10
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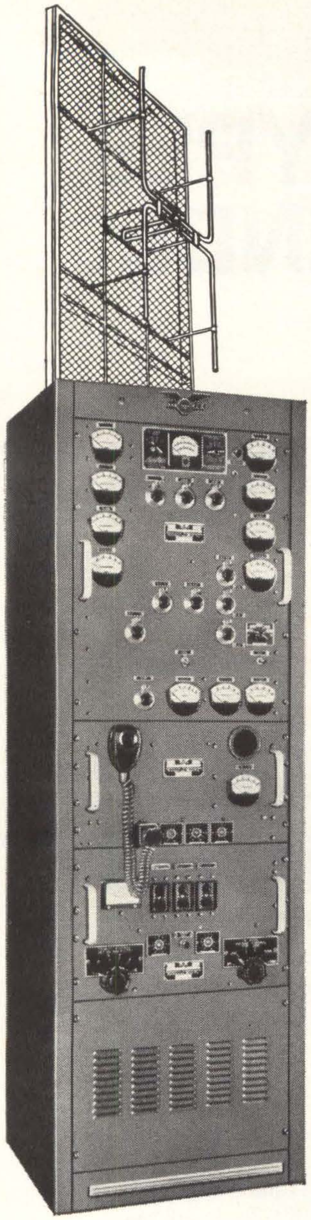

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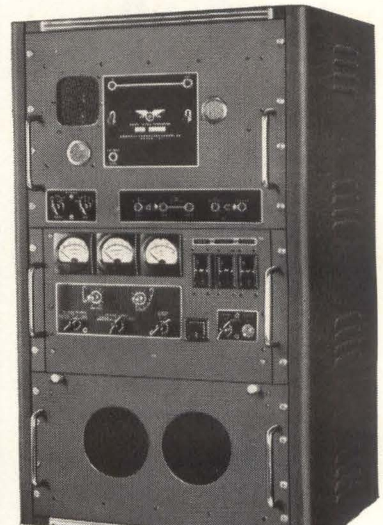

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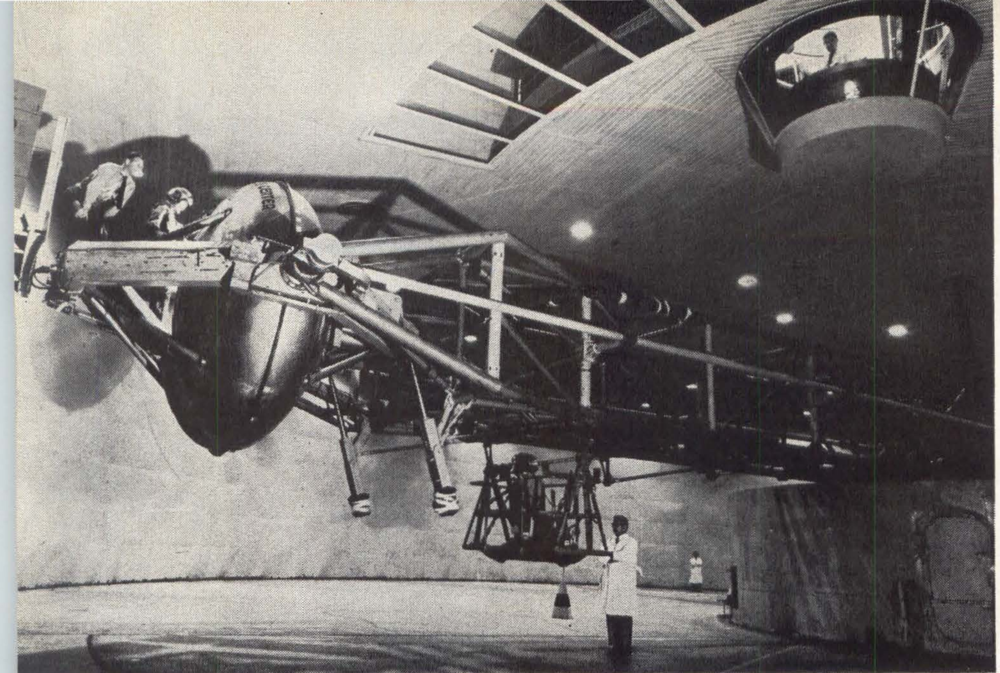


Giant centrifuge at Naval Air Development Center is used to check out pilots and instruments for space flight

1963 RDT&E SPENDING

Type of Activity	Amount ($1,000,000)	%
Basic research	77.7	5
Applied research	146	10
Development of weapons equipment and components	847	57
Test and evaluation	335	23
Program-wide management and support items not distributed elsewhere	68	5
Total	1,473.7	100

Navy Steps

By JOHN F. MASON
Associate Editor

WITHIN A FEW DAYS, the Navy's appropriations request for research, development, test and evaluation (RDT&E) in fiscal year 1963 will go to the Senate floor. The House has approved $1,474 million, about $½ million less than Navy wanted. Major programs are:

Antisubmarine Warfare — At $291 million, this is one of the biggest programs. Since there is no air defense against submarine-launched missiles, defense is concentrated on getting the subs before missiles are launched.

Extensive effort will be placed on shipborne detection/deception and countermeasures. Sonar R&D will be aimed at reducing size, weight and power requirements while increasing detection range. The Navy says the powerful new SQS-26 sonar promises the longest range yet obtained in shipborne active sonar. Range of helicopter sonar and Lofar sonobuoys has also been improved. Sonars now going into ships and subs have 10 times the range of five years ago.

Projects Trident and Artemis will be stepped up. Trident will survey large ocean areas with active and passive sonar and fixed and mobile detection systems to locate submarines beyond their maximum missile-launching range. Artemis, applied research in long-range submarine detection, will include sea trials of signal-processing components in 1963.

Sensitive, airborne infrared equipment will be developed. Experimental infrared gear has detected submerged submarines at night, hours after passage. The passage of submerged submarines has also been detected in restricted waters by active barriers of transducers. A barrier set is being bought this year for operational testing.

A precision graphic recorder (Aspect) for destroyers and helicopters will tell whether the target located is a submarine or fish. Lofar target classifiers and more sensitive magnetic airborne detection (Mad) gear are being developed.

ASW Weapons—The House provided an extra $7 million to overcome difficulties in the Mark 46 torpedo. The components worked, but the assembled torpedo didn't. A lightweight torpedo for aircraft and destroyers, it will use long-range sonar for target searching and homing. Work will begin this year on an asw torpedo with higher speed, longer acquisition and greater depth capability.

Other continuing developments include a wire-guided torpedo, the EX-10, and mines more sensitive to targets and more resistant to countermeasures. The Mark 57 mine development is a project that will be completed.

The Navy is also going ahead with Asroc, Subroc and Dash. Asroc, a ship-launched rocket, delivers a mine or sonar-homing torpedo. Subroc, a submarine-launched rocket-torpedo, is slated for test-firing in December. Dash is a torpedo or nuclear depth charge carried by a drone helicopter controlled from a destroyer.

Missiles—Although Navy is reducing R&D on Polaris in 1963, it will continue developing the A-3 version with a 2,500-nm range.

Typhon, the newest surface-launched missile, is to be used on a nuclear-powered, guided-missile frigate, also in the 1963 budget. Typhon is being developed in long-range and medium-range versions.

Tower near Bermuda is relay point for hydrophones

WHERE NAVY SPENDS RDT&E MONEY

Fiscal Year	1961	1962	1963
		($1,000,000)	
Department of Defense facilities.	527	535	588
Other government agencies.....	6	8	17
Industrial facilities............	719	779	793
Educational and nonprofit organizations..................	78	75	72
Total obligations............	**1,330**	**1,398**	**1,470**

RDT&E ON ASW IN 1962 AND 1963

Fiscal Year	1962	1963
	($1,000,000)	
Detection, classification and localization (65 projects)........................	88.4	119.4
Weapons, ordnance, and fire control (28 projects)...........................	59.6	63.8
Vehicle and propulsion equipment (35 projects)...........................	48.2	58
Collateral, support, and related (24 projects)	35	41.8
Total 152 projects....................	**231.2**	**286**

Up Antisubmarine Warfare R&D

IN ITS $1,474 RDT&E BUDGET FOR 1963

Designed to cope with enemy threats in 1970, it will attack large numbers of targets. The system will use phased-array radar.

Both Typhons will fit into Terrier and Tartar launchers, so ships now carrying those missiles can be backfitted later with Typhon. Navy also wants to improve Terrier, Tartar and Talos shipboard surface-to-air missiles.

RDT&E funds for the air-launched Bullpup are being reduced since it is entering the procurement phase. Technical and operational evaluation of Shrike is slated to begin by July, 1963.

Conventional and Limited War Equipment—Non-nuclear weapons will be modernized and research will start on new weapons.

Developments for the Marine Corps include a man-packed communications jammer, man-transportable mortar locator, Lightweight surveillance radar, lightweight command, tactical and logistics control radios, more reliable ground-to-air radio.

The Marine Tactical Data System (Mtds) will evaluate air situations. Tactical operations centers with digital computers will receive and process radar and IFF information and direct action against enemy aircraft. Long-range, lightweight early-warning and height-finding radar are under development.

Aircraft and Related Equipment—Navy is participating in tri-service development of vertical-takeoff-and-landing planes, the TFX supersonic, all-weather, missile-carrying interceptor and the VAX, to provide close support to troops. TFX's missile control system will use high-power airborne intercept radar.

To improve asw aircraft capability, detection and classification data display and communications equipment is needed.

Communications and Command—R&D is underway on communications systems for future command ships. Operations control centers using advanced data processing and display equipment are also being developed. Future systems must cope with limited wars.

Pacific Missile Range—Navy wants $113.3 million for instrumentation of downrange sites and ships, training support, and tests of Navy, Air Force and Army missiles and satellites.

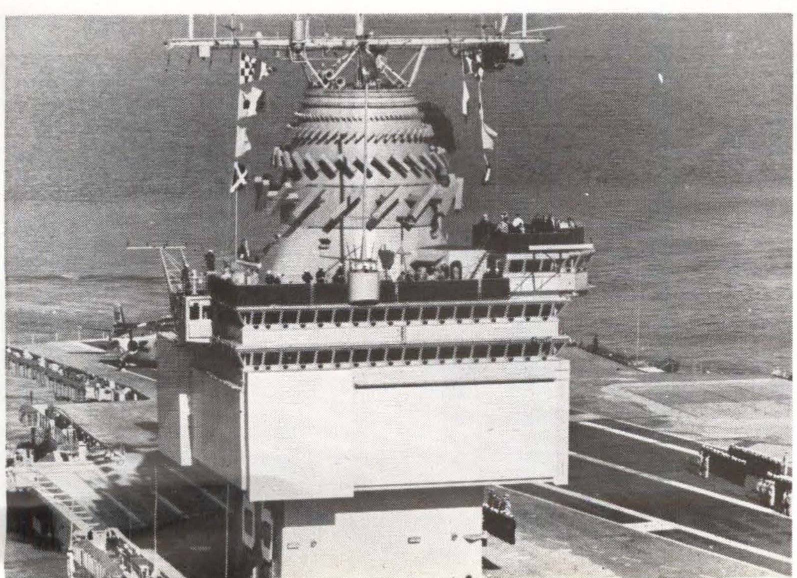
Astronautics—Navy's interests are in navigation, space surveillance, geodesy and communications.

Project Transit, a doppler navigation satellite system, will provide worldwide ship navigation in 1963. A four-satellite prototype system will be established. Six launches are planned for 1963.

Ship equipment is being developed and evaluated for operational use. Ground tracking, computer and control network are required.

Spasur, the operational space surveillance network, will be ex-

Island of aircraft carrier Enterprise. Four rows of horizontal bars are part of ship's radar



tended to monitor satellites and low and high altitudes and to improve satellite prediction accuracy.

Oceanography—Navy will spend $38 million (out of $124 total government funds) on research, much of it aimed at applications in undersea and antisubmarine warfare. Studies include surface waves, ice physics and sea floor. To predict sonar conditions, an antisubmarine warfare environmental prediction system (Asweps) will be developed.

Navy hopes to use infrared-equipped satellites to determine surface water temperatures and thereby currents. Satellites may also receive data from sonobouy-type sensors and provide information on surface weather.

Electronic Sciences—Work includes fundamental principles of devices and circuits, elf and vlf research, non-acoustic submarine detection and communications, thermoelectricity, countermeasures, solid-state power supplies and millimeter waves.

Radar surveillance programs include Projects Madre and Teepee. Madre is a Navy-Air Force program for over-the-horizon detection of missiles and aircraft. Teepee is to detect missile launches. Emphasis in 1963 will be on optimizing multihop backscatter techniques and developing specialized equipment. A two-hop technique has detected at 4,000 miles.

Basic Research—A $77.7 million request has been made for work in biological, physical and mathematical sciences, nuclear physics and physical acoustics.

Programwide Management and Support—Funds will support the Atlantic Undersea Test and Evaluation Center at Andros Island, in the Bahamas. Radar, underwater and optical tracking, telemetry, microwave and communications, computing and data processing equipment will be bought. The range will be fully operational in fiscal year 1964.

ASW Director—As part of its antisubmarine warfare program, the post of Director of ASW Warfare has been created and two auxiliary groups have been formed. The ASW Systems Analysis Group will be concerned with specific research efforts and the Chief of Naval Operations ASW Study Group, long-range plans.

Huge fairgrounds at Hannover cover 9.5 million square feet

German Electronics Spotty

BONN—The German Industries Fair at Hannover last month confirmed that the German electronics industry today presents a confusing picture.

Two years ago, experts predicted it would be a major growth industry. This seemed apparent in 1960 when German electronics output hit $825 million—seven percent of Free World production.

But overcapacity in some sections—particularly entertainment electronics—and rapidly increasing competition from British and U. S. firms have had a major impact. Output dipped sharply to $750 million in 1961 and may drop off even further this year.

Electronics exports increased by about $200,000 in 1961, to $339 million. Against this, imports rose from $27 million to $108 million.

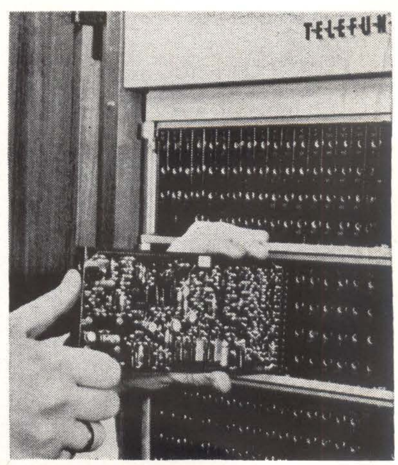
American firms are beginning to show a major interest in the European market, buying into European firms or establishing license agreements. As competitors, U. S. firms are seen to have the advantages of a long start, government help for development and cheaper materials. The high cost of labor in the U. S. is of little import in such a capital-intensive industry as electronics.

Radio and tv sets are still the German industry's bread and butter. With components and allied equipment, this accounts for almost half of total output. But tv sales dropped from 2.28 million sets in 1960 to 1.82 million in 1961. The forecast for 1962 is less than 1.7 million set sales.

Transistor radios are still best sellers, but indications are that competition from Japan and Hong Kong will be increasingly severe.

Manufacturers seem to have made up their minds that their future lies in industrial electronics. The potential market for telecommunications equipment looks enormous, but to date German demand offers little encouragement to manufacturers.

Prospects are bright for inexpensive electronic business machines. Successful prototypes of electronic telephone exchanges have been developed and pushbutton



Telefunken computer uses interchangeable printed circuit boards phone sets are on the market.

In 10 years, major German post offices will be equipped with automatic letter sorters, patterned after one at Darmstadt. The federal Post Office has its first electronic money order accounting system.

Prominent among 230 foreign exhibitors of electronic and electrical equipment were Minneapolis-Honeywell, Budd, Beckman Instruments and Texas Instruments.

Among the German firms, Telefunken unveiled its TR4 general-purpose digital computer. The central computing unit operates with parallel word transmission and has a parallel computer unit for 48 bits. Instruction, binary floating-point notations, binary and decimal fixed point numbers and alphanumeric characters are employed internally. Clock frequency is 2 Mc.

There are two permanent memories, each of 4,096 52-bit words. One is expandable to 24,576 words. Access time is 1 msec. Up to 64 auxiliary units may be connected to eight input and output channels.

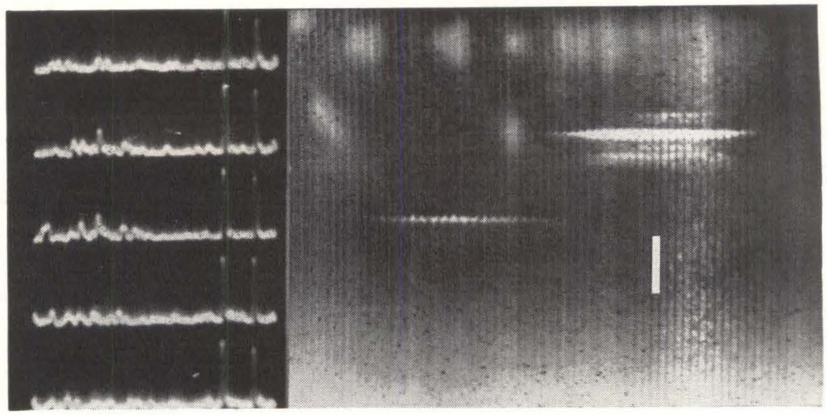
All-Transistor Telephone Switchboard Weighs 500 Lb

CHICAGO—Kellogg Division of ITT Corp. unveiled an all-transistor, 500-pound telephone switching system at the Navy League convention here. Up to 30 trunks and 200 extension lines can be accommodated.

Kellogg designed the system primarily for military and government applications where light weight, minimal maintenance, and mobility are important factors. The equipment can be airlifted.

The company also sees some commercial applications, because of its size. Power consumption is 250 to 600 watts, depending on the number of branch telephones served. It uses 60-cps power; batteries may be used in emergencies.

Heart of the switching system is a scanner using a three-stage cascaded array, permitting a firm register seizure time of 30 μsec. The system features modular construction. A minimum of 48 extensions can be handled economically, but additional lines can be added in increments of four by plugging in modules.



GE says that data in the white rectangle on the thermoplastic recording (right) is equivalent to that on the cro photo (left)

Thermoplastic Tape Records Radar Data

THERMOPLASTIC recording of radar video information may point the way to improvements in radar test evaluation, GE announced recently. The technique was used experimentally during tests of a new airborne radar at the company's Light Military Electronics department.

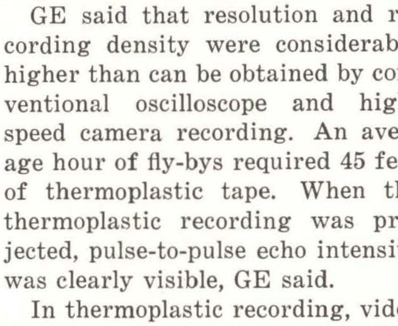
GE said that resolution and recording density were considerably higher than can be obtained by conventional oscilloscope and high-speed camera recording. An average hour of fly-bys required 45 feet of thermoplastic tape. When the thermoplastic recording was projected, pulse-to-pulse echo intensity was clearly visible, GE said.

In thermoplastic recording, video output is fed to an electron gun that places a charge pattern on the tape. The tape is converted in the recorder by heating, converting the charge image into a groove image. Groove depth is proportional to signal strength.

The equipment used has recorded frequencies up to 10 Mc. The recorded data is viewed with a movie projector modified by the addition of Schlieren bars. Clear areas of the tape are seen as dark and grooved areas as light. Illumination varies with groove depth.

GE says it is also working on thermoplastic recording for latent image photography, random access digital storage, recording composite radar, infrared and tv analog signals, and wide-band signals from reconnaissance equipment.

Micro Tv Set



Sony's eight-pound, five-inch, transistor tv (p 7, April 27)

Convert Voice to Digits For Speech Recognition

AUTOMATIC SPEECH recognition program in RCA's Surface Communications division has reportedly achieved recognition accuracy as high as 85 percent. Objective of the program is to convert speech to digital form with an order of magnitude reduction in bandwidth, for teletypewriter transmission.

Speech is analyzed, encoded in binary form and recorded for input to an RCA 501 computer. The 501 picks out and recognizes vowels spoken in isolated monosyllables consisting of an initial consonant, a vowel and final consonant. Vowel location is automatic and no adjustment is made for individual talkers. Problems of error source, accuracy improvement and consonant recognition are under attack.

Work is sponsored by the Air Force. When perfected, speech recognition can foster language translators, phonetic typewriters and voice-controlled machines.

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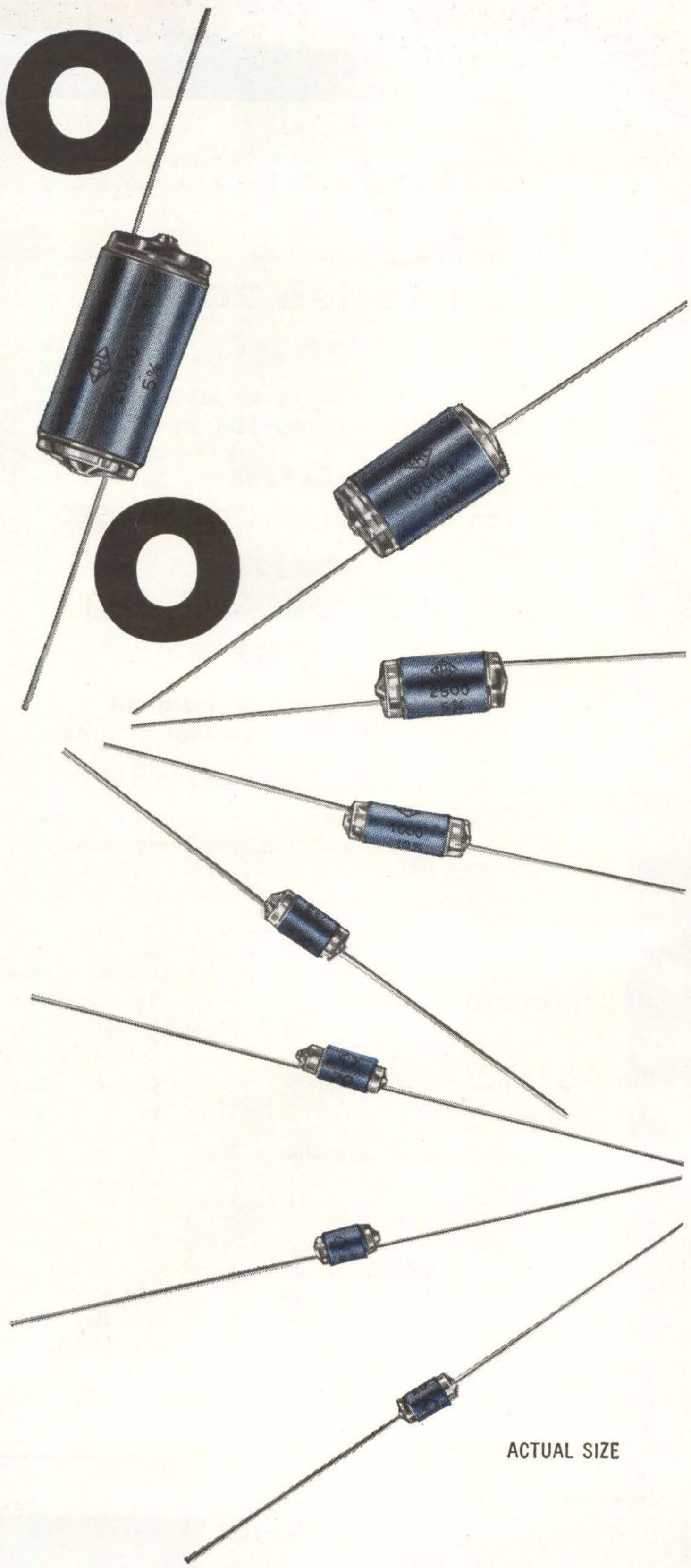
WITH CENTRALAB Q-KAPS POLYSTYRENE CAPACITORS



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EXCEPTIONALLY LONG LIFE AND PROVEN RELIABILITY

The polystyrene film dielectric of these new Centralab capacitors permits their use as direct replacements for micas and Mylars... in any application within their capacity limits and operating temperature range . . . yet their price is fantastically low. Fast delivery is available on all standard EIA (RETMA) values from 20 pf to .01 mf, 500 VDCW, 1500 VDCT, ±5% or ±10% tolerance. Other capacity values, tolerances (±2.5%, ±20%), and voltages (125 VDCW, 375 VDCT) can be supplied on special order.

CAPACITANCE DRIFT: 0.3% or less after temperature cycling of +25, −10, +85, +25°C.

INSULATION RESISTANCE: 5000 Meg/mf or 500,000 Meg, whichever is greater, at 100 VDC, +25°C, 80% R.H.

"Q" FACTOR: Over 2000 at 1 mc, 25°C.

OPERATING TEMPERATURE RANGE: − 10°C to + 85°C.

For detailed information and complete specifications on these new Centralab "Q"-Kaps, write for Bulletin EP1034R3.

Immediate delivery, from stock, of all EIA values, 5% tolerance, is available through Centralab Industrial Distributors.

Centralab CRL

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MEETINGS AHEAD

NUCLEAR CONGRESS & EXHIBIT, Engineers Joint Council; Statler Hilton Hotel, New York City, **June 4-7.**

RADAR ANNUAL SYMPOSIUM, University of Michigan; at the University, Ann Arbor, Mich., **June 6-8.**

MOLECULAR BEAMS CONFERENCE, Brookhaven National Laboratory; Upton, N. Y., **June 11-13.**

ARMED FORCES COMMUNICATIONS AND ELECTRONICS CONVENTION AND SHOW; Sheraton Park and Shoreham Hotels, Washington, D. C., **June 12-14.**

AEROSPACE TRANSPORTATION CONFERENCE, AIEE; Denver-Hilton Hotel, Denver, Colo., **June 17-22.**

BROADCAST & TELEVISION RECEIVERS CONFERENCE, IRE; O'Hare Inn, Chicago, Ill., **June 18-19.**

MILITARY ELECTRONICS 6TH NATIONAL CONVENTION, IRE-PGMIL; Shoreham Hotel, Washington, D. C., **June 25-27.**

ELECTROMAGNETIC THEORY & ANTENNAS SYMPOSIUM, Tech. Univ. of Denmark, et al; Copenhagen, **June 25-30.**

COMPUTER AND DATA PROCESSING SYMPOSIUM, Denver Research Institute; Elkhorn Lodge, Estes Park, Colo., **June 27-28.**

AUTOMATIC CONTROL JOINT CONFERENCE, IRE-PGAC, AIEE, ISA, ASME, AICHE; NY Univ, New York City, **June 27-29.**

RADIO PROPAGATION COURSE, National Bureau of Standards and University of Colorado; NBS Boulder Laboratories, Boulder, Colo., **June 16-Aug. 3.**

LUNAR MISSIONS MEETING, American Rocket Society; Pick-Carter and Statler-Hilton Hotels, Cleveland, Ohio, **July 17-19.**

MEDICINE & BIOLOGY DATA ACQUISITION AND PROCESSING, IRE-PGBME, AIEE, ISA; Strong Memorial Hosp., Rochester, N. Y., **July 18-19.**

INTERNATIONAL SOUND FAIR, Institute of High Fidelity Manufacturers, Magnetic Recording Industry Assoc., et al; Cobo Hall, Detroit, **July 25-29.**

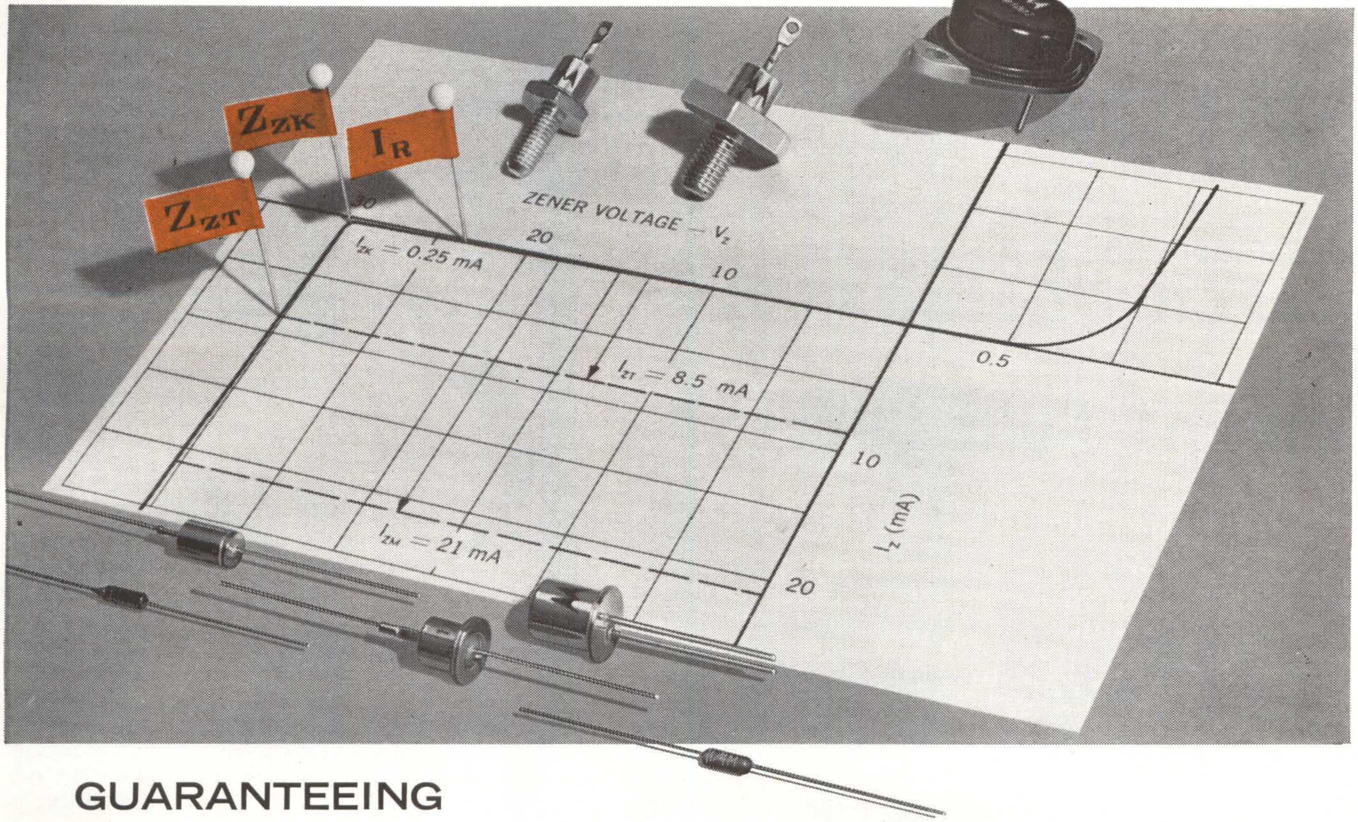
INDUSTRIAL RESEARCH CONFERENCE, Columbia University; Arden House, Harriman, N. Y., **Aug. 5.**

WESTERN ELECTRONICS SHOW AND CONFERENCE, WEMA, IRE; Los Angeles, Calif., **Aug. 21-24.**

ADVANCE REPORT

SPACE PHENOMENA & MEASUREMENT SYMPOSIUM, IRE-PGNS; *Statler-Hilton Hotel, Detroit, Oct. 15-18. July 1 is the deadline for submitting 300-500 word summary and 35-word abstract to: M. Ihnat, Avco Corp., 201 Lowell St., Wilmington, Mass. Topical areas include, but are not limited to, the following: fundamental and applied research on space environment; recent advances on nucleonic instruments and controls; space and laboratory diagnostics.*

MOTOROLA ZENER DIODES
characterized at 3 critical points



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Meaningful, reverse leakage spec (I_R) Clearly defined, zener knee region (Z_{ZK}) Low dynamic impedance (Z_{ZT})

All Motorola zener diodes are tested at 80% of the minimum zener voltage . . . giving you a much more meaningful reverse current leakage specification than you get with those devices having leakage specified at lower percentages of the zener voltage.

Also . . . Motorola zener diodes are unique in that the point of measurement for specified leakage is the same for each power rating from ¼W through 50W . . . and for all voltages . . . rather than the customary and confusing practice of using test points farther away from the zener knee for the lower voltages.

Meaningful reverse leakage current data tells you the precise current drain in the region below breakdown . . . helps to clearly define the critical zener knee region . . . gives you a good indication of cleanliness of junctions.

In addition . . . all Motorola zener diodes are characterized for you by two guaranteed maximum impedances . . . (1) at the practical ¼ power operating point (Z_{ZT}) . . . (2) at the zener knee (Z_{ZK}). These two points help define the zener knee region, and prove that it does not soften past the I_R test point, but continues sharp beyond Z_{ZK} . . . giving you assurance of stability of the zener voltage with current changes.

For the industry's finest, best-characterized zener diodes, specify Motorola. More than 2,000 different types . . . most complete, most meaningful specifications . . . highest-reliability industrial and military devices.

MOTOROLA ZENER DIODES

WATTS	VOLTS	WATTS	VOLTS
¼	2.4 to 200	1.5	6.8 to 200
400 mW	3.3 to 200	10	6.8 to 200
¾	6.8 to 200	50 (TO-3)	6.8 to 200
1	6.8 to 200	50 (Stud)	6.8 to 200

- REVERSE POLARITY 10 & 50W UNITS
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MOTOROLA ZENER DIODE-RECTIFIER APPLICATIONS HANDBOOK

This 185-page engineering reference booklet is invaluable to zener/rectifier users. Available for only $2 from your local Motorola Semiconductor distributor.

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FILTER DESIGNERS!

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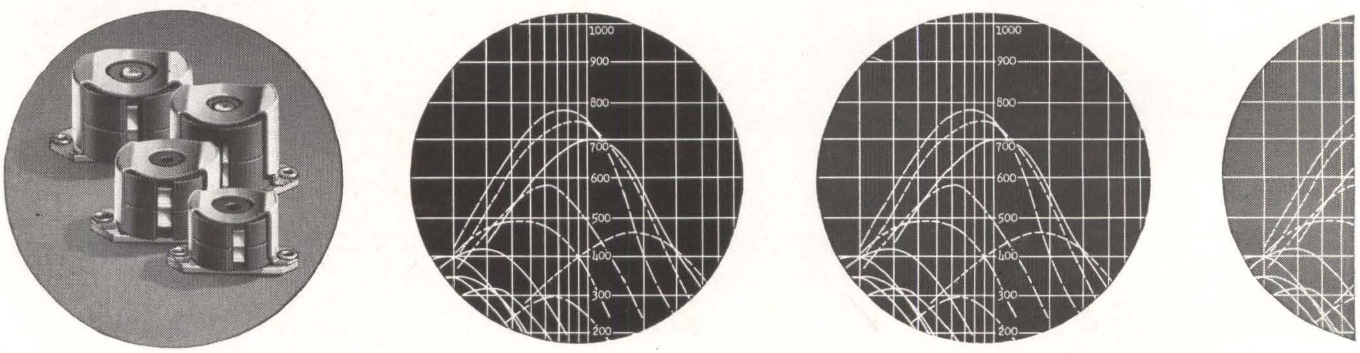

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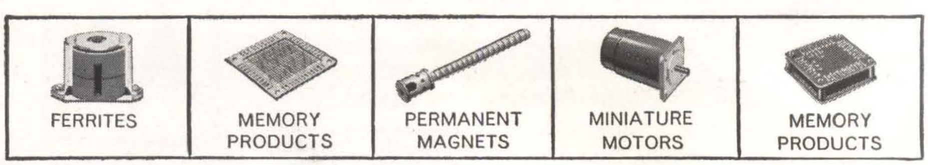
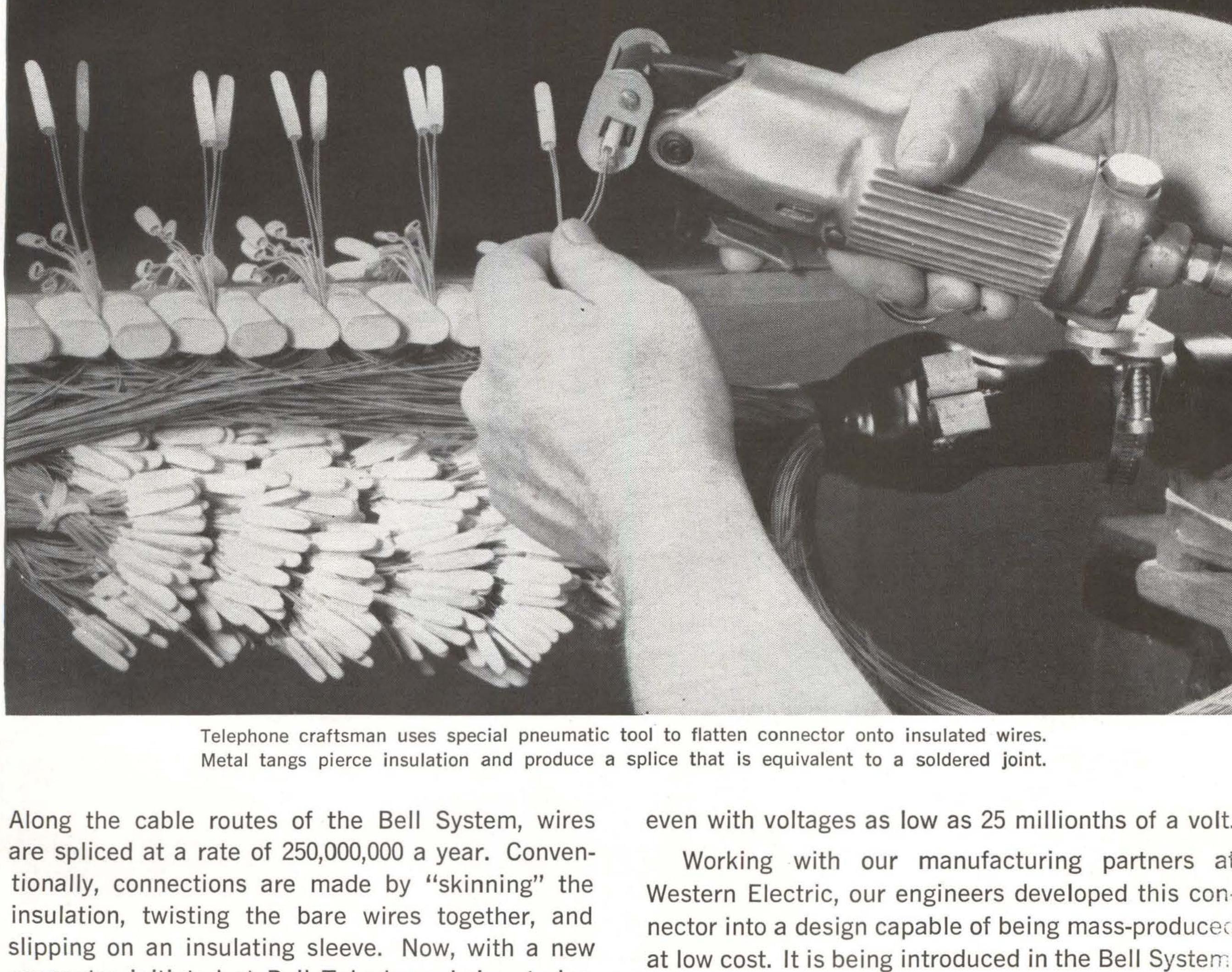
INDIANA GENERAL



BELL LABORATORIES' NEW CONNECTOR STREAMLINES CABLE SPLICING



Telephone craftsman uses special pneumatic tool to flatten connector onto insulated wires. Metal tangs pierce insulation and produce a splice that is equivalent to a soldered joint.

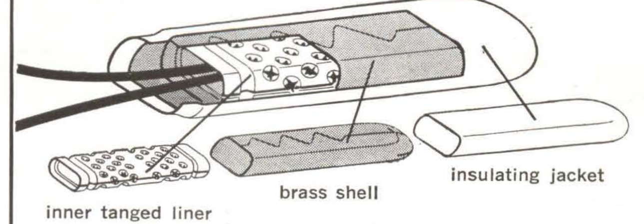
Along the cable routes of the Bell System, wires are spliced at a rate of 250,000,000 a year. Conventionally, connections are made by "skinning" the insulation, twisting the bare wires together, and slipping on an insulating sleeve. Now, with a new connector initiated at Bell Telephone Laboratories, (diagram at lower right) splices can be made faster, yet are even more reliable.

The craftsman slips the two wire ends—with insulation intact—into the connector, then flattens the connector with a pneumatic tool. Springy phosphor bronze tangs inside the connector bite through the insulation to contact the copper wire. The stable, low-resistance splice established is maintained for many years, even under conditions of high humidity, corrosive atmospheres and vibration.

Ultrasensitive measuring techniques devised by our engineers demonstrate that the new connector provides the equivalent of a soldered connection, even with voltages as low as 25 millionths of a volt.

Working with our manufacturing partners at Western Electric, our engineers developed this connector into a design capable of being mass-produced at low cost. It is being introduced in the Bell System.

NEW WIRE CONNECTOR HAS THREE PARTS:



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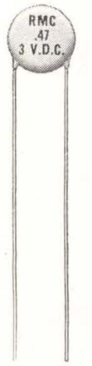
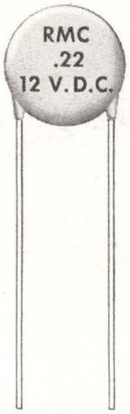
SPECIFICATIONS



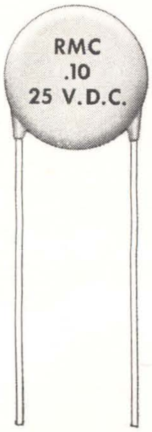
3 VOLT MAGNACAP

Capacitance µf. 1 Kc., .05 vrms max. @ 25° C.	Tolerance %	Dissipation Factor (% Max.) 1 Kc., .05 vrms max. @ 25° C.	Insulation Resistance Min. @ 100% Rated DC Voltage R = E/I	Diameter Max. (Inches)	Thickness Max. (Inches)	Lead Spacing ± .035"
.05	+80 −20	3%	60,000 ohms	.265	.156	.250
.10	+80 −20	3%	30,000 ohms	.265	.156	.250
.22	+80 −20	3%	13,600 ohms	.310	.156	.250
.47	+80 −20	3%	6,270 ohms	.425	.156	.250
1.0	+80 −20	3%	3,000 ohms	.615	.156	.375
2.2	+80 −20	3%	1,360 ohms	.880	.156	.375



12 VOLT MAGNACAP

Capacitance µf. 1 Kc., .05 vrms max. @ 25° C.	Tolerance %	Dissipation Factor (% Max.) 1 Kc., .05 vrms max. @ 25° C.	Insulation Resistance Min. @ 100% Rated DC Voltage R = E/I	Diameter Max. (Inches)	Thickness Max. (Inches)	Lead Spacing ± .035"
.05	+80 −20	7%	800,000 ohms	.310	.156	.250
.10	+80 −20	7%	400,000 ohms	.380	.156	.250
.22	+80 −20	7%	180,000 ohms	.575	.156	.375
.47	+80 −20	7%	85,000 ohms	.800	.156	.375
1.0	+80 −20	7%	40,000 ohms	1.045	.156	.375



25 VOLT MAGNACAP

Capacitance µf. 1 Kc., .05 vrms max. @ 25° C.	Tolerance %	Dissipation Factor (% Max.) 1 Kc., .05 vrms max. @ 25° C.	Insulation Resistance Min. @ 100% Rated DC Voltage R = E/I	Diameter Max. (Inches)	Thickness Max. (Inches)	Lead Spacing ± .035"
.02	+80 −20	7%	10 megohms	.380	.156	.250
.05	+80 −20	7%	10 megohms	.520	.156	.375
.10	+80 −20	7%	10 megohms	.695	.156	.375

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electronics
June 1, 1962

FIBER OPTICS
FOR ELECTRONICS ENGINEERS

A recently developed optical technique is finding a variety of applications in data processing and display, image handling, lasers and other fields. Here is an account of the present state of the art

By GEORGE V. NOVOTNY
Assistant Editor

Loose bundle of optical fibers, made by American Optical Co, conducts light from candle flame and releases it in lower right corner

FIBER OPTICS is the technique of transmitting light through long, thin fibers of glass, plastic or other transparent material. A properly aligned bundle of such fibers can shift a complete image, element by element, from place to place.

At present, use of fiber optics is limited by high initial cost, but this is often justified by special advantages. Fiber optics can channel and guide light, often much more efficiently than lenses can. It can transfer an image over a short or a long distance, while a lens system is limited by its focal length. The increased efficiency results in greater sensitivity and simpler photographic techniques.

Fiber-optic bundles can be made flexible, as in probes and fiberscopes, or can be fused into solid blocks of glass, such as in cathode-ray-tube faceplates. Glass fibers, singly or in various forms, are commercially available to below 10 microns diameter; there is no upper limit.

Light propagates through an optical fiber by a series of reflections from wall to wall; therefore only those rays are propagated that enter the end of the fiber at a small enough angle to cause total reflec-

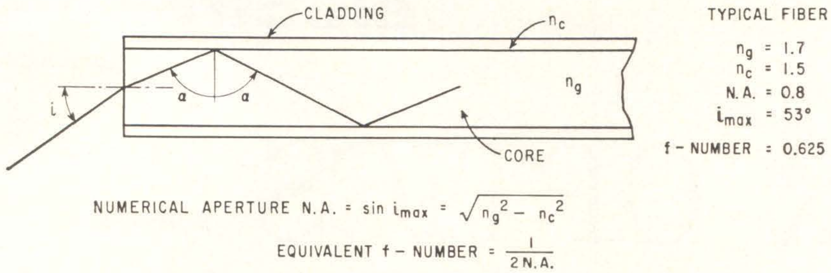

FIG. 1—Maximum angle i_{max} at which a fiber accepts light depends on the indices of refraction of fiber and cladding. Typical values shown at right

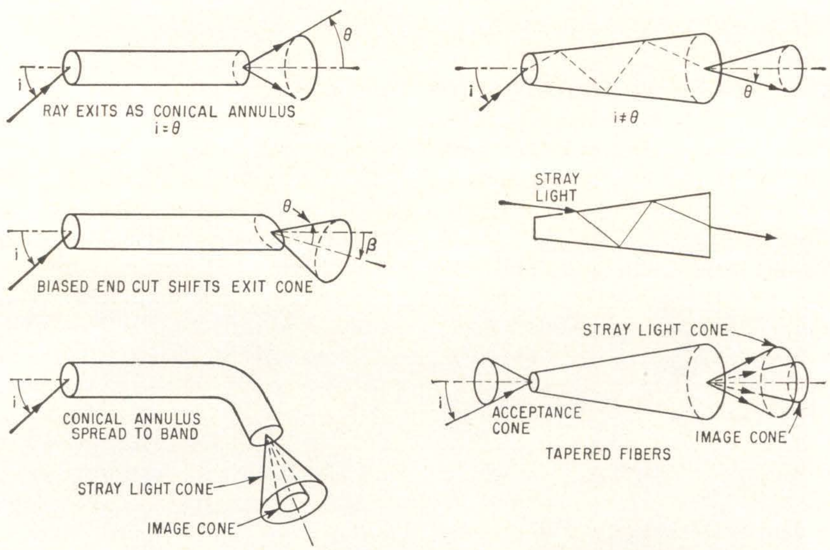

FIG. 2—Behavior of light rays in different fibers. A more complex analysis applies to rays that do not enter through center of face (skew rays)

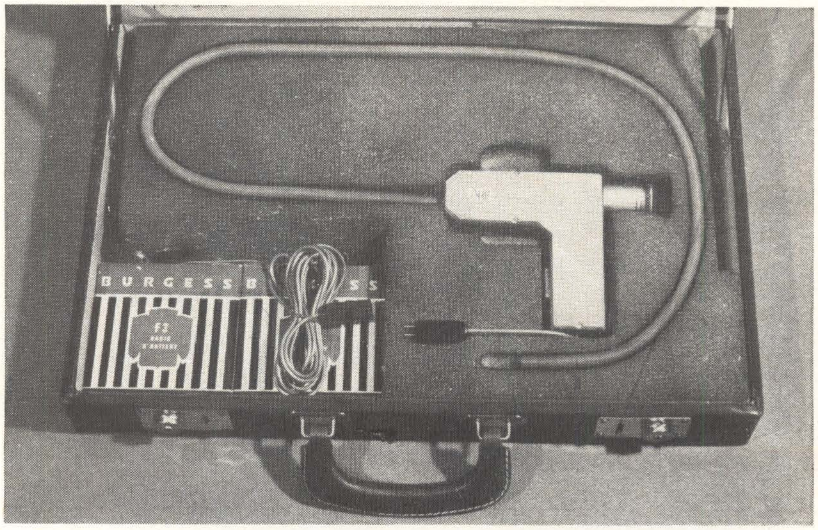

FIG. 3—Flexible fiberscope made by Armour Research Foundation for use by Sandia's Livermore Laboratory in missile applications

tion from the walls (see Fig. 1). For lossless reflection, the walls must be smooth and clean. A ray in a 50-micron fiber undergoes about 4,000 reflections a foot.

When two glass fibers come within about half a wavelength of each other, some light leaks from one to the other. If the fibers are small and closely packed, they touch over an appreciable area, and leakage, or "crosstalk", becomes a serious problem. Such a bundle would degrade the transmitted image by loss of contrast.

For this reason, fibers are usually insulated from each other by a thin jacket of transparent material whose index of refraction is lower than that of the fibers. This cladding, usually glass, both reduces crosstalk and protects the smooth reflecting walls. Cladding must be at least a wavelength, or 0.5 micron, thick.

An additional thin layer of dark absorbing coating is sometimes added over cladding, to further increase contrast and absorb scatter light. This is called E.M.C., extramural cladding, or E.M.A., extramural absorption.

The maximum angle (i_{max}) at which a clad fiber in air accepts light for transmission is determined by the indices of refraction of core and cladding material, n_g and n_c respectively, and is

$$i_{max} = \arcsin \sqrt{n_g^2 - n_c^2}$$

The expression $(n_g^2 - n_c^2)^{\frac{1}{2}}$ is the nominal numerical aperture, N.A., of the fiber, and is a measure of its efficiency: the light-gathering power is proportional to $(N.A.)^2$. Effective nominal apertures are somewhat lower. Typical values are 0.5 to 0.97. Quantity N.A. is related to equivalent photographic lens speed by the relation

$$N.A. = \frac{1}{2\,(\text{f-number})}$$

where the f-number is the ratio of focal length to effective diameter of the lens.

Cladding reduces N.A., since its index of refraction exceeds that of air ($n_o = 1$); also it introduces a dead area into the bundle cross-section.

A fiber optic bundle will not, in

general, transmit an image unless it occurs right on its input face or very close to it. This may be a physical image, such as a drawing, or an optically focused real image (as distinct from a virtual image, such as seen in a telescope eyepiece). Without a focusing system, a bundle will not "see" an image any distance away.

If all fibers of a bundle are aligned in substantially the same relative position at both ends, the bundle is coherent, and will transmit an image. If the fibers are scrambled, the bundle becomes incoherent, and will act as a light pipe, or in special cases as an optical encoder. Bundles can be tapered (each fiber then has a taper) to enlarge or reduce an image or to concentrate or diffuse a light source; the bundle faces may be ground and polished flat or curved, according to the application. Figure 2 shows the behavior of light rays in some differently shaped fibers.

Some light is always lost in transmission through a fiber bundle. Almost all the loss is due to absorption in the glass, not to the reflections from the walls. A typical fiber-optic crt faceplate ½-inch thick delivers 90 percent of the received light, and a flexible bundle 7 feet long loses about half its input light.

The resolving power of a fiber bundle depends on the fiber diameter, fiber separation, cladding thickness. Generally, definition can be expressed as

$$W = \frac{1}{2D} \text{ lines/unit length}$$

where D is the fiber diameter. Using dynamic scanning (vibrating the bundle in the plane of the image) this can be increased to about $1.22/D$ lines per unit length, as the vibrating fibers cover the area that in a stationary bundle would be taken up by cladding and dead space.

Only the fibers in an image bundle transmit useful light; the overall efficiency is reduced by the amount of cladding and spaces between fibers. This depends on the geometrical arrangement of the fibers. The reduction factor ranges from 70 to 92 percent.

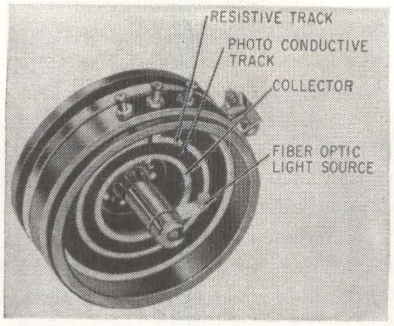

FIG. 4—Duncan Betapot potentiometer uses glass fiber to direct light onto photoconductive track, to make contact between resistive and collector rings

To make a glass fiber, a glass cylinder say 1 inch in diameter and 12 inches long is carefully ground and polished, then tightly fitted with a tube of the cladding glass. The two are fused by r-f heating and then drawn out to the desired diameter.

Fiberscopes are probably the best known application of fiber optics. They consist of clad fibers, loose except at the ends where they are aligned, potted and ground. The entire bundle is protected by an outside sheath. Lubrication between fibers is often used to improve flexibility. Fiberscopes can be bent to a radius of the order of one inch. Typical resolution is 20 to 50 lines/mm.

A representative fiberscope, shown in Fig. 3, has 2,000 fibers, each 0.002 in. in diameter, is three feet long, has overall diameter of ⅜ inch. Lenses at both ends focus images; the inner fibers transmit the image while the outer fibers carry light to the object being viewed.

Similar probes are made for medical purposes: viewing the interior of body cavities, such as the duodenum or the heart. A uretoscope made by American Cystoscope Makers has an outside diameter of 3½ mm, contains 50,000 lubricated fibers. Probes are also used for viewing the inside of missile tanks, engines or other cavities and carrying the image from an inaccessible, vibrating or dangerous location directly to television cameras or eyepieces. One single fiber can carry one bit of information, such as the presence or absence of light or color (fire warning in aircraft). Unaligned flexible bundles provide remote illumination (American Optical's intracardiac illuminator).

An unaligned fiber optic bundle used in a remote pyrometer for missile applications, fabricated by Armour Research Foundation, is illustrated on the cover.

An unusual electronic use of a single optical fiber is the contactless Duncan Betapot potentiometer, shown in Fig. 4. A rotating arm with a light-conducting optical fiber focuses light on a photoconductive track, which then closes the circuit between concentric resistive and collector tracks. This affords a noise-free, frictionless pickoff with infinite resolution and absence of track wear.

Cathode-ray-tube faceplates made of fiber-optic mosaics have a number of advantages in exacting display applications. Since the phosphor is applied directly to the inside face of the fibers, parallax is eliminated, and a brighter-than-normal focused image is available on the outside face of the tube. The image is brighter than normal because the fibers gather light rays that in ordinary glass would be scattered through 180 degrees.

Such an image can be photographed by contact-print methods, eliminating lenses and shutters, saving space and set-up time. Image flattening is often incorporated in the fiber optic faceplate, thus reducing distortion (see Fig. 5). Good resolution is available: a 3-inch diameter faceplate made by Mosaic Fabrications has 625 million fibers (a conventional television image can be resolved by 250,000 elements).

In photographing an oscilloscope trace, the most powerful lens usually available is an f/2.8. The equivalent numerical aperture of an f/2.8 lens working at 1:1 magnification is 0.09, therefore the light gathering power of a fiber-optic faceplate with an N.A. of 0.9 is $0.9^2/0.09^2$ or 100 times greater. Other factors may reduce this advantage somewhat.

Thus a fiber-optic faceplate has available a greatly increased amount of light or radiation energy. If this extra light is not all needed, several circuit improvements can be made: faster scanning rate, reduced final anode potential, lower scanning power, less screen burning and freedom from X-radiation, lower operating beam current, lower drive voltage, sharper focus, possibly even electrostatic instead of electromagnetic focusing.

Comparable advantages result from applying fiber optics to other image-handling tubes (see Fig. 6). Fiber-optic-faced vidicons respond to as little as 0.5 footcandle illumination on the tube face. For high resolution, vidicon faceplates use fibers as small as 0.0006 in. For more sensitive requirements, a fiber-optic image orthicon (RCA) can operate with as little as 0.02 footcandle on the tube face, and in special applications at much lower levels.

Manufacture of image orthicons with fiber-optic faceplates presents special problems because of chemical interaction between the photocathode and the fiber glass; also special sealing techniques had to be developed because of unusual expansion characteristics of the nonhomogenous fiber-optic faceplate.

A related use is in image-handling systems such as image intensifiers, where fiber-optic bundles are used as coupling between stages, again saving space and improving quality over lens systems. A possible two-stage image intensifier is shown in Fig. 7A. In such applications, extramural absorption coating is usually applied to preserve contrast of the faint images. A similar application is image intensification in X-rays to cut down exposure time.

A direct outgrowth of fiber optic faceplates are electrical mosaics, which consist of a glass matrix with metal wires running from one face to the other. The wire center-to-center spacing is 0.001 to 0.004 in., with wire diameters a tenth to half the space. They are used as cathode-ray-tube faceplates for direct electrostatic readout. This has been done successfully by A. B. Dick Co.

The resolution of a simple electrical mosaic is limited by capacitive coupling. An improvement is the chemically etched "intagliated" electrical mosaic, shown in Fig. 7B, which has low interelectrode capacitance and high writing-area efficiency.

A suitably designed fiber optic bundle can take an image in one form and convert it into a more convenient form, for recording, readout or other processing. A scan converter, illustrated in Fig. 8A, converts the rectangular image on a crt into a long thin image. If a photographic film is placed against the thin end of the converter, it can be moved continuously to record all information shown on the tube. This process increases the effective resolution of the image, and simplifies the recording or transmission of the image.

Such a system can be used with a high-speed, high-resolution facsimile transmitter. For instance, in transmitting a 20-in. wide detailed drawing using a flying-spot scanner with a 3-in. long scanning line, the smallest element size that could be resolved is about 0.02 in. in diameter. If a fiber-optic transformer bundle with 20,000 fibers of 0.001-in. diameter is used, an element size of at least 0.002 in. in diameter can be resolved.

Another image shape converter, shown in Fig. 8B, converts a circular trace to a straight line. Such a converter has been also used in reverse for a rotary-scanning spectroscope. Other possibilities are radial converters (radar and sonar), spiral converters (radar).

Image dissection with fiber optics can be used in flying-spot scanners, as shown in Fig. 9A. Fiber-optic coupling here is much more efficient than a lens system, and thus more light is transmitted with greater accuracy. This shows up in the system as an improvement in the signal-to-noise ratio of the

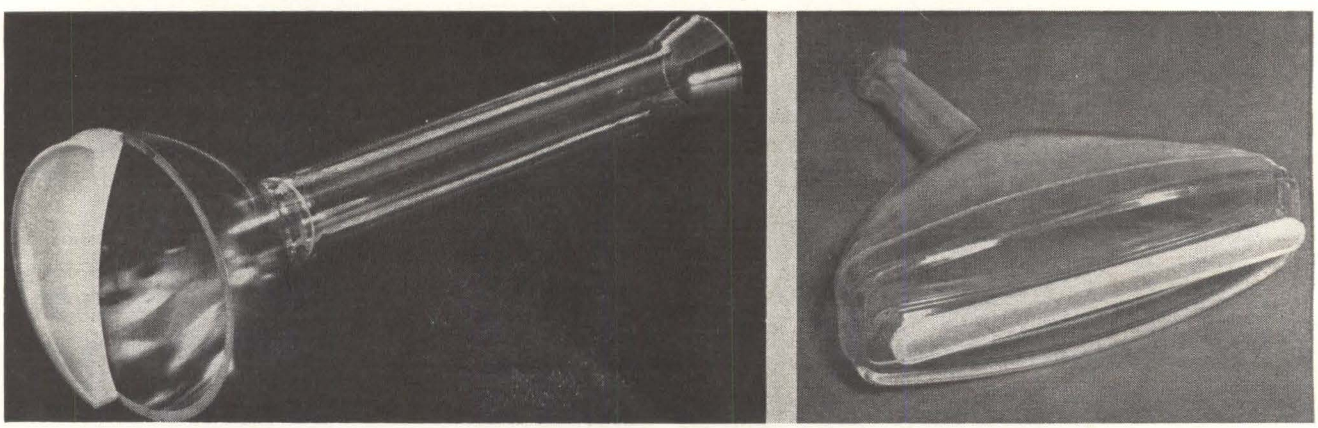

FIG. 5—Cathode-Ray-tube with image-flattening fiber optic faceplate, Mosaic Fabrications, (left); faceplate for full-page readout, with $\frac{3}{8}$ by $8\frac{1}{2}$-inch fiber-optic strip by American Optical, (right)

order of 25, and a consequent reduction in error rate, or a possible increase in scanning speed. Such scanners are also applicable in computers with optical memories.

A fiber-optic scanner using a revolving lens, developed by Gulton Industries, is shown in Fig. 9B. Here the crt image is transformed into a circle of fibers, and the rotating lens focuses each fiber successively onto a phototube.

Coding of secret messages is a classical application of fiber optics. A fiber bundle is aligned at both ends, then scrambled in the middle, potted and cut. The resulting halves serve as encoders or decoders: a scrambled message appears as a random scattering of black dots. The problem, of course, is how to make the scrambler reproducible in quantity. A device marketed by RCA for use by banks for coding clients' signatures is shown in Fig. 10.

At present, fiber optics is expensive, most of the cost being due to custom fabrication and precision labor. A 5-inch crt faceplate costs roughly $1,200; a 5-mm square flexible fiberscope four feet long costs $1,050. Incoherent and low-definition devices are cheaper, while image transformers and other custom items are considerably more expensive. Prices can be expected to

FIG. 6—Video tubes using fiber-optic faceplates, from top to bottom, cathode-ray tube, two image orthicons and a vidicon, all by RCA

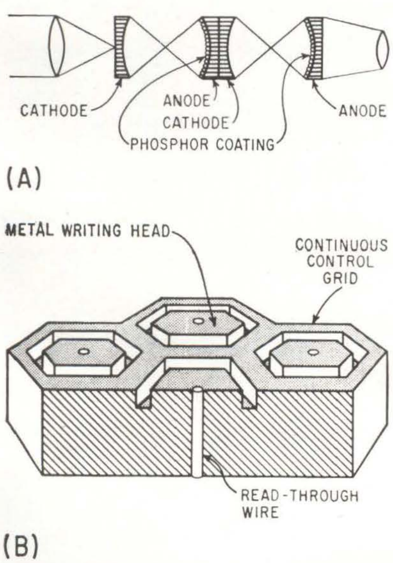

FIG. 7—Image intensifier, (A), uses fiber optic coupling between stages; an electrical mosaic such as used in an electrostatic readout c.r. tube, (B)

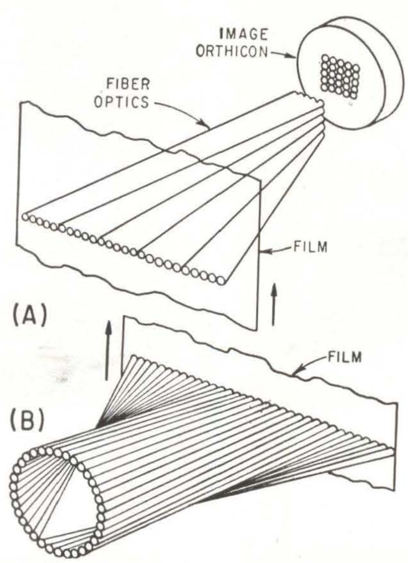

FIG. 8—Image converters transform information into more convenient form: raster to line, (A), circular-to-line, (B)—both can also operate in reverse

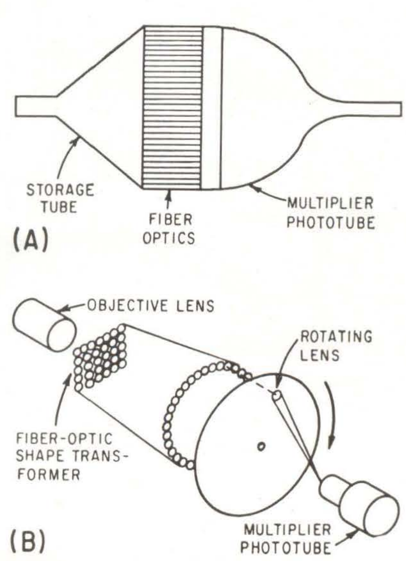

FIG. 9 — Fiber-optic flying-spot scanner, (A), can be used for reading optical memory in computer. Revolving-lens fiber optic scanner, (B) produces sequential scanning

drop as mass production and some degree of standardization are introduced.

Optical fibers are generally made for the visible spectrum, and their response falls off at both the ultraviolet and infrared ends. Recent researches have extended the range.

At the ultraviolet end, glass fibers transmit down to 3,300 angstroms, but 4,000 is the present practical limit. Quartz fibers operate to 2,000 angstroms but are difficult to clad.

In the infrared region, practical limit is 10 to 12 microns. Arsenic trisulfide glass is used for special infrared fibers, with experiments up to 25 microns in progress. At this end, the path length of the ray between reflections approaches half its wavelength and absorption results.

As the glass fibers are made thinner and their diameters become comparable to the wavelength of light, optical geometrical analysis no longer applies, and the fibers behave as dielectric waveguides, exhibiting waveguide transmission modes (see Fig. 10). It is then possible to calculate the waveguide modes that can be established and deduce the conditions for their excitation.

By its ability to sustain a relatively small number of modes with extremely low loss factor, the glass fiber fulfills one of the important conditions necessary to produce a laser action. Optical fibers, therefore, may find their most important application in the future not as simple light pipes but as conductors for ultrahigh-frequency radiation.

A single optical fiber replaces the ruby crystal in the laser; rather than acting as a resonator with both ends silvered, it is left "open" and acts as a traveling-wave oscillator or amplifier. Light travels in one direction throughout the length of the fiber, interacting with virtually all the atoms in its path, and emerging with high energy density. Fiber lasers have two main advantages:

By controlling the indices of refraction of the core and cladding materials, the modes of the laser can be varied, corresponding to different waveguide modes. This is not possible with crystal lasers.

Laser action by glass fibers is at much lower power levels than other existing laser schemes. Energy spikes from the fiber are much shorter than with a crystal; of the order of 0.5 microsecond compared to about 5 microseconds. A number of fiber lasers can be operated from one single low-power flash tube. The first fiber laser was built by E. Snitzer of American Optical Co. in Southbridge, Mass.

Laser fibers are commercially available (Mosaic Fabrications) in diameters from 0.5 to 8 mils; they are made of glass doped with neodymium, which produces the characteristic wavelength of 1.06 microns, and are about 30 inches long. The smaller fibers, 2 mils and below, can be wrapped around the laser flash tube. A subject of current research is the use of fiber lasers in computers, and for amplification of complete images.

Thanks are due to the following for their help in preparation of this article: Robert J. Potter, IBM; J. W. Hicks, Mosaic Fabrications, L. J. Krolak, RCA; L. E. Curtiss, American Cystoscope Makers; E. Snitzer and R. Kazarian, American Optical Co., N. S. Kapany, Optics Technology Inc.

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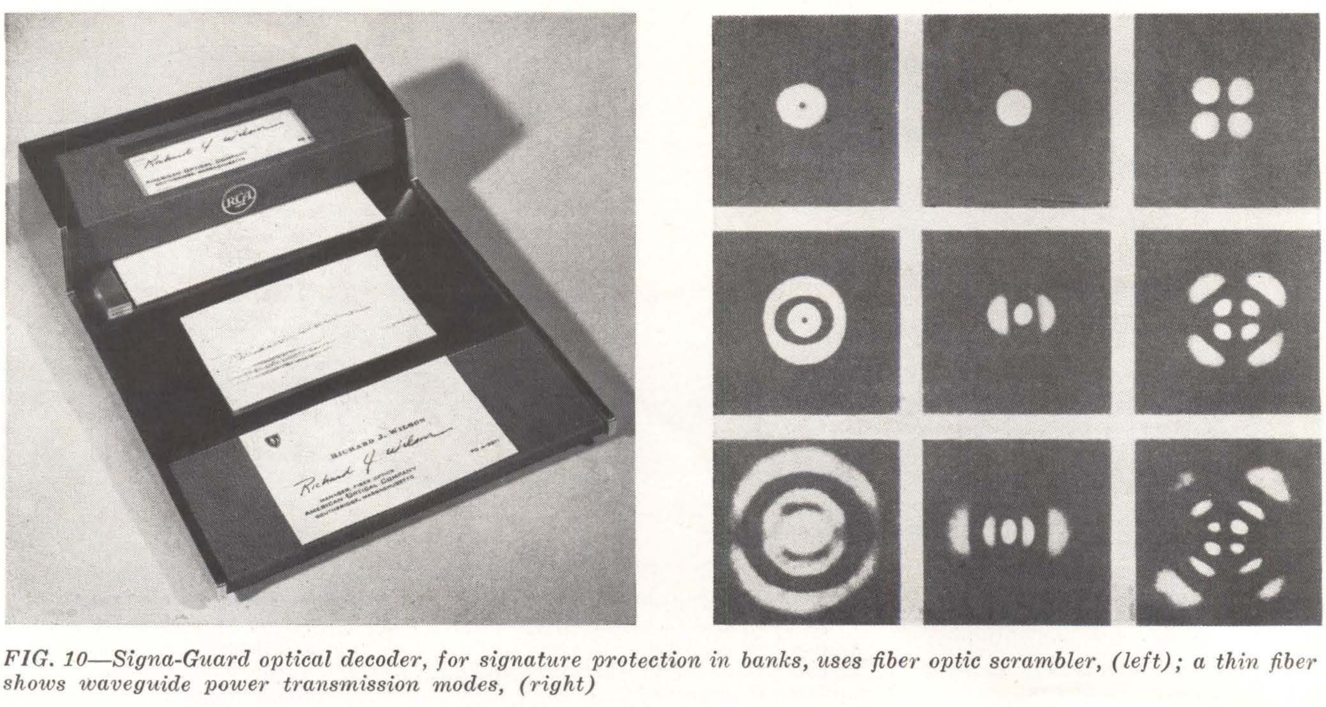
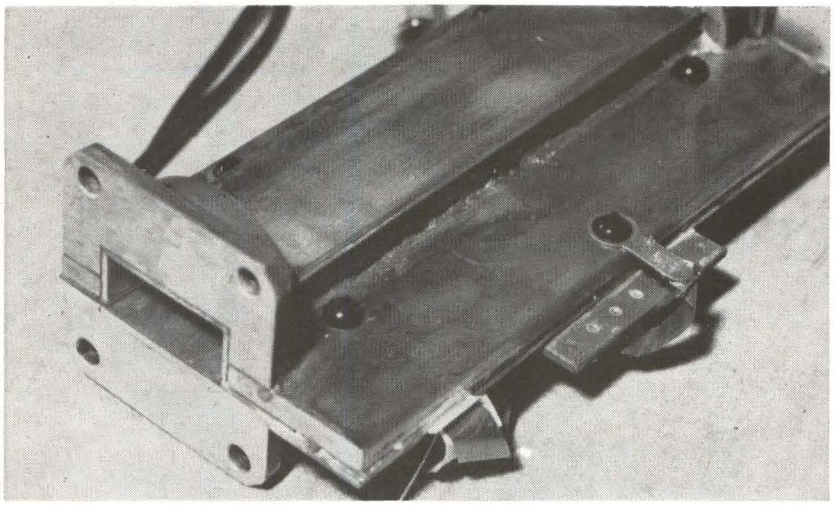


FIG. 10—Signa-Guard optical decoder, for signature protection in banks, uses fiber optic scrambler, (left); a thin fiber shows waveguide power transmission modes, (right)



Microwave tunnel diode mount. The diode is mounted underneath

EXTENDING

Tunnel Diode Operating Frequency

Using a special waveguide transformer and mounting, top operating frequency of a tunnel diode can be raised to 100 Gc

By KORYU ISHII
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ALTHOUGH TUNNEL (ESAKI) diodes are now commercially available only for frequencies up to X-band (8,200-12,400 Mc), it is possible to operate ordinary tunnel diodes at frequencies as high as 100 Gc.[1] Tunnel diodes are generally economical in comparison with thermionic devices, but this is not always true at microwave or higher frequencies; the price of microwave tunnel diodes rises rapidly with the operating frequency. For example, the X-band tunnel diode is 25 times more expensive than the audio-frequency tunnel diode and 5 times more expensive than the S-band (2,600-3,950 Mc) one. Thus, it is economical to use a low-frequency tunnel diode at the higher frequencies.

Given a tunnel diode mounted in a microwave circuit, the only physically adjustable parameter in the microwave circuit is the circuit itself. The microwave circuit must be designed so that the microwave impedance of the circuit matches the negative impedance of the tunnel diode at a desired operating frequency. A 1N3219A S-band tunnel diode was used in a microwave circuit designed to operate with this diode in the X-band.

A schematic diagram of the experimental system is shown in Fig. 1. The 1N3219A S-band tunnel diode (strip-line type package) was mounted in a specially designed X-band waveguide transformer. The waveguide transformer section was d-c insulated from the remainder of the X-band waveguide circuit to provide biasing and oscilloscope display. The tunnel diode was biased by either the variable d-c bias supply or sweep bias supply. The d-c bias voltage was read by a millivoltmeter and the volt-ampere characteristic of the tunnel diode displayed on the oscilloscope. Connecting flange *A* to *B* in Fig. 1, the microwave output of the tunnel diode was detected by an RWT microwave superheterodyne receiver and displayed on the output meter and oscilloscope, the E-H tuner was used for impedance matching and the isolator was used for stabilizing the circuit.

Frequency of oscillation was determined by the cavity wavemeter, waveguide shorting plunger and RWT receiver (a wide-range multiband receiver 2-75 Gc). The tunnel diode output power was compared with the output of a 2K25 reflex klystron test oscillator for the output power measurement. This method was used because the output power of the tunnel diode was too small for accurate measurement by a conventional power meter. Connecting flange *B* to *C* and waveguide switch 1 to 2 in Fig. 1, the reflex klystron output was fed to the receiver. The TPX-27PB/77A attenuator was adjusted to produce the same output meter reading on the receiver as the tunnel diode output. From the atttenuator reading and the power measured at the waveguide switch by the bolometer and the power meter, the output power of the tunnel di-

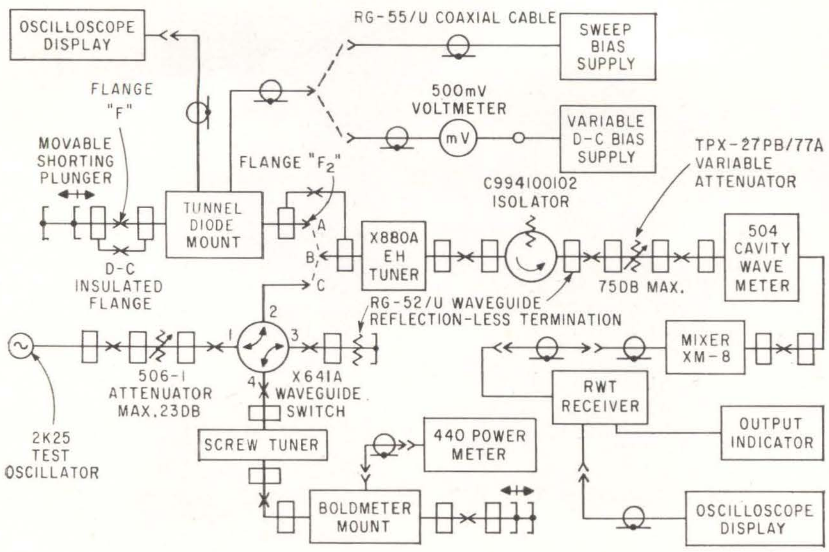

FIG. 1—Schematic diagram of the test circuit used to extend tunnel-diode operating frequency

ode was determined by calculation.

A sketch of the tunnel diode mount used in this experiment is shown in Fig. 2. The mount was designed for 8.5 Gc. It uses the tapered waveguide section for impedance transformation and a quarter wavelength line r-f bypass on one side of the guide and a three quarter line r-f bypass on the other side of the guide plus a resistive film network one half wavelength from the inside of the guide for the tunnel diode characteristic display. The two sections of the waveguide are insulated with polystyrene, and clamped with nylon bolts. The entire waveguide is insulated from the remainder of the microwave circuit by a dielectric spacer between the end flanges. The diode is mounted using a spring-loaded pressure contact and can be positioned at any point along the cross-section of the waveguide. This mounting allows the diode to be placed at the optimum position within the guide where input impedance to the mount provides a proper load to the diode for maximum power output.

Two film resistor strips were employed to suppress low-frequency parasitic oscillations and to display the diode volt-ampere characteristic for monitoring. Both film resistors were separated by a brass strip as shown in Fig. 2. Bias voltage was applied between the upper part of the waveguide and the brass strip. The bias voltage appeared between the upper and lower sections of the split waveguide and was applied to the horizontal axis of the scope. The voltage appearing across the 18-ohm resistance strip, which is proportional to the diode current, was applied to the vertical axis of the oscilloscope.

The design absorbs the junction capacitance of the diode into the distributed-parameter capacitance of the mount, thereby rendering it ineffective and enabling the diode to operate beyond its self-resonant frequency, determined by its series inductance and junction capacitance. Assuming both ends of the waveguide mount are matched, the load impedance presented to the tunnel diode was calculated using a modification of the method proposed by Tanaka.[2]

$$Z_l = \frac{1}{2}\left[\frac{T^2}{1+T^2} + j\frac{T}{1+T^2}\right]\frac{b_o}{b} \cdot \frac{\lambda_g}{\lambda_o} \quad (1)$$

λ_o is the operating free space wavelength, (meter)

λ_g is the operating waveguide wavelength, (meter)

b is the height of the rectangular waveguide, $(10.2 \times 10^{-3}$ meter)

b_o is the height of the tapered waveguide at the narrowest portion, $(1 \times 10^{-3}$ meter)

$$T \equiv \frac{2a}{\lambda_g}\tan\frac{\pi x_o}{a} \quad (2)$$

a is the width of the rectangular waveguide $(22.9 \times 10^{-3}$ meter) and x_o is the mounting position of the diode, that is the transverse distance from the waveguide wall to the center of the diode. The load impedance Z_l was calculated using a digital computer for the frequency range 8.5 Gc to 9.6 Gc for various mounting positions x_o. The magnitude and phase angle of the load impedance is shown in Fig. 3. These computed results indicate that the load impedance of this type of waveguide mount is suitable for matching to the tunnel diode impedance.

Before a signal can be detected using a receiver, the presence of microwave oscillations of the tunnel diode is evidenced by noting the shape of the volt-ampere characteristic displayed on the oscilloscope. When there is no oscillation, the *V-I* curve is smooth as shown by the top pattern in Fig. 4. When the

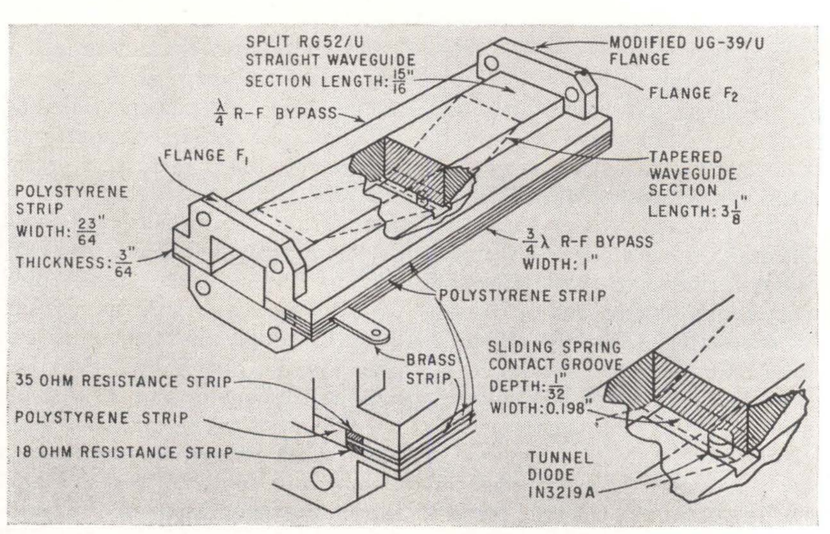

FIG. 2—Waveguide mount for the tunnel diode; the position of the diode can be adjusted continuously to find optimum input impedance

diode oscillates with adjustment of the microwave circuit, a step appears in the negative resistance portion of the *V-I* curve as shown by the middle pattern in Fig. 4. With strong oscillation, the step is more emphasized as shown by the bottom pattern in Fig. 4. It appears that this method of detection is more reliable than the use of a superheterodyne receiver at the extremely small signals encountered.

Once the presence of oscillation is observed from the oscilloscope display of the volt-ampere curve, the microwave superheterodyne receiver can detect the microwave output of the tunnel diode. The frequency of oscillation was checked with the cavity wavemeter and by measuring the waveguide wavelength using the shorting plunger. The three different ways of checking the S-band tunnel diode frequency agreed, indicating that the diode was indeed oscillating in the X-band. The frequency was very stable both for mismatching and for long time operation.

Factors determining the microwave tunnel diode oscillator performance were the shorting plunger, mounting position of the diode, bias voltage, dielectric block tuner and end flange insulation. The waveguide shorting plunger terminating one end of the tunnel diode mount has a certain effect on the tunnel diode performance. The plunger setting had a marked effect on the output power due to impedance matching. The output frequency deviation due to the shorting plunger was 8 Mc, which was small. When the output power was optimally adjusted, the shorting plunger had little control on frequency.

Theoretical analysis indicated that the load impedance to the tunnel diode varied as a function of the diode mounting position, as shown in Fig. 3. Thus, there is an optimum mounting position for a given diode. Although the experimental results indicate that $\frac{1}{3}$ of the waveguide width from the $\lambda/4$ r-f bypass wall is the optimum mounting position, the results might not be conclusive due to an uncontrollable contact resistance between the diode package and the waveguide. This experiment indicated that it may be advisable to silver-plate the contact surfaces to reduce the contact resistance. The operating frequency varied as much as 1.5 Gc with changes in the contact condition.

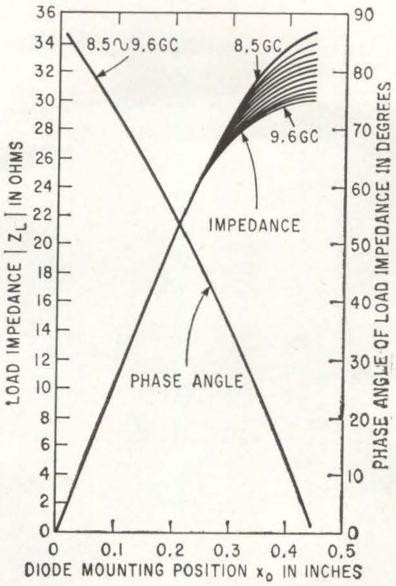

FIG. 3—Load impedance of the tunnel diode, and phase angle, against mounting position

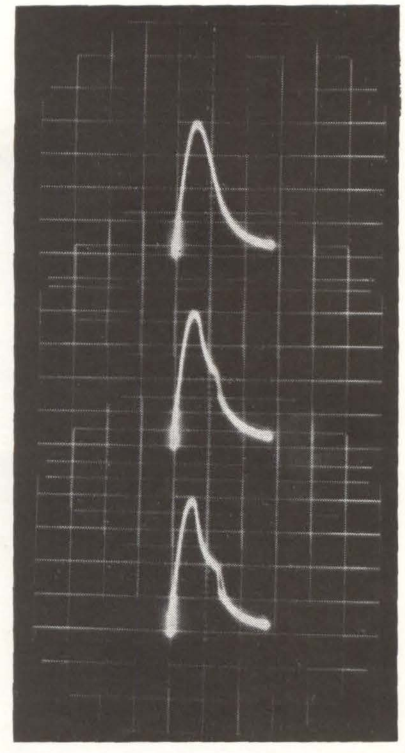

FIG. 4—Tunnel-diode voltage-current curve; no oscillation (top), weak (center), strong oscillation (bottom)

The bias supply voltage had significant influence on the output power and frequency. The experimental results indicate that the frequency can be varied over a range of approximately 60 Mc by adjusting the bias supply voltage. There exists an optimum bias supply voltage for maximum output at a given load impedance. Also the output power changed considerably with the bias voltage. To avoid this output power change during voltage tuning, the following experiment was performed. A dielectric block of 12 mm $\times$ 10.5 mm $\times$ 16 mm made of Plexiglass was mounted on the $\lambda/4$ r-f bypass so that the dielectric block could slide along the r-f bypass. The dielectric block was capable of changing the frequency over a range of 25 Mc with an output power change of less than 1 db with the bias voltage fixed for maximum power output.

The thickness of the insulation between the end flanges F_1 and F_2 in Fig. 1 had a considerable effect on the power output and the frequency of oscillation. The dielectric (polystyrene) spacer at flange F_1 had to be at least $\frac{1}{16}$ inch thick to obtain a high power output. Power output varied from -37.5 dbm to -25 dbm by using spacings of 0.004 inch to $\frac{1}{16}$ inch respectively. Negligible effect on frequency was noted. The spacing at flange F_2 had a large effect on frequency, but a negligible effect on output power. A frequency change of 1,710 Mc from 7,300 Mc to 9,010 Mc was observed by changing the spacing from 0.004 inch to 0.001 inch respectively.

The microwave tunnel-diode oscillator exhibited good frequency stability over a wide range of load mismatch. The 1N3219A S-band tunnel diode operated in the X-band producing a maximum frequency of 9.5 Gc with a maximum power output of -15 dbm. The diode was voltage tunable, the voltage tuning range being 40 Mc at 7.4 Gc which is comparable to or better than that of reflex klystrons.

The authors thank the Marquette University Computing Center for the use of the IBM 1620 digital computer. The authors also thank J. E. Billo, J. A. Stefancin and S. Krupnik, Jr., for their assistance.

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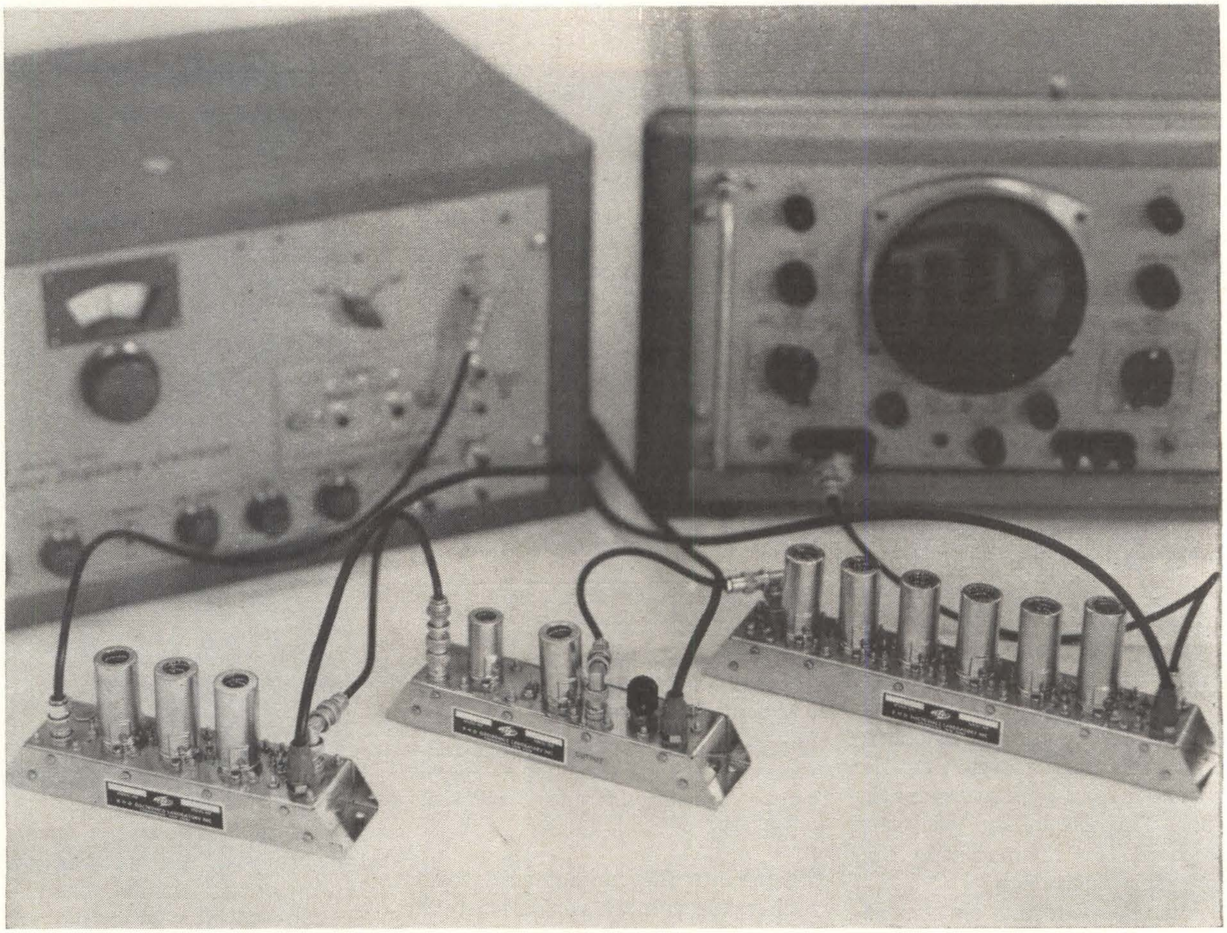

Variable bandwith filter can be used to make bandwith a function of signal level

Voltage-Variable Bandwidth Filter

Two-tube circuit has voltage controlled, continuously variable bandwidth between 200 Kc and 15 Mc at 30-Mc center frequency with nominal insertion loss of zero db

By RONALD HIRSCH, President, RHG Electronics Laboratory, Inc., Farmingdale, L. I., New York

DURING a military program to provide a search radar system with added flexibility and extended useful range, the requirement for several preamplifiers was presented. The existing system had a typical front end consisting of an X-band mixer and a 30-Mc low-noise preamplifier with 10-Mc bandwidth. To achieve a greater search range, the bandwidth of the system had to be narrowed since noise power is directly proportional to bandwidth.

The first thought was to provide a series of filters covering the range of bandwidths and a number of coaxial relays to choose the filter. However, this was a cumbersome technique, offered only a series of steps of bandwidth, and was mechanical. The following characteristics were deemed optimum; bandwidth should be variable from 500 Kc to 15 Mc; adjustment should be continuous, not steps; insertion loss should be 0 db nominal at all settings; control should be accomplished by a voltage or current of low power drain; the device should be all electronic, with no moving parts and should be of reasonable size and easy to install.

The circuit of Fig. 1A shows that variable bandwidth is achieved through control of bias on a grounded-grid stage. Power gain of the pentode stage is $Gm_1^2\ R_1\ R_L$ while power gain of the triode is $Gm_2\ R_o$. However, $R_L = (r_p +$

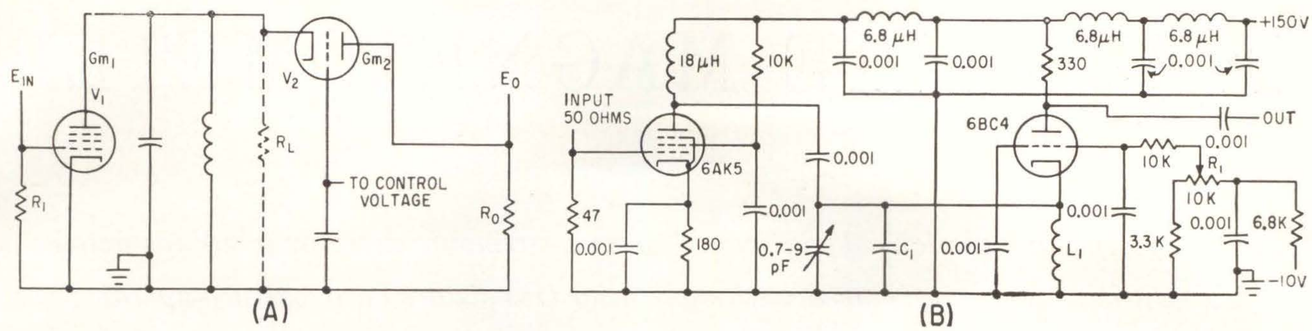

FIG. 1—Basic circuit of variable bandwidth filter (A) and final circuit (B)

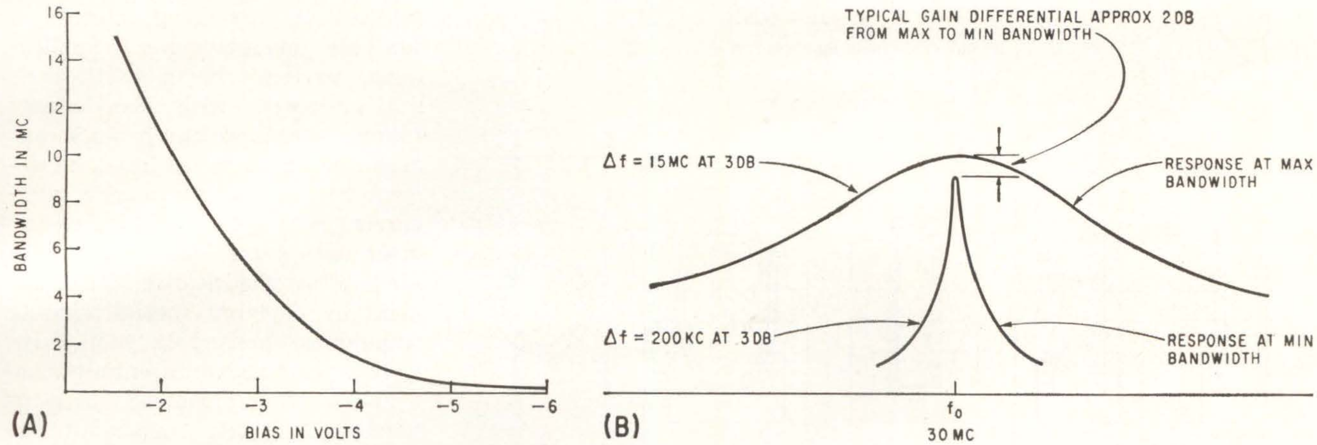

FIG. 2—Bandwidth against applied bias in a typical performance (A) with bandpass response (B)

$R_o)/\mu$ in parallel with the coil interstage losses. Neglecting the interstage losses and assuming that R_o is small compared to r_p, then $R_L = r_p/\mu = 1/Gm_2$. The gain of the pentode stage is then $Gm_1^2 R_1 (1/Gm_2)$ and the overall gain then becomes $Gm_1^2 R_1 R_o$. However, the interstage bandwidth is $1/2\pi C R_L$ and since $2\pi C$ is constant, the bandwidth varies directly as the Gm of the triode.

As tube loading approaches circuit loss loading, a slight reduction in overall gain occurs. The interstage tank circuit uses high-Q components, and allows narrow bandwidths to be achieved.

The two important factors in the design of the unit in Fig. 1B are the available Q in the interstage, and the input impedance at the cathode of the grounded-grid stage at its normal operating point. For the 6BC4, $1/Gm \cong 100$ ohms is the resistive load at widest bandwith (heaviest damping) presented by the tube; using $\Delta f = 1/2\pi RC$ and $C = 1/2\pi R \Delta f$ with $\Delta f = 15$ Mc and $R = 100$ ohms, $C \cong 105$ pf. Thus to achieve a maximum bandwidth of 15 Mc when the 6BC4 is operating in the normal current region, a total shunt capacitance of 105 pf must be provided.

Allowing about 15 pf for tube capacitance, a padding capacitance of 90 pf must be used. In the actual circuit, an 82-pf mica and a 1-9 pf glass trimmer supplied this amount.

To minimize the effects of coil loading, coil Q must be kept as high as possible. At 30 Mc, to resonate with 105 pf, a coil of about 0.28 μh is required. This coil may be achieved by winding 5 turns of No. 12 wire on a ½-inch form. To insure the best Q, silver wire should be used.

Measurements of Q indicate that it is well over 350, and will have little effect on the circuit.

If a standard slug-tuned coil were used, the available Q would have been less than half this amount.

Referring to Fig. 1B note that a 330-ohm resistor is used in the plate of the 6BC4. This is a d-c return as the load resistor of 50 ohms, which is used externally, will control the impedance level. Should the saturation capability be too low for an application, this impedance level may be raised by an r-f transformer.

Figure 2A shows a plot of bandwidth against applied bias. This curve can be shaped to any pacticular curve desired through the use of large cathode resistors, plate resistors, and networks preceding the bias input to the grounded-grid stage.

Figure 2B is a presentation of bandpass response at maximum and minimum settings of R_1.

There are many applications where this instrument will offer advantages.

Several of these are: laboratory studies of noise and related phenomena where system bandwidths (and, therefore, noise bandwidths) must be optimized; panoramic receivers, to achieve variable resolution; radar receivers, where the stc voltages or agc voltage may be used to improve s/n ratios by narrowing bandwidths; and evaluation of optimum fixed bandwidths in systems by substituting a variable device in prototype system.

FLUX-GATE MAGNETOMETER

Toroidal core with semicircularly wound second-harmonic detector windings acts as a field-sensitive element, is used with switching transistors in a battery-operated flux-gate magnetometer of small size, light weight and minimum power requirements

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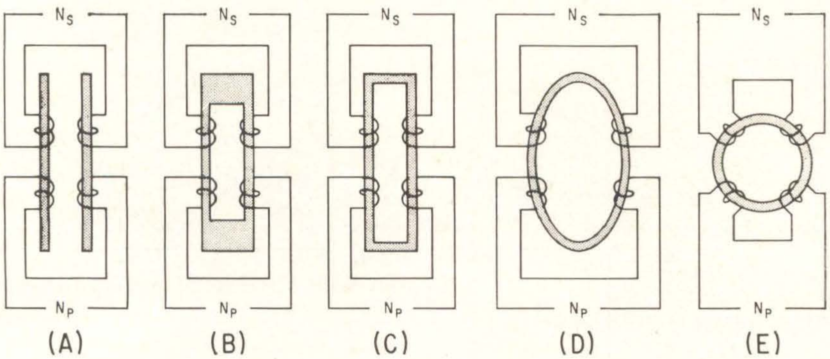


FIG. 1—Various core configurations illustrate the evolution of the ring-core flux-gate magnetometer

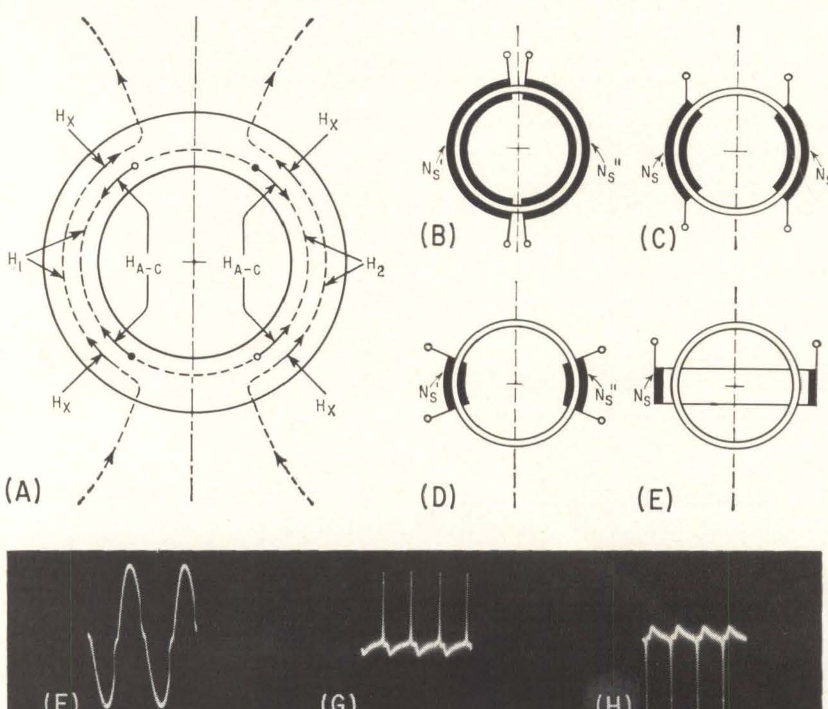


FIG. 2—Fundamental principle (A) of the ring-core flux-gate element; various windings arrangements with winding angles of 180 deg (B), 90 deg (C) and 45 deg (D), plus the single-winding type (E); waveforms characterizing the operation: exciting current (F), phase-reversible output voltage (G and H)

IN VIEW OF increasing interest in flux-gate magnetometers applications, particularly in earth-satellite equipment with solar-battery supply, recent research work has produced an improved flux-gate element with minimized magnetizing-current requirements. This development uses a toroidal core without air-gap as the field-sensitive element by applying special winding techniques, preferably semi-circularly wound and differentially connected second-harmonic detector windings.[1] Other important aspects are various advantageous circuit configurations and a novel method for providing the a-c excitation of a ring-core flux-gate element from a switching-transistor magnetic-coupled multivibrator so that the oscillation frequency is solely determined by the parameters of the ring core and its excitation windings.[2] Since, in this arrangement, the core flux is swinging between saturation levels, and because all parts of the ring core operate in the saturation region, memory effects are eliminated.

The field-sensitive elements of conventional forms of second-harmonic flux-gate magnetometers[3] consist of two parallel nickel-iron alloy strips or scrolls, Fig. 1A, with series-aiding a-c excitation (primary) windings N_P and series-opposing detector (secondary) windings N_S. In such straight-core structures with a large air gap (open magnetic circuit), the effective permeability (μ_{eff}) is a function of the core geometry as well as of the permeability of the magnetic material itself.[4] To obtain a high sensitivity of these flux-gate elements (a high value of μ_{eff}), the longitudinal dimension of the straight cores is generally great in

USES TOROIDAL CORE

proportion to the transverse dimension.

In the modified flux-gate construction of Fig. 1B, a closed magnetic circuit has been provided to reduce the magnetizing current requirements. This construction, however, has the serious disadvantage that, although the magnetic material near the rectangular core window may be driven well into saturation, large portions of the core do not operate in the saturation region. Thus, undesirable memory effects, due to remanence after applying a large external field, may be produced in this type of single-core flux-gate element.

This undesirable property of the core configuration of Fig. 1B can be eliminated by applying a rectangular core, Fig. 1C, having substantially the same cross-sectional area around the core window. Figures 1D and 1E show that either an elliptical or toroidal core may be used equally well, provided that the effective permeability μ_{eff} has a sufficiently high value. The ring-core structure of Fig. 1E provides the important advantage that commercially available, either tape-wound or laminated (washer-type), cores can be used without any change, by varying the arrangement of the windings.

The results of investigations with toroidal cores of various sizes and different core materials have shown that the effective permeability μ_{eff} of such a ring-core flux-gate element is a function of i-d/o-d ratio and mean diameter of the core, as well as of the permeability of the magnetic material. For example, when using Supermalloy 2-mil tape cores (i-d/o-d ratio is in the range from 0.85 to 0.98; mean diameter is 0.5 to 1.5 in., or less) with semicircularly wound and differentially connected second-harmonic detector windings, a sensitivity of 1,000 microamperes per oersted or 1 volt per oersted can be achieved.

Besides the possibility of employing such commercially available toroidal cores, application of ring-core flux-gate elements has these advantages:

(1) Relatively high excitation frequencies, above 10,000 cps, may be used by taking full advantage of the favorable magnetic properties of ¼-mil or ⅛-mil tapes (considerably reduced eddy-current losses and skin effect), preferably wound in the usual way on small, ceramic bobbins. Such ultrathin tapes, however, can not be used successfully for the conventional straight forms of flux-gate elements, Fig. 1A.

(2) The size of ring-core flux-gate elements may be correspondingly reduced (mean diameter = 0.5 in., or less) to permit point measurements on small areas of inhomogeneous fields.

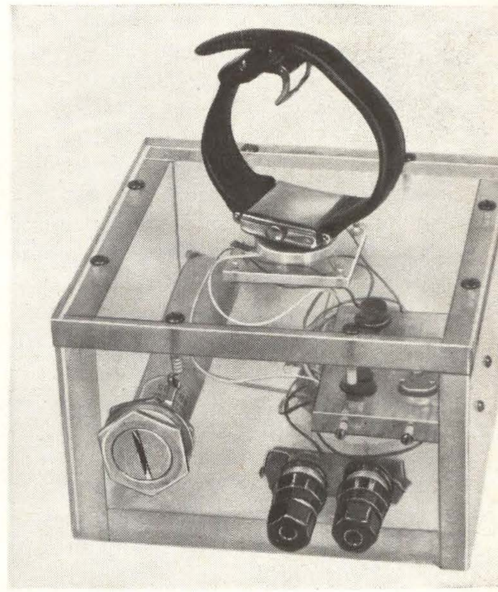
(3) Because a closed magnetic circuit is provided in the ring-core structure, the magnetizing-current requirements are reduced to the minimum.

(4) Since all parts of the ring core, acting as a flux-gate, operate in the saturation region, memory effects, due to remanence after applying a large external field, are eliminated.

(5) Because the two active parts of the flux gate; that is, the two semicircular portions of the ring core, belong to the same core, the matching of the magnetic characteristics of these parts is greatly facilitated.

(6) Distortion of the magnetic field in the vicinity of a ring-core flux gate is inherently independent of its angular position. This contrasts with the properties of straight-core flux gates, Fig. 1A, and other core configurations, Fig. 1B to Fig. 1D, where the field-distorting effect depends upon the angular position of the flux gate.

(7) The symmetrical core structure of a ring-core flux-gate element, Fig. 1E, makes it possible to apply, for special purposes, several second-harmonic detector windings having different angular displacements with respect to the direction of the external field. Application of such multiple detector windings on a common core permits, for example, removing the cosine-law directivity and providing an omnidirectional magnetometer having a nearly circular directional characteristic, for coverage in all directions in a horizontal or vertical plane.



Demonstration magnetometer with ½-inch flux gate and polarity-sensitive demodulator uses 6.75 v, detects movements of ferromagnetic parts of watch

Although the ring-core structure and the conventional flux-gate structure with two parallel straight-core elements are different, their operating principle is the same. Figure 2A shows that the semicircular portions of the toroidal core are influenced alternately, by the sum of difference of $H_{A\text{-}c}$ and the external steady field H_X to be measured during both half-cycles of the exciting a-c magnetomotive force $H_{A\text{-}c}$ for example, the earth's field. Thus, the total magnetomotive force in these semicircle portions will be $H_1 = H_{A\text{-}c} + H_1$, and $H_2 = H_{A\text{-}c} - H_X$. The magnetomotive forces, H_1 and H_2, give rise to corresponding fluxes, $\phi_1 = \phi_{A\text{-}c} + \phi_{SH}$, and $\phi_2 = \phi_{A\text{-}c} - \phi_{SH}$. The first component, $\phi_{A\text{-}c}$, is common to both semicircle portions of the core and varies with the excitation frequency. The second (even-harmonic) component, ϕ_{SH}, exists because of H_X combined with $H_{A\text{-}C}$. The corresponding phase-reversible second-harmonic output voltage, produced across the detector windings, is a measure of the external field influencing the toroidal core which acts as a flux gate.

The semicircle portions of the ring core, Fig. 2A, operate like two separate cores, corresponding to the two parallel strips or scrolls, Fig. 1A, for second-harmonic flux components. These flux components can be utilized by second-harmonic detector windings, which are associated with the semicircle portions of the core. These windings are uniformly distributed along the semicircular portions of the core (winding angle = 180 degrees), as shown in Fig. 2B, but smaller winding angles, Fig. 2C and 2D, or a single, diametrically wound detector winding, Fig. 2E, may be applied equally well.

In a given magnetic field, the second-harmonic output voltage varies from a maximum (when the axis of the ring-core element indicated in Fig. 2B to 2E and the field are parallel) to zero when they are perpendicular (cosine-law directivity). Thus, the symmetry axis of the ring core must be aligned with the field being investigated to insure measurement of the total field. Three orthogonal flux-gate elements of this type may be employed in the usual way, in combination with various kinds of second-harmonic or total-even-harmonic detector systems.

The oscillograms of Fig. 2F to 2H show waveforms of the exciting current (400 cps) and of the phase-reversible even-harmonic output voltage (800 cps) corresponding to a Supermalloy washertype core which consists of three 6-mil laminations (inside diameter = 1.125 in., outside diameter = 1.500 in.). This output voltage may be measured in the usual way by a phase-sensitive detector system; for example, a polarity-sensitive demodulator operating with a center-zero-scale, d'Arsonval-type, indicating or recording, instrument.

Second-harmonic flux-gate magnetometer circuits may be subdivided into two main groups:

(1) Transformer-type circuits with several winding units which are isolated from each other and are used separately as a-c excitation windings and second-harmonic detector (pickoff) windings.

(2) Bridge and differential circuits with autoconnected winding units acting simultaneously as a-c excitation windings and second-harmonic detector windings.

The choice of circuit configuration may be influenced by the properties of the even-harmonic detector system. Such systems may be classified as:

(a) Second-harmonic detector systems, in which the second-harmonic component of output voltage is selected by filtering and used to control a tuned vacuum-tube or transistor a-c amplifier having a phase-sensitive rectifier (demodulator) in its output circuit.

(b) Even-harmonic detector systems, in which the peak height of the even-harmonic output-voltage waveform, Fig. 2G and 2H, is measured after a-c amplification by a polarity-sensitive peak rectifier acting as a demodulator.

(c) Even-harmonic detector systems without a-c amplifier, in which the even-harmonic output voltage is measured directly by a polarity-sensitive demodulator, as widely used with even-harmonic-type magnetic modulators (static d-c to a-c signal converters.)

Figure 3A shows a transformer-type ringcore magnetometer circuit with a simple polarity-reversible demodulator[5] consisting of a parallel-rectifier combination $D'D''$, and a reservoir capacitor C with d'Arsonval-type, center-zero-scale microammeter M. Because operation of this form of demodulator

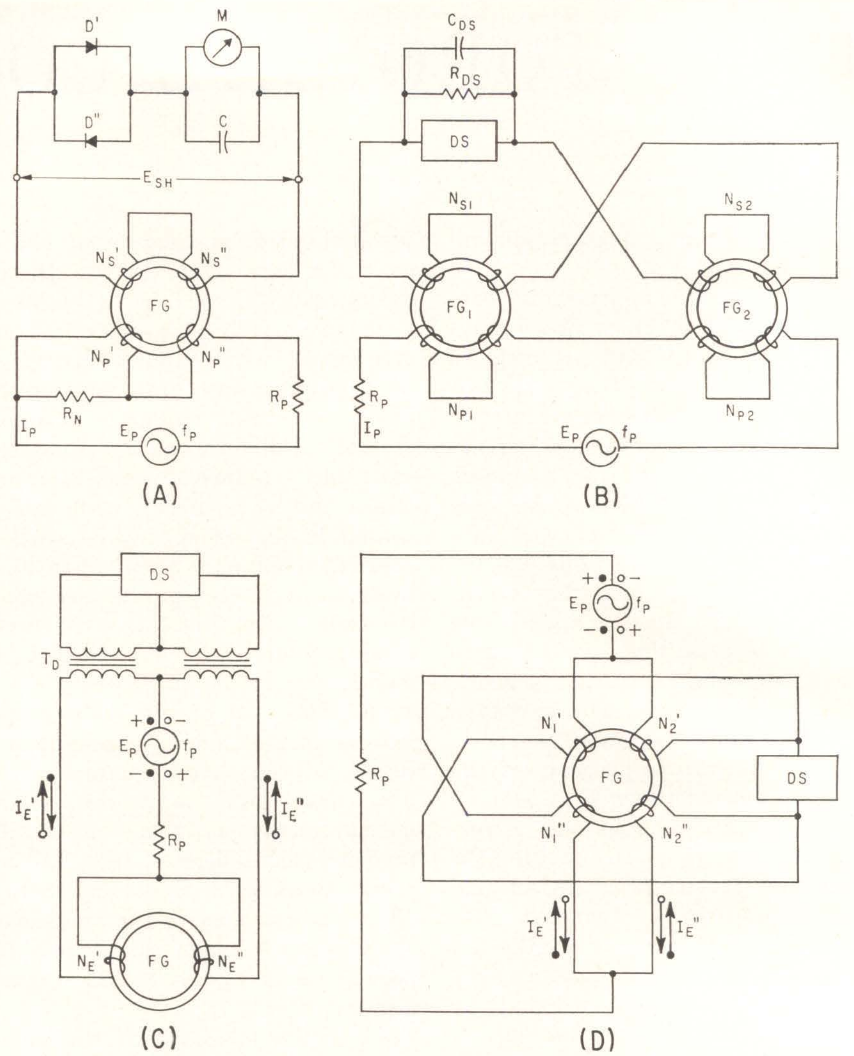


FIG. 3—Transformer circuits: magnetometer (A) with a single flux gate; gradiometer (B) with two equally rated flux gates. Autoconnected magnetometer circuits: differential (C) with two windings and center-tapped output transformer; bridge (D) with four equally rated windings

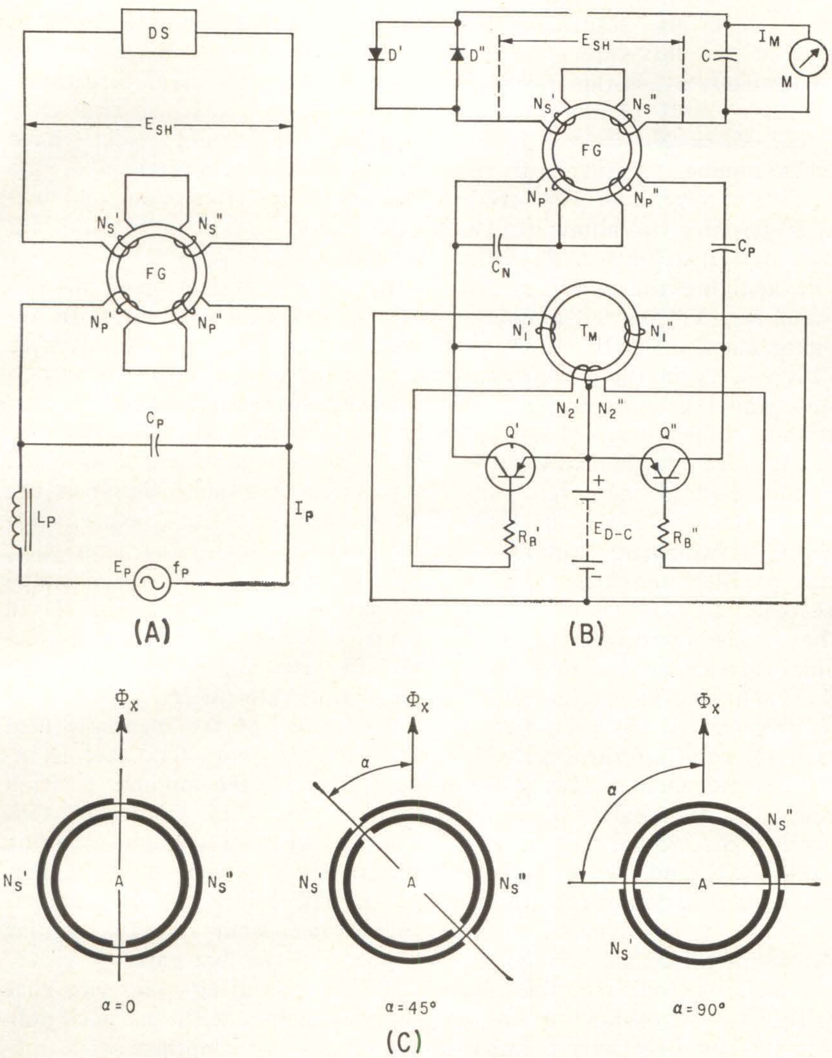


FIG. 4—A-c excitation: ferroresonant circuit (A); switching-transistor magnetic-coupled multivibrator (B). Angular positions (C) element with semicircularly wound second-harmonic detector windings

is governed by the level to which the second-harmonic output-voltage pulses are adjusted, it is necessary to fulfill these conditions:

(1) The slope of the voltage-current characteristic of the diodes D', D'' must change rapidly near the origin. Copper-oxide rectifier elements have proven to be suitable, but germanium diodes may be used equally well.

(2) Performance of such a polarity-sensitive demodulator circuit may be improved (higher sensitivity of the magnetometer) by introducing asymmetry between the two windings on the semicircle portions of the core. In the arrangement of Fig. 3A, selection of the winding unit (N_P' or N_P'') and determination of the optimum value of the shunt resistor R_N (about 10,000 to 30,000 ohms) are made empirically.

In the gradiometer circuit, Fig. 3B, with two equally rated ring-core flux-gate elements, FG_1 and FG_2, the primary windings, N_{P1} and N_{P2}, are series-aiding connected, while the secondary windings, N_{S1} and N_{S2}, are series-opposing connected. The second-harmonic output voltage across the detector system *DS* is linearly proportional to the difference between the field intensities influencing the flux gates, FG_1 and FG_2. Figure 3B also shows that the sensitivity of the gradiometer and that of other ring-core flux-gate magnetometer circuits may be increased by connecting across the second-harmonic output terminals a capacitor C_{DS} which tunes the output circuit to the second harmonic and provides a positive-feedback effect. As indicated in Fig. 3B, it is advisable to add a shunt resistor R_{DS} to this tuning network to prevent instability of the detector system.

In the differential circuit of Fig. 3C, the two portions of the center-tapped transformer winding are primary windings, and the secondary winding of the differential transformer T_D (in this example with center tap) may be matched with the input resistance of the detector system *DS*; for example, a vacuum-tube or transistor amplifier. The a-c supply with current-limiting resistor R_P is connected with the a-c excitation windings N_E', N_E'' so that an alternating magnetomotive force, $H_{A\text{-}C}$, is produced in the core, Fig. 2A.

Figure 3D shows a bridge circuit, the four branches of which consist of the toroidal winding units N_1' N_1'' and N_2', N_2''. These four equally rated winding units are associated with the two semicircle portions of the core so that the second-harmonic output voltage appearing across the detector system *DS* is proportional to the difference of currents I_E' and I_E''.

To eliminate memory effects, the primary requirement to be met by the a-c excitation source is that it deliver sufficient power to drive the core material well into saturation. A small 400-cycle generator is often a desirable way for feeding such circuits. This includes application of a ferroresonant constant-voltage transformer to obtain stability of operation.

Figure 4A illustrates use of the ring-core flux-gate element as the saturating reactor of a parallel-connected ferroresonant circuit. The linear reactor L_P with a Molybdenum-Permalloy powder core is a current-limiting impedance. Constant average value of the excitation voltage across the primary windings N_P', N_P'' and minimum of the supply current I_P can be obtained by selecting the proper rating of capacitor C_P.

Another method for providing the a-c excitation is preferred where small size, light weight and power drain not exceeding 20 to 50 milliwatts are of prime importance. This method consists in combining the ring-core flux-gate element with a switching-transistor magnetic-coupled multivibrator so that the oscillation frequency is determined by the parameters of the ring core and its excitation windings. Since the core is swinging between saturation levels, and because all parts of the ring core operate in the saturation region, memory effects are eliminated.

In Fig. 4B, the excitation windings N_P', N_P'' of the ring-core flux gate *FG* are supplied from a miniature common-emitter multivibrator operating as a static d-c to a-c power converter with 70 to 80 percent efficiency. This prototype design contains:

(1) The flux-gate element, *FG*, with a tape-wound Supermalloy core having 26 wraps of 2-mil tape (tape width = 0.125 in.) and an inside diameter of 1.375 in. or 1.750 in., respectively ($N_P' = N_P'' = N_S' = N_S''$ = 800 turns of No. 34 wire).

(2) A transformer, T_M, with (unsaturated) Supermalloy 2-mil tape core (i-d = 1.00 in., o-d = 1.25 in., tape width = 0.25 in.), primary windings ($N_1' = N_1''$ = 800 turns of No. 32 wire, and feedback windings ($N_2' = N_2''$ = 400 turns of No. 32 wire).

(3) Two *pnp* switching transistors, Q' and Q'', type 2N43A.

(4) Two bias resistors, $R_B' = R_B''$ = 4,000 ohms.

(5) Blocking capacitor, C_P = 2 microfarads, which prevents direct current from flowing through the a-c excitation windings N_P' N_P'' of the flux-gate element.

(6) The d-c power supply (6-volt battery).

(7) A polarity-sensitive even-harmonic detector system, corresponding to the arrangement of Fig. 3A.

(8) A shunt capacitor, C_N = 0.1 microfarad, which provides high sensitivity of the magnetometer by introducing asymmetry between the windings, N_P' and N_P'', on the semicircle portions of the core.

There are many other such multivibrators in which the electrodes of the two switching transistors are connected in different ways with the primary windings N_1', N_1'' and feedback windings N_2', N_2'' of the transformer T_M. In the preferred arrangement of Fig. 4B, the oscillation frequency of the multivibrator circuit is determined by the parameters of *FG* and is given by

$$f_O = \frac{E_{D\text{-}C}}{4\, B_S\, A_{FG}\, N_P} \times 10^8$$

where $E_{D\text{-}C}$ is the d-c supply voltage (volts,) B_S is the saturation-flux density of the flux-gate core material (gauss), A_{FG} is the cross-sectional area (cm^2) of the toroidal core and $N_P = N_P' = N_P''$ is the effective number of turns of the multivibrator circuit of Fig. 4B.

It is possible to eliminate the unsaturated transformer T_M, Fig. 4B, by applying the windings N_1', N_1'' and N_2', N_2'' on the ring-core flux-gate element itself. However, any asymmetry in the circuit components and the characteristics of switching transistors, Q' and Q'', will introduce an undesirable d-c flux component in the core. Thus, the arrangement of Fig. 4B with separate unsaturated transformer T_M and d-c blocking capacitor C_P is preferred.

The cosine-law directivity of a toroidal core acting as a field-sensitive element in the magnetometer circuit of Fig. 4B has been demonstrated by rotating the core, Fig. 4C, in a homogenous magnetic field produced by Helmholtz coils. The respective directional characteristic; that is, the microammeter current I_M as a function of the angular deviation α of the symmetry axis A from the direction of the external field ϕ_X, indicates the relationship: I_M = constant $\times$ cos α. The cosine-law directivity is important in direction-finding systems (Permalloy compass). In using the ring-core flux gate for direction finding, the position for minimum rather than maximum response will be used because the percentage of change of response with small change in core position is much greater in near zero output; that is, around the zero position of the pointer of the microammeter M in the arrangement of Fig. 4B.

The symmetrical core structure of this type of flux gate makes it also possible to apply several second-harmonic detector windings having different angular displacements with respect to the direction of the external field ϕ_X. Using a single toroidal core having three groups of detector windings and bridge-type, full-wave rectifiers with series-connected d-c terminals, an omnidirectional flux-gate magnetometer was developed for coverage in all directions in a horizontal or vertical plane. It was possible to remove the cosine-law directivity of ring-core flux-gate elements with a single group of detector windings and to provide a magnetometer with nearly circular directional characteristic. Measurements with rotating Helmholtz coils have shown that the deviations of the characteristic from the ideal circular characteristic are about ± 2 percent.

In a given angular position (α) of the flux-gate element with respect to the field ϕ_X, preferably with α = O, the second-harmonic output, for example, the microammeter current I_M, in Fig. 4B, is a function of the actual magnitude of ϕ_X which represents the input signal of the magnetometer. Thus, experimentally determined characteristics, $I_M = f(H_X)$, may be termed input-output characteristics. This is in contrast to the directional characteristics showing $I_M = f(\alpha)$, with a constant value of H_X.

Distortion of the magnetic field near the ring-core flux gate is independent of the angular position of the core. This contrasts with the properties of straight-core flux gates, Fig. 1A, and those of Fig. 1B to 1D, where the field-distorting effect depends upon the angular position of the flux gate.

When operating the ring-core magnetometer with a push-pull-type magnetic amplifier with infinite internal gain, the d-c flux in the core is balanced by an opposing d-c flux (self-balancing flux-gate magnetometer).[6] The output current of the magnetic amplifier is varied by an infinitesimal d-c flux increment in the semicircle portions of the ring core; and the external magnetic field to be investigated; for example, the earth's field near this core, remains undisturbed. In a modified arrangement acting as a gradiometer,[6] a similar balance method may be applied for measurement of inhomogeneity of magnetic fields.

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SIMPLE TRANSISTOR Q-Multiplier or Oscillator

Insensitive to temperature drift of transistor parameters,

this circuit uses only one coil to achieve high Q multiplication

By JAMES R. WOODBURY

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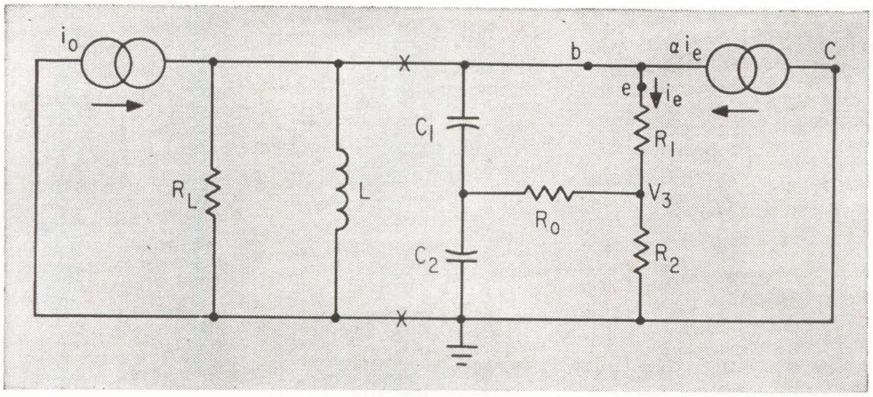


FIG. 1—Equivalent circuit of the Q-multiplier or oscillator configuration

A USEFUL ACTIVE Q-multiplier network, often overlooked by filter or oscillator designers, is shown in Fig. 1. Using stages of this type, filters requiring high Q's can be built with ordinary coils. However, the circuit is often not considered because it is assumed that a Q multiplier, especially one using a germanium transistor as the active element, is too sensitive to temperature variations to be practical. But with proper design the circuit Q can be made insensitive to drift in the parameters of the active element.

The active element in Fig. 1 is represented by the three-terminal constant-current generator, αi_e. If the element represents a transistor, the emitter, base, and collector will correspond to points *e*, *b* and *c*; and $\alpha < 1$. If the active element is a vacuum tube pentode, *e*, *b* and *c* would correspond to cathode, grid, and plate; and $\alpha = 1$. The effect of a finite emitter resistor, r_e (or vacuum tube transconductance, g_m) is included in resistor R_1. The frequency response of the transistor can be inserted by using the usual R-C approximation

$$\frac{1}{\beta} = 1 - \alpha = \frac{1}{\beta_o} + \frac{p}{\omega_t}$$

where p is the frequency variable ($j\,\omega$ for steady state sinusoids). The collector-to-base (or plate-to-grid) capacitance may affect the tank circuit center frequency slightly, but otherwise it can be neglected.

Resistance R_L includes the generator (i_o) impedance and the equivalent shunt conductance of the coil. The output can be taken either at V_3 (in which case R_2 includes the load resistance as well as the emitter, or cathode, biasing resistor); or the output can be taken, usually with some loss, from a resistor in series with the collector (or plate).

The nodal equations for the circuit looking to the right of XX determine the input admittance at this point as

$$Y_1 = C_s[ap + (b - ae) + \Delta] \quad \text{where}$$

$$\Delta = \frac{ae^2 - eb + c}{p + e}, \quad a = 1 + \frac{R_p}{\omega_t R_1}\left(\frac{1}{R_2 C_s} + \frac{1}{R_o C_1}\right)$$

$$b = R_p\left[\frac{1}{R_o R_2 C_2} + \frac{1}{\beta_o R_1}\left(\frac{1}{R_2 C_s} + \frac{1}{R_o C_1}\right) + \frac{1}{\omega_t R_o R_1 R_2 C_1 C_2}\right],$$

$$c = \frac{R_p}{\beta_o R_o R_1 R_2 C_1 C_2}, \qquad e = \frac{1}{(R_o + R_{p1})(C_1 + C_2)}$$

$$\frac{1}{R_p} = \frac{1}{R_o} + \frac{1}{R_1} + \frac{1}{R_2}, \qquad \frac{1}{R_{p1}} = \frac{1}{R_1} + \frac{1}{R_2}, \qquad \text{and}$$

$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2}.$$

The Δ term in most cases is negligible and will be dropped.

Including the generator and inductor, the circuit therefore becomes a simple shunt RLC. The total shunt conductance is: $G_T = C_s\ (b - ae) + 1/R_L$. This can be made negative, in which case the circuit will be an oscillator, or slightly positive, in which case the Q can be multiplied by any desired factor, depending on the stability requirements. Circuit resonant frequency is $\omega_o = 1/\sqrt{LC_s}$, and the Q is: $Q = 1/G_T\omega_o L = \omega_o C_s/G_T$. The Q multiplication is $M = Q/Q_L = 1/G_T R_L$. ($Q_L = R_L/\omega_o L$.)

Typically R_1 is made as small as possible ($R_1 = r_E$ or $1/g_m$), and R_2 is made as large as possible ($R_2 \geqq (n + 1)\ R_o$, where $C_1 = nC_2$). For frequencies where the $1/\omega_t$ terms are small the following condition is obtained for R_o:

$$R_o = \frac{nR_L}{(n+1)^2\left(1 - \frac{1}{M}\right)}$$

The primary variations in Q will be due to variations in G_T. By differentiating the expression for G_T an expression can be obtained for the percentage change in G_T as a function of the percentage change in β_o, r_e, and R_L. Assuming that the parameters of the generator, coil, and the value of Q multiplication desired (M) are given, and assuming $R_1 = r_e << R_o$, $n \geqq 1$, $R_2 \geqq (n + 1)\ R_o$, and

$$\omega_t \gg \frac{4\omega_o}{Q_L}$$

the following expression results:

$$\frac{k_g}{M} = \left[\frac{R_L}{R_2} + \frac{n+1}{n}\left(1 - \frac{1}{M}\right)\right] \left[k_r\left(\frac{r_e}{R_L}\right)(n+1)\left(1 - \frac{1}{M}\right) - \frac{k_\beta}{\beta_o}\right] - k_L$$

where k_g, k_r, k_β, and k_L are the percentage changes in G_T, r_e, β_o, and R_L. This expression shows that k_g is minimum when β_o is large, r_e is small, $n \approx 1$, and $R_2 \geqq R_L/2$ for large M.

The equations will hold for a vacuum tube where $r_e = 1/g_m$ and $1/\beta = 0$. Of course, $g_m >> 1/R_o$ for the approximations to hold.

A practical design procedure is as follows: a suitable coil is selected. The value of R_L and the value of M necessary to give the desired Q are computed from the coil Q. ($1/M$ should be slightly negative for stable oscillator applications). A value of $n = 1$ is generally used, so that $C_1 = C_2 = 2C_s$. Then R_o becomes $R_L/4\ (1 - 1/M)$. (This value of R_o will usually be 5 to 10 percent high due to the approximations.)

The maximum value of R_2 is usually limited by the emitter current required, and it often must be less than $R_L/2$. The emitter current should be large, since it must be much greater than the peak signal emitter current; and also since r_e, which should be small, is inversely proportional to emitter current.

A typical circuit is shown in Fig. 2. Applying the stability equation to the circuit

$$k_g = 12.8[2.5k_r - 10k_\beta]10^{-3} - 6k_L$$

A change of 30 deg C in junction temperature will produce a change of about 10 percent in r_e. The change in G_T due to this change in r_e is only $k_g = 0.32$ percent. A 10 percent change in β_o would give $k_g = -1.28$ percent. However, a change in R_L of only 1 percent would produce a change in G_T, or the circuit Q, of -6 percent.

Therefore, this circuit is relatively independent of the transistor parameters, so that the only major stability problem becomes that of finding tank circuit elements with stable Q's.

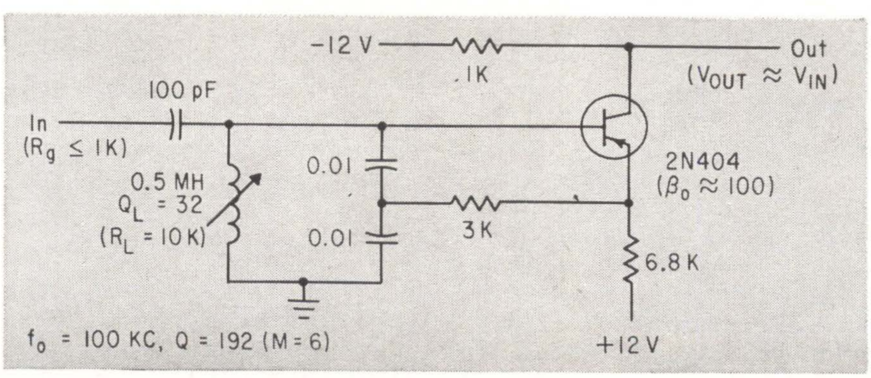
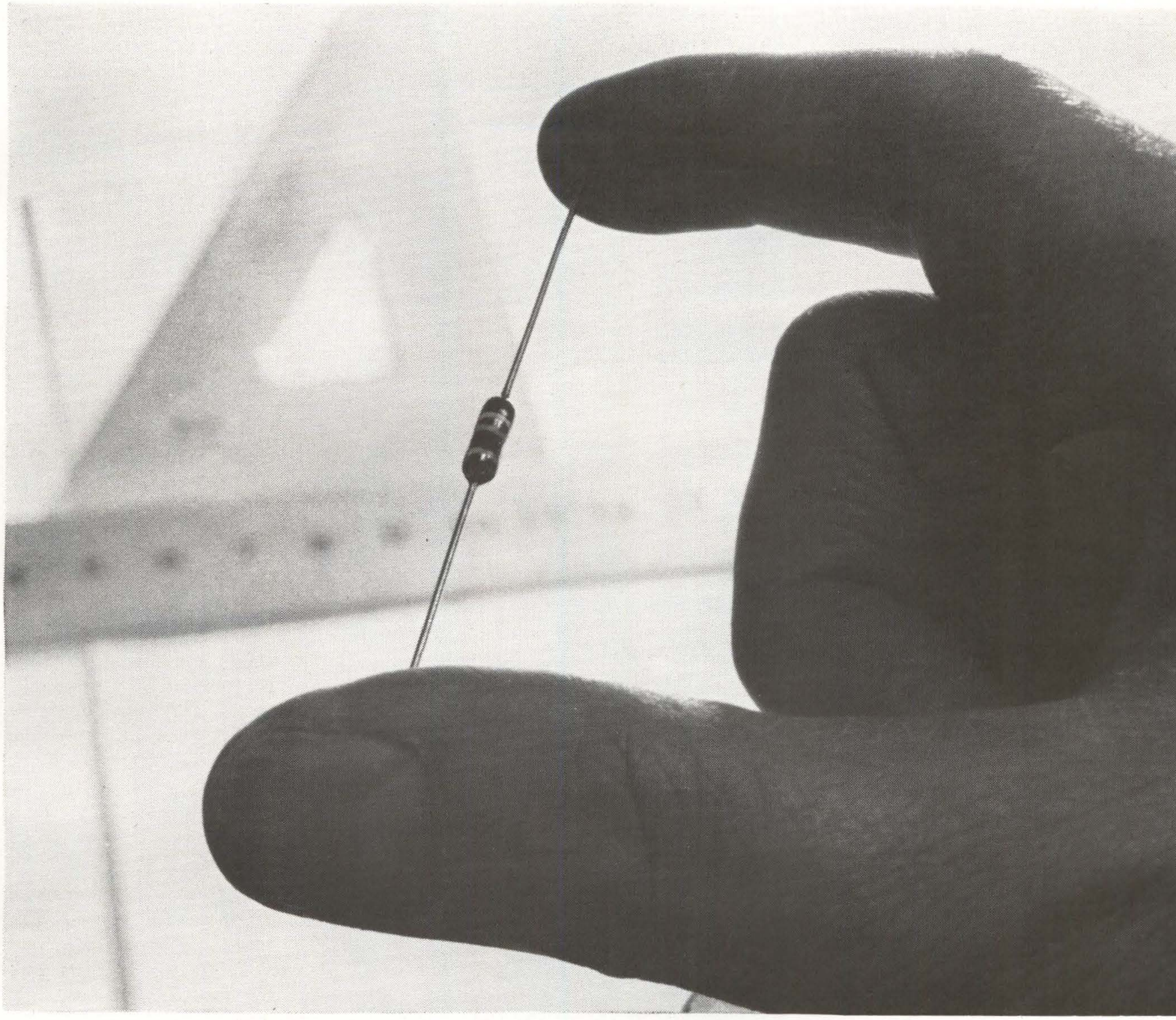


FIG. 2—Typical practical Q-multiplier circuit using a transistor as the active element



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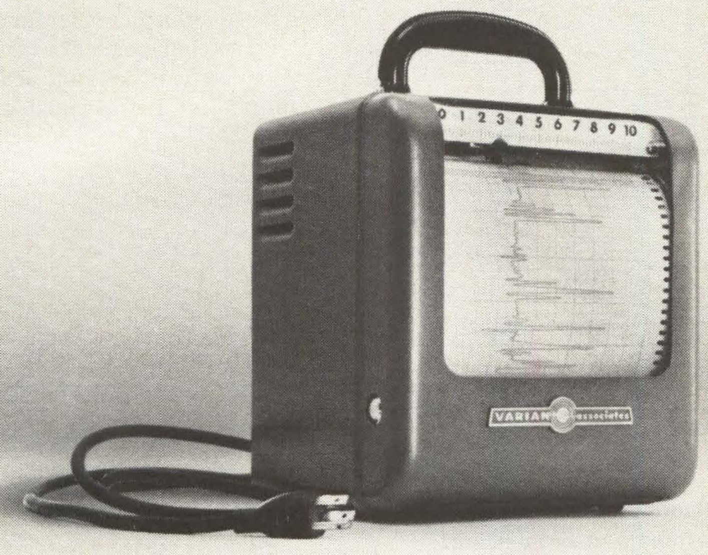

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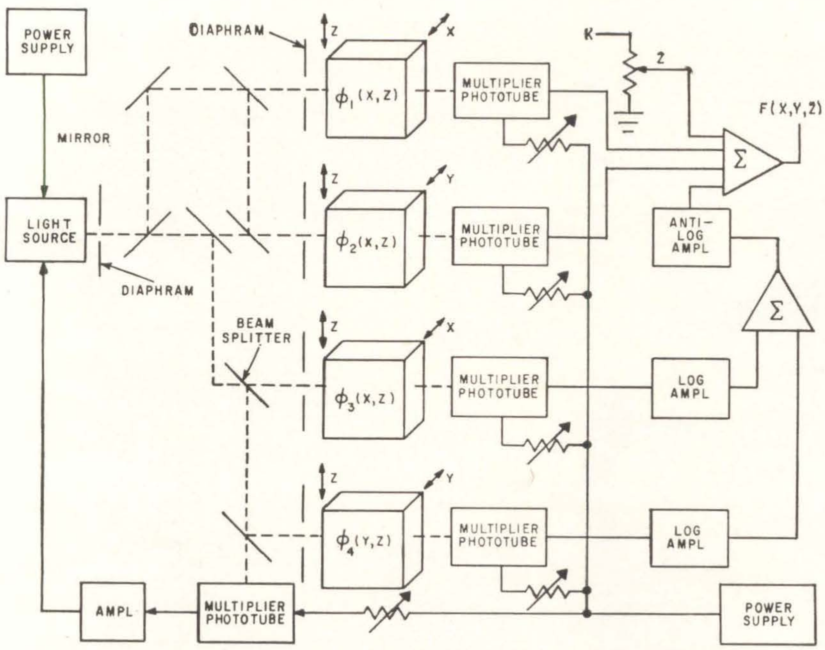

FIG. 1—Functions of three independent variables are generated by driving plastic blocks with servos to the instantaneous values of the variables

By WILBUR H. DAY
Link Div., General Precision, Inc., Binghamton, New York

FUNCTIONS dependent on several variables can be generated simply and accurately using optical techniques. These multidimensional functions are inherent in the increasingly complex problems considered for solution by computers. However, conventional methods for generating them require large numbers of operational amplifiers in analog computers or large storage space in digital computers.

The three-independent variable generator in Fig. 1 provides a more economical method for generating such functions. A regulated light source with such optical components as diaphrams, mirrors and beam splitters provide stabilized light beams as generator inputs.

Data required to generate a multidimensional function, one of three variables X, Y and Z, for example, is stored in four plastic blocks as $\phi_1(X,Z)$, $\phi_2(Y,Z)$, $\phi_3(X,Z)$ and $\phi_4(Y,Z)$. The blocks are driven by servos to the instantaneous values of the independent variables X, Y and Z. The attenuated light beams are then converted by multiplier phototubes into d-c signals. The signals are fed through appropriate circuits using log, antilog and summing amplifiers and converted into a form that satisfies the equation:

$$F(X,Y,Z) = K + \phi_1(X,Z) + \phi_2(Y,Z) + [\phi_3(X,Z)]\,[\phi_4(Y,Z)] \qquad (1)$$

If greater accuracy is required than that attainable with one set of product functions, overall errors can be reduced to almost any specified tolerance by adding components to include additional product pairs. The requirements of a function generator using two sets of product pairs is shown in Fig. 2. It solves an equation of the form:

$$F(X,Y,Z) = K + \phi_1(X,Z) + \phi_2(Y,Z) + [\phi_3(X,Z)]\,[\phi_4(Y,Z)] + [\phi_5(X,Z)]\,[\phi_6(Y,Z)] \qquad (2)$$

The mathematical formulation[1] was intended for implementation in mechanical computers for fire-control systems and generally limited to generation of functions of only two independent variables. However, the mathematics is applicable to analog computation in general.

A function of two variables (Fig. 3) can be approximated using the least squares method[1] by the equation:

$$F(X,Y) = K + f_1(X) + f_2(Y) + f_3(X) + f_4(Y) + f_5(X) f_6(Y) + \cdots \qquad (3)$$

Well-behaved continuous functions of three independent variables X, Y and Z can be reduced to a set of functions of two variables[1] as follows:

$$F(X,Y,Z_1) = K_{Z1} + f_{1Z1}(X) + f_{2Z1}(Y) + f_{3Z1}(X) f_{4Z1}(Y) + \ldots$$

$$F(X,Y,Z_2) = K_{Z2} + f_{1Z2}(X) + f_{2Z2}(Y) + f_{3Z2}(X) f_{4Z2}(Y) + \ldots$$

$$F(X,Y,Z_n) = K_{Zn} + f_{1Zn}(X) + f_{2Zn}(Y) + f_{3Zn}(X) f_{4Zn}(Y) + \ldots$$

This matrix of functions can be combined to define $\phi_1(X,Z)$, $\phi_2(Y,Z)$, $\phi_3(X,Z)$ and $\phi_4(Y,Z)$. The set of functions are:

$f_{1Z1}(X), f_{1Z2}(X), \ldots f_{1Zn}(X)$ defines $G_1(X,Z)$

$f_{2Z1}(Y), f_{2Z2}(Y), \ldots f_{2Zn}(Y)$ defines $G_2(Y,Z)$

$f_{3Z1}(X), f_{3Z2}(X), \ldots f_{3Zn}(X)$ defines $G_3(X,Z)$

$f_{4Z1}(Y), f_{4Z2}(Y), \ldots f_{4Zn}(Y)$ defines $G_4(Y,Z)$

where $G(\;)$ is a function of two variables.

The final functions used to define the data stored in the plasdic blocks are derived by taking the values of the natural logs of $G_m(X,Z)$, $G_n(Y,Z)$ for all X_i, Y_j and Z_k, where $m = 1, 3, 5 \ldots, n = 2, 4, 6 \ldots$ and i, j and k are discrete values of the variables over the ranges of interest.

Studies indicate that analogs can be generated of original multidimensional functions within 2 to 3 percent with the number of product terms restricted to one pair. By adding a second pair, the total error can be reduced as much as half that for a single-pair generator. This total is composed of 0.5 to 1 percent from mathematical approximations, 0.5 percent from physical inaccuracies in plastic block fabrication, 0.25 to 0.5 percent from electro-optical components (power supplies,

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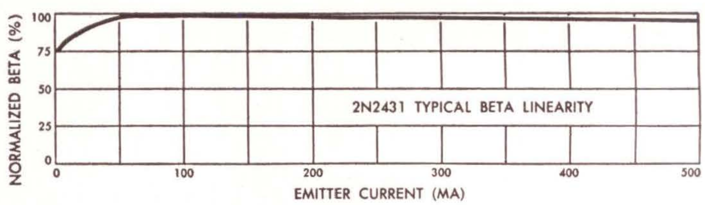
To take but one example from among the first five U.L.T. types available in production quantities: The 2N2431, a PNP medium power transistor designed for Class A and B audio output stages, is capable of up to 2 watts power output per pair. It is available in a TO-1 case, as are all five U.L.T. transistors. The exceptional linearity of its beta is dramatically shown in the curve reproduced at right where beta remains substantially constant up to the maximum rated current of 500 ma. Further, the 2N2431 offers high gain with a beta of 50 to 180, 550 mw maximum dissipation and a collector-to-emitter breakdown voltage of 32 volts.



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ULT Transistor Type No.	Case	Application	Breakdown Voltages	Beta	Peak Current	Collector Dissipation
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2N2429 PNP	To-1	Preamps, drivers and low wattage output devices	−32 volts	130-300	100 ma	165 mw
2N2430 NPN	To-1	Preamps, drivers and low wattage output devices	−15 volts	65-190	100 ma	165 mw
AC127/132 NPN PNP	To-1	Matched pair, NPN-PNP for 200 mw output stage using complementary-symmetry circuits.	15 volts	65-190	100 ma	165 mw
2N2431 PNP	To-1	Class A & B audio output stages up to 2 watts.	−32 volts	50-180	500 ma	550 mw

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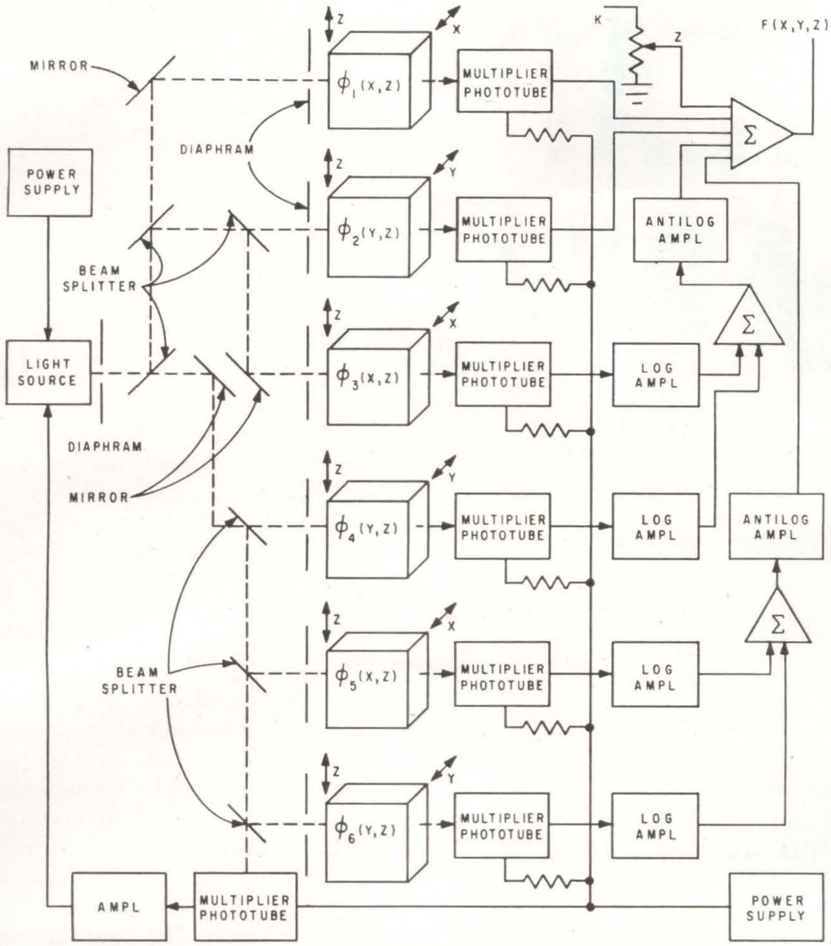

FIG. 2—Using double instead of single product pairs reduces errors

finite beam width, beam refraction, residual noise), 0.5 percent from electromechanical sources and 0.5 to 1 percent from miscellaneous sources. Errors of this magnitude in the case of emperical data are often well within the degree of original certainty.

REFERENCE

(1) Eugene W. Pike and Thomas R. Silverberg, Designing Mechanical Computers, Machine, Design, p 131, July 1952.

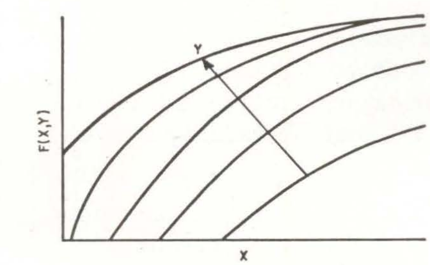

FIG. 3—Functions of two variables are found by least squares method

Simplified Technique Classifies Patterns

PATTERNS can be classified rapidly and without elaborate equipment. The logic for a relatively simple method of pattern classification has been designed called the parapropagation pattern classifier. The system can be constructed using present technology. The system was reported by the Computer and Mathematical Sciences Laboratory, AFCRL.

Most approaches to pattern recognition require sophisticated computer programs and circuits. Letters and numbers are often catalogued by their loops, angles, open ends or other characteristics. However, a simpler approach is possible.

Several operations are performed on each letter. It is first placed into one of two major classes and then into its subclass. By continuing through successive subclasses, the range of possible classifications is narrowed until the letter is identified. As many as eight subdivisions may be needed.

The classifier consists of an array of identical cells each of which can exist in its original zero state or in the one state. The cells are connected so that a change from the zero to the one state can be propagated across the array from the right, from the left, from the top downward or from the bottom up.

A two-dimensional pattern can also be projected on the array by illumination. As the change of state is propagated inward toward the illuminated cells, the illuminated cells prevent further propagation. The illuminated pattern thus forms an outline of cells that remain in the zero state.

Readout of Array

After propagating changes of state in a programmed sequence, the array is tested to determine the number of cells that have remained in the zero state. The cells that are not changed to the one state depend on the illuminated pattern and on the sequence of propagating changes of state. If propagation were only from the left and from the top, the cells remaining in the zero state would usually be quite different from those remaining if propagation had been from the right and from the bottom.

By propagating commands in the proper sequence, the classifier can also derive a new pattern from the original pattern that is also capable of blocking propagation. Making tests on the new pattern can provide the basis for further classification of the original pattern.

Superconducting Magnet Does Not Require Wire

TECHNIQUE for increasing the strength of magnetic fields is simpler and less expensive than existing methods. Magnetic fields up to 15,000 oersteds have been produced using the new method, and fields of 20,000 to 25,000 oersteds are attainable. Theoretically, fields exceeding 100,000 oersteds seem possible.

The new technique was described at the Spring Meeting of the Amer-

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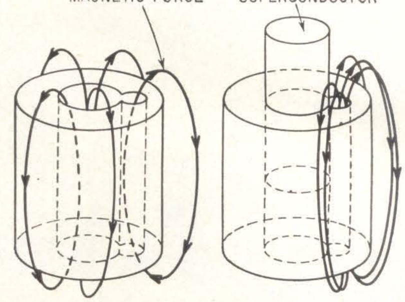
ican Physical Society in a paper by P. S. Swarz, General Electric Research Laboratory, and co-authored by C. H. Rosner. (See Electronics, p 8, April 27.)

Resistance of superconductors to the penetration of magnetic fields into their interiors is the basis for the new method. A magnetic field is established inside a hollow cylinder of superconducting material, as shown in the figure. The cross section of the hole in the cylinder is shaped like a figure eight with the loops joined by a narrow neck.

When the magnetic field has been established inside the hollow cylin-

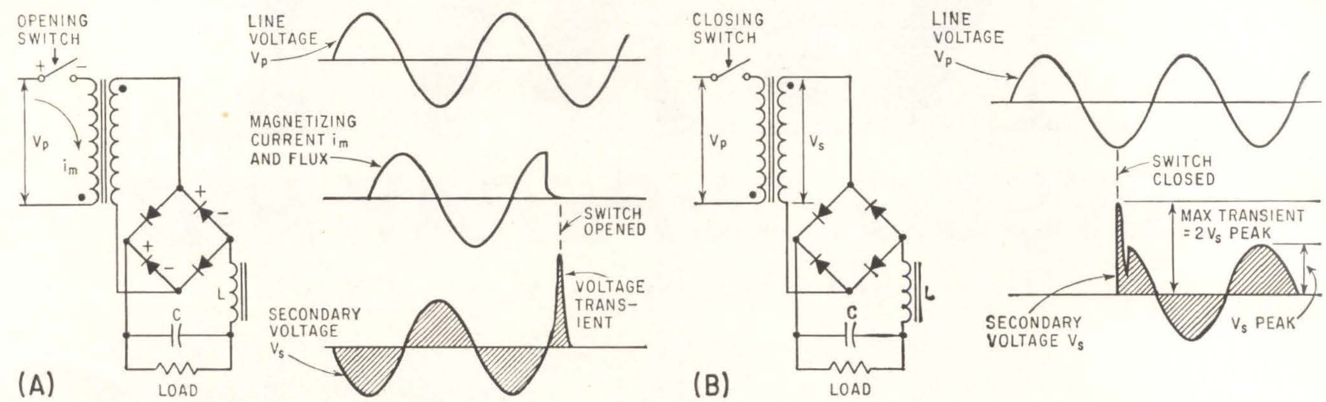


Magnetic lines of force are distributed evenly until superconductive material is inserted

der, a superconductor is inserted into the larger hole, filling it. Since the magnetic flux cannot penetrate the superconductor, the magnetic lines are forced into the smaller hole, creating a concentrated field in it.

Devices built at the laboratory were normally operated near liquid helium temperature (4.2 degrees K). The superconducting material used is Nb_3Sn, which Bell Labs first succeeded in forming into wire. This wire wound into a coil can function as a superconducting solenoid producing strong magnetic fields. Research on such solenoids is being conducted at several laboratories using this wire and alloys of niobium and zirconium. Unlike most superconductors, these materials remain superconductive in strong magnetic fields.

The main advantage of the technique announced by General Electric is that the superconducting material is used in bulk form. The solenoid-type design requires superconducting wire, which is difficult to fabricate. Therefore, the cost and complexity of the GE device is greatly reduced.



Transient voltage due to interruption of transformer magnetizing current (A), and transient voltage caused by energizing transformer primary (B)

Avalanche Breakdown of Silicon Rectifiers

FAILURES PREVENTED BY PROPER DESIGN TECHNIQUES

By S. P. FAIRCHILD JR,
Electronics Engineer
Federal Aviation Agency,
Tallahassee, Florida

NEW DESIGN TECHNIQUES and protective devices, properly employed, can eliminate many silicon rectifier failures caused by severe environmental stresses. Unforeseen failures in the field can be prevented by understanding voltage transients involved in the avalanche breakdown mechanism, and designing the system accordingly.

Current flow through a silicon diode in the forward direction may greatly exceed normal currents for small durations. Most small diodes rated for about 0.5 amp operation are able to handle 10 times this rating as a 60 cps recurrent peak amperage and about 50 times this amount up to about 5 milliseconds[1].

On the other hand, when a silicon diode is overvoltaged in the reverse direction beyond its piv rating, the device is usually destroyed in microseconds by avalanche breakdown. This characteristic of the silicon diode causes excessive power supply failures in the field.

A silicon diode is usually overvoltaged by transients in the reverse direction by switching transients, and by power line overvoltage and transients caused by thunderstorm activity.

When a transformer is energized by being switched on, a transient oscillation may be set up in the secondary. If the primary is energized at the peak of the supply voltage, the transient may approach twice the normal piv in the secondary, if little or no damping is provided in the circuit[2] (see diagram).

Opening the primary circuit of a transformer interrupts the transformer magnetizing circuit. The sudden collapse of this current and the magnetic flux which is proportional to the magnetic current couples a high voltage transient into the secondary, unless a discharge path is provided in the primary or secondary circuits. The amplitude of this type of transient depends on the instant during the a-c cycle at which the circuit is opened. Highest transients occur if the switch opens at or near the point where the primary voltage swings through zero[2].

Power line transients can be generated in four ways:

Switching transients, mentioned previously are caused by power going off and coming back on.

Transients are also caused by *direct* lighting strokes to nearby power lines.

Transients can be caused by *induced* voltages into the line by lightning not actually striking the line.

Surges and transients are caused by reflected waves and surges of the power company equipment trying to adjust to the load after momentary power interruption.

Worst Offender

As a destroyer of silicon diode rectifiers, thunderstorm activity is by far the worst offender. In a great majority of cases, silicon diode failure occurs while a thunderstorm is in progress.

In addition to the lightning protection equipment used by the power company, a lightning protector of the thyrite magne-valve type is installed in many equipment buildings. If a lightning arrester with a 175-v rating is installed at the site, the question arises whether this would offer sufficient protection for electronic equipment installed nearby. This rating of 175-v does not mean that all voltages over 175-v to ground are eliminated. Once a lightning arrester breaks down, its internal resistance falls to a very low value around one ohm. The voltage generated by several hundred or several thousand amperes flowing through one ohm means however

that instantaneous voltage levels can rise tremendously. The 175-v rating is the extinguishing voltage at which the arrester disconnects when the peak of the overvoltage is past. This prevents the arrester from being a short to ground for the normal power line voltage. Silicon rectifiers fail at sites with lightning arresters and one cannot depend on these devices to prevent failures.

Thunderstorm Transients

A direct lightning strike on a power line acts as a d-c voltage with a steep wavefront even after a lightning arrester has broken down and diverts current to ground. This d-c wavefront travels with the velocity of light over the power distribution system. This d-c voltage causes saturation of the iron in the supply transformers and distribution transformers connected from line to ground, thereby changing the transformer from its previously high surge impedance of several thousand ohms to a relatively low resistance (approaching the d-c resistance of the primary winding) from line to ground. After the transition, each transformer presents a low resistance drainage path in parallel with that of the arrester, thereby diverting a large portion of the long duration stroke current away from the arrester. Urban systems with multi-grounded neutral will result in less severe long duration discharge duty on arresters, because the high density of relatively large transformers connected from line to ground will divert more of the long duration current away from the arrester. Conversely, rural systems having lower density of relatively small transformers divert less current away from the arrester.[3] This means that lightning transients are more severe and of longer duration in rural areas.

Voltage Transients

One solution to increase piv ratings is to put two or more rectifiers in series. But this creates additional problems. If the reverse resistance and leakage currents of diodes in series are not equal, then the inverse voltage across each rectifier will not be equal. This is solved by shunting each diode with a fixed resistor forming a voltage divider network that equalizes back resistances. A similar capacitive volt-

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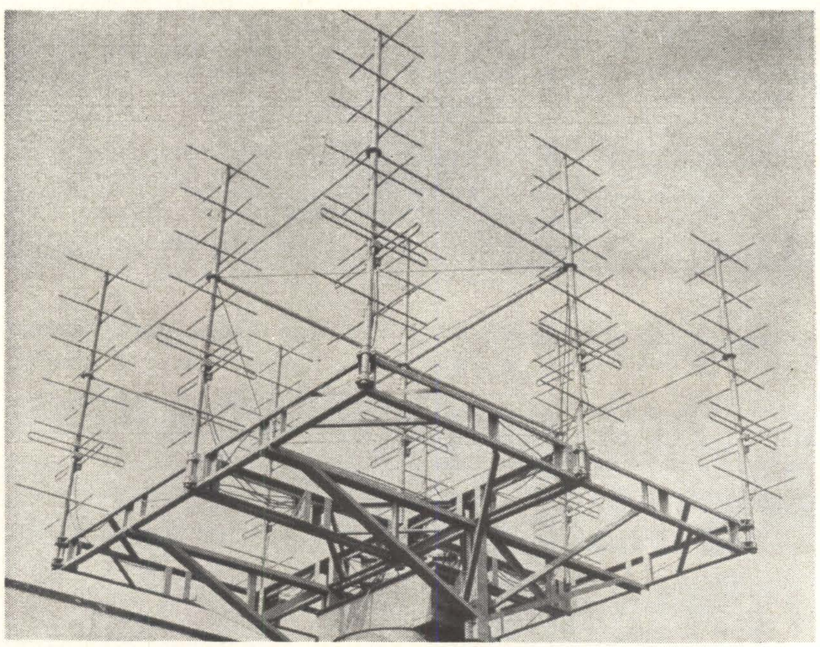

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age divider equalizes transients.[1] Thyrite resistors, or spark gaps across transformer secondaries can also be used.

Eliminating Transients

Several interesting devices have been developed recently to combat the avalanche problem. Silicon rectifiers with piv ratings to 10,000 volts and even higher are now available. A device to eliminate transients in the power supply is the selenium transient suppressor. This is a "back to back zener" type device that draws negligible current below rated recurrent peak voltage. However, as the voltage rises above this point, as would be the case in a transient condition, the diode current increases rapidly and dissipates the transient energy. They are marketed under such names as General Electric's Thyrector and Sarkes Tarzian's Klipvolt lines.

Recently General Electric announced their Controlled Avalanche rectifier. Carefully controlled nondestructive internal avalanche breakdown across the entire junction area protects the junction surface and eliminates destructive local surface heating that permanently destroys the conventional rectifier. Thus a great deal of avalanche breakdown protection is a "built in" feature of this rectifier.

The help and assistance of the Rectifier Components Department of General Electric and of the Sarkes Tarzian Company in the preparation of this article is gratefully acknowledged.

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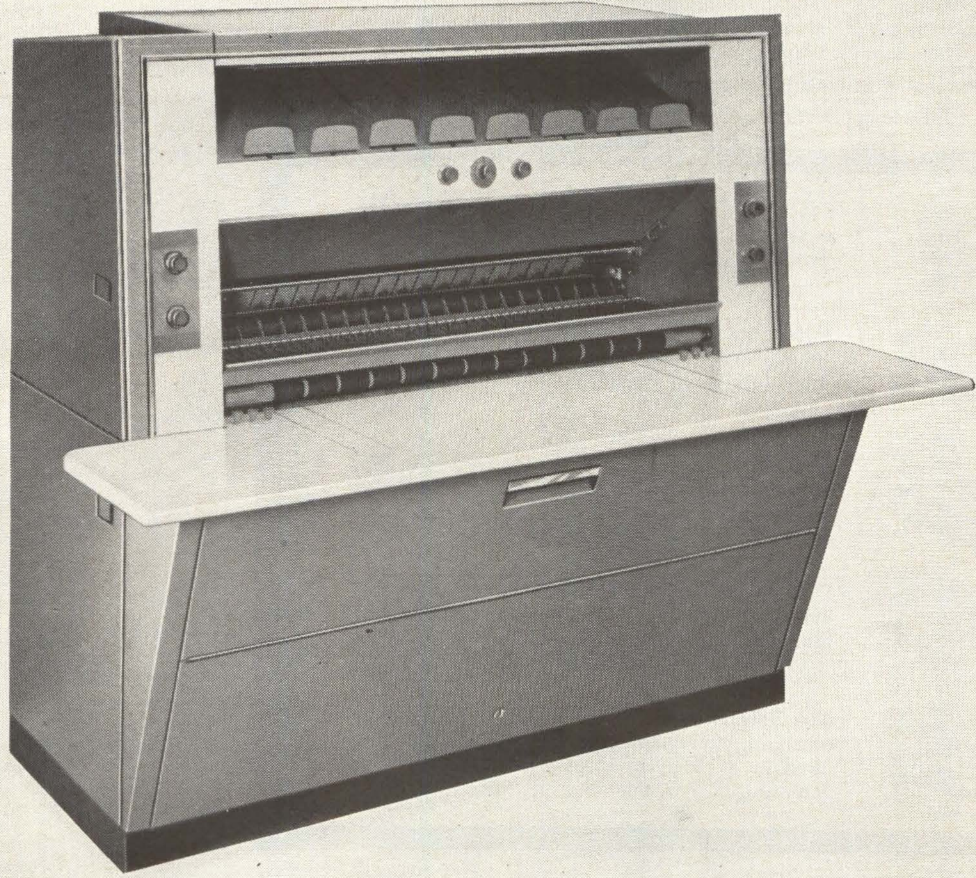
(1) Kampf, H. A., Electronics, Oct. 2, 1959.
(2) General Electric Company, Silicon Controlled Rectifier Manual, Second Edition.
(3) Towne, H. M., Lightning Protection of Distribution Equipment and Circuits, paper presented at Southwestern Distribution Power Conf., Austin, Texas, Oct. 20, 1953 Published by General Electric.

Extending Range of Controlled Rectifiers

A NEW TECHNIQUE developed by Transitron Electronic Corporation increases the usefulness of silicon controlled rectifiers over a wider temperature range and provides more desirable firing characteristics. This process is now used in



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the production of the firm's silicon controlled rectifiers.

David H. Navon, Director of Transitron's Research and Development, points out that while silicon transistors can operate safely at temperatures of 150 C and higher, and the current gain in general becomes greater as the temperature rises, some silicon controlled rectifiers can fail at temperatures not much in excess of 150 C.

Above this temperature the rectifier no longer maintains its high impedance and switches automatically to a low impedance state at some elevated temperature.

It is desirable to stabilize the sili-

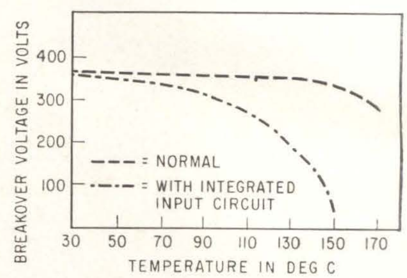


FIG. 1—Controlled rectifier breakover voltage vs temperature

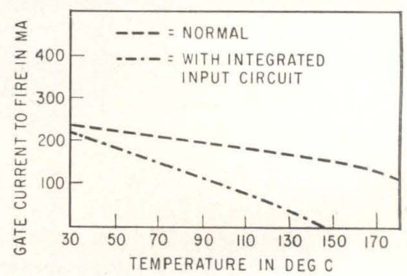
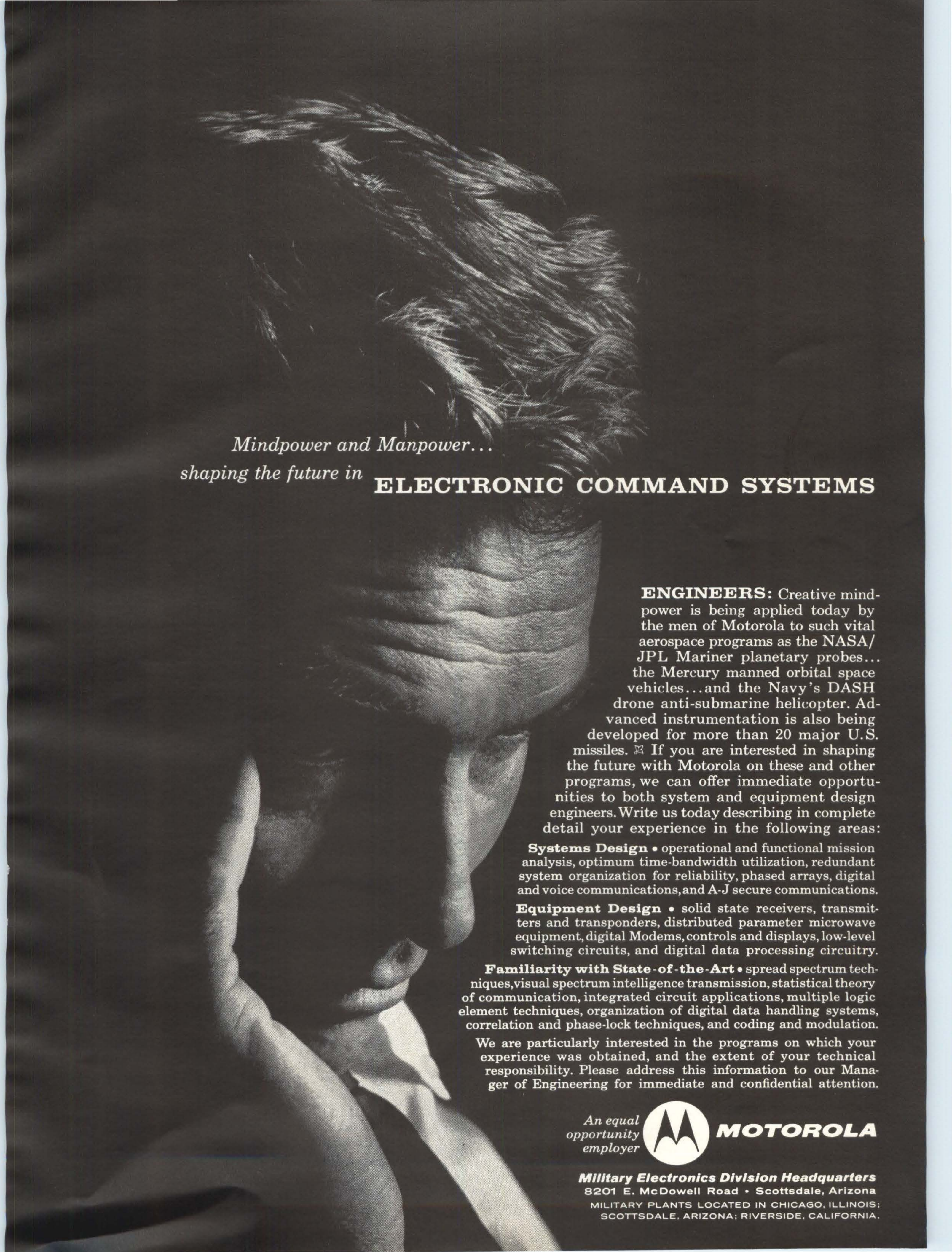


FIG. 2—Controlled rectifier gate current to fire vs temperature

con controlled rectifier so that its blocking voltage is maintained at higher temperatures. Also, it is convenient to have the gate current necessary to fire the rectifier essentially constant and independent of temperature.

To accomplish this, an appropriate input circuit has been integrated into the device. Figure 1 shows the rectifier blocking voltage and Fig. 2 the gate firing current as a function of temperature in a normal controlled rectifier. Also included is the data for a similar rectifier that incorporates the integrated input circuit. The integrated device is useful over a much wider temperature range and has significantly more desirable firing characteristics.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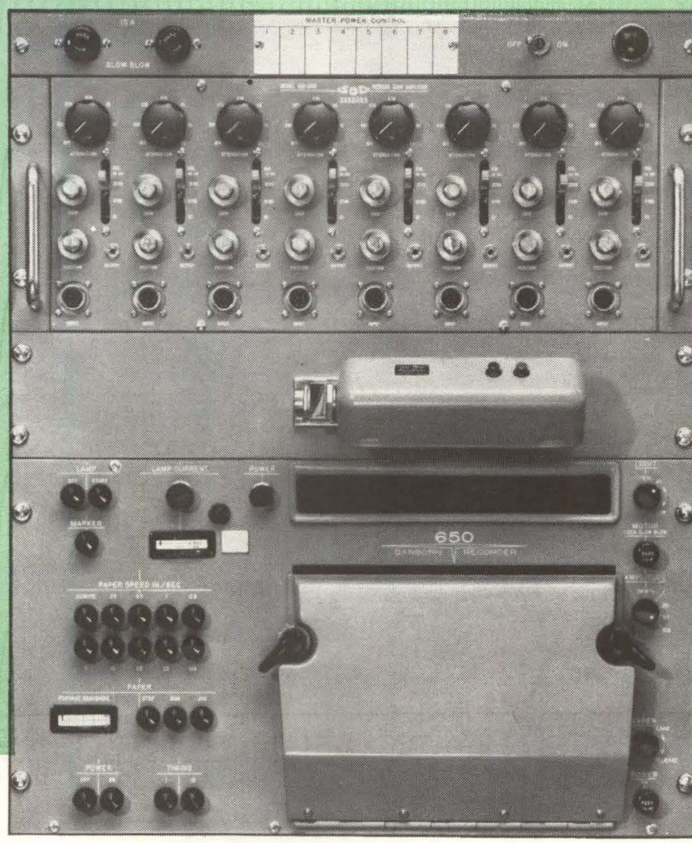

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INPUT RESISTANCE 100,000 ohms all ranges, floating and guarded; DC source resistance must be kept below 1000 ohms on mv ranges only.

COMMON MODE PERFORMANCE Rejection at least 140 db at DC, tolerance to ±500 volts, max.

GAIN STABILITY Better than 1% to 50° C. and for line voltage variation from 103 to 127 volts.

LINEARITY 1½% of full scale (8 in.)

NOISE 0.02" peak-to-peak, max.

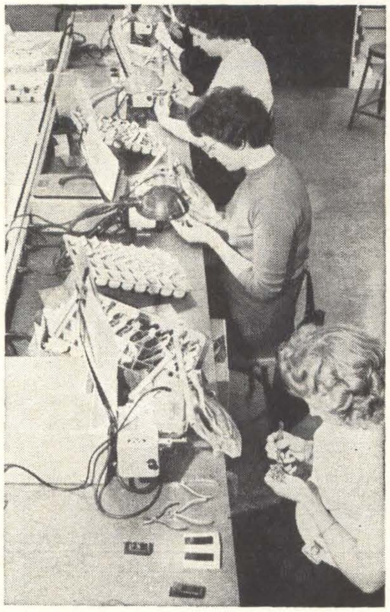
MONITOR OUTPUT On front panel; provides ±1v full scale across 100,000 ohm load

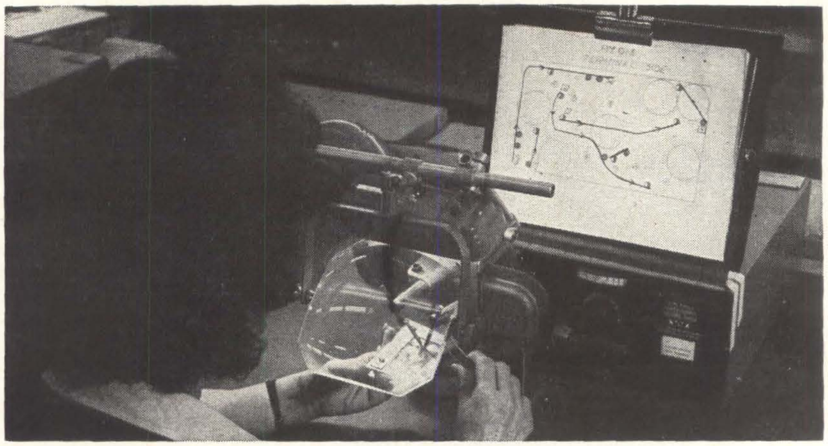
POWER REQUIREMENTS 103-127 volts, 60 cycle AC, 625 watts

Contact your Sanborn Sales-Engineering Representative for complete specifications and applications engineering assistance. Offices throughout the U. S., Canada and foreign countries.

SANBORN COMPANY
INDUSTRIAL DIVISION
175 Wyman St., Waltham 54, Massachusetts

CIRCLE 77 ON READER SERVICE CARD





Qualification examination at end of course consists of welding components and wires to complete a typical electronic module

In 20-hour course, welders and inspectors learn principles of welding and how to make uniform, reliable welds

Welding School Improves Circuit Reliability

By STEPHEN W. MAHON
Westinghouse Air Arm Div.,
Friendship Airport,
Baltimore, Maryland

ADVANTAGES of formal training for production workers in welding electronic circuits appear to be well worth the cost and effort involved. The major result is better workmanship and thus increased reliability. Cost savings in production have not yet been thoroughly evaluated but are known to be occurring, primarily as a result of reduction in rework and inspection and from greater uniformity in workmanship.

To obtain maximum results from a formal training course, certain conditions should be met. A classroom within the plant with conditions similar to actual working conditions is desirable since it does not create a false image of the job as it will be performed on the production line. In-plant training also allows adequate control over the program and the equipment used.

The instructor should be selected for three qualities: ability to do the work to high standards, ability to teach, and ability to motivate and lead the trainees. Production foremen often make good instructors but in this case the instructor was selected from the engineering group that worked out the production problems of introducing resistance welding to the plant.

Group training is preferable to work-station training since it makes the best use of the instructor's time and focuses the trainee's attention on the training, rather than serving as a make-work operation during what would otherwise be non-productive time. Work-station training during non-productive time can often be costly because of the amount of rework required.

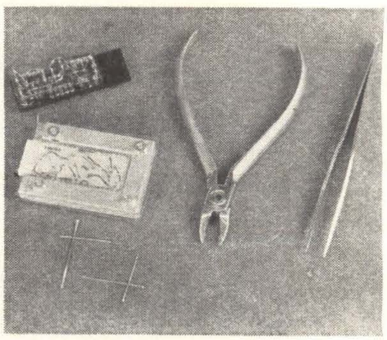
When a regular course in training is set up, it is good practice to let the trainees attend it without interruption, rather than attempt to fit in the training when it is convenient.

Course Organization

It was possible to meet all the above conditions in the welding course set up here recently. The course itself is organized as shown in Table I. Twenty hours of classroom work is provided, with no distinction being made between trainees on the basis of prior circuit welding experience. A training department representative makes the introductory remarks, explaining course objectives and impressing trainees with the need for introducing new tools and methods, management support of the program and the need for reliable circuits.

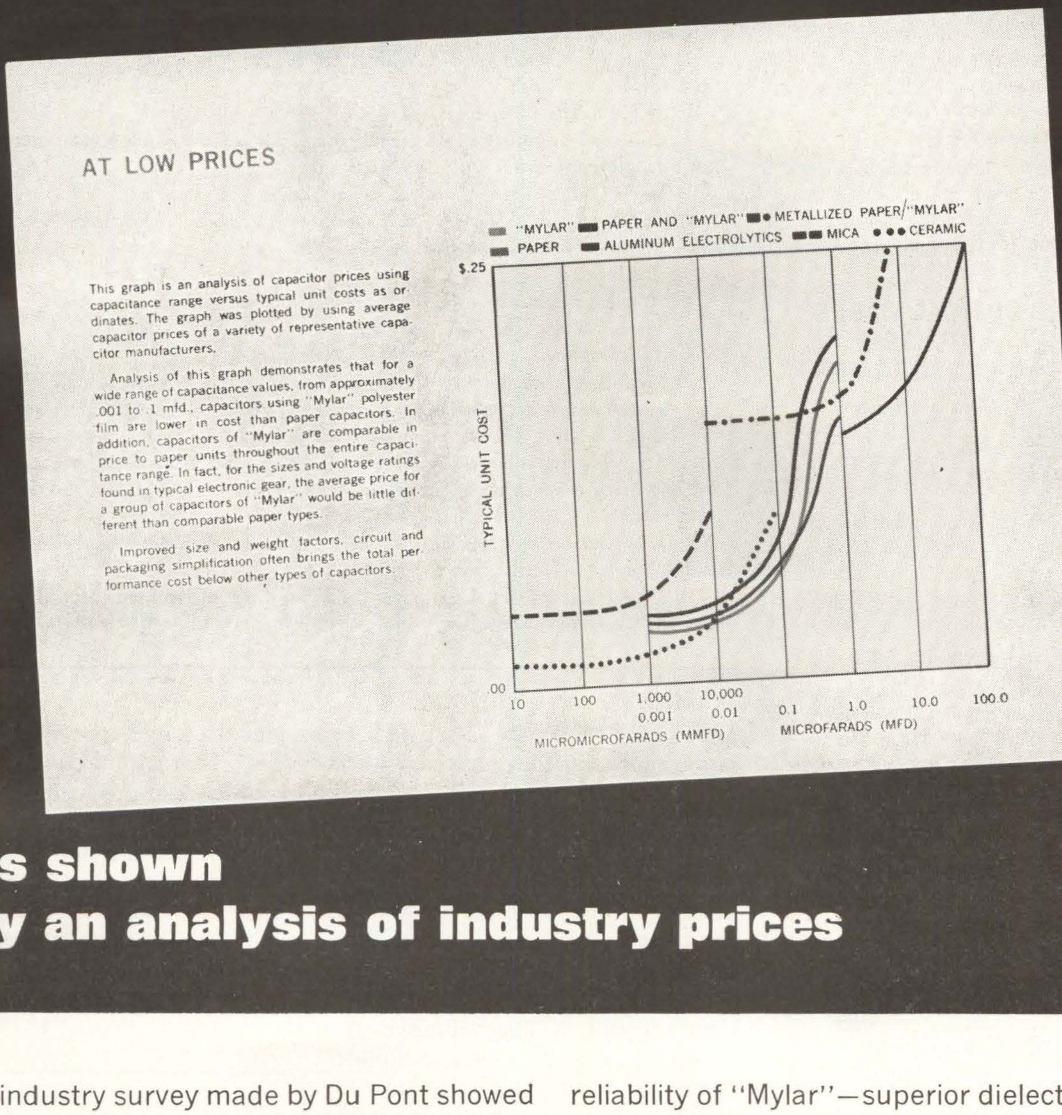
Developing Skills

The rest of the course is devoted to giving the student a thorough grounding in welding techniques and in developing his skill to the maximum. Individual guidance and shop practice is the largest block of time (14 hr.) in the program,



Welded module, fixture, and simple tools

Capacitors of MYLAR® often cost no more than paper—sometimes cost less



As shown by an analysis of industry prices

A recent industry survey made by Du Pont showed that most design engineers did not consider capacitors of "Mylar"* in the same low price range as paper. Yet a study of manufacturers' average prices, as reported in our capacitor booklet, points out THAT OVER A RANGE OF SIMILAR CAPACITANCES AND RATINGS—UNITS MADE WITH "MYLAR" COMPARE CLOSELY IN PRICE WITH THOSE OF PAPER.

This means, at no greater cost, you get the extra reliability of "Mylar"—superior dielectric strength, moisture resistance, and thermal stability over a wide range of temperatures. And you can design more compact components with the reduced capacitor size permitted by "Mylar".

Write for this industry study and price chart. Evaluate the full advantages and properties of "Mylar" before specifying your choice of capacitors. Du Pont Co., Film Dept., Wilmington 98, Del.

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

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BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

only **DU PONT** makes
MYLAR®
POLYESTER FILM

TABLE I—WELDING SCHOOL PROGRAM

I Introduction (0.5 hours): purpose and objectives of the welding school program.

II Orientation and indoctrination (0.5 hrs.): School rules, good housekeeping and safety, new machines and accessory tools and equipment.

III Introduction to resistance welding miniature modules (2 hrs.):

A. Reasons for welding: elimination of flux, closer packing of components, less danger of contamination through encapsulation, less heat damage, more postive control.

B. Components and leads: recognition of components and leads, precautions in handling, percautions in assembly.

C. Welding machines: principles of operation, power, pressure, electrodes, importance of machine settings.

D. Weld schedules and certification of machine: explanation of procedures and forms.

E. Weldability of materials.

F. Electrodes: effect of electrode materials, effect of electrode shape, cleaning and dressing electrodes, electrode alignment.

IV Individual guidance and shop practice (14 hrs.):

A. Welding cross wire joints: component leads (Alloy 42, Kovar, Dumet), nickel ribbon interconnections.

B. Pull-test.

C. Welding dummy modules: circuit sketch, positioning nickel ribbon with respect to leads, sequence of operations on both sides of dummy module, visual inspection.

D. Welding complete module: introduction to circuit sketch (weld settings for diodes, resistors, transistors, terminals), visual inspection of complete module.

V Pre-test review (1 hr.): machine characteristics, misalignment of leads yhile welding, cleaning electrodes, trimming leads and nickel ribbon, placing nickel ribbon with respect to mylar, welding on correct side of lead, review of defects and causes.

VI Qualification examination (2 hr.): welding complete module in accordance with sketch of circuit..

VII Inspection of work: review and grading of welded module by product reliability department, including visual inspection and electrical test.

and excellence is strived for throughout; welding speed will develop later when the trainee puts his knowledge to use on the production line.

The qualification examination given at the end of the course consists of welding 9 resistors, 6 diodes, 3 transistors, jumper wires, pins and terminals for a total of eighty welds. The allotted two hours is more than enough time to make the welds and is made long deliberately to encourage excellence and to discourage hasty and slipshod work.

Test modules are graded by the Product Reliability Department on the basis given in Table II; each of the 80 welds is graded on each of the eight points listed. A score of 90 percent is needed to pass the course and a certificate of course completion is awarded each successful student.

Of the first 26 employees taking the course, 21 passed the examination on the first try. Of the five who failed, four repeated the complete 20-hour course and passed it. Test scores of those passing the course averaged 96.7 percent, indicating that the program is effective in meeting the training goals.

Training costs, including direct labor costs of the trainees, training materials, and instructor's time, averaged about $80 per student for

TABLE II—GRADING SYSTEM FOR WELDED MODULES

A. Length of component lead above ribbon
B. Length of ribbon tail beyond the terminal
C. Spacing between ribbons or ribbons and terminals
D. Spacing between ribbon and film
E. Deviation of ribbon from film outline
F. Centralization weld on lead
G. Overall module thickness
H. Other flaws

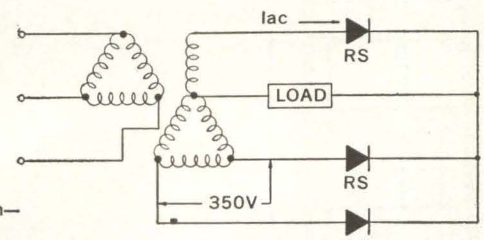
(Inadequate workmanship in categories A, B, and F gets 2 demerits; in C, D, E, G, and H, one demerit.)

TARZIAN DESIGN IDEAS

RS = Economical Power Conversion

Sarkes Tarzian hermetically sealed medium and heavy current rectifiers combine efficient operation with low cost. A wide choice of ratings and circuitry fit power supply applications from air space to electrochemistry. Tarzian literature is available to show you the products—Tarzian engineering assistance is ready to apply them to economical solutions to your power conversion problems—at no cost. Write or call us now.

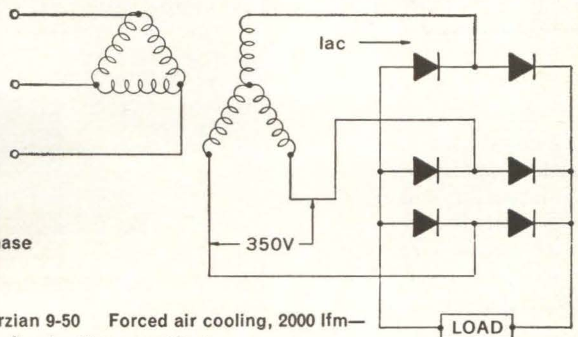
FOR HEAVY CURRENT APPLICATIONS...



Three Phase Half Wave

RS—Sarkes Tarzian 9-50
Forced air cooling, 2000 lfm—
fin size 6" square (Cu.)

Output—230 VDC @ 625 amps   Ripple—20% (unfiltered)
Iac—370 amp RMS

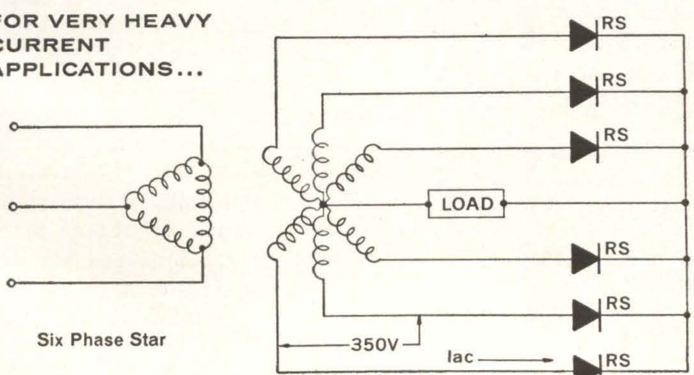


Three Phase Bridge

RS—Sarkes Tarzian 9-50   Forced air cooling, 2000 lfm—
fin size 6" square (Cu.)

Output—465 VDC @ 625 amps   Ripple—4.5% (unfiltered)
Iac—510 amps RMS

FOR VERY HEAVY CURRENT APPLICATIONS...

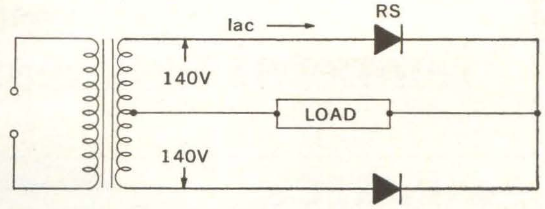


Six Phase Star

RS—Sarkes Tarzian 9-50
Forced air cooling, 2000 lfm—
fin size 6" square (Cu.)

Output 230 VDC @ 1250 amps DC
Ripple —4.5% (unfiltered)
Iac—500 amps RMS

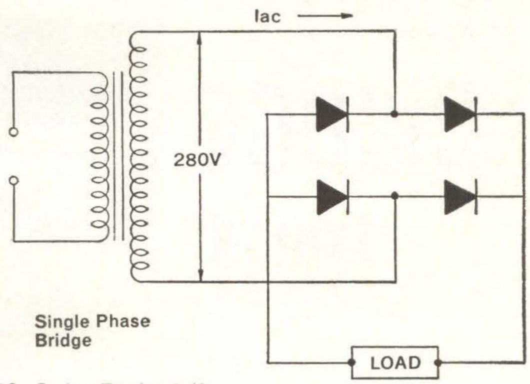
FOR MEDIUM CURRENT APPLICATIONS...



Single Phase Center Tap

RS—Sarkes Tarzian 40H3
Convection cooling—fin size 3" square (Al.)

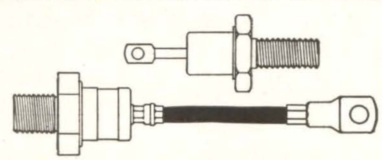
Output—125 VDC @ 12 amp DC
Ripple—52% (unfiltered)
Iac—9.5 amp RMS



Single Phase Bridge

RS—Sarkes Tarzian 2-40
Convection cooling—fin size 4" square (Al. or Cu.)

Output—250 VDC @ 25 amp DC
Ripple—52% (unfiltered)
Iac—28 amp RMS



Some Typical Sarkes Tarizan Hermetically Sealed Rectifiers

Type	Max. Peak Volts	Max. DC Amps*
Type H3 - 6 Amp Series		
20H3	200	6
40H3	400	6
60H3	600	6
Type 2 - 12 Amp Series		
2 - 20	200	12
2 - 40	400	12
2 - 60	600	12
Type 9 - 250 Amp Series		
9 - 20	200	250
9 - 40	400	250
9 - 60	600	250

Positive or negative base polarity available in all types
*with adequate cooling fins

SARKES TARZIAN, INC.

World's Leading Manufacturers of TV and FM Tuners • Closed Circuit TV Systems • Broadcast Equipment • Air Trimmers • FM Radios • Magnetic Recording Tape • Semiconductor Devices

SEMICONDUCTOR DIVISION • BLOOMINGTON, INDIANA

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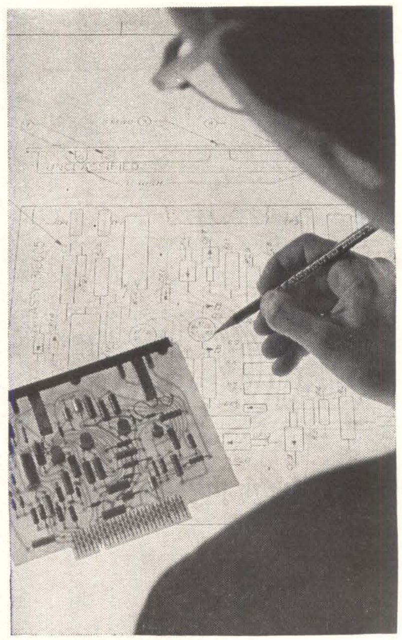
the first group trained. These costs are expected to be offset by savings realized in 1962 from reductions in repair work and inspection time, due to the uniformity of connections. It is believed by all concerned that basic production training has a vital bearing on reliability.

Drafting Technique Shows Both Sides of PC Boards



Faded-out circuit pattern plus component layout simulates actual pc board

A DRAFTING TECHNIQUE that shows both sides of an etched circuit board has been developed by Hughes Aircraft Co. communications division at Culver City, Calif.

Dual visibility is achieved photographically by printing a bold outline of the component side of the circuit board over a faded outline of the back, or solder side. Thus the complete circuit, with the location of all the components in relation to the solder points, is visible at a glance. The technique reduces error in circuit layout and has reduced design drawing costs by 50 percent. Microfilmed copies of the drawings meet the strictest military specifications.

First a master drawing of 4 to 1 scale is made of only the etched side of the board. This is photographically reduced to make negatives of machine and assembly drawings. Two negatives of the master are

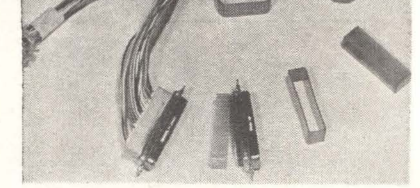
made, both reduced to 2 to 1 scale to fit on D-size sensitized drawing film.

Dual visibility is achieved by projecting the etched circuit on sensitized film and fading it out by use of a screen. Then the components are inked in and the boldness of the component outline over the faded circuit presents a distinctive drawing, providing marked contrast between the two sides.

The same technique can be employed to show circuits on a double-sided etched board. The circuit on the near side is shown bold and the reverse side is faded out.

Differences in line density readily distinguish the component, circuit near-side, and circuit far-side in the double-sided etched board.

Simple Forms Aid Cable Making

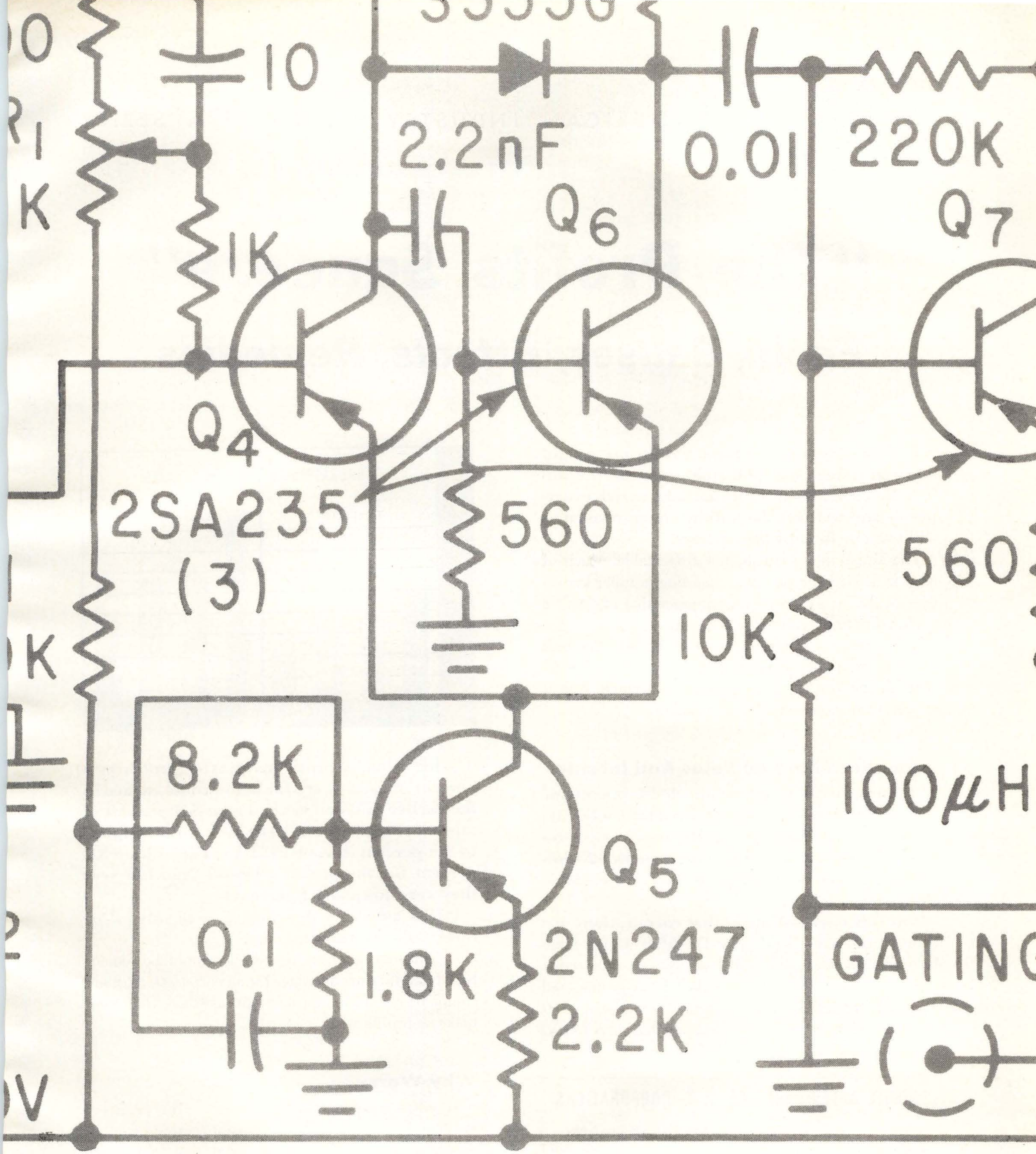


A SPACE PROBLEM in an airborne monitoring unit was solved at Lockheed Electronics Co. by using specially molded cable connector potting forms of glass epoxy made by Stevens Tubing Corp., East Orange, N. J.

Standard cable connector forms were too large and restricted the direction of wire take off. A special shorter form was designed to snap fit over the connector receptacle. The form was then filled with RTV Silastic compound, encapsulating the wire connections.

The resulting cable assembly—with its high resistance to moisture, temperature, and shock—was more economical than conventional connector components.

Inexpensive potting forms are made by cutting short pieces from lengths of glass laminated epoxy or silicone tubing, molded with tight tolerances to snap fit over the connector receptacle.


10
2.2nF
0.01
220K
Q6
Q7
1K
Q4
2SA235
(3)
560
560
10K
8.2K
100μH
Q5
2N247
0.1
1.8K
2.2K
GATING

"The Profits Squeeze"

Facts, Causes, Effects, Remedies

U. S. business is in a bind. Profits are caught between rising costs and stable prices. And unless the pressures are substantially eased, everyone — and not just the nation's businessmen — will soon be hurt by the squeeze.

The situation is critical, but correctable. Much of what is needed is more understanding, a fuller knowledge of the facts, and a wider appreciation of the role profits play in the American economy.

This statement is designed to contribute to this end. It shows what has happened to profits since World War II. It looks at events behind the change. And it suggests routes out of the predicament.

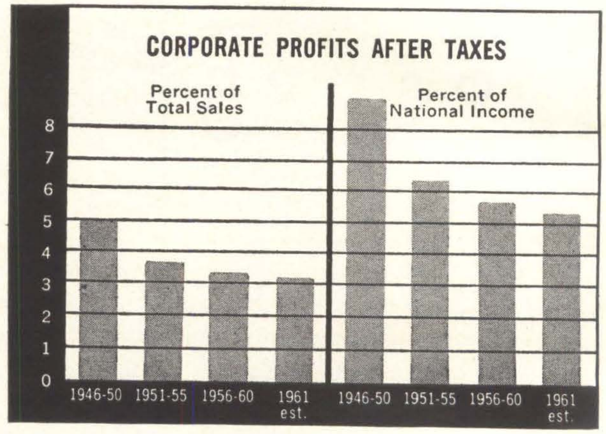
A Smaller Share Of Sales And Income

Among the most important developments of the present business recovery is the rise in corporate profits. Edging slightly above the 1960 level, after-tax profits last year rose to $23 billion. They are likely to push on to a new high this year.

But this does not mean that corporations are doing unusually well. Far from it. As the table below shows, profits for 1961 were less than those for 1959 and 1956. They just equalled 1955 profits, and were only a hair's breadth above the earnings of 1950 when the economy was 45% smaller than it is today.

PROFITS AFTER TAXES OF U. S. CORPORATIONS

Year	Billion Dollars	Year	Billion Dollars
1946	$13.4	1954	$16.8
1947	18.2	1955	23.0
1948	20.5	1956	23.5
1949	16.0	1957	22.3
1950	22.8	1958	18.8
1951	19.7	1959	23.7
1952	17.2	1960	22.7
1953	18.1	1961 estimate	23.0



What's more, profit margins — profits as a percent of sales — are far below those earned in the earlier postwar years. From 5.0 percent of sales during the years 1946-50, profits dropped to 3.6 percent during 1951-55. They slid to 3.2 percent for the period 1956-60. And last year they were down to 3.1 percent.

Profits are also a shrinking share of national income, as the chart above shows.

In considering these figures, it should be remembered that they are averages for all corporations. Some companies make more than the average, and some make no profits at all.

Why Worry?

If only a few companies were making low profits or showing losses, there would be scant reason for public concern. But when business firms generally begin showing a poor profit record, it becomes the proper concern of everyone — stockholders, managers, workers, government officials and consumers. This is because profits perform three indispensable jobs in the American economy:

First, profits provide economic motive power. They induce businessmen to research new products and new techniques of production. They encourage risk-takers to put their savings into economic activity that is useful to the entire community.

Second, retained profits are the single most important source of growth capital. As President Kennedy said in his Economic Report to Congress, "While we move toward full and sustained use of today's productive capacity, we must expand our potential for tomorrow."

Third, the quest for profits directs labor and other resources to the jobs people want done. They tell management whether it is doing a good job or a bad job, and channel resources into the production of the things consumers want.

If profit margins continue dwindling at the present rate, these jobs can't be done efficiently. Businessmen will provide fewer new goods and services for consumers. Investors won't buy the new plants and equipment that mean more employment opportunities and better working conditions for labor. And some companies will lose their zeal for shifting their efforts in accord with consumer preferences.

Behind The Decline

While profit margins have been falling, the corporate compensation of employees has taken a growing share of both corporate sales and national income. The following table shows what has been happening here.

CORPORATE COMPENSATION OF EMPLOYEES

Year	Percent of Total Sales	Percent of National Income
1946-50	23.5	40.1
1951-55	24.3	42.4
1956-60	24.4	43.8
1961 estimate	25.0	43.5

But generally confronted by increasingly competitive conditions, both at home and abroad, companies have usually been unable to pass along a bigger wage and salary bill to their consumers in the form of higher prices, even if they wanted to. In the early years after World War II it was often possible to pass along higher costs by marking up prices, but in these days of general abundance intense competition for sales makes this difficult. Hence the squeeze of profits between rising costs and relatively stable prices.

High federal taxes also intensify the profit squeeze. Except for the profits of very small companies, the federal government still takes 52 percent of business profit. This is the same giant slice that was taken before tougher competition made profit dollars so much harder to acquire.

What Can Be Done?

There is no disposition here to deprecate the desirability of high wages. Nor is there any lack of appreciation that the federal government must have very large revenues if it is to perform its role in the 60's properly.

But it is important to realize that excessive wage hikes and excessive taxes can be self-defeating. They can lead to reduced wages and reduced tax revenues if they squeeze profits to the point where these cannot play their vitally necessary role in the economy. Before this happens both labor and government should take time out to ponder the long-run effects of today's actions.

There is an ancient and honorable phrase which says that "the laborer is worthy of his hire." Labor leaders, as they sit around the negotiating tables this year, should remember that profit makers, no less than they, are likewise worthy of their hire.

In considering new tax legislation, it's up to Congress to keep constantly in mind that a prosperous business community is absolutely essential to the defense of freedom, to the maintenance of high employment, even to the revenues that pay Congressional salaries. The present tax load works against having this prosperous kind of business community.

Of course, business too has an obligation to keep profits from falling to an ineffective remnant. One of the best ways it can discharge this obligation is by continuing its research efforts, by developing new products and new cost-cutting ways to make them as well as their present products and services.

The prevailing profits squeeze is a matter of vital concern to every American. We all have a stake in seeing that steps are taken — in the offices of business management, in halls of Congress where tax laws are made and revised, and at the bargaining tables where agreements on wage rates are made — to see that this squeeze is relaxed.

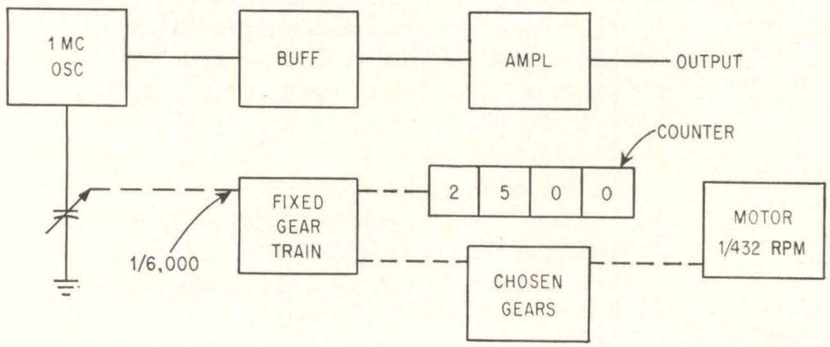
This message was prepared by my staff associates as part of our company-wide effort to report on major new developments in American business and industry. Permission is freely extended to newspapers, groups or individuals to quote or reprint all or part of the text.

Donald C McGraw

PRESIDENT

McGRAW-HILL PUBLISHING COMPANY

DESIGN AND APPLICATION



Clock Compensated Oscillator

1 MC WITH STABILITY OF 1 PART IN 10^8

RECENTLY announced by Manson Laboratories Inc., 375 Fairfield Ave., Stamford, Conn., is the model RD 144A-010 clock-driven transistorized oscillator that generates a 1 Mc signal adjustable within 4 cps, having a drift rate less than 1 part in 10^8 per week after initial aging period. The tuning capacitor of the oven-controlled crystal oscillator is connected (see sketch) through a gear train having a fixed reduction of 1/6,000, and a set of chosen gears to a motor having 1/432 rpm. The chosen gears are selected after an examination of the crystal aging characteristics and a proper set are picked. As the clock motor and fixed gear train operate, the tuning capacitor is varied at 5.5×10^{-4} revolutions per day or 0.2 degree. The tuning capacitor has a travel range of 150 degrees and can vary frequency by 3 cps. A change of 0.2 degree per day equals frequency change of 4 parts in 10^9 per day (assuming chosen gear ratio of 1:1). As the unit operates, a front-panel digital counter indicates the amount of compensating capacitance remaining. No other adjustment is required for a minimum period of one year.

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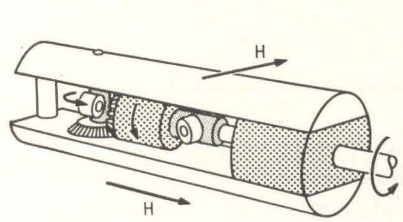

Axial Field Gaussmeter

FOR THREE DIMENSIONS

MANUFACTURED by Rawson Electrical Instrument Co., Inc., 110 Potter St., Cambridge 42, Mass., is the type 729 gaussmeter capable of measuring a magnetic field in three dimensions. Having a probe diameter of $\frac{1}{16}$ in. and a length of approximately 20 inches, ranges are 0.4, 1.2, 4, 12, 40 and 120 kilogauss. Accuracy is 1-percent of full scale. The device has a second coil (see sketch) rotating at right angles to usual coil and sensitive only to fields along the axis. The two coils are matched in sensitivity and either can be used with the indicating meter. A field in any direction can be measured by combining the measurements of the two coils. Using the transverse coil, the tranverse field is located in direction by rotating the probe on its axis until a maximum reading is obtained. An arrow on the case indicates direction and the meter indicates intensity. Switching to the axial coil then gives a reading showing component of field along axis. Rotation of probe around axis does not vary reading of axial coil. Vector sum can be computed to give total field. All three mutually-perpendicular components can be measured separately if preferred. Measurements can be made of magnetic fields of solenoids, focussing coils and magnets for ion or electron beams.

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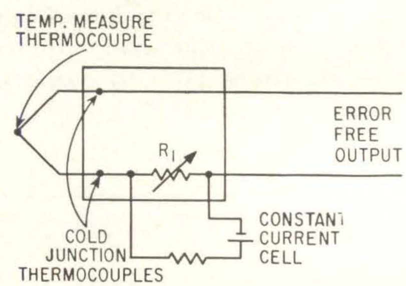


Thermocouple Reference

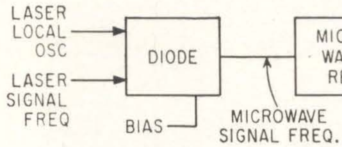
PASSIVE SELF POWERED

ANNOUNCED by Consolidated Ohmic Devices, Inc., New Hyde Park, New York, is the model EZT205 self-powered passive state thermocouple reference junction with ± 0.5 degree accuracy. The 25 gram weight device contains its own power source and can be supplied between -200 F and $+500$ F reference temperature. It may be used with chromel/alumel, copper/constantin and iron/constantin thermocouples as well as other thermocouple metals. Multiple installations may be achieved with infinite inter-channel resolution. Cold junction compensation (see sketch) is achieved by introducing an emf equal and opposite to the error emf produced by the cold junction thermocouples. Zero error is achieved by producing an emf across R_1 whose reciprocal equality to the cold junction thermocouple

PULSE WIDTH
FREQUENCY
DELAY
MICROVOLTS
ATTENUATOR
POWER SET
ZERO SET
FM AMPLITUDE
MODULATION SELECTOR
MEGACYCLES
POWER
RF OUTPUT
MICROWAVE SIGNAL GENERATOR
EMPIRE DEVICES INC.

emf is maintained over an expanded temperature range. Exacting selection and temperature compensation of the constant-current source as well as unique alloy combinations for R_1 permits near perfect compensation for a wide variety of thermocouples. The resultant output voltage of the system is exactly equal to that generated by the thermocouple measurement junction.

CIRCLE 303 ON READER SERVICE CARD



Photomixer Diode

DEMODULATES LASERS

MANUFACTURED by Philco Corporation, Church Road, Lansdale, Pa., the L-4500 silicon planar epitaxial diode is used to detect difference frequency between two closely-spaced optical laser frequencies. It provides high quantum efficiency and operates with bandwidths up to 5 Gc. In detecting wideband transmission from a laser, the mixing process is analogous to conventional superheterodynes. Unlike conventional crystal mixers, this device need not respond electrically to either a signal or a local oscillator frequency, merely to the difference frequency. At 7,000 A, quantum efficiency is estimated to be typically 85 percent. It is packaged in a coaxial microwave housing similar to conventional K-band mixer crystals. Direct coupling to a 50-ohm line is provided as the unit is also mounted in a BNC UG88/U coupler.

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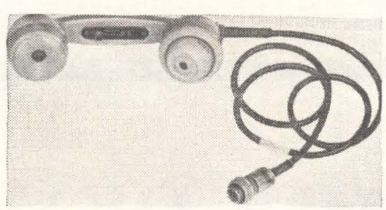


Heavy Duty Handset

FOR MILITARY USE

ROANWELL CORP., 180 Varick St., New York 14, N. Y. Model RH-169 (38) heavy duty, naval/military communications handset, is designed to operate with a high level of intelligibility in high ambient noise level areas. The microphone effectively cancels unwanted sound by directing ambient noise to sound chambers on both sides of the diaphragm. Recommended load is 30 ohms. Frequency range is 300 cps to 5,000 cps and sensitivity is 35 db ref: 1 mv at 1,000 cps with sound pressure of 28 dynes/cm^2 applied.

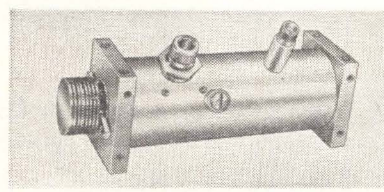
CIRCLE 305 ON READER SERVICE CARD

Tetrode

PULSE MODULATOR

CALVERT ELECTRONICS, INC., 220 E. 23rd St., New York 10, N. Y. The 4PR60WB/C1149 pulse modulator tetrode features a reinforced grid/cathode structure that gives it extra reliability and long life characteristics under conditions of extreme vibration and mechanical stress.

CIRCLE 306 ON READER SERVICE CARD



Pulse Oscillator

HIGH POWER

TRAK MICROWAVE CORP., Tampa, Fla. Type 2971 pulse oscillator has these typical characteristics: frequency, 1600 Mc; peak power, 5 Kw nominal; duty cycle, 0.0033 max; weight 12 oz and size 2.0 in. in diameter by 6 in. long. Required operating voltages and currents: peak cathode voltage 3,500 (negative), peak plate current 5 amp max, heater voltage 6.3 v a-c or d-c and heater current 1.3 amp.

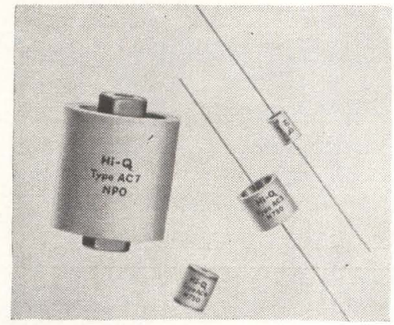
CIRCLE 307 ON READER SERVICE CARD

Audio Oscillator

BARKER & WILLIAMSON, Bristol, Pa. Model 210 provides a sine wave signal from 10 cps to 100 Kc; output level within ±1 db when working into 600 ohms (reference 5 Kc); power output, variable to above 150

mw; hum and noise, −70 db at 5 v output; distortion, less than 0.2 percent at 5 v output from 50 to 20,000 cps.

CIRCLE 308 ON READER SERVICE CARD

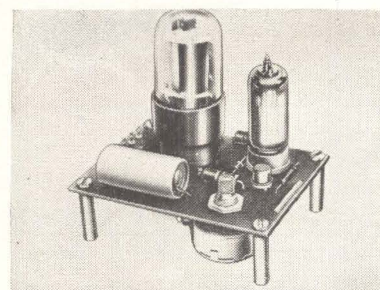


Ceramic Capacitors

FOR H-F SERVICE

HI-Q DIV., Aerovox Corp., Olean, N. Y. Aerocup small, light weight, ceramic capacitors are useful in such applications as transmitters, ultrasonic equipment, electronic welding machines, ovens and induction heating devices. Values range from 2 to 1,000 $\mu\mu$f, depending on type, with standard tolerances as low as ±5 percent. Capacitors also have a low power factor—ranging from 0.05 percent to 0.1 percent, max.

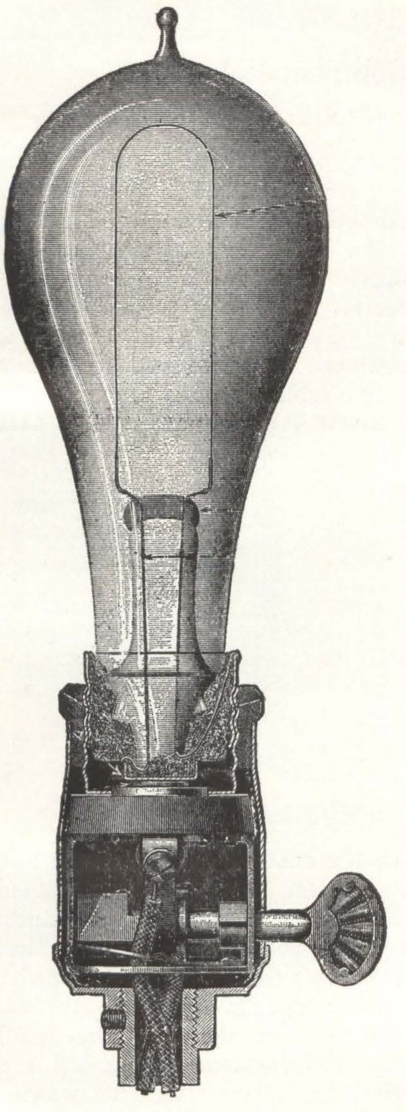
CIRCLE 309 ON READER SERVICE CARD



Power Supply Modules

SMALL SIZE, LOW COST

PRODUCTION ELECTRONICS INC., 525 Lehigh Ave., Union, N. J. Model DCV-121 is designed to provide regulated d-c output from unregulated d-c input. Entire circuit is on a p-c board provided with threaded standoffs for mounting. The ACV-121 uses the same regulating circuit as the DCV-121 and has its own built-in power transformer, rectifier and filter to provide operation directly from the a-c power line. An auxiliary a-c output of 6.3 v at 2.0 amp is provided. Both units have



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electronics

A McGraw-Hill Publication, 330 West 42nd St., N. Y. 36

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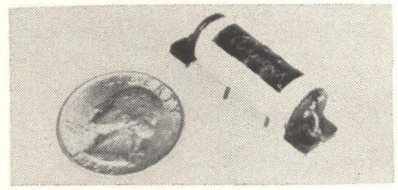
typical regulation of 0.02 percent for both line and load variation.

CIRCLE 310 ON READER SERVICE CARD

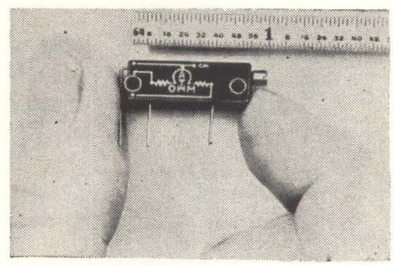


Compact Relay

GENERAL PURPOSE

WHEELOCK SIGNALS, INC., Long Branch, N. J., offers a long life, 4 pdt relay. Contacts conservatively rated at 15 amp, 115 v a-c are separated by molded Melmac arc barriers for increased switching reliability. Fast, one plane wiring is achieved through the use of new crimp-solder terminals.

CIRCLE 311 ON READER SERVICE CARD

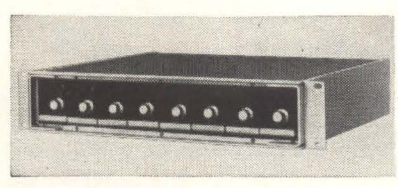


Trimmer Pot

RECTILINEAR

ATOHM ELECTRONICS, 7648 San Fernando Rd., Sun Valley, Calif. Model 225 is a mil-quality, rectilinear trimmer pot with p-c lugs and measuring less than 1 in. overall. Resistance range is 10 ohms through 100,000 ohms with ±5 percent tolerance, and power rating is 2 w at 70 C. Operating temperature range is −65 C to +200 C. End resistance is 0.25 percent or 1 ohm, whichever is greater. Case is sealed against humidity.

CIRCLE 312 ON READER SERVICE CARD



Amplifier

FOR GALVANOMETERS

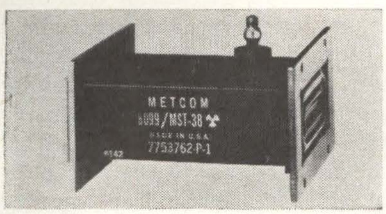
VIDAR CORP., 2296 Mora Drive, Mountain View, Calif. A high-level d-c amplifier, model 410, is designed to drive galvanometers and other low impedance loads requiring high current output. Input impedance is greater than 1 megohm; output impedance, less than 1 ohm. Output is ± 10 v at ± 100 ma. Gain is continuously adjustable from 1 to 20, plus four calibrated settings. Response is flat within ± 2 percent, d-c to 10 Kc.

CIRCLE 313 ON READER SERVICE CARD

Down Converter

INTERNATIONAL MICROWAVE CORP., 1 Seneca Place, Greenwich, Conn. Microwave down converters, operating in the 2 to 12 Gc range, measure 8 cu in., include a transistor i-f preamplifier with 34 db gain and 100 Mc bandwidth.

CIRCLE 314 ON READER SERVICE CARD

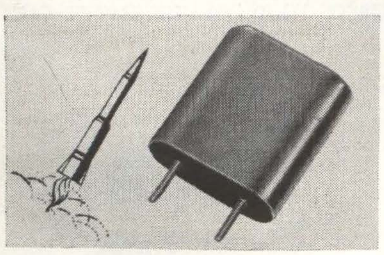


TR Tube

100 KW PEAK POWER

METCOM INC., Salem, Mass. The MST-38 is a crystal protector TR tube for use in high pressure systems. It has a peak power of 100 Kw; has a frequency range of 2,625-2,925 Mc, and can be used in systems pressurized up to 50 psig.

CIRCLE 315 ON READER SERVICE CARD

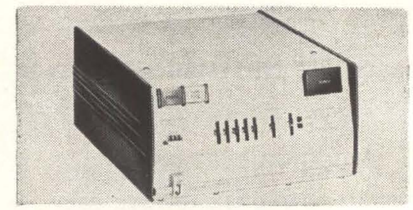


Crystals

HIGH VIBRATION

MONITOR PRODUCTS CO., INC., 815 Fremont Ave., South Pasadena, Calif., announces the MC-V series in frequency ranges from 4 Kc to 100 Mc. Vibration is 30 g at 20 to 3,000 cps. Shock is 100 g. Frequency tolerance over temperature range of −55 C to +105 C to ±0.003 percent depending on frequency. Frequency tolerance under vibration is not more than 5 parts per million. Prices from $9 to $55 each in small quantities.

CIRCLE 316 ON READER SERVICE CARD



Tape Punch

SEMIAUTOMATIC

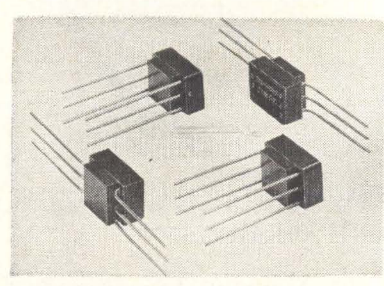
JONATHAN ELECTRONICS CORP., 1151 E. Ash St., Fullerton, Calif. Although a single-column punch, model J-3000 performs the functions of more expensive block punch units through the use of a system of panel thumbwheel switches which position a set of memory cams. These cams program the punching logic to the correct hole pattern for each block of data, while returning the panel switches to the zero position. Unit has a standard capacity of 117 bits per block.

CIRCLE 317 ON READER SERVICE CARD

Industrial Laminate

GENERAL ELECTRIC CO., Coshocton, O. Low-cost warm-to-hot punching grade of Textolite industrial laminate, grade 11602, is available. The paper base phenolic laminate is a NEMA grade XP and is rated Class A for insulation purposes.

CIRCLE 318 ON READER SERVICE CARD

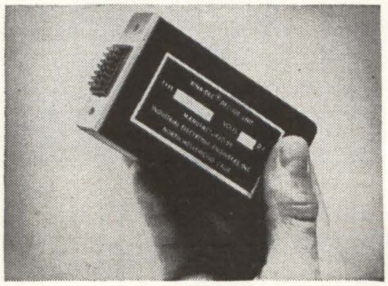


Pulse Transformers

MINIATURIZED

TECHNITROL INC., 1952 E. Allegheny Ave., Philadelphia 34, Pa. Genie pulse transformers have a rectangular shape, 0.650 by 0.425 by 0.350 in., which results in a minimum waste of space between components. Even when a transformer is mounted flush against a p-c board, the leads are exposed on both sides of the board for convenient testing. The exposed leads also permit solder flux to be easily flushed away. Lead clearance eliminates the need for tight tolerances on hole spacing.

CIRCLE 319 ON READER SERVICE CARD

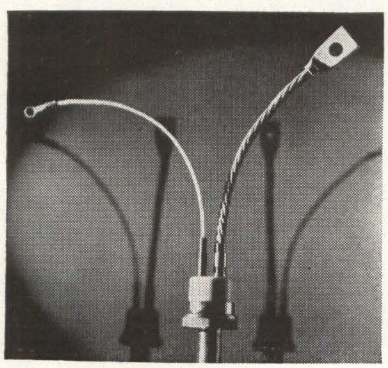


Decode Unit

ELECTROMECHANICAL

INDUSTRIAL ELECTRONIC ENGINEERS, INC., 5528 Vineland Ave., N. Hollywood, Calif. Low-cost electromechanical decoder can be driven directly by transistor circuitry. Requiring only 40 mw per bit with a 4 w set pulse, the Bina-Dec decoder will accept any 4-bit code. The 50-w output contact capacity can be used without amplification to drive readouts, indicator tubes, printers, key punches and other equipment requiring decimal output.

CIRCLE 320 ON READER SERVICE CARD



Four-Layer *PNPN* SCR

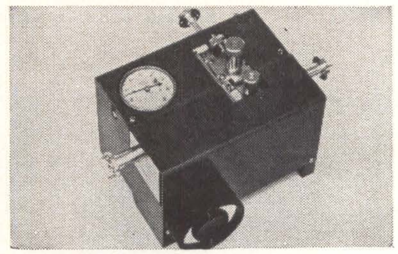
70-AMPERE

WESTINGHOUSE SEMICONDUCTOR DIV., Youngwood, Pa., offers a 70-amp Rock-Top Trinistor controlled-rectifier line with forward blocking voltage to 400 v and prv to 480 v. The scr features a turnoff time of 10 to

CIRCLE 99 ON READER SERVICE CARD

20 μsec. Turn-on time is 0.6 to 3.0 μsec and max d-c current is 110 amp. Typical applications include high-power inverters, light dimmers, motor control, magnetic amplifier replacement, ignitron firing, frequency changers and d-c power regulators.

CIRCLE 321 ON READER SERVICE CARD

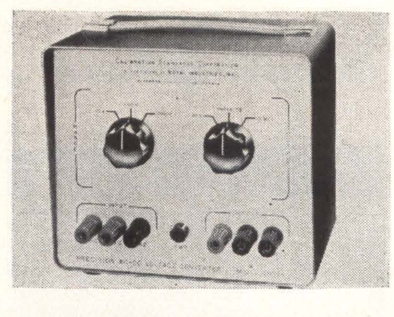


Calorimeters

USED AT 26-140 GC

TRG, INC., 400 Border St., East Boston, Mass. Line of calorimeters, useful over the entire 26 to 140 Gc band, have a power range of 10^{-4} to 0.5 w, and a vswr of 1.3 max. Stabilization time is 10 sec, accuracy is 5 percent (5 to 500 mv), water flow rate is approximately 2 cc per min, and power is supplied by internal batteries. Units provide rapid, accurate and relatively inexpensive measurement of millimeter power.

CIRCLE 322 ON READER SERVICE CARD



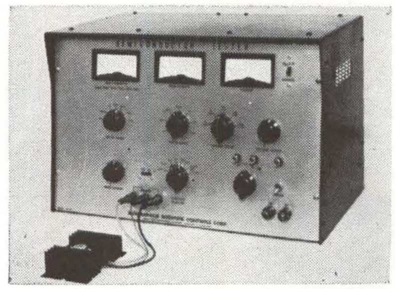
A-C/D-C Converter

SOLID STATE, LOW COST

CALIBRATION STANDARDS CORP., 1031 Westminster Ave., Alhambra, Calif. Designed to extend the operation of existing d-c precision and digital voltmeters to have a-c measuring capabilities, the model C-100A is also used in electronic systems where an a-c signal must be converted to d-c prior to control, computing or measuring. Instruments feature a frequency range of 30 cps to 10 Kc with accuracy of 0.15 percent. Voltage ranges, 0.5 to

10, 10 to 100 and 100 to 1,000 v a-c. Voltage linearity is better than 0.02 percent typical; frequency linearity, better than 0.05 percent typical.

CIRCLE 323 ON READER SERVICE CARD

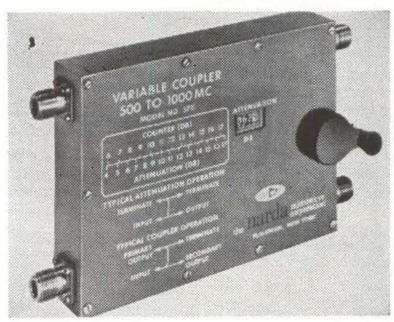


Semiconductor Tester

VERSATILE UNIT

MINNEAPOLIS SCIENTIFIC CONTROLS CORP., 9330 James Ave. S., Minneapolis 20, Minn. Model ST101 tests d-c characteristics of transistors, diodes and rectifiers. It features 25 amp current capability and simplicity of operation. Used for either production or laboratory testing, the unit's output power range is up to 150 w. Three meters are mounted in the face plate and give readings for base current, main current and voltage.

CIRCLE 324 ON READER SERVICE CARD



Digital Attenuator

PRECISION UNIT

NARDA MICROWAVE CORP., Plainview, L. I., N. Y. Model 3711 coaxial coupler-attenuator features an accurate digital counter. The high power unit exhibits an extremely low vswr (1.1 above 15 db) and covers the octave frequency range from 500 to 1,000 Mc. For any setting above 20 db, relative accuracy is 0.1 db within any 10 db range and 0.3 db max up to 70 db range. Absolute accuracy is 1 db anywhere in the attenuation or frequency range.

CIRCLE 325 ON READER SERVICE CARD

CIRCLE 101 ON READER SERVICE CARD

PRODUCT BRIEFS

WELDING MACHINE 6,000 F torch flame. Henes Mfg. Co., 1336 N. 21st Ave., Phoenix, Ariz. **(326)**

ASYMPTOTIC CALORIMETER 10 mv full scale output. Hy-Cal Engineering, 12105 LosNietos Road, Santa Fe Springs, Calif. **(327)**

SOLID-STATE DIGITAL CLOCK features flexibility. Ransom Research Div., Wyle Laboratories, San Pedro, Calif. **(328)**

TAPE RECORDER BRAKE in one complete assembly. Magnasync Corp., 5546 Satsuma Ave., N. Hollywood, Calif. **(329)**

CLUTCH-POTENTIOMETER size 9, low cost. FAE Instrument Corp., 16 Norden Lane, Huntington Sta., N. Y. **(330)**

LASER POWER SOURCE and energy storage bank. Electro Powerpacs, Inc., 5 Hadley St., Cambridge 40, Mass. **(331)**

FREQUENCY-PHASE LOCK CONTROL SYSTEM with 100 percent accuracy. Sequential Electronic Systems, Inc., 66 Saw Mill River Road, Elmsford, N. Y. **(332)**

A-M RECEIVER 2.0 to 30.0 Mc range. Advanced Communications, Inc., 7225 Alabama Ave., Canoga Park, Calif. **(333)**

DECADE INDUCTOR direct digital readout. Arnold Magnetics Corp., 6050 W. Jefferson Blvd., Los Angeles, Calif. **(334)**

VARACTOR MOUNT high heat dissipation. Microwave Associates, Inc., Burlington, Mass. **(335)**

DIGITAL FREQUENCY METER 300 Kc. Racal Electronics Ltd., Bracknell, Berkshire, England. **(336)**

RELAYS dry reed contacts. Hathaway Instruments, Inc., 5800 E. Jewell Ave., Denver, Col. **(337)**

FIELD EFFECT TRANSISTOR diffused silicon. Amelco, Inc., 341 Moffett Blvd., Mtn. View, Calif. **(338)**

COMPUTER SUPPLY multiple output. Atlas Controls, Inc., 9 Erie Drive, Natick, Mass. **(339)**

HALL EFFECT MULTIPLIER single unit priced at $50. Helipot Div. of Beck-

man Instruments, Inc., 2500 Harbor Blvd., Fullerton, Calif. **(340)**

GALVANOMETER AMPLIFIER solid state. Vidar Corp., 2296 Mora Drive, Mtn. View, Calif. **(341)**

SEQUENCE TIMER battery powered. Geodyne Corp., 180 Bear Hill Road, Waltham 54, Mass. **(342)**

FAULT-RECORDING SYSTEM automatic. Western Electrodynamics, P.O. Box 98, Colorado Springs, Colo. **(343)**

PRECISION POTENTIOMETER low-priced Micropot. Borg Equipment Div., Amphenol-Borg Electronics Corp., Janesville, Wisc. **(344)**

COMPACTRON TUBES 12-pin. Tung-Sol Electric Inc., 1 Summer Ave., Newark 4, N. J. **(345)**

EVENT RECORDING SYSTEM 120-channel. Sanborn Co., 175 Wyman St., Waltham 54, Mass. **(346)**

TRANSFORMERS used at 300 cps to 30 Mc. Aladdin Electronics, Nashville 10, Tenn. **(347)**

SILICON RADIATION DETECTORS for alpha particle detection. Ferranti Electric Inc., Industrial Park No. 1, Plainview, L. I., N. Y. **(348)**

CLIMATE CONTROL CABINET compact unit. Dexon Inc., 3517 Raleigh, Minneapolis 16, Minn. **(349)**

THERMISTOR PROBE fast acting. Fenwal Electronics, 63 Fountain St., Framingham, Mass. **(350)**

INDUCTORS subminiature. Vanguard Electronics Co., 3384 Motor Ave., Los Angeles 34, Calif. **(351)**

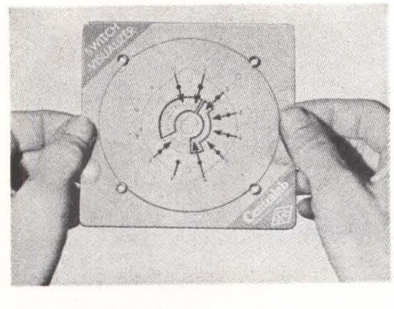
NPN CHOPPER TRANSISTORS silicon planar/epitaxial. Advanced Micro Electronics, 99 Bald Hill Road, Cranston 10, R. I. **(352)**

SIGNAL GENERATOR transistorized. Consolidated Cybernetics Controls, P. O. Box 67, Station H. Montreal 25, P. Q., Canada. **(353)**

1-MC OSCILLATOR high stability. Hewlett-Packard Co., 1501 Page Mill Road, Palo Alto, Calif. **(354)**

POT PRESSURE TRANSDUCER carbon-film resistive element. Computer Instruments Corp., 92 Madison Ave., Hempstead, N. Y. **(355)**

Literature of the Week



SWITCHES Centralab, 900 E. Keefe Ave., Milwaukee 1, Wisconsin. A 43 page catalog and reference bulletin covers rotary, slide and lever switches. Available via a card in this catalog is a switch visualizer made of translucent plastic (see photo) which represents a 12-position rotary switch section. The plastic can be drawn on and erased repeatedly. The main square card represents the stator while the rotor can be revolved to simulate actual switch action. Using the rotor and stator connections for the switch in question, the visualizer readily and conveniently finalizes switch section design before referring to and filling in the switch specification sheet. A series of switch specification sheets are also available. These sheets, used in conjunction with the switch visualizer, list and illustrate design parameters of switch type under consideration and can be used as master drawings. **(356)**

AEROSPACE GROUND EQUIPMENT Arma Div., American Bosch Arma Corp., Garden City, N. Y., has issued a brochure describing its capabilities in development and production of aerospace ground equipment. **(357)**

MEMORY SYSTEMS Indiana General Corp., Electronics Div., Keasbey, N. J., has published a 6-page "Applications Guide to Magnetic Core Memory Systems." **(358)**

MAGNETIC AMPLIFIERS Military & Computer Electronics Corp., 900 N.E. 13th St., Ft. Lauderdale, Fla., offers a data sheet kit on its Ultamag harmonic type solid state magnetic amplifiers. **(359)**

POLYESTER-FILM CAPACITORS Sprague Electric Co., 35 Marshall

St., North Adams, Mass. Technical paper No. 62-11 reports results of an evaluation program on wrapped-type PETP polyester-film capacitors. Available upon letterhead request.

ELECTRON-BEAM WELDING W. S. Romark and Co., Inc., 18233 S. Miles Parkway, Cleveland 28, O. Technical manual describes the electron-beam welding process and its application for joining miniature components. **(360)**

SEMICONDUCTORS General Instrument Corp., 65 Gouverneur St., Newark 4, N. J. Bulletin SR3099 covers silicon and germanium transistors and diodes, silicon Zener diodes and nanocircuits. **(361)**

MICROWAVE BULLETIN Empire Devices, Inc., Amsterdam, N. Y. Bulletin discusses five categories of microwave equipment. **(362)**

TIME INTERVAL COUNTER Eldorado Electronics, 2821 Tenth St., Berkeley 10, Calif. Bulletin describes the 108 series solid state 10 nsec time interval counter. **(363)**

L-F OSCILLATORS Accutronics, Inc., 12 South Island, Batavia, Ill., has produced a 4-page brochure entitled "How To Specify Low Frequency Oscillators." **(364)**

THIN FILM TECHNOLOGY Metavac, Inc., 45-68 162nd St., Flushing 58, N. Y. A 10-page catalog describes high vacuum thin film technology products for the microwave, electronics, optical and infrared industries. **(365)**

HAND WINDER Geo. Stevens Mfg. Co., Inc., Pulaski Road at Peterson, Chicago 46, Ill. Catalog page describes a heavy duty hand winder with 2 speed torque ranges. **(366)**

DIGITAL COMPARATOR Kearfott Div., General Precision, Inc., Little Falls, N. J. Reference sheet C05 9152 illustrates and describes a digital comparator. **(367)**

SPECTRUM ANALYZER Panoramic Electronics Inc., 520 S. Fulton Ave., Mt. Vernon, N. Y. Six-page folder describes the SPA-10 spectrum analyzer for signals in the 10 Mc through 43 Gc range. **(368)**

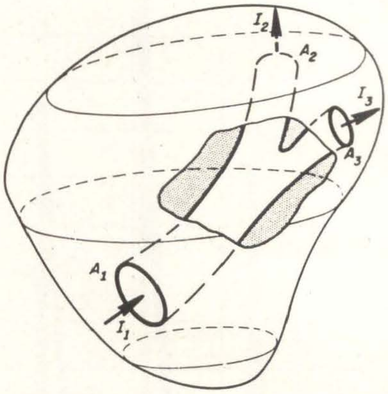
SOLDERS AND PAINT Joseph Waldman & Sons, 137 Coit St., Irvington 11, N. J., offers a bulletin on the use of epoxy silver solders and conductive coatings. **(369)**

NEW BOOKS

Electromagnetics

By ROBERT M. WHITMER

Prentice-Hall, Inc., Englewood Cliffs,, N. J., 1962, 357 *p*, $13. Second Edition.



A surface enclosing the junction of three conductors

Written on a senior-to-postgraduate level, this text covers the electromagnetic theory from Coulomb's law through Maxwell's equations to circular waveguides. Vector analysis is developed concurrently with subject matter up to the Hertzian vector. The treatment is detailed and well illustrated, with problems and references in each chapter.

Radio-Electronic Transmission Fundamentals

By B. WHITFIELD GRIFFITH, JR.

McGraw-Hill Book Company, Inc., New York, 1962, 612 *p*, $10.75.

A guide and reference book on the generation and handling of high-power electrical energy at radio frequencies, this work has four major parts—Electrical networks, transmission lines, radio antennas and radio transmitters. Some knowledge of radio is presupposed; the mathematics is basic and ample problems are included.—G.V.N.

Inertial Guidance.

Edited by GEORGE R. PITMAN, JR.

John Wiley & Sons, Inc., New York, 1962, 481 *p*, $18.50.

Each detailed chapter is written by a different author, selected as an authority in his field. The book has three parts: principal inertial sensing instruments and components of a modern inertial guidance system; the problems of designing and mechanizing inertial guidance systems for aircraft and ships; and finally, inertial guidance systems for rocket propelled vehicles and space navigation. An interesting chapter is devoted to error analysis and performance optimization.—G.V.N.

Square-Loop Ferrite Circuitry: Storage and Logic Techniques

By C. J. QUARTLY

Iliffe Books Ltd., London, 1962, 166 *p,* $6.

Here is a fine introduction to the use of magnetic cores in computers and other digital equipment, with an absolute minimum of mathematics and a large number of well-arranged and informative illustrations, in the usual clear and concise Iliffe style.

Starting with the history and properties of square-loop materials, the book describes various systems in detail. Later chapters go into nondestructive readout, storage circuits, logic circuits, multi-aperture logic elements and counting circuits with more than two flux levels.—S.B.G.

Principles of Electronic Warfare

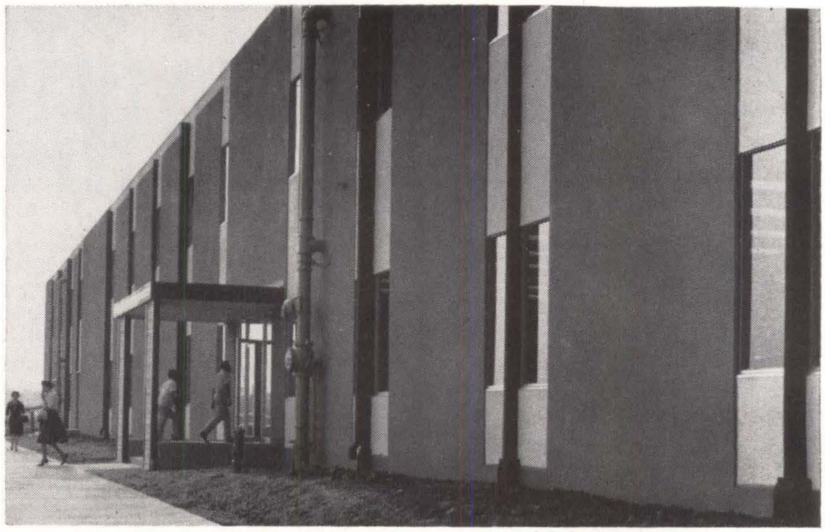
By R. J. SCHLESINGER, K. ABBEY, R. W. EHRHORN, K. J. FRIEDENTHAL and S. H. LOGUE

Prentice-Hall, Inc., Englewood Cliffs, N. J., 213 *p,* $8.

In discussing electronic countermeasures (ECM) and their role in electronic warfare, the authors provide broad and useful—though brief—surveys of many areas involving ECM. Among these are radar, recovery of signal information in the presence of noise, and antennas. ECM problems that are described are largely on radar and aerospace warfare; communications aspects are not discussed in detail and surface and subsurface warfare are implied rather than described.—S.V.

Space-General Consolidates in El Monte

SPACE-GENERAL CORPORATION, Aerojet-General's subsidiary engaged in the design, development and assembly of complete space and missile systems and subsystems, has consolidated administration and engineering functions of its Azusa and Glendale, Calif., plants in a new 167,000-sq-ft, two-story facility in El Monte. Construction was supervised by the company's AETRON division.

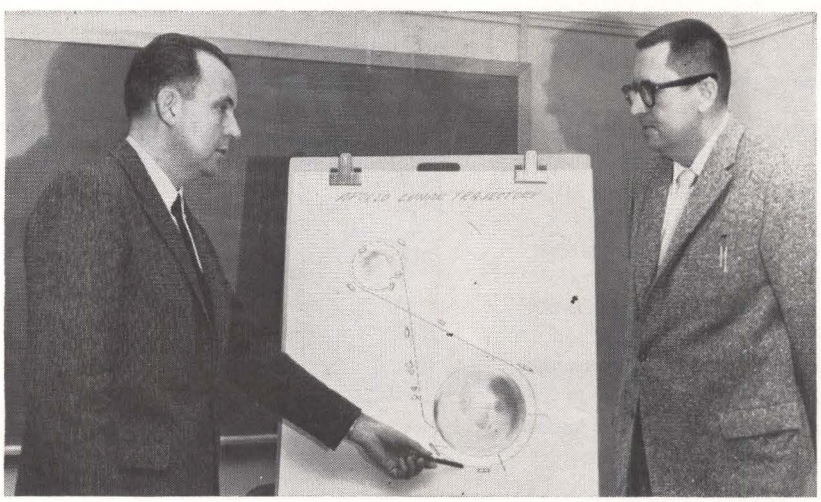


The new building is the first of three to be completed on a thirty-acre tract. A systems evaluation facility is now being erected and beside it the foundation for a cafeteria is underway. When completed in July, the three buildings will incorporate 250,000 square feet for a total cost of about $6 million.

As a major subsidiary of Aerojet-General, Space-General was organized in June, 1961, with about 700 employees and a multimillion dollar business base to provide capabilities in advanced electronics, nucleonics, communications, spacecraft, payloads and data processing systems.

Programs now underway at Space-General include Ablestar upper stage used in the Transit/Courier satellite series, Aerobee and Astrobee research rockets, scientific satellites, attitude control systems, rocket sleds, instrumentation for Ranger and Surveyor lunar spacecraft, subsurface communications, advanced deep space telemetry systems, ICBM terminal guidance, compact moonmobiles and satellite search and rescue systems.

Prepare Telecommunications for Apollo



Dallas, Texas—Development of the telecommunication system for the Apollo spacecraft gets underway at Collins Radio Co. under the direction of Dr. Simeon E. Watson, left. He is discussing one of the many problems involved in the project with Stephen E. Hamilton of the North American Aviation Space and Information Systems division. Hamilton is serving as liaison between Collins and North American, prime contractor for NASA. Collins previously designed and built the communication system for the Mercury space program

Elect Barreca Admiral President

VINCENT BARRECA, executive vice president of Admiral Corp., Chicago, Ill., has been elected president, succeeding Ross D. Siragusa, who had held the post since establishing the company 28 years ago. Siragusa continues as chief executive officer and chairman of the board of directors.

Arwood Opens Sixth Casting Plant

ARWOOD CORP., New York City, recently opened its sixth investment casting plant in Cleveland, O. The 45,000-sq ft plant is a fully-integrated foundry with its own tool and die making facilities.

Among its features are electronically-controlled melting furnaces, one with a melting capacity of 1,500 lb; precise environmental

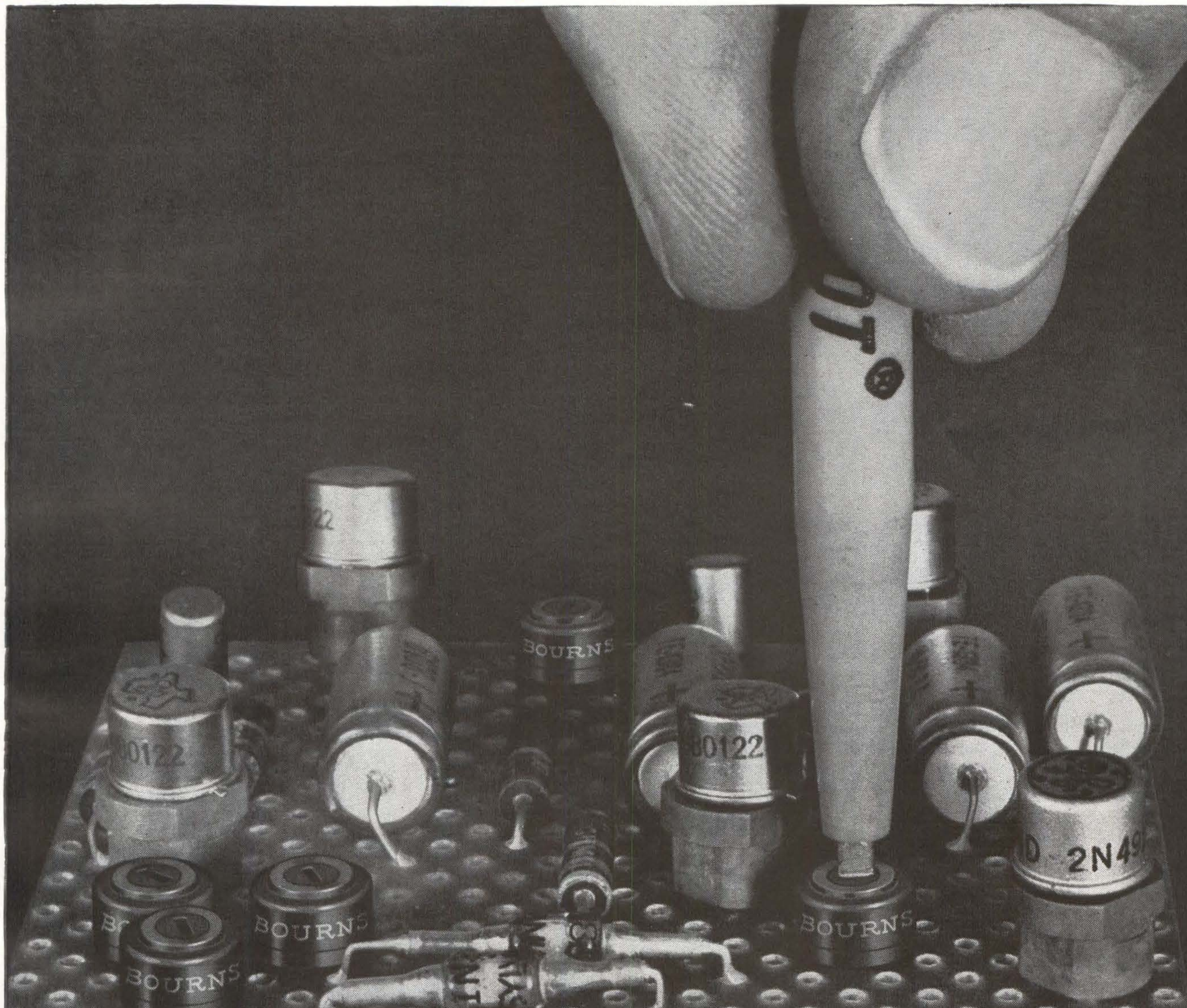
Presenting Bourns Trimpot® Model 3300 – The Only Potentiometer with All These Features:

NUMBER 20—NEW PRODUCT SERIES

(1) Smaller-than-transistor size—just 5/16" dia. x 3/16".
(2) Resistance from 50Ω to 20K.
(3) Full compliance to MIL Specs for cycling humidity, sand, dust, salt spray, fungus (meets MIL-STD-202, MIL-E-5272).
(4) Positive end stops.
(5) Precious-metal contacts.
(6) Sealed lightweight plastic case (no shorts to the board).
(7) Industry-standard pin arrangement.
(8) Exclusive Silverweld® multi-wire termination (virtually indestructible under thermal or mechanical stress).

The single-turn, 0.5 watt Model 3300 is as tough as it is tiny. It stands up to 175°C heat, 30G vibration and 100G shock. Its quality is checked by 100% inspection and double-checked by the rigid Bourns Reliability Assurance Program. In every unit, the performance you specify is the performance you get.

Production quantities available immediately with either printed circuit pins or solder lugs and bushing mount. Write for complete data.



Manufacturer: Trimpot® potentiometers; transducers for position, pressure, acceleration. Plants: Riverside, California; Ames, Iowa; and Toronto, Canada

CIRCLE 109 ON READER SERVICE CARD

control; and a straight-line production set-up which eliminates unnecessary delays.

William I. Matthes, company president, said that almost $700,000 has been spent in equipping the plant, and additional planned expenditures will bring the total to about $1 million in the near future.

Arthur Bruno Joins Audio Devices

AUDIO DEVICES, INC., New York, manufacturer of magnetic tapes, has appointed Arthur J. Bruno manager of research and engineering. Bruno assumes his duties at the company's newly opened research and engineering building in Glenbrook, Conn.

Before joining Audio Devices, Bruno was technical manager of the Johns-Manville Corp., Dutch Brand Division in Chicago, Ill.

Name G. W. Harrison Allegany President

G. WILLIAM HARRISON has been named president of Allegany Instrument Co., a division of Textron Electronics, Inc. He had been vice president and general manager since 1960.

Allegany Instrument, with headquarters in Cumberland, Md., manufactures precision electronic measuring devices, pressure transducers, load cells and thrust measuring systems.

Faflick Moves Up At Sylvania

APPOINTMENT of Carl E. Faflick as director of the advanced systems planning organization of Sylvania Electronic Systems in Waltham, Mass., is announced. He was formerly senior staff specialist-systems for the division.

PM Electronics Changes Name

PM ELECTRONICS, INC., San Diego, Calif., has changed its name to California Instruments Corp.

The name change follows an earlier announcement that PM has expanded its product line to include automatic oscilloscopes and analog voltage comparators, as well as its established line of d-c instrumentation amplifiers for both ground support and missileborne applications.

Sola Names McGuire Senior V-P and G-M

JOHN V. MCGUIRE has been named senior vice president and general manager of Sola Electric Co., Elk Grove Village, Ill. He joins the company after extensive experience with the Allis-Chalmers Mfg. Co., most recently as general manager of that company's Pittsburgh, Pa., plant.

Kazan Accepts New Position

BENJAMIN KAZAN has joined the staff of Electro-Optical Systems, Inc., Pasadena, Calif., as chief scientist of the Solid State division. He will be responsible for solid state research and development programs in thin film techniques and light-imaging and amplifying devices.

Prior to joining EOS, Kazan was head of the solid state display group of the Hughes Research Laboratories.

Van Slyck Assumes New Zenith Post

WILLIAM S. VAN SLYCK has been appointed to the new position of assistant director of Zenith Radio Corporation's Government and Special Products division in Chicago, Ill.

He was formerly chief electrical engineer for Zenith's Military division.

Shockley Announces R&D Appointments

ADOLF GOETZBERGER and Robert Tamblyn have been given new duties in the R&D section of Clevite/Shockley Transistor in Palo Alto, Calif.

Goetzberger, a member of the senior research staff for three years, is appointed manager of R&D.

Tamblyn, controller of the organization, takes on the additional work of R&D administrator.

Raytheon Appoints Sidney Topol

RAYTHEON COMPANY recently appointed Sidney Topol general manager of Raytheon (Europe) A.G., a wholly-owned subsidiary located in Zug, Switzerland. He will have management and supervisory responsibilities for all companies in which Raytheon (Europe) A.G. has a controlling interest.

Topol joined Raytheon in 1949. He was named director of planning for Europe in 1959.

PEOPLE IN BRIEF

George J. Mozek is promoted to chief application engineer for National Transistor Mfg., Inc. **Alan F. Stevens** leaves Telecomputing Services, Inc., to join the Systems Div. of Electro-Mechanical Research, Inc., as a senior engineer. **Robert Moffat** and **William A. Hriszko** advance to executive v-p and v-p of manufacturing and engineering, respectively, at Webcor, Inc. Raytheon elevates **Frank F. Oddi** to managing director of A. C. Cossor, Ltd., its London subsidiary. **Chandler L. Goldthwaite** moves up at Sanders Associates, Inc., to operation mgr. of its new New Hampshire facility. **Walter L. Schlenker** of GE named a project mgr. in its internal automation operation. ITT ups **Mortimer Rogoff** to v-p, program planning and development, for its Federal Laboratories. **G. O. Haglund,** former General Mills exec, elected v-p of Vitro Corp. of America. **William Turner,** previously with Lionel Corp., appointed mgr. for research at Dynamic Electronics Div., Capehart Corp. **Robert O. Case, Jr.,** ex-North American Aviation now director of research for Tamar Electronics, Inc., and its four divisions. Promotions at Entron, Inc.: **James L. Lahey,** to president and chief executive officer; **Henry M. Diambra,** to chairman of the board; **W. C. Godsey, Jr.,** to head of the executive committee. **Arthur H. Schweitzer,** g-m of the Jet Div. of TRW Inc., elected a v-p of the company.

EMPLOYMENT OPPORTUNITIES

electronics

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ATTENTION: ENGINEERS, SCIENTISTS, PHYSICISTS

This Qualification Form is designed to help you advance in the electronics industry. It is unique and compact. Designed with the assistance of professional personnel management, it isolates specific experience in electronics and deals only in essential background information.

The advertisers listed here are seeking professional experience. Fill in the Qualification Form below.

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Your Qualification form will be handled as "Strictly Confidential" by ELECTRONICS. Our processing system is such that your form will be forwarded within 24 hours to the proper executives in the companies you select. You will be contacted at your home by the interested companies.

WHAT TO DO

1. Review the positions in the advertisements.
2. Select those for which you qualify.
3. Notice the key numbers.
4. Circle the corresponding key number below the Qualification Form.
5. Fill out the form completely. *Please print clearly.*
6. Mail to: D. Hawksby, Classified Advertising Div., ELECTRONICS, Box 12, New York 36, N. Y. (No charge, of course).

COMPANY	SEE PAGE	KEY #
BRISTOL COMPANY Waterbury, Connecticut	94*	1
COLLINS RADIO COMPANY Dallas, Texas	91	2
DOUGLAS AIRCRAFT CO. Missile and Space Systems Div. Santa Monica, California	85	3
E. I. DU PONT DE NEMOURS & CO., INC. Wilmington, Delaware	116	4
EITEL-McCULLOUGH INC. San Carlos, California	83	5
HAMILTON WATCH CO. Metals & Electronics Div. Lancaster, Pennsylvania	93*	6
INTERNATIONAL BUSINESS MACHINES CORP. New York, New York	115	7
INTERNATIONAL BUSINESS MACHINES CORP. Space Guidance Center Owego, New York	91*	8
LAWRENCE RADIATION LABORATORY Livermore, California	93*	9
MARTIN COMPANY Orlando, Division Orlando, California	116	10
MICROWAVE SERVICES INTERNATIONAL, INC. Denville, New Jersey	118	11
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION Washington, D. C.	117	12
NATIONAL CASH REGISTER CO. Dayton, Ohio	116, 118	13
NORTHROP CORP. Norair Div. Hawthorne, California	81*	14
NORTHROP CORP. Space Laboratories Hawthorne, California	83*	15
PAN AMERICAN WORLD AIRWAYS INC. Guided Missiles Range Division Patrick AFB, Florida	93	16

CONTINUED ON PAGE 118

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electronics WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

Personal Background

NAME ....

HOME ADDRESS ....

CITY ....................ZONE.....STATE............

HOME TELEPHONE ....

Education

PROFESSIONAL DEGREE(S) ....

MAJOR(S) ....

UNIVERSITY ....

DATE(S) ....

FIELDS OF EXPERIENCE (Please Check)

6162

☐ Aerospace	☐ Fire Control	☐ Radar
☐ Antennas	☐ Human Factors	☐ Radio—TV
☐ ASW	☐ Infrared	☐ Simulators
☐ Circuits	☐ Instrumentation	☐ Solid State
☐ Communications	☐ Medicine	☐ Telemetry
☐ Components	☐ Microwave	☐ Transformers
☐ Computers	☐ Navigation	☐ Other ....
☐ ECM	☐ Operations Research	☐ ....
☐ Electron Tubes	☐ Optics	☐ ....
☐ Engineering Writing	☐ Packaging	☐ ....

CATEGORY OF SPECIALIZATION

Please indicate number of months experience on proper lines.

	Technical Experience (Months)	Supervisory Experience (Months)
RESEARCH (pure, fundamental, basic)	......	......
RESEARCH (Applied)	......	......
SYSTEMS (New Concepts)	......	......
DEVELOPMENT (Model)	......	......
DESIGN (Product)	......	......
MANUFACTURING (Product)	......	......
FIELD (Service)	......	......
SALES (Proposals & Products)	......	......

CIRCLE KEY NUMBERS OF ABOVE COMPANIES' POSITIONS THAT INTEREST YOU

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

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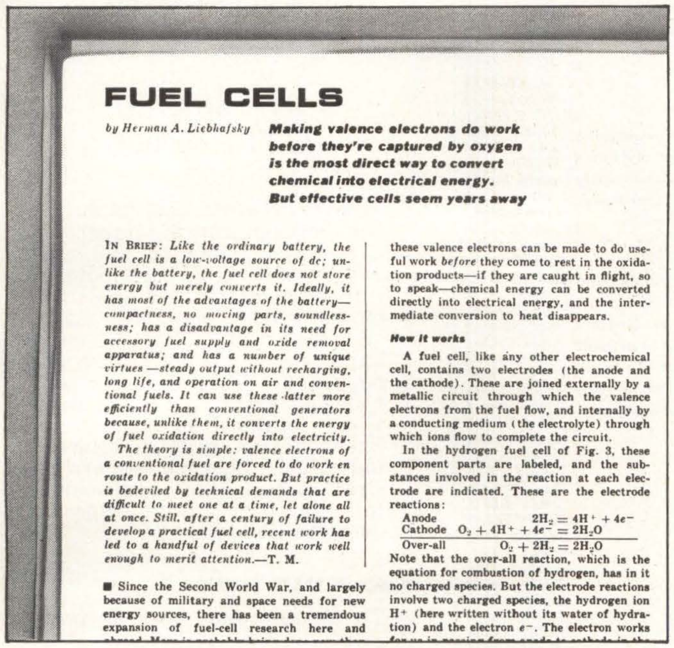
What is known?



FUEL CELLS

by Herman A. Liebhafsky

Making valence electrons do work before they're captured by oxygen is the most direct way to convert chemical into electrical energy. But effective cells seem years away

IN BRIEF: *Like the ordinary battery, the fuel cell is a low-voltage source of dc; unlike the battery, the fuel cell does not store energy but merely converts it. Ideally, it has most of the advantages of the battery—compactness, no moving parts, soundlessness; has a disadvantage in its need for accessory fuel supply and oxide removal apparatus; and has a number of unique virtues —steady output without recharging, long life, and operation on air and conventional fuels. It can use these latter more efficiently than conventional generators because, unlike them, it converts the energy of fuel oxidation directly into electricity.*

The theory is simple: valence electrons of a conventional fuel are forced to do work en route to the oxidation product. But practice is bedeviled by technical demands that are difficult to meet one at a time, let alone all at once. Still, after a century of failure to develop a practical fuel cell, recent work has led to a handful of devices that work well enough to merit attention.—T. M.

■ Since the Second World War, and largely because of military and space needs for new energy sources, there has been a tremendous expansion of fuel-cell research here and

these valence electrons can be made to do useful work *before* they come to rest in the oxidation products—if they are caught in flight, so to speak—chemical energy can be converted directly into electrical energy, and the intermediate conversion to heat disappears.

How it works

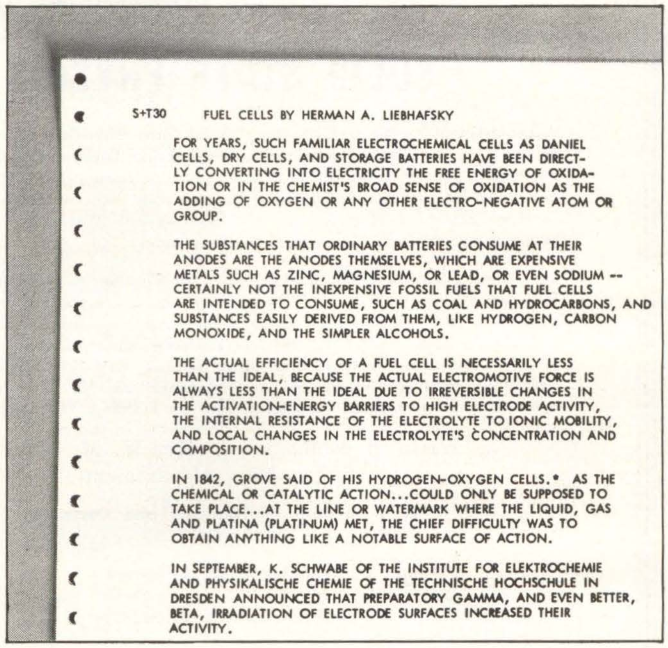
A fuel cell, like any other electrochemical cell, contains two electrodes (the anode and the cathode). These are joined externally by a metallic circuit through which the valence electrons from the fuel flow, and internally by a conducting medium (the electrolyte) through which ions flow to complete the circuit.

In the hydrogen fuel cell of Fig. 3, these component parts are labeled, and the substances involved in the reaction at each electrode are indicated. These are the electrode reactions:

Anode	$2H_2 = 4H^+ + 4e^-$
Cathode	$O_2 + 4H^+ + 4e^- = 2H_2O$
Over-all	$O_2 + 2H_2 = 2H_2O$

Note that the over-all reaction, which is the equation for combustion of hydrogen, has in it no charged species. But the electrode reactions involve two charged species, the hydrogen ion H^+ (here written without its water of hydration) and the electron e^-. The electron works

This 4000-word article appeared in the January, 1962, issue of International Science and Technology. *To abstract the article, a document analyst would read it, define its purpose, and summarize its essential points.*



S+T30 FUEL CELLS BY HERMAN A. LIEBHAFSKY

FOR YEARS, SUCH FAMILIAR ELECTROCHEMICAL CELLS AS DANIEL CELLS, DRY CELLS, AND STORAGE BATTERIES HAVE BEEN DIRECTLY CONVERTING INTO ELECTRICITY THE FREE ENERGY OF OXIDATION OR IN THE CHEMIST'S BROAD SENSE OF OXIDATION AS THE ADDING OF OXYGEN OR ANY OTHER ELECTRO-NEGATIVE ATOM OR GROUP.

THE SUBSTANCES THAT ORDINARY BATTERIES CONSUME AT THEIR ANODES ARE THE ANODES THEMSELVES, WHICH ARE EXPENSIVE METALS SUCH AS ZINC, MAGNESIUM, OR LEAD, OR EVEN SODIUM -- CERTAINLY NOT THE INEXPENSIVE FOSSIL FUELS THAT FUEL CELLS ARE INTENDED TO CONSUME, SUCH AS COAL AND HYDROCARBONS, AND SUBSTANCES EASILY DERIVED FROM THEM, LIKE HYDROGEN, CARBON MONOXIDE, AND THE SIMPLER ALCOHOLS.

THE ACTUAL EFFICIENCY OF A FUEL CELL IS NECESSARILY LESS THAN THE IDEAL, BECAUSE THE ACTUAL ELECTROMOTIVE FORCE IS ALWAYS LESS THAN THE IDEAL DUE TO IRREVERSIBLE CHANGES IN THE ACTIVATION-ENERGY BARRIERS TO HIGH ELECTRODE ACTIVITY, THE INTERNAL RESISTANCE OF THE ELECTROLYTE TO IONIC MOBILITY, AND LOCAL CHANGES IN THE ELECTROLYTE'S CONCENTRATION AND COMPOSITION.

IN 1842, GROVE SAID OF HIS HYDROGEN-OXYGEN CELLS.* AS THE CHEMICAL OR CATALYTIC ACTION...COULD ONLY BE SUPPOSED TO TAKE PLACE...AT THE LINE OR WATERMARK WHERE THE LIQUID, GAS AND PLATINA (PLATINUM) MET, THE CHIEF DIFFICULTY WAS TO OBTAIN ANYTHING LIKE A NOTABLE SURFACE OF ACTION.

IN SEPTEMBER, K. SCHWABE OF THE INSTITUTE FOR ELEKTROCHEMIE AND PHYSIKALISCHE CHEMIE OF THE TECHNISCHE HOCHSCHULE IN DRESDEN ANNOUNCED THAT PREPARATORY GAMMA, AND EVEN BETTER, BETA, IRRADIATION OF ELECTRODE SURFACES INCREASED THEIR ACTIVITY.

This abstract was prepared by an IBM computer. The text was first coded in machine language. The computer then counted key words, and printed out sentences having the greatest statistical significance.

Each year in the physical and life sciences, some 50,000 technical journals will be published throughout the world. 100,000 research reports and 60,000 technical books will also be written. Somewhere in this mass of knowledge may be information you need. To tell what is known—and where to find it—IBM is investigating systems for the dissemination, storage, and retrieval of information.

To create an advanced information retrieval system, labels must be found for *all* useful information in documents. With conventional library indexing, it is difficult to make allowance for new kinds of knowledge. However, computers let us use more versatile methods of indexing. In one of these, the KWIC INDEX (Key Word In Context), a computer selects significant terms in the titles of documents, then prints them out as index entries.

Once indexed, characteristics of documents' contents can be used to notify people of their existence. The Selective Dissemination of Information system at IBM stores profiles describing individuals' interests. A new document's key words are matched against key words in a person's profile. If there is sufficient correlation, he is informed of the document. Profile matching can also be used to retrieve information by storing documents and feeding key-word queries through the system.

At present it is relatively difficult to get text into machine-readable form. However, the development of high-speed optical character readers, automatic language translators, and improved methods of capturing linguistic information at the source may make it possible to introduce information directly into retrieval systems. Once harvested, vast quantities of information will present storage problems. IBM is investigating random-access photostorage systems capable of storing millions of documents and retrieving them in seconds. Out of systems like these may come total information centers which will acquaint scientists and businessmen with all the information needed in their work.

If you have been searching for an opportunity to make important contributions in information retrieval, component engineering, optics, space systems, or any of the other fields in which IBM scientists and engineers are finding answers to basic questions, please contact us. IBM is an Equal Opportunity Employer. Write to: Manager of Professional Employment, IBM Corporation, Department 554S1, 590 Madison Avenue, New York 22, New York.

NCR

RESEARCH

SOLID STATE PHYSICS

New programs in semi conductor and thin films research have created ground floor opportunity for qualified and vigorous research scientists in NCR's expanding research and development effort. Our interest is not temporary; rather it is an element of the stable long range viewpoint that has led to 78 years of leadership in the field of business equipment and systems. Perhaps you qualify to become a part of this respected organization.

Openings in our Physical Research Department include:

Ph.D in physics, with at least five years experience in semi conductor component research and development, a theoretical understanding of semi conductor (silicon and germanium) physics, research and development experience in the semi conductor device fabrication techniques such as diffusion, alloying, masking, etching, and in particular be familiar with the epitaxial formation of multilayer semi conductor structures.

Assignment involves technical leadership for a program in molecular electronics which will first be concerned with the investigation and exploitation of the epitaxial technique to determine its limitation and capabilities as related to the fabrication of functional semi conductor structures.

Ph.D in physical chemistry with three years of experience in the areas of electro-chemistry, preferably as applied to the formation of thin magnetic films. He should be familiar with the process of electro-deposition as related to magnetic materials and alloys, and have considerable understanding of magnetic theory, processes of crystal nucleation and growth as they are related to the formation of metallic electro-deposited films. It is also desirable to have technical familiarity with x-ray and electron diffraction examination and analysis methods, so that these skills may be brought to bear on the problem of the relationships of film composition and crystalline structure to the magnetic characteristics of electro-deposited films.

Ph.D in physical chemistry, with approximately 5 years experience and theoretical understanding of the problems of materials preparation, structural and compositional analysis and interpretation, and methods of materials evaluation. Particular emphasis should include solid state materials, such as semi conductors, magnetic materials, superconductors, and dielectrics.

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- Alan Glou ......Technical/Scientific
- Sid Hopner .....Sales/Marketing

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Willingness to do invited traveling

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Electronic Engineers—We have immediate openings for competent engineers to develop electronic devices and to design electronic circuits for analytical instruments. Bachelors or Masters degree with experience in vacuum tube and solid state technology required. These are unusual growth opportunities with a dynamic and rapidly expanding organization. Please send resume with references and salary requirements to: Mr. James R. Badger, F & M Scientific Corp., Starr Road and Route 41, Avondale, Pennsylvania.

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electronics

WEEKLY QUALIFICATIONS FORM FOR POSITIONS AVAILABLE

(Continued from page 114)

PHILCO TECHREP DIVISION SUB. OF FORD MOTOR CO. Philadelphia, Pennsylvania	94*	17
RAYTHEON CO. Missile & Space Div. Bedford, Massachusetts	92*	18
REPUBLIC AVIATION CORPORATION Farmingdale, L.I., New York	92*	19
SCOPE PROFESSIONAL PLACEMENT CENTER Waltham, Massachusetts	118	20
SPERRY GYROSCOPE COMPANY Div. of Sperry Rand Corp. Great Neck, L.I., New York	93*	21
P-8932	94*	22
P-9005	118	23

* These advertisements appeared in the 5/25/62 issue.

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CIRCLE 461 ON READER SERVICE CARD

INDEX TO ADVERTISERS

Audited Paid Circulation

• **AMP Incorporated** **15**
Aerocom 24
Aeroflex Laboratories Inc. 83
Air Express 20
• **Airpax Electronics, Inc.** **32**
Aladdin Electronics 99
Allen Organ Co., Inc. 76
• **Amperex Electronic Corp.** **62, 63**
Ansco 67
Avco Electronics & Ordnance Div..... 71

Babcock Relays, Inc. 17
• **Ballantine Laboratories, Inc.** **96**
Bausch & Lomb, Inc. 66
• **Beckman Instruments, Inc. Berkeley Division** **69**
Bell Telephone Laboratories.......... 35
Bendix Corporation Semiconductor Division 23
• **Bird Electronic Corporation**.......... **107**
• **Bliley Electric Co.** **100**
Bourns Inc. 109
• **Bud Radio Inc.** **100**

• **Centralab, The Electronics Div. of Globe-Union Inc.** **31**
• **Clarostat Mfg. Co., Inc.** **21**
Collins Radio Co. 91
Cominco Products Inc. 90
Consolidated Electrodynamics Corp. 94, 95
Corning Electronic Components....... 55

Datapulse Inc. 84
Delco Radio 14
Douglas Aircraft Co. Missiles & Space Systems Div........ 57
duPont de Nemours & Co., Inc. E. I... 79

• **Edgerton, Germeshausen & Grier Inc.** .. **80**
• **Eitel-McCullough, Inc.** **83**
Electronic Industries Association of Japan 110
• **Electronic Instruments Co., Inc. (EICO)** **119**
• **Empire Devices, Inc.** **89**

Gamewell Co., The 11
General Electric Co. Receiving Tube Dept............... 25
• **Gudebrod Bros. Silk Co., Inc.** **64**

• **Hewlett-Packard Company** ....**Inside Front Cover**
Honeywell Precision Meter Division........... 113

• **Indiana General Corp.** **34**
International Telephone and Telegraph Corp., Kellogg Division 74
Itek Electro-Products Co. 72

Kelvin Electric Co. 106
• **Kintel, A division of Cohu Electronics Inc.** ....**3rd Cover**

• **Lepel High Frequency Laboratories, Inc.** **76**

Matthews Research Inc. 58
Minneapolis Scientific Controls 101, 103, 105
Minnesota Mining & Mfg. Co. Mincom Division 61
• **Mitsumi Electric Co., Ltd.** **106**
Moore Associates Inc. 29
Motorola Semiconductor Products Inc. 33
Motorola Military Electronics Div..... 75

NRC Equipment Co. 104
Narda Microwave Corporation........ 13
Niagara Mohawk Power Corp......... 10

Ozalid, A Div. of General Aniline & Film Corp. 73

• See advertisement in the July 20, 1961 issue of Electronics Buyers' Guide for complete line of products or services.

Pan American World Airways........ 93
Pic Design Corp. 58
Powell Electronics Inc. 101

• **Radio Corporation of America...4th Cover**
Radio Materials Co.................. 36
Roanwell Corp. 111
Rosemount Engineering Co............ 82

• **Sanborn Company** 77
• **Sanders Associates, Inc.** 76
Sarkes Tarzian Inc. 81
• **Sierra Electronic Corp.** 6
Sprague Electric Co. 4, 9, 30
Sweeney Mfg. Co., B. K............. 70

Tektronix, Inc. 22
Texas Instruments Incorporated...... 65
• **Tung-Sol Electric, Inc.** 5

• **Utica Drop Forge & Tool Division, Kelsey-Hayes Co.** 102

Varian Associates 59

Welch Scientific Co., The........... 103
Weldmatic Division/Unitek 92

PROFESSIONAL SERVICES 118

CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.

EMPLOYMENT OPPORTUNITIES.115-118
SPECIAL SERVICES 118
EQUIPMENT
(Used or Surplus New)
For Sale 118

■

INDEX TO CLASSIFIED ADVERTISERS

• **Communications Equipment Co.......** 118
du Pont de Nemours & Co., Inc., E. I.. 116
Intercontinental Industries Inc. 118
International Business Machines Corp. 115
Martin Co., Orlando Division......... 116
Microwave Services International Inc. 118
National Aeronautics and Space Administration 117
National Cash Register Co........116, 118
Scope Professional Placement Center.. 118

• See advertisement in the July 20, 1961 issue of Electronics Buyers' Guide for complete line of products or services.

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electronics

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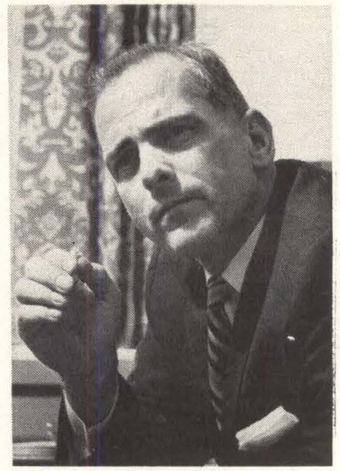
The Dangerous Years



BETWEEN World War II and the Korean conflict, before missiles came of age, the electronics industry was reverting to peacetime products and customers. In that period the inefficient went to the wall and the company with the right combination went to the top. And the right combination was, in more than one case, ability to predict what was needed, to produce it with quality and at a price. Sounds simple. What we call diversification today was known then as turning out a new product.

But the years since Korea have gone quickly, until today the Federal government is the direct customer for more than half our electronic goods and services, the indirect but identifiable stimulator of a far larger total. The government does business with our industry much as though it were a gigantic job shop. As a result, has the requirement for ingenuity "gone by the boards"? New-product ingenuity is an ingenuity which does not exist per se in a corporate body. It costs time, and money, to generate and maintain. In short, ability to diversify quickly, being neither understood nor accepted by the government as a prerequisite of doing business, is a luxury which large prime contractors can't afford. These are dangerous years.

We were no little shocked to learn that a telegram was sent to the President early this year requesting rescheduling of the F-105D airplane. Assuming that the F-110 is more suitable for the Nation's defense, it is hardly logical that the F-105D should be reconsidered on the basis that its abandonment would cause a labor problem of major proportion in one location. And it was on this basis the request was made.

Geographic concentrations of military suppliers, while desirable and logical on some counts, create the possibility of temporary but near disastrous unemployment, the costs of which can be astronomic to local, State and Federal government.

Is there an obligation of government to maintain employment through contract assignments to specific corporations, the major portion of whose volume is in government contract work? What is the obligation of such corporations to shareholders and employees to diversify in consumer and industrial goods, or to perform research and development work which will reasonably assure a continuing flow of government contract work on the merit of proposals?

Are there not, on the part of the government, two obligations? First, to insure sufficient profit on production contracts to permit the corporation to fund reasonable R & D from profit dollars? Second, since 75 percent of all R & D is government-funded, to look favorably on assignment of R & D work to producer corporations, as opposed to strictly R & D firms, with particular reference to "non-profit" research organizations?

The corporation bears a parallel obligation to spend more profit dollars more sensibly in properly-directed R & D, particularly product-oriented and product-producing programs, so that diversification may be accomplished. The major airframe corporations are now in the business of manufacturing electronic apparatus and systems. These firms grew large, not in the electronics industry but in their own aircraft industry, as creators and producers of products, many of them entirely proprietary. It is neither economical nor proper that these same companies, having entered the electronics industry, should fail to develop new proprietary electronic products. Realistic R & D programs could not help but alleviate the feast-or-famine of government contract work, could not help but contribute to more stable employment.

James Girdwood

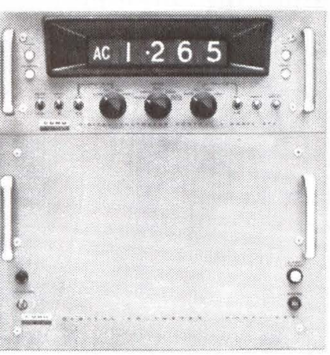
PUBLISHER

Why settle for too little or pay for too much in a digital voltmeter?

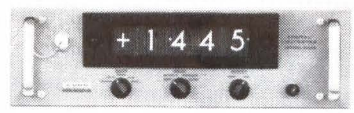
...now you can get exactly what you need at a sensible price from KIN TEL

These eight KIN TEL instruments, plus off-the-shelf accessories, meet every known requirement for digital voltmeters. This means you no longer have to over- or under-buy. You just select the one instrument that delivers the exact degree and combination of speed, accuracy, stability, adaptability, range, and reliability your particular applications call for.

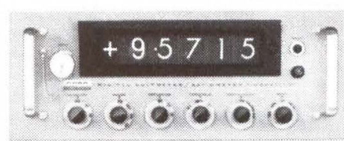
Militarized Digital Voltmeter (Model 412). Rugged, programmable, differential input. Auto ranging, displays polarity. Measures AC and ±DC potentials between 0.001 and 999.9 volts. Accuracy is 0.01% (of reading) ±1 digit for DC, 0.1% of full scale for AC. Designed to MIL-E-4158A. Ideal for use in automatic systems. Price, in quantities of five or more: $10,000.



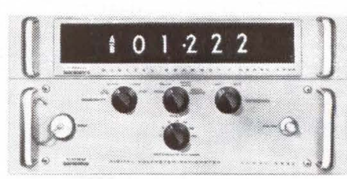
DC Digital Voltmeter (Model 864A). New! High speed, solid state, programmable, modular construction. Measures 0.000 to ±999.9 volts to 0.05% accuracy within approximately 0.02 second – within 0.005 second when programmed to any single range scale. Bidirectionally follows inputs changing as fast as 10 volts per second on the low range, 100 volts per second on the 100-volt range, or 1000 volts per second on the high range. Has electrical outputs for BCD, BCD excess-3, or 10-line parallel signals which are accessories. Price: From $3180.



AC/DC Digital Voltmeter/Ratiometer (Model 551). New! First to bring you 5 readings-per-second speed with mercury-wetted relays. Full 5-digit, measures DC from 0.0000 to ±999.99 volts to an absolute accuracy within 0.01% of the reading, ±1 digit; AC from 30 to 10,000 cps between 0.0000 and 999.99 volts to an accuracy within 0.1% of the reading or 0.05% of full scale, whichever is greater. Adaptable without modification to fit a variety of data-logging systems. Ideal for laboratory use. Accessories include projection readout, BCD mercury-relay output, 10-line mercury-relay output, and AC converter. Price (without optional visual readout) for the basic 5-digit instrument with buffer register and auto/manual/command range: $4150.

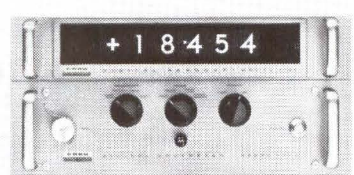


DC Digital Voltmeter and Ratiometer (Model 507D). Measures voltages between ±100 microvolts and ±1000 volts, ratios between ±0.0001:1 and ±999.9:1 with 0.01% (of reading) ±1 digit accuracy. Accessories permit AC/DC and AC/AC ratio measurements. Stepping switches guaranteed for 2 years. Price: $3835.



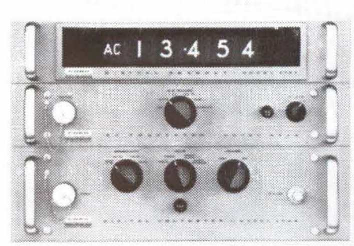
DC Digital Voltmeter (Model 501B). Four-digit, fifth-digit over-ranging. Measures positive or negative DC between 100 microvolts and 1000 volts, with 0.01% (of reading) ±1 digit accuracy. Automatic or programmable range; auto polarity. Combines the useful accuracy of a 5-digit voltmeter with the stability, reliability, and price advantage of a 4-digit voltmeter. Stepping switches guaranteed for 2 years. Price: $2995.

DC Digital Voltmeter (Model 501BZ). Similar to Model 501B (see above). Circuit is automatically and continually calibrated against a Zener diode reference source instead of against an unsaturated mercury-cadmium standard cell. For submarine and other special environment applications. Price: $3160.



AC/DC Digital Voltmeter (Model 502B). Gives you AC accuracy within 0.1% *of reading;* over-ranging on both AC and DC; automatic ranging and remote (programmable) control. Measures DC between ±100 microvolts and ±1000 volts, AC from 30 cps to 10 kc between 1 millivolt and 1000 volts. Five-digit readout. Stepping switches guaranteed for 2 years. Price: $4245.

AC/DC Digital Voltmeter (Model 502BZ). Similar to the Model 502B (see above). Circuit is automatically and continually calibrated against a Zener diode reference source instead of against an unsaturated mercury-cadmium standard cell. Price: $4410.



Write for detailed literature or a demonstration of any of these exceptional instruments. Representatives in all major cities. All prices FOB, San Diego, Calif. 50 cps/220 volt operation at additional cost.

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