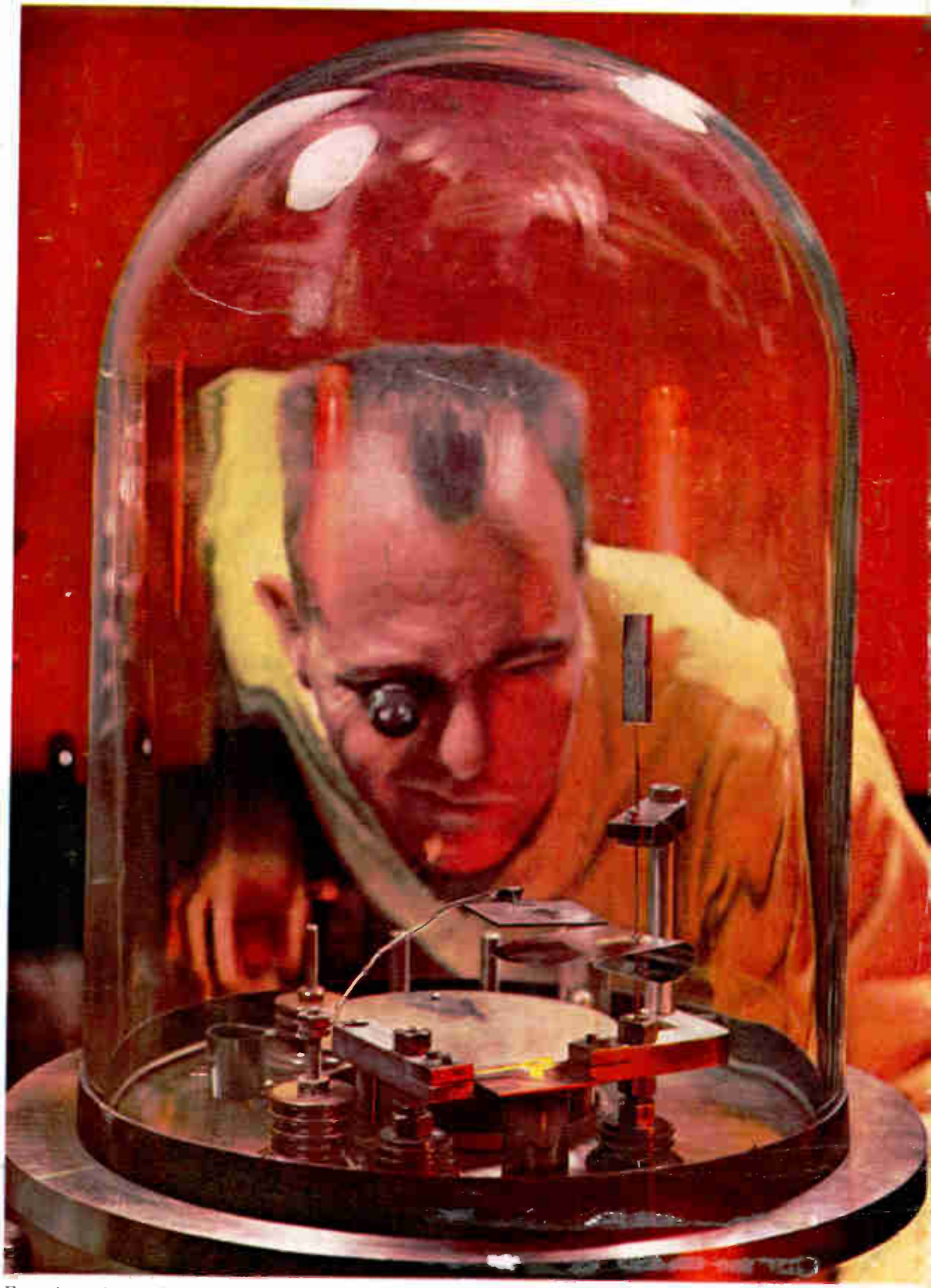
November 25, 1969

electronics

A McGraw-Hill Publication 75 Cents

SPECIAL REPORT

on Micro-miniaturization discusses concepts, approaches, problems, techniques and applications of microminiature components, circuits and systems



Experimenting with thin-film evaporative deposition

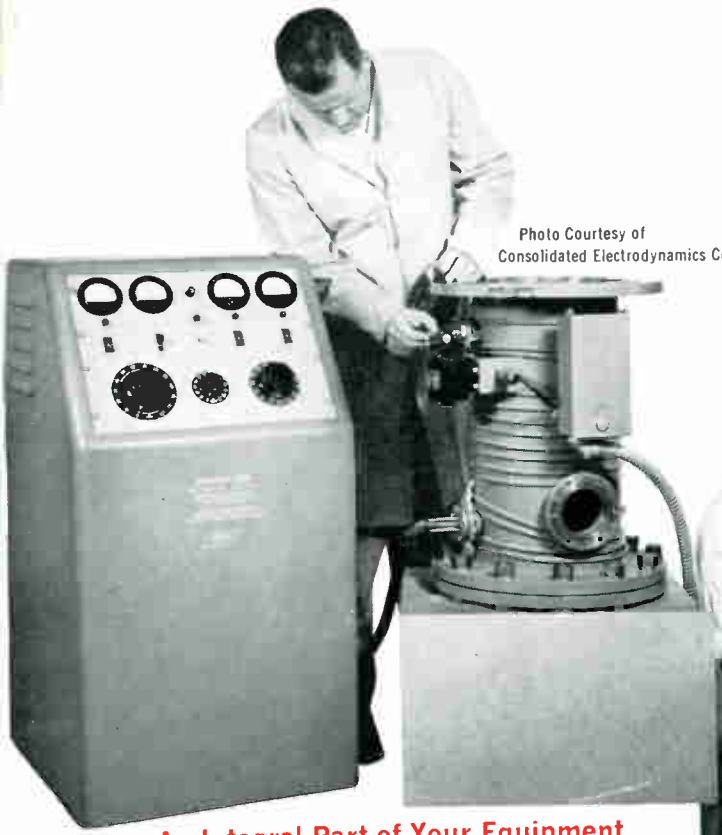
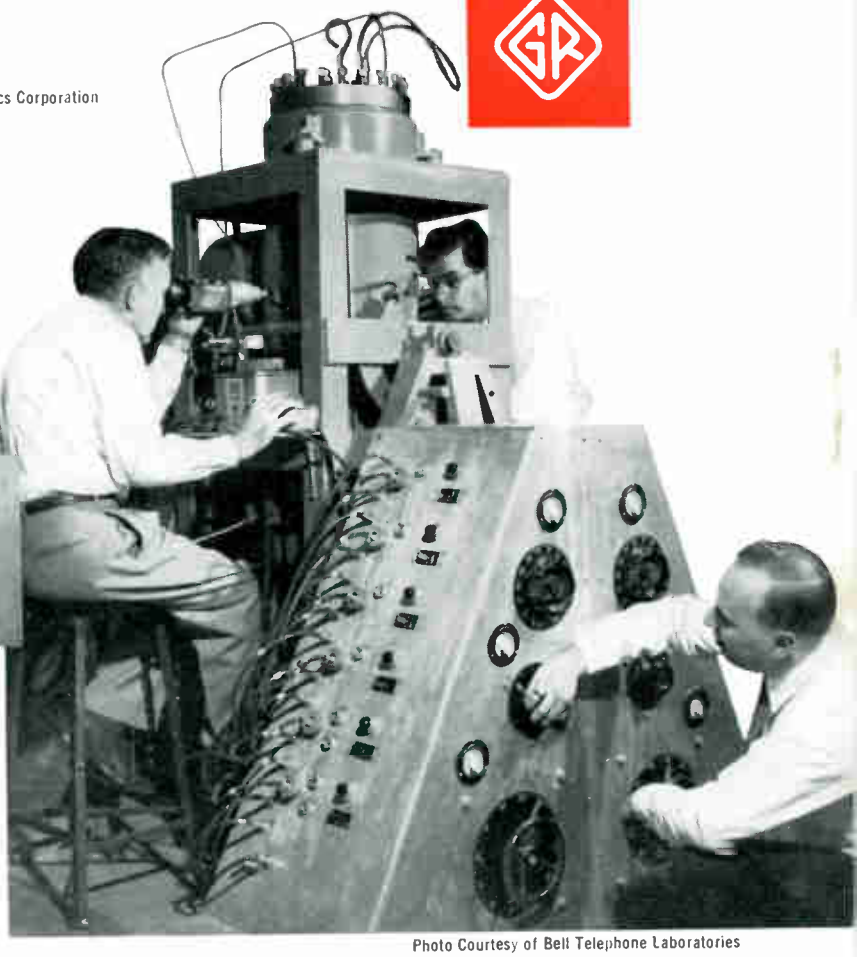


Photo Courtesy of
Consolidated Electrodynamics Corporation

An Integral Part of Your Equipment

This high-vacuum pump incorporates three Variacs for the control of motor speed and voltages.

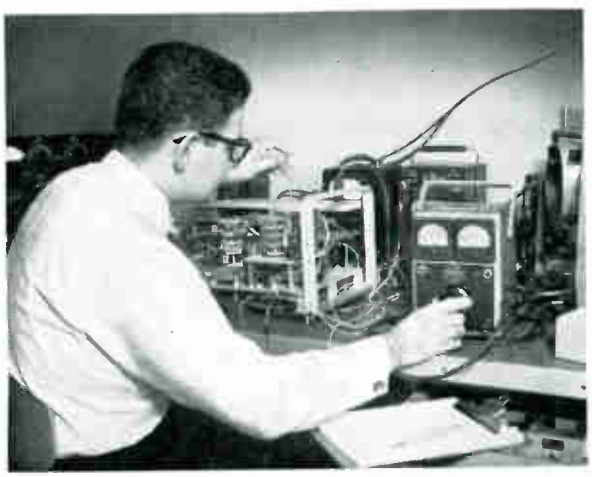


A Research Tool

Variacs control current through coils used for heating ingot of experimental semiconductor material.

Photo Courtesy of Bell Telephone Laboratories

Variac®



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. . . featuring DURATRAK,* G-R's exclusive treatment for the Variac contact surface.

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A Handy Workbench Accessory

Engineer uses a Metered Variac to check voltage range specifications of a prototype electronic instrument.

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Variacs are backed by
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November 25, 1960

electronics

A McGraw-Hill Publication 75 Cents

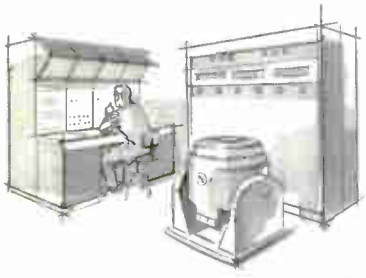
W. W. MacDONALD, Editor

BUSINESS

ENGINEERING

DEPARTMENTS

New MB vibration unit extends range, accuracy and efficiency of accelerometer calibration



The C12 moving element is a solid magnesium casting. This design guarantees pure linear motion, an absolute requirement for accurate calibration. Amplifier and controls are enclosed in desk type console with ample panel space for accessories making up complete calibration system.

Now, for the first time, a single system enables you to accurately calibrate vibration transducers at any frequency from 5 to 10,000 cps with accelerations up to 100 g.

Complete and self-contained, the MB calibration system saves you space, time and money. This entirely new system incorporates all the necessary instrumentation required for fast, accurate calibration. Newly designed circuits simplify calibration procedure and eliminate special techniques.

Powered by an extremely low distortion amplifier, the MB Model C12 calibrator produces 150 pounds of high-fidelity linear force.

The new exciter-calibrator pictured above is another example of MB's continuing efforts to anticipate the needs of the environmental test engineer. It is another reason why engineers everywhere recognize that *the important advances in environmental testing come from MB.*

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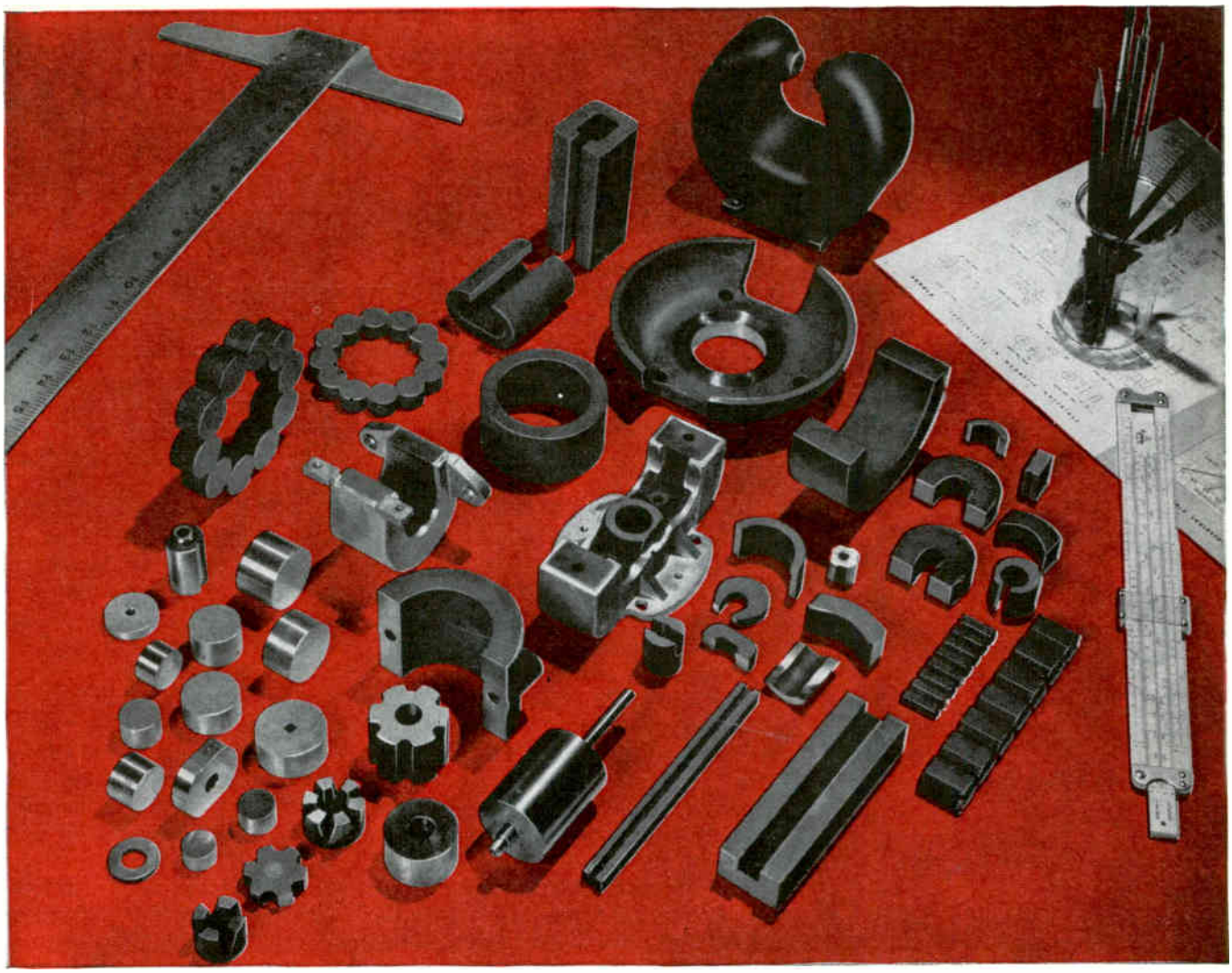
A DIVISION OF TEXTRON ELECTRONICS, INC., 1102 State Street, New Haven 11, Conn.



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Write for your copy of *Bulletin GC-106C*, a general catalog of all Arnold products. It contains useful data on the physical and magnetic properties of Alnico magnets. Lists stock items and standard tolerances for cast and sintered magnets—also stock sizes and pertinent data on tape cores, powder cores, C & E cut cores, etc.

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For your convenience, we carry a wide range of the more popular sizes and types of Alnico magnets in stock for immediate shipment. Unsurpassed plant facilities assure quick delivery of all special orders.

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electronics

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CROSSTALK

ORGANIC SEMICONDUCTOR CONFERENCE. In the Spring of 1961 ELECTRONICS, in partnership with the Armour Research Foundation of Illinois Institute of Technology, will co-sponsor an Inter-Industry Conference on Organic Semiconductors in Chicago.

This will be a new experience for us, and we do not undertake it lightly. However, we regard the activity as a natural outgrowth of our accustomed and well-established function, which is to communicate in depth facts about significant developments in our industry.

The study of organic semiconductors is one of the most rapidly growing areas of research in the scientific world. It may also be one of the most fruitful for the electronics industry. Our interest was stimulated almost a year ago, when we received a report on Soviet investigations into the use of polyacrilonitrile for transistors (ELECTRONICS, p 26 and p 68, January 22). On digging further, we discovered that many U. S. firms were also active in organic semiconductor research.

At present, the bulk of the work has to do with measurement of the properties of organic materials. These include conductivity, carrier mobility and Hall coefficient. It is early in the game, and practical devices based on present knowledge are just in the discussion stage. But it is already apparent that here is a vast untapped reservoir of new and exciting developments whose significance may equal and possibly transcend the transistor itself.

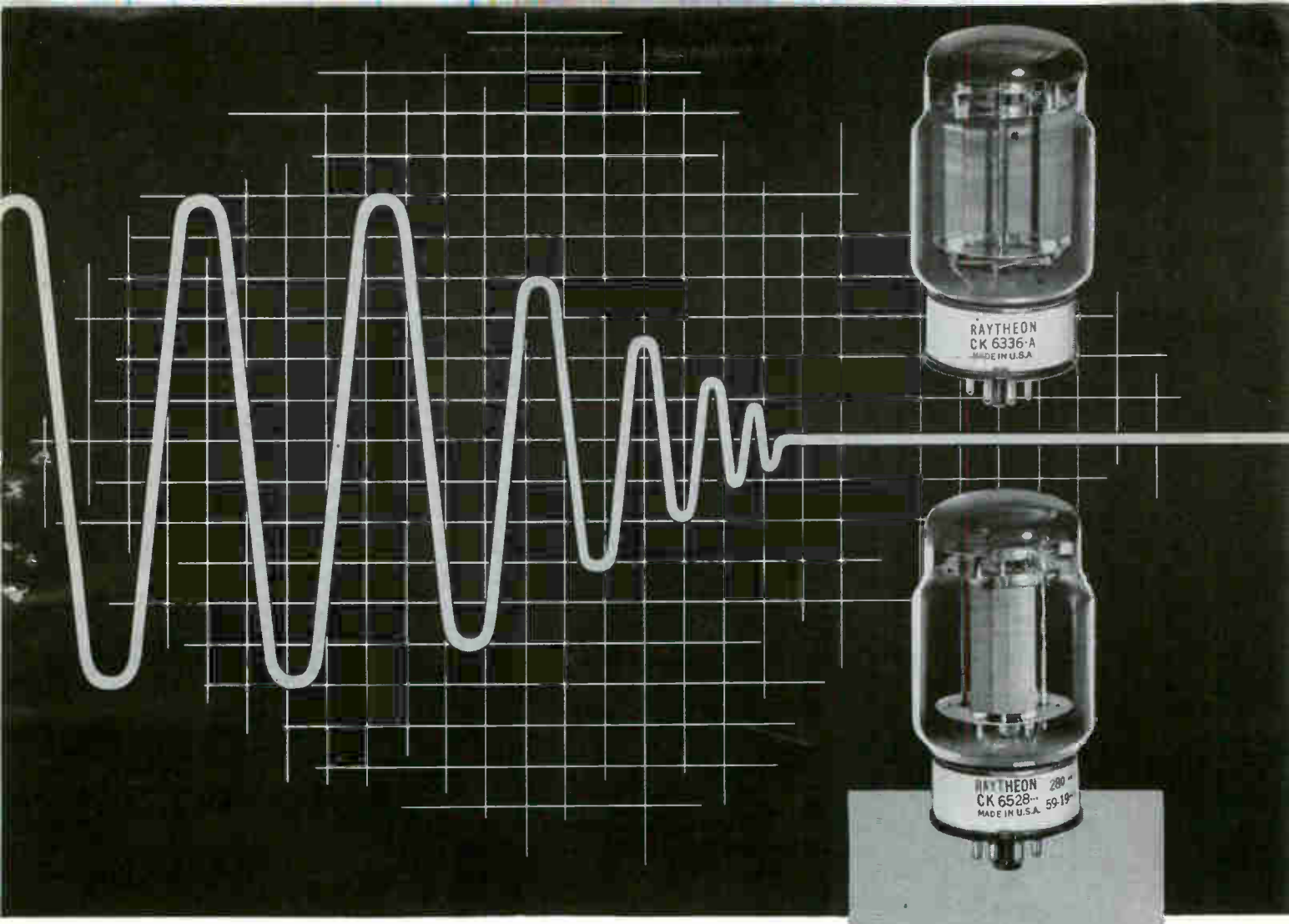
Our aim in co-sponsoring the conference with Armour is to provide industry with a forum in which to evaluate the present state and future potential of organic semiconductors. Present plans call for a number of invited and contributed papers which will contain the latest results of research in industrial and government laboratories.

We think the conference will be a significant event for the electronics industry. Further details will be published in ELECTRONICS in the near future.

SPECIAL REPORT. Since their interpretive article on progress in solid-state technology (ELECTRONICS, p 39, March 4), Associate Editor Perugini and Assistant Editor Lindgren have been paying close attention to trends in microminiaturization. One result is the comprehensive 32-page Special Report that begins on p 77 of this issue. In addition to learning where we stand on component, circuit and function-oriented approaches, you'll find out how microminiaturization techniques are being applied to equipment and systems. You'll also find reliability figures for thin-film resistors, surface passivated diodes and microelements and micromodules.

Coming In Our December 2 Issue

LAMINAR JUNCTIONS. As brought out in this issue's Special Report, laminar junction layers mark one of the new techniques for constructing microcircuits. In our next issue, J. E. Allegretti and D. J. Shombert of Merck Sharp & Dohme Research Laboratories in Rahway, N. J., describe how silicon semiconductor devices can be formed by vapor deposition of single-crystal silicon layers on a single-crystal silicon substrate. Their informative article shows how the technique can be applied to the formation of complete circuits.



A Pair of Smoothies For Series Regulator Service

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Stringent power supply regulation requirements are no problem for these "smoothies." Get full technical data on the CK6336A and CK6528 as well as Raytheon's expanding line of high voltage rectifiers, pulse modulators, and transmitting types. Please write to: Raytheon, Industrial Components Division, 55 Chapel St., Newton 58, Mass.

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RATINGS

	Max. Plate Voltage	Max. Plate Dissipation Watts	Max. Plate Current (per plate)	Amplification Factor
CK6336A	400	2 x 30	400 mAdc	2.7
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RAYTHEON CK6336A AND CK6528

RAYTHEON

COMMENT

Upgrading the Consumer

Regarding your comments on upgrading the consumer in Crosstalk in the Oct. 21 issue (p 4):

You neglected the improvement that could be made in tv receivers by adding components to minimize or eliminate television interference. Especially plagued by the omission of such components are the many conscientious radio amateurs who operate well designed, completely shielded, properly adjusted, adequately filtered transmitters that emit clean signals. These operators are constantly harrassed by protests of tvi from set owners who possess poorly designed built-to-a-price receivers that are notorious for poor shielding, wide-open tuners that lack sharp cutoff below channel 2, improper i-f frequencies, and other faults.

No problem faced by radio amateurs has the enormity of this problem. Despite the increase of U. S. radio amateurs to well over 200,000, tens of thousands of them are radio amateurs in name only due to the curtailment of their activity since World War II resulting from tvi. For only since World War II have millions of cheap high-frequency broadband receivers been in the hands of the public—all for tv reception.

J. S. LEE

WESTERN ELECTRIC
CHICAGO

. . . Among your comments regarding upgrading the consumer, you mentioned several possible improvements in circuit design but fail to mention shielding or wave-trapping to kill spurious emission from superheterodyne receivers. Granted that most consumers don't realize their sets put out a signal (except when tuning whistlers cross over their radio settings and hash up the audio), still these spurious emissions are serious. They may be fouling up our missile guidance, and they are sufficiently confusing to air-navigation devices that all airlines have banned use of portable radios, tv sets and tape recorders while aircraft are aloft.

J. A. BIBB

HIALEAH, FLA.

Hams and airline spokesmen alike attest the validity of these statements. While not properly falling under the heading of Upgrading the Consumer, the shielding of spurious emissions should become a part of a general campaign for upgrading the consumer set.

USSR in Space

Everybody was saying that the USSR would launch a man in space while Khrushchev was at the UN. He's come and gone—so?

GENE G. MACAULAY

PHILADELPHIA

So two things. Firstly, there's a sizable body of evidence that some large space attempt was made by USSR scientists around the time Mr. Khrushchev came to the U. S. It could have been a man-into-space shot; more probably it was a Mars probe, since conditions then were optimum for such a shot. In any event, the attempt—if made—was either abortive or so successful that it's been kept under wraps.

Secondly—and possibly providing an illumination on previous Soviet experiments—Russian rocketeer F. Sergeyev remarked recently in Moscow that the USSR has the "means and conditions" for sending a man into space, but needs "practical experience . . . in launching satellite space ships and effecting their safe and reliable return to earth." He added that last spring's orbiting doghouse "is in excellent state and can be used for more flights."

Electronics Abroad

I am writing to tell you how interesting I find your new feature Electronics Abroad. Almost daily we in the industry are made to realize how much activity is going on beyond our borders of the U. S. Your interest in this area helps readers to learn and share in this expanding field. Keep up the good work.

C. REUBER

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NEW, COMPACT, PROGRAMMABLE, HALF-RACK, ®REGATRAN POWER SUPPLIES...

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MODEL NUMBER	DC OUTPUT		MAX. RMS RIPPLE
	VOLTS	AMPS	
TR212A	0-100	0-100 MA	250 μv
TR018-1	0-18	0-1 AMP	150 μv
TR036-0.2	0-36	0-200 MA	150 μv

For a closer look, ask your local Electronic Measurements representative for a copy of Specification Sheet 5000 . . . or write direct.

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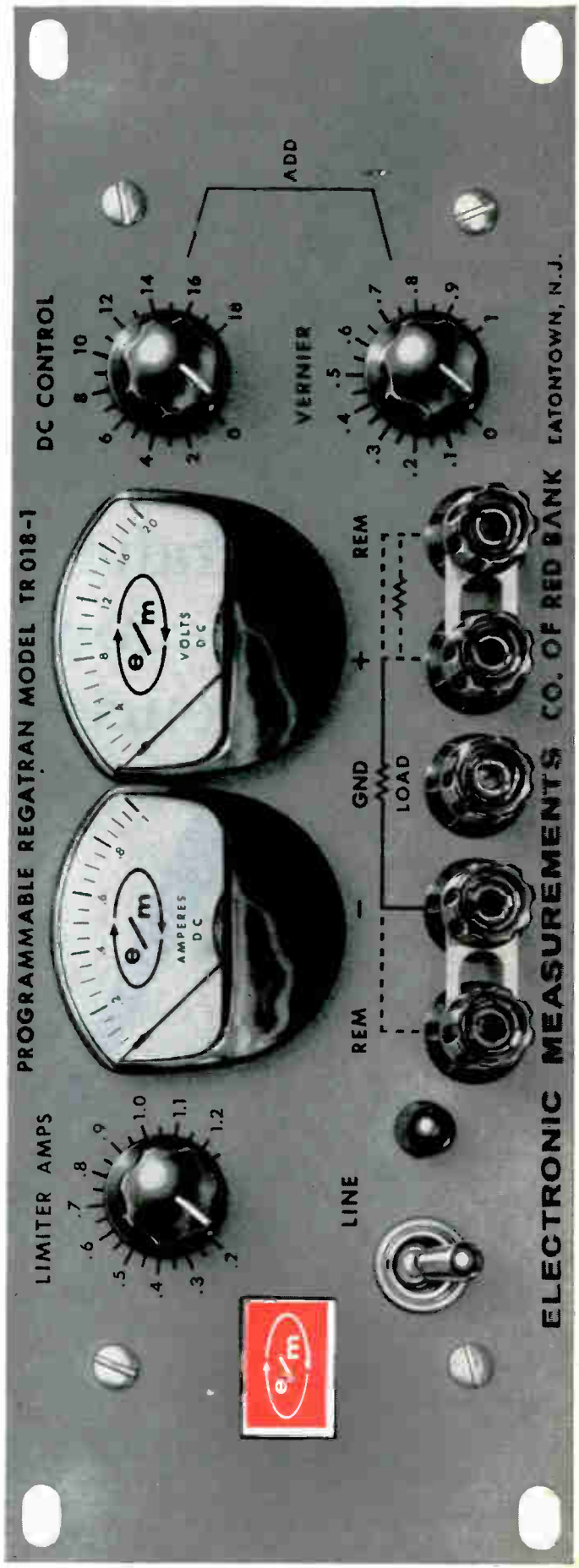
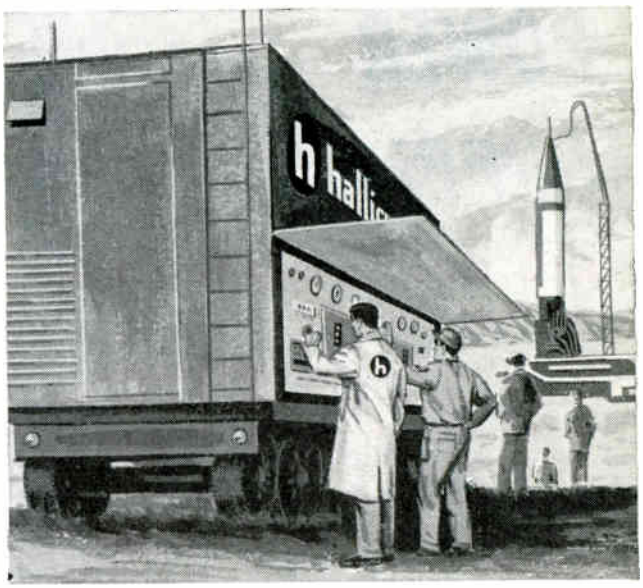


Every breakthrough in military electronic equipment design creates new, complex and urgent problems in installation, modification, testing, maintenance and personnel training. Hallicrafters radical new "Blue Streak" project—utilizing quick-reaction techniques—*offers experienced Hallicrafters support teams to assist key military personnel . . .* pinpoints problems in advance . . . solves them on the spot with new levels of speed and economy.

from hallicrafters' "quick-reaction" experience...



TEAMWORK IN MAINTENANCE: Hallicrafters mobile test vans and in-house repair of black boxes sets new standards in speed and reliability.

Looking for a challenging new opportunity?
For this expanding program, we have openings for qualified aeronautical electronic equipment systems and installation engineers. For full details in confidence, contact William F. Frankart, Director of Engineering.

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TEAMWORK IN PLANNING: Hallicrafters "BLUE STREAK" Teams provide electronic industry technology in support of military programming groups for SAC aircraft at OCAMA and other materiel commands.

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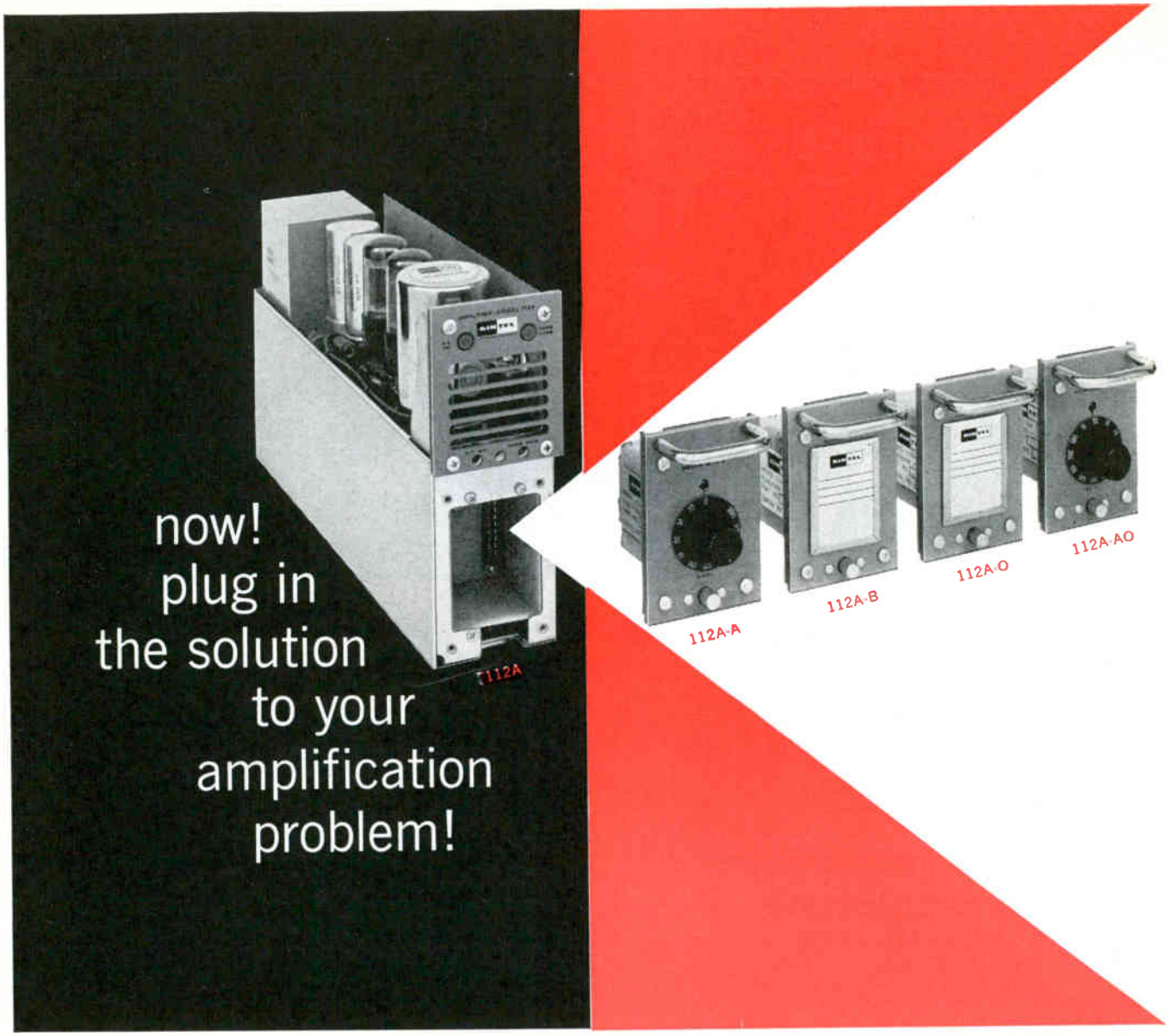
hallicrafters **blue streak project**

For further information on Hallicrafters facilities and experience in military electronics research, development and production, please write to: THE HALLICRAFTERS CO., MILITARY ELECTRONICS DIVISION, CHICAGO 24, ILLINOIS.



Special Plug-In Units Make KIN TEL's Wideband DC Amplifier the Basic Component in a Variety of Data Acquisition Systems. Why Not in Yours?

With a 112A-A Plug-in, the amplifier provides accurate drift-free signals at any of ten fixed gains from −20 to −1000 with a stability of ±0.1% and an accuracy within ±0.5%. A Micro-Gain control sets individual fixed gains within ±0.01%, and a 2:1 vernier control adjusts gains between fixed steps. Outputs are available up to ±45 volts or ±40 ma at an impedance less than 1 ohm, linear within 0.01% at DC and within 0.1% to 2 kc. Drift is less than 2 μv for 400 hours, and noise is less than 5 μv from DC to 750 cps, less than 12 μv to 50 kc. Bandwidth is within ±0.5% to 2 kc, ±3% to 10 kc, ±3 db to beyond 40 kc.

With a 112A-B Plug-in, the amplifier gain is fixed at +1 with an accuracy, stability, and linearity within ±0.001% at DC, ±0.1% to 2 kc. Input impedance is 10,000 megohms +100μμf at DC, 1,000 megohms +100 μμf at 2 kc. Bandwidth extends to 100 kc. Output capabilities are the same as with the 112A-A plug-in.

With a 112A-O Plug-in, the user may install resistances for any fixed gain or for +1 operation as described above. Resistive and reactive components may be installed for use as a summing amplifier, an integrator, or for other specialized operational application.

With a 112A-AO Plug-in, ten fixed gains are available with all the features described for the 112A-A unit, and in addition, an operational position is provided on the panel control for use with an external feedback network in specialized summer, integrator, or computer functions.

With any plug-in, the 112A may be used in a single-amplifier cabinet on a bench or in either a one- or six-amplifier module to fit a standard 19-inch rack. Write today for detailed technical literature or demonstration. Representatives in all major cities.

PRICES:

112A amplifier alone	$530.00
112A-A Ten-gain Plug-in	95.00
112A-B Plus-one Plug-in	85.00
112A-O Empty Plug-in	45.00
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ELECTRONICS NEWSLETTER

Tunneling Observed In Supercooled Thinfilms

ELECTRON TUNNELING, previously observed in various semiconductor devices, has now been demonstrated in supercooled thinfilm sandwiches.

Researchers at General Electric have disclosed that if a sandwich formed of dissimilar metals separated by an insulating barrier about 10^{-7} in. thick, charge carriers in other than forbidden energy states can tunnel through the barrier. Experiments used lead and aluminum, with an aluminum-oxide layer about 10 molecular-diameters thick.

With only the lead superconductive (between 1.2 K and 7.2 K), the voltage-current curve resembles a triode characteristic. When both metals are superconductive (below 1.2 K), there is a pronounced negative-resistance "knee." Use of magnetic fields—which cancel superconductivity in metals—permits changing the negative-resistance region. At 0.2 mv applied voltage, GE reports, "we have found . . . the current through a lead-aluminum-oxide-aluminum sandwich at 1 K changes by a factor of 100.000" when the lead is switched from superconductive to normal.

Negative-resistance characteristic is independent of the current direction, unlike the same characteristic in the tunnel diode. GE figures the new device could be made to function as a switch, diode, negative-resistance diode, triode, resistor or capacitor—depending on the application of voltage and magnetic fields.

Long-Life Fuel Cell Uses Sodium, Bromine

FUEL CELL designed to provide electrical power in an unmanned space vehicle has been developed by Hoffman Electronics. The cell uses sodium and bromine as mutually reactive fuel elements, mercury as a carrier for the sodium. Oxidation of the sodium by the bromine produces a power output of 2.8 v per cell; input from solar cells electrolyzes the sodium bromide into its constituents for recycling.

Unit has a lifetime in excess of 10,000 charge-discharge cycles, can produce peak currents of 10 kilamps per sq ft for a tenth of a millisecond. Cells are impervious to short-circuit damage. Prototype shown to ELECTRONICS is about the size of a one-pound coffee can; Hoffman says secondary power source models can be made as small as an aspirin tablet. Shelf life claimed is virtually infinite.

Company has also been pushing work on gallium-arsenide semiconductor devices for high-speed applications.

Piezoelectric Device Sparks Sparkplugs

"SPARK PUMP" and timer are used in a novel ignition system developed by Cleveland graphite bronze division of Clevite Corp. The spark pump is made of a piezoelectric ceramic capable of operating reliably up to 250 F and developing voltages up to 30 Kv. Operated at from 16 to 21 Kv, the life of the ceramic is about a hundred million cycles, or 500 hours of life at 3,600 rpm.

Ceramic and its housing are encapsulated in a $3\frac{1}{2}$-cu.-in. volume weighing 8 oz. Spark is squeezed out by application of pressure; 80 psi produces 16 Kv without need for an autotransformer. Mechanical timer triggers the application of mechanical pressure. Rise time is of the order of 10 nanoseconds.

Soviets "Discover" Ionospheric Scatter

SOVIET NEWS AGENCY Tass reports that Nikolai Kabanov has been awarded a diploma for his 14-year study of a phenomenon, to be known as Kabanov's Effect, by which radio energy when reflected by the ionosphere is partially scattered, a certain portion back-scattering to the radiation source.

Kabanov postulates that the backscatter from the earth's surface can be used to get radar coverage of areas thousands of miles away, admits that any returned energy would also include a picture of intermediate hop-points.

Tass adds that the main significance of the discovery is expected to lie in helping select favorable frequencies for long-distance communications, and in observing and exploring the ionosphere. "It also should enhance the reliability of radio communications, making it possible to transmit from low-power stations with simpler antennas and less interference."

Australia to Receive Mills Cross Radiotelescope

GIANT RADIOTELESCOPE of the Mills cross design will be erected in the homeland of B. Y. Mills, of Sydney, Australia, after whom the design is named.

The telescope will be built on an as-yet unselected site in New South Wales, will be 20 times as powerful as the Jodrell Bank paraboloid in England. Estimated cost is $750,000. University of Sydney's Radioastronomy Center is sponsoring the project, hopes to have one section operating by yearend 1962. Australia will also help the Organization for European Economic Cooperation build the cruciform instrument now being considered for the Benelux high country near Luxembourg (ELECTRONICS Newsletter, p 11, Sept. 16).

The New South Wales design will include two arms forming a cross oriented east-west and north-south. Each arm will be a mile long and forty feet wide, consisting of a mesh of reflectors focused on an antenna running down the center of the arm.

Mills cross systems are not steerable, but can be tilted. Tilting of one arm and electronic phasing of the other will permit viewing all the southern sky. The Benelux unit will provide complementary data on the northern heavens.

Minnesota Sales To Top $600 Million

NORTHWESTERN NATIONAL Bank of Minneapolis, which has helped foster the rapid growth of electronics in the Land o' Lakes, reports that the industry in Minnesota will rack up more than $600 million in sales for 1960. Estimate was included in

a plant location study.

The report points out that there are 117 electronics and related-science companies operating in Minnesota. Of the total, 105 are in the Twin Cities area. Sixty are classed as manufacturers of electronic equipment and devices, 32 as electronic component manufacturers, nine as engineering and research service companies. Sixteen companies are specialty and custom manufacturers for electronics and related sciences. The companies employ 40,000 people, with an annual payroll running about $200 million.

Japanese Designers On Miniaturization Binge

INDUSTRIAL DESIGNERS in Japan are trying their traditional skills at handling small objects, tying into the postwar progress in optics and electronics which has sparked Japan's business boom.

At last week's new products show in Tokyo, sponsored by Ministry of International Trade & Industry, tiny versions of earlier designs took the limelight. Several companies showed miniature tape recorders; one, built by Eiwa, fits into the palm of your hand. Others showed even smaller transistor radios, including one by Sony with a watch movement that turns it into an alarm-clock radio. Miniature "fish-finder" sonar, less than $8 \times 6 \times 3$ inches and weighing less than six pounds, was on display; it operates on a dry battery, can run continuously for 13 hrs.

Navy Needs Practical, Reliable Gear: Bennett

PRACTICAL CONSIDERATIONS of electronic equipment design were stressed last week by Rear Admiral Rawson Bennett, Chief of Naval Research. Speaking to engineers at the New England Research & Engineering Meeting in Boston, Bennett warned that the day is fast passing when the cost of military equipment is not a factor.

"In our pride of technical accomplishment, we are in danger of developing things that are too small to be economically practical," the admiral said. "We do need equipment to win wars, but all the services are going to be forced to determine what is good enough. Our opposition is doing so. Our overseas rivals are pretty good at making things just good enough to do the job."

In reliability, Adm. Bennett said, we take two steps backward for every step forward. Component reliability has improved significantly, but we are building complexity into systems at a faster rate than our improvement in reliability.

Ultrasonics Sorts Beef For International Exposition

ULTRASONIC DEVICE will judge prize steers during a ten-day international exposition opening this week in the Chicago stockyards amphitheatre.

A search unit operating at 20 Kc will be passed along the animal's back to determine the depth of backfat covering the loins and ribs, and to measure the size of the loin-eye, lean-meat source of filets. The measuring unit was developed by J. R. Stouffer, animal husbandry expert from Cornell University.

Emerging signals are recorded on 60-second film, will help judges evaluate proportion, size and quantity of lean-meat-to-fat distribution throughout entire animal. Later comparison with dressed carcass will give officials opportunity to check accuracy of soundings.

New era of cattle judging is expected to result from this ultrasonic circuit and others under development at Michigan State and Beltsville, Md., and in Europe. Measurement technique could also become very important to stock raisers in selecting breeding stock to produce more high-quality lean meat with less fat.

"Voice" Awards Contract For Greenville, N. C., Site

U. S. INFORMATION AGENCY has awarded the contract for the big transmitter Voice of America is building near Greenville, N. C. Low-bidding team — Alpha of Texas and Continental Electronics, both Texas-based companies—will put up the facility for $12.2 million, a little less than half the total cost of the installation.

Project is expected to be in operation by the end of 1962, will comprise six 500-Kw, six 250-Kw and six 50-Kw transmitters.

Soviets Display Two New Missiles

TWO MISSILES not previously observed in the USSR's armaments were displayed in the rocket-rattling show of strength that formed the climax of the Soviet Union's annual Nov. 7 celebration.

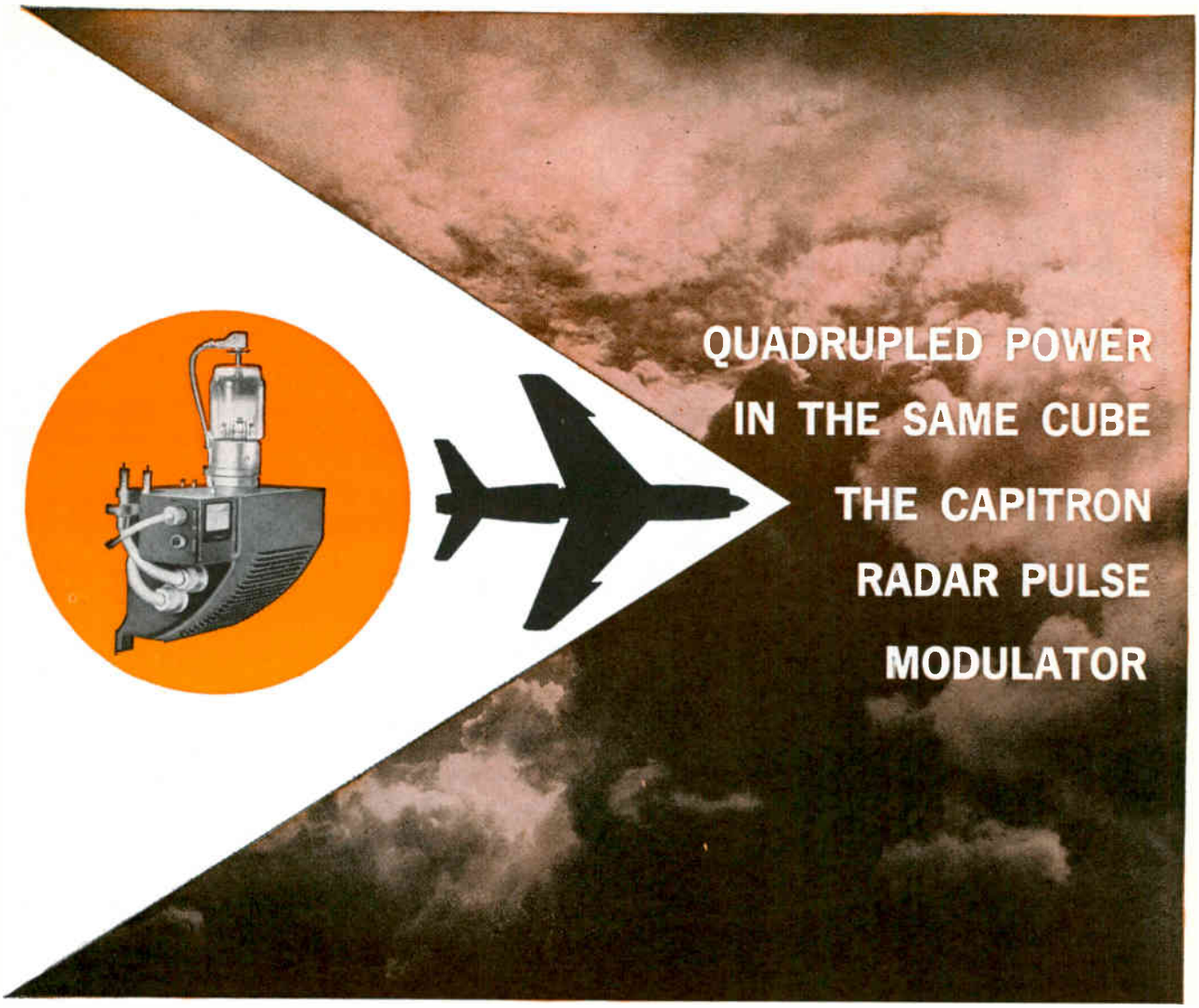
The parade commemorating the 43rd anniversary of the Bolshevik revolution showed off massed battalions of motorized infantry, paratroopers, artillery and missiles. Among the latter was a surface-to-air missile resembling the Nike-Ajax which appeared to be a heatseeker and may be an improved version of a rocket weapon long in use in Soviet forces. The missile is probably one that downed the U-2.

A surface-to-surface missile bigger and longer than anything previously observed in the Soviet arsenal also showed up in the parade. It had a larger exhaust opening indicating longer range, probably in the ICBM class.

Air Agency to Try Tropo For Transatlantic Commo

RESEARCH & DEVELOPMENT Bureau of the Federal Aviation Agency has ordered a special antenna system and high-power amplifier gear to test forward-scatter vhf transmission for possible use on the long transatlantic reaches. Pan American Airlines has been operating a vhf link with a 400-mi range out of Shannon Airport. FAA is hoping to build on Pan Am's experience to replace present h-f communications—highly susceptible to atmospheric disturbances and fading—with a vhf system.

FAA will build two transmitters on the North American end of the transatlantic airway, then build others in Europe if the tropo-scatter system works out.



HA/HV LEADS AND TERMINALS

Insulated and corona free to 23 KV peak pulse, the AMP shielded magnetron cable assembly #836547 is a high voltage, high temperature unit that fits exceptionally confined spaces.

To see through peasoup fog or moonless night, the Navy F8U2N Jet interceptor required a quadruple-power radar modulator that would fit in the same volume as the original power units.

The problem was a natural for AMP's Capitron personnel and facilities. New transformer design standards were developed, new high temperature insulations tested, new components created. The unit was packaged and tested in record time. Capitron is now in volume production of this unit . . . the AMP #855053.

Specifications: delivers 600 KW of pulse power to transmitter . . . 22,000 volts . . . requires only three inputs—DC voltage, system triggers, and AC for filaments . . . internal temperature range from −70°C to +150°C . . . conforms to mil specs.

Complete specifications available. Send for them today.

CAPITRON DIVISION
AMP INCORPORATED
Elizabethtown, Pennsylvania

Capitron products and engineering assistance are available in Canada through Aircraft-Marine Products of Canada, Ltd., Toronto, Canada

WASHINGTON OUTLOOK

SHAKEUP in the organization of the nation's space operations seems to be definitely among the plans of the new administration. The separation of the program into military and civilian space applications is considered impractical and unwieldy by many influential advisors to the President-designate.

These observers think the split has delayed important policy decisions, fostered duplication of effort and wasteful rivalries, and stymied effective formulation of long-range plans. Lyndon Johnson, who headed the Senate's space committee in the late 86th Congress, is known to have a special interest in reorganizing the space program.

National Aeronautics & Space Administration and the Pentagon are both, for instance, competing for funds to develop active communications satellites and super-power rocket boosters. Advanced Research Projects Agency has turned over the responsibility for communications satellites to the Army Signal Corps, but NASA still retains an interest. Contractors gripe because they don't know where to submit project proposals. And Congressional leaders are peeved because the space programs lack central direction.

It's still too early to see exactly how drastically the space operations will be overhauled. But it is clear that any reshuffling of bureaus and responsibilities will aim at meshing the military and civilian sides of the program under more centralized administration.

NASA AND THE DEFENSE DEPARTMENT are studying a joint proposal from Aerojet-General and Todd Shipbuilding for construction of rocket-launching complexes at sea. The two companies seek funds to support detailed engineering studies of the project and to compare costs of ocean-launch systems with conventional land installations.

The companies say that ocean-launch facilities are "feasible and inevitable." They claim that ocean-launching sites would minimize critical problems of design, water supply and safety in super-power chemical rockets of the million-pound-thrust class, and nuclear-powered rockets now under development.

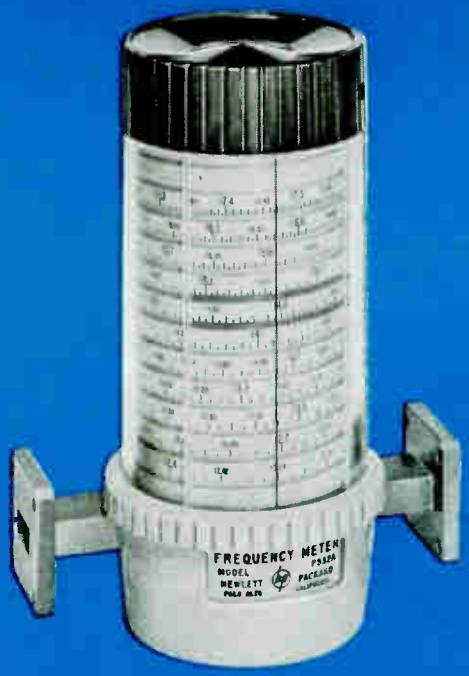
They propose several ocean-launch concepts: coastal cliff sites, offshore pier sites, missile drydocks and modified Texas towers. The most ambitious plan in the Aerojet-Todd package would build a "planetary rocket ocean platform" (PROP), envisaged as a huge buoyant seabase for use in fabricating, assembling, static-testing and launching large missiles and space vehicles.

IN THE WAKE of the Presidential election, you can expect a renewed drive to cut defense procurement costs. Funds for individual projects will be hiked (the talk here is of a $2 billion or more rise in overall defense spending next year), but there will be more emphasis on holding down costs so that the increase in money will buy even more defense.

Kennedy believes, for example, that a billion dollars or so can eventually be saved through "efficiency improvements." Much of this would be based on Pentagon reorganization.

Some defense experts argue that additional money can be saved if contracting practices are overhauled. This philosophy will be demonstrated by a Congressional push to consolidate procurement as much as possible, to get rid of incentive-type contracts, to stress advertised bidding, and to increase competition for negotiated contracts.

AIR FORCE SECRETARY Dudley C. Sharp has ordered a series of plant inspections to "survey management practices" of major Air Force contractors. Martin's Titan ICBM project will be the first program scrutinized. The surveys are the latest step in the Air Force's efforts to screw down the lid on costs and to prod contractors into buying more efficiently and exercising tighter control over production.



COMPLETE FREQUENCY COVERAGE

Highly accurate, direct reading wide band

FREQUENCY METERS

3.95 to 40 KMC!

Now hp offers you high quality, moderately priced precision Frequency Meters covering eight important microwave bands.

Frequency is read directly in KMC on the large, precisely calibrated spiral scale. No charts or interpolation are required. Accuracy is high—up to 0.06% including 0 to 100% relative humidity change, 20° C temperature variation and dial accuracy (See Specifications).

Model 532 Frequency Meters comprise a special waveguide section mounting a high Q resonant cavity tuned by a choke plunger. A 1 db or greater dip in output indicates resonance. There are no spurious modes or resonances. Tuning is by a precision lead screw, spring loaded to eliminate backlash. Minimum calibration spacing is 1/32" to provide good resolution.

SPECIFICATIONS

Model No.	Overall Accuracy (%)	Frequency Range KMC	Dial Calib. Accuracy (%)	Calibration Increment (MC)	Max. Temp. Coefficient % per ° C	Price
G532A	0.065	3.95 - 5.85	0.033	1	0.0012	$325.00
J532A	0.065	5.30 - 8.20*	0.033	2	0.0012	300.00
H532A	0.075	7.00 - 10.0	0.040	2	0.0015	195.00
X532B	0.080	8.20 - 12.4	0.050	5	0.0010	150.00
M532A	0.085	10.0 - 15.0	0.053	5	0.0012	275.00
P532A	0.100	12.4 - 18.0	0.068	5	0.0012	210.00
K532A	0.110	18.0 - 26.5	0.077	10	0.0013	230.00
R532A	0.120	26.5 - 40.0	0.083	10	0.0017	250.00

K and R band models available with circular flange adapters; specify K532AC and R532AC respectively.

*When used between 5.3 to 7.5 KMC, or 5.7 to 8.2 KMC, single mode resonance is achieved.

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

For complete details, call your hp representative or write direct

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hp complete instrumentation for microwave measurements

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are creating a climate conducive to significant scientific achievement

"Essentially, this corporation will be people—people of the highest quality. The United States Air Force recognizes that men of great scientific and technical competence can perform at their best only when they can exercise their initiative to the full under leadership which creates the climate for creativity. We expect Aerospace Corporation to provide that kind of environment."

SECRETARY OF THE AIR FORCE

Among those providing their leadership to this new non-profit public service corporation are: Dr. Ivan A. Getting, president; Allen F. Donovan, senior vice president, technical; Jack H. Irving, vice president and general manager, systems research and planning; Edward J. Barlow, vice president and general manager, engineering division; and Dr. Chalmers W. Sherwin, vice president and general manager, laboratories division.

These scientist/administrators are now selecting the scientists and engineers who will achieve the mission of Aerospace Corporation: concentrating the full resources of modern science and technology on rapidly achieving those advances in missile/space systems indispensable to the national security.

The functions of Aerospace Corporation include responsibility for: advanced systems analysis; research and experimentation; initial systems engineering; and general technical supervision of new systems through their critical phases, on behalf of the United States Air Force.

Aerospace Corporation is already engaged in a wide variety of specific systems projects and research programs—offering scientists and engineers the opportunity to exercise their full capabilities, on assignments of unusual scope, within a stimulating environment.

Immediate opportunities exist for:

- SENIOR ELECTRONICS ENGINEERS:
  Communications Systems
  Navigation Electronics
  Radio Techniques
  Electro-Mechanical Design
  Information Theory
  Sensing Systems
- SPACE VEHICLE SPECIALISTS:
  Senior Power Systems Engineer
  Sr. Flight Performance Analyst
  Re-entry Aerodynamicist

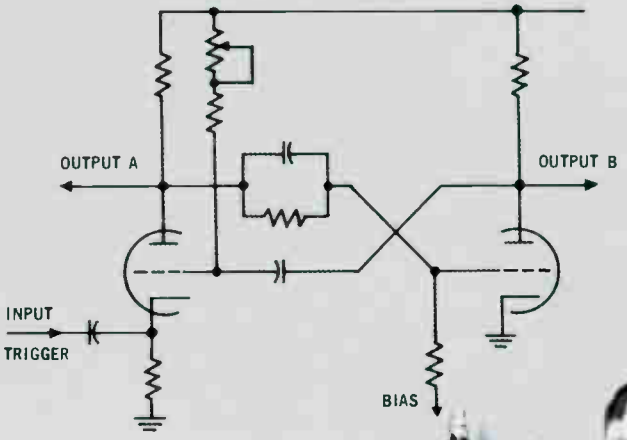
Those capable of contributing in these and other areas are invited to direct their resumes to:

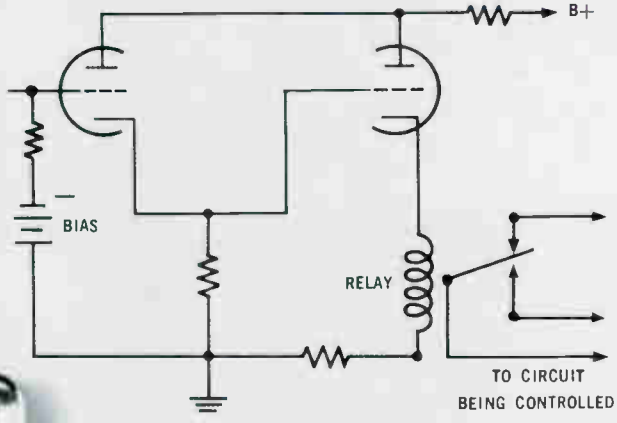
Mr. James M. Benning, Room 110
P.O. Box 95081, Los Angeles 45, Calif.

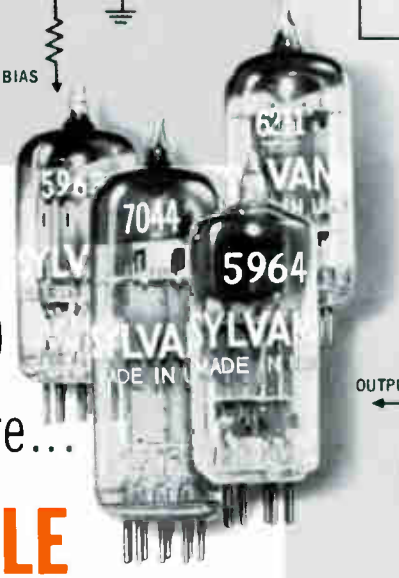
A new and vital force AEROSPACE CORPORATION *engaged in accelerating the advancement of space science and technology*

ELECTRON TUBE NEWS
...from SYLVANIA

specifically for "on-off" and control applications...

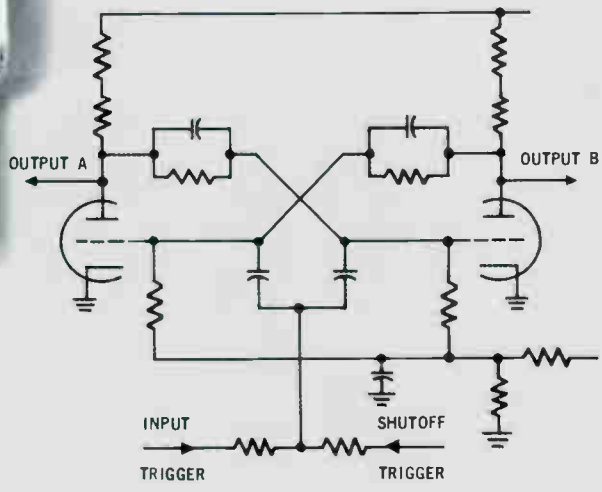






SYLVANIA GOLD BRAND TUBES feature...

- **REMARKABLE RELIABILITY**
- **EXCEPTIONAL STABILITY**
- **LONG LIFE EXPECTANCY**
- **HIGH UNIFORMITY**



More than a decade ago, Sylvania developed the first vacuum tube specifically for computer-type applications . . . the reliable 7AK7. Today, there is a large family of field-proven Sylvania types specifically designed for "on-off" control applications, including eleven premium-quality *Gold Brand Tube* types.

Sylvania *Gold Brand Tubes* for computer applications exhibit highly stable electrical characteristics even under long periods of operation at cutoff conditions – offer high uniformity of characteristics from tube to tube – feature long life and reliability. This is the direct result of stringent material and process controls to assure minimal cathode interface formation, low cathode sublimation, improved plate dissipation capabilities and low interelement leakage.

SYLVANIA MEDIUM-MU TWIN TRIODES Absolute Maximum Ratings			
Sylvania Type	Description	Plate Dissipation (Watts)	DC Cathode Current (mA) (Each Section)
GB-5844	7-pin, T-5½ miniature, relatively high zero-bias plate current and sharp cutoff.	0.50	9.0
GB-5963[1]	9-pin, T-6½ miniature, mid-tapped heater for 6.3V or 12.6V operation. Bulb temperature capability of 120°C. Designed for multivibrator applications.	2.5	20
GB-5964	7-pin, T-5½ miniature. Utilizes "flat" cathode which enables use of "flat" grid wires for exceptional accuracy in grid alignment. Large plate area for excellent heat dissipation. Max. bulb temp. rating is 150°C.	1.5	15
GB-5965[1]	9-pin, T-6½ miniature, mid-tapped heater for 6.3V or 12.6V operation. Offers high zero-bias plate current and sharp cutoff characteristic.	2.2	15
GB-6211[1]	9-pin, T-6½ miniature, mid-tapped heater for 6.3V or 12.6V operation. Especially designed for frequency-divider circuits.	1.0	14
GB-6350[1]	9-pin, T-6½ miniature, offers high zero-bias plate current and sharp cutoff. High perveance type with g_m per unit of 4600 μmhos. Utilizes "flat" cathode, "flat" grid wires, large plate area. Max. bulb temp. rating is 120°C.	3.5	25
GB-7044	9-pin, T-6½ miniature, features g_m per unit of 10,000 μmhos. Uses "flat" cathode, "flat" grid design. Large plate area has "wings" for improved heat dissipation capabilities. Max. bulb temp. rating is 160°C. Designed for cathode-follower applications.	4.5	50

[1]Separate terminals for each cathode

In addition to 100% tests for ac and dc shorts, samples are life-tested for 1000 hours of "on-off" operation and checked at intervals of 40, 200, 500 and 750 hours. Rigid performance requirements are placed on such end points as cathode interface impedance, plate current stability, cutoff stability, heater-cathode leakage, interelement insulation, continuity, grid current. Heater cycling tests are performed for a minimum of 2000 cycles—one minute "on," four minutes "off."

Ask your Sylvania Sales Engineer for full information about Gold Brand Tubes for "on-off," control and other critical industrial-military applications.

SYLVANIA DUAL-CONTROL* MULTIGRID TYPES Absolute Maximum Ratings			
Sylvania Type	Description	Plate Dissipation (Watts)	DC Cathode Current (mA)
GB-7AK7	8-pin, lock-in base, T-9 pentode. Features high zero-bias and sharp cutoff. Designed for gating or driving applications.	8.5	—
GB-5915A	7-pin, T-5½ heptode. Designed for gated amplifier service.	1.0	20
GB-6145	8-pin, lock-in base, T-9 pentode. Features g_m of 9700 μmhos.	10.0	—
GB-6888	8-pin, T-9 pentode. Max. bulb temp. rating is 130°C. Designed for pulse amplifier, core driver and coincidence circuits.	8.0	80

*Grids #1 and #3 can be used as independent control electrodes.

NEW! SYLVANIA-7738, -7803

. . . feature high electrical stability, high reliability in short continuous service under difficult environmental conditions.

DESIGN MAX. RATINGS Continuous Class C Svc at 175 MC	7738	7803	
Plate Voltage	330	200	Volts
Plate Dissipation	5.0	3.5*	Watts
Plate Input	7.5	5.5*	Watts
Cathode Current	40	30*	mAdc
Grid Current	10	2.5*	mAdc
Negative Grid Voltage	50	75	Volts
Grid Circuit Resistance			
Fixed Bias	0.1	0.1	Megohm
Cathode Bias	0.5	0.5	Megohm

*Each section

Originally designed for service in expendable sonobuoy equipment dropped by aircraft, these two types are typical of Sylvania capabilities in the design, development and manufacture of tubes for specialized industrial-military applications. If your design requirements demand specialized industrial-military type tubes, draw on the creative engineering and production capabilities of Sylvania. Your Sylvania Sales Engineer is ready to work with you.

SYLVANIA-7738. . . a miniature high-mu triode, 7738 utilizes silver-plated pins and high grid-wire T. P. I. for excellent VHF performance. Lead inductance is optimized by the use of shielding. It is capable of withstanding 450g shock.

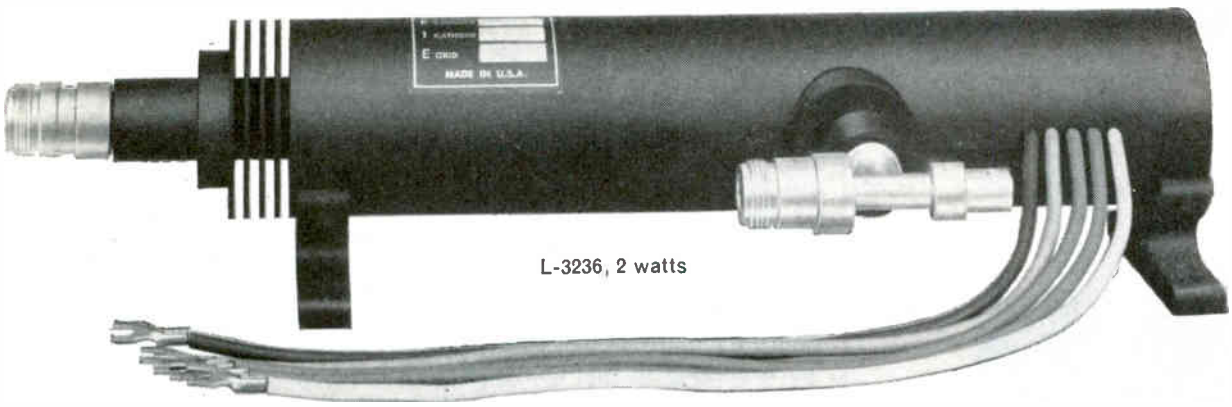
SYLVANIA-7803 . . . a miniature double-triode, it offers high g_m of 12,500 μmhos per unit and low capacitance. 7803 uses the Sylvania-developed, rugged strap frame grid—enabling use of fine grid wire, high T. P. I.

For further information, contact the Sylvania Field Office nearest you. Or for data on specific types, write Electronic Tubes Division, Sylvania Electric Products Inc., Dept. K, 1100 Main Street, Buffalo 9, N. Y.

SYLVANIA

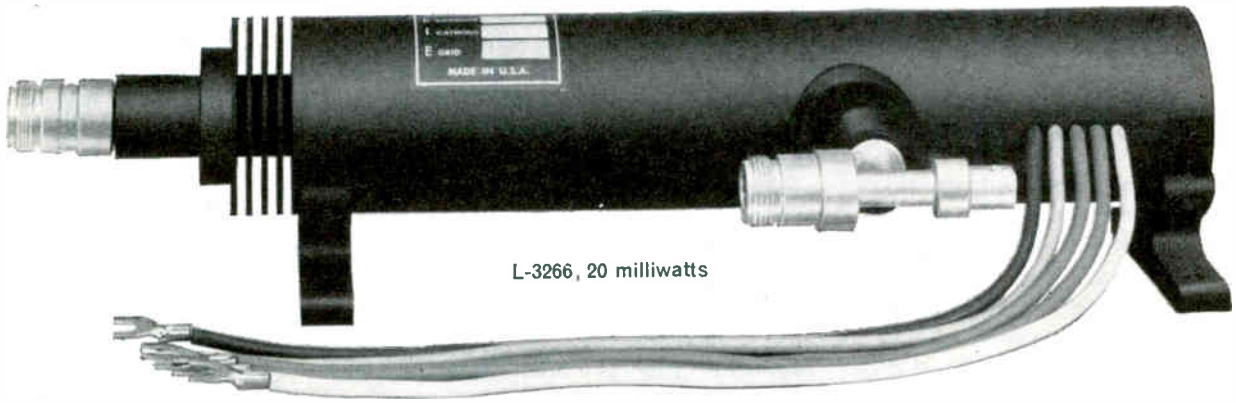
Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**

N-8637-3



L-3236, 2 watts

TWTwins



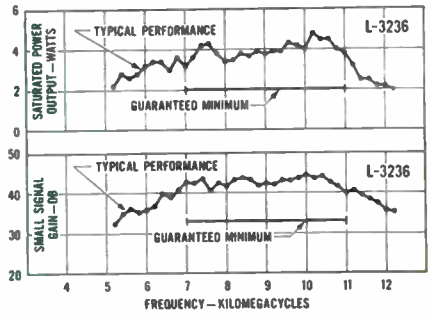
L-3266, 20 milliwatts

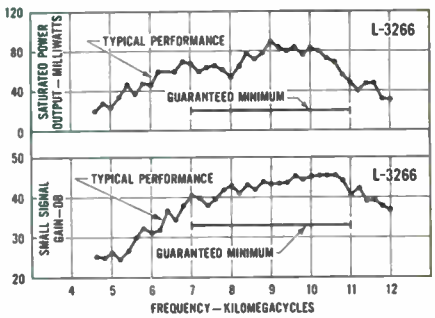
These Litton TWT twins are PPM focussed X-band traveling wave tubes. They are *not* prototypes. They are metal and ceramic tubes in field application *now*.

Designed to cover X-band with minimum saturated CW power of 20 milliwatts (L-3266) and 2 watts (L-3236), they may be operated in cascade to amplify signals as small as —50 dbm to the 2 watt level. Their performance, far exceeding the conservative specifications, is evident in the accompanying graphs.

Small size (less than 12″ in length), light weight (under 4 pounds each), and extreme environmental capability (temperature compensated —54°C to 86°C) make these tubes the ideal choice for military applications. A typical airborne equipment, designed and manufactured by Granger Associates of Palo Alto, California, incorporates the L-3266 and L-3236 and occupies only 0.75 cubic feet, including all necessary power supplies, modulating circuitry, cooling, etc. This equipment is now in field operation.

If your work involves ECM repeaters, radar target enhancement, frequency diversity radar or any application requiring broadband microwave amplifiers, appraise these new tubes. In production quantities their price is the lowest in the field. Ask for catalog sheets on the L-3266 and L-3236. Address: Litton Industries Electron Tube Division, 960 Industrial Road, San Carlos, California.





LITTON INDUSTRIES
Electron Tube Division
MICROWAVE TUBES AND DISPLAY DEVICES

"Capability that can change your planning"

Reports Cite Earnings Dips

ELECTRONICS COMPANIES with strong lines of consumer products though often accustomed to steady or rising gains, are beginning to show some fluctuations according to reports coming in this quarter. Here are some examples:

Hallicrafters, Chicago, manufacturer of ham radio gear, electronic organs, shortwave radios and military electronics equipment, reports a gain of 15½ percent in net sales and a 30-percent rise in earnings after taxes for the year ended Aug. 31. Net sales figures, up this year, were $29,374,490 as compared with 1959's $25,417,364. Earnings after taxes this year were $907,777 as against $689,037 last year. Sales backlog in commercial products at the end of this year was $10 million as compared with last year's $5 million.

Motorola reports third quarter sales this year were up by a slight margin over previous third quarter records, although profits compared to the similar period last year were lower by about 9 percent. Net sales for the quarter were $77,201,664 as against $77,145,487 last year. Profits were $3,276,633 as against $3,598,653. R. W. Galvin, company president, commenting on the dip, said volume was held down by reduced demand for tv receivers and certain other consumer products, as well as reduced volumes in the company's military division. Also mentioned as factors were increased general costs, temporary start-up costs on new transistors and the company's decision to expand new-product investigation and engineering.

Magnavox Co., Ft. Wayne, Ind., announces company earnings show a continuation of the trend to higher earnings levels established last year with a 50-percent increase in profits. Net profits for the nine months ending Sept. 30 were $3,534,000, compared with $2,384,000 last year, equal this year to $1.50 a share compared with $1.01 for 1959. Company president Frank Freimann says the "disproportionate increase in earnings is the result of a greater profit margin on the government and industrial operations of the company, and a more favorable mix in consumer products, as well as an improvement in operating efficiency." September quarter sales for the firm, however, were off by 10 percent in television and stereo hi-fi products, due in part, according to company officials, to delayed shipments and industry-wide sales declines during the period. Sales in October are reportedly up and the fourth quarter, said to be historically the most profitable, looks favorable.

Admiral Corp.'s president Ross Siragusa says his company's sales and profits on tv and radio receivers were higher during the first three quarters of this year, but adds that appliance sales slipped sharply during the period. "The severe industry-wide slump in appliances and the subsequent operation of our Galesburg, Ill., appliance manufacturing facility at below capacity were responsible entirely for the lower profits this year," he said. Consolidated sales for this year's first nine months were $144,976,988, compared with $145,849,148 in 1959. Profits were $1,207,764, compared with $4,906,253 last year, before taxes.

After-tax figures were $497,072 or 21 cents a share this year as against $2,371,376 or 99 cents a share last year.

Zenith Radio reports a drop in consolidated net earnings which slid from $9,319,921 for the first nine months of 1959 to $8,577,752 for the same period this year, a drop of $742,169. A company statement says although consolidated sales for the nine month period were up 4½ percent over last year, to a figure of $183,952,012, profits in the period were affected by "a continuation of unrealistic pricing

and liquidations on the part of several principle competitors which placed continued pressure on the company's profits."

Consolidated sales for this year's third quarter were reported at $65,688,191, as compared with $69,127,237 last year.

Borg Warner, which manufactures a variety of electronic items through its B-W Controls division, Pesco Products division and its recently established Omnitronics division in Philadelphia says, "The current down-drift in economic conditions" adversely affected sales and earnings during the third quarter of this year. Roy C. Ingersoll, company chairman, says that despite increased selling costs, selling prices of appliances and air conditioning equipment are below those of a year ago. B-W sales during the first nine months of this year were $451,458,928 compared with $484,194,024 for 1959, a decrease of six percent.

Earnings after taxes this period were $17,839,366 or $1.96 a share as against $25,566,788 or $2.83 a share in 1959, a decline of 30.2 percent.

25 MOST ACTIVE STOCKS

WEEK ENDING NOVEMBER 11, 1960

	SHARES (IN 100's)	HIGH	LOW	CLOSE
Lockheed Aircraft	1,317	28¼	25½	27
Gen Tel & Elec	1,310	27¾	26⅛	27⅜
Avco Corp	842	14⅝	13⅝	14½
Gen Electric	816	80	75¼	78⅞
RCA	747	54⅞	51⅜	54⅛
Westinghouse	621	50⅛	47⅜	49⅝
Sperry Rand	611	19¾	18¾	19⅜
Int'l Tel & Tel	545	40¾	38⅝	40⅛
Litton Ind	512	81⅜	74⅝	80⅜
Gen Inst	509	36¼	31⅞	36
Texas Inst	498	188¾	169¼	185
Gen Dynamics	438	40⅛	37⅛	39⅝
Martin Co	429	55⅞	52⅝	54⅝
Philco	406	20⅜	18¾	19⅝
Varian	364	46¾	41½	45¼
Univ Controls	363	15⅝	14¼	15¼
Fairchild Cam & Inst	340	162	145	158½
Raytheon	288	35¾	32	35⅛
Elec & Mus Ind	284	6¼	6	6
Polarad	283	20⅞	17½	20⅜
Zenith	274	102⅜	96¾	101⅛
Standard Kollsman	271	20⅞	18¼	20⅜
Lear Inc	269	18	15⅞	17¾
Cubic Corp	264	51⅛	42¾	49
Collins Radio	262	48	42⅝	47⅛

The above figures represent sales of electronics stocks on the New York and American Stock Exchanges. Listings are prepared exclusively for ELECTRONICS by Ira Haupt & Co., investment bankers.

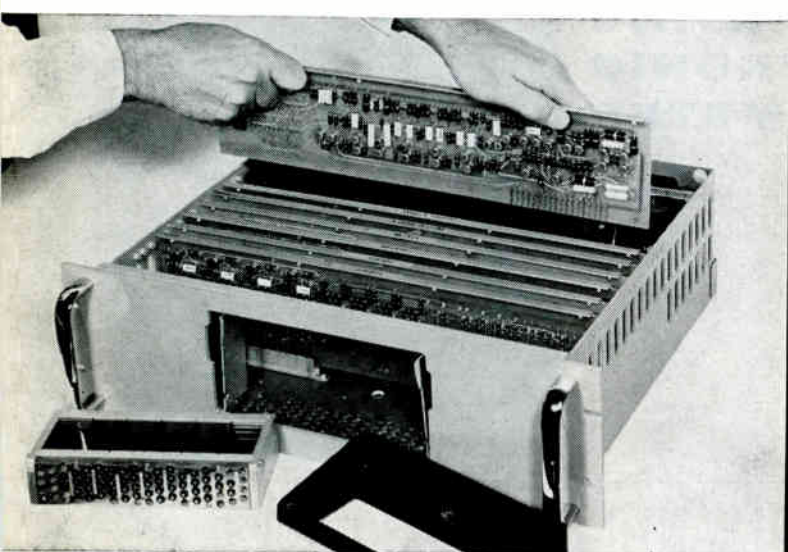
The Important Difference In Digital Voltmeters...

Check the design and construction features pictured here. These are the subtle marks of quality that exemplify the engineering leadership of NLS . . . the *important difference* between NLS digital voltmeters and those of other manufacturers. These are the engineering innovations that assure accuracy and rugged reliability . . . that minimize maintenance and downtime . . . that add to the long-term efficiency and usefulness of NLS instruments. Yes, there's more to a digital voltmeter than meets the eye . . . so look behind the front panel and beyond the specification sheet before you buy! Call on your NLS representative to demonstrate the instrument of your choice . . . to show what engineering leadership means to you in digital voltmeter performance and usefulness. Write today for the NLS catalog that describes the world's most complete line of digital voltmeters . . . by purpose, by price!

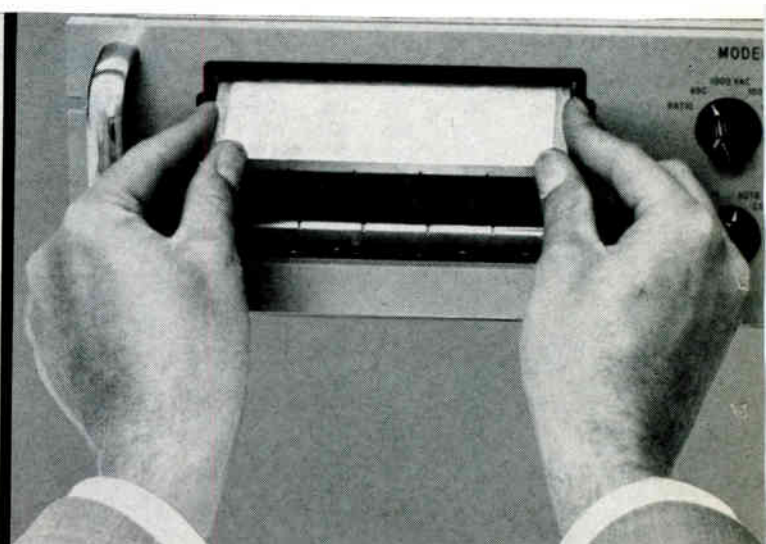
Originator of the Digital Voltmeter

non-linear systems, inc.

DEL MAR, CALIFORNIA

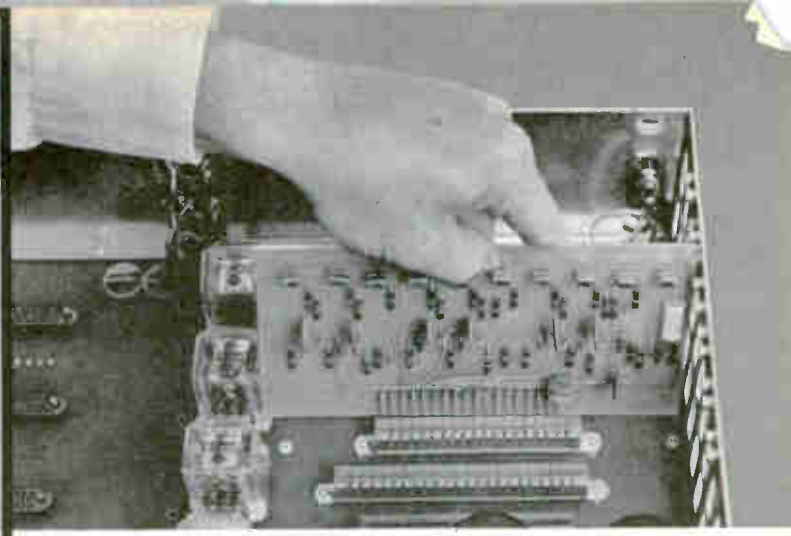


1 **PLUG-IN MODULAR CONSTRUCTION** *simplifies servicing, drastically reduces maintenance costs, keeps instruments on the job. More than 99% of the components of the NLS V44, Series 20 and Series 30 instruments are mounted on plug-in modules.*



2 **SNAP-OUT READOUT**, *exclusive on all NLS digital instruments, permits 20-second bulb replacement through front panel without tools. Precisely engraved readout numerals can be read all day from close up or far away without eye fatigue.*

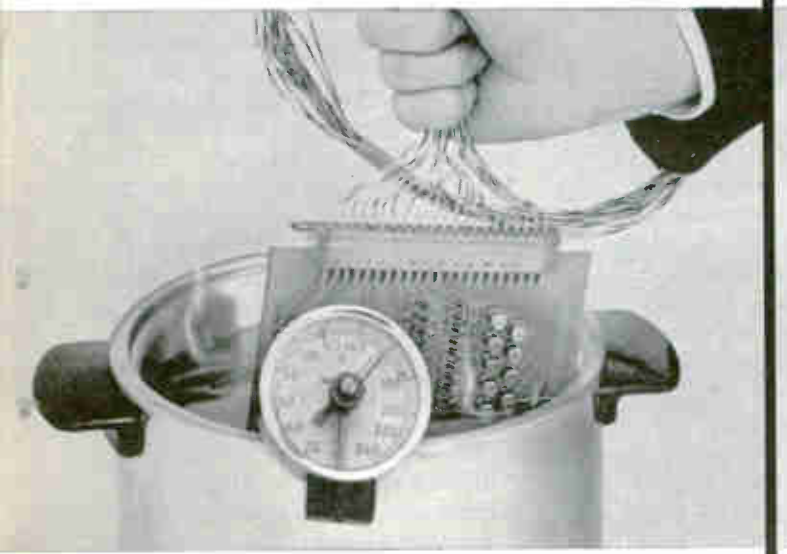
3 **COMPACT DESIGN** — *illustrated by the 5¼"-high NLS 484 DVM, complete with recording controls – is one of the more obvious clues to superior engineering. Even the lowest cost NLS instruments are more compact with fewer cables and connections. Result: greater reliability.*



4 **"NO-NEEDLESS-NINES" LOGIC** *in Series 30 results from a new concept in transistor logic which eliminates unnecessary, time-consuming cycling of stepping switches through their 9's and 0's positions. This increases accuracy, speed, reliability and usefulness, particularly in systems applications.*

5 **FULLY AUTOMATIC OPERATION,** *pioneered by NLS, includes automatic selection and indication of range and polarity. Human error is virtually eliminated.*

6 **PLUG-IN ACCESSORIES** *can be mated in minutes with an NLS digital voltmeter to form hundreds of combinations. These include AC/DC converters, preamplifiers, input scanners, and virtually every type of data recorder.*



7 **"NO POTS AT ALL" STABILITY** *of the NLS V44 DVM is checked by the "boil in oil" test at 158°F. This feature eliminates all trimming of decade and amplifier circuits.*

8 **PLUG-IN OIL-BATH STEPPING SWITCHES** *in Series 30 instruments outlast dry switches by a factor of five . . . completely eliminate periodic disassembly for manual lubrication of switches.*

MARKETING

Survey Probes Defense Spending

"THE FUTURE for defense spending after fiscal 1961 is beyond any reliable means of estimate," says the marketing services division of Smith, Winters, Mabuchi, Inc. in its report issued this week—An Examination of Various Aspects of the Defense Market.

Future defense spending levels are uncertain at this time because they depend too heavily on political and international factors, the firm's marketing division says.

In the broad sense, funds committed to defense have been at a stable level for several years. So has the apportioning of monies to the various services.

The New York agency that issued the report has been in the marketing analysis business for many years, started to make marketing studies because it felt marketing techniques such as selling, advertising, sales promotion and publicity, can be applied intelligently only after market analysis.

Although the overall budget has been fairly static for several years uses of funds for procurement of equipment and for research and development have shown changes such as:

(1) Aircraft—moving down
(2) Missiles—moving up
(3) Electronics and Communications—moving up
(4) Research and Development —moving up

Of interest in the aircraft expenditure trend are two points:

(1) New obligations are at a comparatively stable level
(2) Expenditures are falling

The missile trend shows:

(1) Obligations now at a peak (which may be a plateau from which they will rise to new highs)
(2) Continuing increase in expenditures

Aircraft expenditures dropped from a peak of $8.3 billion in fiscal 1954 to $6.2 billion in fiscal 1960. Missile expenditures have risen from $1.2 billion in fiscal 1956 to $3.9 billion in fiscal 1960.

However, electronics will take a larger and larger share of the dwindling aircraft total. In fiscal 1956 the electronics share of total aviation expenditures was estimated at 25 percent and may rise to 40 percent in the sixties.

Our industry's share of missile expenditures will rise to 60 percent or more of the total in the sixties. In 1956 electronics' share of missile spending was 50 percent, the report states.

The gross expenditure picture and that for electronics do not quite agree because the electronics percentage of total expenditures is rising.

Next year, on the whole, will be another record year of business activity, reports McGraw-Hill's Department of Economics. M-H's economic opinion is backed up by a score of leading business economists who participated in the company's economic conference panel. The economists recently traveled through many of the nation's industrial and financial centers where they obtained up-to-the-minute information on the outlook for the major industries.

However, there is widespread agreement that there will be a decline in many activities in the early quarters of 1961.

Some reductions in industrial output in gross national product are expected before business begins to move ahead in 1961, says the McGraw-Hill economics group. Their opinion is that the decline in gross national product and in industrial production in early months will be only half as severe as 1958. This opinion contrasts with that recently reported by economists of the Chase National Bank who look for a decline about equal to that of 1958 (ELECTRONICS, p 24-25, Oct. 14).

During the early months of 1961, industrial output will decline about 7 percent, reports Douglas Greenwald, Manager of Economics for McGraw-Hill.

A higher operating rate for steel

is expected in the months ahead because inventories are low; but production record for 1961 is expected to fall a little short of the 1960 mark, about 5 percent.

Auto industry sales for 1961 are expected to be down about 10 percent from 1960's total of 6.6 million units, including imports. This industry's production decline will be aggravated by the trend to lower priced compacts which could mean a still larger drop in dollar sales. Here is a summary of outlook for other industries:

(1) Machinery and electrical machinery—inventories are high, relative to sales volume. Inventory problems of electrical appliance makers won't be solved quickly.

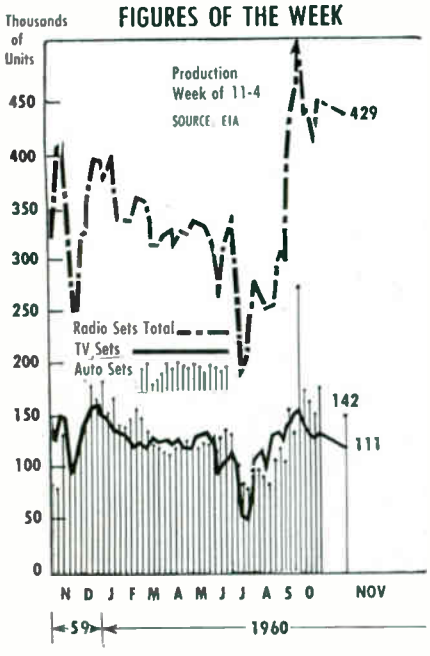
(2) Nondurable producers and retail outlets (soft goods) outlook is relatively bright.

(3) Chemical industry — expected to hold sales gains made this year despite expected cuts in industrial production.

(4) Paper makers and petroleum producers—expected to fare better than industry as a whole.

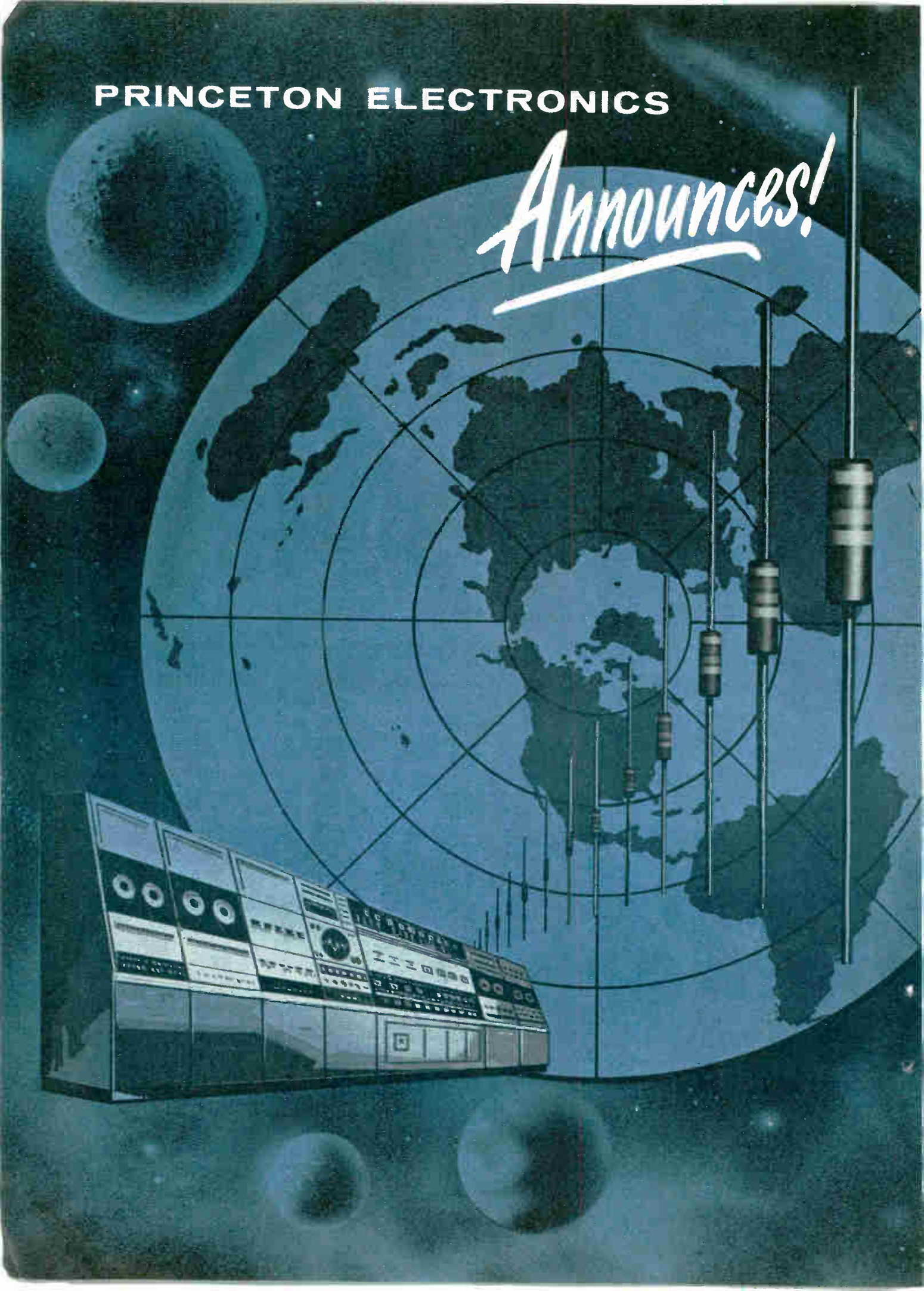
Manufacturers will feel a sharp bite on profits. It has already become evident. From a $45.7-billion annual rate in the second quarter of 1960, profits before taxes are expected to slip to $41-billion rate in the third quarter. The slide is likely to continue into mid-1961 and profits should begin to improve as production rebounds.

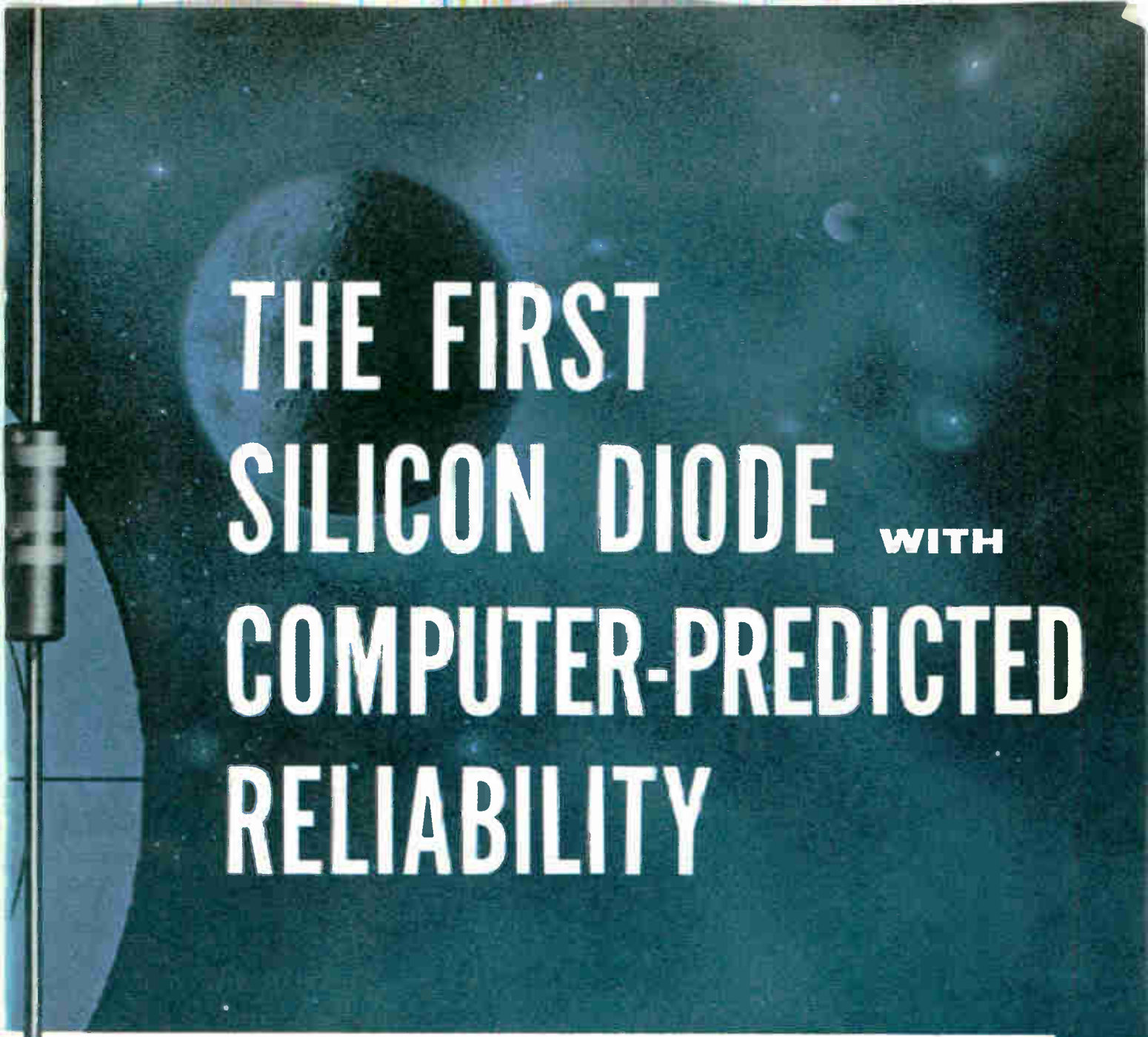
FIGURES OF THE WEEK



PRINCETON ELECTRONICS

Announces!





THE FIRST SILICON DIODE WITH COMPUTER-PREDICTED RELIABILITY

YOU CAN'T ARGUE WITH COMPUTER LOGIC . . .

Computer processes applied to product on and performance ana y-sis by Princeton Electronics Corporation are establishing new stan-dards of reliab lity in si icon diodes. PEC, manufacturers of silicon diodes for computers and other demanding applications, have de-veloped the use of computer logic as a gu de to production control and product quality

The life history of every diode is computer recorded and available for analysis and evaluation — a major step forward in the over-all effort towards complete reliability in electronic systems.

Every design engineer understands the need for extreme reliability in electronic components, particularly for complex systems. No engi-neer could deny the advantages of this newest, most exacting method of manufacture, testing and evaluating potential performance.

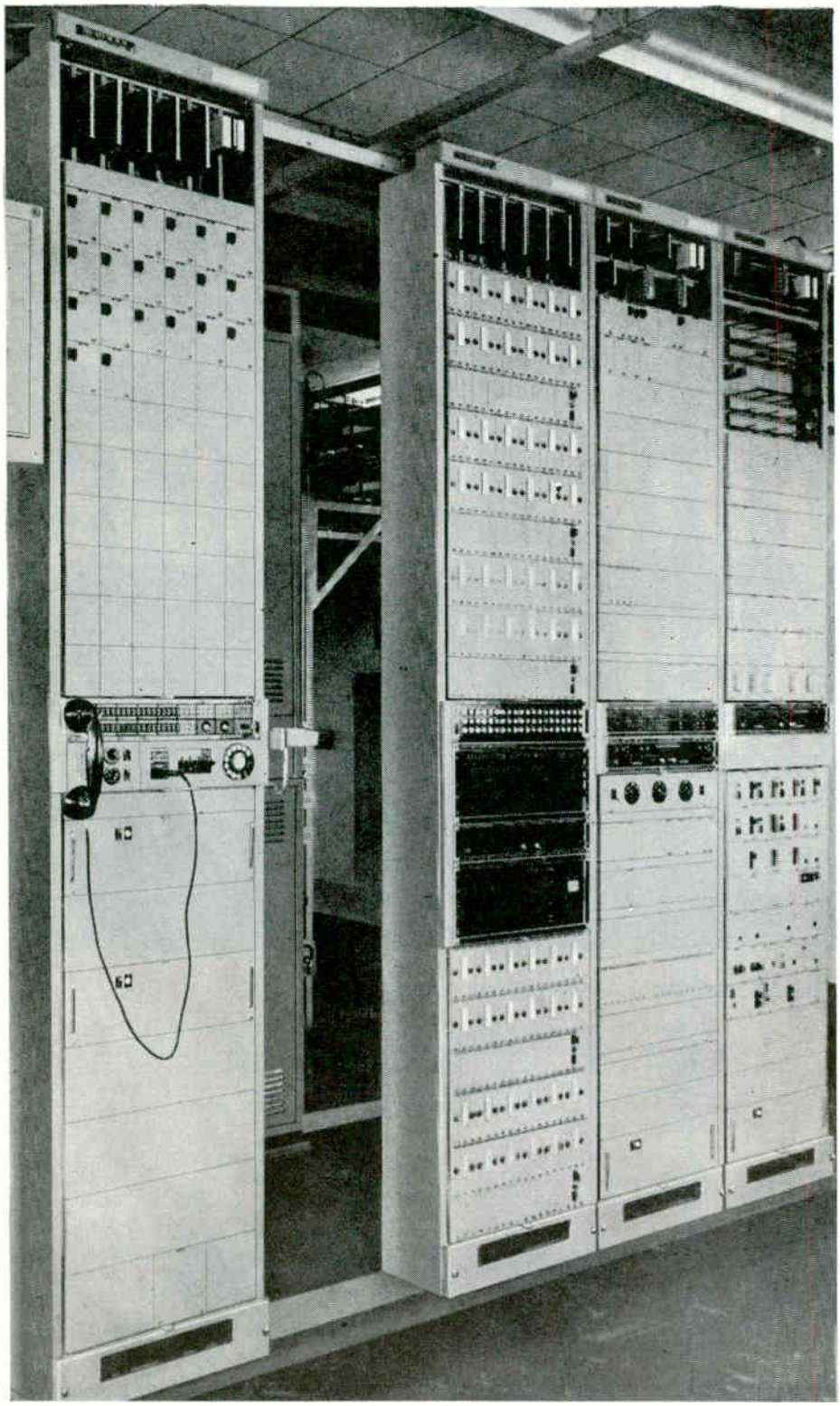
Write today for complete information on the silicon diode with computer-predicted performance.

logically best

PRINCETON *Electronics* CORPORATION

P O. BOX 127, PRINCETON NEW JERSEY

NEC microwave carrier terminal equipment with transistor reliability



4-bay array of NEC 120-channel terminal equipment for microwave links

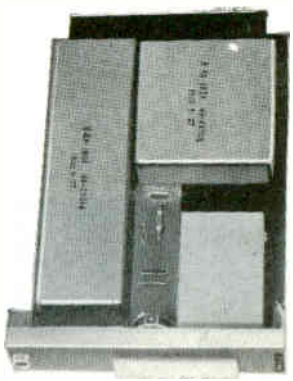
This fully transistorized carrier telephone equipment for microwave links provides 120 toll quality telephone channels. Characteristics meet or surpass all CCITT requirements.

It offers these advantages over conventional tubed equipment:

* 90% reduction in power consumption
* Lower operating temperature
* Less floor space
* Increased reliability, resulting in lower maintenance costs.

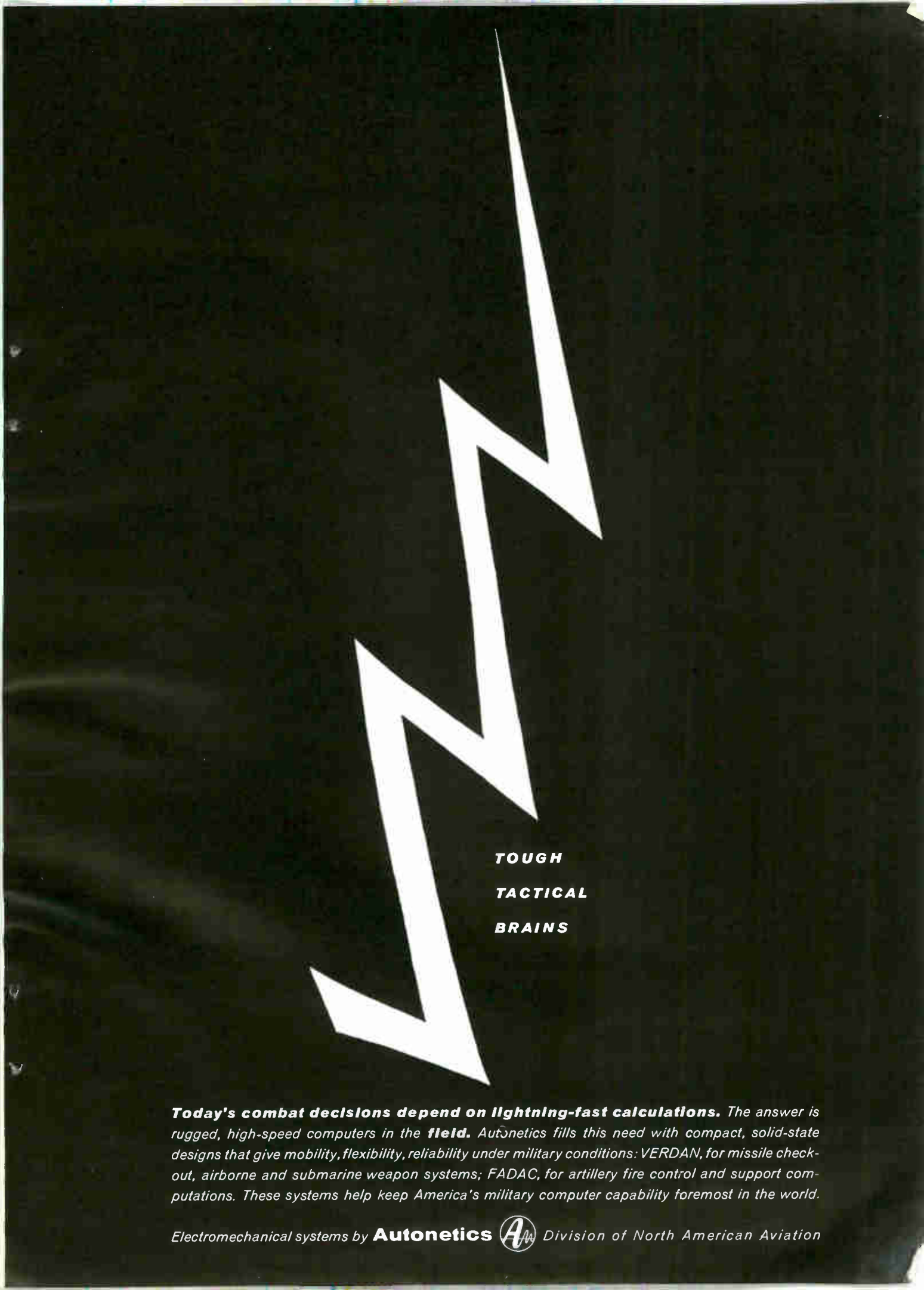
Each 300–3,400 c/s telephone channel can accommodate 24 voice-frequency telegraph channels operated at a keying speed of 50 bauds.

NEC will also make available within this year 600-channel transistorized equipment.



A part of print-wired channel translating unit

NEC Communications Systems / Electronics
Nippon Electric Co., Ltd. Tokyo, Japan



Today's combat decisions depend on lightning-fast calculations. *The answer is rugged, high-speed computers in the* ***field.*** *Autonetics fills this need with compact, solid-state designs that give mobility, flexibility, reliability under military conditions: VERDAN, for missile check-out, airborne and submarine weapon systems; FADAC, for artillery fire control and support computations. These systems help keep America's military computer capability foremost in the world.*

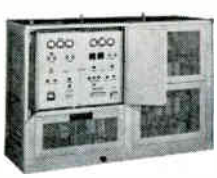
Electromechanical systems by **Autonetics** *Division of North American Aviation*

FIRST in H-F Rotary Power Supplies

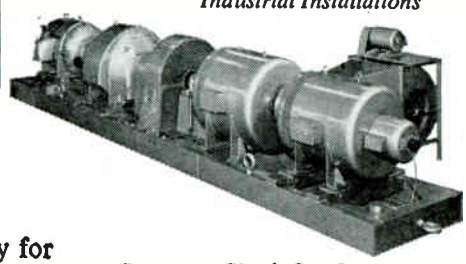
All your needs for dependable High Frequency Power Supplies can be found at *one source*—American Electronics' Precision Power Division. Here engineering skills and manufacturing know-how have been pioneering new Rotary Power developments for over a decade.

Typical Generator for H-F Industrial Installations

FIRST to introduce a brushless, inductor type 400 cycle generator. Field windings are cast integrally with the rotor. Windings are practically indestructible.



FIRST to furnish 1200 cycle generators as the power source for industrial and medical X-Ray equipment—equipment used to check the NAUTILUS and other atomic submarines for perfection of hull weldments and seams.



Computer Check-Out Generator, 400 and 1600 Cycle

FIRST to meet the demands of the aircraft industry for 1600 cycle power to check out airborne computer systems.

Standard 2 Bearing Generator

FIRST to provide the high cycle generator as the power source for high speed routers for metal working.

FIRST to furnish power source for ultra high frequency lighting systems for more efficient lighting at lower cost.

AC-DC Supply for Production Check-Out Station

Write or call for our Rotary Power brochure, which gives the complete story on these and other power supply units.

AMERICAN ELECTRONICS, INC.

PRECISION POWER DIVISION

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TELEPHONE: MADISON 5-7192

Frozen solid and still full of life!

Freezing temperatures hold no threat for this hardy battery! The performance of Mallory's new low-temperature, wound anode mercury cell far surpasses that of conventional pressed powder anode cells at temperatures around 32°F. This improved performance yields increased capacity per unit volume for all-weather uses, such as navigational buoys, emergency beacons, air-sea rescue transceivers, survival kits, marker lights, warning devices, and many other applications.

The ribbon wound zinc anode of this new mercury cell has a large surface area in contact with the electrolyte. The interleaved absorbent retains the electrolyte and facilitates ionic transfer over the entire anode surface area. This lowers the temperature sensitive anode impedance in the freezing temperature zones.

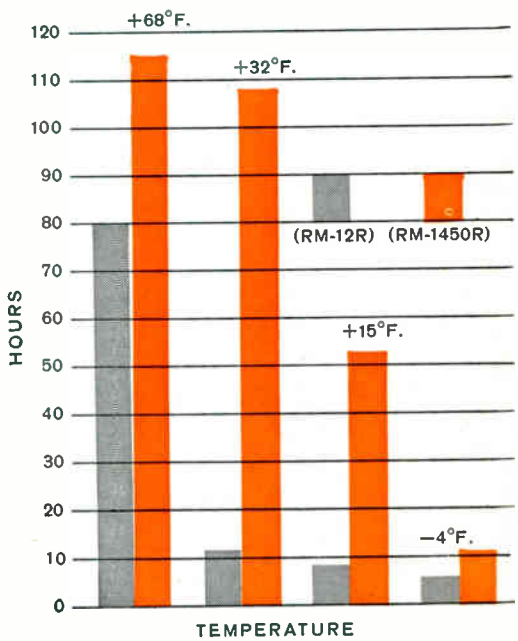
Wound anode construction also increases cell efficiency. At drains up to 100 ma, 90% of available room temperature capacity is attained. Cell units can be packaged to yield up to 45 watt hours per pound.

Write for complete engineering data, including sizes available, suggested applications, characteristics curves and tables. Detailed information on current military uses is available to authorized companies.

HOURS LIFE VS. TEMPERATURE OPERATION

Wound Anode (RM-1450R) vs. Pressed Powder (RM-12R)

Data shows hours life to .9v cut-off on typical transceiver duty 10ma rec. 5 min. 75ma trans. 5 min. continuous cycle.



Mallory Battery Co., North Tarrytown, N.Y.
a division of

P.R. MALLORY & CO. Inc.
MALLORY

In Canada, Mallory Battery Company of Canada Ltd., Toronto 4, Ontario

CIRCLE 31 ON READER SERVICE CARD

Simpson's New VOM

featuring . . .

1½% Accuracy

Excellent Repeatability

Predictable Accuracy

over wide temperature range

Photo courtesy of Admiral Corp. Engineer shown is using the Model 270 in evaluating operating characteristics of developmental type deflection tube.

Model 270

AC-DC VOLT-OHM-MILLIAMMETER

- MIRROR SCALE
- ½% RESISTORS
- GOLD BONDED DIODES
- FAMOUS "STAY ACCURATE" MOVEMENT
- POLARITY SWITCH

Do you need to check day-to-day variations in circuit operation? Or know what accuracy you're getting at different temperatures? If so, you especially will appreciate the capabilities of this new volt-ohm-milliammeter. For example, any particular voltage value will give identical readings today, next week, next month at an accuracy you can pinpoint from 67° to 87° F. The 270 is an engineer's VOM. Its base accuracy of 1½% DC (77°F, at full scale) covers a wide range of critical checks. It is portable, self-powered, built to have the rugged dependability typical of all Simpson VOMs. Accessories include carrying case and a variety of probes. Look it over at your Electronic Parts Distributor soon.

DC Voltage (20,000 ohms-per-volt): 0-250 mv; 0-2.5 v; 0-10 v; 0-50 v; 0-250 v; 0-1000 v; 0-5000 v. (Accuracy, 1½%)
AC Voltage (5000 ohms-per-volt): 0-2.5 v; 0-10 v; 0-50 v; 0-250 v; 0-1000 v; 0-5000 v. (Accuracy, 2%)
AF Output Voltage (With .1 microfarad internal series capacitor): 0-2.5 v; 0-10 v; 0-50 v; 0-250 v.
Volume Level in Decibels (Zero DB equal to 1 milliwatt across a 600-ohm line): —20 to +10 DB; —8 to +22 DB; +6 to +36 DB; +20 to +50 DB.
DC Resistance: 0-2000 ohms (12 ohms center); 0-200,000 ohms (1200 ohms center); 0-20 megohms (120,000 ohms center).
Direct Current: 0-50 mu a; 0-1 ma; 0-10 ma; 0-100 ma; 0-500 ma; 0-10 amp.
Model 270, complete with test leads and Operator's Manual **$59.95**

Simpson

ELECTRIC COMPANY

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Phone: EStebrook 9-1121
In Canada: Bach-Simpson Ltd.
London, Ontario

WORLD'S LARGEST MANUFACTURER OF ELECTRONIC TEST EQUIPMENT

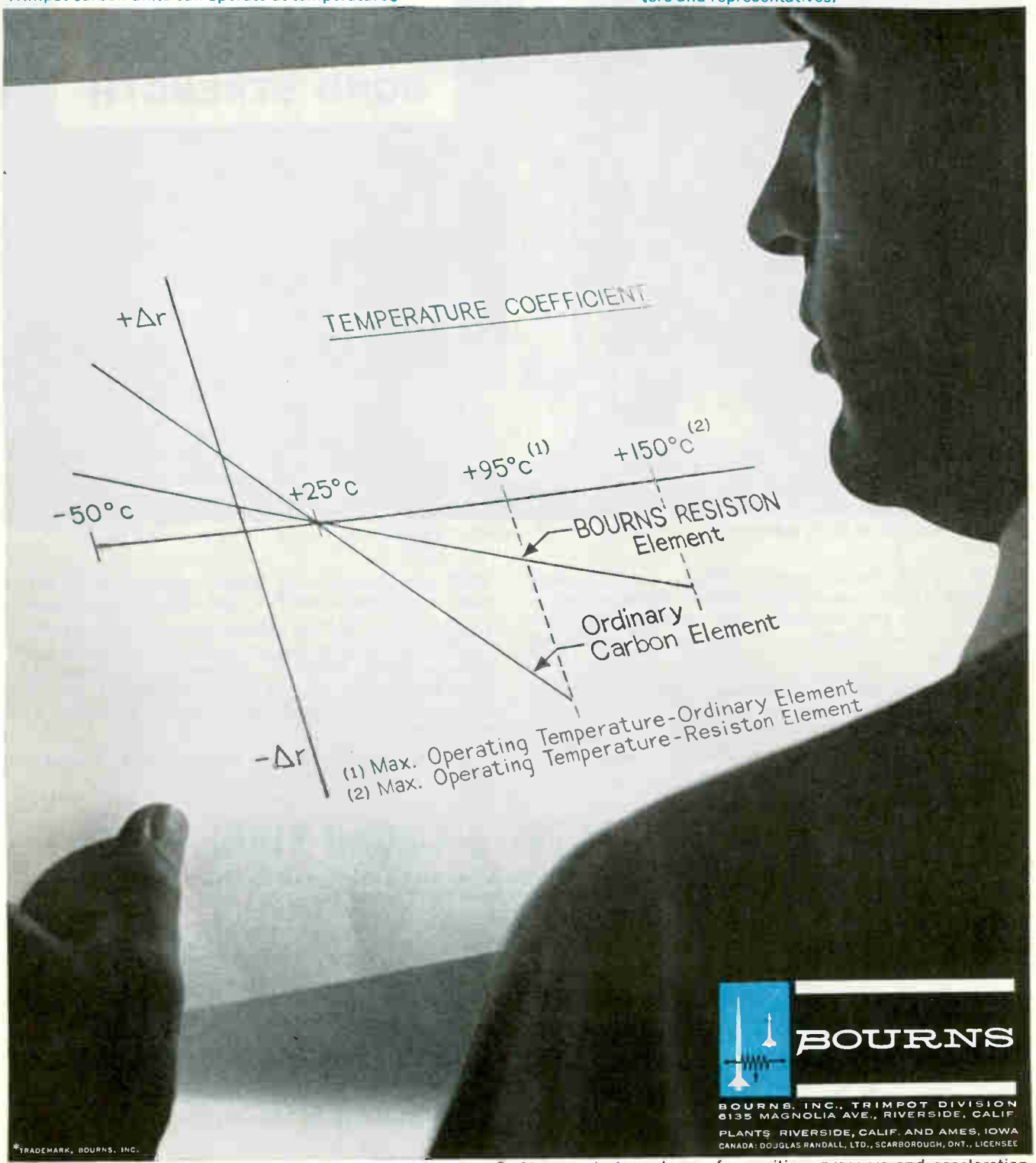
At Last– High Reliability in Carbon-Film Potentiometers!

NUMBER 10–RELIABILITY SERIES

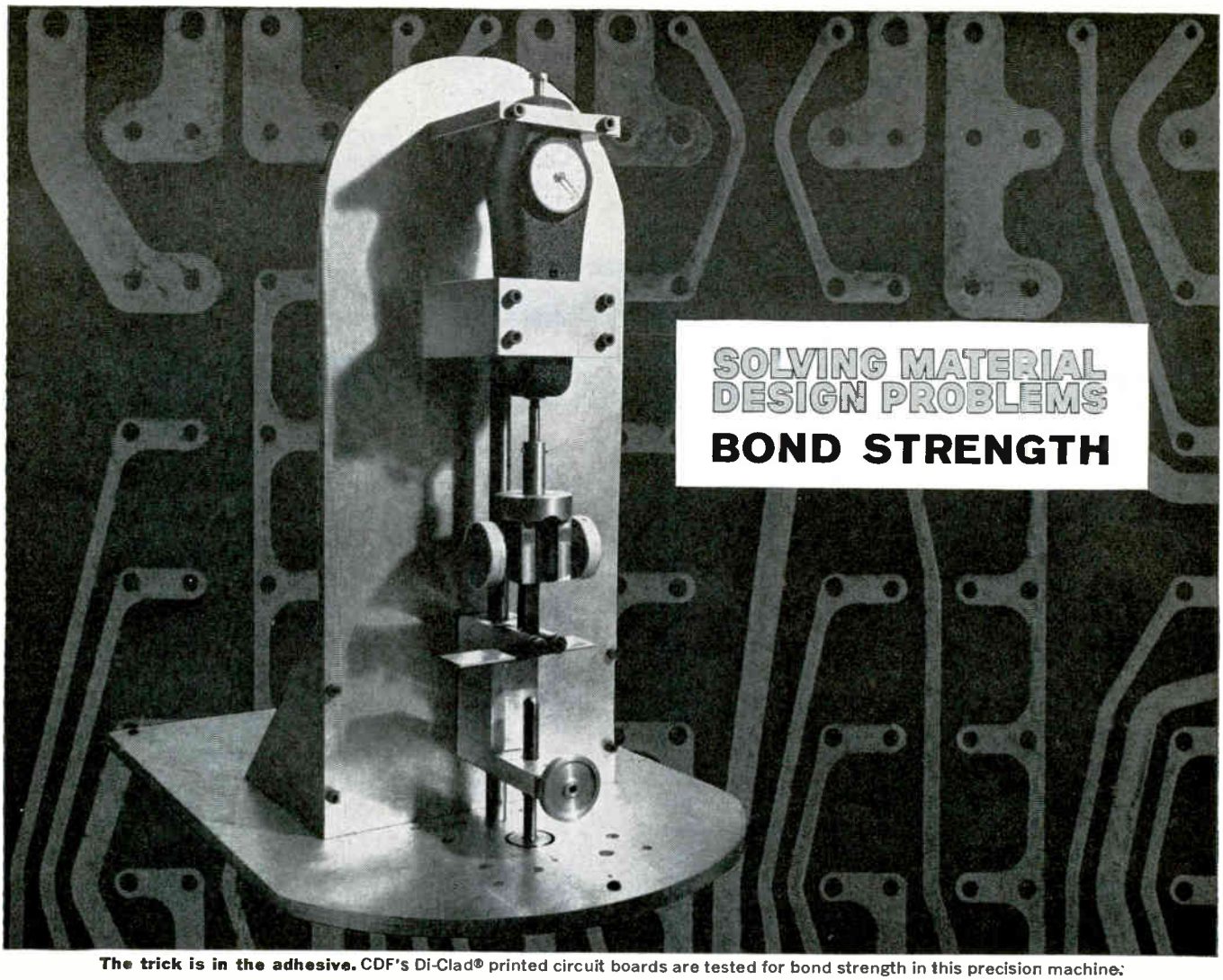
Bourns Trimpot® carbon-film potentiometers now offer you twice the stability of any carbon unit heretofore available... at temperatures as high as 150°C. Now, for the first time, you can incorporate high-resistance, infinite-resolution potentiometers in your circuit without sacrificing reliability. The reason: Resiston*, a remarkable new carbon element that virtually eliminates the problems normally caused by extremes of temperature and humidity.

Thanks to this exclusive Bourns development, Trimpot carbon units can operate at temperatures up to 150°C—with resistance shift only half that of ordinary carbon elements. In addition, they far exceed the requirements of Mil-Specs for humidity and MIL-R-94B.

Trimpot Resiston units are available from factory and distributor stocks with three terminal types... three mounting styles ...and standard resistances ranging from 20K to 1 Meg. Resiston elements are available in most Bourns configurations. Write for the new Trimpot summary brochure and list of stocking distributors and representatives.



Exclusive manufacturers of Trimpot®, Trimit® and E-Z-Trim®. Pioneers in transducers for position, pressure and acceleration.



The trick is in the adhesive. CDF's Di-Clad® printed circuit boards are tested for bond strength in this precision machine.

CDF has developed special adhesives for bonding copper foil to laminated plastic boards. These adhesives produce high peel strength, have excellent hot solder resistance, etch cleanly, and provide high insulation resistance.

In addition to its own adhesives, CDF makes resins and papers. This extends quality control several steps beyond simple pressing operations . . . provides you with Di-Clad boards of excellent and uniform properties.

CDF manufactures the largest selection of grades to meet every major civilian and military requirement.

In addition to Di-Clad printed circuit boards, CDF has special combination materials to solve extra troublesome problems. Example: asbestos bonded vulcanized fibre for circuit breaker arc chutes where the fibre quenches the arc and the asbestos guarantees fire resistance.

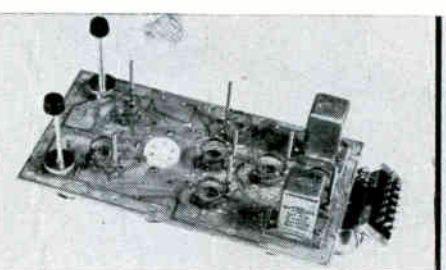
If you don't see the grade you want in CDF's catalog in Sweet's PD file, write us.

CONTINENTAL-DIAMOND FIBRE

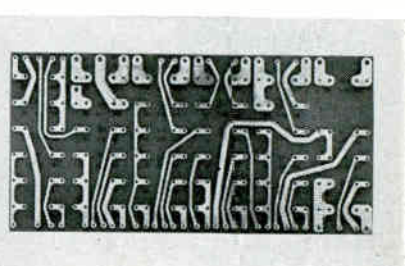
A SUBSIDIARY OF THE Bmhf COMPANY • NEWARK 16, DEL.

In Canada, 46 Hollinger Road, Toronto 16, Ont.

Vibration-free plug bases, fabricated by CDF. A special bond of CDF Dilecto laminated plastic and rubber.



High reliability printed circuits for military applications. Made from CDF's glass-base Di-Clad laminated plastic.



Low-Cost commercial circuits. Made from CDF's paper-based Di-Clad copper-clad laminate.

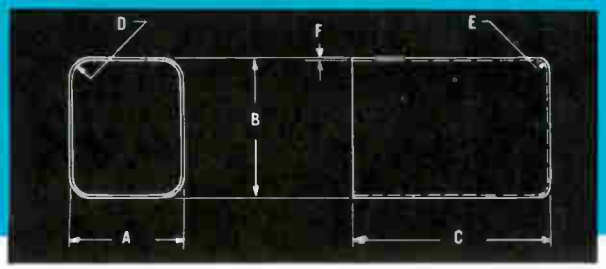
NEED MIL-T CANS *Right Now?*

HUDSON has them in stock!

- MIL-T-27A SIZES FROM AF TO OA
- WITH OR WITHOUT COVERS
- MATERIALS: ALUMINUM, BRASS, COPPER, STEEL, MU-METAL, STAINLESS STEEL, NICKEL SILVER
- DEEP-DRAWN CONSTRUCTION

FOR DETAILS, SEE OTHER SIDE

MIL-T-27A SPECIFICATION CASES



All These Sizes Available From HUDSON Stock

Add suffix to part number to indicate material:
1-ALUMINUM • 2-BRASS • 3-COPPER • 4-STEEL
S-MUMETAL • 6-STAINLESS STEEL • 7-NICKEL SILVER

MIL-T-27 No.	Hudson No.	Size A	Size B	Length C	Inside Radius Side D	Inside Radius Bottom E	Stock Thickness F	Cover Inside
AF	HU-133	45/64	45/64	1 1/16	3/32	3/32	.019	HU-132C
	HU-1124	3/4	3/4	1 7/64	3/32	3/32	.019	HU-1124C
AG	HU-1107	3 1/32	3 1/32	1 1 1/32	3/32	3/32	.019	HU-1107C
	HU-197 HU-134	1	1	1 1 1/32 1 23/64	3/32 5/32	3/32	.019	HU-135C HU-134C
AH	HU-156 HU-589	1 17/64	1 17/64	1 1 1/16 1 3/4	1/8	1/8	.019	HU-156C
AJ	HU-188 HU-186	1 19/32	1 19/32	2 1 1/32 2 3/8	13/64	3/16	.019	HU-188C
EA	HU-153	1 3/4	1 7/8	2 1 1/16	5/32	1/8	.025	HU-152C
EB	HU-152	1 3/4	1 7/8	2 3/8	5/32	1/8	.025	HU-152C
FA	HU-234 HU-859	2	2 1/4 2 9/32	3 1/16	7/32	1/8	.032	HU-234C HU-858C
FB	HU-233 HU-858	2	2 1/4 2 9/32	2 7/16	7/32	1/8	.032	HU-234C HU-858C
GA	HU-158	2 5/16	2 1 1/16	3 3/4	5/32	1/8	.032	HU-157C
GB	HU-157	2 5/16	2 1 1/16	2 3/4	5/32	1/8	.032	HU-157C
HA	HU-347	2 9/16	2 1 5/16	4 3/16	5/32	1/8	.025	HU-348C
HB	HU-337 HU-226	2 9/16	2 1 5/16	3 1/8 3 3/16	5/32	1/8	.025	HU-348C
JA	HU-367	3	3 1/2	4 1 3/16	3/8	1/8	.032	HU-367C
JB	HU-368	3	3 1/2	3 1 3/16	3/8	1/8	.032	HU-367C
KA	HU-369	3 5/16	3 7/8	5 3/16	3/8	1/8	.032	HU-369C
KB	HU-370	3 5/16	3 7/8	4 1/4	3/8	1/8	.032	HU-369C
LA	HU-837	3 5/8	4 1/4	5 1/2	3/8	3/16	.036	HU-837C
LB	HU-838	3 5/8	4 1/4	4 7/16	3/8	3/16	.036	HU-837C
MA	HU-839	3 15/16	4 5/8	5 15/16	3/8	3/16	.036	HU-839C
MB	HU-840	3 15/16	4 5/8	4 7/8	3/8	3/16	.036	HU-839C
NA	HU-841	4 1/4	5	6 3/4	3/8	3/16	.036	HU-841C
NB	HU-842	4 1/4	5	5 7/16	3/8	3/16	.036	HU-841C
OA	HU-843	4 7/16	5 7/16	6 1 1/16	3/8	3/16	.036	HU-843C

MODIFICATIONS—All sizes can be supplied with holes, slots, cover stops, knockouts, screws, inserts, and other special features.

FINISHES—To MIL-T specifications. Alkali-etch, anodize, centrifugal hot-tin dip, electroplate.

FILE THIS SHORT-FORM CATALOG FOR REFERENCE—TEAR ALONG PERFORATION.

Get your complete HUDSON catalog—write on company letterhead today.

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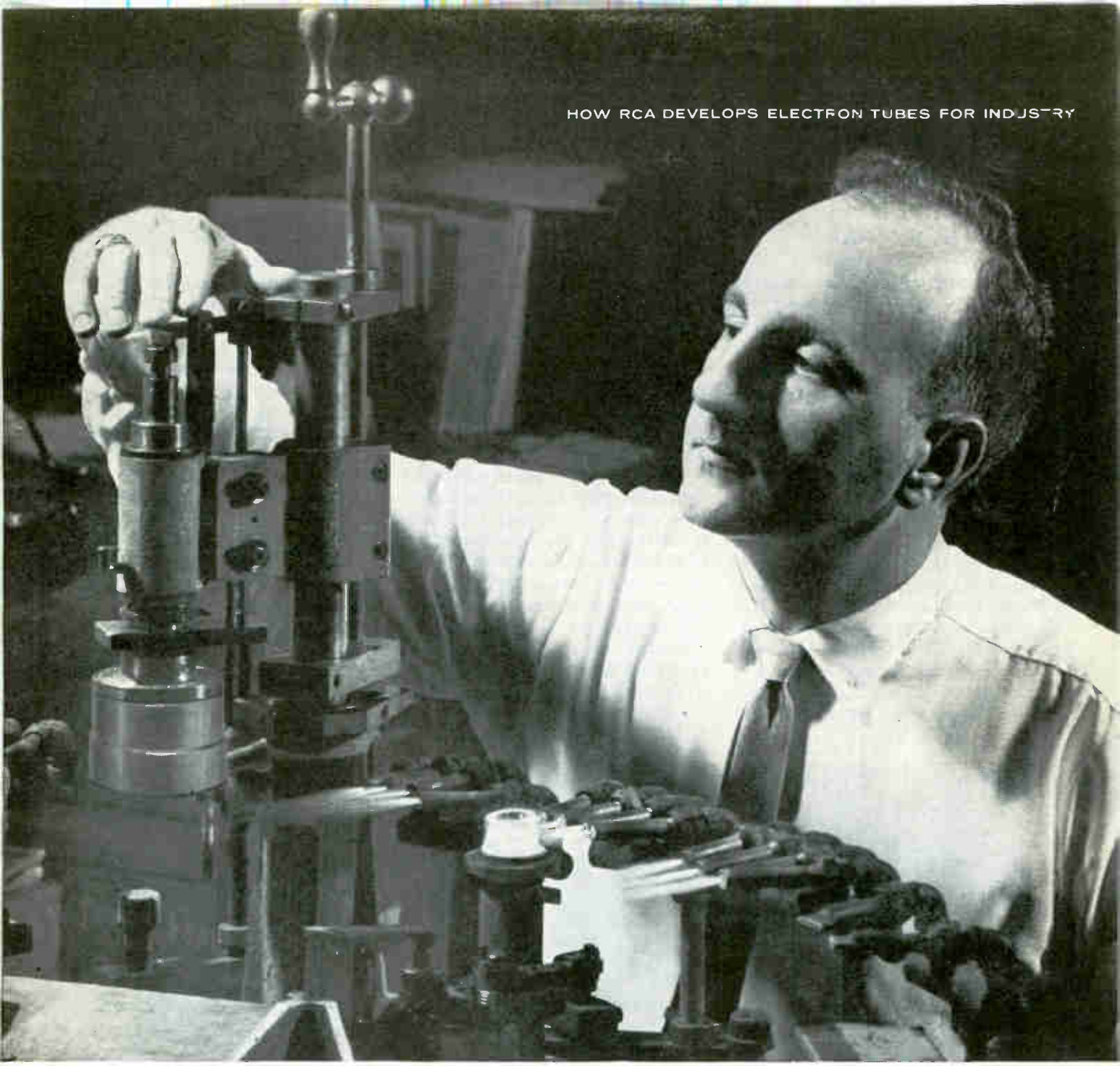


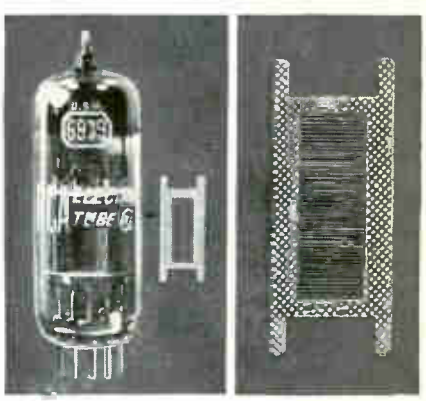
Roy Caprarola cooks up a new tube...

This engineer, so absorbed in "cooking" a glass tube base in a concentrated gas jet, has two important responsibilities that directly benefit you.

He's Roy Caprarola, Manager of our Receiving Tube Methods and Processes Lab. One of his jobs is to refine manufacturing processes to improve tube performance. Closer interelement tolerances, sturdier cage structures, tighter seals, higher vacuums are his objectives. Above, for example, he's working on an improved pin-sealing technique for the bases of our new developmental NOVAR tubes.

He has another responsibility. When our Advanced Development engineers come up with an idea for a new tube structure, it's Roy's job to develop a practical way to produce it. Case in point: the frame grid shown at right, the key element in the new RCA-6939 industrial twin pentode. The Methods and Processes Lab developed the manufacturing technique—and even took over initial production—for this vital element.

Roy's job has many facets, all of which present challenges. But the solving of these challenges means new advances: improved performance from your RCA Industrial Receiving Tubes. The work of the M & P Lab is typical of our determination to achieve top quality through constant research.



Frame grid of RCA-6939 Holds grid wires under tension This grid design permits closer spacing and precise positioning of wires to provide more accurate control of electron flow.

RCA ELECTRON TUBE DIVISION—FIELD OFFICES

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GERMAN EXHIBIT SHOWS

Big switch to electronic control in West German industry brightens electronic business

By JAMES MORRISON,
McGraw-Hill World News

DUESSELDORF—EUROPEAN manufacturers are eschewing research and development to concentrate on repackaging and transistorizing their measuring and control instruments. That's what many engineers concluded last month after visiting West Germany's eight-day International Congress and Exhibition of Measuring Instruments and Automation (Interkama).

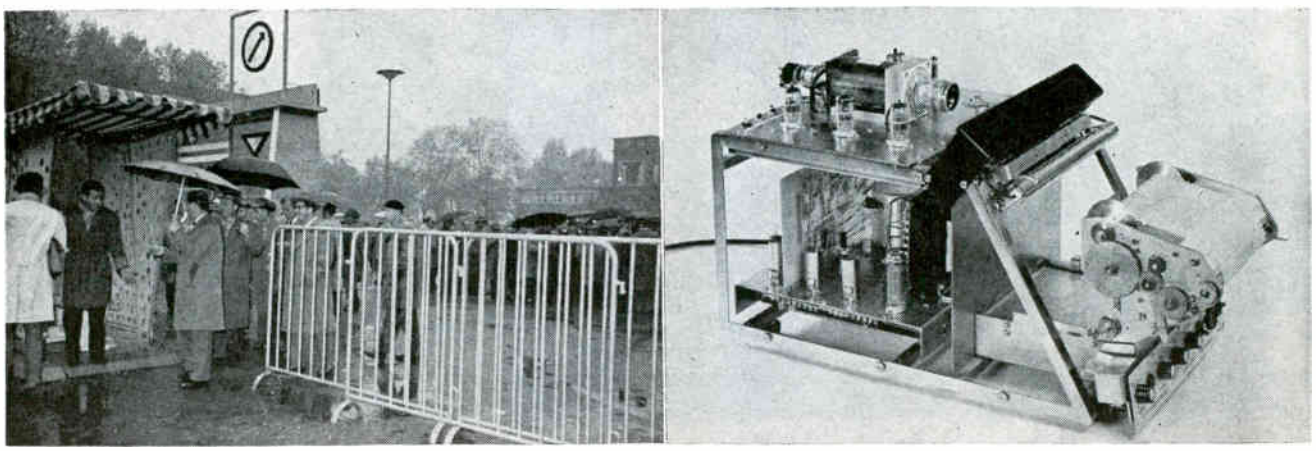
Attendance at the big show this year totaled 110,000; some 7,500 engineers and scientists from 62 countries participated in the technical sessions. A total of 48 U.S. firms were represented at the exhibition; Great Britain had more firms present, France a few less. Hungary's one booth and a collective East German booth representing 14 firms constituted the Iron Curtain contingent at the show.

From a standing start in 1945, the electrical control industry in Germany has grown into a major enterprise employing 50,000 people and ringing up $260 million in annual sales. About $50 million of this is export business, mostly to other European countries; $5 million goes to the U.S.

Bright spots in the German business picture are the switch to electrical-electronic control in local industry, and the missile-control business expected if a NATO missile program gets underway. German instrumentmakers, however, are pressed by U.S. competitors who offer quick delivery on items that local firms would take a year to deliver. German manufacturers are also apprehensive over possible Japanese competition in off-the-shelf equipment.

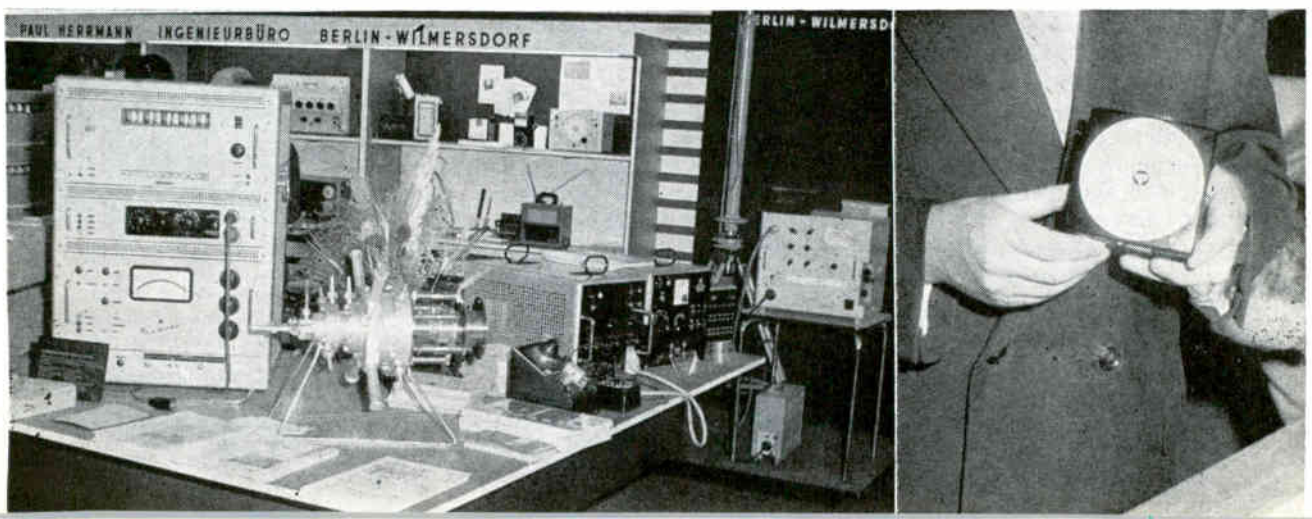
Many German firms have teamed up with U.S. manufacturers. They wait until basic research and engineering are done in the U.S., then put small but highly skilled teams of experts to work redesigning the instrument for local production. Consensus at the show was that investment in R&D gives the U.S. industry about a year's lead on the European state of the art in most areas, two years in some. Europe's engineering fraternity is only now, for instance, coming to grips with transistorization, microminiaturization.

Hybrid solid-state switching and control devices are gaining increased use in Germany. Siemens and AED showed transistorized plug-in single-cell units with



Engineers queue up in rain outside Duesseldorf's Interkama exhibition; inside (right) an automatic reader by Siemens of Munich evaluates recorder charts

Plasma rocket engine, center left, is feature of East German exhibit. Nine of the recorders at right, developed by Swiss firm Elmes, Staub & Co., fit in 1-sq-ft panel



PROGRESS IN CONTROLS

picture. Research effort lags but progress is evident in product development

printed circuits and magnetic-amplifier output. ACEC of Belgium showed prototypes of multiple units sealed in a common housing. Several companies displayed automatic data-logging systems.

Engineers at the exhibition noted that Europeans are veering away from five-channel punched-paper tape toward eight-channel tape. Punched tape is more commonly used in European digital systems than magnetic tape.

Analog computer systems continue to receive much attention from Europe's engineers. Principal trend in these systems is towards full transistorization. Use of function plugs, wired-core fixed memories and other preset devices has substantially reduced problem set-up time on the analog systems. Also, many systems are being designed to handle several related families of problems by means of fixed-memory cyclers and program devices such as patch panels.

On-line and laboratory analysis instruments were shown in abundance. By austere design, European manufacturers have been able to pare equipment prices down to about a third of going U.S. levels, but they are still finding it necessary to fight hard against stateside competition. European analyzer gear is especially good in the areas of gas-moisture monitors, refractometers and sulfur-trace monitors. The German industry seems to lead in automatic titration equipment.

Britain's Rank organization displayed an electronic level indicator designed by its Taylor, Taylor & Hobson division. The indicator is said to be capable of registering level changes of less than a second of arc, equivalent to five millionths of an inch of change in an inch. The instrument can be used to check either horizontal or vertical level. Conventional spirit bubble is replaced by a pendulum that operates on a pair of transducers to provide a displacement signal; this signal is amplified and fed to a zero-center meter. Meter is scaled in angular displacement and gradient. Equipment can be left in position for months with only one or two seconds deviation; rezeroing is simple.

ACEC of Belgium showed a model of a train-braking system now being field-tested on a stretch of railway between Brussels and Antwerp. Red, yellow and green block signals select one of three saturable reactors in a track unit clamped to the rails; these reactors control the tuning of a circuit that passes information on the state of the block signals, slowing speeds, and track gradients to a logic unit mounted on the locomotive. As the train passes over the track-mounted unit, the logic unit picks up one of fifteen input frequencies from the track circuit. Bandpass filters are used in the logic unit to direct the signal to an integrator and function generator that initiates an inverted velocity-time signal; this signal in effect sets the maximum permissible train speed that will allow the train to stop at the next red signal. This voltage is compared against velocity data from the train; if the train is going too fast, the brakes are automatically applied.

Pneumatic actuators are teaming up with electrical and electronic controls in some European designs shown at Dusseldorf. Some all-electric types were also displayed. Siemens unveiled an electropneumatic control system using electrical gear for measurement, electronics for transmission of data, pneumatics for control—especially recommending the latter use in explosive atmospheres.

Samson Apparatebau of Frankfurt/Main showed a two-stage pneumatic balance controller. Required and actual values of a physical parameter are fed to the controller by means of compressed air at pressures between 3 and 15 psi. Metal bellows are linked to the ends of a differential lever. Measured differences in pressure cause one bellows to move, opening and closing a pilot valve.

Elektro-Mechanik GmbH of Wendenerhuette showed a rapid-reversing geared magnetic-particle clutch with a linear relationship between excitation current and transmission torque, capable of smoothly regulating torque between zero and 100 percent. The same firm showed an electrohydraulic edge control system using photoelectric techniques. Using either transmitted or reflected light, the system detects any wander of the edge of the measured material. Amount of deviation is measured and passed to a transistor amplifier, then on to a plunger-coil regulator that drives a servomechanism.

Blackburn Electronics, Brough, England, exhibited a rate-of-change temperature transducer for direct reading where thermocouple output is not sensitive enough and datum-setting or balancing is awkward. Rated sensitivity is 250 to 500 microvolts per degree C per minute, with a time constant of 60 to 250 seconds.

Telefunken showed a working model of a traffic analyzer that can distinguish among four kinds of vehicles—motorcycles, automobiles, trucks and truck-trailer combinations—and measure up to ten different speed categories to 3-percent accuracy. Speeds covered by the analyzer are from 15 to 70 mph. The German company also unveiled a transistor desk-type d-c analog computer. Basic unit can be cascaded to build up a large computer installation. Operational amplifiers in the system are chopper-stabilized so that long-time computations are possible. System consumes 90 v-a.

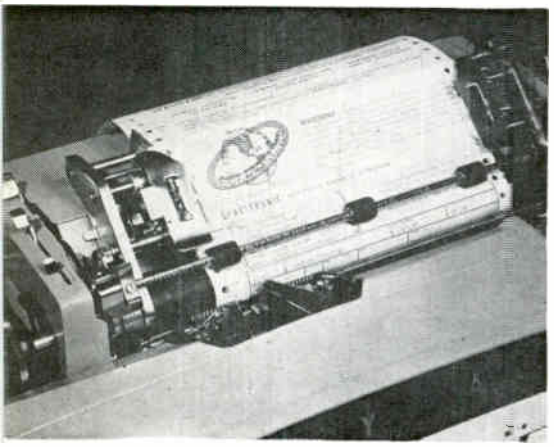
VEB Vakutronik displayed an ion source for possible rocket applications. The engine is a Manfred von Ardenne configuration, with an orifice size of just over 1 mi. It is a duo-plasmatron type of engine, operating on 125 v, with a magnetic field strength of 2,250 ampere turns, beam power of 500 w, exhaust beam current or ion current of 22 amp/cm^2. The device consumes propellant at the rate of 70 cc/hr, is rated as 99-percent efficient, produces a thrust of 0.035 mm Hg.

Data Systems Featured At

Computers, data converters, transmission systems, document processors and teaching units are among electronic aids shown to nation's businessmen

Inquiry station displays information requested from computer. It is part of A. G. Dick Videograph

Transmitting punched-card information over telephone lines with IBM's 1001 data-transmission system



Photoelectric sensing device provides horizontal and vertical format control for Royal-McBee's Spacetronic

LOS ANGELES—At least one management consultant thinks the consumer of tomorrow will do all his buying electronically.

At the recent Business Equipment Exposition here a spokesman for Booz, Allen and Hamilton verbally sketched a universal automatic credit-card system. At the center of the web would be a so-called financial utility where each consumer's account would be kept on magnetic tape. Employers would transmit payroll data digitally; utilities would be charged for by automatic metering, purchases would be charged by feedback from point of purchase.

But the equipment on display was more down to earth. According to John H. Howard, director of the data-processing group of the sponsoring Office Equipment Manufacturers Institute, the 64 manufacturers exhibiting account for 90 percent of a $4½ billion-a-year business. By 1965, he predicts, this annual gross will swell to $8 billion. An increasing amount of this is becoming electronic.

Featured speaker Rear Adm. J. P. Monroe, while reviewing the country's satellite programs and deterrent missile capabilities, commended the achievements of business machine and computer systems developers. He called attention to the Navy's Spacescore exhibit at the entrance to the show's exhibit area. It was a visual readout of orbiting satellite locations determined by the Naval Ordnance Research Calculator. The NORC has a 13-decimal digit capacity and a speed of 15,000 operations a second. Intelligence comes from a six-station data-acquisition network stretched along a great circle from San Diego to Fort Stewart, Georgia. Triangulation, by groups of paired 108-Mc receivers 500 miles apart and a 50-Kw transmitter half-way between, enables the Navy's space surveillance system to position any object passing through its electronic fence.

Among commercial equipment at the show was Friden's tape-to-tape converter, designed to integrate data processing when two different tape code systems are used. The machine punches or reads Flexowriter 8-channel tape for conversion to or from a 5, 6 or 7-channel system. The converter is controlled by a panel that permits programming for practically any input or output. Clary demonstrated a compact wide-carriage printer, developed by Kienzle Corp. of West Germany. Completely transistorized, the printer can accept coded or decimal information using logical level inputs. In its final form, the machine will print five lines, or five blocks of figures a second.

A system that enables branch offices, regional warehouses or remote plants to interrogate a computer miles away was introduced by A. B. Dick. Information is displayed alphanumerically on the face of a 14-inch tv tube in an array of ten lines, 19 characters to the line, in response to the digital input signals.

Heart of the Videograph display console is a monoscope character generator, developed with Stanford Research Institute, which converts digital information retrieved from a memory unit into television signals.

The IBM 1001 data-transmission system enables firms with multiple locations to send information in machine language to a processing point over telephone circuits. Leased lines are unnecessary, and the system transmits both fixed data from prepunched cards and variable data manually entered on the keyboard. Data is received at the central point in punched card form and may be fed directly into the processing system.

IBM's 870 document-writing system enables one operator to produce business information simultane-

Business Show

By HAROLD C. HOOD,
Pacific Coast Editor

ously as typewritten copy, punched cards and paper tape. Data, besides being introduced to the system manually, can be fed in by paper tape or cards.

West Coast bankers and businessmen got a look at Burroughs' B251 Visible Record Computer that enables them to retain records in conventional form while processing at electronic speeds. The fully transistorized VRC consists of a sorter-reader, computer, ledger processor and control console. In banking, checks are placed in account number sequence by the sorter-reader, and dollar amounts and other information are relayed to the computer.

Electronic teaching machines were represented by Dictaphone's Dictalab, a tape-teaching system for language comprehension. Students sit in sound-protected booths and listen through earphones to preprogrammed lessons. The teacher, at a control console, can monitor or communicate with students. Students listen, repeat and record at their stations, and compare their verbalism with those of the master tapes.

Businessmen were likewise able to run hypothetical problems on Royal McBee's RPC-9000, a sophisticated descendant of the LGP-30. An internally programmed, solid-state computer, the machine features building-block design, in-line processing and an operating speed of millionths of a second. Capable of reading, recording and computing simultaneously, the RPC-9000 uses interchangeable cartridges containing 35-mm Mylar tapes that can hold up to 1 million alphanumeric characters. Internal memory of the computer is magnetostrictive delay lines from each of which 96 characters are available in less than two-thousandth second.

Next OEMI Exposition will be held in New York Coliseum, next April.

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PD301	10	50	4	.025 (–20V)	50 (–20V)	4	$2.85
PD305	10	100	4	.025 (–20V) 5.0 (–75V)	50 (–20V)	4	4.50
PD306	10	50	2	.025 (–20V) 5.0 (–75V)	50 (–20V)	4	4.25
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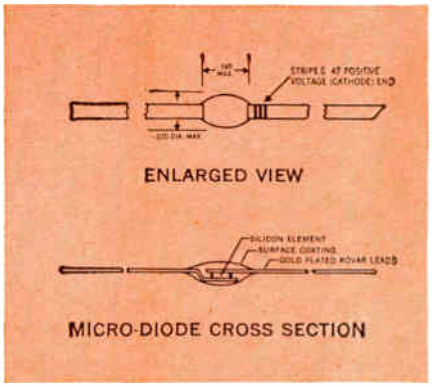

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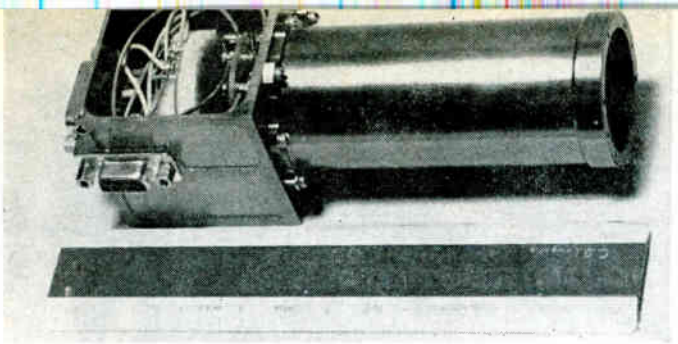
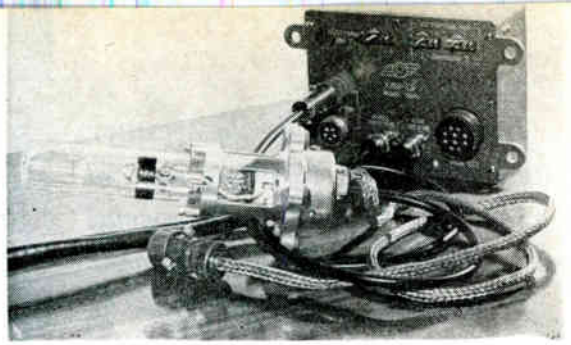


Ionization detector and amplifier for U.S. moon shot



Ionization detector and amplifier used in Sputnik III (Sovfoto)

Space Miniaturization: U.S. vs USSR

Soviet and United States photos of space gear show up Russia's lag in miniaturization techniques. We had to miniaturize because of vehicles but our achievements are now reaping benefits

LIMITED THRUST, coupled with interest in a wide variety of space phenomena requiring different instruments for each, forced the U. S. to miniaturize space-borne equipment.

The Soviet Union, with thrust capable of propelling an elephant into orbit and narrower interests in space, has not been driven to such inventive measures. Soviet satellite gear is built largely with conventional components and packaged in a free and easy way.

In the long pull, our early hardships will pay off. With an operational Saturn plus miniaturized equipment we should move ahead at a good pace.

Left, are pictures showing a comparison of two devices carried in Soviet and U. S. space shots.

Top, left, is the ionization detector and amplifier built by the State University of Iowa that will go in the U. S. moon shot next year.

Top, right, is the ionization detector and amplifier used by the Soviets in Sputnik III.

The American detector and amplifier are built in a package about six inches long. Unit has a circular potted amplifier, miniature connectors and an enclosed detector.

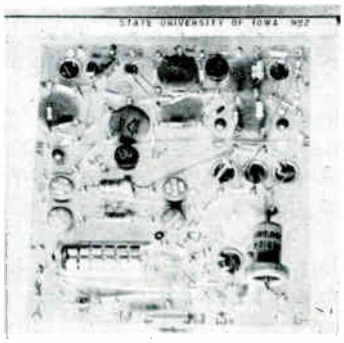
The Soviet gear is in two separate packages connected by a cable that appears to be about two feet long. The detector, shown exposed, is probably enclosed by a tubular section, like the American detector. It is probably bolted to its enclosure and then cabled to the amplifier, which in turn is bolted to the satellite structure. Note the use of bolthole lugs on both amplifier and detector. This physical separation of the devices may be to achieve correct internal weight distribution to avoid lopsided spinning.

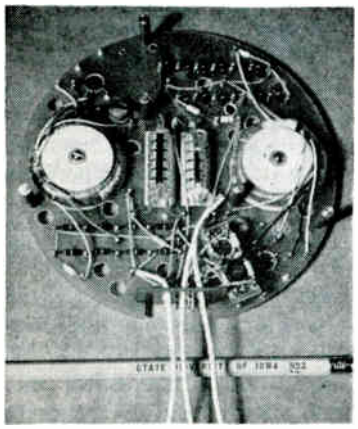
Lower, right, shows the mass spectrometer tube and amplifier used in Sputnik III. Lower, left and center, electronic pulse-scaling and amplifying decks in Explorer IV built at the State University of Iowa.

Bulk, weight and complexity of the Soviet amplifier is typical of many other amplifiers used in Soviet space shots.

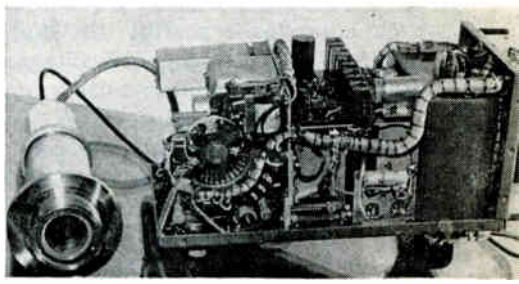
Components appear to be conventional in size and weight. The relays are bulky—one is completely exposed. The large stepping relay, capacitors, resistors and trimming potentiometers might well be used in manned aircraft. The wiring harness shows absence of printed circuits. Large mechanical connectors and conventional military-type cables and plugs connect the amplifier to its associated equipment.

The American printed circuit amplifiers are typical of those used in our current space missions.





Left and above are two electronic pulse-scaling and amplifying decks in Explorer IV



Mass spectrometer tube and amplifier used in Sputnik III (Sovfoto)

High-speed facsimile scanner and automatic printing system team with special letter-handling equipment to transmit mail over cable or microwave link while preserving privacy

Typewritten letter is transmitted digitally to xerographic printer at left using Stromberg-Carlson facsimile scanning and printing equipment

Digital Facsimile Speeds Mail Transmission

LOS ANGELES—Technical details on a new high-speed facsimile scanner and automatic printing system used in the U. S. Post Office's electronic speed-mail system were revealed here last week.

Speed mail makes possible transmission of mail to any point in the country in three seconds.

Systems manager for the program is Intelex Corp., an ITT subsidiary. Equipment developed by Stromberg-Carlson, San Diego, include a high-speed facsimile scanner (S-C 6400) and an automatic printing system (S-C 6000) using the xerographic printing process of Haloid Xerox, Inc.

Letters prepared on special uniformly sized stationery, similar to World War II V-mail, are scanned at fifteen pages a minute and transmitted by coaxial cable or microwave link. This is 400 times faster than press picture-transmitting facilities. Special letter opening machinery and facsimile sealing equipment, developed by Pitney-Bowes, Inc., insures privacy.

Initial development contract with the P. O. Dept. calls for installation of 14 facsimile printers and eight mail scanners at test sites.

Stromberg-Carlson project engineer Kenneth Morgan says digital techniques make possible the high speed of the system. Advantages include: high signal-to-noise ratio and elimination of all noise in output signal of scanning photocells; the possibility of coding the system if intelligence information is to be sent; the reduction of bandwidth requirements, since white does not have to be transmitted—it can be synthesized. This third advantage opens up possibilities of using bounced signals from satellites.

Secondary advantages are: the possibility of selecting a high-contrast print-out medium, with resultant clearer pictures from a smaller amount of energy; ability to transmit grays using conventional half-tone techniques.

The S-C 6400 scanner operates by sweeping a spot of light across the face of a cathode-ray tube 360 times a second. This spot is focused on the mail being transmitted and the varying reflection is picked up by a multiplier phototube and converted to an electrical signal.

At the receiving end, a synchronized cathode-ray tube impinges on a light-sensitive selenium-coated drum on which an image of the letter appears. Black powder cascades over the drum, adhering only to those areas that have not been discharged by the light beam. The powder is transferred to paper as the drum rotates, and is permanently fused by heat.

The success of the system depends partially on a uniform light intensity in the scanning beam. To insure this, a half-silvered mirror is used to bounce 60 percent of the light to letter being scanned and allow the remaining 40 percent to be directed on a reference target. A second multiplier phototube picks up the reference reflection, and its signal is added algebraically to that of the primary scanning tube by connection with the crt grid.

Thus, uniformity of the light source is continuously monitored.

To make its system digital, S-C starts with an analog signal from the scanning multiplier phototube, selects an arbitrary percentage reference level as a demarcation between black and white, then clips the signal. Clipping level varies in voltage but remains constant as far as percentage. To accomplish this, the pulse is introduced to a delay line, analyzed to extablish voltage corresponding with percentage level, then sent to gain control of an amplifier where gain is set for that pulse. By delaying pulse long enough for amplifier to adjust, clipping is accomplished at proper moment. Signal, as transmitted, is essentially a noise-free square wave.

A series of automatic checking points assures proper operation of both scanner and printer; otherwise, equipment is shut down and audible alarm sounds. One such safeguard is the scan verification signal. Three lines at the beginning of the scan section generate three pulses indicating that scan has started. A similar group of lines at the end indicates that scan has been completed. If these three pulses are not received by machine, it is automatically shut down until trouble has been fixed. The system is said to have a 3-sigma probability of accurately reproducing a letter if no trouble is indicated by interlock system. Checkout console, with selector knob, monitors major circuits and isolates trouble. With the exception of two tubes in the printer, all circuits are solid-state.

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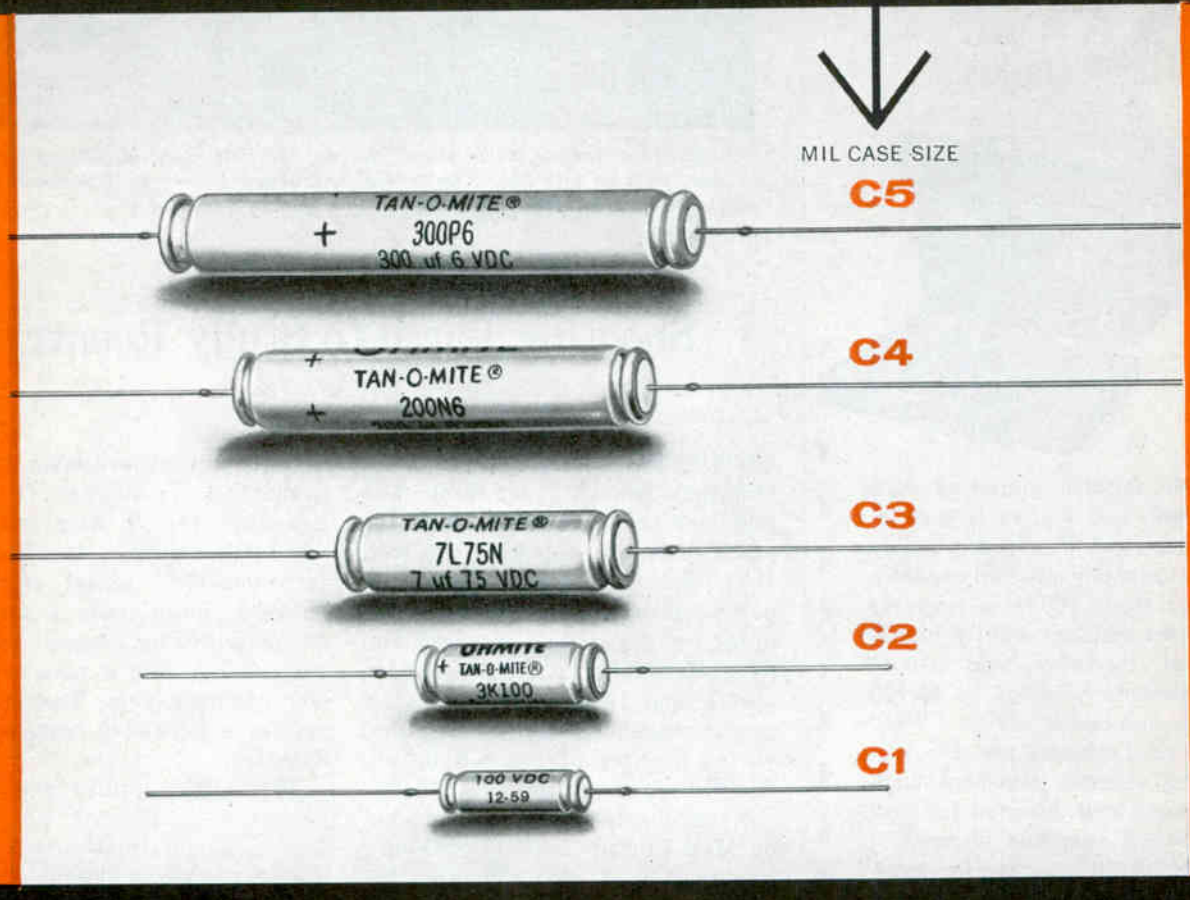

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Write for Specification Bulletin 152G which lists 200 stock values, including all MIL values, and shows a *handy scale for conversion* between "equivalent series resistance," "power factor," and "dissipation factor."

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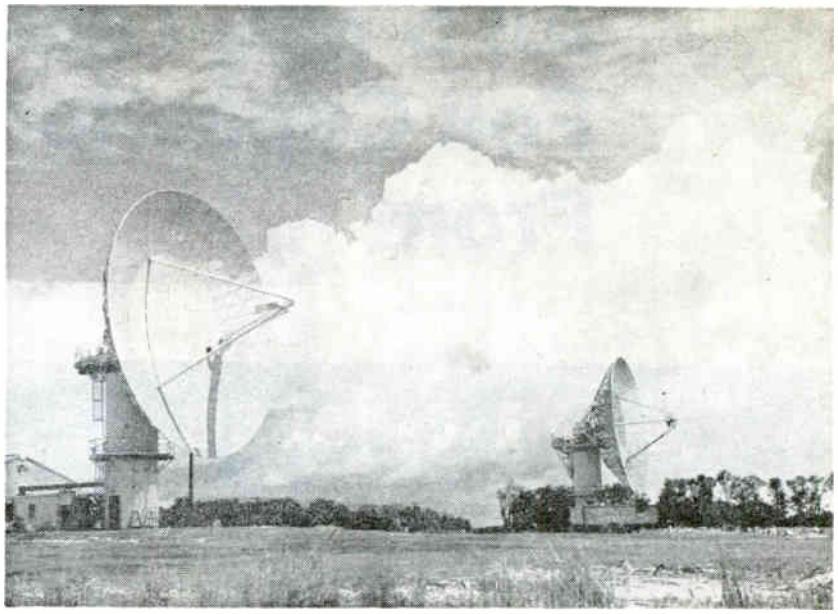


These two antennas serve three radars. Unit at right is S-band tracking radar; unit at left has X-band and uhf pencil beams to determine reflection from reentering vehicle as a function of frequency

Shooting Earth to Study Reentry

BOSTON—Last week at NEREM scientists from MIT's Lincoln Lab told how they are shooting at the earth to study reentering vehicles.

The five-inch payload of an experimental rocket is fired from 200 miles for antimissile research and to explore effects of the plasma sheath and related phenomena on communications and navigation during reentry of manned or unmanned space vehicles.

Experiments are being conducted by MIT Lincoln Laboratory under sponsorship of the Advanced Research Projects Agency through an Air Force contract. Radar and optical equipment are at the Lincoln Lab field station at Arbuckle Neck, Va., adjacent to NASA's Wallops Station.

A six-stage rocket designed by Langley Research Center and dubbed Trailblazer I is currently being used for the field studies. The 5-inch spherical rocket motor for payload weighs only a half-pound.

To permit heavier payload for reentry instrumentation and to permit more variation in shape for the final stage, a second-generation test vehicle will be available in about 6 months. Trailblazer II will be a 4-stage vehicle with two downward-firing stages, the last a 15-inch spherical rocket engine for payload. Trailblazer I has three downward-firing stages with the payload reaching a velocity of 16,000 miles per hour. The final stage carries a telemetry transmitter at 234 Mc.

Theoretical studies and lab experiments conducted by Lincoln Lab in cooperation with Ames Research Center of NASA provide a picture of the flow field about a hypervelocity object, also electron density profiles between the body surface and the shock wave, and microwave measurements of trail lengths as determined from the amplitude of reflected radiation at radar frequencies in uhf, S-band and X-band.

Velocities up to 25,000 ft per sec are obtainable at the Ames hypervelocity ballistic range. For supplementary measurements and instrumentation development, Lincoln Lab has constructed a hypervelocity range at its Lexington, Mass., field station.

Radar and optical equipment in the field measure radar cross-section, radiant intensity and spectral distribution. Three pencil beam radars at X-band, S-band and uhf are provided with two 60 ft. reflectors on modified 5-inch Naval gun mounts. The S-band radar is a tracking radar on one of the mounts. The uhf and X-band radars are duplexed onto the second reflector which is slaved to the S-band tracker. The X-band feed illuminates only the 34-ft solid center section of the reflector.

Lincoln Lab's uhf radar at Millstone Hill, Mass., is also used in the experiments, and hf measurements are being started.

Optical equipment includes a six-inch special spectrographic Schmidt camera and two super-Schmidt cameras borrowed from Harvard University's meteor group. A 12-inch reflector radiometer will be installed soon. A 48-inch spectrometric tracking telescope is under construction.

Seven Trailblazer vehicles have been fired to date including three development shots.

Orders Data Subsystem For Air Traffic Control

A $4-MILLION CONTRACT for a data processing subsystem at Boston Air Route Traffic Control Center has been awarded by the Federal Aviation Agency to Librascope division of General Precision, Inc.

This is the first of more than 20 such computer installations FAA will be placing in traffic control centers across the nation by 1965.

The high-speed, random-access computer will partially automate current instrument flight control procedures at Boston. It will tie in with display subsystem, costing an additional $4 million, designed by General Precision Laboratories.

The entire system will implement rather than replace current control procedures by performing virtually all routine calculations and clerical functions, which sometimes take up 80 percent of a controller's time. Traffic controllers will thus be freed to handle emergencies and unusual situations.

Chicago El line supervisor (foreground, left photo) flips control box switch and gets operating information from motorman aboard train

Installs Rolling Communications Net

CHICAGO—ROLLING NETWORK of 70 transistorized f-m transmitter-receivers started using the third rail of this city's North-South elevated-subway as the "antenna" for a train-phone communications system early this month.

Motorman's voice, converted to 32-watt, 85-Kc radio signal by 19-transistor, 16-lb portable unit, is transmitted through the third-rail power distribution system of the elevated line. Signals are tapped off each mile or so, fed into telephone cables on the track structure. Cables carry signals to a-c operated wayside receiver-transmitter stations for demodulation to voice impulses, which are led by telephone lines to central operations control room in the Merchandise Mart at the edge of the downtown Loop.

New system permits rapid action in emergencies—such as illness of passenger, failure of equipment, or necessity to warn other motormen of trouble ahead—through direct report to operations control. Central operations superintendent may also broadcast messages direct to passengers of any train involved in emergency situation.

North-South line serves some 360,000 passengers—about 65 percent of system's total traffic—on an average weekday. City Transit Authority plans to extend the system to six remaining rapid-transit routes, has also been experimenting with electronic method for recording intervals between in-service buses—using individual bus transcievers for interrogation by strategically-located stations along its route.

Computermaker Licensees Fight Japanese Companies

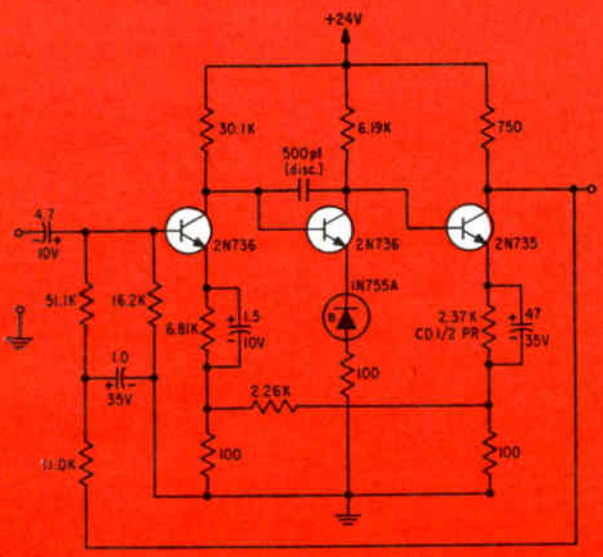
FOLLOWING UP its recently signed agreement with Ministry of International Trade & Industry (see ELECTRONICS, p 40, Sept. 23), IBM last week signed provisional licensing agreements with eight Japanese manufacturers. Included were Hitachi, Tokyo Shibaura, Nippon Electrica Fuji Communications, Oki Electric, Matsushita Electronics, Mitsubishi Electric and Hokushin Electric.

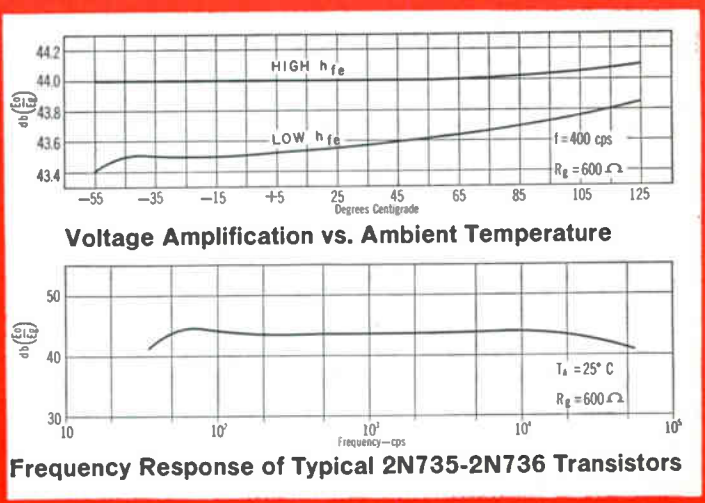
Five-year contracts allow the licensees to manufacture punch-card equipment, call for 10-percent royalties in total sales. Approval by Japan's Foreign Investment Council is still required.

Six days later, MITI reactivated a 3-year-old proposal to establish a national electronic computer company with the expense to be shared half by government and half by private industry. MITI wants to promote Japan's computer industry, figures its former plan may take hold this time. The ministry plans on having the proposed company act as volume buyer of components for member firms, take half the computer output of its members and rerent to users.

HOW TO GET FLAT FREQUENCY RESPONSE

FROM 37 CYCLES TO 45 KC





Specify TI 2N734 Series Silicon Transistors for Your Amplifiers!

For your audio/servo amplifiers, power supplies and medium-speed switches, design in TI 2N734 Series Silicon Transistors. Obtain a flat frequency response of ±1.5 db from 37 cycles to 45 kc . . . guaranteed beta at 25°C (1 ma at 1 kc) (5 ma at 1 kc) (5 ma at 30 mc) and at –55°C (5 ma at 1 kc) . . . guaranteed 500-mw free-air dissipation . . . reduced equipment size and weight with TO-18 package.

For even greater power dissipation, investigate the design flexibility of the equivalent TO-5 packaged 600-mw TI 2N1564 Series Silicon Transistors.

GUARANTEED MINIMUM BETAS

Symbol	Parameter	Test Conditions	2N734	2N735	2N736
h_{fe}	A-C Common-Emitter Forward Current Transfer Ratio	V_{CE}=5v I_E=5ma f=1 kc T_A=25°C	20	40	80
h_{fe}	A-C Common-Emitter Forward Current Transfer Ratio	V_{CE}=5v I_E=1 ma f=1 kc T_A=25°C	15	30	60
h_{fe}	A-C Common-Emitter Forward Current Transfer Ratio	V_{CE}=5v T_A=-55°C I_E=-5 ma f=1 kc	12	20	40
$\lvert h_{fe} \rvert$	A-C Common-Emitter Forward Current Transfer Ratio	V_{CE}=5v I_E=5 ma f=30 mc T_A=25°C	1	2	2

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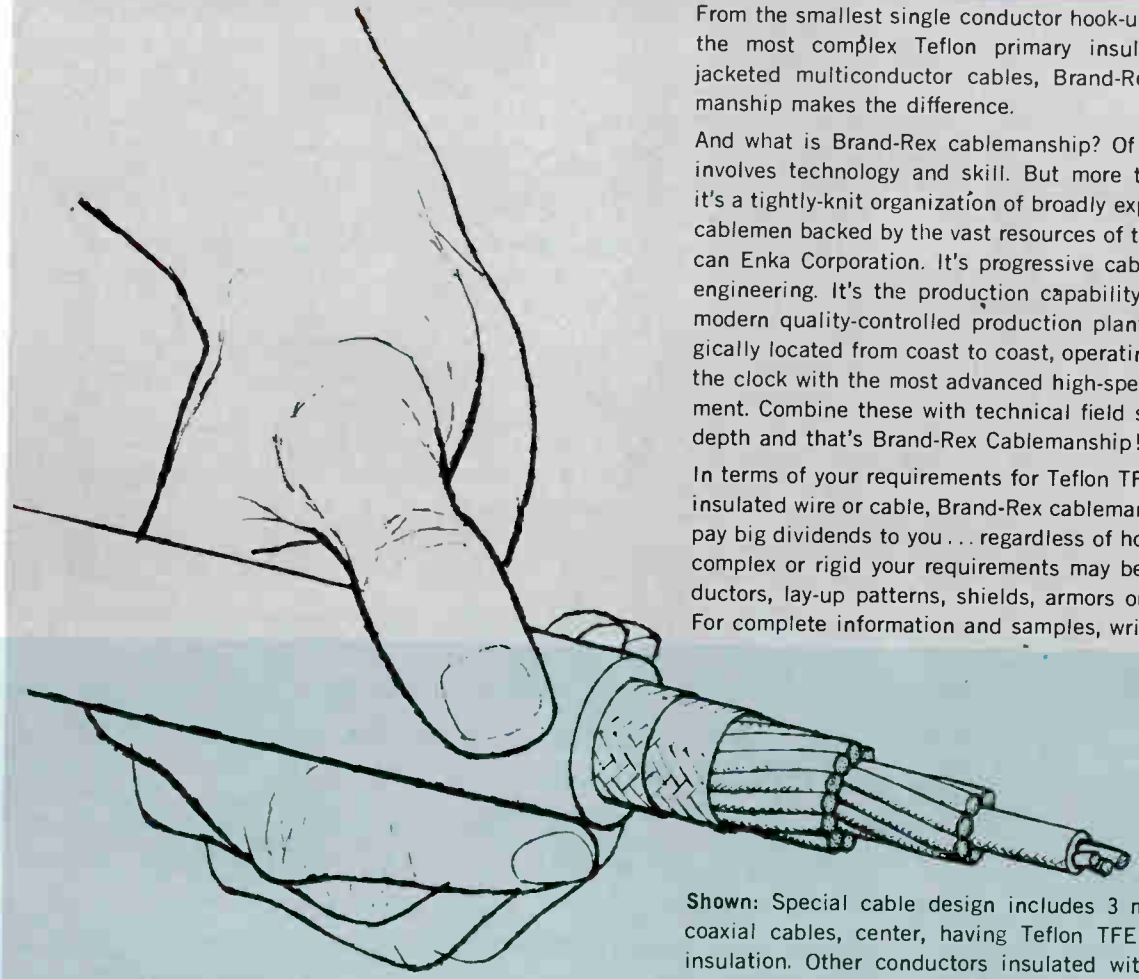
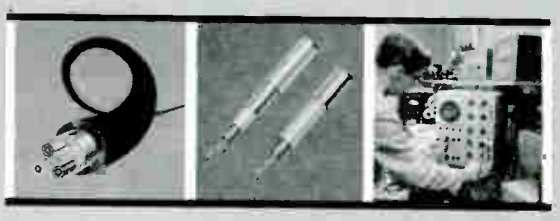


From the smallest single conductor hook-up wires to the most complex Teflon primary insulated and jacketed multiconductor cables, Brand-Rex Cablemanship makes the difference.

And what is Brand-Rex cablemanship? Of course it involves technology and skill. But more than that, it's a tightly-knit organization of broadly experienced cablemen backed by the vast resources of the American Enka Corporation. It's progressive cable design engineering. It's the production capability of three modern quality-controlled production plants, strategically located from coast to coast, operating around the clock with the most advanced high-speed equipment. Combine these with technical field service in depth and that's Brand-Rex Cablemanship!

In terms of your requirements for Teflon TFE or FEP insulated wire or cable, Brand-Rex cablemanship will pay big dividends to you . . . regardless of how varied, complex or rigid your requirements may be for conductors, lay-up patterns, shields, armors or jackets. For complete information and samples, write today!

Shown: Special cable design includes 3 miniature coaxial cables, center, having Teflon TFE primary insulation. Other conductors insulated with Teflon FEP. Braids Dacron. Jacket Neoprene.



Left: Cables can be furnished with individual coaxials, pairs, triples or other components positioned within the cable exactly to specs. **Center:** Brand-Rex coaxial cables use Teflon dialectrics and meets all government and commercial requirements. **Right:** Brand-Rex quality-control procedures cover every step of manufacture.

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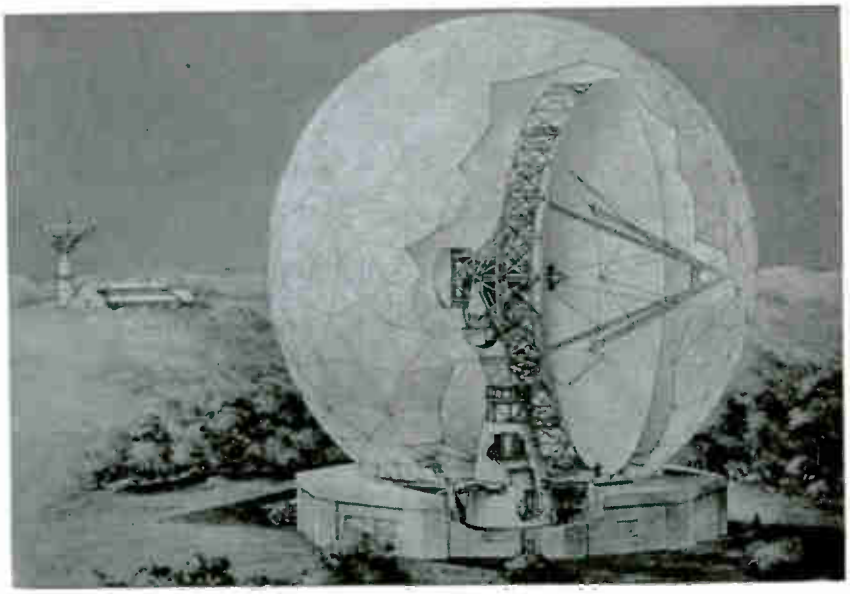


Haystack cutaway sketch shows Millstone Hill predecessor on nearby hill

Versatility Designed into X-Band System

BOSTON—A versatile X-band transmitter-receiver with a 120-ft precision Cassegrainian antenna will be built by the Air Force near Millstone Hill in Westford, Mass., for development and testing of new communications and radar-tracking concepts. Estimated cost of the Haystack Hill installation is between $4-$5 million.

Designed by MIT Lincoln Laboratory, Haystack will be built primarily to tie in with the new global microwave communications system announced in September before the International Scientific Radio Union in London. W. E. Morrow Jr. of Lincoln Lab proposed an orbital scatter technique using tiny reflective tuned dipoles orbited in belts above the earth (ELECTRONICS, p 43, Sept. 30).

The signals reflected from these needles will be detectable in the Haystack.

Flexibility, however, is one of the major considerations in design of Haystack, for adaptibility to new missions. In addition to the tuned-dipole application, the installation will help develop and test new-generation communications satellite networks and also will lend itself to modifications for long-range radar tracking of satellites, missiles and space vehicles, probably in both skin-tracking and beacon-tracking modes.

Flexibility of design is reflected in provisions for the cab behind the primary feed. The cab will be readily interchangeable for a variety of applications, for use of low-noise receivers such as masers and parametric amplifiers, and to take advantage of new communications and tracking techniques.

In some respects, Haystack will be a next-generation Millstone Hill, the uhf research radar operated for the past three years by Lincoln Lab.

But where Millstone operates at 440 Mc, Haystack will have a nominal operating frequency of 8,000 Mc; Millstone uses an 84-ft parabolic antenna, Haystack will have a 120-ft dish.

Average transmitted power of Haystack will be 100 Kw. A high-duty-cycle transmitter will be installed, and provisions for a low-duty-cycle transmitter of comparable average power is under study. The antenna system will be adaptable to a variety of uses at frequencies decades below and perhaps somewhat above the nominal frequency.

The 120-ft antenna will be supported on an elevation-azimuth mount and will be protected from the elements by a CW-412 radome 150-ft in diameter with a rigid frame. Radome footing will contain office, lab and equipment space.

MEETINGS AHEAD

Nov. 29-30: Science and Engineering Symposium, Air Research and Development Command (ARDC); Statler-Hilton Hotel, Boston.

Nov. 30-Dec. 2: Electronics Exposition, Long Island Electronics Manufacturers Council; Roosevelt Raceway Exhibit Hall, Westbury, Long Island, N. Y.

Dec. 1-2: Vehicular Communication, Annual Meeting, PGVC of IRE; Sheraton Hotel, Phila.

Dec. 5-7: Electronic Equipment Maintenance, EIA; Hilton Hotel, San Antonio, Tex.

Dec. 5-8: Electrical Insulation, National Conf., AIEE, NEMA; Conrad Hilton Hotel, Chicago.

Dec. 8: Man's Environment in Outer Space, Institute of Environmental Sciences; Henry Hudson Hotel, New York City.

Dec. 11-15: American Nuclear Society, Winter Meeting, ANS, AIF; Mark Hopkins Hotel, San Francisco.

Dec. 12-14: USA National Committee, URSI, Fall Meeting; NBS, Boulder, Colo.

Dec. 13-15: Eastern Joint Computer Conf., PGEC of IRE, AIEE, ACM; New Yorker Hotel, New York City.

Dec. 16-17: Combined Analog Digital Computer Systems Symposium, Simulation Councils, Inc., General Electric; Sheraton Hotel, Phila.

Jan. 8-12: Thermoelectric Energy Conversion, Dept. of Defense, Joint Technical Society; Statler-Hilton Hotel, Dallas.

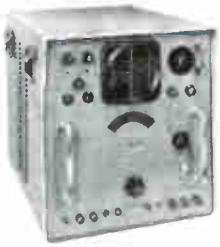
Jan. 9-10: Plasma Dynamics; S. Methodist Univ., Dallas.

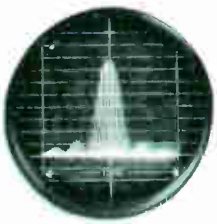
Jan. 9-11: Reliability & Quality Control, ASQC, AIEE, PGRQC of IRE; Bellevue-Stratford Hotel, Phila.

VISUAL MICROWAVE ANALYSIS 10 to 44,000 mc

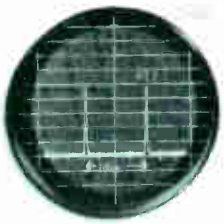
MODEL TSA
DIRECT-READING SPECTRUM ANALYZER

10 to 44,000 mc with five plug-in tuning units





0.4 μSEC PULSE



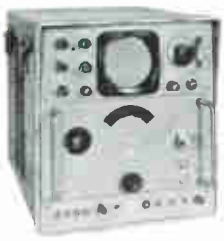
STANDARD SIGNAL

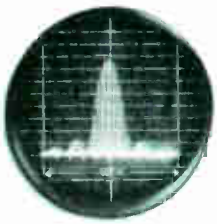
DECODED MULTIPULSE SPECTRUM

INCIDENTAL FM ANALYSIS

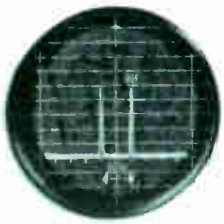
MODEL TSA-S
COMBINATION SYNCHROSCOPE-SPECTRUM ANALYZER

10 to 44,000 mc with five plug-in tuning units

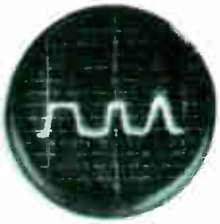




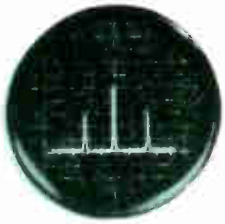
10 μSEC PULSE



STANDARD SIGNAL



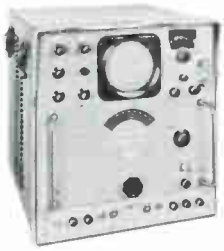
ANALYSIS AS A FUNCTION OF TIME



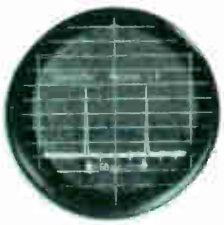
IDENTIFICATION OF AMPLITUDE MODULATION

MODEL TSA-W
WIDE DISPERSION SPECTRUM ANALYZER

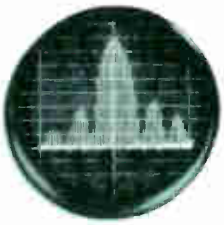
10 to 44,000 mc with five plug-in tuning units—70 mc dispersion



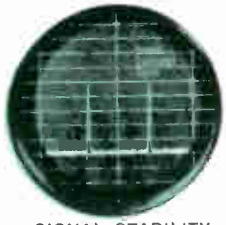
0.1 μSEC PULSE



AFC ACTION



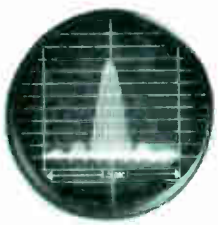
LOG DISPLAY



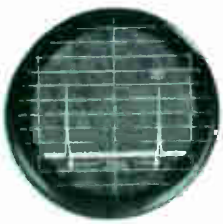
SIGNAL STABILITY MEASUREMENT

MODEL SA-84
UNIVERSAL SPECTRUM ANALYZER

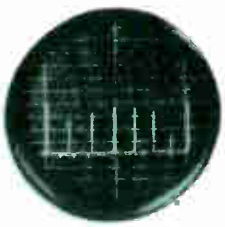
10 to 44,000 mc in one integrated self-contained unit



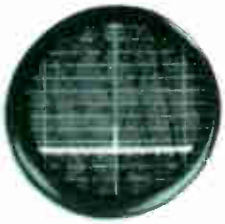
4 μSEC PULSE



STANDARD SIGNAL



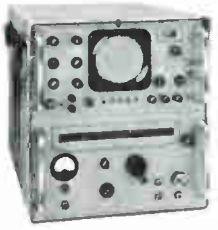
FM SIGNAL ANALYSIS



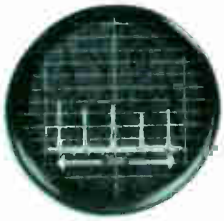
LEAKAGE AND RADIATION MEASUREMENT

MODEL SA-84W
WIDE DISPERSION UNIVERSAL SPECTRUM ANALYZER

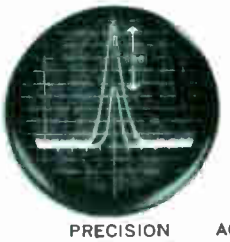
10 to 44,000 mc in one integrated self-contained unit—features over 80 mc dispersion



0.08 μSEC PULSE



CRYSTAL HARMONICS



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- ☐ Model TSA
- ☐ Model TSA-S
- ☐ Model TSA-W
- ☐ Model SA-84
- ☐ Model SA-84W
- ☐ Model RW-T Antenna Pattern Receiver (see reverse side)

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ULTRA-BROADBAND COVERAGE
2,000 to 75,000 mc
in a single unit

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- **B** **Flexible cable connects mixer to receiver.** Eliminates cumbersome rigid waveguide.
- **C** **Internal electronic 1000 cps sweep** allows direct operation into any standard make AC antenna pattern recorder.
- **D** **CW, AM, FM and pulse reception.**
- **E** **Sensitivity.**
  - 2 kmc to 10 kmc....–85 dbm.
  - 10 kmc to 35 kmc....–80 dmb.
  - 35 kmc to 75 kmc....–70 dbm.
- **F** Linearity maintained over 40 db dynamic range.

Model RW-T Microwave receiver being used to make antenna pattern measurements on Polarad range.

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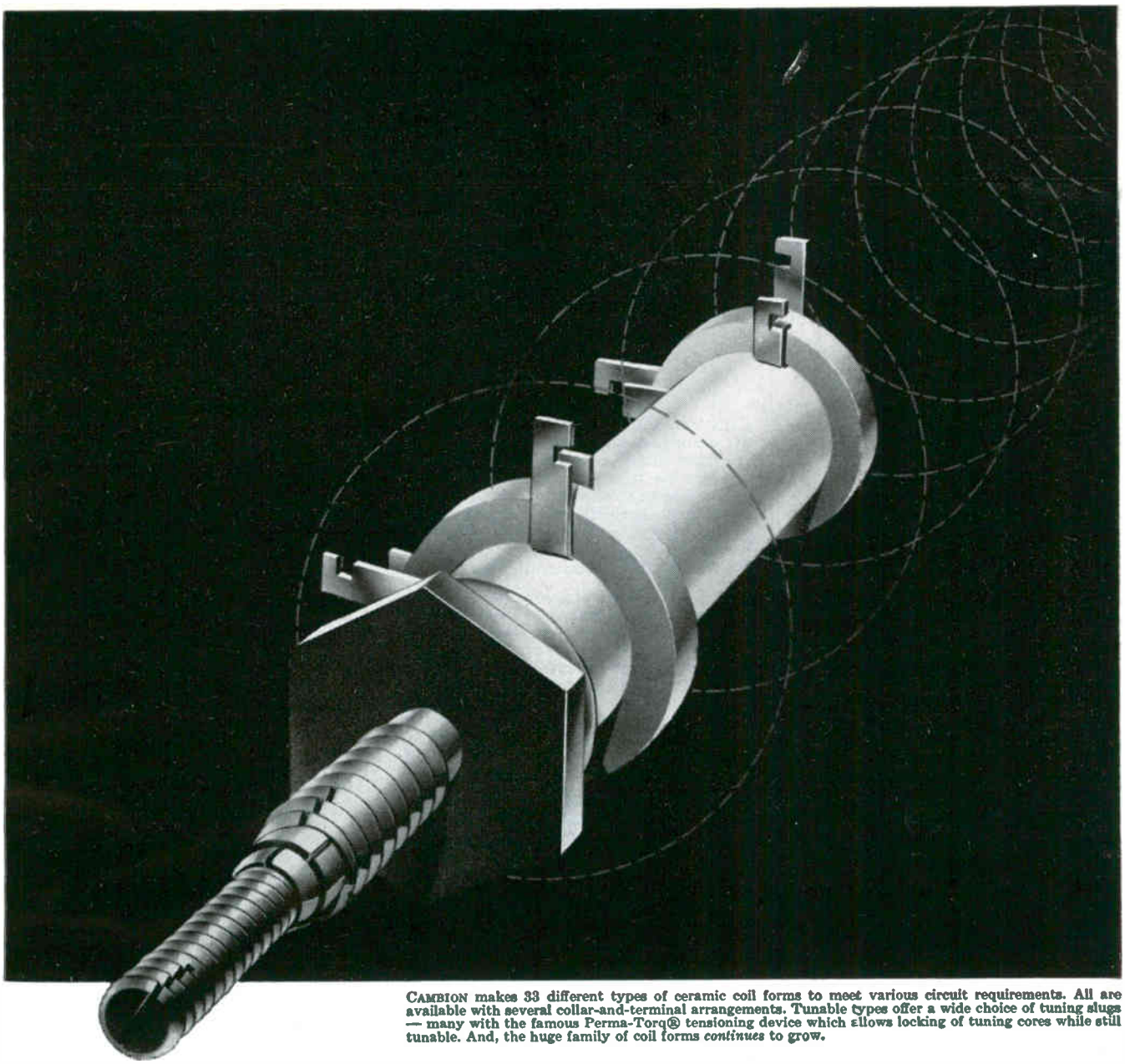

CAMBION makes 33 different types of ceramic coil forms to meet various circuit requirements. All are available with several collar-and-terminal arrangements. Tunable types offer a wide choice of tuning slugs — many with the famous Perma-Torq® tensioning device which allows locking of tuning cores while still tunable. And, the huge family of coil forms *continues* to grow.

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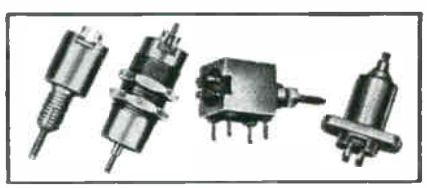
Get complete details. Write to Cambridge Thermionic Corporation, 437 Concord Avenue, Cambridge 38, Massachusetts.



CAMBION Shielded Coil Forms are available in 4 different configurations. They include single and double-tuned types and types for both conventional and printed circuits. One type incorporates CAMBION's unique, new traverse tuning which provides smoother, more precise tuning.

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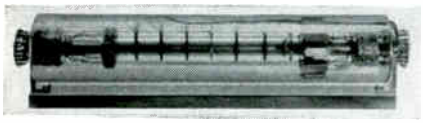
CAMBION®

The guaranteed electronic components

Vol. 2, No. 3

Nickelonic News

DEVELOPMENTS IN INCO NICKEL AND NICKEL ALLOYS AND THEIR APPLICATIONS

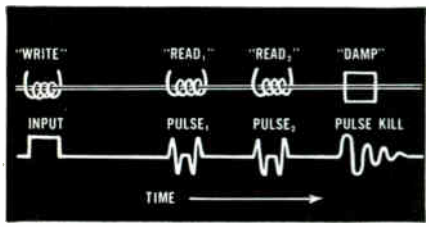


Magnetostriction of Nickel drives Deltime data storage unit. With these units some 15 million bits of data could be handled in a 3x7x7 foot space, engineers estimate.

Shock waves in Nickel "store" 1500 bits of information

MAMARONECK, N. Y.: Magnetostriction produces shock waves in Nickel that travel one foot in about 63 microseconds. Deltime, Inc. uses this property of Nickel to build electronic delay lines. Their latest is a data storage unit that packs eleven 300-microsecond delays in a small space. Ten lines "store" 150 bits of data each, the other "clocks."

Center rod of unit (shown with plastic cover to reveal detail) is structural. Nickel delay lines are concentrically located around rod. Diagram below shows schematic of a single line with associated pulses.



Delay lines are Inco Electronic-Grade "A"* Nickel, drawn fine and stranded to reduce eddy currents. Deltime engineers say Nickel combines large and efficient magnetostrictive response, minimum corrosion, excellent mechanical properties.

Pertinent Literature: Write for Inco Bulletin 127B: "Magnetostriction".

5 new Inconel-protected instruments retain accuracy at missile speeds, heats

. . . point the way to more reliable high temperature parts design

CHICAGO, ILL.: Streaking through the air on mile-a-second missile nose cones . . . fixed in hot, corrosive fluid streams . . . the five new instruments described below operate reliably at glowing temperatures. Aero Research standardizes on Inconel* nickel-chromium alloy for parts of these instruments that bear the brunt of this demanding service.

(1) Total temperature probe — withstands 1740° F generated by friction during flight on missile nose cones. (See photos below.) For maximum reliability, its Inconel sheathing also withstands oxidation and thermal shock.

(2) Wide-range thermocouple — measures temperatures from as low as — 320° up to + 1900° F in high-velocity fluids. Inconel sheathing effectively resists these severe erosive-corrosive conditions.

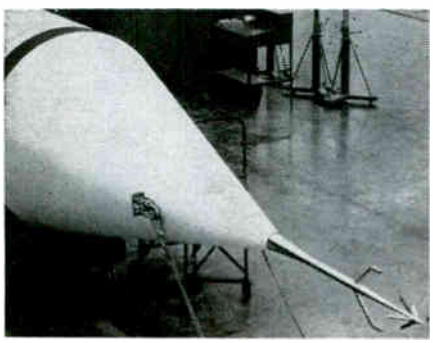
(3) High-accuracy, high-temperature probe—measures temperatures between 0° and 1800° F. Again, Inconel sheathing assures reliability, protecting its accuracy in supersonic jet exhausts, high-temperature furnaces.

(4) Jet thrust measuring rake, water-cooled — operates in 3500° F jet afterburner gases. Inconel alloy construction provides essential high strength at high temperature, plus corrosion resistance.

(5) Sonic-speed, 4430° F, wind tunnel, water-cooled — Inconel alloy forms all major components, gives tunnel the backbone needed to stand up under terrific velocity and heat.

You, too, can give parts high temperature stamina with Inconel alloy. It retains useful strength through 2000° F, and can be easily welded and formed into intricate shapes.

Pertinent Literature: Write for Bulletin T-7: "Engineering Properties of Inconel and Inconel X", and "Inco Nickel Alloys for Electronic Uses".



Inconel-sheathed total temperature probe mounted on Redstone missile nose cone — assures high strength at high temperatures and readily withstands oxidation, erosion and thermal shock at extreme velocities. Probe (shown at right) is product of Aero Research Instrument Company, Inc., Chicago, Illinois.

Sensitive transducer measures minute changes of pressure in human body

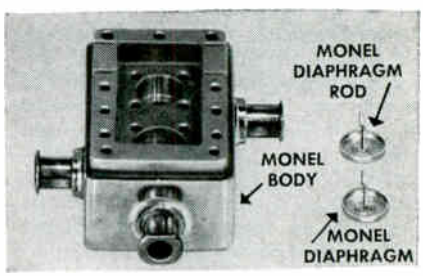
. . . Monel fluid chambers withstand corrosion, do not affect saline purity

WALTHAM, MASS.: This sensitive pressure transducer measures a wide range of physiological pressures — from 400 mm Hg down to less than 1 mm Hg.

Absolute and differential pressures travel from source (needle or catheter) through a saline-filled tube to actuate two small Monel* nickel-copper alloy diaphragms. Monel diaphragm rods pivot a tiny differential transformer core, producing a signal which is fed to amplifiers for quick reading.

Monel alloy was chosen for the parts above because it withstands corrosive attack from all common saline and sterilizing solutions. As a result, Monel alloy does not affect saline purity. In addition, Monel alloy is easy to form, machine, to braze, solder and weld.

Pertinent Literature: Write for Bulletin T-5; "Engineering Properties of Monel and R Monel".



Monel transducer body and diaphragms resist corrosive saline solutions for long, reliable service. Transducer is made by Sanborn Company, 175 Wyman St., Waltham, Mass.

*Trademark, The International Nickel Company, Inc.

INCO TRADE MARK **ALLOY PRODUCTS**

HUNTINGTON ALLOY PRODUCTS DIVISION
The International Nickel Company
Huntington 17, West Virginia

Newest, Smallest Bourns Trimpot® – with the square configuration

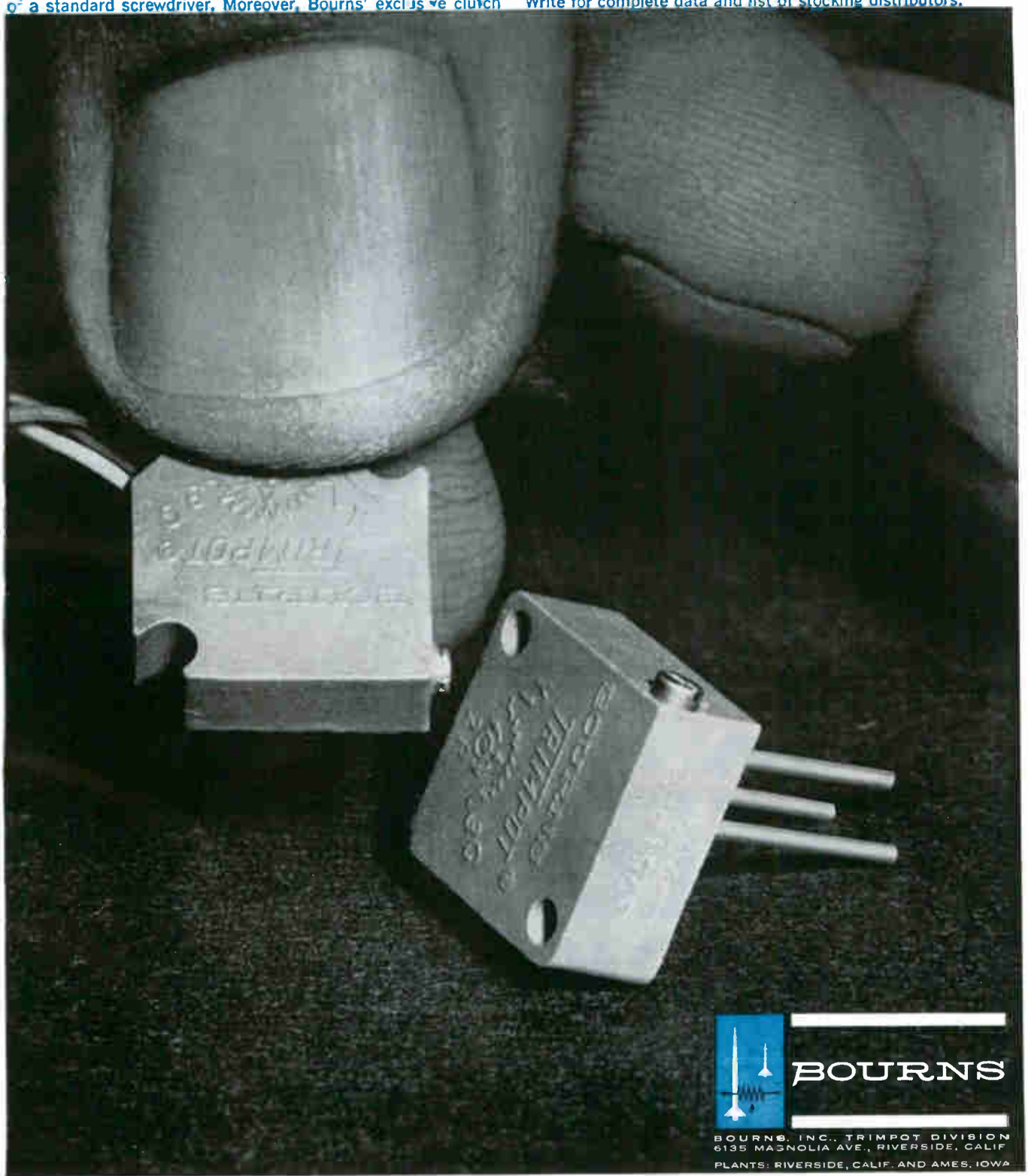
Now... Bourns reliability is in an even smaller package; these new wirewound units measure just ½" x ½" x 3/16". In addition, they offer you a choice of two terminal types—insulated stranded leads or printed circuit pins.

Because of unique package design, Model 3250 withstands the most severe environmental conditions... meets or exceeds Mil-Spec requirements. Its 25-turn adjustment permits precise balancing, while the shaft head size makes possible the use of a standard screwdriver. Moreover, Bourns' exclusive clutch design, combined with positive end-stops, eliminates any possibility of damage to internal parts.

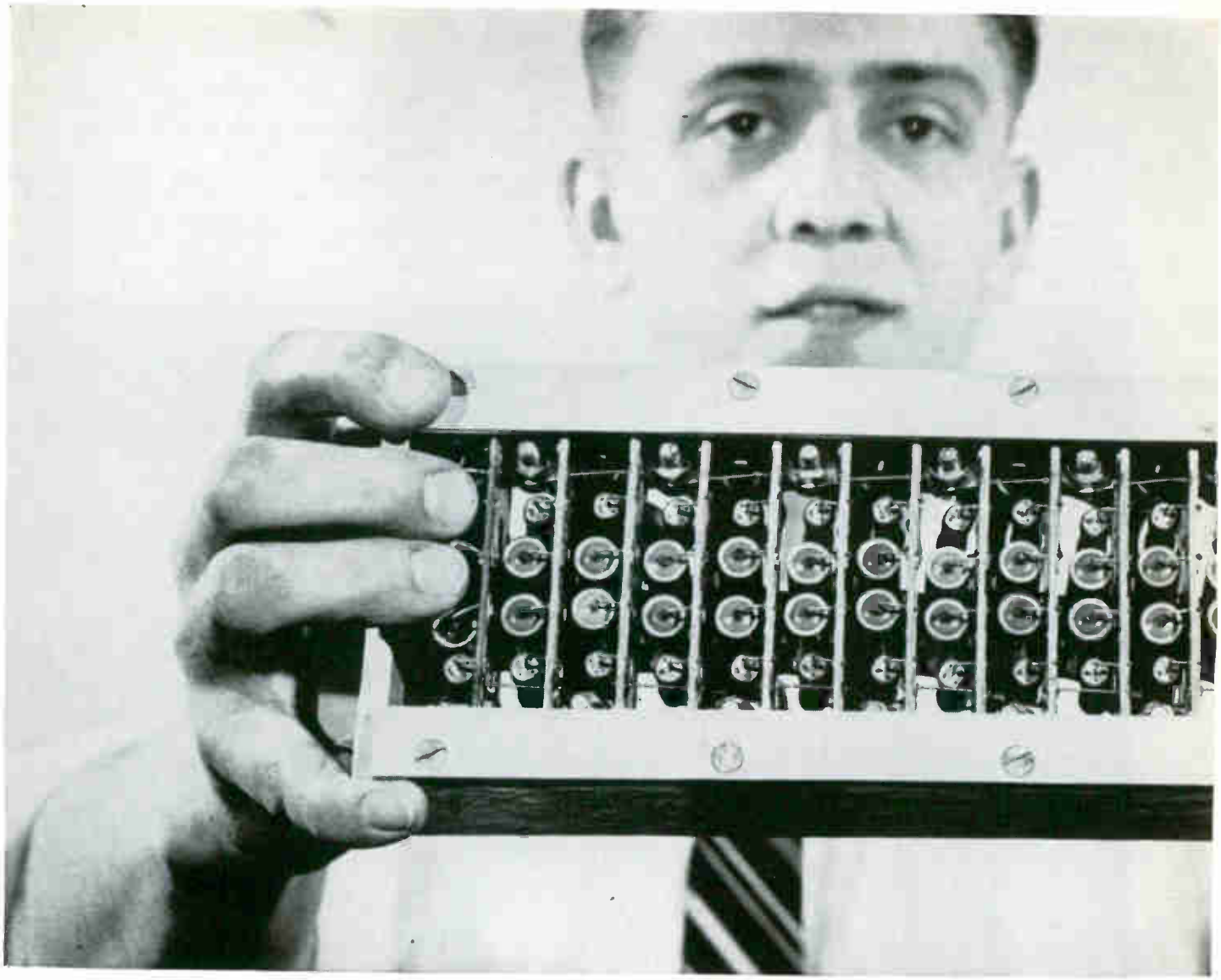
Like all Trimpot potentiometers, this new model is designed, built and tested to give you performance you can count on.

Max. Operating Temperature	Power Rating	Resistances
+175°C	1 Watt @ 70°C	100Ω to 50K

Write for complete data and list of stocking distributors.



Exclusive manufacturers of Trimpot®, Trimit® and E-Z Trim®. Pioneers in transducers for position, pressure and acceleration.



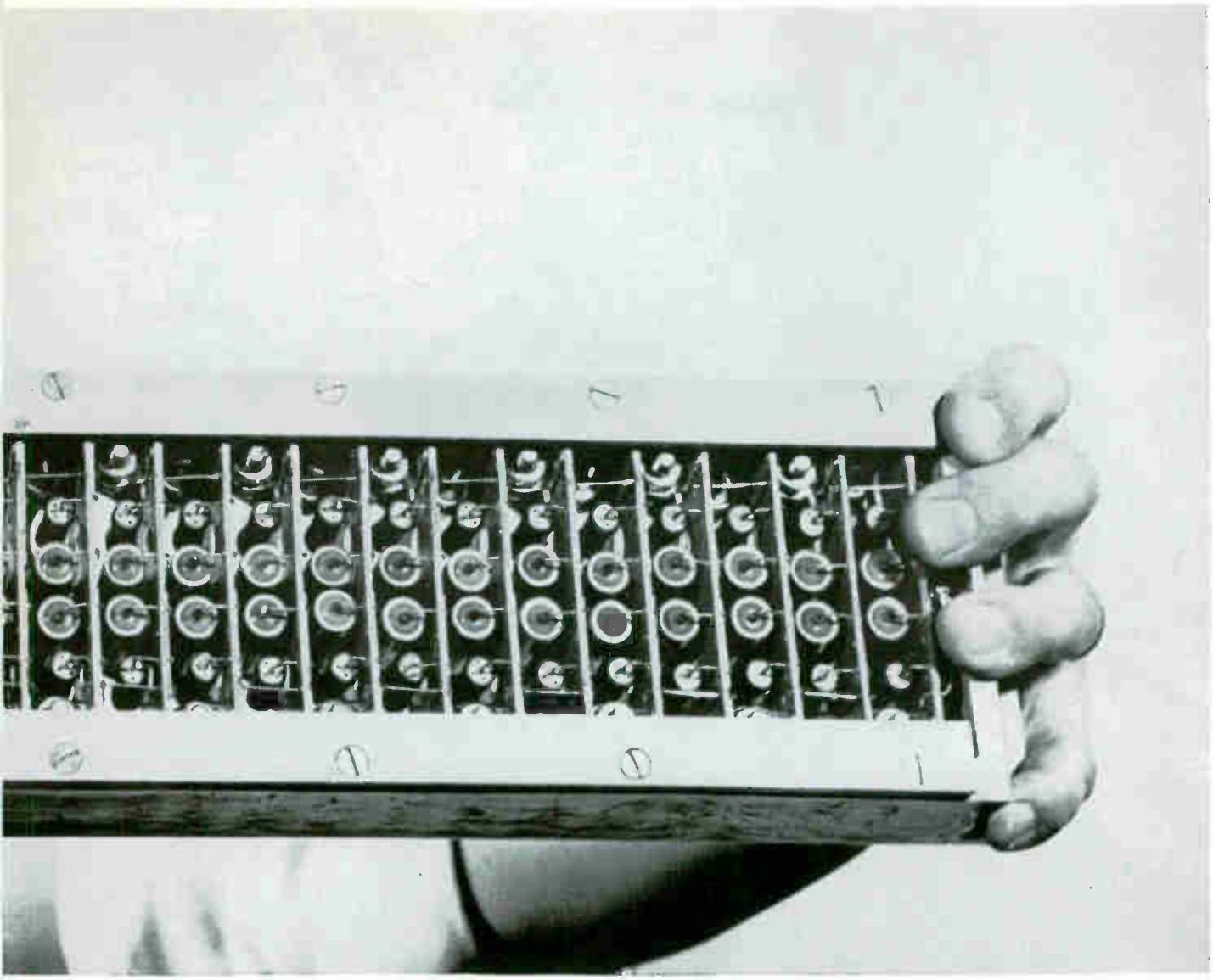
18,750,000

~~10,000,000~~

FAILURE-FREE STACK-HOURS!

RELIABILITY PROVEN BY 17,000 KW IN FIELD APPLICATIONS

WESTINGHOUSE SILICON HIGH-VOLTAGE RECTIFIER STACKS



New Westinghouse Stacks top their own failure-free record! Number of stack-hours for units currently in use has nearly doubled in less than six months! Proof not only of outstanding reliability, but of an increasing industry-wide acceptance of Westinghouse Silicon High Voltage Stacks.

Why Westinghouse Silicon Rectifier Stacks are the most reliable. They are made to highest standards of circuit design, quality control, and assembly. Exclusive Westinghouse circuits guarantee uniform division of reverse voltages, provide optimum steady state as well as transient and overload characteristics. Only MIL Type shunting resistors, capacitors, and mounting boards are used. All components are 100% tested *before and after assembly*. Spacing and cooling of components allows operating in ambient temperatures as high as 110°C. As a result of these and other Westinghouse quality features, there is no record of a single stack failure in any type of application.

Westinghouse Silicon Rectifier Stacks are available in a range of current ratings from 1.2 Amps to 18 Amps . . . from 9.6 K.V. to 35 K.V. For higher voltage requirements Stacks may be connected in series.

For full information, or engineering assistance, contact your local Westinghouse Representative or write: Westinghouse Electric Corp., Semiconductor Dept., Youngwood, Penna. SC-1016.

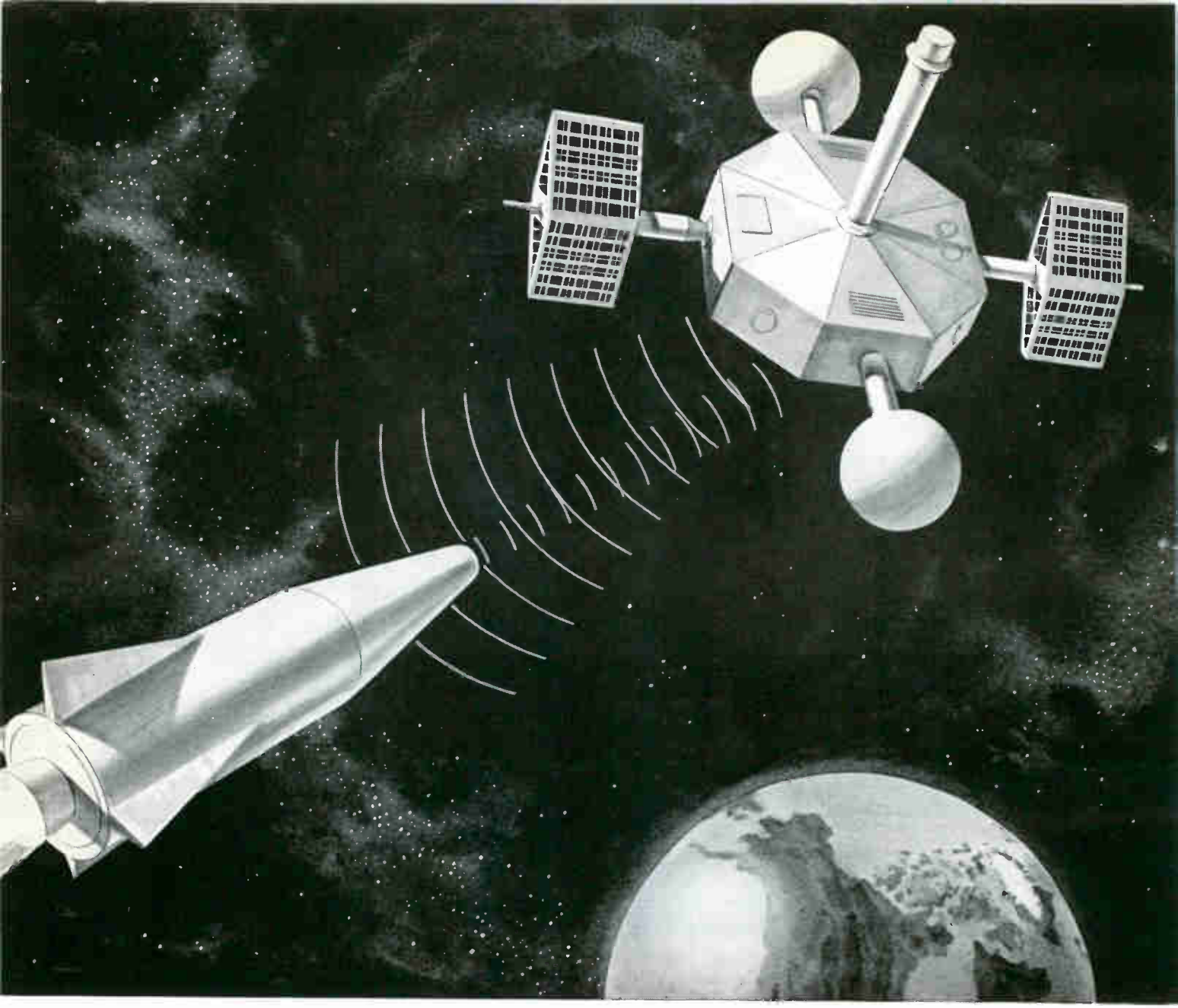
You can be sure . . . if it's Westinghouse

MIL TYPE COMPONENTS

Unique Westinghouse modular inserts feature MIL Type shunting resistors, capacitors, and mounting boards. All components are 100% tested before and after assembly.

APPLICATIONS

- *Electrostatic precipitators*
- *Radio broadcasting transmitters*
- *Radar transmitters*
- *Ultrasonic transducers*
- *Radar pulse forming networks*



For Space Applications, Raytheon offers proven, off-the-shelf techniques in CW Radar

Raytheon has been investigating, developing and producing Continuous Wave Radars for more than ten years. Impetus for the program was the anticipated problems of clutter rejection, ever-increasing intercept velocities, and low weight-high reliability requirements in the aero-space era.

This pioneering effort has resulted in several dramatic achievements: multi-kilowatt, low noise transmitters; unique antennas that transmit and receive simultaneously; a feed-through nulling device that adds isolation to the antenna; precise, highly sensitive Doppler data processors.

Raytheon CW Radar Systems incorporating these advances are light weight, low volume and low cost. They are also simple, reliable, and require considerably less input power.

For satellite intercept, space rendezvous, lunar or planet soft landings . . . for any space application requiring velocity data . . . Raytheon can now offer *empirically proven* CW Radar techniques. Existing Raytheon CW hardware is now operational in Missile Guidance, Altimetry and Doppler Navigation Systems.

For CW Radar Brochure, write:

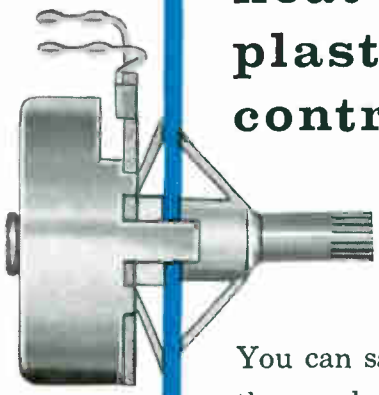
DIRECTOR OF MARKETING,
Equipment Division,
Department L-3, Raytheon Company,
West Newton, Massachusetts

RAYTHEON EQUIPMENT DIVISION

EXCELLENCE IN ELECTRONICS

Save on labor costs

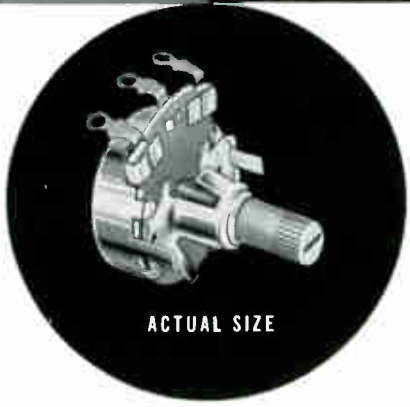
Centralab's heat-stable plastic shaft controls



SNAP into place

You can save on installation costs—up to $10.00 per thousand units—because CENTRALAB Model 2 variable resistors SNAP into position.*

This exclusive "Snap-Tite" design is but one of the many features that make the Model 2 so practical. The thermo-setting plastic shaft is UL approved. You have a choice of six shaft lengths—and the shafts have service adjust screwdriver slots front and rear. The shaft and contact rotor are molded in one piece for rigid, vibration resistant construction.



SPECIFICATIONS

Resistance element: Composition
Resistance range: 250 ohms to 10 megohms
Taper: Available in seven standard tapers
Effective Rotation: 300°
Shaft Lengths: 3/8", 1/2", 5/8", 3/4", 7/8", 1"
Terminals: Standard, plug-in or wire-wrap
***Mounting:** Interchangeable with panel piercing for bushing and twist tab mount

Further information and detailed engineering data available in CENTRALAB Engineering Bulletin EP-815. Write for your free copy.

Centralab CRL ®
B5971

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914L E. KEEFE AVE. · MILWAUKEE 1, WIS.
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VARIABLE RESISTORS • ELECTRONIC SWITCHES • PACKAGED ELECTRONIC CIRCUITS • CERAMIC CAPACITORS • ENGINEERED CERAMICS

←CIRCLE 60 ON READER SERVICE CARD

CIRCLE 61 ON READER SERVICE CARD 61

NEW! CONTROLLED

4 TRANSITRON TYPES AUGMENT

Silicon Controlled Rectifiers / Switches

NEW! CONTROLLED SWITCHES

TSW31S · TSW201S PNPN bistable switching devices in TO-18 packages, with maximum holding current of 1 ma.

- High gate sensitivity 20 μa to fire
- Covers current range from 1 ma to 200 ma @ 75°C ambient
- Voltage ratings up to 200 volts available
- Temperature range: −65°C to +150°C

CIRCLE 220 ON READER SERVICE CARD

NEW! TO-5 PACKAGE CONTROLLED RECTIFIERS

Two series of diffused silicon PNPN bistable switching devices with very low triggering requirements and micro-second switching.

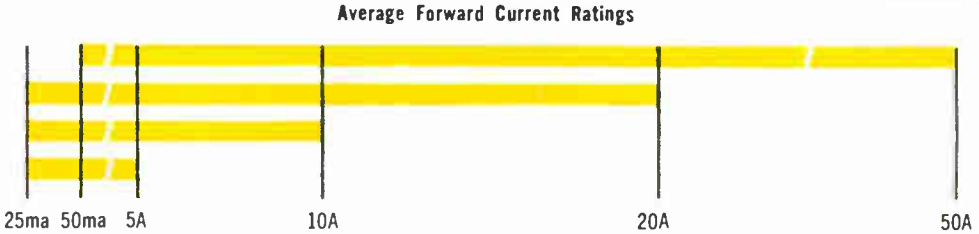
TCR251-TCR4001 series featuring:

- Low leakage: 100 μA @ 125°C case
- High gate sensitivity: 200 μA @ 25°C
- Low Holding Current: 5 mA maximum @ 25°C
- Current rating: 1 amp at 80°C case or 600 ma at 25°C ambient
- Voltage ratings: Up to 400 volts

Plus **2N1595-2N1599** series with same current and voltage ratings

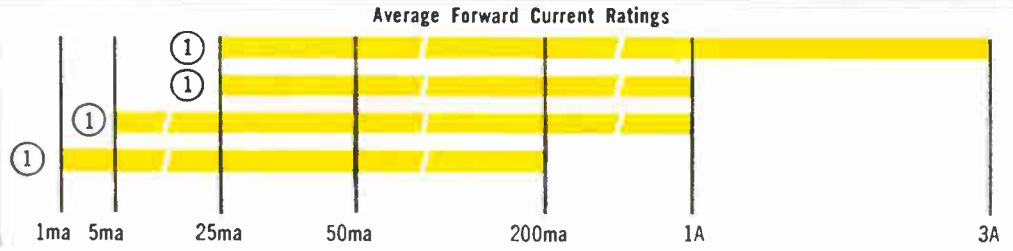
CIRCLE 221 ON READER SERVICE CARD

Series	Package
TCR 550	1⅛ hex base
TCR 520	1⅛ hex base
TCR 510	1⅛ hex base
TCR 505	⅞ hex base



2N1600	⅞ hex base
2N1595	TO-5
TCR 251	TO-5
TSW 31S	TO-18

(1) Maximum Holding Current Values



The complete Transitron line of Controlled Rectifiers and Controlled Switches includes the following higher current types:

NEW! 2N1600-2N1604 and TCR505-TCR4005 series diffused Silicon Controlled Rectifiers

- Current ratings: 3 amps at 80°C case; 1 amp @ 125°C case
- Voltage ratings: Up to 400 volts
- Package: ⅞" hex base

CIRCLE 222 ON READER SERVICE CARD

10 Amp Series

- Current ratings: 10 amps @ 25°C case; 5 amps at 100°C case
- Voltage ratings: Up to 400 volts
- Package: 1⅛" hex base

20 Amp Series

- Current ratings: 20 amps @ 25°C case; 10 amps at 100°C case
- Voltage ratings: Up to 400 volts
- Package: 1⅛" hex base

CIRCLE 223 ON READER SERVICE CARD

NEW!
50 Amp Series

- Current ratings: 50 amps at 100°C case
- Voltage ratings: Up to 400 volts
- Package: 1⅛" hex base

CIRCLE 224 ON READER SERVICE CARD

RECTIFIERS & SWITCHES

INDUSTRY'S BROADEST LINE!

Binistors / Transwitches

THE BINISTOR

(by-nis-tor)

Transitron's new silicon NPN Tetrode offers simpler, more reliable, more economical switching and storage circuitry. The key parameters of this bistable, negative resistance device are determined by external circuitry, providing remarkable stability and uniformity over wide temperature ranges. The signal and output swings are compatible with present transistor and diode circuits. Two series are available: The wide temperature range or military types and the commercial and industrial computer types. The stability and uniformity of each unit in the military series is absolutely guaranteed by the method of specification at critical temperatures (−65°C and +150°C).

CIRCLE 225 ON READER SERVICE CARD

ABSOLUTE MAXIMUM RATINGS

	3N56	3N57
Collector to Emitter Voltage (V_{CE})	15 Volts	15 Volts
Collector Current @ 25°C (I_C)	30 mA	30 mA
Storage & Operating Ambient Temp. Range	−65°C to +150°C	−55°C to +100°C

3N56 MILITARY TYPE

SPECIFICATIONS & TYPICAL CHARACTERISTICS (At Noted Ambient Temp.)

TURN-ON	AMBIENT TEMP	MIN.	TYPICAL	MAX.	TEST CONDITIONS
D.C. Collector Saturation Voltage (V_{CE})	−65°C	--	0.46	1.0 V	I_C = 10mA, I_b = + .5mA*
	+25°C	—	0.7	1.0 V	V_J = 4V, R_J = 3K
	+150°C	—	1.2	1.5 V	supply
Critical Injector Current ($I_{j\ crit}$)	−65°C	0	.38	.5 mA	I_C = 10mA, I_b = − 50μa
	+25°C	0	.28	.5 mA	
	+150°C	0	.21	.5 mA	
	−65°C	0	1.10	1.5 mA	I_C = 0.25mA, I_b = − 50μa
	+25°C	0	0.86	1.5 mA	
	+150°C	0	0.40	1.5 mA	
TURN-OFF Base Cutoff Current (I_{bo})	−65°C	—	—	—	V_{CE} = 15 volts, V_{JE} = + 13 volts
	+25°C	—	.020	0.2 μA	V_{BE} = − .6 volts
	+150°C	—	2.0	10.0 μA	

3N57 COMPUTER TYPE

SPECIFICATIONS & TYPICAL CHARACTERISTICS @ 25°C

TURN-ON	MIN.	TYPICAL	MAX.	TEST CONDITIONS
D.C. Collector Saturation Voltage (V_{CE})	—	0.7	1.0 V	I_C = 10mA, I_b = + .5mA* V_J = 4V, R_J = 3K supply
Critical Injector Current ($I_{j\ crit}$)	0	.28	0.5 mA	I_C = 10mA, I_b = − 50μa
	0	.86	1.5 mA	I_C = 0.25mA, I_b = − 50μa
TURN-OFF Base Cutoff Current (I_{bo})	—	.020	.2 μA	V_{CE} = 15 volts, V_{JE} = + 13 volts V_{BE} = − .6 volts

*Unit must switch on under the above conditions; however, actual V_{CE} measurement is made with I_b = − 50μa

THE TRANSWITCH

A PNPN bistable silicon computer element that can be turned on and off with gate current. The device is available in the TO-1B package, and is designed for miniaturized memory circuits, ring counters, shift registers, controlled rectifier drivers, and flip flop equivalents. A 100 ma series (TSW-31A-TSW-201A) has been added to the Transwitch series. Both series (50mA and 100mA) are available in voltage ratings up to 200 volts. For commercial and industrial applications, the SW-30 type is now available. This unit, especially designed for lower temperature applications, features maximum collector current rating of 30mA and maximum voltage rating 30 volts.

CIRCLE 226 ON READER SERVICE CARD

ABSOLUTE MAXIMUM RATINGS

	SW-30	TSW-31 thru TSW-201	TSW-31A thru TSW-201A
Forward current I_f	30 mA	50 mA	100 mA
Operating temp. range	−55°C to +85°C	−55°C to +125°C	−55°C to +125°C

SPECIFICATIONS (AT 25°C)

	SW-30	TSW-31 thru TSW-201	TSW-31A thru TSW-201A
Max. Saturation Voltage (V_S)	1.5 V @ 30 mA	1.5 V @ 50 mA	2 V @ 100 mA
Max. Forward "OFF" Current (I_{CGO})	10 μA	10 μA	10 μA
Max. Reverse Current (I_R)	10 μA	10 μA	10 μA
Max. Forward "OFF" Current (I_{CGO})	50 μA @ 85°C	50 μA @ 125°C	50 μA @ 125°C
Max. Reverse Current (I_R)	50 μA @ 85°C	50 μA @ 125°C	50 μA @ 125°C
Max. Gate Voltage to Switch "ON" ($V_{G\ ON}$)	1.0 V	1.0 V	1.0 V
Max. Gate Current to Switch "ON" ($I_{G\ ON}$)	1.5 mA	1.0 mA	1.0 mA
Max. Gate Voltage to Switch "OFF" ($V_{G\ OFF}$)	−5.0 V	−4.0 V	−6 V
Max. Gate Current to Switch "OFF" ($I_{G\ OFF}$)	−8.0 mA	−10 mA	−20 mA
Max. Holding Current (I_H)	10.0 mA	5.0 mA	7.0 mA

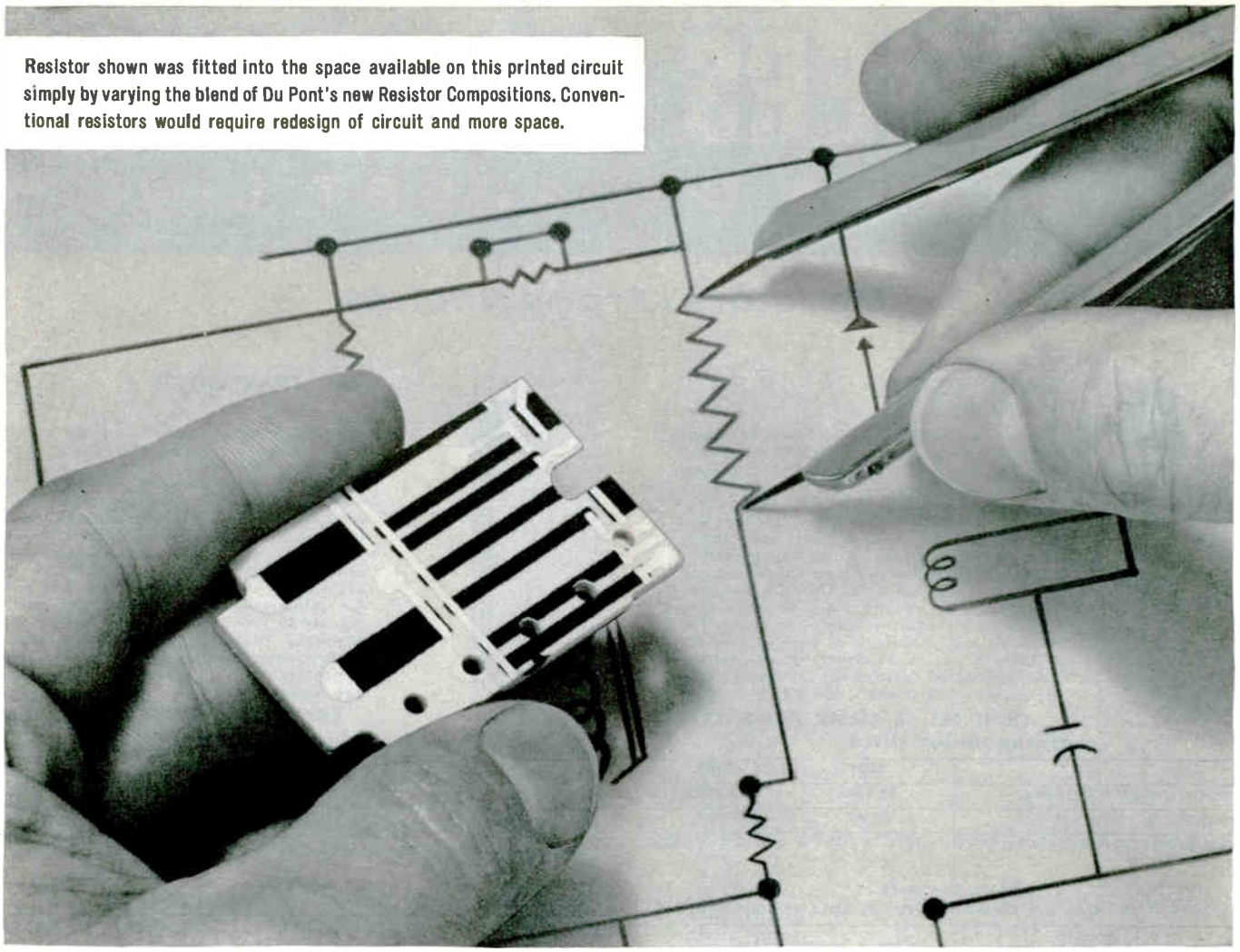
In writing for further information on all these devices, refer to the following bulletin numbers:

Controlled Rectifiers & Switches		Binistor & Transwitch	
TSW-31S series	Bulletin # TE-1356E	TSW-31A	Bulletin # TE-1357B-1
TCR-251 series	Bulletin # TE-1356D	TSW-31	Bulletin # TE-1357B
2N1595 series	Bulletin # TE-1356C	SW-30	Bulletin # TE-1357E
2N1600 series	Bulletin # TE-1356B-1	3N56	Bulletin # TE-1360A
TCR-505 series	Bulletin # TE-1356B	3N57	Bulletin # TE-1360B
10 amp series	Bulletin # TE-1356A-1		
20 amp series	Bulletin # TE-1356A		
50 amp series	Bulletin # TE-1356AA		

Transitron electronic corporation
wakefield, melrose, boston, mass.

"Leadership in Semiconductors"

SEE YOUR AUTHORIZED DISTRIBUTOR FOR QUANTITIES FROM 1-999



Resistor shown was fitted into the space available on this printed circuit simply by varying the blend of Du Pont's new Resistor Compositions. Conventional resistors would require redesign of circuit and more space.

Du Pont announces—New Resistor Compositions that permit varied resistance values without changing geometric form . . . simplify design, save space

Now, new Du Pont Resistor Compositions offer a second dimension for controlling resistance. You can vary resistance values by changing the composition of the resistor without the need for altering the geometric form. These new resistor compositions give you greater design flexibility, essential for miniaturized circuits. Du Pont Resistor Compositions are available at three approximate resistance values: 500, 3,500 and 10,000 ohms/square per mil thickness, and they can be blended to give a range of intermediate values.

Du Pont Resistor Compositions are easy to apply . . . may be brushed, dipped, screen-printed or sprayed. Surfaces can be fired under normal atmospheric conditions in the 1100-1400°F. range.

Printed resistor patterns and coated rods have abrasion and impact resistance similar to fired silver coatings and show only small variations in resistivity under humidity, overload, temperature and voltage conditions as typical laboratory data show:

Temperature coefficient	±350 ppm./°C. from -55°C. to +125°C.
Voltage coefficient	Less than .02%/volt, negative
Humidity exposure	± 1% change after 250 hr. @ 95% relative humidity
Overload	±0.5% change with standard short-time overload
Temperature cycling	± 1% change after 5 cyclings from -55°C. to -125°C.
Load life	±2% change after 1,000 hr. at 70°C. at full load

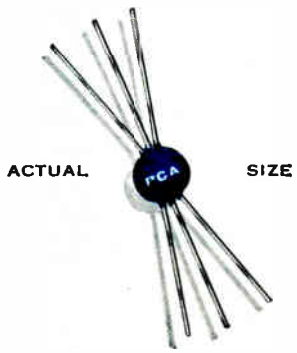
Fired samples are available for your own evaluation. Request them on your letterhead, indicating application you have in mind. Complete technical information will also be sent. Write: Du Pont, Electrochemicals Dept., Ceramic Products Div., Wilmington 98, Delaware. Du Pont does not manufacture resistors . . . produces only resistor compositions and other high-quality conductive coatings: gold, silver, platinum and palladium.

DU PONT RESISTOR COMPOSITIONS

DU PONT
REG. U.S. PAT. OFF.

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

Subminiature pulse transformers—
Only 6 times larger than the head
of a pin . . .



ELECTRONICS, INC., 16799 SCHOENBORN STREET, SEPULVEDA, CALIFORNIA, EMpire 2-0761

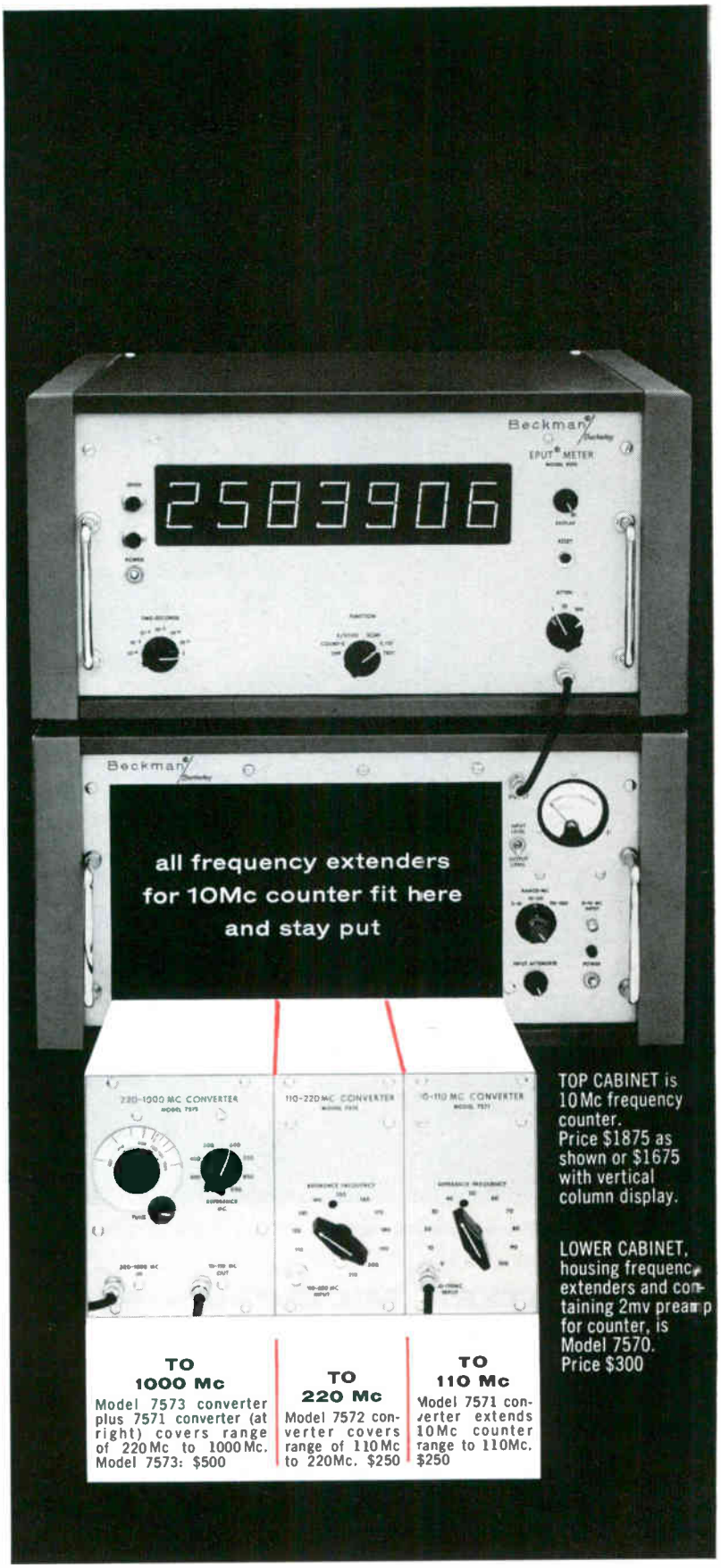
Leading manufacturer of pulse transformers and delay lines

Career opportunities available for engineers with experience in pulse techniques

measure rf to 1000 mc without replacing plug-ins

It's all here in two easily-movable cabinets — a digital frequency-measuring system of wider range and lower price than any comparable equipment on the market. The counter in the top cabinet measures all frequencies from 10 cps to 10Mc. Heterodyne converters—added to the bottom cabinet as you need them—extend range to 110Mc, 220Mc or 1000Mc. • This provision for expanding the system simply and economically makes the equipment a wise long-term investment. Buy only the range you need now, rest assured that you can cover higher frequencies whenever need arises. • Accuracy is .00004% or better from 1Mc to 1000Mc. Sensitivity is unequalled: 2mv from 10Kc to 10 Mc, 10mv to 110Mc, 20mv to 220Mc and 1mw to 1000Mc.

WRITE FOR DETAILED TECHNICAL BULLETINS ON MODEL 7570 SERIES



Beckman® | *Berkeley Division*
Richmond, California

INSTRUMENTAL IN YOUR FUTURE 25 YEARS 1935-1960

T27

November 25, 1960

CIRCLE 67 ON READER SERVICE CARD 67

Electronic accounting machines are inspected at Burroughs Corporation's Plymouth Plant, Plymouth, Michigan.

SOUTHEASTERN MICHIGAN'S SCIENTIFIC CLIMATE—

where the electronics industry can best grow. Basic to the electronics industry are the technical skills and experience of capable men and women—those adept at developing, producing and testing intricate equipment. In this respect Southeastern Michigan has the advantage. Here is plenty of skilled manpower to produce complex and sensitive missile guidance computers, data processing systems, communication equipment and the like.

Southeastern Michigan possesses other resources of prime interest. Respected universities are nearby. Their proximity and reputations encourage graduate work. They make staff members available as industrial consultants; undertake on-campus research and development for industry.

Many communities in the area have comprehensive land use plans, industrial subdivisions, non-profit development corporations. In short, there are very tangible reasons why Southeastern Michigan offers an excellent environment for electronically oriented firms.

Plant location is one of our special interests. May we suggest that you write to us—Plant Location Service, Area Development Division, Detroit Edison Company, Detroit 26, Michigan.

DETROIT EDISON

New, tri-dimensional packaging and interconnecting of modern electronic functions.

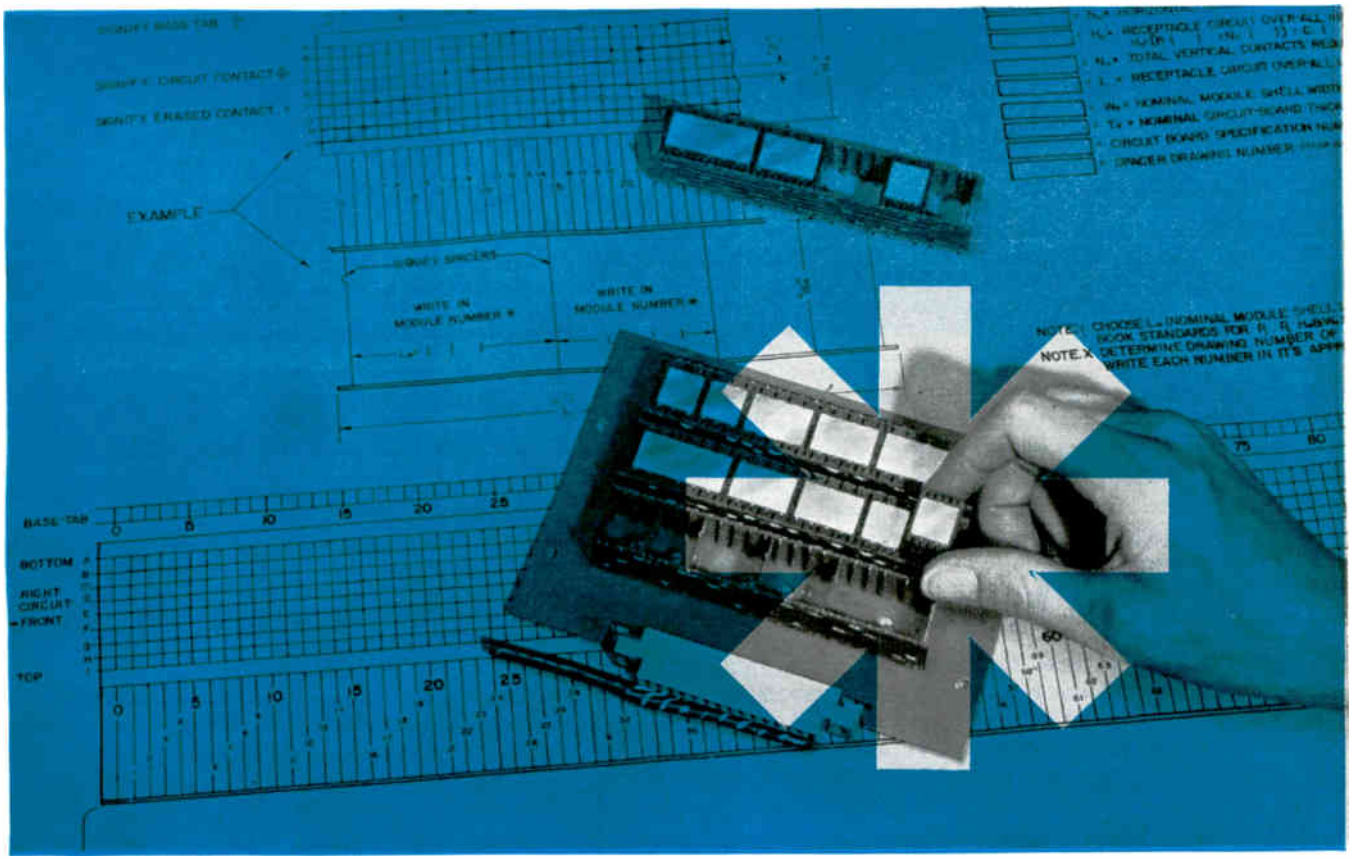
Here is simplicity from start to finish . . . the most complicated designs worked out on AMP-MECA's graph layout sheets in hours rather than days or weeks . . . finished modular construction that's "building-block" easy . . . extreme reliability and complete resistance to shock and vibration.

YOU GOT IT MADE WITH MECA

Electronic functions are encapsulated for complete throw away or functions are assembled in open base cells for individual component replacement. Easily replaced, pluggable AMP-Cells work independently of or in harness with each other when programmed into AMP's 3-D circuit boards.

Available in 0.1" or 0.2" grid systems, AMP-MECA offers tri-dimensional flexibility—cells can be made larger or smaller—stacked, spread or lined-up in unlimited scope to accommodate your design needs. And production can be set up to fit your goals . . . by hand, or by programmed automation.

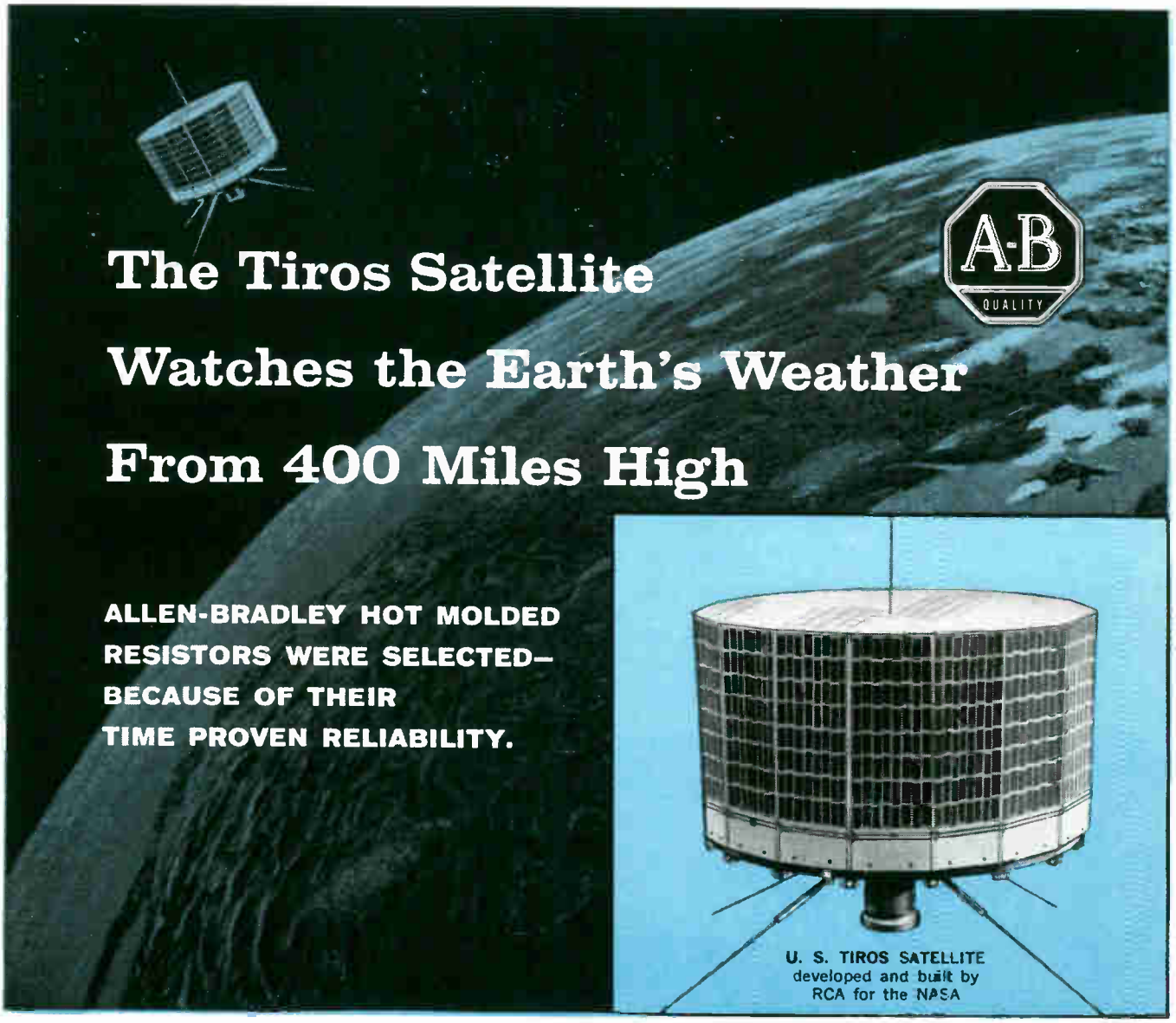
Learn how AMP-MECA can make it simple for you. Send for the full story on simplified interconnection of circuit functions and information on prototype assembly kits.



AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

AMP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • West Germany



The entire world recognizes the success of the Tiros—the world's first weather observation satellite. We are proud that the superior performance of Allen-Bradley composition fixed resistors contributed significantly to the more than 22,000 television pictures of the earth's cloud cover obtained from the Tiros. The highly complex electronic systems within the satellite and the vast array of associated ground equipment used strictly standard Allen-Bradley Type EB (½ watt) and Type GB (1 watt) composition resistors.

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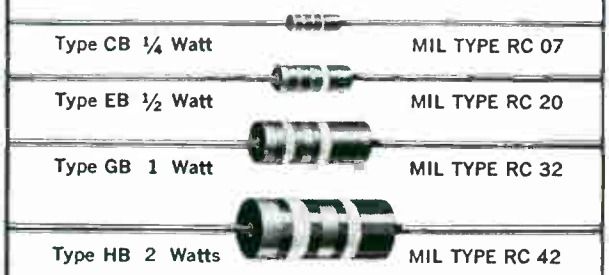

Type CB ¼ Watt	MIL TYPE RC 07
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Allen-Bradley hot molded composition resistors are available in all standard EIA and MIL resistance values and tolerances.

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EL84 6BQ5

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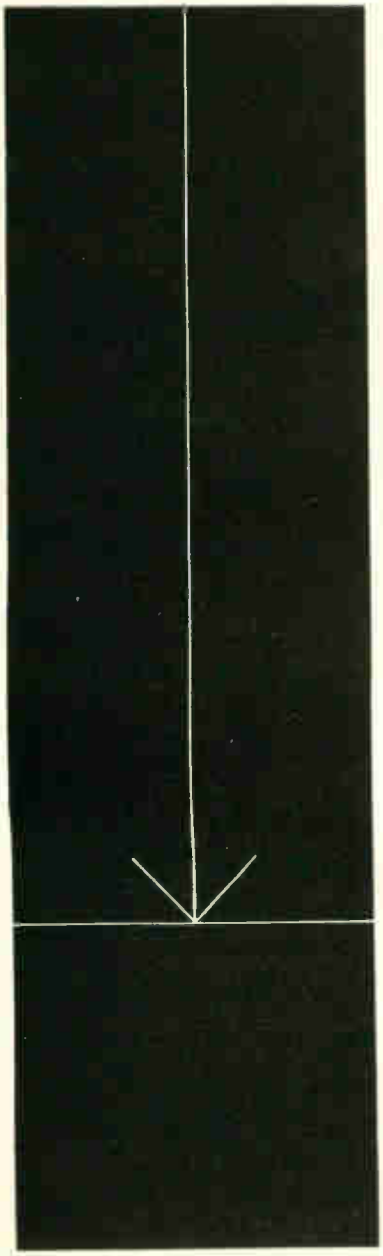

Output pentode rated for 12W anode dissipation, primarily intended for use in a.c. mains operated equipment.

characteristics

V_a	250	V
V_{g2}	250	V
I_a	48	mA
I_{g2}	5.5	mA
V_{g1}	-7.3	V
g_m	11.3	mA/V
r_a	38	kΩ
μ_{g1-g2}	19	

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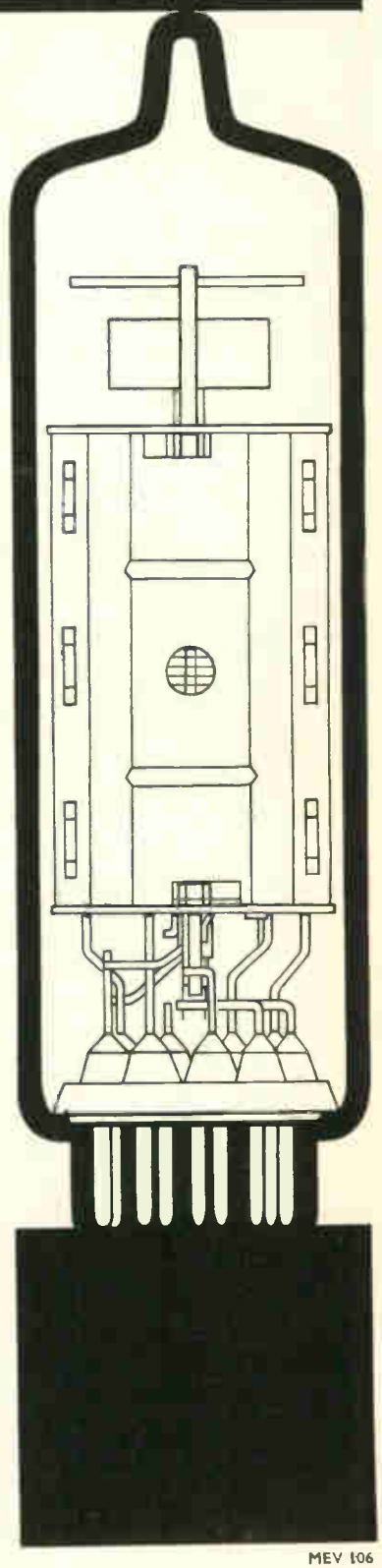
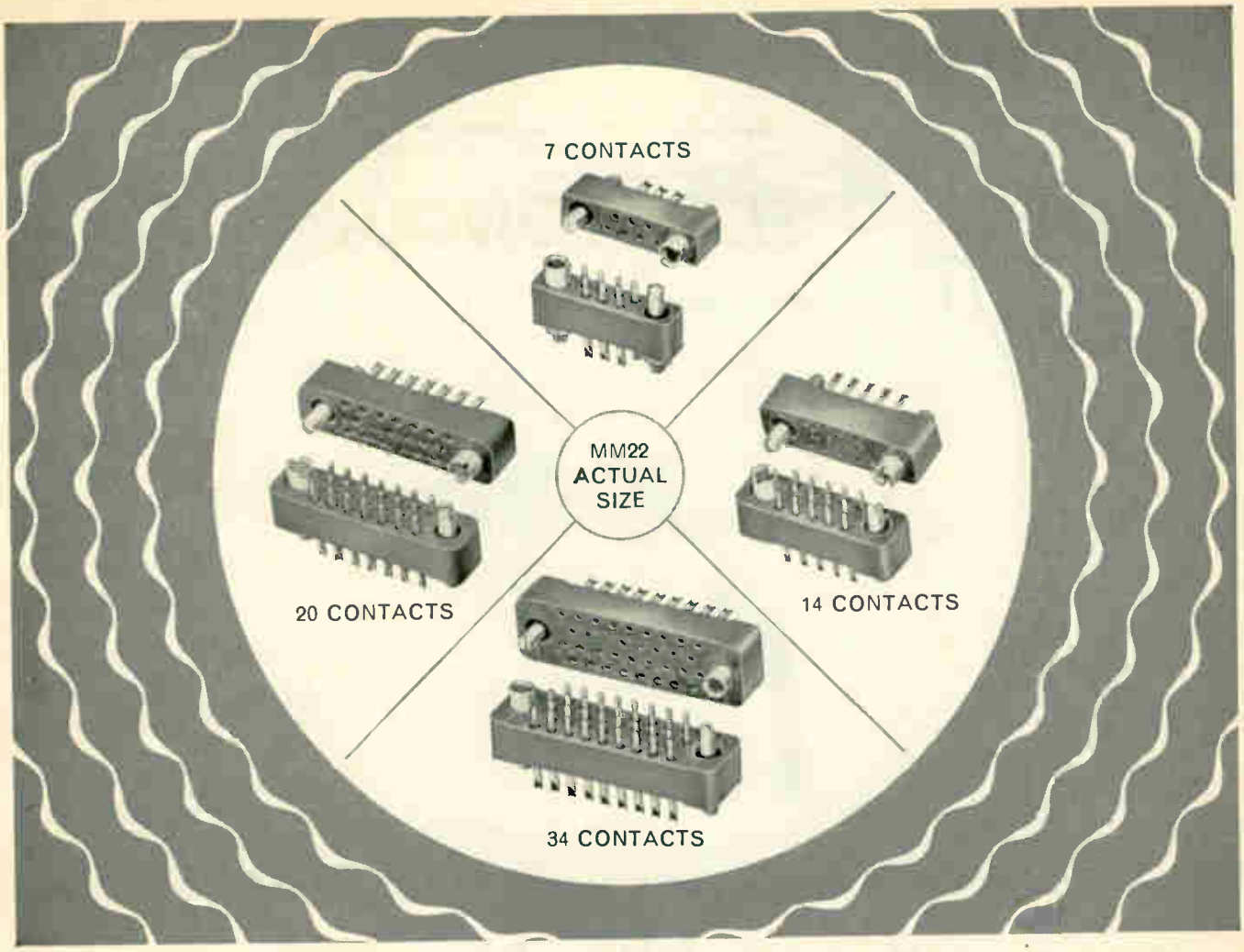


MEV 106



THESE 'LITTLE GIANTS' WITHSTAND SHOCK AND VIBRATION

Micro-Miniature Ruggedized Continental Connectors

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- Available with 5, 7, 9, 11, 20, 26, 29, 34 and 44 contacts
- Reversed guide pin and socket for positive polarization
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Continental Connector's Series MM22 precision micro-miniature connectors simplify interconnection of compact sub-assemblies where space limitations demand the smallest components and highest reliability.

ELECTRICAL AND MECHANICAL RATINGS

Voltage Ratings:	Breakdown	Recommended Test
At Sea Level	2400V. RMS	1600V. RMS
At 70,000 Ft.	650V. RMS	425V. RMS

Current Rating	3 Amps
Minimum Creepage Between Contacts	1/16"
Minimum Air Space Between Contacts	.040"
Contacts, Center-to-Center	3/32"
Pin Diameter	.030"
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Technical data sheets on micro-miniature and other Continental Connectors are available on request. Specify your requirements to Electronic Division, DeJUR-AMSCO Corporation, 45-01 Northern Boulevard, Long Island City 1, N. Y. (Exclusive Sales Agent.)

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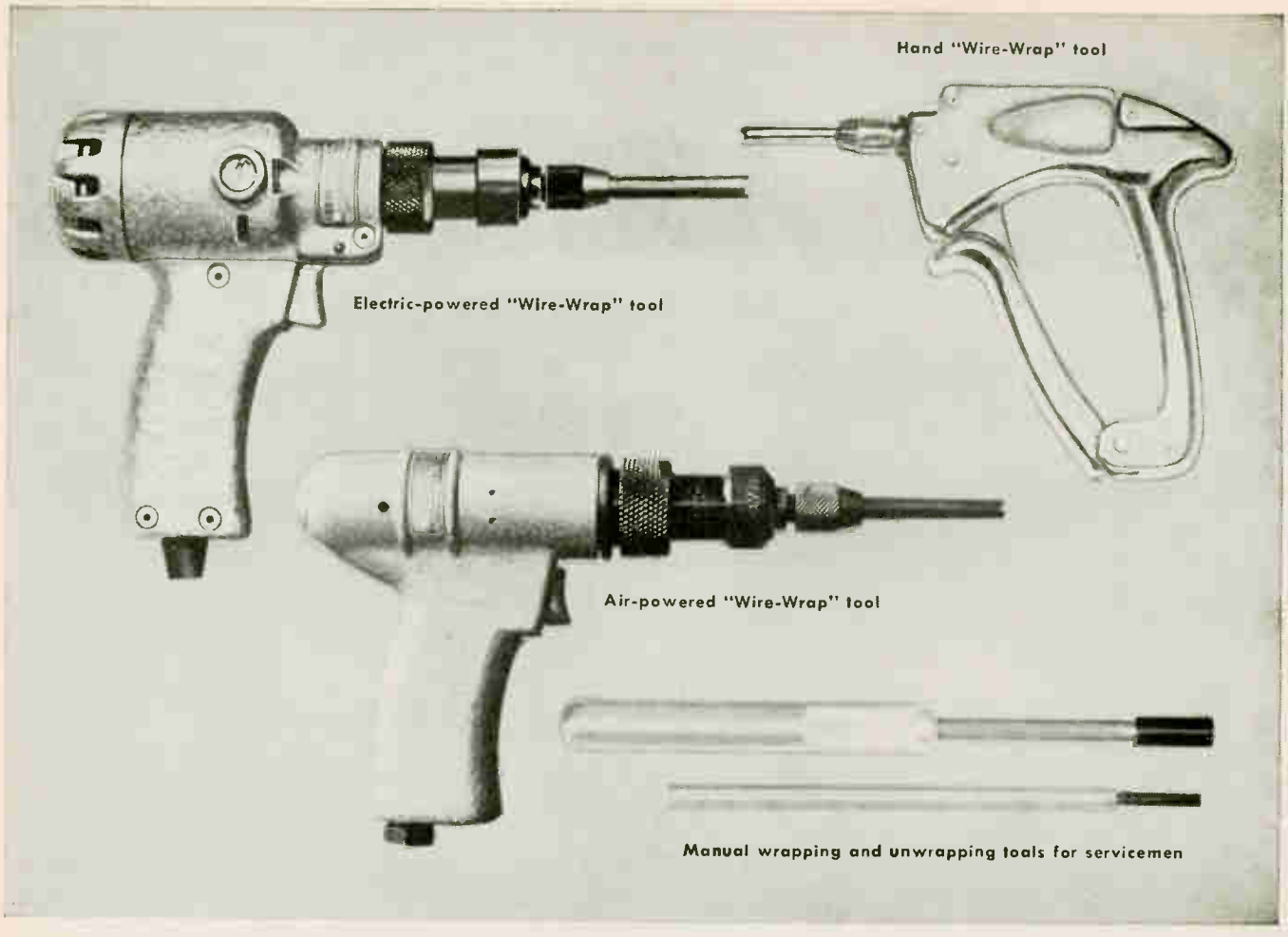

Gardner-Denver Wire-Wrap® roundup

Choose from Gardner-Denver's complete line of hand-held "Wire-Wrap" tools and put your electrical connections on a 3-second production schedule. That's all the time it takes to make a permanent electrical connection using the solderless wrapping method.

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automatic "Wire-Wrap" machines like the one at right. If you have a special problem in multiple operations of connecting wires, it'll pay you to see Gardner-Denver first. Want details? Write for bulletins.

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one man gang

- 30 G TO 5000 CPS VIBRATION IMMUNITY
- 100 MW. SENSITIVITY
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- DPDT (POLARIZED)
- −65°C. TO +125°C. OPERATING TEMP. RANGE
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The problem some people have is finding a good subminiature "on-off" relay that will work in *their* circuits — e.g., if it's really subminiature and sensitive enough, it won't take the surrounding vibration or shock . . . or it may work under 30 g's to a couple of thousand cycles, but only on watts instead of milliwatts. Worse still, the relay "works" but not according to its specs, resulting in real system troubles. The possible combinations and permutations of these individual requirements can grow to agonizing proportions.

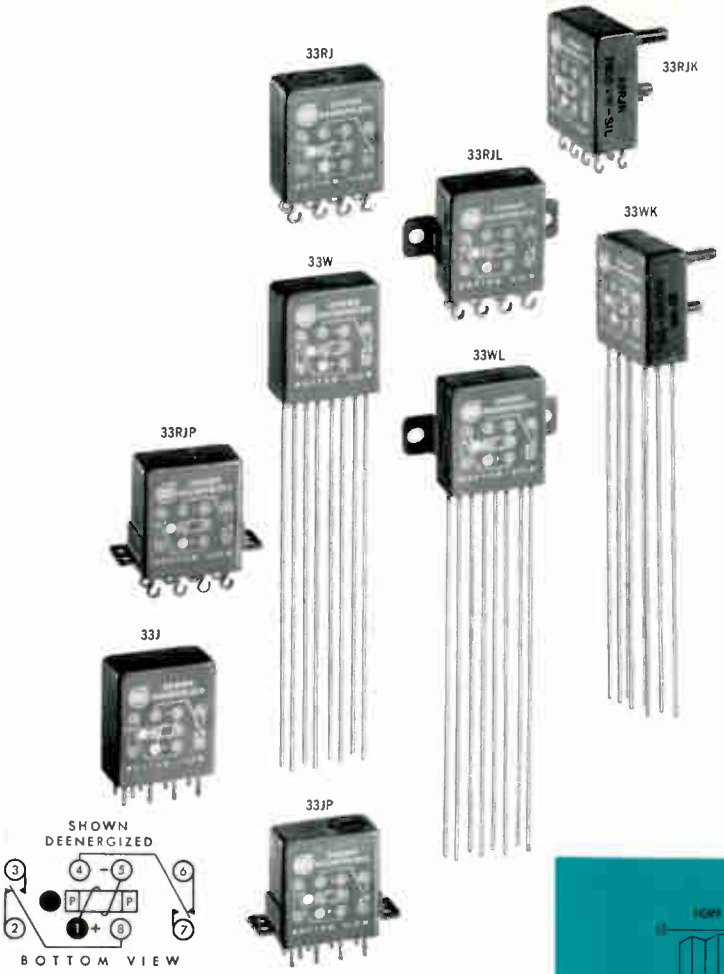
Here is a relay designed to tranquilize such agony. There is plenty of built-in safety margin to guarantee that it will work according to *all* the ratings published here, without any fudging. Power drain and heat dissipation are kept to a minimum by the small power requirements of the "33". And you *don't* have to give it more than the rated 100 mw. required, to be sure that it will always work. Calling it a "gang" may not be dignified, but if these are the specs you need in *one* relay, dignity is the least of your problems. The official designation is the Sigma Series 33.*

(See reverse side for major specifications)

SIGMA

SIGMA INSTRUMENTS, INC.
14 Pearl Street, So. Braintree 85, Mass.
AN AFFILIATE OF THE FISHER-PIERCE CO. (Since 1939)

* This *isn't* the magnetic latching member of the family — that's the Series 32.



PERFORMANCE

Sigma Series 33 Subminiature Relay

(See reverse side for basic design & application data.)

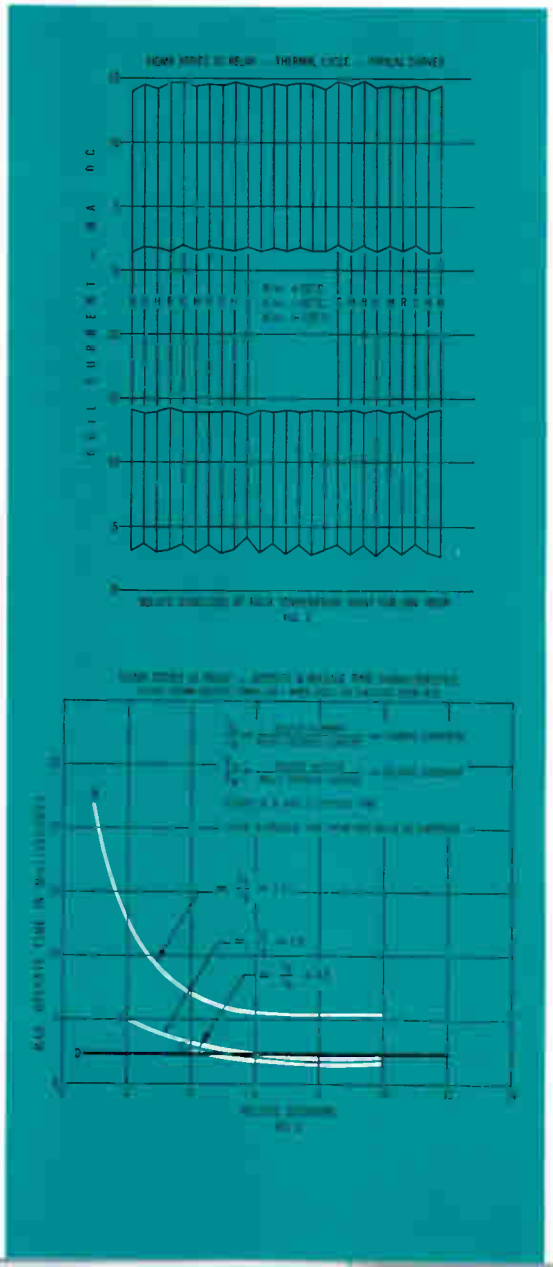
SIGNAL "INPUT"—SWITCHING "OUTPUT" The "33" is a DPDT polarized relay with magnetic bias (Sigma Form Y): when the coil is abruptly energized by a signal of given polarity and sufficient magnitude, the armature transfers from its normally-closed position to its second position; signal removal returns the armature to original position. Required energizing power is 100 mw. (VG Adjustment), or 200 mw. (VW Adjustment). Contact load rating is 2 amperes at 28 VDC/120 VAC (resistive) for 100,000 operations minimum at +125°C., max., with standard silver contact material; gold alloy contacts are recommended and available for dry circuit applications. Contact resistance is 100 milliohms, max., after 100,000 operations at rated load.

ENVIRONMENTAL CAPABILITIES The "33" will not open its contacts, whether energized or de-energized, at 30 g to 5000 cps vibration or under shock and constant acceleration of 70 g for VG Adjustment, 100 g for VW Adjustment. All ratings apply over an operating temperature range of −65°C. to +125°C.

TIMING CHARACTERISTICS AND THERMAL STABILITY of the relay are shown in the graphs, Figs. 1 and 2.

MOUNTING STYLES, CONNECTIONS, MECHANICAL DATA All series 33 relays are hermetically sealed in enclosures 0.80" x 0.40" x 0.90" high. Weight is approximately 18 grams, depending on mounting style and connections. Mounting styles available as illustrated: flange, side bracket or stud; connections: J-hook solder terminals, 9-pin plug-in or 3" wire leads. All connections spaced on 0.200" grid.

FOR FURTHER INFORMATION AND APPLICATION ASSISTANCE . . . write to Sigma, outlining in as much detail as possible your application, the relay driving and load circuits, and the required speed and rate of operation. We can then help you get the relay performance you want.



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MICROMINIATURIZATION

By M. M. PERUGINI, Associate Editor, and NILO LINDGREN, Assistant Editor

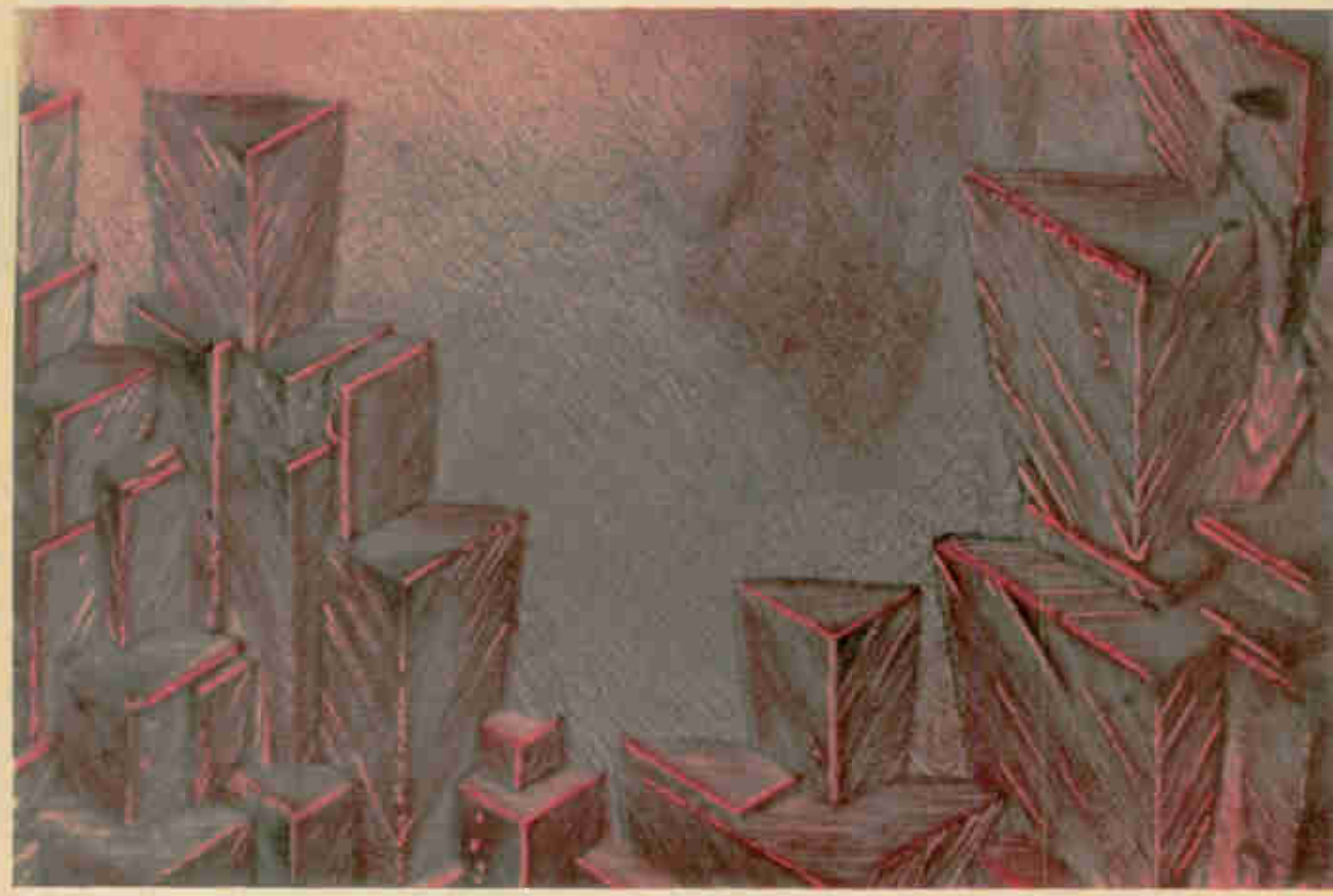


Photo shows vapor growth of silicon crystals (IBM)

Component-Oriented Approaches

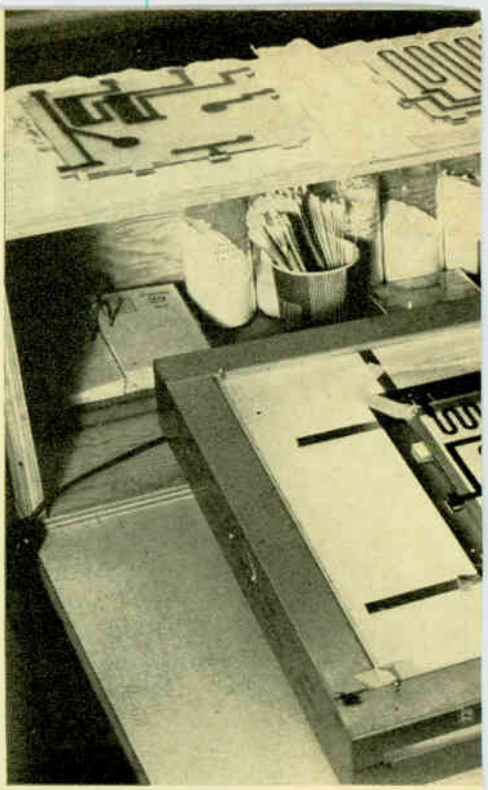
New Form Factors

Circuit-Oriented Approaches

Function-Oriented Approaches

Equipment and Systems

INTRODUCTION



Microminiaturization seems to be the answer to the next generation of engineering developmental problems—it promises high reliability, eventual low cost, and reduction in size, but much of this promise is yet to be realized

FOR SEVERAL YEARS there has been much discussion of the need to make electronic components, circuits and systems orders of magnitude smaller. Many new names have been attached to techniques of making them smaller, but the name that seems most likely to stick is microminiaturization.

Microminiaturization is not aimed at size reduction for its own sake[1]—rather, small size is inherent in solid-state technology, and solid-state technology plays a key role in present engineering development work.

However, there are also good arguments for size reduction in itself. Because today's systems have grown so fantastically complex, composed of increasingly large numbers of components, the reliability of these systems has become increasingly important; despite the fact that individual components are being produced to more stringent reliability standards, this greater component reliability has not offset the increasing probability of system breakdown. Various forms of microminiaturization promise greater inherent reliability, but to achieve this promise, a significant research and engineering development program is necessary. The electronics industry is now engaged in this program.

In many cases, the predicted inherent reliability of microminiaturization has not yet been proved. It is still too early. However, on the grounds alone that electrical components and systems can be made significantly smaller than existing components, it is argued, redundancy can be built into systems without any increase in overall system size, and this redundancy will increase reliability.

There are arguments against this stand—for instance, methods for switching standby circuits into action may be less reliable than the redundant circuits. Nevertheless, industry at large is convinced that microminiaturized systems will be more reliable.

EFFECTS ON INDUSTRY—Eventually, microminiaturized components, circuits and systems should cost less, because many microminiaturized forms lend themselves to automation and regularized fabrication techniques. However, the initial cost outlay to develop techniques and equipment is large. In many cases, only large companies have the capital to make such outlays.

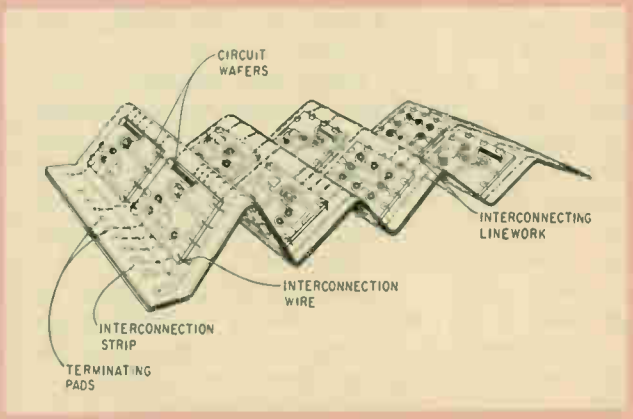
Some idea of the cost of getting into microminiaturization is given in a Navy report[2]: "As a very general guide line . . . it appears that small but meaningful research projects can be established for about $50,000 to $100,000 per year (2- to 4-man effort); experimental device development and application projects will cost between $200,000 and $500,000 per year; and the development of prototype equipment for an average sized system may run from $500,000 to $1,500,000 per year."

As more advanced microminiaturization methods take hold, the impact of microminiaturization on industry will be tremendous. From the same report quoted above:

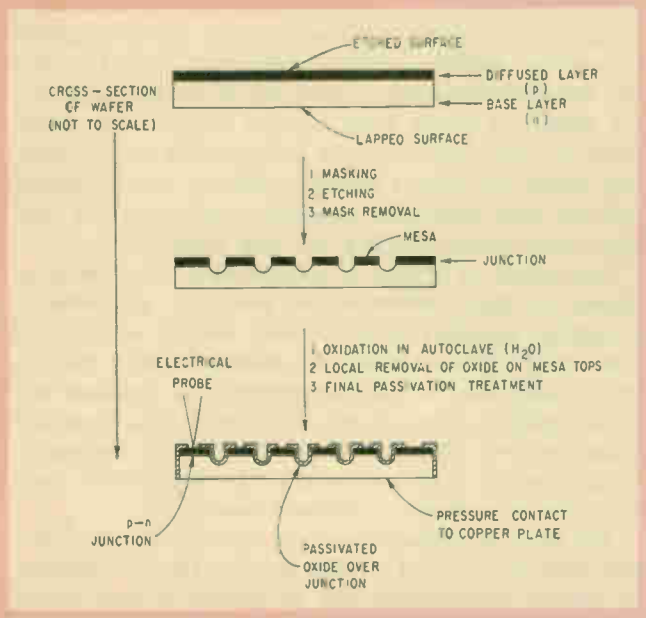
"The impact of microelectronics on the electronics industry, generally, is likely to be a profound and basic one. Its effects are not limited to a small class of devices but strike at the underlying manufacturing, fabrication, and assembly processes of electronic circuitry. The necessity of participating in this evolution is fully realized by both the industry itself and by cognizant government agencies. Even at present, with only vague lines of application apparent, the total investment in developing microelectronics is conservatively estimated at upward of 100 million dollars, of which at least 20 to 25 millions are directly furnished by government support."[2]

GENERAL APPROACHES—Microminiaturization is taking many forms . . . almost as many forms as there are companies engaged in this work. Naturally, as in any new field, clear lines of direction are not yet evident, concepts have not yet fully crystallized; and considerable effort goes into defining and categorizing, and into inventing trade names, often as not for products not yet fully developed; in the early stages of microminiaturization, this tended to create confusion. In this survey, we are

Photographic techniques: Microcircuit layout is a two-layer plastic tape pattern on two transparent plastic wafers. The two wafers with patterns are photographed down to actual size. (In the case of Sylvania, shown here, final wafer size is ½ inch square.) Two photographic negatives are produced, one with the conductor pattern and the other with the vacuum-deposition mask pattern through which films will later be vacuum-deposited

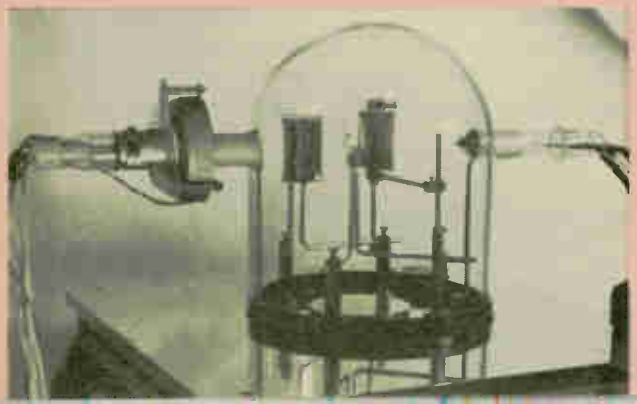


Novel packaging and interconnection schemes are being explored throughout the industry. Here is an experimental design by Arma for its guidance computer with circuit wafers mounted on flexible interconnection strip that is folded accordion-fashion into housing



Surface Passivation: If there can be generated on the semiconductor surface a strongly bound chemical film layer that does not adversely affect surface electronic properties, and which leads to acceptable device characteristics, then hermetic sealing will not be required. Here, PSI's technique of surface passivating a mesa diode is indicated. Process involves substitution of various organic groupings into structure of oxide film, since oxide films alone have been found inadequate

Sputtering: Metals may be vacuum-deposited on ceramic substrates by sputtering. Metal to be volatilized is made the cathode, and substrate to be coated is placed near and parallel to cathode. Grounded chamber is anode. After evacuation, high voltage is applied between the electrodes, and metal emitted from the cathode splatters onto substrate. Photo is from Bell Labs



Electron and ion beam processing: Entire microelectronic circuits on semiconductor or other substrate materials can be produced by sequenced ion or electron-beam cleaning, heating and surface alloying operations and evaporation procedures in high vacuum. Equipment here is used by CBS Labs. Inside bell jar is a fixture for holding the semiconductor crystal, evaporation sources for the deposition of surface layers and the two electron guns, one for large-area cleaning and heating and the other for fine-spot heating up to alloying temperatures. Electron-beam processing promises high resolutions

starting with those approaches which, because they are relatively modest extensions of the state-of-the-art, have already been well-developed and are being applied, and follow with those approaches whose inherent sophistication requires greater development time—from a few years up to a decade or more.

Component oriented: Includes tighter packaging techniques using conventional components, miniaturization of conventional passive and active components, and miniaturization of hardware accessories.

New form factors: These are essentially component-oriented approaches, in which all components have a common form, such as shape, area or thickness.

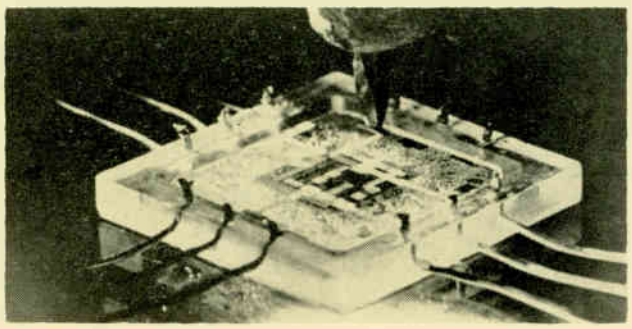
Circuit oriented: Substrates containing circuits and subcircuits. Usually a one-to-one correspondence between circuit diagram and substrate elements. Generally, these are thin-film approaches.

Function oriented: Those approaches in which a single piece of semiconductor material is altered to get the desired functions. Includes approaches in which there is little correlation with conventional circuits.

Microminiaturized systems are discussed last.

GENERAL PROBLEMS—Approaches using individual components have the immediate advantages of not requiring large-scale developmental effort and of providing high production yields. Even with new form factors, where relatively more development is required for perfecting reliable components, smaller companies can be readily geared into production programs. But, component-oriented approaches yield lower packing densities than other methods and the number of interconnections required is high.

Circuit-oriented approaches, those that place circuits or subcircuits on a single wafer, feature high space efficiency, fewer interconnections and, generally, fewer processing steps. Whole circuits can be placed in a protective environment, and deposition methods can achieve better connections than those possible with soldering and welding. Before these advantages can be fully realized, however, adequate encapsulation procedures must be developed and stability of components and quality of the circuit must be assured. Subjecting each wafer to an entire series of process steps may decrease yields.



Thermal compression bonding: Wires or ribbons as thin as 0.0003 inch can be bonded to metallic films as thin as 200 A in an area of 0.001 inch diameter with thermal compression bonding equipment. Such bonds, which have been found exceptionally reliable, are also used for attaching active devices into thin-film circuits, as in the IBM multilayer thin film circuit above

Function-oriented devices offer a significant weight and size reduction when compared to other techniques. Reliability of these devices should increase as connections are reduced and as surface protection techniques are improved. Actual producibility of wider classes of functions must be proved before these solid-state devices become satisfactory design tools. Economic production of these devices will not be obtained without further extensive research into techniques and materials.

Problems common to all microminiaturization methods have to do with heat dissipation, interconnections and signal interactions.

Because system packages are getting smaller and more tightly packed, it is difficult to remove the heat generated internally. This problem may be overcome by keeping signal levels low, designing more efficient devices, developing devices with low quiescent power and using heat exchangers.

As the size of components and circuits decreases, interconnections require a greater proportion of total space; less and less surface area is available for interconnections, yet input and output leads are still required. To solve these problems, designers are using flexible printed wiring, multilayer printed wiring, multilayer welded wiring matrices and multilayer deposited connections. In one case, even optical coupling has been proposed.

The means of making interconnections is presently a subject of much debate in the industry. Over thirty companies are using or investigating welding as an interconnection method. Other manufacturers insist that in many cases, such as when components are mounted between printed circuit boards, soldering is the most reliable method. The Air Force is currently making a comprehensive investigation into the applicability and reliability of welding in electronic systems[3].

The small separation of signal carrying paths in microminiature devices and circuits requires special attention to contact arrangements and geometries as well as to interconnections and high-frequency shielding[4]. Even conventional circuits must often be redesigned.

In the scaling down in size of electronic components, large values of inductance and capitance are hard to obtain. These problems are being circumvented by designing circuits that do not require such large values. Research is going into new methods of making inductors and capacitors with semiconductors and thin films.

Many manufacturers produce active devices mounted in microminiaturized hermetically sealed cans; but now controversy centers on the standardization of the size and shape of these cans. Efforts to reduce size even further by surface passivation techniques are being pursued; diodes have been successfully surface passivated. Transistors, apparently, still present some problems.

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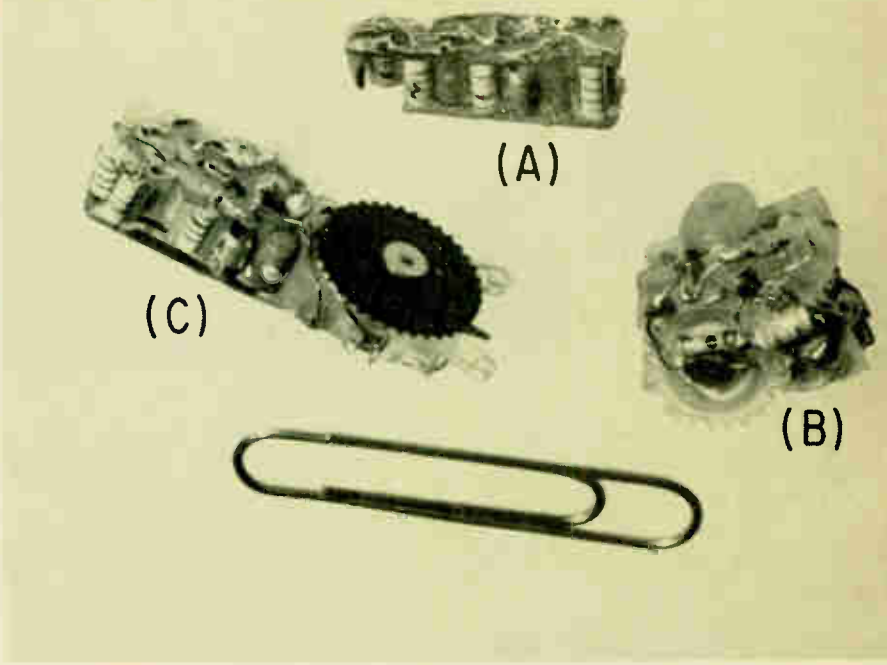
(4) W. W. G. Gärtner, Integrated Circuitry, Micro-Miniaturization and Molecular Electronics, *Semiconductor Products*, 2, No. 12, Dec. 1959.



Transistor amplifiers with three (A), four (B) and five (C) transistors are used in Dictograph's Acousticon hearing aids

COMPONENT-ORIENTED APPROACHES

Equipment and system builders must make use of presently available components, yet their approaches must be flexible enough to incorporate advances in all other fields of microminiaturization

SYSTEM PLANNERS today cannot wait for breakthroughs in microminiaturization to help them solve their problems. Systems must continue to be designed, and they must be built with available components. Such systems should have the flexibility to incorporate advances in components and other fields of microminiaturization. Approaches having these capabilities and some of the conventional components used with these approaches are covered in this section.

WELDING APPROACH—A recent trend in system packaging is to use welding for interconnections. The high-density packaging technique shown in Fig. 1 features an overall package design based on a specific study of the system to be miniaturized. The technique uses encapsulated throw-away elements composed of mutually supported components connected by resistance-welded conductors. Multiple layers of encapsulated interconnecting or back panel wiring interconnect modules.

In the encapsulated elements, most of the components are arranged with their leads parallel to each other and with their bodies packed closely enough together to provide mutual support. Mylar film with accurately punched holes for locating each component lead are used at both ends of the components. Long components are turned on their sides and their leads welded to wires parallel to the rest of the component leads and extending through the positioning films. To make circuit connections, nickel or copper ribbon is welded to the component leads directly above the positioning film. In circuits requiring a large number of connections two levels of wiring are used. Prewelded wire matrices may be used for one or both layers of wiring.

Heat-producing components are cemented in aluminum heat-transfer blocks. These blocks provide a conductive path through the potting compound to the surface of the elements. Heat is picked up at the surface of the element by aluminum foils located between the elements. These foils are connected to the frame of the assembly or to cold plates that can be cooled by air or by other means.

An encapsulated wiring module interconnects the elements by wire-wrap terminals. (For applications where modules will not be disconnected more than 4 to 6 times interconnections are made by welding.) The wiring module also serves as a termination for cables to other parts of the system. The wiring module is a multiple pin, female connector with self-contained wiring. The self-contained wiring has prewelded metal ribbon ma-

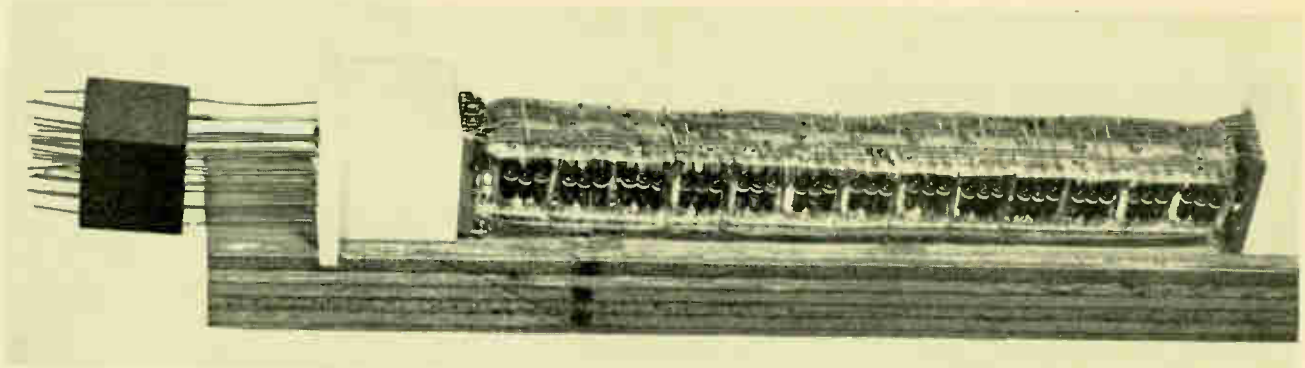
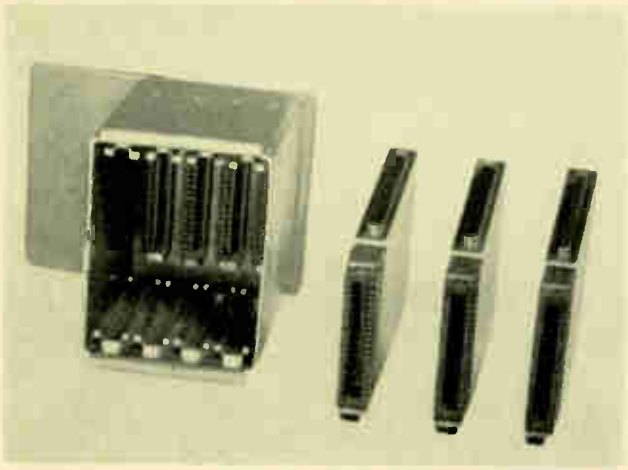


FIG. 1—Unpotted logic stick from Polaris FBM Guidance Computer uses packaging technique by Francis Associates. Unit was built by the Sippican Corporation for MIT Instrumentation Laboratory. Computer has a total of 54 sticks



Application of Amphenol's Micro-Min connectors in a modular package. Plug-in boards have component mounting area of 1 × 1 in.

trices laid between the terminals. These matrices are stacked one above the other within the connector.

Cable connections to other units are handled in two ways. One technique is to lay single conductors from a flat cable in the same channels occupied by the nickel ribbon matrices and to provide a grommet or cable clamp where the cable leaves the encapsulated module. A more flexible method uses nickel ribbon matrices to carry the signals to the outside edge of the wiring module where a second set of wire-wrap terminals connects to a matrix wiring unit.

This matrix wiring unit permits connections to adjacent units of a similar design without previous knowledge of the exact signal termination at the pins. If certain interelement connections are carried to this unit, a change in the interelement wiring may be accomplished by replacing the matrix wiring unit rather than the wiring module.

Since the elements possess high compressive strength and have rectangular form factors, they are normally designed with a mounting hole in the center for stacking. Stacks of four to nine elements are pulled in compression between plates by a stud through the mounting hole. These element stacks may be tied into a frame structure composed of aluminum plates, cold plates or honeycomb panels, depending on the size of the package and the thermal requirements.

Based on welding experience in vacuum-tube production, it is estimated that in assemblies each containing 700 welds, only 1 in 10,000 assemblies will be rejected because of bad welds.

CHIP APPROACH—The Macro-Module concept is said to miniaturize complete systems in such a way that problems of interconnection, heat, service, component availability and continuous updating are easily solved. Three features of the concept are: use of available components; constructing circuits in two dimensions, the system in the third; and including the heat exchanger within the construction. Advantages include: reduced bulk and weight, reduced wiring length and increased mechanical strength. Finally, the technique simplifies shipping, handling, maintenance and repair.[3]

The chip is the basic component of the Macro-Module. It contains the smaller elements—resistors, transistors, capacitors—shown in Fig. 2 in the circuit pattern.[4] These chips are integrated into the complete system as shown in Fig. 3. Progress in miniaturization of the chip will occur as advances are made in component miniaturization.

MULTIPLE APPROACH—One manufacturer has approached the packaging problem by two techniques: the multilayer laminate and the welded module.[5] Multiple circuits used with multilayer circuit boards eliminate receptacles and increase the number of intraconnections that may be made in the board.[6] Figure 4 is the top view of a high-speed computer multiplier using this technique. The figure shows the in-line attachment of the individual modules to the multilayer circuit board. A transparent view of the multilayer board (Fig. 5) shows the many layers of wiring available for circuit intraconnections and interconnections. A module is removed by heating each pin with a soldering iron and blowing the molten solder away with air. This can be done many times without damaging the laminate material. Elimination of connectors is one of the advantages of this technique.

The welded module allows much higher density than that obtainable with conventional two-dimensional construction. This method permits superior thermal cooling because liquid or forced air circulation can be used. Elimination of solder joints and their problems offers

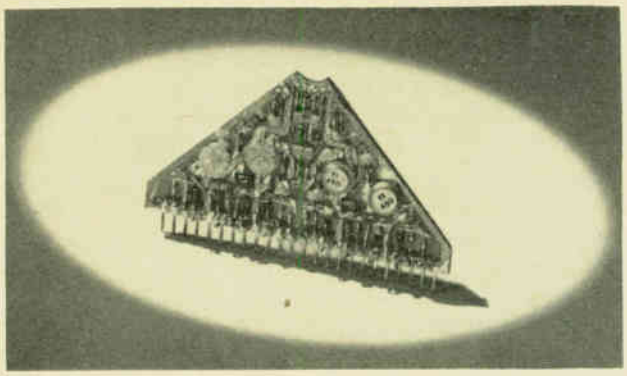


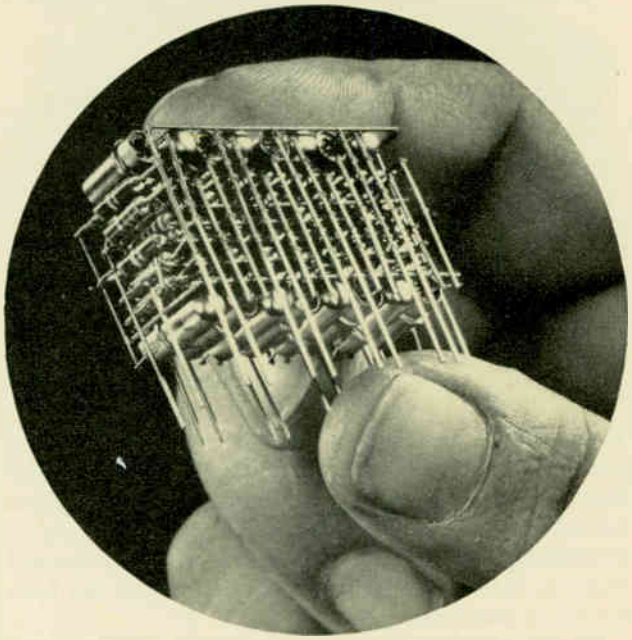
FIG. 2—Burroughs chip contains two flip-flops with a total of 52 components. Transistors marked TI 450 are 0.180 in. in diameter

another advantage. [7,8] In addition, thermal damage to semiconductors is eliminated.

Welded construction provides a flexible technique for interconnecting purchased components in a minimal volume, the limiting factor being the geometry of the components. Modules so constructed are usually restricted to use where a throwaway maintenance concept is dictated, since repair is difficult and often impractical.

CUBES—Republic Aviation's Missile Systems Division is manufacturing digital circuit elements in cube-shaped encapsulated modules. Interconnections within the module are accomplished by using two printed-circuit boards between which conventional pigtail components are mounted. Duplicate circuits on board surfaces of each printed-circuit board and plated-through holes are provided to improve reliability. Soldering is by flow-solder techniques. A thin rubber coating on critical components prevents damage from differences in expansion coefficients. Modules are molded in filled epoxy. Component leads are brought out on a 0.025-in. grid for module connections. Multilayer circuit techniques permit tight packaging of the modules. Conventional printed-circuit techniques can also be used.[9] Among others, Diamond Ordnance Fuze Laboratory and Harman-Kardon are using techniques similar to Republic's.

OTHER PACKAGES—Amp, Inc., provides, under the



Litton's flip-flop module shows application of welding to interconnections

name MECA, plastic cells for modules.[10] These cells have interconnection clips in the cell walls. Chips, wafers or standard components can be mounted within the cells. Cells are plugged into special mounting boards. The MICRAM approach, a joint venture of Aerovox, Cleveland Metal Specialties, Pacific Semiconductor, Raytheon and Sylvania, packages microminiaturized individual components in standard modules or in special modules to meet specific customer needs.[11] Cambridge Thermionic Corporation is producing input-gate, bistable-multivibrator and level-trigger modules operating at 10 Mc. Representing a compromise of speed and reliability with cost and size, the units have a form factor of 0.75 in. × 0.635 in. × 0.75 in. They have been subjected to extensive testing—reliability checks on the multivibrator indicates a 0.7-percent failure rate per 1,000 hours at

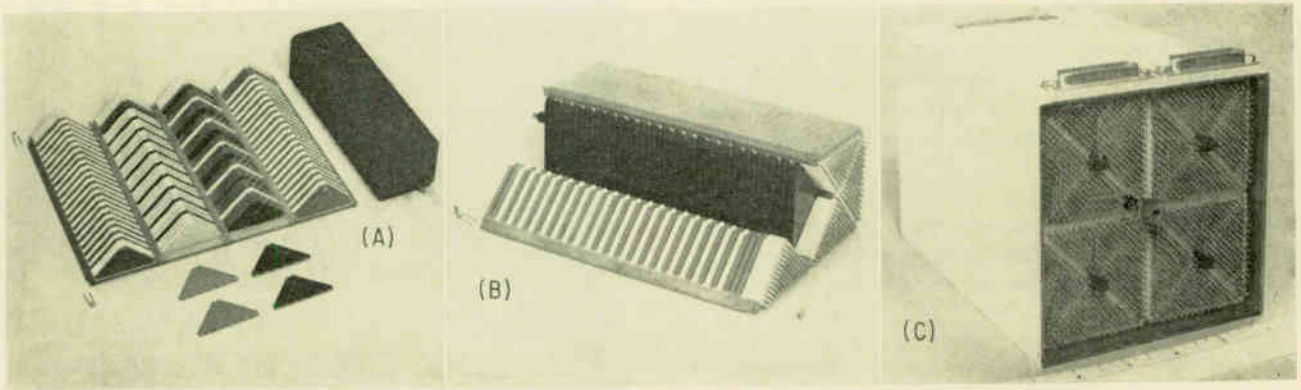


FIG. 3—Assembly of plug-in chips (A) is folded to enclose heat exchanger (B). Resulting modules are interconnected to form system (C). This technique is being used to build a digital differential analyzer (Burroughs)

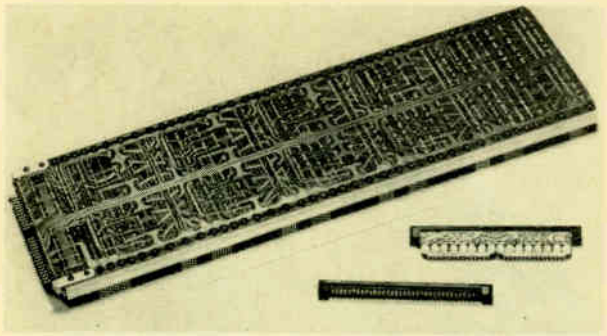


FIG. 4—High speed multiplier showing typical Litton Systems module. Unit shown contains over 4,700 components, including 2,000 diodes, in 43 modules

90-percent confidence level. Packing density is in the order of 400,000 to 500,000 components a cubic foot.[12]

COMPONENTS—The components in these packaging systems are getting smaller. Practically all the major transistor manufacturers have introduced miniaturized devices. A subcommittee of the EIA is attempting to establish geometries for both semiconductor and passive elements, hoping that these geometries can be the basis for future standards.[13]

Recent advances in the semiconductor field include Motorola's use of a thin organic film to protect semiconductors and the development of epitaxial transistors. Dendritic crystal growth and applications of tunnel diodes are other areas of interest. Some manufacturers are providing uncased transistors for thin-film approaches. The outlook for making active elements using thin-film techniques is discussed under circuit-oriented approaches.

An example of smaller components are microdiodes and microtransistors. Figure 6 shows use of these devices in various methods of miniaturization. Pacific Semiconductors Inc. has recently completed life test on microdiodes made over a year ago. Results of 8,000-hour tests show that during the first several hundred hours the failure rate is relatively high but decreases to a constantly low level for the rest of the test. These higher initial failures are now being eliminated by a 200-hour 200 C burn-in period on all units.

Failure rate for these surface passivated diodes in storage- and operating-life tests are low. Rates vary from 0.01 percent per 1,000 hours to 1 percent per 1,000 hours depending upon the test and the definition of failure.[14] Although these figures give some indication of the reliability of surface passivated diodes, there is no comparable data on surface-passivated transistors. It will be a year or two before there will be enough data on surface passivated transistors to establish any significant reliability figures.

Work is progressing in miniaturizing other components. Though these devices may seem large when compared to other miniaturized components, they represent effective use of volume for the job they must do.

INDUCTORS—Obtaining high values of inductance in a small volume is a difficult problem. Shielded r-f chokes 0.375 long with a 0.157 inch diameter cover a range of 0.01 to 56,000 μh. The small size results from reducing the size of the core walls (Fig. 7), using different magnetic materials and by employing a duo-lateral winding technique.[15] The manufacturer of these inductors is tooling up to make inductors ranging to 0.1 henry in a 0.310-inch long by 0.125-inch diameter package. These units will use 1-mil wire for core windings. Theoretical analysis for still smaller devices has been completed. If these are practical to manufacture, they will have half the volume and twice the range of the 0.310 by 0.125-in. units.

Research by Varo Mfg. indicates the feasibility of making transformers and other inductive components by vacuum deposition.[16] Pinhole-free dielectrics can insulate winding from magnetic materials, making possible closely coupled yet well insulated conducting films. One experimental deposited transformer has aluminum film windings of 150 ohms resistance and a measured inductance of 1 mh. Although Varo claims no conclusive results, increased research effort in this field seems warranted. The method outlined in Fig. 8 is used to obtain thin-film inductors.[17]

Many attempts are being made to develop practical semiconductor inductors.[18,19,20] These inductors can be used as components or can be integrated into the function-oriented approaches. Another approach to the inductance problem is to redesign circuits to eliminate the need for an inductive element.

MEMORIES—A significant reduction in the volume of memory systems using ferrite cores can be achieved by using continuous wire drive lines through memory planes and then folding the planes. General Ceramics claims a memory stacked in this manner will occupy as little as 2 percent of the volume of its conventional counterpart.[21] A prototype of twelve 16 × 16 planes, along with the heating element and controls needed to keep temperature of the cores constant, measures 2 × 2½ × 2½ in. Operating range is from −55 C to 125 C.

Other attempts being made to reduce memory size include the use of ferrite planes, thin films, twistors and

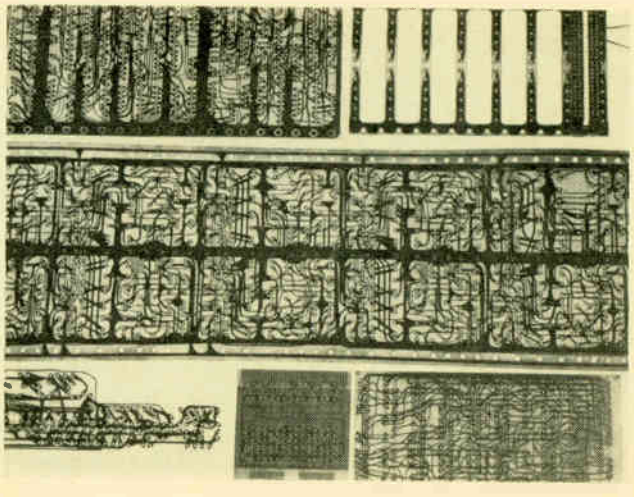


FIG. 5—Transparent view of Litton Systems multilayer boards shows how this method makes connections

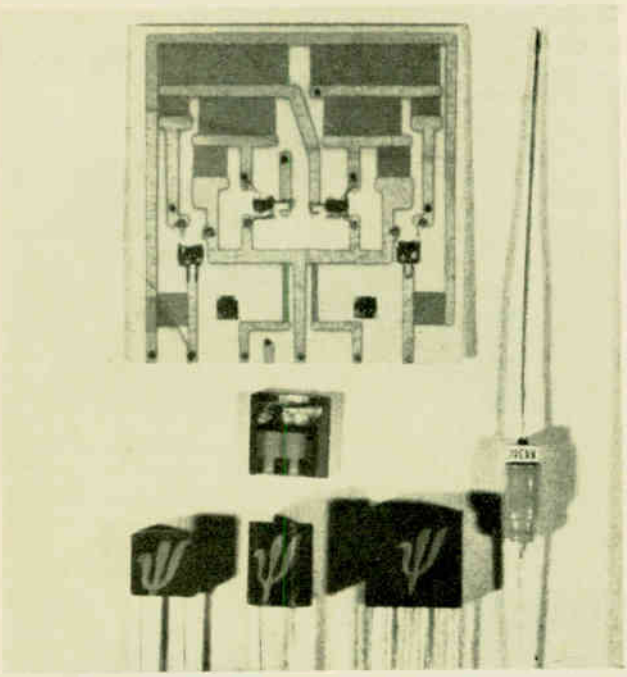


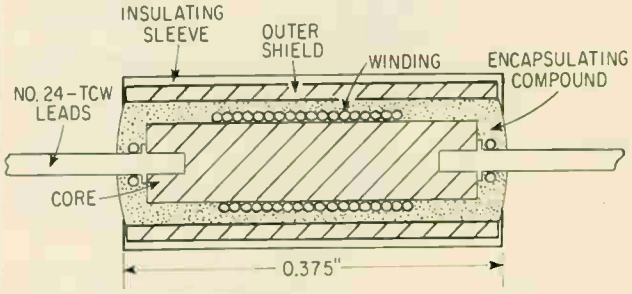
FIG. 6—Applications of microactive devices include use in Varo flip-flop (top), an IRC NOR gate (center) and PSI modules (bottom). Conventional diode is on right

cryotrons. One company is investigating the use of silicon whiskers measuring 1 mil in diameter by 10 mils long in a solid-state memory plane. Plans are to use these whiskers to form such circuit elements as linear resistors, capacitors and active devices such as tunnel diodes. The planar array shown in Fig. 9 will be used to stack these elements.[22]

Circuit properties of these elements will be fed into a conventional computer. This computer will determine the interconnection scheme for a specific memory plane using the elements. A mask of these interconnections will be made by photolithographic techniques.

DELAY LINES—A delay line that makes use of the relatively good dielectric properties of many ferromagnetic materials to provide capacitors is under development. A section formed from a ferrite disk is illustrated in Fig. 10A. The print wiring is equivalent to a toroidal winding while the capacitors consist of the opposed metalized areas displaced by the thickness of the disk. In another approach miniaturized inductors are combined with two dimensional capacitor strips made from thin copper-clad Teflon. Overall dimensions are then governed almost solely by the total size of the inductors (Fig. 10B). The ultimate in this approach (Fig. 10C) is where inductors and capacitors are etched out of copper-clad Teflon. Sections may be arranged in linear fashion (potted dimensions for the 10-nanosecond, 50-ohm, 80-Mc delay line of Fig. 10C are 5 × 1.5 × 0.1 in.) or stacked module fashion with thin ferrite shields between them. The manufacturer is also working on an approach to miniaturize long audio delay networks by using the apparent inductance of thermistors.

Wire sonic delay lines by GE presently have a maximum bandwidth of 1.25 Mc. Delay lines operating at one megacycle have been packaged in units as small as



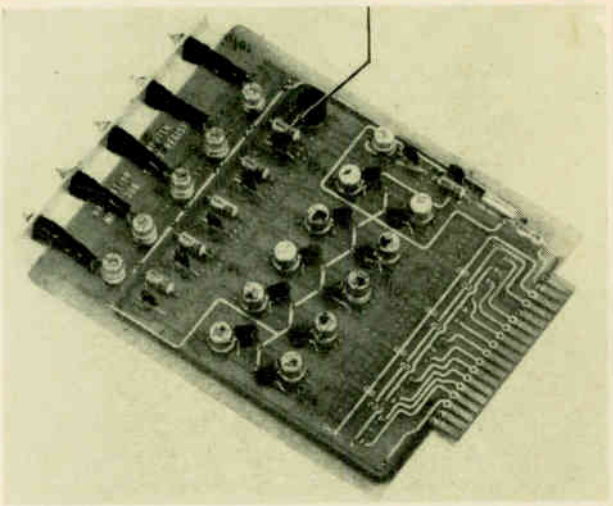
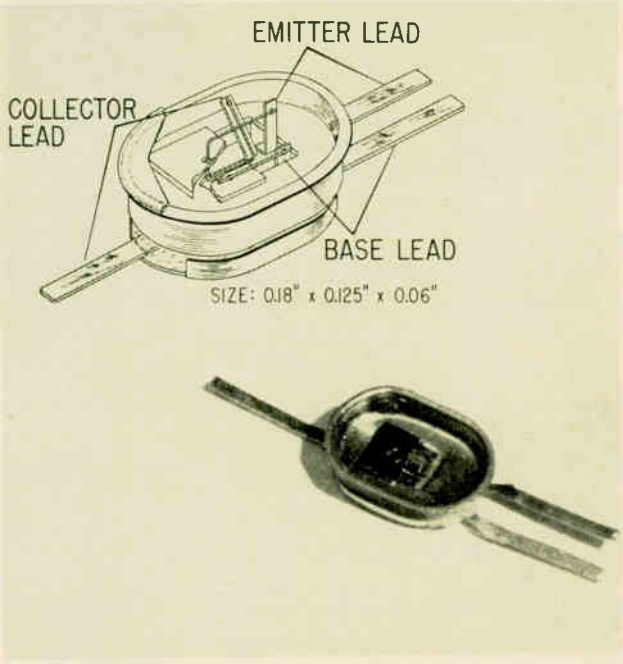


FIG. 7—Cross-section shows construction of Nytronics shielded chokes which are mounted on printed circuit board for Navigation Computer's Model 308 shift register



Lower portion of Philco's small transistor package is a metallic base plate and a rounded rectangular cup separated by a layer of glass. Leads are metal strips 0.003 inch thick imbedded in glass. Top plate is cold welded to flange, forming hermetic seal

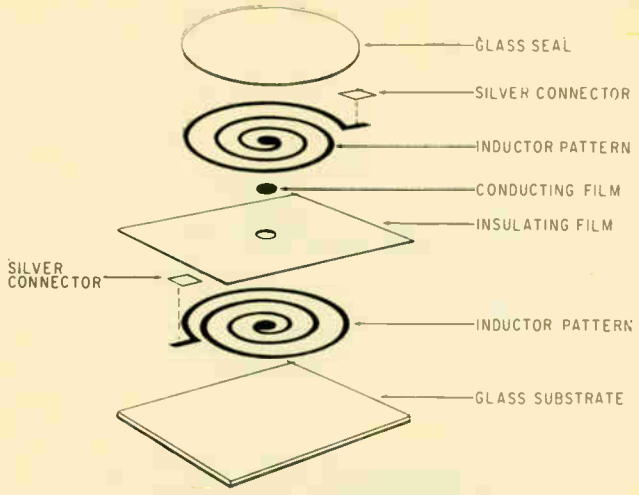


FIG. 8—Thin film techniques by Intellux make possible multilayer inductors. Alternate layers of right and left hand spirals are separated by insulating films

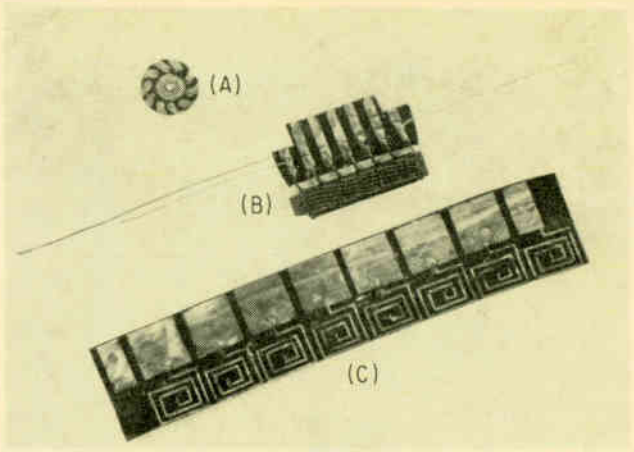


FIG. 10—Examples of delay line construction include: Ferrite section (A), h-f line with printed capacitors (B) and printed h-f delay line (C) (Richard B. Brew & Co.)

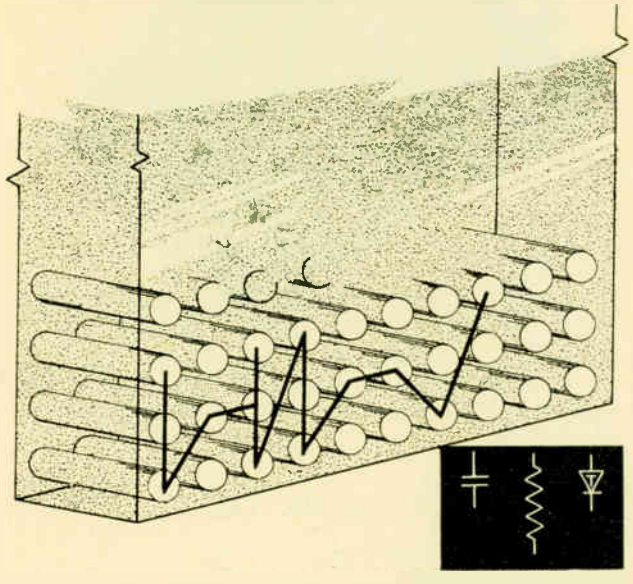
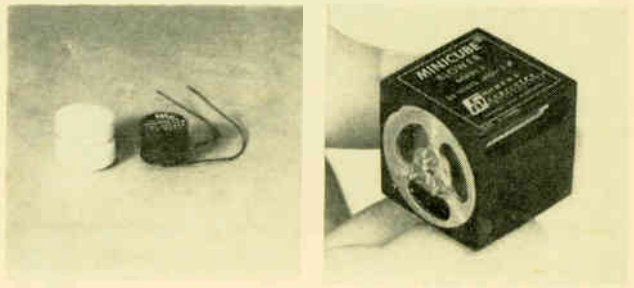


FIG. 9—Micromemory under development by Electro-Optical Systems uses filamentary two-terminal circuit elements in a regular pattern



Motor by A. W. Haydon was developed to power repeat cycle timer. Sanders Associates' 1-in. cube blower operates from either single or two-phase power

4 × 4 × 0.25 in. and have a 1,000-microsecond delay.

Microminiaturization of electronic components has had a profound effect in allied fields. Manufacturers who supply component makers have an important stake in this field. One effect of miniaturization has been a tightening of tolerances. Accurate Specialties indicates that tolerance specifications are twice as severe as last year. This applies to dimensions and to the purity of materials.[23]

Miniaturization is also evident in the electromechanical field. Typical examples are a blower with a volume of 1 cu. in., weight of 1¼ oz.; and an 115-v, 400-cycle motor that has a ⅜ in. diameter and is $\frac{9}{32}$ in. long. The motor weights ⅒ oz. and has a torque of 0.0005 oz.-in.

Microlamps $\frac{1}{64}$ in. in diameter and $\frac{1}{16}$ in. long have been developed. These require 15 ma at 1.5 v d-c.

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microminiaturization

NEW FORM FACTORS

In some microminiaturization programs, conventional components are being redesigned to standardized forms. These programs aim at higher packaging densities, regularized fabrication techniques, possible automation and the encouragement of a broad base of participating companies

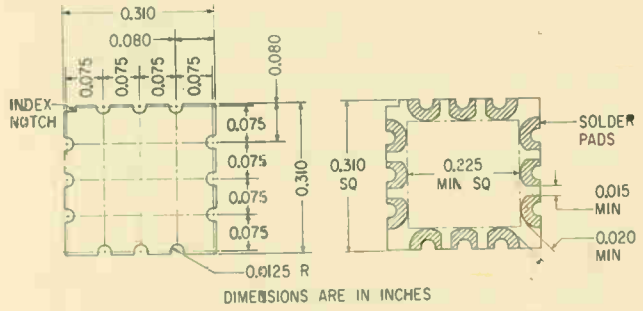

FIG. 1—Layout of a typical microelement wafer, and same wafer with solder pads. This kind of wafer is the basic building block of micromodules

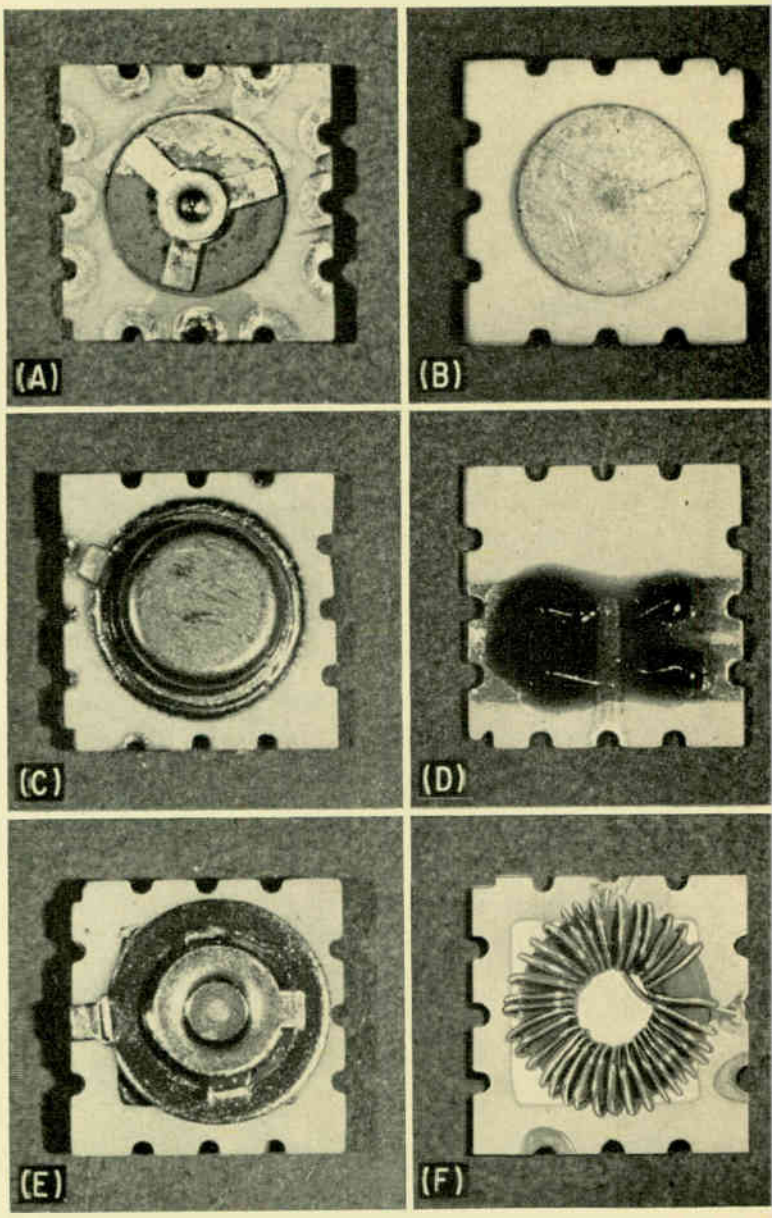

FIG. 2—Microelements developed for micromodule program: trimmer capacitor from Centralab, range of 3 to 10 pf (A); ceramic filter (4.3 Mc) from Clevite Corp. (B); transistor from RCA (C); four microelement diodes mounted on single wafer, supplied by PSI (D); transistor package from Hermetic Pacific, Inc. (E); and (F) combination of inductor and ceramic capacitor (RCA)

IN ADDITION to methods for packaging circuits using conventional components, there have been significant developments in reducing discrete components, both passive and active, to a rigidly standardized geometry.

The micromodule program, one of the more extensive of such development programs, is sponsored by the U. S. Army Signal Corps. Prime contractor is the Radio Corporation of America. It has been conservatively estimated that the government is presently putting between $20 million and $25 million into microelectronics per year. Of this, nearly $15.4 million will by 1962 have gone into the Signal Corps micromodule program. Of this, $7.4 million will have gone into the development of microelements, $3.3 million into equipment and $4.7 million into production engineering measures.[1]

This program was originally meant to work within the state-of-the-art of engineering and material development. To some extent, the work has gone somewhat beyond this. The program was also partially intended to spur industry-wide interest in microminiaturization. The thinking was that if a large sector of industry did not actively participate in such programs, then, like earlier approaches, such programs would fail. Some forty or more companies have had subcontracts in the micromodule program, supplying various types of components. Table I shows companies involved and the

Resistors	Weston Instrument, Glass Products, Chicago Telephone Supply, Corning Glass, Centralab, Microelectron, Mallory, Daven
Capacitors	Magnavox, Aerovox, Sprague, Mallory, C-D, Erie, Centralab, RCA
Inductors	ARF Products
Transistors	Philco, RCA, Texas Instruments, Rheem, Fairchild, Sylvania, Transitron
Power Transistor	CBS Laboratories
Transistor Package	Isotronics, Hermetic Pacific, Zell
Diodes	PSI, General Instrument, Hoffman Semiconductor, Transitron
Crystals	Midland Mfg. Co., Union Thermoelectric
Cores	Radio Cores, Polymer, RCA
Materials Processes	American Lava, ACF Industries, Coors Porcelain, National Beryllia, Ceramics for Industry, Kawecki Chemical, Mitronics
Others	Sanders Associates

MICROELEMENT	DESCRIPTION
RESISTORS	
Deposited alloy and metal film	10 to 100 kilohms; 150 v; ⅛ w per element or ½ w per wafer; temp coeff, 200 ppm per deg C; resistance tolerances, 1, 5 and 10 percent
CAPACITORS	
Precision, single layer	0.5 to 1000 pf; capacitance tolerance, ±1, ±5 and ±10 percent; 100 v dc; temp coeff, NPO, N030, N150 and N220
Precision, multilayer	50 to 2000 pf; capacitance tolerance ±1, ±5 and ±10 percent; 50 v dc; temp coeff, NPO, N150 and N220
General purpose, single layer	1 pf to 5000 pf; 100 v dc; capacitance tolerance ±20, +100 and −20 percent
Multilayer	0.012 to 0.3 μf; 50 to 25 v dc; capacitance tolerance ±20, +100 and −20 percent
Electrolytic	Solid tantalum up to 50 μf v; capacitance range 0.1 to 30 μf; 2 to 35 v
INDUCTORS	
Ferrite core toroid	Inductance up to 1.5 mh for 4.3 Mc, 11 Mc and 60 Mc
Powdered iron core	Inductance up to 1.5 mh for 4.3 Mc and 11 Mc
TRANSISTORS	
	Equivalent to: 2N109, 2N44, 2N1.4, 2N384 (Note: Types 2N706, 2N699, 2N113 and 2N697 are under development)
DIODES	
Group F_1 (1N277)	Low frequency rectifier – detector
Group F_2 (1N643)	Fast switching type
Group H	Zener reference type
CRYSTALS	
Quartz	7 to 70 Mc range

components in which they have specialized.

The micromodule program is involved in five areas: development of a range of microelements, single components mounted on individual substrates of a standardized configuration; design and development of equipment and systems; development of a production capability, that is, processes, tooling and production techniques for large-scale production of a variety of active and passive microelements. These three areas of development are complemented by a program of dissemination of technical information, both within RCA and throughout industry.

A fifth aspect, not directly related to the micromodule development, includes advanced developments in integrated electronics, techniques which may yet be three to ten years away, but which conceivably would be compatible with the micromodule method (that is, mounting complete solid-state circuits on single micromodule wafers).

MICROELEMENTS—Building block for this method is a ceramic substrate 0.31 inch square and 0.01 inch thick (see Fig. 1).

Wafer substrates for microelements are made of ceramic or glass-base material, depending upon the electrical component built upon it. The twelve rounded notches in the edges of the wafer are terminals for the component and for the riser connecting wires that run vertically through the module. These notches are metallized and provided with solder pads. The index notch in the corner of the wafer is for orientation.

The microelements built on these wafer substrates include general-purpose, precision and tantalum-electrolytic capacitors, resistors, inductors (transformers and chokes), transistors, semiconductor diodes, piezoelectric crystals, as well as combinations of components.[2] A number of multicomponent substrates have also been developed, such as the four-diode wafer shown in Fig. 2D. Some microelements developed by different companies for this program are shown in Fig. 2. Table II provides more detailed data on the microelement program. Latest reliability data on microelements appears in Components and Materials, p 138, of this issue of ELECTRONICS.

BUILDING MODULES—The method by which microelements are assembled into micromodules or circuit packages is shown in Fig. 3. Actually, two types of wafers have been developed, the notched, as shown, for insertion of interconnection riser wires that are soldered to the wafer, and a notchless design for connection by flat ribbon conductors welded to the connection points. Stacking of the microelements to achieve the best electrical characteristics, with spacing between wafers for electrical decoupling, results in the micromodule, a complete circuit package that can be sealed by molding or encapsulation to form a solid body resistant to environmental effects. Figure 4 shows how the individual module packages or subassemblies can be plugged into a printed-wiring board. Micromodules are specially adapted to

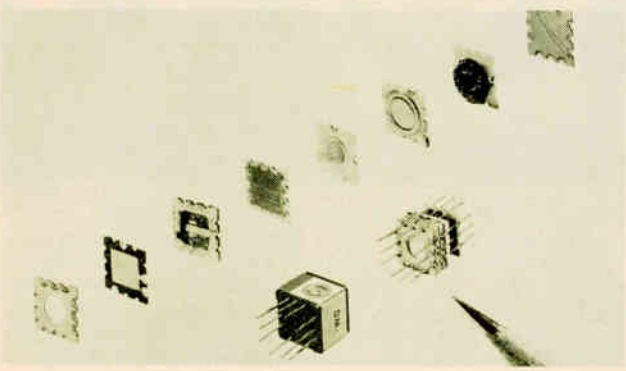

FIG. 3—How the microelements forming a complete circuit are mounted and soldered on riser wires and then encapsulated to form a single plug-in unit (RCA)

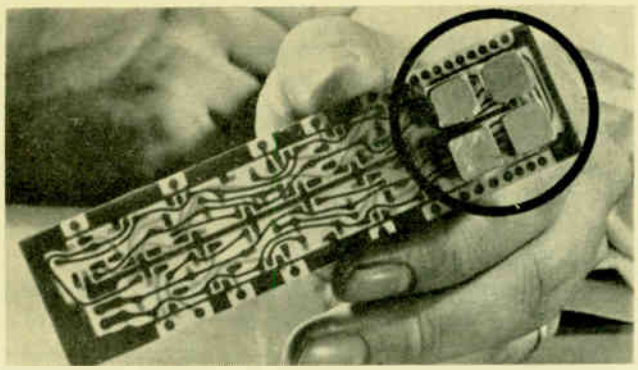

FIG. 4—Top view of four micromodules (circled) mounted on printed circuit board (RCA). Different methods of mounting micromodules into mother boards gives a designer some control over packing densities

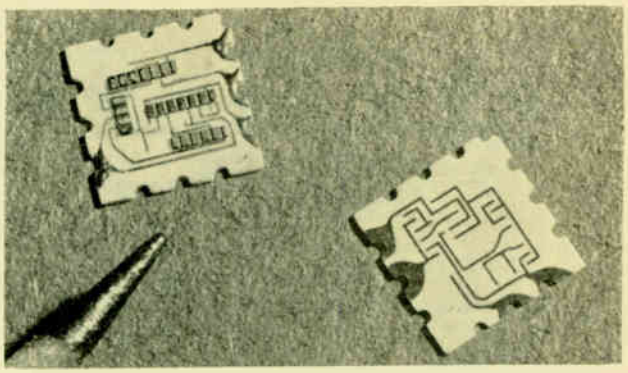

FIG. 5—Top and bottom views of an experimental adder circuit mounted on single wafer. Four groups of unipolar transistors, upper left, perform functions that usually require 100 individual components (RCA)

printed-wiring board methods. Leads are indexed into holes and soldered into place.

COMPLETED MICROMODULES—Micromodule circuits or subassemblies that are commercially available include a large range of types. Some of these are: an autodyne converter stage intended for a-m receivers; single-stage 455-Kc i-f amplifier for a-m receivers; 455 Kc i-f detector stage for a-m receivers; single-stage low-level audio amplifier for radio receivers and other audio-amplifier applications; one half of a binary divider (a complete divider is made from two of these halves.

More recent module designs include gyro temperature controls, resolver amplifiers, counting pulse generators, reset blocking oscillators, compensation networks, double emitter followers, NOR gates, AND gates and bridge-T networks.[3]

MULTICOMPONENT WAFERS—Integrated electronic techniques are directed towards developing complete circuits that perform the functions of large numbers of discrete components. Figure 5, for example, shows an experimental adder circuit for computers.

Equipments and systems being developed to demonstrate the compatibility of the micromodule technique include a field computer and a helmet radio transmitter and receiver.

COSTS—In the design of micromodules, RCA stresses reliability, size and cost. Micromodular equipment now costs about two to one-and-one-half times as much as conventional equipment.[4]

HUGHES MICROELECTRONICS—Another scheme for standardizing electronic components to a single form factor is proposed by the Hughes Aircraft Company. Dubbed Microelectronics, this concept is based upon diodes, transistors, resistors and capacitors packaged within envelopes essentially 0.05 inch in diameter and 0.03 inch high.[5] These standardized components are mounted in a perforated circuit board. The components are contained within the board with interconnnecting circuits carried on the two surfaces.

Figure 6A shows the relation of the components and circuits. The circuit, shown raised on the surfaces of the board, can be formed by evaporation, chemical etching or deposition. This method allows for freedom in the formation of passive components. They may be formed by film techniques on the board surfaces or inserted into the board as are the active devices.

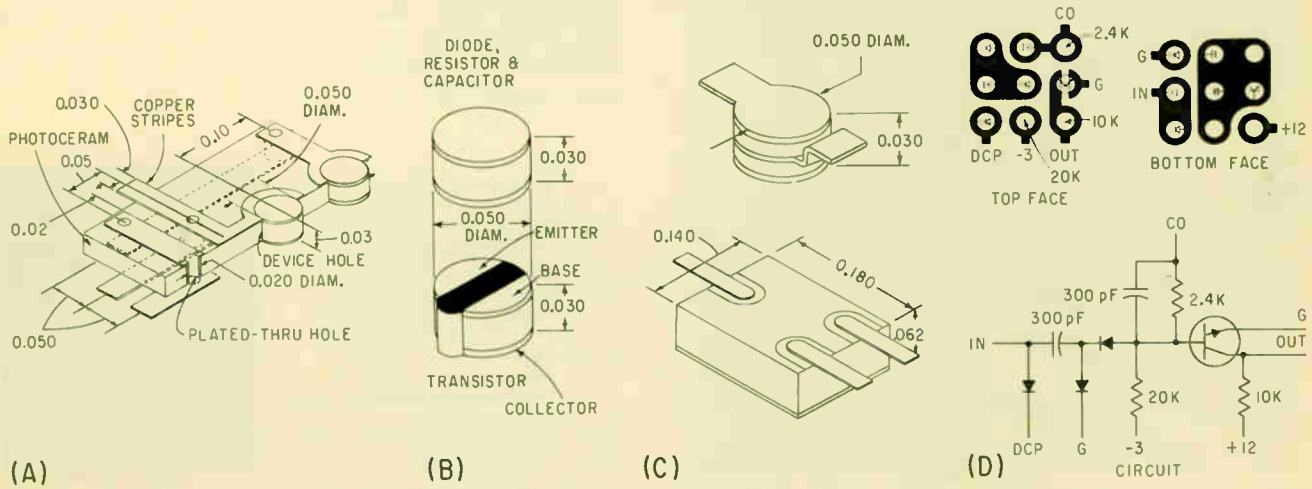

FIG. 6—Microelectronics format proposed by Hughes Aircraft Co.: method of assembly (A) of circuitry and components (B and C); and formation of a half flip-flop (D). Dark areas are connections

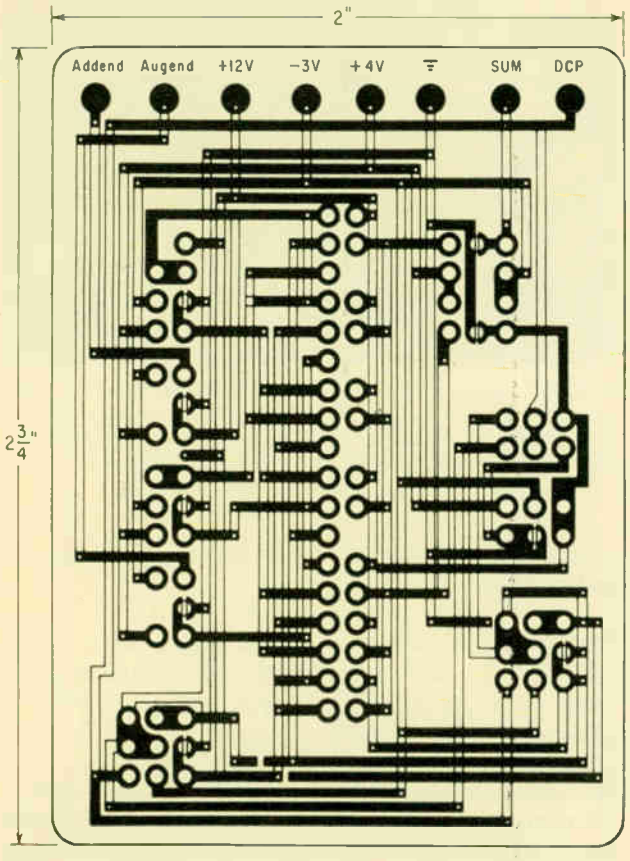

FIG. 7—Schematic of a full adder constructed by Hughes method. Half flip-flop is at lower right

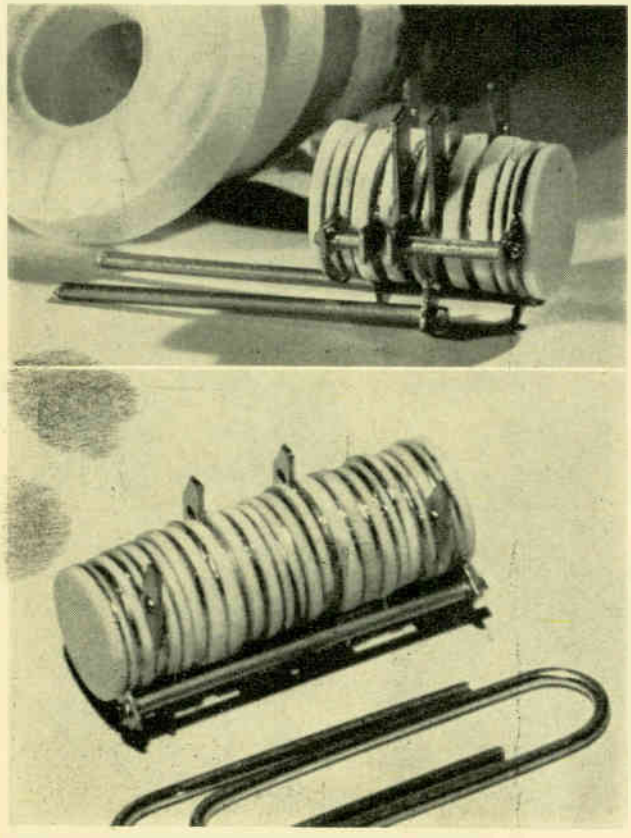

FIG. 8—(top) Multivibrator circuit constructed from General Electric TIMM's. Gadget to left is a Lifesaver. Below: a double NOR circuit used in computer

Diode and transistor construction is indicated in Fig. 6B. Diodes, resistors and capacitors have gold-clad end plates. Transistor construction is as shown, although in this approach, active components will also be supplied in other forms such as in Fig. 6C. As an example of the packaging capability of this approach, a single board measuring 0.04 × 2× 2¾ inches can hold a full adder consisting of some eighty-five active and passive components spaced 0.1 inch apart.

An illustration of the relative simplicity of this form of circuit is shown in Fig. 6D. Here is the circuit of a half flip-flop on the top and bottom faces of the circuit board. This half flip-flop is one element of a larger circuit built to demonstrate the feasibility of this method. The larger circuit, a full adder is shown in Fig. 7.

A ramification of this approach is that the components are constructed with one face slightly magnetized, thus providing polarity discrimination for elements such as diodes and, additionally, providing a ready approach to automation of microelectronic circuits.[5]

PELLET APPROACH—Another approach is contemplated by the Mallory Company. They intend using pellet-shaped active and passive components inserted in a 62 mil base material. Component pellets will have dimensions of 100 to 250 mils in diameter, with length equal to the base material thickness, 62 mils. Interconnections are made with metal-filled paste, printed wiring and other methods. Connector pins are brought out from one side of the base material to provide subassemblies with plug-in capability. (See photos below.)

A number of resistors and capacitors in pellet form are under development. In full engineering production are two capacitors: RMC Discaps, 0.235 inch in diameter to 1 inch in diameter, 0.001 μf to 0.1 μf, with and without leads and coating; and tantalum slugs, 0.07 inch by 0.21 inch, encased, 1μf to 10 μf.

TIMM'S PACKAGES—A departure from other microminiaturization approaches is that embodied in the thermionic integrated micromodules. Although in this approach standardized component packaging is employed, transistors are not. Instead, small heaterless electron tubes are used, auxiliary cooling is eliminated and heat losses generated within the equipment produce thermionic cathode emission. The approach, known as TIMM's, has been developed by the General Electric Company. Figure 8 shows typical TIMM's packages, a multivibrator circuit and a double NOR circuit used in a computer. One fea-

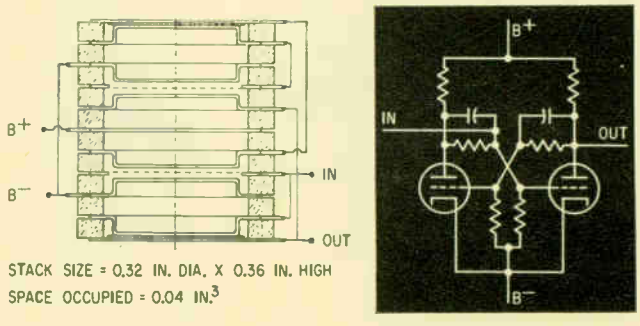

FIG. 9—Cross-sectional view of stacked TIMM's circuit showing electrical connections. To right, the circuit schematic, a bistable multivibrator

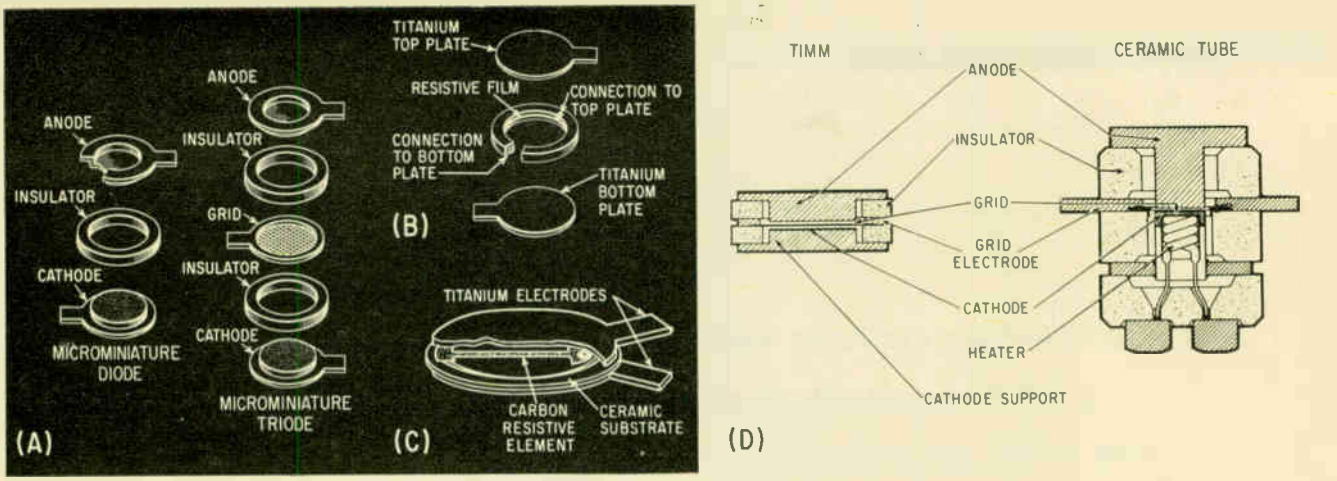

FIG. 10—Construction of TIMM's: Exploded view of titanium-ceramic diode and triode (A); titanium-ceramic resistor (B); carbon resistor (C); and triode tube structure compared to present microminiature ceramic triode

ture of TIMM's is resistance to radiation.

Components in this approach are constructed from ceramic and metals (titanium and carbon). All components for circuit functions are exhausted and sealed in a vacuum at about 1,000 deg C, using metal-ceramic techniques now used in the manufacture of ceramic receiving tubes. Thermionic diodes, triodes, resistors, capacitors and inductors have been made by this technique. Figure 9 shows how circuits are built up from these modules. These circuits operate at a temperature of 580 C. Overall size of TIMM components is 0.32 inch in diameter, although some components are larger. Constructional features are shown in Fig. 10.

By operating at high temperature, individual heaters and thermal isolation associated with cathodes are eliminated. Titanium electrodes provide a continuously gettered vacuum enclosure for both tubes and other circuit components. Once circuits begin operating, passive and active components generate enough heat to sustain tube operation with the circuit enclosed in an insulated box. Circuits are stable and reliable, rugged in construction, and radiation tolerant—devices have operated in an atomic reactor for 1,600 hours without deterioration. Transconductances up to 2,000 micromhos per ampere have been achieved at low plate voltages. Component density can be as high as 10^6 parts a cubic foot.

Some difficulties with TIMM's appear in the area of capacitances and inductances—even using synthetic mica sheets in capacitors, only small capacitances have been obtained. TIMM's cannot be used across the frequency spectrum, so that their communications uses are somewhat limited. However, such disadvantages can be partially off-set by circuit design.

Development of TIMM's, which started some four years ago, has now reached the point where a whole range of components is being produced. Life tests on resistors have been run out to 18,000 hours without their exhibiting significant change. Many subassemblies have been constructed, including many NOR circuit logic arrangements. One system, a servo amplifier, has been designed, built, and is now being flight tested (see last section). A ballistic missile computer has also been designed and is now under consideration for use in a missile that has not yet been flown (see last section).

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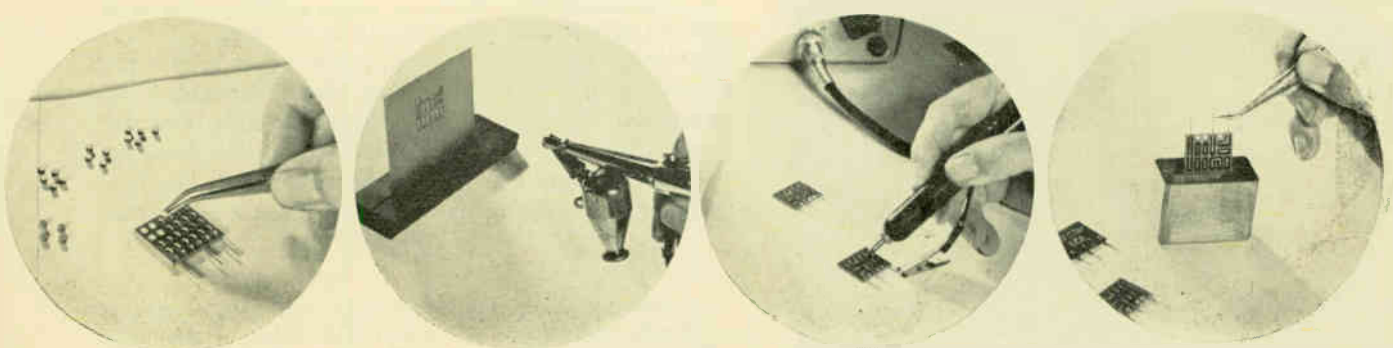

Some of the laboratory operations involved in packaging pellet components, as practiced by P. R. Mallory & Co.

microminiaturization

CIRCUIT-ORIENTED

Thin film techniques are being used now to lay down only the passive portion of a circuit. Experiments point to the capability of producing both active and passive components in thin-film form

A NATURAL EXTENSION of form factor approaches, such as the micromodule, is to place circuits, subcircuits or functioning stages on a single wafer or substrate. Many companies are doing this with thin films. In these thin-film approaches there is usually a one-to-one correlation between the components in thin film and conventional form.

A typical method[1] of producing these circuits is indicated in Fig. 1. The methods of laying down thin film are many and varied. Present technology allows film making by reactive deposition, evaporation, sputtering, photolithographic techniques, etching and many combinations of these. Work has been done with both active and passive substrates of various types.

THIN FILM TECHNOLOGY—The literature on thin films is already vast, and the extent of research and development in thin films has been growing steadily. The reduction of components and circuits to thin-film form has as objectives: an increased reliability of these components and circuits, a significant decrease in size and (because thin films promise a high degree of automation in their fabrication) an eventual real cost saving in construction of complex equipment.

Many types of thin films are being developed—magnetic films, insulator and conductor films, superconductive films—but, to date, most components and circuits being reduced to thin-film form are still in the developmental stage. Real progress has been made. Manufacturers have not hesitated to push the work in thin films to the greatest of their capability, but it may yet be a few years before we will be seeing commercial-type equipment based on thin-film circuits as routine items.

Despite the magnitude of the technological problems involved in developing thin-film circuits, such circuits will be developed because the complexity of modern systems demands some such technological tool. Although some manufacturers are expending their biggest efforts on function-oriented approaches, they are working hard in the thin-film area too, for it is the common belief that functional devices that are reliable, reproducible and cheap are about seven to ten years away, and the thin-film approach is an excellent interim technology.

VAPOR GROWTH—Growth of thin single crystalline layers of semiconductors from the vapor state may prove to be one of the most fruitful techniques yet developed in thin-film technology. Although not fully developed, vapor growth could be used in depositing active elements in thin-film circuits. However, many problems remain to be solved before its potential can be realized.

Many companies are working with vapor growth and many have had success (see function-oriented approaches). The methods of vapor growth have been well discussed recently in the technical literature.[2] Although its role in the deposition of active elements directly into thin-film circuits is still far in the future, it has a high poten-

Inspecting microminiature sputtered resistors, capacitors and connecting leads. This Bell Lab technique won 1959 Microminiaturization Award sponsored by Miniature Precision Bearings

APPROACHES

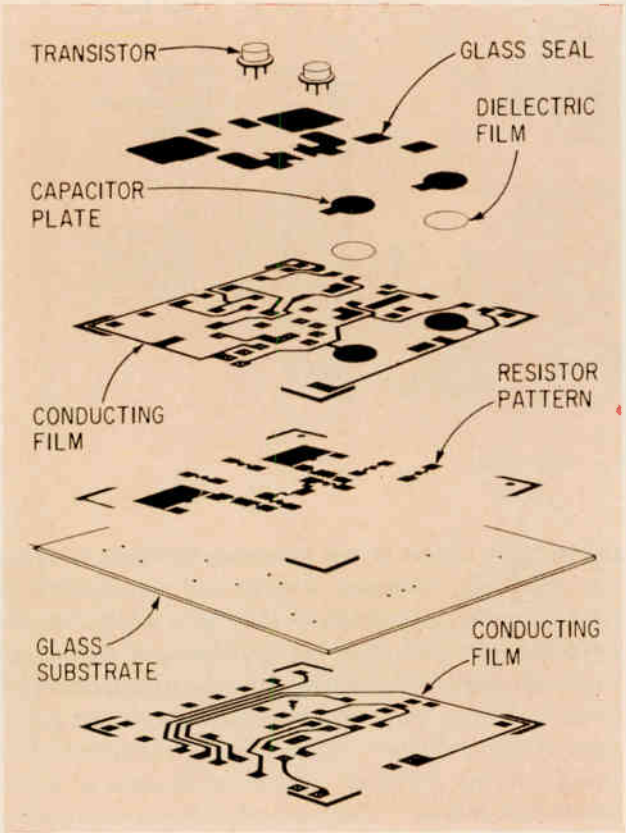

FIG. 1—Exploded view shows how thin films are used by Intellux to make circuits. Commercially available active devices are connected to the thin-film circuit and the entire unit is hermetically sealed in glass

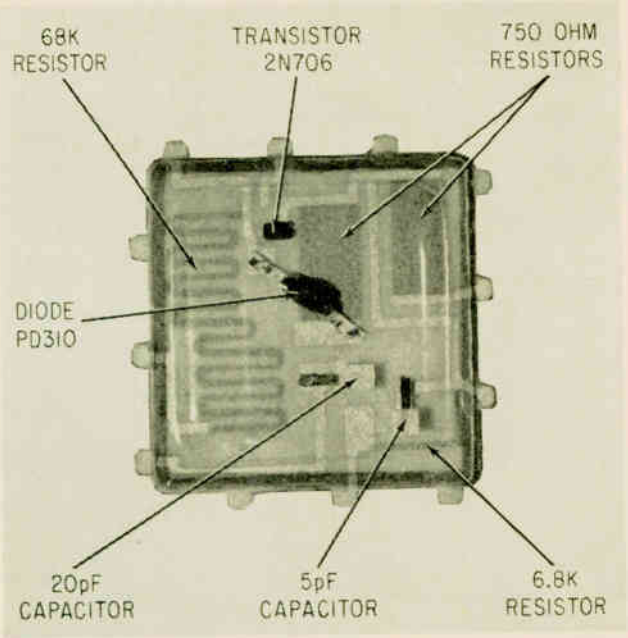

FIG. 2—Circuit on $\frac{1}{2} \times \frac{1}{2} \times 0.01$-in. alumina ceramic wafer by Sylvania is 20-Mc binary divider. Wafer has glass-hat hermetic seal

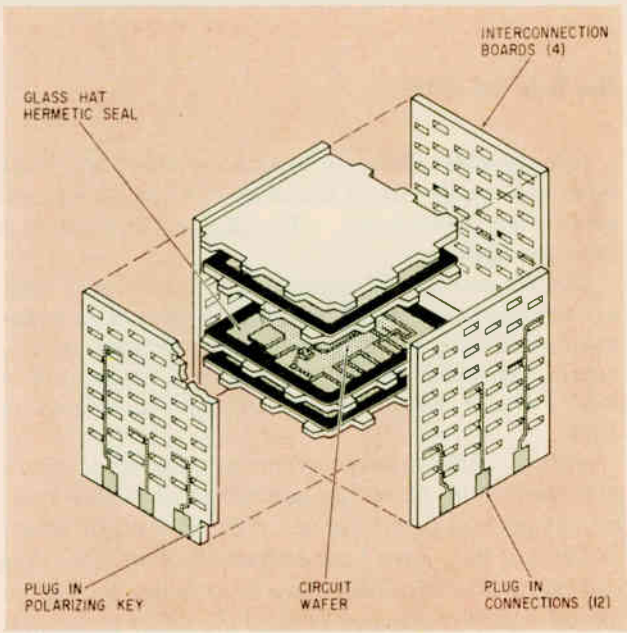

FIG. 3—Exploded view of module construction shows method of making interconnections (Sylvania) →

tial for both thin-film circuits and functional devices.

SIZE—A problem in building thin-film circuits on substrates of various sizes is interconnection. Substrate sizes must be decided upon, and methods must be fully developed for interconnecting the various subassemblies.

The interconnection problem and substrate size are related directly to the maintenance problem. How much of a circuit is one willing to throw away when some portion of it ceases to operate? Or, how can one get the optimum reliability with reasonable cost? A larger substrate, presumably carrying a larger equivalent number of components, may be more likely to fail sooner than a smaller substrate with a smaller number of equivalent components. On the other hand, with smaller substrates, easily thrown away, the interconnection problem gets worse and reliability falls off.

FUNCTIONING STAGES—A common approach to thin films has been to have a functioning stage on an alumina substrate. In one approach a notched 0.5 x 0.5 in. wafer is used and each stage is hermetically sealed.[3, 4] After hermetically sealing, the individual stage can be treated as any sealed component.

Figure 2 shows a sealed wafer. To make sealing possible, a grass ring is fused around the edge of the wafer after the conductors have been laid down but before the circuit is made. After the circuit is made, a glass hat is fused to this ring at 1,200 F without adversely affecting the transistors. Fusing is accomplished by bringing an

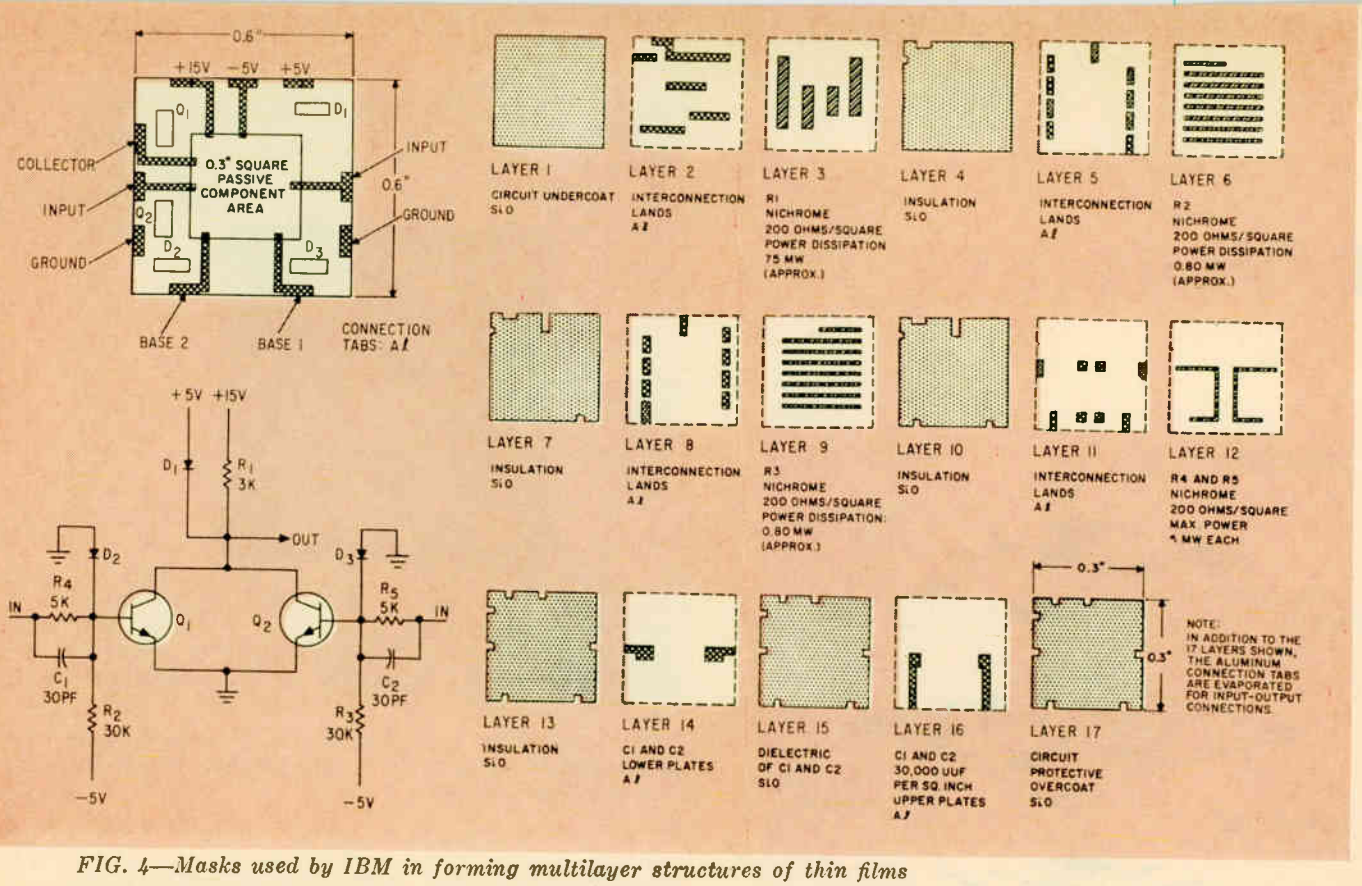

FIG. 4—Masks used by IBM in forming multilayer structures of thin films

The Role Of DOFL

Industry-wide efforts in microelectronics have been influenced by the Signal Corps and the Diamond Ordnance Fuze Laboratories. The Signal Corps effort is discussed elsewhere.

DOFL's role has been seminal. It began work early in microminiaturization, it stimulated interest in the industry, it is working in all types of microminiaturization to remain competent to appraise industry results and it held a major symposium on microminiaturization in 1958.

Although DOFL has programs on all levels of microminiaturization, from tiny assemblies of minute commercial parts to functional networks, their major efforts in the past year have been concentrated on what they call the 2-D level. They have built linear as well as digital circuits, have used most of the major techniques in the fabrication of their wafer-mounted circuits (photolithographic techniques, thin-film deposition using vacuum, chemical and screening methods, conductive adhesives, ultrasonic drilling and air abrasion to form substrates and devices), they have worked on interconnection and shielding problems of individual wafers to form subassemblies, and in conjunction with Sprague Electric they have been buying contract quantities of binary counter wafers to study circuit margins, manufacturing problems, and for evaluation of interconnection schemes. They are planning to construct a program timer with about 500 *parts to make field evaluations of a digital system. They are also developing with 2D techniques parts of missile fuzing and telemetry systems.*

In another direction, DOFL has worked on producing large arrays of diodes on germanium wafers with good success using a variety of techniques and microhandling equipment which it has developed.

REFERENCE

Private Communication, N. Doctor, Research Supervisor, Microminiaturization Branch, Diamond Ordnance Fuze Labs, Wash., D. C.

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intense localized heat to the joint area between the glass ring and the glass hat. There is no physical contact between the heating source and the wafer or the hat. Any gas or combination of gas can be employed around and under the hat during sealing. This allows any desired atmosphere to exist under the completed seal. Figure 3 shows the method of interconnecting these wafers. The completed modules are mounted on a ceramic base and interconnection is made by spring fingers or by soldering.

Shielding, when necessary, can be accomplished by one of two methods. The first approach is to silver the back of the wafer to the tab and connect this to the printed circuit board ground. The second method, still under development, is to use a metal hat to replace the glass hat.

Generally there is a one-to-one correlation between present circuits and wafer circuits. Various circuit breadboards have been directly translated into wafer circuits. A laboratory model of a tunable broadcast-band transmitter, measuring ½ × ½ × ⅞ in., has been built by this method.

PHOTOLITHOGRAPHIC TECHNIQUES. In its ap-

proach to thin-film circuits, one large transistor manufacturer started by redesigning its transistors, then moved on to the designing of the passive components. Choosing silicon as the semiconductor and using photolithographic techniques to make the devices. Philco decided to use bipolar transistors because of their relatively low power dissipation, ease of fabrication and adaptability to thin-film techniques.

In its general philosophy of approach, the firm is not concerned with standardizing substrate size or developing interconnection methods between substrates. Rather, it is developing larger circuit functions on single substrates with as many as 20 to 100 active elements in one system. It is approaching circuit synthesis using simple topological arrangements as well as coupling techniques, and it is considering circuits with a high degree of tolerance to component variation and low operating power levels needed for high speeds.

Philco fabricates circuits by using a thin layer of silicon on a ceramic substrate and forming isolated lumped-constant components on this silicon by photolithographic techniques. One-sided transistors are made by this technique, silicon resistors are obtained by diffusion (common diffusion techniques are used for both transistors and resistors), conductors are formed from evaporated metal film such as aluminum, gold, silver and chromium.

COMPONENTS—Typical geometry for a 10,000-ohm resistor is a diffused area of 5 × 250 mils. Electrical properties of these components are closely related to the resistivity of the bulk silicon crystal, geometry being controlled by oxide masking and the reproducibility of diffusion. In separate studies, aluminum and tantalum capacitors have been formed on various substrates by anodization and oxidation of metallic films. This approach was favored over the diffused *p-n* capacitor because of the higher possible capacitance values per unit area that were attainable, plus a lower dissipation factor. Aluminum capacitors were more moisture sensitive than tantalum. However complete circuits ultimately will be hermetically sealed.

To demonstrate the feasibility of its approach, the manufacturer fabricated a number of bistable silicon flip-flops on substrates measuring 0.375 in. square and 0.03 in. thick, tested them in a complemented binary counter, and found that they operated satisfactorily.[5] Switching times indicated a maximum input rate of 0.5 Mc.

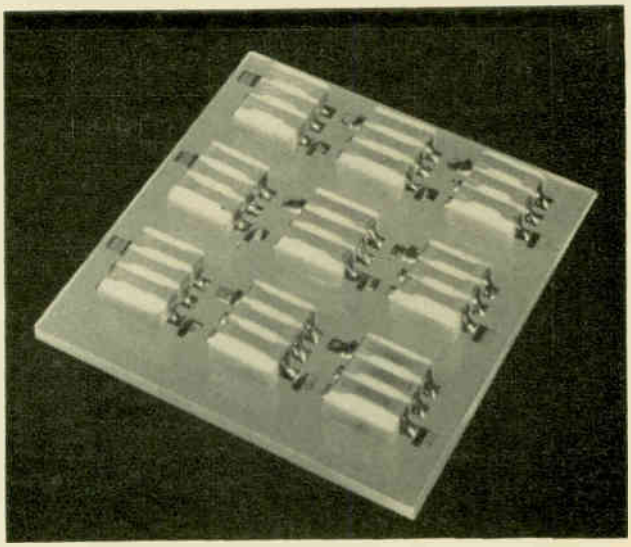


FIG. 5—Connecting plate used for multilayer film circuits. Circuits are attached to plate by soldering, adhesives or thermal compression (IBM)

TUNNEL DIODES—In addition, Philco has built scaler or counter circuits using arrays of tunnel diodes on a single substrate, building arrays of as many as nine diodes. With further development, using gallium arsenide tunnel diodes, the company expects to produce scalers that will count reliably at 2.5 Mc.[6,7]

Other programs under investigation include thin-film memories and tunnel-diode memories. In these programs, they are aiming at developing design techniques that will allow fabrication of devices in array form.[8]

MULTILAYERED STRUCTURES—A method that aims at carrying the design of circuits to the system level and which aims at achieving extremely dense interconnection networks relies on multilayered structures of thin films. Work done at IBM on multilayer vacuum-deposited interconnections shows promise at achieving these aims. Six different circuit types for switching and communication applications have been fabricated using multilayer films as the resistive, capacitive and inductive networks. In these networks, unencapsulated transistors were at-

Characteristics of Thin Film Resistors

	MIL-R-11	MIL-R-10509C Characteristic B	Thin Film Resistors
70 C Load Life Time	1,000 hours	1,000 hours	750 hours
Avg Percent Change	6	1	*
Short Time Overload	2.5 percent	0.5 percent	0.09 percent
Temperature Coefficient	625 to 1250 ppm/C	500 ppm/C	150 ppm/C
Voltage Coefficient	0.02 percent/volt	Not Required	0.0014 percent/volt
150 C No Load Time	130 C 1,000 hr	1,000 hours	1,000 hr
Avg Percent Change	6	1	0.5

*The percent change is a function of film resistivity and power loading per unit area.

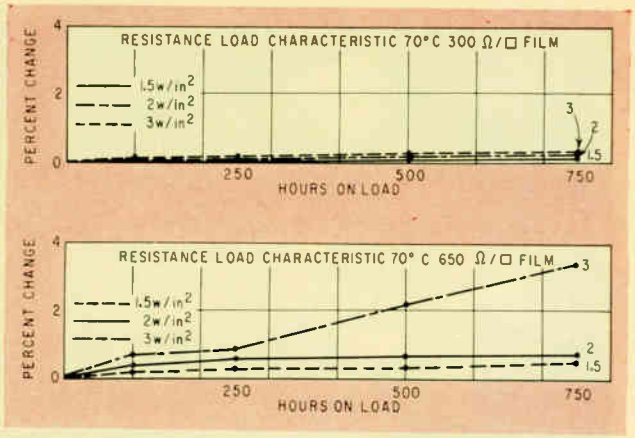


FIG. 6—Change in resistance characteristic is a function of film resistivity and power loading per unit area (IRC)

tached to the wafers by thermocompression bonds.[9]

In this fabrication process, thin glass substrates measuring 0.6 inch by 0.6 inch by 0.02 inch are coated in vacuum with alternate patterns of conductors and insulators. Nichrome is used for resistors, silicon monoxide for insulation and aluminum for conductors. These conductors and insulator materials are heated until they evaporate. Substrates are maintained at a lower temperature than the material source so that the evaporant condenses upon it. Thus, there is formed a multilayer structure to which a variety of devices or circuits can be connected without feedthrough pins, plated holes or jumpers.

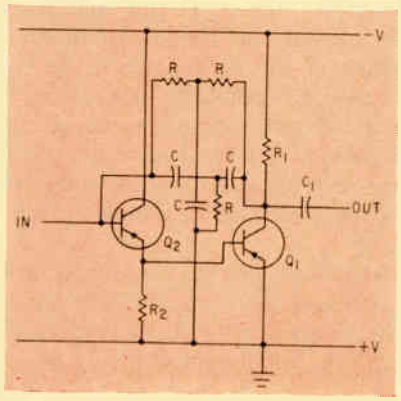
This kind of fabrication method promises to lend itself to low cost, automatic production not only of passive elements and circuits and a variety of microminiaturized bulk elements, but be compatible as well with the deposition of active elements by vapor-growth methods.

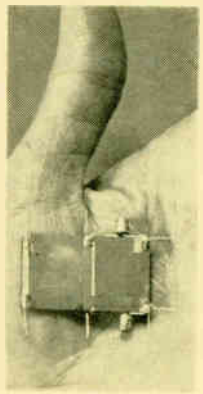
PROCESS—The fabrication process consists of eight steps:[10] (1) Layout topology, based on the geometrical capabilities of the deposition process, taking into account distributed effects, the end result of which is a set of masks as seen in Fig. 4. (2) Mask fabrication by such techniques as photoetching, arc erosion and milling, holding close tolerances. (3) Substrate preparation: as in all thin-film processes, careful substrate preparation is important for high yields. Substrates are screened for imperfections, chemically and ultrasonically cleaned, and then stored in isopropyl alcohol. The final and important step in substrate preparation in the IBM process is to vacuum-deposit an undercoat of silicon monoxide. (4) Conductor deposition: on the prepared substrate are laid down the interconnection lands of aluminum. Although copper and gold can be used for conductors, aluminum is used because it is most compatible with silicon monoxide. Conductor thickness can be between 5,000 and 50,000 angstrom units. (5) Insulator deposition: insulator deposition has been a key problem in multilayer depositions. Silicon monoxide and silicon dioxide are used. Gaps in the insulator films allows for conductive connections between layers. (6) Additional conductor and insulator layers: additional layers, as shown in Fig. 4, are deposited through successive masks. The final insulating layer of SiO covers the entire structure with the exception of the land areas to which other circuits or active devices are attached. (7) Device and circuit connections. Fig. 5 shows the connection plate. The raised cubicle areas represent the built-up circuits which have been fabricated by the multi-layer process. Once these multilayer circuits have been tested, they are attached to the connection plate by soldering, conductive adhesives, or thermal compression bonds. Figure 5 also shows a series of test joints made by the solder reflow process. Pretinned land areas are placed in contact with pretinned lands on the raised circuit blocks, and the entire assembly is baked briefly in a vacuum oven until the solder fillets reflow. (8) Installation of outer package: final packaging is dictated by the application—this could range from a conformal coating to hermetic sealing of the total assembly in a container.

ACTIVE SUBSTRATE—In many thin-film approaches only the conductors, resistors and capacitors are deposited. The active elements such as diodes and transistors are subsequently attached. Litton has developed positive and negative coefficient thermistors as well as diodes and rectifiers in a barium-titanate substrate. It is possible that with further research passive and active components may be developed into one unit.[11]

With a barium titanate substrate, only three depositions are required to achieve an operational circuit. Inactive substrates require four to eighteen depositions for the same circuit. The peculiarity of the titanium atom of a crystal of barium titanate in reacting to vibration with reproducible characteristics is expected to be useful in computer memory applications.[12]

How Lockheed Builds a Bandpass Amplifier





The fabrication of this amplifier was not complicated by elaborate mechanisms or automation. The conductive patterns were deposited using a sequential evaporation of copper and then indium onto an American Lava T-172 substrate. The substrate was then removed from the chamber and the external connections and the transistors were attached. The assembly was replaced in the chamber and the necessary electrical connections were made between the circuit and the external test equipment. A typical NRC vacuum system was used and the evaporation was from tungsten boats. Nichrome was used for the resistive material.[a]

REFERENCE

(a) W. D. Fuller and P. S. Castro, A Microsystems Bandpass Amplifier, Proc of NEC, p 139, 1960.

An incoming pulse stimulates the titanium atom to be displaced in proportion to the vibration level, altering the polarity in the crystal, which generates an electrical signal similar to unbalance of a bridge. Readout is binary 1 or 0, depending on the polarity, which is a function of the original pulse.

This technique has the advantage of retaining polarity for long periods. In practice the polarity (and the binary symbol) will be retained until subjected to a new electrical pulse. Actual period varies with temperature, but it is as high as 25 years at 0C.

Another crystal vibration memory application is in remembering the phase of the electrical current until a current with a new phase is applied. Because a resonance is established and maintained, the power requirement is reduced. This phase reversal method of providing a binary indication is used in the parametron computer.

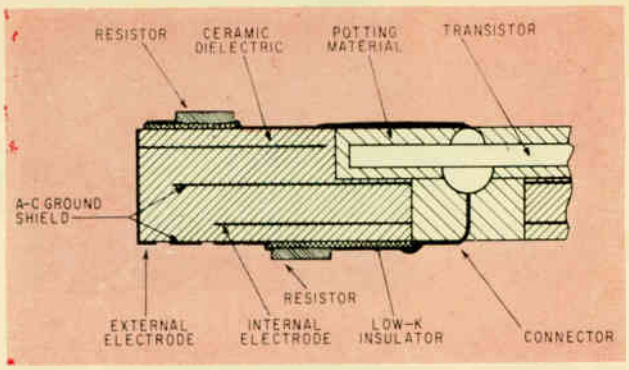
OTHER EFFORTS—An R-C coupled i-f amplifier using mesa transistors and thin film passive components has been built by Motorola.[13] Although making a major effort in combining thin film and semiconductor technologies, Motorola is also studying the function-oriented approach.[14] Haloid-Xerox is working with etch-formed circuits. In this approach layers of materials are evaporated without using masks. Then stenciling and etching form the R-C pattern. Active elements are mounted on end plates that connect the R-C wafers.[15]

Within one or two years Lear expects to be able to deposit active elements as well as passive components. Presently they are evaporating passive components and attaching uncased transistors in their thin-film work.[16] Magnetic thin films have promise as computer elements because of small size, switching speeds obtainable, low power requirements and high reliability. Honeywell Research Laboratories have investigated the intrinsic and the functional characteristics of these films. Fabricated films now vary less than 10 percent in thickness within batches or from batch to batch, permitting mass production of identical circuits.[17]

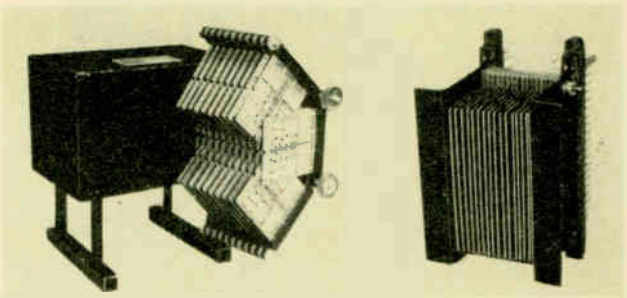
EVALUATION OF THIN FILMS—Although much has been published recently on methods and approaches to reducing the size of electronic assemblies, and although much stress has been given to reliability, little, as yet, has been published on the actual performance and reliability of such assemblies. One of the first such definitive papers was presented at the 1960 Electronic Components Conference in Washington, D. C. on May 11, 1960, by the International Resistance Co.[18]

The general approach by IRC has been to build thin-film circuits on thin glass and ceramic substrates by laying down passive components by vacuum deposition. Active components are secured from other manufacturers and mounted into the IRC, so-called mu-circuit. Miniature cased and uncased transistors have been used. IRC has not pursued the interconnection of their substrate assemblies to completion, although a number of interconnection schemes are being explored. However, they have made environmental and life tests on their thin-film resistors. Figure 6 shows some of the results.

The table compares thin-film resistors with MIL specifications. These resistive elements were designed to show results under maximum thermal stress to demonstrate the maximum range of resistivities and power levels that could be used. Resistive films used in these tests have protective coatings. In its report, the firm concludes that elements consistent with MIL-R-10509C requirements can be produced.



Cross-section of Sprague's multilayer construction shows how two built-in capacitors are shielded by a ground plane. Resistors and the transistor are insulated from the capacitor by low-dielectric constant layers applied by printing techniques



Typical methods of interconnecting and packing Maico's micro-cards are the interleaf principle using plug-in connectors (left) and flexible printed interwiring (right)

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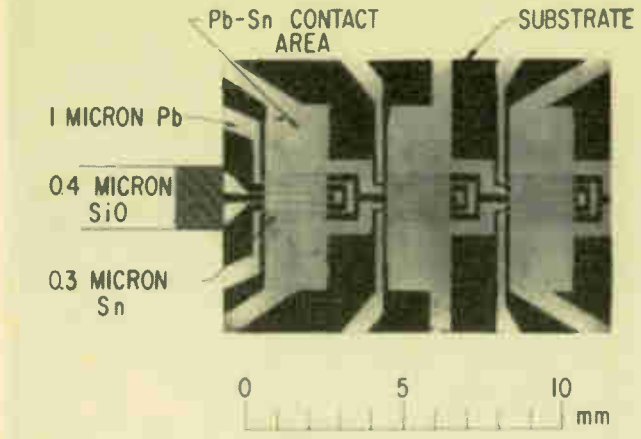

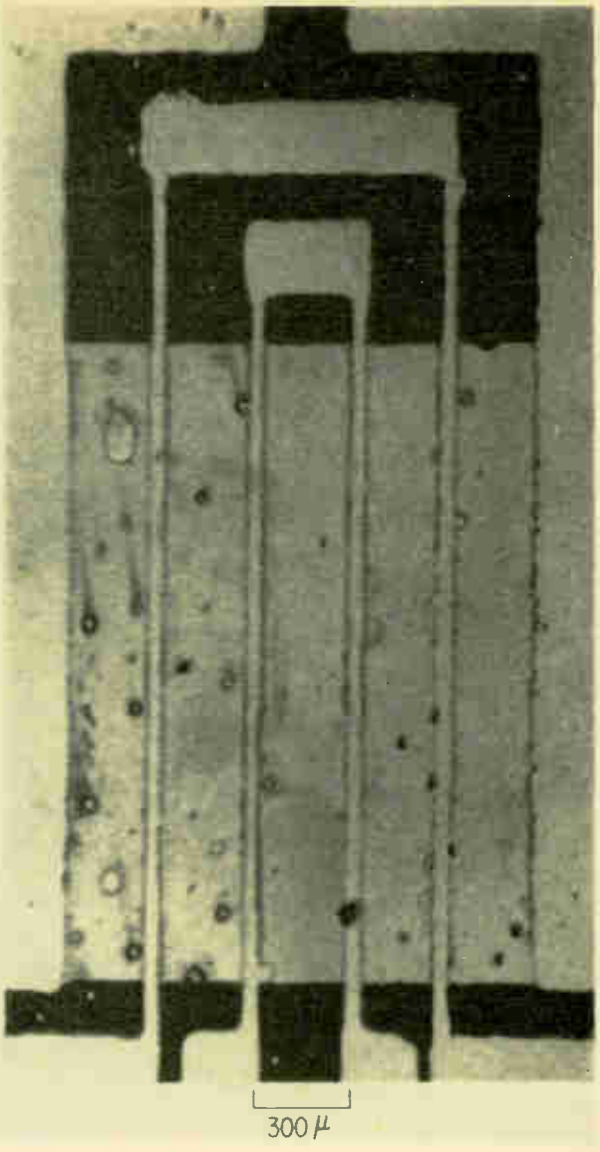

Potential of the Crossed-Film Cryotron

The present generation of digital computers is made of transistors, cores, etc., that are individually wired. The development of the crossed-film cryotron[a, b, c] (CFC) makes it possible to deposit simultaneously large arrays of switching and storage elements, together with their interconnections, at negligible cost. CFC's have been operated for both switching and memory and are far simpler to fabricate than either the existing semiconductor or magnetic devices.

The photograph shows two views of a CFC shift register compared with a stained section from the brain of the cat.[d] This demonstrates that the separation in one dimension between active cross-overs of the shift register is already comparable to the separation of nerve cells in the cat brain. The component density of this shift register is of the order of 18,000 active elements per square foot. Because the d-c dissipation of a CFC is only a few microwatts, it should be possible, using the attained component density of 18,000 per square foot, to fabricate computers containing more than one million elements in a one-foot cube of liquid helium, with a total average dissipation of less than one watt.

Used as amplifiers, CFC's of the low dissipation type which can readily be produced in large arrays with good yields have operating speeds of the order of 1 Mc. Operating at this speed, it is estimated that CFC systems of moderate cost and physical size will outperform even the fastest and largest existing computers, because of the large number of virtually cost-free CFC's which can be used in a given system.

Moreover, in the area of gigacycle computers, it appears that CFC's or some other type of superconducting film arrangement will prove to be the best component for use in a random access memory.

Because of all these attractive features, we may confidently expect that in the next few years several types of superconductive data handling systems will come into use.

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Resistivity bridge is used by Texas Instruments to sort and test silicon wafers before fabricating them into semiconductor networks

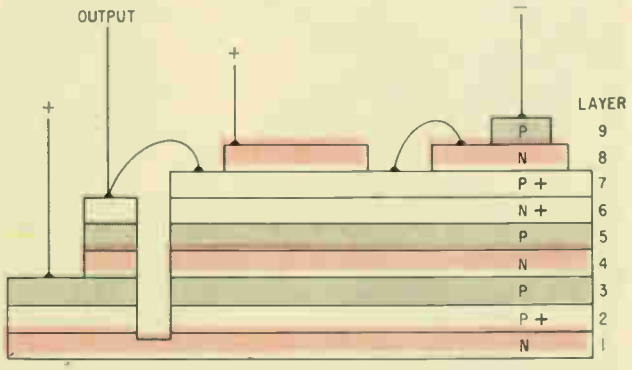
FUNCTION-ORIENTED APPROACHES

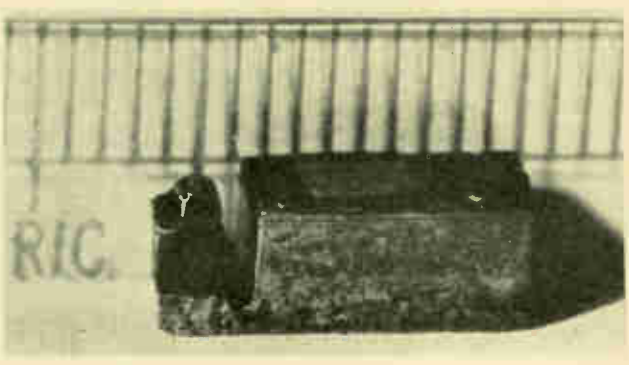
Semiconductor crystals that are altered to perform required circuit functions offer high parts density. Look at one future microminiaturization method shows return to discrete vacuum devices

IN FUNCTION-ORIENTED APPROACHES, the individual circuit elements become difficult to distinguish. Making a direct comparison with a conventional circuit becomes more difficult and less important as these functional devices or circuits become more sophisticated. In many cases attempts are made to correlate these functional devices with conventional circuits because there are no simple procedures to translate a circuit into a functional device by other means.[1]

A major effort is being made to fabricate the equivalent of a complete circuit on or in blocks of semiconductor material. Generally, conventional transistor processing techniques can be used to make these semiconductor devices. Manufacturers are combining oxide masking, diffusion, metal deposition, alloying, electron-beam machining and surface shaping to produce single-crystal semiconductor wafers.

TOOLS—Structures that are incorporated into these functional devices range from some simple ones that have component counterparts to those that perform functions that have no correlation to the circuit being re-





Cross-section and photograph of vapor-grown circuit made by Merck Sharp & Dohme

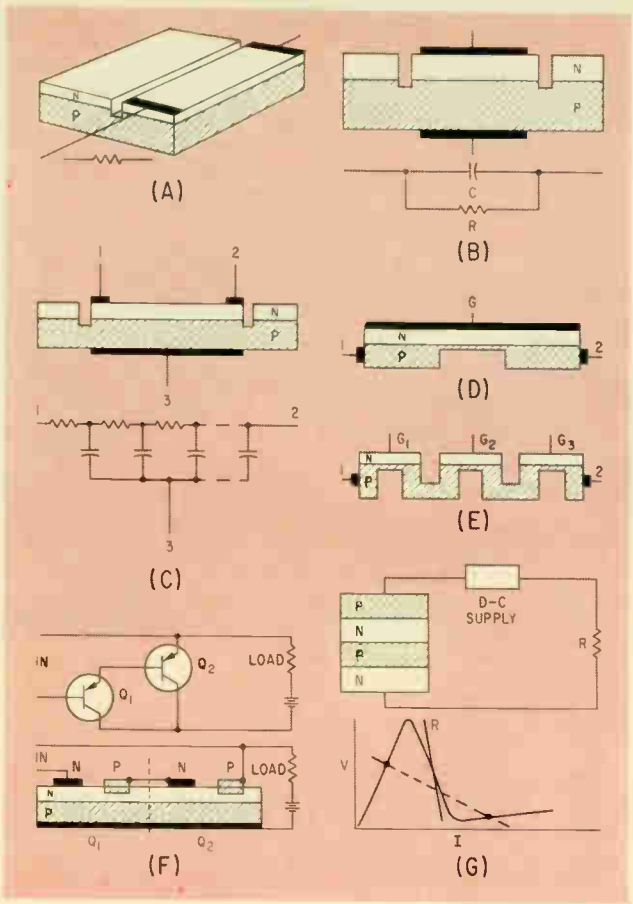


FIG. 1—Semiconductor is modified to provide resistor (A), R-C network (B) and phase shift network (C). Unipolar transistor used for gating (D) and to get direct coupled logic (E). Darlington amplifier (F) and four-layer diode oscillator (G) are more complex functions

placed. Figure 1 shows some typical structures. A resistor (Fig. 1A) is formed by diffusing antimony into a *p*-type block to obtain a thin skin of *n*-type, low resistivity silicon. Because the substrate-to-skin resistivity ratio is greater than 100, the thin slit shown isolates the region that has leads. Typical slotting methods include: fine diamond sawing, sandblasting and etching through photoresist masks. Leads are attached by furnace fusion, welding and thermocompression bonding.[2]

Attaching metallic areas to each side of the diffused junction gives the circuit shown in Fig. 1B. Capacitance and resistance vary with the applied voltage. These variations can be useful in some applications. The configuration of Fig. 1C results in a deviation from discrete components. This phase shifting and low-pass filter has capacitance and resistance distributed through the block.

UNIPOLAR TRANSISTOR—Properties of the unipolar transistor can be used to obtain gating action as shown in Fig. 1D. The cut in the *p*-layer extends close enough to the depletion layer region so that when reverse bias is applied the resistance between points 1 and 2 is high. With zero bias this resistance is low. Thus, the bias on the *n-p* junction gates the path between 1 and 2.

This concept can be extended to obtain the direct-coupled logic of Fig. 1E. The top slots form a resistor between the unipolar transistors. If none of the gates is biased there is a signal path from 1 to 2. If one or more of the gates are strongly reverse-biased no current will flow from 1 to 2.

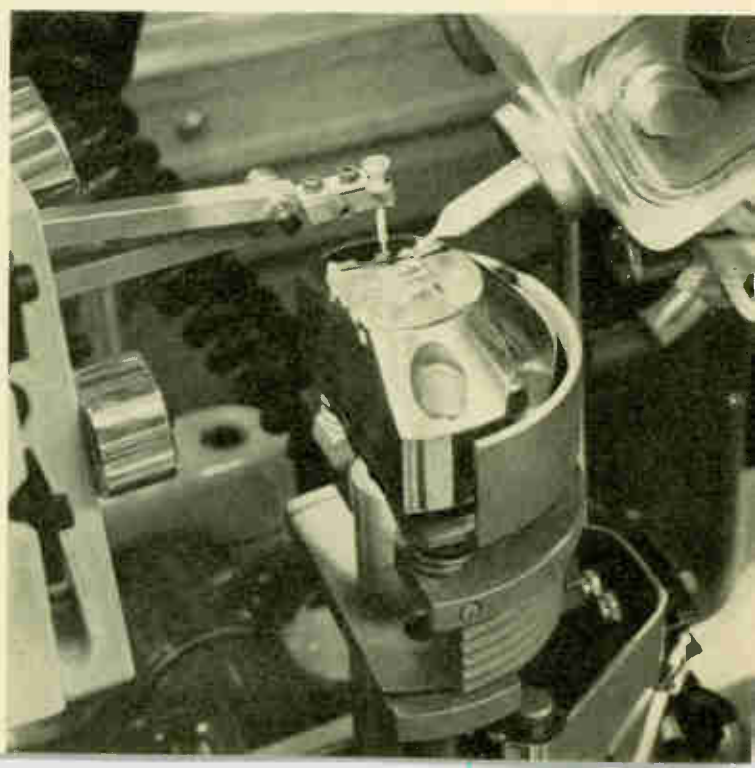
The Darlington amplifier circuit (Fig. 1F) can be constructed from a solid block. A metal electrode on the *p*-region forms the collector connections. Base areas are provided by a metal that forms an *n*-connection with the *n*-region. The transistors are completed by a *p*-alloy junction to the *n*-region. Transistors are connected by allowing the *p* emitter of Q_1 to fuse at one point to the *n* base of Q_2. This simplified illustration omits temperature compensating resistors and coupling capacitors. These can be included to get more stable operation with temperature variations.

A block that has little analogy to the circuit it replaces is the four-layer diode oscillator of Fig. 1G. With the load resistance shown by the dotted line, the circuit will have two stable states. Using a higher load resistance (R) the circuit will oscillate with a sawtooth output. Output frequency is a function of the applied voltage. These devices can be incorporated to provide more complex functions.

TRANSLATING CIRCUITS—Although comparison between the more complex semiconductor network and conventional circuits are best made on a functional basis, it is possible to translate a circuit into its equivalent semiconductor block by relating known circuit elements to conductance paths in the semiconductor. One procedure for making a circuit semiconductor begins with the circuit shown in Fig. 2A. This NOR circuit has one transistor, four diodes, three resistors and one capacitor.[3]

Resistor-capacitor combination R_1 and C are changed to a distributed R-C network as indicated in Fig. 2B. Since the voltage applied to C does not change polarity, a *p-n* junction capacitor can be used. Resistivity of silicon can be used to form the resistors. Using 2-mil thick 10 ohm-cm silicon, resistor R_A needs an area of 10 by 20 mils, R_B requires 10 by 50 mils and R_C 10 by 10 mils.

Resistors and other components are arranged as shown in Fig. 2B. A starting wafer of *n*-type silicon (Fig. 2C) forms the transistor collector region, the resistors and the cathode of each diode. A layer of *p* material is then diffused to provide the transistor base region, the



Closeup shows how Westinghouse uses thermal compression bonding to attach leads to silicon wafer

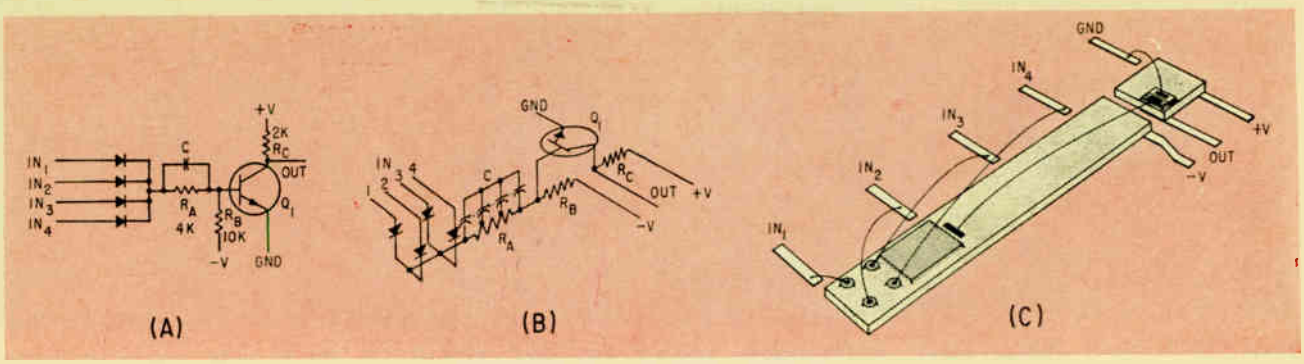


FIG. 2—Development of Texas Instruments' NOR circuit: schematic diagram of circuit (A), three-dimensional schematic (B), and circuit in semiconductor form (C)

anodes for the diodes and the capacitor over R_A. An *n*-type diffusion is required for the emitter region.

These steps are typically applied to a 210 by 440-mil silicon wafer. After the contacts are deposited, this large wafer is separated to form 16 complete NOR circuits. As a final step, input and output connections are provided and internal jumpers attached. Jumper connections are made with thermally bonded gold wires.

CUSTOMER NEEDS—Although it sells Solid Circuits from stock, the majority of Texas Instruments' present efforts have been directed to the designing and fabricating semiconductor networks to meet specific customer requirements. They feel custom designing is one of the characteristics of the function-oriented approach. Functions delivered to date have been principally in the digital field. These include such functions as bistable multivibrators, logic elements, gates, inverters, and buffers. All of these have been made from silicon and have been encased in a hermetically sealed package.

To establish production capabilities, TI is reducing to practice an orderly design approach; has established a pilot line that has been operating consistently for the past few months; has decided on a definite package form factor (this is a hermetically sealed enclosure); and is investigating various means for interconnecting networks. Additional catalog items will be released during the coming months. These will be in the area of digital circuits. The company has no immediate plans to market analog or bandpass devices.[3]

FUNCTIONAL BLOCKS—Using design criteria that a single piece of semiconductor be used, that no wires connect parts internally and that there be no cementing of parts, Westinghouse has developed 18 different types of functional blocks.

In April of this year Westinghouse completed a study for the Air Force. The possibility of using functional blocks in a uhf receiver, telemetry system, reconnaissance system, adaptive flight control system and an infrared application where studied. Second phase of this $2.3 million contract is to deliver, by Oct. 1961, the following: a 250-Mc superhet receiver using functional blocks from the i-f section on, and telemetry and reconnaissance systems with key functions using functional blocks.[4]

In producing the blocks three basic structures are used: alloyed structures, base diffused structures and double-diffused oxide-mask structures. Figure 3 illustrates the substitution of functional block in an audio amplifier. The low-level and high-level amplifiers of Fig. 3B replaces the 4-transistor amplifier in Fig. 3A.

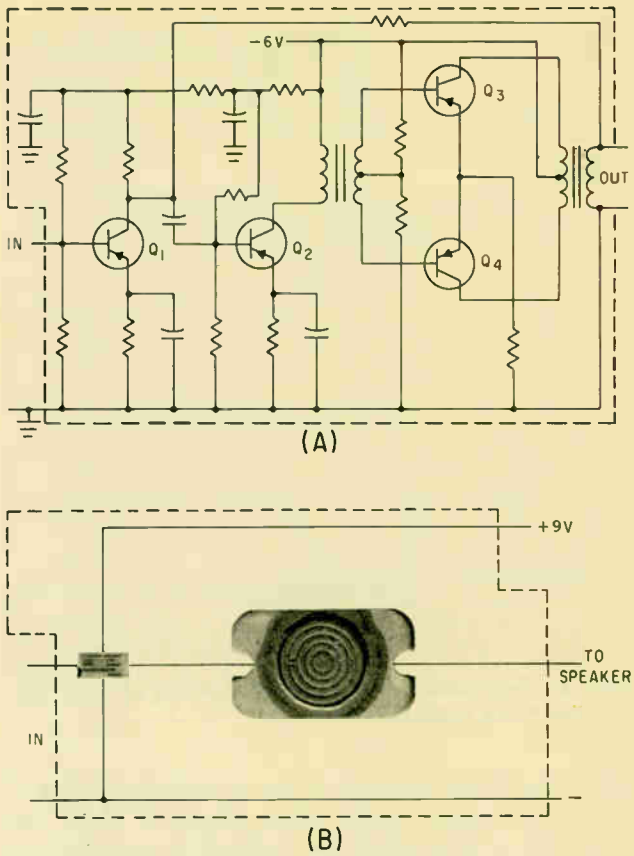
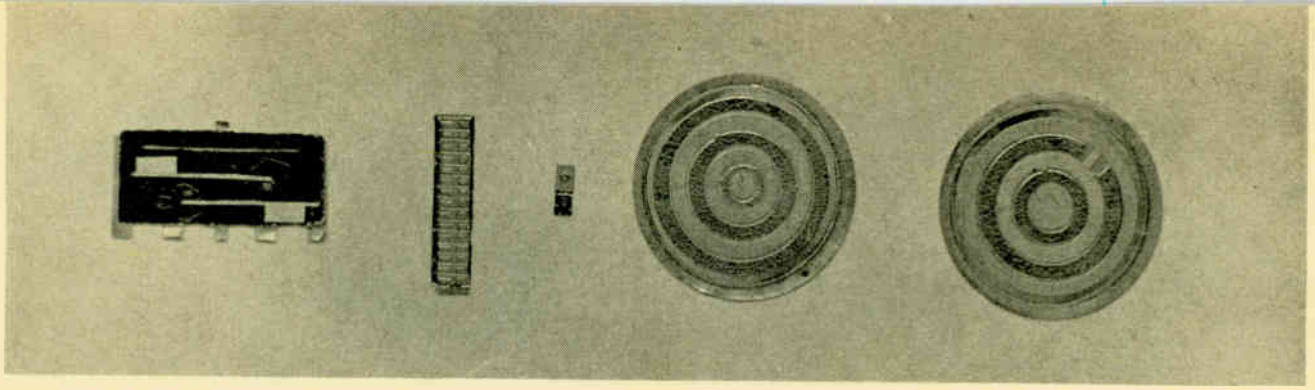


FIG. 3—Two Westinghouse functional blocks (B) replace four transistors and associated components (A). Blocks are shown actual size

LOGIC FUNCTIONS—Fairchild Semiconductor combines the characteristics of several transistors in a packaged element. Presently a JEDEC TO-5 package with eight leads is used, future plans call for a TO-18 can. Elements developed include: buffer, flip-flop, gate, half-adder, counter adapter and half-shift register. Work is underway on other micrologic elements. Techniques used in diffused mesa transistor operation are employed to make these elements. Interconnections of elements are made by using a printed-circuit board.[5]

A 1,000-element 7.5 Mc computer requires 0.15-cc with an infinite heat sink.



From left to right—500-Kc bistable multivibrator, multiple 3-terminal pnpm switch, 100-Kc pulse generator, 3-stage high-level amplifier (output of 1 to 2 amp, current gain up to 1,000) and 2-stage amplifier (output of 1 to 2 amp; current pain of 500) by Westinghouse. Amplifiers are ½ inch in diameter

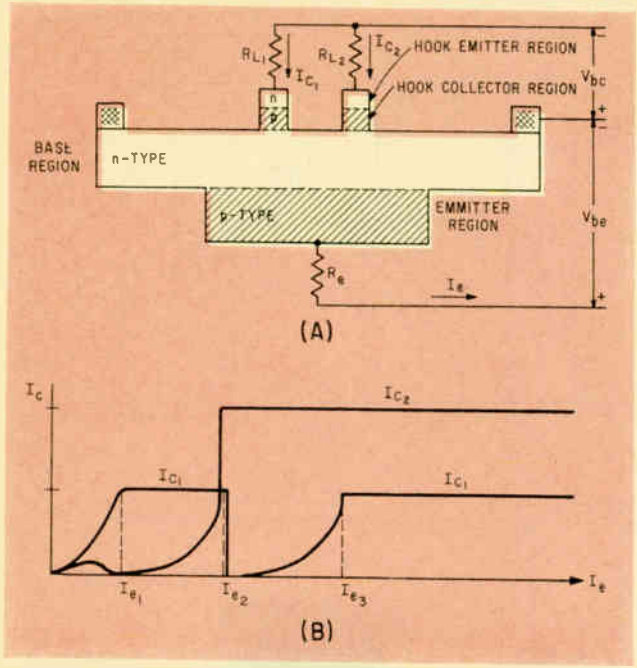


FIG. 4—Two-collector semiconductor device of IBM (A) has operating cycle shown in (B)

This same circuit operating in free air with an ambient of 25 C would require a cube with a volume of 77 cc. Devices now in development are expected to reduce power dissipation by a factor of five.

SOLID LAMINATES—A method of depositing films to form a three-dimensional self-supporting matrix capable of performing a function has been suggested by a capacitor manufacturer.[6] This method of generating solids composed of a group of compatible materials has been used by Vitramon to make capacitors. Demonstrations going back to the late 1940's indicate that this is a practical way to produce entire systems. A laminant is generated of strata of solid particles with different layers, each layer having selected properties, but all being fusible into a single solid. It is possible for chemically reacting ingredients or doped strata to provide a broad range of functions and properties.

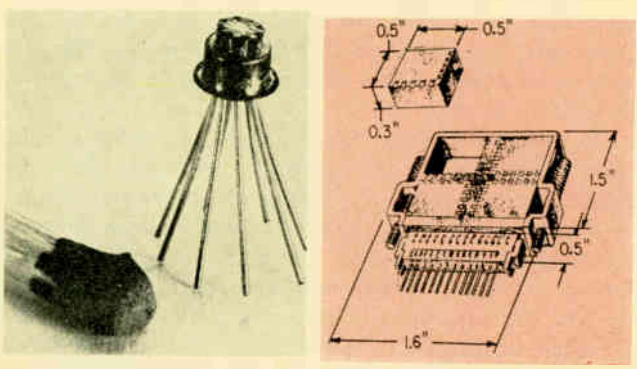
Available for use in such an approach are: porcelains, ferrites, titanates, piezoelectric and other ceramics, voltage and heat sensitive semiconductors, and conductive and semiconductive metals.

Multiple-collector semiconductor devices can be used as a building block in the design of large digital computer.[7,8] A two-collector device is shown in Fig. 4A, switching action in Fig. 4B.

VAPOR GROWTH—Contiguous deposition of single crystal silicon layers on a single crystal silicon substrate by vapor-growth methods is a new approach to building solid-state circuits. Laminar layers formed in this process can be controlled in conductivity type, resistivity, and thickness. By combining this technique with oxide masking, diffusion, and alloying techniques, these deposited configurations can be made into microcircuits. Full description of this process will appear in ELECTRONICS next week.

SILICON DIGITAL SYSTEMS—A corporation dealing in digital systems is working on fabricating digital functions. Using techniques somewhat similar to the approach of Westinghouse and TI, the Sperry's Semiconductor division is fabricating inverters, NOR circuits, and flip-flops. Their present package for these functional circuits is a TO-5 type transistor case with eight leads. Eventually, the firm expects to use a flat package, to match the form of their silicon wafer more exactly. Connection leads will project from the four smallest area faces of the parallel-piped. This package is still under development and its configuration will depend to some extent on system requirements.

Briefly, the fabrication method is as follows:[9] silicon is properly doped, sliced, lapped and polished; proper im-



Fairchild Semiconductor's flip-flop on a TO-18 header compared to a match head (left). Packaging technique (right) for circuit function modules is being developed by Lear, Inc.

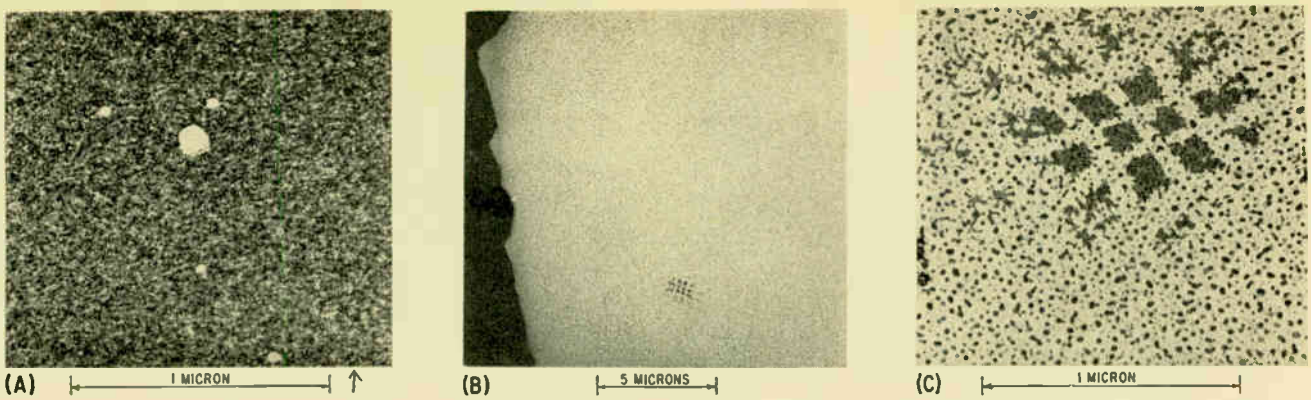


FIG. 5—Molybdenum film deposited by thermal evaporation (A) is etched to obtain pattern shown in (B) with low magnification and in (C) with high magnification

purities are diffused (by a double diffusion process) in certain areas of the polished silicon slices to obtain the device configurations; metal contact points are vacuum deposited on the slices; external connections are thermocompression bonded to some of the metal contact points; the devices are sealed and given final electrical tests. Trademark for these microelectronics devices is Semi-Nets.

THE FUTURE—A number of machine generations from now we may be seeing computers being built that have the complexity of human neural networks and that will have achieved a spectacular and unprecedented reduction in size. Work at the Stanford Research Institute has as an objective the design of a data processing system composed of 10^{11} active components, occupying 100 one-inch square substrates, assembled in a package measuring only one cubic inch.[10]

We are not speaking now of functional blocks and of distributed effects, but of the excruciatingly careful machining of discrete components in the molecular domain by electron microscope techniques. An average component would have outside dimensions of about one micron and an equivalent thickness. In building components at this level, resolutions of construction techniques must be on the order of 100-200 angstrom units.

SRI researchers feel their dream can be realized, and they are designing and building the equipment and techniques with which they can do it. Under development now at SRI is an integrated apparatus consisting of an ultrahigh vacuum system containing an electron microscope optical system, deposition and etching chamber, vacuum locks and mechanical manipulators. Using simple vacuum deposition equipment and a commercial electron microscope, SRI workers have already demonstrated to some degree that their goals for electron-beam machining are attainable.

Figure 5 is a series of micrographs which depict stages of the micromachining process. In this process, a 200 A thick film of molybdenum was deposited on a 200 A thick aluminum oxide film by thermal evaporation (Fig. 5A), the films being supported on an electron microscope specimen screen. Following this, the molybdenum was coated with triphenylsilanol (which under electron bombardment decomposes to form a silica resist), and exposed in the electron microscope with a reduced pattern of a screen wire mesh. Then the molybdenum was etched in chlorine. The resulting image of the screen wire

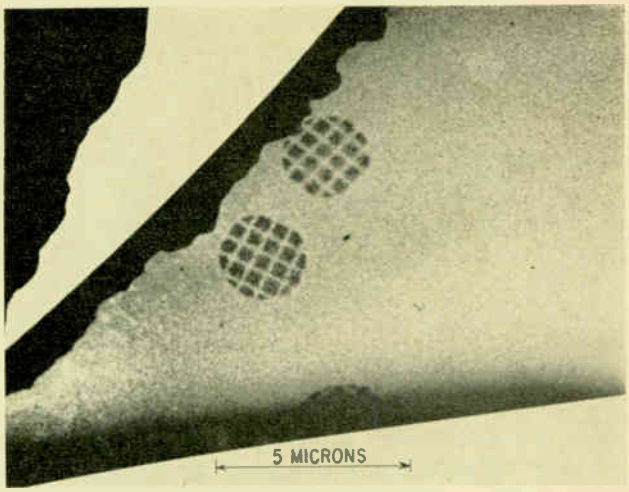


FIG. 6—Example of silicon image made on silicon dioxide by micromachining process (SRI)

pattern is shown with low magnification in Fig. 5B and with high magnification in Fig. 5C. The image is distorted into a pincushion shape by the electron-optical system. In Fig. 5C, image size is such that the screen wire spacing is 2,500 A or 100,000 mesh per inch. Resolution is about 300 A. Figure 6 shows screen of silicon on silicon dioxide made by similar techniques.

Many micromachining techniques are being developed in the program: both solid and gaseous sources have been used with molecular beam techniques in high vacuum to etch surfaces of materials to convert them to volatile compounds; the etching of holes in thin films with depth-to-diameter ratios of 10:1 has been explored; atomic-beam etching methods for application to low temperature etching, the use of ion beams to sputter material from a substrate to produce straight-sided etching with no undercutting and depth-control methods effective to one percent have all been worked on.

At the present time, the fabrication of one-micron sized components is limited by construction techniques, but it is expected that with the perfection of these micromachining techniques and equipment such components will be fabricated and (according to Kenneth Shoulders who heads up this work), conceivably, fabricated in vast arrays by self-formation methods.

But, what kind of components will these be?

COMPONENT CONSIDERATIONS—In scaling down

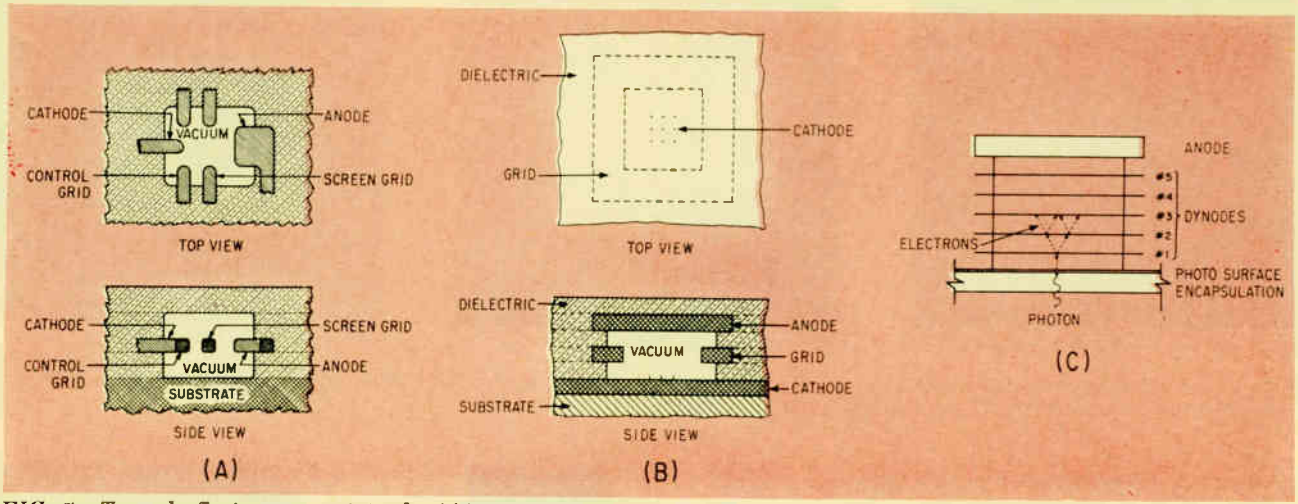
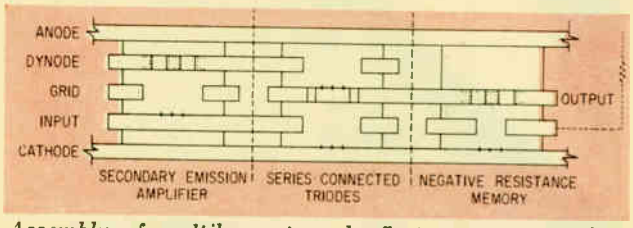


FIG. 7—Tunnel-effect vacuum tetrode (A), multilayer tunnel effect vacuum triode (B) and thin film transmission type multiplier phototube (C) are proposed components (SRI)



Assembly of multilayer tunnel effect components gives an active memory requiring low quiescent power

electronic components to the one-micron domain the designer encounters new problems: interconnection between widely-separated (relatively speaking) components would be constrained by high electrical resistance of the transmission lines—active components of high impedance are required; switching times shorter than 10^{-11} second result in excessive interconnection loss at room temperature and above; L-C filters would have extremely low Q; R-C filters would be prone to temperature drift; small sizes give high surface-to-volume ratios that causes materials to migrate under the action of surface tension forces and causes increased carrier recombination at semiconductor surfaces; production of uniform crystallinity in films is extremely difficult.

TUNNEL EFFECT COMPONENTS—To answer some of these problems Shoulders proposes a new component based on quantum mechanical tunneling of electrons from a metal into a high vacuum. Having an estimated switching time of 10^{-10} second, immunity to temperature variations and adaptable to self-forming fabrication methods giving component uniformity, this type of tunnel-effect component seems particularly suited for a microelectronic system built on the scale proposed.

Using only stable metals and dielectrics in various geometrics, it is expected that diodes, triodes and tetrodes can be fabricated. Figures 7A and B show two tunnel-effect devices, a tetrode and a triode.

PRACTICAL METHODS—Serious investigation has gone into practical methods for fabricating these tunnel-effect components as well as accessory devices. In Fig. 7B, the multiple-tip field emission cathodes with radii of 100 A are expected to be made uniformly by self-formation methods which have been devised; unique methods for creating the device vacuum chamber have been developed; Fig. 7C shows a thin-film transmission-type electron multiplier that may be used with tunnel-effect devices; internal interconnection between substrates may be performed by optical coupling on as many as 10^4 channels by using light generators, possibly aluminum oxide coated on tungsten field emission tips, and light detectors like that in Fig. 7C; switching for low-level signals would be accomplished by electrostatically operated mechanical relays with frequencies up to 10 Mc; simple metal and dielectric diaphragms or small metal splinters would serve as electromechanical filters between 4 Mc and 600 Mc; substrates are to be of sapphire one inch square and 0.01 inch thick; interconnections on a single substrate may be made by electrically steerable, periodically focused electron guides (called slalon focusing).

The expectancy is that this work will lead to the development of a highly parallel machine that has the capabilities of an intelligent technician. Considerable theoretical work has been done by others on the features and organization of a machine made of such microelectronic components.[11]

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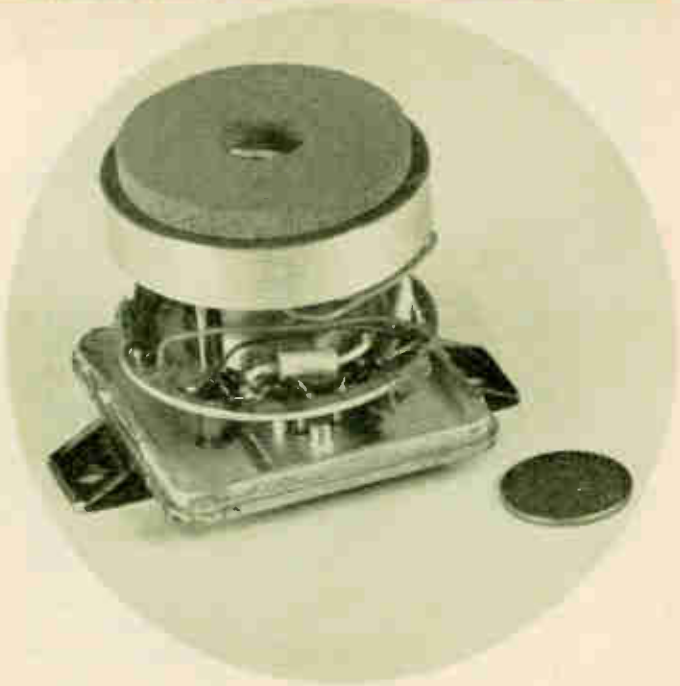
EQUIPMENT AND SYSTEMS



Heterogeneous system: Special glass substrates with thin-film components are used along with conventional components (by Minneapolis-Honeywell) in this summing amplifier for the B-58 center-of-gravity control system

Microminiaturization approaches are beginning to reach the system stage. Designs are tentative and aim at proving feasibility of different approaches and concepts. Computers get most attention

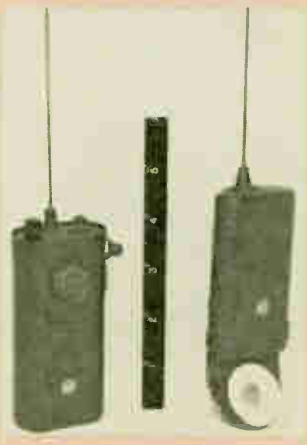


FIG. 1 — Micromodular AN/PRC-34 transmitter and receiver: transmitter (left) is hand-held for tactical field communications. Receiver (right) is a helmet-mounted unit (RCA)

FIG. 2—This MicroPac tactical field computer is one of two equipments being delivered by RCA under the U. S. Army micromodule production program

INTRODUCTION. What kinds of systems are actually being designed and built today using available and interim-type microminiaturization techniques and components? A few systems based on different approaches are described here, but it is certain that many more are being developed than can be yet revealed for reasons of military secrecy and proprietary protection of patent rights. Typically, many manufacturers who answered our inquiry remarked that they were deeply involved in microminiaturization but were not yet able to reveal the nature of their work.

MICROMODULE EQUIPMENT—To prove that micromodules can be used effectively in equipments, at least two different types of equipment are being built. First deliveries on these equipments, which are being built to military requirements, are slated for the middle of 1961.[1]

One set of equipment, the AN/PRC-34, consists of a single-channel helmet-mounted receiver and a single-channel pocket-mounted transmitter. Each unit is complete with antenna, batteries and transducers (see Fig. 1). Range of the transmitter-receiver system is 500 yards, signal is frequency modulated with either voice or tone, and operating frequency is 51 Mc. Temperature operating range is —20 to 110 F.

Eight types of micromodules make up the receiver: r-f amplifier, crystal oscillator, mixer, i-f amplifier (4 per set), limiter, discriminator, audio amplifier, and squelch

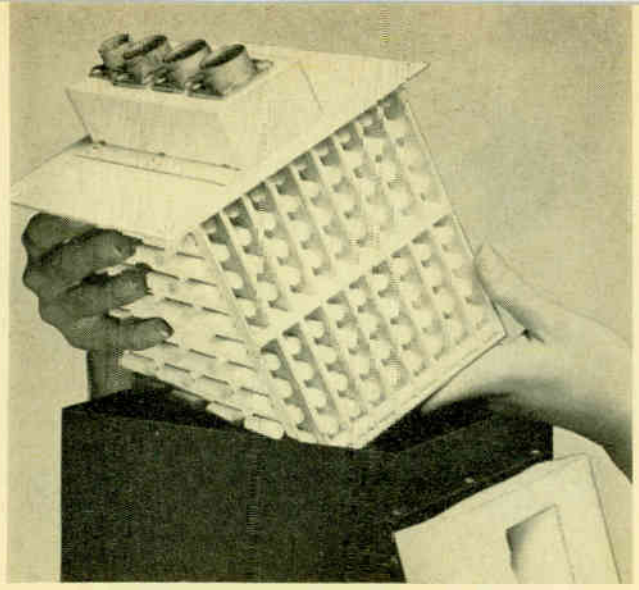


FIG. 3—Mockup of ballistic missile computer designed with GE TIMM's. Internal operating temperature is about 580 C; external temperature during operation will be about 100 C

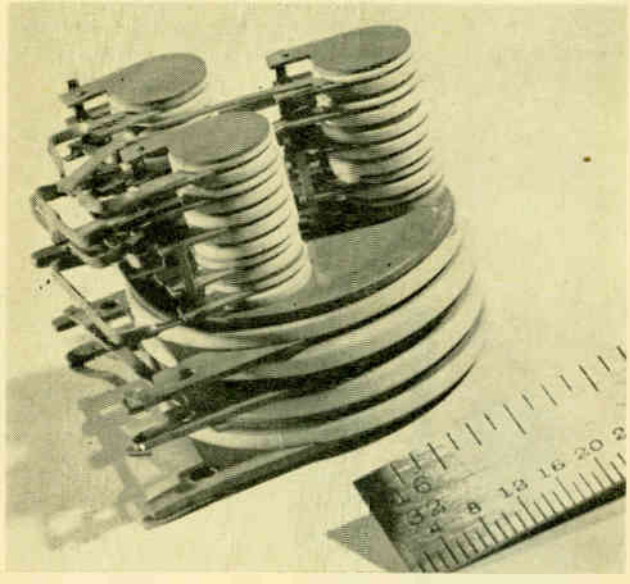


FIG. 4—This four-stage servo amplifier built with TIMM's micromodules operates with a 400-cps signal voltage, exhibits a gain of 800 volts per volt, and delivers a driving power of about ½ watt d-c to the load. Entire module weighs about 30 grams, occupies about one cubic inch. Unit is now in flight test

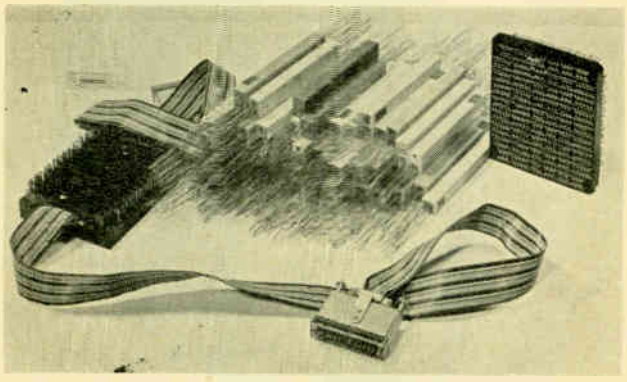


FIG. 5—Disassembled Polaris guidance computer consists of 54 sticks. Assembled, this unit occupies 0.12 cubic foot, containing 7,500 components. Sticks are color coded, orange for logic, light blue and light purple for memory (Francis Associates)

amplifier. Specifications for the receiver are: sensitivity, 4 μv or less; audio power output, 2 mw, max.; bandwidth (with Clevite resonators), 50 Kc at 6 db, and 200 Kc at 60 db. The receiver weighs 4 oz.

Six types of micromodules make up the transmitter: modulator-tone oscillator, crystal oscillator, phase modulator, tripler, doubler (2 per set—one operates as intermediate power amplifier), and power amplifier. Specifications: power output, 100 mw; battery supply, 7 N-cells (10.5 v); deviation, ± 4 Kc at 100-percent modulation; weight, 5 oz.[2]

MICROPAC COMPUTER—Another equipment intended to prove out the micromodule concept is a field-data computer, called MicroPac, that will become a part of an integrated automatic data-processing system or part of a corps or division tactical operations center.

The unit (Fig. 2) is a small, stored-program general-purpose computer, a binary synchronous, serial machine with a 38-bit word length. Only the memory is in micromodular form.

Using a coincident-current, magnetic-core memory with a 2,048 word storage, the computer can perform twenty instructions. Operating speeds are: add and subtract, 80 μsec; multiply and divide, 1,000 μsec; transfer of control, 40 μsec; memory access, 40 μsec.

Three modes of input-output access are provided: the control console, which is integrated in the front panel, paper tape units, and a real-time input-output channel that connects the memory with digital-data terminals or real-time sources.

Less than three cubic feet in volume, and weighing 55 pounds, the computer is one-third the size of an equivalent field computer whose memory is not micromodular. The computer contains nearly 3,000 micromodules. Of these, 1,400 are diode-input transistor gates, and 500 are flip-flops. Pair delay for the gates is 60 nanosec, and each gate is capable of driving four similar circuits. Clock rate is 1.5 Mc. Temperature range: 125 to — 25 F. Alternating-current power requirements are less than 2.5 Kva at 0.8 power factor.[3]

INERTIAL GUIDANCE PLATFORM—An unusual application of the micromodule packaging is a lightweight (21.5 lb) inertial reference platform developed for missile and short-range aircraft guidance. The electronics portion of the gyro, in a micromodular package, is mounted on the innermost gimbal. With this construction, stray pickup is kept to a minimum, fewer slip rings are required, and system reliability is increased.[4]

MISSILE COMPUTER—Serious consideration is being given to the development of a TIMM's ballistic-missile computer for a missile that has not yet been flown.[5] The ceramic modules should be useful in space vehicles since they require no cooling and are radiation resistant. Table 1 shows a comparison[5] between a transistorized version of the ballistic-missile computer and a TIMM's version. Both computers have the equivalent of a 1,500-bit memory, including drivers, and approximately 750 multivibrator flip-flops. Figure 3 shows a full-scale mockup of the proposed computer.

A servo amplifier built with different-sized TIMM's

appears in Fig. 4. This four-stage amplifier weighs about 30 grams, measures one inch in diameter and stands one inch high. It is presently being flight tested.

MICROLOGIC COMPUTER—Effectiveness of the micrologic approach to miniaturization may also be measured by a comparison with techniques presently used. Fairchild Semiconductor, as Table II shows, has compared the characteristics of a typical real-time computer using transistor-resistor logic and one using their micro-elements.[6] Prices are based on production units of the elements. Fairchild expects the numerical reliability of the micrologic element to be as good or better than that of a transistor. Fewer interconnections should increase reliability.

The sizes quoted are for elements in a TO-5 package mounted on a printed-circuit board.

POLARIS COMPUTER—Figure 5 shows a disassembled IX-4 Polaris guidance computer packaged for MIT. This high-density package weighs approximately one-half that of a printed-circuit package.

COMPREHENSIVE DESIGN PROGRAM—A design program for a 1961 developmental computer to be built using microminiaturization techniques shows how one systems manufacturer sees the start-of-the-art.

In early 1959, the Arma Division of the American Bosch Arma Corp. started a program of microminiaturization to produce a reliable, small, lightweight, flexible and inexpensive digital computer for ballistic-missile guidance, space navigation and extended-time navigation. During this program, the company evaluated various microminiature concepts for their applicability to circuits previously developed for the computer. A number of subcontracting companies were asked to apply their techniques to the adder of the computer. In all, some thirty-five subcontractors and consulting companies were involved.

Among the approaches considered were: the DOFL approach of using wafers with a multiplicity of components with fabricated photolithographic transistors and diodes, printed resistors and small surface-mounted capacitors; the RCA micromodule approach that uses wafers containing single components; the Texas Instruments Solid Circuit approach of using a single semiconductor crystal and performing all circuit functions within the crystal; the Varo approach of vacuum mixing pure

TABLE I—Ballistic Missile Computer, Comparison

	Semi-conductor Version	TIMM Version
Weight	63 lb	25 lb
Volume	3,100 in^3	560 in^3
Power	160 w (reg)	110 w (73 w is unreg)
Cooling	liquid	none
Radiation Pulse Tolerance	10^5 R/sec	10^9 R/sec
Repet. Rate	1 Mc	1 Mc
Clock Freq.	500 Kc	500 Kc

TABLE II—Relative Characteristics of Typical Real Time Computer Logic Section

CHARACTERISTICS	TRANSISTOR–RESISTOR LOGIC	MICROLOGIC ELEMENT
OPERATING		
Speed (serial)	Greater Than 2 Mc	
Power requirements	160 w at 4.4 v 9 w at 15 v	30 w at 3 v
Ambient operating temperature	–55 C to 125 C	
Other ambient environment	Full Military	
PHYSICAL		
No. of components	2,000 Transistors 8,000 Resistors	1,000 Elements
No. of printed circuit holes	22,000	8,000
No. of printed circuit boards	40	4
Length of printed circuit conductors	600 ft	60 ft
Number of interboard connections	1,000	60
Length of harness wiring	125 ft	5 ft
Size	0.8 ft^3	0.08 ft^3
COST		
Prototype	$200,000	$50,000
Each succeeding unit	100,000	25,000

metals in gaseous atomic form and controlling their deposition on a substrate to create alloy characteristics that determine, in part, the properties of the circuit—in this approach, fully-cased semiconductors were assembled with the deposited circuit; the molecular electronics approach as practiced by Westinghouse; the GE TIMM's approach of using titanium and ceramic micromodules that operate at high temperatures and which can withstand nuclear environments; and others, including the early Navy sponsored Project Tinkertoy that had been directed primarily toward high-volume production of electronic equipment, but never achieved widespread use.

Arma asked four companies to use their fabrication techniques to make adders—Aerovox, Centralab, Sprague and Texas Instruments. Semiconductors were supplied by Transitron, Inc., General Transistor Co. and Pacific Semiconductor Co. Texas Instruments supplied both circuits and semiconductors in their approach. The full adders were checked under operational conditions, including checks for reliability under shock, vibration, temperature and humidity.

Problems considered in the design concerned volumetric efficiency and relative reliability. Reliability, in turn depended upon the number of solder joints, number of components on a wafer, number of wafers in functional block assemblies, level of hermetic sealing (whether for individual semiconductors, wafers, larger functional assemblies or the entire computer) and methods of interconnection (conventional wiring, printed wiring, multilayer printed wiring, flexible printed wiring, spotwelded connections).

After completing its first-phase study program, the company concluded: "The preliminary evaluation of various concepts has indicated that although the solid-state concept is most promising, it has not been developed far enough to be adapted for Arma's computer of 1961. Therefore, an approach similar to a 2-dimensional ap-

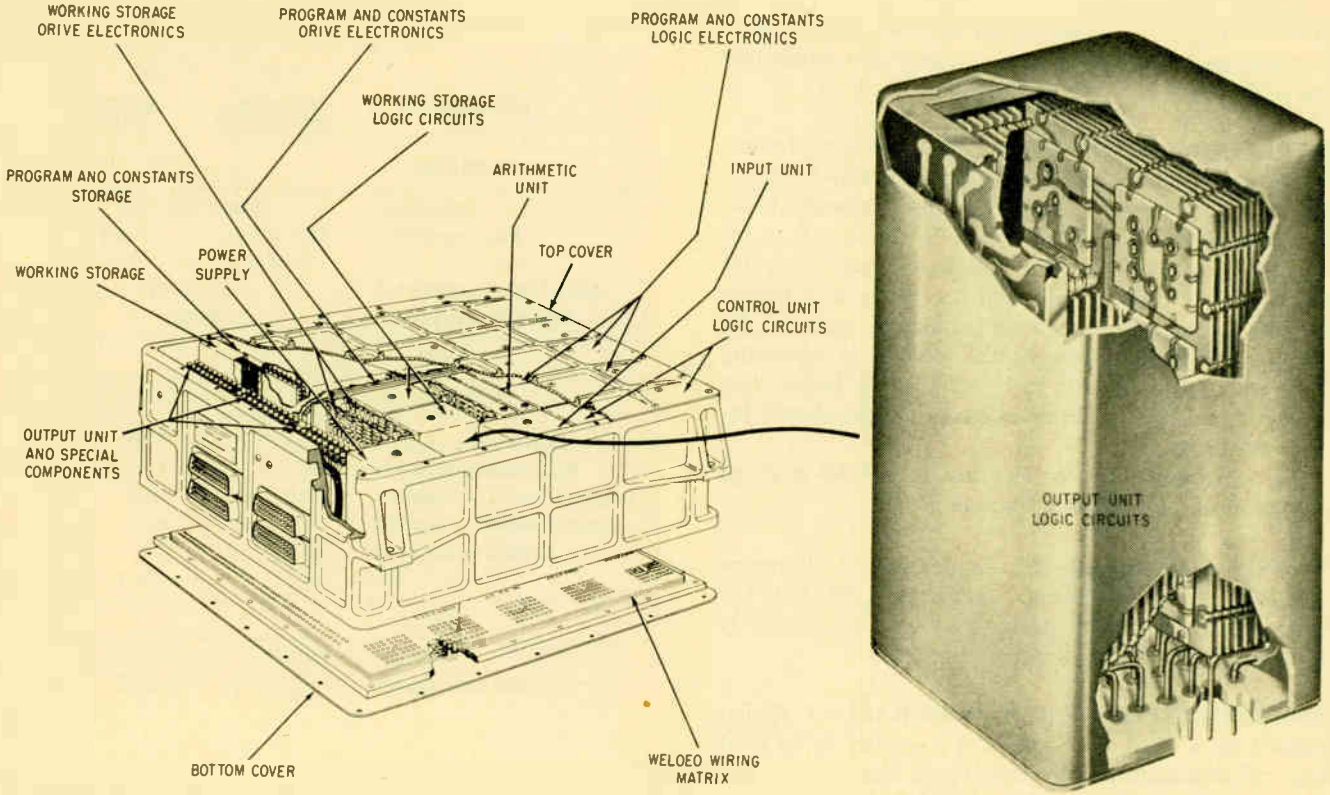


Fig. 6—Diagrammatic view of microminiature computer being designed by Arma. Cutaway view to right shows final assembly of circuit wafers and interconnections. The comprehensive design program carried out by Arma in the development of this 1961 computer reveals some of the problems confronting the systems designer who wants to microminiaturize now

proach would be the most practical concept for the first developmental-model microminiature computer of 1961."[7]

Arma finally decided on a combined flat-plate and Tinkertoy packaging method (see Fig. 6) based on multiple-component wafers, though the number of components to be printed on a single wafer was not to exceed ten. Single-component wafers, they felt, resulted in too many interconnections and were wasteful of space gained otherwise, thus canceling the advantages of high-production yield and individual component reliability.

In the computer design, resistors are printed carbon, capacitors are thin square wafers with one side soldered directly to the linework and a lead soldered from the other side to the linework; linework consists of thin metallic ribbons of screened and fired silver paint, or applied by photolithography or vacuum deposition; transistors are inserted into 0.1-inch diameter holes and diodes into 0.06-inch holes. Some evaporated resistors and capacitors will also be used.

Major interconnection wiring between functional blocks will be multilayer welded wiring matrices. Although hermetic sealing for the entire computer was considered most efficient, sealing on the functional block level was considered best for maintenance. To reduce the size of the information storage package, a flat-plate method of mounting memory cores that would reduce wiring was explored. Case structure for the computer is a precision-cast magnesium alloy. Weight of the computer is not to exceed 15 pounds. Figure 6 shows some details of the assembly.

CONCLUSION—Depending upon a systems manufacturer's needs and objectives and on the many types of microminiaturization methods and techniques becoming available, it is conceivable that many different types of systems designs will be arrived at. The systems discussed here are only a beginning or interim points along a line of engineering development. Certainly, as these different techniques and approaches are perfected and proved reliable, the electronics industry will find itself enriched in the possibilities it can exploit.

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(1) T. J. Tsevdos, Private Communication, RCA, Camden, N. J.
(2) Signal Corps Technical Requirements.
(3) Signal Corps Technical Requirements, SCL-4249, July 22, 1960.
(4) Technical Description of the RCA Inertial Guidance Platform, RCA, Burlington, Mass., Nov. 1959.
(5) J. R. Topper, Private Communication, G.E., Owensboro, Ky.
(6) R. Norman, Status Report on Micrologic Elements, 51st Bumblebee Guidance Panel, June 22, 1960.
(7) J. Maguire, Microminiature Computer, 1959 Study Program, Phase 1, Document No. MM/2/60.

(PART 1)

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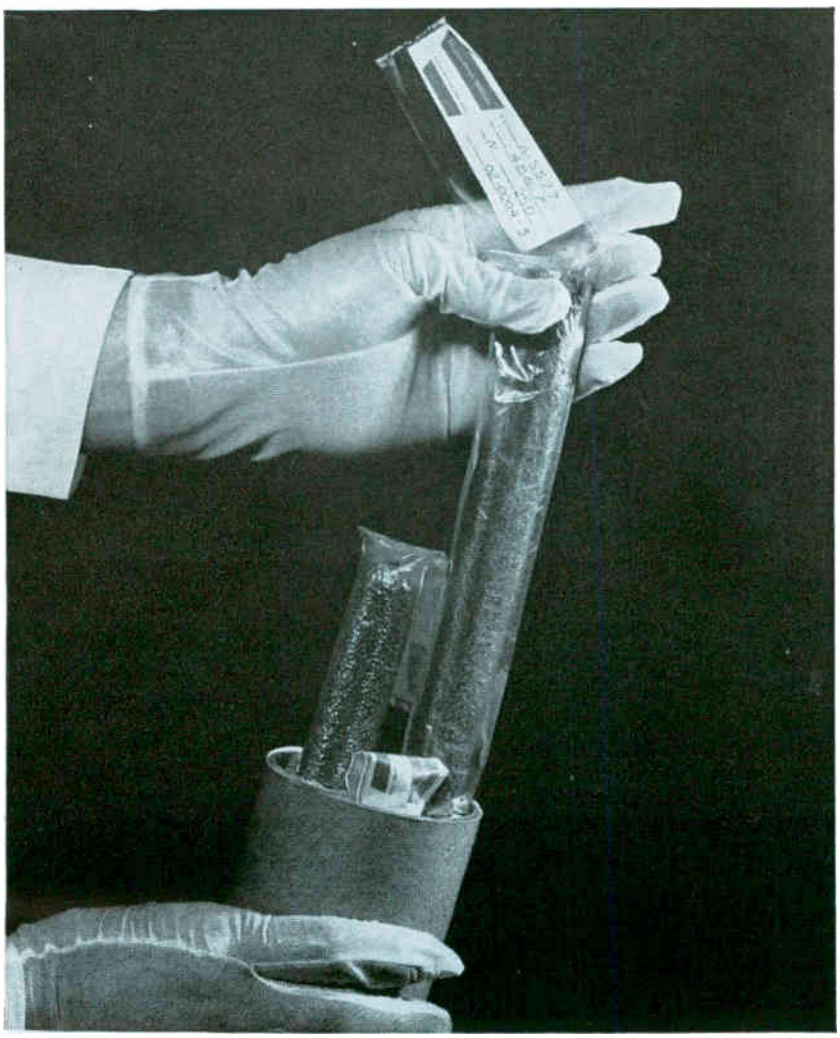

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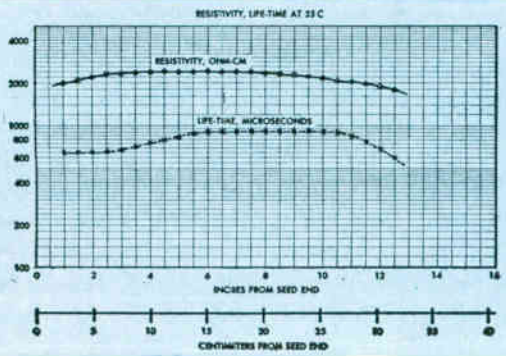

Typical Properties of Polycrystalline Silicon

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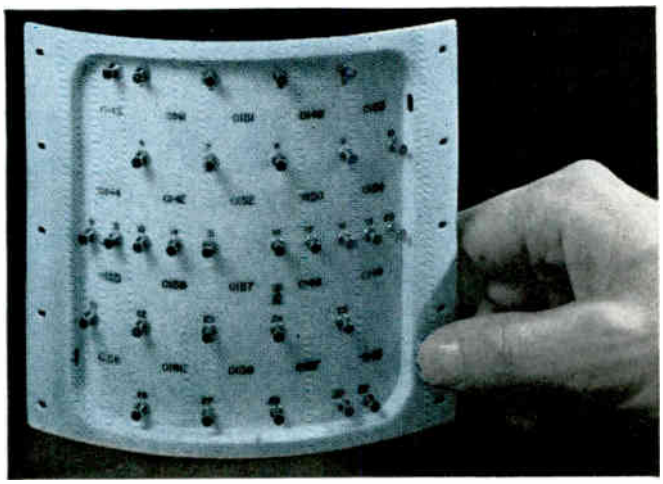

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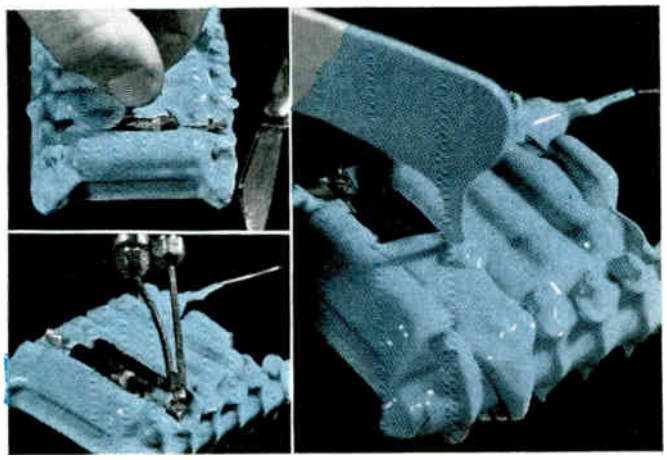

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Regulation (line)	Better than 0.025% or 3 mv over input range (whichever is greater)		
Regulation (load)	Better than 0.05% or 5 mv, no-load to full-load variation (whichever is greater)		
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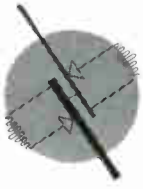

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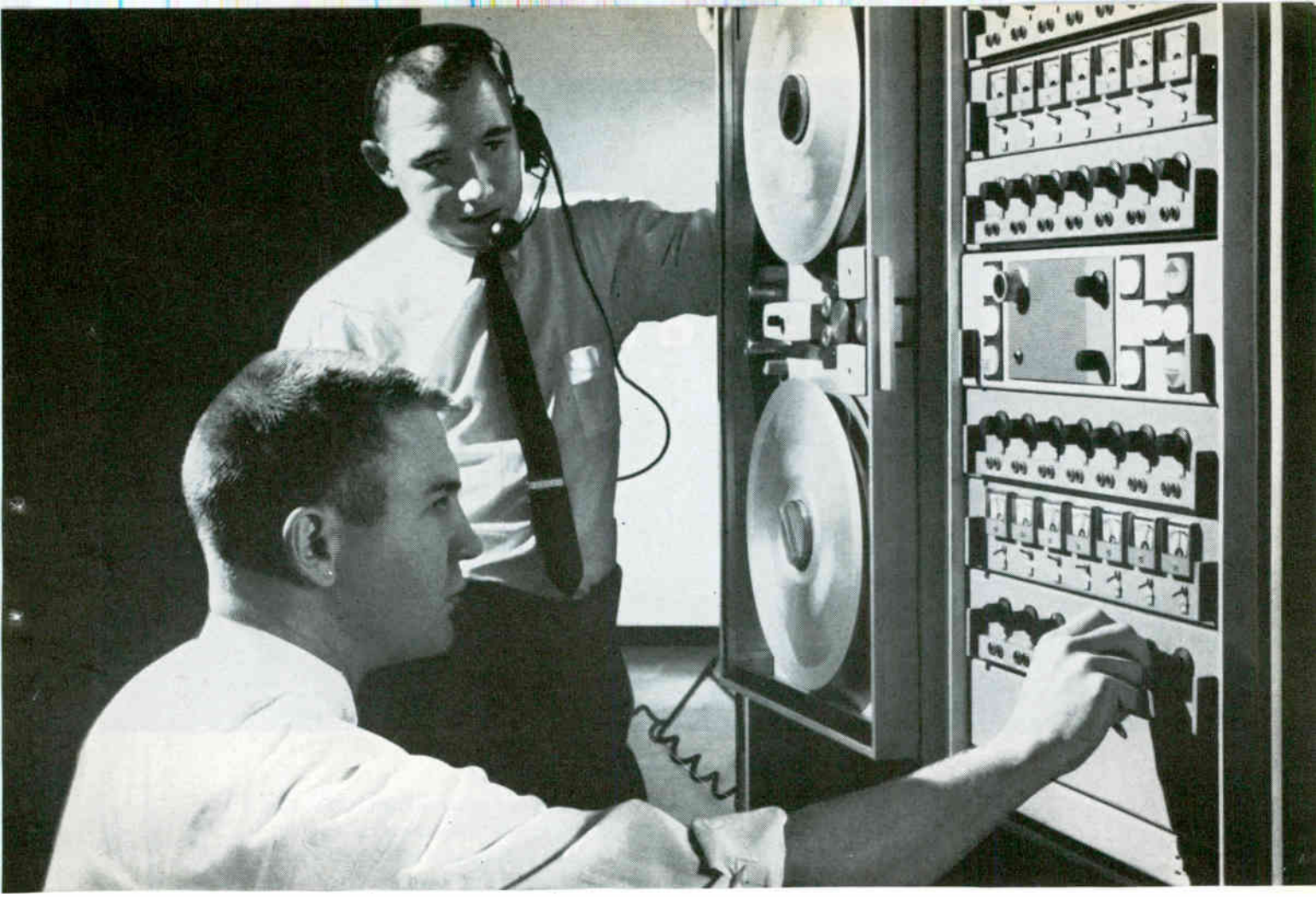

AMPEX specifies Tung-Sol transistors for FR-600 analog tape recorder

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With reliability the keyword, the choice of components for the FR-600 had to be an exacting one. Tung-Sol germanium power and switching transistors were specified for several major assignments. Tung-Sol's high stability 2N379 transistors deliver reliable power to the motor drive amplifier, the FR-600 control unit, and each bay power supply of the recorder. Tung-Sol's precision 2N414 germanium switching transistors handle important switching functions in the direct record amplifier, direct reproduce amplifier, FM record, FM reproduce, pre-amplifier and frequency standard.

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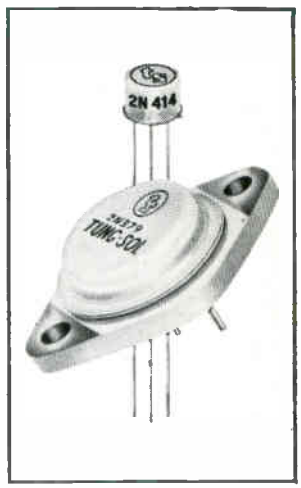

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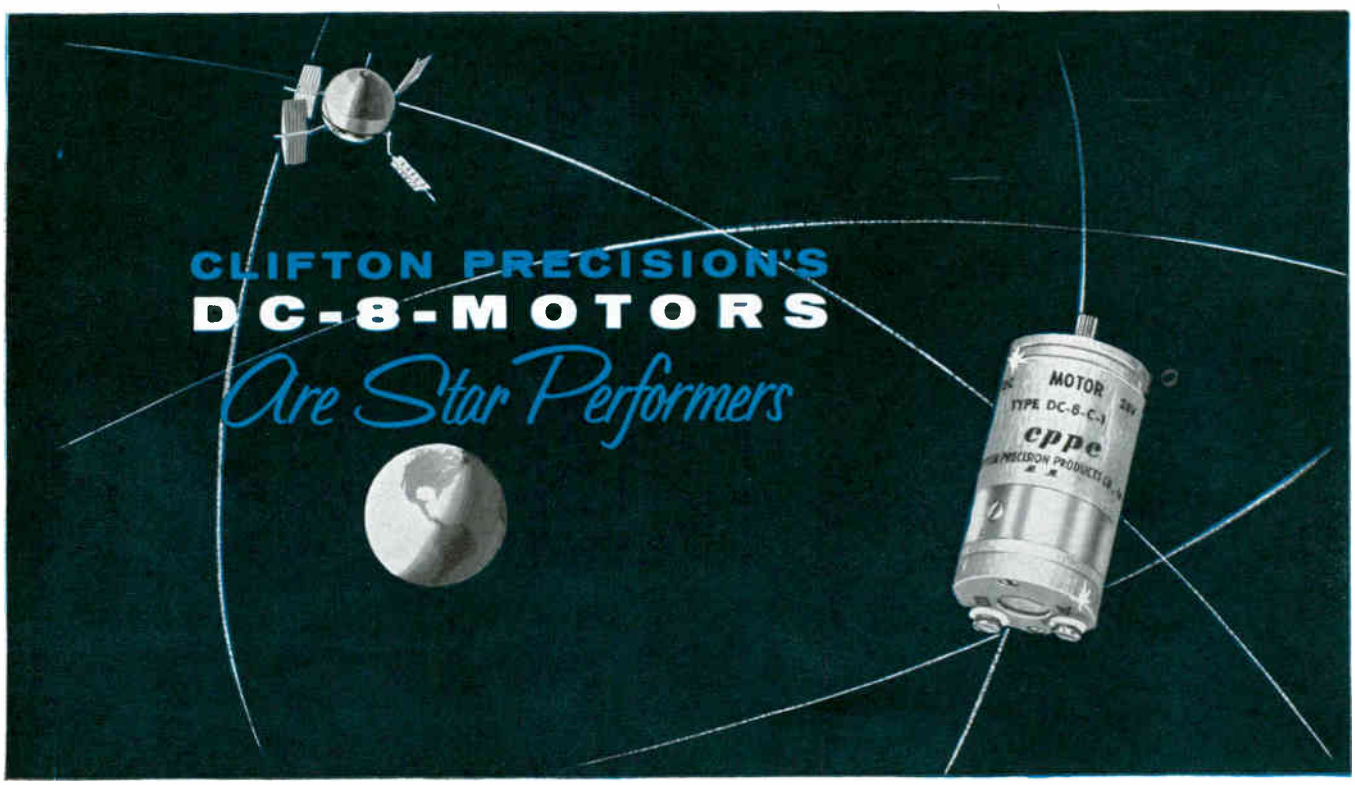

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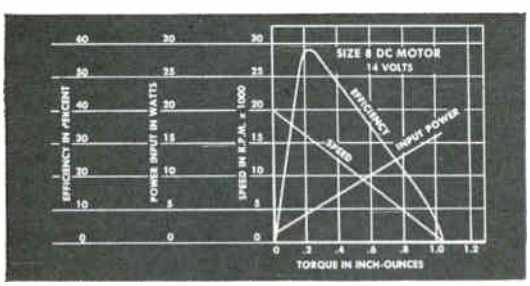

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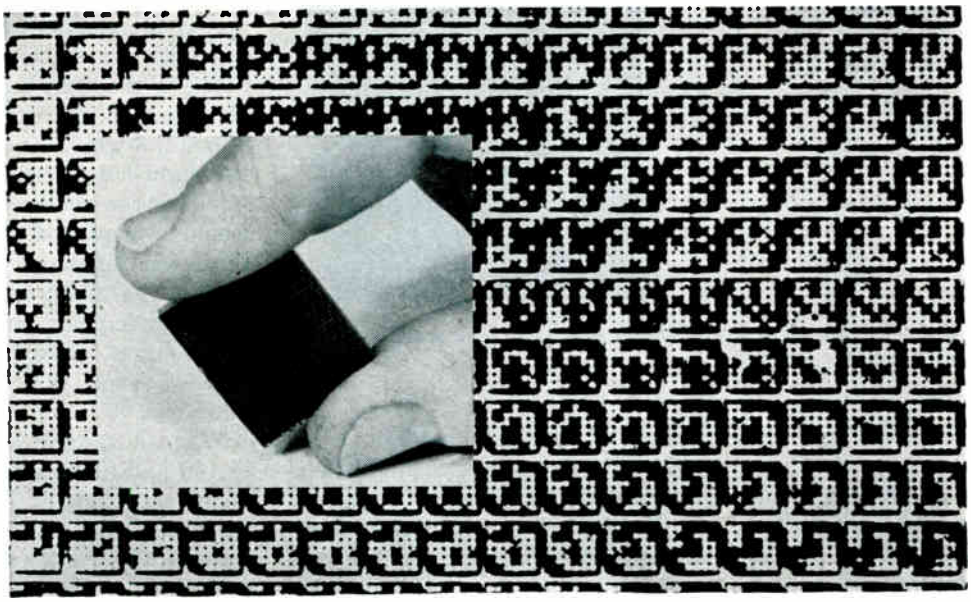


FIG. 1—Inset shows complete character reading wafer while large pattern shows dot arrangements for thirty-six messages

Nonscanning Character Reader Uses Coded Wafer

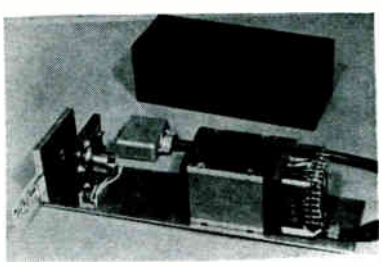
Noncritical lenticular-array character reader can recognize patterns, letters or numerals without use of scanning, special inks or complex logic circuits

By LAURENCE R. BROWN,
Briggs Associates, Inc.,
Norristown, Pennsylvania

IN MANY APPLICATIONS it would be desirable to use an electronic character reader with documents such as adding-machine and cash-register tapes and typewritten ledgers and bills if the character reader were simple and did not require a special format or type font.

When timing is required as in scanning or correlation methods of recognition, exacting specifications must be imposed on speed, skew, slippage and synchronization capabilities of document-handling equipment. A major source of expense and criticality of operation can be eliminated by specifying a synchronous reading that is not dependent on timing, positioning or speed regulation of the input characters during reading.

Many systems become complex in their logic sections. If a general-purpose high-speed computer is used, a large degree of reading flexibility may be programmed. However, the cost is high and the reliability may be questioned because of the complexity. The logic manipulations required are extremely complex in sorting out myriads of desired combinations of character elements from closely related groupings that represent erroneous readings. If logic or logical method can be simplified, cost and reliability can be improved.



Laboratory model of reading head assembly

The approach to character recognition outlined in this article has permitted simplification without sacrifice of functional performance.

A laboratory model of a reading-head assembly is shown at the left. Shows the document-feed channel, a reflection-projection lens surrounded by prefocussed long-life bulbs and the logic reader with output leads at which fully decoded numerical digits are available.

The wafer, shown in Fig. 1, (inset) is both the logical and optical array that serves as a multiple sieve-funnel combination that sorts characters of different charac-

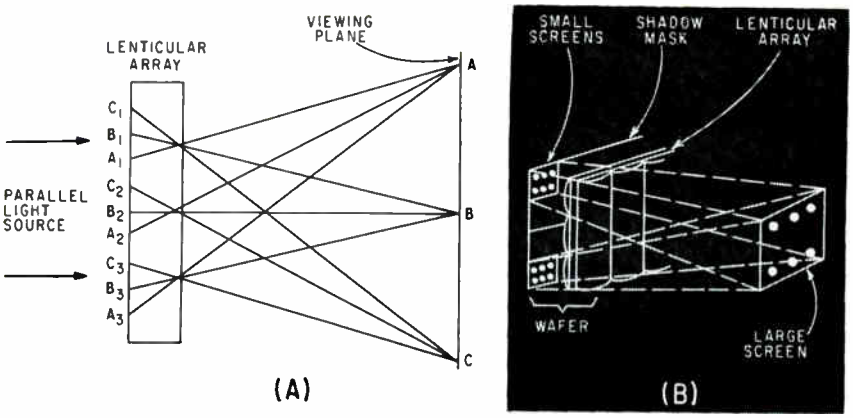


FIG. 2—Operation of lenticular lens array shows how each lens coordinate acts as independent spherical lens

teristics into corresponding selection channels.

The wafer is a direction sensitive optical message-bearing unit known as a lenticular display. Forms of this wafer are used in presenting two or more views as the lens array is tilted to change the viewing angle. The number of messages written on this wafer may vary from two to about sixty four. Figure 1 shows a magnified view of the message area used for thirty six patterns selectable from a corresponding six-by-six directional matrix pattern.

The lenticular array consists of two sets of minute hemispherical ribs positioned at right angles to each other. Each lens coordinate is a minute spherical lens.

Operation of the lenticular lens is shown in Fig. 2A. Each composite lens of the lenticular array acts as an independent spherical lens to direct the light from a parallel source to discrete positions on the viewing plane. As shown in Fig. 2A, at points *A*, *B* and *C* of the viewing plane, the light is focused respectively to each position from a series of multiplexed positions across the surface of the lens array. Thus, light passing through points C_1, C_2, C_3 . . . C_n is directed to point *C* on the viewing plane. The same operation applies to points *A* and *B* (and all other) points of the viewing plane.

By applying a parallel light source to the lens array and masking all points C_x, points *A* and *B* will receive light while point *C* will receive less light. Conversely, substituting a light source for point *A* of the viewing plane will cause light to be seen at all points A_x across the lenticular array.

If a large screen with the geometrical pattern shown in Fig. 2B is illuminated, each minute spherical lens will focus the pattern into a related small screen directly behind each lens. The reverse is also true and if identical small-screen patterns behind each lens were illuminated, then this geometrical pattern would show on the large screen. Photocells could be substituted for each of the black dots making up the geometrical pattern of the large screen shown in Fig. 2B, and an opaque mask substituted for the shadow mask. Then, if holes were punched in the same place in each small screen and a parallel light source applied from behind the shadow mask, only one photocell would receive light.

To make the wafer shown in Fig. 1, photographic film is placed at the shadow-mask position. The number of photocell positions (one for each message—with each pattern, numeral or letter to be identified being one message) is then established in some geometrical array at the large-screen position. A small light bulb is substituted for each photocell. Individual message transparencies such as digits of the type font (or any other pattern, numeral or letter) to be used are selected. The message transparency is then registered with the lenticular array to cast its shadow on the film in some desired position.

The light bulb at the chosen photocell position for that particular message is momentarily lit to expose the film. A new message transparency is then selected and the light bulb at the new chosen photocell position is lit to expose the film. This process is continued until all messages are on the film. The film is then developed.

Each message is then written across the shadow mask in a halftone-like dot matrix of points exposed by the light beam from a single direction. In a typical case, the numeral 8 would be composed of all the right-hand corner dots of each small screen while the numeral 4 would be composed of all the dots in the lower left-hand corner, and so forth. The small screens then become single-plane multiplexed message sources. Figure 1 shows a section of such film made for 36 messages.

When a specific numeral is displayed and illuminated in the document-feed channel, light will pass through some holes of some tiny screens while other holes are shadowed by the darker numeral background. One photocell then will receive less light than the others.

Mechanical registration to control the position of a misaligned printed character may be accomplished by a motor-cam combination that wobbles the lenticular wafer. The wafer is small and light enough to be almost an inertialess mass. The assembly may be moved parallel to the viewing plane without changing the selection angle viewed by the photocells. Although the dots on the screen are about 0.002 in. apart, the photocells may be moved greater than a quarter inch without misregistration with another message. Thus, assuming horizontal presentation of a character strip with an added vertical camming action, the misregistration of alignment may be as great as the amount of vertical motion.

Motion of horizontal presentation need not be carefully controlled and may even be jerky as with a paper tape punch or card punch because identification occurs instantaneously upon static operation of matching and does not require stability, timing or positioning during the scanning action. Since neither dynamic reading speeds nor timing regularity need be attained, misspacing of characters is not a problem.

To take care of a wide range in contrast variations resulting from changes in paper, ink, light level and photocell temperature, the most - prominent - signal selection

system is used. If the waveforms at the photocells are observed while drawing a printed character through the document feed channel, some signal is observed at each photocell with the largest signal appearing at the required photocell. Depending on the contrast range, these signals will vary in amplitude, the chosen signal always having the largest amplitude.

The circuit shown in Fig. 3 selects the single channel that has the greatest amplitude. This is done by a single NOR-like transistor circuit per channel where the base mixer resistance network establishes a signal-bias level at the greatest signal level encountered in all except the designated channel. The transistor conducts only when the designated signal at the emitter becomes greater than all other signals. Since only one signal is greatest, a unique selection appears as an output pulse. The bias control selects a threshold level above noise conditions.

In addition to variable-contrast operation, there also occur pinholes produced by omission (or severe change in contrast) of part of a character area due to faulty ribbons, oily paper and other mechanical reasons; and smudges caused by ink that has gotten outside of the character area. In this example, the logic selection for 10 characters is made by twenty photocells, two for each character (10 transparent characters on opaque background and 10 opaque characters on transparent background). One photocell provides a select match and the other a reject match. In the simplest form, the character patterns to be matched in the respective cases will be a positive or transparent mask of the character shape and a negative or opaque mask of the character shape for reject.

Operation of select and reject is shown in Fig. 4. In the select condition (upper portion) the mask is opaque with a numeral 7 cut out. The characters to be recognized are a 7 with a smudge that forms a partial 9 and a 9 with pinholes that forms a partial 7.

The mask is located between a light source and a photocell. If the photocell output is observed while passing both the 7 and 9 past the 7 cutout, the waveform will null when the cutout 7 on the mask is

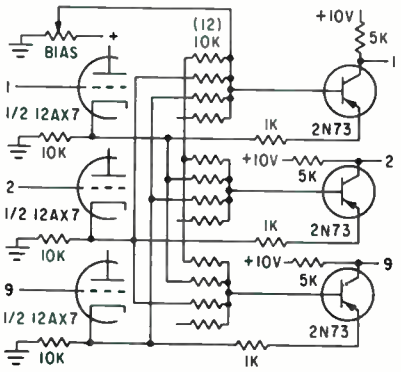


FIG. 3—Most-prominent-signal contrast-control circuit

completely covered.

In the reject position (lower portion) the mask is transparent and the numeral 7 is opaque. Now when the opaque 7 is passed across the mask, the output waveform goes down when the opaque 7 enters the mask and then goes to a peak when the opaque 7 is directly superimposed on the mask opaque 7. If the numeral 9 or smudged 7 passes through, the waveform goes down as the character enters the mask then raises to a peak as the character superimposes on the mask 7. However, some portion of the 9 or the smudge on the 7 is exposed as superimposition occurs, so that the waveform does not reach the same level peak as with the clean 7. The action of the photocells shown in the partial schematic of Fig. 4 is additive in a differential sense so that the combined output will provide a peaking output for the selected character.

Variable resistors associated with each photocell may be used to weight the individual effect of the selecting or rejecting action on the output signal.

Thus, in selection, pinholes tend to reduce the peak and, in rejection, smudges tend to reduce the peak. By weighting the effect of the positive and negative signals in this (or any other convenient way), a threshold selection can be made tolerable to the appearance of a limited amount of either pinhole or smudge character distortion. In addition, the double-cell action provides enough redundancy to assure reliable selectivity for almost any type font without special shaping of characters or extra post-recognition logic circuits.

Typical voltage levels provided by matched photocells when using 25-message masks and sampling with 50 dot-elements per inch from good quality ⅜-in. characters show that the selected character signal has about 1-volt differential above the highest unwanted character signal. Under ideal conditions, thyratron or transistor circuits with threshold settings may be actuated directly from the photocells for relay closure.

Contributions to this effort made by Stuart F. Nadeau in photographic and lenticular techniques are gratefully acknowledged.

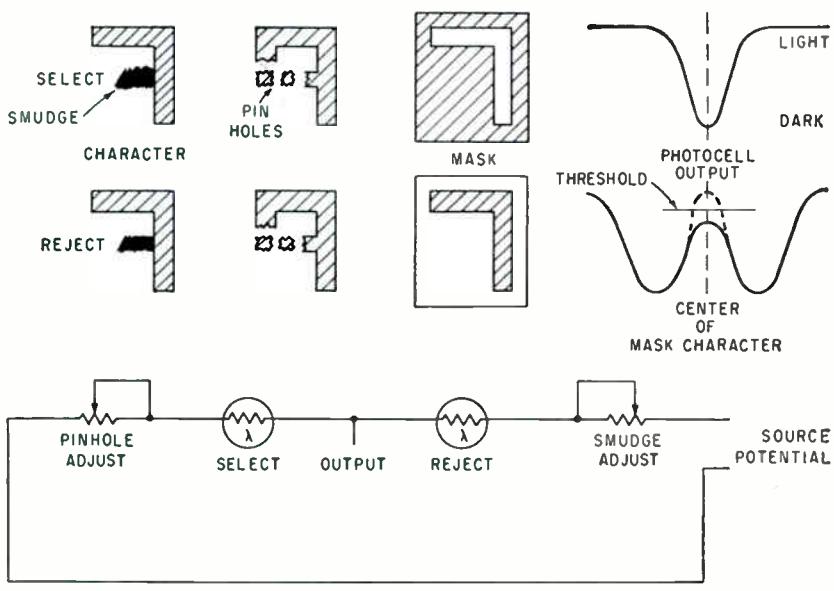


FIG. 4—Differential weighted output technique; simplified circuit

Data Recorder for Airplane Flight

Continuous record engraved on metal tape is designed to survive air accidents

By HARRY E. SCHAUWECKER,
Chief Electronics Engineer,
Technical Products Division,
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AIRCRAFT ACCIDENT INVESTIGATION will be made easier under a new FAA mandate requiring all commercial carriers flying turboprop or turbojet aircraft to carry a flight data recorder aboard each plane. This will provide a crash-resistant, fire-resistant record of time, air speed, altitude, heading and vertical acceleration. Recorder will produce an indestructible record of the events immediately preceding a crash or accident, available for later analysis. The record must be able to withstand an impact of 100 g's, flames of 1,100 C enveloping at least 50 percent of the case for 30 minutes and immersion in sea water for 36 hours. For utmost reliability, all electronic circuits should use solid-state components.

This flight data recorder is composed of two sections. An aluminum casting houses the tape magazine and the electromechanical portions of the system, while the rear section is an aluminum chassis housing electronic circuits. The magazine can record up to 400 hours of aircraft performance on Inconel (stainless steel) foil approximately 5 in. wide and 0.001 in. thick. Four cam-actuated scriber arms with diamond cutting edges are placed in contact with the foil twice a second while the foil moves through the magazine at 12 in. per hour. The result is a series of small engraved marks on one side of the foil. Although the marks occur intermittently they overlap so that a continuous line record results. The magazine protects the record from flying shrapnel and provides for easy removal for reloading.

Four primary channels of information are recorded on the tape. Two of these, the altitude and speed indicators, use pneumatic sensors and involve no electronic or electromechanical action. The arms of the sensors are free to move without any load for approximately 90 percent of the time. During the other 10 percent of time a cam action places the arms against the foil to make a mark. This intermittent motion provides a dithering action to relieve mechanical friction while allowing an accurate indication due to the absence of mechanical load on the sensors.

The heading system consists of a servo position followup on the compass signal. A vertical accelerometer at the center of gravity of the aircraft feeds the vertical acceleration channel, using a differential transformer transducer.

The maximum vertical-acceleration signal in each ½ second period is recorded. The servo portion of the recorder uses an a-c tachometer to provide rate feedback for stabilization of the servo system and a feedback potentiometer to provide position signal.

Time is recorded by a sprocket drive on the metal foil, driven by a hysteresis synchronous motor supplied with 440 cps independent of line voltage and temperature variations. A trip and date encoder is a part of each recording system. This device may be mounted in the cockpit and is used to indicate the flight number and date. An event button allows the pilot to insert an indicating mark whenever some unusual occurrence is noted.

In addition to the four scriber

Complete flight data recorder is shown at left installed in aircraft. right removed from unit. Magazine can record up to 400 hours of

Analysis

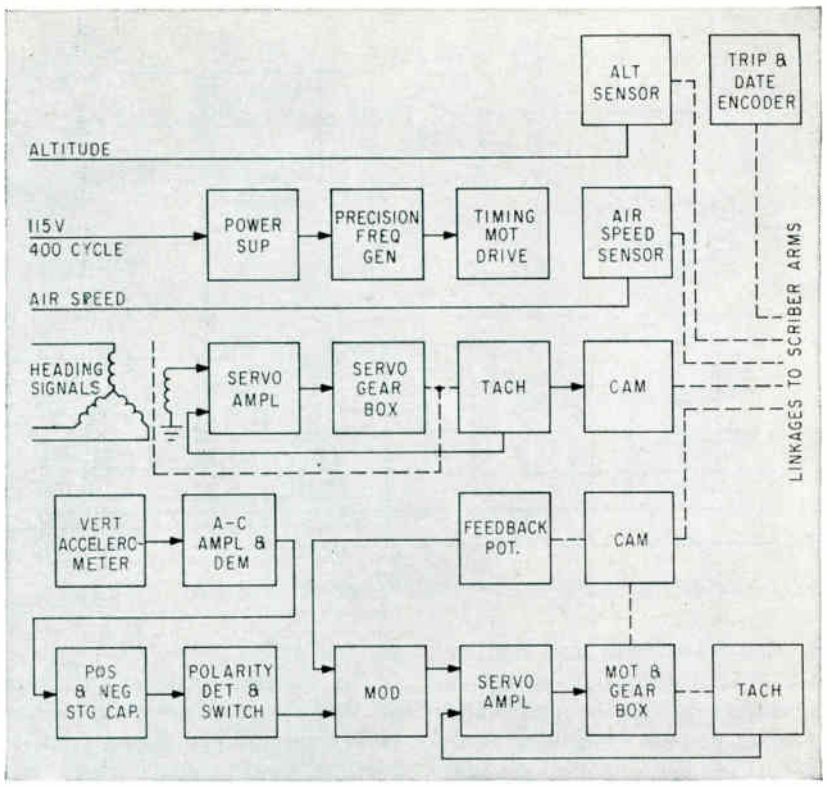
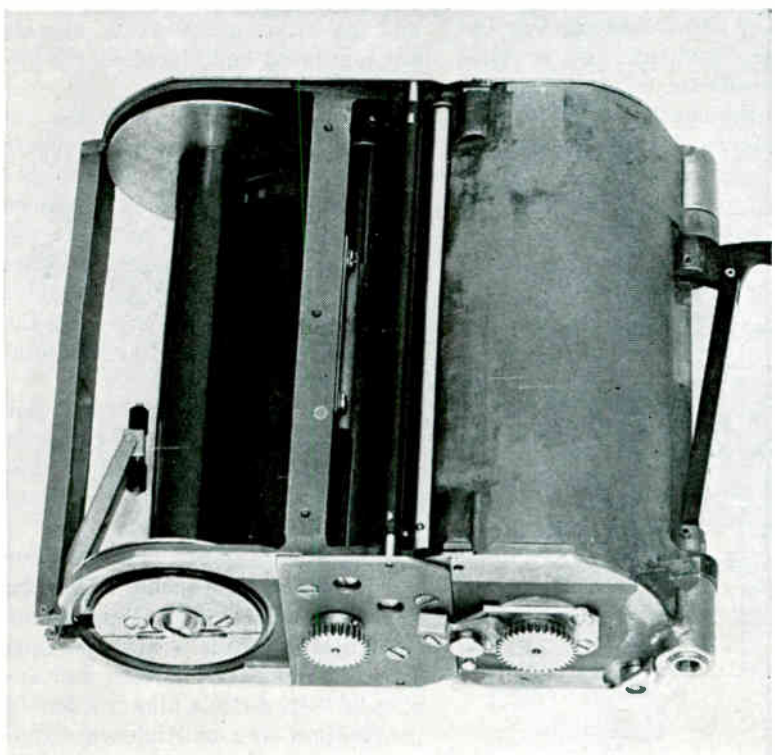


FIG. 1—Block diagram shows functional arrangement of flight recorder circuits

arms, four binaries are supplied for providing additional information and there is space for five additional servo driven scribe arms and two more binaries that can record simultaneously on the reverse side of the foil.

The precision frequency generator provides 440 cps at 115 volts for the timing motor. It uses a saturating-transformer oscillator and auxiliary regulating circuits to maintain precise voltage and frequency. The normal saturating-transformer square-wave oscillator frequently employed with transistors has an output frequency directly proportional to applied voltage and output voltage directly proportional to input voltage. Since both vary linearly with applied voltage, it is possible to sense the output voltage and supply a correction to the oscillator that will provide a constant output voltage and a constant output frequency.

Figure 2 is a schematic of the precision frequency generator. Transistors Q_4 and Q_5 are the oscillating transistors with feedback provided through windings 4, 5, and 6 and output voltage for the servo motor taken from winding 10, 11, and 12. Input power is applied to the emitters through the feedback winding and to the collectors through the collector winding. The base voltage which determines the collector voltage swing of the transistors is produced by the voltage drop across resistor R_1. The output voltage is sampled by winding 7, 8 and 9, rectified by diodes D_5 and D_6 and applied to a differential amplifier stage consisting of Q_1 and Q_2. A portion of the output voltage is applied to the base of Q_1 through the network $R_2 - R_3$. A reference voltage obtained from R_6 and D_7 is applied to the base of Q_2. The amplified difference voltage is applied to the base of Q_3 whose emitter is tied to a fixed reference, permitting regulation of the voltage across R_1 to maintain constant output voltage and frequency. Resistors R_4 and R_5 are a thermistor and a Sensistor respectively, mounted on the chassis and on the saturating transformer to maintain a constant output frequency irrespective of temperature variations. Transistors Q_4 and Q_5 are power transistors mounted on heat sinks since, in contrast with normal saturating transformer multivibra-



Front portion houses crash-resistant data magazine, shown at the aircraft performance on stainless-steel foil

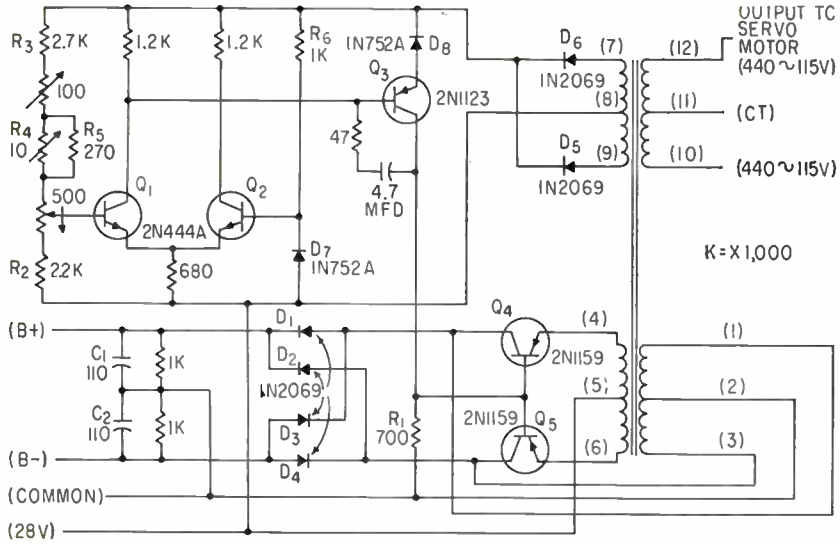


FIG. 2—Schematic diagram of precision frequency generator

tors, the transistors are not operated in saturation but the saturation voltage varies in accordance with input voltage variations. Since both positive and negative d-c voltages are required for other portions of the electronic circuits and since the output voltage from the square-wave oscillator is regulated, this square wave is rectified by D_1 to D_4 and filtered by C_1 and C_2 to provide a positive and a negative regulated d-c output voltage of approximately 20 volts. This unit provides motor power regulated to 1 percent for both frequency and voltage for input voltage variations of ±10 percent and temperature variations from −50C to +50C. Approximately 25 watts of power are supplied to drive a size 8 synchronous hysteresis motor.

The vertical acceleration channel of the recorder accepts a phase-reversible 400 cps signal from the vertical accelerometer which is in phase with the reference voltage for positive accelerations with respect to +1 g and has 180-deg phase shift with respect to the reference voltage for negative accelerations with respect to +1 g. The acceleration input is fed into the amplifier modulator shown in Figure 3. Transistors Q_1 and Q_2 form a feedback amplifier with an open loop gain of approximately 10,000 reduced to a closed loop gain of approximately 1.6. Degenerative feedback is supplied from the collector of Q_2 through R_1 and R_2 to the emitter of Q_1 with R_2 functioning as a gain adjustment

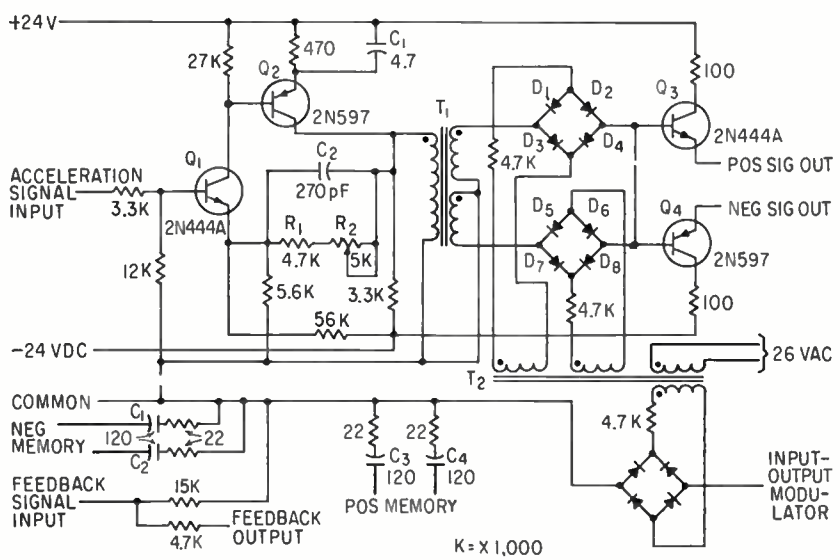


FIG. 3—Schematic diagram of modulator-detector circuit for vertical acceleration channel

for calibration. The feedback amplifier thus serves also as an impedance matching network providing a high input impedance for the accelerometer and a low output impedance for driving the demodulator. Due to the high negative feedback the slight gain is relatively stable with respect to temperature and voltage variations. The output is coupled through transformer T_1 to the two full-wave synchronous demodulators consisting of diodes D_1 to D_8 and transformer T_2. The synchronous demodulators separate the positive and negative signals. Positive output signals corresponding to in-phase signals are applied to the base of Q_3 while negative output signals corresponding to out-of-phase signals are applied to the base of Q_4. Transistors Q_3 and Q_4 provide impedance transforming action or current amplification for respectively the positive and negative output signals to minimize loading of the demodulator. The storage capacitors shown as C_1, C_2, C_3, and C_4 are alternately connected to the positive and negative signal output positions by a commutator. Thus a positive and a negative storage capacitor is always connected to the accelerometer. While one capacitor is being read out another capacitor is being charged for storage. At this point both positive and negative acceleration signals are separated and stored as capacitor charges.

The stored signals from the capacitors are applied simultaneously to a polarity detector which selects the signal with larger absolute magnitude and applies it to the servo system. A phase-reversible 400-cps signal is produced to drive the servo motor one way or the other to achieve a null at the summing junction.

The servo amplifiers used for heading and acceleration channels are identical, each providing approximately 4 watts of power to drive a size 8 servo motor.

The flight number and date encoder consists of a group of decade selector switches and a switch or commutator which scans the outputs of the selector switch and applies 28 volts d-c to a binary solenoid providing a time-multiplexed signal indicating, in decimal form, the trip and date along the edge of the foil.

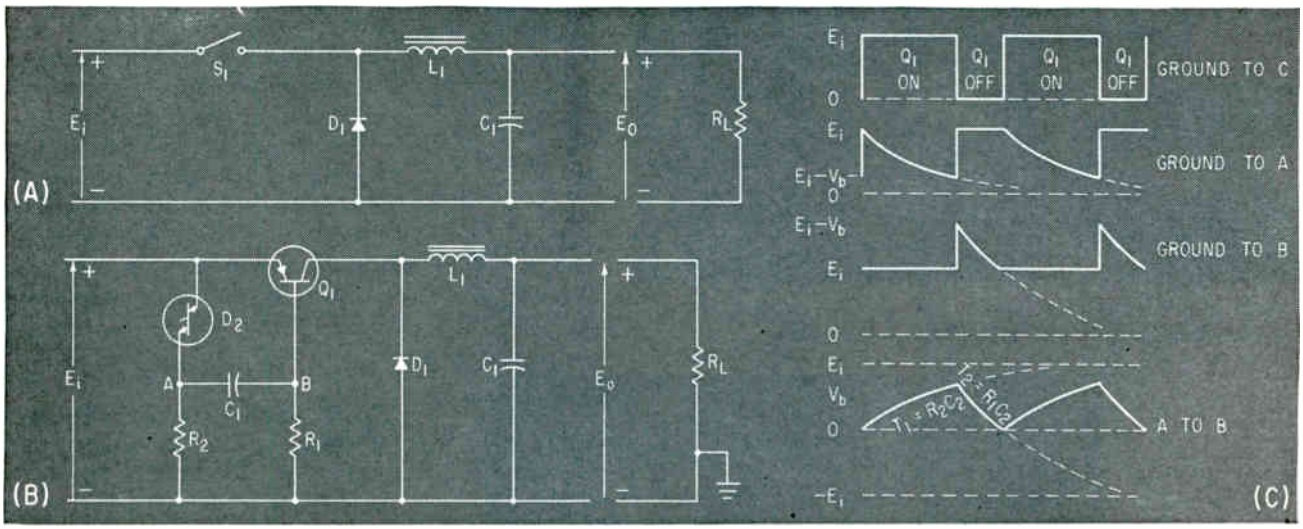


FIG. 1—Principles illustrated with mechanically operated switch (A); mechanical switch replaced by transistor (B); waveforms show operation of transistorised regulator (C)

Solid-State D-C Switched Regulators

Switching system, analogous to phase control of thyratrons in a-c circuits, permits higher efficiency than the series regulators are able to provide

By ALBERT A. SORENSON,
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IN VOLTAGE REGULATOR circuits a constant output voltage is produced irrespective of changes in input voltage or output load. The voltage regulator is characterized by its nominal input voltage, permissible input voltage range, nominal output voltage, load range, ripple voltage and output voltage regulation.

Physical specifications include efficiency, size, weight, cost and reliability, which in some cases are more important than the electrical specifications.

Conventional series regulators are usually elaborations of the simple rheostat. For a given load resistor R_L, and an input voltage E_i there always exists some series resistor R_s, that will produce an output voltage E_o, as long as $E_i \geqq E_o$ and $R_L \neq 0$. The series resistor R_s is equal to

$$R_s = R_L (E_i - E_o)/E_o$$

If either E_i or R_L varies, R_s may also be varied to hold E_o constant. Series resistor R_s is usually a transistor or a vacuum tube, whose resistance is varied by feedback to stabilize the output level.

Series element R_s must dissipate power to provide regulation. The power to the load is $P_L = E_o^2/R_L$ and total power input is $P_i = E_i^2/(R_s + R_L)$.

The circuit efficiency is then

$$\eta = P_L/P_i \times 100$$
$$\eta = E_o^2 (R_s + R_L) \times 100/E_i^2 R_L$$
$$\eta = E_o/E_i \times 100/\text{percent} \qquad (1)$$

If E_i has a large range, the lowest efficiency occurs for the largest E_i. All series regulators are limited to the efficiency of Eq. 1 as a maximum.

The power dissipated in R_s is $P_s = (E_i - E_o)^2/R_s$. This power must be dissipated by the series vacuum tube or transistor necessitating high-power transistors, large heat sinks and good cooling, all of which are weighty and space consuming.

In a-c regulators, series regulation has generally been abandoned. Instead, switched regulators are used to control the output voltage by controlling the conduction period of each a-c cycle. Common circuits of this type use magnetic amplifiers, controlled rectifiers or thyratrons.

Similar circuits have now been built for use as d-c regulators, and will be called switched regulators. Figure 1A shows the simplest switched regulator.

Assume that switch S_1 is opened and closed at a regular rate. Filter L_1 C_1 is designed so that voltage E_o will be some fraction of E_i and have a low ripple content. Diode D_1 permits energy stored in L_1 to be delivered to the load while S_1 is open. This diode must carry the maximum load current and have a voltage rating of the maximum value of E_i.

The inductance should be made just larger than the minimum, that is $L_{min} \cong R_{Lmax}/6\, f_{min}$ where R_{Lmax} is the load resistance at the minimum load, and f_{min} is the frequency of the minimum repetition rate at which S_1 is opened and closed. The filtering capacitance must be just

Technician adjusts the circuit for optimum ratio of R_1 and R_2 (see Fig. 2) for best stabilizing performance

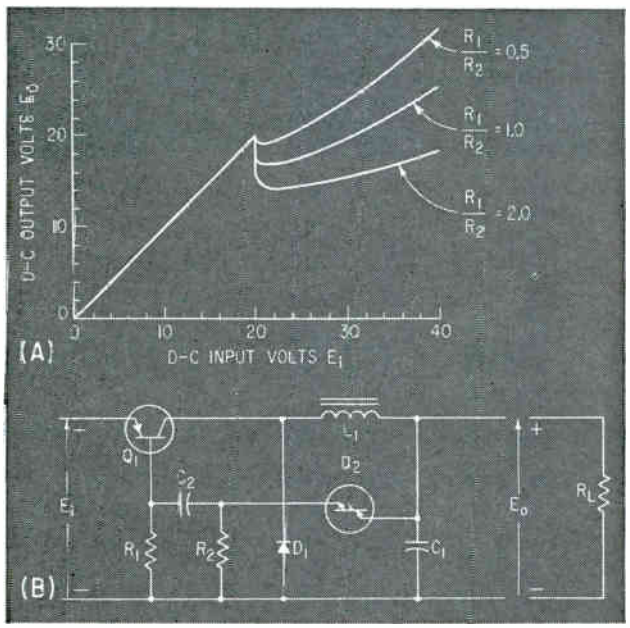

FIG. 2—Optimum regulation is achieved with R_1 greater than R_2 (A); improved circuit has the four-layer diode anode returned to stabilized output (B)

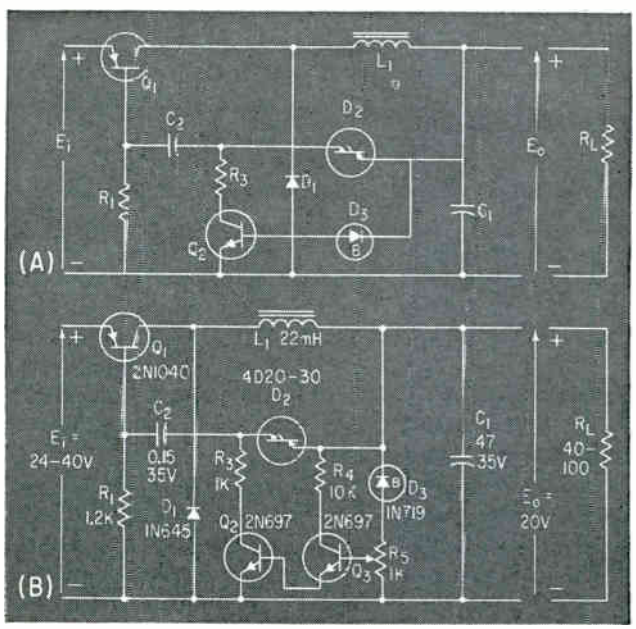

FIG. 3—Zener diode introduces a higher stability (A); final circuit uses d-c amplifier and Zeners for optimum performance (B)

larger than $C_{min} \cong E_o/(2\ \pi\ f_{min})^2\ L\ E_{rmax}$, where E_{rmax} is the maximum output rms ripple voltage. The voltage rating of the filter capacitor, which may be electrolytic, is determined by E_o maximum.

The output voltage is varied by altering the relative periods for which S_1 is opened and closed. The proportion of time X, in which S_1 is open is $X = (E_i - E_o)/E_i$ where $0 \leqq X \leqq 1$. This may be solved for E_o as

$$E_o = (1 - X)\ E_i \qquad (2)$$

With perfect components the total efficiency is 100 percent, independent of E_i and E_o. This is because the power is switched in time and not amplitude.

The difference between perfect and actual components is small. The inductance can have low d-c resistance, silicon diodes already have small forward voltage drops and capacitors are near-perfect compoments anyway. By using a transistor for the switch a near-ideal switch is achieved since the transistor has low leakage when open and low voltage when closed. The transistor may be small and will dissipate little power. Usually no heat sink is necessary.

Comparing conventional and switched regulators of the same rating, the conventional circuit requires a large, high-powered transistor and heat sink, and has an efficiency of perhaps 60 percent. The switched circuit uses a small, low-powered transistor without heat sink, has an efficiency of about 90 percent, but requires a diode, inductor and capacitor. Using powdered iron high-mu materials and high switching frequencies, the inductor may be small. The capacitor will also be small at high frequencies, especially when using tantalum capacitors.

The simplest circuit for a switched regulator is shown in Fig. 1B. The network consisting of transistor Q_1, four-layer diode D_2, capacitor C_2, and resistors R_1 and R_2, form an oscillator to switch Q_1 on and off and also provide some regulation. Assume that Q_1 is on. Resistor R_1 is chosen so that $R_1 = \beta_{min}\ R_{Lmin}$ where β_{min} is the minimum beta of transistor Q_1 and R_{Lmin} is the resistance at maximum load.

The resistor R_1 will thus hold Q_1 on.

A four-layer diode is a bistable switch. As the voltage across it is increased from zero, no conduction occurs until the breakdown voltage V_b is reached, it then conducts with little drop and continues conducting until either the voltage is reversed or the current drawn becomes less than the holding current.

As long as Q_1 is on, D_2 will be off. Capacitor C_2 charges through R_2 and the emitter-base path of Q_1. When the voltage across C_2 reaches the breakdown voltage V_b of D_2, D_2 is turned on and back-biases the emitter-base diode of Q_1 by the voltage across C_2, turning Q_1 off. Capacitor C_2 then charges in the opposite direction through D_2 and R_1. Resistor R_2 also draws current through D_2. When the sum of these two currents has decreased to less than I_h, the holding current of D_2, or the voltage across C_2 has reduced to the V_{br} of Q_1, D_2 opens and Q_1 is permitted to turn on. The minimum value for R_2 is E_i/I_h. Resistor R_2 may be varied to control the output voltage E_o. Repetition frequency is proportional to C_2.

Since the switching frequency of the four-layer diode is fast, Q_1 is also switched rapidly. The fall time and minority carrier storage time of Q_1 is made small because of the high initial reverse base current. See the waveforms of Fig. 1C.

For the circuit to oscillate $E_i > V_b$. Capacitor C_2 charges to V_b with aiming potential E_i and time constant $t_1 = R_2C_2$, thereby determining the ON time; it then discharges from V_b to 0 with aiming potential $-E_i$ and time-constant $t_2 = R_1C_2$ to determine the OFF time. Expressions for the ON and OFF times, t_1 and t_2 are

$$t_1 = R_2 C_2 \ln [E_i/(E_i - V_b)] \quad (3)$$

$$t_2 = R_1 C_2 \ln [(V_b + E_i)/E_i] \quad (4)$$

The output voltage is found from Eq. 2 to be

$$E_o = E_i t_1/(t_1 + t_2) = E_i/(1 + t_2/t_1) \quad (5)$$

and from Eq. 3, 4 and 5

$$E_o = E_i/\left\{1 + \frac{R_1}{R_2} \frac{\ln [(V_b + E_i)/E_i]}{\ln [E_i/(E_i - V_b)]}\right\}$$

This indicates that E_o is independent of C_2. If $E_i = n\ V_b$

$$E_o = n\ V_b/\left\{1 + \frac{R_1}{R_2} \frac{[\ln (n+1)/n]}{\ln [n/(n-1)]}\right\}$$

Figure 2A shows E_o plotted against E_i for $V_b = 20$ v and for three different values of R_1/R_2. This curve indicates that for optimum regulation $R_2 < R_1$. A range of nominal output voltages may be obtained by choosing different types of four-layer diodes each with a different value of V_b. In general, V_b must be smaller than the lowest value of the input voltage, but should be as large as possible. Capacitor C_2 should be chosen to give a high operating frequency, but not so high that the rise and fall times of Q_1 become appreciable in comparison to t_1 or t_2.

Performance is improved by returning the anode of D_2 to the output terminal. This provides better regulation by using simple feedback to produce a more constant voltage for D_2 reference as Fig. 2B shows. Here C_2 charges to V_b while aiming at E_o, and discharges to 0 while aiming at $-E_i$. Writing the expressions for t_1 and t_2

$$t_1 = R_2 C_2 \ln [E_o/_n(E_o - V_b)] \quad (6)$$

$$t_2 = R_1 C_2 \ln [(E_i + V_b)/E_i], \quad (7)$$

and from Eq. 5, 6 and 7

$$E_o = E_i/\left\{1 + \frac{R_1}{R_2} \frac{\ln [(E_i + V_b)/E_i]}{\ln [E_o/(E_o - V_b)]}\right\}$$

which is transcendental. Since this is only solvable by substitution, the best design approach for the more complex circuits is to have an understanding of the effect of change of value of the portions of the circuit and then to design the circuit by building it and varying component values (mainly V_b and R_2 for this circuit) to obtain the output voltage and regulation. This circuit also provides some load regulation, which the simpler circuit did not.

These first two circuits will provide no better than ±5 percent regulation for ±20 percent input variation. For some purposes this is adequate, but mainly the description of these circuits illustrates basic principles. Further improvements in regulation are possible by increasing the negative feedback and/or introducing a more stable reference than the four-layer diode, such as a Zener diode. To do this resistor R_2 must be replaced with an active circuit. Circuits embodying such improvements are shown in Figs. 3A and 3B.

The circuit of Fig. 3A gives ±1 percent regulation for a −15 percent, + 30 percent input voltage variation and the circuit of Fig. 3B, for which the circuit values are given, provides ±0.5 percent regulation for the same input variation. The efficiency of the latter circuit ranges from 90 percent to 95 percent. An equivalent linear series regulator would have an efficiency of from 83 percent to 50 percent over the same range.

Circuits of this same general type have been built up to 50 watts output, but there is no reason to limit the capacity to that level. For higher power an amplifier transistor should be used to drive Q_1.

If more than one output voltage is desired, the best method is to have a single input switched regulator driving a static converter from which the several output voltages are obtained by separate conventional winding-diode-filter arrangements. One of the static converter outputs may then be used to feed back to the regulator.

The resistor R_1 consumes the major amount of power dissipated in the circuit. When using a static-converter in conjunction with the switched regulator, an extra winding may be added to the winding of the converter, which through rectification and filtering will provide the turn-on voltage for Q_1. Another, higher resistance, resistor should then be run from the base of Q_1 to either the collector of Q_1 or to ground to start oscillations.

More elaborate circuits may also be developed to provide current limiting action. When using a static converter with a switched regulator it is best if the regulator frequency and the converter frequency are different. This prevents one frequency from locking on the other.

Credit for these designs should go to Richard A. Nylander, who invented them, and who has developed them.

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Tunnel Diode Generates Rectangular Pulses

Negative-resistance characteristic enables fast rise time independent of signal frequency

By G. B. SMITH,
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TUNNEL DIODES have found many practical applications since the discovery by Leo Esaki in 1958. This article shows how fast-rise-time rectangular pulses can be derived with the tunnel diode.

Figure 1A shows the voltage-current charactristics of tunnel diodes compared to conventional low-power junction diodes. Typical values of peak current I_1 and ratio of peak current I_1 to valley current I_2, measured on a batch of type JK 11A tunnel diodes, are

$I_1 = 25$ ma $\qquad V_1 = 75$ mv

$\frac{I_1}{I_2} = 2.5 \qquad V_2 = 240$ mv

If a resistance R greater than the numerical value of the negative slope resistance of a given tunnel diode is connected in series with the diode, only two stable states are possible for a given supply voltage, and are shown by points A and B in Fig. 1B.

Consider the voltage waveform across the tunnel diode when a sine-wave emf with peak value greater than V_2 is applied. This waveform can be plotted on a load-line diagram as shown in Fig. 2.

From point A on the tunnel-diode characteristic, follow load line PB to point B on the voltage axis. Projecting across to point C on the input voltage curve find point E, giving the time when the tunnel diode reaches voltage OD. By repeating this procedure for a number of points on the characteristic the tunnel diode voltage waveform can be plotted.

Note that on the negative-slope part of the characteristic the input voltage has no control over the diode voltage. This causes the diode voltage to change from F to G when the input voltage is increasing, and from H to J when it is decreasing, at a rate determined by the junction capacitance of the tunnel diode. When operated in its reverse direction, a tunnel diode has low resistance so that during the negative half-cycle the diode voltage is zero for all practical purposes.

The minimum peak sine-wave emf required to drive the circuit satisfactorily is determined by the position of point F and the value of R. For a given R, the supply emf must be such that the load line at peak voltage passes through or above point F. However, in order to make use of the whole negative-slope portion of the characteristic, we could use as the minimum value of R the factor

$$\frac{V_2 - V_1}{I_2 - I_1}$$

(see Fig. 1A), and thus find the required input emf by projecting the load line from F to the voltage axis.

When finding the optimum value of R, the maximum current available from the source must also be taken into account, the maximum peak current required being I_1 (see Fig. 1A).

A similar design procedure can be used when the input signal is already in pulse form. The circuit can then be used to improve the rise time of rectangular pulses that have deteriorated after passing through many stages.

The small amplitude of pulses available from the basic circuit makes it impractical for most applications. However, the circuit will work satisfactorily even while heavily loaded. For example, it can feed directly into a common-base transistor amplifier with the advantage of its high cut-off frequency so that little or no deterioration of the pulse edges occurs. To obtain a variable duty ratio, R can be made variable and the input signal d-c restored to obtain duty ratios greater than one half. A typical circuit is shown in Fig. 3A. The transistor base bias resistor must be chosen so that the transistor does not switch on until the pulse skirt voltage (OK in Fig. 2) is reached. Measurements on this circuit showed that at 50 cps the pulse rise times at test points 1 and 2 were respectively 100 and 110 nanoseconds. The measurements were repeated at 10 Kc and showed no change in rise time.

An improvement in the output-voltage waveform can be effected by using Zener diodes as shown in Fig. 3B.

This method of obtaining sharp-edged rectangular pulses from sine waves has the advantage, over clipping diodes and amplifiers, that rise time is virtually unaffected by signal voltage frequency.

Junction capacitance of a JK 11A tunnel diode is of the order of 1,300 pf and gives a rise time of 100 nanoseconds. Contemporary tunnel diodes, available in the U. S., have much lower junction capacitances of the order of 5 pf or less. Used in the circuit described, this would give much faster rise times.

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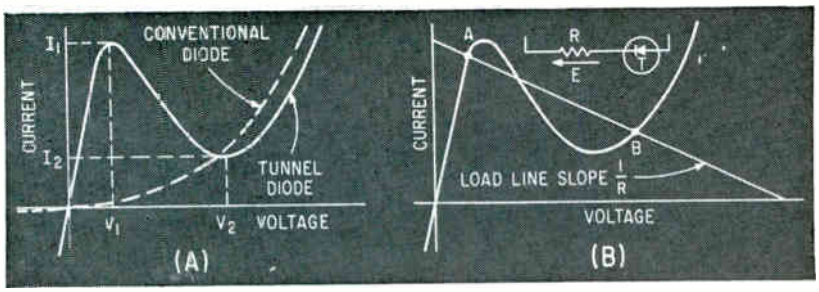

FIG. 1—Comparison of voltage-current characteristics of tunnel diode against conventional junction diode (A); characteristics of tunnel diode in series with resistance (B)

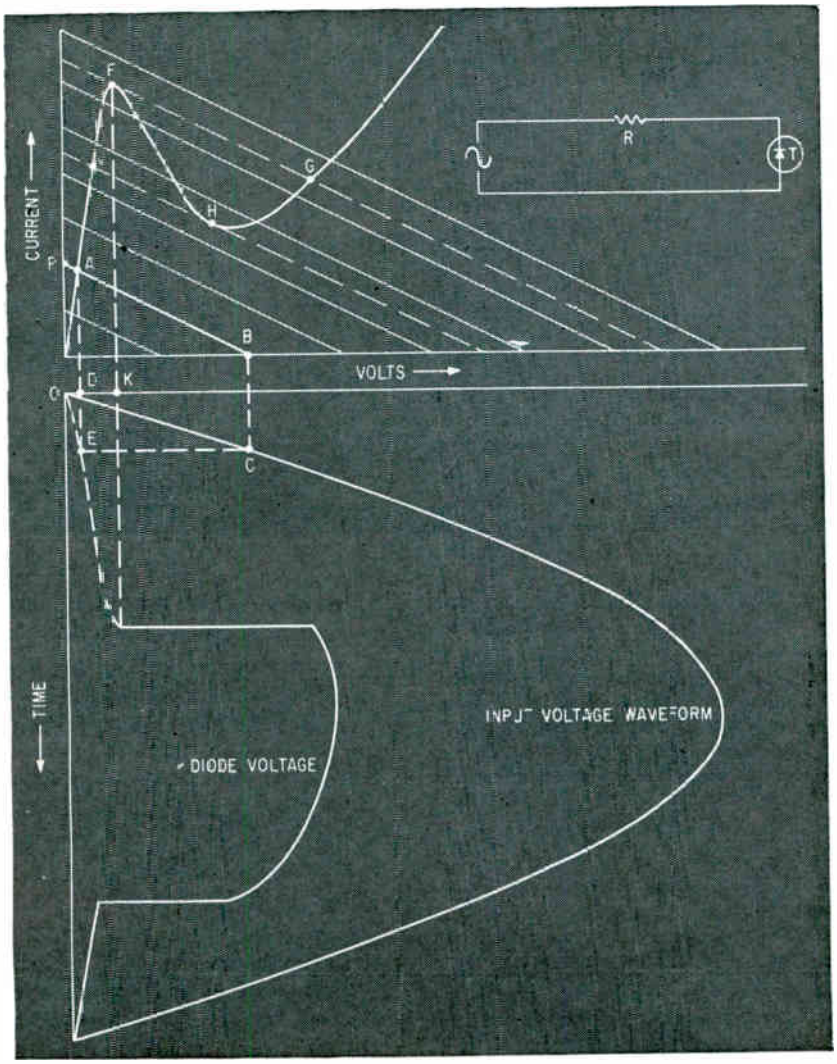

FIG. 2—Graphical method of determining tunnel diode pulse waveform directly from signal waveform and series resistor value

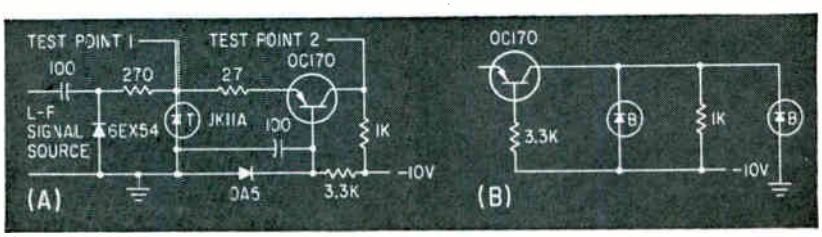

FIG. 3—Practical tunnel-diode pulse circuits with common-base transistor amplifier (A), addition of Zener diodes to improve output waveform (B)

How to Select Cooling Blowers

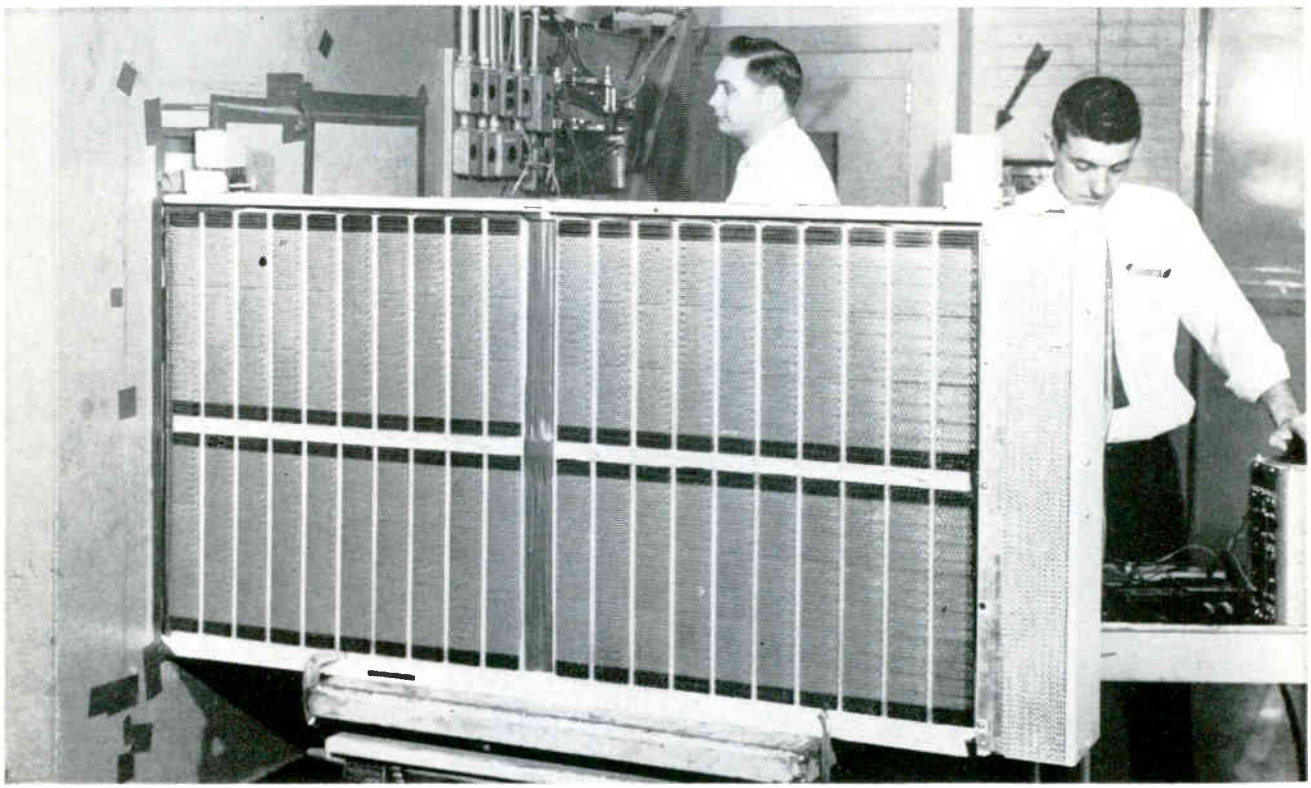

FIG. 1—Checking flow of cooling air through a stacked-circuit gate for IBM's solid-state STRETCH computer. Total air flow of 360 cfm is required to maintain acceptable ambient temperature in a space where 864 circuit cards are mounted in tight layers. Air is forced through the 5-ft gate into test chamber at left by two double-inlet units in housing at right end of gate. Blowers provide long, thin air flow across section while occupying an unusually narrow space. Specified output of 180 cfm for each blower unit is delivered against static pressure of 0.5 inch of water at impeller motor speed of 5,700 rpm.

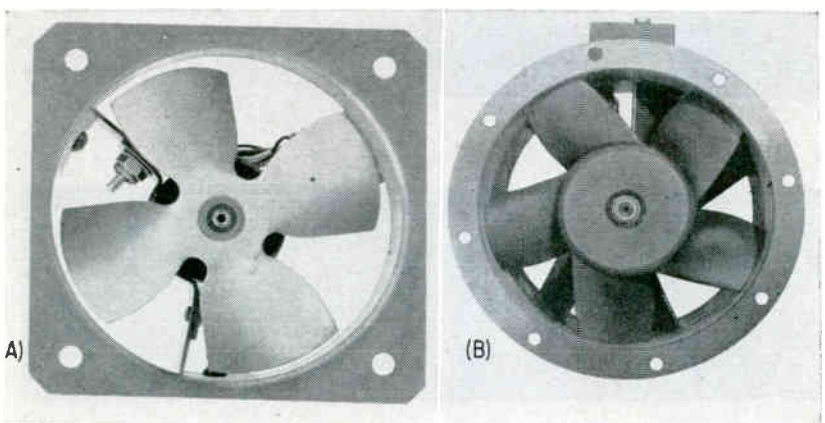

FIG. 2—Photographs illustrate two types of axial blower units. Partially cased impeller (A) and vane-axial impeller (B)

EQUIPMENT DESIGNERS can gain by becoming familiar with air cooling. Such knowledge will equip them to specify blower characteristics realistically and help them design the air-flow path to minimize the blower load and thus keep down blower size, cost and power consumption.

Forced cooling of ground or airborne electronic equipment requires a blower that contributes minimum weight, space and cost. The blower must frequently meet a large number of requirements, with design standards well above those of other blower applications. Variety of blower characteristics makes it unlikely that a standard, off-the-shelf unit will give the best results; therefore custom design is common.

Major requirements of an equipment cooling system are:

(1) Air-flow rate Q, determined by the amount of heat transfer required.

(2) Static pressure p_s, determined by the total system resistance that must be overcome to maintain Q.

for Electronic Equipment

Intelligent selection of blower type coupled with design of air flow path can pay dividends in blower efficiency and economy

By ADAM M. WILCZENSKI and KENNETH A. MERZ,
The Torrington Manufacturing Co., Torrington, Conn.

(3) Density ρ of air or other fluid circulated.

(4) Flow distribution—the shape and size of flow cross-section for good distribution over the heat source. This factor is not important when the blower unit merely maintains air circulation in an enclosed space.

(5) Electrical characteristics—frequency, voltage, maximum current and power and motor type. Total electric power must be shared with many other components, often little is left for the blower. Power consumption is critical in portable or airborne equipment.

(6) Noise and vibration—noise limits may exist, for example, in communications equipment or in medical electronics. Vibration may have limits to avoid disturbing other elements.

(7) Space—one of the most troublesome requirements. If cooling is considered early enough in design, sufficient space can be provided in the expected air flow path. Otherwise space may be too small or of awkward shape, affecting both cost and efficiency.

(8) Weight—usually critical in portable and airborne equipment.

(9) Environmental specifications—the blower unit may have to pass environmental tests of specifications like MIL-E-5272A and MIL-E-5422B. The specifications include resistance to external vibration, shock, corrosion and fungi.

(10) Mounting method and hardware—horizontal or vertical position, flange dimensions and bolthole sizes.

(11) Life — projects have requirements for operating life in hours of continuous or intermittent duty without failure or attention.

Where the circuit elements can cool themselves by free convection, the blower need only ventilate the enclosure. The relation between heat-dissipation rate, permissible temperature rise of the air, and flow rate enables the flow rate to be computed; then the system resistance characteristic may be established by test.

More commonly, the circuit elements are cooled by forced convection and air-flow testing is necessary. The significant parameter is surface temperature of the circuit element, which is affected by local rather than average, air velocity and temperature. It is then necessary to supply air to the unit from whatever air source is convenient, while the unit is operated at rated output and control temperatures of the elements are monitored. When the cooling rate is obtained by adjusting the air-flow rate and direction, flow rate and pressure drop through the unit may be measured. Flow testing may be done with any reliable method[1], although such tests are more conveniently performed by the blower manufacturer. Figure 1 shows such tests being conducted on a stacked-

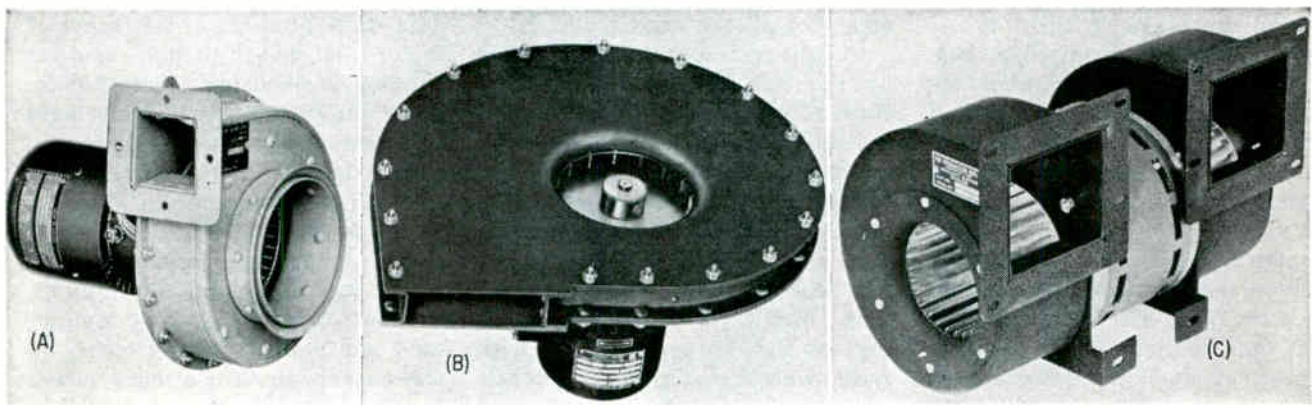

FIG. 3—Pictures show forwardly-curved impeller blade blower unit (A), high-altitude "pancake" blower unit (B) and a compact forwardly-curved impeller, double-scroll unit (C)

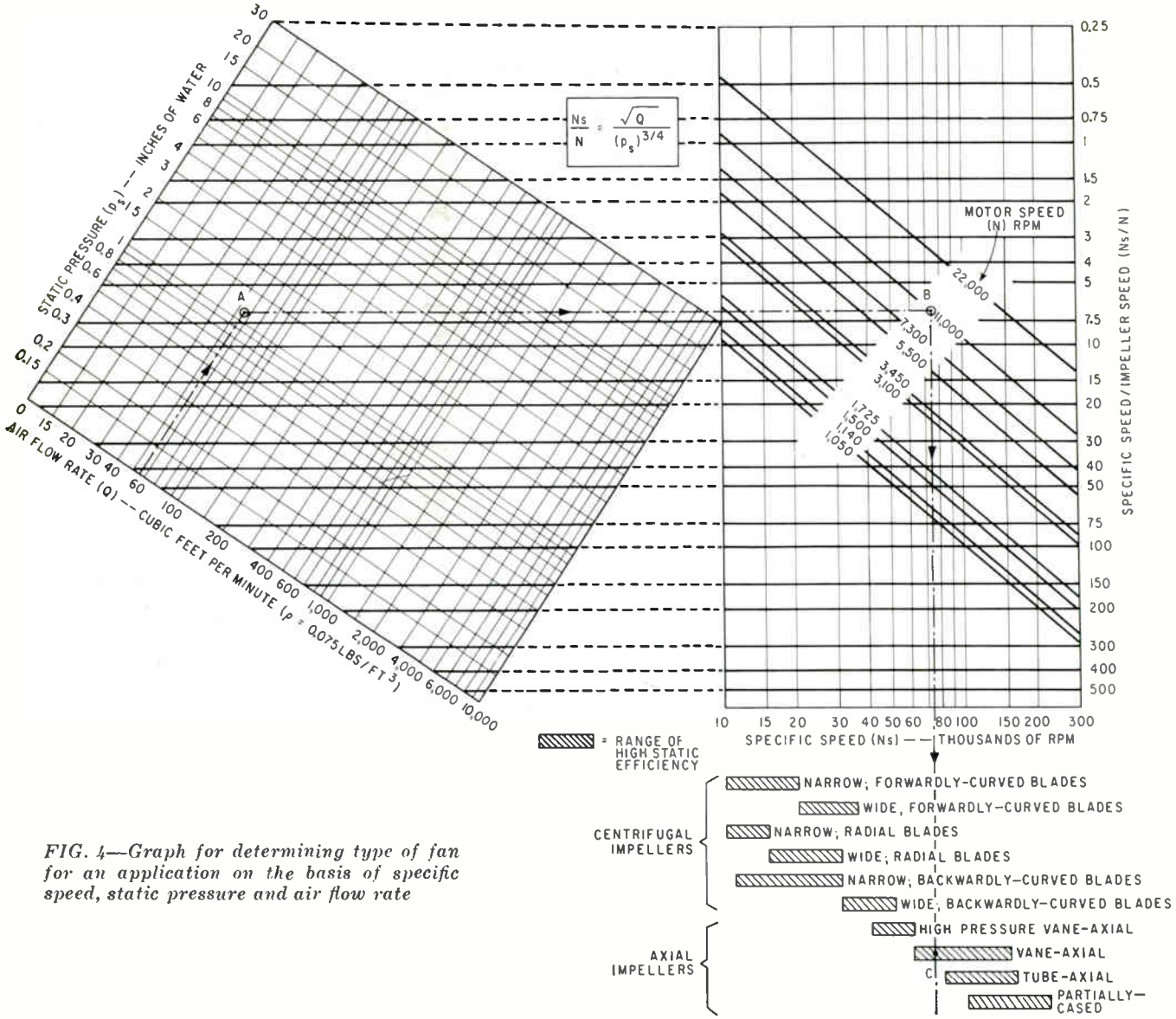

FIG. 4—Graph for determining type of fan for an application on the basis of specific speed, static pressure and air flow rate

circuit gate of IBM's Stretch computer.

Blower units include an impeller, housing or orifice to govern the flow of air and driving motor. They are classified, according to the impeller type used, as axial or centrifugal.

Axial units are of three types: the partially cased impeller, Fig. 2A, where a simple impeller operates in a shallow orifice that merely channels flow through the impeller; tube-axial, where the impeller operates in a section of duct; and vane-axial, Fig. 2B, where one or more impellers operate with one or more sets of straightener vanes in a duct. Tube-axials are more efficient than partially cased impellers because of reduced leakage past blade tips, but the air still flows helically and the tangential component of flow represents wasted energy. In vane-axial units the straightener vanes remove the tangential component and convert its energy to pressure. Thus, vane-axials have the highest pressure characteristics and highest efficiency of all the axial types.

Centrifugal units are classified by the type of impeller blading: forwardly-curved, Fig. 3A, where the discharge edge of the blade is inclined forward in the direction of rotation; radial-bladed, and backwardly curved. No one type is clearly superior to the others; highest peak efficiencies are attained with backwardly curved wheels, highest speeds are possible with radial wheels, and greatest flow and pressure for a given size and speed are possible with forwardly curved impellers.

The two centrifugal units in Fig. 3B and 3C show how blower units can be adapted. The pancake blower in Fig. 3B, designed for cooling at high altitudes, was constructed to provide high performance (500 cfm at a static pressure of 2.4 inches of water at 65,000-ft altitude) and yet the impeller housing is only 3.08-in. wide. In Fig. 3C, two scrolls have been combined with a motor to provide 400 cfm at a static pressure of 0.8 inch of water.

The most efficient blower unit produces the necessary air horsepower with minimum power input, smallest motor, and least weight, cost, and noise. While efficiency in the conversion of electrical power to air power is always desirable, blower units in air conditioners,

Heat removed by air flow, based on average specific heat of 0.24 Btu/lb is

$$Q\rho\,(T_o - T_i)/237 \text{ kilowatts} \quad (1)$$

where Q = air flow in cu ft/min, ρ = air density in lb/cu ft, T_i = air inlet temperature in deg F, and T_o = air discharge temperature, deg F.

The heat dissipated from a single circuit element by forced convection cooling is

$$W = 0.293\, h_c A\, (T_c - T) \text{ watts} \quad (2)$$

where h_c = forced convection heat transfer coefficient in Btu/hr-sq ft-deg F, A = cross-sectional area through which heat flows in sq ft, T_c = maximum surface temperature of heat source in deg F, and T = mean circulating air temperature at heat source in deg F. The independent variable in equation (2) for a given flow system is the heat-transfer coefficient h_c, itself a function of Reynolds number, Nusselt number, thermal conductivity of the fluid, and some dimension of the object being cooled. For a particular object being cooled by air under a particular set of conditions, $h_c \simeq V^r$ Btu/hr-sq ft-deg F; V is the air velocity in ft per min, and r depends on the type and orientation of heat transfer surfaces ($r = 0.6$ is commonly used for electronic equipment cooling systems.[4]

Since $Q = A \times V$, V may be changed by varying either Q or A. However, h_c varies more slowly than V (doubling V increases h_c about 50 percent). Once the flow cross-section A has been established, holding the maximum surface temperature T_c to desired values requires a certain velocity V and then becomes a blower-system problem of producing Q cubic feet per minute.

Static pressure p_s added to a cooling system by a blower unit to overcome flow resistance is related to air flow Q in cfm in the expression

$$p_s = KQ^2 \text{ inches of water} \quad (3)$$

The three solid curves in Fig. 6 show the system-resistance characteristics of three air flow paths of decreasing system-resistance constant K_1 to K_2 to K_3, representing lower total resistance in the path. To maintain a flow rate Q_1 along a flow path, higher static pressures, p_{s3} to p_{s2} to p_{s1}, must be introduced by the cooling blower as the resistances in the system increase.

Air horsepower P_a, defined as the energy a blower delivers to an air-moving system, is

$$P_a = Q \times p_s/6{,}360 \text{ horsepower} \quad (4)$$

For a heat transfer coefficient resulting in flow rate Q, the air power input depends directly on the system resistances. Comparison of this equation with the relation between h_c, air flow rate, and air flow path area shows how important it is to channel air closely over components requiring a high h_c, so that Q, and consequently air horsepower, may remain small.

The static efficiency of a blower unit is

$$\eta_s = P_a \times 100/P_e = (Q \times p_s) \times 100 \text{ percent}/6{,}360\, P_e \quad (5)$$

where the air horsepower P_a and electrical power input to the impeller P_e are in identical units, either watts or horsepower. Each type of air impeller will reach peak static efficiency at one combination of air flow rate, static pressure and motor speed. This is expressed by a factor called specific speed, given by

$$N_s = N \sqrt{Q}\, /p_s^{3/4} \quad (6)$$

where N = impeller speed in rpm. This characteristic is not truly dimensionless and it is customary to evaluate it when the blower is handling air at standard density (0.075 lb/cu ft).

Static efficiency is plotted in Fig. 7 as a function of specific speed for each of the major types of axial and centrifugal impellers. These curves demonstrate several facts:

1. *Each type of impeller has a single peak efficiency.*
2. *There are large differences in the magnitudes of peak efficiency.*
3. *The specific speed of different impeller types at peak efficiency varies widely.*

Desired values of flow rate Q, static pressure P_s and a motor speed N may be substituted in Eq. 6 to obtain the particular specific speed for a cooling blower that will properly match the flow system.

For a given impeller type, size and speed, changes in air density (ρ) affect flow, rate (Q), static pressure (p_s), and impeller power (P) in the following manner.

$$Q_2 = Q_1 \quad (7)$$

$$p_{s2} = p_{s1}\,(\rho_2/\rho_1) \quad (8)$$

$$P_2 = P_1\,(\rho_2/\rho_1) \quad (9)$$

Flow rate is thus independent of altitude, and the static pressure and power required to maintain a given flow rate become smaller as altitude increases. Thus it is easy to compute blower performance at altitude conditions.

EXAMPLE

Forced-convection cooling must remove $W = 180$ watts of heat from a single electronic circuit element whose maximum allowable surface temperature $T_c = 180$ F. The heat-producing element is in a location where mean circulating air temperature is 85 F. It is necessary to determine the flow rate Q, static pressure p_s, air horsepower P_a and the type of impeller unit that will most efficiently fulfill these conditions.

The initial performance test used an available propeller fan at 11,000 rpm and showed the measured $T_c = 210$ F, 30 deg above the maximum desired value. Other measurements give $Q = 57$ cfm, $p_s = 0.5$ inch of water and $P_a = 3.4$ watts. To reduce T_c to 180 F, Eq. 2 is used as follows:

From initial test
$$180 = 0.293\, h_{c1} A\, (210 - 85)$$
desired condition
$$180 = 0.293\, h_{c2} A\, (180 - 85)$$
then $h_{c1} \times (125) = h_{c2}\,(95)$
or $h_{c2}/h_{c1} = 125/95 = 1.3$

It is then necessary to increase h_c by 30 percent, which may be accomplished in either of two ways. First, by increasing Q with no change in the full area of the air flow path:

since $h_c \simeq V^{0.6}$
then $h_{c2}/h_{c1} \simeq (V_2/V_1)^{0.6} = (Q_2/Q_1)^{0.6} = (Q_2/57)^{0.6}$

and $Q_2 = 57 \times 1.3^{1.67} = 88$ cfm
so $p_{s2} = p_{s1}\,(Q_2/Q_1)^2 = 0.5\,(88/57)^2 = 1.2$ inches of water
and $P_a = 1.2 \times 88/6{,}360 = 0.016$ hp or 12 watts

Second, by decreasing the area of the flow path with no change in flow rate:

Since $Q_2 = Q_1 = 57$ cfm
then $V_2 = (1.3)^{1.67}\, V_1 = 1.545\, V_1$

so that the area of the flow path must be reduced

$$\left(1 - \frac{1}{V_2/V_1}\right) \times 100 = 35.3 \text{ percent}$$

$p_{s2} = (V_2/V_1)^2\, p_{s1} = 1.545^2\, p_{s1} = 1.2$ inches of water

(as it should be, the calculated p_s is the same with either method)

$P_a = 1.2 \times 57/6{,}360 = 0.0107$ hp or 8 watts

If the area of the flow path can be conveniently reduced by 35 percent, this is a more efficient method for reducing T_c, since only two-thirds the air horsepower is required. The specific speed and most efficient types of impellers can be determined in Fig. 4 for $Q = 57$, $p_s = 1.2$ and $N = 11{,}000$. The efficiency bars at lower right indicate that for $N_s = 75{,}000$ rpm the vane-axial impeller will be the most efficient type.

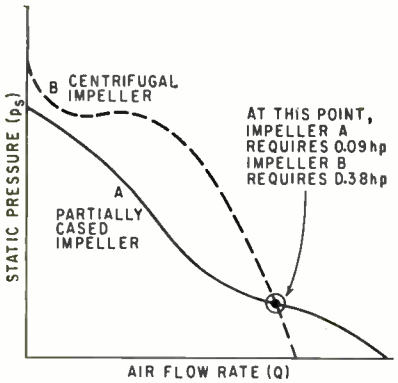

FIG. 5—While two different impeller types may both be usable, the partially cased impeller is four times more efficient.

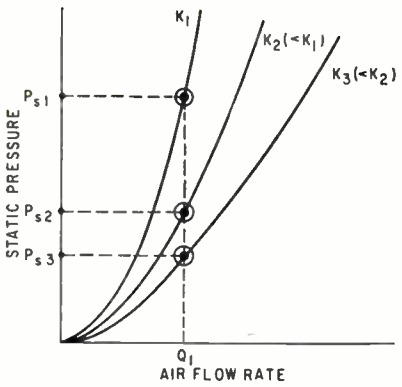

FIG. 6—Graph illustrating system resistance characteristics. Factor K determines the static pressure necessary for a given air-flow rate

ventilators and other domestic units are often operated at less than peak efficiency to obtain some other advantage such as lower cost, higher flow rate or a particular motor speed. In electronic cooling applications, however, there is usually little extra power or space available to accommodate an inefficient blower unit.

Specific speed presents a simple way to determine which type of blower will be most efficient in any application. Each type, regardless of size, develops its peak efficiency at a characteristic specific speed. Once motor speed is decided upon for a given application, it is possible to compute the specific speed at which the impeller efficiency must peak and to choose a unit that does peak at that speed. Figure 4 helps to determine the specific speed and the types of impeller with high static efficiency at any given specific speed. While any specific speed that occurs in the range of a shaded bar indicates satisfactory efficiency for that impeller type, the peak value is found around the midpoint of each bar. Whatever the refinements in design *within* a type of impeller, such as a forwardly curved blower wheel or vane-axial unit, the effect is usually to increase peak efficiency rather than to cause it to occur at a different specific speed.

Figure 5 illustrates how excessive power consumption can develop when blower type is not properly chosen. Motor speed is fixed, and a partially cased impeller, curve *A*, is ideally matched to the application, with specific speed of 129,000. By cut-and-try methods a centrifugal blower, curve *B*, is found which seems to do the job. However, its power input is 0.38 hp, compared to the power requirement of 0.09 hp for the partially cased impeller. Comparison of the required specific speed of 129,000 with the optimum specific speed of about 28,000 for the centrifugal unit (Fig. 4) would have warned initially that the cooling job was not suitable for this type of impeller.

Once the most efficient blower type has been determined on the basis of flow rate, static pressure and motor speed, the size of the blower unit can be estimated. The space occupied in the equipment depends on (1) the design of the blower and (2) the dimensions of the scroll or fan orifice, motor, flange and other accessories. Unless a blower has been selected off the shelf, exact dimensions of the unit cannot be known until a prototype has been built and tested. Dimensions can be predicted[2, 3] but where basic data is not at hand, impeller size, and hence unit size, can be estimated from $D = K_D \sqrt{ps}/N$ and $D = C_D \sqrt[3]{Q}/N$ where K_D and C_D are constants that may be obtained from ratings of geometrically similar units by substituting values taken from the desired portion of the performance curves.

The best cooling job with the least difficulty for the electronic designer is thus most likely to be attained by taking advantage of the blower manufacturer's specialized knowledge. The designer must then determine and specify fully and accurately the required operating parameters to the blower specialist.

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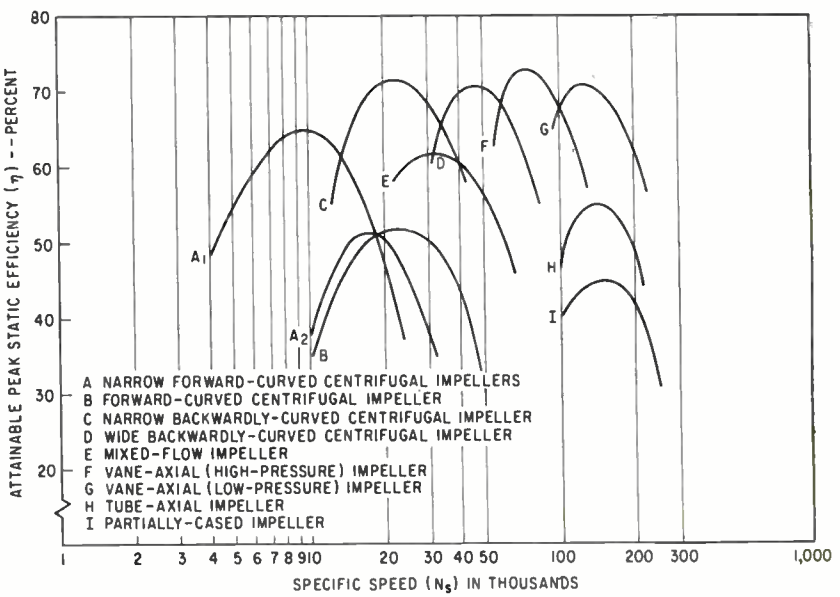

FIG. 7—Peak static efficiency is shown for different impeller types, plotted against impeller specific speed

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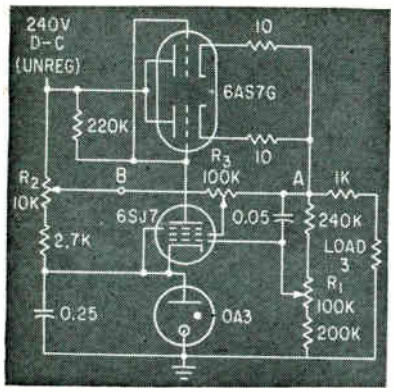


Regulator supplies constant current for heating thermocouple

Regulated Power Supply For Instruments

Simple power supply provides 0.1 percent current regulation for thermocouple gage application

By WILLIAM V. LOEBENSTEIN,
Surface Chemistry Section, Div. of Chemistry, NBS, Washington, D. C.

LABORATORY INSTRUMENTS requiring a fixed input immune to fluctuations in line voltage often need a current or voltage supply regulated to ±0.1 percent. One application is in heating a thermocouple vacuum gage. To be economically feasible, the regulator should be simple as compared with other available instruments of comparable performance.

A thermocouple gage that needed a source of constant current was custom-built. Its heater required a high current (140 ma) compared with commercial gages. Voltage developed by the thermocouple (output of the vacuum gage) was plotted on a chart recorder. The recorder trace showed fluctuations caused by changes in the heater current when these variations were greater than 0.2 ma. Therefore, regulation of the heater current to tighter limits was necessary. However, there was no need to strive for better than 0.1-percent regulation because changes in room temperature produced second-order voltage fluctuations of equal magnitude.

The possibility of using an available regulator circuit was investigated. A comparison of the more common circuits is discussed in the Navy's Handbook of Preferred Circuits.[1] It was desirable that the circuit be no more complicated than preferred circuit No. 1, which consists of a regulator triode, a single-pentode d-c amplifier and a series-connected voltage regulator reference tube. This circuit, however, is rated for only one-percent regulation.

The key to improved regulation seemed to depend upon a more careful design of the screen supply network of the pentode amplifier. Advantage can be taken of the fact that there is no need to make frequent changes in the load. Also, since no fluctuations requiring regulation originate in the load, the circuit gives better overall regulation than with a variable load.

It is known[2] that line-voltage variations can be overcompensated for by supplying the screen from the input side of the regulator. It can also be verified experimentally that undercompensation results if the screen is supplied from the output side. Between these two extremes it is possible to locate an optimum setting for the screen supply.

A regulator circuit, which has now been in satisfactory use for more than two years, is shown in the figure. Provision has been made for adjusting the screen supply. Settings for the potentiometers were determined using the following procedure.

Nominal value of the voltage at A, required to give the desired current through the load, was first obtained by adjusting potentiometer R_1. Potentiometer R_2 was next adjusted until no voltage drop occurred between A and B.

The final and most difficult setting was that of potentiometer R_3. The line voltage was deliberately varied by 15 percent in each direction using a variable autotransformer set alternately at 95 and 125 volts. Simultaneously, a constant fraction of the output voltage was fed to a recorder equipped with a zero-point suppression control so that changes of less than 0.1 percent were detected. When the setting of R_3 was too close to B, an increase in line voltage resulted in a decrease in the output, indicating overregulation. The opposite was true when the wiper of potentiometer R_3 was too close to A. A few trials located a setting for R_3 such that the output voltage showed no tendency to increase or decrease when the line voltage was changed.

Similar circuits examined in the literature have, at most, one potentiometer to serve the function of R_2 and R_3. The circuit in the figure, in which R_2 is used for the selection of unregulated voltage supply before balancing out the ripple with R_3, requires no readjustment of R_1 to compensate for the change in operating point of the pentode. Also, a more linear correction for ripple can be expected.

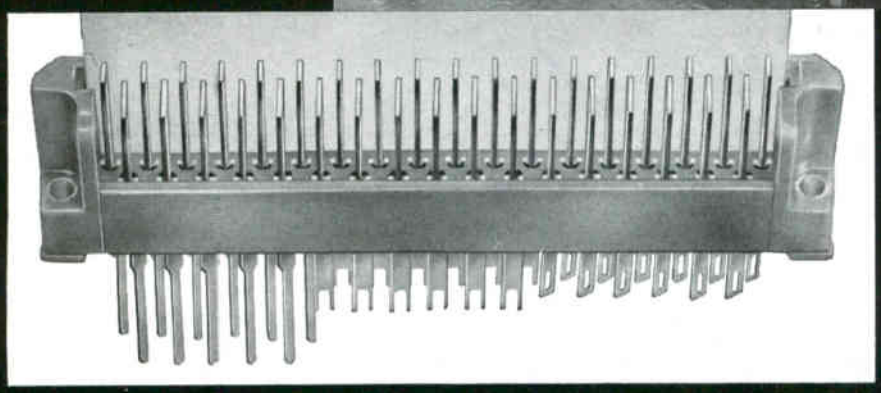
The recorded voltages showed that the regulator held the output to within ±0.1 percent over extended periods of time. The unregulated line showed brief fluctuations of about four percent and long-period drifts as large as 8.5 percent. Performance of this circuit was compared with that of other experimental circuits and with that of a larger regulator. The regulator described in this article performed better than any of the other units.

REFERENCES

(1) National Bureau of Standards, "Handbook Preferred Circuits, Navy Aeronautical Electronic Equipment," NAVAER 16-1-519, 1955.
(2) F. Langford-Smith "Radiotron Designers Handbook," 4th Ed., p 1219, RCA Electron Tube Division, Harrison, N. J., 1960.

View of entire NDP system being delivered to Federal Reserve

ELCO VARICON Series 7001 and printed circuit board. Note 3 types of contact terminals: for conventional soldering; "bus;" and Keller wrap wiring.



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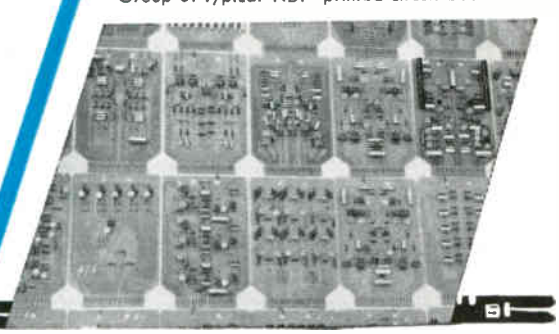
Group of typical NDP printed circuit boards



Algebraic Method Finds Target Information

By J. H. MORRISSEY,
Philco Corp., Philadelphia, Pa.

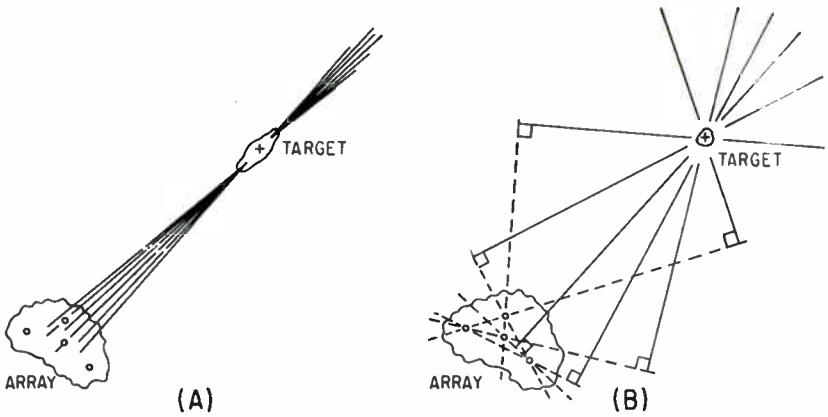
POSITION of a target detected by multiple-unit radar or sonar systems, velocity of the target or both can be determined using linear algebra and geometry. A wide variety of navigation and tracking applications are expected for the system, which could ultimately modify or replace some existing position-finding and tracking systems.

The new method is called Mulcap when applied to position finding and Mulcave when used to determine velocity vectors. The desired information is yielded by means of a data-processing algorithm involving presolution of two redundant systems of linear simultaneous algebraic equations.

Suitably extended and modified, it could replace traditional systems using the intersections of quadratic loci (hyperbolas, hyperboloids, ellipses, ellipsoids, circles or spheres). Instead, the data-processing algorithm could be described geometrically as target location by intersecting planes. Multiple roots of quadratic equations are eliminated, and a single unique estimate of target position, velocity or both is provided regardless of the number of intersecting planes involved. Direction cosines of the planes are determined in advance by the configuration of the stations and are independent of the target.

Inputs are differences or sums of arrival times of a target-transmitted or target-reflected signal among n fixed stations. In general, the stations can be regarded as constituting a field consisting of p transmitters and q receivers, where $p + q = n$, $0 \leq p \leq (n - 1)$ and $n \geq q \geq 1$. For three-dimensional applications, $n = 5$ and for plane applications, $n = 4$.

Outputs are three cartesian coordinates of target position, velocity or both. Variations can yield position alone, position and then velocity or a simultaneous estimate of the six coordinates.



Conventional method for locating distant targets using intersecting hyperbolas or hyperboloids (A) has limited range resolution compared with new approach (B) using intersecting planes

Families of planes (lines in plane applications) are each associated with a distinct transmitter-receiver or receiver-receiver pair. If p transmitters and q receivers locate or track a reflecting target, pq families of such planes are available. Similarly, with n receivers only, $(n/2)(n - 1)$ families of planes are available.

Each member of a family is exactly parallel to every other member of the same family. Thus each family shares a common set of three direction cosines—those of a line joining one pair of the elements in the field. The common intersection of the planes of each family is target position. The direction cosines of each plane forming the locating cluster are the same regardless of target position.

Noise would prevent the intersecting of all planes at a single point. A residual sum-of-squares measure of departure of the planes from the intersection provides a measure of the precision of target location.

Position coordinates are computed from $x = x_o - 2plk$, $y = y_o - 2pmk$ and $z = z_o - 2pnk$. Direction cosines l, m and n are those of a unique line on which the target must lie; x_o, y_o, z_o is a point within the field that locates the unique line translationally; and p is mean range to target from all n field elements. The un-normalized direction cosines lk, mk and nk are linear transformations of the covariance between observed time delays among n field elements and the projection on the x, y and z axes, respectively, of the corresponding spatial separation among the n field elements.

Mean range to target p is computed by minimizing a parabolic

Scimitar Antenna Test

Scimitar type antenna is type used on B-52 bomber. Tests are being made at Boeing laboratory, Wichita, Kansas

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MODEL	DC OUTPUT VOLTS	DC OUTPUT AMPS.	PANEL HEIGHT
SM 14-30	0-14	0-30	8¾"
SM 36-15	0-36	0-15	
SM 75-8	0-75	0-8	
SM 160-4	0-160	0-4	
SM 325-2	0-325	0-2	
SM 14-15	0-14	0-15	5¼"
SM 36-10	0-36	0-10	
SM 75-5	0-75	0-5	
SM 160-2	0-160	0-2	
SM 325-1	0-325	0-1	
SM 14-7	0-14	0-7	3½"
SM 36-5	0-36	0-5	
SM 75-2	0-75	0-2	
SM 160-1	0-160	0-1	
SM 325-0.5	0-325	0-0.5	

REGULATION: 0.1%*

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Model SM75-8M

Model SM325-1M

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function giving the residual variance of the locating planes as a function of a variable range parameter. Sharpness of the minimum point on this function (precision of mean range determination) is heavily dependent on number of stations. A closed solution for the critical value of the variable range parameter has been found and is applicable to all configurations meeting the minimum requirements.

This methodology is believed to be immediately or potentially applicable to air traffic management; air, sea and space navigations; satellite and missile tracking; range measurement with noise-modulated c-w signals; infrared range measurements; police alarm systems; and radio homing systems.

Machine-Animal Analogies

COMPLETELY RANDOM pattern recognition machines are not practical. So said Theodore Kalin of the Computer and Mathematical Sciences Laboratory recently.

This is in contradiction to the beliefs of other investigators who have designed experimental random machines based on the apparent example found in mammals, including human beings. They assume that the visual cortex of the brain must learn to assemble randomly distributed bits of light and shadow it receives into a meaningful pattern because there are few if any traceable nerve pathways within the visual cortex that would automatically assemble patterns. Machines, they say, might also learn to assemble random pattern elements even though all connections and logic circuitry are randomly connected.

From purely mathematical considerations, Kalin has shown that connections between the eye and higher cortical centers cannot be assumed random. His work involved a systematic study of mammalian visual-system neuroanatomy. He found that a minimum of organization must exist. In the theory developed, he says that neurons in the cortex receiving visual signals should be functionally arranged in a plane with an even density of incoming fibers over its surface. Even though this seems to

rule out completely random machines, machine analogies of a partially random kind appear possible on the basis of the apparently random cortical connections within the mammalian visual cortex. This is in contrast to the completely structured arrangements of present computers.

Balloon-Borne Gear Counts Cosmic Particles

INSTRUMENTS for measuring cosmic radiation were recently lifted by balloon to 112,000 feet, where the altitude is sufficiently rare to make precise measurements of heavy primary cosmic particles. Purpose of the flight is to gather more information about this radiation, which presents a hazard to manned space flight.

The program is a joint venture of the Air Force Cambridge Laboratory and RIAS, the Martin Company's Basic Research Institute. The helium-filled, one-million cubic foot balloon was launched from Lordsburg, New Mexico.

As well as telemetering and other electronic equipment, the 100-pound payload included a double ionization chamber to measure radiation. Telemetered results were recorded on magnetic tape for later analysis. Specific information sought includes the source of the heavy primary particles, their size and number, and whether changes related to the radiation take place from day to night.

The present experiment is one of a series using balloons, rockets and satellites. The high altitudes are required to measure the primary particles before collisions with denser atmosphere disintegrate them to form secondary particles. At the 112,000-foot altitude, both primary and secondary radiation was detected.

The chamber contains a cylinder filled with argon under pressure. A high-speed particle passing through the chamber removes an electron from each atom it encounters. The free electrons collected by a positively charged conductor at the center of the chamber are counted. The amount of ionization produced is measured, which enables precise determination of the particle.

Evaluation Report of Microelements

DEVELOPED FOR A MICROMODULAR PROGRAM

By MICHAEL F. TOMAINO,
Associate Editor

AS A RESULT of RCA's Micromodule Reliability Program*, 171 digital micromodules now meet equipment requirements at the 1,000-hour life-test point, the half-way mark in a 2,000-hour test program.

These module tests encompass 1.3 million hours of element operation without a circuit failure. The types and quantities of components used for these modules are shown in Table III. Eight types of circuit modules are included: binary divider, binary gate, sawtooth generator, time modulator, 192-Kc oscillator, clipper, pulse shaper, and output amplifier. This reliability level was attained as a result of an overall reliability program involving an additional 5.2 million element test hours to make 6.5 million total element test hours. One additional type of digital micromodule and seven types of communication micromodules must yet be tested.

The Micromodule reliability program was designed to include continuous in-process testing and data

*Conducted as part of the U. S. Army Signal Corps Micromodule Program under Contract No. DA 36-039 SC-75968. This program provides a broad potential which enables the construction of microminiature electronic equipment. The micromodules integrate with other micromodules and with associated components to provide subassemblies and equipments, and are consistent with machine production. For more about micromodules, see New Form Factors Section of the Special Report on Microminiaturization in this issue. Also refer to paper given at Northeast Electronics Research and Engineering Meeting by S. G. Bassler on Micromodule Program Status and Progress, Nov. 15, 1960, Boston.

Table I—Microelement Environmental Tests—1960

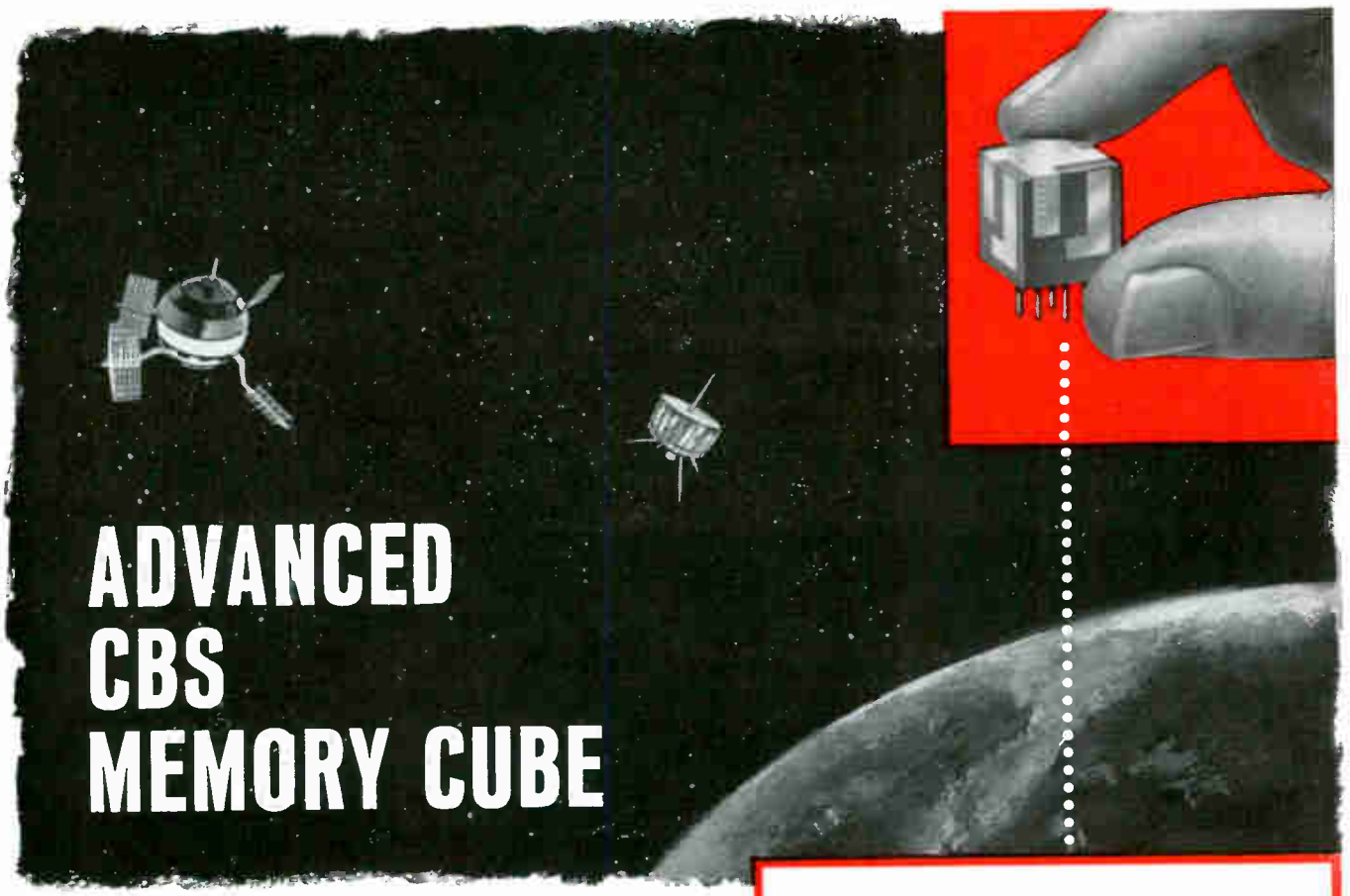
	Shock (50g)	Temp. Cycling Moisture Resistance (no load) Within 24 Hrs	Temp. Cycling Moisture Resistance (no load) After [a] Aging	Vibration (2,000 cps)
Single Layer Capacitors				
Precision	0/38	1/38	0/38	0/38
Gen. Purpose	0/10	4/10	0/10	0/10
Multilayer Capacitors				
Precision	0/20	0/20	0/20	0/20
Gen Purpose	0/20	1/20	0/20	0/20
Electrolytic Capacitors	0/21	0/21	0/21	0/21
Resistors	0/12	0/12	0/12	0/12

Legend—units failed/units tested
a—units aged at normal ambient conditions and retested approximately two months after moisture resistance test.

Table II—Microelement Life Test Data—Passive Microelements

Component	Units Tested	Element-Hours ($\times 10^3$)	Catastrophic Failures	Limits	Degradation Analysis	Test Conditions
Capacitor-Single layer ceramic general purpose	201	402	8		35 failures due to high dissipation factor. Of these, 33 had diss.fact. no greater than 1.07 × the specified value	all capacitor tests at 85C. Run at 3 times rated voltage. All units encapsulated in test modules
precision	199	398	5	0.318%[a] 10^3 megohms[b]	1 unit–0.378% 1 unit–6.5 megohms	
Capacitor-multilayer ceramic general purpose						
encapsulated	170	340	3	5.0%[a]	all within limits	
unencapsulated	200	400	1			run at twice rated voltage
precision						
encapsulated	195	390	1	0.286%[a]	all within limits	
unencapsulated	200	400	0			
Capacitor-electrolytic						
encapsulated	95	190	3	leakage 120% of initial	all within limits	
unencapsulated	419	2095	2		1 unit-high leakage	run at rated voltage
Resistor Wafers-metal film (four resistor paths per wafer)	202	404	3	%ΔR 1.0	17 paths 1.0–2.0%	resistors tested at 71 C ambient with 110 C hot spot
Inductors	121	218	0		all within limits	

a—dissipation factor; b—insulation resistance



ADVANCED CBS MEMORY CUBE

Now available for evaluation

For customer evaluation, CBS Electronics offers a working 16-bit *sample* memory cube. Its "new-concept" design features plastic-encapsulated ferrites and deposited conductors, resulting in compactness, light weight, and shock resistance never before achieved.

Check the features, unique construction and technical information. Order the CBS M-267 sample memory cube from stock . . . nominal charge $50.00. Evaluate for yourself, firsthand, the benefits of its advanced design.

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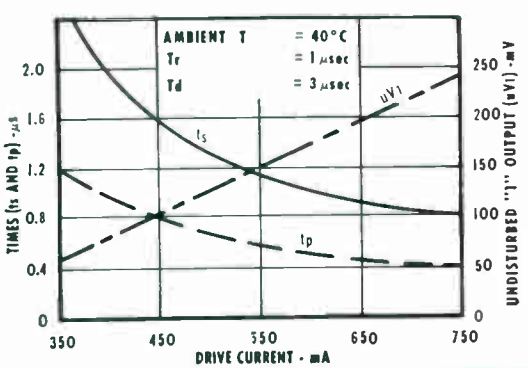
Uniformity . . . the "ONE" outputs of the 16 bits in the test cube reach amplitudes within ±5% of each other.

Environmental . . . improved temperature, humidity, shock and vibration characteristics are provided, yet encapsulation techniques employed have no adverse effects on the ferrites.

TYPICAL OPERATING CHARACTERISTICS
CBS M-267 at 40°C



CUSTOMIZED SYSTEMS

After your evaluation of the M-267, CBS Electronics can supply development facilities for custom-designing memory systems for your military computer requirements. This typical CBS customized memory pack, a multi-aperture, nondestructively-sensed, word-organized system, achieves a density of 15,456 bits in less than 23 cubic inches. Other CBS custom designs include nondestructive readout memories and ferrite logic systems. The ferrite cores in the memories meet a wide range of requirements for signal output, switching time, and current drive.

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Technician assembles microelements prior to life tests

tabulating to facilitate identification of failure mechanisms at each vendor's plant. Recognition of the failure mechanisms and the resulting corrective actions aided materially in quality improvements.

Life and environmental microelement tests were conducted by the component vendors and RCA at the prototype and final program phases. Most microelement tests were made in simulated modules operated at or above maximum ratings. The same assembly and potting facilities were used for producing the test modules and micromodules.

The microelements were purchased to specifications designed to be more rigid than Mil Specifications. Exemplifying this are the life test requirements of 2,000 hours where Mil Specs require only 1,000 hours.

Approximately 160,000 microelements have been produced for this program.

Table III—Microelement Life Tests[a]

Components	Units Tested	Unit Hours
Transistors		
Type 2N104	248	248,000
Type 2N384	2	2,000
Diodes		
Type 1N277	198	198,000
Type 1N643	102	102,000
Capacitors	405	405,000
Resistors	312	312,000
Inductors	49	49,000
Crystals	19	19,000
Totals	1,335	1,335,000

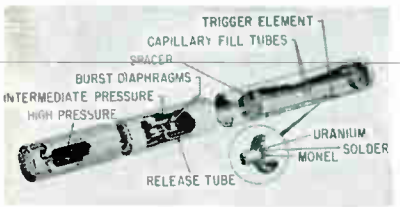
a—data resulted from operation in micromodule performance testing at 70 C and 75 C

Tables I, II and III present the first data released on environmental and final phase life tests.

Safety Fuse Controls Reactor

NINE NUCLEAR REACTOR safety fuses, built by Atomics International, a division of North American Aviation, Inc., for the Atomic Energy Commission, will be used in the Maritime Gas-Cooled Reactor Critical Experiment, operated by the General Atomic Division of General Dynamics Corporation, at San Diego, under contract with the Atomic Energy Commission.

The fuses automatically shut down research reactors without external controls. While all reactors contain control systems to make them safe, a fuse provides additional protection in certain types of experimental reactors.

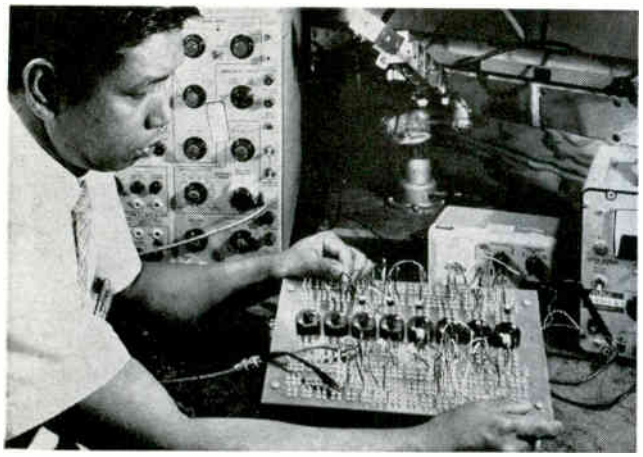


Reactor safety fuse releases boron trifluoride gas

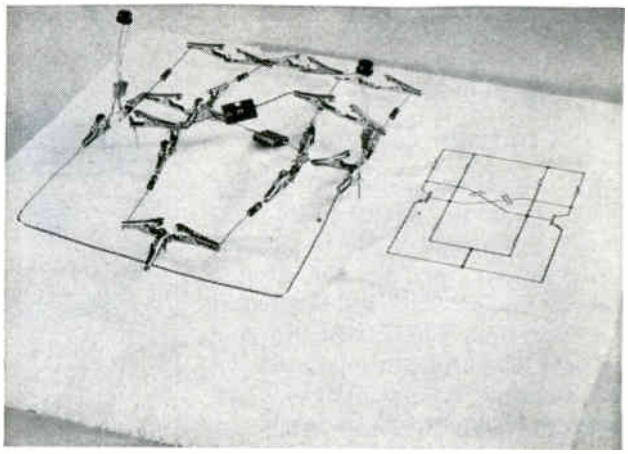
The devices are compared to electrical fuses which shut off power to overload. Fabrication was done at Atomics International's Canoga Park, Calif., laboratories.

Completely self contained in a cylinder, a fuse is partly inserted in the core of a reactor where atomic fission takes place. The part outside the core contains boron trifluoride gas. In an operational device the gas is released automatically into the other part of the cylinder in the event of a power surge. The gas absorbs neutrons required to maintain the chain reaction, bringing the reactor under control instantly and without damage.

Atomics International began early work on a safety fuse in 1952 and has been developing the present concept for the AEC since 1957. Operational experience of the safety fuse concept will be gained as part of the experimental program at General Atomic.



Taper pin breadboard is useful for transistor circuits



Circuit assembled on foam slab resembles schematic

Better Breadboards Save Time, Parts

By ALBERT T. OWENS

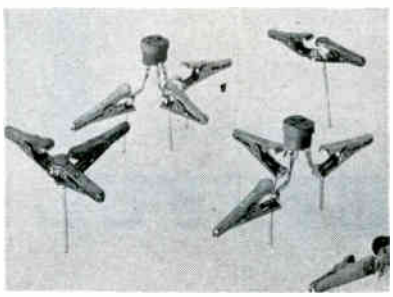
Advanced Projects Lab., Eng. Div.,
Hughes Aircraft Co., Culver City, Calif.

CIRCUIT DEVELOPERS have gotten a lot of mileage from the terminal boards normally-used for breadboarding, but there are faster and better methods. The improved methods shown cover the entire frequency range from d-c to uhf.

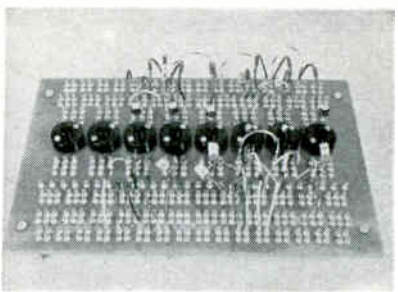
Valuable "inspiration" circuit ideas are often lost by the time-consuming nuisance of assembling a conventional breadboard. Furthermore, a clean layout is needed so that the breadboard circuit will resemble the schematic design. The resemblance leads to faster assembly and easier circuit diagnosis.

A foam breadboard was developed for temporary lower frequency broadboards. The stray capacitance and inductance of the clips used may become objectionable as frequencies rise into the megacycle region.

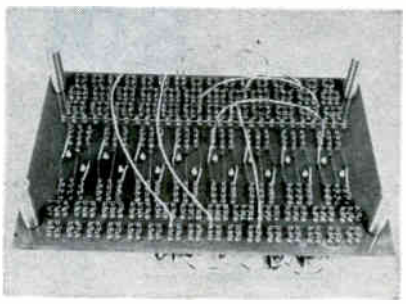
The base is a Styrofoam slab about 2×12×18 inches. Terminals are made by soldering together small alligator clips, sockets and short pieces of wire. The clips are crimped slightly with pliers so they bite leads better. Clips and sockets can be inserted anywhere in the slab and components and jumpers routed without the inhibitions of predetermined terminal spacing or the necessity of soldering connections.



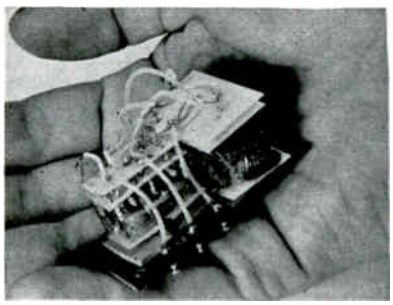
Clips and sockets for foam breadboard



Components go on top of taper pin breadboard



Jumpers are placed on bottom of taper pin board

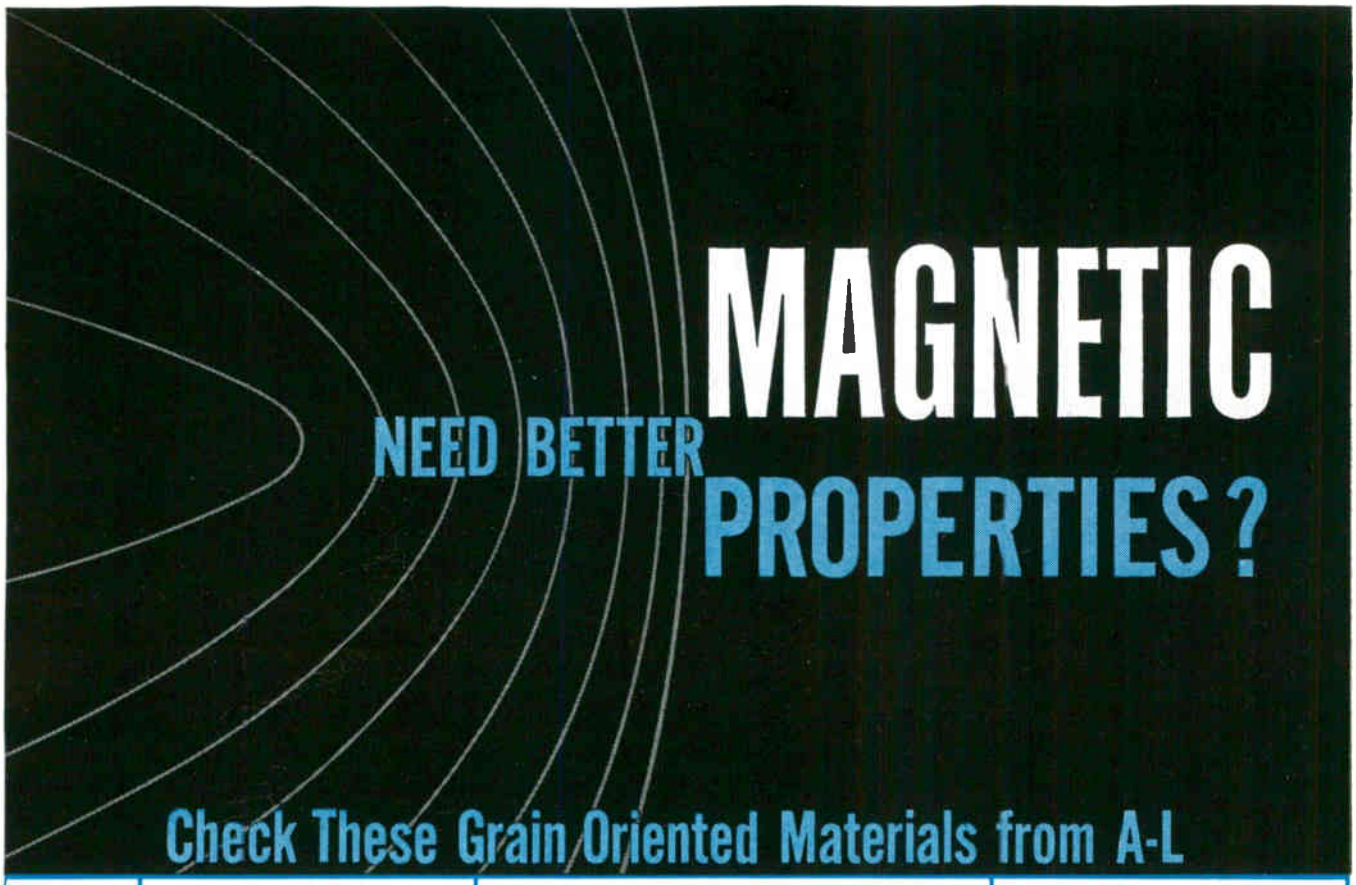


Punched sheets make milliminiature breadboard

The multivibrator illustrated was made in four minutes, while the same circuit took 34 minutes to assemble on a conventional breadboard. The saving in time is significant since breadboarding is usually done by high-paid personnel Components are not damaged, the circuit can be disassembled without soldering and the components and jumpers can be reused.

An array of taper pin sockets and transistor sockets on an epoxy-glass board is especially well-suited to digital computer work. This board is also used for high-temperature circuit testing, the temperature limit being the melting point of the solder used on permanent jumpers. It is being used now to test at 240 C.

Terminals are regular CTC tapered solder terminals. Transistor



NAME	DESCRIPTION	SPECIAL PROPERTIES	TYPICAL USES
Silectron	Grain oriented silicon strip. Available in coils and laminations in thicknesses of .012 and .014 inch.	Very low 60 cps core losses, high permeability, and low exciting currents at high inductions in the rolling direction.	Power and distribution transformers large turbo generators, small power and audio transformers.
Thin Gage Silectron	Grain oriented silicon strip. Available in coils in thicknesses of 1, 2, and 4 mils.	Low core loss and high permeability at frequencies greater than 60 cps in the rolling direction.	High frequency transformers, pulse transformers, magnetic amplifiers, communication equipment.
Deltamax	Grain oriented, 50 percent nickel, balance iron. Available in coils and laminations.	Low coercive force and rectangular hysteresis loop developed after a high temperature, hydrogen anneal.	Magnetic amplifiers, computers, mechanical rectifiers, saturable reactors.

For the utmost in magnetic properties, design your flux paths to take advantage of directional properties of Allegheny Ludlum's grain oriented materials. By careful control of rollings and quality processing, Allegheny Ludlum creates grain oriented materials that permit the ultimate for design consideration and economic application.

Allegheny Ludlum Silectron®, a grain oriented cold rolled 3 percent silicon steel, is much superior to the corresponding nonoriented grade when magnetized in the rolling direction. Iron-silicon alloys are usually graded on the basis of core loss or watt loss. Silectron's core loss is only .659 watt per pound measured parallel to the rolling direction compared to 1.11 for the corresponding nonoriented alloy. (Both measurements made at 15 kilogausses and 60 cycles per second.) In fact, Allegheny Ludlum Silectron is so superior to conventional grades that it gives better results even when 20 percent or more of the flux path is cross grain.

Allegheny Ludlum Deltamax is a 50 percent iron, 50 percent nickel alloy which has equally good magnetic properties in three directions—in the rolling and cross rolling directions and also normal to the plane of the strip. Deltamax has a rectangular hysteresis loop with a very high peak induction at a magnetizing force only slightly greater than the coercive force. Its high residual induction and superior permeability at peak inductions is combined with a reasonably low coercive force.

When your magnetic requirements are exacting, consult with Allegheny Ludlum. A-L makes a complete line of magnetic materials, is glad to supply you with the technical data you need in design and manufacture. ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pennsylvania. Dept. E-11.***

ALLEGHENY LUDLUM

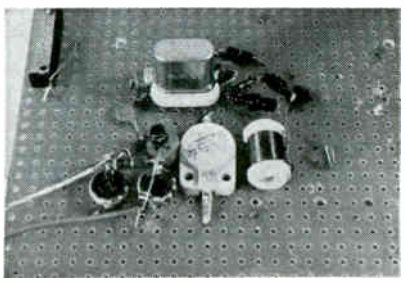
PIONEERING ON THE HORIZONS OF STEEL

2991

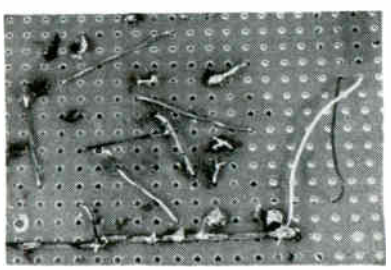
sockets (Loranger, Warren, Pa.) are partitioned internally so leads cannot be shorted while the transistor is being inserted or removed. Resistors, diodes, capacitors and jumpers are prepared by crimping taper pins to their leads. The components can be reused indefinitely. Transistors need no preparation.

Milliminiature circuits usually require two breadboard stages. In the first, the circuit is tested without regard to its size. Breadboard flexibility must be maintained when it is next built in its final size, so that components and jumpers can be changed readily.

Laminated fiberglass sheet is ruled into a 0.10-inch grid and cut into the desired shapes. Holes punched at the corners of the grid squares provide proper spacing, insulation and support for leads.



Top view of printed wiring prototype board

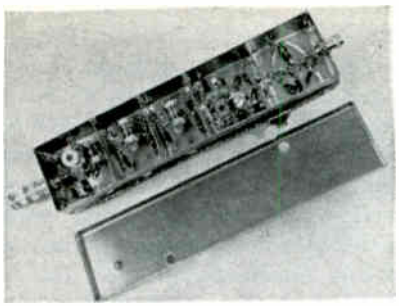


Bare wiring on bottom simulates etched wiring

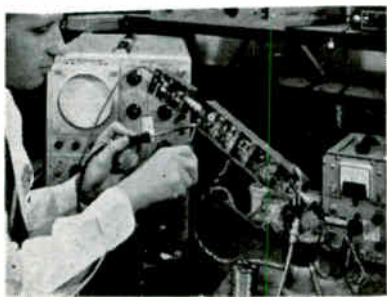
The two modules of the audio amplifier illustrated were breadboarded separately. The components in each module are mounted vertically, with the leads projecting through the rectangular inner sheets. This mounting allows components to be changed. Leads are connected on top of the sheets.

After each module is made and tested, the outer, T-shaped sheet is added and the connections between modules made on this. Only module interconnections are brought out through this insulator.

Preparing etched wiring circuit drawings directly from a schematic



Covered breadboxes provide high-frequency shielding



Two breadboxes being used to prepare uhf circuits

or conventional breadboard frequently leads to errors in the etching layout. A simple solution is illustrated by the breadboard version of a crystal oscillator circuit.

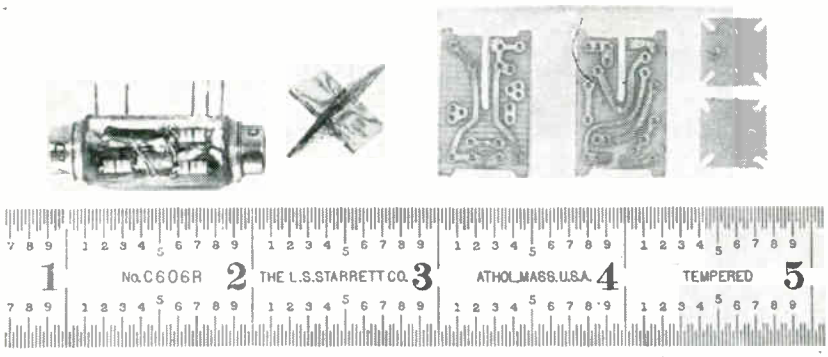
The circuit is laid out in its final configuration on punched phenolic board, omitting all terminals. Bare wire is threaded through the holes to simulate, on the bottom of the board, the etched wiring. If the circuit operates in this form, the actual etched boards should be free of error. The breadboard is the model for the etched pattern drawings.

At uhf and vhf, circuits must be shielded and lead lengths minimized. Instead of breadboards, brass breadboxes are used. Breadboxing is not as fast as breadboarding, since the physical arrangement strongly influences circuit performance. However, it does permit a relatively straightforward approach.

The boxes, about three inches wide and two inches deep, and their covers are made in advance. Seams are brazed. The brass is cleaned and coated with acrylic spray or a similar film to prevent oxidation.

Solder connections can be made many months later without further cleaning. The heat of soldering burns the film from the area being soldered. Partitions are soldered in place as needed. Tuning holes are drilled in the cover or sides of the box, so the circuits can be tuned with the cover on.

New On The Market



Printed Circuit Modules

INTERLOCKING BOARDS

PRINTED CIRCUIT boards for modular construction consist of crossed printed circuit boards interlocking to form a structural column. End plates may also be printed circuits and can carry tube sockets or transistors and plug-in connectors.

The structure can be made in a wide variety of shapes and sizes including a subminiature version about ⅜ inch square. The structure offers advantages in miniaturization by providing maximum circuit board area in a given space, as well as providing a rugged, self-supporting structure resistant to high shock and vibration. The patented Plus modules are being manufactured by Arthur Ansley Mfg. Co., New Hope, Penn.

CIRCLE 301 ON READER SERVICE CARD

Stereo Headphones

30 CPS TO 20 KC

FEATHERWEIGHT K-50 stereo headphones are now available with frequency response from 30 cps to 20 Kc. Coupled with its light weight of only three ounces, including the cable, the clarity and fidelity of reproduction help reduce fatigue during long hours of quality-monitoring in broadcast and recording, in communications work, and in private home-music listening.

Requiring less than one milliwatt input, the headphones have a high output when used with line and cathode-follower circuits with the U-50 transformer, and thus can be used without a power amplifier. It converts between binaural and monaural without soldering; price is

$31 retail net from Electronics Applications, Inc., Stamford, Conn.

CIRCLE 302 ON READER SERVICE CARD

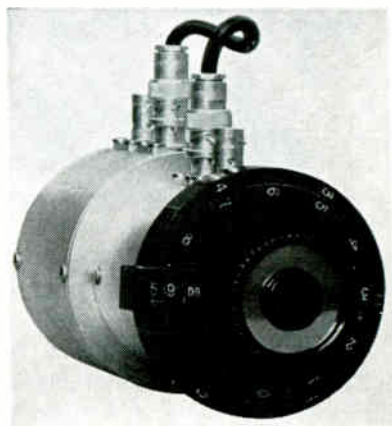
Transistor Socket

FOR PRODUCTION TESTING AND MOCK-UPS

SOCKET for production testing 3- or 4-lead transistors is available from Jettron Products Inc., 56 Route 10, Hanover, N. J. Socket occupies a volume ⅛ square by 1 7/16 inch long.

Designed for ⅜ panel mounting in keyed hole, and retained by a snap ring, sockets may be mounted on 0.812 centers. Double fingered spring contacts grip leads close to base of transistor with frictional force in excess of 50 grams on 0.017 diameter lead wires. Large entry funnels assure ease of lead insertion; contacts are beryllium copper, silver plated and terminate in rigid solder terminals on each face of body; body is molded of glass filled Diall FS-5; socket weight is less than 9 grams; cat. No. 72-101.

CIRCLE 303 ON READER SERVICE CARD



Turret Attenuator

ONE-DB STEPS TO 59 DB

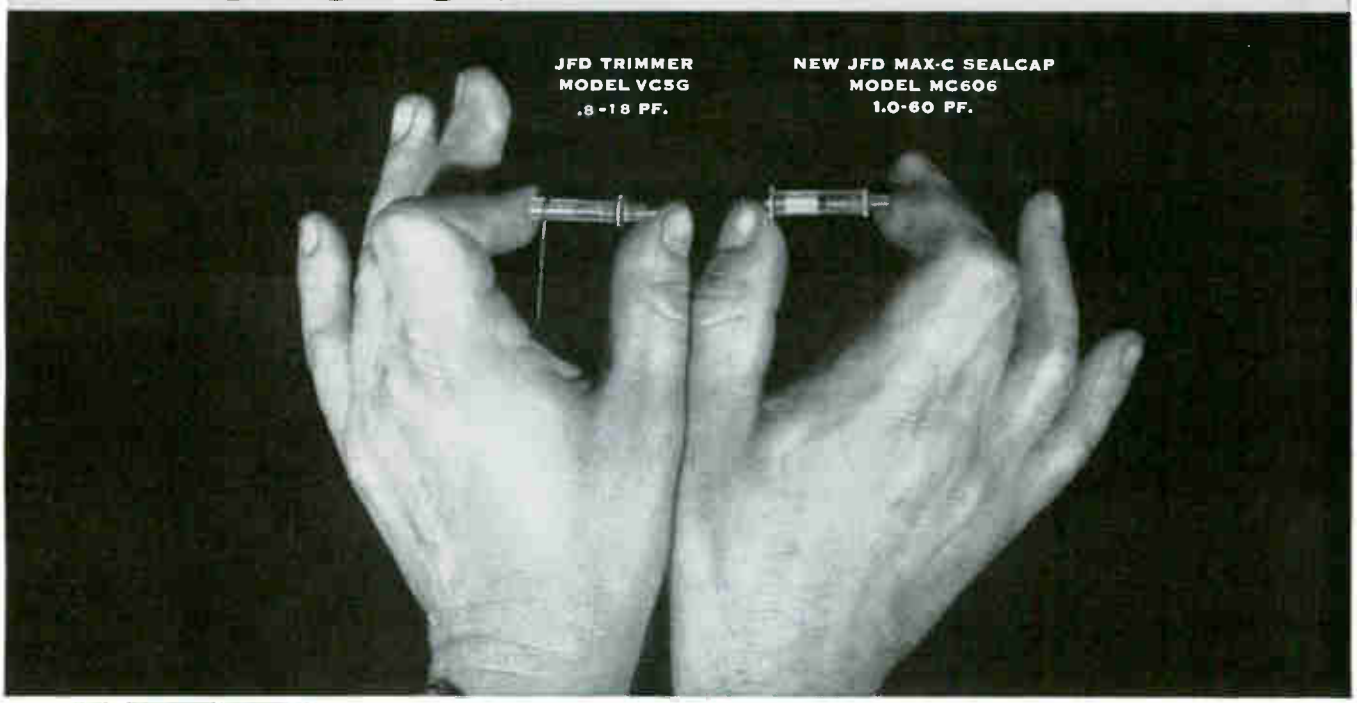
TURRET ATTENUATOR TAB-50 is designed for use from d-c to 1,250 Mc. A knob and dial allows the attenuation to be set in 1 db steps at any value between 0 and 59 db.

The unit can be used either unmounted as a laboratory device, or panel-mounted in a complete instrument or system, and in a variety of environments. Outside dimensions of the case are 3 x 4¾ inches; weight is 44 ounces.

Two separate turret attenuators, assembled with concentric shafts and electrically connected in series, make up the unit. One of the attenuators is adjustable in 10-db increments from 0 to 50 db; in series is a 0-10 db unit adjusted in 1-db increments. Decade values are set by an outside dial, while individual db units are set by an inner knob.

Attenuation is achieved by resistive elements within precision-machined rotor assemblies that are designed for optimum match. As each shaft is rotated, separate attenuator pads connect to the input or output BNC connectors and to the interconnecting cable between

300% INCREASE IN RANGE NO INCREASE IN SIZE!



JFD **MAX-C**® MINIATURE TRIMMER SEALCAP®

Now you can cut precious inches and ounces from your assemblies with space-saving, weight-saving MAX-C Sealcaps.

The surprising increase in range of the Max C trimmer capacitor is obtained by embedding the electrode band in the glass cylinder. This design provides the thin dielectric required for a large capacitance range while retaining the ruggedness and mechanical strength of a heavy wall glass tube.

Included in the Max C design is the Sealcap construction which provides the additional stability safeguard of a completely sealed interior.

MINIATURE PANEL MOUNT MAX-C SEALCAP SERIES

Model	Min.	Max. (PF)	Distance Beyond Panel	Maximum Diameter
MC601	1.0	14.0	29/64"	5/16"
MC603	1.0	28.0	11/16"	5/16"
MC604	1.0	42.0	29/32"	5/16"
MC606	1.0	60.0	1 5/32"	5/16"
MC609	1.0	90.0	1 3/4"	5/16"

The Max C retains all the advantages of glass tubular trimmers: Working voltage of 1000 VDC, Insulation Resistance of 10^6 megohms, Q of 500 at 1MC, operating temperature range of −55°C to +125°C, and high stability. It meets or exceeds the applicable performance and environmental requirements of Mil-C-14409A.

Escape from the design limitations of conventional trimmers by specifying JFD MAX-C Sealcaps for your current and projected circuitry. Write today for the complete catalog describing MAX-C Sealcaps and other JFD precision electronic components. Other JFD components are...

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15 Moore Street, New York, N.Y.

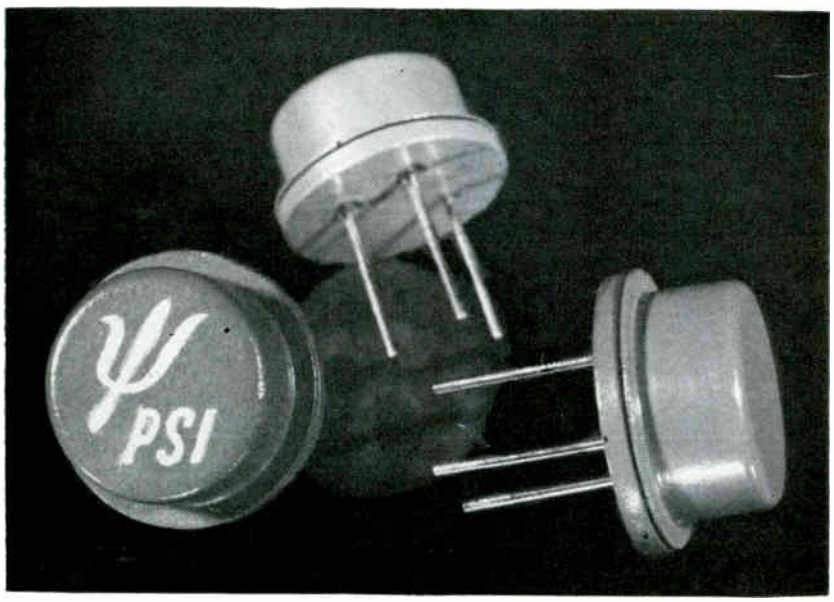
the two units.

Accuracy from 0 to 10 db varies from ± 0.2 db at 200 Mc to ± 0.5 db at 900 Mc. Above 10 db, accuracy is ± 2 percent ± 0.2 db to 200 Mc and ± 5 percent ± 0.3 db at 900 Mc.

Insertion loss is 0.1 db to 300 Mc, and 0.4 db at 900 Mc; power rating is 1 watt; input impedance is 50 ohms and vswr is 1.2:1 to 300 Mc and 1.35:1 at 900 Mc.

Units are available at $225.00 in single-unit lots from Telonic Industries, Incorporated, Beech Grove, Indiana.

CIRCLE 304 ON READER SERVICE CARD



Silicon Transistor

TRIPLE DIFFUSED MESA

SILICON power transistor, PT530, triple diffused mesa is a medium power vhf communications transistor; having extremely low saturation resistance, it is also suitable for switching applications.

Power output is 5 watts at 30 Mc with a power gain of 10 db minimum with collector at 28 v. Useful oscillator power is obtained to 200 Mc.

Because of its high power output, the unit will perform well as a transmitter final amplifier stage or as a driver for high frequency transistors. It can be used to obtain upward of one watt at 1,000 Mc.

Structure of the transistor is *n-p-n-n*$^+$. The line emitter, dual base contacts, and low collector region resistance result in a device optimized for vhf power operation.

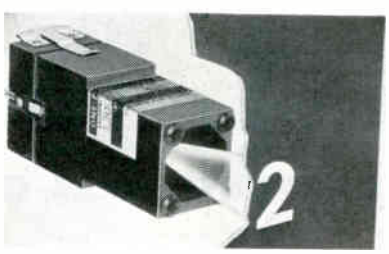
Evaluation quantities are immediately available. Price per unit in these quantities is established at $125. Detailed specifications may be obtained at any PSI sales office or from Pacific Semiconductors, Inc., 12955 Chadron Avenue, Hawthorne, California.

CIRCLE 305 ON READER SERVICE CARD

Digital Readout

SUB-PANEL MOUNTED

SUB-PANEL, miniaturized digital readout is mounted 13/16 inch behind a lucite viewing screen, with the readout projected onto the viewing screen. Readout units are easily accessible for replacement or maintenance since the viewing screen is not an integral part of the readout and may be swung out of position.



Digits are visible from any angle and are uncluttered by mounting holes or other detail. The Series 120000 Digital Readouts are for use with digital computers, control equipment, instruments, aircraft equipment, production and inventory control, and other equipment.

Character size on the viewing screen is $\frac{5}{8}$ inch high, with light obtained from subminiature lamps No. 327, 328, or 330, operating on 6 to 28 v.

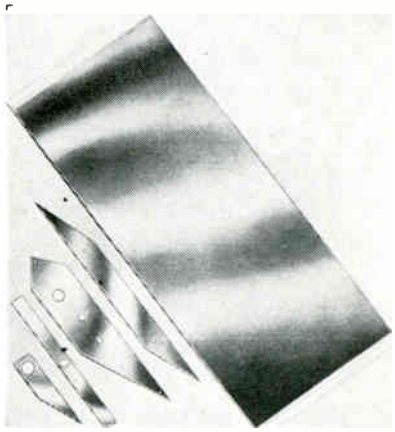
Using module construction with aluminum case, dimensions are $3\frac{1}{8}$ long, 1 wide, and $1\frac{7}{16}$ in. high; weight is $3\frac{1}{4}$ ounces. Unit price is $35.00, available in single units or in assemblies thirty days after receipt of order, from Industrial Electronic Engineers, Inc., 5528 Vineland Ave., North Hollywood, Calif.

CIRCLE 306 ON READER SERVICE CARD

Resistance Cards

METAL FILM ON GLASS

METAL FILM resistance card is a highly stable microwave attenuator material with a base of fine-weave glass cloth impregnated with high temperature thermosetting resin that meets MIL-P-18177. Resistance material is a thin film of pure metal, approximately 50 millionths



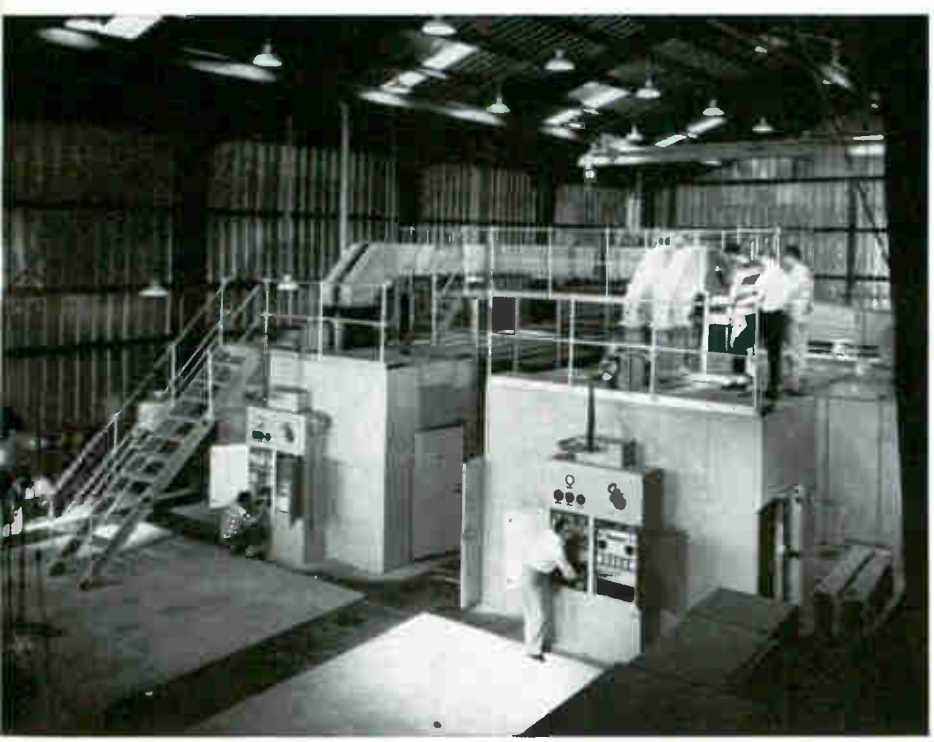
of an inch thick, uniformly deposited on one surface of the plastic. A protective coating is provided over the metal film.

The fibre glass plastic base is dimensionally stable and has extremely low moisture absorption. Special machining techniques are not required and the cards can be punched, drilled, sheared, machined and sanded. Maximum surface temperature should be limited to 130 C.

Standard resistance cards are 5

CIRCLE 149 ON READER SERVICE CARD→

BMEWS... *eyes of the free world*



BMEWS . . . the Ballistic Missile Early Warning System is the free world's first warning of enemy ICBM attack.

Powerful radars with an accurate range of thousands of miles can detect incoming ICBMs minutes after launching. The transmitters for this defense system are being built by Continental Electronics . . . specialists in super power transmitting equipment.

Provided under sub-contract to General Electric and R.C.A., these transmitters from Continental Electronics are another contribution to our country's defense.

Continental Electronics Mfg. Co.

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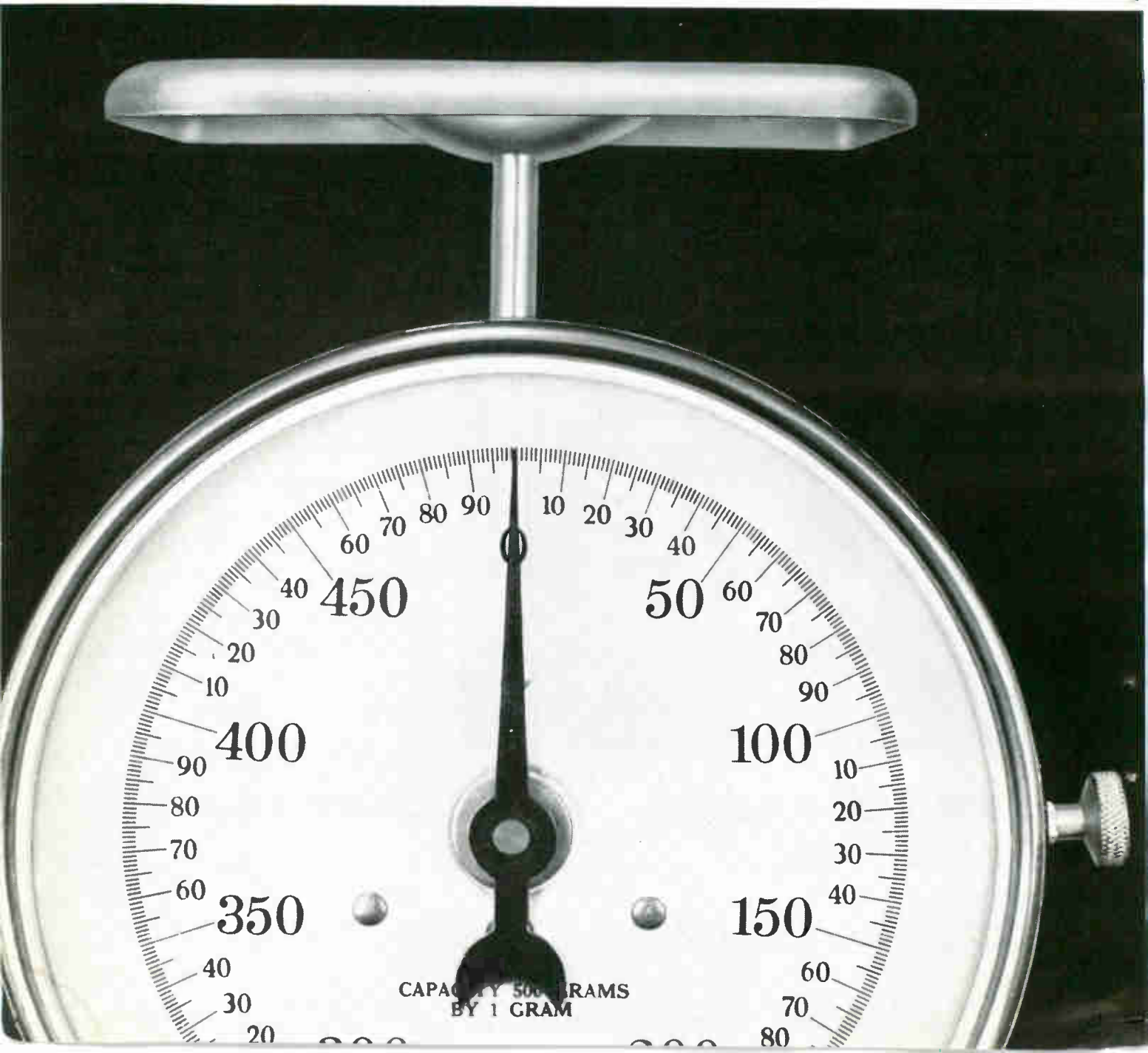
WEIGHT of your system can be cut if you specify components capable of outstanding performance. Example: high output lets *one* Sperry traveling wave tube replace *two* ordinary tubes in Nike-Zeus. If weight reduction is a knotty problem for you, call Gainesville, Florida, FRanklin 2-0411 collect, for full information about Sperry capabilities.

SPERRY ELECTRONIC TUBE DIVISION

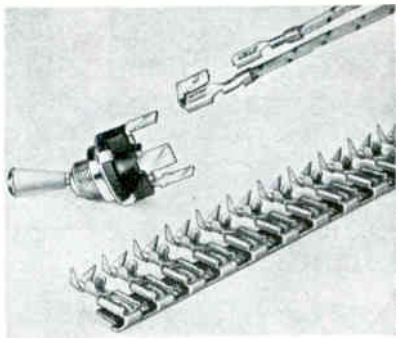
Gainesville, Florida • A Division of Sperry Rand Corporation

SPERRY'S FAMILY OF TRAVELING WAVE TUBES covers P through X Bands with unusually high output and light weight. These characteristics, combined with the inherent ruggedness of metal-ceramic construction, conduction cooling and wide-range thermal compensation, make Sperry traveling wave tubes particularly suitable for airborne applications.



by 12 inches and 0.025, 0.032 or 0.062 inch thick. Resistivity range is 25 to 750 ohms per square. Standard values from stock include 50, 100, 125, 150, 180, 200, 300, 377, 400, and 500 ohms per square. Material is being manufactured by Filmohm Corp., 48 West 25th St., N. Y.. N. Y.

CIRCLE 307 ON READER SERVICE CARD



Double-Duty Connector

MULTIPLE CONNECTIONS

DOUBLE-DUTY quick-connect terminal #3000H21AB provides multiple connections to the same terminal. Space saving and simplified wiring result from use of this female connector, which is for attachment to the male terminals normally furnished on many switches, timers, motors, sockets, relays, solenoids, transformers and junction boards. The connector also has an integral male terminal to which another female connector or double-duty connector can be attached, thus increasing the number of wires that can be attached to one terminal.

Heavy-gage brass construction meets UL requirements for strength and current rating. Accommodating wires #18 to #12, with normal insulation, the connector is available individually or in continuous strips for automatic attachment, from Ark-Les Switch Corporation, 51 Water Street, Watertown 72, Massachusettts.

CIRCLE 308 ON READER SERVICE CARD

Recording Paper

ELECTROSENSITIVE

WESTREX CORP., a division of Litton Industries, 540 W. 58th St., New York 19, N. Y., has introduced Timemark, a new electrosensitive chart recording paper which may be used in many applications, including XY, XYZ, depth, event and facsimile recorders. It also is suitable for use in multistylus applications with places as close as 15 thousandths. Analog and digital information can be recorded at much higher rates of speed than with single stylus equipment. Timemark is a dry recording paper that is clean, white and permanent. It is capable of handling high writing speeds due to its low voltage and stylus pressure requirements.

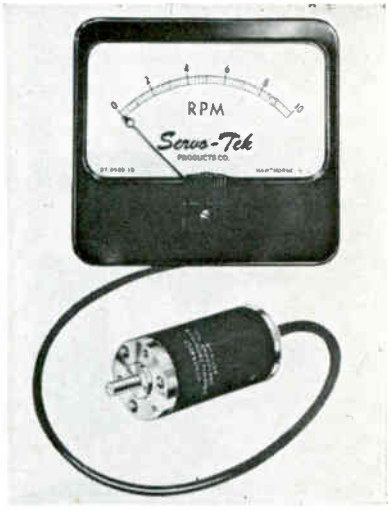
CIRCLE 309 ON READER SERVICE CARD

Switching Transistor

HIGH SPEED

SYLVANIA ELECTRIC PRODUCTS INC., Woburn, Mass. Type 2N1605A *npn* high speed germanium alloy switching transistor offers extra collector-to-base voltage (40 v max.) for h-v circuitry, low reverse leakage voltage (10 μa max.) at 40 v, maximum power dissipation of 200 mw at 25 C, and junction temperature ratings of — 65 C to + 100 C. It is designed in a TO-5 JEDEC package with base connected to metal case.

CIRCLE 310 ON READER SERVICE CARD



Tachometer

FOR VERY LOW SPEEDS

SERVO-TEK PRODUCTS CO., 1086 Goffle Road, Hawthorne, N. J. New tachometer indicates speeds of 10 rpm and lower without annoying pulsations and with an accuracy of better than 2 percent of full scale. System is self-powered with a low-torque d-c generator having virtually unlimited brush life. The 4½

in. panel-mounted meter is shielded to minimize the effects of surrounding magnetic materials such as steel panels. The entire package consists of indicator, tachometer generator, 15 ft of connecting cable and mounting and coupling accessories. Total price is $107, with delivery from stock.

CIRCLE 311 ON READER SERVICE CARD

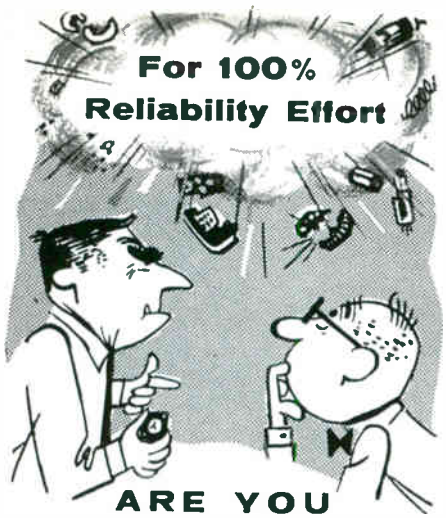
Extruded Tubing
POLYCARBONATE

ANCHOR PLASTICS CO., INC., 36-36 36th St., Long Island City 6, N. Y., has available extruded polycarbonate tubing. The new General Electric material trade-marked Lexan has been successfully extruded in diameters over 1 in. and with wall thicknesses over 0.100 in. Tubing diameters which can be ordered, range from 0.040 in. to 1½ in. and wall thicknesses from 0.015 in. to 0.125 in. Samples of previously extruded tubing are available to designers intending to use the new material. In addition to tubing, strips, small rods and profiles can also be extruded.

CIRCLE 312 ON READER SERVICE CARD

Tiny Relay
FOR P-C BOARD USE

FILTORS, INC., Port Washington, N. Y. The Pillbox is a microminiature relay made specially for use where high-density packaging is required; it is particularly applicable for use on printed circuit boards. It incorporates a completely new relay configuration in which the header has been rotated 90 degrees so that the relay terminals project from the side of the relay rather than the end as in other crystal case relays, permitting it to be mounted on the side with the greatest area. The Pillbox relay is smaller and lighter than standard



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MODEL WT-1 Actual Size

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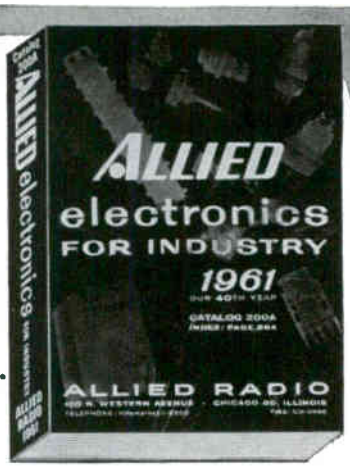

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Try this simple test. Tie a piece of Gudelace around a pencil in a half hitch and pull one end. Gudelace's flat, nonskid surface grips the pencil—no need for an extra finger to hold Gudelace in place while the knot is tied!

Gudelace makes lacing easier and faster, with no cut insulation, or fingers—no slips or rejects—and that's *real* economy. Gudelace is the original flat lacing tape. It's engineered to *stay* flat, distributing stress evenly over a wide area. The unique nonskid surface eliminates the too-tight pull that causes strangulation and cold flow. Gudelace is made of sturdy nylon mesh, combined with special microcrystalline wax, for outstanding strength, toughness, and stability.

Write for a free sample and test it yourself. See how Gudelace takes the slips—and the problems—out of lacing.

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CIRCLE 153 ON READER SERVICE CARD

microminiature relays with potted leads. It employs Filtors' improved Sensi-Tork relay motor.

CIRCLE 316 ON READER SERVICE CARD

Transducer Calibrator
SINGLE CHANNEL

B & F INSTRUMENTS, INC., 3644 North Lawrence St., Philadelphia 40, Pa., announces a versatile, inexpensive single channel portable strain gage transducer conditioner and power supply for use in field or laboratory. Model 110T will accept any resistance transducers and record on any galvanometer, millivolt recorder, or oscilloscope directly or through amplifiers. In the lab it may be used for calibrating transducers prior to installation in data acquisition systems or for single channel measurements. It may be used with 4, 6, 7 or 8 wire input cabling system, thus means are provided to cancel out cable losses. Shields are carried through to permit grounding at one point to eliminate ground loops. The instrument has available four steps of single and/or double shunt resistance calibration in both directions. Bridge voltage is Zener regulated 10 v, 0.1 percent, at 150 ma.

CIRCLE 317 ON READER SERVICE CARD

PNPN Semiconductors
SILICON DEVICES

SOLID STATE PRODUCTS, INC., One Pingree St., Salem, Mass., has extended its line of silicon Trigistors

to the 100 v range. The 3C100 and 3C100A employ all of the design features which have made the Trigistor so valuable in the design of four-layer logic and control circuitry. These features include: reliable operation at low logic levels (down to 1 ma); extremely high sensitivity with firing levels below 50 μa; cold-welded package with all leads isolated; and MIL-S-19500 capability. The new h-v Trigistors have been characterized to fulfill definite system needs and will offer design flexibility to the circuit engineer.

CIRCLE 318 ON READER SERVICE CARD

Trimmer Potentiometers
SUBMINIATURE

HANDLEY, INC., 12960 Panama St., Los Angeles 66, Calif. Model 540 WeeTrim subminiature trimmer potentiometer has demonstrated ability to stand up under 50 g's vibration, and 100 g's shock and acceleration, well above MIL-R-27208/4 specifications. Standard features include 2-w rating, operation to 200 C, and humidity proofing. Unit also excels in resolution, insulation and dielectric strength, and noise free operational life.

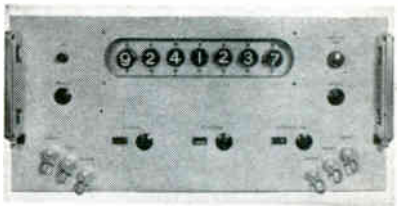
CIRCLE 319 ON READER SERVICE CARD

Current Source
BATTERY OPERATED

GYRA ELECTRONICS CORP., Washington & Elm Sts., La Grange, Ill. Model CS-51 current source is especially useful in any laboratory using

electrometers of any manufacture, where constant accuracy of the electrometer is of paramount importance. It is a portable, battery operated supply of current, which, when attached to the input of the electrometer, allows the user to check the accuracy of the ranges, heat damage to the resistors, and subsequent change in value, as well as a ready check of the entire circuit for accuracy. The current source has a ten step vernier current multiplier which varies the current from one to ten extending the maximum range to 1 x 10^{-6} amps.

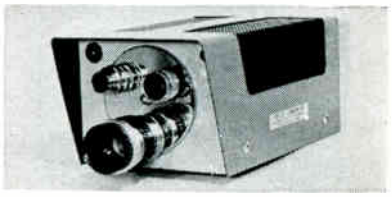
CIRCLE 320 ON READER SERVICE CARD



Counter-Timer
PROGRAMMABLE

SYSTRON-DONNER CORP., 950 Galindo St., Concord, Calif., has developed a solid state 10 Mc programmable counter-timer guaranteed to MIL Spec designed to meet rugged environmental conditions. Measurements include frequencies from 0 to 10 Mc and time intervals to 10 sec with an accuracy of 0.1 μsec. Designed for use as the basic measuring unit in automatic checkout consoles, this unit provides maximum reliability and insures minimum down time for critical missile checkout. Other Systron-Donner modules can be provided to make up a complete checkout system.

CIRCLE 321 ON READER SERVICE CARD

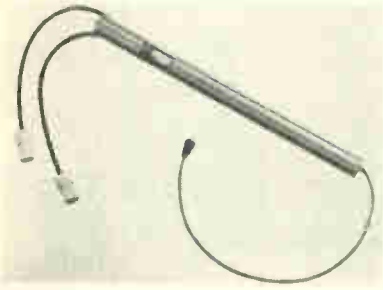


C-C Tv Camera
HIGH RESOLUTION

TELE-TRONICS CORP., 12786 Western Ave., Garden Grove, Calif., announces model 700 c-c tv camera, with the option of built-in sound channel for intercom and educa-

tional tv applications requiring crisp voice communication. It is priced at $1,295. Features include: low-noise cascode video input; 8-Mc video bandwidth amplifiers provide 600-line horizontal resolution; linear phase type aperture correction provides real "snap" to picture; automatic target sensitivity (exposure) control; interlacing sync generator; no-scan protection circuitry for Vidicon; totem-pole high-level video output, source termination; remote control of beam, target and focus.

CIRCLE 322 ON READER SERVICE CARD

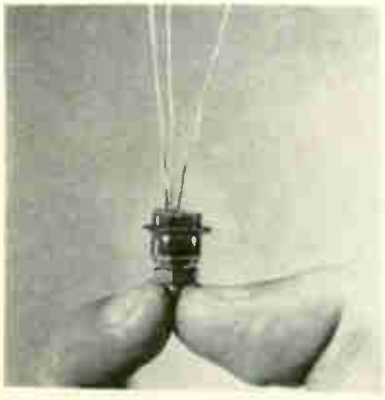


Low Noise TWT

SOLENOID FOCUSED

HUGGINS LABORATORIES, 999 East Arques Ave., Sunnyvale, Calif. The HA-76 low noise twt amplifier is solenoid focused and operates in the S-band at 2,300 to 2,900 Mc with a maximum noise figure of 6 db. Small-signal gain is 30 db minimum, and saturation power output is 0 dbm minimum. The HA-76, without solenoid, weighs 1½ lb and measures 1 in. in diameter and 22½ in. long.

CIRCLE 323 ON READER SERVICE CARD



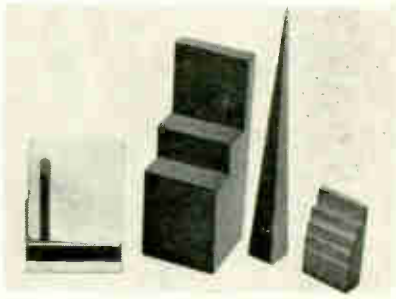
Transistors

MEDIUM-POWER

MINNEAPOLIS-HONEYWELL REGULATOR CO., 1015 Sixth St., South, Min-

neapolis 4, Minn., has introduced a line of miniaturized medium-power transistors. They feature high-frequency response and low leakage current characteristics and are said to remain stable over long periods while dissipating heat. The transistors are designed for use in switching operations, actuating motors, driving relays or for servo, audio and pulse amplifiers. Less than one-half inch in diameter, the units are stud-mounted in a cold-weld package with flexible leads. They are capable of dissipating 15 w at 25 C case temperature.

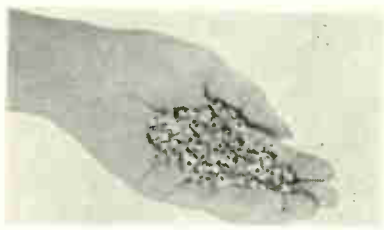
CIRCLE 324 ON READER SERVICE CARD



Microwave Absorber
HIGH TEMPERATURE

CUSTOM COMPONENTS, INC., Caldwell, N. J., has available a new microwave absorber capable of operation at temperatures up to 800 C with no detectable change in electrical or physical characteristics. The new permeable dielectric, CMA 701, has a dielectric constant of 50 at 20 Mc, and an attenuation of more than 38 db/cm at 8,200 Mc, and of more than 26 db/cm at 10,000 Mc. It has a density of 4.05. The material can be machined or molded into shapes suitable for waveguide termination, such as stock shape illustrated.

CIRCLE 325 ON READER SERVICE CARD

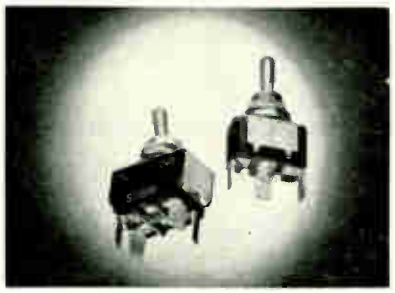


Servo Clamps
SOLID ALUMINUM

THETA INSTRUMENT CORP., 520 Victor St., Saddle Brook, N. J., is offer-

ing standard mounting hardware for synchros, servomotors and pots. Two clamp sizes, each anodized in a different color, may be used on a total of six different housing sizes to facilitate inventory problems. Each piece is machined from solid aluminum stock to provide greater strength under shock and vibration than conventional powdered metal and stamped construction. Prices: 19 cents each in quantities of 100; 15 cents each, quantities of 500; 10 cents each, quantities of 1,000.

CIRCLE 326 ON READER SERVICE CARD



Toggle Switches
WITH TAB TERMINALS

KULKA ELECTRIC CORP., 633 So. Fulton Ave., Mt. Vernon, N. Y., announces a complete line of s-p and d-p, aircraft-type toggle switches having ¼ in. wide male tab connections for use with Burndy, AMP, or Kent female connectors. The single and double throw switches meet all applicable military specifications. They are available in all circuit configurations including momentary on/off modes. The switches are designed for either d-c or a-c applications up to 1,600 cycles. The company's barrier design is employed between all connections for longer leakage paths and minimum chance of direct contact short circuits. The new tab connections are made of brass, electro-tinned to prevent corrosion. Switches are supplied with mounting nuts and sleeve lock-washer.

CIRCLE 327 ON READER SERVICE CARD

Spectrum Analyzer
HIGH-SPEED

FEDERAL SCIENTIFIC CORP., 615 W. 131st St., New York 27, N. Y., announces Simoramic spectrum analyzer model 53. This high-speed fine-resolution analyzer operates in real time, and simultaneously cov-

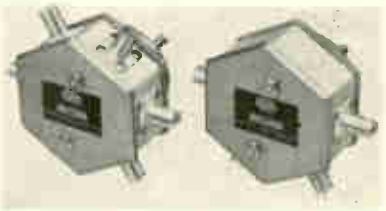
ers any specified 3-Kc wide band without the use of contiguous filters. It has a 3-db resolution of 7 cps and a 40-db bandwidth of 70 cps. Other selectivity characteristics can be provided. All the frequency components of the input signal within the specified 3-Kc band are displayed with 7-cps resolution every 200 milliseconds. Company says the model 53 is at least 430 times faster in operation than a heterodyne-type frequency analyzer of comparable selectivity and coverage. A complete frequency spectrum of the input signal is displayed on a 5-in. oscilloscope every $\frac{1}{3}$ sec.

CIRCLE 328 ON READER SERVICE CARD

Pulse Generator
HIGH CURRENT

E-H RESEARCH LABORATORIES, INC., 163 Adeline St., Oakland 20, Calif. Model 121 is a high current pulser delivering a 50 v pulse into 50 ohms, either polarity. Rise and fall times are less than 5 nanoseconds. Widths are variable from 10 μsec to 200 μsec. Repetition rate from 10 cps to 10 Mc. It is ideal for ferrite and magnetic switching studies, applications in high speed transistor and diode switching, and the design of logic and memory circuits.

CIRCLE 329 ON READER SERVICE CARD

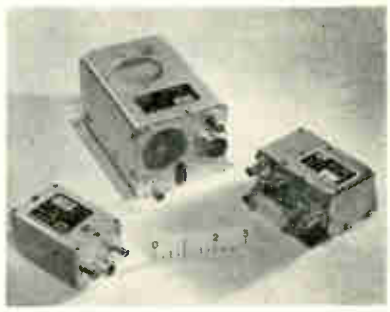


Coax Switches
BNC TYPE CONNECTOR

BARKER & WILLIAMSON, INC., Bristol, Pa. The company's multiposition coax switches are now offered with BNC type connectors. Model 560 is a single pole, 5 position switch and provides contacts for switching

to any one of five separate units such as transmitter, antenna, etc., and handles up to 350 v rms. The 561 is a double-pole, 2-position unit for rapidly cutting equipment in and out of series connection in coaxial lines. Both are designed for 52 or 75 ohm coaxial lines. Maximum cross talk—isolation between adjacent connectors—more than 48 db at 30 Mc. Size across terminals is 4 in., and from front to back, including shaft, 3⅛ in.

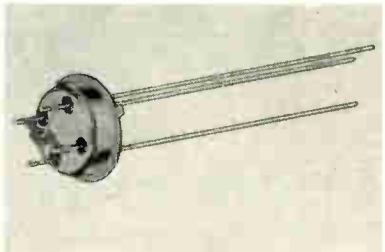
CIRCLE 330 ON READER SERVICE CARD



Power Amplifiers
FLIGHT PROVEN

UNITED ELECTRODYNAMICS, INC., 200 Allendale Road, Pasadena, Calif., features a complete family line of flight proven r-f power amplifiers for use in the 215 to 260 Mc telemetry frequency range. They are doing service in the missile and space programs. Output power of 10 w to 100 w may be obtained with 2-w r-f drive. Model PA-10 features a nominal 10-w output and is the smallest and lightest of the amplifiers. Model PA-11 has 10 to 25 w output with no cooling required. Model PA-14 has a self-contained blower for 100-w operation.

CIRCLE 331 ON READER SERVICE CARD

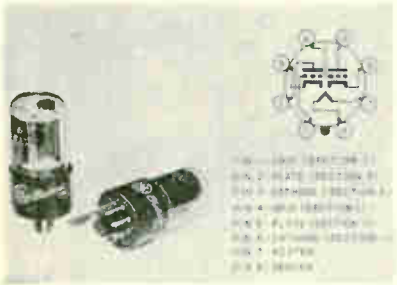


Silicon Transistors
TWO *PNP* TYPES

CRYSTALONICS, INC., 249 Fifth St., Cambridge, Mass., announces two new *pnp* silicon transistors designed for d-c amplifier use at

collector currents of 10 μa. Both have a maximum guaranteed I_{co} of 1 nanoampere. Types C118 and C119 have current gains of 15 and 25 respectively at 10 μa collector currents. Both units are available from stock.

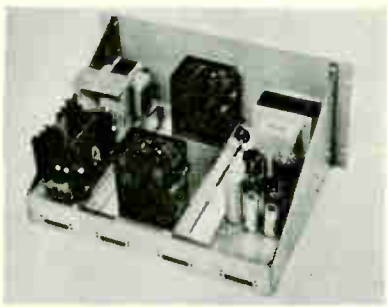
CIRCLE 332 ON READER SERVICE CARD



Double Triode Tube
FOR TV RECEIVERS

GENERAL ELECTRIC CO., Owensboro, Ky. The 6EA7 is a new low-high plate dissipation double triode tube for vertical-deflection oscillator and amplifier applications in tv receivers. Tube contains both a high-mu triode (section one) and a low-mu, high-perveance triode (section two). It is an octal "GT" type. Section one has a design maximum rating of 350 plate volts with peak negative grid voltage of 400 and plate dissipation of 1.0 w. Section two, with a design maximum plate voltage rating of 550 v d-c, is rated at 10 w plate dissipation and 175 ma of peak cathode current.

CIRCLE 333 ON READER SERVICE CARD



Power Supplies
FOUR MODULAR TYPES

DRESSEN-BARNES CORP., 250 North Vinedo Ave., Pasadena, Calif., announces four new modular power supplies which are completely transistorized and packaged to make components accessible for replacement. New split-chassis design provides adequate self-dissipation of

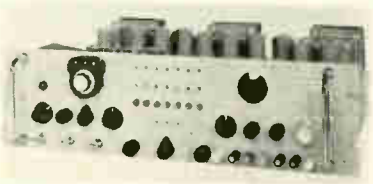
heat. All units are short-circuit protected. A voltage range control and fuse are completely accessible from the top of the package. The four new modules are rated: 0.5 to 30 v at 100 ma, 25 to 55v at 90 ma, 50 to 80 v at 85 ma, and 75 to 100v at 75 ma. Modules may be connected in series for higher output voltage by obtaining instructions from factory.

CIRCLE 334 ON READER SERVICE CARD

Push Button Switches
SNAP ACTION

TRUCO ENGINEERING CO., 289 Fairfield Ave., Hartford, 6, Conn., offers a new design in snap action push button switches. They are available in both illuminated and non-illuminated versions. Of one piece construction they are available in either momentary or alternate action configurations. This design eliminates the need for external accessories. The mounting arrangement allows unusually rigid mounting in virtually any panel thickness. Available configurations include 1 or 2 spdt switches with ratings of 5 amperes at 220 v a-c and 0.25 ampere at 220 v d-c. All switches are rated at one million operations. Prices range from $7.55 to $9 in unit quantities.

CIRCLE 335 ON READER SERVICE CARD

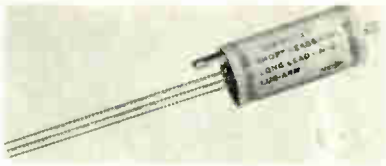


Signal Simulator
RUGGED AND COMPACT

TELEMETRICS, INC., 12927 S. Budlong Ave., Gardena, Calif. An electronic signal simulator, producing precise pam, pdm, or pam/nrz pulse trains for calibration and checkout of telemetry ground station, is announced. Model ESS-204

features a continuously variable pulse rate from 20 to 7,000 pps, programmable signal levels, zero and full scale pulses anywhere within the frames, and provision for application of noise to the pedestal and information levels of the wave train. The simulator offers excellent linearity—within 0.15 percent of full scale; and stability in output (pam) and pulse width (pdm) within 0.15 percent of full scale for 12 hr after 45 minutes warmup. It employs standard plug-in digital logic units, facilitating maintenance or replacement.

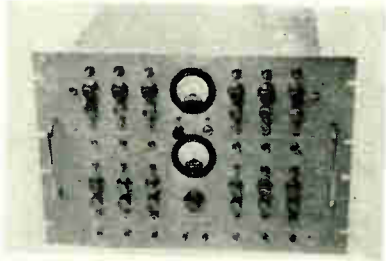
CIRCLE 336 ON READER SERVICE CARD



Tubular Relay
HANDY SHAPE

WHEELOCK SIGNALS, INC., Long Branch, N. J. High vibration and shock immunity is predominant in series 123 tubular relay. The relay also features exceptional switching capacity and contact life; low coil power; and small size, handy shape, and simplified mounting. It has been approved for and is used in missiles. Its construction lends itself to in-line chassis mounting for printed circuits or conventional clamping or encapsulation where high shock and vibration are encountered. Ambient temperature: −65 to 85 C. Mechanical life: 200 million operations.

CIRCLE 337 ON READER SERVICE CARD



Bridge Balance
AND CALIBRATOR

B & F INSTRUMENTS, INC., 3644 N. Lawrence St., Philadelphia 40, Pa. A new input conditioning (bridge balance and calibrating) module for feeding oscillographs directly or

TAPCO ELECTRICAL POWER COMPONENTS

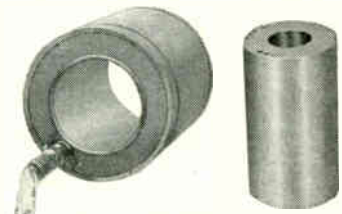
TAPCO Group primary and auxiliary electrical power systems for space, missile, aircraft and ground power applications are tried and proven. Systems performed under environmental conditions including nuclear radiation, high-temperature, liquid metal vapor, zero-G and vacuum.

Below are typical TAPCO components now available for integration into systems for such applications. Other available TAPCO electrical power components include tachometer generators, speed sensors, high temperature electromagnets and solenoids, nuclear reactor rod drive controls, static inverters, voltage regulators and electronic power conversion devices.

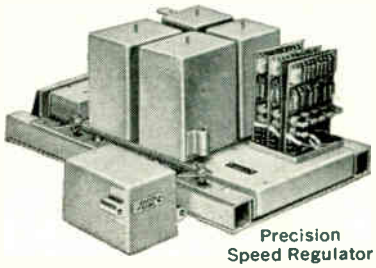
ALTERNATORS

Among the special purpose rotating machines designed by TAPCO is a series of high temperature alternators. These range in capacity from a few watts to 15 kw at temperatures up to 1000°F.

PERFORMANCE DATA: TYPICAL ALTERNATOR—**Power Rating:** 3 kw, 0.8 pf lagging. **Ambient Temp.:** 700°F. max. **Operating Speed:** 40,000 rpm. **Output:** 115v, 2000 cps. **Inherent Voltage Regulation:** ±5%. **Harmonic Content:** 5% total. **Efficiency:** 85%. **Weight:** 9 lbs w/o shaft and bearings. **Size:** 3⅜" OD, 5⅛" long. **Special Conditions:** Operates in mercury vapor.



High Temperature
Permanent Magnet Alternator



Precision
Speed Regulator

VOLTAGE REGULATION AND SPEED CONTROLS

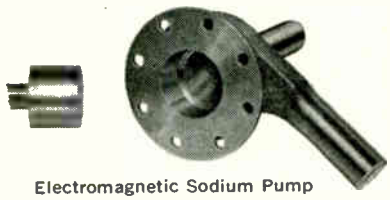
Associated with the TAPCO alternator and drive systems are system speed and voltage controls for extremely accurate frequency and voltage regulation. The unit shown is adaptable to many drive systems.

PERFORMANCE DATA: TYPICAL SPEED REGULATOR: **Frequency Stability:** 1 part in 100,000 integrated over minimum 1 hour period. **Input:** 115v, 400 cps. **Output:** 0-10v, 400 cps (phase reversing). **Feedback:** Valve position 0-57.5v, 400 cps. **Environmental Conditions:** —65 to +200°F, 50g shock for 11 millisec., vibration 0.1" double amplitude from 3 to 23 cps, 10g from 23 cps to 10 kc. **Weight:** 10 lbs. **Size:** 12" x 6" x 5".

LIQUID METAL PUMPS

A rotating permanent magnet driven by an external source induces pumping force in the liquid metal within a hermetically sealed system. This concept provides operation without friction-producing rotating seals and provides exceptional reliability and life.

PERFORMANCE DATA: TYPICAL ELECTROMAGNETIC PUMP—**Fluid:** Sodium. **Fluid Temperature:** 1000°F. **Capacity:** 20 lbs/min. **Driving Speed:** 40,000 rpm. **Pressure Rise:** 3 psi. **Weight:** 3 lbs. **Size:** 2¾" diam. flange bolt circle, ½" nominal pipe size.



Electromagnetic Sodium Pump

Tapco Group Export Representative:
American Avitron Inc. • Mamaroneck, N. Y.

Advanced engineering projects at TAPCO offer excellent career opportunities for qualified engineers and scientists. Write Personnel Director.

TRW

TAPCO GROUP
Thompson Ramo Wooldridge Inc.
DEPT. EL-1160 • CLEVELAND 17, OHIO

DESIGNERS AND MANUFACTURERS FOR THE AIRCRAFT, MISSILE AND SPACE, ORDNANCE, ELECTRONIC AND NUCLEAR INDUSTRIES

CIRCLE 167 ON READER SERVICE CARD 167

front ends of data acquisition systems has been announced. Model 12-200BX will accommodate 12 resistance type transducers, 1, 2, or 4 active arms, employing 3, 5, 4, or 6 wire input techniques thus providing for the cancellation of cable temperature effect. Sensitivity losses due to cable length are calibrated out. Unit will feed sensitive oscillograph galvanometers directly, or high frequency oscillograph galvanometers and voltage controlled oscillators via single ended or differential amplifiers.

CIRCLE 338 ON READER SERVICE CARD

Plug-In Converter
FREQUENCY TO D-C

ANADEX INSTRUMENTS, INC., 14734 Arminta St., Van Nuys, Calif., announces a new plug-in module frequency to d-c converter for flowmeters, tachometers, and other frequency measuring applications. Model PI-400 pulse rate integrator furnishes a low impedance d-c output voltage and current precisely proportional to the frequency or pulse rate of the input. In addition it provides a visual meter indication of input frequency and a pulse output for operating counters and recorders. It is designed for use in the fields of ground support test equipment, engine test stands, control applications, and other types of instrumentation where precision analog forms of frequencies and pulse rates are required.

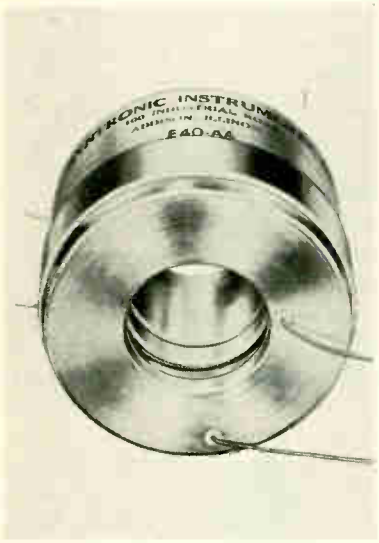
CIRCLE 339 ON READER SERVICE CARD

Silicon Rectifiers
MODULAR TYPE

SARKES TARZIAN, INC., Bloomington, Ind., announces three series of modular silicon rectifiers—S-5536

through S-5541, S-5544 through S-5549, and S-5462 through S-5467. The rectifiers are designed for use individually—as open bridges—or in a variety of circuit combinations, and are designed for printed circuits or terminal strips. The S-5536-41 series is primarily for use as voltage doubler or center tap; S-5544-49, for connections into 3 phase half wave, or 2 modules into 3 or 6 phase connections; and, S-5462-67 for use as open bridge for magnetic amplifiers or connected into bridge, and also as half wave sections—individual, series or parallel. Units are compact, rugged, and easy to assemble. Prices range from $2.05 to $6.50 in sample quantities.

CIRCLE 340 ON READER SERVICE CARD

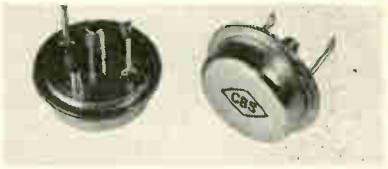


Dynamic Focus Coil
FOR LARGE ANGLE CRT'S

SYNTRONIC INSTRUMENTS, INC., 100 Industrial Road, Addison, Ill., offers a new dynamic focus coil which provides exceptionally sharp overall focusing for 1½ in. neck diameter flat faced large angle cathode ray tubes. Type F40 is engineered for high resolution applications such as 1,000 line tv, radar and advanced photo displays. Optimum alignment results from combining static and dynamic coils into a single unit. Increased efficiency at high frequencies is obtained by new core material and design. Circuits can be simplified and power saved because double gap design isolates the coils from each other. Efficient heat dissipation permits using unit up to 25

Kv accelerating potential. Both static and dynamic coil portions of the unit are available in a wide range of impedances.

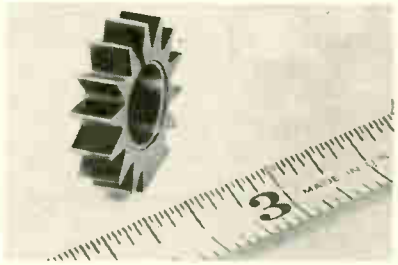
CIRCLE 341 ON READER SERVICE CARD



Power Transistor
SAVES SPACE, WEIGHT

CBS ELECTRONICS, 100 Endicott St., Danvers, Mass. A single new 85-w *pnp* power transistor saves space and weight and reduces costs by replacing two 40-w or four 20-w paralleled transistors. These high-power transistors (nine types) can provide 30 w Class A, 100 w Class B, or 1,000 w switching. Collector voltages up to 100 v are available. A large signal current gain of 70 at 5 amperes collector current can be achieved. Maximum working current of 15 amperes is permissible for all types. The emitter has a low-distortion ring construction. All of the new transistors are hermetically sealed in the welded JEDEC TO-36 male industrial case.

CIRCLE 342 ON READER SERVICE CARD



Transistor Radiator
FOR TO-8 PACKAGES

THE BIRTCHER CORP., 745 S. Monterey Pass Road, Monterey Park, Calif., has developed a radiator to reduce heat and permit up to 25 percent more efficient operation of all transistors having TO-8 packages. The model 3AL-705 is designed for horizontal or vertical mounting on p-c boards or metal chassis. When mounted vertically on the board the unit also serves as a retainer for the transistor. Vertical mounting is accomplished by means of a 6-32 tapped hole in the

base of the radiator. Overall dimensions are 1 in. maximum diameter by 0.312 in. thickness. Inside diameter is 0.480 in. with a counterbore for the transistor base 0.078 in. deep and 0.609 minimum to 0.619 maximum in diameter. Material is aluminum and finish is black anodize per MIL-A-8625.

CIRCLE 343 ON READER SERVICE CARD

Beacon Transmitter
TRANSISTORIZED

GENERAL ANTRONICS CORP., 9036 Culver Blvd., Culver City, Calif., announces the model BT 201 uhf-vhf transistor beacon transmitter. It measures 5⅜ in. by 3⅛ in. by 1¼ in. including self contained mercury batteries. The transmitter and batteries weigh 1 lb 12 oz. Power output is 250 mw at either 121.5 Mc or 243 Mc, and the battery life is 20 hr. Either frequency is available upon order. Crystal control is used to maintain the chosen frequency. The transmitter is modulated class A2 by a 1,400 cycle tone, approximately 3 pulses per sec. It is designed for extreme conditions of shock, vibration, and temperature.

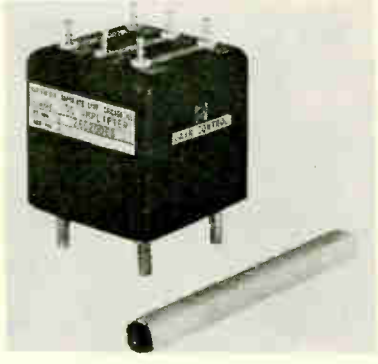
CIRCLE 344 ON READER SERVICE CARD

Insertion Tool
FOR TAPER PINS

AMP INC., Harrisburg, Pa., has developed a tool for inserting both

its formed and solid taper pins into shielded patchcord programming systems and panels. A single push to insert, and then a single pull on the tool's pull test handle, will properly seat and inspect the taper pin insertion. The insertion spring of the tool is calibrated at 18-20 lb. When this insertion pressure is reached, the spring will "give", and a dished washer will be actuated which will make a very positive audible click. The pin is then seated. The pull test device on the tool, which may be used as a standard tool for patchcord programming systems, is calibrated at 6¼ lb. This poundage is achieved as soon as the pull test handle starts to be displaced from its normal position. Price of the tool is $26.

CIRCLE 345 ON READER SERVICE CARD



D-C Amplifier

COMPLETELY STATIC

VAPOR HEATING CORP., 6420 West Howard St., Chicago 48, Ill., announces a new d-c amplifier for either temperature control or pressure control applications. This compact, completely static amplifier can be used with either a temperature pickup, pressure pickup, or potentiometer—anywhere amplification of low level signals is required. The unit can be used also as a relay driver; its parameters are easily adjusted to provide essentially bistable action. In this configuration, a relay can be energized with a signal voltage change of 1 mv.

CIRCLE 346 ON READER SERVICE CARD

Program Board

WITH GOLD CONTACTS

SEALECTRO CORP., 610 Fayette Ave., Mamaroneck, N. Y. The Sealectoboard is now available with gold-

plated contact strips to meet the needs of specialized applications requiring extremely low contact resistance over long periods of time. It is a cordless program board that offers the added versatility of component interposition. It is offered in all configurations with virtually unlimited X- and Y-axis functions. The standard Sealectoboard incorporates silver-plated contacts for the usual requirements. The new gold-plated version is ideal for use in installations handling extremely small electrical flows, such as thermocouple programming, in which cases the gold-plating assures corrosion free, low contact resistance connections.

CIRCLE 347 ON READER SERVICE CARD

Computing Resolvers
HIGHLY ACCURATE

VERNITRON CORP., 123 Old Country Road, Carle Place, L. I., N. Y., has available 0.05 percent accuracy computing resolvers with non-bifilar compensating winding capable of withstanding 500 v d-c between stator and compensator for 1,000 hours, and equal accuracy units with bifilar compensating windings. In 23, 15, and 11 frame sizes, the resolvers have an inter-axis error of ±2½ minutes. All units are designed and manufactured to MIL R-14346 specifications.

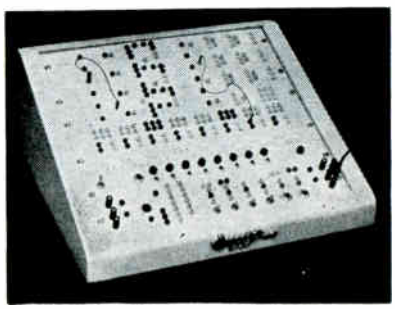
CIRCLE 348 ON READER SERVICE CARD

Solderless Terminals
ONE-PIECE CONSTRUCTION

MALCO MFG. CO., 4025 W. Lake St., Chicago 24, Ill., has available a line of solderless terminals designed for

fast, easy and stable wire connections. Smooth funneled mouth gathers frayed wire leads. Multiple V-notches in the barrel insure positive contact and exceptional holding power. A ¼-in. long shank facilitates wire location when crimping and provides a large crimping area for permanent, vibration-free, moisture-proof connections. The terminals are of strong, one-piece construction and are made of pure soft copper, electro-tin plated for maximum corrosion resistance. Load carrying capacity is greater than that of the wire itself. Types and styles are available for all popular applications and are stocked in 22-16, 16-14 and 12-10 wire ranges.

CIRCLE 349 ON READER SERVICE CARD



Logic Trainer

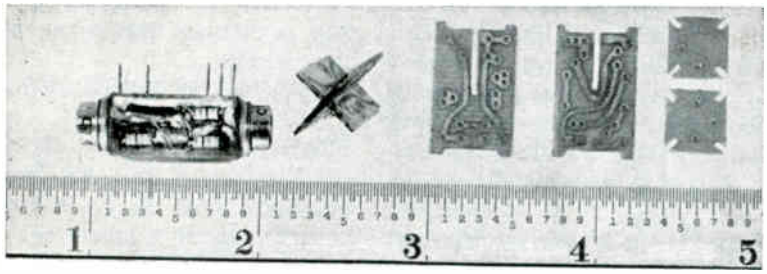
VERSATILE UNIT

EPSCO, INC., 275 Massachusetts Ave., Cambridge 39, Mass. The TDC digital logic trainer is a versatile, easy-to-use instruction and demonstration tool designed for training in digital circuit operation, logic design bread-boarding and testing digital circuits. The trainer effectively demonstrates basic circuit operation, as well as effects of loading and timing on circuit and network performance. The coupling of various circuit types for control, storage, timing, and logic can be easily understood. The front panel contains 50 prewired S100 digital circuits, with logic symbols for each clearly identifying input-output connections and their function. All connections may be made on a large patchboard front panel with pin jack jumpers. Input-output jacks are color coded for direct observation of terminal function. Circuits, switches, and controls are clearly marked for instruction in use of the trainer.

CIRCLE 350 ON READER SERVICE CARD

ANSLEY MINI-MODULE

U. S. Patent #2,958,013



SUB-MINIATURIZATION with
Standard "off the shelf" Components
Proven Printed Circuit Techniques
Accepted MIL Spec Materials

The *Mini-Module* is a small edition of the *PLUS Module* and its ruggedized version the *Missile Module*. It offers maximum circuit board area in a given space; a rigid self-supporting column formed of interlocking printed wiring boards. We will be glad to help in packaging your circuit into *PLUS Module* form. Ask us for details.

ANSLEY also offers a
COMPLETELY INTEGRATED PRINTED CIRCUIT SERVICE . . .
DESIGN • PRODUCTION • ASSEMBLY

Send for our FREE Booklet: *Value Analysis of Printed Circuits.*

ARTHUR ANSLEY MFG. CO. **AXtel 7-2711** **New Hope, Pa.**

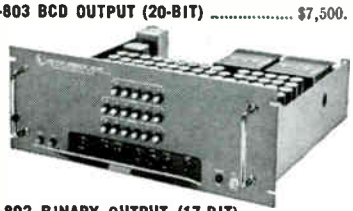
CIRCLE 207 ON READER SERVICE CARD

TIME TEAM

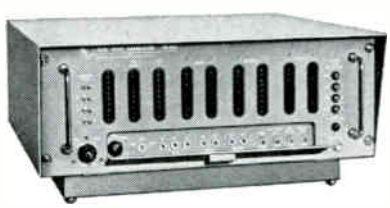
HOW EECo'S ALL-STAR LINEUP OF TIME CODE GENERATORS WINS ON EVERY POINT

Look at these unparalleled advantages offered by EECo Time Code Generators! Frequency stability, 3 parts in 10^8, based on extremely stable crystal oscillator. 100% plug-in circuits to keep generator working for you day in and day out. Emitter-follower low-impedance outputs for long-distance transmission. Wider operating-temperature stability. Operable from aircraft power. Provision for external frequency standard. Human-engineered. Check it all out and you must choose EECo!

ZA-801 BCD OUTPUT (24-BIT)
Time-of-day code output (24-hour recycling) and any 2 of 8 pulse rates. $7,500.
ZA-803 BCD OUTPUT (20-BIT) ..... $7,500.



ZA-802 BINARY OUTPUT (17-BIT)
Time-of-day code output (24-hour recycling) and any 2 of 8 pulse rates. $7,000.



ZA-810 100 PPS CODE (36-BIT)
ZA-810-M1 IRIG TYPE C (23-BIT 2-PPS CODE)
Day-of-year plus time-of-day. Proposed Inter-Range Instrumentation Group formats. ZA-810 used by NBS on WWV. Either model, $10,100.

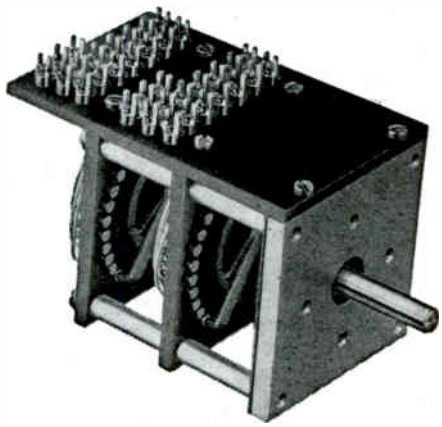
SEND FOR TIME CODE GENERATOR FILE 301

Electronic Engineering Company *of California*
1601 East Chestnut Avenue • Santa Ana, California • Kimberly 7-5501 • TWX: S ANA 5263

EE O-14

CIRCLE 230 ON READER SERVICE CARD

RUGGED
BUT PRECISE



CINEMA

INSTRUMENT SWITCHES

- ★ Long Life
- ★ Rugged Construction
- ★ Low Circuit Resistance
- ★ Meet Military Specifications

Cinema Engineering offers a complete range of instrument switches to meet practically every application and all the requirements of critical circuitry and precision performance.

Switches feature contacts of one homogenous material to provide minimum EMF and to insure positive metal-to-metal wiping contact and continuous low electrical resistance for long-life operation. Advanced engineering and construction techniques provide permanent precision alignment and elimination of field failures. Available in 1 to 8 deck styles for operation up to 100KC and for all DC circuits. 2 to 16 decks are available on a single shaft through the use of a unique Cinema precision gear drive.

Choice of Contact Arrangement—shorting (make-before-break) or non-shorting (break-before-make); Contact Material — solid nickel silver or Coin Silver for lower switch circuit resistance; Deck Material — fine linen base phenolic or glass epoxy for extremely high insulation resistance.

Write for your free copy of our all-new Precision Switch Catalog.

CINEMA ENGINEERING
DIVISION AEROVOX CORPORATION
1100 Chestnut, Burbank, California

CIRCLE 177 ON READER SERVICE CARD

Literature of the Week

DIGITAL VOLTMETER Cubic Corp., 5575 Kearny Villa Road, San Diego 11, Calif. A recent catalog sheet contains features and specifications for the four-digit V-45 digital voltmeter, a fully transistorized, accurate, economically priced unit.

CIRCLE 351 ON READER SERVICE CARD

SILICON TRANSISTORS Sperry Semiconductor Division, Sperry Rand Corp., Norwalk, Conn., has released a specification sheet covering the electrical and physical characteristics of a series of silicon *pnp* alloy junction transistors.

CIRCLE 352 ON READER SERVICE CARD

FREQUENCY COMPARISONS Tektronix, Inc., P. O. Box 500, Beaverton, Ore. A 4-page pamphlet gives a detailed presentation of high-ratio frequency comparisons using roulette patterns on the crt of Tektronix types 502, 503, and 536 oscilloscopes.

CIRCLE 353 ON READER SERVICE CARD

VHF FREQUENCY METER Gertsch Products, Inc., 3211 South La Cienega Blvd., Los Angeles 16, Calif. Two-color data sheet describes a continuously variable frequency meter designed to measure and generate over a frequency range from 20 to 1,000 Mc, with guaranteed accuracy of 0.0001 percent.

CIRCLE 354 ON READER SERVICE CARD

HIGH-VOLTAGE PENTODE The Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio. A four-page bulletin is illustrated with cutaway section of the type 7683 high-voltage pentode, gives dimensional and schematic data, and illustrates typical circuits in which the pentode can be used as a series regulator or as a shunt regulator.

CIRCLE 355 ON READER SERVICE CARD

LOGIC TRAINER Epsco, Inc., 275 Massachusetts Ave., Cambridge 39, Mass., offers a four-page brochure and instruction booklet on a unique new, self-contained logic trainer for training in digital circuitry and logic. The trainer described can be used in classroom or laboratory for studying basic, as well as complex operations of various circuits.

CIRCLE 356 ON READER SERVICE CARD

STANDARD BRIDGE Mid-Eastern Electronics, Inc., 32 Commerce St., Springfield, N. J. A two-page bulletin describes model 801 standard bridge which extends the range of accurate resistance measurement to 10^{14} ohms. Description includes bridge accuracy plotted against test potential up to 1,000 v, physical and electrical data, price and delivery.

CIRCLE 357 ON READER SERVICE CARD

SUBMINIATURE MOTOR The A. W. Haydon Co., 232 North Elm St., Waterbury, Conn. Technical Bulletin AWH MO-809 describes the series 14100 subminiature reversible d-c motor.

CIRCLE 358 ON READER SERVICE CARD

VARIABLE DELAY NETWORKS ESC Electronics Corp., 534 Bergen Blvd., Palisades Park, N. J., has published a bulletin describing the series 700 miniature variable delay networks designed for printed circuit mounting.

CIRCLE 359 ON READER SERVICE CARD

CONDUCTIVITY MONITORS Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa. Four-page data sheet E-95(3) describes two new transistorized, continuous indicating conductivity monitors.

CIRCLE 360 ON READER SERVICE CARD

THERMAL SWITCHES Control Products, Inc., 280 Ridgedale Ave., Hanover, N. J., has prepared an eight-page brochure describing eleven bimetal thermal switches.

CIRCLE 361 ON READER SERVICE CARD

SEMICONDUCTORS International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif., has published an up-to-date 24-page catalog covering over 800 semiconductor devices. Also included is a comprehensive listing of JEDEC rectifier types, with cross reference to device classification, rating and page number. Copies should be requested on a company letterhead only.

Go Ahead, TRIM SQUARE

Trimmers shown actual size

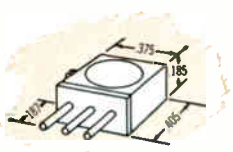
with NEW

SPECTROL

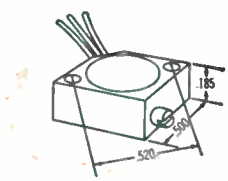
Trimming Potentiometers

- SIZE
- PERFORMANCE
- RELIABILITY
- ECONOMY

SIZE



THE MODEL 50
3/8" square, 3/16" high, and weighing 1 gram, the Model 50 is available in standard resistances of 50 ohms to 20K ohms.



THE MODEL 60
1/2" square, 3/16" high, and weighing 2 grams, the Model 60 is available in standard resistances of 50 ohms to 50K ohms.

PERFORMANCE

Stack 'em . . . up to 35 Model 50 trimmers in one cubic inch. Adjust 'em, 25 turns for full electrical travel . . . take your choice of side or top adjustment, slotted fillister head screw, Allen hex socket, or slotted headless screw flush mounted. Dissipates 1 watt—Model 50 and 2 watts—Model 60. Dual wiper provides double assurance of positive contact under all conditions. High resolution, typically 0.061% for the 50K ohms model. Resistance tolerance, ±5%, temperature range, −55 to +150° C.

RELIABILITY

At no extra cost, Spectrol trimmer potentiometers meet or exceed all applicable military specifications for altitude, fungus resistance, salt spray, sand and dust, humidity, temperature cycling, shock and vibration. Guaranteed load life, 1000 hours minimum.

ECONOMY

Prices in 1-9 quantities: Model 50—$7.50 each, Model 60—$6.50 each. Spectrol trimmers are ready now for immediate delivery from your local distributor. For complete technical information, call your Spectrol representative or write Dept. 42.

SPECTROL ELECTRONICS CORPORATION

1704 South Del Mar Ave. • San Gabriel, California
ATlantic 7-9761 • CUmberland 3-5141
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28

CIRCLE 179 ON READER SERVICE CARD 179

Sylvania Building Tube R&D Center

SYLVANIA ELECTRIC PRODUCTS INC., a subsidiary of General Telephone & Electronics Corp., has begun construction of a new electron tube research and development center in Emporium, Pa.

Matthew D. Burns, president of Sylvania Electronic Tubes, a major division of the company, said research and engineering activities are being intensified "because we have evidence that tube uniformity and reliability can be increased twofold by the imaginative use of new materials and new designs."

First stage of the R&D construction program is a 42,000-sq-ft facility to house research activities on "Sarong" cathode coating and various types of "stacked-tubes", Burns said. A portion of the new structure also will be made available for the division's chemical development research, currently performed in three separate buildings in Emporium.

Sylvania's "Sarong" is a cathode in which the electron-emitting materials are in the form of a skin-tight film wrapped around the tube cathode. In conventional tube manufacture, cathode coating is sprayed on in liquid form. The "stacked-tube", introduced by Sylvania in 1954, employs a "planar" or sandwich-type mount structure where elements are stacked one upon the other. In conventional tubes, the elements are built around a common axis. Both developments assure more stable tube characteristics and longer tube life, Burns said.

Occupancy of the new facility is scheduled for mid-1961. Additional buildings, still in the planning stage, are scheduled for completion in 1963.

Kramer Assumes New Position

EMERSON RADIO & PHONOGRAPH CORP., Jersey City, N. J., recently announced that Herbert Kramer has joined its technical products division as chief of industrial engineering.

Kramer's most recent position was that of chief of industrial engineering, ultrasonics, for Acoustica Associates.

Joseph Hicks Joins Beckman & Whitley

JOSEPH J. HICKS has joined the instrument division of Beckman & Whitley, Inc., San Carlos, Calif., as engineering manager. In this post he will have charge of all engineering, including administration, management, and development of new products for the two product-line departments of the division. These include high-speed photo instrumentation and accessories as well as meteorological sensors and systems.

Prior to this appointment, Hicks served as a control-system specialist with Aerojet-General Corp.

Gulton Industries Fills Two Key Posts

GULTON INDUSTRIES, INC., Metuchen, N. J., has appointed Daniel S. Schwartz as senior research physicist of the company's research and development division, and Aaron Waldman as supervisor of the instrumentation division's electromechanical group. Schwartz and Waldman were both formerly senior project engineers with the Kearfott Division of General Precision, Inc., Clifton, N. J.

Thermosen Appoints General Manager

NATHAN H. MAGIDA has been named general manager of Thermosen, Inc., Stamford, Conn. The company is presently engaged in the manufacture of emission limited diodes as well as other special types of vacuum tubes.

Prior to joining Thermosen, Inc., Magida was marketing manager for industrial products for Consolidated Avionics Corp., Westbury, N. Y.

Rheem Semiconductor Names E. J. Quirk

EDWARD J. QUIRK has been appointed works manager at Rheem Semiconductor Corp., Mountain View, Calif. He will direct manufacturing, manufacturing services and quality control and the man-

agers of these departments will report directly to him. These three departments comprise some ⅔ of Rheem's 800 employees.

Prior to joining Rheem, Quirk was plant manager in charge of manufacturing and engineering at the CBS-Hytron, Lowell, Mass., plant.

Keystone Electronics Elects President

THE KEYSTONE ELECTRONICS CO., INC., Newark, N. J., manufacturer of crystal ovens, crystal filters and discriminators, and quartz crystals, recently elected Adolph M. Gross to the office of president. He is also treasurer and a director of the company.

Since 1956, Gross has been president of Electronic Enterprises, Inc., a subsidiary of Keystone, and vice president of Keystone.

Davison Joins ITT Division

WALTER C. DAVISON has been named product manager of closed circuit television systems at the industrial products division of International Telephone and Telegraph Corp., San Fernando, Calif.

He joins the division after heading his own management consultant firm for four years.

Victory Engineering Plans New Plant

A MODERN 43,000 sq ft executive offices and research laboratory building will be constructed for Victory Engineering Corp. of Union, N. J., on a five-acre site in Springfield, N. J.

New factory will facilitate production of thermistors, varistors and other electronic products now manufactured by Victory in the Union plant.

Lockheed Electronics Advances Basarab

JOHN BASARAB, JR., who joined Lockheed Electronics Co., Plainfield, N. J., four years ago as a design engineer, has been named supervisor engineer in the company's shipboard electronics department, military systems division.

He assume engineering responsibility for some of the division's major Navy contracts, including those concerned with the Regulus guidance system, gunfire control systems, and various radar equipments.

Dynamic Science Corp. Has New Facilities

MARSHALL INDUSTRIES' subsidiary, Dynamic Science Corp., recently occupied new facilities in South Pasadena, Calif. The corporation, operating as an autonomous subsidiary, will maintain separate facilities from the manufacturing and sales divisions of the parent company.

The new 14,000-sq ft facility provides research laboratories and offices for 100 senior scientists and engineers. M. Edmund Ellion is president and Melvin Gerstein vice president of the new advanced research and technical development organization.

Specialty Electronics Names Wolf G-M

ARNOLD M. WOLF has joined Specialty Electronics Development Corp., Syosset, N. Y., as general

manager. The company manufactures a variety of electronics, communications and radiation detection instruments and systems.

Wolf was formerly vice president and general manager of the engineering products division of General Instruments Corp.'s Radio Receptor Division.

Ampex Corporation Fills Key Post

ARTHUR H. HAUSMAN has been appointed vice president and director of research at Ampex Corp., San Francisco, Calif. He succeeds Walter T. Selsted who was recently appointed vice president, engineering, for the corporation.

For the past 12 years, Hausman has been with the U. S. Government in research and development of classified communications equipment.

Hughes Names Mueller To New Position

WILLIAM M. MUELLER has been appointed assistant manager of manufacturing for the microwave tube division of the Hughes Aircraft Co., Los Angeles, Calif. In addition to management responsibilities, involving microwave tube production, he will be in charge of special development projects in the manufacturing department.

Mueller formerly was a member of the technical staff of the Hughes Research Laboratories in Malibu, Calif.

Etu Joins Aerovox As Manufacturing Mgr.

J. ROGER ETU, formerly production manager at General Electric, Irmo, S. C., has been appointed manu-

facturing manager, paper capacitor department, of the New Bedford, Mass., division of Aerovox Corp.

Electro-Mechanical Names Two Executives

ALAN M. BROWN has been named president and Bernard Klibaner vice president in charge of engineering and manufacturing of the Electro-Mechanical Corp., New Rochelle, N. Y. Company manufactures precision electronic equipment.

Both men formerly held executive positions at Adler Electronics.

Tensor Organizes New Division

TENSOR ELECTRIC DEVELOPMENT CO., INC., prime and sub-contractors of electronic test equipment for the military for the last 10 years, recently formed a commercial products division.

Company, which maintains offices and production facilities in Brooklyn, Flushing and Manhasset, L. I., N. Y., has already commenced introduction of its equipment to the commercial market.

Microwave Electronics Appoints Section Head

ROBERT W. DEGRASSE has joined Microwave Electronics Corp., Palo Alto, Calif., as an engineering section head. He will take leading responsibility in the development of a program in low-noise microwave devices.

DeGrasse came recently from Murray Hill, N.J., where he was a member of the technical staff of Bell Telephone Laboratories for three years.

SEARCHLIGHT SECTION

(Classified Advertising)

BUSINESS OPPORTUNITIES

EQUIPMENT - USED or RESALE

EMPLOYMENT OPPORTUNITIES

The advertisements in this section include all employment opportunities—executive, management, technical, selling, office, skilled, manual, etc.

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Subject to Agency Commission.

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Box numbers—count as 1 line.

Discount of 10% if full payment is made in advance for 4 consecutive insertions.

Not subject to Agency Commission.

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Representatives desired by manufacturer of Industrial Electronic Instruments and Controls. P.O. Box 8246, Tulsa 15, Oklahoma.

EMPLOYMENT OPPORTUNITIES

wanted:

engineers, physicists and mathematicians

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Dept. E-34, Guided Missiles Range Division
Pan American World Airways, Inc.
Patrick Air Force Base, Florida

PAN AM

GUIDED MISSILES RANGE DIVISION

PATRICK AIR FORCE BASE, FLORIDA

CIRCLE 381 ON READER SERVICE CARD

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■

CLASSIFIED ADVERTISING

F. J. Eberle, Business Mgr.

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Life — over 700 hours reported
Peak power available — more than 10 kw. (More power than you can get from any other device at this frequency)
Duty cycle — up to 0.001. (For the BL-221, it is 0.00055)
Vibration — will survive 10 g's
Shock — 50 g's at 4 millisec
Lightweight — 7.25 lbs
Mounting — mates to modified standard flange
Ruggedized — Ceramic and metal construction
Fixed tuned

Band	Tube Type	Frequency Range (MC)	Minimum Peak Power (KW)	Output Mates with
V	BL-235	51,000–54,000	10	UG385/U
V	BL-236	54,000–57,000	10	UG385/U
V	BL-237	57,000–60,000	10	UG385/U
V	BL-221	69,000–70,500	10	UG385/U

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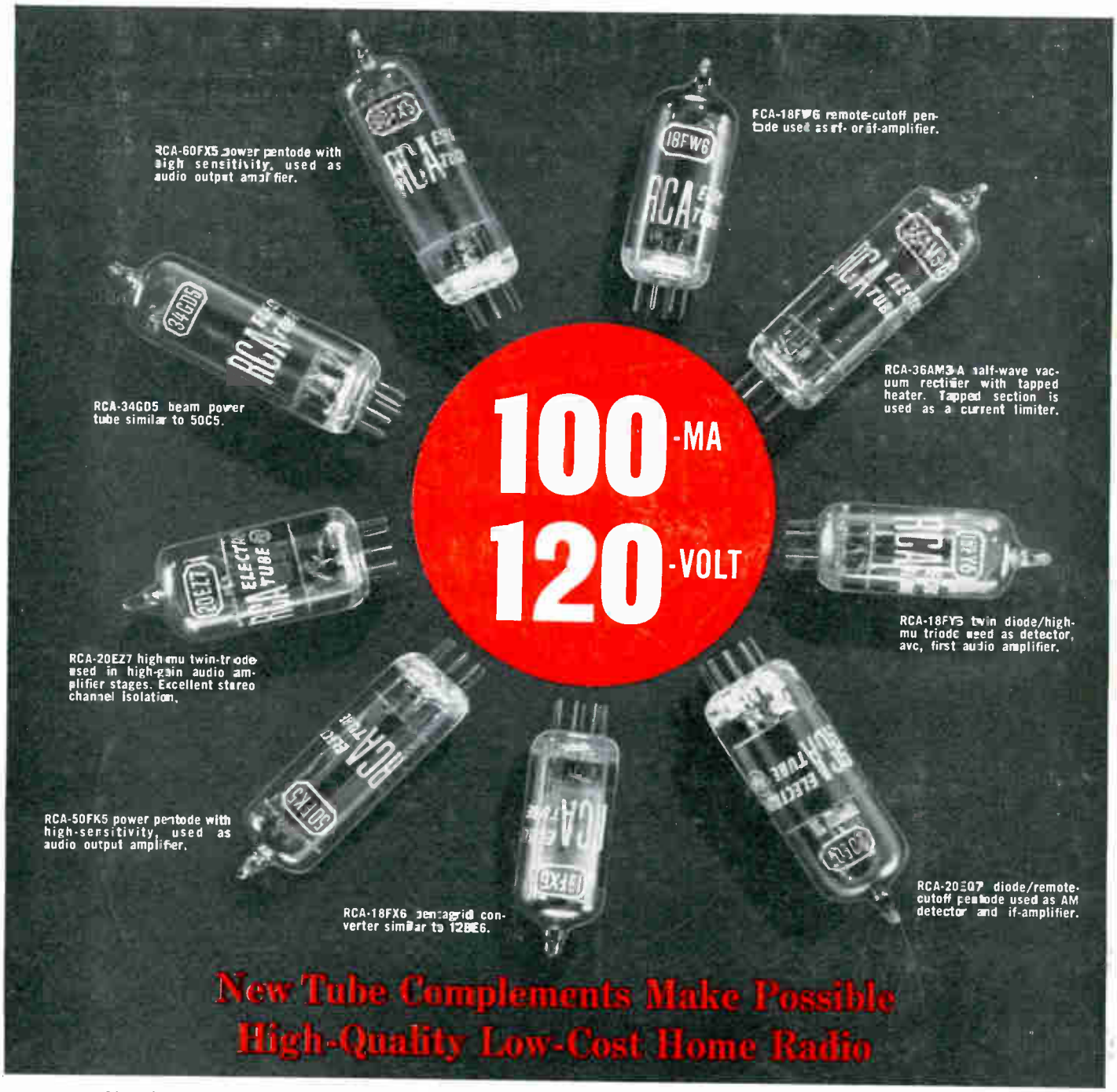
Leaders in the design, development and manufacture of TR, ATR, Pre-TR tubes; shutters; reference cavities, crystal protectors, silicon diodes, magnetrons; klystrons, duplexers, pressurizing windows, noise source tubes, high frequency triode oscillators, surge protectors.



New RCA complements of 100-milliampere heater tubes for 120-volt series-heater complement, bring important sales advantages to your ac-dc radio and phonograph designs.

Slimmer, smaller cabinets—greatly reduced heat—longer life expectancy—high operating efficiency!

Now you can design these sales advantages into ac-dc home radio and stereo, thanks to a new series of RCA tube complements developed for 120-volts, 100-milliampere series-heater operation. These are the first kits of 100-milliampere tubes whose heater voltages add up to 120 volts, the normal value of power supply that RCA considers available in most American homes.

With these new tube kits, temperature of cabinet hot-spots has been cut 15-25%. This decrease in temperature permits reduction of cabinet size (or retention of present size with cooler operation and better acoustic response); lessens possibility of cabinet warping or discoloration; allows wider choice of cabinet materials; and lends new flexibility to positioning of parts and printed-circuit boards. *And important to you*—these 100-milliampere heater tube complements provide performance equal to that of a 150-milliampere heater tube complement; furthermore little or no modification is required in your basic circuit design.

Get full details on these new 100-milliampere heater tubes! Check with your RCA Field Representative, or write: Commercial Engineering, *RCA Electron Tube Division, Harrison, N. J.*

NEW 100-MA HEATER TUBE COMPLEMENTS

5-Tube Radio Complement
18FX6, 18FW6, 18FY6, 34GD5, and 36AM3-A. Performance equals 150-MA heater tube complements! Yet 100-MA complement dissipates much less heat.

4-Tube Economy Radio Complement
18FX6, 20EQ7, 50FK5, 36AM3-A. Top performance for a 4-tube complement.

2-Tube Stereo Complement
Two 60FX5's can provide 1.3 watts output per channel using a high-output stereo cartridge.

3-Tube Stereo Complement
20EZ7, two 50FK5's. 20EZ7 permits use of stereo cartridges with moderate output.

4-Tube Stereo Complement
36AM3-A, 20EZ7, two 34GD5's. Capable of delivering 1.4 watts per channel with a B+ supply voltage of 110 volts.

RCA FIELD OFFICES

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