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electronics

FIRST SYNCOM SATELLITE

Next stop: 22,000 miles up

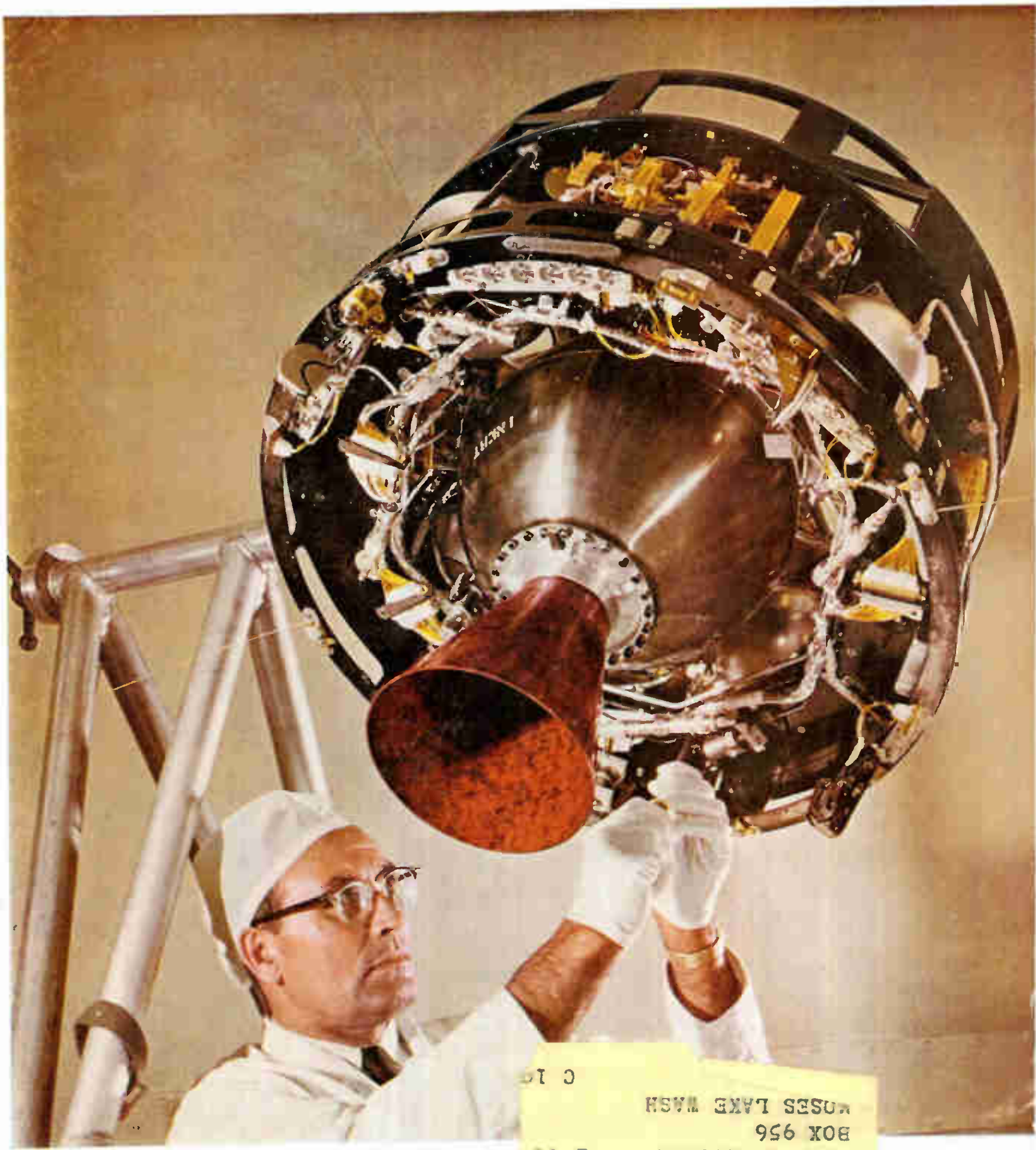
(photo below)

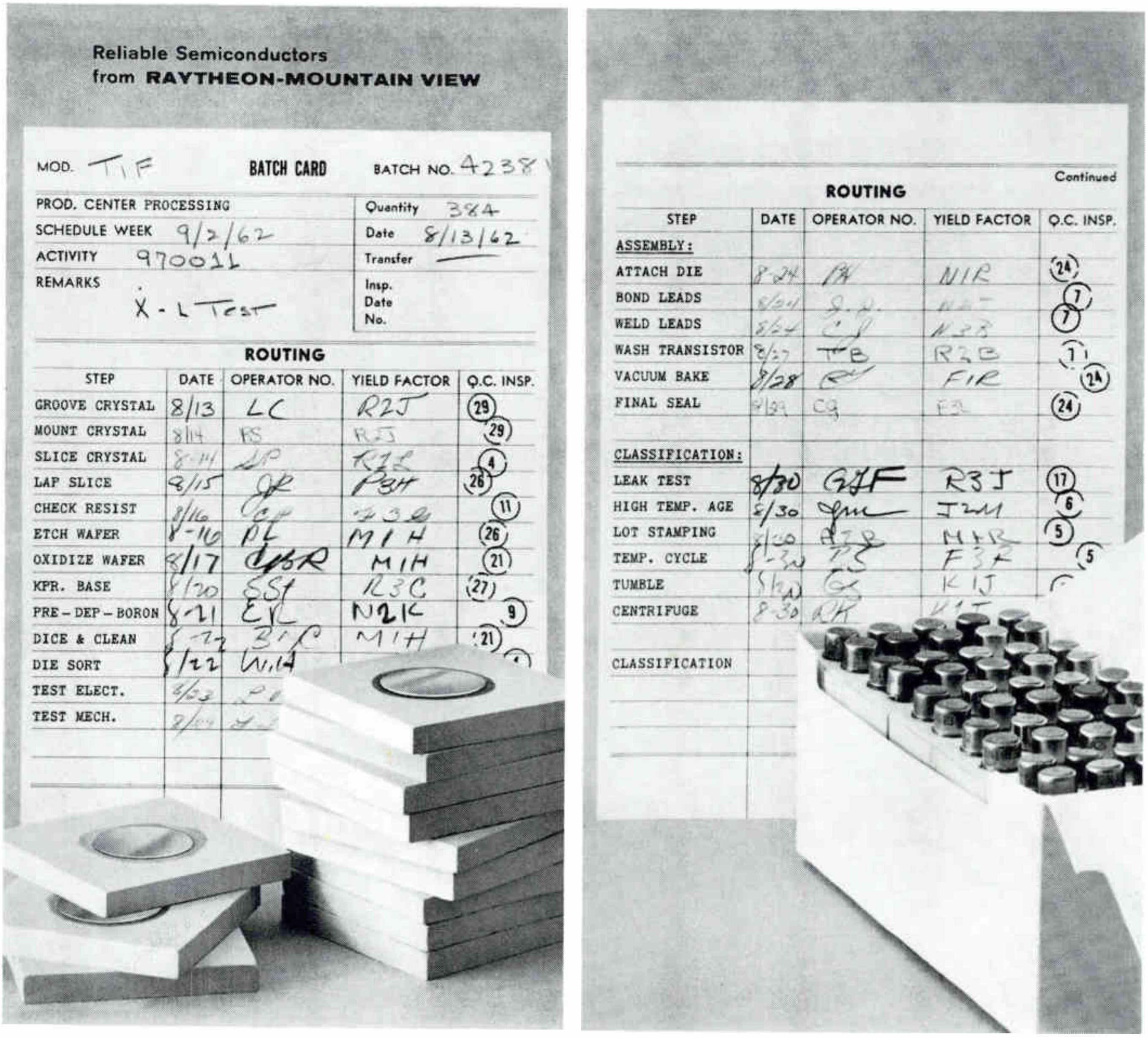
ATOMIC CLOCKS

Ultimate frequency standards, p 31

TELEMETRY FOR TITAN II

Latest encoding approach p 36





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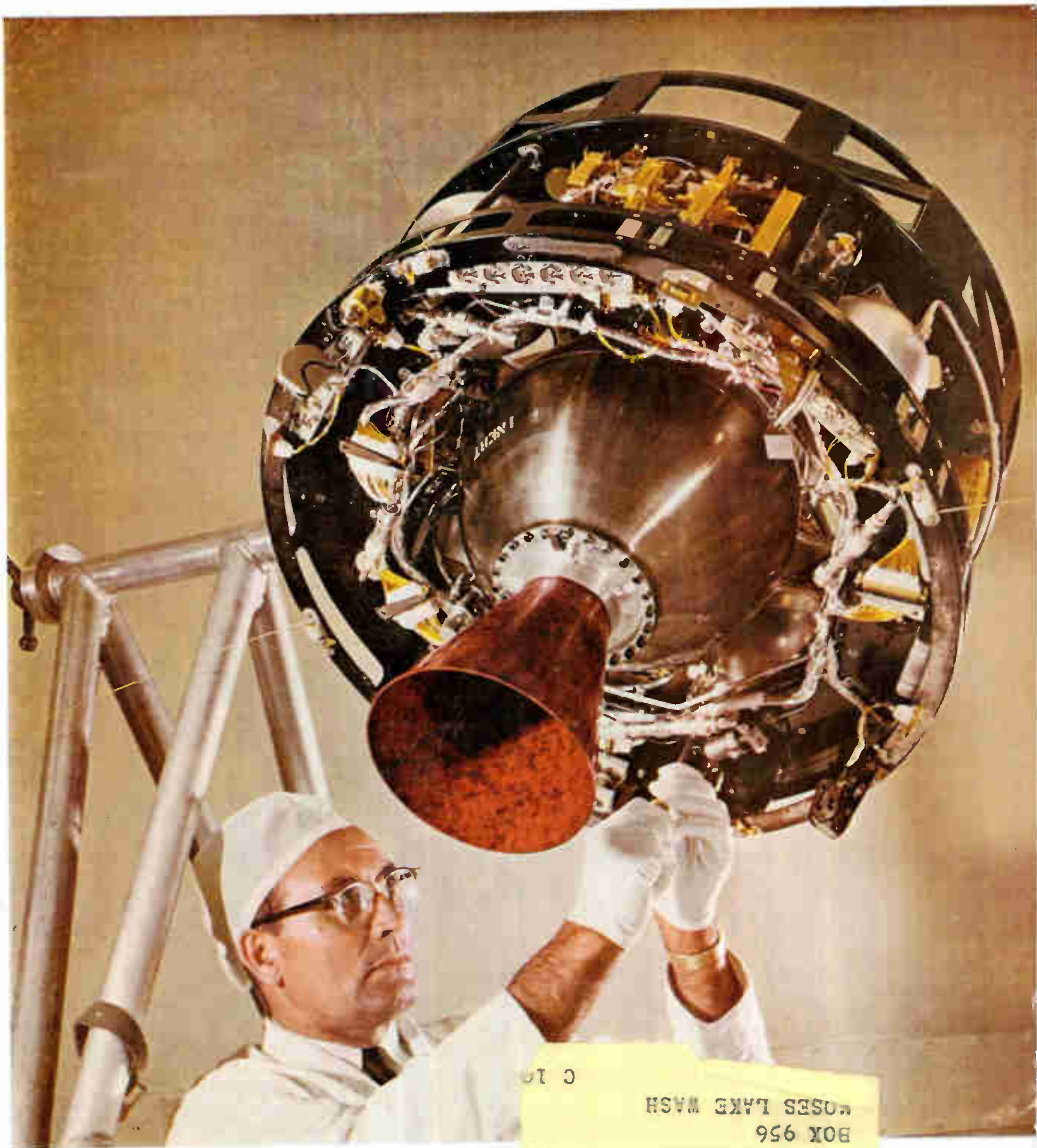

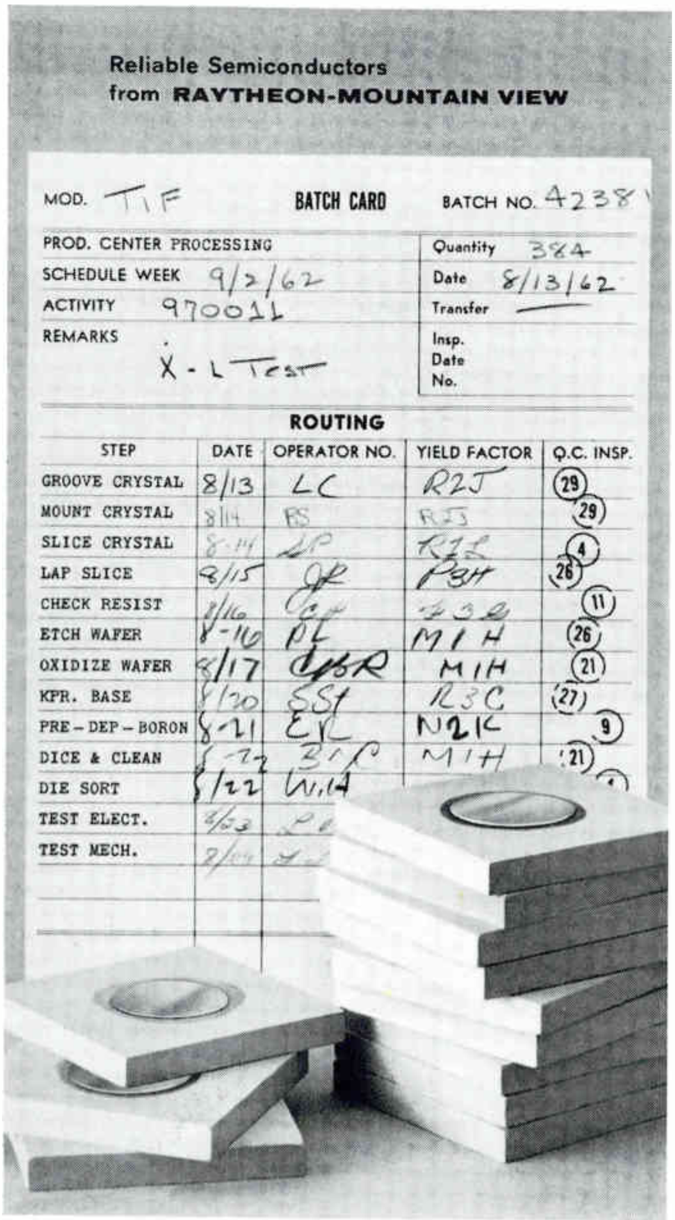

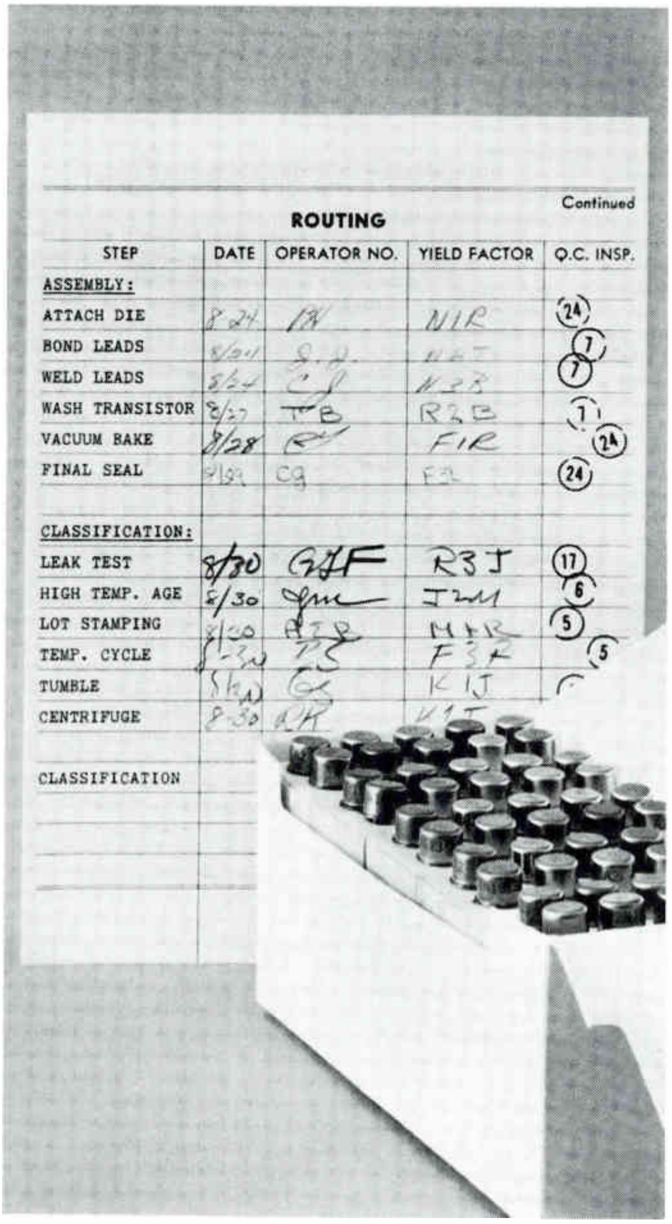

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W. W. MacDONALD, Editor

SYNCOM SATELLITE will be fired into a high, or stationary orbit, and will relay television and multiplexed communications signals between different points on the globe. Hughes Aircraft is developing Syncom for NASA. *Next year, three experimental satellites with limited communications capacity will be launched* COVER

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CROSSTALK

DIODE LASERS. The other day, we received a phone call from an engineer with an arc-welding equipment company. His company had heard about light amplifiers, felt they could develop power supplies for the ruby type, and wanted information about lasers.

He sounded eager to get going, but we asked him to hold the phone while we explained a few facts of life.

Was he aware a number of companies already make such power supplies?

More important, had he heard about the rapid emergence in the past few weeks of the gallium-arsenide diode laser?

No he wasn't and no he hadn't, he replied.

He agreed the wisest course would be to first make a thorough study of laser developments and then to consider what kind of power supplies might be fruitful for a company new to the field.

This conversation points up a question that is also in the minds of people more familiar with lasers: what will happen to gas lasers and lasers using ruby crystals and other optical materials when the diode lasers really get rolling?

Last week, Senior Associate Editor Wolff attended the laser symposium at Ohio State University. He asked the same question of a number of people there. The answer, given in more detail on p 14, is that the new diode lasers probably will not obsolete the other lasers, but will complement them.

This is strictly a seat-of-the-pants judgement. Laser developments have been coming too thick and fast for anyone to be absolutely certain what tomorrow will bring. In fact, we can't remember any series of developments—with the possible exception of transistors—with the pace and importance of what has happened to lasers. The events of the past few weeks have certainly brought this home to us, because several times we had to remake our news pages to get in a late flash on diode lasers.

One of our stories last week was first headlined "C-W Diode Lasers Expected in Few Weeks." Monday morning, just before the printers put the page on the press, we needed a new lead and a new head.

Over the weekend, c-w operation had been achieved.

POWER TRAMP. As we mentioned in *Crosstalk* a month ago (p 3, Oct. 26), there are no insoluble technical problems barring use of power transistors in a greater variety of equipment. The occasion for our comment then was an article on stabilizing power transistors. This week we are prompted by an article by D. J. Hancock, of the Martin Co., p 47.

Conventionally, load sharing between solid-state devices is handled by putting a resistor in series with each unit to swamp out variations in parameters. But the equalizer can dissipate too much power.

Another way is to use a nonlinear resistor whose ambient dissipation is low, but whose resistance quickly rises to combat dangerous transients—like a lamp. But the fairly high resistivity of tungsten means that a lamp with low enough resistance at ordinary current levels may have thick filaments and high thermal inertia, hampering protection.

Hancock (shown with the equipment in the photo above) tells how to make the balancing resistor from a short coil of copper wire. Its temperature coefficient of resistance is like tungsten's, but its resistivity and thermal inertia is much lower.

There is a drawback to the copper resistor, but a few days ago the author told us of a proposed solution. To overcome oxidizing or evaporation of the copper at high temperatures, Martin may put the copper wire into an evacuated envelope, like a lamp.

Maybe such a lamp will become an important new component in the high-power transistor field. Since it deals with transients, we'd like to suggest a name: the "tramp"—for transistor-resistor lamp.

WHEN WILL IT BREAK DOWN? That is the question underlying Managing Editor Carroll's special report on reliability next week. The report boils down into 24 pages the ways and means that electronics engineers can predict the reliability of existing systems, and it describes new approaches to meeting the needs for ever more reliable equipment.

COMMENT

More On Logic Problem

Relative to Ted Powell's fascinating letter in *Comment* (p 4, Nov. 2) about the Bell Labs logic problem that he solved using "and-or algebra," his solution is most ingenious.

However, instead of simultaneous equations and ten hours of perspiration, it would appear easier to use logic, and only logic. My solution took 17 minutes, and there must be an even simpler approach.

Given that $d = 5$, and no digit repetition allowed in the coded addition of

$$\begin{array}{rcr} d\ o\ n\ a\ l\ d & & 5\ o\ n\ a\ l\ 5 \\ +g\ e\ r\ a\ l\ d & \text{or} & +g\ e\ r\ a\ l_1\ 5 \\ \hline r\ o\ b\ e\ r\ t & & r\ o\ b\ e\ r\ 0 \end{array}$$

Consider the letters $o + e = o$. Letters o and e cannot be zero. If $o = 1$, e must be 9 plus 1 carried, to make a number ending in 1. If $o = 2$, e must be 9 with 1 carried, to make a number ending in 2, and so on. Therefore, $e = 9$ plus a carryover of 1 that came from the third column. With e equal to 9, the sum of letter o plus $9 + 1$ will give a carryover of 1 to letter g. So we have

$$\begin{array}{cccccc} 5 & o & n & a & l & 5 \\ g_1 & 9_1 & r & a & l_1 & 5 \\ \hline r & o & b & 9 & r & 0 \end{array}$$

Since t = zero and $e = 9$, and the first r in Robert is a single digit, r must be less than 10 and more than 5. So $r = 6$, 7 or 8.

The sum of $l + l + 1$ is r, so it will end in 6, 7 or 8, and must be 6, 7, 8, 16, 17 or 18. Subtracting, $2l = 5$, 6, 7, 15, 16 or 17. Since fractions are taboo, $2l$ must be even, so $l = 3$ or 8. (Store this in our memory drum.) In either case, $2l + 1$ will give a number ending in 7 (7 or 17), so $r = 7$. Then $g + 1 = 7 - 5 = 2$, so $g = 1$. We now have

$$\begin{array}{cccccc} 5 & o & n & a & l & 5 \\ 1_1 & 9_1 & 7 & a & l_1 & 5 \\ \hline 7 & o & b & 9 & 7 & 0 \end{array}$$

Searching our "memory," l was either 3 or 8. If 3, the sum of $l + l + 1$ would be 7 with nothing to carry, and the operation $a + a + 0 = 9$ is not valid. Therefore, $l = 8$. As a check, $2l + 1 = 17$, and the final digit 7 checks ok. With 1 carried over, the operation $a + a + 1 = 9$ is valid. And if $2a = 9 - 1$ or 8, then $a = 4$. So we have

$$\begin{array}{cccccc} 5 & o & n & 4 & 8 & 5 \\ 1_1 & 9_1 & 7 & 4_1 & 8_1 & 5 \\ \hline 7 & o & b & 9 & 7 & 0 \end{array}$$

Only the numbers 2, 3 and 6 have not been used, so they must apply to the letters n, o and b. But which is which? For $7 + n = b$ to hold true, with 1 to carry as above, we have three choices

$$7 + 2 = 13 \text{ or } 16$$
$$7 + 3 = 12 \text{ or } 16$$
$$7 + 6 = 12 \text{ or } 13$$

Obviously, $n = 6$ and $b = 3$. So letter $o = 2$.

Finally we have

$$\begin{array}{cccccc} 5 & 2 & 6 & 4 & 8 & 5 \\ 1 & 9_1 & 7 & 4_1 & 8_1 & 5 \\ \hline 7 & 2 & 3 & 9 & 7 & 0 \end{array} \quad \text{QED}$$

J. M. Bruning

Computer Engineering
Eclipse Pioneer Division
Bendix Corporation
Teterboro, New Jersey

And Still More Logic

The Donald plus Gerald equal to Robert puzzle does not seem to need the invention of a new algebra. Here is my eight minutes of reasoning that leads to the unique answer.

Grant you that doing the same problem at an interview is a different story.

Since $t = 0$, we have, from the first column, $g \neq 0$, and $r > 5$. From the fifth column, r must be odd. Therefore, $r = 7$ or 9.

From the second column, e must be either 0 or 9. 9 must be accompanied by carry from the third column, and must carry into the first column. Since $t = 0$, $e = 9$. And since $e = 9$, $r = 7$. And $g = r - 5$ $-$ carry $1 = 1$.

In the fourth column, since $e = 9$ and is odd, there must be carry from the fifth column, therefore $2l + 1 = 17$, and $l = 8$. From the fourth column and $e = 9$, $2a +$ carry $1 = 9$ or 19, or $a = 4$ or 9. Since $e = 9$, we have $a = 4$.

Numbers not assigned up to now are 2, 3 and 6. Since the second column required a carry from the third column, and $r = 7$, n must be >3, or $n = 6$. Therefore $b = 3$, and $o = 2$. Q.E.D.

F. F. Lee

Norristown, Pennsylvania

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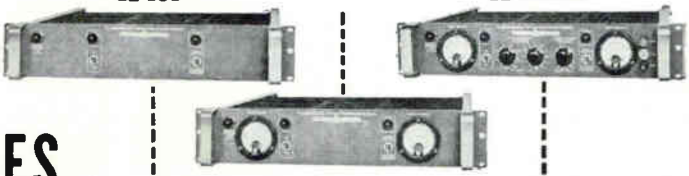

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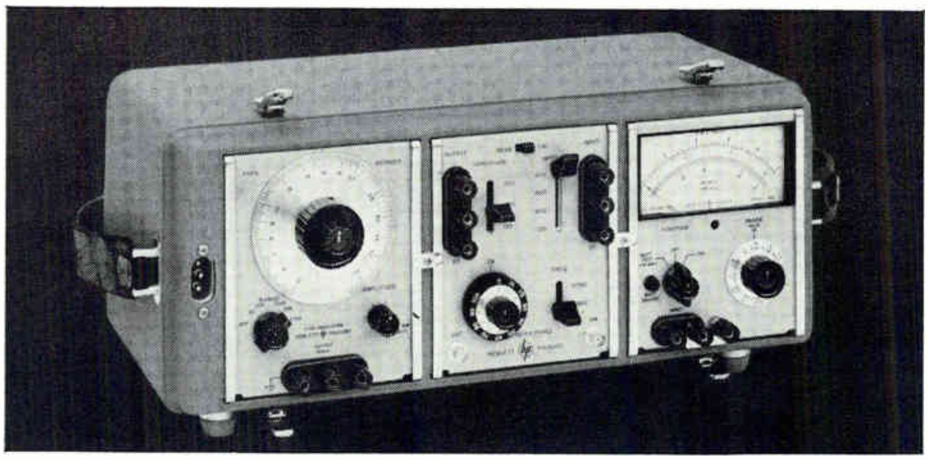

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ELECTRONICS NEWSLETTER

NASA Stabilizing Budget, Stalling Nova

NEW YORK—"Should the resources allocated to our national space effort continue to double each year?" James E. Webb, NASA administrator, asked this question during an after-dinner speech last week and answered himself with a qualified "no."

Webb said the rate of buildup in the space program is slowing down, that it is a fast but prudent program, and not a crash program. He didn't say how much NASA wants in the 1964 fiscal year budget, but he indicated increases will be less than in previous years. Unless there is an "unforeseen opportunity" or "new requirement" no supplemental or deficiency funds will be requested for fiscal 1963.

The Nova booster, intended for space flights after 1970, will remain under study and R&D for two more years, Webb said. This decision means less spending, but the prime purpose is to give solid-fuel or nuclear-powered boosters time to show what they can do. Another NASA spokesman said Nova might even be scrapped for a much larger booster.

Since the Nova decision affects the timetable for interplanetary flights, Webb said he expects the decision to spark a national debate on how fast the space program should move and its basic objectives. Congress, in its budget considerations, will decide if the civilian and military programs are in balance, he indicated.

Webb was in town to accept for NASA the annual award of the West Side Association of Commerce, of New York. His remarks were inserted at the last minute into an otherwise routine speech on NASA activities.

Mapmakers May Light Satellites with Lasers

WASHINGTON—Using lasers in mapping the earth is being considered by the U. S. Coast and Geodetic Survey. The idea is to use laser light sources to illuminate dark or dead satellites, to make them a part of the survey's optical tracking network (see p 22, this issue). Thus far, the network has been able to use only visible satellites, like Echo and Anna. The survey got the idea from NASA, which will try laser-tracking with the S-66 satellite.

Body Heat Powers Color Tv Receiver

NEW YORK—Miniature color-tv receiver, radio transceiver and hearing aid, all reportedly powered only by body heat, were shown here last week by Regal Audio Instruments, of Fort Erie, Ontario, Canada. The tv receiver and the transceiver are prototypes. Some 8,000 of the hearing aids have been produced and shipped, the company said.

The tv set was not demonstrated. Endell Are, company president, said it is tuned to receive only channel 80, available from a Buffalo station received in Ontario. The set is powered from the heat of the viewer's hand through photovoltaic cells, uses silicon integrated circuits and has a solid-state screen that synthesizes colors from basic red, yellow and blue, he said.

The transceiver is the size of a peanut, has a reported output power of 5 μw and a frequency of about 2 Gc. Its range is said to be 500 feet when used with another of the transceivers and 10 miles when a central relay station is used.

Radiation Belt Will Be Gone by Next July

CAMBRIDGE, MASS.—Artificial radiation belt created by the high-altitude nuclear blast last July is not a permanent threat to communications, astronomy, or space vehicles according to James A. Van Allen. It will disappear by next July, he said.

Van Allen told newsmen last week that early reports that the belt would ruin astronomy were "nonsense." He also called "ill-considered" a preliminary report on the belt by the President's Science Advisory Committee. Predicted effects corresponded to actual effects within a factor of two, he said. Although satellite damage was not predicted, it was predictable and should not have surprised satellite people, he added.

Van Allen addressed the New England Space Conference on a dif-

Development of $300 Color Tv Reported

COLOR-TV SETS COSTING $300 or less, retail, can come from development of a new low-cost optical projection system, it was reported exclusively to ELECTRONICS last week by J. Owen Harries, president of Harries Electronics Corp. Ltd. The development was done at his laboratory in Bermuda.

Key to the low cost, Harries said, is the use of optical elements with bandwidth fitted to that of NTSC transmission. Redundant bandwidth made earlier projection systems too costly.

The new optical elements include molded-plastic optical distortion corrector called a "sunflower," spherical mirrors and meniscus. The sunflower takes the place of selection of color dots and eliminates earlier methods of color registration used in projection tv.

The elements are small enough to allow use of very small picture tubes. Phosphor area in one of several of such tubes is only 0.35 square inch and the phosphor is kept cool by mounting it on metal. This provides greater picture luminance for a given power input.

A $300 receiver would provide 60 to 70 foot-lamberts, have a 23.6-inch-diagonal picture, cabinet depth of 20 inches, width of 34 inches and height of 19 inches. Economy models could be built for $200 and larger, brighter sets for up to $900.

ferent subject: a preview of recommendations to NASA resulting from the Iowa Summer Study on Space Research. Among techniques and requirements the report will underline is the use of bistatic radar astronomy to study planetary atmospheres and the interplanetary medium. In addition to ground equipment, equipment that would fly by a planet and receive reflected signals is proposed.

Big Job Waiting For Small Company

BEDFORD, MASS.—There's a million dollars worth of Air Force work here which can go only to a small business company, one that is independently owned and operated and employs not more than 500 persons. The "set aside" is the largest ever earmarked for small business by Electronic Systems Division's office of procurement here.

The job is R&D on energy transfer and storage processes. Goal is development of systems for space vehicles in which both solar energy and flight-generated thermal energy can be converted to electrical energy and stored for subsequent use in space vehicle control and communications.

Work will be done for space physics section of AF Cambridge Research Labs. Initial funding is $1,150,000. Ultimate cost of program estimated at $4 million.

New Saturn Rocket Tops in Telemetry

WASHINGTON—NASA's third Saturn rocket—successfully launched—is the U. S.'s most heavily instrumented vehicle yet. No less than 612 flight measurements were to be radioed to the ground after liftoff, supplemented by 104 so-called blockhouse measurements, provide the profile of rocket performance.

Two new data links are part of the instrumentation. A pcm transmitter in the first stage modulated a signal in digital form instead of analog. A transmitter in the payload section was probably the first attempt to employ uhf for a rocket telemetry system. The Saturn's first stage was powered. Second and third stages were inert, ballasted with water to stimulate the propellant weight.

Two Tv Stations Are Using the Same Antenna

ONE TRANSMITTING antenna is being shared by stations WROC-TV (channel 8) and WHEC-TV (channel 10), of Rochester, N. Y. The method, new to this country, according to RCA, has been used before in Canada and Europe. RCA built the diplexed antenna system.

A broadband diplexer combines the stations' two audio and two video signals and transmits them at the assigned frequencies. The basic antenna is a 72-foot-high, 12-bay unit. Transmitter signals are combined by a 3-db coupler.

Originally the two stations shared a tower with a stacked antenna array. When WROC shifted from channel 5 to 8 early this year, it had to change its antenna. The decision to use a common antenna followed.

Japanese Report Another Computer Joint Venture

TOKYO—Oki Electric says that it and Mitsui & Co. will establish a joint venture with Remington to manufacture Univac computers and punched-card equipment in Japan.

(A Remington Rand official in New York last week confirmed that an agreement with Oki has been reached, but would not comment on the stock arrangement, and emphasized that the deal must still be approved by MITI, the Japanese Ministry of International Trade and Industry.)

Last year, a joint venture deal by Remington, Toshiba and Mitsui reportedly fell through because MITI insisted the Japanese control 50 percent or more of the stock.

The equipment to be produced by the new firm will be sold or rented through Japan Remington Univac, a joint venture established a few years ago by Sperry Rand, Toshiba and Mitsui. Reportedly, Toshiba may drop out of the firm. Remington's move was seen in Tokyo as a counter to Japan IBM.

In Brief . . .

WESTINGHOUSE will build a solid-state static inverter power conversion unit for the Apollo spacecraft.

GENERAL ELECTRIC will design a pushbutton remote control unit and meter for a pay-television system developed by Home Entertainment Company of America. The meter will automatically keep a record of the programs the viewer selects.

RAYTHEON has purchased the bulk of the assets and businesses of Autometric Corp., a subsidiary of Paramount Pictures.

GENERAL DYNAMICS will develop an 80-pound coastal defense sonobuoy for the Navy. Receiver will weigh 45 pounds. Present models weight about 1,000 pounds, the company said.

NUCLEAR-CHICAGO and Radiation Instrument Development Laboratory will merge.

NASA IS BUYING a Univac 1107 for use at Goddard Space Flight Center. The thin-film-memory system will process data telemetered from satellites.

NAVAL ACADEMY has purchased six TR-10 computers from Electronic Associates, for instructing midshipment in analog computer techniques.

DYNALECTRON has a $842,595 contract from Air Force and Boeing for parts and test equipment for the ALE-20 infrared countermeasures device. ALE-20 defends jets against heat-sensing missiles.

PHILCO received a $5,881,478 contract from the Navy for production of guidance and control systems for the Sidewinder.

ADLER ELECTRONICS will engineer and install communications control systems for the Atlantic Missile Range under a $600,000 Air Force contract. Installations will be made at Cape Canaveral and Antigua and Ascension islands.

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CIRCLE 9 ON READER SERVICE CARD

WASHINGTON OUTLOOK

UHF TV SCORES HIGH IN NEW YORK TESTS

KEENER INTEREST IN UHF-TV BROADCASTING in major cities may come from FCC's report on its uhf reception tests in New York. Reception on WUHF, the experimental station, was found 10 percent inferior to vhf reception when indoor antennas were used, but outdoor antennas made the difference negligible.

A sample of the New York area was obtained from reception tests at 768 locations within 25 miles of the Empire State Building. Similar sets and antennas were used at each site to compare uhf and vhf picture quality in black and white, and in color.

Generally, simple antennas provided pictures rated from fine to excellent by viewers. In difficult spots, however, complex antennas didn't always improve the picture. Proponents of uhf have claimed that it is better for color than vhf, but FCC found no difference. Finally, testers suggested that distorting pickup—signals entering sets at points other than antennas—could be reduced with coaxial cable lead in, if receivers had transformers to match the low cable impedance.

WILL CITY TV BE ALL-UHF?

UHF'S APPARENT ABILITY TO EQUAL VHF in skyscraper cities—often without extra equipment—will spark talk of a controversial plan. The plan, which has some adherents at FCC, is to use uhf exclusively in large cities since they provide a large audience in a small area, and to reserve vhf longer-range for rural broadcasting.

This might not happen for some years, if ever, but broadcasters are aware it might provide more use of the tv spectrum. The possibility that this switch would put big city uhf broadcasters ahead may make metropolitan uhf broadcasting more appealing now.

MORE UHF DATA DUE

EIA hasn't made any formal comment on the uhf report, and can't be quoted. However, an EIA man who has studied it thinks it's an honest report that "does seem to answer the critics" who said uhf wouldn't work in big cities. He noted that it seems to be critically important to get a proper antenna installation. He also questioned the lack of direct comparisons between uhf and vhf for specific locations. He feels the report honestly justified the FCC's enthusiasm for uhf.

He feels that the report should encourage broadcasters to go into cities with uhf. He also says he will be looking forward to the second part of the report, covering measurements at 5,000 locations made with portable sets. This part tests reception outside the 25-mile range.

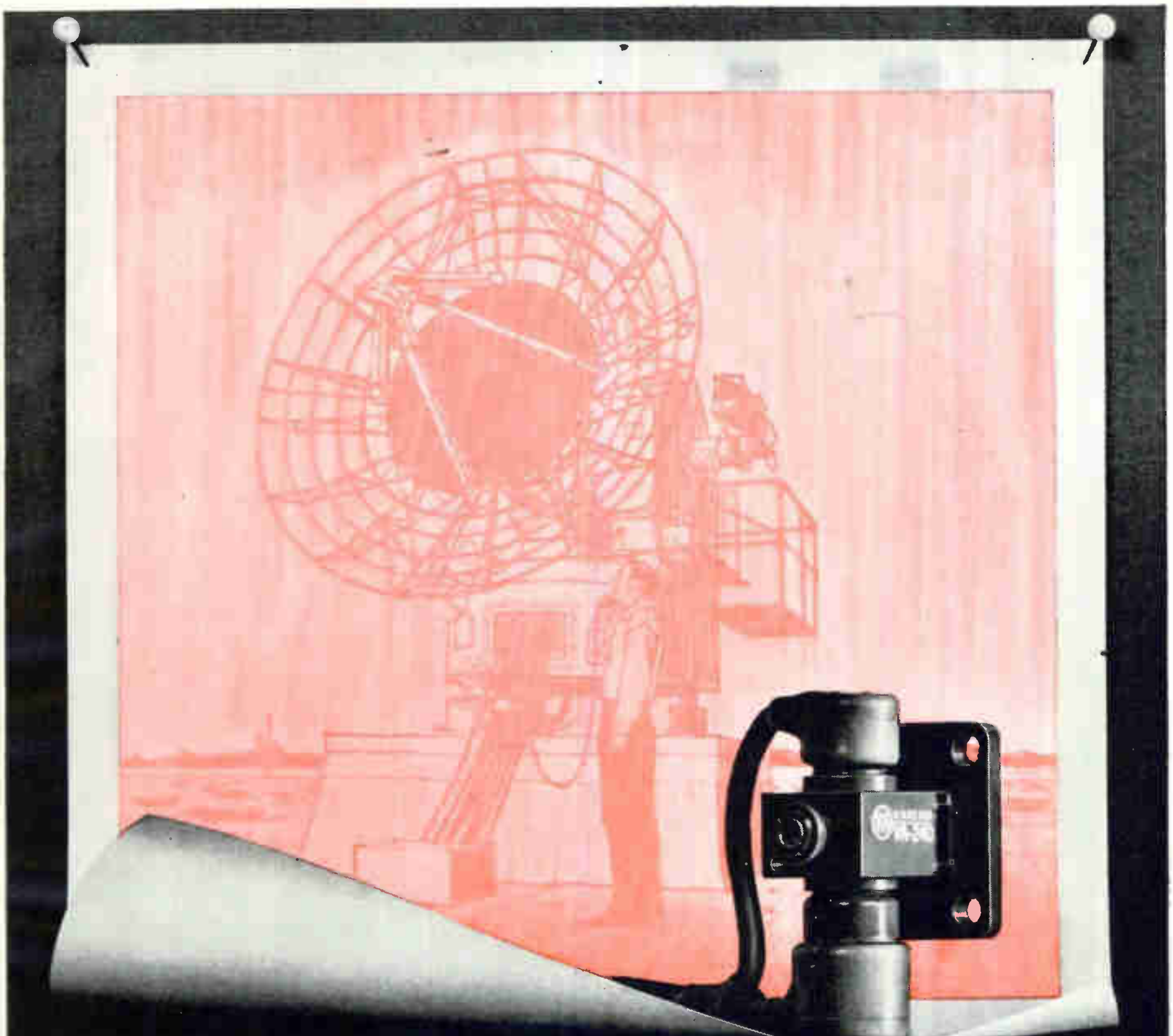
WAGE RATES SET FOR EQUIPMENT

THE LABOR DEPARTMENT this week proposed a minimum wage of $1.52 an hour for the electronic equipment industry. The determination, being made under the Walsh-Healey Public Contracts Act, will apply to workers on government contracts above $10,000.

The proposed figure is about what industry expected. Nationally, not much objection is expected. However, small plants, and firms in New England, will bear the brunt of the minimum pay scale.

Comments on the proposal may be filed with the department's Wage and Hour and Public Contracts division until Dec. 6. After that, Labor Secretary W. Willard Wirtz will make the final determination, which will become effective a week after it has been made.

The Walsh-Healey minimum, the first for electronic equipment, has been in the making since June 1960.



VA-240 12.4-18.0 Gc. 250 mW minimum.

from Varian: STABLE PUMP TUBES FOR PARAMETRIC AMPLIFIERS

Highly-stable reflex klystrons by Varian can significantly improve your parametric amplifier system design. Tube types, from 8.2 to 26.5 Gc are available for immediate delivery. From low-cost laboratory models to rugged 70 Gc tubes, all have Varian's inherent high quality of manufacture and performance.

Varian parametric amplifier pump tubes benefit from exhaustive research and testing for metals capable of contributing to precise control of temperature coefficients. For Varian pump tubes, this figure is less than 100 Kc per degree Centigrade. More than a dozen types of Varian reflex klystrons suitable for parametric pump use are operable in severe environments—20G shock, —55 to +85° C—and demonstrate excellent unattended long life characteristics. Improved optics in tube design provide maximum bandwidth. Power and frequency remain stable over a wide variety of environmental conditions.

Tubes in the VA-240 series (see chart) are rugged, field trimmable, conduction-cooled. Other Varian tubes suitable for parametric amplifier application have similar features. Write Tube Division.

TUBE NO.	OPERATING FREQUENCY (Gc)	MINIMUM OUTPUT (mW)	MECH. TUNING RANGE (Mc)	ELECT. TUNING RANGE (Mc)	BEAM VOLTAGE (volts)
VA-240	12.4-18.0	250	50	40	750
VA-253	15.0-22.0	200	1000	40	750
VA-241	18.0-26.5	200	100	40	800
VA-254	18.0-26.5	150	1000	40	850

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CIRCLE 11 ON READER SERVICE CARD

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A STATUS REPORT FROM

Get higher sensitivity and greater economy with advanced LS-400 planar silicon light sensors from TI

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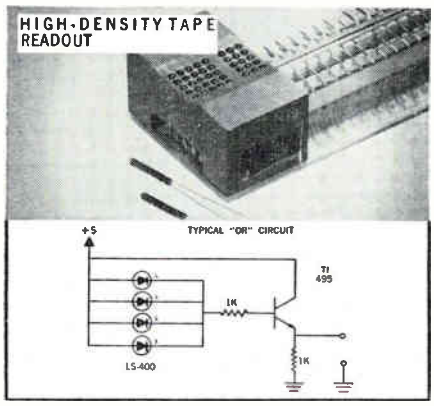


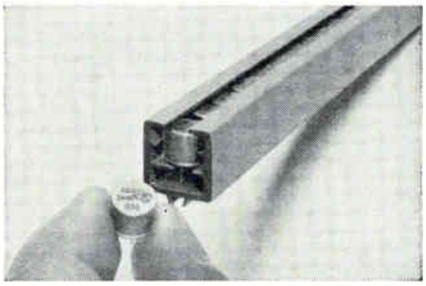
Texas Instruments LS-400 photoconductive sensors give you cycle capability to 25,000/sec — sensitivity ten times that of other subminiature photovoltaic or photoconductive sensors (typical output 9 ma @ 1000 ft-c), eliminating the need for extra gain stages — temperature stability to 1%/°C — off-storage-on stability to ±5%. Its highly reliable, planar, surface-passivated construction gives extremely low leakage — two decades lower, typically .01 μa in the dark condition. You can design more compact scan heads as the LS-400 exclusive end-reading design requires less space to accommodate the desired number of sensing units.

Slide-Pak* feed magazine greatly reduces transistor handling costs

Slide-Pak feed magazine — a new concept in packaging, shipping, and using transistors — is now available from Texas Instruments.

This unique transistor-handling method offers the volume transistor user many cost-saving advantages, such as: all transistor leads are pre-clipped to desired length; leads are straightened and kept straight; each transistor is uniformly oriented for identical insertion. Though ideally suited and specially designed for automatic insertion equipment, the Slide-Pack magazine offers important time-and-cost saving advantages for manual insertion operations as well.

You also realize important space

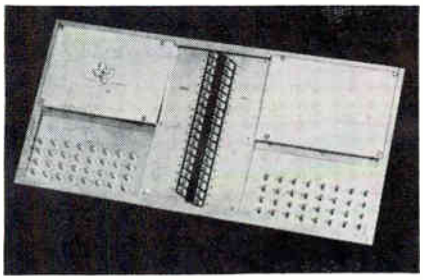


and weight savings in shipment and storage. Made of rugged, dimensionally stable plastic, the Slide-Pak magazine will not warp or crack and will hold its tolerance, thereby eliminating transistor jamming. You can utilize this new packaging technique with either TO-5 or TO-18 devices.

Texas Instruments can offer you valuable production experience in the application of this packaging technique to your special needs.

Greater bit-per-second economy with new high-speed magnetic memories

Texas Instruments is now offering the computer designer operating speeds to 5 mc in random-access word-organized memory systems. These new memory systems offer special promise for military and commercial application because of their inherent high speed coupled with potential low cost.



Typical of the systems now being designed is a memory of 8000 words, 50 bits per word, and 1.0 microsecond cycle time. The storage medium in these new systems is continuous sheets of thin magnetic

SEMICONDUCTOR-COMPONENTS DIVISION

COMPUTER PRODUCTION COSTS

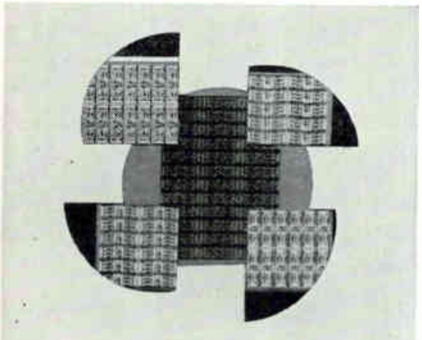
TEXAS INSTRUMENTS

film deposited on aluminum substrates. This aluminum substrate adds excellent mechanical rigidity to the over-all low-noise, low-drive-power systems.

To simplify engineering evaluation of the memory systems Texas Instruments provides a pair of magnetic-film memory planes arranged in a word-organized array comprising 64 words of 18 bits each. The designer can combine conventional electronics components with this new MS-1 memory stack to yield a small memory system capable of 0.2 microsecond cycle time.

New economical Solid Circuit* semiconductor networks customized with "Master Slice"

Today you can get the exceptional reliability and miniaturization benefits of SOLID CIRCUIT semiconductor networks in many customized circuit design variations — at only slightly more cost than standard, catalog circuits. The flexible "master slice" design concept developed by Texas Instruments makes this achievement possible.



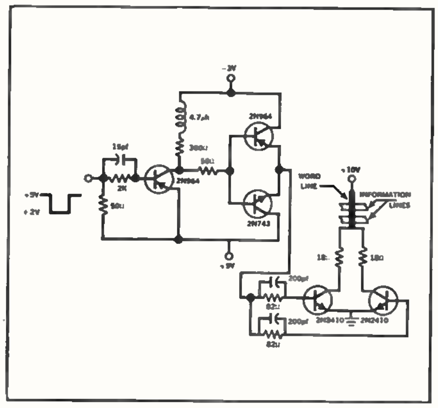
First, standard "master slice" integrated circuit bars — complete except for interconnections — are taken from established, high-volume production lines. Second, a special interconnection pattern mask for your circuit is prepared. Third, your special interconnection pattern is photo-etched in aluminum on the "master slice" circuit bar.

You get a complete semiconductor network — integrating resistors, capacitors, diodes and transistors into a single, high-purity silicon wafer—to your specifications. Evaluation samples can be available within four weeks from final design approval. Because preparation of the special interconnection pattern is the only custom step in the manufacturing process, you get most of the economy and delivery benefits of standard TI production units.

Now . . . reduce circuit costs and switch 1 amp in 39 nsec with new Snowflake* transistor

Now . . . you can greatly increase computer information-handling capacity and reduce circuit cost by designing TI 2N2410 Snowflake transistors into your thin-film driver circuitry.

As shown in the following circuit above, two TI 2N2410 transistors will perform the same function as ten less-advanced transistors — made possible by the high-current switching capability of Snowflake. Typically, the 2N2410 will switch 0.5 amp in 85 nanoseconds and 150 ma in 75 nanoseconds. Guaranteed total switching times are 120 nanoseconds at 150 ma and 130 nanoseconds at 500 ma. The ideal combination of high current and fast switching you need for advanced, high-speed computers can now be obtained with these NPN silicon epitaxial planar Snowflake transistors. Your circuits will be



capable of operating at higher frequencies with faster switching of higher current. You have the high-speed at high-current advantage of TI's epitaxial planar process combined with the new "Snowflake" six-point emitter geometry . . . available now in production quantities.

For further information, contact your Texas Instruments sales engineer, or write to Department 442, P. O. Box 5012, Dallas 22, Texas.

"TI cannot assume any responsibility for any circuits shown or represent that they are free from patent infringement."

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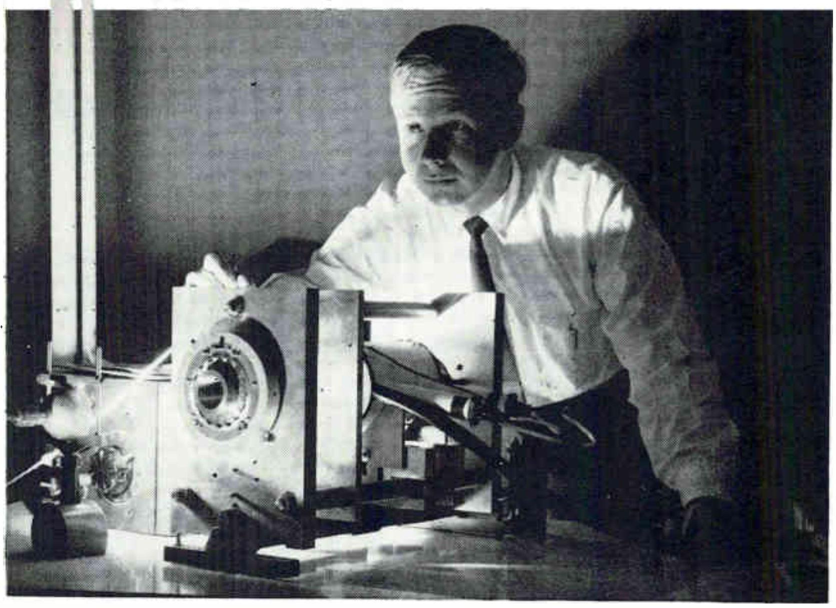
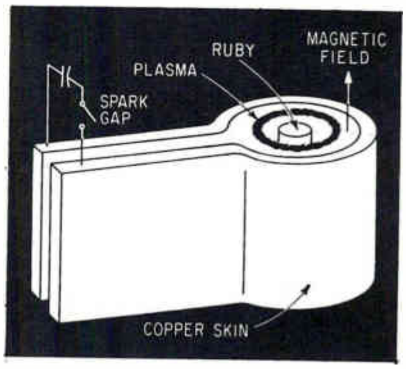




PLASMA *impingement scheme under study at Litton Systems*

SELECTING LASER *modes (diagram at bottom of page)*

Will Diode Lasers Obsolete

Best guess is that they won't—at least not for a long time

By MICHAEL F. WOLFF
Senior Associate Editor

COLUMBUS, OHIO—What is the outlook for gallium-arsenide diode lasers? Even at this early stage, the experts foresee an important future for the new devices.

Will the new lasers obsolete existing lasers? Probably not—it is much more likely that they will become an important complement to earlier types of lasers, with the net effect a broadening of the total range of applications for lasers.

Attendees interviewed at Ohio State University's recent symposium on Lasers and Applications agreed the injection diode laser is now starting to demonstrate its potential for high efficiency and power output. But it may be difficult to reduce its spectral linewidth to that of the gas laser or certain types of solid-state lasers.

In addition to applications relying on its modulation potentialities, the diode laser may soon be valuable in such applications as laser pumping and experimental optical computers.

As its size and power output grow, it will become increasingly useful in power applications. As yet, however, it is still a long way from the megawatt power pulses that ruby lasers can put out. Diode laser prf's are faster, though—presently on the order of 10 to 100 times a second.

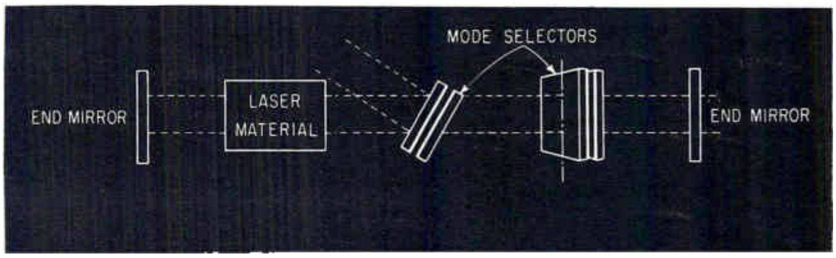
Since diode lasers now have a spectral linewidth of about 0.3 angstrom, compared with a few hundred millionths for gas lasers, gas lasers will potentially remain superior for some time in such high-precision applications as time standards. Beam divergence of the diode laser is close to that of the ruby laser, however. J. D. Kingsley of GE Research Laboratory reported divergence of 1 deg (in one plane), compared with about ½ degree for standard ruby lasers.

While stressing that progress at this early date was rapid, Kingsley told ELECTRONICS it appears the diode laser will not replace the solid-state laser in high power applications for a long time. The diodes will also require external optics to be as well-collimated as the gas laser. However, he feels amplitude and frequency modulation will be easy, foreseeing several hundred megacycles for the former.

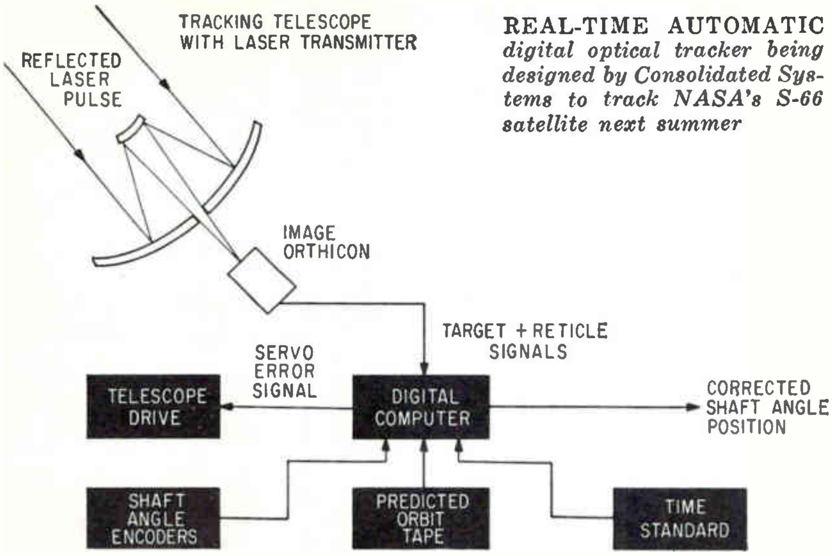
WHAT'S NEXT?—Some observers predict gallium phosphide will be the next semiconductor diode laser. This material would radiate in the visible region and might be useful simply as a light source because of its high efficiency.

In other developments at the symposium:

• T. S. Johnson, of NASA's Goddard Space Flight Center, described their laser tracking experiment for the S-66 Polar Ionosphere Beacon satellite (ELECTRONICS, p 20, Sept.



LASER MODE *selector developed by Sperry Rand (p 7, Nov. 16) uses Fabry Perot interferometer pairs to simultaneously limit the radiated frequency spectrum and narrow the beam angle to its theoretical limit*



REAL-TIME AUTOMATIC *digital optical tracker being designed by Consolidated Systems to track NASA's S-66 satellite next summer*

Earlier Lasers?

7). Ultimate goal is to track both in the earth's shadow and daylight, and to measure range. Transmitter is a ruby laser employing Q switching; expected parameters are: pulse energy, 1 joule; prf, 1 per sec; range, 1,500 Km; divergence of the reflected beam, 0.1 milliradian.

Automatic real-time tracking will be provided in later experiments by the system illustrated. Initially the telescope will drive along a predicted trajectory stored in the computer. When the target is acquired servo error signals will be generated to keep the telescope locked on the target. Angle readout from the shaft encoders is expected to be accurate to 5 seconds of arc.

• A type of solid-state laser that might compete with gas lasers was described by Z. J. Kiss, of RCA Labs. He said the fluorescent lines of four-level lasers using divalent rare earth dopants were narrow enough that these lasers could have beamwidth, stability and spectral purity comparable to that of gas lasers plus higher output powers.

Also, the divalent laser operates in a single longitudinal mode.

• Search for ways to eliminate flashlamps was illustrated by C. H. Church, of Westinghouse, who discussed optical pumping with exploding wires, and G. Fonda-Bonardi, of Litton Systems, who described pumping by plasma impingement. Fonda-Bonardi said early experiments indicate a ruby laser can be pumped by having plasma hit with a velocity of 5×10^5 meters per sec. The plasma is generated in the so-called θ-pinch geometry illustrated.

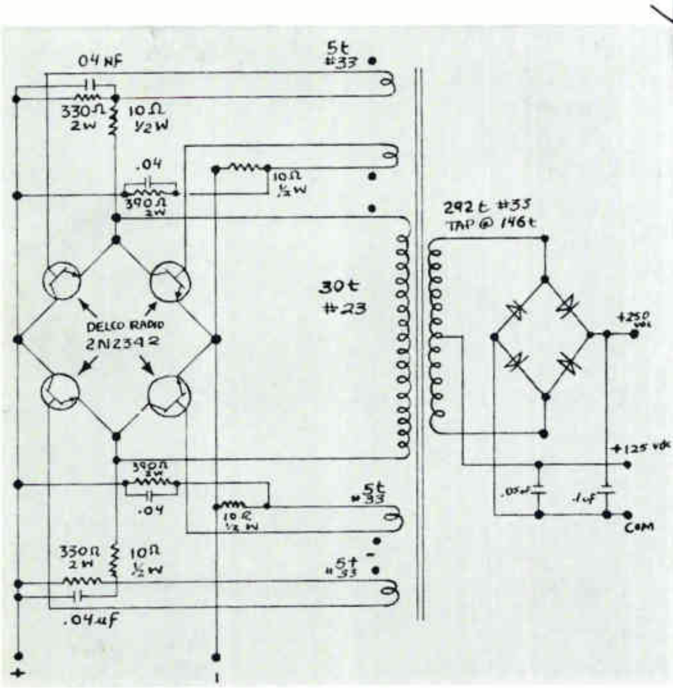
• Broad-band modulator scheme in which a coaxial transmission line is filled with KDP crystal was proposed by I. Kaminow, of Bell Labs. With light passing straight down the line, a practical device might operate up to 3 Gc, he said. With light following a zig-zag path it would in principle be possible to operate above 3 Gc. Work was done in conjunction with W. W. Rigrod.

• A substantial harmonic generation effect was reported by P. D. Maker, of Ford Motor Co. He said 20 percent conversion from the fundamental to the second harmonic had been achieved in ADP crystal using a pulsed ruby laser.

• T. S. Jaseja, of MIT, reported an r-f beat with an average frequency variation of less than 50 cps in 1 sec had been obtained between two c-w helium-neon lasers. This indicates changes in length smaller than 2 parts in 10^{13} could be detected, spurring interest in seismology and relativity experiments.

Silicon power transistors from Delco Radio

CUT YOUR POWER CONVERTER PACKAGES DOWN TO SIZE



Circuitry utilizing Delco 2N2342 miniature silicon power transistors makes for a compact, high efficiency DC to DC power converter package that will easily slip into a 1½" x 2" x 3" area. The 28VDC, 6KC bridge oscillator circuit shown provides a 13- to 15-watt, 250VDC output with efficiency of 65%. This practical efficiency and compactness would not be possible with germanium alloy devices, yet you pay no more for the increased versatility of Delco silicon transistors. For complete engineering data or applications assistance, call or write our Sales Office or your Delco Radio Semiconductor Distributor.

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

Thermal resistance of 8°C/watt max. Typical Alpha cutoff of 15 Mc • Rise Time of .2 μ seconds—.75A, IB=40 ma (Vce=12V). Fall Time of .5 μ seconds—(IC=0 Veb=2v Reb=37 Ω)

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- Winners, and their companies, will receive plaques commemorating the award
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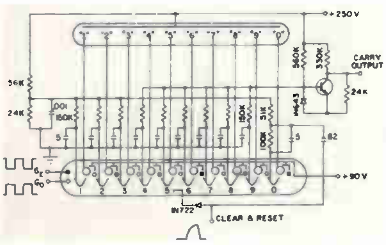
ENTRY IS SIMPLE

Anyone responding to this announcement will receive our new 40 page BEAM-X Switch Circuits Brochure, a 28 page BEAM-X Switch Technical Brochure, and an entry blank. The brochures give you detailed information on the BEAM-X Switch including specific circuits covering a number of applications.

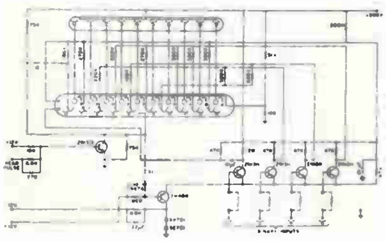
Starting with the brochures as a guide, you should design a paper circuit which utilizes these or other BEAM-X Switch circuits in a novel manner. Include with your circuit all written information necessary for a full evaluation. In addition, be sure to return your completed entry blank.

Your circuits will be reviewed by our staff of BEAM-X Switch application engineers for technical correctness. All entries which pass this screening will be turned over to our panel of judges who will make the final selections.

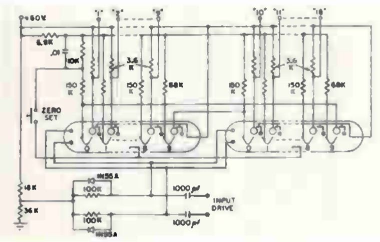
TO GET YOU STARTED, CONSIDER THESE TYPICAL APPLICATIONS OF THE BEAM-X SWITCH . . .



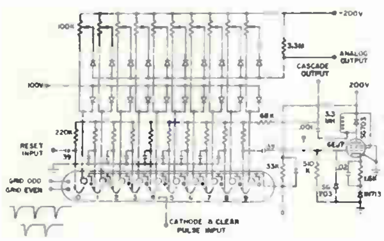
1. CIRCUIT FUNCTION: Decimal Decade Counting and Timing.
TYPICAL APPLICATIONS: Military, Laboratory and Industrial Frequency Meters and Time Bases, Digital Voltmeter.



2. CIRCUIT FUNCTION: Binary Decoding.
TYPICAL APPLICATIONS: Computer Readout, Stock Quotation Systems.



3. CIRCUIT FUNCTION: Multiposition Distributing.
TYPICAL APPLICATIONS: Industrial Process Control Scanning and Multiplexing, Communication and Telemetering Systems.



4. CIRCUIT FUNCTION: Step Function Generation.
TYPICAL APPLICATIONS: CRT Displays, Digital to Analog Conversion.

COMPETITION RULES

1. This competition, where not prohibited by local or state law, is open to anyone who resides within the United States of America except employees, representatives or agents of Burroughs Corporation and its related companies, and members of their families.
2. Entries must be original, and represent a novel method of using the BEAM-X Switch.
3. Include with your entry:
   (a) A circuit diagram illustrating your application
   (b) A written description of purpose and function as necessary for evaluation
   (c) A signed entry blank
4. Specific entries must not have been previously published or incorporated in a device which has been made commercially available prior to October 1, 1962.
5. There is no limitation to the number of entries any contestant may submit. In addition, joint entries (2 or more engineers) are acceptable. However, each entry must be accompanied by a signed entry blank.
6. In the case of joint entries, the award will be divided equally.
7. Awards will be judged on the following points:
   A. The Directness of the Circuit Design — Example; The utilization of a minimum number or the best combination of components to perform a circuit function.
   B. The Originality of Circuit Design — The newness of the circuit approach.
   C. The Originality of the Application — The use of the BEAM-X Switch in a new or different manner.
   D. The Value of the Circuit or Application — The usefulness to industry to the advancement of Science.
   E. Technical Feasibility — The ease with which the entry can be reduced to practice.
8. Screening will be performed by BEAM-X Switch application engineers. Final judging will be performed by the Editors of EDN, Electronics, Electronic Design, and Electronic Equipment Engineering. The decision of the judges will be final.
9. Winners will be notified prior to March 1963. Awards will be announced in March 1963 issues of Electronic Equipment Engineering, Electronic Design, Electronics, and EDN.
10. All entries must be postmarked no later than January 15, 1963. Entries should be mailed to Burroughs Corporation, Electronic Components Division, P. O. Box 1226, Plainfield, New Jersey; Attn. BEAM-X Switch Circuit Design Competition.

The receipt of a circuit from a contestant does not create or imply a confidential relation between the contestant and Burroughs Corporation or any of the judges of the contest. The contestant shall retain all patent rights in circuits he submits in this contest, but waives all other rights such as those relating to publication of the circuit.

ACT NOW . . . YOUR IDEA MAY BE WORTH A THOUSAND DOLLARS

ANOTHER ELECTRONIC CONTRIBUTION BY
Burroughs Corporation
ELECTRONIC COMPONENTS DIVISION
PLAINFIELD, NEW JERSEY

PROGRESS IN MICROWAVE COMMUNICATIONS

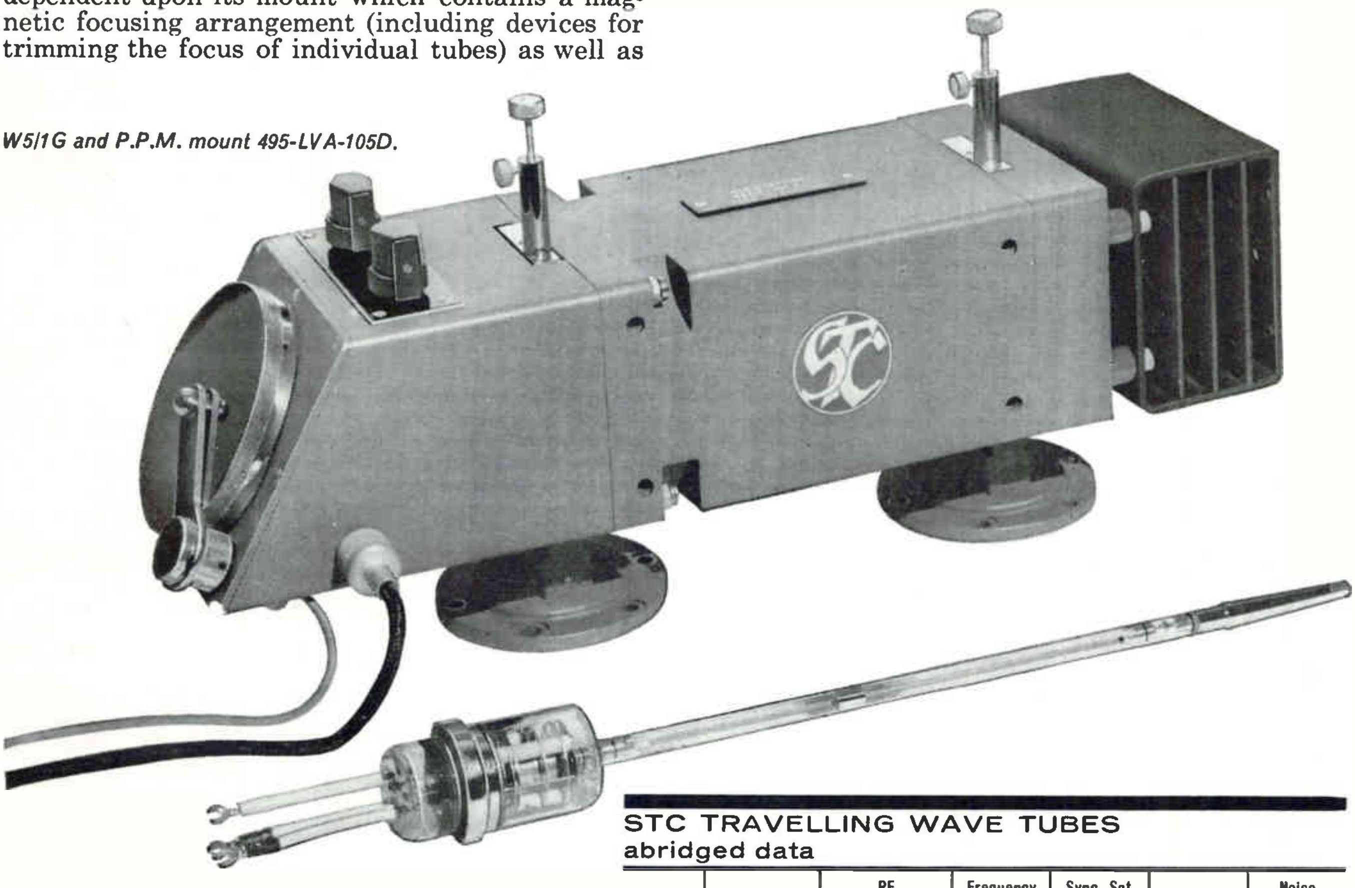
Advances in components design have brought far-reaching changes in circuit techniques employed in microwave link repeaters but, for broadband response, the travelling wave tube amplifier maintains its position supreme. This does not imply complacency on the part of the tube manufacturer. On the contrary, continuous efforts are made to produce tubes of better and better performance—improved gain, lower noise factor, higher synchronous saturated output level and reduced phase modulation distortion. During the last decade, STC have maintained a leading position in this field.

The travelling wave tube cannot be considered in isolation. Its correct performance is very much dependent upon its mount which contains a magnetic focusing arrangement (including devices for trimming the focus of individual tubes) as well as arrangements for coupling the input and output signal to and from the tube helix together with the requisite matching contrivance.

Whilst the mode of operation of the travelling wave tube does not permit much change in the overall length of the mount, economy has been achieved by replacing power consuming solenoids by periodically reversed permanent magnets; forced air systems by convector coolers, and focus-trim deflector coils by mechanical fine adjusting screws.

STC designs are based on a vast experience of manufacturing components for microwave equipment in use in major communication systems installed in 19 countries of the world.

W5/1G and P.P.M. mount 495-LVA-105D.



Announcing another NEW Type

STC TRAVELLING WAVE TUBES
abridged data

Tube Type	Mount Type	RF Connexion (W.G. Flange)	Frequency Range (Gc/s)	Sync. Sat. Output (W)	Gain (dB)	Noise Factor (dB)
W5/1G	495-LVA-105B	UG344/U				
	495-LVA-105C	CMR137	5·85 to 7·2	8 to 11	35 to 39	26
	495-LVA-105D	UG344/U				
W5/2G	495-LVA-107B	UG344/U	5·8 to 6·6	> 14	37 to 41	27
W7/3G	495-LVA-104	12A*	3·6 to 4·2	8 to 10	28	27
W7/4G	495-LVA-101A	12A*	3·6 to 4·2	10	42	27

*Transition pieces to WR229 available

Write for brochure MS/113
"STC Microwave Tubes"

Standard Telephones and Cables Limited
VALVE DIVISION · BRIXHAM ROAD · PAIGNTON · DEVON · ENGLAND
USA enquiries for price and delivery to ITT COMPONENTS DIVISION · P.O. BOX 412, CLIFTON N.J. ITT

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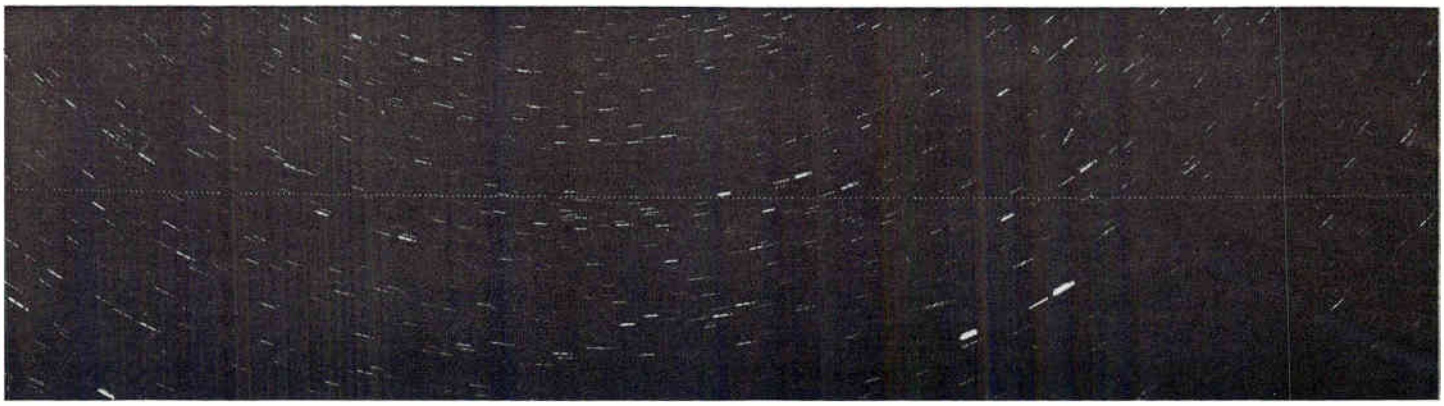
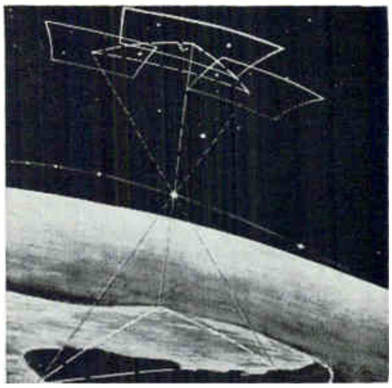


PORTION OF PHOTO *of Echo I orbiting past Ursa Minor. Path of Echo is horizontal dotted line*

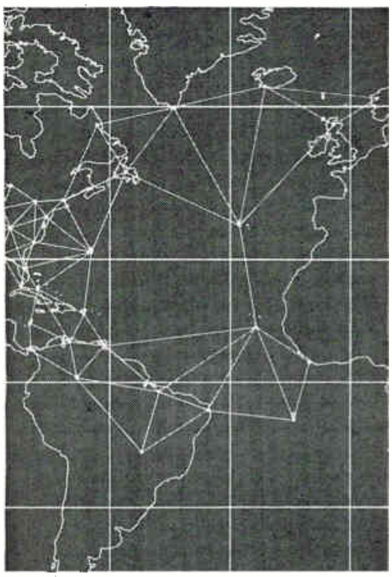
Need an Accurate Map? Photograph a Satellite

By HAROLD C. HOOD, Pacific Coast Editor



SATELLITE AT CONVERGENCE *of slant lines is photographed by cameras at three points to obtain space triangle*

TRIANGULATION *by satellite technique allows interconnections*



Satellite triangulation system to provide precision earth charts

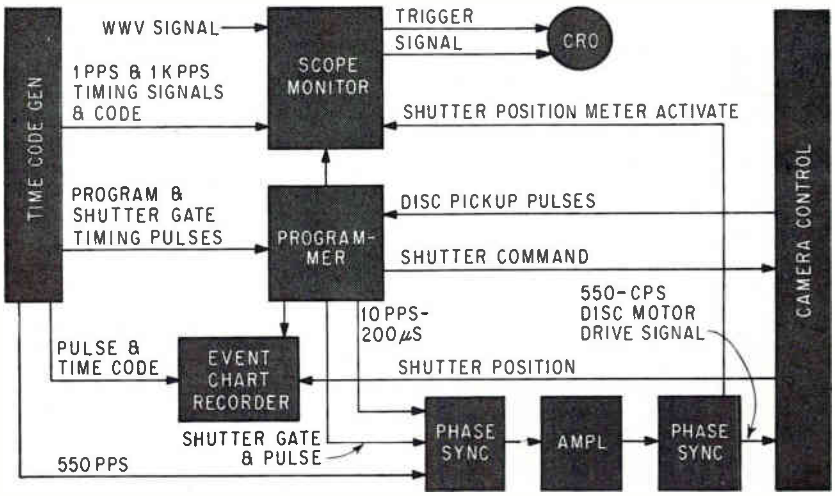
LOS ANGELES—A welcome by-product of Echo and other satellite programs is the newly-developed capability of Coast and Geodetic Survey to chart any point on earth to an accuracy of 30 feet within a distance of 3,000 miles.

Reportedly several times as accurate as any previous technique, C&GS's satellite triangulation system depends upon specially adapted ballistic cameras with high-precision electronic synchronization systems, able to photograph artificial satellites against the stars.

Photographic plates 18 cm square are successively exposed for durations of 1/60, 1/30, and 1/15 of a second in a Wild BC-4 camera. Geodesists, knowing the relative position and identity of the stars appearing, and the exact time of their appearance, can determine the satellite's position and speed and the camera's orientation.

By simultaneously photographing a satellite from two or more properly chosen locations on the earth's surface, "space triangles" may be established for accurately computing distances and baselines.

SYNCHRONIZER — Electronic synchronization systems, built by



CAMERA CONTROL *synchronizes shutter openings to standard radio-frequency transmissions of radio station WWV*

Electronic Engineering Company of California, are referenced to timing signals broadcast from Bureau of Standard's station WWV, and generate precision coded signals and pulse rates for controlling exposure times and operation of the shutters of the cameras.

Each camera is equipped with a rotating 3-blade disk-type shutter which "chops" the satellite trail and causes it to appear as an intermittent line on the photographic plate.

Satellite trails are referenced to exposure-coded star trails on the same plate.

Heart of the camera synchronization system is a time code generator having a stability of better than 3 parts in 10^8. If the distance between the system and point of transmission of the WWV signal is enough to cause a significant delay due to transmitted signal propagation time, the time code generator may be advanced to correct the delay.

SHUTTER DRIVE—The system supplies a 500-cps drive signal to operate the camera's disk shutters and then monitors the return signal for synchronization with real time. Out-of-sync conditions are indicated by a display counter and an oscilloscope. So that the disc shutter open time may be advanced or retarded, the signal from the code generator is converted to a sine-wave signal and channeled through a resolver where the phase

SYNCHRONIZATION *system with ballistic camera*

BENEFITS OF SATELLITE TRIANGULATION

Fixing positions on earth by the stars is an old and highly accurate technique, but it cannot satisfy all the needs of geodesists. And there are slight inaccuracies, such as the effect of local gravity vectors, in land-based techniques.

Photographing a satellite's path simultaneously from two or more stations provides a triangle in space, referenced to the stars. From these space triangles, extremely accurate baselines can be projected to earth. Data can be reduced by available techniques and most of the required computer programs have already been developed. The satellite can be a passive one, like Echo, or an active one carrying a flashing light, like the Anna satellite presently in orbit. Anna, carrying an 8-million-candlepower beacon light, is expected to double the number of hours the camera system can be used daily.

Satellite triangulation is expected to provide corrections for existing baselines and to extend the baseline network across continents and oceans. Accuracies of 1 part per million in baselines several hundred miles long are expected. An eventual overall network accuracy of 2 ppm is anticipated.

Such a network is needed not only by geodesists, mapmakers and surveyors, but for the nation's missile defense system, for establishing navigational systems like Loran C, for oceanographic surveys, and for correlating satellite orbit perturbations with the earth's gravity field

may be advanced or retarded.

For accurate evaluation of data recorded by the camera, each system is equipped with a chart recorder which keeps tabs on pertinent events that transpire during operation. Disk shutter opening time, capping shutter opening time, time code, shutter synchronization, and so on, are all available for later analysis.

FIVE STATIONS—To date, one complete $95,000 system has been installed at Aberdeen, Md., and two portable systems are on order.

The Aberdeen system is being integrated into tracking networks maintained by other agencies until the second C&GS unit is operative, probably later this year. Ultimately, at least five systems will be in operation and it is anticipated that a new survey of the U. S. and its territories will result in a long needed "tighter" geodetic control network.

An earlier model of EECO's ballistic camera synchronization system, delivered to the Ballistic Research Laboratory, has been in operation at Cape Canaveral since January, 1961, to provide data on missile speeds and trajectories.

New Zealand Gets All-Transistor Studio

READY FOR SHIPMENT *to the New Zealand Broadcasting Corp. in Wellington is this all-transistor radio studio made by Toshiba. It will centralize and integrate seven broadcast stations and provide for their remote control. The system includes a main control console and 14 subcontrol consoles, plus 318 other equipments. The new system is expected to require almost two-thirds less power than conventional equipment. It will go on the air next August*

Solid-State, High Speed, Ultra-Stable, Automatic, Programmable AC/DC DVM for $6,250

Key specifications of the outstanding new EAI Series 5002 AC/DC solid-state digital voltmeter are:

- Range and Resolution: 0.0001 to 1199.9 volts
- Absolute Accuracy, DC: ±0.01% ±1 digit, AC: ±0.06% + 1 digit to 5 kc, ±0.1% + 1 digit to 10 kc
- Stability: *6 months* without recalibration
- Reading time max., DC: 10 ms.**, AC: 160 ms.**
- Input impedance, DC: 10 megohms constant, AC: 1 megohm resistive
- Size: 8¾ inch by 19 inch RETMA panel

Features include automatic ranging or remote command of range, function, trigger, etc.; complete electrical outputs; overrange protection; in-line, in-plane display; and simple DC calibration for both AC and DC inputs.

***without range or polarity change*

Other EAI solid-state instruments with comparable *resolution, accuracy, stability, speed* and *reliability* are:

Series 5000 4 digit DC voltmeter

Series 5001 4 digit with overrange, automatic and programmable DC voltmeter

Series 5101 4 digit with overrange, automatic and programmable DC volt-ohmeter

Series 5003 4 digit with overrange, automatic and programmable AC/DC volt-ohmeter

Write today for detailed descriptive literature.

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ELECTRONIC ASSOCIATES, INC. *Long Branch, New Jersey*

WORKMEN *climb onto structure*

Maybe There's a New Propagation Path Above

By THOMAS MAGUIRE
New England Editor

Finding out will be one job of new 150-foot radio telescope

BOSTON—Will high-altitude irregularities in the ionosphere provide new paths for communications propagation?

Investigating that possibility by radio-astronomy techniques will be one job of the 150-foot-diameter radio telescope that Air Force Cam-

Microscope Tv Trains Surgeons

Miniature camera gives students enlarged view of microsurgery methods

NEW YORK—A woman who used a hearing aid 14 years had her hearing restored this month by an operation on her inner ear.

What was unusual about the operation was that a group of newsmen could see on tv screens every step of the operation—called a stapedectomy.

They could see Dr. Alan Scheer, of Polyclinic Hospital, roll back the membrane over the inner ear and tamp its edges against the sides of the ear channel.

Could the woman hear now? How did it sound, Dr. Scheer asked. "Sounds good to me," she exclaimed, as the newsmen applauded spontaneously.

The operation demonstrated a development in television that is expected to help solve one of the critical problems in microsurgery—the training of an adequate number of surgeons in the technique.

TRAINING AID—Tv viewing will enable Polyclinic Hospital to have 20 to 30 surgeons in each training class, instead of the usual 7.

More surgeons will mean fewer deaf people. Of the 17 million people who suffer hearing loss in the U. S., it is estimated that nearly 3 million might be cured by stapedectomy.

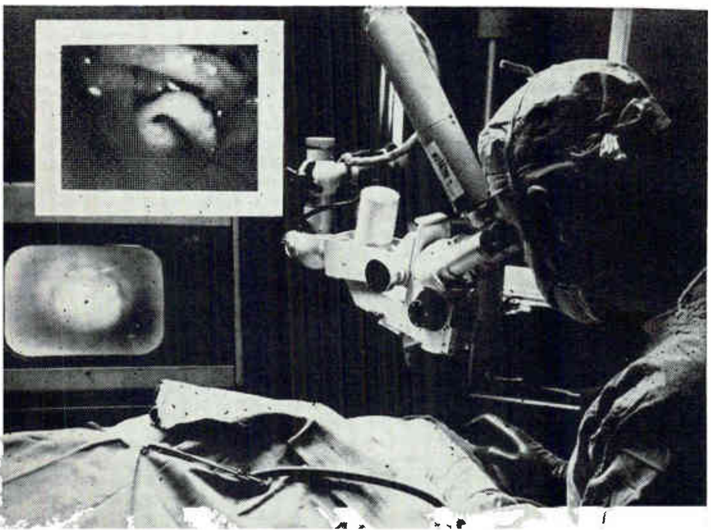
Dr. Scheer estimates there are 150,000 surgeons who could be taught the operation, but only 300 have been trained. Polyclinic and four other institutions are the only ones who teach it now.

The new system is expected to have equal importance in training surgeons in other types of microsurgery, for example, eye operations, neurosurgery and plastic surgery.

MICROSCOPE TV—Du Mont developed a 22-ounce tv camera that can be mounted on the Zeiss Diploscope, a double microscope that lets both the surgeon and a viewer watch such an operation.

During the operation, 40-times and 63-times enlargements of the inner ear structure were seen on the tv screens. The miniature camera did not interfere with the surgeon's use of the microscope.

The camera contains an electrostatic focused 1-inch vidicon tube, operating circuits and preamplifier in an assembly 10 inches long and 1¾ inches in diameter. There are 7 transistors. The camera is designed for maximum vertical resolution, has standard 2:1 interlace, 525 lines and 60 fields.



INNER EAR STRUCTURE *on tv screen is duplication of what surgeon sees in operation microscope. Small tv camera does not interfere with microscope's balance or freedom of movement. Inset photo above screen is enlargement of tv view*

Communications the Exosphere

bridge Research Labs is building at Hamilton, Mass. The Sagamore Hill Radio Astronomy Observatory there already has an 84-foot dish that will be used with the 150-footer in some of the studies.

The facility will be one of the world's most important centers for studying the atmospheric structure. Two-thirds of its program will be devoted to atmospheric investigations, only one-third to pure radio astronomy.

BIG DISH GOING UP. *Huge cranes lift 63-ton radio telescope into position on towers at right. Reflecting surface of the 150-foot antenna is aluminum mesh*

The telescope will also be available for beacon-tracking of deep-space vehicles. Its frequency versatility makes it valuable too, for specialized functions such as the detection and tracking of Soviet satellites and space probes.

When fully operable, the dish will provide hemispherical coverage. It will go into limited operation next spring. There are only two other 150-footers in the U.S. A twin at Stanford University will cooperate with Sagamore Hill in bistatic studies (separate transmitting and receiving antennas).

IONOSPHERIC STUDIES—Basic task will be atmospheric studies at 1,420 Mc or lower frequencies, using the moon as a reflection target or radio stars as point sources. Both the 150-foot and the 84-foot dishes are suitable for 1,420-Mc.

Most investigations with the new telescope will be at lower frequencies. A 220-Mc, 50-Kw transmitter will be installed for a series of moon studies in cooperation with Jodrell Bank and other observatories. Fort Monmouth and University of Illinois will join in bistatic moon-reflection studies.

For low-frequency ionospheric absorption studies, Air Force researchers will use the 150-footer and a receiver (now used for studies of Jupiter) with a sweep frequency of 20 to 40 Mc. It will watch a point source in the sky and follow it through various angles to disappearance. Data gained will be useful for detecting and tracking low-frequency satellites.

PROPAGATION PATHS—Astronomers will also try to look at ionospheric anomalies and attempt to determine whether they can be used as propagation paths.

This prospective new communications technique has been labeled "exospheric scatter," but the researchers will be looking at the F2 layer and beyond, not the exosphere.

In this program, the 150-foot dish at Stanford University will transmit with a 300-Kw unit at 25 Mc. Sagamore Hill will receive.

INTERFEROMETER — Long-range plans include using the 84-footer and the 150-footer together as an extremely sensitive interferometer. Taking advantage of the large aperture of the two antennas the swept-frequency technique will allow radio astronomers to determine position and angular size of signal sources with a narrow angular resolution. Interferometer nulls and peaks are expected to yield positions accurate to minutes.

The new telescope, funded jointly by the Air Force and by the Defense Atomic Support Agency, was designed by Stanford Research Institute for AFCRL. Jules Aarons, chief of the AFCRL Radio Astronomy Branch, is director of the observatory's research program.

Storage Cuts X-Ray Power

PUTTING AN IMAGE storage tube into an x-ray viewing system significantly reduces the time required to set bone fractures, Raytheon reports. It also cuts down on the amount of x-radiation exposure of operating-room personnel.

The system works like this: x-ray views are taken in two planes with image intensifiers. Vidicon tv cameras view the images. Images are stored in a storage tube. The x-ray views are compared side-by-side on one or more tv monitors.

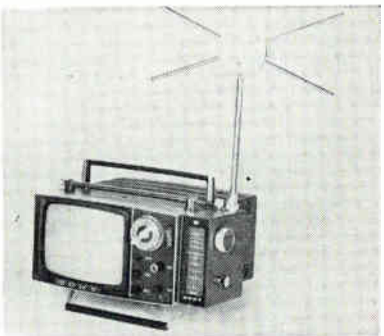
Pictures are taken in 1/25 second, at intervals of 1 to 6 seconds. If photos are required for the record, they can be made before the stored picture is erased.

The advantages of the system are, according to Raytheon: the surgeon can follow his manipulations of bone fragments without continuous fluoroscopy and he doesn't have to wait for the development of x-ray film to get comparative views.

The system—still experimental—was explained recently by Dr. George Berci when he visited Raytheon. He developed it with a group of associates at the University of Melbourne, Australia. Raytheon and its subsidiary, Machlett Labs, make components of the system.

Dr. Berci plans another system for viewing four pictures.

Piggyback Converter



ONE-POUND *uhf-tv converter for miniature tv set (p 8, Oct. 5) is aimed by Sony at U.S. market—Japan doesn't have any need as yet for uhf converters*

MEETINGS AHEAD

ULTRASONIC SYMPOSIUM, IRE-PGUE; Columbia University, New York City, Nov. 28-30.

FALL JOINT COMPUTER CONFERENCE, IRE-PGEC, AIEE, ACM; Sheraton Hotel, Phila., Pa., Dec. 4-6.

VEHICULAR COMMUNICATIONS CONFERENCE, IRE-PGVC; Disneyland Motel, Anaheim, Calif., Dec. 6-7.

SPACE PHYSICS CONFERENCE, American Rocket Society; Philadelphia, Pa., Dec. 26-31.

MILLIMETER AND SUBMILLIMETER CONFERENCE, IRE-Orlando Section; Cherry Plaza Hotel, Orlando, Florida, Jan. 7-10.

RELIABILITY & QUALITY CONTROL SYMPOSIUM, IRE-PGRQC, AIEE, ASQC, EIA; Sheraton Palace Hotel, San Francisco, Calif., Jan. 21-24.

INSTITUTE OF ELECTRICAL & ELECTRONICS ENGINEERS WINTER GENERAL MEETING & EXPOSITION, IEEE; Statler and New Yorker Hotels, New York City, Jan. 27-Feb. 1.

MILITARY ELECTRONICS WINTER CONVENTION, IRE-PGMIL; Ambassador Hotel, Los Angeles, Calif., Jan. 30-Feb. 1.

QUANTUM ELECTRONICS INTERNATIONAL SYMPOSIUM, IRE, SFER, ONR; Unesco Building and Parc de Exposition, Paris, France, Feb. 11-15.

ELECTRICAL & ELECTRONIC EQUIPMENT EXHIBIT, ERA, ERC; Denver Hilton Hotel, Denver, Colo., Feb. 18-19.

SOLID STATE CIRCUITS INTERNATIONAL CONFERENCE, IRE-PGCT, AIEE, University of Pennsylvania, Sheraton Hotel and U. of P., Philadelphia, Pa., Feb. 20-22.

PACIFIC COMPUTER CONFERENCE, AIEE; California Institute of Technology, Pasadena, Calif., March 15-16.

IEEE INTERNATIONAL CONVENTION, Institute of Electrical and Electronics Engineers; Coliseum and Waldorf-Astoria Hotel, New York, N. Y., March 25-28.

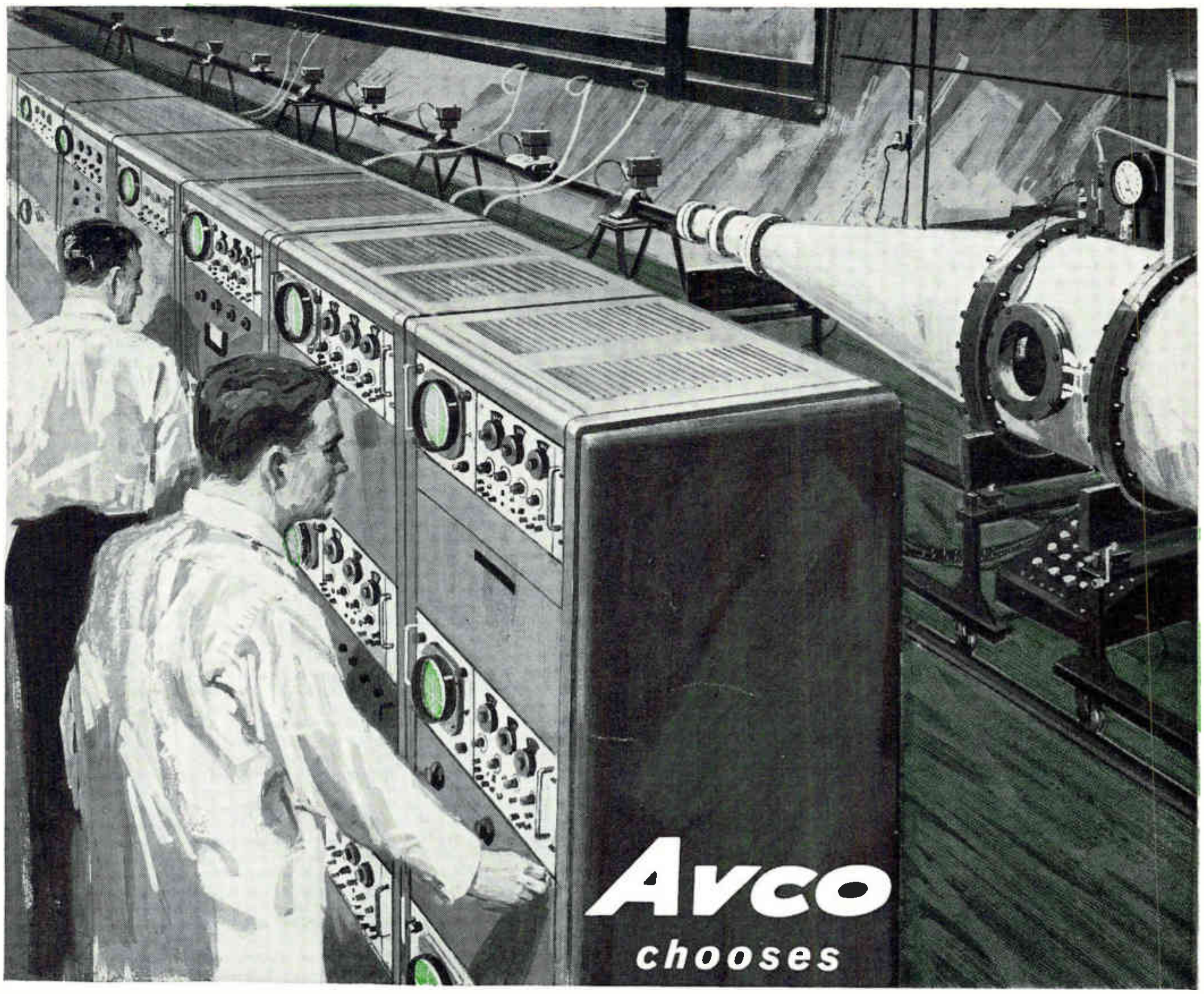
ENGINEERING ASPECTS OF MAGNETOHYDRODYNAMICS; IRE-PGNS, AIEE, IAS, University of Calfiornia, UCLA, Beverly, Calif., April 10-11.

SOUTHWESTERN IRE CONFERENCE, IRE, Dallas Memorial Auditorium, Dallas, Texas, April 17-19.

NON-LINEAR MAGNETICS SPECIAL TECHNICAL CONFERENCE, IRE-PGEC, PGIE, AIEE; Shoreham Hotel, Washington, D. C., April 17-19.

ADVANCE REPORT

BIOMEDICAL ENGINEERING SYMPOSIUM, IRE-PGME, AIEE, *et al; Del Webb's Oceanhouse, San Diego, Calif., 22-24 April. Dec. 15 is the deadline for submitting full-length drafts of papers to: John H. Mcleod. Chairman Program Committee, 8484 La Jolla Shores Drive, La Jolla, Calif. Interdisciplinary cooperation is the symposium theme and papers are solicited in: (1) medical and biological advances made possible by techniques or equipment of the physical sciences and engineering; (2) Physical sciences and engineering applied to medicine and biology.*



Analab DUAL-TRACE OSCILLOSCOPES

for shock-tunnel tests on advanced ICBM re-entry systems

At Avco Corporation's Research and Advanced Development Division in Wilmington, Mass., re-entry conditions are simulated on nose cones for ballistic missiles and other aerospace projects.

In 4-millisecond test time, 24 channels of extremely low-output temperature and pressure data are transmitted from a model in the Mach 15 flow to a bank of Analab dual-trace oscilloscopes triggered simultaneously.

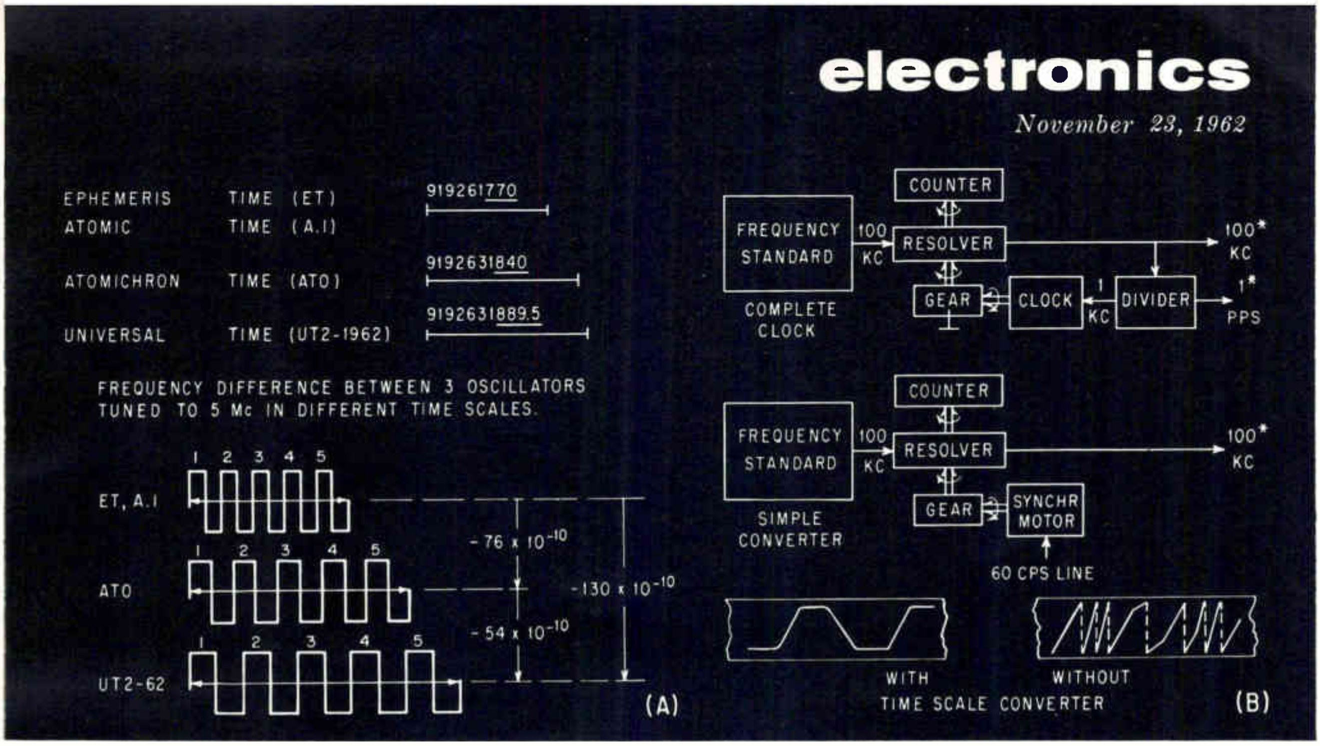
Simplicity of set-up (aided by Analab scopes' trace-tagging beam finder), plus identical high amplifier and triggering stability and sensitivity, permit all the scopes to be made ready in a small fraction of the time required by other scopes. Minimum calibration time and minimum d-c drift also helped Avco's choice of Analab for this demanding service.

Analab, maker of the world's finest oscilloscopes, offers a range of main frames and plug-ins (including storage and sampling) to meet your most exacting requirements. Call, wire, or write for complete technical data.

One of 46 Analab Type 1120R/700 scopes being used at Avco. 100 μv/cm sensitivity and direct-reading null-readout dials permit measurements of amplitude, time, and phase to ±2% accuracy.

Analab INSTRUMENT CORPORATION
A subsidiary of THE JERROLD CORPORATION
Cedar Grove, New Jersey

electronics
November 23, 1962



RELATIONSHIPS *of time and definitions of a second (A); electromechanical time-scale converter and advantages in recording very-low frequencies (B)—Fig. 1*

FOR HIGHEST ACCURACY:

Atomic Frequency Standards

New frontiers in accuracy and frequency stability are opened by atomic standards research. Here are various modern methods that are growing in popularity

By F. H. REDER, Senior Scientist, Solid State and Frequency Control Div., Electronic Components Dept., U.S. Army Electronics R&D Laboratory, Ft. Monmouth, New Jersey

ATOMIC frequency control can now be applied in the entire spectral range up to mm-wave frequencies with an inaccuracy[2] of 2×10^{-11} and a long-term instability of 2×10^{-12}. Conversion from one time scale to any other can be accomplished automatically by simple electromechanical devices. Various cesium atomic beam and rubidium gas-cell frequency standards are on the market at prices compatible with that of the very best quartz crystal standard. Gas-cell standards have surpassed the best crystal standard in small size and low power consumption. Four years of evaluation of a cesium beam standard indicates satisfactory performance with average times of continuous failure-free operation of up to 46 days with a maximum failure-free continuous operational interval as high as 116 days. Further simplification and improvement in the reliability of atomic standards are well within the present technological art and will be the prime objectives of further development work.

LAST Word in Stability

Modern frequency and time measurements needed in communications and navigation demand extreme precision. Good stability can be achieved with improved crystal oscillators but gas-cell devices have proven to be capable of even higher accuracy

REQUIREMENTS—An ultrahigh-performance frequency standard must meet the following basic requirements: High reliability, particularly for clock applications; highest possible accuracy, precision, and stability; smooth, quick, reproducible tuning to permit synchronization with other standards; short warm-up time; reasonable size, weight, and power consumption; minimum price and a reasonable delivery time.

An average quartz crystal

standard is unbeatable with respect to reliability, size, weight and price. Otherwise, it is inferior to atomic standards. The atomic beam frequency standard is the only type that requires no other reference for calibration. It is free from aging and has unprecedented frequency stability. Also, it can be tuned in steps of less than 1×10^{-11}. Tuning a quartz crystal oscillator bears the danger of changing its crystal drive level and aging characteristic. Warmup times of high precision crystal units are measured in weeks; those of atomic standards in hours. The $10,000 to $15,000 price of some atomic standards approaches that of the best quartz crystal standard.

TIME SCALES—Since the second, as the basic unit of time, can have several values[2,4] differing by as much as about 1×10^{-8}, frequency specifications claiming an accuracy of better than 10^{8} are incomplete without specifications of the reference time scale. Figure 1A shows the relations of the various definitions of the second. It is important to remember that the UT2 or universal second may change from year to year[4]. Frequency quotations in UT2 should, therefore, always show the year, such as UT2-1962. All standard frequency transmissions by vlf, l-f, and h-f transmitters are based on UT2.

A simple way of adjusting a frequency standard to some other time scale is provided by electromechanical time scale converters as shown in Fig. 1B. The output signal of the standard passes through a resolver-type phase shifter which is slowly rotated by a synchronous motor. Speed and sense of rotation determine amount and sign of resulting frequency variation. Converters do not degrade long term stability if they are limited to conversions of 10^{-8} or less. They are useful in synchronization experiments and for vlf phase recordings with local oscillators differing from UT2 because they provide single-curve phase records over many days instead of records chopped into short traces due to a large frequency offset.

FREQUENCY CONTROL—Available commercial atomic frequency standards utilize the sharp and stable hyperfine transitions in Cs^{133} or Rb^{87} atoms[1,2]. Such transitions can be induced by a microwave signal from a crystal oscillator with a frequency equal to the atomic resonance frequency. Coincidence of driving signal frequency with atomic resonance frequency can be detected either with a particle detector such as that in an atomic beam or by optical detection as in a gas cell. Phase modulation of the driving signal[2] at a frequency of around 100 cps generates an a-c detector output signal for automatic frequency locking of the flywheel oscillator to the resonance line.

ATOMIC STANDARDS—An atomic frequency standard consists of quantum-mechanical resonator and electronic-frequency translator. A clocks has an additional divider, usually down to 1 pps, and an integrating dial indicator. The resonator may be passive or active such as a maser. Translators require all electronic equipment to frequency or phase lock an r-f crystal oscillator to the atomic resonance line. The table shows atomic frequency standards that have been under study or development.

Masers, while simple in principle, become complicated[2] when intended for practical long-term high-performance applications. Only the hydrogen maser[5] is promising for certain scientific laboratory applications due to its extreme short-term stability and precision. Its application outside the laboratory is doubtful, due to technical problems in size reduction, temperature control, magnetic shielding, buffer film stability and pumping.

The Cs^{133} beam standard and the Rb^{87} gas-cell standard are commercially available.

Rb^{87} GAS-CELL STANDARD—In the gas-cell resonator[6,7] a microwave cavity contains a glass bulb filled with Rb^{87} vapor and a neutral buffer gas. The buffer converts the short, straight-line flight from wall of the Rb atoms into long-lasting zig-zag diffusion, reducing the line width of the Rb^{87} hyperfine transition to about 200 cps. The Rb^{87} vapor lamp generates the Rb^{87} infrared resonance spectrum, while the Rb^{85} filter cell reduces all but those spectral components originating in the microwave ground level. Atoms in the microwave ground level will be raised into infrared levels from which they can fall back into both the upper and the lower microwave levels. Since they originate in only the lower level, the net effect will be a pumping action from lower to upper level. During pumping, the cell is only partly transparent since light is scattered in all directions; but when the new equilibrium has been reached, the cell becomes almost transparent. When the cell is irradiated by a microwave signal having a frequency corresponding to the sharp microwave resonance line, the equilibrium will be disturbed again and the transparency reduced. If the microwave signal is frequency-modulated, the ir-detector output spectrum will contain the modulation frequency.

ADVANTAGES OF GAS CELLS—Short-term stability is high due to the excellent signal-to-noise ratio realizable with combined optical pumping-optical detection techniques.

Required power level of microwave input signal to the resonator is less than 1 microwatt. This permits single-step, solid-state frequency multiplication factors greater than 100.

The observed frequency shift[6] by buffer gases can reduce the complexity of the electronic synthesizer. It also provides a simple way of using the same standard for any time scale that lies within $\pm 4 \times 10^{-8}$ of A1 or atomic time, by changing the microwave cavity and the gas bulb. Inherent motion sensitivity is negligible.

DISADVANTAGES—Gas-cells are not primary frequency standards because the buffer gas pressure cannot be adjusted accurately without monitoring frequency.

Also, gas cells have no self-calibrating feature. They show signs of slow aging and their microwave Q tends to deteriorate due to interaction of Rb atoms with the wall material.

There are four commercial models of gas-cell frequency standards. Figure 2 shows one all-solid-state Rb^{87} standard. It is the smallest atomic frequency standard now available. A block-diagram of this Rb^{87} standard is shown in Fig. 3.

Many technical problems remain to be solved. Some are: Prolongation of bulb life by reducing interaction of *Rb* vapor with container wall, increasing precision of bulb filling to achieve higher accuracy, improving leak detection for bulbs filled with buffer gases of pressures up to 10-mm of mercury, improving Rb^{87} lamps to increase long-term stability of intensity and spectral purity, thereby reducing optically induced frequency shifts and improvement of temperature stabilization of the resonator and reduction of its' warm-up time.

CONSIDERATIONS — Lamps should be filled with Rb^{87}, to reduce optically induced frequency shifts. It is undesirable to tune an atomic standard magnetically by more than $+ 2 \times 10^{-10}$ because larger C-fields tend to magnetize the shields and place a severe stability requirement on the C-field current.

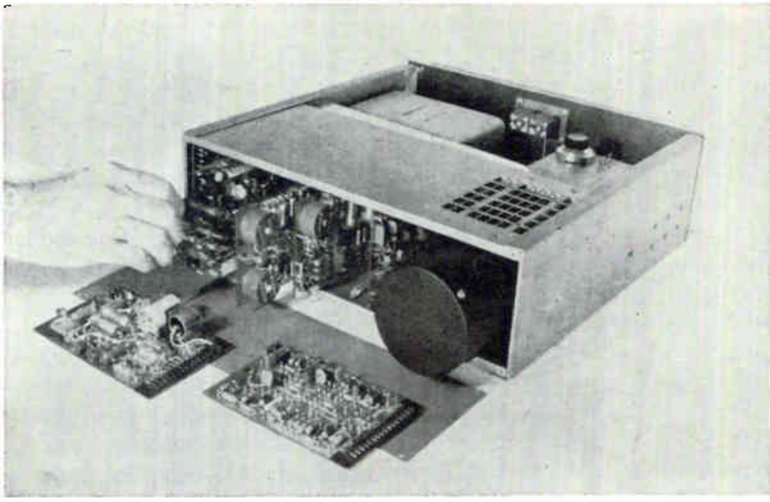
An electronic design with the synthesizer outside the resonator loop is preferable because sidebands and noise from the synthesizer may shift the center frequency of the resonance line.

Modulation should be linear and injected at the lower end of multiplier chain. The modulation frequency should not be larger than half the atomic line width to reduce frequency shifts.

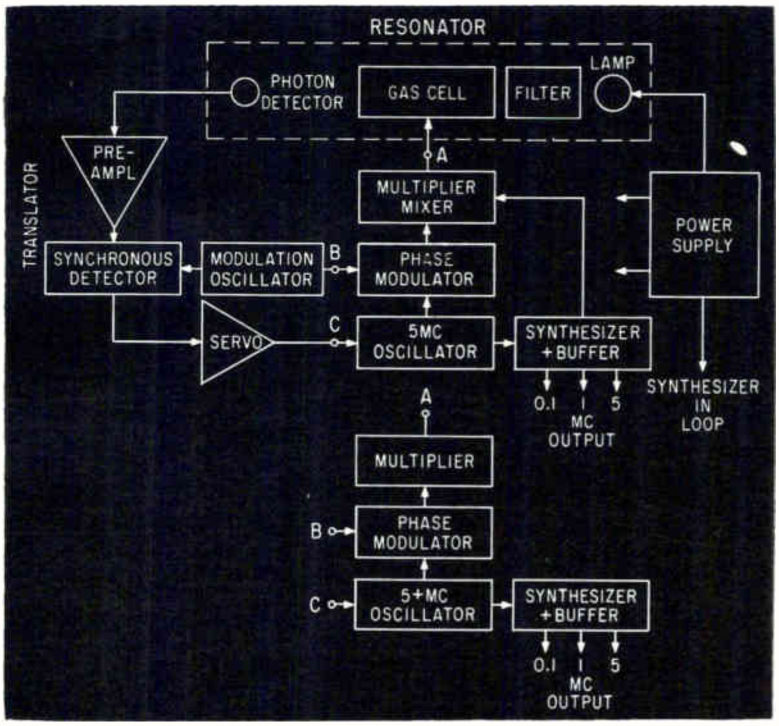
The Rb^{87} gas cell has a good future as a stable, lightweight, secondary frequency standard.

Preliminary reliability test results on several models are encouraging, but performance evaluation data lacks clarity in defining performance parameters and measurement methods. Some r&d work remains to improve resonator lifetime, long-term stabilty and temperature control. These improvements will probably be achieved in the very near future.

Cs^{133} BEAM STANDARD — The principle of the *Cs* beam resonator is shown in Fig. 4. Atoms passing through an inhomogeneous magnetic field are deflected toward the weaker field if they are of higher microwave energy level and toward the stronger field if they are of lower level. If they pass through two inhomogeneous fields separated by a microwave cavity, they are



FREQUENCY STANDARDS *are growing lighter and more compact with each new design—Fig. 2*



RUBIDIUM 87 *gas-cell frequency standard has long-term instability of* 2×10^{-10} *and inaccuracy of* 5×10^{-10}*—Fig. 3*

ATOMIC STANDARDS UNDER STUDY OR DEVELOPMENT

Masers With Phase-Locked Translators	Passive Resonators With Frequency-Locked Translators
N^{14} H_3 beam maser[5]	Cs^{133} beam standard.
N^{15} H_3 beam maser[6]	Tl^{205} beam standard[11]
H beam maser[7]	
Rb^{87} gas-cell maser[8]	Rb^{87} gas-cell standard
Various solid-state masers[9]	Cs^{133} gas-cell standard[12]
Optical masers (lasers)[10]	Mm-wave molecular beam standard[13]

twice deflected in the same direction assuming they do not resonate while passing through the microwave cavity. Such atoms are not detectable. If the microwave field corresponds closely to the atomic transition frequency, the atoms will be deflected back to the axis while passing through the second magnet and contact a hot ionizing wire. The ions then move to an electron multiplier whose output is a measure of how closely the frequency of the microwave field agrees with atomic resonance frequency. Figure 4 shows the detector output of a single-cavity beam tube utilized in a 1958 TRG design, and a 1962 National Company model. Figure 4 also depicts the resonance pattern for a double or U-shaped cavity tube employed in all other beam standards. The U-shaped cavity reduces the line width to 65%, allows long cavities (10 meters) for achieving narrow lines, and reduces the effect of various line broadening and shifting perturbations[1]. The single cavity excitation, if used for cavities not longer than about 30 cm, requires about 15 times less microwave power and yields a single-peak resonance pattern that has less locking ambiguity than the three-peak pattern characteristic for double field excitation[1].

National's Atomichron frequency standard is shown, front and rear, in Fig. 5.

ADVANTAGES — Cesium beam standards are self-calibrating primary frequency standards.

They have the highest known long-term stability, and the shortest warmup time. Their performance has been studied for 6 years, revealing considerable data on long-term behavior, reliability and areas where improvements are needed.

DISADVANTAGES — If operated with U-cavities, *Cs* standards require 100 to 200 μw of 9.2-Gc power derived by frequency multiplication from a 5-Mc crystal oscillator. This power requirement complicates frequency multiplier circuits as compared with gas-cell and single-cavity requirements (1-5 μw).

Recent developments in solid-state harmonic generation will soon solve this problem.

All beam-type passive resonators are somewhat sensitive to fast rotation because coriolis forces divert the beam from the particle detector. Rotational motions encountered in airplanes[3] and cars are too slow, however, to cause damage.

The permanent magnets of the resonator generate magnetic stray fields, which make it necessary to degauss the magnetic beam tube shield occasionally and keep other sensitive equipment 2 meters from beam standards.

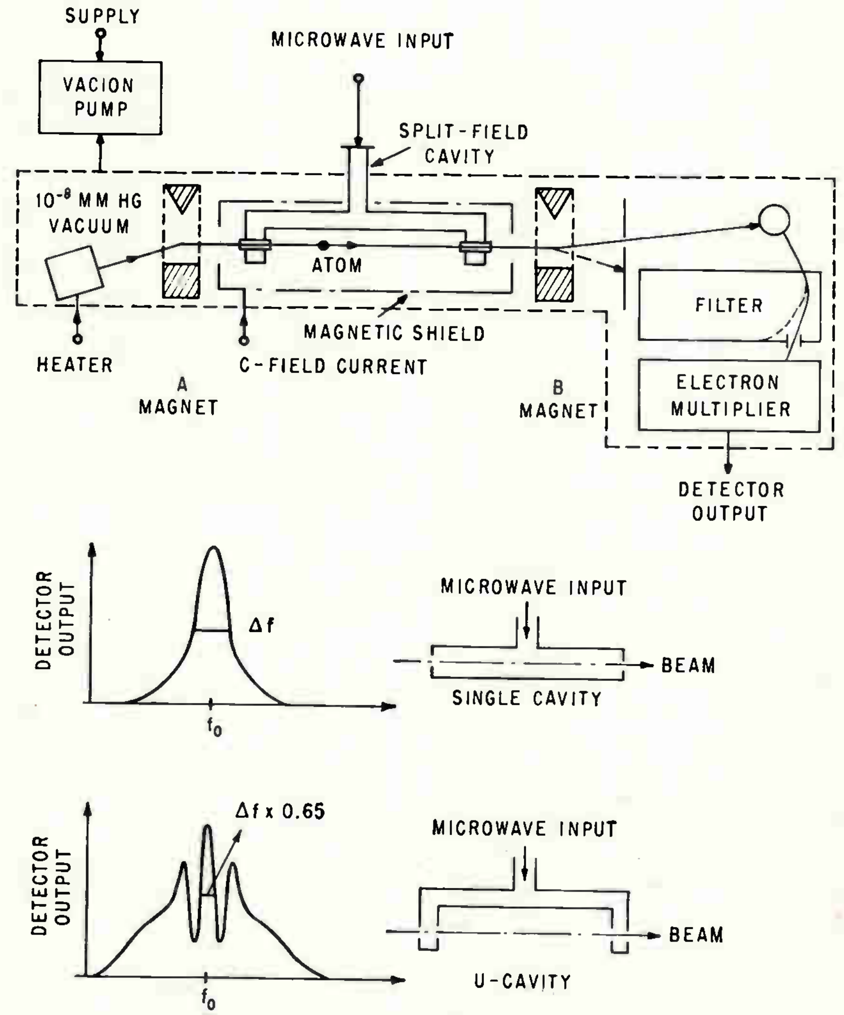
Technical problems remain to be solved. For example, some all-solid-state phase-stable frequency multiplier should be incorporated. Servo control needs improvement to increase short-term stability. It may be advisable to replace or bypass the motor driven capacitor tuning with electronic diode tuning to reduce gear backlash effects. Beam tube life should be increased from 10,000 to 50,000 hours. This requires better utilization of *Cs* to reduce *Cs* getter life time, an improved hot wire material free of potassium with reduced aging, and additional life testing of antimony getters.

There is still some problem with the stray fields of the permanent magnets that magnetize the beam tube. This calls for improved magnetic shields.

Beam tube fabrication techniques should be simplified to reduce fabrication costs by more than 50%.

CONSIDERATIONS — Every device should have at least 400 hours burn-in time to assure debugging. Stabilivac pumps are good only for small volume tubes. All other tubes should have magnetic Vacion pumps to assure long tube life and reliability.

Aquadag getters for expended *Cs* proved acceptable in only the NC1001 tubes. Aquadag alone or carbon-ring getters were not satisfactory in other tubes and often caused early tube failure. Aquadag apparently flaked off or satu-



CESIUM-BEAM *resonator and patterns for U-shaped cavities—Fig. 4* rated within several hundred hours, and carbon rings loaded the vacuum pumps excessively by releasing gases while absorbing Cs[12]. There is evidence that the combination of antimony and aquadag getters may solve this problem.

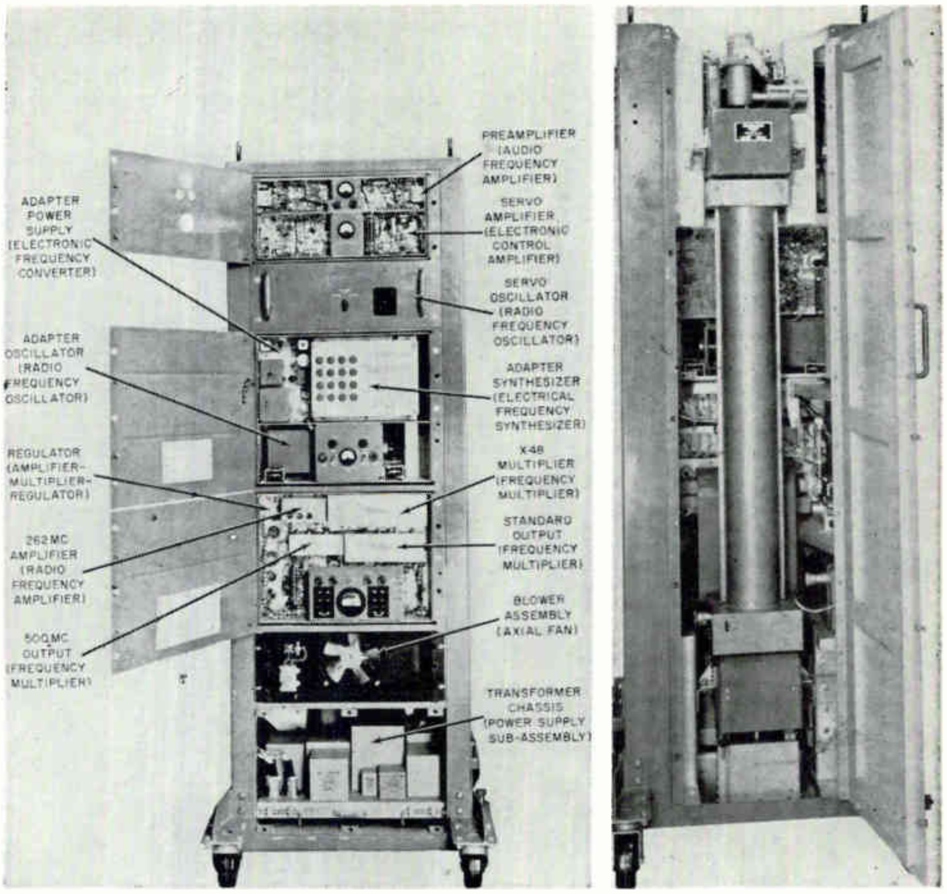
Milliammeters for monitoring the C-field current should be installed.

Replacements for dead beam tubes may either be new or rejuvenated tubes at some cost in life expectancy.

The NC1001 and NC1501 are best operated from line voltage regulators of the motor-driven variac type. Saturated-transformer types proved unsatisfactory due to wave distortion.

Deletion of the mass spectrometer from beam detectors is not desirable unless manufacturers can prove absence of potassium background in the detector. Otherwise erratic K^+ bursts may throw the system out of lock.

As in gas cell standards, the synthesizer should not be part of the main servo loop, the modulation should be highly linear, and the modulation frequency should be smaller than half the line width[8].



NATIONAL'S ATOMICHRON *frequency standard, internal views—Fig. 5*

APPLICATIONS—Atomic standards should be used whenever one of the following requirements must be met: accuracy better than 10^8, negligible aging, short warmup time (1 hour), smooth fine-tuning (10^{-11}) and high environmental insensitivity. In combination with klystron phase-locking techniques, atomic accuracy and stability can also be utilized in the microwave and mm-wave region[2]. In general, the choice of the proper standard for a specific application is: for highest accuracy and long-term stability, and for best temperature stability, Cs beam standard; for high short and long-term stability, and insensitivity to coriolis forces, Rb gas-cell standards; for highest short-term stability, NH_3 or H-masers.

All atomic standards are insensitive to static acceleration, but must be kept away from magnetic fields in excess of 2 gauss. Various applications comprise: Quick definition of the unit of time[4] and of standard frequencies up to mm-wave range. Measurement of rotation and revolution characteristics of the earth[13]. Measurements of electromagnetic propagation velocities[9] and microwave spectral lines, and application in relativity experiments[14]. Precision location of moving or steady objects, using either the doppler effect or widely separated synchronized clocks. This includes navigation[15], guidance, tracking[9], air traffic control[17] and communication.

CONCLUSIONS — Commercial atomic frequency standards have revolutionized the art of frequency and time control. Several models of Cs beam and Rb gas-cell frequency standards have reached the market now and have proven their practicability in a variety of laboratory[4, 10, 13] and field[8, 11] applications. Future applications, particularly as clocks in widely separated ground stations, in airplanes, and space vehicles will require an unusually high reliability and further size and weight reductions.[18]

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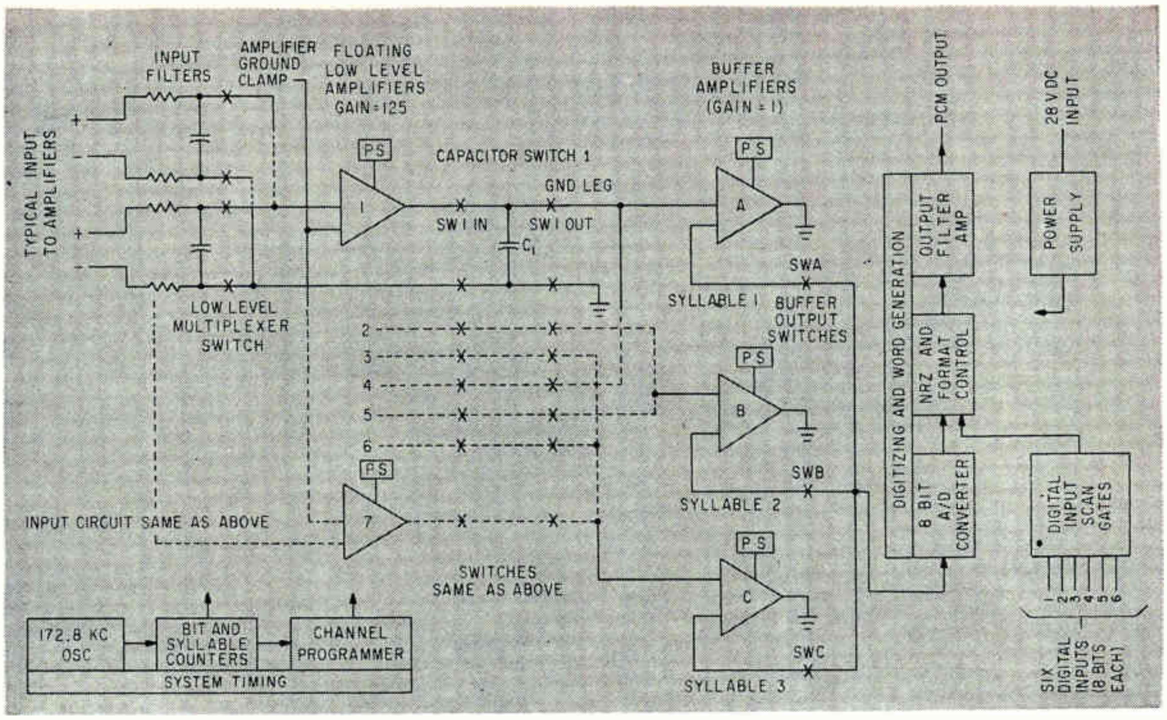

BLOCK DIAGRAM *of encoder; only two of seven amplifiers are shown—Fig. 1*

Low-Level Encoding Approach: Latest

A NEW SOLID-STATE pcm encoder, developed for the Titan II missile, accepts 196 analog and digital signals, and uses a unique low-level multiplexing switch that reduces the number of amplifiers required.

During the research and development phases of Titan II, it was found that approximately 250 parameters, ranging from millivolt analog signals to digital on-off signals, had to be monitored and transmitted during missile flight.

Previous telemetry encoders accepted only order-of-volts analog signals and required conditioning amplifiers for strain gages, thermocouples, accelerometers and other low-level signal sources.

The new encoder accepts 40-mv full-scale analog signals and has 160 μv resolution. Both sides of the input line are switched to the multiplexer because some of the strain gage bridges and thermocouples are connected to various voltage levels, and common-mode $\pm$5-volt d-c together with 1-volt a-c can be present.

Prior to digitizing, each channel line is filtered; also, because they contain high-frequency information, the input signals are sampled and held by a unit driven by a low-level amplifier.

SYSTEM OPERATION—The 196 low-level input signals are connected first to individual filters (Fig. 1), followed by the multiplexer. The channels are evenly divided among seven differential amplifiers. The amplifiers float positive or negative with the common-mode voltages, and amplify only the differential signal. Amplifier gain is 125.

Following the amplifiers are capacitor switches that perform the sample and hold function. As a channel is connected to the input of an amplifier, the input switches to the capacitor are turned on. The capacitor charges to, then follows, the output of the amplifier. Just prior to the disconnection of the input channel, the capacitor input switches are opened, and the capacitor retains a voltage equal to the instantaneous output voltage of the amplifier at the time of disconnect. During the previous cycle, the capacitor output switches were open, allowing both terminals of the capacitor to be driven to the common-mode voltage in the amplifier. As the input switches are disconnected, the signal source as well as the common-mode source are removed from the capacitor, leaving it differentially charged to the amplified signal level.

The capacitor output switches are then closed, connecting the capacitor to the inputs of a buffer amplifier having a high input impedance. The amplified signal is now referenced to ground through the ground leg switch, restoring the signal to a common reference level.

The buffers are amplifiers used in the potentiometric mode with an in-

HEARTBEATS OF A MISSILE

How many separate signals must be monitored continuously to tell how well a modern missile is doing in flight? For the Titan II, there are 250 such signals. And they range all the way from millivolt analog signals to digital on-off pulses of a volt or more.

This new encoder accepts all of them and converts them to a pulse-code-modulated multiplex signal for telemetering back to earth

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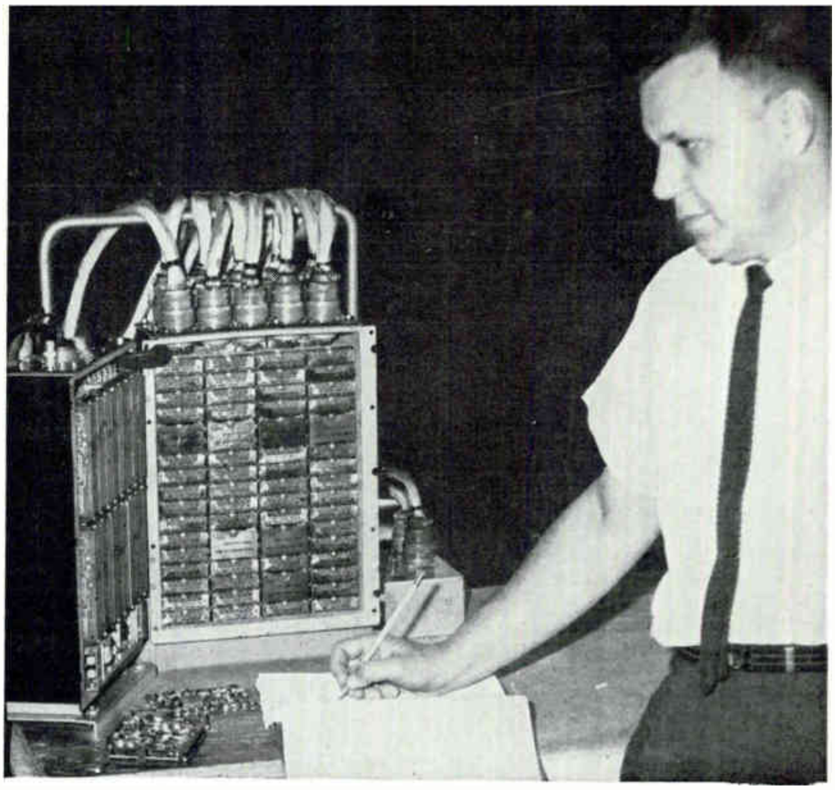
Cambridge, Massachusetts

All solid-state encoder accepts low-level signals, requires few amplifiers, multiplexes up to 196 channels. Unit is compact, lightweight, performed successfully in maiden flight of Titan II



AUTHOR PEGHINY *checks the telemetry encoder*

Details of Titan II Telemetry

put impedance exceeding 50 megohms. These amplifiers have a unity voltage gain and provide impedance buffering between the sample and hold and the A/D (analog-to-digital) converter.

OPERATING SEQUENCE—The timing for the analog section permits 3 channels to be multiplexed simultaneously, one each into amplifiers 1, 2 and 3. Their outputs are stored in capacitors 1, 2 and 3. Following this, three channels are connected to amplifiers 4, 5 and 6. While 4, 5 and 6 are being sampled, capacitors 1, 2 and 3 are read into the three buffers. The outputs of the three buffers are then serially switched to the A/D converter by buffer output switches *A*, *B*, and *C*. The cycle is then repeated from capacitors 4, 5, and 6 to the buffers.

Sampling rates for the 196 input channels, may be 20, 40, 100, 200 or 400 samples a second. Considering worst case tolerances on leakage current and capacitance due to the off switches, a maximum of 35 channels is multiplexed into a single amplifier.

The buffer output switches are followed by the A/D converter, where the analog inputs are converted to a digital codes and inserted in the NRZ (nonreturn to zero) and format control where the output format is assembled. At the proper time, the inputs from the digital input scan gates are inserted with the A/D output and the internally generated synchronization codes.

This combined output, or serial pcm pulse train, is sent to a 5-pole optimum-transient output filter which eliminates the sharp edges of the pulse train and attenuates the high-frequency contents of the driving signal. Each transition approximates a portion of a sinusoid.

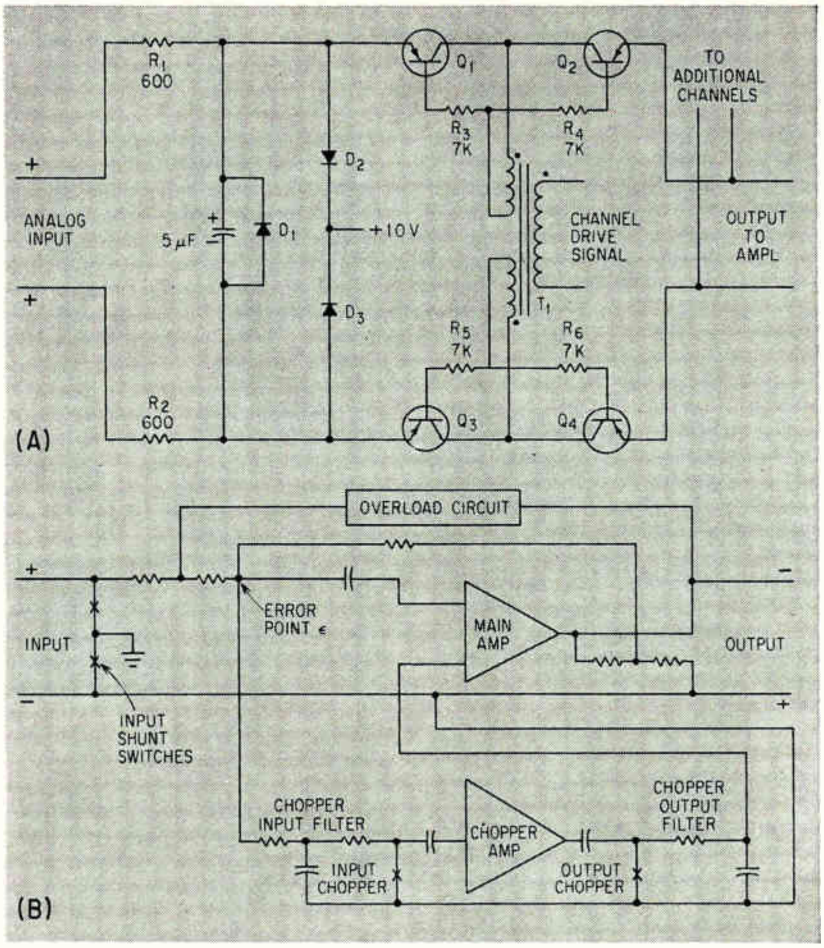
MICRO-MULTIPLEXER — The low-level multiplexer is a solid-state, high-speed, time-division commutator that connects a number of low-level inputs, one at a time, to a common differential bus. Each multiplexer channel consists of two transistor switch pairs (Fig. 2A).

Each switch leg consists of a pair of silicon transistors selected for matched V_{CE} characteristics. The offset voltage across a matched pair is within ±50 microvolts over a temperature range of −4 C to +60 C. For an individual transistor of the pair, V_{CE} is limited to 3.5 mv. This low V_{CE} value is obtained by operating the transistor in the inverted mode with collector and emitter operation reversed. Thus, greater stability is obtained with lower offset voltages and leakage currents.[1]

SHUNT SWITCH—To eliminate crosstalk, a shunt switch is employed between each amplifier input terminal and system ground. Between input samples, these switches are turned on for approximately 10 μsec to discharge all stray capacitances. Therefore, each channel, when multiplexed, is switched to an amplifier input bus with no charge on its stray capacitance.

Three low-leakage silicon diodes, D_1, D_2 and D_3, are contained in each multiplexer channel as shown in Fig. 2A. Diode D_1 limits the maximum reversed polarity voltage across the 5 μ F capacitor to 0.5 v to prevent damage to it.

With the combination of +20 volts fault on one side of an off switch and −5 volts common-mode voltage on the differential multi-



MICROMULTIPLEXER *as used in the encoder (A); low-level amplifier follows the multiplexing switch (B)*—*Fig. 2*

plexer output bus due to an on channel, the voltage across the switch transistors could be 25 volts. Since the maximum voltage ratings of the transistors are 22 volts, diodes D_2 and D_3 clamp the input to +10 volts, insuring that the maximum voltage across the switch is 15 volts or less.

LOW-LEVEL AMPLIFIER—The solid-state chopper is driven at 800-cps by a transformer. The amplifier is powered by a 6.4 Kc square wave coupled through another transformer. The amplifier contains the transformer and floating power supply, as well as input shunt switches that discharge the stray capacitances present on the input lines between multiplexer samples.

The chopper amplifier (Fig. 2B) regulates the operating points within the main amplifier to maintain a low offset and low output drift. The d-c voltage fed to the error point of the amplifier is filtered, chopped to ground to create an 800-cps square wave a-c coupled into the chopper amplifier, amplified 2,000 times and a-c coupled to the output chopper that restores the d-c level. The signal is then filtered and applied to one side of the differential input stage of the main amplifier.

The a-c portion of the error point is capacitively coupled into the other side of the differential input stage, where it is mixed with the amplified d-c signal. The forward gain of the amplifier is 125, giving an output swing of 5 v for a 40-mv input. The loop gain to pulsed d-c signals is 2,000, whereas the loop gain to steady state d-c is over 4 × 10^6 due to the high gain of the chopper section.

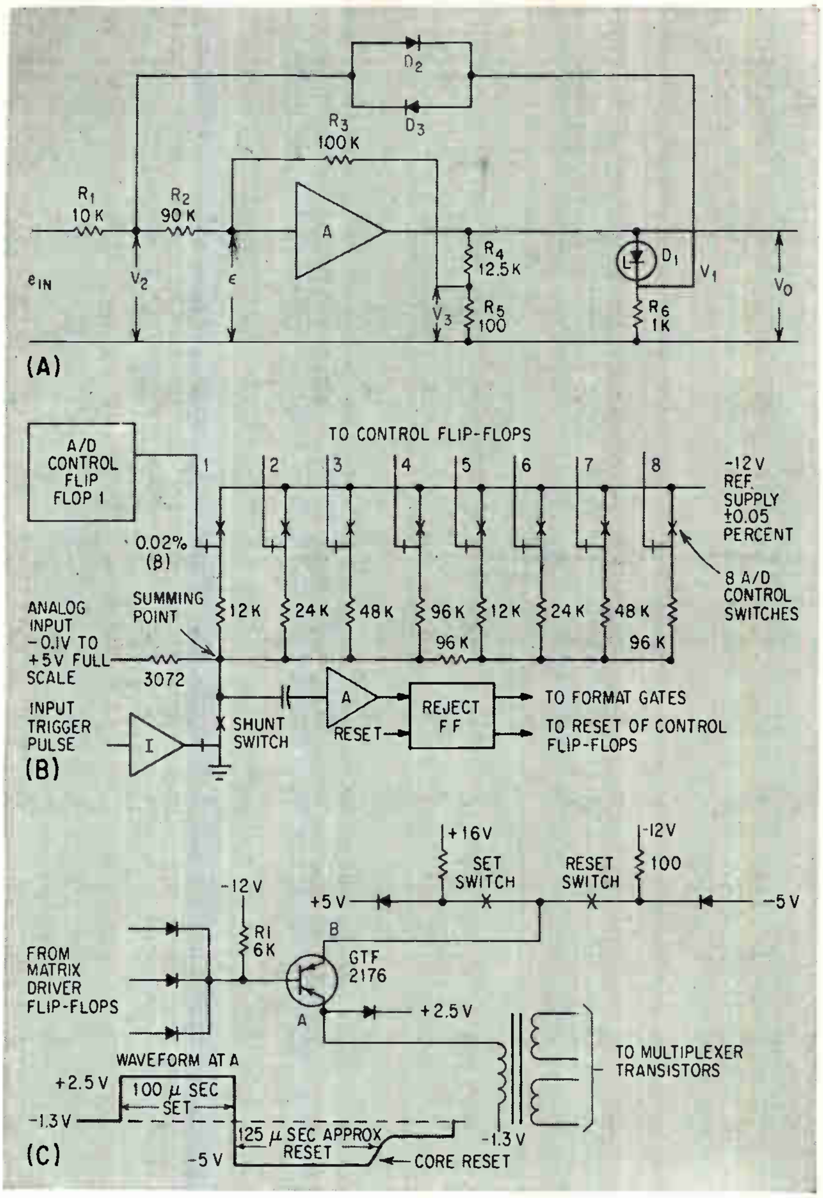
The overload circuit consists of a 6.8-volt zener diode that shunts the output and feedback diodes that limit the input, as shown in Fig. 3A. With input signals of 40 mv or less, the output V_o is −5 volts or less. Diode D_1 is therefore biased off, as are D_2 and D_3. The only feedback is through R_4, R_5 and R_3, which establish the gain of 125. Once the input approaches 54 mv, the output will approach −6.8 volts, causing D_1 to break down in the reverse direction. Voltage V_1 will increase to about −0.5 volt, or until D_2 starts conducting. Equilibrium is reached with E_o = −6.8 v, ϵ = 0, V_1 = −0.5 v, V_3 = −54 mv and V_2 = 49 mv, regardless of V_{in}. If V_{in} goes negative, the output swings positive until it reaches the point where D_1 and D_3 are both forward biased, causing the output to clamp at about 1 v. The new equilibrium voltages will be V_o = 1 v, ϵ = 0, V_1 = 0.5 v, V_3 = 8 mv, and V_2 = −7 mv, regardless of V_{in}. Diodes D_1, D_2 and D_3 therefore act to clamp V_o at −6.8 v and 1 v and maintain linear voltage relationships within the amplifier, preventing its saturation, and allowing recovery from overloads.

BUFFER AMPLIFIER—The buffer amplifier is an impedance transform device, with a gain-of-one connected in the potentiometric mode.[4] It presents an impedance greater than 20 megohms to the capacitor to reduce the droop to a negligible amount while the output is connected to the A/D converter.

The chopper stabilized buffer amplifier contains a floating power supply. As in the low-level amplifier, this chopper is solid-state. The amplifier has a loop gain of over 2,000, a bandwidth of 200 Kc and sets to within 0.05 percent of final value in less than 12 μsec.

The buffer amplifier module contains a shunt input switch for discharging stray capacitances between intervals when the follow-and-hold capacitor is connected to it, and a series output switch to connect the amplifier to the A/D converter.

A/D CONVERTER—The converter, a successive approximation type, provides 8-bit resolution and requires approximately 6 μsec per bit. Figure 3B is a simplified diagram. The analog input from the buffer amplifiers is compared at the summing point with the sequential outputs from the A/D control switches. The control switches are connected to the reference supply, which is −12.000 v d-c, ±0.05 percent. First switch No. 1 is closed by the A/D control *FF* 1. After approximately 4.5 μsec the input trigger is applied which clamps the



OVERLOAD CIRCUIT *for the low-level amplifier (A); analog-to-digital converter (B) and multiplexer driver (C)—Fig. 3*

summing point to ground. If the voltage at the summing point were negative, this would indicate the effective weight of the switch exceeds that of the analog input. The reject flip-flop is operated and switch No. 1 is turned off. This sequence continues for each switch. Each time the reject flip-flop operates, a zero is sent to the output logic. At the end of 8 bits, the digitizing for a particular channel is complete, another channel is connected to the input and the process repeated.

POWER SUPPLY—The power supply provides 12 regulated voltages for use throughout the system. The input of 28 v d-c is filtered, regulated and converted to 6.4 Kc by a flux oscillator. The 6.4 Kc drives a transformer whose secondary windings are rectified to provide the system voltages to an accuracy of ±5 percent.

DIGITAL LOGIC—The logic is conventional, employing clamped transistor flip-flops which drive diode AND-OR gates. The voltage swing for the logic elements is 0 to −5 volts, which permits a maximum of three gating levels between elements. The decoding matrix for the multiplexer transformer consists of a diode matrix that drives bilateral transistors. The transistors are similar to core memories drivers. A simplified drive circuit is shown in Fig. 3C. The input diode AND gate is driven directly from the matrix driver flip-flops, whose output levels are +7 v and −5 v. To set a core, the SET SWITCH is turned on, and point *B* is connected approximately +5 v through the diode clamp circuit. As the AND gate is enabled, the transistor is turned on, with point *A* swinging positive, its swing limited to approximately 2.5 volts by the diode clamp. Thus the drive circuit is regulated to within ±10 percent. The voltage across the transformer is 2.5 v plus 1.3 v plus the diode drop of approximately 0.8 v, or a total of 4.6 v. During the reset period, the base circuit remains enabled; however, the SET SWITCH is turned off and the RESET SWITCH energized, connecting point *B* to −5 v through another clamp circuit.

In this mode, the transistor acts as an emitter follower, with point *A* the emitter. Point *A* is held at approximately −5 v until the core flips, at which time the clamp circuit at point *B* disconnects and swings to approximately −1.3 v. This clamp circuit limits the reset current after the reset of the core flux. The set circuit is also driven through a clamp circuit as a safety precaution.

DIGITAL FUNCTION INPUTS—The 48 digital functions are time scanned eight at a time by diode gates that set an 8-bit flip-flop register. At the proper time the register is shifted into the output pulse train.

The outputs of the A/D converter, digital inputs and the synchronization are combined and drive a flip-flop that generates an NRZ code with a time jitter of less than 0.1 μsec. The NRZ type C code drives the five-pole optimized transient filter. Overshoot is less than 0.3 percent. This filter has a response characteristic such that when alternate 0 and 1 combinations are present, the output approximates a sine wave. The bandwidth requirements of the vehicle transmitter are thus greatly reduced.

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Inexpensive Monitor Reads

High-gain amplifier-microphone combination detects pulse beats and feeds them through a shaper-circuit to hold-relays that lock pressure gages at systolic and diastolic blood-pressure readings

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THE SYSTOLE is the normal rhythmical contraction of the heart, which drives the blood into the aorta and the pulmonary artery. The diastole is the rhythmical dilation of the heart following each contraction, during which the heart muscle relaxes and its chambers fill with blood.

The systolic and diastolic blood pressures are measured by placing a cloth-enclosed rubber bladder, called an occluding cuff, around the patient's arm at the bicep. The bladder is then inflated with air to a pressure greater than the patients systolic pressure. At this point arterial blood flow in the patient's arm is stopped due to the bladder pressure. The bladder pressure is then decreased by slowly letting the air escape from the bladder. At the point where bladder pressure equals the systolic pressure, each contraction of the heart overcomes bladder pressure and forces blood to flow in the artery.

When the bladder pressure has decreased further to the diastolic pressure, each dilation of the heart has sufficient pressure behind it to open the artery for the flow of blood. This provides the minimum pressure necessary to keep the artery continuously open. The artery wall therefore pulsates at heart-beat rate from the point at which bladder pressure equals the systolic pressure to the point at which bladder pressure equals the diastolic pressure. Above the systolic pressure no blood flows and there is no arterial wall pulsation. Below the diastolic pressure the artery is not constricted and no arterial wall pulsation occurs.

In conventional use, a pressure-measuring manometer indicates the pressure in the bladder. An attendant places a stethoscope over the patients brachial artery and listens to the pressure pulsations or the Korotkov sounds at the surface of the arm. The attendant notes the bladder pressure reading when the first pulse is heard, (systolic pressure) and the bladder pressure when the last pulse is heard (diastolic pressure).

SYSTEM DESCRIPTION—This automatic indicator performs not only the function of the attendant listening with a stethoscope to the Korotkov sounds but also stops the meter movement of one manometer at the systolic pressure and stops the meter movement of a second manometer at the patient's diastolic pressure.

The Korotkov sounds are picked up with a dynamic microphone followed by a high-gain low-noise transistor amplifier. After the cuff and the pickup are attached to the patient's arm, the OPERATE button actuates a relay that both applies power to the tracking unit and opens an air release valve allowing air to escape from the bladder.

The pressure in the bladder is continuously monitored by two aneroid manometers. Pressure recordings are made by stopping the indicating pointer with a relay, which presses a strip of metal attached to its armature against the shaft of the pointer. The pressure of the metal strip against the pointer shaft is sufficient to stop the pointer movement and the indicator retains the value of bladder pressure when the relay was actuated.

Automatic tracking of the diastolic presssure presents a problem because the Korotkov sounds grow weaker as the pressure in the cuff is lowered. The last sound is barely detectable amidst the background noise. Sensing unit output indicates on an oscilloscope that the pulses first heard are large and of long duration but that the last two or three pulses are extremely small and relatively narrow.

PROCESSING HEART BEATS—The problem of nonuniform pulses is overcome by feeding the output of the sensing unit into a one-shot multivibrator to provide pulses of uniform height and width. The triggering level of the pulse-shaping one-shot also serves as an amplitude discriminator, eliminating the background noise. A pulse train is then available, the first pulse oc-

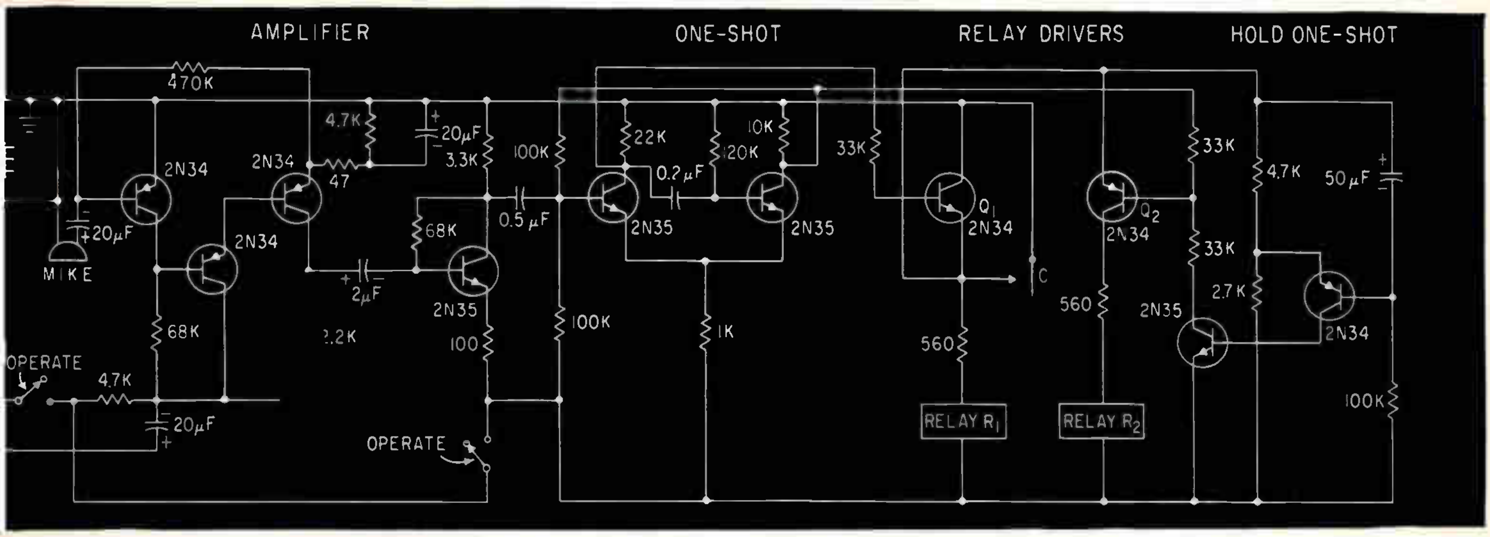
AUTOMATION IN MEDICINE

Usually a physician or skilled nurse takes blood pressure readings by pumping up a bladder fixed around the patient's arm, then letting the air out gradually and listening for pulse beats.

With this mechanized technique, the patient can take his own blood pressure. He doesn't need lots of skill or years of training. The idea might be extended for victims of high blood pressure, who could thereby determine whether another round of golf would be just permissible, or drastically injudicious.

The idea will also dispense with a medic's vigil at the patients hospital bedside while the air-filled bladder slowly deflates. Now the attendant can get on with other work

Blood Pressure Automatically



POINTERS *of gages are locked when pressure in air-filled bladder encircling patient's arm falls to level of patient's systolic and diastolic blood pressures. Relay R_1 locks systolic pointer; R_2 keeps diastolic pointer normally locked, releases it once per pulse-beat to take up new pressure reading. Last audible beat leaves pointer at diastolic pressure*

curring when the bladder pressure is equal to the systolic pressure, and the last pulse when bladder pressure is equal to diastolic pressure.

To detect the systolic pressure, the first one-shot pulse energizes relay, R_1, which stops the movement of the systolic-pressure manometer. The relay is self-locking. Further pulses from the one-shot do not affect the relay and only the reset button can denergize it.

The detection of the last pulse is more difficult because if the device searches for another pulse after the last audible pulse is received, then the diastolic pressure reading will be in error by the bladder pressure drop during the search interval.

Therefore the diastolic pressure is recorded by sampling the pressure in the bladder every time a pulse appears. The diastolic pointer is normally locked by the metal strip attached to the diastolic relay armature R_2. (The diastolic relay is normally energized). When a pulse appears, the pointer is released and falls to the bladder pressure. Since the pointer is spring loaded, it falls to the new pressure in less than 50 milliseconds. The one-shot pulse length is 100 milliseconds, so the pointer is able to follow the bladder pressure accurately. The schematic shows how this operation is performed.

CIRCUIT FUNCTIONS—The on-off switch applies power to the high-gain amplifier but not to the tracking unit. This prevents the device from detecting pulses when the occluding cuff is being pumped up. The OPERATE switch applies power to the tracking unit and actuates the bladder air-release valve.

Both transistors Q_1 and Q_2 are initially off. Relay R_1 holds the systolic pointer and R_2 holds the diastolic pointer.

Both monitors read the falling bladder pressure until the first (systolic) pulse is heard. At this time relay R_1 is actuated, stopping the systolic pointer. Contact *C* closes, locking up relay R_1. Further pulses do not affect this relay, leaving the pointer to indicate systolic pressure.

Closing contact *C* connects the emitter of Q_2 to ground. Transistor Q_2 remains off as the base of Q_2 is connected to the other side of the pulse-shaping one-shot. At the end of each diastolic pulse, transistor Q_2 turns on, actuating relay R_2 and stopping the diastolic pointer. Succeeding pulses turn Q_2 off, releasing the diastolic pointer and allowing it to fall to the new pressure in the bladder. After the pulse disappears Q_2 turns on and the diastolic pointer is held at the bladder pressure in the cuff at the time the pulse was received.

The last audible pulse corresponds to the diastolic pressure. Since there are no more pulses to release R_2, the diastolic pointer continues to indicate the correct diastolic pressure.

To ensure that the patient's arm movement in removing the cuff does not disturb the diastolic reading, a hold one-shot is included. After a short time-delay this hold one-shot locks up relay R_2 so that external noises are not picked up.

CONCLUSION—This device has been tested at the Rensselaer Polytechnique Institute Biomedical Research Laboratory and has been shown to be as accurate as recording manometers. The technique of holding the diastolic movement at the pressure corresponding to the last pulse is the key to the reliable recording of the diastolic pressure. The instrument can be built for less than twenty-five dollars.

PNP-NPN CIRCUITS: NEW LOOK

Regenerative devices using pairs of transistors of opposite polarity can out-perform specialized devices in speed, reliability and flexibility. Specific circuits are given

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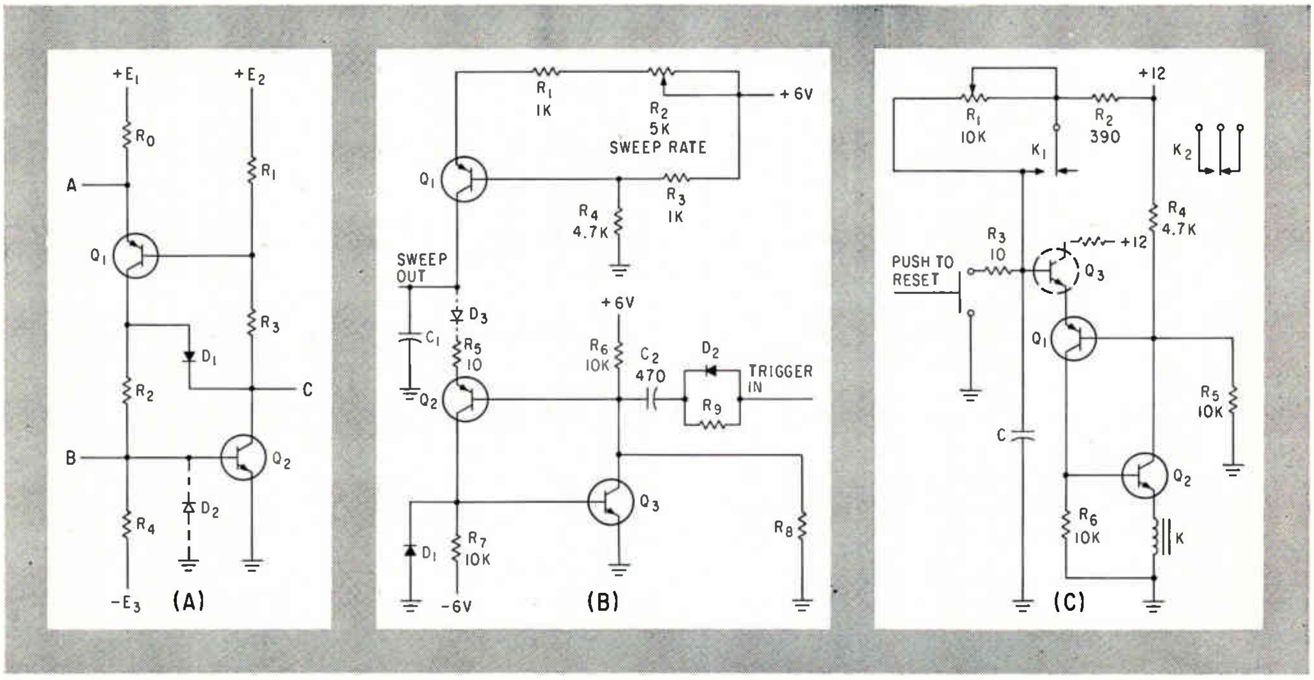
FOUR-LAYER PNPN diodes and related devices have certain common characteristics that severely limit their usefulness. Two of these are the difficulty in turn-off and the long turn-off time that result from saturation occurring if any significant current is passed in the on state. Another practical limitation is price: because of manufacturing difficulties such as obtaining a good base lead, the cost of triode units is high. The *pnpn* diodes, on the other hand, are cheaper, but far less flexible because the load and trigger terminals are identical. Prices are also high because silicon devices must almost always be used to allow stable operation at temperatures as low as 100 C. This is attributable to leakage currents that raise the current gains to the +1 level. Since only one base lead is brought out, I_{co} cannot be prevented from becoming excessive through amplification in the inaccessible base region.

However, another regenerative device can be made by using separate *pnp* and *npn* transistors in a two-stage positive-feedback circuit. This combination in simplest form is directly analogous to the hook collector; hence is generically the same as *pnpn* devices. The point-contact transistor and the unijunction transistor operate in related but slightly different ways, differing mainly in their geometries. The regenerative pair also can be evolved by making an Eccles-Jordan flip-flop with a *pnp* transistor on one side and an *npn* on the other, then simplifying the biasing circuit. In such a device, the regenerative pair performs the desired functions but, without improvements in biasing and without means of preventing saturation, the only significant advantage that the pair has over the other devices is the accessible second base. Figure 1A shows a means of reverse biasing that makes it possible to operate these circuits to the full temperature rating of the transistors just as easily as in the usual logic stages. The biasing voltages are derived from sources E_2 and E_3 through the associated resistors R_1 and R_4. In design, the combined leakage currents are calculated for the highest desired operating temperature, and the voltage sources and resistors selected to prevent thermal turn-on of a stage normally off at this temperature.

In high-speed transistor circuits, a serious limitation arises if the



BASIC PNP-NPN *stage (A) in applications such as a sweep generator (B) and an interval timer (C)—Fig. 1*

AT A FAMILIAR CONNECTION

transistors are allowed to saturate. Saturation occurs when the collector-base voltage is small. Then the depletion region vanishes and charges in the base region are not swept out by the collector; instead, they must slowly diffuse out of the base. If means are provided to prevent the collector-base voltage from becoming too small, saturation will be avoided.

To prevent saturation, diode D_1 is included in the circuits with resistors R_2 and R_3. With a perfect diode, neither transistor can become saturated. This permits high-speed operation. Moreover, because of the direct base drive, momentary overdrives are permitted to reduce the collector voltages below their unsaturated steady state ON levels. These characteristics are advantageous in interstage triggering for rings and related circuits.

Diode D_2 is connected across emitter-base junction of transistor Q_2, as shown in Fig. 1A, to clamp the off base voltage of that transistor to a small back level. This facilitates triggering with small signals, capacitively coupled into terminal B, and also prevents excessive reverse voltage across the emitter-base junction of Q_2.

This basic circuit not only can be turned on with excellent rise time, but can be turned off and recycled at speeds limited only by the basic speed of the transistor and the time constants of the associated circuit. With transistors having 5-Mc alpha cut-offs, reliable ring operation has been attained at frequencies exceeding 1 Mc. Although there are numerous *pnpn* devices on the market that turn on in about 0.1 μsec, the maximum pulsing rate of these is little over 80 Kc.

As is characteristic of the *pnpn* devices, this circuit consumes minimum standby power because the circuit current is almost entirely determined by the external load and the supply voltage. In the off state, only leakage currents are drawn. Further, the negative resistance characteristic at the emitter of Q_1 is much like that of a thyratron, except that the transient current is accurately predictable

$$I_{\text{emitter of } Q1} = (E_3 - E_B)/R_4$$

The steady-state current also is given by this expression, since the turn-on and holding conditions are the same. Because of this, there is an almost vertical change in voltage along the negative resistance region of the voltage-current curve of the transistor, corresponding to the transition from the off to the on condition. In the off region, the current can be as small as the I_{co} currents of the two transistors. In the ON region the voltage-drop is small, limited only by the drops across the resistors.

If minimum recovery time is not required, and if the nonsaturated on condition is not needed for interstage priming, diode D_1 and resistors R_2 and R_3 can be omitted.

NEW LIFE FOR OLD CIRCUITS

When pnpn devices were introduced, some complementary transistor circuits went into decline. However, recent investigation shows that complementary transistor circuits can be superior to pnpn devices in temperature stability, turn-on point stability and operating speed

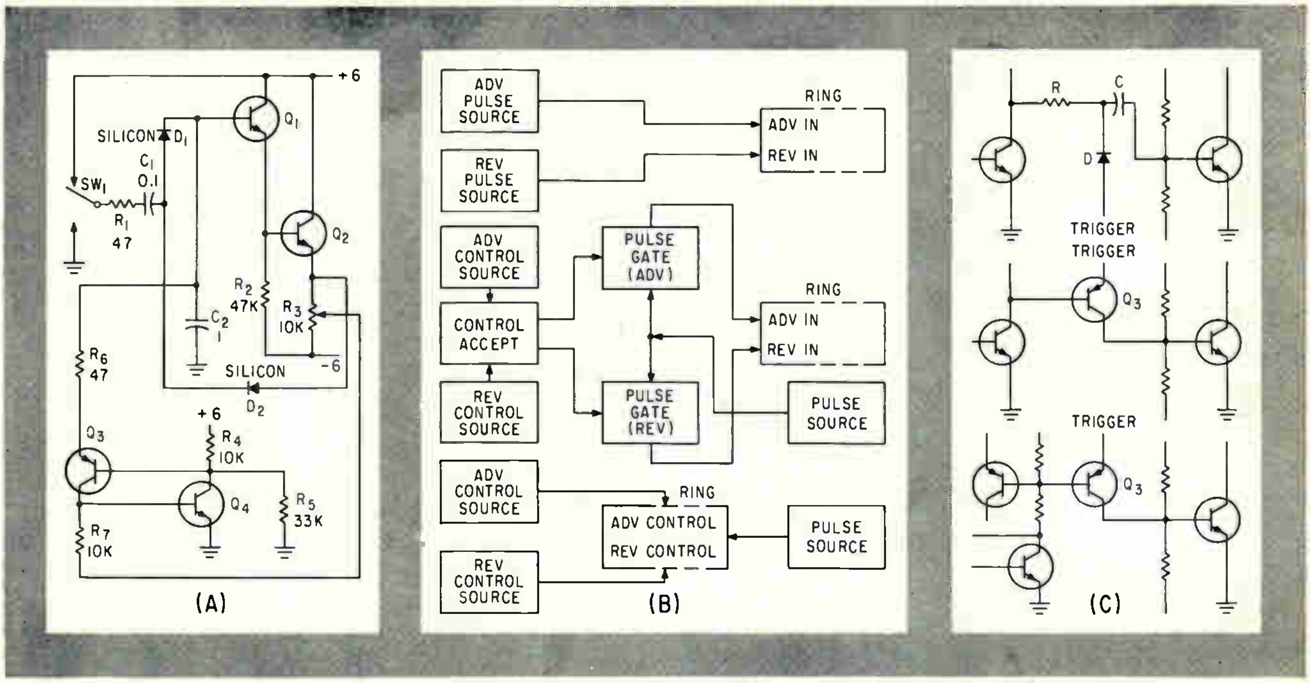
SWEEP GENERATOR—Figure 1B shows a fast-reset sawtooth generator. Transistors Q_2 and Q_3 form the *pnp-npn* pair. Transistor Q_1 is a constant-current charging source for capacitor C_1, the rate of charge being determined by resistors R_1 and R_2. Since transistor Q_1 is in a common-base configuration with an emitter current determined by resistors R_1 and R_2, the apparent source impedance for the collector current of transistor Q_1 is high. With the emitter of transistor Q_2 reverse biased, the collector current of transistor Q_1 produces a nearly linear voltage ramp on capacitor C_1. If extreme linearity is not needed, a simple resistor that permits the capacitor to charge to some voltage preferably over +6 volts, may be substituted for resistors R_1, R_2, R_3, R_4 and transistor Q_1. If the voltage on capacitor C_1 becomes sufficiently positive to forward-bias the emitter of transistor Q_2 the collector current of that transistor, flowing through resistor R_7, becomes large enough to cause the base voltage of transistor Q_3 to become positive and to reverse-bias diode D_1. This value is given by

$$I_{C2} = \frac{6}{10{,}000} - I_{Co3}$$

In this equation, I_{C2} is the total collector current from transistor Q_2 and I_{Co3} is the collector cut-off current for transistor Q_3. At this point, regeneration drives the two transistors far into the ON region. Resistor R_5 limits the surge current upon discharge of capacitor C_1 through transistors Q_2 and Q_3. Transistor Q_1 cannot be damaged as long as the charging current is limited so that the power calculated from the following equation does not exceed the transistor dissipation after derating for the ambient temperature

$$P_{C1} = I_{C1} \times \frac{R_4}{R_3 + R_4} \times 6 \text{ volts}$$

By choice of the resistor R_8, a wide range of trigger points can be selected. In fact, if resistor R_8 is made adjustable or if a reference voltage is substituted for the +6 volt connection to resistor R_6, the trigger voltage level can be variable. For free-running operation, the maximum value of the voltage across capacitor C_1 must exceed the voltage established on the base of transistor Q_2 when transistors Q_2 and Q_3 are off. For triggered operation, the maximum voltage on capacitor C_1 must be smaller than this base bias. In the triggered mode, capacitor C_2, diode D_2 and resistor R_9 form a triggering network that momentarily depresses the voltage on the base of transistor Q_2 to initiate the regenerative action. In the free-running mode, synchronization can be achieved with input triggers as it



FURTHER REFINEMENTS *produce a staircase counter (A); three modes of ring-counter operation (B); interstage networks for ring counter operation are illustrated in (C)—Fig. 2*

is with thyratron sweep generators. However, the trigger amplitude will determine how soon in the sweep there can be a reset. For example, if a trigger pulse of 1 volt is applied to the base of transistor Q_2, the *pnp-npn* pair will not fire unless the voltage on capacitor C_1 exceeds approximately 1.5 volts.

Control of the free-running frequency of the sawtooth generator is easily accomplished by modifying the charging rate of capacitor C_1. A resistor or other current path connected to either the emitter or base of Q_1 will provide control.

The free-running generator frequency is nearly proportional to the base voltage and the emitter current of transistor Q_1. Hence, it is an excellent voltage-to-frequency converter with good linearity.

A change from the triggered mode to the free-running mode can be accomplished by increasing the resistances of R_1 or R_6 or by decreasing the resistances R_3 and R_8.

To preserve the high source impedance provided by transistor Q_1, the output should be matched with a high input impedance amplifier.

When the reverse emitter-base voltage of transistor Q_2 may be excessive, a diode D_3 can be connected in series as shown to block the inverse voltage.

Circuits similar to those shown in Fig. 1B have been operated at frequencies ranging from 60 cps to over 1 Mc and have been tested for a range of temperatures from room temperature to 65 C.

A triggered mode that is normally on, but off if triggered would be accomplished by having the charging current greater than the required holding current of transistors Q_2 and Q_3.

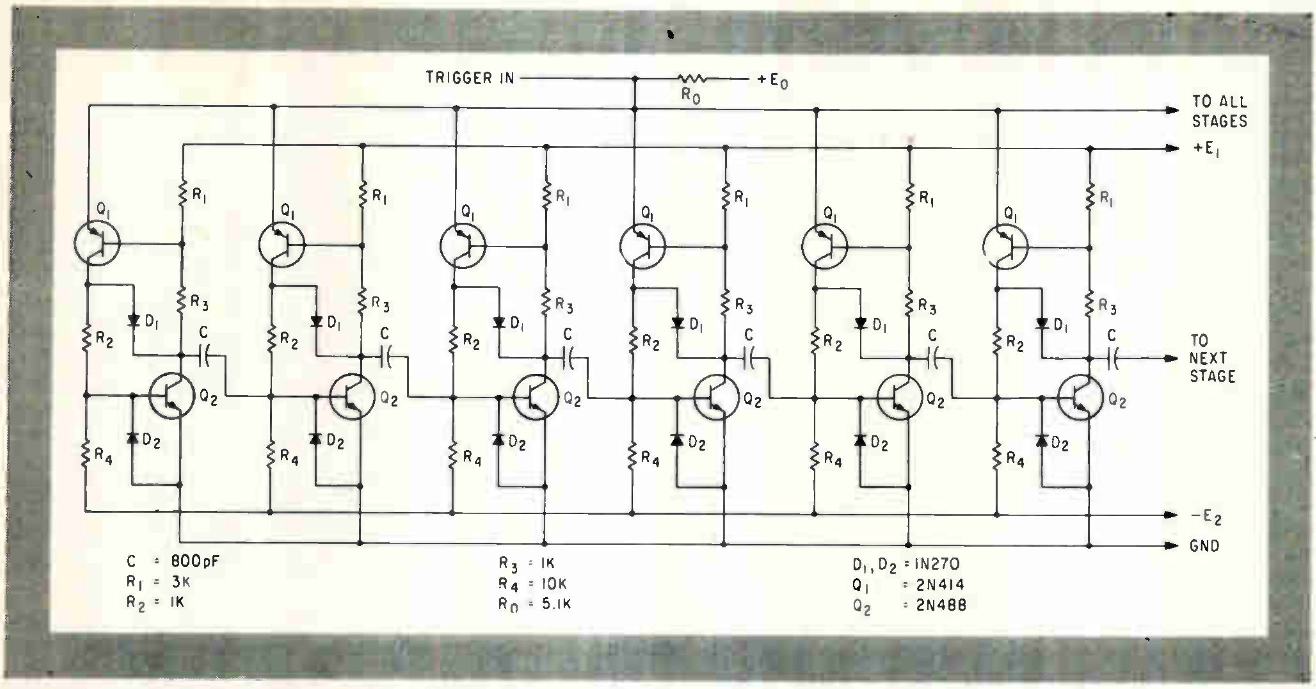
INTERVAL TIMER—The interval timer shown in Fig. 1C is similar to the sawtooth generator. In fact, a sawtooth voltage function is observable across capacitor *C*. Since the relay *K* is chosen so that the current surge after the triggering of transistors Q_1 and Q_2 is sufficient to close the contacts, the front contacts K_1 can be used to maintain latch-up, if desired.

The time-out interval can be aborted by negative pulsing of the base of transistor Q_1. Conversely the time-out interval can be extended at any instant before the final one by quenching the stored charge on capacitor *C* with the reset pushbutton or any other appropriate means. A variety of time intervals can be provided by paralleling the capacitor *C* with other capacitors, the sum of the capacitances determining the interval. One convenient setup is that of a binary sequence of capacitance values to allow integral changes in the selected time interval, the duration of which is determined by the sum of the resistance of R_1 and R_2.

A holding current is provided through resistor R_2 to keep relay *K* energized. It is preferable to keep the timer relay latched in this manner rather than by a direct latch-up to coil *K*, since an immediate pushbutton reset then is possible. Recycle time accuracy is thus preserved. If great recycle time accuracy is not required, recycling can be accomplished by momentary interruption of the power, by grounding of the base of the base of transistor Q_1, or by disconnecting coil *K* from the circuit.

Sensitivity to power-supply variations is slight because all important parameters, such as rates and trigger voltages, are directly proportional to the supply voltage. For long intervals and ordinary values of capacitor *C*, transistor Q_1 may be preceded by an *npn* silicon transistor emitter follower, designated Q_3. No resistance is required in series with the emitter, since transistor Q_1 is a *pnp* type. This circuit is superior to similar ones containing unijunction transistors in that reset is quicker because of the method of latch-up. A current-limiting resistor in the collector lead of transistor Q_3 protects both Q_3 and the power supply when the circuit triggers.

STAIRCASE COUNTER—In Fig. 2A, an analog or staircase counter



ANODE-TRIGGERED *ring counter, triggered by coupling emitters of transistors Q_1 to common bus. This arrangement permits both forward and reverse operation—Fig. 3*

is shown. Transistors Q_1 and Q_2 are parts of a bootstrap amplifier for the voltage on storage capacitor; C_2, an incoming pulse will transfer a charge increment from capacitor C_1 to capacitor C_2. Without the bootstrap, succeeding pulses cause a logarithmically decreasing increment. With the bootstrap, there is a constant increment until the instant the device is reset.

Reset occurs because of the actions of transistors Q_3 and Q_4, the regenerative *pnp-npn* pair. Resistors R_4 and R_5 determine a reverse bias between the emitter and base of transistor Q_3. Reset is initiated by the rise of voltage across resistor R_3. When this voltage crosses zero, transistor Q_4 starts to conduct. The resulting drop in the base voltage of transistor Q_3 causes it to conduct. This opens a path to ground through transistor Q_3, through which capacitor C_2 can discharge. Resistor R_6 limits the resulting current surge.

If a leak resistor or a constant-current discharge circuit is connected from capacitor C_2 to ground, or to some point of negative potential, the circuit becomes frequency sensitive; it will fire only if the input rate is high enough. To economize, transistors Q_1 and Q_2 could be omitted and the anode of diode D_2 could be grounded. A logarithmic charging voltage against frequency characteristic is then obtained. Voltage control of the count can be obtained by substitution of an external voltage and series resistor for resistors R_4 and R_5.

With the circuit shown, the count is independent of rate for a range of rates from 1 cps to several hundred cps. The count can be adjusted by changing resistor R_3. For optimum performance at other than the 10:1 input to output count ratio assumed for the discussion, the ratio of the capacitances C_1 and C_2 can be changed.

If the input pulse is not constant in amplitude, the charge transferred will not be constant and a count variation may occur.

Reliable counts as large as 10 are obtained easily. Counts of 25 have been obtained, but to do this, power supply stability has to be carefully maintained.

RING COUNTERS—Through the *pnp-npn* pair, the designer of ring counters can achieve a reduction in power requirements, improved load capacity, high speed, and a simplification of circuits. As a result, there would be an impressive improvement in the capabilities of ring counters, both unidirectional and bidirectional. These would include driving speeds in excess of 100 Kc with only two transistors per stage of the ring; driving speeds in excess of 1 Mc with three transistors per stage of the ring; several modes of forward-backward operation from two streams of pulses, one stream for advance and the other for reverse; and forward-backward operation from one stream of pulses, with direction reversal on command. Various modes of ring operation are shown in Fig. 2B. The delay in turn-off of the silicon switching components is fairly long. Although such components can be turned on in microseconds, there is a much longer delay in turn-off because there is no way of preventing saturation, especially if large currents have been passed in the ON state.

These circuits have minimal power requirements in that the power consumption is proportional to the load. In contrast, the power requirements of conventional flip-flop rings are proportional to the number of stages and virtually independent of the load. The power requirements of the circuits are almost independent of the number of stages in a ring because little power is absorbed in the off state.

The design of the basic stage depends on the negative resistance obtained in the hook collector connection.[1] If the measurements were performed on the emitter of the *pnp* transistor, it would be found to have an *n*-type negative-resistance characteristic, similar to that of a point-contact transistor. With a common load line to permit only one stage to conduct at a time, and with proper interstage priming or steering, ring-counter performance is obtained. This method is superior to the use of a single transistor per stage with interconnections to allow only one stage to be on, especially with large rings. As the number of stages is increased[2], the complexity becomes great and the operating margins become small. Moreover, the addition of stages increases the complexity of each basic stage, while in using these methods, the addition of stages in no way increases the complexity of the basic stage.

It is possible for a thyratron ring initially to have none of its stages on, so that it must be set or started. This effect also may occur in the ring circuits since the common anode current must be limited if only one stage is to be on. Any division of the total anode current among the stages such that no stage is fully on, even though it is conducting current, will allow all stages of the ring to be in the same state. This quasi-off condition of a stage is possible because the *pnp* emitter from the common anode line may be forward biased to a slight degree without turning the *npn* grounded emitter stage on at all; that is, the collector current from the *pnp* is not sufficient to turn on the *npn* stage.

This effect may be circumvented by providing either a start trigger, reset trigger or a sufficient collector-to-ground conductance for any chosen stage.

The circuits presented are superior to those of King[3] in their simplicity and speed, if the transistor types are the same.

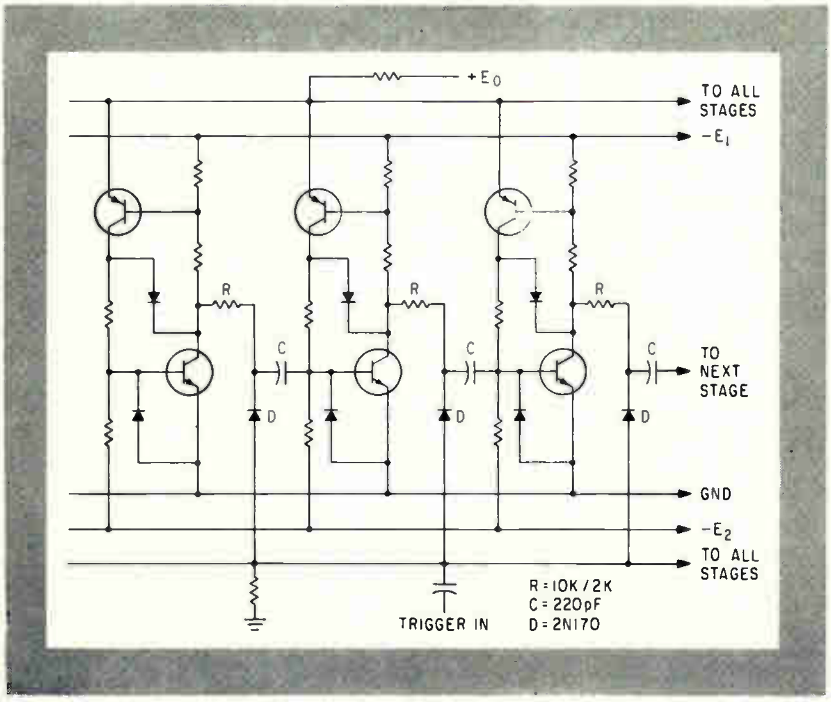
Output power is determined by the signal beta factor, the base drive resistances R_2 and R_3 (Fig. 1A) and the on emitter current of transistor Q_1. Assuming the worst case in which the beta factors may be as small as 10, currents of 10 ma or more can be delivered from the E_2 supply to the collector of transistor Q_2. Somewhat smaller currents can be delivered from the collector of transistor Q_2 to ground, the actual loading being determined by the reduction of the base voltage of a transistor Q_1 in one of the off stages of the ring compared to its emitter voltage as it is turned on.

The interstage coupling networks shown in Fig. 2C provide priming to enable the stage following an on stage to be turned on. It is not necessary to turn off the stage initially on. Triggering directly into the enabled base momentarily will drive the primed stage further into the region of conduction than is normal for unsaturated quiescent conduction, thereby depressing the common anode voltage. As a result, the stage that initially was on, is turned off.

Reversible operation is obtained with this circuit by including both forward and backward prime networks, and separate forward and backward triggers.

To achieve high-speed operation, the simple priming network of Fig. 2C, top, is replaced with one containing a transistor. Thus a third transistor is added to each stage[4]. If this transistor is pulsed from the trigger line, it is driven into saturation. The storage of minority charges in this transistor is used for the interstage memory, an unusual application of a generally undesirable effect. Nonetheless, the use of transistor storage is much better than the simple r-c method because the rise time or lag of the stored charge is much less. To achieve forward as well as reverse operation with the high-speed circuit, a fourth transistor would be used in the same manner to provide priming for the other direction of propagation along a ring. The tolerance of the high-speed ring to trigger variations is appreciably less than that of a lower speed version, because the trigger pulse duration must be less than the memory time of the interstage priming network.

Another mode of triggering can be achieved, as shown in Fig. 3 and 4, by coupling the emitters of transistors Q_1 into the common bus. Turn-off trigger pulses applied there will turn off all stages and, if the pulse duration is not too long compared to the time constant of the priming circuit, the primed stage will fire after decay of the pulse. Both forward and backward operation can be achieved by gating of the primed outputs with an auxiliary pair of control buses, such as used in the reversible operation. This mode of operation does not require two separate streams of trigger pulses, but requires binary control such as by a bistable multivibrator to determine the direction.



REVERSIBLE VERSION *of ten-stage ring counter can be operated at frequencies over 100 kilocycles—Fig. 4*

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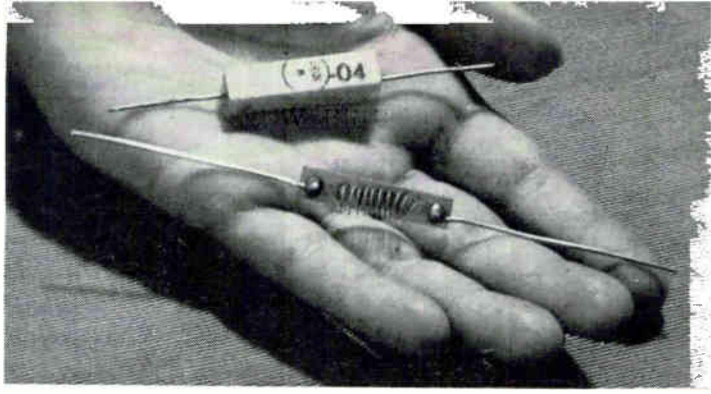

COIL OF COPPER WIRE *requires little space, even when encapsulated, fills about the same area as a ten-watt, wire-wound resistor*

How COPPER WIRE Balances Parallel Power Transistors

Nonlinear equalization permits matching parallel power transistors. The system eliminates the need for large emitter resistors to swamp variations in base-to-emitter threshold voltages and also does away with time consuming matching operations

By DONALD J. HANCOCK
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CONVENTIONAL METHODS of paralleling power transistors use comparatively large emitter resistors to swamp wide variations in base-to-emitter threshold voltages, input impedances and current gains. To obtain proper balance the voltage loss across these emitter resistors is large, often prohibitively so.

NONLINEAR EQUALIZATION—If minimum losses are required, expensive, time-consuming matching offers the only solution. For small-quantity production, the matching technique is acceptable; but for mass production, a new approach must be used. The solution to the problem lies with nonlinear equalization, which requires that: the element exhibit a positive temperature coefficient of resistance; the voltage loss across the element be kept to around 0.5 volt. (For currents in the range of 5 to 50 amperes, this dictates resistance values in the range of 0.1 to 0.01 ohm respectively.); the element effect a balance of about ±5-percent with other parallel transistors; the element remain relatively insenitive to external changes; and that the element should have a relatively small mass to minimize the thermal time lag.

Positive-temperature-coefficient thermistors would be ideal for this application, but are not yet available in the desired resistance and current ranges. A convenient material with a positive temperature coefficient that is available is copper. It has a temperature coefficient of 0.385-percent per degree, which is relatively small. If operated over a wide temperature range, however, the change in resistance can be significant.

The improvement factor of nonlinear over linear equalization can be developed by analyzing the equivalent circuit of two transistors in parallel. This analysis can then be extended to any number of parallel transistors by subdividing the N transistors into successive pairs until only one pair remains. The diagram shows an equivalent circuit and pertinent parameters.

If V_{in} is expressed in terms of symmetrical variables (as in the graph) then the following equation will apply to V_{in}:

$$V_{in} = V_o - \frac{K_2 V_c}{K_1} I + \rho I + rI \qquad (1)$$

$$\text{let } I \text{ approach zero } dI = \frac{dV + Id\rho}{\rho + r - \frac{K_2 V_c}{K_1} + I\frac{dR}{dI}} \qquad (2)$$

The temperature rise of resistor r can be expressed as

$$r(t) = r_o(1 + \alpha t) \qquad (3)$$

$$K_3 t = r(t)I^2 \qquad (4)$$

$$t = \frac{r_o I^2}{K_3 - \alpha r_o I^2} \qquad (5)$$

$$r(t) = \frac{r_o K_3}{K_3 - \alpha r_o I^2} \qquad (6)$$

$$\frac{dr(t)}{dI} = \frac{2\alpha r_o^2 K_3 I}{(K_3 - \alpha r_o I^2)^2} = \frac{2r(t)^2 \alpha I}{K_3} \qquad (7)$$

EQUALIZE WITH COPPER WIRE

The characteristics of a simple length of copper wire will permit it to function as an excellent equalizing device to achieve balance in parallel power transistors. Small mass minimizes thermal time lag and is almost insensitive to external variations.

This system offers an improvement factor of 80-percent with a resistance change of less than two to one and can be applied to almost every case by using different sizes of wire

USE OF COPPER WIRE FOR STABILIZATION

	NO STABILIZATION				EMITTER STABILIZATION												BASE STABILIZATION			
	No Resistance				0.030-Ohm Resistors				0.040-Ohm Resistors				0.040-Ohm No. 28 Wire Nonlinear Resistors				0.75-Ohm Base Resistors			
Transistor No.	1	2	3	% Max. Dev. from Mean	1	2	3	% Max. Dev. from Mean	1	2	3	% Max. Dev. from Mean	1	2	3	% Max. Dev. from Mean	1	2	3	% Max. Dev. from Mean
Run No. 1, I_c	6.4	3.3	4.1	39%	5.8	4.3	4.9	16%	6.6	5.8	6.2	6.5%	6.0	5.7	6.0	3.4%	6.9	4.4	2.3	52%
Run No. 2, I_c	8.3	4.2	5.1	41%	7.9	6.0	6.8	14.5%	8.4	8.0	8.2	2.4%	6.9	6.7	6.7	1.9%	7.6	5.1	2.7	48%

$$I\frac{dr}{dI} = \frac{2\alpha r(t)^2 I^2}{K_3} = 2\alpha[tr(t)] \quad (8)$$

$$\text{thus } dI = \frac{dV + Id\rho}{\rho + r(t) - K_2\frac{V_c}{K_1} + 2\alpha tr(t)}$$

$$= \frac{dv + Id\rho}{\left(\rho + r(t) - K_2\frac{V_c}{K_1}\right)\left(\dfrac{1 + 2\alpha tr(t)}{\alpha + r(t) - \dfrac{K_2V_c}{K_1}}\right)} \quad (9)$$

where a = temperature coefficient of copper (0.385), t = temperature rise above 25 C, and K_s = thermal conductivity of the resistor in air.

The improvement factor is given by

$$1 + \frac{2\alpha tr(t)}{\rho + r(t) - \dfrac{K_2V_c}{K_1}} \quad (10)$$

IMPROVEMENT FACTOR—Examination of the term shows that the improvement factor becomes larger as any one transistor approaches thermal runaway. Note that $\Delta T = I_cV_c/K_1$ where K_1 is the thermal conductivity of the resistor. As transistor power dissipation rises, heating ΔT also goes up, increasing I_c. Then, from Eq. 5, as I_c increases so does the temperature of the nonlinear resistor t, causing resistance r to rise as shown in Eq. 6. The improvement factor can be shown to increase as t and r as a direct result of a rise in ΔT.

The best commercial insulation for copper is ceramic Teflon Ceroc T, which is good up to 250C average temperature. However, short surges exceeding 250C can be tolerated without insulation damage.

Thus typical values are used to obtain numbers for improvement factor and current deviation dI, t_{max} = 250C, ρ = 0.1 volt per amp, $r(t)$ = 0.076 ohm, t = 225C (250C − 25C), V_c = 4.0 v, K_1 = 0.33 watt per deg C, K_2 = 0.002 v per deg C, a = 0.00385 part per deg C, dV = 0.025 v and $d\rho$ = 0.01 amp per volt.

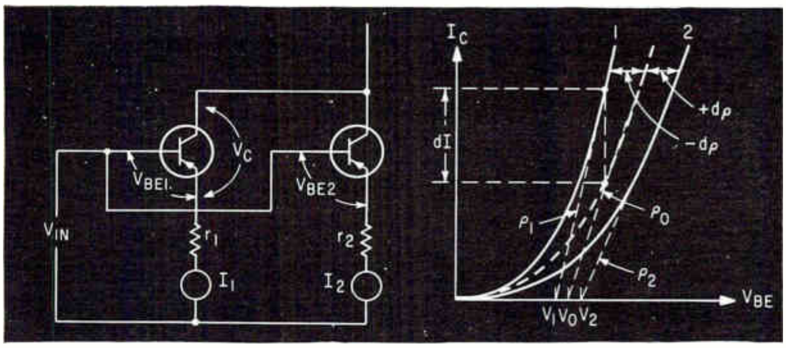
The improvement factor (Eq. 10) is about 1.8, or 80-percent for a resistance change of slightly less than two to one. This increase to 3.3 for a resistance change of three to one. The expected current deviation using the above values is ±0.3 amp.

To realize temperature excursions of the desired magnitude, it is necessary to use wire that fits each range of current. For 4 or 5 amp maximum current, No. 29 wire will be suitable; for six to eight amperes No. 28 wire; and so forth.

One requirement is small thermal time response. By coiling the wire inside a coil form with support on the ends only, a thermal time constant of about 2 or 3 seconds can be obtained. Any added coating or mass on top of, or in close contact with the wire greatly increases the response time.

A typical power supply application required an output of 18 v at 18 amp. Dissipation considerations dictated the use of three power transistors in parallel, each carrying an average of 6 amp at ±0.5 amp. Surge currents can rise to 25 amp. A 7.5-inch length of No. 28 copper wire with a resistance of 0.04 ohm at 25C, was coiled inside a quarter inch square, one inch long, glass fiber coil form. With normal operating currents in the range of 6.3 amp, the wire resistance was about 0.060 ohm and the wire temperature about 120 C. Short current surges of 8.3 amp will then change the resistance to about 0.078 ohm and the temperature to about 245C.

The table shows the results of three typical 2N174A's paralleled and used with various methods of equalization.



EQUIVALENT CIRCUIT *and parameters for matching parallel power transistors*

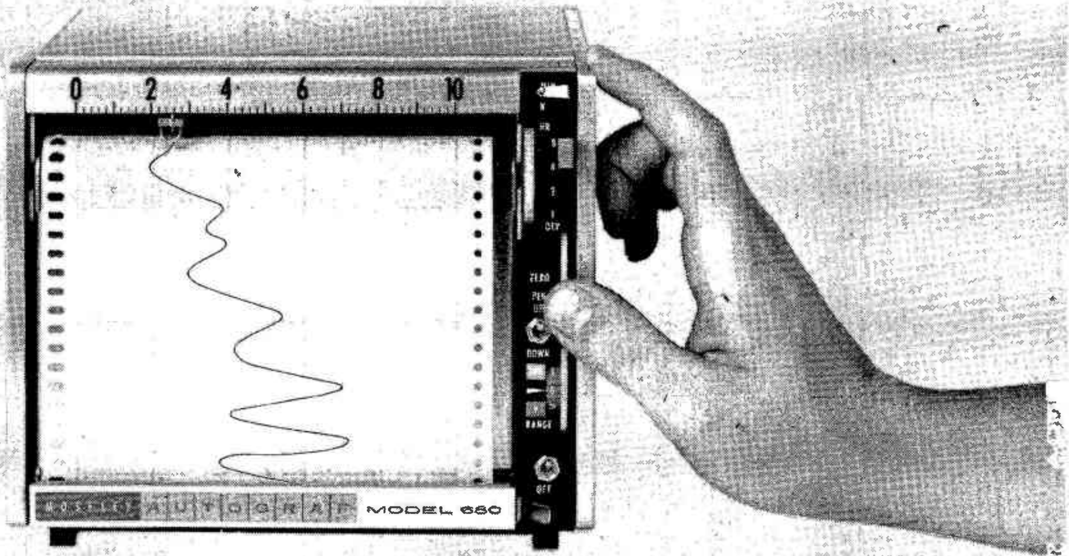
CONCLUSIONS—The use of nonlinear equalization has proved to be a useful technique although it is limited in application by the lack of large positive temperature coefficient materials. The small temperature coefficient of copper wire can be used effectively if large excursions of temperature are utilized.

Since the average temperature of the wire is considerably higher than normal ambient temperature, it is relatively insensitive to ambient changes.

For applications where power loss is critical, nonlinear equalization will give maximum equalization with a minimum of power loss.

The author thanks B. Kruger and J. W. Higginbotham for their assistance.

Moseley Model 680 series solid state recorders



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- Any mounting—rack, table, or industrial panel in sealed, rugged, locked case
- Also thermocouple, milliammeter, single range dual-speed models, 1 mv full scale models

SPECIFICATIONS

Full scale balance time	0.5 second
Accuracy	0.2% full scale
Power	10 watts
Weight	10 pounds

Zero set and remote pen lift
Input isolated 500 volts to ground
Zener reference voltage
All solid state circuitry
Plug-in modular construction

	Model	*Price*
Multi-Range, Multi-Speed	680	$750
Single Range, Dual Speed	681	625
Thermocouple Recorder	682	675
Milliammeter Recorder	683	625

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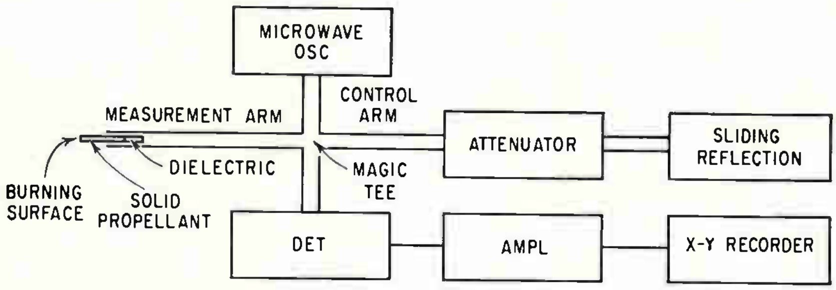
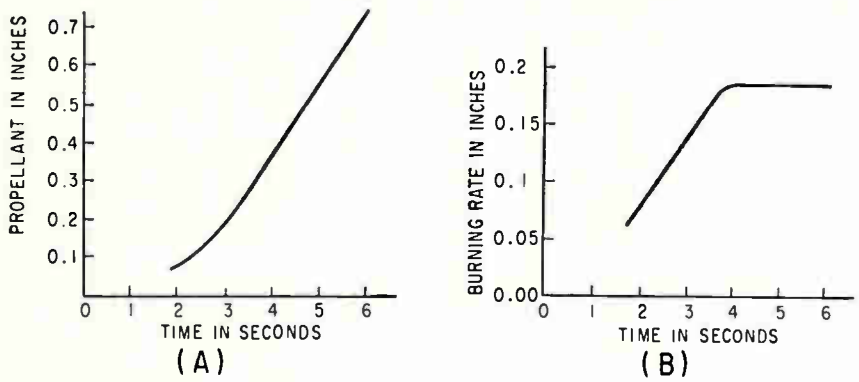
Microwaves Measure Solid Fuel Burning Rates

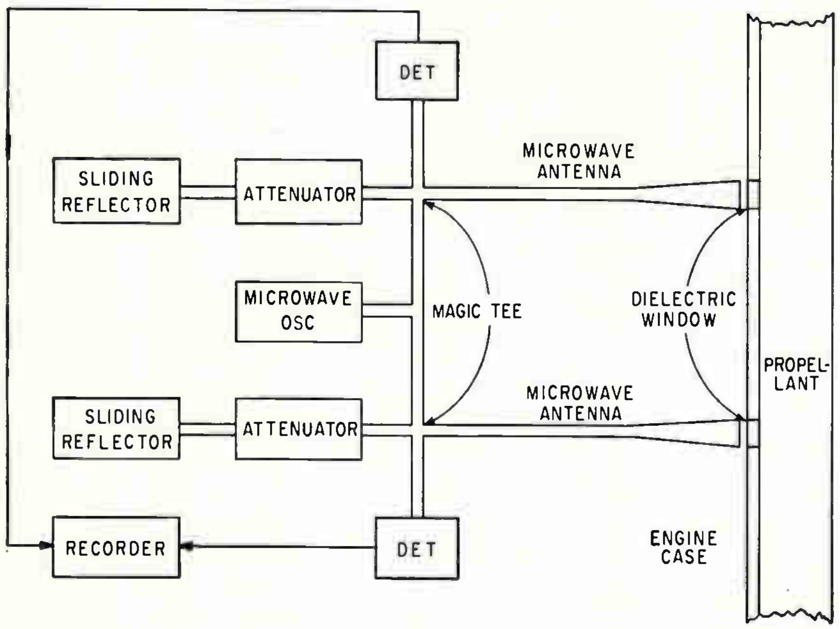
Experimental method could also measure ablation of nonmetallic nose cones



FEASIBILITY *of microwave measurement of propellant burning rates was demonstrated using this test setup—Fig. 1*



PROPELLANT *burned (A) and rate of burning (B) are obtained from measurements made originally in terms of wavelength—Fig. 2*



BURNING *rate of a propellant grain at two points in a rocket motor can be measured using this instrumentation—Fig. 3*

BURNING RATES and burning rate profiles of rocket solid propellants can be determined accurately using microwaves. An experimental method has been developed that permits continuous measurements during burning. It can be used during static firing tests and for quality control in solid propellant manufacturing. The technique developed at Giannini Controls Corp. can also measure ablation of nonmetallic nose cones.[1]

Propellant burning rates must be accurately measured to determine rocket thrust-time programs. Rocket thrust is the product of mass flow and exit velocity of the combustion gases. Exit flow is a function of propellant properties and the expansion ratio of the nozzle. In liquid-propellant rocket, mass flow can be determined from pressure drop in the fuel system. A desired thrust program can be obtained by controlling mass flow.

SOLID PROPELLANTS—After a solid propellant has been ignited, it burns at a rate determined by its burning characteristic and its geometrical configuration, which cannot be controlled in flight. The buring characteristic of a solid propellant is a function of composition, fabrication methods, combustion chamber pressure, temperature of the grain (propellant mass that has been cast or extruded into a single piece) and many other parameters, not all of which are understood.

Combustion in a solid propellant proceeds in a direction normal to the surface. Thus the area of the burning surface can be programmed for a particular grain configuration. Theoretically, a desired thrust-time program can be obtained by an involved calculation

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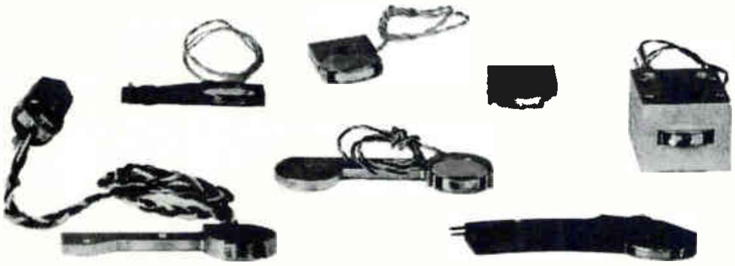

EIC magnetic recording head components are now available for any recording or playback system. Originally designed for use in EIC recording systems, these heads are now proved and offered as industrial electronic components. Their wide range of electrical and mechanical adaptability makes them your best buy for laboratory and industrial applications in recording, control, and data analysis.

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- Process instrumentation and control computers.

Specifications

Type No.	Track Width (In.)	Gap Width (In.)	Over-All Width (In.)	Inductance (mh)	Resistance (Ohms)
A- 12	0.012	0.00025	0.125	6.7	6.75
A- 40	0.040	0.00025	0.125	600	215
A- 50	0.050	0.00025	0.125	750	220
B- 50	0.050	0.00025	0.125	65	30
C- 50	0.050	0.0010	0.125	325	220
A- 60	0.060	0.0010	0.207	3	200
A- 90	0.090	0.00025	0.207	100	30
A-100	0.100	0.00025	0.187	1200	265
B-100	0.100	0.0010	0.187	500	265
C-100	0.100	0.00025	0.187	375	265
A-125	0.125	0.0020	0.207	29	34
B-125	0.125	0.0050	0.207	1.17	1.9
C-125	0.125	0.0050	0.207	0.224	0.7
A-140	0.140	0.0010	0.207	500	230
B-140	0.140	0.0010	0.207	7	10
C-140	0.140	0.0030	0.207	235	230
A-30-3	0.030	0.001	0.145	7.0	14.5

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that takes into account geometrical configuration and propellant burning characteristic. However, certain assumptions must be made in even the most elaborate calculation, and irregular behavior of the grain cannot be taken into account. These irregularities arise from a variety of causes, and precautions can be taken against many of them. However, a newly developed rocket must undergo many static burning tests in which grain composition, configuration and fabrication methods are varied to obtain the desired thrust-time curve.

If a rocket fails on the test stand, it would be desirable to determine where in the grain, at what time and to what extent burning rate deviated from that planned. Techniques have been developed for measuring burning rates of the grain in rocket motors as well as in small pieces of the propellant called strands. However, these methods have a variety of shortcomings including questionable accuracy, inconvenience and high cost. Solid propellant burning rates can be measured accurately and conveniently using electromagnetic energy at frequencies in the upper microwave region.

MICROWAVE METHOD—Feasibility of using the microwave technique to determine solid propellant burning rates was first verified using the arrangement in Fig. 1. The propellant strand was inserted directly into the waveguide. Pressure was not controlled nor side-burning inhibited during the tests.

Output from the microwave oscillator was split by the magic T into a control arm and a measurement arm. Magnitude and position of the standing wave resulting from reflection by the strand was balanced in the two arms by adjusting the attenuator and the sliding reflector in the control arm. Dielectric material is used to match the strand and eliminate reflections from the front surface.

As the propellant strand burns, distance to the reflecting surface changes, causing an imbalance in the two arms. A signal representing this imbalance passes into the vertical arm of the magic T. This signal reaches maximum and minimum levels as distance to the reflecting surface of the burning strand changes in successive quarter wavelength intervals.

Recordings were made with the horizontal axis of the x-y recorder swept at 1 inch per second while the strand burned. To determine length of the strand burned in terms of inches instead of wavelengths, a wavelength was determined by probing the waveguide through a slot for successive minima, which occur at half-wavelength intervals.

TEST RESULTS — Propellant burnt is shown as a function of time in Fig. 2A, in which slope of the curve represents burning rate. Distortion in such a curve indicates irregular burning. Burning rate is shown as a function of time in Fig 2B. Burning rate of strands under pressurized and controlled conditions can be measured conveniently by modifying this technique. By using higher frequencies, sufficiently short wave-lengths can be used for desired resolution.

The burning rate in a selected part of a solid propellant rocket motor can be measured during static firing by replacing the strand-holding fixture with a microwave collimator. The motor case must be modified by inserting small dielectric windows at selected points, as in Fig. 3.

The microwave technique can be used to measure ablation rates of nonmetallic nose cones in much the same manner as the burning rate of propellant grain. Small microwave antennas are inserted at various points in the nose cone, and several horns are used to determine the profile continuously.

Solid propellant burning rates and burning rate profiles can be determined accurately with this method, which eliminates the need for making geometrical assumptions and approximations. Strand measurements can be made for quality control in propellant manufacturing at relatively low cost. Results are provided quickly and precisely. This technique is especially useful in studying erosive burning in hybrid rocket motors where burning rate must be measured continuously.

REFERENCE

(1) Danold L. Johnson, Microwave Measurement of Solid Propellant Burning Rates, *Technical Notes*, Giannini Controls Corporation, July-August 1962.

Why Soviets Talk Up Cold-Cathode Tubes

Lag in electron devices, transistors, leads to cold-emission techniques

By STEWART RAMSEY
McGraw-Hill World News

MOSCOW—Complex electron tubes and transistors are in short supply in Russia, according to the Soviet press. Lev Korablev, apparently Russia's top expert in cold-cathode tubes, believes that almost half of the complex electron tubes and transistors could be replaced by cold cathodes.

Two recent Soviet articles, first on the subject in some time, are careful not to make claims about how many of these tubes are being produced. The line is that there is an annual market for 10 million in the USSR.

According to Tass, Korablev "recently" has found ways to amplify signals of any kind by means of cold-cathode tubes and this means they will "muscle in on electron tubes and transistors" in the near future. Korablev said "It is expected that up to one-third of electron tubes will be supplanted with time."

Evidently, these tubes are being used in computers and automatic instrumentation to some extent. But, in Korablev's view, they can and should also be used in consumer electronics, radio and television.

ADVANTAGES — Cold-cathode tubes can also operate in conditions of heavy radioactive radiation, Tass dispatch points out. Soviets have claimed for some time that cold-cathode tubes have many advantages over electron tubes—they are ten times cheaper and their service life is almost 10,000 times longer, reaching 100,000 hours. They do away with transformers and artificial cooling.

Cold cathodes are said to be simple in design, typical tube contains only six parts. Amount of metal required being only 0.5 to 0.6 grams. They are self inducting. Visual control is possible. They don't require the costly materials with high degree of purity, as do semiconductors, say the Soviets.

In an article in Pravda, Korablev was quoted as saying "we succeeded in finding a way" to solve problems of ignition lag in cold-cathode tubes, but he did not go into detail. He said further that, before it was possible to apply the tubes practically "we had to learn first how to control their current." A great deal of research was needed to find solutions to the tasks now performed by the old electron tubes, he added.

"At the present time we have available several hundreds of methods for utilizing gas-discharge tubes in all kinds of apparatus. It is normal practice to assign a definite type of radio tube to each unit of the electronic installation. As for the gas-discharge tubes, their design remains unaltered, whatever the application. Different circuit diagrams make one and the same tubes perform different functions."

In earlier discussions, the Soviets had referred specifically to the standard Soviet MTX-90 thyratron tube. Tube was not mentioned now.

NEGLECT?—Last year, the Moscow Economic Council was accused of neglecting elementary technological standards in making MTX-90 tubes and failing to give any guarantees as to their reliability. Korab-

New Amplification Techniques?

GIST OF STORY on cold-cathode tubes is that complex electronic devices are in short supply in the U.S.S.R. Soviet engineers are looking for simple, inexpensive methods of amplification and performing circuit functions.

- If Soviets have found new ways to amplify signals, using devices used in this country essentially as voltage stabilizers, this may spell out an advance in the tube art.
- One major advantage of cold-cathode tubes, over transistors, is they can solve a costly servicing problem.

System concept has not been pushed in the U.S. because some American designers have been design-oriented in the direction of transistors and solid-state devices.

We have developed audio output amplifiers using cold-cathode tubes, and have kept up our work on cold emission by ion bombardment. This includes present work on the mechanism of MgO-type cold-cathode emission.

European designers have shown more interest in cold-cathode circuits, but research in cold-cathode techniques has not lagged here. And many of our own designers have shown interest in new trigger tubes.

- One cold-cathode self-sustaining emission tube, developed here, gets away from requirements of filament heating power.
- Cold-cathode principle has found widespread applications in the west in some special branches of electronics.

Here, gas-filled diodes are used as voltage regulators, neon-bulb types are used as indicators in instrument circuits, and triodes are used for switching and counting lev didn't refer to past criticism, but stated that production and design were constantly improving. He identified three engineers as having worked out an "advanced" procedure for quality production of cold-cathode tubes. He said the Moscow Council had shown "good initiative" in suggesting that enterprises, together with the Physical Institute, find ways to replace radio tubes with cold-cathode tubes in home television receivers. He added that "minimum savings" predicted on production and use of 10-million cold-cathode tubes annually, would be two billion rubles (one ruble equals $1.11).

Author of Pravda article, A. Presnyakov, described visiting an underground laboratory at Moscow University where "thousands of tiny tubes with cold cathode" were being used in scientific apparatus designed to trap and sort cosmic rays passing through the earth.

In Russia, tubes also find application in machines for counting parts and banknotes, performing complicated mathematical computations, watching water levels in irrigation canals, and giving commands to conveyor lines, Presnyakov said.

Soviets claim that cold-cathode tubes are being used currently in more than 400 enterprises and institutes. Two years ago, it was "over 200."

More Data Reported For Transistor Mikes

INVESTIGATIONS on transistor microphones (Oct. 19, p 89) have been carried forward independently and concurrently by Bell Laboratories and Raytheon. The Bell piezoresistive microphone has a sensitivity of 2×10^{-5} mv and efficiency of 1.4×10^{-6} percent at 10 dynes per cm^2 pressure. Bell's mike was made from a 20C *npn* transistor, but can use any types having comparatively large emitter and collector regions to which stress can be applied.

Bell scientists suggest even more effective methods for stressing the transistor junctions. For example, the transistor can be affixed directly to a diaphragm without need of a stylus. Or a deformable semiconductor sheet or wafer can be used.

Tape Recorder Simulates Data Transmissions

Simple technique helps isolate data system faults

By L. E. MIKUS
Computer Department
General Electric Co.
Phoenix, Ariz.

TO SIMULATE *transmission lines and remote equipment, simple tape recorder is used*

AN INEXPENSIVE audio tape recorder is being used for diagnostic checking of this division's new data-transmission controller. The approach should be useful in other phases of data communication and also for testing digital and analog computers.

Datanet-15 is a transistor data-communication control device with two basic channels, and 6- or 15-channel capability for queuing. It operates on-line with the GE-225 computer or its peripherals to receive and send digital data on two-wire cable, telephone or telegraph facilities.

When a data-transmission controller is included in a computer system, distant input/output terminals are inaccessible for testing. Moreover, a division of responsibility exists between the manufacturer of the data-processing equipment, the common carrier, and the manufacturer of the remote terminal. When a malfunction in the system occurs, it is necessary to determine who is responsible for repair or readjustment.

The audio-tape-recorder technique allows simulation of a remote station at the computer site and allows the computer to be used for testing. Thus the computer as a trouble source can be quickly isolated.

As is customary, the computer checks itself and its associated peripherals. It can also perform complex diagnostics on other equipment.

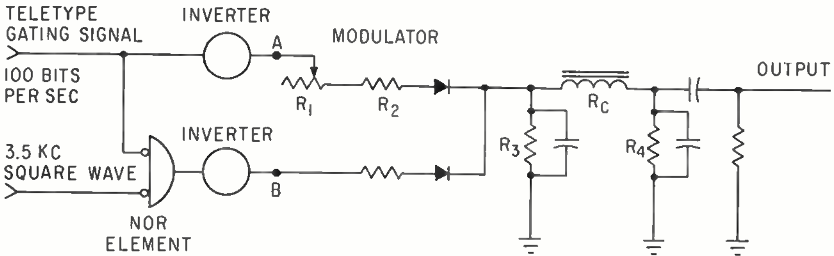
CIRCUITS—To simulate a teletypewriter signal on magnetic tape, a 3.5 Kc tone is generated for a space condition (logical zero), and no tone is generated for a mark condition (logical one). Since a teletypewriter line is in the mark state when idle, no modulation appears on tape until the start of a character.

The start pulse of every character in serial asynchronous digital transmission is a space condition and appears on the audio tape as a burst of 3.5 Kc sine wave. The duration of this burst is determined by the bit rate of the signal; for 100-wpm teletypewriter each pulse lasts 13.5 ms.

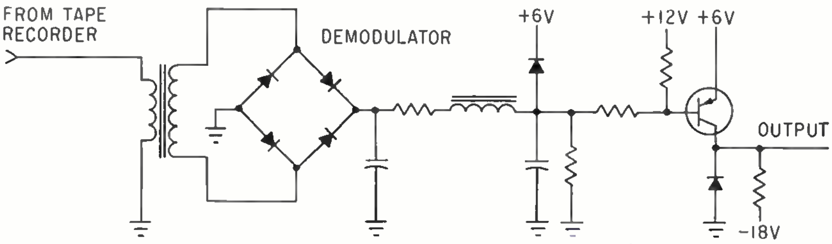
Following the start pulse are the data bits, each represented by either a burst of 3.5 Kc for a ZERO or no modulation for a ONE. At the completion of the data bits, a marking signal is presented for the duration of at least 1½ bits before the start pulse for the next character.

Simple modulator and demodulator circuits, as well as the necessary additional logic elements needed for control functions, easily fit on a single logic card. Both the 3.5 Kc square wave and the teletypewriter gating signal are available in the Datanet-15 control logic. The 3.5 Kc modulation frequency was chosen because of its availability and because it is sufficiently higher than the bit rate yet low enough for a simple tape recorder.

Figure 1 shows the modulator circuit. The 3.5 Kc square wave is gated through whenever the teletypewriter signal from the controller is a space. Inverters provide modulator isolation and a means for "no-signal" biasing.



MODULATOR *circuit converts teletypewriter signal into bursts of 3.5 Kc signals for recording on simple audio tape recorder—Fig. 1*



DEMODULATOR *circuit converts signal from tape recorder into typical teletypewriter signal—Fig. 2*

The gated square wave is passed through a low-pass filter and then to the audio tape recorder. Modulator output of 0.7 v rms is sufficient to drive practically all tape recorders.

In the demodulator, Fig. 2, a step-up transformer raises the output of the tape recorder and provides a match to the demodulator. When a space condition exists, the 3.5 Kc modulation is rectified, filtered, and turns the transistor off. When no modulation is present on the tape, the transistor is turned on. Approximately ½ watt of audio is required to drive the demodulator.

The demodulator drives a logic element, which substitutes the signal from the tape recorder for the signal usually obtained from the remote station.

OPERATION—Practically all the operational features of the data transmission controller can be checked by this tape-recorder routine. The test is so complete that it is used as the major part of the final acceptance test that follows product manufacturing.

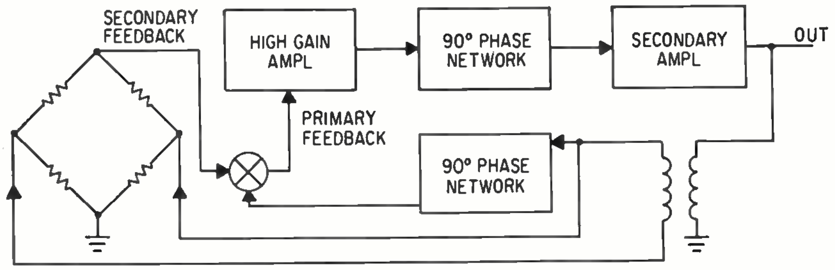
Throughout the run, the computer checks the accuracy and format of the taped data. After each control character, a programmed check is made to insure that the proper control function was performed. Timing and delays, inherent in data communications, are verified.

The computer program is written to display, on a typewriter or high speed printer, both operating instructions and error conditions. Thus the program isolates and displays problem areas.

Since the data transmission controller operates concurrently with all other peripherals in the GE-225 computer system, provision is made in the test to determine if any interaction problems exist. Therefore, even when transmission to or from a remote station is simulated, other peripherals may be operated concurrently.

The technique can be extended to higher-speed controllers and data buffers. The nature of the character remains the same except for the bit rate. As long as the recorder can be operated at a low bit rate for testing, a controller at higher speed can be tested without invalidating the technique.

DESIGN AND APPLICATION



Oscillator Excites Strain Gage at 1 Milliwatt

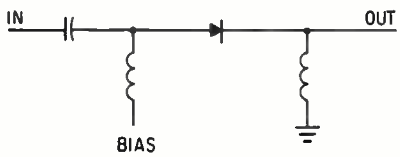
Absence of heating by excitation power adds to inherent stability

INTRODUCED by Arizona Instrument Co., 2045 West Cheryl Drive, Phoenix 21, Arizona, are a series of bridge-controlled oscillators in which the bridge containing a four arm strain gage is an integral part of the oscillator. As approximately 1 mw is present at the transducer, this eliminates thermal problems associated with gage heating due to application of d-c excitation. The units are available in standard IRIG frequencies above channel 9 although other configurations are available. Deviations of ± 40 percent are available and linearity varies from ± ¼ percent or better for ± 7½ percent deviation to ± 1 percent for ± 40 percent deviation. Center frequency drift is ± 0.01 percent for constant temperature and is less than ± 30 parts per million per degree C over a wide temperature range. The device also contains its own internal signal phase reference thus eliminating external phase standards. The sketch shows operation. The unit is basically an oscillator at subcarrier frequency and output is from the secondary amplifier (1 v peak-to-peak at 72 ohms) which also drives the resistance bridge. When the bridge is in balance, no signal appears on the secondary feedback loop and output remains at preset center frequency. When the bridge is unbalanced, feedback signal with phase dependent on sign of unbalance appears. The sum of both feedback signals is shifted in phase depending on unbalance amplitude. As a result, oscillator shifts to frequency that satisfies 360-degree criterion.

CIRCLE 301, READER SERVICE CARD

Crystal Switch Covers 400 Mc to 4 Gc

MANUFACTURED by PRD Electronics, Inc., 202 Tillary St., Brooklyn 1, N.Y., the N6001 crystal switch is a broadband modulator covering the frequency range between 400 and 4,000 Mc. Insertion loss is 2 db maximum and isolation is 32 db minimum. Maximum r-f power handling, depending on bias conditions, are 2 w average and 5 to 15



w pulse. Maximum switching time is 0.16 μsec while rise and fall time is 200 nanoseconds. Maximum vswr in forward bias state is 2.75 between 400 and 500 Mc; 2.00 between 500 Mc and 1 Gc and 1.75 between 1 and 4 Gc. The unit consists of two diodes in series with the center conductor of a 50-ohm coaxial line and helical coils are used for 40 ma forward and 30 v reverse d-c biasing. **(302)**

New Multimeter Uses Magnetic Amplifiers

ANNOUNCED by Keinath Instrument Co., 1313 Chesapeake Ave., Columbus 12, Ohio, the K-Mag 600 multimeter measures resistance in six steps between 1 and 100,000 ohms with 1 and 10 megohm center scale; current in four steps between 10 and 300 μa and seven steps between 1 and 1,000 ma, both a-c and d-c; four steps between 10 and 300 mv and seven steps between 1 and 1,000 v a-c or d-c. Input impedance is 10 megohms on a-c and 10 megohms per volt on d-c. Internal resistance on current ranges is 1 ohm on 10 ma and higher, higher on lower ranges. Using newly developed magnetic core materials, the second-harmonic magnetic amplifier can operate with control currents down to tenths of a microampere and is a true d-c amplifier with inherent zero output with zero

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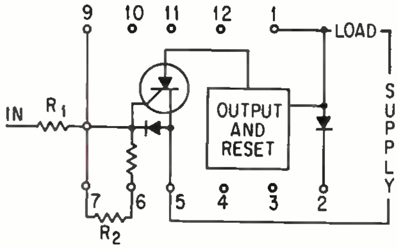
CIRCLE 59 ON READER SERVICE CARD

input. Accuracy is better than 1 percent on all ranges. The device is insensitive to overloads of over 1,000 percent and a protection circuit makes it impossible to damage the meter with up to 1,000 v applied regardless of range. An internal calibration standard is supplied accurate to 1/10 of 1 percent held over temperature range of −30 to 150 F. Automatic polarity switching is also provided.

CIRCLE **303**, READER SERVICE CARD



Miniature *PNPN* Switch Controls 100 W With 10μw

NEW from Sectron Inc., 1 Pingree St., Salem, Massachusetts, the RB1001 universal output driver is a miniature (0.345 cubic inch) *pnpn* controlled switch that can detect input signals from 50 μa to 50 ma, between 0.6 and 400 v to control loads up to 100 w. Voltage detection level between 0.6 and 400 v is determined by R_1 (see sketch) between 0 and 800,000 ohms. Changing R_2 between infinity and 10 ohms changes level of current detection between 50 μa and 50 ma. The module can operate loads dependent on whether an a-c or d-c power supply is used. With a-c, unit stays on as long as input signal is present and resets automatically when signal is removed. With d-c supply, unit latches on with input signal and reset is accomplished by momentary interruption of load current. Circuit changes make it possible to latch an a-c supply and reset a d-c supply. **(304)**

H-V Accelerator

RADIATION DYNAMICS, INC., 1800 Shames Drive, Westbury, L.I. N.Y. Versatile h-v accelerator for simulation of space radiation operates on the Dynamitron principle of cascading rectifiers driven in parallel from a h-f oscillator. **(305)**

PRODUCT BRIEFS

SILICON MICRO DIODES AND DICE for magnetic amplifier applications. They feature ultra-low leakage, high conductance. Micro Semiconductor Corp., 11250 Playa Court, Culver City, Calif. (306)

MERCURY-WETTED-CONTACT RELAY in polarized version. It is for use in computers and data processing equipment. Automatic Electric Co., 400 North Wolf Road, Northlake, Ill. (307)

HELICAL MEMBRANE COAXIAL CABLE offers fast propagation, low signal loss, high temperature resistance. It is available in 50, 75 and 100 ohm impedances. Phelps Dodge Electronic Products Corp., 60 Dodge Ave., North Haven, Conn. (308)

SWITCH PACKAGE weighs 3.25 grams. The Klixon AT3-1 has a threaded jacket for easy installation. Metals & Controls Inc., a corporate division of Texas Instruments Inc., Attleboro, Mass. (309)

MINIATURE TUBULAR CAPACITOR is metal encased with mounting bracket. It permits cold welding direct to terminals. Aerovox Corp., New Bedford, Mass. (310)

POTENTIOMETRIC PRESSURE TRANSDUCER incorporates carbon-film resistive element. Life is to 3 million cycles depending on circuit. Computer Instrument Corp., 92 Madison Ave., Hempstead, L. I., N. Y. (311)

ULTRASONIC CLEANING CONSOLES provide high work capacity and versatility. They have twin 6½ gallon tanks energized by Multipower transducers. Acoustica Associates, Inc., 5331 W. 104th St., Los Angeles 45, Calif. (312)

HIGH RELIABILITY CRYSTALS for 16 Kc to 140 Mc. They are supplied with complete certified in-process and final test results. Monitor Products Co., Inc., 815 Fremont Ave., South Pasadena, Calif. (313)

PRESSURE SWITCH is all solid state. Unit offers built-in calibration check points and has a switching capacity of up to 1 amp. Wiancko Engineering, 255 North Halstead Ave., Pasadena, Calif. (314)

SERVO AMPLIFIER mounted on rack chassis. It is a 75-watt vacuum-tube unit. The Diehl Mfg. Co., Somerville, N. J. (315)

COAXIAL MIXER-AMPLIFIERS cover 125 to 8,000 Mc. Six standard mixer models, each covering an octave bandwidth, can be provided with any one of eight standard i-f amplifiers. Airborne Instruments Laboratory, Deer Park, N.Y. (316)

DIAMOND PASTE COMPOUNDS for polishing and lapping of semiconductor and exotic materials. Geonite is available in eight grades ranging in sizes from ¼ to 30 microns. Geoscience Instruments Corp., 110 Beekman St., New York, N.Y. (317)

Literature of the Week

AIR DATA INSTRUMENTS Giannini Controls Corp., 1600 S. Mountain Ave., Duarte, Calif., has published a new easy reference catalog describing 17 typical products in its line of air data instruments.
CIRCLE 318, READER SERVICE CARD

R-F SHIELDING MATERIALS Emerson & Cuming, Inc., Microwave Products Division, Canton, Mass., has available a technical paper on materials for r-f shielded chambers. (319)

VIBRATION/NOISE/CONTROL Lord Mfg. Co., Erie, Pa. The full range of vibration/shock/noise control products manufactured by the company are described in a new product guide, bulletin No. 905. (320)

DIRECTIONAL COUPLERS Microwave Development Laboratories, Inc., 15 Strathmore Road, Natick Industrial Centre, Natick, Mass., has published a data sheet giving technical information on broadwall multi-hole directional couplers. (321)

QUICK CONNECT ADAPTERS Serco, 43 Hinds St., Seattle 4, Wash. Catalog sheet illustrates and describes the QDC series type N quick connect coaxial adapter. (322)

TRANSISTOR POWER MODULES Deltron Inc., Fourth and Cambria Sts., Philadelphia 33, Pa. Bulletin 2029A-1, -2 and -3, and corresponding price list 1024A cover the newly revised PI series transistor power modules. (323)

SECTIONAL DELAY LINES Nytronics, Inc., 550 Springfield Ave., Berkeley Heights, N.J. Catalog sheet describes Essex sectional Wee Lines, modular L-C delay lines. (324)

SEMICONDUCTOR GUIDE Bendix Semiconductor Division, Holmdel, N.J. A 4-page guide lists a wide range of semiconductor products by type number with information on their pertinent electrical characteristics and case type. (325)

GLASS AND CERAMICS Corning Glass Works, Corning, N.Y., is publishing a series of technical brochures to help keep electronic design engineers abreast of new applications for glasses and ceramics. First of the series is entitled "Materials for Electronics." (326)

ALARM AND ANNUNCIATOR CIRCUITS Clevite Transistor, 1801 Page Mill Road, Palo Alto, Calif. Use of 4-layer diodes in small, solid state, alarm and annunciator circuits is described in an application data sheet. (327)

ENCAPSULATION KIT Dow Corning Corp., Midland, Mich. Four-page brochure describes a kit for encapsulating random-wound stators in Silastic RTV, a pourable silicone rubber that vulcanizes at room temperature. (328)

Carborundum Dedicates New Facility

CARBORUNDUM COMPANY recently dedicated a new facility which doubles the size of its electronics plant in Niagara Falls, N. Y. The new facility, with 40,000 square feet of floor space, was required for production of the company's rapidly expanding electronic product lines.

"We already have the business now to keep the expanded plant working day and night", R. W. Lear, vice president, marketing, said. He predicted that in four or five years the Electronics division of the company will need a plant twice the size of present facilities.

Future growth, he explained, will come from development of new solid state materials and the improvements which these advanced materials will make possible in electronic products. Presently in development are ultrafine silicon carbides, lossy ceramics, boron nitrides, zirconium, insulating materials, and thin-film thermoelectric materials. Products in development include semiconductors and higher-temperature resistive devices.

Some of these new products are in pilot plant production. They are commercially available, but are still under control of the Research and Development division because, Lear emphasized, the company's decentralization policy holds that new products should be "worked out" completely—from research to marketing—by the group responsible for the product creation.

These R&D "new product branches," as they are called, account for product sales of more than $1 million in one year. Altogether, electronic products now account for more than 10 percent of the company's total business volume, and R&D investment in electronics amounts to more than $4 million annually. Besides its Niagara Falls plant, the company operates an electronics plant in Latrobe, Pa.

Arnett Heads Up TI Geosciences

APPOINTMENT of Richard A. Arnett to manager of the Geosciences department of the Science Services division of Texas Instruments Inc., Dallas, Texas, has been announced by TI vice president R. C. Dunlap, Jr.

Formerly head of the Geosciences department's seismic programs branch, Arnett will assume responsibility for all phases of the department's earth and space science operations and will report directly to Dunlap.

Monitor Systems Elects Hoberg

GEORGE C. HOBERG has been elected president of Monitor Systems, Inc., Fort Washington, Pa., a wholly owned subsidiary of Epsco, Inc. Monitor Systems, Inc., specializes in military and industrial data handling.

Hoberg was formerly chief engineer for Tele-Dynamics division of American Bosch Arma Corp.

Gonzalez Assumes New Philco Post

APPOINTMENT of Edmundo Gonzalez as manager, Special Products Operation, Lansdale division, Philco Corporation, is announced. In this assignment he will be responsible for the development, engineering, production and marketing of the division's infrared and microwave components.

Gonzalez has been with Philco since 1956, having most recently served as manager, microwave components, Special Products Operation.

Harman-Kardon Promotes Torn

LAWRENCE J. TORN, general manager of the Data Systems division of Harman-Kardon, Inc., Plainview, N. Y., has been appointed a vice president, it was announced by Sidney Harman, president of the Jerrold Corp., a diversified electronics company.

Herman-Kardon, one of five Jerrold subsidiaries, organized the Data Systems division in 1960 to design and manufacture digital logic modules for subsystems of digital computers and other data processing instruments.

Before joining Harman-Kardon in 1960, Torn was employed by Airborne Instruments Laboratory as general manager of the Apparatus division of that organization.

Appoint Levine to Martin Company Post

BERNARD LEVINE was recently named manager of applications research at Martin Company's Space Systems division, Baltimore, Md. He was formerly with General Electric Co.

PEOPLE IN BRIEF

Harry C. Lieb and **Stanley Wallack** promoted to directors of research of Leesona Moos Laboratories. **Oskar Giesecke,** formerly with Air Marine Motors, Inc., joins Rotating Components, Inc., as v-p of engineering. **Morris H. Arck,** previously with Barnes Engineering Co., now head of infrared research at Aero Geo Astro Corp. ITT advances **Thaddeus L. Dmochowski** to exec v-p of the Information Systems div. **John M. Fluke,** president of John Fluke Mfg. Co., elected a director of Gertsch Products, Inc. **Robert A. Westervelt,** ex-U.S. Navy Underwater Sound Laboratory, appointed technical director of Avco Corp./Marine Electronics Office. **Richard T. Orth,** formerly v-p of operations. named v-p, g-m at Eitel-McCullough, Inc. **Walter R. Chapman,** from Thompson Ramo Wooldridge Inc. to Lord Mfg. Co. as head of a new R&D div. **Thomas A. Jamieson** moves up to engineering v-p of Zero-Max Industries, Inc. **Robert M. Wood** leaves Pacific Semiconductor, Inc., to become v-p, g-m of Keleket X-Ray Corp. **Lyman A. Rice,** most recently with Essex Wire Corp., now chief engineer at Milwaukee Relays. Vard div. of Royal Industries, Inc., ups **John T. McGraw** to exec v-p. Airpax Electronics, Inc., elevates **Thomas W. Coughlin** to mgr. of the Cambridge div. **David M. Pixley** advances to mgr., product development for Havelex, Taunton div. of Haveg Industries, Inc.

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electronics

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HOME TELEPHONE ....

Education

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UNIVERSITY ....

DATE(S) ....

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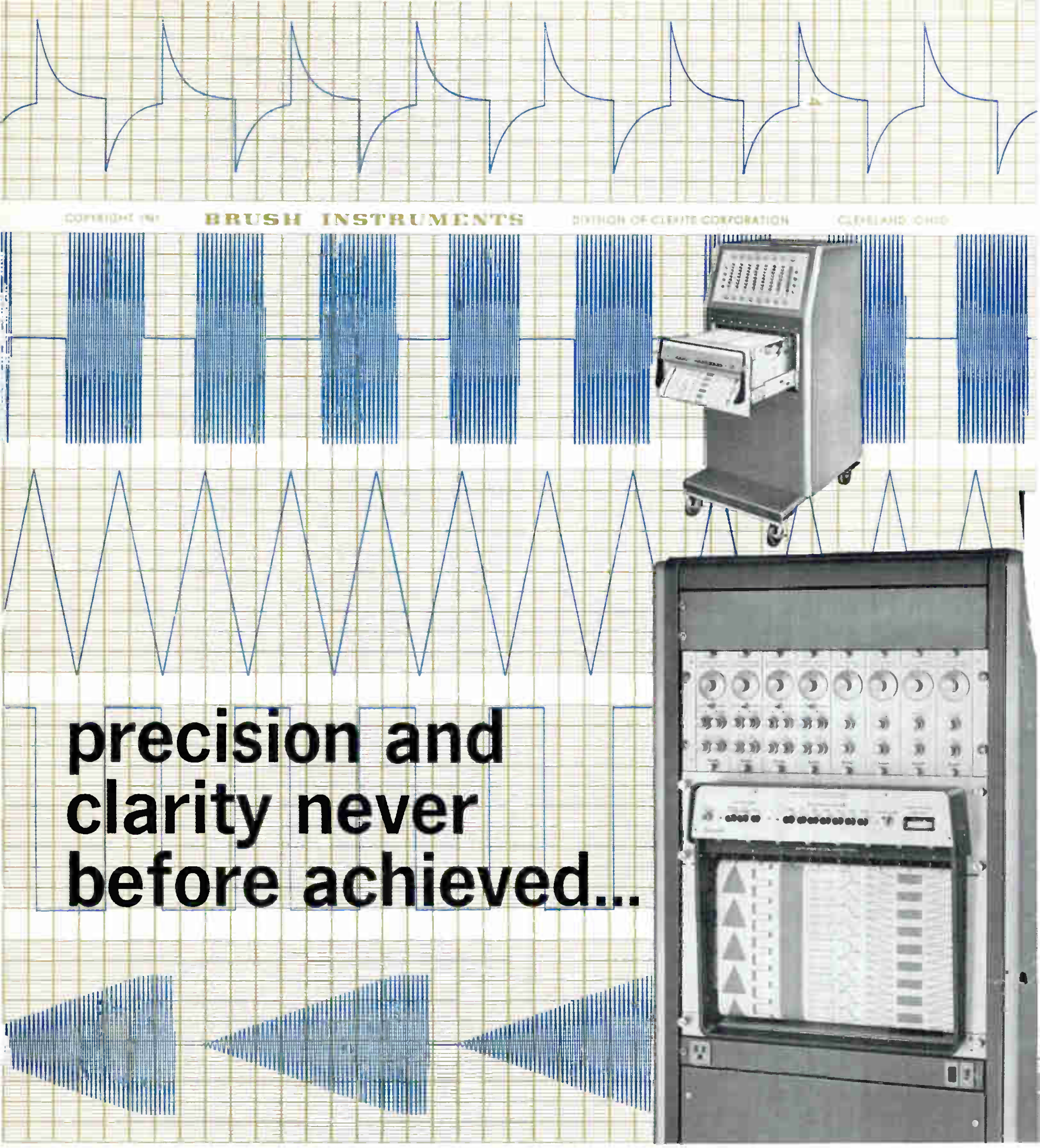

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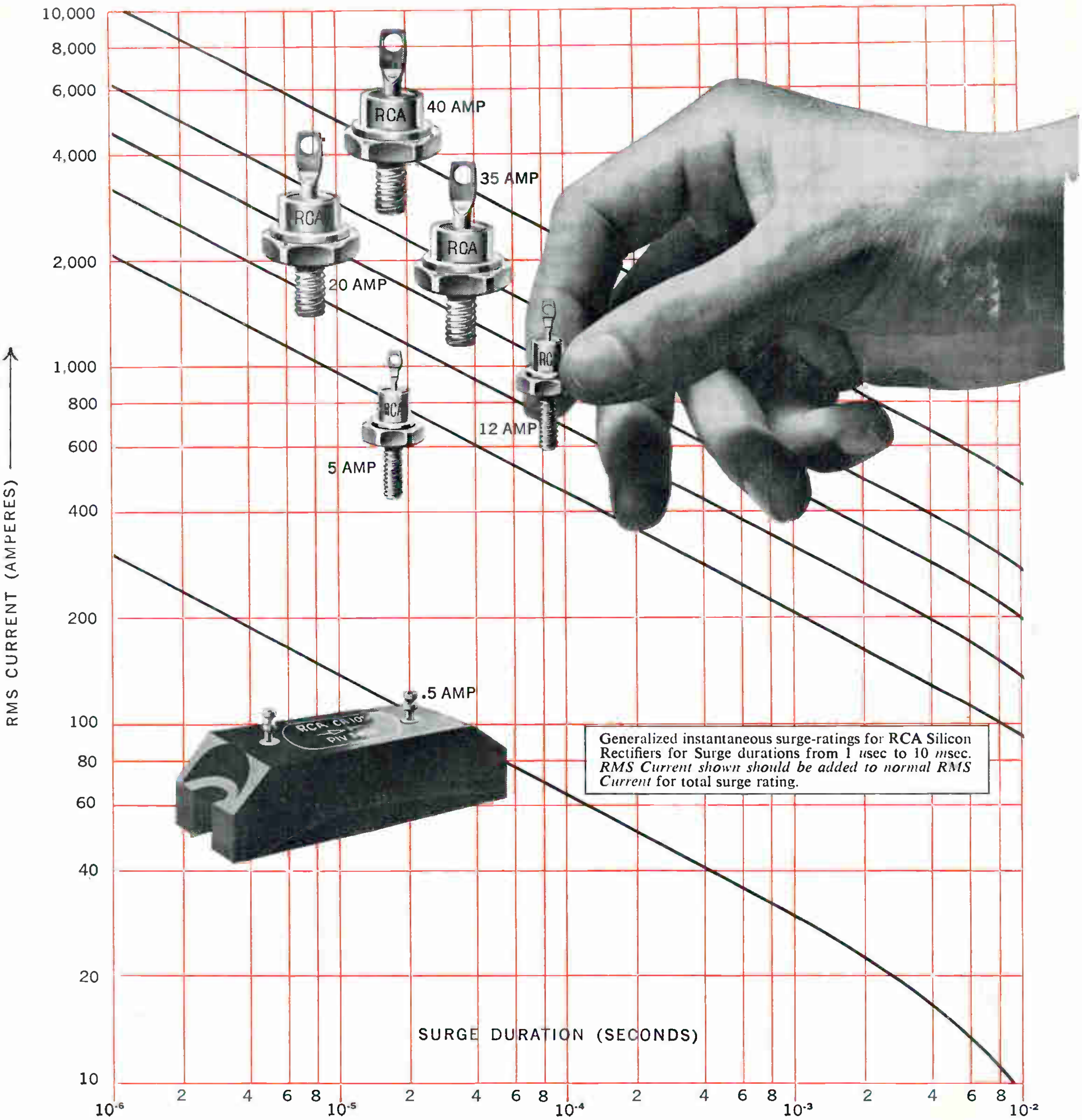

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- Each package designed to meet the stringent environmental and mechanical requirements of today's military and industrial power equipment
- Extra-high-strength zirconium-alloy mounting stud
- Unique internal heat sink assures union of pellet and contact to eliminate high-current hot spots
- Thermal fatigue cycling tests — the best assurance for long and dependable service
- Every unit is dynamically tested prior to shipment

Call your RCA Representative for complete information. For your copy of the RCA Application Note, SMA-4, write to RCA Semiconductor and Materials Division, Commercial Engineering, Section IN11-4, Somerville, N. J.

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