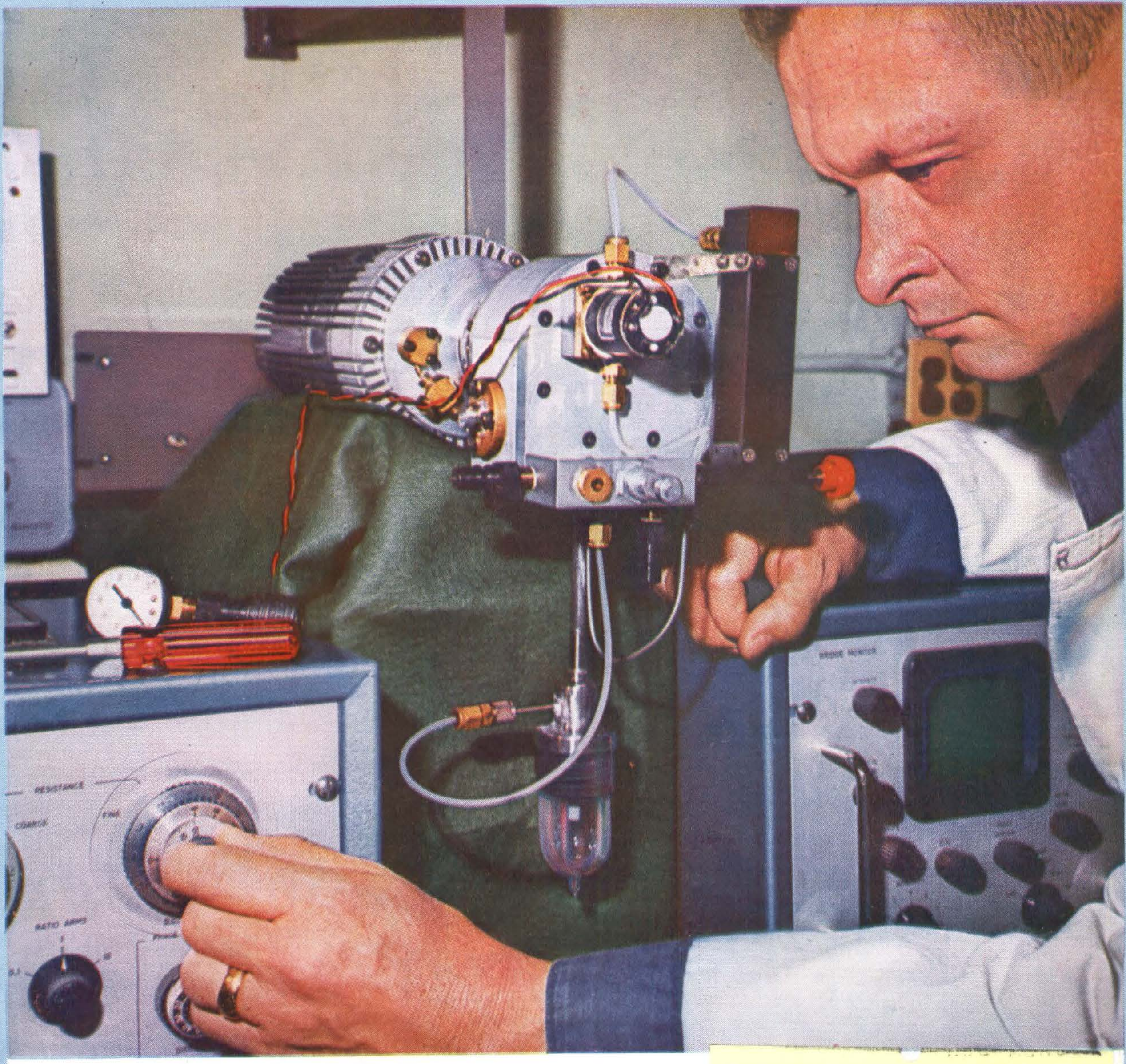
A McGRAW-HILL WEEKLY 75 CENTS DECEMBER 27, 1963

electronics®

LASER DESIGN USING CHARTS
Recalls techniques used in microwaves

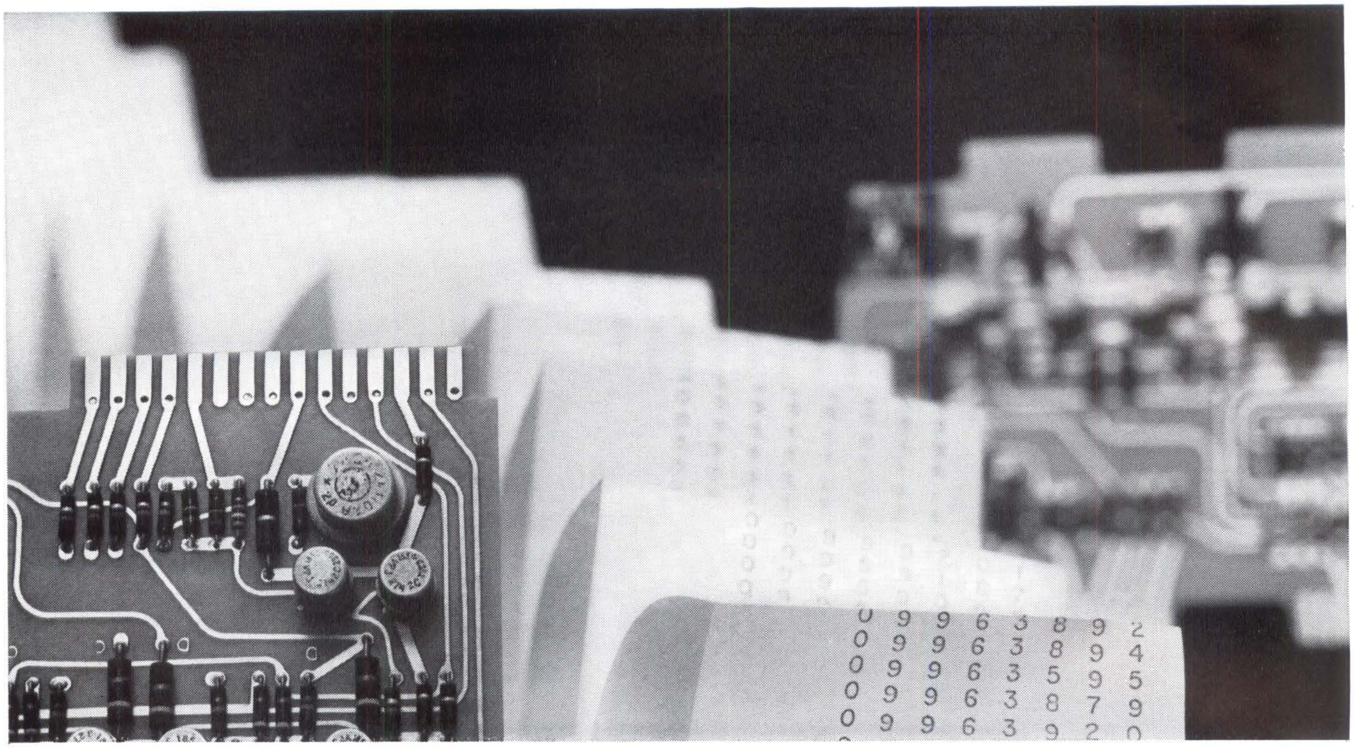
TUNNEL DIODES FOR Q-BAND
Millimeter oscillator employs X-band diode

ANY-LENGTH COUNTERS
Logic design ends trial and error



CRYOGENIC COOLER (finned unit in middle) reaches 25 deg K

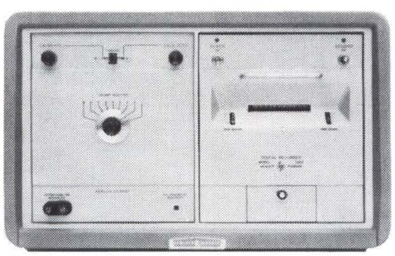
In This Issue: 1963 INDEX



FLEXIBLE PERFORMANCE

with the hp 562A Solid State Digital Recorder

Prints up to 5 lines/second
Accepts data in just 2 msec
Plug-in programming for each column
Optional selection of several BCD codes
Dual input, 10-line code available



SPECIFICATIONS

Printing rate:	5 lines/sec maximum
Column capacity:	11 columns (12 on special order)
Print wheels:	0 through 9, a minus and a blank; other symbols available
Data input:	Parallel entry; BCD (1-2-2-4, 1-2-4-8, 1-2-4-2) or 10-line; difference between "1" and "0" states may be between 4 to 75 volts
Reference voltages:	BCD codes require both "0" and "1" state references; 10-line codes require reference voltage for "0" state; reference voltages may be up to ± 150 v to chassis; input impedance is approximately 270 K ohms
Print command:	+ or − pulse, 6 to 20 volts amplitude, 1 v/μs minimum rise time, 20 μs or greater in width, ac coupled
Transfer time:	2 ms for BCD codes
Paper required:	hp folded paper tape, or standard 3-inch roll tape
Line spacing:	Zero, single or double
Size:	Cabinet, 20¾" x 12½" x 18½"; rack mount, 19" x 10½" x 16⅞" deep behind panel
Price:	Depends upon options; typically $1300 to $2000

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

The performance-proved hp 562A Digital Recorder is unique for its combination of speed, input capability, programming versatility and dependable operation in thousands of applications.

It prints digital data as fast as 5 lines per second, with as many as 12 digits per line. A storage feature for each column permits data transfer in 2 msec, after which the source is free to collect new data.

In addition to four-line BCD codes, ten-line code (without the data storage feature) also is available with plug-in cards. The recorder also accepts dual input (optional) to print data simultaneously from two unsynchronized sources—even if coded differently.

Analog output is available as an option for 562's which have 1-2-2-4 or 1-2-4-8 BCD column boards installed. The option, which includes controls for recorder calibration and zero adjustment, provides accurate analog output for any three columns, even when not printing.

Call or write today for complete information on the basic hp 562A and a detailed description of the many options available, together with a convenient order form that makes it easy to get the solid state recorder just right for your specific application.

8870

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CIRCLE 900 ON READER SERVICE CARD

DECEMBER 27, 1963

electronics

A McGRAW-HILL WEEKLY 75 CENTS

Contents continued

electronics

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Contents continued

DEPARTMENTS

We Approve, With Reservations

THERE IS a move afoot in Washington to broaden government support of research. Behind the move are reasons that can be called both positive and negative. We salute the positive reasons and thumb-down the negative ones.

The positive approach holds that there are numerous social and scientific problems that have not been solved. Greater funding of programs in, for example, pollution control, medical research, meteorology and oceanography, and studies of such problems as the impact of automation, are being urged.

Acceleration of research in such fields would be socially, scientifically and economically rewarding. The electronics industry, in particular, could anticipate greater opportunities to diversify into nonmilitary product areas—diversification that would aid its growth and long-range stability.

It is, therefore, an attractive proposal.

But our enthusiasm is tempered by some of the negative reasoning behind the proposal.

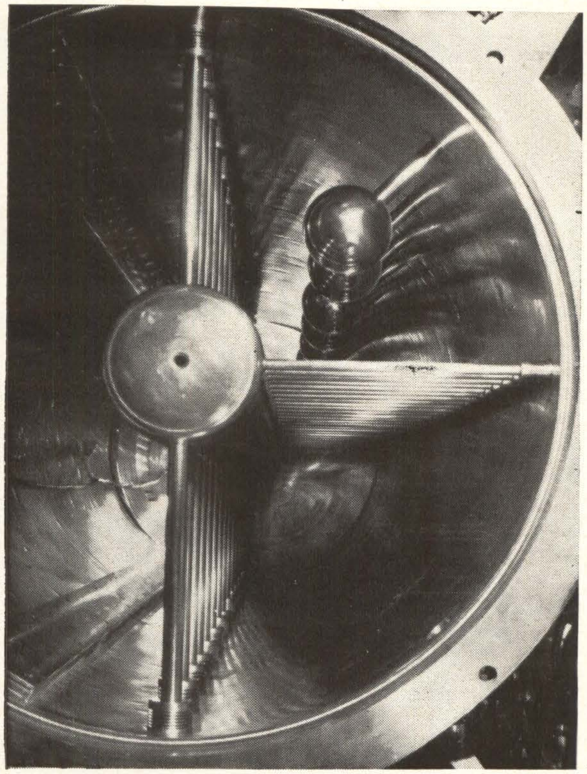
The strongest backing seems to come from those concerned about slowdowns in military research. They want a program to maintain the impetus that military research has given the economy and technology—as a substitute for military research.

If the proposal is accepted on this basis there is danger that the program will never get off the ground. Worse, promoting nonmilitary research as a substitute for military research can build up pressures to decrease military research solely for the purpose of increasing nonmilitary research. It could easily go too far.

This sort of reasoning is highly undesirable because it could stigmatize government-funded nonmilitary research as a sort of scientific WPA that would have to compete with pork-barrel projects for appropriations. It would be very difficult at present to build an effective case for programs to forestall a depression in the "business" of R&D. One recent survey (ELECTRONICS, p 18, Dec. 6) predicted that R&D expenditures in the U.S. next year would total $20 billion, reflecting a $1.1-billion increase in government funding and $500-million increase in industry spending.

If the object of the proposal is to pump money and technology into the economy, rather than to get a job of work done, then there is no necessity for shifting from military to nonmilitary research.

It seems clear, therefore, that government support of nonmilitary research should be supported on the merits of projects proposed. To cite just one example, air pollution: It has been estimated that air pollution costs the nation over $11 billion a year in money and perhaps 19,000 deaths a year. Problems such as this are well worth solving for their own sake.



ZERO GRADIENT SYNCHROTRON at Argonne National Laboratory is one of the latest additions to national research facilities. This is the ZGS's 110-foot linear accelerator

Coming In Our January 3 Issue

THE NEW YEAR. Our next issue contains our annual electronics markets special report. It probes the electronics industry and highlights areas of profit, plateau or penury—in detail. We've developed the outlook for 1964, and beyond, through interviews with government, military, industrial, scientific and marketing specialists. The men we spoke to not only know fairly accurately what is going to happen, in many cases they make it happen. They are in the top echelon of our industry, and their comments reflect the best information obtainable on where the dollars will be spent. In text and figures, we've brought informed order to much of the disparate information we gathered. Join us next week for an inside view of the year ahead.

COMMENT

CASCODE FOLLOWER

I noted with interest the excellent article by R. W. Johnson entitled, The Cascode Follower, which appeared in your Dec. 6 edition (p 69).

The application note at the bottom of the page suggested that a transistor version of this circuit should be possible. You may be interested in the fact that a transistor version of this circuit was published in the Second Edition of the General Electric Transistor Manual as a "hi-fi" amplifier of low output impedance for directly driving loudspeakers. The work that I did on this transistor circuit was, in turn, suggested by Dr. R. A. Stasior who had become acquainted with a similar tube circuit in his student days in Canada. In looking up the tube circuit, we found that it was published, strangely enough, in ELECTRONICS magazine in November of 1946 (p 206).

Perhaps the only conclusion that can be drawn from this is that there should be some technique for making useful circuits available so that it is not necessary for an engineer to "re-invent the wheel." The only suggestion I have is for some publisher like McGraw-Hill to classify circuits somewhat in the form of a dictionary so a person could, for example, find the "cascode follower" circuit with a minimum of difficulty.

H. R. LOWRY

Semiconductor Products Department
General Electric Company
Syracuse, New York

• The United States Patent Office is working on a system for classifying patented transistor circuits with digital codes, to simplify the processing of incoming patent applications.

FIELD EFFECT DEVICE

I read with interest the *Research and Development* article, New Field Effect Device May Aid Integrated Circuit Design, in the Nov. 29 issue (p 44). I would be interested in obtaining one of these devices for experimental purposes. I would appreciate any information or help that you could give me in this matter.

WALTER MAUDERLI

Department of Radiology
College of Medicine
University of Florida-Gainesville
Gainesville, Florida

• For further information, write to H. C. Nathanson (one of the inventors) at Westinghouse Research Laboratories, Pittsburgh 35, Pennsylvania.

REVERSED DIODE

At the risk of being called a "nit picker," I should like to point out what I feel is a discrepancy appearing in your Electronics Color Code chart (p 37, Nov. 15).

At the head of the column describing diode coding, a schematic symbol of the diode appears. However, since the sample color coding of the diodes shown below it show the cathode as being on the left (and it is labelled as such on the chart), it infers that the triangle end of the diode symbol is also the cathode, and the bar end the anode. I am lost—shouldn't it be the other way?

Being heavily involved in solid-state logic circuitry for the last few years and having used the bar end of the diode symbol as the cathode with remarkable success, I feel the symbol should be turned around to agree with the color coding shown. Don't you agree?

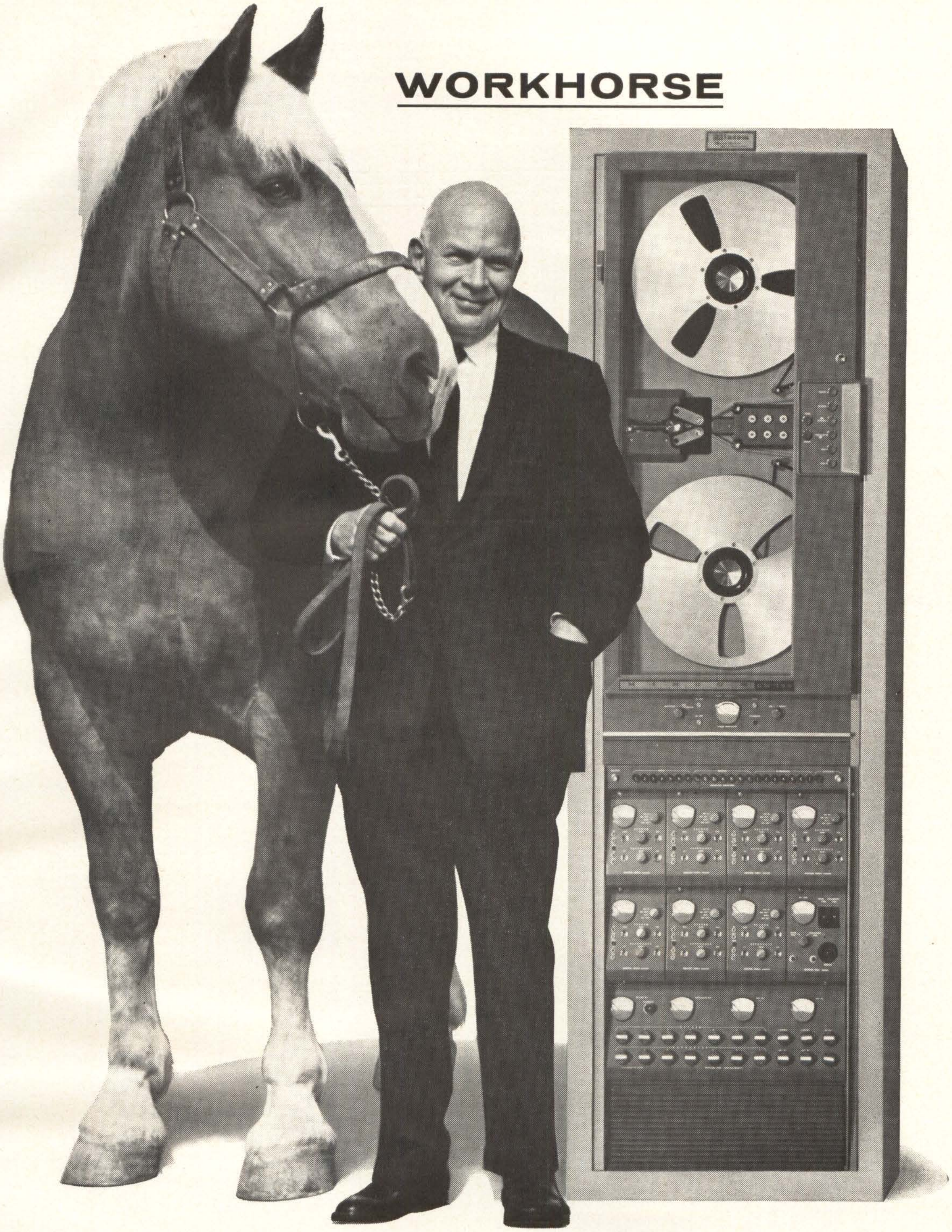
Seriously though, the chart is a beautiful one, which I will keep for reference until the standards change and a new one will be issued (hopefully).

M. ARNAUTOFF

Redondo Beach, California

• We agree. That diode symbol should be turned around.

WORKHORSE



Downtime's nemesis, rugged and reliable as a purebred workhorse — that's Mincom. Common denominator of dependability in all four basic Mincom Recorder/Reproducers is the exclusive Mincom DC Top Plate. Here's a tape transport built with beautiful simplicity: Only 12 moving parts with four easy adjustments, full dynamic braking, instant six-speed pushbutton control, seven or fourteen tracks — plus tape speed accuracy within $\pm 0.005\%$ using Mincom's Cyclelock®. Whether your specifications call for wideband predetection at 1.5 mc, or a comfortable 120 kc at 60 ips, there's a reliable Mincom workhorse to meet your facility's needs. Write today for details.

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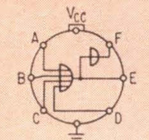
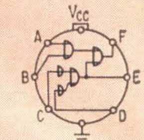
GATE ELEMENT, G



$E=\overline{A+B+C+D}$ (Positive logic)
$F=A+B+C+D$

ELECTRICAL PERFORMANCE (Worst case) $V_{CC}=3V$; —55°C to +125°C	
Input Loading — Pins A, B, C, D	1 Load
Fan-Out — Pin E	3 Loads
— Pin F	4 Loads
Signal Propagation Delay — Output E (Note 3)	40 nsec
— Output F	70 nsec
Power Consumption*	5.0 mW

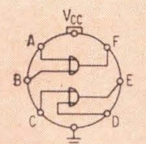
ADDER ELEMENT, A



$E=CD$ (Positive logic)
$F=(A+B)\ (\overline{C}+\overline{D})$

ELECTRICAL PERFORMANCE (Worst case) $V_{CC}=3V$; —55°C to +125°C	
Input Loading — Pins A, B, C, D	1 Load
Fan-Out — Pin E	3 Loads
— Pin F	4 Loads
Signal Propogation Delay — Output E	70 nsec
— Output F	100 nsec
Power Consumption*	12.5 mW

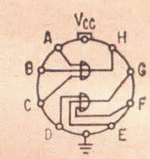
DUAL 2-INPUT GATE ELEMENT, D_2



$E=\overline{C+D}$ (Positive logic)
$F=\overline{A+B}$

ELECTRICAL PERFORMANCE (Worst case) $V_{CC}=3V$; —55°C to +125°C	
Input Loading — Pins A, B, C, D	1 Load
Fan-Out — Pins E, F	4 Loads
Signal Propagation Delay — Pins E, F	40 nsec
Power Consumption*	5.0 mW

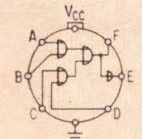
DUAL 3-INPUT GATE ELEMENT, D_3



$H=\overline{A+B+C}$ (Positive logic)
$G=\overline{D+E+F}$

ELECTRICAL PERFORMANCE (Worst case) $V_{CC}=3V$; —55°C to +125°C	
Input Loading — Pins A, B, C, D, E, F	1 Load
Fan-Out — Pins G, H	4 Loads
Signal Propagation Delay — Pins G, H	40 nsec
Power Consumption*	5.0 mW

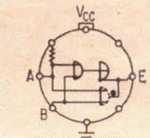
EXCLUSIVE OR ELEMENT, HALF ADDER, H



$E=\overline{(A+B)(C+D)}$ (Positive logic)
$F=(A+B)(C+D)$

ELECTRICAL PERFORMANCE (Worst case) $V_{CC}=3V$; —55°C to +125°C	
Input Loading — Pins A, B, C, D	1 Load
Fan-Out — Pin E	4 Loads
— Pin F	3 Loads
Signal Propagation Delay — Output E	100 nsec
— Output F	70 nsec
Power Consumption*	10 mW

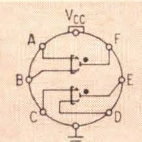
BUFFER ELEMENT, B



$E=\overline{A+B}=\overline{A}\overline{B}$ (Positive logic)

ELECTRICAL PERFORMANCE (Worst case) $V_{CC}=3V$; —55°C to +125°C	
Input Loading — Pins A, B	2 Loads
Fan-Out — Pin E	30 Loads
Signal Propagation Delay — Output E (Full Load)	60 nsec
Power Consumption — 50 percent duty and full load*	12.5 mW

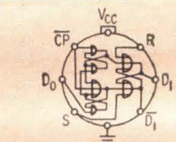
EXPANDER GATE, E



The E element is used to increase the fan-in capabilities of the family. The E is similar to the D element except that the output node resistors are omitted. The E can extend the fan-in of any other element, except the Buffer, up to a maximum of 4 additional inputs without exceeding the guaranteed electrical performance of the other elements.

ELECTRICAL PERFORMANCE (Worst case) $V_{CC}=3V$; —55°C to +125°C	
Input Loading — Pins A, B, C, D	1 Load
Fan-Out — Pins E, F (Note 2)	N.A.
Signal Propagation Delay — Pins E, F	40 nsec
Power Consumption (Note 2)	N.A.

REGISTER ELEMENT, R



The R element is a synchronous clock gated flip-flop with asynchronous set and reset. This element can be used both as a full shift register stage or as a complementing binary flip flop. The complementing function is achieved by coupling back $\overline{D}_1$ to D_0. Data at D_0 are entered during a one-to-zero transition of $\overline{CP}$. The data bit D_0 must be present a minimum of 70 nsec before, and 20 nsec after the 50-percent point of a one-to-zero transition of $\overline{CP}$.

$D_1=S+CPD_0$
$\overline{D}_1=R+CP\overline{D}_0$

ELECTRICAL PERFORMANCE (Worst case) $V_{CC}=3V$; —55°C to +125°C	
Input Loading — Pins D_0, S, R	1 Load
— Pin $\overline{CP}$	2 Loads
— Pins D_1, $\overline{D}_1$	3 Loads
Signal Propagation Delay — Synchronous Entry	Note 1A
— Asynchronous Entry	Note 1B
Power Consumption*	15 mW

NOTES:

1A. Synchronous entry of data: When data are being entered through the D_0 input, the 50-percent points of the D_1 and $\overline{D}_1$ waveforms shall occur within 120 nsec of the one-to-zero transition of $\overline{CP}$.

1B. Asynchronous set and reset: When the R element is set or reset through the R and S inputs, the 50-percent points of the D_1 and $\overline{D}_1$ waveforms shall occur within 70 nsec of the 50-percent point of the R or S pulse.

2. The fan-out and power consumption for the E element are not applicable. The ratings for the element being expanded apply.

3. The maximum signal propagation delay is defined for the entire temperature range of —55°C to +125°C and any combination of the rated loading. Measurement is made between 50-percent points input-output with a G element as a driver.

* Maximum fan-out.

GENERAL FEATURES

Fan-Out: Guaranteed fan-out is 4 from —55°C to +125°C. Buffer element increases fan-out to 30.

Speed: Guaranteed worst-case propagation delay of 40 nanoseconds per node.

Power: Average dissipation per function varies from 4 milliwatts to 10 milliwatts. Typical, 2 milliwatts per node.

Application: Simple design rules permit rapid application and insure compatibility between functions.

Functional Complexity:

Shifting and counting can be done with a single element. Other elements are also of high complexity.

The average element consists of 4 NOR functions, thus permitting the use of two-sided printed circuit board for element interconnection and resulting in exceptionally high packaging density.

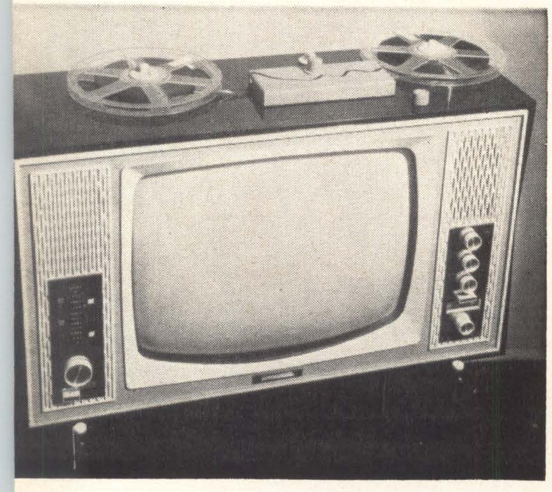
Cost is not linearly proportional to functional complexity, but is related primarily to die size. Additional elements of like complexity can be produced on a custom basis at a comparable price. For example, in quantities of 49-200:

Elements	R	D_2
Transistors	15	4
Resistors	21	6
Die area	2500 mil²	1600 mil²
Price	$33.15 ea.	$16.25 ea.

Home Tv Tape Recorder—It Really

By ALEXANDER A. McKENZIE
Associate Editor

DAN SMITH
Assistant Editor



FIRST MODEL to reach the market will have the Telcan tv tape recorder mounted on a slide under the tv receiver (top), which Nottingham Electronic will also sell. Second version will combine the recorder and tv set

British device gives picture adequate for entertainment purposes

NEW YORK—At an offhand demonstration last week, the American press got its first glimpse of the much-publicized Telcan home video tape recorder (p 19, Sept. 13; p 7, Aug. 23; p 7, Aug. 16; p 8, July 5).

Allowing for conditions, which were terrible, two observers from ELECTRONICS agreed that the British device probably does live up to its advance billing. It should provide adequate recordings of television programs and vidicon-camera signals, and at its price—$160 for the model to be sold in the United Kingdom beginning in March—may find a wide market among ordinary tv viewers.

The demonstration, held in a basement room of a local Cinerama theater, was bad on two counts. Tv reception was poor at the location, so that the signals fed to the recorder were weak and fuzzy, and interference, probably from stray tv signals, played hob with the recordings.

Michael Turner, a director of Nottingham Electronic Valve Co., Ltd., of England, developer of the device, said the interference problem in Manhattan had been overlooked in planning the presentation. The trouble, he said, could be easily corrected with proper shielding of the recorder. To illustrate his point, he moved his hand back and forth near the recorder head, producing a visible change in the interference displayed on the tv screen.

Picture Quality—Deterioration is another matter, Turner said. Some is always present between the signal picked up by the tv receiver and that reproduced by the recorder. The deterioration was evident in the demonstration, but, because of the interference and the poor quality of the tv signals, it was impossible to judge exactly how good a picture Telcan can deliver.

However, this much could be told. The pictures that actually were reproduced probably would have been found adequate—if barely so—by most viewers, but the degree of deterioration makes it unlikely Telcan can be used for any purpose other than entertainment. Pictures taken with an inexpensive vidicon camera, which the company also plans to sell for about $160, were reproduced more clearly by the tape recorder.

Price Is Right—The announced price of the tape recorder, which has been greeted with some skepticism in the press, will be no trouble to meet, according to Turner. But a more sophisticated version than the one planned for the British market might be selected for the U. S., he said, with a consequent increase in price. Nottingham Electronic will make the recorder for the United Kingdom market. A new company, jointly owned by Cinerama and Nottingham, will manufacture the devices for sale in the western hemisphere. These won't reach the U. S. in any quantity until next fall, Turner said.

Major innovations in the tape recorder, Turner said, have to do with actual recording methods—the setting of the tape, for instance. Nottingham Electronic is reluctant to discuss these because it presently holds only a British provisional patent on the device. However, Turner did supply many technical details.

Overall System—The recorder is connected to the detector circuit of the home tv set and records whatever signal is tuned in on the set. Alternatively, it records signals from a home camera. In this case, the NEV camera feeds r-f output into the antenna input of the tv receiver. On playback, the recorder works into the detector-output point of the tv set and the signal, amplified by the video stages, is normally displayed.

Recorder—The recorder has one motor to operate the tape-drive capstan, and, through a pulley and belt arrangement, the tape supply and tape takeup reels. Tape speed

Works

is 120 inches per second. Tape used is ¼-inch, ½-mil Mylar. Machine can handle up to 11½-inch diameter reels. Transport is capable of handling thinner tapes that would give up to 30 minutes on a side but such tape is not presently available.

With present reels and tapes, 22 minutes of recording are possible on each side of tape, or a total of nearly 45 minutes. With automatic tape turning, a continuous performance of 45 minutes might be possible. The tape-turning mechanism is not yet available.

As received by the recorder—which handles the picture processing—the composite video signal is split into synchronizing and video information, amplified and fed into the one video recording head. On replay, a preamplifier separates sync and video signals and feeds them into the appropriate receiver circuits. Bandwidth is better than 2 Mc but the equipment has a 3-Mc rise time and its resolution depends upon noise. Resolution in the highlights is better than in the blacks. Resolution is enhanced between mid-gray and peak white.

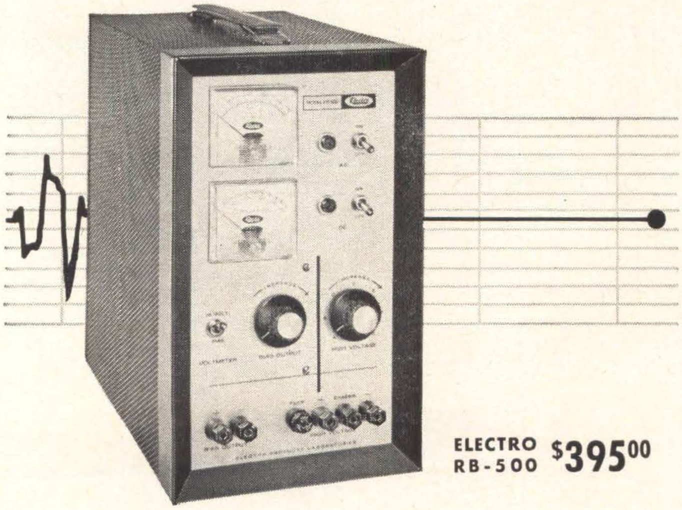
The high-resolution heads are not expensive nor are they long-lasting. They are expected to be serviceable for about 100 hours after which they can be replaced for about $2, like a record stylus.

Recorder circuits are transistor and the driving transistor delivers about 1 watt to the recording head. The signal off the tape is about 1 to 1.5 volts and a divider across the output maintains that level. The volume control on the tv set, therefore, is operated normally. In the future, color can be accommodated (at half the playing time per tape—driving the tape in one direction only) by using one of the 18-mil signal tracks for color difference signals.

Camera—The vidicon camera's circuits are all-transistor. It delivers about 30 millivolts to the antenna terminals of the receiver. Tv camera techniques (no shutter needed) allow putting most of the money into good optics. An f 1.9 lens is used.

PRODUCT
NEWS from EPL

NEW... hi-voltage regulated DC Power Supply under $400.



ELECTRO RB-500 $395.00

Compare Value

Brand	Volts	Current	Regulation (Combined line & load)	Price
K	0-325	0-200 MA	0.02%	$495.00
S	0-500	0-200 MA	2.0%	400.00
Electro RB-500	0-500	0-250 MA	0.03%	395.00

Compare Features

High Voltage Output: 0-500 VDC. 0-250 MA
Precise Regulation: 0.03% or .015V, whichever is greater, for combined line (105-125V) and load (no-load to full-load) variations.
Ripple: 5MV, RMS maximum.
Bias Output: 0-150 VDC.
Filament Outputs: Two separate 6.3V at 5A outputs for 6.3V at 10A or 12.6V at 5A.
Primary and Secondary Protection.
2% D' Arsonval Meters: Dual scale . . . 0-500V/0-150V. 0-250 MA
Separate AC, DC Switches.
Continuous Output Voltage Adjustment: Regulation maintained well below 3V output setting.
Wherever precisely regulated DC power is a must, the EPL RB-500 fills the bill economically. Engineered and built for heavy-duty production testing; electronic circuitry development and design in industry, laboratories and schools.

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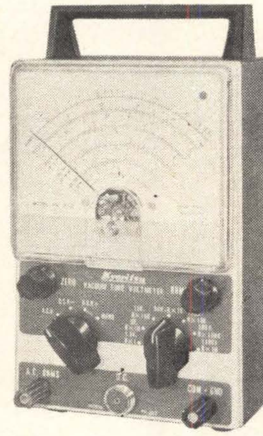

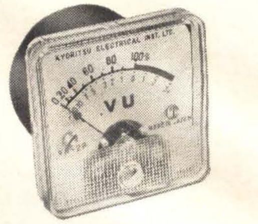

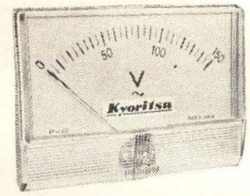

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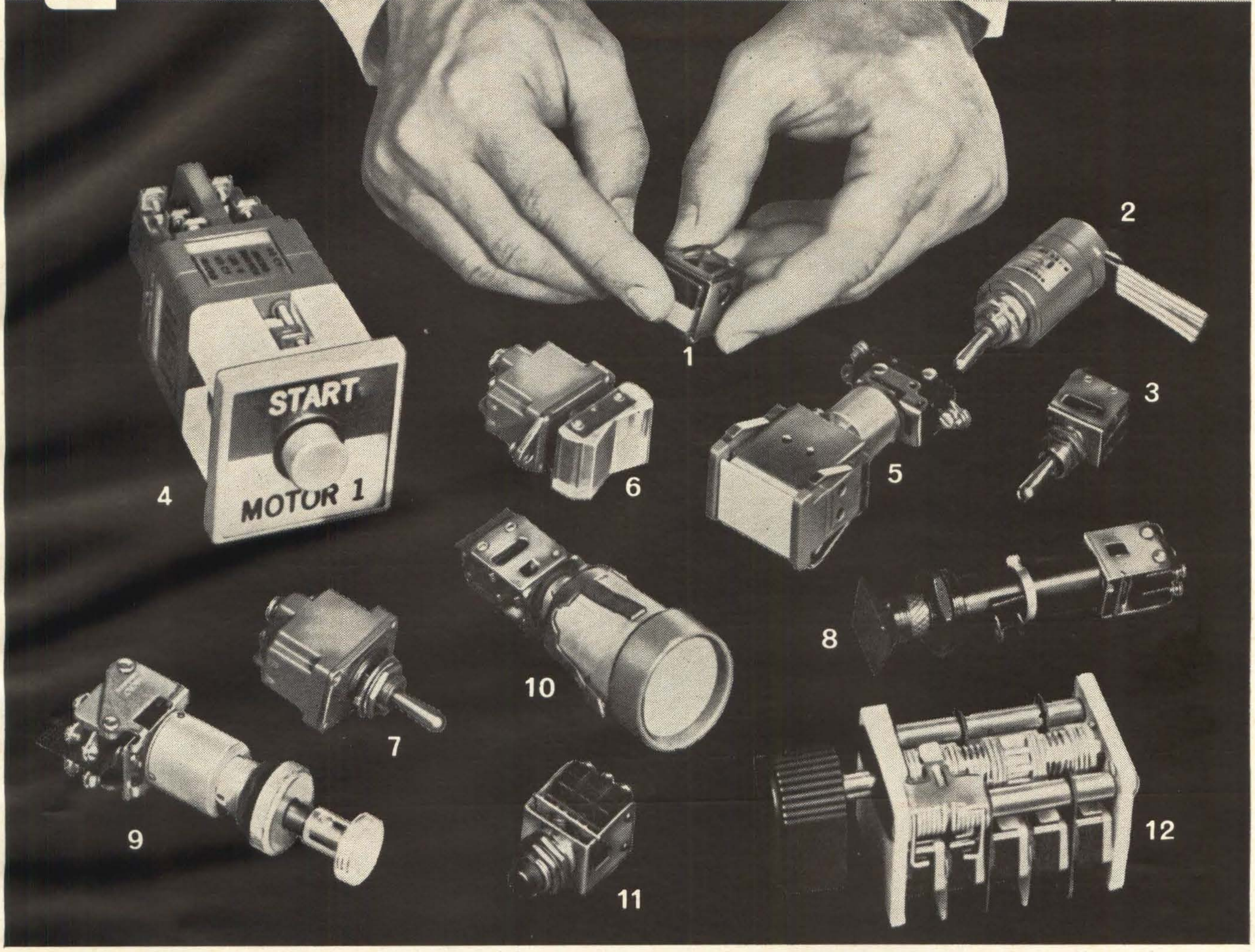

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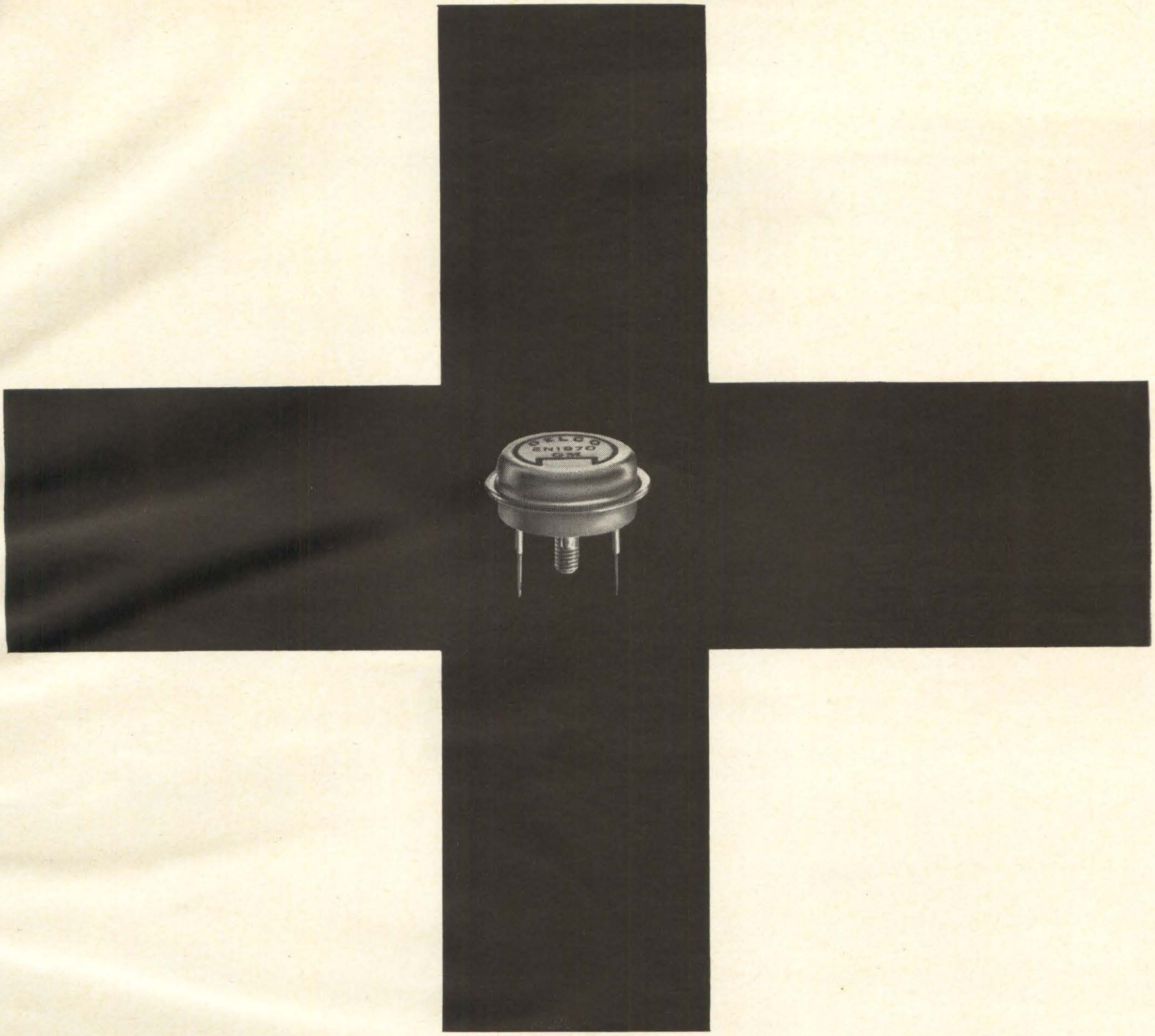

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ComSat Proposals Due Feb. 10

WASHINGTON — Industry proposals for the first commercial communications satellite system (p 20, Dec. 20) are due Feb. 10. Design specifications for the system were detailed this week by the Communications Satellite Corp.

The corporation wants designs for both intermediate-altitude and high-altitude synchronous satellites and may choose either or both for six-month follow-on studies. Intermediate satellites would be ready for launch in 1966, with initial global coverage in 1967; synchronous system launch would begin in 1967, for global coverage in 1968.

The satellite system is to permit one-way monochrome television to be transmitted on an alternate basis with two-way 4-kc channels. There is to be a capability of 270 two-way channels in 1966 to 1968; 400 two-way 4-kc channels in 1969; 600 in 1970, 800 in 1971 and 1,200 in 1972.

The corporation wants 18 satellites for a random intermediate-altitude system; 12 satellites for a phased intermediate-altitude system, or 6 satellites for a synchronous-altitude system. Frequencies specified include 5,925 to 6,425 Mc for the up-link and 3,700 to 4,200 Mc for the down-link.

ComSat Corp. also plans to launch an earlier, experimental synchronous satellite, independent of these design requests, in 1965 to link the U. S. and Europe. Bandwidth and power capability would provide for either tv facsimile or telegraph message traffic, or up to 240 two-way telephone channels. Purchase of these satellites will be negotiated directly with Hughes, developer of the Syncom satellites.

Experts Lay Groundwork For World-Wide Dialing

GENEVA — Telecommunication experts have quietly given the go-ahead for world-wide direct dialing. International Telecommunications Union's Committee for the General Plan for Development of Telecommunication Networks, meeting in Rome, agreed on future routing and a numbering plan using a series of 11 or 12 digits.

Recommendations were also made about planning, operations, standards and maintenance. The enormous distances, the noise problem, the propagation time and the need for echo-suppressors were cited as examples of the difficulties to be overcome. It was agreed that the line and information signals should be kept separate. Line signaling would be link by link using a compelled sequence code of signals, and the inter-register signalling system would use a multifrequency code. Automatic exchanges would contain memories to store dialing data.

Patient Says Laser Healed Eye

MENLO PARK, CALIF.—First human patient operated on by laser for a detached retina says the treatment was a success (p 17, Sept. 13 and p 30, April 19). His physicians are more cautious. The patient is Donald Scheuch, director of the Electronics and Radio Sciences Division of Stanford Research Institute. He suffered the injury while playing ball and received his first laser treatment about Sept. 1 from Dr. H. Christian Zweng and Dr. Milton Flock. Two subsequent treatments were given.

Scheuch reports he is leading a normal, active life and the retina has remained attached. Dr. Zweng and Dr. Flock say the longer it remains attached, the greater the chances for full recovery, but they will not make a long-range forecast.

Dr. Scheuch says the treatment is simple and requires no anaesthetic as does the Zeiss machine used on comedian Bob Hope here last week. This machine requires about one to one and one-half second pulse, while laser pulse is less than one-half millisecond. Dr. Scheuch says you see only short, bright light. No discomfort is experienced

Omega Approved For Use in Fleet

NAVY Bureau of Ships says the Omega long-range navigational system has been proved feasible and eventually should be installed throughout the fleet, possibly by 1969 (p 17, Dec. 20). About $9.5 million will be spent on the system during the 1963 fiscal year.

"An improved aircraft receiver will be ready to test fly very shortly," a spokesman said. "Development of data necessary for preparation of world-wide charts is proceeding on schedule. The British government is cooperating and in October, Omega test transmissions were started at Criggion, Wales."

Dielectric Speeds Up Integrated Circuits

SUNNYVALE, CALIF. — Low-capacitance dielectric, with breakdown voltage near 1,000 v, should increase attainable speeds of semiconductor integrated circuits by at least one order of magnitude—possibly to more than 100 Mc—says its developer, Signetics. The development eliminates the use of reverse biased *p-n* junctions that presently provide d-c isolation between components. A new approach to the fabrication of components in a monolithic block is substituted, the firm says. Result is a radical change in the circuit's physical structure that is expected to produce wider junction configuration variety and improve yields significantly, according to Signetics.

FAA Asks for Comments On Cockpit Recorders

FAA HAS PUT its stamp of approval on cockpit recorders and asked interested parties for their comments (p 53, Nov. 15). Little opposition is expected because the concept has already received the endorsement of plane manufacturers, airlines and pilots. Under the FAA proposal, commercial jetliners would be required to have the devices by July 1, 1965; four-engine prop airliners by Jan. 1, 1966, and two-engine planes by July 1, 1966. The recorder would retain 30 minutes of crew conversation to aid investigators in the event of a crash.

NASA Awards $60 Million Lunar Orbiter Pact

WASHINGTON — Boeing Co. has been awarded a $60-million incentive contract to build five lunar orbiter spacecraft, designed to take high-resolution photographs of the lunar surface. The photos will help find landing sites for LEM vehicles and for unmanned landings of Ranger and Surveyor spacecraft. The first Lunar Orbiter, slated for launch in 1966, will also carry radiation measuring and micrometeoroid density sensors. Later orbiters will carry a larger variety of sensors. The craft will have an Eastman-Kodak camera system and RCA communications subsystem.

Punch-Card Shopping Bows at Swedish Market

FOOD SHOPPING by data cards is being tried in Sweden. Shelves in one Stockholm market hold samples of each commodity, with batches of punched cards beneath. The shopper takes one and gives it to the cashier for invoicing by a Bull data machine. The bill is sent to a basement stock room where clerks collect items by hand and bag them; the customer then picks up her goods at the door. The store, which opened in August, says personnel costs and shoplifting are reduced, sales areas kept smaller, stock control aided, and shopping made easier. Possible disadvantages? Fresh foods are virtually eliminated, the firm says, and the customer may feel rigidly mechanized or deprived of the "charm" of shopping. She must also line up twice—once to pay, again to collect purchases.

Gamma-Ray Exposure Retards Lasing Action

SPOKANE, WASH.—Gamma rays hinder lasing in uranium and neodymium-doped crystals, says GE. Twice as much energy was needed to induce laser action after the crystals were exposed to 1.5-million roentgens of gamma radiation—making the firm doubtful that gamma energy can be converted to laser output energy. The studies, conducted at GE's Hanford Labs, were stimulated by speculation that useful energy could be converted from nuclear reactors and fission products; now GE thinks this improbable due to the increase in energy required after gamma exposure. The phenomenon could bear also on the use of lasers in space probes, GE says, or in other space applications.

MEETINGS AHEAD

RELIABILITY-QUALITY CONTROL NATIONAL SYMPOSIUM, IEEE, ASQC, ASME, EIA; Statler Hilton Hotel, Washington, D. C., **Jan. 7-9.**

ENGINEERING INSTITUTE: LASERS, University of Wisconsin; University, Madison, Wisconsin, **Jan. 9-10.**

INTEGRATED CIRCUITS SEMINAR, IEEE New York Chapter; Stevens Institute of Technology, Hoboken, New Jersey, **Jan. 15.**

CHARGE TRANSFER COMPLEX SYMPOSIUM, USAF Scientific Research Labs; Denver, Colo., **Jan. 19-24.**

ANTENNA RESEARCH APPLICATIONS FORUM, Midwest Electronics Research Center; University of Illinois, Urbana, Ill., **Jan. 27-30.**

MANAGEMENT CONFERENCE, ERA; New Orleans, La., **Jan. 28-31.**

ANNUAL MEETING-SEMINAR, Precision Potentiometer Manufacturers' Association, Hollywood Beach Hotel, Hollywood, Fla., **Jan. 29-31.**

INSTRUMENTATION SYMPOSIUM, ISA North Central Area; New Sheraton-Ritz Hotel, Minneapolis, Minn., **Jan. 30-31.**

MILITARY ELECTRONICS WINTER CONVENTION, IEEE-PTGMIL; Ambassador Hotel, Los Angeles, Calif., **Feb. 5-7.**

ELECTRONIC COMPONENTS INTERNATIONAL EXHIBITION, FNIE, SDSA; Paris Exhibition Park, Paris, France, **Feb. 7-12.**

PHYSICAL METALLURGY OF SUPERCONDUCTORS MEETING, AIMMPE Metallurgical Society; Hotel Astor, New York, N. Y., **Feb. 18.**

INTERNATIONAL SOLID STATE CIRCUITS CONFERENCE, IEEE, University of Pennsylvania; Sheraton Hotel and University of Pennsylvania, Philadelphia, Pa., **Feb. 19-21.**

NUMERICAL CONTROL PRESIDENTS' CONFERENCE, Numerical Control Society; Hotel Plaza, New York, N. Y., **Feb. 20-21.**

SCINTILLATION-SEMICONDUCTOR COUNTER SYMPOSIUM, IEEE, AEC, NBS; Hotel Shoreham, Washington, D. C., **Feb. 26-28.**

ADVANCE REPORT

SYMPOSIUM ON STATISTICAL ASSOCIATION METHODS FOR MECHANIZED DOCUMENTATION, RICASIP, NBS, *American Documentation Institute; National Bureau of Standards, Washington, D. C., March 17-19; Jan. 15 is deadline for submitting titles and 200-word abstracts to Mary Elizabeth Stevens, National Bureau of Standards, Washington, D. C. 20234. Topics include information retrieval and search renegotiation, statistical association methods and citation indexing, automatic classification and categorization, automatic assignment indexing, pioneering applications of statistical association techniques in documentation.*

Computers Due for Another Good Year

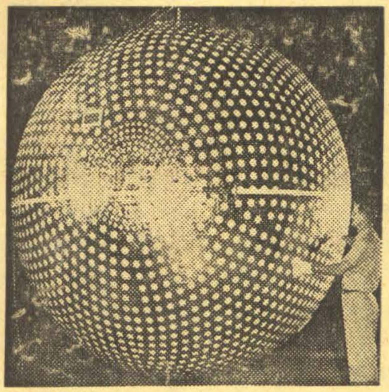
WASHINGTON—The electronic computing and accounting machine industry continues to move ahead, with 1964 factory shipments, estimated at $1.99 billion, expected to show a 9.5-percent increase over 1963 shipments of $1.82 billion, the U. S. Department of Commerce, estimates.

Shipments of electronic computing and accounting machines rose 10.8 percent in 1963 over 1962; 1964 shipments are estimated to rise about 9.5 percent. Electronic data processing machines and associated equipment showed a greater percentage rise than the whole industry in 1963, 16 percent, and are expected to show a 13.6 percent increase in 1964. Conventional computing and related machines, including cash registers, rose 6.8 percent in 1963 and are estimated to continue at this rate in 1964.

Dollar volume of 1963 exports rose to $295 million, an increase of 9 percent over 1962 exports of $271 million. The estimate of 1964 exports is $340 million, a 15-percent increase over 1963.

Federal government use of computers has soared from one computer in 1949 to an estimated 1,248 computers in 1963. An additional 317 are planned for installation during fiscal year 1964. The government spent $188 million for computer leasing in 1963; the 1964 estimate is $243 million.

New Explorer



AIR DENSITY Explorer launched last week is expected to tell NASA whether there are enough gas molecules to cause resistance or drag to spacecraft moving through them. White painted dots control temperature for tracking beacon, solar cells and batteries mounted on skin

Closed-Cycle Plasma Power Source Developed

NEW YORK—The Martin Company said last week it has produced electrical power with a closed-cycle magnetoplasmadynamic system. Mostafa E. Talaat, manager of Martin's Energy Conversion Laboratories, said the experiment proved the principle that with magnetically-induced, nonequilibrium ionization, electron temperatures twice the temperature of the host gas could be obtained (p 29, Sept. 1, 1961). Gas conductivity at 2,600 F was equivalent to that at 5,200 F in combustion gases.

Martin estimates that the new equipment would occupy about one-tenth the space of a comparative steam turbogenerator. Talaat thinks mpd plants will have efficiencies on the order of 50 percent, compared to 30 to 35 percent for conventional systems. With fewer moving parts, maintenance is also expected to be less costly.

Teaching-Machine Market Getting Big, New Entrant?

IBM'S ANNOUNCEMENT last week that it plans to buy Science Research Associates, Inc., Chicago, a publisher of educational materials, stirred speculation that the giant manufacturer of computers might be getting ready to enter the teaching-machine market. An IBM spokesman said he had no comment on this but that his company had been conducting research on teaching machines for some time. Science Research Associates prints mostly programmed teaching material, similar to material used in teaching machines, a representative of that firm told ELECTRONICS.

IN BRIEF

TIROS 8 weather satellite, successfully launched last Saturday, will evaluate the first experimental Automatic Picture Transmission (APT) camera system (p 20, July 26).

POST OFFICE has given Farrington Manufacturing Co. a $1,176,277 contract to produce an automatic mail address reader. The machine, which will go into operation a year from now in Detroit, will sort 27,000 letters an hour for 50 states and 50 large cities.

FIRST industry-built Saturn initial stage, scheduled for launching from Cape Kennedy late next year, was turned over to NASA's Michoud Operation by Chrysler Corp. this week.

LOCKHEED says instrumentation aboard polar orbiting satellites indicates the auroral curtain is several hundred miles thick.

MODEL of Airborne Instruments Laboratories' microwave instrument landing system (p 24, Aug. 2) will be part of the science exhibit at the New York World's Fair. It will include a complete ground control pattern of an airport with an airplane that periodically lands and taxies up to unload.

SYLVANIA has tested an electronic device that protects bombers from air-to-air and ground-to-air, radar-guided weapons.

ORDERS for the Honeywell 200 (p 10, Dec. 13) total $50 million in sales value, firm says.

EITEL-McCULLOUGH has licensed two British companies to manufacture its family of uhf, tv klystron tubes in England. The two firms are English Electric Valve Co. and Standard Telephones & Cables, Ltd., ITT's British subsidiary.

DOUGLAS has received an additional $48,064,658 contract for its part in the Saturn program.

UNIVERSITY of Michigan will study radar detection of moving ground vehicles from the air for the Air Force.

DEEP-SEA seismometers are being used in the Pacific to develop methods for detecting underground nuclear detonations. Tests, part of the Vela uniform program, will also help development of underwater devices.

SWEDISH newspapers report that three Swedish companies, Saab Asea and L. M. Eriksson — have combined forces to make a $50,000, six-month preliminary study for Europe's first satellite.

Red Tape Will Be Next Target of Pentagon Scissor

A pilot study aimed at reducing Defense Department monitoring of contracts will begin soon. The objective is to cut back on the volume of reporting, auditing and other controls without losing the effectiveness of the monitoring. Northrop Corporation's production of the T-38 jet trainer and F-5 fighter has been picked for the first test. An electronics firm will be selected early next year for a similar study.

The Pentagon believes that reducing the burden of paperwork on its contractors will let them lower costs, and in turn offer the government lower prices. This thinking stems from the new emphasis on fixed-price contracting. In the loosest type of contract—cost plus fixed fee—need for monitoring is highest. But it declines steadily with the tighter forms of contracting the government now favors.

By Watching the Millions, Says Air Force, It Saved a Billion

Air Force is now detailing the results of its cost-cutting efforts in the past year. It claims savings of $1.2 billion against a programmed goal of $982 million. The goal for the current fiscal year is $1.5 billion. Here are some examples of methods being used to reduce costs:

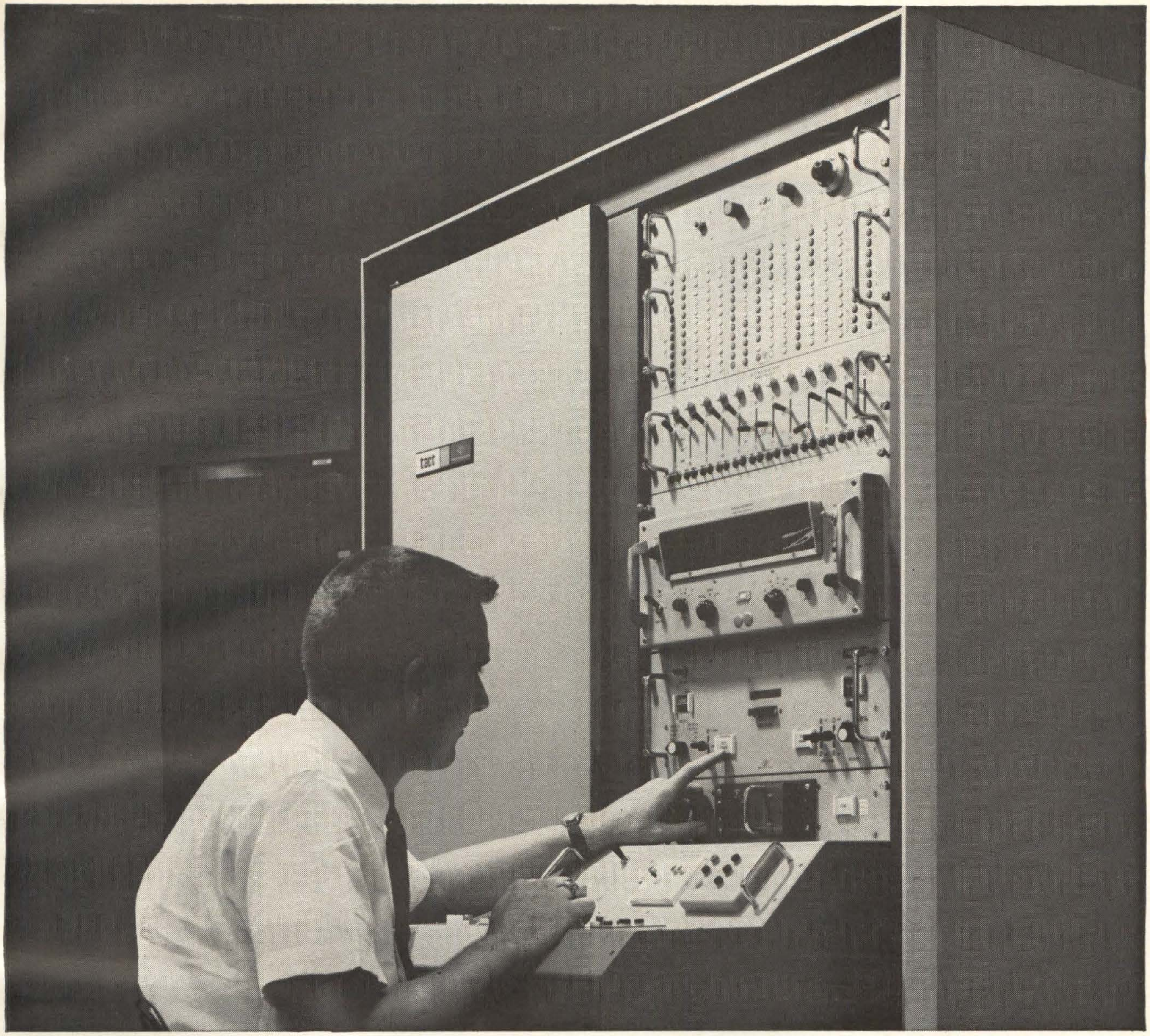
- A contractor buying a high-reliability vacuum tube for the Minuteman from a single source was directed by Air Force's contract management branch at Philadelphia to a lower-price commercial tube. Total saving: $1 million.
- Flying suits for high-altitude use were being bought from a single company. Air Force divided the suit into its components. As a result, three firms divided the order, eliminating subcontracting. Davis Clark Co. supplied coveralls, gloves, boots and helmets; Pioneer Central got the controllers portion, and Firewel Co. the regulators portion. Saving: $3 million.
- A magnetic-tape rehabilitation facility—believed to be the first of its kind—was put into operation, with equipment supplied by General Kinetics, Inc. Some 18 million feet of used tape was cleaned up in a few months, at a saving of one-quarter of the $40 cost of a new reel. Total saving: $50,000.

NASA Wants Spanish Station

A giant tracking station will be built in Spain by the National Aeronautics and Space Administration, providing agreement can be reached with the Spanish government. The station is needed for tracking the three-man Apollo spacecraft. The Spanish government wants complete assurance that the purpose is peaceful.

President May Ground Nuclear Rocket Program

President Johnson is now deciding the fate of Project Rover. His 1965 federal budget spending plans will include a basic decision on whether to hold back or go full steam ahead on the big-payload-capacity spacetruck (ELECTRONICS, p 20, Nov. 22, 1963; p 24, Dec. 28, 1962). Rover was one of Johnson's pet projects when he headed the National Space Council, but his science adviser, Jerome B. Wiesner, is suggesting that a cutback in the nuclear rocket effort offers a chance for big savings. Atomic Energy Commission and NASA, however, say their request for next year for $280 million has already been cut to $200 million for Rover by Wiesner and the Budget Bureau. This is about as deeply as the program can safely be cut, they argue. But Wiesner counters that by stressing reactor development work only, and slowing down space vehicle development, the total AEC-NASA expenditure could be held to $50 million.



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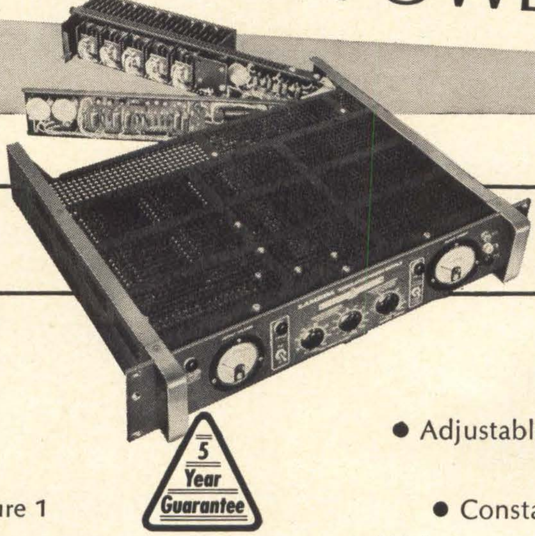

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LE103	0-36 VDC	0-15 Amp	595
LE104	0-36 VDC	0-25 Amp	775
LE105	0-18 VDC	0- 8 Amp	425
LE106	0-18 VDC	0-15 Amp	590
LE107	0-18 VDC	0-22 Amp	695
LE109	0- 9 VDC	0-10 Amp	430
LE110	0- 9 VDC	0-20 Amp	675

(1) *Current rating applies over entire voltage range.*
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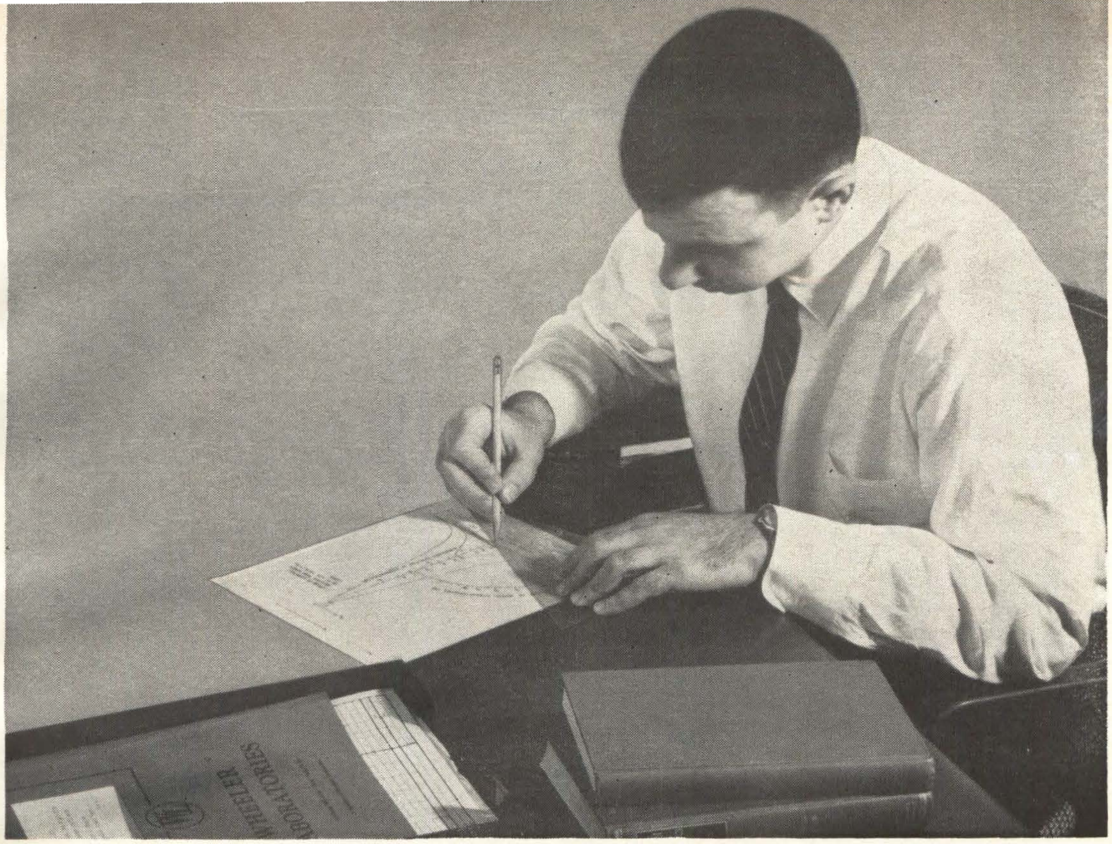


AUTHOR evaluates a laser design with the help of his pump-power chart

DESIGNING LASERS WITH PUMP-POWER CHARTS

Chart relates the three most easily measured, and most often specified laser parameters—pump power, wavelength and propagation direction—in easy-to-use graphical form, for rapid performance evaluation of lasers

By **ROBERT A. KAPLAN**
Wheeler Laboratories
Great Neck, New York

THE DEVELOPMENT of the laser provides a source of highly coherent radiation at optical wavelengths. Numerous applications of this device have been proposed; however, the evaluation of a laser requires an understanding of the characteristics of the emitted radiation.

As is well known, a laser oscillator comprises two essential parts: an active material and a resonant circuit. The active material is capable of storing the pump energy and using this energy to amplify an electromagnetic wave. Energy is stored by pumping the active system into excited energy levels. Amplification is accomplished by stimulated emission of a photon and a corresponding quantum transition of the system between the laser energy levels.

The resonant circuit of the laser is usually a modified Fabry-Perot interferometer formed of high-reflectivity end walls and low-reflectivity side walls. Because of the large dimensions of the typical resonator, compared to the wavelength of the emitted radiation, the cavity can support a large number of modes, where each mode is described by a particular stable field configuration.[1-4] The usual method of designating a particular mode is by three integers, which are related to the field variations along particular coordinates in the resonator. An alternate method is to specify the resonant wavelength and direction of propagation, relative to the resonator axis, of the nearly plane waves which comprise that mode. This latter description permits a simplified approach to the evaluation of laser performance.

The possible modes that can be supported by the resonant cavity of a laser depend on the resonator geometry and the wavelength. The modes that actually oscillate, however, depend not only on the geometry of the resonator, but also on the properties of the active material and the pump power. These factors contribute to the loss and gain, which in turn determine the threshold condition. (The threshold condition is specified by the requirement that the gain exceed the loss.) The geometry and the wall reflectivity are the major factors determining the loss in each mode; this loss depends chiefly on the off-axial direction of propagation of the nearly plane waves comprising the mode. The characteristics of the material determine the gain in each mode as a function of pump power; this gain depends chiefly on the departure of the resonant wavelength from the central wavelength of the quantum transition. By specifying the modes of a laser in terms of a direction of propagation and resonant wavelength, the conditions for oscillation may be readily found by means of the pump-power chart.

As a first step, the modes of the resonator are plotted on a mode chart in terms of the direction of propagation and resonant wavelength of the plane waves comprising those modes. The relation between threshold pump power and these factors appears as contours on the chart, forming the pump-power chart.[5] This chart permits the determination of the modes of oscillation of a laser at a given pump level in terms of wavelength and direction of propagation, and thereby permits the determination of the frequency and angular spectra of the emitted radiation. In particular, the total bandwidth and beamwidth of the laser output may be obtained directly. Although the chart does not provide exact values for the wavelength and direction of propagation of each mode of oscillation, the information provided is useful in practical situations.

Resonator Modes—The modes of most interest in a laser are those with directions of propagation near the resonator axis. If the resonator dimensions are large compared to the wavelength, an approximate relation between resonant wavelength and direction of propagation can be used to describe these modes.[5] This relation, given in Eq. 1, forms the basis of a mode chart, similar to those used at microwave frequencies.[6] The use of normalized variables, Θ and Λ, simplifies the extension of this chart to lasers of arbitrary configuration and material. The transverse character of a mode is described by Θ, where Θ can only assume discrete values corresponding to each transverse mode. The axial character of a mode is described by Δp; modes with the same value of Δp are said to lie along a "modal characteristic."

$$\frac{2L}{\lambda_o}\frac{\delta\lambda}{\lambda_o}\Lambda = -\Delta p - \frac{D^2}{L(\lambda_o)}\Theta^2 \quad (1)$$

A typical example of a chart is presented by the solid curves in Fig. 1A. Note that the Θ scale is quadratic, so that the modal characteristics are linear. In addition, since only certain discrete values of Θ are allowed, as determined by transverse considerations, the actual modes of oscillation are represented by discrete points on the chart. These points are determined by the intersections of the modal characteristics and horizontal lines representing the possible values of Θ. The permissable values of Θ are represented by the dotted lines in Fig. 1A. The spacing between these lines ($\Delta\Theta$) is given in Eq. 2. This $\Delta\Theta$ is usually small so that Θ may often be considered almost as a continuous parameter; for clarity the spacing between horizontal lines has been exaggerated in Fig. 1A.

$$\Delta\Theta = \frac{1}{2}\left(\frac{\lambda_o L}{D^2}\right) \quad (2)$$

Although the modal characteristics have been drawn for a specific laser configuration and material, the mode chart with a quadratic Θ-scale may be obtained by the following simple procedure for any other laser. Since the modal characteristics of Fig. 1A are linear, all that need be known is their slope and intercept. The slope (m), as determined from Eq. 1, is given in Eq. 3. The absolute value of the intercept of the central modal characteristic is arbitrary within the approximation made in Eq. 1; however, the spacing between intercepts for successive modal characteristics ($\Delta\Lambda$) can be determined and is given in Eq. 4.

$$m = 2\frac{\delta\lambda}{\lambda_o}\left(\frac{L}{D}\right)^2 \quad (3)$$

$$\Delta\Lambda = \frac{1}{2}\frac{\lambda_o^2}{L\,\delta\lambda} \quad (4)$$

Definitions and Symbols—TABLE I

- L = resonator length (cm)
- D = resonator width or diameter of laser filament (cm)
- R = $\sqrt{R_1 R_2}$ = effective combined reflectivity of end plates (power ratio)
- R_s = effective specular reflectivity of side walls (power ratio)
- g = gain by stimulated emission (power ratio)
- g_o = gain at central wavelength of quantum transition (power ratio)
- N = population density of active particles (cm^{-3})
- ΔN = inversion population density = excess of systems in excited state over number in terminal state (cm^{-3})
- α = $\frac{\Delta N}{N}$ = fraction of inversion
- t = photon lifetime in resonator = average time a photon in a given mode will remain in the resonator before removal by transmission, absorption or scattering (sec)
- t_o = photon lifetime of axial modes (sec)
- P = pump power (watts)
- P_o = threshold pump power (watts)
- v = velocity of electromagnetic waves in resonator material (cm/sec)
- c = velocity of electromagnetic waves in free space (cm/sec)
- λ = wavelength in resonator medium (cm)
- λ_o = central wavelength (in medium) of quantum transition (cm)
- $\delta\lambda$ = natural half-power linewidth of quantum transition (cm)
- $\Delta\lambda$ = $\lambda - \lambda_o$ (cm)
- Λ = $\Delta\lambda/\delta\lambda$ = normalized wavelength
- p = axial mode number = number of half wavelengths in axial dimension (integer)
- p_o = axial mode number of central-wavelength mode (integer)
- Δp = $p - p_o$ (integer)
- m = $2(\delta\lambda/\lambda_o)(L/D)^2$ = slope of modal lines
- $\Delta\Lambda$ = $\frac{1}{2}(\lambda_o^2/L\delta\lambda)$ = spacing of Λ-intercepts
- n = c/v = index of refraction of resonator medium
- θ = angle from axis to direction of propagation in resonator (radians)
- Θ = $(L/D)\theta$ = normalized direction of propagation (radians)
- $\Delta\Theta$ = $\frac{1}{2}(\lambda_o L/D^2)$ = spacing of modes on Θ-axis (radians)
- ϕ = angle from axis to direction of radiation (radians)
- $\Delta\phi$ = total beamwidth of laser oscillator (radians)
- Δf = total bandwidth of laser oscillator (cycles/sec)

Resonator Loss—The loss experienced by a wave in a laser resonator is one of the two important factors determining the threshold condition. This loss depends on the geometry and wall reflectivity of the resonator and on the particular mode under consideration. The lack of perfect reflectivity of the resonator end plates is often the major factor determining the loss in the axial modes, since this loss is by design usually made equal to or greater than the total losses due to dissipation, diffraction and scattering to maximize the laser output. Loss can be specified in terms of a photon lifetime, which is the average time a photon in a given mode will remain in the resonator. This photon lifetime is directly proportional to the Q of the mode. In particular, the photon lifetime of the axial modes is given by[7].

$$t_o = \frac{L}{v\,(1 - R)} \qquad (5)$$

For off-axial modes the lifetime is limited by both the end-plate reflectivity and the finite number of reflections before a photon in a particular mode leaves the cavity at the side walls. The approximate lifetime may be derived directly from geometrical considerations by considering the average number of reflections a photon will experience.

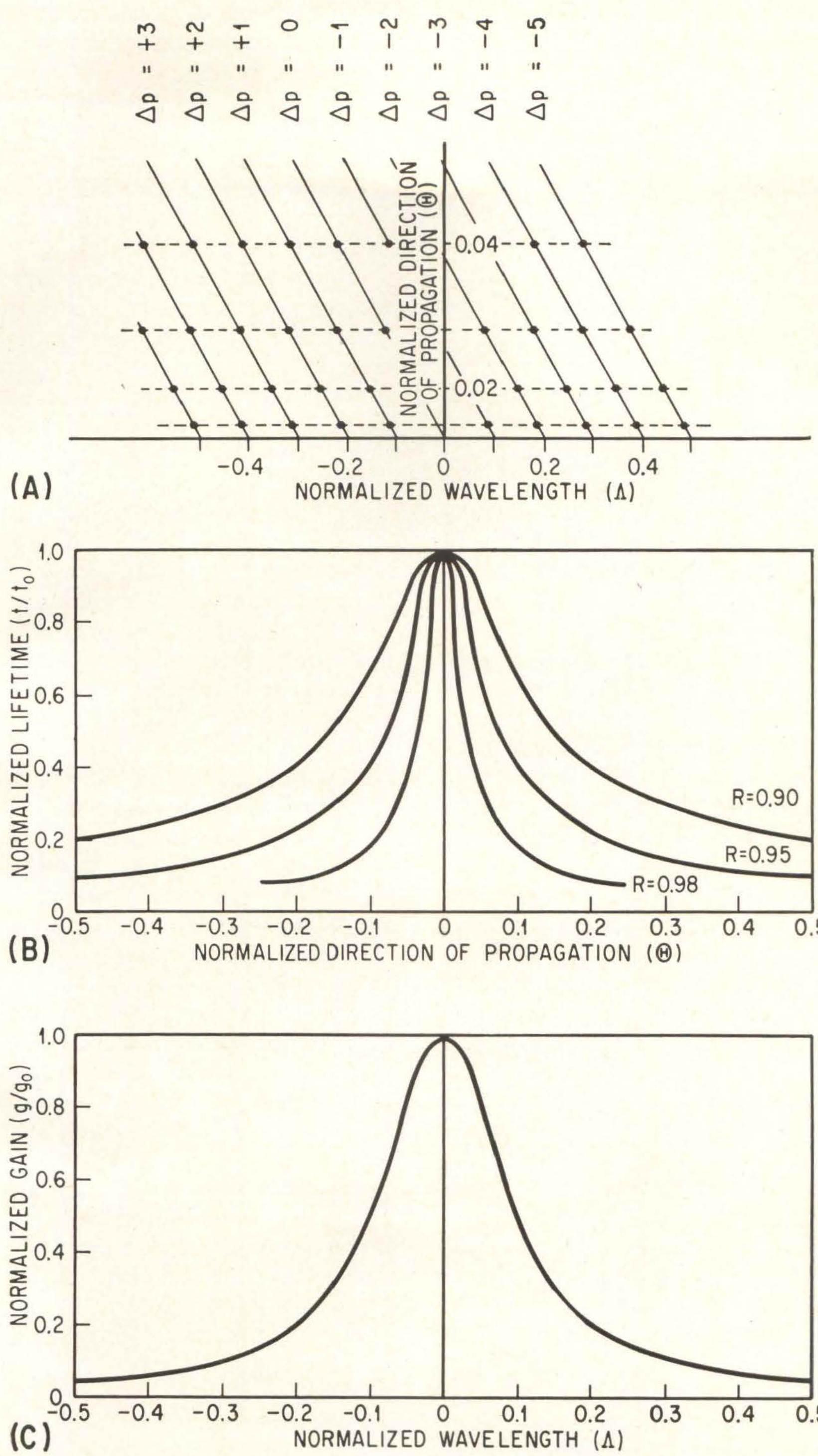
$$t = \frac{L}{v \cos \theta}\,\frac{1 - R^{1/\Theta}}{(1 - R)} \qquad (6)$$

The lifetime of off-axial modes with nonreflecting side walls and highly reflecting end walls, normalized to that of the axial modes, is therefore

$$\frac{t}{t_o} = \frac{1 - R^{1/\Theta}}{\cos \theta} \approx \frac{(1 - R)}{\Theta} \qquad (7)$$

The normalized lifetime of a photon in a resonator is shown as a function of the normalized direction of propagation in Fig. 1B for three different values of end-wall reflectivity. This curve, therefore, graphically presents the relation between the loss and the off-axial direction of propagation, in terms of the photon lifetime.

Gain—The other important factor, which determines the threshold condition, is the gain in the laser material. An electromagnetic wave propagating through a laser material may experience gain due to stimulated emission if enough systems (active



MODE CHART for laser resonator (A); dependence of photon lifetime on direction of propagation (B); dependence of laser gain on wavelength (C)—Fig. 1

atoms or ions of the material) are in an excited state. The conditions required for gain were originally presented in Ref. 7.

The gain of the laser is a function of the wavelength because of the finite linewidth of the laser material. For most materials the spectral distribution assumes a Lorentzian shape, maximum gain occurring at the central wavelength of the quantum transition. The gain as a function of wavelength, normalized to that at the central wavelength of the quantum transition, is

$$\frac{g}{g_o} = \frac{(\delta\lambda)^2}{(\lambda - \lambda_o)^2 + (\delta\lambda)^2} = \frac{1}{\Lambda^2 + 1} \qquad (8)$$

This function is shown graphically in Fig. 1C. It presents the relative gain of a laser material as a function of wavelength.

The gain (g) of the laser is directly proportional to the population inversion (ΔN).[8] Since this population inversion is a function of pump power, the gain is also a function of the pump power. For a four-level system, the population inversion and gain are directly proportional to pump power. This assumes that the population of the metastable state equals the population inversion. For a three-level system the population inversion and gain are less sensitive functions of the pump power; they are proportional to the pump power plus a large constant. This is because a large fraction of the power is required to maintain the population of the metastable level equal to that of the terminal level without providing the population inversion necessary for gain.

Pump-power Chart—The dependence of gain on pump power and wavelength, developed above, can be combined with the dependence of the losses on the direction of propagation to determine the conditions for oscillation of the individual modes of the laser. The relation between these three parameters (pump power, wavelength and direction) is not simple, however, and the relation may best be presented graphically. This graph has been termed the pump-power chart.[5] The significance of this chart is that it relates the three most easily measured and most often specified parameters of a laser, and thereby permits the rapid evaluation of performance.

The pump-power chart is based on the threshold condition of a laser oscillator. The power required for stimulated emission, for any particular values of wavelength and direction of propagation, depends on the photon lifetime (Fig. 1B) and relative gain (Fig. 1C) of the material. The pump power must be sufficient to provide a gain equal to or greater than the losses represented by the shortness of the photon lifetime. The particular value of power required for stimulated emission in the central wavelength, axial mode (highest-Q mode) is termed the threshold power (P_o). For a four-level laser material, this power is inversely proportional to the product of the photon lifetime and the relative gain of the quantum system.[8] Therefore, the pump power, required for stimulated emission in any other mode relative to the threshold pump power, is given by

$$\frac{P}{P_o} = \frac{1}{(t/t_o)} \frac{1}{(g/g_o)} \qquad (9)$$

(This assumes that the modes of the resonator are weakly coupled, which is a good assumption for many lasers.)

For a three-level laser material, the required pump power is a different function of the gain, as mentioned. The pump power required for stimulated emission in any mode, relative to the threshold pump power, is

$$\frac{P}{P_o} = \frac{(t/t_o)\,(g/g_o) + \alpha}{(t/t_o)\,(g/g_o)} \qquad (10)$$

However, it should be noted that at wavelengths far from the center of the quantum transition, the power is again inversely proportional to the gain.

The curves of Fig. 1B and 1C combined with Eq. 9 or 10 may be used to plot contours of constant P_o/P on the mode chart shown in Fig. 1A. For each value of normalized direction of propagation (Θ) and wavelength (Λ), the normalized values of lifetime and gain may be determined from Fig. 1B and 1C respectively. These values may then be substituted in either Eq. 9 or 10 to determine a value of P_o/P for those particular values of Λ and Θ. Contours of constant P_o/P, plotted in the Λ-Θ plane, are shown in Fig. 2. Since this plane is also the plane of the mode chart, shown in Fig. 1B, the individual modes are represented by points and Fig. 2 can be used to determine the relative pump power required for oscillation in each mode. For this reason, this figure is termed the pump-power chart.

A typical pump-power chart for a four-level laser is shown in Fig. 3. The end-plate reflectivity has been chosen as 0.95; the side walls are assumed completely non-reflecting. The modal characteristics have not been plotted directly on the chart but are obtained by using the circular reference scale. For a specified resonator geometry and material, the proper line is obtained by computing the slope (m) of the modal characteristic. A family of parallel lines is then obtained with a separation along the Λ-axis given by $\Delta\Lambda$. (The exact location of this family of lines is indefinite by an amount $\Delta\Lambda$, since a cavity resonance has arbitrarily been assumed to occur at λ_o.) The points on the lines, representing the off-axial modes, are separated by $\frac{1}{2}$ $(\lambda_o L/D^2)$ along the Θ-axis. These rules may be used to graphically determine the point representing any particular mode.

To illustrate the use of the chart, it is noted that at any relative value of pump power, oscillation can occur only in those modes within the proper power contour as shown in Fig. 4A. The total bandwidth of all the modes of the laser output is proportional to the maximum spread of normalized wavelength determined by the intersection of the modal characteristic curves and the power contour; the actual bandwidth is

$$\Delta f = \frac{v\,\delta\,\lambda}{\lambda_o^2} \,(\max \Lambda - \min \Lambda) \qquad (11)$$

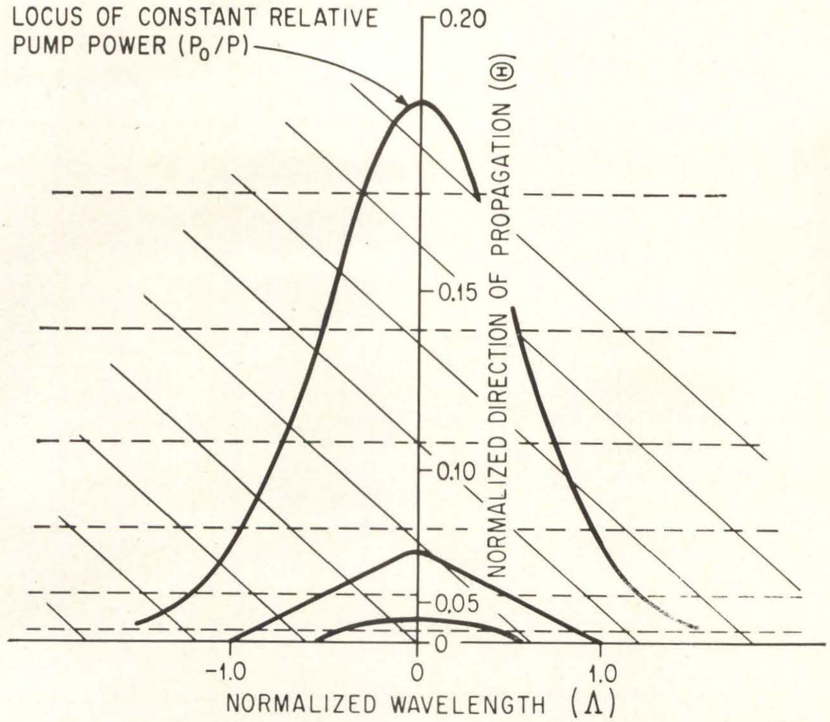
The wavelength spectrum of the output, as derived from the pump-power chart, is shown in Fig. 4B. Each point on the pump-power chart, representing a single mode, gives rise to a single frequency in the laser output, as shown by the vertical lines in Fig. 4B. Each group of modes on the same modal characteristic, having the same value of Δp, gives rise to a broad spectrum represented by the envelope of the vertical lines, also shown in Fig. 4B. The amplitude of each mode is not shown exactly since this level is a complicated function of pumping conditions. Part of the information required to determine this level is available from the pump-power chart; however a consideration of the competition between modes for the available excited systems is also required. For short pulses, competition between modes may be neglected and, since the gain in each mode is proportional to the intensity of that mode,[8] the relative output of the modes is expected to be a function of exp $(P/P_o - 1)$. Also, since the wavelength separation of off-axial modes is very small, the spacing of these modes is only shown symbolically.

The radiation beamwidth of the laser output is proportional to the maximum direction of propagation of the modes of the resonator, which is again determined by the intersection of the modal characteristic curves and the power contour; the beamwidth is

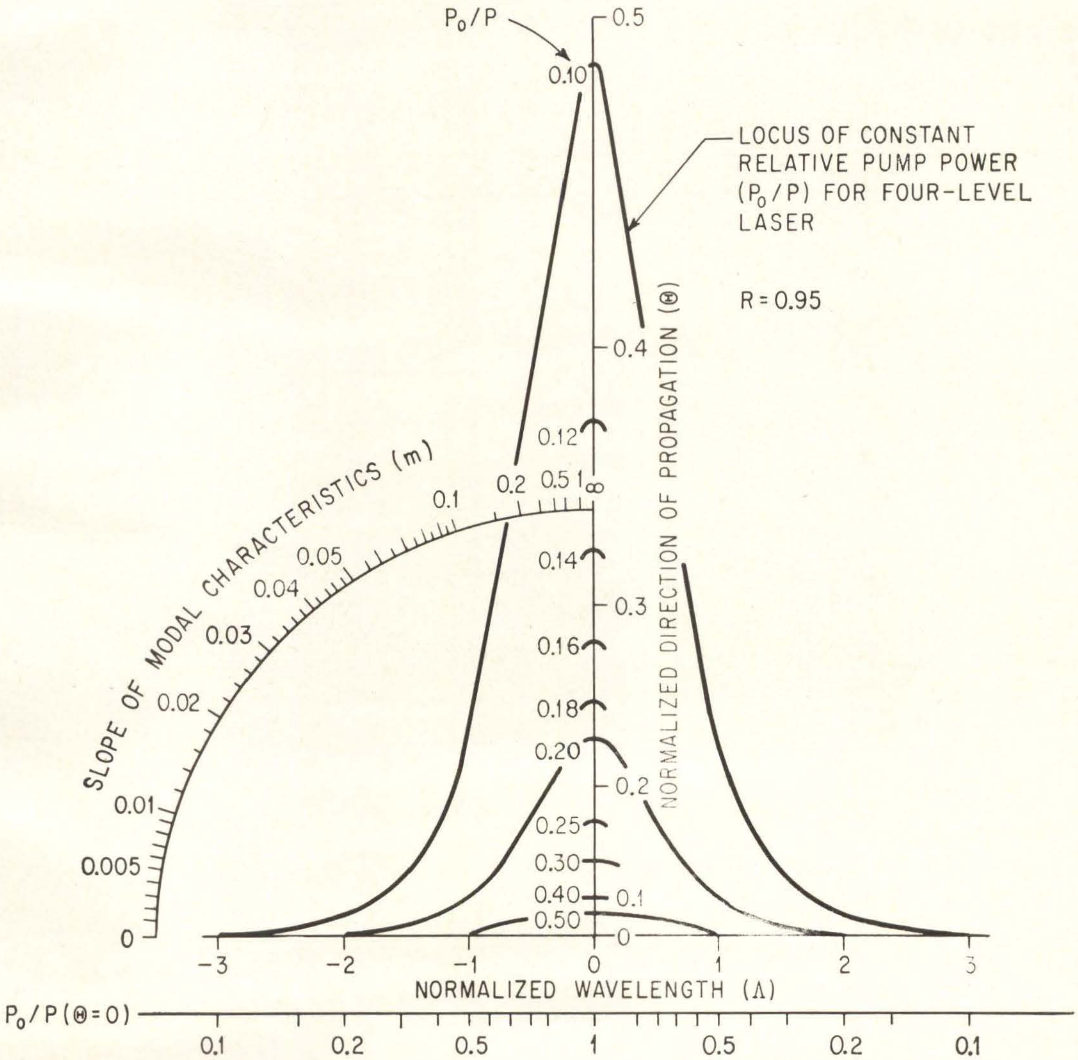
$$\Delta \phi = 2n \frac{D}{L} \max \Theta \qquad (12)$$

This relation describes the beamwidth as determined by geometric optics. It is not valid in the special case when only one mode is excited since the beamwidth will then be determined by diffraction. An angular spectrum, similar to the wavelength spectrum shown in Fig. 4B, could also be obtained directly from the pump-power chart.

The above discussion has indicated the use of the chart for a given set of input conditions and laser parameters. The variation of the laser oscillator bandwidth and beamwidth as a function of the input conditions (pump power) and laser parameters (dimensions, linewidth, end-plate reflectivity, etc.) may also be determined directly from the pump-power chart. The effects of pump power are indicated by the power contours; the effects of laser parameters are determined by drawing new modal characteristics. Be-



CONTOURS of constant pump power on laser mode chart —Fig. 2



PUMP-POWER chart—Fig. 3

cause of the particular choice of normalization used, the relative power contours do not depend on the parameters of the laser.

Application Example—The application of the pump-power chart will be investigated by computation of the performance of a specific four-level solid state laser oscillator. The pertinent data for this oscillator are listed in Table II.

First, the slope of the modal characteristic (m) is computed to be 0.003 (Eq. 3); this line (O-A) is drawn on the power chart, using the circular reference scale as shown in Fig. 4A. The family of modal characteristics are spaced along the Λ-axis by a computed value of 0.3 (Eq. 4) and are drawn parallel to O-A. As discussed previously, the actual Λ-intercepts of these lines may not be known exactly, since the central wavelength of the quantum transition may not exactly correspond to resonance in an axial mode of the cavity. Since, in general, there are a large number of modes, the character of the output is essentially independent of the exact location of the modal characteristics on the pump-power chart. The modes in which oscillation may occur are represented by points within the power contour as shown.

It is noted that the minimum normalized wavelength of oscillation is —0.97 as indicated on the chart. The maximum normalized wavelength is 0.90. The oscillation bandwidth, as computed by Eq. 11 from the parameters obtained from the chart is 26 Gc. The entire spectrum is shown in Fig. 4B. As can be seen, there are a large number of overlapping modes so that the resultant spectrum will appear essentially continuous. The results are in qualitative agreement with reported measurements of the bandwidth of laser oscillators.[9]

The maximum normalized angle of propagation is 0.73 as indicated on the chart. The radiation beamwidth, as computed from Eq. 12, is therefore 48 milliradians.

This illustrates a typical operation on the pump-power chart. The chart is being used at Wheeler Laboratories to evaluate more complex laser parameters such as power density, spectral brightness and beamwidth and bandwidth as a function of power input. In all these cases, approximate results are easily obtained by this graphical technique.

In addition, the variation of the bandwidth and beamwidth with the parameters of the laser, (length, diameter, wavelength and linewidth) are obtained by considering the changes in the modal characteristics with the respective parameter. Therefore, the pump-power chart may be used as a tool to picture the effects of variations in the parameters of a laser oscillator on the character of the output signal.

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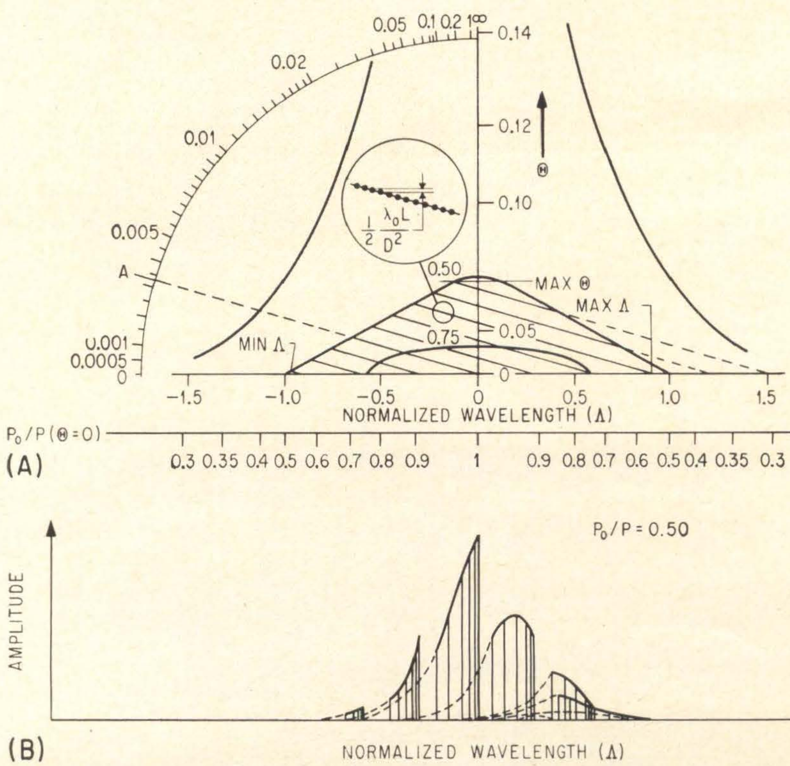
Parameters of Typical Laser Oscillator—TABLE II

Quantity	Units	Value
Diameter (D)	centimeters	0.32
Length (L)	centimeters	1.86
Wavelength (λ_o)	centimeters	5.5×10^{-5}
Linewidth ($\delta\lambda$)	centimeters	2.7×10^{-9}
Pump power (P)	watts	2 P_o
Refractive index	....	1.92



OBTAINING modal characteristics on the pump-power chart (A); wavelength spectrum of laser output (B)—Fig. 4

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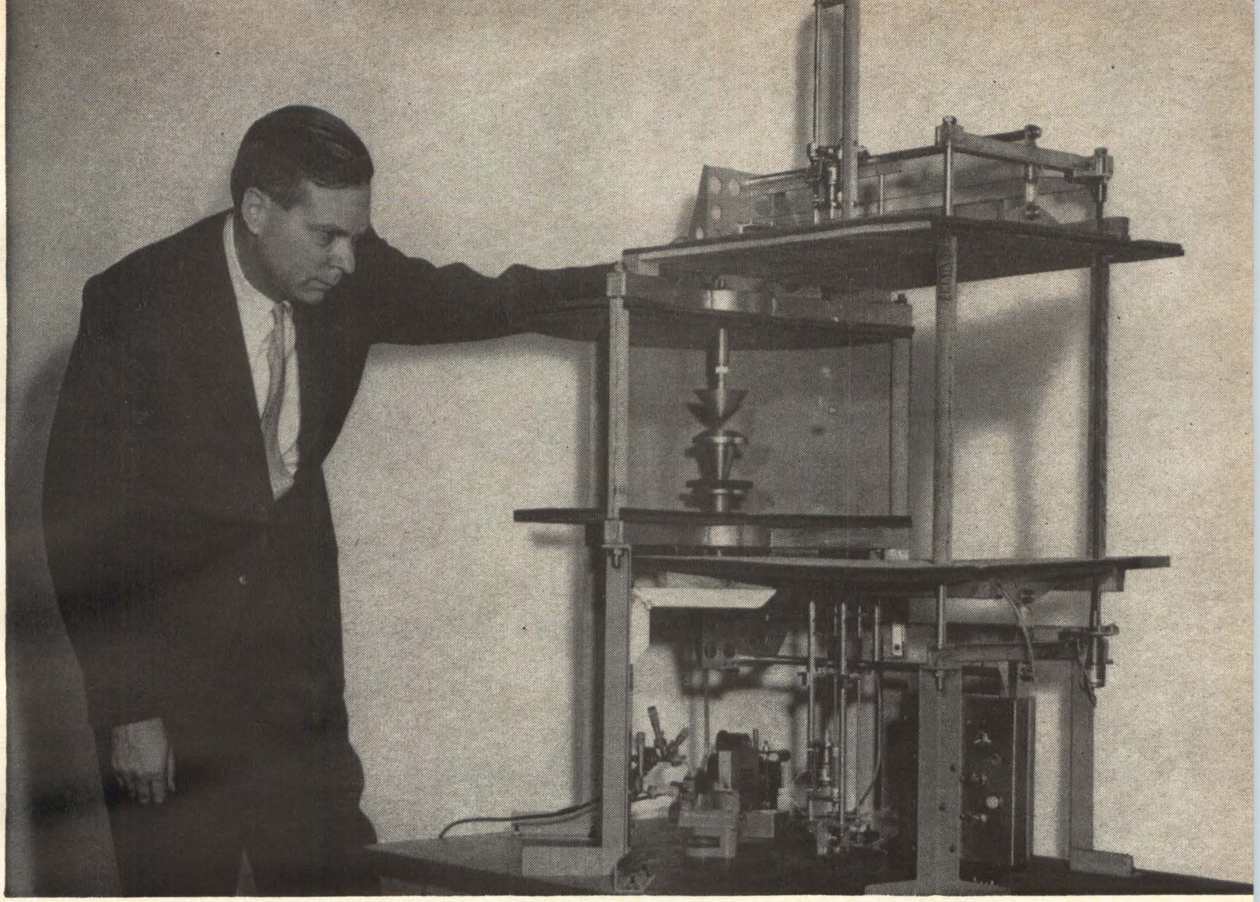

PROBE scan apparatus showing the rotary joint, feed and conical reflector at left

NEAR-FIELD PLOTTER:

Design Tool for Millimeter-Wave Antennas

Initial design based on ray optics or first-order calculations is refined in consecutive steps using field recordings

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FIELD RECORDING used as a design tool is a modification of the spinning dipole technique described by Cullen and Parr.[1] A small scattering probe is introduced into the antenna near field and the associated reflected wave in the antenna feed line measured as a function of probe location. The field perturbation method at millimeter wave lengths is actually superior to direct measurement of the local field. The probe is suspended by a nylon cord and rotated to modulate the reflected signal. It is thus readily distinguished from spurious reflections from stationary objects. The probe must be small to prevent disturbance but large enough so the reflected signal is above the receiver noise level.

Oval Mirror—A flat, elliptically shaped metallic reflector is best. The probe is rotated about its minor axis, with the rotation axis oriented approximately parallel to the H vector of the antenna field. The reflected signal comprises a series of pulses, of a period twice the probe rotation frequency. A pulse occurs each time the probe faces are parallel to the local wavefront of the field.

The test setup is shown in Fig. 1. A c-w microwave signal is applied through a hybrid junction and a phase shifter to the antenna. A servo system scans the probe through the antenna field. The wave

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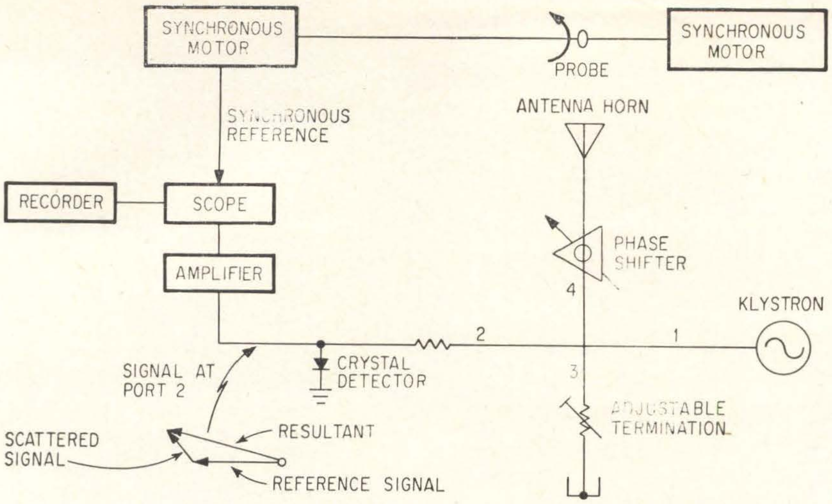
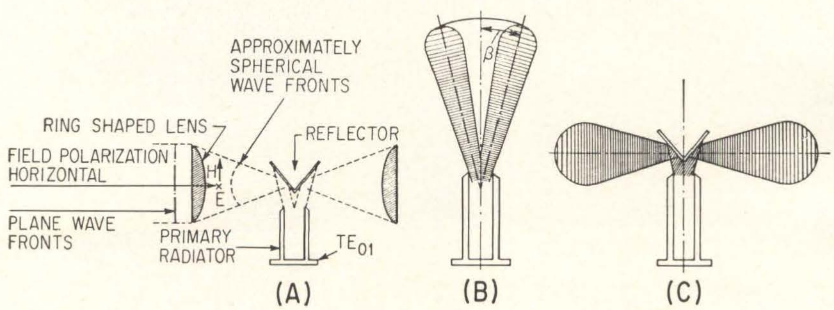
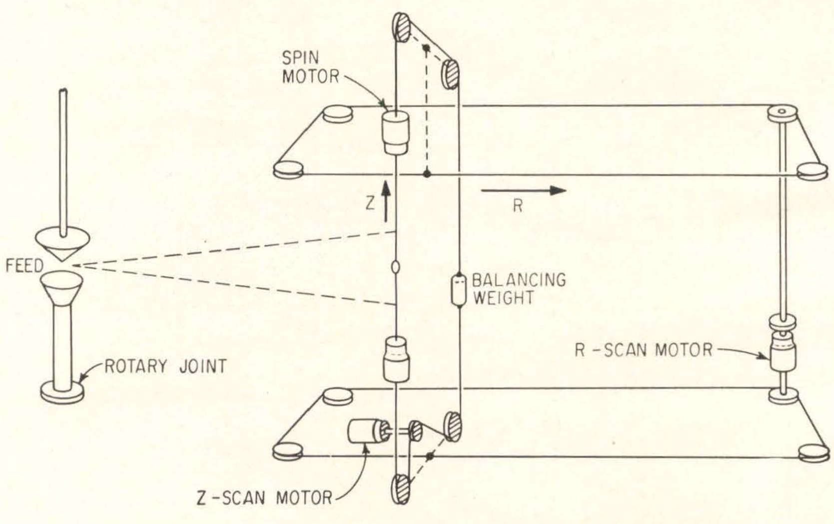


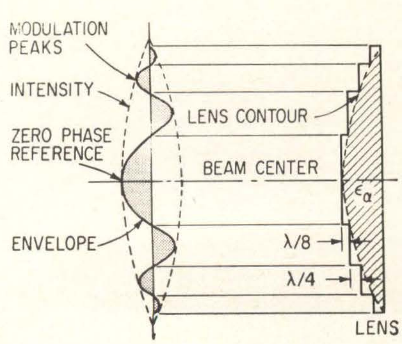
SPINNING probe technique in which reflected energy is returned to the antenna from probe. Vector diagram shows relationships—Fig. 1



FEED and lens system (A) radiation intensity from the cylindrical horn (B) and beam deflected horizontally (C)—Fig. 2



SERVO system used to position the probe scan apparatus relative to the antenna—Fig. 3



LENS design is possible using a single-scan record—Fig. 4

reflected by the probe passes through the phase shifter and the hybrid to be detected at port 2. Port 3 is terminated in a load with a tunable mismatch, which causes a part of the microwave signal to bypass the antenna and go directly to port 2. The crystal detector at port 2 receives two signals, the small reflected signal and a fixed phase reference from the termination at port 3. A time vector presentation of the resultant signal is shown for a particular phase between the reference and reflected signals. The signal is detected and the a-c components are amplified and displayed on an oscilloscope or recorded with a galvanometer.

Wavefronts—To measure the wavefronts of the field, it is practical to scan the probe at a constant velocity and to record the changing modulation as a function of the scanning coordinate. Modulation records are made with a compressed time scale so only the envelope of the modulation pulses is shown. A change of the envelope amplitude from a maximum to a null corresponds to a rotation of the reflected signal vector through 90 degrees from in-phase to out-of-phase with the reference signal vector. The 90-degree rotation is related to a phase difference of 45 degrees, or $\pi/4$, between the E-fields at the two probe locations at which the envelope maximum and null are recorded as shown in the photograph.

Probe Scan—The design of the apparatus must be adapted to the field configuration of the antenna system under measurement. In particular, the scanning coordinates must be chosen such that the probe rotation axis is maintained approximately parallel to the H field throughout probe scan. However, this condition is not critical during tests of the crude antenna design. As the desired field configuration is approached through design refinements, errors caused by incorrect orientation of the probe's rotation axis decrease.

The layout of the millimeter wave antenna system to which the experimental design technique was applied is shown in Fig. 2A. The system has rotational symmetry about the vertical system axis and consists of a conical horn, a reflector

PRAGMATIC APPROACH

This rapid and reliable technique of measuring the near-field pattern makes possible the design of millimeter-wave antenna systems regardless of the number of parameters. Systems too complex for calculations can be optimized experimentally in iterative steps

and a ring-shaped lens. The mode in the feed waveguide is the circular TE_{01}, which propagates into the conical horn (Fig. 2B) and is deflected at the reflector to form a flat pancake-like radiation pattern shown at Fig. 2C. The intensity maximum is directed horizontally and the wavefronts radiated by the horn-reflector combination are approximately spherical. Considering the TE_{01}-mode pattern (Fig. 2A), it is evident that the E-field lines form circles about the system axis. The H-field lines are orthogonal to the E field and parallel to the wavefronts.

Phase Front—The field configuration of concern, which determines the far-field characteristics of the antenna system, is the amplitude and phase pattern at the aperture of the ring-shaped lens. A cylindrical phase front (flat, as seen in an elevation plane) is required, with an appropriate illumination taper to obtain optimum gain and sidelobe level ratios.

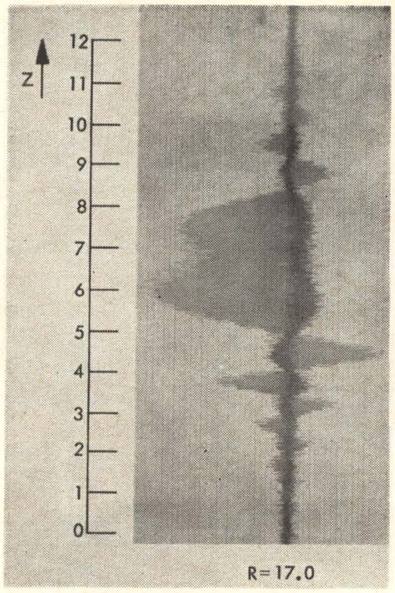
The probe scanning apparatus was designed to provide vertical probe scanning parallel to the wavefront of the desired field, with the probe's rotation axis parallel to the H field. For vertical scanning, the probe can be set at different radial distances from the system axis. A photograph shows the apparatus and a horn-reflector combination under test. Rigid mounting makes possible exact alignment of the antenna system elements.

Scattering from structural elements in the region of high field intensity is reduced by using Eccosorb covers. The three-pole mounting unit supporting the antenna elements during near-field tests (at the left in the photograph) can be detached and used as a mount for far-field testing. The rotary joint in the feed line and the bearings needed to rotate the antenna system during tests for cylindrical symmetry are an integral part of the mounting unit.

The servo system used to rotate and scan the probe through the antenna near-field is illustrated in Fig. 3. Accurate probe setting and a constant scan velocity with no noticeable backlash were achieved using precision-ground drillrod rails to guide the motor assemblies during the scanning operations. At 70 Gc, a tolerance of 0.010 inch normal to the wavefront corresponds to a phase error of approximately 21 degrees. The horizontal and vertical scan velocity is 0.84 cm per sec. Probe rotation is 943 rpm.

Antenna Design—The design of the antenna system was begun with the layout of the horn-reflector combination. The horn flare angle and the desired illumination function at the lens aperture were assumed and the reflector profile was constructed using ray tracing. The lens was designed last, using the measured wavefront of the finalized horn-reflector field.

For the field tests, the horn and the reflector were set in the mounting unit in precise axial alignment. Circular symmetry of the near-field was tested first. Noncircular modes in the circular feed waveguide were eliminated by mode filtering. The experimental design of the reflector was then carried out. The design procedure consists of axially positioning and contour shaping the reflector under observation of the field wavefront and illumination at the lens aperture.



VERTICAL scan record for a fixed distance from the antenna shows main lobe at approximate center scale

A typical vertical scan record taken at the approximate lens distance is shown in the photograph first referred to. Distances between two consecutive nulls of a scan record correspond to phase differences of $\pi/2$. The wavefronts of the field were obtained from a set of such records taken in an elevation plane approximately $\lambda/4$ apart. A scaled mapping of the envelope nulls of all the records of the set was made. Identification of equal phase points was easily made and the wavefronts were drawn $\lambda/4$ apart. The illumination (field intensity), was then plotted by evaluating the magnitudes of envelope maxima, which are proportional to E^2.

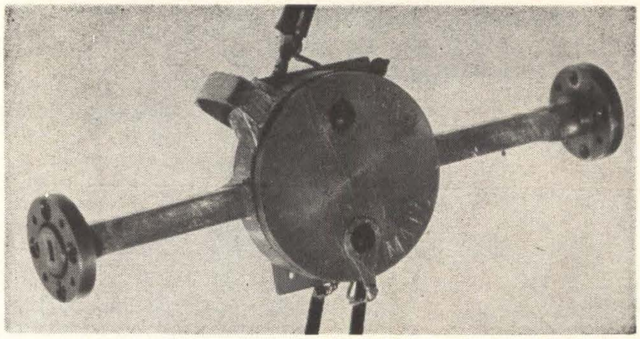
Final Result—In conducting the experimental reflector design, it was found that necessary incremental changes of the position and the shape of the reflector needed to approach the desired field were easily derived. Increasing or decreasing the separation between the horn and the reflector shifts the direction of the intensity maximum up or down without appreciably influencing the shape of the wavefronts. By increasing reflector convexity, the illumination is broadened.

A lens was designed and built to collimate the wavefronts of the final horn-reflector combination. A cross section of a lens designed from a single probe scan record is shown in Fig. 4.

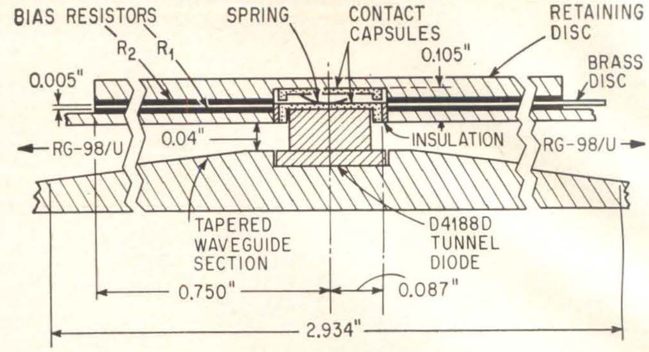
The aperture field of the complete antenna system was tested for phase errors. Deviations in the order of 10 degrees were measured by vertically scanning the probe close to the lens face and observing the modulation waveforms on the oscilloscope. Lens corrections were made accordingly.

REFERENCE

(1) A. Cullen and T. Parr, A new perturbation method for measuring microwave fields in free space, Proc. IRE, Paper 1921R, Sept. 1955.



X-BAND TUNNEL diode in Rg-98/U waveguide produces Q-band frequences at much less expense than a Q-band diode—Fig. 1



THE TAPERED waveguide section serves as an impedance transformation device in waveguide mount. Special requirements are placed on the film resistors—Fig. 2

Operating X-Band Tunnel Diodes

Impedance transformation technique allows a tunnel diode to operate at up to four times rated frequency. And an X-band diode may cost only 1/12th as much as a Q-band diode (Q band = 33 to 50 Gc)

TUNNEL DIODE oscillation above theoretical limits has recently been achieved.[1,2,3] Using a specially designed tunnel diode waveguide transformer and mount, a 1N3219A S-band tunnel diode has produced fundamental X-band oscillations. To obtain this X-band oscillation, the microwave circuit was "designed so that the microwave impedance of the circuit matches the negative impedance of the tunnel diode at a desired operating frequency."[1] This was accomplished by impedance transformation, with the lumped junction and package capacitance of the packaged tunnel diode transformed into the distributed parameter capacitance of the waveguide. This technique does not eliminate these parameters, but it does reduce their effect on the maximum frequency of oscillation. Also, the technique[4] allows a redefinition of the terminals in the tunnel-diode equivalent circuit.

Employing the same principle of impedance transformation, a millimeter wave circuit has now generated Q-band (33 to 50 Gc) fundamental oscillations with an X-band (8.2 to 12.4 Gc) tunnel diode. The tunnel diode employed is a D4168D, Serial Number 1381-63, A89-3, X-band diode. Pertinent parameters for this particular diode are: $I_p = 2.00$ ma, $C_J = 0.6$ pf, $R_s = 2.1$ ohms, $R_n = 69$ ohms, $f_{osc} = 11.3$ Gc, and $f_{RO} = 21.74$ Gc.

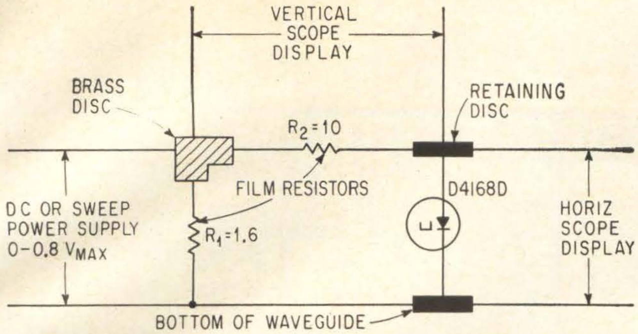
Tunnel diodes for Q-band are commercially available but most of them are permanently mounted in a waveguide and are not interchangeable. Also, such a tunnel diode-waveguide system is 12 times more expensive than the X-band tunnel diode utilized in this investigation. The size, weight and power consumption advantages of the tunnel diode as compared to the klystron at millimeter frequencies are self-evident.

Diode Mount—The tunnel diode waveguide mount is shown in Fig. 1 and a cross-section is shown in Fig. 2. The mount uses the impedance transformation technique of a tapered waveguide section and was designed specifically for a packaged, commercially available tunnel diode. The diode is mounted in the center of the waveguide with a spring-loaded pressure contact. Retaining disk and the waveguide are fastened together with nonconducting bolts. When necessary, these sections are also insulated from one another with an acrylic insulating material.

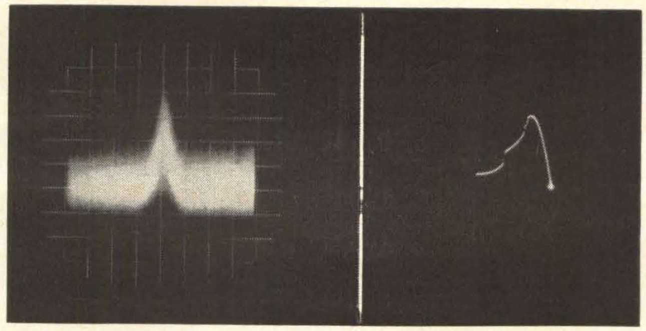
Resistive films are specially designed to bias the tunnel diode, to display volt-ampere characteristics, and most important, to suppress low-frequency parasitic oscillation. As shown in Fig. 3, the resistive films are separated by a brass disk. The d-c power

OUTSMARTING TUNNEL DIODES

In the June 1, 1962 issue of **Electronics,** Professor Ishii and C. C. Hoffins presented results of their work on extending the frequency of oscillation of an S-band tunnel diode up to X-band. Now the same basic principles with some new refinements are used to push an X-band diode up to Q-band frequencies. Much cheaper diode cost is the reason for using the lower frequency unit to get the higher frequency output



OSCILLATION FREQUENCY is primarily determined by the magnitude of the bias voltage. A tuning range of 250 Mc was obtained with this circuit—Fig. 3



KINK IN TUNNEL diode characteristic (right) indicates the diode is oscillating. Output signal (left) is 42.355 Gc at 70 dbm—Fig. 4

at Q-Band

By STANLEY V. JASKOLSKI and KORYU ISHII, Department of Electrical Engineering, Marquette University, Milwaukee, Wisconsin

supply, whose output is placed across R_1, has an output impedance of one ohm. Consequently, R_1 must be approximately one ohm to insure that disturbances within the power supply are not propagated to the tunnel diode circuit. This tends to isolate the power supply from the tunnel diode circuit. The volt-ampere characteristic is monitored on an oscilloscope, placing the voltage across the diode on the horizontal, and the voltage across R_2, which is proportional to the current through the diode, on the vertical. Total resistance of R_1 in series with R_2 is 11.6 ohms.

Film Resistors—The film bias resistors must be so constructed that current paths are through the films rather than around them. Current flow must be straight through conduction current as opposed to radial current. Also, the conductivity per unit area per film resistor must be extremely uniform to eliminate current bunching within the film. Satisfactory resistors tend to maintain uniform field distribution within the waveguide circuit.

Film resistor R_1 consists of an extremely porous paper base coated with a homogeneous mixture of number ten motor graphite and silver conducting paint. Resistor R_2 is painted directly on the waveguide retaining disk, thereby reducing contact resistance at this point, and consists of a homogeneous mixture of Q-dope polystyrene and number ten motor graphite. Both resistors were baked at 125 C for 45 minutes, then placed in the waveguide circuit; the waveguide retaining disk was then bolted to the waveguide. The resistors were cured this way for two weeks. At the end of this aging period, the films appear uniform and constant in conductivity.

Oscillation of the D4168D tunnel diode in the circuit was detected by a large kink, Fig. 4, in the negative resistance region. Shape and magnitude of this kink is a function of how tightly the retaining disc and the waveguide are bolted together. Correspondingly, since the amount of pressure applied varied the value of the bias resistors, the magnitude of the film bias resistors affects circuit operation. As the pressure is varied oscillation can be completely suppressed.

Frequency—With the pressure set to obtain the large kink, oscillation was detected with a RWT receiver having a range from 2 to 75 Gc. Fundamental oscillation was detected and verified with both the receiver and a calibrated shorting plunger at 42.29 Gc for a bias of 155 mv. Oscillation frequency is essentially a linear function of bias voltage, ranging from 42.39 Gc at 130 mv to 42.14 Gc at 200 mv, giving a 250 Mc tuning range with bias voltage. The oscillation is easily reproducible and is stable with time and variations in load. Output power is a function of load, bias voltage and the magnitude of the film bias resistors. Maximum power output was −70 dbm at 42.34 Gc and bias of 160 mv. Oscilloscope display of the RWT receiver output due to the tunnel diode oscillating at 42.29 Gc is shown in Fig. 4.

Exhaustive experiments were conducted to verify that the observed oscillation was a fundamental and not a harmonic.

Unpackaged, laboratory made tunnel diodes, mounted in waveguide structures, have been operated at 100 Gc.[5] Such diodes are not commercially available but packaged tunnel diodes, designed for operation up to 30 Gc, are commercially available upon special request.

The authors thank J. E. Billo, J. A. Stefancin, S. Krupnik, Jr. and C. C. Hoffins for their assistance in this investigation. This research is supported in part by a University Committee on Research grant.

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(1) K. Ishii, C. C. Hoffins, Extending Tunnel Diode Operating Frequency, ELECTRONICS, **35**, June 1, 1962.
(2) K. Ishii, C. C. Hoffins, X-Band Operation of S-Band Esaki Diodes, *Proc IRE* (Correspondence), **50**, July, 1962.
(3) C. C. Hoffins, K. Ishii, Microwave Tunnel Diode Operation Beyond Cutoff Frequency, *Proc IEEE* (Correspondence), **51**, Feb., 1963.
(4) M. K. McPhun, Operation of the Tunnel Diode Above the Resistive Cutoff Frequency, *Proc IEEE* (Correspondence), **51**, p 1265, Sept., 1963.
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HOW TO DESIGN Arbitrary-Length

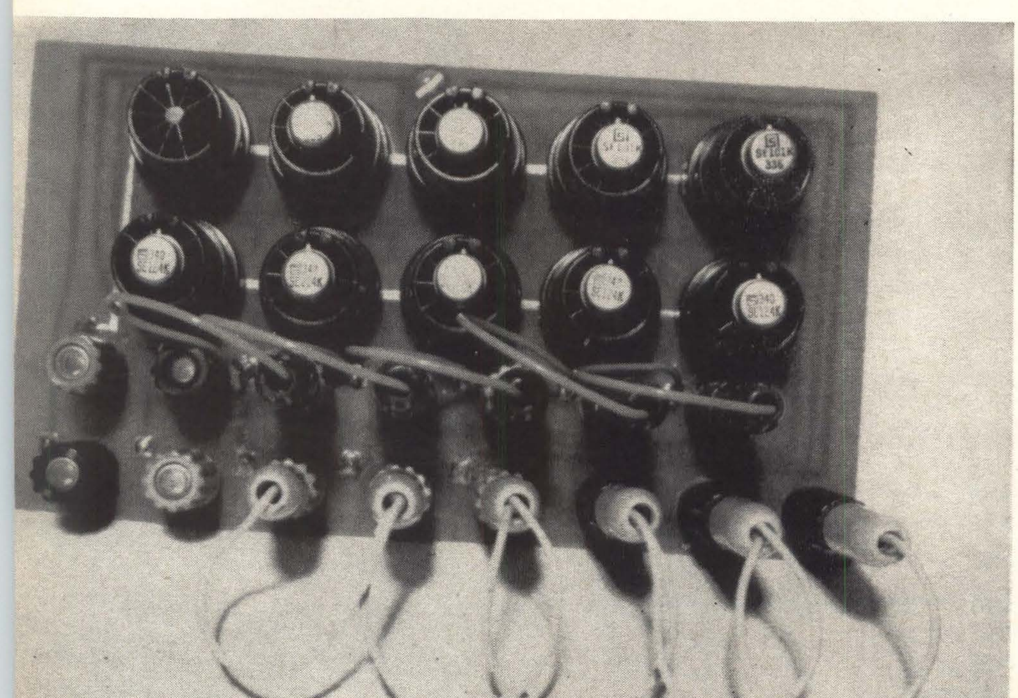
BINARY COUNTERS

Simple set of design rules for building binary counters for any length sequence saves time and eliminates trial-and-error procedures

By **B. W. MEYER,** Signetics Corp., Sunnyvale, Calif.

INSIDE THE COUNTER

The variable-modulus counter, shown in the photo, is made up of integrated circuits, fabricated within monolithic silicon substrates by planar techniques. The circuits are designed for applications in high-speed low-power computer systems

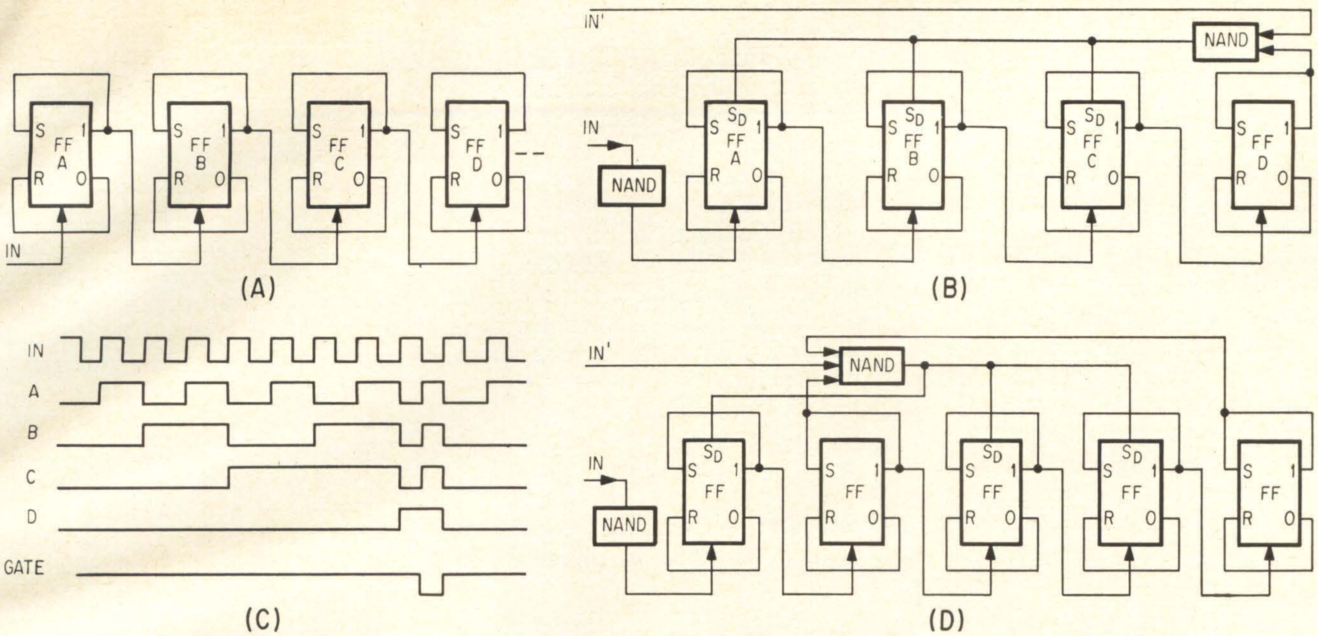


VARIABLE MODULUS counter, designed for and using integrated circuit modules, shown packaged in modified TO-5 cans

IN NEARLY EVERY system designed, the need arises over and over again for counters to count to some arbitrary length sequence. By trial and error, one can eventually find a logic design that will do the job, but trial and error seldom produces a minimum package count. Here is a set of rules that will consistently produce a design for a counter of any length sequence with a minimum number of packages, and in which the required fan-in and fan-out of the gates used are minimized. Also, in applications where the

BINARY COUNT SEQUENCE

D	C	B	A	
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9
1	0	1	0	10
1	0	1	1	11
1	1	0	0	12
1	1	0	1	13
1	1	1	0	14
1	1	1	1	15



SIMPLE binary ripple counter (A); nine counter (B) and timing chart (C); 19 counter (D). Direct set input is S_D—Fig. 1

counter designed according to these rules must merely count repetitively rather than start at a predetermined state, no "clear" signal is necessary. After a short count through some of the out-of-sequence states, the counter will automatically go into the desired sequence.

Operation—Consider first a simple binary ripple counter as shown in Fig. 1A.

The flip-flops trigger on the negative-going edge of the clock input signal if one logic input is down. If the first flip-flop of the counting chain above is in the ZERO state, the ONE output is low, and therefore, the set input is low. When the input line goes down, the flip-flop goes to the ONE state, with its ONE output high, and ZERO output (and, therefore, reset input) low. On the falling edge of the next clock pulse the flip-flop returns to the ONE state; thus, the first flip-flop changes state on the falling edge of every input pulse. In similar fashion the second flip-flop changes state every time the ONE output of the first flip-flop falls, and similarly for succeeding stages. Thus it can be seen that the network counts the input pulses in binary. If a continuous train of pulses is applied to the input, the counter will cycle through all of its possible states, return to its initial state and cycle through the same states repetitively. Since the number of possible states is a power of two, the length of the counting sequence is also a power of two. Specifically, if the number of flip-flops is n, the length of the sequence is 2^n, which, for the counter shown, is 16. Now consider how to get sequences of other lengths.

Modifications — To understand the design procedure, consider the count sequence in the table for a simple four-stage binary counter. There are a total of 16 possible states in the table, and therefore, the counter will count a sequence of length 16. If means are provided to prevent the counter from reaching some of the possible states, then the length of the sequence can be limited to any desired number (L) less than 16.

A commonly accepted practice is to force the counter to go from the state representing L-1 back to the beginning of its normal sequence (all zeros) on the Lth clock pulse. This is usually accomplished with a configuration of gates that causes the counter to reset automatically on the Lth pulse. This technique, however, may frequently require an uneconomical number of gates. In the following example, it will be shown that with a minimum number of gates, one can force a counter from L-1 through its normal final count (all ones) and back to all zeros, in the duration of the Lth clock period.

Assume the 16-counter shown above is to count a sequence of length 9. Note from the table that on the eighth count (L-1) flip-flops A, B and C are zeros, and D is ONE. The objective is to return the counter to all zeros by the end of the ninth clock pulse. If one connects, as inputs to a NAND gate, the clock pulse and the ONE side of flip-flop D, the output of this gate will go down only when both of these inputs are high. Connect the output of this gate to the set inputs of flip-flops A, B and C as shown in Fig. 1B. Now consider the timing diagram for this counter, Fig. 1C. On the falling edge of the eighth clock pulse, the counter goes to 1000 with flip-flop D up. On the rising edge of the ninth clock pulse, the gate output goes down, since both its inputs are up, and thus causes flip-flops A, B and C to change to ones. Flip-flop D remains at ONE, being unaffected by a rising voltage at its clock input. In *half* a clock time, then, the counter has gone from state 8, or 1000, to state 15, or 1111. On the falling edge of the ninth clock pulse, the gate output rises, and the counter goes to all zeros. Thus, the cycle from state 8 through 15 and back to zero is completed during one clock time, and the counter has made nine counts.

It should be noted that, in the practical implementation of this technique, the propagation delay through the feedback gate should be compensated for to assure reliable operation. This is readily done by inserting an identical gate in the clock line. Since the gate will invert its input signal, the input to this gate and to the feedback gate must be complementary. Relative timing of *In* and *In'* is not critical, the only requirement being that *In'* go down no later than *In* goes up.

Note also, in the example given, that it is not necessary to use the entire configuration for state 8 as a feedback or reset signal, as is commonly the case. Fan-in and fan-out requirements for the feedback gate are minimized, because only those flip-flops that are ones for the *L*-1 state are connected to gate inputs, and the gate fans out only to those flip-flops that are zeros for state *L*-1.

Design Rules — The example and observations above can be generalized into the following set of design rules:

(1) Determine desired length of sequence. Call this *L*.

(2) If *L* is a power of 2—as 4, 8, 16, etc.—merely construct a binary ripple counter according to instruction 4, with $L = N$.

(3) If *L* is not a power of 2, find the next higher power of 2. Call this *N*.

(4) Find $\log_2 N$. This is the number of flip-flops required in the ripple counting chain. Construct this counter.

(5) Determine the binary equivalent of *L*-1.

(6) Connect, as an input to a NAND gate, the ONE side of all flip-flops that will be ones when the counter reaches *L*-1. Include as an additional input the inverse of the counter input.

(7) Connect the gate output to the d-c SET input of all flip-flops which are zeros at *L*-1.

Example — Construct counter to count a sequence of length 19.

(1) $L = 19$.

(2) $L \neq$ a power of 2.

(3) Next larger power of 2, $N = 32$.

(4) $\text{Log}_2 N = \log_2 32 = 5, \therefore 5$ flip-flops required.

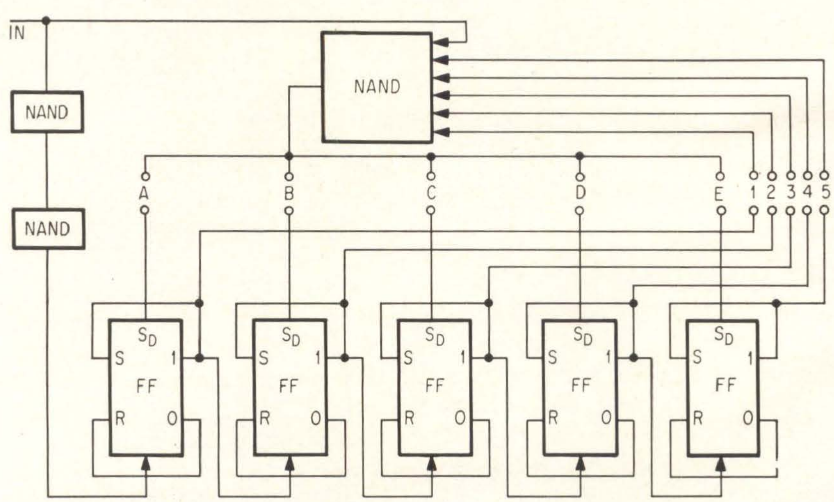
(5) $(L - 1)_2 = (18)_2 = 10010$.

Construct the counter as shown in Fig. 1D. The added gate, previously discussed, compensates for the delay of the feedback gate. Actually, for those counter configurations that do not require feedback to the first stage, the delay problem does not exist, and this added gate may be eliminated.

Limitations — As with counters of other designs, consideration must always be given to limitations on counting rate. The maximum rate at which the counters described here can count is a function of the length of the sequence. In the worst case, a signal must propagate through the length of the counter, back through the feedback gate and through the first flip-flop again before the next input pulse arrives. In cases where this propagation time must be decreased, consideration should be given to breaking the counter into a number of smaller counters running in parallel with their outputs gated together. The sequence length is then the product of the sequence lengths of the individual counters, and the maximum propagation time is that of the largest individual sequence length plus the delay associated with the required gating at the output. In designing such counters, care should be taken to avoid the occurrence of common factors in the sequence lengths of any of the individual counters used. Where common factors occur, the sequence length will be the product of the individual sequence lengths divided by the common factor. Thus, an 18 and a 6 counter operated in parallel and gated together will count 18 and not 108.

It should be apparent from the discussion that counters designed in accordance with the rules specified will automatically come into the desired sequence no matter what their state when power is first applied. If it is necessary to have the counter start at all zeros when power is applied, an initial clear signal should be applied to all the d-c reset inputs. Provided that this signal is longer than the maximum possible carry propagation, the counter will be forced to the clear state.

The rules and observations presented here were checked empirically on an experimental variable-modulus counter in which the sequence length can be changed conveniently on a patch panel (Fig. 2). This counter can be made to count up to any number from 2 to 32, by connecting the feedback gate inputs and outputs in accordance with the table in Fig. 2, which conforms to the rules previously discussed.



FEEDBACK CONNECTIONS	SEQUENCE LENGTH 2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
GATE INPUTS	NONE	2	NONE	3	1 3	2 3	NONE	4	1 4	2 4	1 2 4	3 4	1 3 4	2 3 4	NONE
GATE OUTPUTS	NONE	A	NONE	A B	B	A	NONE	A B C	B C	A C	C	A B	B	A	NONE

FEEDBACK CONNECTIONS	SEQUENCE LENGTH 17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
GATE INPUTS	5	1 5	2 5	1 2 5	3 5	1 3 5	2 3 5	1 2 3 5	4 5	1 4 5	2 4 5	1 2 4 5	3 4 5	1 3 4 5	2 3 4 5	NONE
GATE OUTPUTS	A B C D	B C D	A C D	C D	A B D	B D	A D	D	A B C	B C	A C	C	A B	B	A	NONE

VARIABLE MODULUS counter and chart of connections for constructing a counter of any length from 2 to 32—Fig. 2

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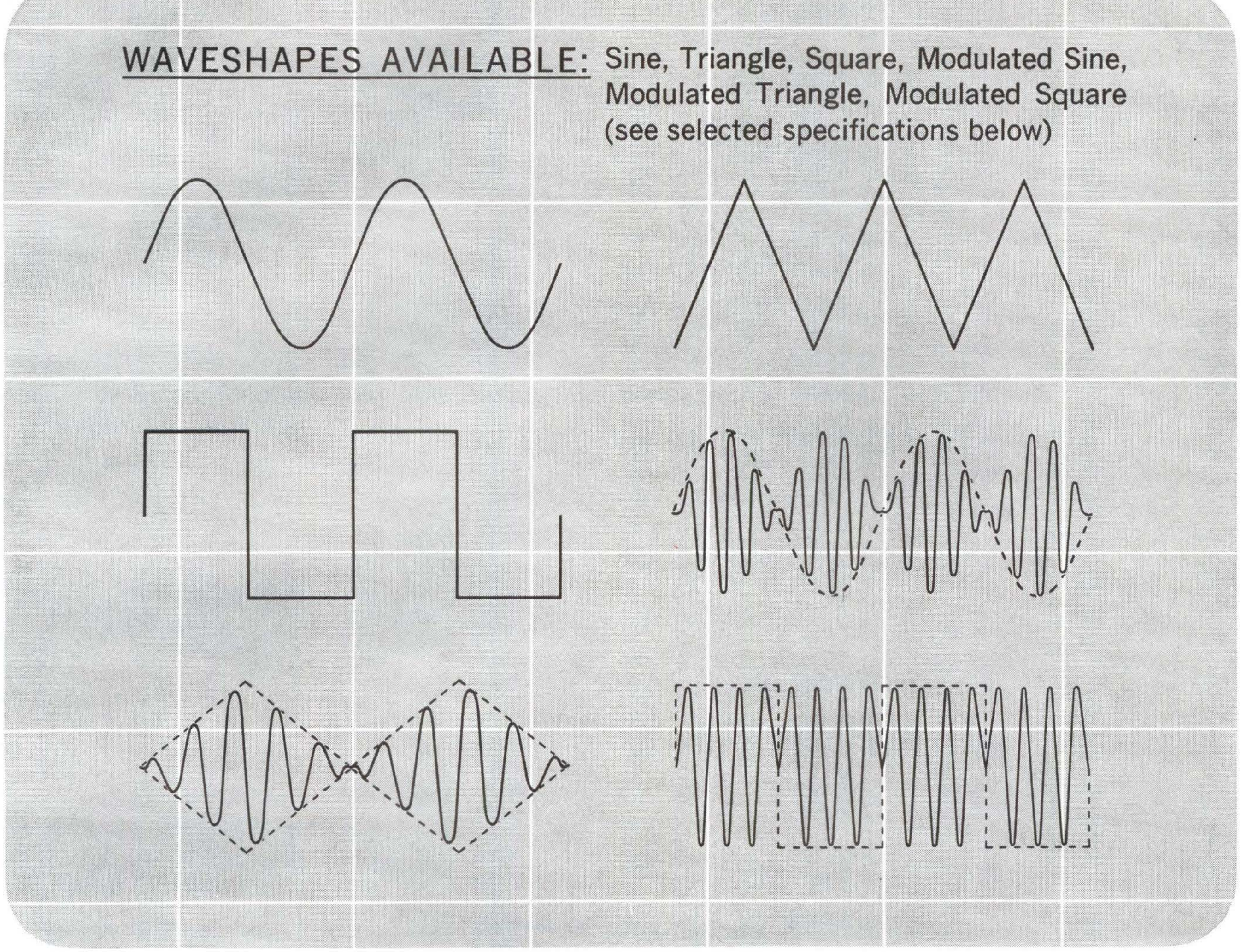

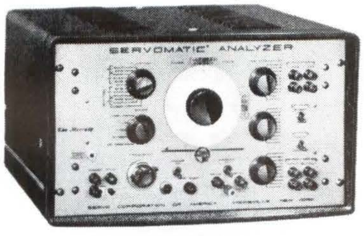

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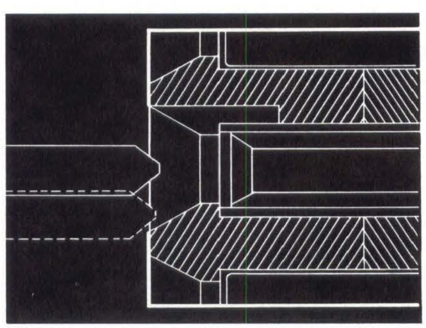

Figure 1. Slight misalignment is self-corrected by the beveled entry of the Ultra-Mate connector. Badly bent pins will prevent mating until they are replaced.

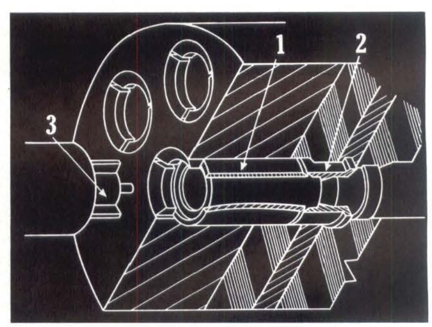

Figure 2. Standard removal tool depresses activation sleeve (1) which spreads tangs of retention clip (2) apart. Tool (3) never directly touches clip.

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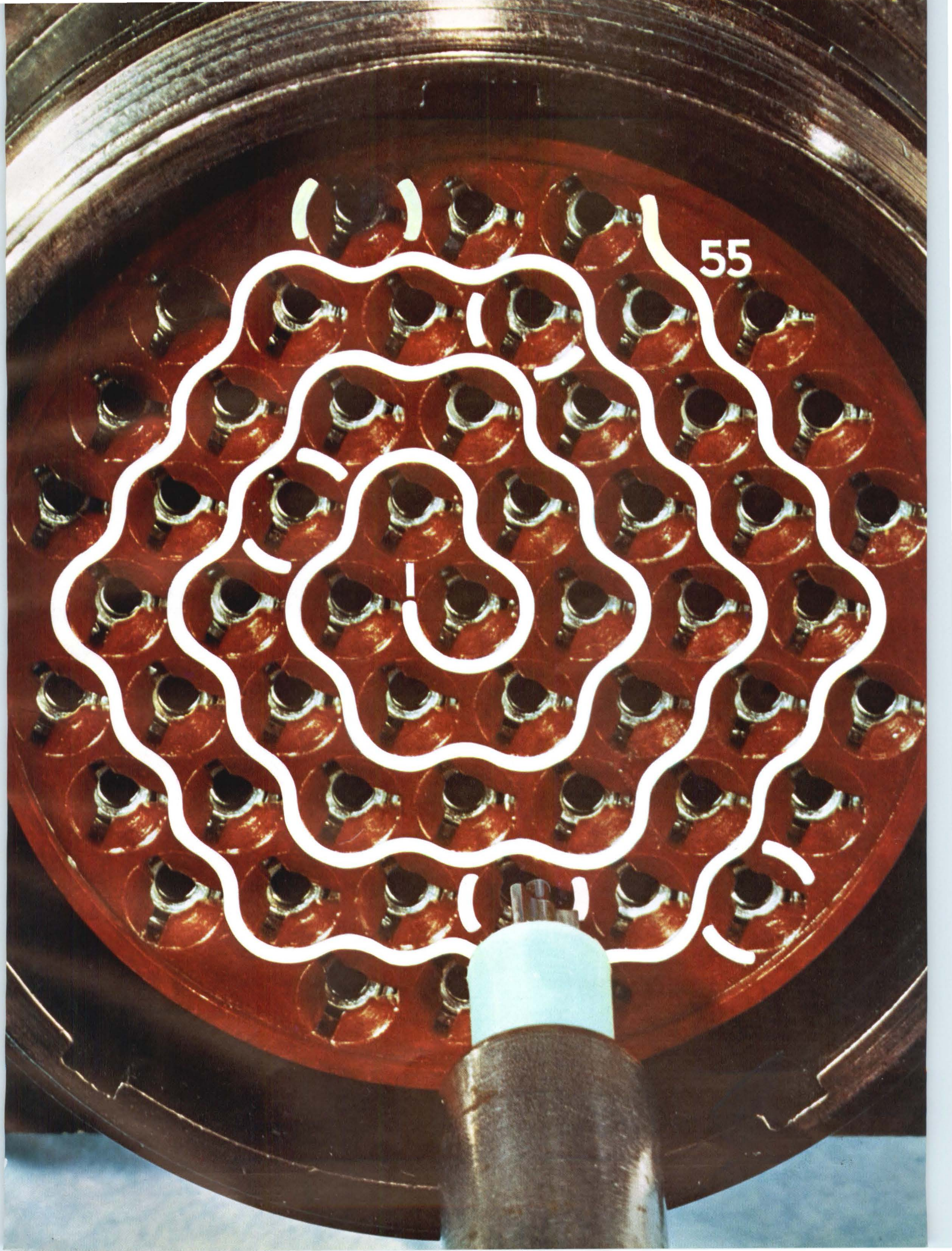

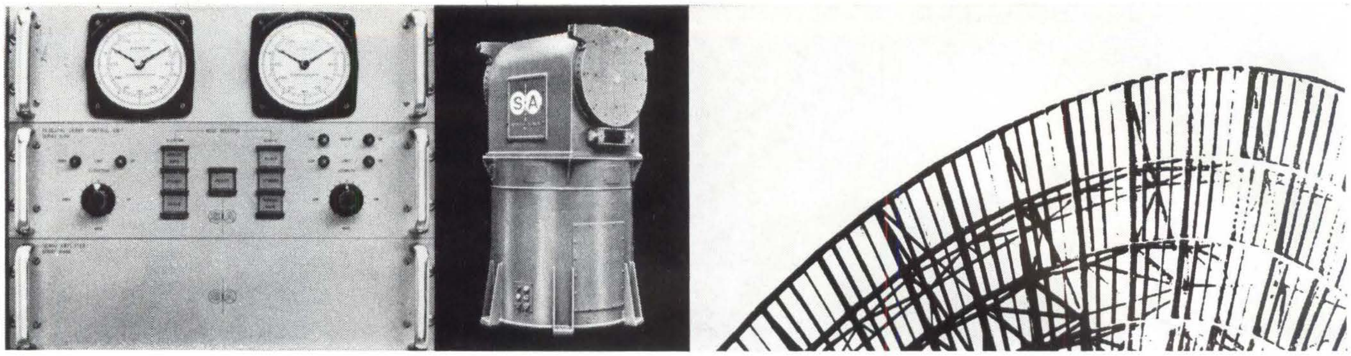

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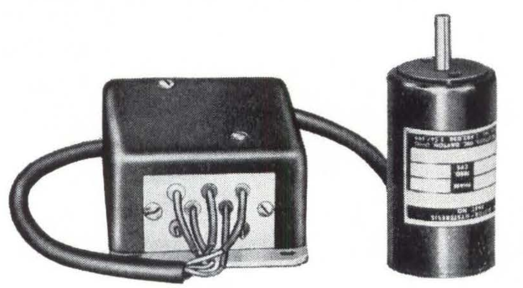

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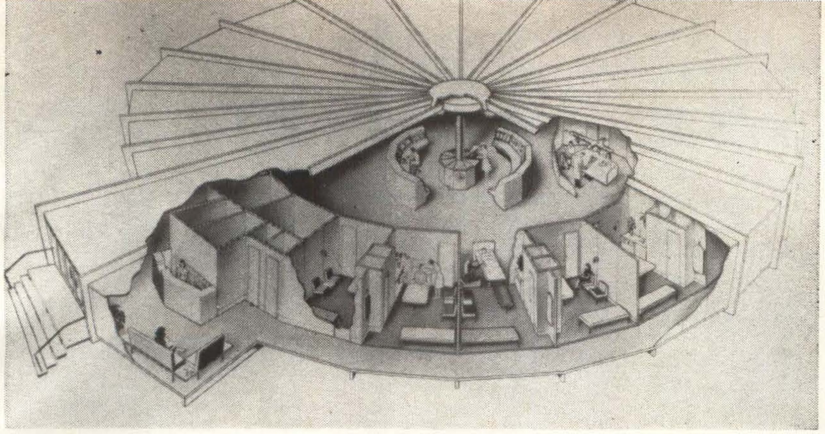
 CIRCLE 40 ON READER SERVICE CARD

CIRCLE 204 ON READER SERVICE CARD



CUTAWAY VIEW shows arrangement of rooms around monitoring consoles

"Electronic" Hospital Opens

Experimental hospital's twin will be used at New York World's Fair

MONTGOMERY, ALA.—Business and medical men here are backing a new concept in hospital design, one aimed at lowering the cost of medical care. Hospital bedrooms are built around a core containing electronic patient-monitoring and data-handling consoles.

The first Atomedic Research Center was opened here last month with an assist from electronics firms who loaned or donated much of the equipment.

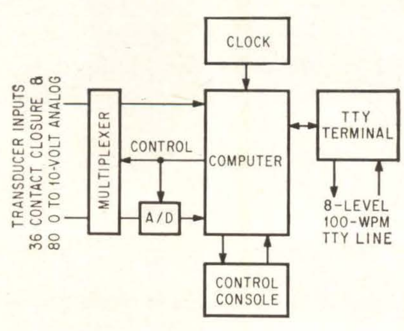
Atomedic's director, Dr. Hugh C. MacGuire, hopes the experimental hospital will step up world-wide use of modern medical technology. A twin of the 22-bed hospital in the round is scheduled to serve the New York World's Fair in March.

Monitoring—For electrocardiogram monitoring, miniature transducers and an 87-Mc f-m transmitter are taped to the patient. Signals are picked up by a monopole antenna in the bedroom ceiling and go by coaxial cable to one of 22 receivers at the central console. The ekg waveform is displayed on a Tektronix 565 oscilloscope. An abnormal heartbeat triggers an alarm lamp and buzzer. Aero Geo Astro, which designed the equipment, says the system can be expanded to handle other physiological parameters, such as temperature and respiration, by adding modules and multiplexing the transducer signals.

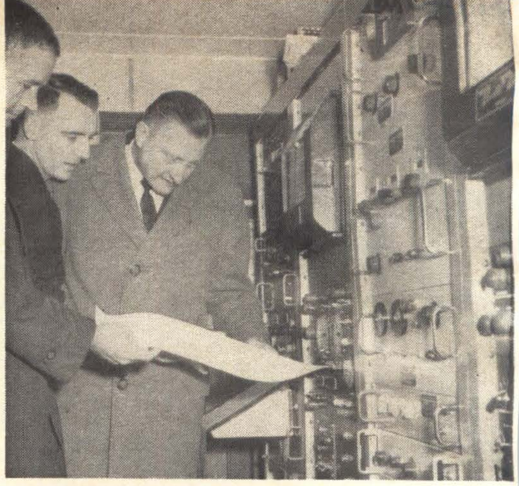
Computer—A Control Data 160 computer scans data inputs and activates the alarms when readings exceed preset limits or change from past readings. It can scan 80 analog and 36 closure inputs at rates of 100 and 1,000 points a second. Data is converted to digital form and displayed or recorded on demand. This system, when expanded, will also record ambient hospital conditions and handle clerical data and information retrieval.

Closed-Circuit Tv—This system lets nurses watch four beds at once from the central console. Low-light-level, automatic cameras made by Packard Bell are installed in each room. Miratel supplied the monitors.

Southern Bell's communications system provides for outside phone calls and also acts as an intercom system. Data-Phone transmission units can be plugged in to transmit medical data to a larger parent facility in the future.



COMPUTER processes and presents data from patient-monitoring transducers



MARSHALL Space Flight Center officials check automatic readout

Radiosonde data is gathered and printed out by ground station

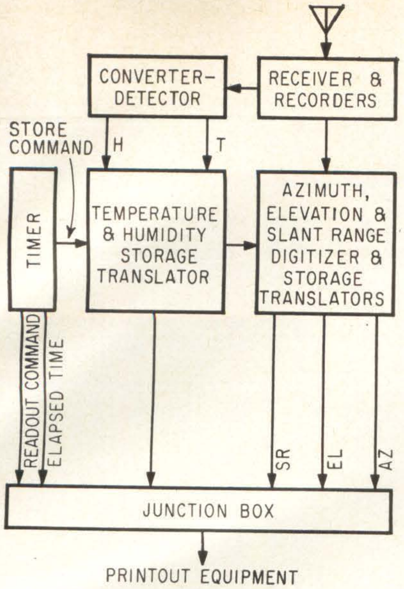
Weather Readout

WEATHER STATION that automatically translates and prints out radiosonde data as it is received has been demonstrated by NASA's Marshall Space Flight Center at Huntsville, Ala.

The radiosonde automatic data-processing system was designed by Friez division of Bendix to work with the Rawin set AN/GMD-2 (or upgraded AN/GMD-1) and modified radiosonde AN/AMQ-9 or AN/DMQ-9. Every five seconds, it will print out a card giving temperature, humidity, slant range, azimuth and elevation angles of the weather balloon, and the time the card is prepared.

Data Handling—Angle and range data are converted from the synchro signal outputs of the GMD-2 to bcd (binary coded decimal) form with servo-driven shaft-to-digital encoders. Data are then put into 10-line decimal form and stored by transistor-controlled relay matrixes for simultaneous, automatic readout on commands from the timer.

The AMQ-9 transmits meteorological signals at 1,680 Mc to the GMD-2 receiver. The GMD-2's a-f signals go to the converter-detector chassis and are converted to d-c voltages for level detection and fur-



DATA is read out of system on IBM cards at rates of 6 or 12 cards a minute. A 1620 computer then processes data

Is Automated

ther conversion to bcd form.

Temperature and humidity frequency ratios are stored in separate bcd to 10-line decimal matrices in synchronism with the radiosonde commutator. Although the Huntsville installation feeds an IBM 526 card punch, output can be in field data, teletypewriter, bcd or 10-line decimal codes if needed.

Equipment Modifications—In the Huntsville system, a control recorder and an AN/TMQ-5 radiosonde recorder normally provide manual backup. The control recorder also provides antenna slewing, receiver tuning and power distribution by remote control.

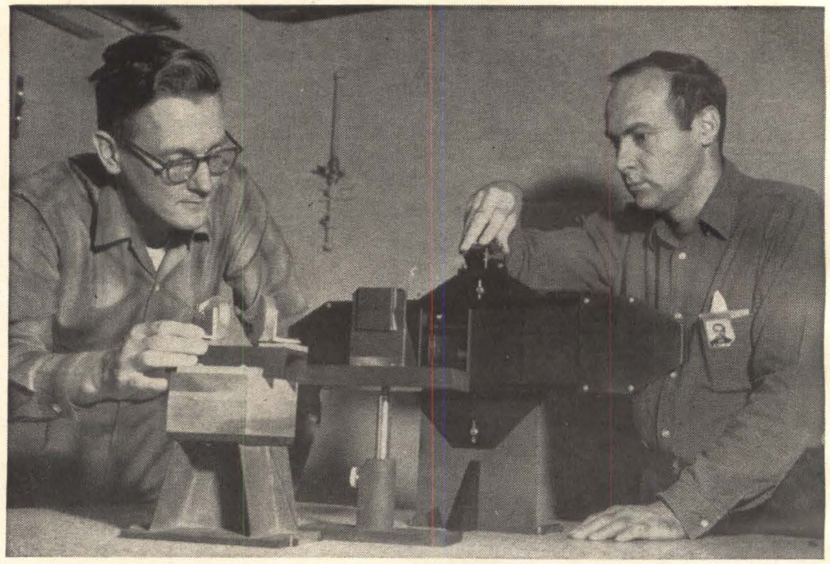
Two AN/GMD-lb Rawin sets were modified to slant-range measuring capability in meters. AN/AMQ-9 radiosondes with new commutators provided short duration reference identifiers preceding humidity and temperature segments to facilitate decommutation. The equipment cost $72,000 to build using commercially available parts.

Bendix Friez recently developed a distance indicator to correct for ambiguous slant-range measurements resulting from signal loss. The company expects to put this feature in future versions of the system.

Lensless Optical System Uses Laser

Opaque 3-D objects may be imaged without lenses using reflected light

By **LEON H. DULBERGER**
Associate Editor
CHARLES WIXOM
McGraw-Hill World News



LENSLESS CAMERA at University of Michigan. Film is held in fixture at right; object to be photographed in device at center; reference beam of laser light is reflected past object and onto film by mirrors at left. Second step in process yields recognizable photograph

CLEAR PHOTOGRAPHS are being produced without use of lenses in a new optical technique developed at the University of Michigan. The new system may have extensive effects on photographic technology. Though it has not been demonstrated at x-ray wavelengths, the lensless technique may afford sharp images, rather than the shadowgraph images now available for x-ray systems.

The work was carried out at the University's Institute of Science and Technology, by Emmett N. Leith and Juris Upatnieks. The research engineers use a two-step process, requiring spatially coherent and monochromatic light. The experiments are readily carried out with a helium-neon gas laser. A mercury arc lamp and an interferometer may also be used, with longer exposure.

Using a transparency as the object to be reproduced, light from the laser is passed through the transparency onto a film contained in a camera-like device (see photo). At the same time, a portion of the laser light is passed through a prism, set at an angle to direct it onto the film, superimposing it on the Fresnel diffraction pattern produced by the light passing through the transparency. The second beam, termed a reference beam, provides phase information by producing a fringe pattern superimposed on the diffraction pattern. Thus a hologram recording is produced with phase information for later reconstruction. The fringe pattern is both amplitude and phase modulated by the Fresnel diffraction pattern; the film acts as a square-law modulating device.

In the second step of the process, collimated monochromatic light from the laser is directed through the hologram, using a projector-like device. The hologram acts as a diffraction grating, which produces a real image at a displaced position, a distance from the hologram. A photograph of this reconstructed image produces a high-quality picture of the original transparency, without the use of lenses. The reconstructed image has the same contrast as the original, and is positive if the transparency is positive.

Laser Application—Gas lasers rated at 1 to 5 mw were used. Operating wavelength is 6328 Å. Pulsed lasers should also work, and might have advantages when short exposure times are desired. The type of spatial coherence required of the light source is such that the phase at one point in space be time-invariant with respect to the phase at another point in space. However, the point-by-point variation of this phase can be a completely random function. Thus the laser light may be passed through a frosted glass to diffuse the light, and the two-step process can still be carried out. Monochromaticity must be provided.

According to Emmett Leith, commercial uses may be hastened as the process is extended to shorter wavelengths—regions of the spectrum where good lenses are not available, as u-v, ir and x-ray.

Leith points out that it is possible to record opaque three-dimensional objects using reflected light, and that this has been done. The image reconstructed from the hologram can be photographed, completing the second step. In addition it is possible to view the reconstructed image directly by placing the eye so as to intercept the light emerging from the hologram. A three-dimensional projection is formed, having the effect of stereo projection, though only one hologram is used.

An important beginning to this work was made by D. Gabor, who published a paper on a two-step imaging process in 1949. It did not, however, permit reproduction of continuous-tone transparencies.

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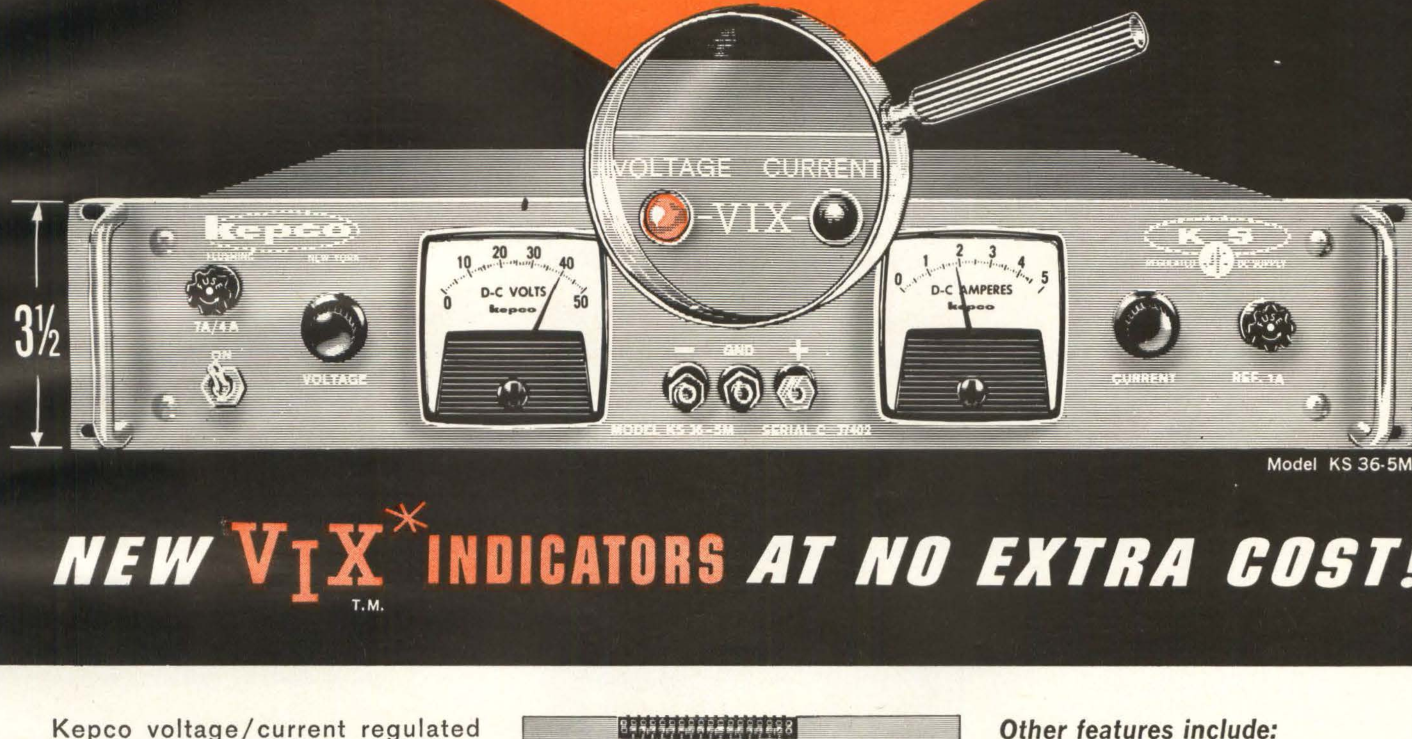

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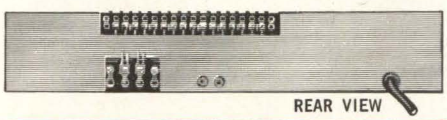

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CIRCLE 45 ON READER SERVICE CARD

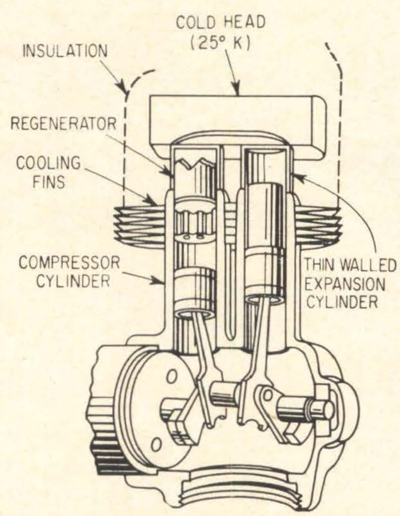
COMPONENTS AND MATERIALS

Miniature Closed-Cycle Cooler Produces 25°K Reliably

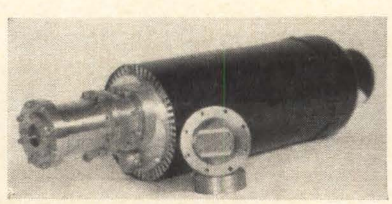
Valveless unit cascaded for lower temperatures for space systems

By **C. R. WHETSTONE**
Assistant Editor

HIGH BRIDGE, N. J.—Cryogenic temperatures on the order of 25° K are produced by a miniature in-line cooler no larger than a football. Working on a modified Stirling cycle, the closed-cycle system has a cooling capacity of 12 watts at 77° K —the temperature of liquid nitrogen —with a rotary input of 100-watts.



ARTISTS CONCEPTION of Cryomite cryogenic cooler



COOLER measures 14 inches in length and 5-inches in diameter yet cold head reaches temperatures on the order of 25°K

Some of the applications for the Cryomite—developed by Malaker Laboratories — include continuous cooling of infrared devices, temperature-sensitive semiconductor devices antennas and parametric amplifiers; reliquefaction and refrigeration of gases; cooling of densely packed electronic units for space applications; and spot cryogenic cooling of airborne or satellite components.

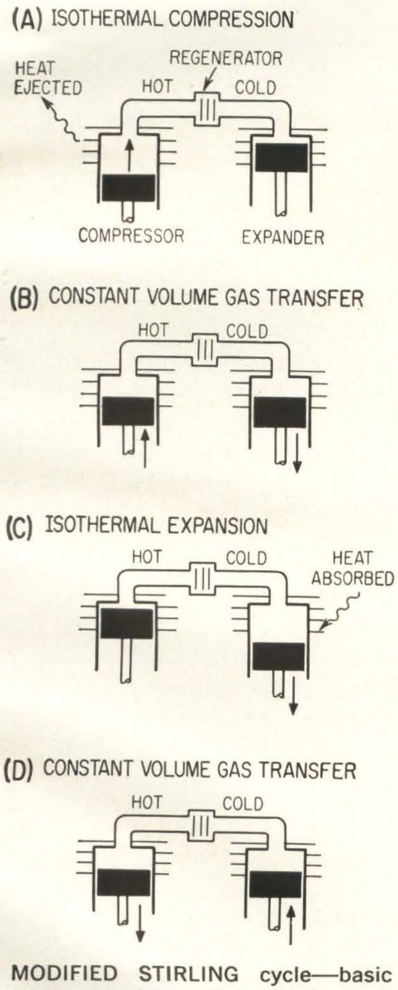
The Cryomite can mount infrared sensors or other devices directly on the cold head. It has also been designed into systems that previously used liquid nitrogen from a supply dewar.

Cooling Methods—There are five basic methods for cryogenic cooling: 1) cascaded evaporation systems; 2) systems based on Joule-Thompson cooling; 3) isentropic expansion systems, such as the Claude system, using reciprocating expansion engines or turbo expanders; 4) the Taconis system, using displacement expanders; and 5) modified Stirling cycle systems.

Careful evaluation of the various methods disclosed problems that would be encountered in miniaturization. For example, lack of reliable, miniature, block-free expansion valves make it difficult to utilize cascaded evaporation, Joule-Thompson, or Claude systems. The major drawback of the Taconis system is that a source of pressurized gas or an external compressor is required for operation.

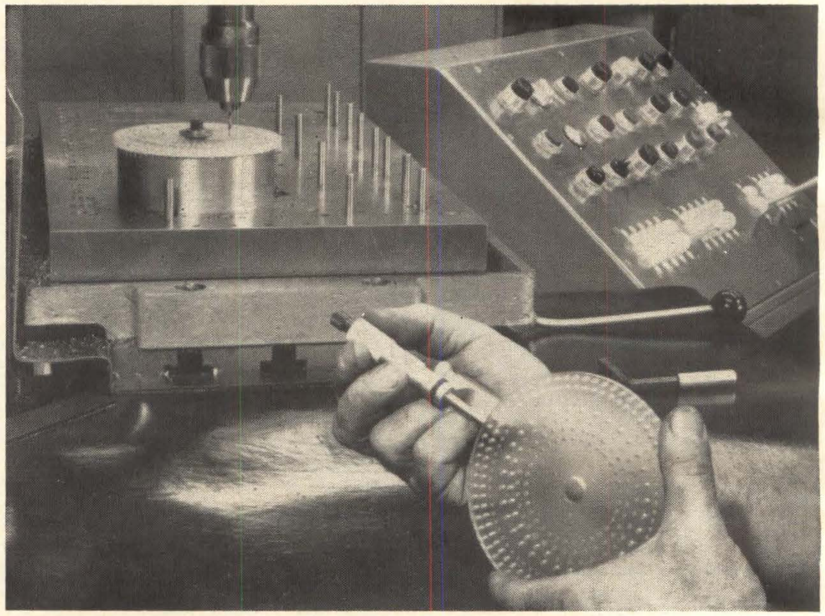
Stirling Cycle—The modified Stirling-cycle engine picked by Malaker Laboratories, has a simple construction, partly because no valves are used. Since it is a closed-cycle system, there is no problem of contamination. The system is self-contained, and requires no external gas supply. No constrictive passages for gas flow exist, so blockage problems are avoided. The refrigeration temperature can be adjusted to the desired value by control of the motor speed. The engine can readily be made in a variety of sizes, based on a single design.

The fundamental requirements for a Stirling-cycle refrigerating engine are: to have a compression volume, V_c, at the higher temperature, T_c; an expansion volume V_E, at the lower temperature, T_E; and to allow a fixed quantity of gas to pass alternately from one volume to the other via a regenerator—thus no valves are used (see fig.). In order to maintain a refrigerating effect, the movements of the pistons in the two volumes must be out of phase, such that the expansion volume leads with respect to the compression volume. The necessary steps in the functioning of a refrigerating engine operating on an idealized Stirling cycle are shown in the figure.



MODIFIED STIRLING cycle—basic system used in unit to obtain cryogenic temperatures efficiently

Programmed Machine Cuts Cost of Plastic Parts



WORKPIECE is drilled by machine controlled with punched paper tape. Self-contained tape puncher is programmed by the operator

Cost is less in short runs than molding or conventional drilling

By **BEN E. SHERESHAW**
Chief Engineer
Dun-Rite Manufacturing, Inc.
East Rutherford, N. J.

INCREASED use of plastics in electronic equipment in small quantities is posing a tough production problem for the electronics industry: how to hold down production costs and lead time on short-run, high-precision plastic parts. A practical answer is a low-cost numerically controlled milling machine.

Example—A small order from ITT Federal Laboratories, Nutley, N. J. is an example of the savings in both lead time and money with low-cost numerically controlled systems.

This order called for 30 Rexalite 1422 discs (Rexalite 1422 is a translucent, thermosetting, styrene-based copolymer with a low dielectric constant). These discs, were to have a diameter of 4.76 in. and be 0.291 in. thick, and have 267 holes drilled at intervals of 5.45 deg in concentric circles positioned to an accuracy of 1 mil.

Alternate Methods—Injection molding, the most common production technique for high-volume, low-precision plastic parts, was quickly rejected because shrinkage of the material inside the mold during cooling moves the closely spaced holes out of tolerance. The mold costs $2,500 with six to eight weeks required for fabrication.

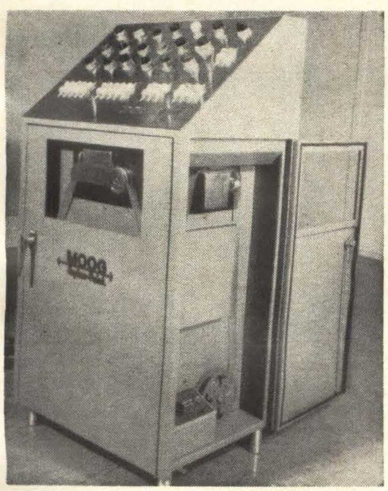
Rotary indexing devices essential for conventional drilling introduce large margins and many drilling errors. An automatic indexing device would help but costs $2,500.

The most practical solution to precision short runs such as this is obviously numerical control. With this technique a Bridgeport milling machine is driven by a numerical control console made by Hydra-Point division of Moog Servo Controls, Inc., Depew, N. Y. It is equipped with a self-contained Hydra-Point automatic tape punch. Coordinate locations for the holes are punched into the tape that moves the drilling spindle of the milling machine. To maintain a high degree of accuracy, drill chucks are changed manually on signal from the programmed tape. To avoid error, an indicator points out the specific chuck required. Once the first work piece is checked out against the program sheet there is no longer any possibility of error.

Six hours was devoted to programming followed by tape punching at the numerically controlled machine. The first part, made during the punching of the tape, was checked: four errors were found. It took a total of two hours to find and correct the errors (all four were human errors made during programming).

The 30 pieces were run off one at a time under tape control taking 130 minutes each. No further inspection was needed.

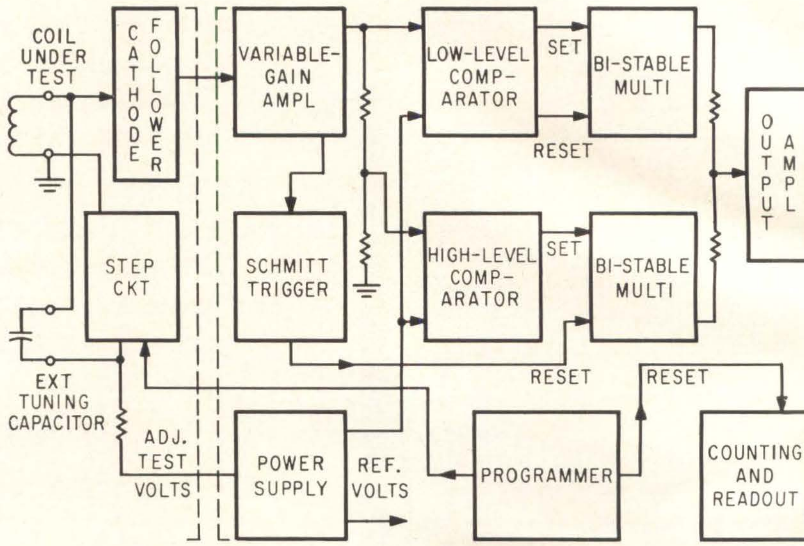
The complete job, from receipt of the customer's order, including procurement of materials, took 30 days and was accomplished during regular working hours.



CONTROL CONSOLE has key board for operator to set in drilling coordinates. Tapes are reused for each work piece

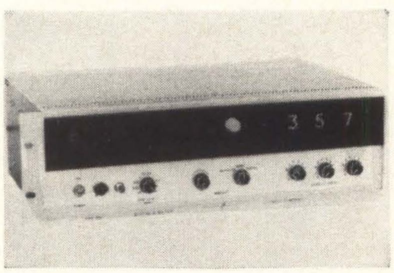
Instrument Displays Q Digitally

Device eliminates constant oscillator retuning



TYPE 71A digital Q meter displays measurement information in digital form in the Q range between 0 and 999. Complete measurements can be performed in a fraction of a second, even by unskilled personnel. The instrument's inherent digital design eliminates the necessity for retuning the Q meter for each inductor being tested.

Unit can also be used for go/no-go testing. Preset switches permit Q-limit selection throughout the full range of the instrument. Panel lamps indicate the over- or under-limit status of each measurement.



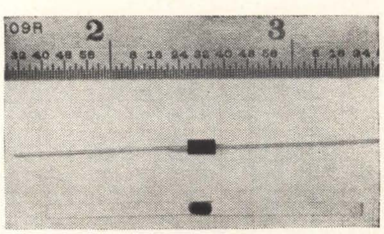
Type 71A is intended for testing the characteristics of components such as toroids, filters and i-f transformers. It is readily adapted to automated production setups and digital or analog recording of measurements.

Frequency range of the device is 10 kc to 1 Mc. Test voltages are selectable in ten steps from 10 mv to 10 v. Inductance range is 10 μh to 1 h. Accuracy is 2% or 1 digit of Q, depending upon which is greater. Type 71A is priced at $2,190. J-Omega Co., 2278 Mora Way, Mountain View, Calif.

CIRCLE **301,** READER SERVICE CARD

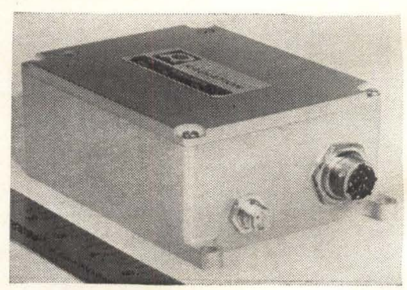
Tiny Zener Diodes Have Low Impedance

Micro Zener diodes are 750 mw units featuring sharp zener breakdowns, low impedance and leakage and low zener noise voltage. Voltage ranges from 6.8 v to 47 v. Units will meet specifications for MIL-S-19500 and can be supplied with specific burn-in, environmental and device specification reliability test data for individual units or lots.



Size is 0.150 inch × 0.060 inch with 0.5-inch minimum gold-plated silver leads that are 0.046-inch × 0.006-inch thick. Price ranges between $4.32 and $5.63 per unit in quantities of 100. MicroSemiconductor Corp., 11250 Playa Court, Culver City, Calif. **(302)**

F-M Transmitter for Telemetry Band



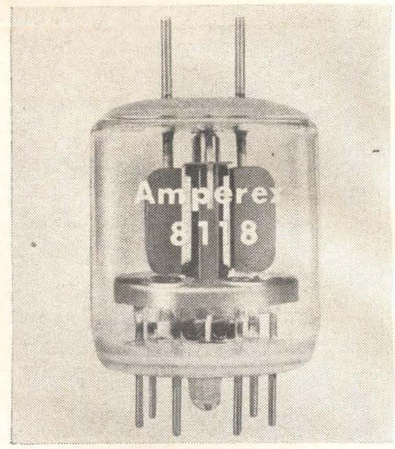
A NEW f-m telemetry transmitter for operation in the 216 to 260-Mc telemetry band and featuring all solid-state construction has been developed. Model 3116 also features completely separate power supply ground, case ground and modulation input return. Missile instrumentation system using the 3116 will not have the ground loop problems of other off-the-shelf transmitters not having separate grounds. Designed with built-in protection against transients and short circuits, the transmitter's circuitry provides a 4-w minimum power output at high efficiency for a wide input voltage range and extremes of temperature. Unit accommodates any signal having components between 30 cps and 200 kc, and differential input allows complete freedom in system input circuitry design and shielding arrangement. Radiation Inc., Melbourne, Fla. **(303)**

Shrinkable Tube Is Flame Resistant

SHRINKABLE tubing of modified Teflon FEP that shrinks instantly at 300 F and lower to permit inserted objects to have a surface of Teflon with a continuous service temperature of 400 F is now available. The shrinking process does not affect the electrical, mechanical and chemical properties of the modified Teflon FEP: good dielectric strength (500 to 1,000 v/mil); low dielectric constant (2.0) and dissipation factor (0.002); no change of electrical properties with temperature (— 25 C to + 250 C) or frequency (60 cps to 100 Mc); zero moisture absorption; unaffected by any commercial chemical. Penntube II-SMT is available in natural color and lightweight wall thickness. Pennsylvania Fluorocarbon Co., Inc., Clifton Heights, Pa. **(304)**

Push-Pull Tetrode Heats Instantly

INSTANT-HEATING, push-pull tetrode —the 8118—is intended for use as an r-f amplifier, driver or frequency multiplier at frequencies up to 500 Mc. In typical Class C operation as an r-f amplifier, it can deliver over 21 w of useful power to the load at 470 Mc with as little as 3 w drive power. Plate dissipation rating is 2 × 10 w under CCS conditions. Input capacitance is 4.5 pf, while output capacitance is 1.8 pf. Tube



has a directly heated Harp Cathode which operates on a heater voltage of 1.6 v and warms up to deliver 70 percent of full power output within 500 millisec. Amperex Electronic Corp., Hicksville, L.I., N.Y., 11802.

CIRCLE **305,** READER SERVICE CARD

Data Logging System Features Flexibility

MODEL 6511 includes solid state circuits; voltage, resistance and time measurements; 120 channel scanner capacity with provisions for true random scanning; plug-in crossbar scanner switch and 1 to 2 readings per sec average speed. The individual modules are standard catalog items, making a variety of basic system combinations possible. Model 6511 readily adapts to measurements of temperature, pressure, acceleration, shock, velocity and electrical quantities for either military or industrial use. Electro Instrument, Inc., 8611 Balboa Ave., San Diego 12, Calif. **(306)**

LITERATURE OF THE WEEK

COMPUTER SYSTEMS Radio Corp. of America, Camden 2, N.J., offers a brochure containing 11 technical papers on computer systems. **(360)**

DYNAMIC ANALYZER TUNER Spectral Dynamics Corp. of San Diego, P. O. Box 671, San Diego, Calif., 92112. Description and specifications of a new dynamic analyzer tuner are presented in a four-page bulletin. **(361)**

PRECISION POTENTIOMETERS Markite Corp., 155 Waverly Place, New York 10014. Six standard sizes of thinner, lower-cost Slimline infinite resolution conductive plastic precision pots are described in bulletin SL. **(362)**

INDUSTRIAL INSTRUMENTS Texas Instruments Inc., P. O. Box 66027, Houston, Texas 77006. Short form catalog covers a line of recording, testing, digitizing and sensing instruments. **(363)**

MAGNET MATERIAL Indiana General Corp., Valparaiso, Ind. Data bulletin 350A discusses a new improved Alnico V-7 magnet material. **(364)**

CONDUCTIVE EPOXY ADHESIVES Chomerics, Inc., 380 South St., Plainville, Mass. Booklet describes the nature of electrically conductive epoxy adhesives, cements and solders—and factors of primary importance in their selection and application. **(365)**

ADJUSTABLE POWER SUPPLIES Sola Electric Co., Elk Grove Village, Ill. Bulletin DC-105 describes Solavolt a-c and d-c adjustable power supplies. **(366)**

CONNECTORS The Pyle-National Co., 1334 N. Kostner Ave., Chicago 51, Ill. Bulletin 674 is a 12-page reference-guide to a line of environmental-resistant plugs and receptacles used primarily in electronic and aerospace industries. **(367)**

TOGGLE SWITCH Micro Switch, a division of Honeywell, Freeport, Ill. Data sheet 211 describes the 7ETI-T, a 3-position magnetic hold-in toggle switch. **(368)**

VIBRATION MEASURING INSTRUMENTS MB Electronics, P. O. Box 1825, New Haven, Conn. 06508. An 8-page booklet describes a full line of vibration measuring instruments. **(369)**

POWER SOURCES AND INSTRUMENTS Electronic Research Associates, Inc., 67 Factory Place, Cedar Grove, N. J. An 8-page catalog supplement describes a line of full range power sources and solid state instruments. **(370)**

METALLIZED PAPER CAPACITORS Aerovox Corp., New Bedford, Mass. Bulletin NPJ-128 gives data on microminiaturized dipped type P95ZN metallized paper capacitors. **(371)**

B-W OSCILLATOR Stewart Engineering Co., 467 Bean Creek Road, Santa Cruz, Calif. Technical bulletin describes the SE-303 miniature X-band backward-wave oscillator. **(372)**

H. F. Lello

D. H. Deaver

GT&E Elevates Two Executives

HERBERT F. LELLO has been named executive vice president-manufacturing of General Telephone & Electronics Corp., New York City, effective January 2. He is now president of GT&E's subsidiary, Automatic Electric Co., Northlake, Ill., where he has been active in telecommunications equipment manufacturing since 1923.

Darwin H. Deaver, executive vice president of Automatic Electric, succeeds Lello as president. He joined the firm in 1945 and was elected executive vice president last year.

Automatic Electric produces communications equipment for the independent telephone industry and also manufactures automatic control systems and devices. In addition to Automatic Electric, the domestic manufacturing subsidiaries of GT&E include Sylvania Electric Products Inc., and Lenkurt Electric Co., Inc.

Keonjian Accepts Grumman Post

EDWARD KEONJIAN has been appointed a full-time staff consultant by the Grumman Aircraft Engineering Corporation, Bethpage, N. Y. He will lead the efforts to apply microelectronics concepts to advanced systems, integrate Grumman-funded microelectronic advanced development programs and prescribe areas for incorporation of microelectronics into current weapon system programs.

Formerly, Keonjian was a staff scientist at Arma's Garden City, N. Y., Division. He continues in his posts as chairman of the EIA Advisory Committee on Microsystem Electronics and as a member of the Avionics Panel of the NATO Advisory Group for Aeronautical Research and Development

Antenna Systems Elects Williams

ANTENNA SYSTEMS, INC., Manchester, N.H., announces that A. G. Williams has been elected to the position of vice president by the board of directors. He will continue to act as manager of ASI's Electronic Systems division in Maitland, Fla.

PEOPLE IN BRIEF

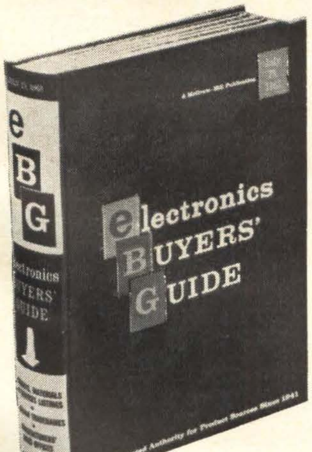
Basil Staros leaves Sperry Rand Corp. to join General Applied Science Laboratories, Inc., as director of systems technology. **Charles E. Kuivinen,** formerly with Hughes Aircraft Co., appointed product mgr., microwave tube products, at Electra Megadyne Inc. **J. N. Marshall** promoted to mgr., common components and standards engineering, RCA Electronic Data Processing. **George M. Underberger,** previously with Microwave Products, named project mgr. on the technical staff of E&M Laboratories. **William E. Bushor** joins Bryant Computer Products from LaRue and Cleveland, Inc., as director of information services. **Paul D. Rodgers** advances to associate director of the Tracking and Instrumentation lab of the Astrionics Center, ITT Federal Laboratories. **Lyman R. Fink,** former GE v-p, elected a v-p of Otis Elevator Co. in charge of engineering. **James Bailey** and **Leo Galin** move up to director of R&D and chief engineer, respectively, at Switchcraft, Inc. **Gilbert B. Sokolow** elevated to v-p, mfg., by Reon Resistor Corp. **Joseph Sternberg** raised to R&D mgr. for Martin Co.'s Baltimore div. **Bartow Bechtel,** formerly with Astro Technology Corp., appointed senior design engineer at Frequency Engineering Laboratories. **Byron Mable,** from Advanced Vacuum Products to Ceramics International Corp. as chief development engineer. **William Johnston** promoted to mgr., established reliability products, at Electra Mfg. Co. **Robert W. Graham,** ex-International Electric Corp., named mgr. of data communications for ACF Electronics.

HOW TO USE YOUR ELECTRONICS BUYERS' GUIDE

Advertising Product Sections

Advertisements in the ELECTRONICS BUYERS' GUIDE are grouped together according to the kind of product advertised. All Power Supply advertisements, for example, will be found in the same section of the book. Thus it is made convenient for you to "shop" through the specifications presented to you by advertisers, without having to flip pages back and forth constantly. Keep your ELECTRONICS BUYERS' GUIDE close to your work area at all times.

*



EMPLOYMENT OPPORTUNITIES

POSITION VACANT

Electronic Engineers, Mechanical Engineers, Consultants, Managers—Work for leading firm of licensed professional Engineers. Write to United Engineers, 150 Causeway Street, Boston 14, Mass.

SEARCHLIGHT SECTION

(Classified Advertising)

BUSINESS OPPORTUNITIES

EQUIPMENT - USED or RESALE

DISPLAYED RATE

The advertising rate is $27.25 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request. AN ADVERTISING INCH is measured ⅞ inch vertically on one column, 3 columns—30 inches—to a page. EQUIPMENT WANTED or FOR SALE ADVERTISEMENTS acceptable only in Displayed Style.

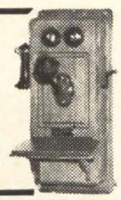
UNDISPLAYED RATE

$2.70 a line, minimum 3 lines. To figure advance payment count 5 average words as a line.

PROPOSALS, $2.70 a line an insertion.

BOX NUMBERS count as one line additional in undisplayed ads.

DISCOUNT OF 10% if full payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals).



Your Inquiries to Advertisers Will Have Special Value . . .

—for you—the advertiser—and the publisher, if you mention this publication. Advertisers value highly this evidence of the publication you read. Satisfied advertisers enable the publishers to secure more advertisers and — more advertisers mean more information on more products or better service — more value—to YOU.

N | C | R

ELECTRONIC ENGINEERS
CIRCUIT/SYSTEMS/LOGIC
INTEGRATED CIRCUITS

Character Recognition:

Participate in system design of integrated automatic document handling and character recognition system.

BS-MSEE

3-5 years experience in one of the following:

Circuit Design (High speed digital) (Wide bank analog circuits)
Information Processing System Design
Electromechanical Design

Working knowledge of optics, photoelectronics, principles of information theory and system design theory.

Salary open.

Processor and Display Devices:

For high speed analog signal processors and cathode ray display devices.

Timing circuits, oscillators and digital logic circuits as part of high speed analog and digital signal processing equipment.

To select digital modules for economical instrumentation of logic. Assist in design of wide band-width signal processing circuits.

BS-MSEE

3 or more years experience in circuitry design. Logical design and use of digital modules in complex mixed analog-digital system.

EDP Systems:

A senior level position currently exists at the R & D facilities of NCR in Dayton, Ohio.

The individual with whom we are interested in discussing the present opportunity will have a BSEE or MSEE and 3 to 5 years' experience in digital techniques with EDP hardware systems orientation.

You are invited to investigate the many advantages of being associated with a major computer manufacturer whose stability is enhanced by previously established compatible products.

Please address inquiries to: **Mr. T. F. Wade, Technical Placement. The National Cash Register Company, Main & K Streets, Dayton 9, Ohio**

An equal opportunity employer

INDEX TO ADVERTISERS

CLASSIFIED ADVEFTISING
F. J. Eberle, Business Mgr. (2557)

CLASSIFIED ADVERTISERS INDEX

■

• See advertisement in the July 25, 1963 issue of electronics Buyers' Guide for complete line of products or services.

This Index and our Reader Service Numbers are published as a service. Every precaution is taken to make them accurate, but **electronics** assumes no responsibilities for errors or omissions.

electronics

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Congress 2-1160 (area code 617)

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Harvey W. Wernecke,
Robert M. Denmead
645 North Michigan Avenue,
Mohawk 4-5800 (area code 312)

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George F. Werner (212) 971 3617
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500 Fifth Avenue

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SAN FRANCISCO, CALIF. 94111
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255 California Street,
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34 Dover St.

FRANKFURT/Main:
Matthee Herfurth
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GENEVA:
Michael R. Zeynel
2 Place du Port

TOKYO:
George Olcott,
1, Kotohiracho, Shiba, Minato-ku

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330 West 42nd Street
New York, N. Y. 10036

EDITORIAL INDEX

electronics®

January through December, 1963, Vol. 36

Additional copies available at 25¢ each

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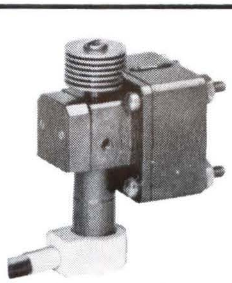
A few examples of the best U band oscillator capability in the industry

These families of Sperry tubes are representative of the most complete selection of U band klystron oscillators available anywhere.

Four tuning arrangements—fixed-tuned, gap-tuned, trim-tuned, and dielectric-tuned—enable the designer to select the U band klystron with the exact combination of operating characteristics required by his system.

Since Sperry's line of U band klystrons is already in the hardware stage, you get fast delivery and low prices. For complete information, contact your Cain & Co. Sales Engineer, or write Sperry, Gainesville, Florida. In Europe, contact Sperry Europe Continental, Paris.

For High Power Output

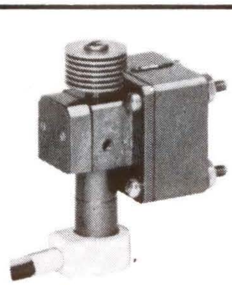

Fixed-tuned (Two-cavity) Klystrons (SOU-4040 Series)


Gap-tuned Reflex Klystrons (SRU-419 Series)


Trim-tuned Reflex Klystrons (SRU-4470 Series)


Dielectric-tuned Reflex Klystrons (SRU-4480 Series, in development)

For Extreme Mechanical Stability


Fixed-tuned (Two-cavity) Klystrons (SOU-4040 Series)


Trim-tuned Reflex Klystrons (SRU-4470 Series)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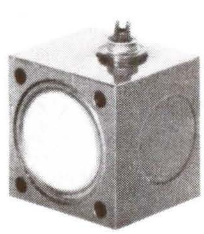
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For Low Voltage Operation


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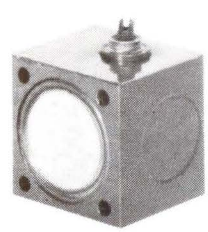
Trim-tuned Reflex Klystrons (SRU-4470 Series)


Dielectric-tuned Reflex Klystrons (SRU-4430 Series)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For Wide Tuning Range


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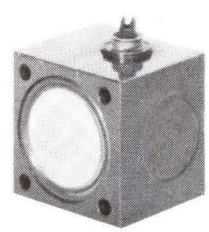
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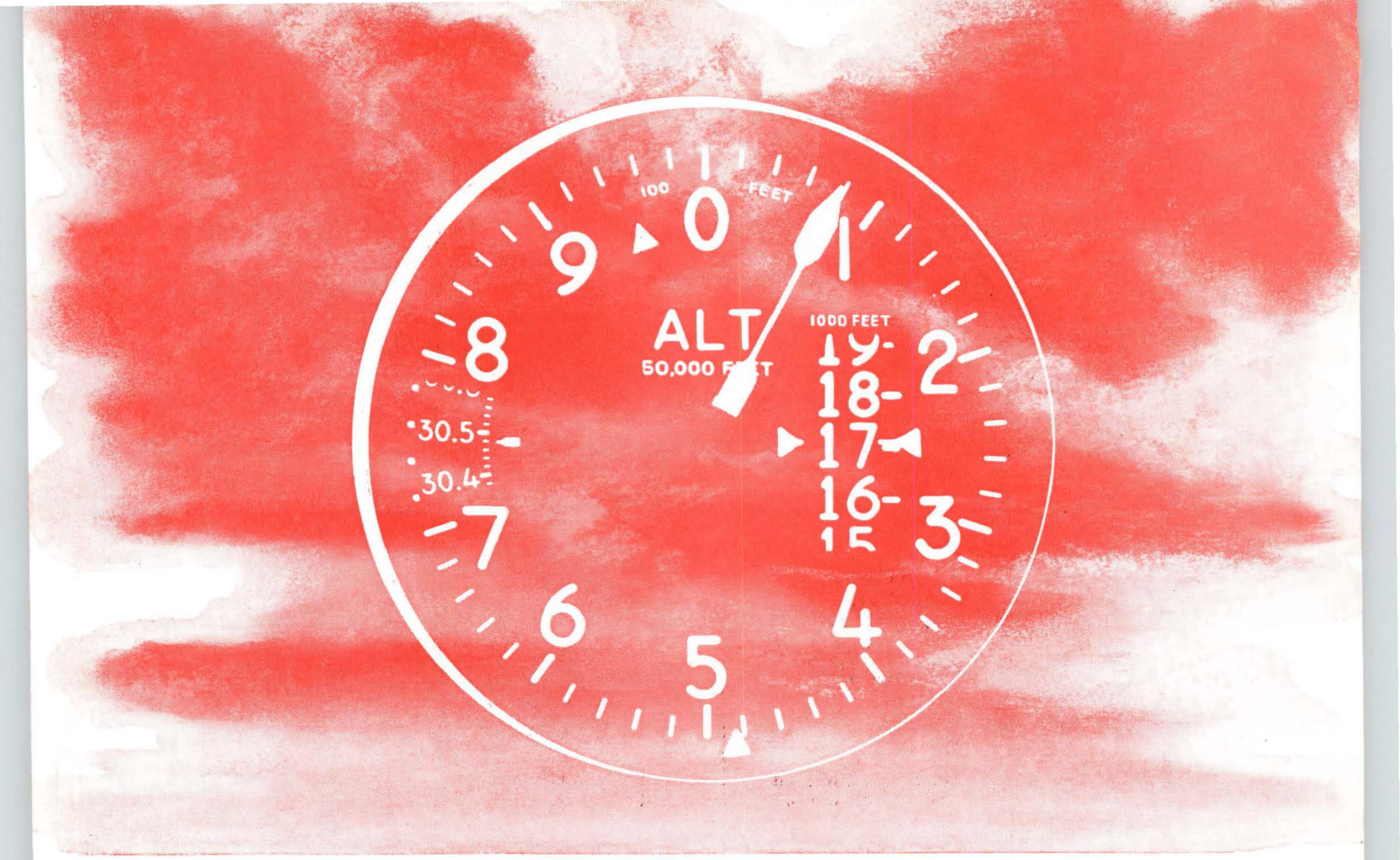

RCA-A15288 PENCIL TRIODE

MORE TUBE POWER FOR MINIATURIZED MICROWAVE DESIGNS

Increased power per unit weight—that's the challenge successfully met by the RCA-A15288. An excellent example of recent advances in Microwave tube design, this tiny pencil triode can provide I Kw of useful peak power output at 5 Gc as a plate-pulsed oscillator.

For use in telemetry, altimeters, and UHF transceivers, the ceramic-metal RCA-A15288 is designed to operate at altitudes up to 25,000 feet at 3.5 Kv without pressurization. Furthermore, the coaxial arrangement of electrodes around the RCA-A15288 heater practically eliminates tube characteristic changes caused by heater-voltage variations.

If your design involves miniaturized Microwave equipment for application in the 5 Gc region, consider the RCA-A15288. It offers exceptional reliability in vibration and shock environments. Heater power requirement is a low 1.6 watts; warm-up time is 4 seconds.

For information on how the RCA-A15288 can be used in your design circuits, see your RCA Industrial Field Representative, or write: Manager, Microwave Marketing, RCA Electronic Components and Devices, Harrison, New Jersey.

RCA-A15288

Plate-Pulsed Oscillator at 5 Gc	Typical Operation
Peak Positive Plate Supply Voltage	2,500 volts
DC Plate Current	0.0022 amp
DC Grid Current	0.0015 amp
Grid Resistor	2,000 ohms
Useful Power Output at Peak of Pulse	1,000 watts
Pulse Duration	1.0 μsec
Pulse Repetition Rate	1,000 pps
Plate Efficiency	20%

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