OCTOBER 15, 1957

ELECTRONIC DESIGN

OCTOBER 29, 1958

HIGHLIGHTS OF ISSUE

October 29, 1958 Vol. 6
Number
22

SUBSCRIPTION POLICY

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NBP BPA

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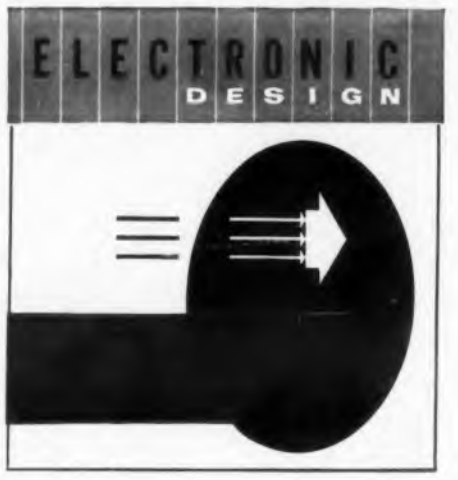

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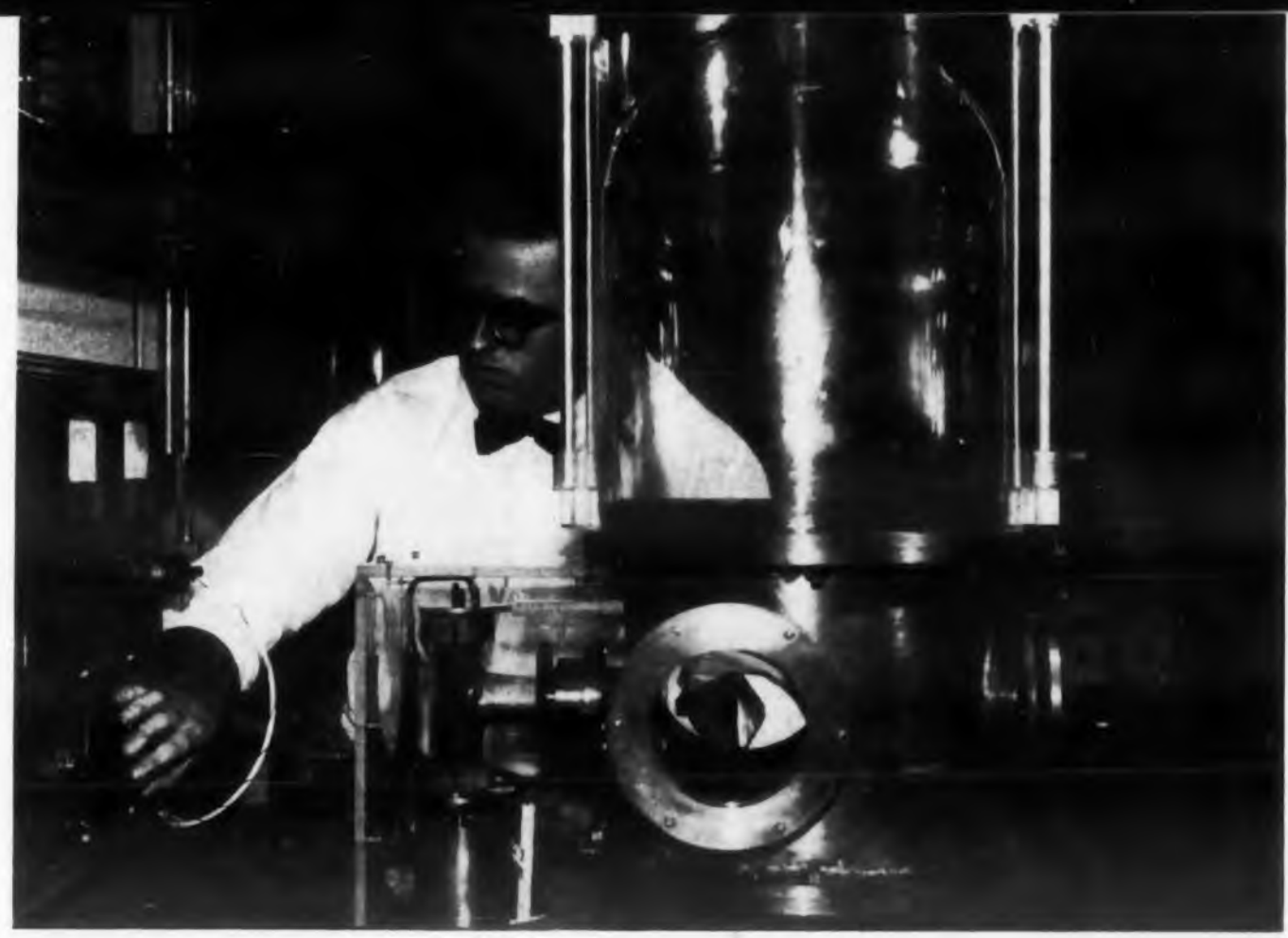
DESIGN

BEHIND THE NEWS



Pulsed plasma turns paddle-wheel visible through the porthole. Current is stored in two capacitors, then dumped through the spark gap inside the accelerator to create the plasma. Extending vertically across the arm of the "T" are the brass electrodes. The electric spark which breaks the air into ionized plasma is generated across the gap between them. Current is returned through the brass strap along the back of the tube, creating a magnetic field that propels the plasma.

How to Steer a Space Ship

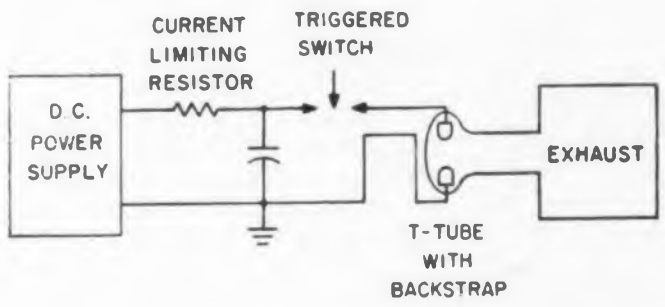
Magnetohydronamics (MHD) promises to yield the ultimate in space vehicle propulsion—at least until something better comes along. The technical problems MHD presents, however, are vast. But inroads are rapidly being made. GE recently developed a working model of a "pulsed plasma accelerator" which can change space vehicle direction in flight.

It was demonstrated at the Air Force Association meeting in Dallas last month. As the device is now set up, it requires a peak curent of 5000 amps at 2500 volts to ionize the air in the tube and create the required magnetic field. The laboratory device requires a 100 kw power supply to generate this kind of power—10 kw at 10 amp. To drive a space ship would require much greater power.

Needs Much Work Yet

The GE development is the forerunner of a system that would utilize a nuclear reactor as the prime power source. But GE's present design is very new and will require considerable refinement before it can be used.

MHD operation is, in essence, no different from that of a motor. Electric and magnetic fields assert a force upon an ionized fluid much like rotor reaction in a motor. Ultimate advantage of an MHD system is that it can propel a low density gas at such a high specific impulse as to exceed present exit velocities of chemical propulsion systems (approximately 4 km/sec) by 10 to 100 times.



Circuit of Pulsed Plasma Accelerator

GE's working model consists of a glass T-shaped tube with electrodes in two arms of the T, between which a spark is generated from a stored capacitor. The third arm is used for transit of the plasma. The plasma moves away from the electrodes partially by the action of a magnetic field set up by the discharge current. This is accomplished by a backstrap around the outer end of the electrode portion of the T-tube.

Energy from Capacitors

Capacitor energy is delivered to the accelerator tube through a three-element switch, which consists of a series spark gap and trigger electrode. The latter is energized by a high voltage pulse from a pulse forming circuit. The switch and pulse forming network are modifications of the design of the Lovotron circuit of Dr. W. Chace of the Air Force Cambridge Research Center.

Essentially the accelerator relies on the rapid

Creative Microwave Technology

Vol. 1 No. 1

Published by MICROWAVE and POWER TUBE DIVISION
RAYTHEON MANUFACTURING COMPANY, WALTHAM 54, MASSACHUSETTS

NEW DEVELOPMENTS IN ELECTRONIC TUBES AND CERAMICS

Where abnormal conditions of vibration (25 to 2000 cps at 10G) are encountered, such as in advanced airborne applications, this pulsed-type X-band (9245 ± 40 Mc) air-cooled RK6967A/QK366A magnetron oscillator maintains exceptional frequency stability and operational reliability. Optimum performance is assured by a double-end supported cathode and aluminum-clad integral magnets. Nominal peak

power output is 100 kw at typical pulse conditions of 0.5 μ sec. (.001 duty cycle). The tube operates at a peak anode voltage and current of 15 kv and 13.5 amp. respectively.

CIRCLE 519
Reader Service Card

* * *

Integrally insulated semiconductors can now be produced by using high-alumina ceramic stem assemblies. Heat dissipating ceramic wafer (arrow) in the base insulates up to 2000 volts dc and withstands soldering temperatures as high as

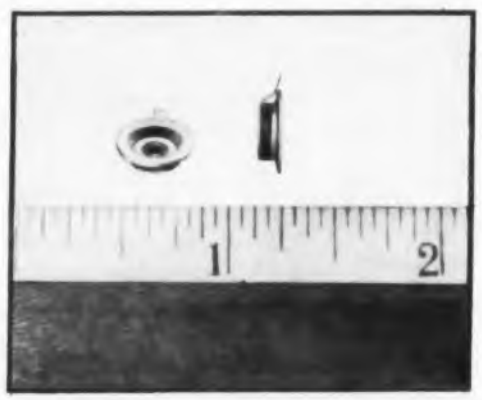
1100C. Bases can be directly mounted to chasses or cold plates. Stems are available to all semi-conductor manufacturers.

CIRCLE 520
Reader Service Card

* * *

Miniature gyro feed-throughs provide take-off points from gas-filled gimbal housings. These high-alumina, vacuum-tight, R-95 ceramic assemblies can be soldered to housings at temperatures up to 1000C. They also assure positive electrical insulation with leakage less than one micro-ampere per 500 volts dc.

CIRCLE 521
Reader Service Card

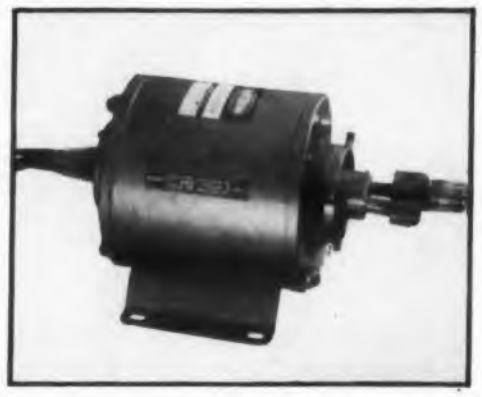


A Leader in Creative Microwave Technology

RAYTHEON

Designed for voltage tunable CW or pulsed operation over the Government X-band (8500 to 9600 Mc), the QK-684 integral magnet backward wave oscillator delivers 10 to 50 mW over delay-line voltages ranging from 215 to 325 vdc. Regulation of a special control grid facilitates pulsed or amplitude modulation to meet power and frequency requirements. Models available for coupling to standard, type "N" connectors.

CIRCLE 522
Reader Service Card



* * *

Compiled as a Raytheon service to the field, new Consolidated Data Booklet contains comprehensive information about principal unclassified magnetrons, klystrons, backward wave oscillators and special purpose tubes manufactured by Raytheon. Characteristics presented include maximum ratings, typical operating values, band or frequency ranges and other essential data for microwave engineers and purchasing departments.

CIRCLE 523
Reader Service Card

BEHIND THE NEWS

charging of a capacitor bank, the much more rapid discharge through the switch and T-tube when energized by the trigger pulse, and the subsequent push obtained on the plasma formed by the heating of the gas and the magnetic field produced. Gas is exhausted into a large bell jar. A pinwheel mechanism indicates thrust obtained from the plasma. A ballistic pendulum arrangement has been fashioned, which can be calibrated directly in ounces of thrust. The model produces a thrust of 0.303 oz.

As the accelerator is presently assembled, the thrust is directly proportional to the amount of current of each discharge. This current determines first the amount of ionization obtained, and secondly the magnitude of magnetic field at the discharge to be used for repulsion of the plasma. A high current is dependent on electrical circuit parameters and original capacitor charge for each burst.

Efficiency of this initial model is necessarily small because of losses in the switch and accelerating mechanism. Work is underway for increase of plasma production efficiency and magnetic energy coupling to the plasma.

Fuel is Problem

Introduction of fuel to the accelerator is also a problem for designers as is the problem of plasma production and exhaust when ambient pressure conditions are those of upper atmosphere and outer space. Present plasma production is readily obtained at ambient pressures of roughly 0.001 atmosphere, as in the present model.

Adaptation of this principle to outer space control equipment presents a challenge to the spaceminded engineer. At present accelerator work is proceeding at GE's Missile and Space Vehicle Dept. under the $158 million contract for Atlas and Thor nose cone development. Other accelerator guns are being designed, and larger power equipment for more realistic operating conditions will be used in the near future.

13 New Members Admitted to EIA

Thirteen additional manufacturing firms have been accepted for membership in the Electronic Industries Association: Aeronutronic Systems, Systems, Inc., Amco Engineering Co., Columbus Electronics Corp., The Martin Co., Master Mobile Mounts, Inc., Resistron Laboratories, Inc., The Siegler Corp., SNC Manufacturing Co., Inc., Syncro Corp., U. S. Semiconductor Products, Inc., United Transformer Corp., Wyco Metal Products.

$BaTiO_3$ May Shed Light On Why It "Forgets"

Barium titanate is undergoing self-analysis at the National Bureau of Standards to determine why this ferroelectric material tends to "forget" when used as computer memory elements. The fact that different types of electrodes have a direct influence upon this characteristic—a dependence which implies a surface effect—has generated the study of surface layers.

Recently, NBS scientists observed electroluminescence from the surface layer of barium titanate. This effect is now providing information on the unusual surface layer which may contribute to the development of better ferrodevices.

To produce light emission from the surface of $BaTiO_3$, the most satisfactory arrangement is a concentric configuration of the electrodes. This concentrates the rf field around the small center electrode and produces maximum light output. Light emission, however, is extremely low in both intensity and efficiency. Although various metals serve successfully as electrodes, best results are obtained from either indium-gallium rubbed directly on the crystal surface or evaporated silver, soldered with indium.

The studies conducted with this arrangement show that at the Curie point—the temperature above which ferroelectric materials lose their spontaneous polarization—of $BaTiO_3$ the light emission intensity jumps to about 1000 times its value at lower temperatures.

Electroluminescence may tell scientists why barium titanate "forgets" in computer memory work.

BEHIND THE NEWS

SAC Orders Global

The global command system for the Strategic Air Command—involving display, computing, and communication switching equipment—is to be drastically improved under a contract awarded recently to International Telephone and Telegraph Co.

Ultimately, the multimillion dollar system (System 465L) will allow the Omaha-based SAC staff to plan, direct, and control global peacetime and wartime operations of the command faster and more directly. There is also a high probability that the system may cost as much as $150 million before it is eventually linked to System 456L—a modernization program for the present SAC communications system.

ITT's role in the global command system will be that of systems manager. Initially, this means first deciding how best the system should be designed and then finding the equipment to go into it. Here, the electronics industry will be canvassed to determine what equipment is immediately available for the proposed system.

Recognizing that the success of the whole program depends on the development of the concept and the availability of equipment to bring it to life, the Air Force has released only $3 million of a budgeted $32.6 million to ITT. Once the concept and the availability of equipment have been set and determined, the remainder of the program allotment will be released.

Can It Be Done?

One interpretation of this partial allocation may be the desire of the Air Force to find out if a reasonable system can be developed within the guidelines—technical and financial—set down by SAC. ITT—and many Air Force officers—express great confidence in the idea.

One of the program managers will be ITT's G. M. Mooney. He expects to spend the next few months canvassing the industry for equipment. He told ELECTRONIC DESIGN emphatically that time and money will not allow the development of new equipment, new techniques, or breakthroughs.

Biggest equipment problem, according to the ITT official, is display. A tremendous amount of information is expected to flow into the global command system. Unfortunately, there is no abundance of equipment currently available

Command Network

that is designed to handle this magnitude of traffic. Moreover, whatever equipment is finally selected will have to be of reasonable size in spite of the desired capacity.

ITT plans on using computers not now in the company inventory. Mooney estimates the computers must have a capacity 10 times that of the IBM 704—but not great as LARK and STRETCH.

As for communications switching, ITT officials feel that available circuitry will do the job. The problem will be to convert existing techniques to new applications.

Start with Wire Links

As a first step in the process, ITT plans to design the system for landline linkage. As this phase progresses, other engineers will begin studying how the system on this continent can be most efficiently linked to the whole global SAC network. It is expected that the Air Force's experience in tropo and ionosphere communications will receive high priority consideration.

Just Plane Riveters

Four new numerically-controlled are riveters building wing panels for the B-52 Stratofortress at Boeing's Wichita plant. All four machines are controlled by signals on punched tapes. Each machine automatically drills and countersinks the hole, inserts a rivet slug, upsets both ends, shaves off the outer head, and then moves on to the next rivet. Eight to ten rivets per min are driven, fastening stiffeners to lower wing panels. The new riveters are about 12 feet high and 10 feet wide and roll back and forth over the work on floor rails. Wing panels as big as 75 feet in length and four feet in width can be riveted.

Printed Circuits Made

Cathode metal sputtering may be useful in producing precision circuits. Research at Bell Telephone Laboratories indicates that entire circuits, including resistors, capacitors, and leads, may be laid down by this technique.

In cathode sputtering, an effect noted a century ago, a plate of the metal to be deposited is used as a cathode. The substrate on which the film is to be deposited is placed on a table close to the cathode. After evacuation, argon or other suitable gas is introduced and maintained at a pressure of approximately 20 to 40 microns.

When a voltage is applied, ionized atoms of the gas bombard the cathode, dislodging metal atoms or clusters of atoms, which then deposit on the substrate.

Bell has produced thin films of a number of high melting point metals. Tantalum and titanium, for example, melting at 3000 C and 1670 C respectively, can be laid down in films which show sufficiently high resistivity to be useful as resistors in printed circuits. With proper masking of the substrate, lines and patterns of practically any desired shape and size can be formed, ranging in widths down to a few mils. These sputtered films generally are between a few hundred and a few thousand angstroms thick.

Some alloys such as those of nickel-copper and nickel-chromium can also be sputtered without difficulty. They appear to retain their approximate original composition.

Printed capacitors have been produced by a combination of sputtering and chemical methods. A tantalum film of the proper shape and

NEWS BRIEFS . . .

. . . **ROCKET TO THE SUN** with an assist from the moon suggested by GE satellie engineer. R. P. Haviland says that this "stepping-stone" trip would be made possible by the "crack-the-whip" effect of centrifugal force generated by the moon in its orbit around earth. Under the present state-of-the-art, according to Haviland, 50-lb probes could be sent as far as the plant Mercury using five-stage vehicles with 250,000-lb take-off weights.

By Metal Sputtering

Experimental sputtering apparatus which laid down resistor film under inspection.

size is first sputtered onto the substrate and then anodically oxidized to form a tantalum oxide dielectric film. The counter electrode, a film of gold, can then be evaporated onto a dielectric to form the completed capacitor "sandwich."

Copper leads can be sputtered without difficulty to connect the various components. The technique is attractive since it eliminates the need of any organic adhesives.

In "reactive sputtering," films of inorganic compounds are formed by introducing a small controlled amount of a reactive gas such as oxygen, nitrogen or hydrogen sulfide into the apparatus. Compounds which can be formed in this way include the oxides, nitrides, and sulfides of a number of metals.

. . . **TWENTY MILLION DOLLARS** awarded to Northrop Aircraft by Air Force for construction of Snark, intercontinental guided missile. Total contract may total $70,000,000. Nortronics, division of Northrop, also announced development of miniature electronic refrigerator capable of inducing 50 degree temperature drop in thermally sensitive electronic components. Device uses Peltier effect. Navy is presently evaluating it. Unit measures 1/4 in. square x 1 1/4 in. long.

WASHINGTON REPORT

Herbert H. Rosen

Canada to Integrate Bomarc-SAGE System

Boeing Aircraft's Bomarc missile and Western Electric's SAGE are scheduled to assume a major role in Canadian defense as the Royal Canadian Air Force gradually phases out fighter interceptors. While this move brings more business to Boeing and the SAGE manufacturing team, it means RCA, Minneapolis-Honeywell, Canadian Westinghouse and others involved in the CF 105 ARROW fighter program must look elsewhere for business.

Canadian Prime Minister John D. Diefenbaker's announcement of the change in September caught many in Washington unawares. In his statement he cast doubt on the need for supersonic interceptor aircraft beyond the 1960's. Instead, Canada will introduce missiles into the air defense system.

Diefenbaker disclosed that "negotiations are underway with the United States to work out arrangements for obtaining BOMARC guided missiles and the necessary equipment for maintenance, testing, and launching them. Discussion will also be held on the best way for Canadian industry to work in the production programs related to such missiles and associated equipment."

(Canada has for several years been trying to build up its aircraft and electronics industries. However, the strong core of these industries is made up of subsidiaries of U. S. firms.)

Want Radar Improved

Diefenbaker continued, "The government has also approved the extension and strengthening of the PINE TREE radar control system which was constructed and is being operated jointly by the United States and Canada. Several additional large radar stations will be constructed . . .

"In order that the PINE TREE radar system will be able to deal more effectively with the increased speed and number of aircraft to be controlled by the introduction of the BOMARC guided missiles, the Canadian government has decided to install SAGE electronic control and computer equipment in the Canadian Air Defense system. This will be integrated as part of

the North American Sage System under NORAD."

By this act, the speed at which SAGE systems can be installed is increased. Moreover, an IBM official told ELECTRONIC DESIGN that the Canadian Sage system will incorporate the very latest techniques. The two installations in the U. S., however, represent 1952 technology. Later sites, fortunately, will be updated.

Very likely the last Canadian fighter aircraft will be the CF 105 ARROW. It is an extremely long-range craft incorporating very special electronic equipment. The system, ASTRA, was developed and was to be manufactured by RCA. Douglas and Canadair were to supply Sparrow missiles for the fighter. All of these contracts have been cancelled—including those of the major subcontractors. In fact, only the engine and airframe development contracts for the CF 105 remain.

To Use Hughes System

In an effort to save money, negotiations are now underway with Hughes for its "stock" MB-1 control system. This electronic flight system is now part of the U. S. F-106. The Douglas Genie free flight rocket will replace the Sparrow missile.

The Genie costs about $7000. When fitted with a nuclear war head, the price jumps up to $250,000 per rocket.

Unfortunately, the range characteristics of the Hughes system coupled with Genie will force the RCAF to modify the long-range mission originally set for the CF 105 interceptor.

Canada appears to be risking little by adopting Bomarc-SAGE. Besides the insurance of our own Tactical Air Forces, recent tests have shown the 200 mile plus Bomarc to be a very effective weapon.

The latest Bomarc success featured guidance from the SAGE center in Kingston, N. Y. with launching from Cape Canaveral, Fla.

More Missile Successes

Meanwhile, other missiles are making the news. Firings of Polaris components are occurring more frequently, although a flight of the complete missile is some time off. Recently, the Interstate Electronics Corp. received nearly $3 million in contracts for construction of "data gathering electronic instrumentation" for installation aboard the Polaris submarine.

Western Electric also was given a hefty $135 million contract to continue work on the Nike Zeus system. About $21 million is earmarked for the R & D, while the remainder is primarily for procurement of experimental supporting equipment and missiles.

LETTERS

Cut Life With Care

Dear Sir:

Mr. G. R. Carl and R. A. O'Connor's article on Airborne Electronic Transformers was enlightening. However, derating life expectancy in order to achieve small size has not, in our opinion, proven too rewarding.

If maximum temperature rise, regulation, and all other factors are specified, one thing we gain by cutting life expectancy is the utilization of lower temperature insulating materials. This can provide two savings. One, lower temperature materials are cheaper in cost, and second, some lower temperature materials are less bulky than the higher temperature ones. However, cost saving is negligible as long as we do not hit the Teflon category. The proper use of the polyester series of insulations produces a transformer which will last for 10,000 hours at 190°C, 2500 hours at 205°C, and 500 hours at 225°C. The savings in cost between these polyester materials and the paper and enamel series of compounds (105°C maximum temperature) is usually not worth the life expectancy derating. The saving in space due to the bulky materials is of course completely absent as the polyester family is extremely efficient size-wise.

The only other saving comes from allowable corona limits. Because of the paucity of accurate life vs. corona data on polyester materials, it is suggested that either the absence of corona or life under 500 hours be designated. We do not believe that a little bit of corona can be tolerated for long life expectancy. It, of course, should be realized that only a small percentage of transformers work at a high enough voltage to gain anything by purposeful inclusion of corona in order to cut down insulation.

To summarize, cutting life expectancy only pays if (a) the maximum life expectancy is 500 hours or less, (b) maximum hot spot temperature is over 200°C, (c) voltage stresses are over 2000 volts, (d) the unit is an appreciable size, 1 cubic inch or larger and probably using the higher power frequencies (400 cycles and higher so as to allow the inclusion of higher core losses).

Howard Buschman, Pres.
Bush Transformer Corp.
Endicott, N.Y.

More on Short-Cut Drafting

Dear Sir:

This letter is in reply to a letter recently published in your magazine on the subject: "The False Economy of Short-Cut Drafting." I would like to take the opportunity at this time to add further discussion concerning my impression of the "false" in "The False Economy of Short-Cut Drafting."

Much has been written and said, pro and con, regarding short-cut drafting. Any one person's definition of it would be prompted by what he has been exposed to in the way of drafting systems. A definition which would suit all is this: "A means of communication wherein the information to be communicated should be as brief and clear as possible, but complete (only to the degree that completeness of assembled information is necessary to promote efficiency in all subsequent phases of use) and decipherable to anyone familiar with reading drawings."

There is hardly a company existing which does not design and make drawings for equipment which it will have outside vendors manufacture. Therefore, if a company adopts heterodox short-cut methods which cannot be easily deciphered and decoded by the average craftsman who must translate from drawing to physical reality, then much is lost in man hours. Time is lost first in the deciphering and decoding of the hieroglyphics on the drawing, and secondly in remaking pieces which are wrong because of ambiguity so often present in the simplified approach. . . .

How efficient short cut methods can transmit information depends upon how successfully standardization of simplified approaches can be imposed upon industry as a whole, and upon the judicious use of these methods to preclude ambiguity, but include clarity and brevity.

William R. Golz
RS Electronics Corp.
Palo Alto, Calif.

Open Letter

To the Editor and Your Readers

You have attended many Conferences. You have listened to speeches at luncheons and dinners. You have been entertained by people who had something to sell you. You have listened or dozed while papers were read by men, inexperienced in public speaking.

You have been bored stiff. You have wondered what it was all about.

You have wondered if you could honestly justify the money your Company spent in sending you to the Conference.

LETTERS

When you got back home, you had to write a report to justify the time and money you spent. You had to scratch your head and maybe make believe, that you really brought something back of value to your Company.

The third E.I.A. Conference on Reliable Electrical Connections, Dec. 2, 3, and 4, 1958, Dallas, Texas is going to be conducted on a different basis.

The usual authors of papers will be there, but you will not have to listen to them read their papers. They will be published and offered for sale October 15.

You can read the papers before the conference takes place. You can prepare questions, which you can ask of the authors.

You may also ask questions of other men who are specialists in the field in which you are interested. You will be able to pursue a subject to its bitter end in order to get the facts.

You will not be distracted by exhibits. You will not be solicited by men who want to sell you something. You will not be entertained except as you entertain yourself. There will be no planned lunches or dinners.

You can devote your entire time to getting answers to your questions and to personally meet the men you want to meet.

You can contribute to their knowledge and they can contribute to yours.

Every known type of electrical connection, both internal and external, will be discussed. All the materials and all the processes which go to make up an electrical connection and protect it, will be discussed.

There will be no holds barred. You will have an opportunity to acquire the knowledge you honestly seek, provided you are willing to contribute something.

In this case, you can contribute by coming and by asking questions.

Will be looking forward to seeing you in Dallas.

R. George Roesch
General Chairman
1068 S. Clinton St.
Syracuse 4, N.Y.

▶ We can't, as a rule, publish in toto publicity chairman's reasons for attending such and such a conference. But because we are extremely interested in Mr. Roesch's unusual efforts to improve communications between speaker and listeners and all conference attendees in general, we're printing this letter in full. Write Mr. Roesch to get advance conference papers.

EDITORIAL

We've A Long Way To Go

If there's one thing that stood out in ELECTRONIC DESIGN's recent survey among users of industrial control equipment, it is this:

Three types of actuators led all the rest in popularity—solenoid valves, servomotors, and humans. Humans!

Mind you, this is in the day and age when many of us believe that the completely automatic factory is just around the corner; when our technology has advanced to the point where we can toss balls around the world; when we even consider pitching a few around the moon.

Yet we still need a man to close a valve, open a switch, or shove a lever. Why? For one thing, we simply don't understand enough about some of our processes. Our chemists know what will happen if they mix some ingredients together and let them settle. They know sodium hydroxide and hydrochloric acid will yield salt and water. But they're not quite sure what happens while they're mixing.

Beyond that, the art of control still has a long way to go. There are still lots of things we don't know how to do economically—or how to do at all. For example, we'd like to

- measure moisture in granular materials—in sugar, flour, wheat;
- measure moisture in cloth;
- measure pH under high pressure, high temperature conditions;
- measure liquid level in a closed tank in a radiation environment.

Yes, we can make these measurements in the laboratory. But that's a far cry from measurements on the line—in flow processes.

More processes than not have a man someplace in the control loop. Often, it's because we know of no other way of doing things. Often, it's because we need a man's judgment. Often, it's because it's cheaper to use a man than it is to use a machine. And very often, it's because control equipment may not have the reliability we need.

If you ask control equipment users what they need in their equipment above all else, they'll cry out with one voice—"longer, trouble-free life."

So there's much to be done. We need much more understanding of our basic processes. We need many more sophisticated instruments of control. And we need hardware we can trust a lot more. We've a long way to go.

George D. Rostky

Dr. Robert J. Jeffries, president of ISA speaking at Keynote Session.

MEETING REPORT

Reliability Accented At Instrument-Automation Conference

"WHEN an electronic component fails it is the fault of the design engineer nine times out of ten." This observation was made by Kenneth Halrorsen speaking at one of the Data Handling Workshops of the 13th annual Instrument-Automation Conference and Exhibit. The Conference was held in Philadelphia from September 14th through the 19th. It was sponsored by the Instrument Society of America.

Are Electronics Reliable?

Discussing the topic "Are Electronics Reliable in Control?" Mr. Halrorsen emphasized that reliability is a nebulous term. "Any control system," he said, "that failed every day but didn't blow up the process or plant it monitored could be considered relatively reliable. However, the control system that failed every three years and destroyed every thing it monitored at that time would have to be considered less reliable."

Summarizing, Laurence M. Silva, chairman of the Data Handling Workshop session on electronic reliability, confirmed the findings of ELECTRONIC DESIGN's staff report on Industrial Electronics in this issue. He said:

In considering reliability, the time it takes to fix a failure must be evaluated along with the interval between failures.

Equipment should be designed for quick location of trouble, and test points should be liberally located in the equipment.

Mechanical failures are just as much a source of trouble as electronic failures in the breakdown of complicated control systems.

Tubes should not be checked regularly. Pulling tubes can lead to socket failure.

Basic, proven circuits should be used. A multiplicity of circuits only confuses troubleshooters.

How Good Transducers?

At another workshop session it was generally agreed that transducers have come a long way in the past year in meeting the need for accuracy. Manufacturers, though, are still pressed to produce transducers to meet a wide variety of seemingly impossible conditions. In the past, units that operated within a two or three hundred degree range were considered satisfactory. But now there is need for transducers that will function properly from —300 to +600 C. And they have to stand rough and rugged handling too.

What would help the manufacturer a lot, stated one speaker, would be the user examining his requirements carefully, and determining over just what range his transducer must be accurate. Transducers that are accurate over a wide range are costly and often unnecessary.

Whither Computers?

Computers are playing an ever increasing role in controlling industrial processes. Not everyone is fully sold on computers, though. Most expenditures for computer control equipment fall in the $25,000 bracket. Only a few companies want to take a $250,000 plunge into a computer that will fully control a process.

One reason that everyone is interested in computers today is that computers are relatively new and still a novelty. This partially explains the widespread purchase of small units which are, in effect, data loggers rather than control computers.

There is one basic reason why more companies aren't buying the big, "closed-loop" control systems. It is often very difficult to economically justify controlling an industrial process by computers. Thomas Vickroy, an Instrument Consultant Group Supervisor at Du Pont admitted that computers are getting better every year. But the marginal increase in productivity, he said,

that computers can provide in some processes doesn't warrant their purchase. He illustrated his case by citing a chemical process that might be operating more efficiently if under the control of a computer. But, he explained, if someone came up with a better catalyst for the chemical process, the process might become efficient enough to operate without the aid of a computer.

It was generally agreed though, that if what has to be done in a given process can be rigidly defined, if an equation can be written for it, then a computer can outperform human operators and provide more safety and efficiency.

In the future, the big problem will lie in designing plants for control by computers. Present designs and plans are similar to those of the past. Plants are laid out for control by human beings. New philosophies and new techniques will have to be developed so plants can more easily be controlled by computers. Of course, the first question to be answered is whether computer control is desired or even necessary for a given process.

Instrumentation—Big Business

"Instruments are big business," said Thomas R. Jones, president of Daystrom, Inc. "A recent report," he continued, "states that the instrument industry is growing at a rate about five times greater than that of the entire economy." Since the sundial—probably man's first instrument, instruments have developed until they are now the five senses of our industrial giant.

About half a billion dollars worth of equipment was on display at over five hundred exhibits. Units ranged from a butterfly valve that was over a yard in diameter and could handle 42,000 gallons a minute to a transistor.

The Future

Kicking off the convention at the keynote session, Dr. Robert J. Jeffries, president of the Instrument Society of America took a look into the future and said that instrumentation would play a vital role in:

- Increasing economic prosperity through increased productivity.
- Developing new products and processes.
- Improving world health through reducing the cost of medical drugs.
- Providing more national security.
- Bettering industrial management through improved data gathering and analysis.

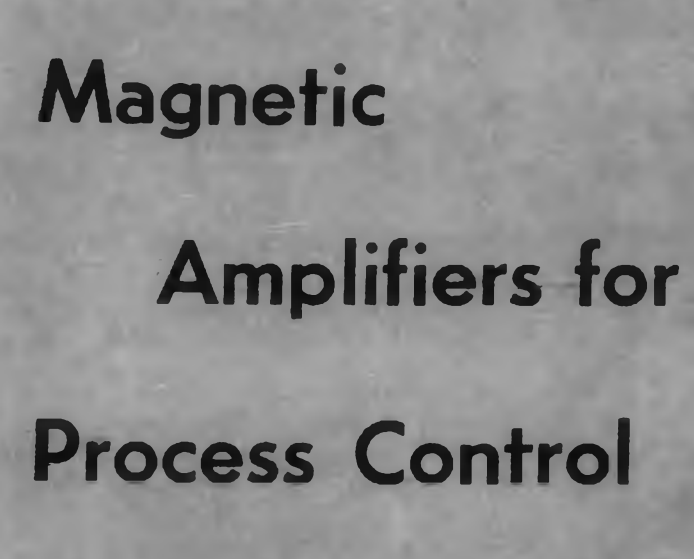
Dr. Gaylord P. Harnwell, president of the University of Pennsylvania and another keynote speaker, urged the instrumentation engineer to aim for simplicity in the design of new equipment.

Magnetic Amplifiers for Process Control

Horace E. Darling
Foxboro Company
Foxboro, Mass.

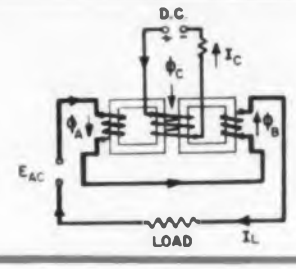
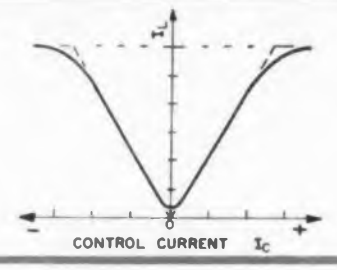
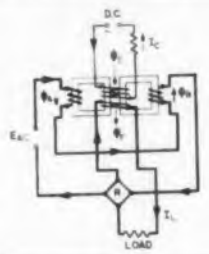
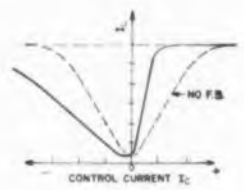
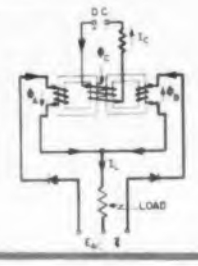
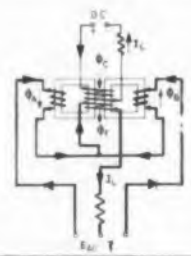
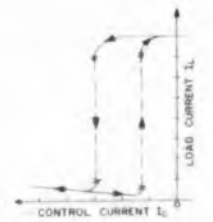
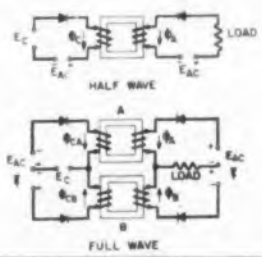
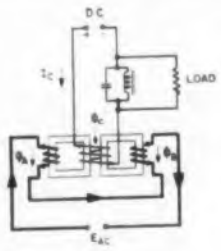
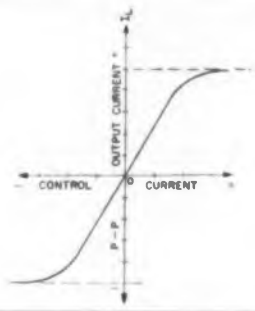
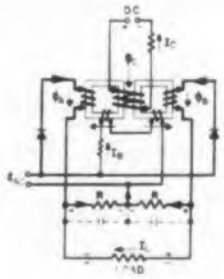
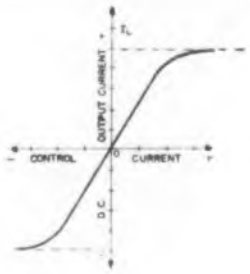
Here is a guide to the most useful magnetic amplifiers for industrial electronic applications. Some of the circuits tabulated here, were revealed only recently for the first time.

On the following page there is a discussion of these amplifiers, and a presentation of the four basic cores in general use—their advantages, their disadvantages, and their problems.



Horace Darling has spent 14 years in research and development, mostly on solid state devices for industrial control. The last 5 years have seen an accent on magnetic amplifiers. During this time, he developed a variety of new types, particularly for operation from extremely small power input.

Magnetic Amplifiers

Amplifier Type	Schematic	Transfer Curve	Reliability
Saturable Reactor			Least complex of all magnetic amplifiers. Potentially most reliable.
SR with Feedback			Reliability of rectifiers in bridge must be considered.
Self-Saturating Reactor			Only slightly more complex than SR. Potentially very reliable. Reliability related to rectifiers used.
Bistable SSR			Basically simple. A very reliable relay: no moving contacts; hence, indefinite life. With proper design, bias system normally used to adjust latching point does not detract appreciably from reliability.
Fast Response SSR			Reliability and life (determined largely by rectifiers in control circuit), comparable to any SSR.
Second Harmonic Magnettor			Circuitry simple. Reliability very high.
Balanced SSR			No rectifiers in bias circuit. Reliability comparable to any SR but probably not as great as magnettor.

for Industrial Electronics

Power Output	Stage Gain	Response Time	Sensitivity	Notes
Milliwatts to kilowatts.	Power gain to 40 db. Current gain 10 to 30.	4 cycles or more. Varies with current gain and supply frequency. Cannot reproduce a step input.	Not suitable below 10^{-6} watts.	Output is distorted alternating current. Four-unit bridge rectifier required for dc output, decreasing reliability. Output level varies directly with supply voltage. Does not recognize control signal polarity. Rarely used except where high current and power levels make rectifiers impractical, impossible, or undesirable.
Milliwatts to kilowatts.	With positive feedback, more current and power gain than SR. Less with negative feedback. Power gain to 50 db. Current gain 100-200.	Response time greater than SR. Increases directly with current gain. Decreases with negative feedback.	To 10^{-7} or 10^{-8} watts, but only with positive feedback, and at cost of long time constant.	Rectifier bridge required for feedback. Output can be ac or dc. Becomes more polarity sensitive as feedback is increased. Otherwise similar to SR.
Limited only by current rating of available rectifiers—to kilowatts.	Power gain to 60 db at low power output; to 40 db at high power output. Current gain to 5000 at low power output; to 100 at high power output.	4 cycles or more. Increases with current gain.	To 10^{-8} amps and 10^{-12} watts. Low levels demand matched cores and rectifiers.	One of the most popular types. Good recognition of control current polarity. Easy to control reaction on control circuit or driving stage. If bias supply is derived from power mains, at least two additional rectifiers required.
To kilowatts.	Power gain to 40 db. Current gain 10-100. Depends on latching interval.	10 cycles or more.	High current sensitivity possible. Input power to 10^{-6} watts.	Limited to bistable use. Pulsating dc output often requires filter. Operation possible from many control signals.
Fractions of a watt to kilowatts.	Power gain to 50 db. Voltage gain equals ratio of control to gate turns.	1 cycle.	Not suited for low voltage or low current control circuits because of interaction. Input power to 10^{-6} watts under favorable conditions.	Input can be dc or ac for either dc or ac output. Control can be ac or dc voltage, resistance, or reactance. Low impedance source required for ac or dc control. Control current is from power source, not control source, so interaction always is present. Matched cores recommended.
Microwatts.	Voltage gain (frequency sensitive) 100 or more (with tuned circuit and high impedance load.) Power gain 20-30 db.	Usually much greater than 10 cycles.	To 10^{-9} amps, 10^{-14} watts or noise level of cores. Core design and matching critical for low level work.	Acts as static chopper and one stage amplifier. Adaptable to any audio supply frequency. With feedback, input impedance can be megohms. Most effective as voltage converter working into high impedance load. Works well with tubes or transistors. Difficult to drive other magnetic amplifiers. Output has double the supply frequency. Ideal for thermocouples or low impedance emf devices. Very low level work requires magnetic shielding against earth's field or stray fields. Altered physically, it can serve as flux detector or magnetometer.
Microwatts to milliwatts.	Current gain to 2000. Power gain to 50 db.	4 cycles or more. Increases with current gain.	To 10^{-9} amps or less, 10^{-12} watts or noise level of cores. Core design and components critical for low levels.	Controlled by dc signal, or ac signal at supply or twice supply frequency. Rectifier pairs must be matched for forward conduction and temperature changes. (Only silicon junction rectifiers). Matched pairing required for load resistors and filter capacitors. Choke isolating impedance required for high current and power gain. Its time constant usually major factor in stage time constant. Low level work demands magnetic shielding against stray fields and electrostatic shielding against ac pickup.

Magnetic Amplifiers for Process Control continued

OF ALL THE magnetic amplifier types, those described in the table on the previous page are the most useful building blocks for control systems. Each is treated as a single stage unit. As such, its properties are quite well understood, and performance can be predicted with good accuracy.

But when stages are cascaded, they interact, and predictions are no longer easy. One often has to rely on instinct and experiment to solve interaction problems. Nevertheless, cascading of as many as four stages is now a practical reality. Happily, this is adequate for all control problems encountered to date.

Cascaded Magnetic Amplifiers

As the number of stages increases, expected reliability goes down rapidly. One has to build the maximum reliability into each component.

Years of work has shown that when the utmost in reliability is designed into each stage, a three or four stage amplifier can have virtually the same life expectancy as a single stage unit—ten years being very probable. Much of this performance and reliability can be attributed to the superior qualities of the silicon junction rectifier.

Cores

The heart of the magnetic amplifier is its core. It should be carefully selected for each individual application. There are four core types in general use, each with its advantages and disadvantages.

E-I Cores

Unsuited for low input power levels. For levels above one watt, core assembly is rugged, moderately reliable, and inexpensive, but rather bulky, and sensitive to external fields.

Rarely used in instrumentation work, except for power transformers and chokes.

Core assemblies always have a temperature sensitive residual air gap. Poor square hysteresis loop results, along with low to moderate current gain per stage (10 to 30). Obtainable in many different alloys, but shape prevents effective use of grain orientation.

Production techniques assure uniformity of magnetic characteristics. Core matching is difficult. Mass production winding techniques are adaptable, and provide maximum potential reliability of windings.

Square loop properties are degraded by eddy current insulation, mechanical strains of assembly, impregnation, and mounting.

DU Cores

Useful to microwatt input levels, with current gains of 100 per stage, and power gains of 40 db.

Core assemblies have much lower effective air gap than equivalent E-I cores, so they are less temperature sensitive, and have a more nearly square hysteresis loop. They make better use of grain orientation and they approximate toroid properties.

Production techniques assure uniformity of magnetic characteristics. Core matching is difficult. Mass production techniques apply.

As with E-I cores, insulation and mechanical strains of assembly, impregnation, and mounting detract from square loop properties. For best results, great care is needed during assembly. Core is rugged, reliable, and inexpensive, but bulky, and sensitive to external fields.

Tape Wound Cores

Useful to input levels of 10^{-8} watts or less (limited by noise level of cores). Current gains to 1000 per stage. Power gains to 50 db.

Core assemblies have the ultimate in grain orientation, squarest hysteresis loop, and a very small effective air gap.

Production techniques assure highest possible uniformity. Core matching to close tolerances is standard procedure.

Special winding required. Assembly is compact, and relatively immune to external fields.

Cores, if properly packaged in metal boxes, liquid or grease filled, hermetically sealed, and encapsulated, are insensitive to shock and acceleration, mounting strains, corrosion and temperature effects. Very rugged and reliable. No mounting problem.

Stamped Ring Cores

Useful to 10^{-14} watts. Noise level can be less, depending on material. Current gains to 5000 per stage. Power gains to 60 db.

Core assemblies have no air gap. They use grain orientation effectively, and have moderately square hysteresis loops.

Production techniques yield high uniformity. Balanced core pairs easily obtained. Differential temperature effects very small. Most stable cores known.

Special winding techniques required. Assembly is compact, and relatively immune to external fields.

Cores must be mounted in metal boxes, liquid filled or, with paper separators between lams, hermetically sealed, and encapsulated. Most nearly strain free assembly of any core. Immune to shock, acceleration, corrosion, and mounting strains. Very stable with temperature.

For reprint, circle 103 on Reader-Service card.

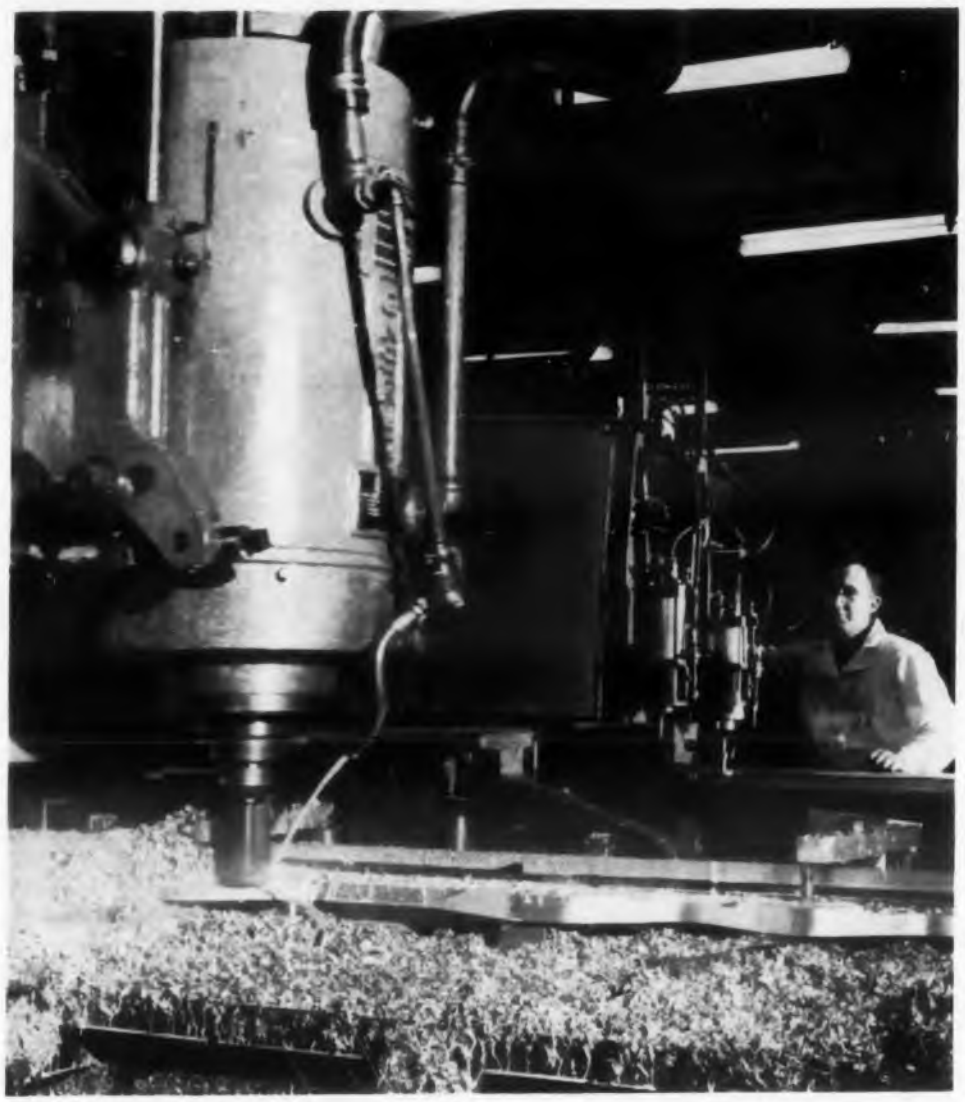


Fig. 1. The price of small components is negligible in comparison with the cost of developing the controls for a giant miller like this one. This electronic tracer-controlled profile miller has all but eliminated hand finishing on B-52 wing spars. Total production time for wing ribs for a single B-52 part has been knocked down from 200 hours to 8.

Designing for Industrial Electronic Equipment Reliability

W. H. Lesser

Specialty Control Department
General Electric Co.
Waynesboro, Va.

Bill Lesser has spent most of his ten years with the General Electric Company in the fields of quality control and reliability engineering.

"Reliability," he comments, "goes hand in hand with the design objectives of product leadership and customer acceptance at optimum cost. Dependable equipment performance has always been the ticket to long range customer acceptance."

In this article, Mr. Lesser shows how, with a division of responsibility, all parts of an organization can contribute to reliable equipment performance. This approach has been tested and found to work admirably.

IN CONTRAST with military reliability, determined by combat conditions, industrial equipment reliability is determined in the economic balance with performance and price. Only the proper relative weights of these ingredients can assure customer acceptance and adequate profit margin.

Planned reliability must include the following activities:

- Establishing overall reliability specifications early in product life in terms of per cent down time, expected product life, or average time between service calls. Equipment performance requirements must be anticipated, often before the customer knows his own requirements. A sound market analysis, followed by calculated business risks early in product life, often save valuable months of development. They can result in a valuable "market first."
- Allocating a proportionate share of overall reliability to each assembly, subassembly, and component. Thus one quickly discovers weak links in the reliability chain. This, in turn, directs development effort to the area most needing attention.
- Selecting component parts for adequate reliability. One must use performance tests, field results, and derating curves to appraise components.
- Monitoring decision making procedures that can change or degrade a reliable design.
- Assuring information from field service organization.

Table 1 shows some basic reliability functions of different departments in a typical organization. Notice that each department must contribute to product reliability. Feedback of information is essential for successful performance. Obviously such a decentralized program needs the full support of top management. Reliability objectives must be emphasized, together with the more talked about management objectives of cost reduction, inventory control, and profit margin.

Design Engineering

Faced with the problem of obtaining high equipment reliability and limited by inadequate component performance data, the design engineer must resort to conservative design practice. He prefers component derating to the practice in home radio-TV design of working components at rated loads or higher.

He doesn't depend on random tube characteristics which are not a part of the general tube specification. For example, in a timing circuit which depends on abnormally low grid current for successful operation, reliability is impaired by grid current aging characteristics. Here, it is desirable to design for a charging current considerably larger than the grid current to minimize

the effect of grid current changes on timer performance.

In general, the wise engineer designs a circuit whose performance is not affected by component tolerance buildup or aging.

Cost. When conservative design calls for higher currents, the increased cost of components must be weighed against the improvement in reliability.

Often, component cost is negligible, as for example, in the expensive machine tool control shown in Fig. 1. Here, development expense is so high that small components can practically be given away to minimize customer complaints.

This type of industrial equipment is often overdesigned at the start to protect against unknown duty cycles. Then, after operating conditions are better known, cost reductions can be made without degrading reliability.

Standardization. The value of standardization to reliability, both in components and circuits, must be emphasized. A recent survey by a large electronic equipment manufacturer revealed that 81 types of power supplies were provided on equipment shipped over a five year period. Preliminary review showed that 9 preferred types would have been completely satisfactory.

Duplicated engineering effort can often be

Table 1. Basic Reliability Functions

Sales

1. Establish overall equipment reliability requirements.
2. Sell equipment within capability limits.
3. Constantly evaluate competition's equipment performance.

Engineering

1. Allocate required reliability to assemblies, subassemblies and components.
2. Evaluate component reliability data.
3. Derate components to assure overall reliability.
4. Integrate component reliability into optimum system reliability in terms of performance—reliability—cost ratios.

Quality Control

1. Assure product conformance to established specifications.
2. Control decision making which would degrade design reliability, such as: changing component vendors, changing tooling and manufacturing methods.
3. Report quality assurance test results in terms of corrective action.
4. Feedback recommended improvements to Engineering.

Field Service

1. Assure adequate installation of equipment.
2. Assure adequate operating instructions to customer personnel.
3. Adequately report customer complaints.
4. Feedback recommended improvements to Engineering.

saved by an index and history of proven circuits. This can enable the designer to put more creative effort on new designs. Inexperienced people can be trained more quickly with less risk of design errors reaching the assembly floor.

Standardization, of course, imposes the responsibility of keeping circuits up to date. It also imposes the need to watch the break-even point, where the cost of maintaining standards exceeds the savings realized.

Reliability Engineering

This new title has recently found its way into many organization charts. Previously known as component or parts engineering, its function is to evaluate parts for reliable performance and general acceptability. Here also, conservative design by derating can improve reliability. For example:

- Expected operating life of dry electrolytic capacitors can often be doubled by reducing working voltage to 70 per cent of rated value.
- Expected life can double for each 10 deg C drop in ambient temperature within a nominal temperature range.

Such derating prolongs expected life and overcomes unavoidable drift.

One of the difficult problems is to specify the degree of reliability to expect for a given performance characteristic. This problem quickly becomes statistical. Answers are based on the number of performance tests, or on the amount of field data available.

Fig. 2 shows the results of many load life tests on a small industrial type relay. In this case, nominal life occurs at 50 to 60 million operations, but life can extend out to 100 million operations.

The corresponding reliability curve in Fig. 3 is sometimes called a "survivor curve." Here the reliability at any point in life is equal to the number of survivors at that point divided by the number of units originally placed on test. Such a curve can reveal the magnitude of failures expected over the range of relay operating life. Combined with reliability curves for other components, it can give a rough idea of overall equipment performance.

The reliability engineer can provide information valuable to purchasing agents in vendor selection. This can include:

- Original component qualification and subsequent comparative performance test results.
- Vendor performance rating based on tests to verify component specifications.
- Cost reduction as a result of working closely

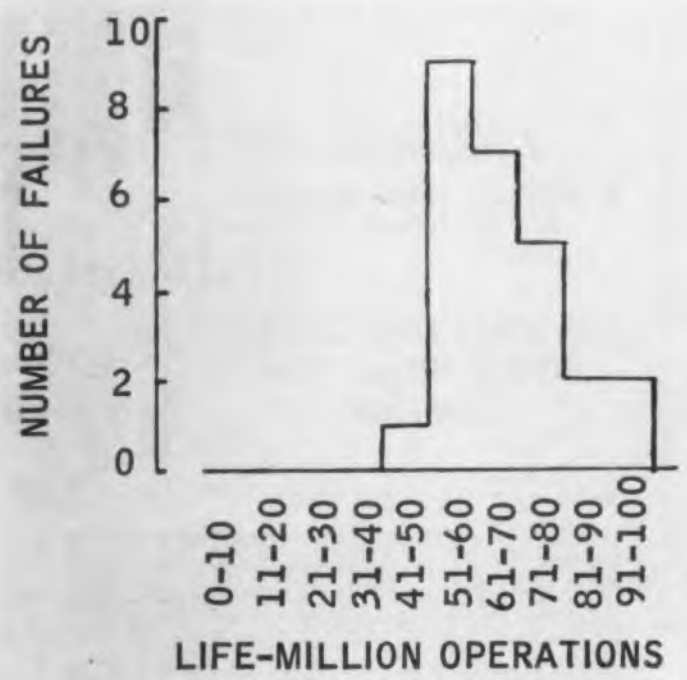


Fig. 2. Load life test results on an industrial type relay.

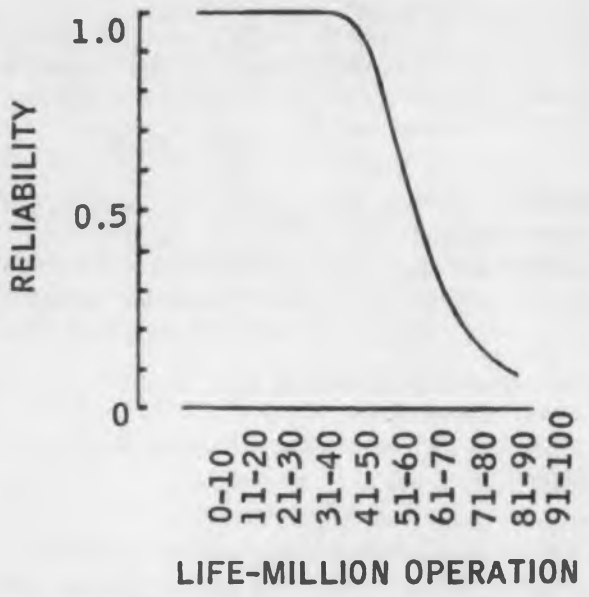


Fig. 3. Reliability curve for expected relay life.

with vendors on application and manufacturing problems.

Quality Control

Almost every design engineer has had the experience of striving for the last bit of performance from a design, only to see its reliability fall off due to subsequent degrading. This can be corrected by effective quality control. Established procedures, preferably documented, should control the decision making functions which can change the designed reliability. Look for those conditions where:

- Quick changes are made in component vendors without adequate evaluation of production samples and test results.
- Repairs or replacements are made in high production tools.
- Meters or calibration methods are changed.
- Disposition is made of obsolete and defective production materials.
- Selective assembly of component parts is the accepted practice to "make equipment work."
- Abnormal test conditions may occur, such as aging of test tubes, variations in line voltage, or mishandling of fragile equipment.

Poor control over any of these conditions guarantees reduced product reliability.

Expansion by traditional electronic equipment manufacturers into the computer and machine tool control business requires learning how to deal with new mechanical problems. Methods of precision gaging, hydraulic testing, and accurate assembly methods demand new skills and quality control methods.

Field Service

Reliable feedback of field information is vital, not only in making product improvements, but in evaluating the effectiveness of field service. An alert service organization can obtain corrective action to improve product reliability as follows:

- Instruction of customer's repairmen on how to adjust for component variations rather than replace expensive parts.
- Teaching customers how to lengthen tube life by operating filaments continuously.
- Instituting preventive maintenance with due care to avoid unnecessary tube testing.
- Reporting minor and nuisance errors such as faded wire color codes, labels upside down to customer but right side up to factory tester, sliding replacement part trays that fall out, absence of lock washers in vital locations, etc.
- Providing additional control cabinet ventilation.

A successful planned reliability program requires the coordinated effort of each function in an organization to obtain customer acceptance and maintain product reputation.

100 Design Suggestions

THE PURPOSE of the NEL* *Relibality Design Handbook* is to increase the reliability of electronic equipment. As a handy check list, it points out the need for techniques having low-failure rates. Most of our readers are already familiar with the 1957 edition. Here are some of the additional design suggestions that has been included in the 1958-59 edition. Request for copies of this booklet should be directed to the Commanding Officer and Director (Code 3560) U. S. Navy Electronics Laboratory, San Diego 52, Calif.

Cooling Factors

- Natural Cooling Factors:

1. Specific heat-flow paths must be used.
2. Heat-flow paths should be as short as possible.
3. Provide metal heat-flow paths.
4. Arrange hot parts to form a bank of minimum height.
5. If vertical stacking is used, the parts should be staggered.
6. Use heavy metal chassis to conduct heat.
7. Make good heat conducting joints throughout.
8. Isolate temperature-sensitive parts from heat sources.
9. Use polished or unpainted radiation shields to protect sensitive parts less than 2 inches away from hot parts.
10. All parts dissipating more than 1/2 watt should be mounted on a metal chassis.
11. Plastic chassis must have metal heat conductors if its parts dissipate more than 1/2 watt.
12. Heat sources should have high emissivity.
13. Provide metal heat conductors for embedded heat sources.
14. Louvers should be provided.

- Forced-Air Cooling Factors:

1. Direct cool air on hot spots.
2. Cool hot parts with parallel air flow.
3. Do not use "second-hand"air for cooling.
4. Maintain all air-flow paths free and unobstructed.
5. Isolate intake port from exhaust.
6. Provide air passage and ducts of proper size.
7. Blower capacity must be adequate.

*Navy Electronic Laboratory

8. Air flow in equipment should be measured and mapped with smoke.
9. Design to utilize induced draft.
10. Provide adequate air filters, accessible for easy cleaning and replacement.
11. Cool blower motors.
12. Protection should be provided if a blower fails.
13. Measure critical temperatures.
14. Minimize air-flow noise.
15. Provide critical power tubes with adequate air flow.
16. Protect fragile fins.
17. Pass air over seals of critical tubes first.

- Liquid Cooling Factors:

1. Direct liquid cooling:
   a. The coolant must be nonflammable and nontoxic.
   b. The coolant must be chemically neutral to parts.
   c. Provide for coolant expansion.
   d. Design container to withstand expansion pressure.
   e. Hermetically seal the unit.
   f. Provide drain and filler plugs.
   g. Design so that the coolant will not boil under maximum conditions.
   h. Provide coolant maintenance placards.
2. Indirect liquid cooling:
   a. Provide drains at system low points.
   b. Provide bleed valve at the high point.
   c. Use a check valve on each disconnect.
   d. Provide for expansion of coolant.
   e. Design so that coolant will not boil or freeze.
   f. Provide adequate piping.
   g. Select exchangers specifically for the system design.
   h. Design to preclude condensation of moisture in the equipment.
   i. Provide temperature control, if necessary.
   j. Select design wherein air "locks" cannot form.
   k. Provide coolant maintenance placards.
   l. Coolant must be noncorrosive to exchangers and piping.

- Vaporization Cooling Factors:

1. Check all liquid cooling factors, preceding.
2. Expendable evaporative cooling:
   a. Provide adequate quantity of coolant.
   b. Install make-up reservoir if required.
   c. Vent vapor to the atmosphere.
   d. Prevent toxic fumes from contacting personnel.
   e. Provide pressure control valve.

(Continued on following page)

100 Design Suggestions

f. Include a pressure relief valve.

3. Continuous vaporization cooling:
   a. Test refrigeration system in its ultimate environment.

Parts Considerations

■ Electron Tubes:

1. Tubes and tube sockets should be free from discoloration.
2. No "glass-sucking" should occur.
3. The design must not allow the anodes to operate at red heat except for tantalum anode transmitting tubes.
4. Space unshielded tubes 1-1/2 diameters apart.
5. Prevent tubes from "seeing" each other.
6. Do not pot tubes in plastic.
7. Measure bulb temperatures.
8. Use thermatrons to investigate critical tube applications.

■ Tube Shields:

1. Use the correct shield.
2. Shields must fit tightly.
3. Shields should provide adequate protection from mechanical damage.
4. Blacken inner surface of shields.
5. Conduct heat to the chassis.
6. Provide low resistance metal joints.
7. The chassis must be able to dissipate the heat.
8. Conduct heat to the chassis.

■ Resistors (The following factors apply to resistors which dissipate more than 1/10 rated power.):

1. Clamp resistors to a heat sink.
2. Use short leads.
3. Mount resistors in free-flowing air.
4. Mount power resistors in groups vertically.
5. A single resistor over 5 inches long should be mounted vertically.
6. Prevent power resistors from radiating heat to sensitive parts.

■ Capacitors (Capacitors are heat sensitive in the following order of decreasing sensitivity: (1) electrolytic; (2) paper-tubular (wax impregnated); (3) phenolic molded paper; (4) oil-filled, sealed, metal clad; (5) ceramic, barium titanate; (6) Teflon; and (7) glass and mica.):

a. Do not mount heat sensitive capacitors near hot parts.
b. Use radiation shields.
c. Capacitors must be free from bulging and leaking.

■ Transformers and Iron-core Inductors:

1. Provide clean, low-resistance thermal joins to heat-conducting chassis.
2. Design magnetic power devices so that the heat is conducted from the windings to the chassis.
3. Clean thermal joints of impregnant and paint.
4. Mount heat-sensitive inductors away from hot parts.
5. Protect i-f and r-f coils from radiated heat.

■ Transistors and Semiconductors (These devices are temperature-sensitive, and thermal designs are critical.):

1. For power transistors, provide low thermal resistance path to heat-conducting chassis.
2. Liquid cool the chassis where feasible.
3. Provide constant temperature environment.
4. Transistors dissipating more than 100 mw should be clamped to a chassis.
5. Design circuitry to prevent performance deterioration with increasing temperature.

■ Semiconductor Power Rectifiers (These devices must be well cooled.):

1. Provide low thermal resistance to cooled chassis.
2. Use rectifiers with large fins.
3. Select cool spot to mount rectifiers.
4. Mount fins vertically.

Reliability

Failures in electronic equipment have been so numerous and so frequent that tactical operations have been impaired seriously. Failure data have indicated the following approximate mean-time-between-failure (MTBF) rates for existing electron-tube-type equipments. (M (hours) = mean-time-between-failures, and N = total number of electron tubes.):

For shipboard electronic equipment: $M = \frac{1.4 \times 10^4}{N}$

For airborne electronic equipment: $M = \frac{2.5 \times 10^3}{N}$

For ground electronic equipment: $M = \frac{1.8 \times 10^4}{N}$

Field studies have indicated that failures are distributed in time in a chance or random manner describable by a Poisson process. In this process, the time intervals between failures are exponentially distributed, and the probability,

P_o, of failure-free operation during time t is given by the expression:

$$P_o = e^{-t/m} \quad (1)$$

where

P_o = probability of nonfailure,
t = time in hours,
m = mean-time-between-failure, and
e = 2.718 (natural base).

Designers must enhance reliability by every means available. Following are some suggestions:

Simplify circuitry. Expressed in fashion similar to equation (1), above, the reliability of a multipart equipment is:

$$P_o = e^{-nt/T} \quad (2)$$

where

T = part mean-time-between-failures, and
n = number of parts (a measure of complexity).

Thus, if part life is constant, the fewer the parts, the longer will be the mean-time-between-failure.

Use safety factors. Most electronic parts have longer life if the applied stress is reduced below their ratings. If this stress (dissipation in composition resistors is reduced to 60 per cent of rated, the mean-time-between-failures is increased two or three times. The excursions of primary and secondary stress factors must be minimized. These excursions are noted in powerline voltage and frequency, vibration resonance, high-impact shock, humidity, and temperature.

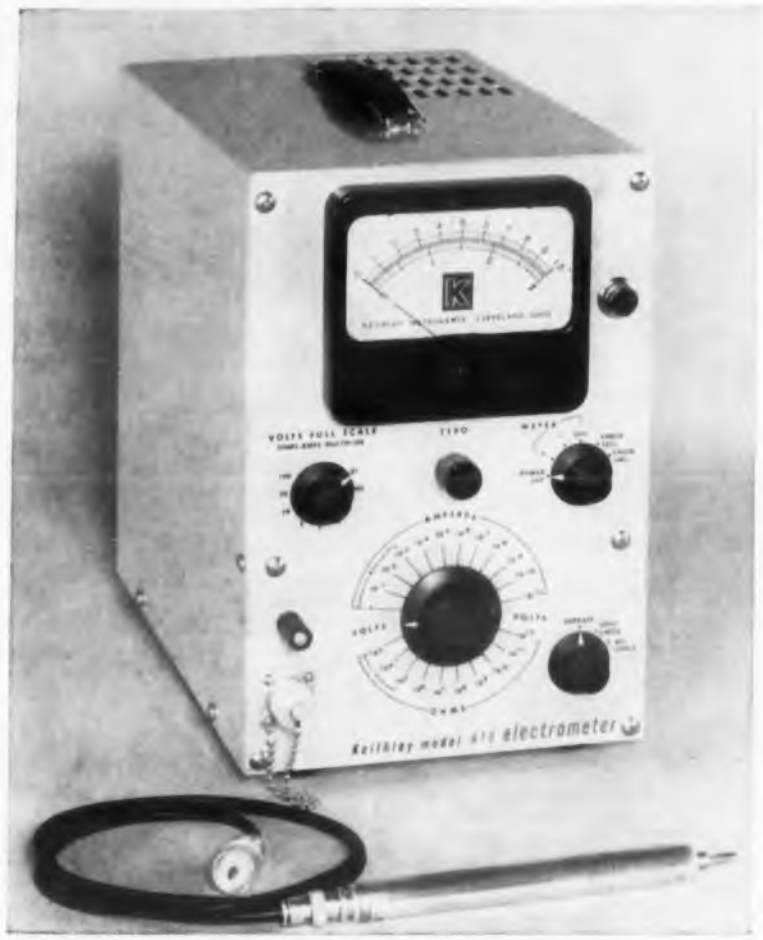
Reduce operating temperature, and position parts in equipments to minimize the effect of connection and radiation heat. The life of most parts can be improved by reducing the temperature of parts (such as by reducing the internal ambient temperature in equipments). For one type of equipment the MTBF was doubled when the internal ambient temperature was reduced 20 C.

Use redundancy. When state-of-the-art limitations preclude achieving the reliability objective, the use of redundant parts, circuits, and equipments must be utilized.

Use techniques inherently reliable. The use of solid-state devices—magnetic circuits, transistors, dielectric amplifiers—will enhance reliability in some applications. Thermionic devices have high failure rates—sometimes one order of magnitude greater than solid-state devices.

Use conservative circuit design. Check circuit function with transistors or tubes having life-test-end-point performance. Use prescribed derating factors and compensate in circuit design for known weaknesses of parts. Military preferred parts should be used in all applications possible.

Keithley electrometers for every dc laboratory test



Model 610, line-operated, 59 ranges

The Keithley 610 Electrometer is a laboratory workhorse, doing the work of several instruments. It covers the extreme spans of dc voltage, current, and resistance tabulated below, and is a useful preamplifier as well. It has precise gains to 1000, a dc to 500 cps bandwidth, and 10-volt and 1-ma outputs. Input resistance of the 610 is selectable from one ohm to over 10^{14} ohms. It checks its own resistance and voltage supply standards. Zero drift is comfortably within 2 millivolts per hour after warmup.

Model 600, battery-operated, 53 ranges

The Model 600 is a small, portable, battery-operated sister of the 610. Its many ranges also are tabulated below. Like the 610, its input resistance may be varied from one ohm to over 10^{14} ohms, permitting an optimum balance of low circuit loading verus minimum pick-up. Output is sufficient to drive potentiometric recorders directly, with a dc to 100 cps band-width, and zero drift is within 2 millivolts per hour. The 600 will check its own batteries; minimum battery life is 500 hours.

Need a few specials?

Recent Keithley developments include instruments for the Navy's Vanguard, for Army research balloons, and for Air Force research missiles. Your special problem will receive a prompt reply.

MODEL	FULL SCALE RANGES			PRICE
	VOLTAGE	CURRENT	RESISTANCE	
610	10 mv to 100 volts	10^{-13} amp. to 3 amperes	10 ohms to 10^{14} ohms	$465.00
600	10 mv to 10 volts	10^{-13} amp. to 3 amperes	10,000 ohms to 10^{13} ohms	$380.00

THREE ACCESSORY probes are available to facilitate measurements and extend the measuring range to 30 kv (Model 610) or 10 kv (Model 600). A convenient accessory test shield permits rapid checks of small components. Write today for more details.

KEITHLEY INSTRUMENTS, INC.

12415 EUCLID AVENUE • CLEVELAND 6, OHIO

CIRCLE 25 ON READER-SERVICE CARD

High-Speed Sampling

HIGH-SPEED sampling of low-level signals is accomplished by a new all-transistor electronic commutator. Designed by Radiation Inc., P. O. Box 37, Melbourne, Fla., the device is capable of operating at rates up to 24,000 samples per second. It contains 50 diode gates which enable the commutator to sample up to 50 channels. Distortion and losses are negligible.

Called Radiplex, the unit may be controlled by synchronizing signals or commanded from an external source computer. An important feature is the ability of the commutator to mix signals of full scale amplitudes as high as ± 10 v with signals at levels as low as ± 10 mv. Output may be connected to analog-digital converters to obtain coded outputs for storage or computation. Input can be obtained from accelerometers, thermocouples, etc. without a preamplifier.

Reliable operation at the extreme sampling speeds has been made possible by new sample and hold circuitry. Sequential output of the diode bridge is sampled over a period of 4 microseconds. Then the output information is held,

Switch . . .

for low-level signals

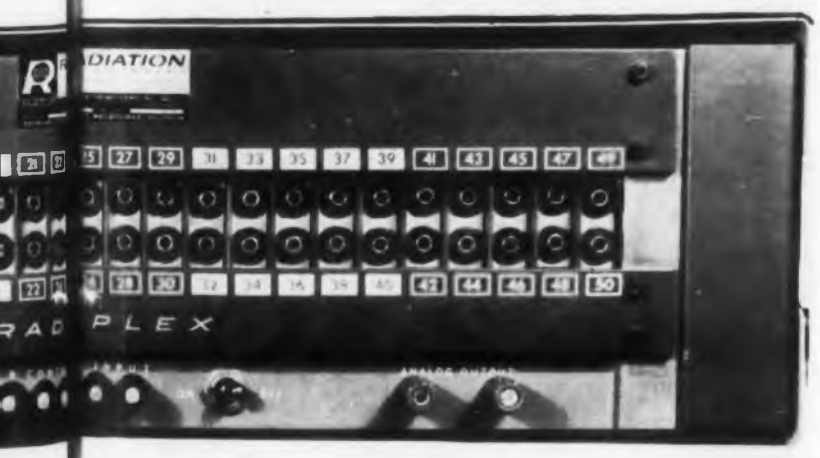
or remembered for 40 microseconds.

Flexibility is provided to enable the operator to program a variety of sampling rates. Often it is necessary to sample different channels at different rates. With Radiplex, the operator may preprogram the unit for almost any combination of channels (one to fifty), and sampling rates. For example, it is possible to program the unit to use two channels, sampling each at 12,000 per second. Or all 50 channels may be sampled at 480 per second.

Fifty channels are available; sampling rate is from 0-24 kc. Input is ±10 mv to ±10 v full scale with an input impedance of 30,000 ohms. Recommended driving source impedance should be less than 1000 ohms.

Linearity is within 0.1 per cent with interchannel modulation of 10^{-4} for a source impedance less than 1000 ohms. Power supply is built in and will operate from 60-400 cps ac sources.

For more information about this high-speed electronic commutator, turn to Readers Service Card and circle **101.**



New high-speed electronic commutator can be preprogrammed to perimit sampling of any logical arrangement of channels and switching rates. Patch plugs are at the rear (bottom photo).

MEETING REPORT

First Insulation Conference Probes Material Problems

L. N. Tolopko
Assistant Editor
ELECTRONIC DESIGN

DEMANDS being made on insulation material today are similar to those being made on electronic components and equipment: it must be able to stand up to higher and higher temperatures, occupy less volume, and weigh less.

This trend was made clear at the first National Conference on the Application of Electrical Insulation. The conference, cosponsored by the American Institute of Electrical Engineers and the National Electrical Manufacturers Association, was held in Cleveland on September 3, 4 and 5. Over one hundred papers were delivered at the sessions which were divided into four groups: rotating equipment, transformers, controls and instrumentations, and electronics. In addition, an exhibition provided the opportunity for displaying the latest advances in insulation and a meeting ground where manufacturer and user could thrash out common problems.

Undoubtedly the greatest advances in recent years have been the development of the silicones and fluorocarbon materials. To meet today's ultrahigh temperature requirements these substances, along with the newer plastics, are being combined successfully with the traditional insulating materials.

Spurring today's demands are the requirements of military aircraft. As airplane speeds increase so do the ambient temperatures. If any useful load can be carried, permissible conductor temperatures must be raised to 1000 F. and higher.

The User's Gripe

Chief complaint from the users of insulation material, as sampled in the corridors and various forums, was that they were never quite sure of quality of the material they were receiving. As a result, virtually every user talked to admitted to testing the material they purchased before using it. One user complained that generally the manufacturer's data sheet is correct but suffers from incompleteness. He related how he had taken used wire which was supposed to maintain its insulation at 130 C. After using the material he discovered this to be true. What they had forgotten to tell him was that the insulation shrunk by three per cent. Another user supported this contention. He said the data sheets he received gave the characteristics of the materials, but that how the characteristics were obtained was never given. The data sheets were therefore meaningless to him.

The Manufacturer's Side . . .

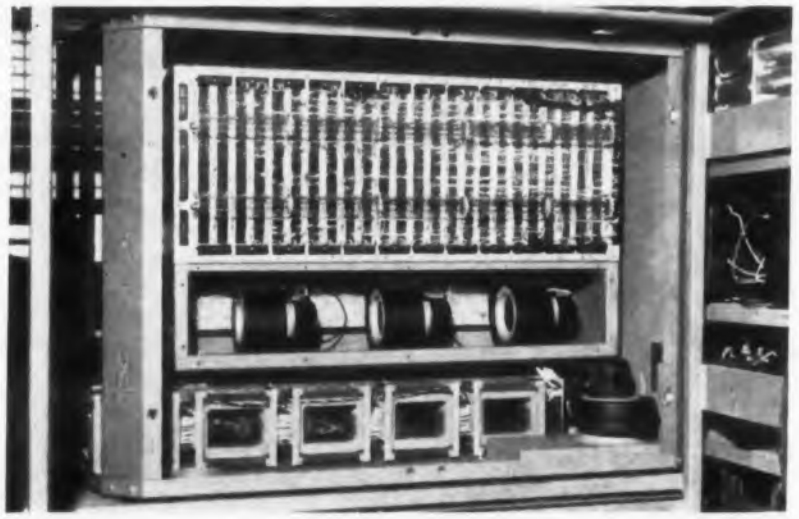
The trouble, a representative of the manufacturer explained, is that there are no standards regarding the testing of material. Everyone seems to be testing dielectric strength, flexure strength and what have you their own way. The ground rules have not been laid down. He related how his company had been asked to develop a material that would remain noncombustible in the presence of a Bunsen flame. The material had been developed and tested satisfactorily in the manufacturer's laboratory. However, when submitted to the user, the material was turned down because it burned when touched with the flame of a Bunsen burner. After extensive studies it was discovered that the BTU value of the user's gas flame was much higher than that of the manufacturer's. The representative of the manufacturer said that the most useful outcome of the conference would be everyone agreeing to a set of common ground rules and definitions. This, he admitted, might take several years. But this first conference was a good start, he concluded.

The Work Ahead

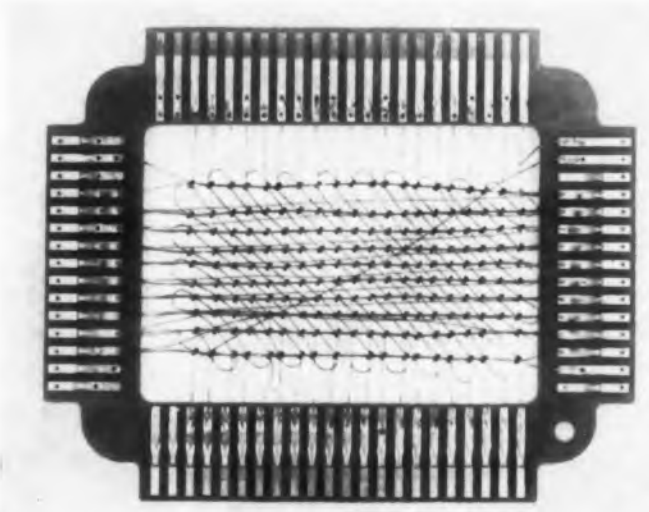
Incoming chairman of the AIEE Committee on Electrical Insulation, K. N. Mathes of General Electric, and other members of the committee, hope to bring peace into the area of insulation. At a dinner meeting, ambitious plans to define basic insulation terms, and methods of testing to

THE NATIONAL SCENE

KEEPING "ELECTRONIC BRAINS" FROM LOSS OF MEMORY. One of science's greater marvels is IBM's 705 Electronic Data Processing Machine—which makes intricate calculations and logical decisions in millionths of a second. Heart of this electronic "wizard" is its main magnetic core memory. Designed for use with the machine's high-speed printer is the IBM 760 Control and Storage Unit containing its own core memory of 1,000 positions which allows central processing to continue in the 705 while other data are being printed. Helping the 760 remember what information is to be printed is a job for PHENOLITE* Laminated Plastic. PHENOLITE's unique combination of properties makes it ideal for this application.



MOST ADVANCED FORM OF ELECTRONIC STORAGE. The 1,000-position core memory for the IBM 760 Control and Storage Unit—a portion of which is shown here—consists of pinhead size cores strung on copper-wired frames of PHENOLITE. Electrical impulses, passing through wires, alter the magnetic state of cores so that a group of them stands for a word or figure. Reversing the process recalls information from storage. PHENOLITE frames safeguard the circuit and permit stacking of core planes as shown.



PHENOLITE MEETS CRITICAL STANDARDS. Core frames like the one shown are punched out of laminated PHENOLITE by IBM. Each frame has printed circuit type terminal strips and soldered connections. PHENOLITE proves an ideal material for this application because it is mechanically strong and stiff, punches cleanly, etches well, remains flat, has high dielectric properties and withstands the heat of dip soldering.

determine insulation to everyone's satisfaction were laid out for the coming year.

Roundup of Papers

Some of the papers delivered at the conference and of value to the electronic design engineer are abstracted in the following paragraphs.

In discussing "Dielectric Papers for Electronic Applications," S. W. Pease of the Crocker Burbank & Co. Asson., told how to select the best paper for a particular application.

"If a unit is in production using a particular grade of paper, but improvement is desired, the following factors should be considered:

"1. To improve dielectric strength: Use a greater number of thinner sheets or change to a higher density, better formed paper. In either case, the cost of the paper will be higher, but the cost of the unit may or may not be affected since production losses may be lowered.

"2. To lower the dissipation factor: Use a lower density paper. If a drop in the 30 to 60 C range is desired, use a modified kraft pulp paper.

"3. To lower cost: Since thicker papers usually cost less per pound, using a few thicker sheets will be cheaper than a greater number of thin sheets. If some latitude in properties is available, examine the cost figures of the different density sheets. The price per pound of the paper is not a good indication of the cost of using a particular grade in any specific application.

"If a paper grade is to be chosen for a new unit of a completely different design, it is necessary to analyze the properties desired and make a well-educated guess at the grade of paper to start with. Having established the properties of the units, one may proceed as above. In either case, the suggestions of the paper company will be helpful.

"A word of caution should be added to the engineer evaluating a new grade of paper. Various grades of paper need to be handled in different ways. The winding, drying, and impregnation processes suitable for one grade may prove entirely unsatisfactory for a grade with completely different properties."

Characteristics the design engineer should consider in selecting and insulating material was covered in "What Every Engineer Should Know About High Temperature Wire and Cable," a paper prepared by F. X. Buschman, Tensolite Insulated Wire Co., Inc.

"1. Temperature Rating. That is, the maximum temperature at which the material may be used in operation continuously without loss of its basic properties.

"2. Dielectric Constant which is a measurement of its insulating efficiency. Dielectric constant is in itself a comparison of the insulating effectiveness of a material as compared to a vacuum

which is arbitrarily assigned a constant of unity.

"3. Chemical Resistance. If the finished wire will operate in or around presence of materials which can corrode or otherwise deteriorate a conductor, or if penetrable to the conductor can cause dielectric loss, an insulating medium must be chosen to present these actions.

"4. Flexibility. Particularly in electronics and aircraft or missile installation where assemblies of flexibility must be maintained.

"5. Moisture Absorption. Where conditions of high humidity or the presence of water are anticipated, a resistance to the absorption of moisture becomes critical in the selection of insulating materials.

"6. Effects of Soldering. Since many wire terminations in electronics and aircraft assemblies are accomplished by soldering the conductor to a termination point, and this is frequently done in confined spaces, an insulating material which is not affected by the heat present in the soldering operation is very frequently a must."

"Analysis of Soldering and Conductor Breakage in High Temperature Hook-Up Wire" was the title of a paper prepared by Messrs. W. Nold and C. Brown of the Laboratory For Electronics, Boston, Mass. The following points were made:

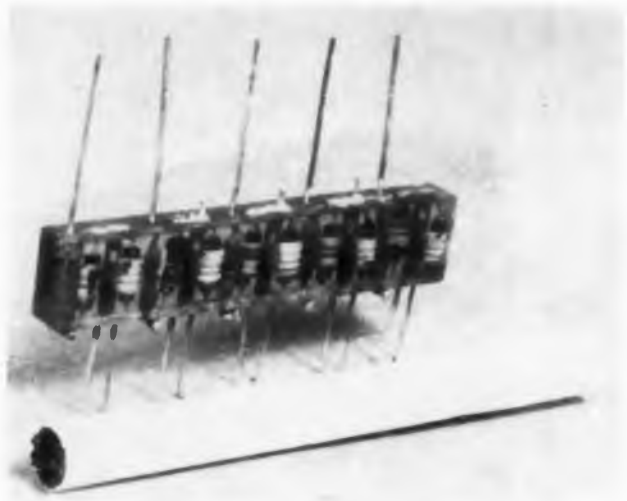
"Good flexibility of the conductor is necessary to reduce breakage due to repeated bending, and individual strands of high-temperature wire can not be tin-coated as in the usual hook-up wire, because tin-coated strands would fuse together at the temperatures used in curing the high-temperature insulations on the wire.

"The composition of the solder and the temperature at which it is used greatly affects the amount of bending that the soldered connection will stand. In general, the higher the tin content of the solder and the higher the temperature at which the soldering is done, the poorer the bend endurance of the soldered connection. The best results were had from a solder which was composed of equal parts of tin and lead with 1-1/2 per cent copper; this solder melts and flows as freely as ordinary 50/50 tin-lead solder.

"Soldering which is done at temperatures below 550 F usually produce lumpy-looking connections and the long time required to heat up the wire and the termination may actually result in heating up adjacent areas to an undesirable degree, even to the extent of melting previously soldered connections."

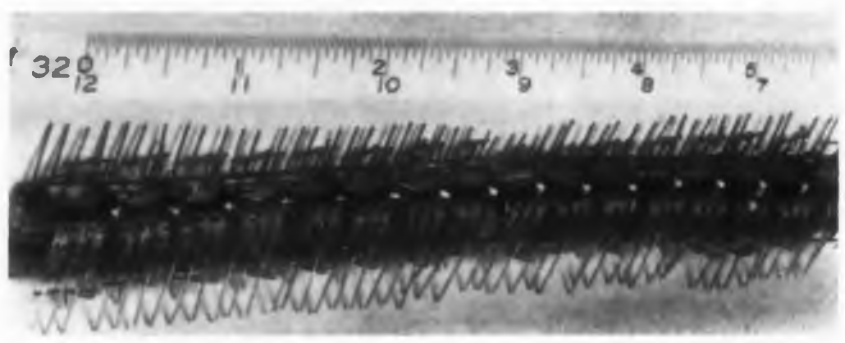
After testing wire for bend endurance it was found that: "As might be expected, very large angles of bend caused greatly reduced bend-endurance. All breaks occurred within the soldered area of the wire, sometimes between the end of the insulation and the connector pin, sometimes within the insulation."

Instrument Sticks For Tomorrow's

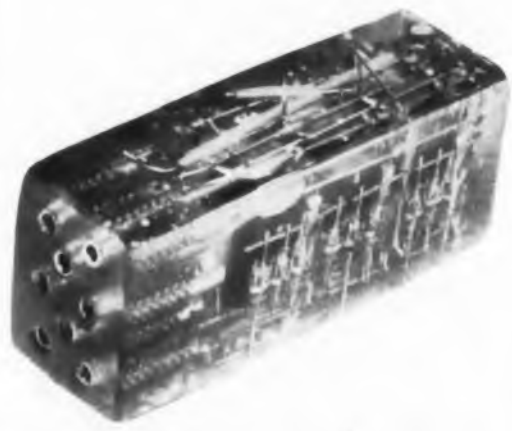


Instrument stick (above) with soldered connections by Lind Corp.

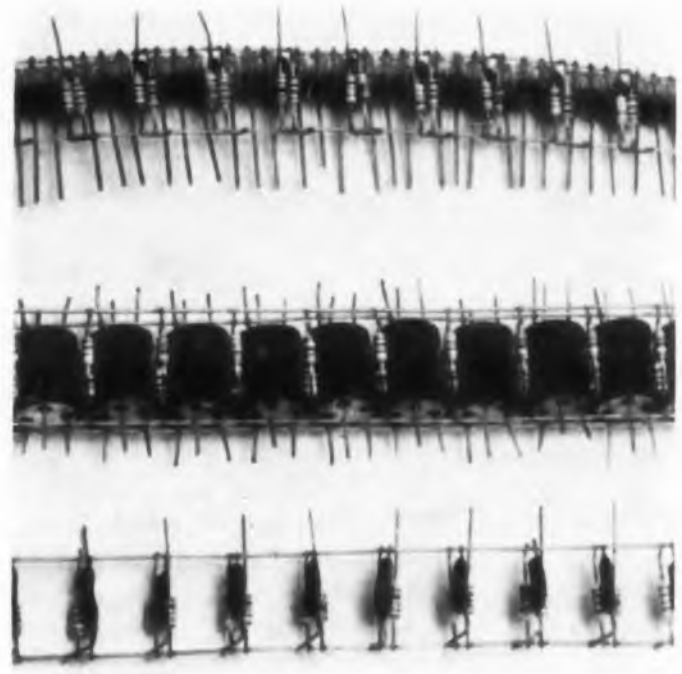
Rigid plastic foam (right) cushions against shock in this Lind assembly.



Back-to-back power transistors are flanked by diodes, resistors, and capacitors to form a fragment of computer logic. In this Sippican unit, all interconnections are resistance spot welded.



Circuit assembly (above) with end connectors—ready for use. (Sippican)



Three sticks (right) ready for assembly. (Sippican)

Packages

EXTREMELY high component densities, to 74 per cent, are featured in "instrument sticks," a new packaging concept. Almost at the same time, two companies, working independently, announced this new packaging service. Unbeknownst to each other, both companies coined the same term for their packages—"instrument sticks."

Available from Sippican Corp., Marion, Mass. (an affiliate and licensee of Francis Associates), and from Lind Corp., Research Park, Princeton, N.J., the sticks are similar in appearance and basic concept, yet they have important differences.

Units Are The Same . . .

In both cases, each component is in close physical contact with its neighbors and no supporting structure is normally required. Sticks of components are normally encapsulated in a suitable potting resin, and individual modules may be strapped together and stacked. The potting protects against humidity, fungus, and salt spray.

Packages are very strong and rigid. Lind lists typical specifications for vibration of 25 to 2500 cycles at 25 g; 150 g for 11 msec, for shock; and 150 g of continuous acceleration.

Since leads are very short and well insulated cross-talk and interference are very low.

Thin sheets of metal can be interleaved in parallel planes among the sticks assembled in a cube for high thermal conductivity, or thermal problems can be eliminated with an aluminum "sandwich."

Surgery can be performed on either unit to replace defective components—but the operation is a ticklish one.

. . . Yet Different

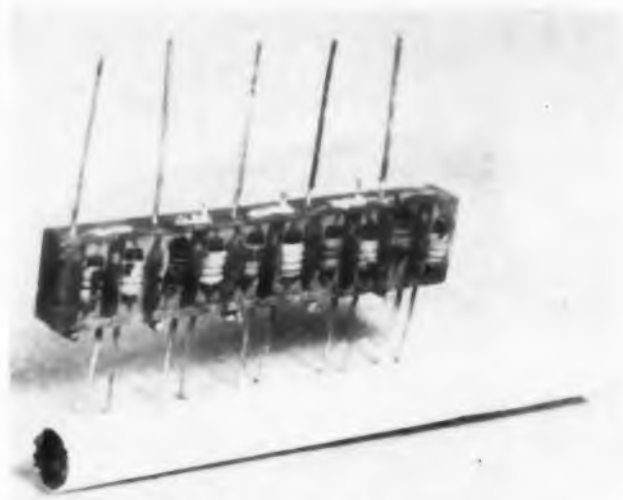
The outstanding difference between the packages is that interconnections are made by resistance spot welding in the Sippican models, and by soldering or electroplating in the Lind units.

Sippican uses structural engineering principles —depending on the natural compressive strength of the components packed so densely, and the tensile strength of the interconnecting wiring. If the assembly is potted in a suitable casting resin —its strength is roughly analogous to a steel reinforced concrete beam.

Lind casts the individual modules in an epoxy stick, straps them together, then uses a rigid plastic foam to hold the members together.

For further information on both techniques, turn to the Reader-Service Card and Circle **102.**

Instrument Sticks For Tomorrow's



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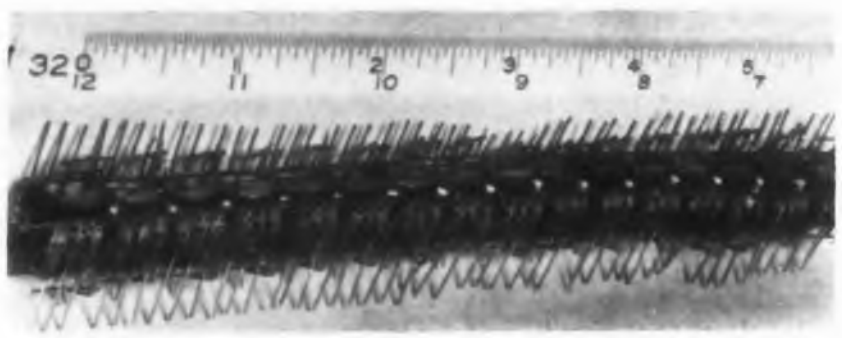

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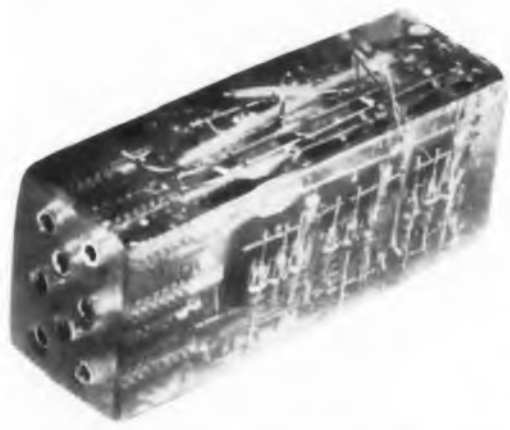

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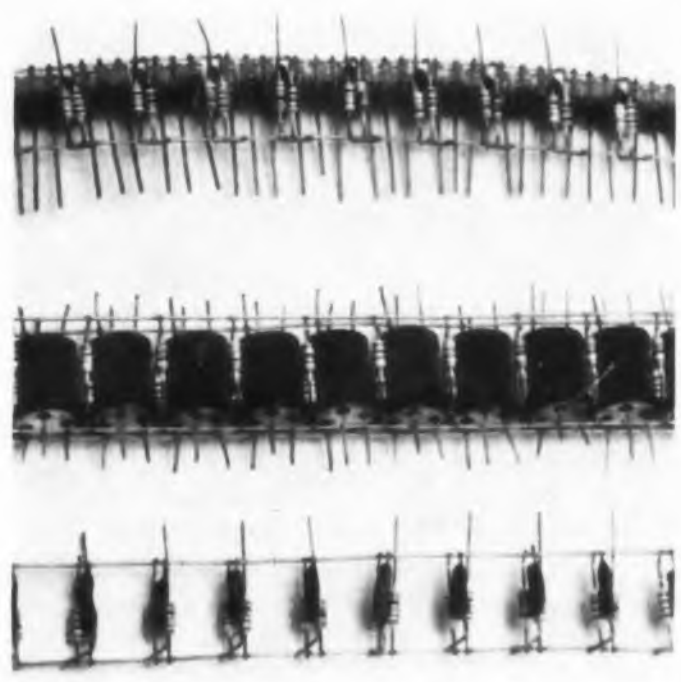

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NEW PRODUCTS

Covering all new products that might generally be specified by an electronics engineer engaged in the design of original equipment.

TRANSDUCERS

Transducers do one thing: change energy of one form into another form. Shown on this page are three of the newest transducers available. All are designed for use in converting pressure variations into frequency variations. The next issue of ELECTRONIC DESIGN will describe several transducers which were unearthed at the recent National Symposium on Telemetering.

Input pressures of 0 to 1000 psi are converted into a direct electrical output in terms of frequency by this transducer. Output of the unit is in the form of an audio (fm) signal, with a frequency inversely proportional to applied pressure. In the model 8815 the frequency output is achieved by means of a vibrating wire which is stretched between an anchor point and a pressure-sensitive metal diaphragm. The stretched wire is set into motion in a permanent magnetic field by an alternating current through the wire. Current is supplied by an associated amplifier connected in an oscillator circuit. Frequency of oscillation is controlled by the vibrating frequency of the stretched wire. Featuring accuracy, linearity, and ruggedness, the unit can be used in military or industrial airborne or ground equipment.

BJ Electronics, Borg-Warner Corp., Dept. ED, 3300 Newport Blvd., Santa Ana, Calif.

CIRCLE 33 ON READER-SERVICE CARD

Model S-60 is a single coil, variable reluctance, diaphragm type transducer. It is designed for use as the variable inductor in commercially available inductance and reactance controlled fm fm subcarrier oscillator systems. Differential, gage, and absolute models are offered with a selection of pressure ranges between 0 to 10 and 0 to 5000 psi. Its sensitivity to shock, vibration, and acceleration is 0.001 to 0.01 per cent per g, or less, depending on pressure range. Rise time is 75 to 150 μsec. Basic size is 7/8 in. diam and 7/8 in. long. Operating temperature range is from −85 to +240 F. Units are suited for a wide variety of telemetering applications.

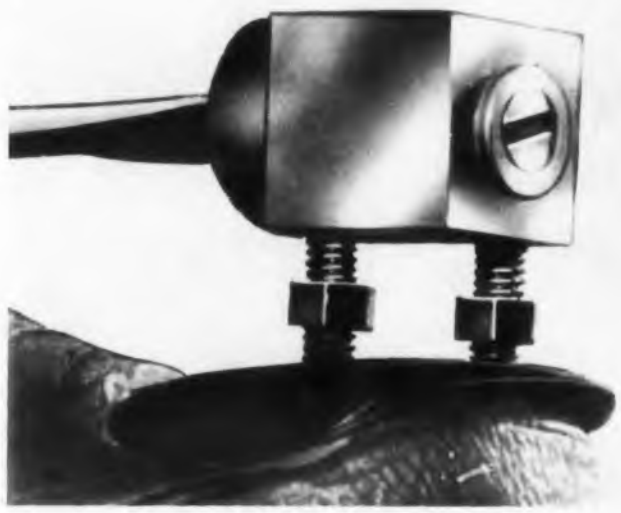
Ultradyne, Inc., Dept. ED, P.O. Box 3308, Albuquerque, N. Mex.

CIRCLE 34 ON READER-SERVICE CARD

Pressure-to-frequency converter OS-1000 can be used in missile, aircraft, and industrial telemetering. The unit combines a variable inductance diaphragm type transducer and a temperature stabilized transistor oscillator. It needs three connections: 28 v dc at 2 ma, ground, and output. For all IRIG channels, units are diaphragm and flush-type with ranges from 5 to 5000 psi differential, absolute, or gage.

Solid State Electronics Co., Dept. ED, 8158 Orion Ave., Van Nuys, Calif.

CIRCLE 35 ON READER-SERVICE CARD



TRIMMER POTENTIOMETERS

Measuring 1/4 in. sq by 3/8 in. long, these trimmer potentiometers are designed for horizontal mounting applications. Model MS-4 can be stud mounted and MS-5 is lead-mounted on printed wiring boards. Units are rated at 1/4 w and are available in standard resistance values from 100 to 10,000 ohms. Weight of unit is 0.05 oz and wiper is made of palladium alloy.

Miniature Electronic Components Corp., Dept. ED, Holbrook, Mass.

CIRCLE 36 ON READER-SERVICE CARD

RHEOSTAT

Capable of 12.5 w dissipation at 40 C, the model E rheostat is 7/8 in. in diam and extends 11/16 in. behind the mounting panel. Unit has a ceramic hub, independent contact arm pressure, and a vitreous enamel coating. Rheostat is available in 23 different resistance values with linear winding. Nonlinear taper, tandem or other types can be provided.

Ohmite Mfg. Co., Dept. ED, 3698 Howard St., Skokie, Ill.

CIRCLE 37 ON READER-SERVICE CARD

NEW PRODUCTS

Silicon Rectifier

Can stand short circuits

Short circuits can be withstood by these rectifiers while protected by commercially available fuses. Recommended fuse rating is approximately 160 per cent of rms current. The rectifier stacks are available in half-wave or full-wave configurations from one to several hundred amperes, with peak inverse ratings in 50 volt multiples to thousands of volts. They are hermetically sealed cells for magnetic amplifier and power supply applications. Providing a regulation characteristic of less than one volt per cell forward drop, they can be used without derating from —65 to +150 C. Up to 99 per cent efficiency is possible with these units.

Trans-Sil Corp., Dept. ED, 55 Honeck St., Englewood, N.J.

CIRCLE 39 ON READER-SERVICE CARD

Constant Current Source

1 to 100 ma range

Model 5900 constant current source can be used to test semiconductors, thermistors, clutches, magnetic cores, and other current sensitive devices. Output is 0 to 100 v, 1 to 100 ma. Line regulation is 0.5 per cent and load regulation is 0.25 per cent.

Measurements Research Co., Dept. ED, 3801 Castor Ave., Philadelphia 24, Pa.

CIRCLE 40 ON READER-SERVICE CARD

◀ CIRCLE 550 ON READER-SERVICE CARD

Signal Sources

Provide 10 w output

Covering 1 to 11 kmc, these 10 w signal sources have internal modulation facilities for pulse, square-wave, and fm operation. For 1 to 2 and 2 to 4 kmc, models 231T and 231T2 provide: 40 to 4000 pps sweep; 0.5 to 10 μsec pulse widths; and 0 to ±2.5 mc fm deviations adjustable from center frequency. For 4 to 8 and 8 to 11 kmc, models 231T3 and 231T4 offer: 10 to 10,000 pps sweep; 0.2 to 10 μsec pulse widths; and 5 mc min deviations. Accuracy for all units is ±1 per cent; output vswr, 2 to 1.

Levinthal Electronic Products, Inc., Dept. ED, Stanford Industrial Park, Palo Alto, Calif.

CIRCLE 41 ON READER-SERVICE CARD

Stepping Motors

Rotate control mechanisms

Translating pulses into incremental shaft positions, series 2 and 3 motors rotate control mechanisms, potentiometers, counters, and switches. A 36 degree angular increment per pulse gives 10 indexing positions with ±0.5 degree detent accuracy at a maximum stepping rate of 15 per sec. The units meet MIL-E-5272A tests and operate from −55 to +80 C up to 90,000 ft. Load capacity for series 2 units is 13 oz-in. For series 3 units, it is 2 lb-in.

G. H. Leland, Inc., Dept. ED, 123 Webster St., Dayton 2, Ohio.

CIRCLE 42 ON READER-SERVICE CARD

CIRCLE 43 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Pulse Generator

Offers multiple pulse code trains

Modules of the B3-2A pulse generator are connected through a patch panel so that multiple pulse code trains can be set up. The generator provides repetition rates from 10 cps to 1 mc. Four variable delay circuits have delays from 0 to 10,000 μsec for controlling pulse position or width. The two pulse forming units produce positive or negative pulses with 0.02 μsec rise and fall times and 25 v amplitude. Output impedance is 50 ohms, and the duty factor of the output pulse is 25 per cent. Rise time can be degraded to 1 μsec.

Rutherford Electronics Co., Dept. ED, 8944 Lindblade St., Culver City, Calif.

CIRCLE 45 ON READER-SERVICE CARD

Temperature Recorder-Controllers

Ranges between —100 and +100 F

These temperature recorder-controllers cover the full range of filled systems. Model 7815 is a single pen recorder; models 7816 and 7817 are two pen, two control and one control units. Charts are 12 in., and ranges are between —100 and +100 F. A universal controller can be used for proportional, on-off, or differential gap control.

Daystrom, Inc., Daystrom-Weston Industrial Div., Dept. ED, Newark 12, N.J.

CIRCLE 46 ON READER-SERVICE CARD

Resistance Bridge

Range of 1 K to 110 million meg

For calibrating high megohm resistors, this standard bridge covers the range from 1 K to 1.1×10^{14} ohms. Accuracy is 0.2 per cent up to 10^{13} ohms. The test potential is continuously variable up to 1 kv, permitting accurate voltage coefficient analysis of components.

Mid-Eastern Electronics, Inc., Dept. ED, 32B Commerce St., Springfield, N.J.

CIRCLE 47 ON READER-SERVICE CARD

Voltage Regulators

In sizes to 7.5 kw

With these primary voltage regulators, 10 to 20 per cent regulation in existing systems can be improved to 1 per cent for all conditions of line and load variation. In sizes to 7.5 kw, and 3 and 1 phase at 50 and 60 cps.

Gemco Electric Co., Dept. ED, 25685 W. Eight Mile Rd., Detroit 40, Mich.

CIRCLE 48 ON READER-SERVICE CARD

Digital Voltmeter

Modular construction

Composed of a universal power module and a four-digit switch module, the DVA-400 transistorized digital voltmeter measures dc voltages from 0.0001 to 1100 v. The unit is accurate to ± 0.01 per cent and 1 digit.

Electro Instruments, Inc., Dept. ED, 3540 Aero Court, San Diego 11, Calif.

CIRCLE 49 ON READER-SERVICE CARD

CIRCLE 50 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Null-Balance Indicator

Utilizes accumulative reading

To obtain high readability and accuracy, this miniature null-balance potentiometer indicator utilizes an accumulative reading. Supplied with a remotely mounted servo amplifier, the unit has 0.25 per cent accuracy and 0.1 per cent sensitivity.

Westronics, Inc., Dept. ED, 3605 McCart St., Fort Worth, Tex.

CIRCLE 51 ON READER-SERVICE CARD

Memory Processor

Has two recording modes

An 8-in. diameter hermetically sealed disc, this memory processor has two recording modes. One uses fixed channels for digital computation and control; the other uses a scanning head channel for data processing and correlative control.

Genesys Corp., Dept. ED, 10131 National Blvd., Los Angeles, Calif.

CIRCLE 52 ON READER-SERVICE CARD

Not So Fast

Consolidated Electrodynamics' type 5-680 recorder/reproducer starts and stops in under 3 msec—not 3 μsec, as reported in the Sept. 3 ELECTRONIC DESIGN.

RECTIFIERS FOR ALL DC REQUIREMENTS...FROM MICROWATTS TO MEGAWATTS!

RECTIFIER CORPORATION PRODUCTS

LINE OF QUALITY RECTIFIERS ON EARTH!

All designed and manufactured to meet the most rigid military requirements!

POWER TYPES FOR INDUSTRIAL AND MILITARY APPLICATIONS

SILICON AND SELENIUM MEDIUM CURRENT TYPES TO 150 AMPS.

Utilizing junctions rated to 1.25 amps DC output
These stacks consist of hermetically sealed junction diodes mounted on copper cooling fins, stacked to include the interconnections required for specific circuits. Junction ratings: 1.25 amps. DC output: 70 to 350 AC input volts rms. Request **Bulletin SR-137A**

Conservatively rated to provide a substantial safety factor in industrial applications. Hermetically sealed, all-welded case construction provides reliability over a long life. Types available in a wide voltage range. For details **Contact Factory.**

Rating: 50 to 500 volts PIV • 25 to 45 Amps.
Advanced ceramic techniques assuring excellent thermal characteristics and mechanical stability are used in the production of these highly reliable, hermetically sealed rectifiers for military or industrial applications. For complete technical data, request **Bulletin SR-304**

Ratings: 50 to 800 volts PIV • 45 to 150 Amps.
An extensive series of standard and reverse polarity types. Optional mounting bases including machine thread and pipe thread types. Machine thread base types: **Bulletin SR-300,** Pipe thread base types. **Bulletin SR-301,** Complete stack assemblies: **Bulletin SR-302**

SILICON, SELENIUM AND GERMANIUM HIGH CURRENT TYPES TO 670 AMPS. PER JUNCTION

Ratings: 45 to 150 Amperes per Junction
Consisting of hermetically sealed junction diodes mounted on aluminum or copper cooling fins, stacked to include the interconnections required for specific circuits. Junction ratings: 45 to 150 amps average DC. Write for application data.

Ratings: 50 to 500 volts PIV • 75 to 250 Amps.
Standard and reverse polarity types offered in a series of machine thread and pipe thread mounting styles. Complete assemblies in all circuit configurations also available. Rugged construction and hermetic sealing assure long life and reliability. Ask for **Bulletin SR-305**

Ratings: 6 to 30,000 volts • 50 to 2,300 Amps.
Specifically designed for industrial DC power needs. Patented construction features assure long life. Descriptive bulletins available are: **Bulletin C-349,** (26 volt cells), **Bulletin SR-160,** (45 to 52 volts per cell) and **Bulletin SR-152,** on high current density cells.

Ratings: 500 amperes • 26 to 66 volts rms
High capacity junctions especially designed for high-current, low-voltage electrochemical installations. Air cooled, these hermetically sealed junctions provide efficiency to 98.5%. Cast aluminum airfoil housing effects maximum heat transfer. For details **Contact Factory.**

SPECIAL SEMI-CONDUCTOR DEVICES

Complete series of AC and DC types.
Designed to eliminate arcing and erosion across the contacts of relays, switches, etc. A complete series in each of three basic types: diode type, cartridge type and hermetically sealed types for industrial application. For complete data **Bulletin SR-150-A**

Ratings: From 600 milliwatts to 10 watts
A complete series in 6 types. Miniature single junction types, multiple junction types and double anode units. 750 milliwatt and 1 watt types: **Bulletin SR-251,** 3.5 and 10 watt types: **Bulletin SR-252,** Multiple junction 5 watt types: SR-253, Double anode types: SR-254

Temperature compensated for stability to ±.001% °C
Extremely precise units for power supplies and voltage sources. Temperature compensated for excellent stability over a temperature range of from −55°C to +150°C. Manufactured to meet the most rigid military requirements. Types 1N430, 1N430A, 1N430B. **Bulletin SR-255**

(Wide range of silicon and selenium types.)
Self generating cells available in standard and custom sizes, mounted or unmounted. For details on wide selection of selenium types, request **Bulletin PC-649.** Silicon solar cells in mounted and unmounted types are described in technical detail—specify **Bulletin SR-156.**

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REPRESENTATIVES THROUGHOUT THE WORLD

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ELECTRONIC TYPES

Silicon and Selenium Low Current Types to 1 amp.

	Circle Numbers Indicated Below on Reader-Service Card
Miniature Silicon Power Diodes	(301)
Pigtail Type Silicon Power Diodes	(302)
Stud Mounted Silicon Power Diodes	(303)
Sub Miniature Selenium Diodes	(304)
Selenium Rectifier Stacks	(305)
Selenium TV and Radio Rectifiers	(306)
Silicon TV Rectifiers	(307)
High Q Voltage Variable Capacitor	(308)

Silicon and Selenium High Voltage Types

High Voltage Silicon Power Diodes	(309)
High Voltage Silicon Cartridge Rectifiers	(310)
Selenium High Voltage Cartridge Rectifiers	(311)
Special High Voltage Types	(312)

POWER TYPES

Silicon and Selenium Medium Current Types to 150 amps.

Silicon Rectifier Stacks	(313)
12 Amp. Silicon Power Diodes	(314)
25 Amp. Silicon Power Diodes	(315)
150 Amp. Silicon Power Diodes	(316)

Silicon, Selenium and Germanium High Current Types to 670 Amps. per Junction

Silicon Rectifier Stacks	(317)
250 Amp. Silicon Power Diodes	(318)
Selenium Heavy Power Rectifiers	(319)
Germanium Power Rectifier Junctions	(320)

Special Semi-Conductor Devices

Selenium Contact Protectors	(321)
Silicon Voltage Regulator Zener Diodes	(322)
Silicon Zener Voltage Reference Elements	(323)
Photoelectric Cells and Sun Batteries	(324)
Please have representative call	(325)

NEW PRODUCTS

Transistor Circuit Tester

Checks designs without soldered wires

With this synthesizer, designers can check transistor circuit performance without a breadboard of soldered wires. Common base, common emitter, and common collector circuits may be assembled. The tester has a master meter panel and four independent, transistor stage panels. These may be combined for amplifier, flip-flop, oscillator, gate, and other circuit assemblies. Either pnp or npn transistors may be used. The metering panel has a curve tracer which, with an external oscilloscope, allows a display of the collector voltage versus collector current plot.

National Electronics Labs., Inc., Dept. ED, 1713 Kalorama Rd., N.W., Washington, D.C.

CIRCLE 54 ON READER-SERVICE CARD

Power Supply

Series regulated

Regulation is better than 0.1 per cent in two models of series regulated ac to dc power supplies. Model PS 8001 has a current rating of 0 to 1.5 amp, and the PS 8002 is rated at 0 to 0.15 amp. Both models can be factory preset to any specified output voltage between 100 and 200 v. Output is adjustable by potentiometer to ±5 per cent. Weight is 7 oz and it measures 1.875 x 1.5 x 3.0 inches. Operates from −50 to +125 C.

Power Sources, Inc., Dept. ED, Burlington, Mass.

CIRCLE 55 ON READER-SERVICE CARD

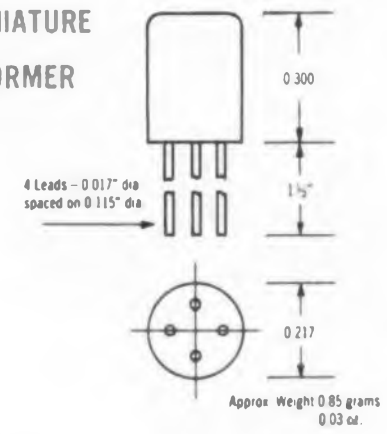
not for nearsighted design engineers

NEW ESC MICRO-MINIATURE PULSE TRANSFORMER

Fractional Micro-Second Pulse Width

Where space and weight limitations are precious, ESC's new Micro-Miniature Pulse Transformer fills a vital need in missiles, computers and other electronic equipment. ESC Micro-Miniature Pulse Transformers can be custom built to your specifications for both military and commercial applications. Write for complete technical data today!

ESC MICRO-MINIATURE
PULSE TRANSFORMER



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exceptional employment opportunities for engineers experienced in pulse techniques

Pulse transformers • Medium and low power transformers • Filters of all types • Pulse forming networks • Miniature plug in encapsulated circuit assemblies • Distributed constant delay lines • Lumped constant delay lines • Variable delay networks • Continuously variable delay lines • Pushbutton decade delay lines

CIRCLE 56 ON READER-SERVICE CARD

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ENGINEERS...
Experienced Computer Components

ESC Corporation, one of America's fastest growing engineer-managed electronics manufacturers, offers both a challenging position in design and development and a chance to share in its growing profit-sharing plan. You can work under supervision or assume responsibility for these vital ESC projects:

Audio and Video Filters
Delay Lines
Core Matrices
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Windsor 7-0400

CIRCLE 551 ON READER-SERVICE CARD

NEW PRODUCTS

Oscillograph Recorder

Mobile 12 channel unit

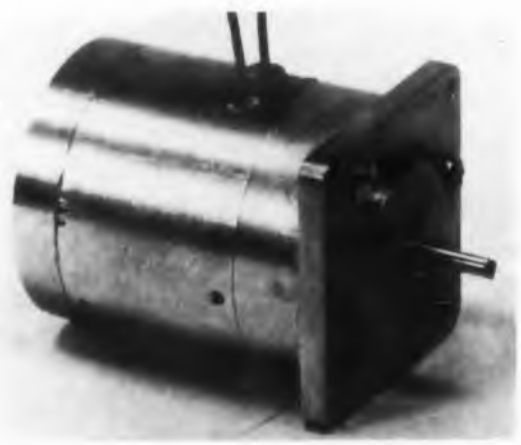
This 12-channel mobile oscillograph recorder has interchangeable plug-in preamplifiers, separately mounted driver amplifiers and a multichannel recorder. Write-out is by ink, electric or heated stylus. The direct-writing galvanometers are protected from signal overload damage and are mounted in a compact array for minimum recording table width.

Edin Co., Div. of Epsco, Inc., Dept. ED, 207 Main Street, Worcester 8, Mass.

CIRCLE 58 ON READER-SERVICE CARD

Stepper Motor

Offers reliability



This stepper motor has a life that exceeds 24,000,000 steps. It will meet MIL specifications on vibration, temperature, shock and acceleration. The unit steps 9 times per revolution and weighs 4.5 oz. At 17.5 w input it will produce 2.5 oz in. of torque and follow a 25 cps pulse with a low torque, low inertia load. Higher pulse rates are possible if torque requirements are reduced.

Globe Industries, Inc., Dept. ED, 1784 Stanley Ave., Dayton 4, Ohio.

CIRCLE 59 ON READER-SERVICE CARD

Sinusoidal Oscillator

25 cps to 100 kc range

Epoxy encapsulated, the S-100 silicon transistor oscillator creates a sine wave signal source. It stands 500 g shock for 11 msec, 30 g vibration to 2500 cps, and 700 g acceleration. Frequency range is 25 cps to 100 kc.

Solid State Electronics Co., Dept. ED, 8158 Orion Ave., Van Nuys, Calif.

CIRCLE 60 ON READER-SERVICE CARD

Silicon Rectifiers

Low current units

Hermetically sealed series H silicon rectifiers have a welded case and heavy duty junction. Ratings are 100 to 600 piv and 750 ma to 55 C.

Sarkes Tarzian, Inc., Dept. ED, 415 N. College Ave., Bloomington, Ind.

CIRCLE 61 ON READER-SERVICE CARD

Miniature Blower

Delivers 165 cfm

At 20,000 rpm the Aximax-3 fan delivers 165 cfm. For cooling electronic gear in missiles, it is 2.8 in. in diameter, 2.3 in. deep.

Rotron Mfg. Co., Inc., Dept. ED, Woodstock, N.Y.

CIRCLE 62 ON READER-SERVICE CARD

CIRCLE 63 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Time Delay Relay

Instant recycling

Using any standard ac or dc operating voltage, the MTRH-8 time delay relay offers instant recycling and accurate timing, independent of voltage variation, for 15 to 180 sec fixed delays. The spst unit weighs 3 oz.

Branson Corp., Dept. ED, 41 S. Jefferson Rd., Whippany, N.J.

CIRCLE 64 ON READER-SERVICE CARD

Spectrum Analyzer

10 mc to 44 kmc range

With one tuning head, the SPA-4 spectrum analyzer covers frequencies from 10 mc to 44 kmc. Amplitude scales are calibrated for voltage and power as well as log.

Panoramic Radio Products, Inc., Dept. ED, 514 S. Fulton Ave., Mount Vernon, N.Y.

CIRCLE 65 ON READER-SERVICE CARD

Power Resistors

5 to 50 w units

Powerpack silicone sealed miniature power resistors have anodized radiator finned aluminum housing and come in 5 to 50 w sizes. Tolerances are from 0.05 to 5 per cent; resistances, from 0.1 ohms to 100 K.

Tech-Ohm Resistor Corp., Dept. ED, 36-11 33rd St., Long Island City, N.Y.

CIRCLE 66 ON READER-SERVICE CARD

Ohmmeter

Measures 1 microhm

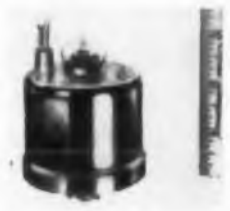
This portable low resistance test set combines model 151-S microhm meter and model SM rectifier for supplying both a 10 and 100 amp dc current source. It measures resistances down to 1 microhm with 2 per cent accuracy.

J. W. Dice Co., Dept. ED, Englewood, N.J.

CIRCLE 67 ON READER-SERVICE CARD

Vibrating Capacitor

±0.2 mv drift in 24 hours



Filled with inert gas, these vibrating capacitors drift less than ±0.2 mv in 24 hours at constant temperatures. Capacitance is 20 μμf, and excitation voltage is 4 v rms, 50 to 200 cps.

Tracerlab, Inc., Dept. ED, 1601 Trapelo Rd., Waltham 54, Mass.

CIRCLE 68 ON READER-SERVICE CARD

Microwave Attenuators

Direct reading

Frequency ranges of these direct reading microwave attenuators are from 2.6 to 3.95 kmc to 12.4 to 18 kmc. Units in each range have 20 or 40 db maximum attenuation. They have a maximum vswr of 1.15 and feature accurate attenuation settings.

Polytechnic Research & Development Co., Inc., Dept. ED, 202 Tillary St., Brooklyn 1, N.Y.

CIRCLE 69 ON READER-SERVICE CARD

CIRCLE 70 ON READER-SERVICE CARD

NEW PRODUCTS

Breadboard Kit

For transistors

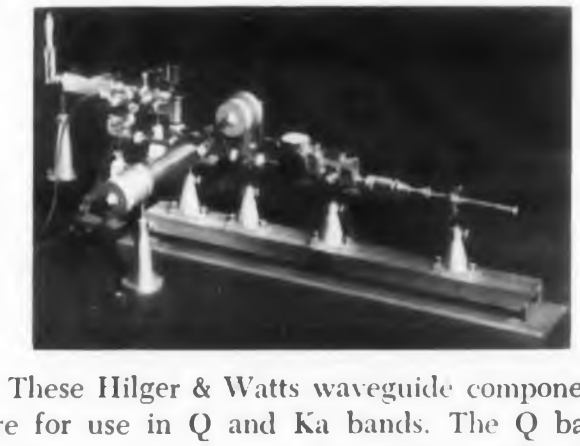
Model BP-31TR transistor mounting kit contains twenty push-in type lugs for component wiring, four no. 3304 round sockets and rings for mounting, four no. 799BC rectangular sockets and four clamps for mounting in flat position.

Specific Products, Dept. ED, 21051 Costanso St., Woodland Hills, Calif.

CIRCLE 72 ON READER-SERVICE CARD

Waveguide Components

For Q and Ka bands



These Hilger & Watts waveguide components are for use in Q and Ka bands. The Q band equipment includes mechanically tuned reflex klystrons, swr indicators, wavemeters, thermistors with mounts, and precision attenuators.

British Industries Corp., Dept. ED, Port Washington, N.Y.

CIRCLE 73 ON READER-SERVICE CARD

Inverter

All transistorized

Transistorized model 4309 is a 9.5 lb, 250 va static inverter that produces both 1 and 3 phase 400 cps power from 28 v dc input. Single phase power is 170 to 200 va; 3 phase, about 50 w.

Varo Mfg. Co., Inc., Dept. ED, 2201 Walnut St., Garland, Tex.

CIRCLE 74 ON READER-SERVICE CARD

Combination Potentiometer and Milliammeter

Two voltage ranges

The MV-1 potentiometer section has two voltage ranges: 0 to 60 mv and also 95 to 105 mv. Its ammeters are scaled from 0 up to 5.0 ma dc.

Technique Associates Inc., Dept. ED, P.O. Box 91, Indianapolis 6, Ind.

CIRCLE 75 ON READER-SERVICE CARD

Pressure Transducer

For airborne telemetering use

For airborne telemetering and control, the P21 pressure transducer comes in ranges from 1 to 1000 psi gage, differential, and absolute. Accuracy is ±0.5 per cent full scale.

Pace Engineering Co., Dept. ED, 6914 Beck Ave., North Hollywood, Calif.

CIRCLE 76 ON READER-SERVICE CARD

Microwave Filter

0.5 db insertion loss

With a power rating of 300 w cw, model 210 tunable uhf cavity filter covers the 200 to 420 mc range. Insertion loss is about 0.5 db; Q factor, about 150; and vswr, 1.3.

Adams-Russell Co., Inc., Dept. ED, 292 Main St., Cambridge 42, Mass.

CIRCLE 77 ON READER-SERVICE CARD

CIRCLE 78 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Q Meter

Range of 100 kc to 100 mc

For use at frequencies between 100 kc and 100 mc. Oscillator is modulated at 60 cps 50 per cent, so that dc amplifiers need not be used in the voltmeter.

North Hills Electric Co., Inc., Dept. ED, 402 Sagamore Ave., Mineola, N.Y.

CIRCLE 80 ON READER-SERVICE CARD

Telemetering Transmitter

Highly stable

Crystal stabilized, the TR-12 telemetering transmitter offers a 225 to 260 mc tuning range and up to 4 w output with a plate supply of 250 v. Its true fm design permits a 125 kc deviation over a 300 cps to 80 kc modulation range with 1 per cent distortion.

Dorsett Labs, Inc., Dept. ED, 401 E. Boyd St., Norman, Okla.

CIRCLE 81 ON READER-SERVICE CARD

Miniature Connectors

Have removable contacts

Snap-in DS connectors have removable contacts, silicone inserts, and crimp-type solderless terminations. Wire depth can be checked after crimping through an inspection hole. The units withstand temperatures from −100 to +300 F.

The Deutsch Co., Dept. ED, 7000 Avalon Blvd., Los Angeles 3, Calif.

CIRCLE 82 ON READER-SERVICE CARD

Flexible Coupling

Weight 1.5 g

Gear Grip 5-G is a flexible coupling 0.74 in. long with a 0.4 in. OD. It weighs 1.5 g. End fittings are available with or without 4-40 set screws. Standard shafts are 1/8, 3/16, and 1/4 in.

Guardian Products Corp., Dept. ED, 1215 E. Second St., Michigan City, Ind.

CIRCLE 83 ON READER-SERVICE CARD

Multipoint Control

Nonindicating

Adjustable for one through six-point operation, model 6134 is a continuous control for use where no chart record is needed. The device needs no batteries, standard cell and standardizing mechanisms, or periodic standardization. Scanning cycle is adjustable to 2, 5, or 10 sec per point.

Daystrom, Inc., Daystrom-Weston Industrial Div., Dept. ED, Newark 12, N.J.

CIRCLE 84 ON READER-SERVICE CARD

Silicon Transistor

For switching and transmission

A vacuum-sealed npn unit, the 2N560 double diffused silicon transistor is for low power, high gain switching and transmission applications. Maximum collector voltage is 60 v; maximum collector saturation current, 0.1 μa at 20 v; and maximum collector capacitance 12 μμf at 5 v.

Western Electric Co., Inc., Dept. ED, 120 Broadway, New York 5, N.Y.

CIRCLE 85 ON READER-SERVICE CARD

CIRCLE 86 ON READER-SERVICE CARD ►

NEW PRODUCTS

Time Delay Relay

60 msec to 600 sec

This time delay relay is a 6pdt, 5 amp type with delays from 60 msec to 600 sec. Either delay-on-make or delay-on-break configurations are available. Accuracy from —62 to +72 C at constant 28 v dc is ±4 per cent. Shock, acceleration, and vibration meet MIL-E-4970.

Voi-Shan Mfg. Co., Dept. ED, 8463 Higuera St., Culver City, Calif.

CIRCLE 87 ON READER-SERVICE CARD

Audio Oscillator

±0.002 per cent frequency stability

Frequency stability of the TCO 300-OC transistorized crystal oscillator is ±0.002 per cent from —55 to +85 C. The unit has oven control and square-wave type output. It stands 100 g shock and 10 g vibration to 2000 cps.

Dynamics Corp. of America, Reeves-Hoffman Div., Dept. ED, Carlisle, Pa.

CIRCLE 88 ON READER-SERVICE CARD

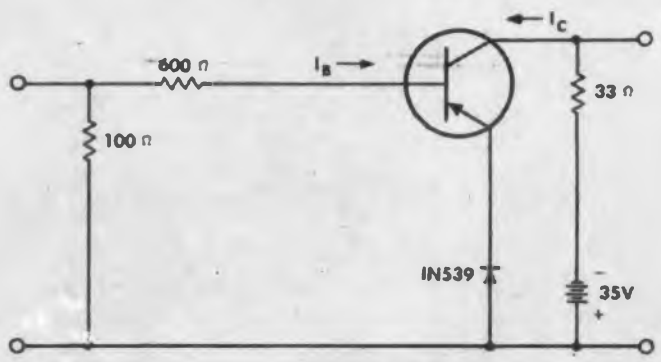
Miniature Motor

Weighs 3 oz

Producing 0.2 oz-in. torque at 10,200 rpm, the 65JG1 blower motor is 1.07 in. in diameter, 1.32 in. long, and weighs 3 oz. The 27 v ac,

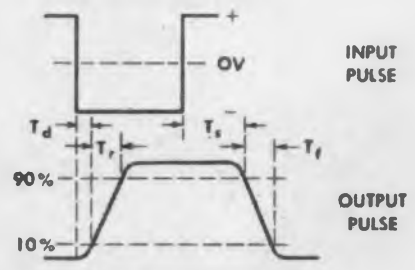
GERMANIUM POWER TRANSISTORS!

TYPICAL SWITCHING CHARACTERISTICS



TYPICAL SWITCHING TIMES

T_d	Delay Time	0.3	μsec
T_r	Rise Time	0.7	μsec
T_s	Storage Time	1.2	μsec
T_f	Fall Time	0.5	μsec



TEST CURRENTS

I_{B1} (Turn-on Current) = – 30mA

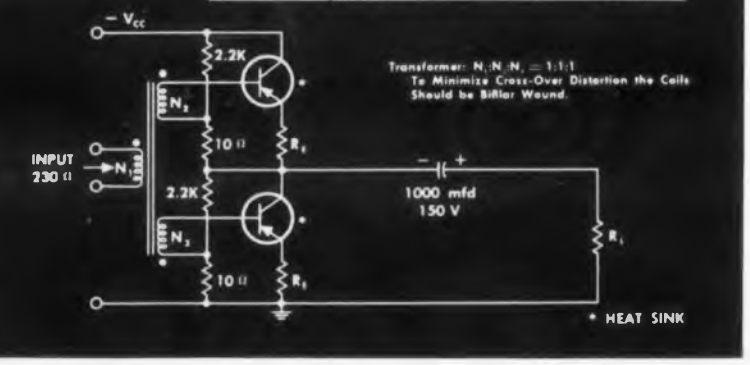
I_{B2} (Turn-off Current) = + 30mA

I_C (Collector Current) = – 1A

TYPICAL 20 WATT AMPLIFIER

POWER GAIN = 23 db

TRANSISTOR	V_{CC} V	R_L Ω	EFFICIENCY	DISTORTION 20 WATTS	R_s Ω
2N1021	–80	30	66%	2%	3
2N1022	–100	50	66%	2%	5



NEW HIGHEST FREQUENCY COMPUTER POWER TRANSISTOR

(ACTUAL SIZE)

NEW TI 2N1046 combines *high power, high frequency* and *high voltage* performance in a single transistor package! This P-N-P diffused base germanium transistor has *guaranteed* dissipation to 15 watts and collector breakdown voltage to 80 volts with 12 mc typical alpha cutoff. Extremely low collector reverse current averaging 0.2 ma at 40 volts and a low 0.75 ohm saturation resistance assure reliable operating characteristics.

Designed for your deflection circuits and computer core driving applications, the 2N1046 has a typical 10mc internal cutoff frequency, f_T (point at which forward current transfer ratio equals unity).

NEW HIGHEST VOLTAGE TRANSISTORS

(ACTUAL SIZE)

NEW TI 2N1021 and 2N1022 germanium transistors, *with maximum operating voltages of 100 V and 120 V respectively,* provide typical betas of 70 at 1A . . . 23 at 5A!

You get *guaranteed* 700 μA maximum collector reverse current at one-half rated voltage and 2mA maximum at full rated voltage in addition to extremely low saturation resistance . . . 0.08 ohm R_{CS}.

For your audio, servo and power applications, consider these outstanding performance characteristics and specify TI germanium transistors.

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3 phase, 400 cps unit meets MIL-M-13787 specifications.

Western Gear Corp., Dept. ED, P. O. Box 182, Lynwood, Calif.

CIRCLE 89 ON READER-SERVICE CARD

Quarter Square Multiplier

For analog computers

For use with analog computers, model 7007 multiplier utilizes a variation of the quarter square multiplication technique and avoids the need for internal amplifiers. Besides improving the frequency response of any analog computing facility, the unit offers low noise and infinite resolution.

Electronic Associates, Inc., Dept. ED, Long Branch, N.J.

CIRCLE 90 ON READER-SERVICE CARD

DC Differential Amplifiers

Transistorized

Series 130 amplifiers are high gain dc differential units with two inputs and two outputs. They offer a wide variety of performance characteristics which can be obtained by selection of feedback elements. Open loop gains from 60 to 85 db are available.

Burr-Brown Research Corp., Dept. ED, Box 6444, Tuscon, Ariz.

CIRCLE 91 ON READER-SERVICE CARD

◀ CIRCLE 92 ON READER-SERVICE CARD

NEW PRODUCTS

Power Transistors

Maximum ratings of 65 w and 13 amp

Germanium pnp types, power transistors CTP 1511 through 1514 are capable of a current gain of 60 to 120 at 5 amp and 50 at 10 amp. Collector to base breakdown voltage ranges from 40 in the CTP 1514 to 100 in the CTP 1511. Absolute maximum ratings are 13 amp of collector current, 90 C junction temperature, and 65 w collector dissipation. Total power dissipation at 70 deg and mounting base temperature is 20 w.

Clevite Transistor Products, Div. of Clevite Corp., Dept. ED, Waltham 54, Mass.

CIRCLE 93 ON READER-SERVICE CARD

Panel Meter

Has many faces

A variety of panel meters in one, the Unimeter has a basic movement section to which any number of dial components can be fitted in seconds. Dustproof and accurate, it has self-shielded bar-ring movements and ac and dc linear scales.

The Triplett Electrical Instrument Co., Dept. ED, Bluffton, Ohio.

CIRCLE 94 ON READER-SERVICE CARD

Waveguide Tube

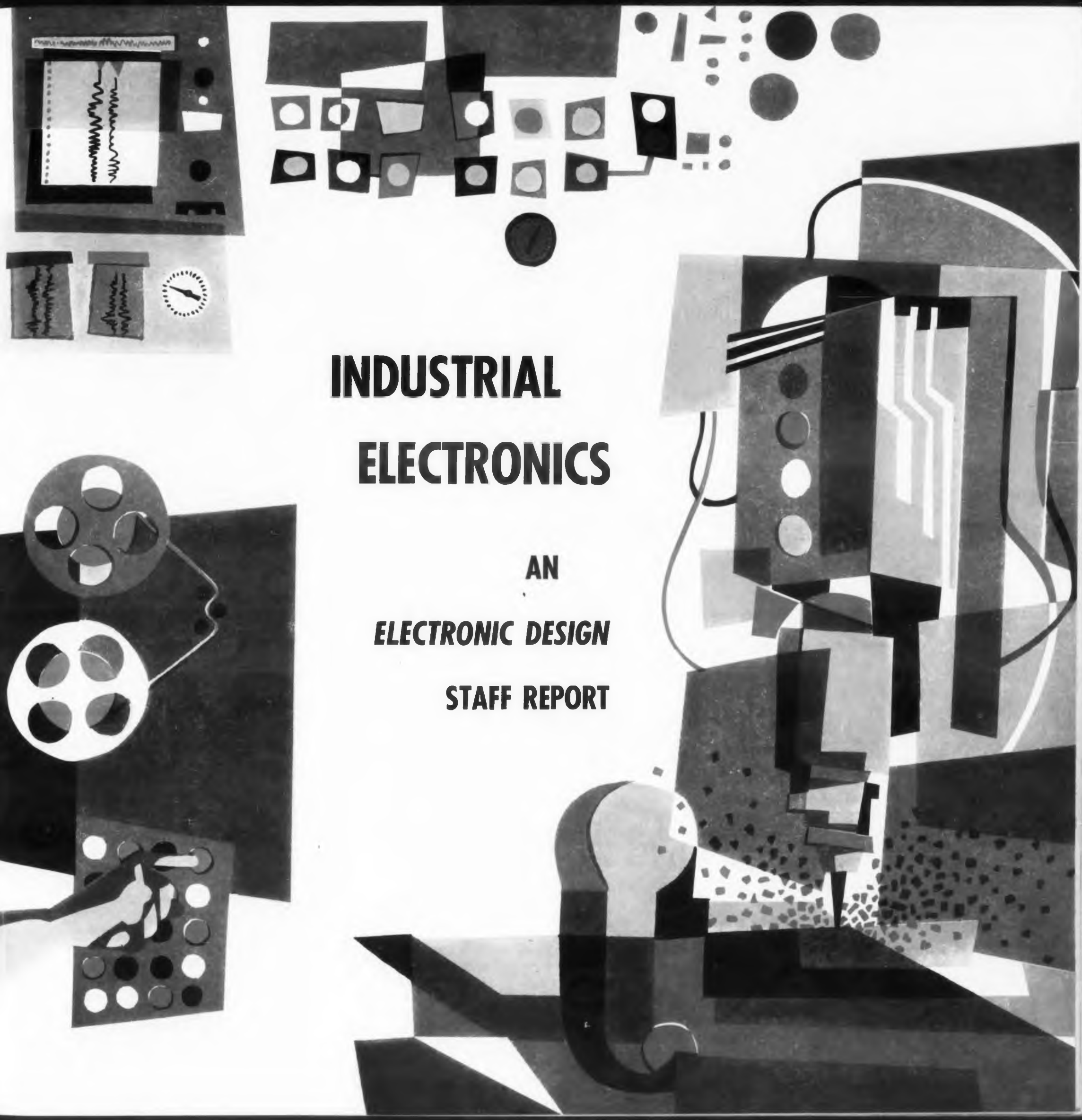
Has sharp corners

Sharp radii permit critical waveguide dimensions to be held into the corners of this stainless steel rectangular tubing. Standard tubes are 5 ft long with inside dimensions from 0.311 x 0.622 ±0.002 in. to 0.0 x 0.9 ±0.003 in.

Superior Tube Co., Dept. ED, 1521 Germantown Ave., Norristown, Pa.

CIRCLE 95 ON READER-SERVICE CARD

◀ CIRCLE 96 ON READER-SERVICE CARD



INDUSTRIAL ELECTRONICS

AN

ELECTRONIC DESIGN

STAFF REPORT

Industrial Electronics

An ELECTRONIC DESIGN staff report

George H. Rostky

Associate Editor

Process and Machine Control in Action

Lithium Corp.'s processing plant uses both pneumatic and electrical instrumentation, provided by The Bristol Company.

"ANYTHING you want done, we can do with electronics." This old saw has worked out so well in military applications that we lose sight of the fact that there are other ways of doing things. The electronics engineer, on his first tour through a chemical processing plant, or an oil refinery might be quite surprised to see how much control is in the hands of pneumatics, or hydraulics, or mechanical gear.

He may well wonder: "Can't we do these things with electronics? Why don't we?" And therein lies a tale.

Decisions, Decisions, Decisions

From the very start, an engineer on a plant automation project must make far-reaching decisions—many of them by no means clear cut. He'll have to decide:

- Is automation worthwhile? Will production economies, increased production, a superior product, or tougher competition justify the expense of automatic control?
- How extensive should the system be? Should we control one machine, one line or process, or an entire plant? Shall control be open-loop or closed-loop?
- How reliable will it be? How much will reliability cost? What will down-time cost?
- How many measurements are necessary and how important are they?
- How accurate and how must the system be? be?
- Shall instrumentation be electronic, pneumatic, hydraulic, mechanical—or a combination?

Fingertip control for Northrop Aircraft s giant Kearney and Trecker profile and contour milling machine.

The business end of a giant tracer-controlled profile milling machine. Electronic controls are by GE's Specialty Control Dept.

Chips fly as a deep cut is made in stainless steel by a numerically-controlled machine system with controls by Northrop.

■ If electronic—shall it be vacuum tubes, transistors, or magnetic amplifiers.
■ Shall information be analog or digital?

Some Typical Installations

Our engineer might want to look into some installations to see just how things have worked out. He'd want to know what headaches others have had as well as the successes they've had. Here's what he'd probably note.

Oil Refining. Tidewater's Delaware Refinery is the largest ever planned and constructed as one overall effort. C. F. Braun & Co. designed and constructed the refinery, but many other companies provided systems, instruments, and hardware. Panellit, Inc. designed thirteen data handling systems to process information from 4700 points throughout the refinery.

Most of the instrumentation is pneumatic. This was motivated by several factors:

• Since control houses are centrally located, the average distance of signal transmission is no more than about 250 feet.
• Response speed is not particularly critical for controlling most of the processes.
• Many employees were already familiar with pneumatic instruments.
• There was no electronic signal standard among manufacturers, while there is a pneumatic signal standard (3 to 15 psi to represent zero to full range).

Tidewater insisted on a high degree of equipment standardization to cut inventories and ease maintenance. Redundancy was one of the keys to reliability. Almost every motor, for example, can be powered via two distinct paths.

■ At the de-waxing plant of Esso Standard Oil Co.'s Bayonne, N. J. Refinery, our engineer would find a sticky problem automatically controlled. An electro-pneumatic system controls filter washing. Before its installation, filters were cleaned by manually operating a sequence of valves. Now, a battery of electrical timers is energized when the system detects too low a filter feed rate, indicating a dirty filter cloth.

Relays connect time-controlled contacts to electro-pneumatic actuators for the filter control valves. Then feed, vacuum, and cold solvent valves are closed. The valve for hot solvent filter wash is opened and the filter is cleaned. Hot solvent is then closed off automatically, and feed and cold solvent returned to service.

In addition to automatic and semi-automatic control, the system provides visual indication of the cycle progress on a panel and warns of abnormal conditions.

■ An installation where computers are especially helpful is at the Baton Rouge Refinery of Esso Standard Oil Company. Here, a field trial system installed by Leeds & Northrup has been operating round-the-clock since July 1, 1958.

One hundred sixty process variables are scanned at about a point a second. A Speedomax Type "H" indicator, equipped with a Giannini shaft position encoder, digitizes the millivolt-level analog signals. On command from the computer, the digital information is sequenced into a Royal Precision LGP-30, general purpose, small-sized digital computer.

Operations including averaging readings on an hourly and daily basis, checking for "off-normal" points, preparing information for print-out, scaling, and linearizing are performed by the computer. In addition, the computer solves complex equations and prepares 27 operating guides including catalyst circulation rate, carbon burning rate, and material balance.

Though the computer doesn't automatically control the system, it guides the operator in changing control loop set points. Closed-loop control may follow when the operator's knowledge and experience can be reduced to equations which can be programmed into the computer, and when equipment is added which can adjust control set points based on information from the computer.

Chemical Processing. Pneumatic controls are far in the lead over other types in the chemical industry. Only now, with newer requirements for faster and more complex control, and with the need for rapid computer processing of information, are the chemical industries beginning to turn to electronic control. But they have many qualms which must be overcome.

At the Bessemer City, N. C. plant of the Lithium Corp. of America, the production of vital lithium compounds is controlled over every step from the first kiln heating to the final continuous crystallizer. Normally in operation 168 hours a week, the instrumentation provided by The Bristol Company had to withstand corrosive

INDUSTRIAL ELECTRONICS

Input control console of Daystrom Systems' solid state computer, controlling 350 point alarm-scanning system at the new steam electric station of the Louisiana Power and Light Co., Monroe, La.

attacks of excessive moisture, abrasive effects of dust, and interference from vibration.

Though temperature, pH, pressure, and flow are measured and controlled with pneumatics and electronics, all the instrument-directed automatic controls are pneumatic.

Steel Processing. Steel mills throughout the country have been using electronics extensively for measurement and control, and electrical, mechanical, and hydraulic devices for actuation. X-ray thickness gages detect steel thickness and relay information to remote indicators and recorders. Infra-red width gages, in closed loop systems, help keep strip width within tolerances. Industrial television allows a close view of difficult-to-get-near processes.

Metal Working. Here, electronic sensing, and control by magnetic or punched tape are married to electro-mechanical or hydraulic-mechanical actuation. Companies like General Electric's Specialty Control Dept., Bendix Aviation Corp.'s Industrial Controls Section, Magnasync Mfg. Co., Electronic Control Systems, Northrop Aircraft, and many others have developed controls for milling machines, drill presses, jig borers, stampers, welders, and a host of other machine tools. These controls insure greater precision and speed as well as dollar economies.

Lamp Making. Here is an industry where a very large variety of measurements must be made; where many types of action must be controlled; where high speed and accuracy are the rule rather than the exception. At Westinghouse Electric Corp.'s Lamp Division in Bloomfield, N. J., one might see measurements with photocells, ultrasonics, geiger counters, optical systems, and microphones.

Resistance of photoflash lamps (less than 1/2 ohm) must be measured to within one per cent at speeds faster than 3000 per hour. Thermocouples measure oven temperatures; waxes, stains, and radiation devices measure temperatures of moving parts. Temperatures to be measured vary from minus 40 C to 2400 C.

Measuring rates vary over the wide range from one per minute to 1000 per second. Required actuator response varies from a millisecond to five minutes. Instruments often have to tolerate tough environments—humidity, heat, and corrosion.

Electric Power Generation. Here is an area where electronic control is a natural. At the Sterlington Station of the Louisiana Power and Light Company, Daystrom Systems has installed a solid state, general purpose digital computer for alarm scanning and print-out. This versatile equipment replaces conventional historical recorders, scan recorders, bearing monitors, integrators, and hand logging.

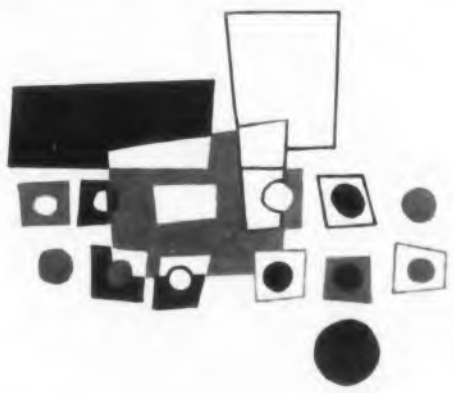
Automobile Assembly. Assembly line speed control is very important in any mass production industry. Ford Motor Company's assembly plant in Mahwah, N. J. uses an adjustable speed motor control to regulate assembly line speed. An eddy-current coupling transmits power to the line from a constant speed synchronous motor through a magnetic coupling.

A small tachometer on the output shaft generates a voltage proportional to shaft speed. It is fed back to the magnetic coupler to keep slip speed constant.

All That Glitters . . .

Armed with just a glimpse of a few installations, and knowing the monumental effort and planning behind them, our engineer may want to probe more deeply. He may want to see just why one installation used electronic control rather than pneumatic; why one company preferred transistors, another vacuum tubes, and another magnetic amplifiers.

What he would learn appears on the following pages of this report, a free reprint of which is available if you turn to the Reader-Service card and circle **100**.



Instrument panel section for controlling drying kiln for Lithium Corp. of America.

Designing For Industry

INDUSTRY measures almost everything. An ELECTRONIC DESIGN survey among users of industrial control equipment revealed a wide variety of measurement requirements in addition to the usual flow, pressure, temperature, liquid level, and displacement.

Even within individual companies, types of measurements might include diameters, speed, pH, viscosity, humidity, presence of parts, position, and weight. Transducers run the gamut from bourdon tubes, strain gages and thermocouples to photocells, pyrometers, microphones, Rayotubes,* differential transformers, and a variety of resistive, capacitive, and magnetic devices.

The range of measurements is very wide indeed. Pressures vary from 1 to 20,000 psi, temperatures from minus 65 to 2400 C, weight from less than a milligram to more than 500 lb.

Accuracy requirements fall between 0.1 and 10 per cent with the dominant requirement for 1.0 per cent accuracy (or repeatability).

Preference for amplifying devices was split almost evenly among electron tubes, magnetic amplifiers, and transistors, with tubes leading by a small margin. Most users preferred line operation to batteries; and most didn't rate equipment size an important consideration.

Results of our survey and of many personal interviews revealed many of the motivations underlying the decisions designers have to make. They show clearly why designers grey too soon.

Electronics? Pneumatics? Hydraulics?

No doubt the first decision the systems man faces is what type of energy he wants to handle, what type of signal he wants to transmit. Each has merits. Each has drawbacks.

Pneumatics. In the chemical and petroleum industries (largest users of process control instrumentation), pneumatic signal transmission is far and away the most popular form—for many reasons. For one thing, pneumatics came first. By now pneumatic signal levels and impedance levels are well standardized. All manufacturers use signal levels of 3 to 15 psi to represent zero to full range for transducers, actuators, and recording instruments. This makes it easy to build integrated systems with equipment supplied by different manufacturers. (Electronic equipment manufacturers, on the other hand, are too shy to publicly disclose what signal levels they're using.)

For simple process controls, pneumatic hardware is fine. Pneumatic circuits are fast enough for short transmission distances, yet they can provide long time constants. Simple logical circuitry (AND, OR, etc.) can be designed. And

* Leeds & Northrup trademark.

with minimum maintenance, pneumatic equipment can work for years.

But for control over long distances, pneumatic systems are sluggish. Response is slow for transmission distances much in excess of 200 feet. For complex controls, pneumatics becomes cumbersome, if not impossible.

Pneumatic power supplies require very careful design. The equipment just can't work on dirty oily air.

Hydraulics. For servo control of machine slides, probably nothing is more popular than the hydraulic piston. It provides high dynamic response and stiffness; accurate, rapid, position control; and very smooth, short, straight-line strokes. And it's fine for heavy duty cycles with lots of start-stop action.

Offering repeatability to better than 0.001 in., hydraulic actuators are smaller than electrical ones, and they have less inertia.

Faster even than pistons, are the rotary hydraulic motors which, with preloaded ball-bearing leadscrews, provide fast, rigid, straight-line drives. And happily, high gain, highly stable systems are easy to design.

On the other side of the ledger—hydraulics is almost never justified for fractional horsepower applications, and the compressibility of oil limits frequency response. Hydraulic power supplies are large, and almost always dirty and greasy. And though some units boast very low leakage, they are rare. Leakage is a constant problem.

Mechanics. Particularly in machine control, it's almost always necessary to convert the rotary motion of a prime mover to a linear machine motion. This mechanical link is usually a leadscrew.

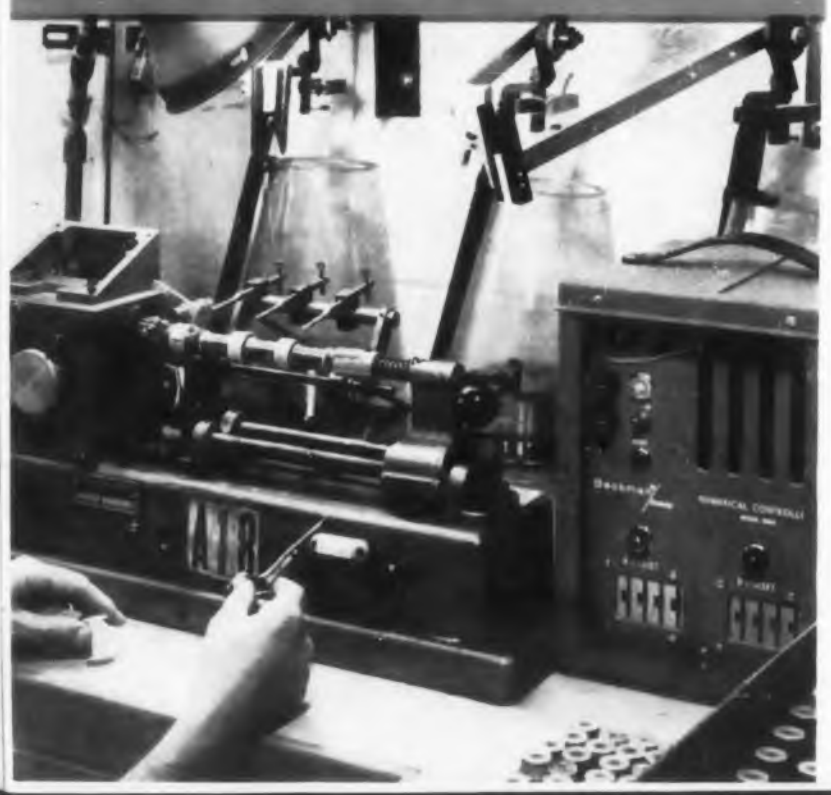
The conventional leadscrew has a high mechanical advantage. That's good. It's rigid. That's good too. But to minimize backlash and elasticity, friction and stiction, a leadscrew requires very exacting design. And for motion beyond about eight to ten feet, the leadscrew must be displaced by a rack and pinion, which suffer from backlash even more. The machine designer has to fight with deflection, weight, and inertia, backlash and elasticity, friction and stiction. And he has to keep the price down too.

Electronics. For very complex control, where there are many interdependent variables; for the most rapid control over long distances; for accuracy, flexibility, and versatility; for handling lots of data; and for the fastest computation—nothing beats electronics. Even the chemical companies, traditional users of pneumatic equipment, even they are "looking electronic."

The costs for pneumatic and electronic equipment are comparable. Though first costs of electronic equipment are somewhat higher, installation costs are somewhat lower. Electronics can

Hydraulic servo on Bendix punched tape controlled milling machine.

Mechanical rotation is converted to digital electronic form by magnetic proximity pickup in Beckman's automatic coil winder.



now match pneumatic performance. Until recently, electronic equipment couldn't provide the long time constants (minutes or even hours) required in some applications. But now it can. Improved materials (like Mylar), have enabled the design of capacitors with very low leakage, and with reasonable size and cost.

Electronics has a long way to go to win the field. Its complexity can frighten a man who works with pipes and tubes that carry stuff you can touch. Electronics must overcome his prejudices. This man's attitude on the reliability of electronic equipment may have been formed when his television receiver at home conked out in the middle of a World Series game.

Electronic equipment manufacturers have not standardized their signal levels, as have pneumatics companies. And they have not yet fully convinced the rest of the industry that electronic equipment can be as safe (explosion-proof, for example), and as reliable as any other.

Tubes? Transistors? Magnetic Amplifiers?

Electron Tubes. Tubes are good. They're good for high impedance circuits, for high frequencies, and for high voltages. They can control power levels up to about 40 watts with no strain. And by now, tube makers know how to turn out really good tubes that can last for years—if you don't push them too hard, and if you don't keep pulling them for testing.

Even the old, full-sized, low cost radio receiver tubes are good. Many plant service and maintenance people distrust them. They don't realize that many of their premature failures were caused by misuse and misapplication. According to Harry Palmer, Manager of Engineering at GE's Specialty Control Department, these tubes are remarkably reliable considering their price. He points to considerable evidence to indicate that if a tube of this type has operated in given application for 15 or 30 days, it has exceedingly high probability of lasting 3 to 5 years—if undisturbed and not subjected to abnormal operating conditions.

Disturbing a tube for testing serves no purpose. Conventional tube testers have little value in testing for deterioration. They just fail to consider how a tube is used in a circuit.

But tubes do fail. And it's hard to predict when they'll fail.

Transistors. These ten-year-olds have a promising future. Newer production methods promise even better transistors and diodes. Silicon units especially, with their tolerance to high temperatures, will establish a firmer foothold in industry—when their price comes down more.

In contrast to tubes, marginal operations of transistors and semiconductor rectifiers can be checked. End of life can be predicted, so unscheduled down-time can be avoided.

Perhaps the most exciting development in the semiconductor field is GE's new silicon controlled rectifiers. These "semiconductor thyratrons" can be controlled with very small power levels. They can deliver heavy currents to a load. And they should last many times longer than the relays and gas-tube thyratrons they can replace. Unfortunately, they usually require special drive circuitry. Most bitter complaint about them: "Can't buy enough of them for adequate tests."

To industry, the most attractive aspect of transistors is their potentially indefinite life. The most troublesome aspects are their sensitivity to temperature variation, their low voltage ratings, and their low power dissipation. Their gain drift with temperature can be tolerated in operational amplifiers and a few other circuits, but in most applications it must be compensated for at the cost of added circuit complexity.

Their small size, a boon to the military, is no powerful consideration for industry. Battery operation is something industrial users are a bit chilly about. Keeping a stock room supplied with a large assortment of batteries (with limited shelf life) is nothing to look forward to.

Magnetic Amplifiers. Magnetic amplifiers are moving into industry—and at an ever increasing pace. Some magnetic amplifier types can operate from infinitesimal signal levels. Others can control power levels unthinkable with most tubes. They can be designed for very long life (10 to 20 years). And they can do many jobs that relays can do—without moving parts.

But they are expensive. Each one must be designed for a specific job. Companies like Westinghouse and Control, Div. of Magnetics, Inc., have made a valuable contribution by introducing lines of standard control reactors as stock items.

Their usual time constant of 8 to 10 cycles makes them too slow for most plants which are limited to 60 cps current. They're fine for controlling temperatures—a slow process anyway. Their principal weakness is that a magnetic amplifier is no better than the diodes it uses. Improved techniques of diode manufacture, and very conservative design can correct this.

Analog? Digital?

Analog. Almost every process or machine control system starts with analog information. A trans-

ducer measures some process variable, and provides a signal proportional to the variable. In many cases, the signal is quite feeble, so amplifiers are needed. The more amplification required, the more likely it is that the system will suffer from jitter, instability, or drift. These amplifiers demand excellently regulated power supplies.

Usually less expensive, less rapid, and less accurate than digital computers, analog computers serve admirably in simulating complex processes, and thus lay the groundwork for optimum control.

Digital. For fastest computations, or computations where large volumes of data must be handled, digital computers are the answer. They're highly flexible, and most accurate.

However, since transducer signals are analog, these signals must be digitized for computer use. And if the results of computation are to be used directly to control actuators, the computer's output must be converted back to analog form.

Analog to digital, and digital to analog converters are weak links. They lose accuracy in the system, and they're less reliable than other parts. The solution is obvious: Somebody must invent transducers with digital output and actuators for digital input.

Proportional? Discontinuous?

There are always processes that almost cry aloud for one specific type of control action. But more often, it's necessary to weigh relative advantages.

Discontinuous action is usually less expensive and potentially much faster. Actuators work at top speed, with full power applied, for a larger portion of their duty cycle. But discontinuous action usually demands very exacting start-stop control and complex computing circuitry. That's why proportional servos are the usual choice for rapid response. Furthermore, proportional circuitry can often be used to correct for certain errors in the controlled machine.

Problems With Recorders

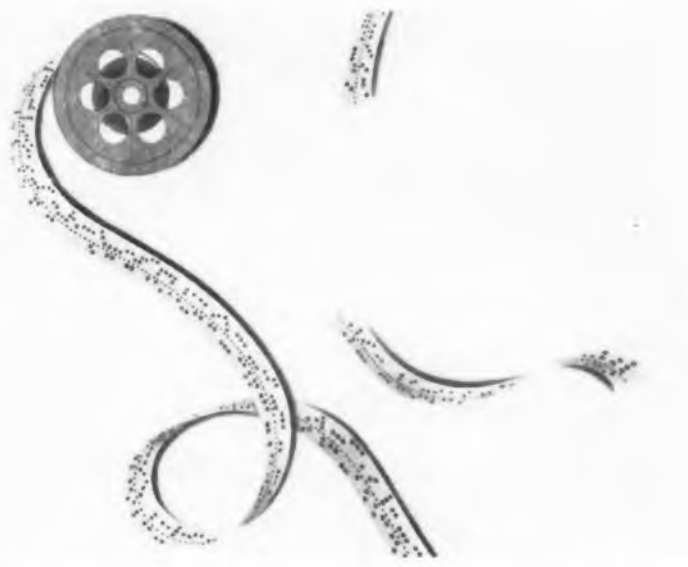
Written records of process variables will be required at almost any installation. Control centers for any sizeable process are always marked by vast panel areas covered with indicating devices and a multitude of recorders. This has gone about as far as it can go.

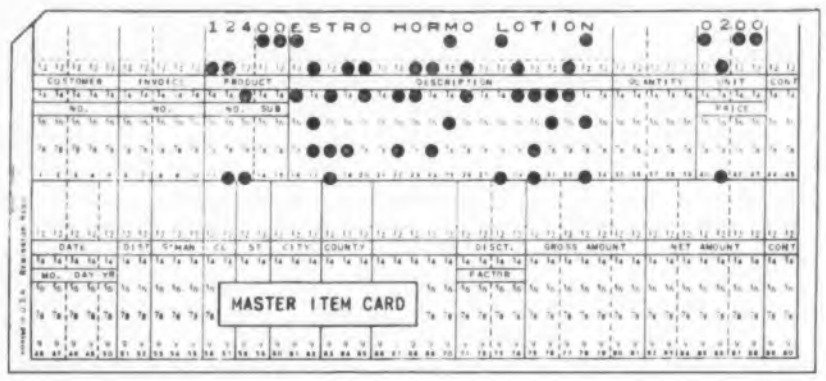
The trend today is away from walls full of recorders. Replacing them are smaller, less expensive indicators, and a handful of portable plug-in recorders. Even these are being replaced by data loggers.

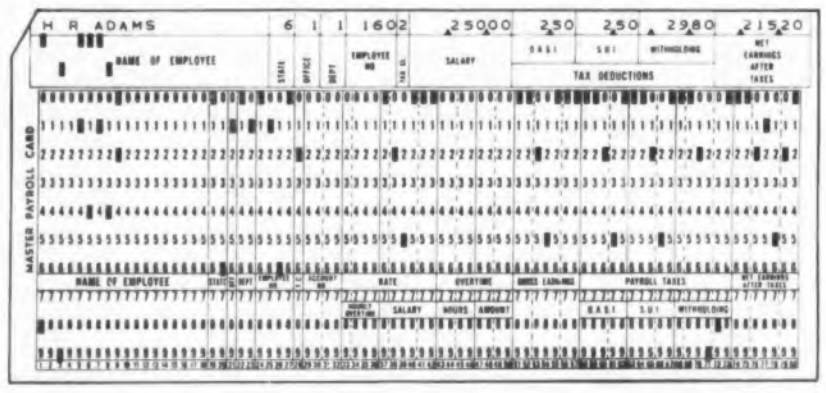
(Continued on following page)

Recorders have problems. The same instrument may have to follow very slowly varying curves or extremely rapid pulses.

Writing on paper is tough. Almost all pens skip at one time or another—or they pour. Inks are a headache. Fast drying inks evaporate too fast and can leave pigment all over the inside of the equipment. If ink dries too slowly, it may run over the paper or smudge.







Remington Rand's "round hole" punched tape (top) and 90 column punched cards (center) and IBM's "square hole" punched card (bottom). Cards and tapes like these are the information and control center for a vast array of industrial control applications. In modern industrial control, they are perhaps the most popular forms of storing information.

Paper must be very carefully designed. It must be neither too slick nor too absorbent. It must resist the effects of temperature and humidity variations. Pressure sensitive paper is good, but it must be shielded from ambient light.

Print wheels, used instead of pens, can alleviate many problems—but they're often not as fast, and seldom plot as closely.

Everybody Wants Reliability

Industry wants reliability. Not the same kind the military needs—nor at the same price. A thousand hours of dependable life for a resolver, synchro, or selsyn will usually keep the military happy. But that's not enough for industry.

The military will often sacrifice long component life for small size and optimum shape; and will pay top dollar for the package. Even "commercial grade" rotary inductive components are basically in a military package. This may be satisfactory, say for commercial airlines, where everything is overhauled every 500 hours. But it's not good enough for industrial environments.

Industry needs less costly, longer-lived components, and will accept larger, over-designed parts (a luxury the military usually can't afford).

Some manufacturers boast of millions of operations for their relays, contactors, solenoids, and other components with moving parts. But for fast moving production lines this is not enough.

At Westinghouse Electric's Bloomfield, N.J., Lamp Division, Dave Bogdan, in charge of electrical equipment design, points to requirements for 3000 operations an hour, 16 hours a day, for a year at least, preferably five years—without replacement. Virtually nothing on the market meets with such requirements. Many relays fail at pivots before contacts go. Coils burn out before other parts fail. And solenoid valves stick.

The Plug-In Dilemma. Low-cost, plug-in components (even resolvers and synchros) would find a ready market. Many companies designing control systems can't afford to design and manufacture their own components. Standard plug-in components, designed for long life, high accuracy, easy maintenance, and wide adaptability, can be a boon to designers of industrial control systems.

But many engineers don't trust plug-ins. They're suspicions of any sliding or pressure contact. They feel that the only truly reliable electrical connection is the soldered joint.

This may be so, but it certainly makes for problems. If a resistor fails in a large complex assembly, how much down-time will it cost before it can be found and replaced?

However reliable the soldered joint may be, few engineers would risk installing complex gear in an industrial environment without provision

or plug-in subassemblies.

The Servicing Dilemma. Everybody wants reliability. But it's not an unmixed blessing—especially with complex equipment. How do we acquire servicing experience with equipment that rarely gives trouble? What happens if, after two or three years of uninterrupted service, the equipment fails? Who knows how to fix it?

One chemical company spokesman told ELECTRONIC DESIGN of a recently installed piece of electronic control equipment that performed superbly. Nobody at the chemical plant knew how to service this complex apparatus. It never needed service.

If it ever broke down, the manufacturer would send the original design engineer to repair it. He, and only he, understood the equipment thoroughly. "If he should leave that company—or die," commented the chemical man, ". . . we shudder to think."

The Cost Dilemma. Reliability is expensive. It often involves overdesigned components and redundant circuitry. But the cost of one unscheduled shutdown can by far exceed the additional expense of reliable equipment. In one case, sixteen hours of down time for a data logger cost a company a month's savings that the logger had accrued.

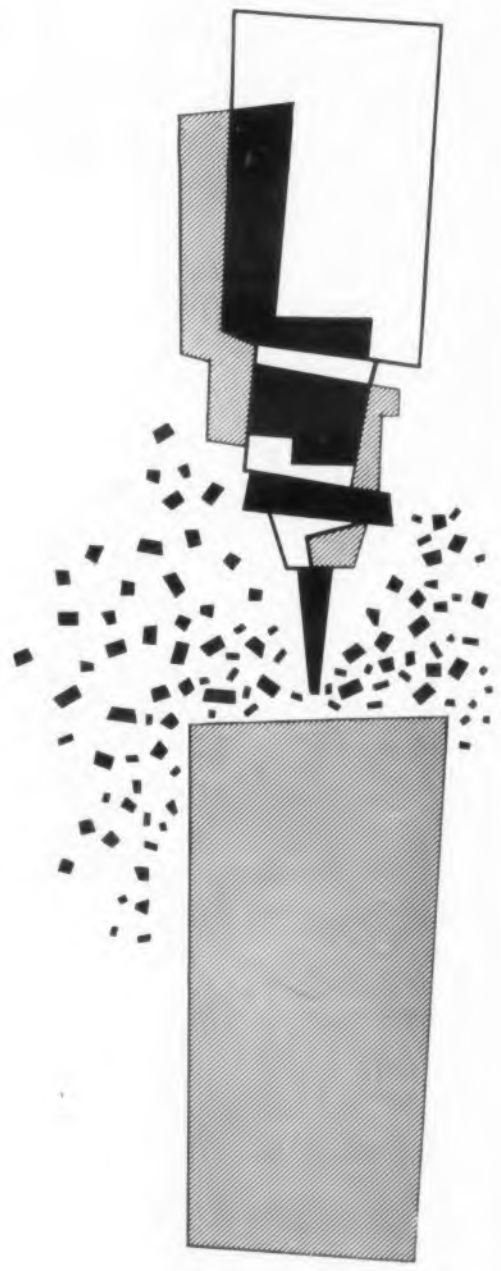
Costs can often be cut without sacrificing reliability. Where components will live in a protected environment (inside a cabinet), protective component housings can often be eliminated. Costs go down when open transformers, inductors, and relays are used instead of sealed and potted units.

But extra design care is required with exposed components. Moisture, dust, and other contaminants can impair their reliability). (Purified cooling air may often be required.) Even nonconducting particles can spoil bearings, pivots of contactors and relays, and create severe leakage problems in high impedance circuits.

Where Do We Go From Here?

There's plenty of room for progress in controlling processes and machine tools. We still need transducers with huskier output signals, and more accurate position transducers for machine control. We still would like to improve machine accuracy without sacrificing speed or stability. We still would like to get around the limitations imposed by moving parts. The speed of many control systems is limited by the time it takes to move a piston, close a relay, open a solenoid or stop a motor.

The host of problems besetting the control engineer testify to the fact that the ideal control system is not yet with us.



CREDITS

Our many thanks to the following companies and their engineers who supplied information for this report.

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The Bristol Co.
Waterbury 20, Conn.
Corning Glass Works
Corning, N.Y.
Daystrom Systems
Div. of Daystrom, Inc.
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Hawthorne, Calif.
The Swartwout Co.
18511 Euclid Ave.
Cleveland 12, Ohio
Tidewater Oil Co.
Wilmington, Del.
Westinghouse Electric Corp.
Lamp Div.
Bloomfield, N.J.

Precision Comparator

For go, no-go measurements

Measurement regions may be set up accurate to 0.01 per cent with these dc comparators. The units permit go, no-go regions to be established for any measurement which may be expressed in dc voltage terms. Detectable differences are 1 mv, and drift is less than 1 μv per day. All models are fail-safe.

Optimized Devices, Inc., Dept. ED, P.O. Box 38, Gedney Station, White Plains, N.Y.

CIRCLE 113 ON READER-SERVICE CARD

UHF Amplifiers

3 to 7 db noise figure

LNA series two-stage grounded-grid amplifiers have a 250 to 1000 mc frequency range and a 3 to 7 db noise figure. They are available with cavity or line type interstage and output coupling. Gain is 25 to 38 db for the line type; 33 to 38 db for the cavity type.

Ewen Knight Corp., Dept. ED, Needham Heights 94, Mass.

CIRCLE 114 ON READER-SERVICE CARD

RF Transmission Cables

Foamed and solid dielectric

For TV systems, this line of eight rf transmission and distribution coaxial cables includes single and double shield types in both foamed and solid dielectric.

Entron, Inc., Dept. ED, P.O. Box 287, Bladensburg, Md.

CIRCLE 115 ON READER-SERVICE CARD

NEW PRODUCTS

Hall Generator

Flat frequency response to 1 mc

Useful in instruments and as an nalog computer element, the Hall generator can multiply two elec-rical quantities if they are ex-ressed as current and magnetic ield. This is because its voltage utput is proportional to the roduct of the control current pass-ng through it and the magnetic eld perpendicular to its major ace. Owing to its fast response, his semiconductor device can also e used to measure the power con-nt of transients. Maximum value f control current is 500 ma; in-rnal resistance for control cur-nt, 1 ohm; and flux density range, to 10 kilogauss. Frequency re-ponse is flat up to 1 mc.

Westinghouse Electric Corp., Dept. ED, P.O. Box 2099, Pitts-urgh, Pa.

CIRCLE 117 ON READER-SERVICE CARD

RF Coaxial Connectors

Have aluminum shells

With aluminum shells, ALN and LSC connectors are 35 to 40 per nt lighter than comparable stand-d rf coaxials. The plugs have a lack anodic coating for corrosion sistance.

Cannon Electric Co., Dept. ED, 208 Humboldt St., Los Angeles 31, alif.

CIRCLE 118 ON READER-SERVICE CARD

Oscillator-Mixer

For fm data systems

For fm data systems, oscillator-ixer GRO-2 generates a reference equency and mixes it with an n/fm telemetering multiplex. It so de-emphasizes the multiplex ectrum for recording and matches ference and signal amplitudes. A ug-in frequency unit adapts it to ny reference frequency to 100 kc to tape speed.

Data-Control Systems, Inc., Dept. D, Danbury, Conn.

CIRCLE 119 ON READER-SERVICE CARD

Power Supplies

Low voltage

Transistorized ac to dc power supplies, types 550 and 551 are rated at 0 to 1.1 and 0 to 2.5 amp, respectively. Designed for energizing resistance type transducers and for transistor circuitry, they provide 1 to 40 v dc, continuously variable, with 0.005 per cent regulation.

Owen Labs, Inc., Dept. ED, 55 Beacon Place, Pasadena, Calif.

CIRCLE 120 ON READER-SERVICE CARD

Accelerometer

Self amplifying

Effects of humidity and rf radiation are eliminated in these self amplifying accelerometer systems. Designated 2806-2807 and 2808-2809, the systems combine two units, one for vertical, one for horizontal vibration measurement. Sensitivity up to 300 mv per g is preset to user specifications. First accelerometer resonances are above 35 kc with frequency range ±5 per cent from 10 cps to 2 kc.

Endevco Corp., Dept. ED, 161 E. California St., Pasadena, Calif.

CIRCLE 121 ON READER-SERVICE CARD

Phototube

For scintillation counters

Designed for scintillation counters, the 7264 is a 14-stage, head-on multiplier phototube. Its spectral response is 3000 to 6500 angstroms.

Radio Corporation of America Electron Tube Div., Dept. ED Harrison, N. J.

CIRCLE 122 ON READER-SERVICE CARD

CIRCLE 123 ON READER-SERVICE CARD

NEW PRODUCTS

Recorder

Displays two thirds of data

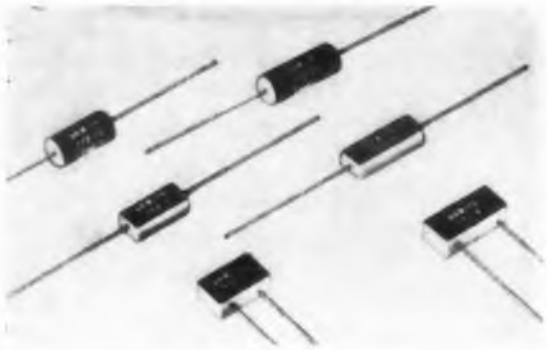
Rack mounted Model 2484 recorder can handle up to three channels. The chart, two-thirds of which is continually visible, can record data from 8 to 72 hours. Heated styli produce helical impressions on heat sensitive paper. Linearity is ±2 per cent up to 3 in. deflection. Sensitivity is 15 ma (52 v) per in., peak to peak.

The Geotechnical Corp., Dept. ED, 3712 Haggar Drive, Dallas 9, Tex.

CIRCLE 124 ON READER-SERVICE CARD

Metal Film Resistors

Tolerance of ±1 per cent



Standard tolerances of series 77 low cost metal film precision resistors are ±1 per cent, but tolerances of ±0.1 per cent can be furnished. Resistance range of the line is 25 ohms to 400 K.

Ohmite Mfg. Co., Dept. ED, 3695 Howard St., Skokie, Ill.

CIRCLE 125 ON READER-SERVICE CARD

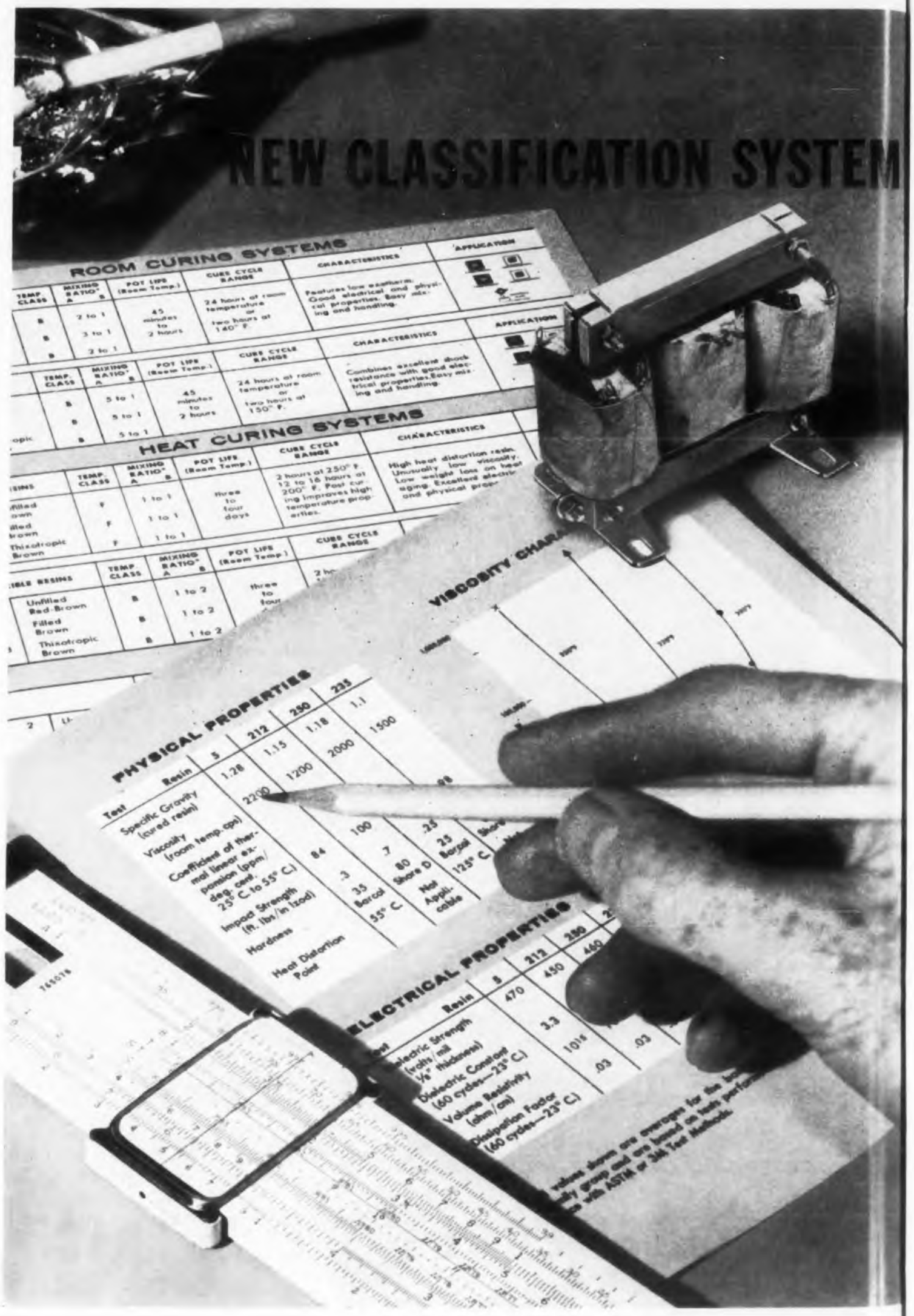
Coaxial Terminations

dc to 10 kmc frequency range

Series SC 50-ohm coaxial connectors have a maximum vswr of 1.1 to 1.3 with 2 to 5 per cent accuracy from dc to 10 kmc. Input is 1 w average, 1 kw peak.

Weinschel Engineering, Dept. ED, 10503 Metropolitan Ave., Kensington, Md.

CIRCLE 126 ON READER-SERVICE CARD



Optical Transducer

Works in broad daylight

Model 701 vibration, motion, and displacement transducer is a noncontacting optical unit that operates in broad daylight. It measures from 100 micro-inch resolution to 1 inch full scale with different lenses. Frequency response is 0 to 5 kc.

Optron Corp., Dept. ED, 3526 State St., Santa Barbara, Calif.

CIRCLE 128 ON READER-SERVICE CARD

Latching Relay

Stands 30 g shock

A 1.5 w pulse for 10 msec transfers the contacts in the KE series miniature relay. The 6pdt dc unit operates under 30 g shocks and 10 g vibration at 55 cps. Contact rating is 2 amp, 115 v, 60 cps for resistive loads.

Potter & Brumfield, Inc., Dept. ED, Princeton, Ind.

CIRCLE 129 ON READER-SERVICE CARD

Microwave Absorber

Absorbs up to 400 w

A broadband, power absorbing waveguide waterload, the BL-570 can absorb up to 400 w of cw power over the 4.95 to 10.5 kmc range. Vswr is under 1.2 over the same range.

Bomac Labs, Inc., Dept. ED, 1 Salem Rd., Beverly, Mass.

CIRCLE 130 ON READER-SERVICE CARD

WESTINGHOUSE TAKES A GIANT STEP IN SILICON POWER TRANSISTORS

Through major improvements in silicon purification and transistor fabrication, Westinghouse has broken down the previous limitations of Silicon Power Transistors. The result is a new series of Westinghouse Power Transistors which can operate at high efficiencies in the "true power range."

LIFE-SIZE DRAWING shows how Westinghouse Silicon Power Transistor is designed for attachment to heat sink with a screw stud. All leads are in the base.

	CURRENT RATING	V_{CBO}	V_{CE} (V_{EB}=0)	R_S
WX1015	2 AMPERES	30-300V	30-300V	0.5 OHMS TYPICAL
WX1016	5 AMPERES	30-300V	30-300V	0.4 OHMS TYPICAL

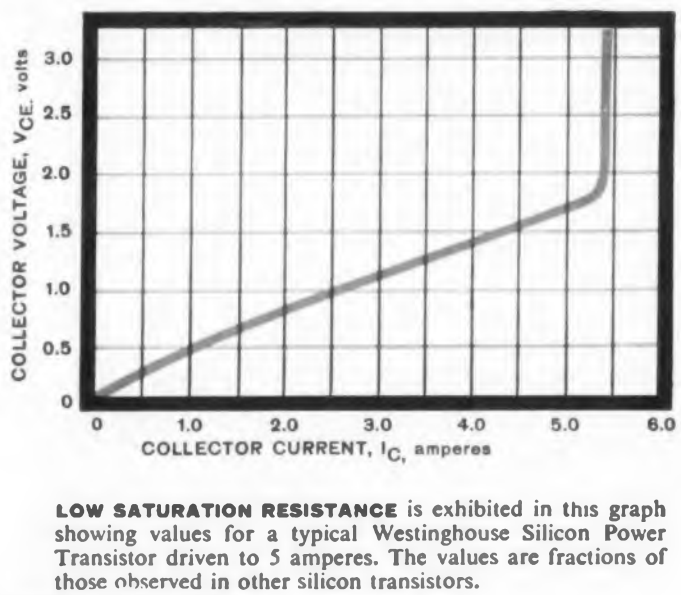
Thermal resistance—Junction to case, 0.7°C/watt typical. Current ratings based on the current at which current gain is equal to or greater than 10. It is possible to switch higher collector currents with some sacrifice in gain.

These are the first members of an entirely new family of Westinghouse Silicon Power Transistors, which have the advantages associated with silicon (high voltages and high operating temperature) without the disadvantages (high losses). As you can see from the chart below, these units possess exceptionally low saturation resistance—less than one half ohm. This low saturation resistance results in low internal dissipation. Coupled with high power handling capacity, it makes possible silicon transistors which can efficiently handle 1000 or 1500 watts. For example, as a DC switch, handling 1.5 kw (300 volts at 5 amperes) the internal dissipation of the units is about 12.5 watts with a resulting efficiency of better than 99%.

Like other silicon devices, these transistors can operate in ambient temperatures up to and exceeding 150°C while germanium units are limited to 85°C. Thus, where the higher power rating is not required these units may be used for their high temperature capabilities. It also follows that wherever germanium power units are presently employed, a switch to silicon transistors will result in higher reliability of operation, because of the greater margin of safety with respect to operating temperature.

There are a great many circuits for which this new type of silicon power transistor is made to order. It will find use in inverters or converters (AC to AC, AC to DC, DC to AC, DC to DC), to control frequencies for data processing, servo output, and other aircraft information applications. It will serve as a low frequency switch, as mentioned above; it will operate efficiently with low power supply voltages; and it will find a number of uses in class A amplifiers. There are also many additional applications—too numerous to list here.

These Westinghouse Silicon Power Transistors are available in sample quantities for your testing and immediate application. Call your Westinghouse representative or write directly to Westinghouse Electric Corporation, Semiconductor Dept., Youngwood, Penna.



LOW SATURATION RESISTANCE is exhibited in this graph showing values for a typical Westinghouse Silicon Power Transistor driven to 5 amperes. The values are fractions of those observed in other silicon transistors.

YOU CAN BE SURE...IF IT'S

Westinghouse

CIRCLE 131 ON READER-SERVICE CARD

NEW PRODUCTS

Relay Control

Requires 1/4 μw to switch

A self-contained unit with power relay, thyratron amplifier, and power supply, this sensitive miniature relay control requires 1/4 μw for switching. The unit contains printed circuitry and has an edge-type plug-in arrangement. It mounts vertically or horizontally. Output, one to three poles, is 5 amp each at 250 v ac.

Victory Engineering Corp., Dept. ED, 523C Springfield Rd., Union, N.J.

CIRCLE 132 ON READER-SERVICE CARD

Magnetic Amplifier Relays

40 to 150 μw sensitivities

For missile and other military and industrial uses, this magnetic amplifier relay series includes three types: 15 amp RL-101 with 0.5 sec response time and 140 μw sensitivity; 2 amp RL-102 with 0.4 sec response and 40 μw sensitivity; and 2 amp RL-103 with 0.6 sec response and 80 μw sensitivity. All units are dpdt.

Ad-Yu Electronics Lab, Inc., Dept. ED, 249 Terhune Ave., Passaic, N.J.

CIRCLE 133 ON READER-SERVICE CARD

Hydraulic Servovalve

1 per cent hysteresis

Miniature model 410 hydraulic servovalve has 1 per cent hysteresis and 0.1 per cent resolution. Its first and second stages can pass 200 micron particles without malfunctioning. Maximum flow ranges from 0.5 to 5 gpm with 1000 psi drop.

Raymond Atchley, Inc., Dept. ED, 2340 Sawtelle Blvd., Los Angeles 64, Calif.

CIRCLE 134 ON READER-SERVICE CARD

Rotary Switch

Has plastic rotor

Miniaturization of this rotary switch was accomplished through the use of a plastic rotor. Used for multiple circuit selection, the switch has a 1-3/32 in. diam and a switch section 1/16 in. thick. The rotor is chemically inert, resists thermal shock and has high impact strength.

Oak Manufacturing Co., Dept. ED, Chicago, Ill.

CIRCLE 135 ON READER-SERVICE CARD

Metallized-Paper Capacitors

Rated at 50 v dc

Type P1232NNG metallized-paper capacitors are rated at 50 v dc and were designed for transistor applications. The units, sealed in a metal tubular case, operate from —65 to +85 C at full voltage rating.

Aerovox Corp., Dept. ED, New Bedford, Mass.

CIRCLE 136 ON READER-SERVICE CARD

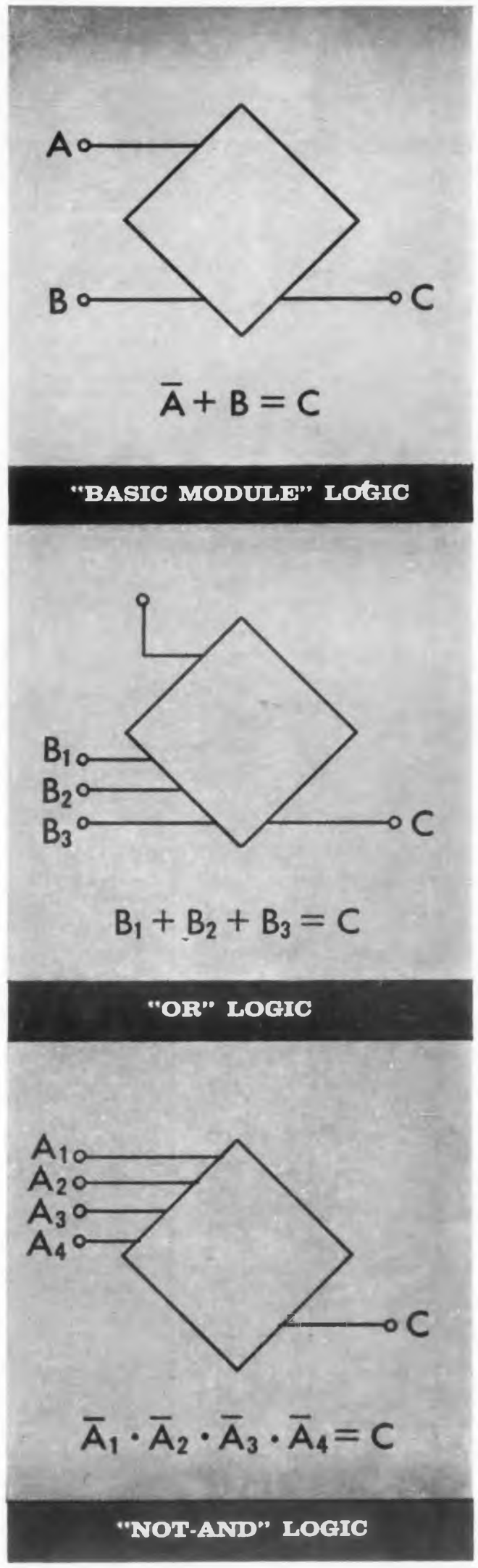
Recorders

Circular chart type

Recorders and recorder-controllers with pneumatic or electric control, these units come in two types: The 6836 are potentiometer devices and the 6856 are Wheatstone bridge instruments. All have a 12-in circular chart mounted on a rotating plate that prevents slippage. Pneumatic control is proportional, on-off, or differential gap; electric control is on-off and proportioning, with and without relays.

Daystrom, Inc., Daystrom-Weston Industrial Div., Dept. ED, Newark 12, N.J.

CIRCLE 137 ON READER-SERVICE CARD



NEW PRODUCTS

Counting Dial

Sealed unit construction

Used with ten turn potentiometers, these Migit-Mite counting dials have sealed unit construction. Numerals are held in place until completion of the next full rotation of the dial. The dials provide continuous operation in either direction, and come in sizes up to 2 in. OD.

S. A. Asquith Co., Dept. ED, 427 W. Chevy Chase Drive, Glendale, Calif.

CIRCLE 140 ON READER-SERVICE CARD

Silicon Voltage Reference

High accuracy to 200 C

A temperature coefficient of 0.0005 per cent per deg C over a temperature range of —65 to +200 C is featured in this diffused silicon voltage reference. A silicon wafer construction makes possible the small size. Available in both axial lead and lug terminal styles for use in computers, measuring instruments and controls.

U.S. Semiconductor Products, Inc., Dept. ED, Phoenix, Ariz.

CIRCLE 141 ON READER-SERVICE CARD

Magnetic Frequency Detector

0 to 500 μa output

Using only static components, the 510 magnetic frequency detector measures audio frequencies directly. It delivers 0 to 500 μa of dc output for 0 to 500 cps input and needs no external power sources. Accuracy is 1 per cent.

Acromag, Inc., Dept. ED, 22519 Telegraph Rd., Detroit 41, Mich.

CIRCLE 142 ON READER-SERVICE CARD

Phase-Lock Receivers

215 to 260 mc range

Series 1400 phase-lock receivers cover a frequency range of 215 to 260 mc. In the case of IRIG fm/fm telemetry using standard receivers of 500 kc bandwidth, noise bandwidth can be reduced by a factor of approximately 2.5 when all subcarriers are used, resulting in a theoretical improvement of nearly 7.96 db both in reduction of receiver threshold and in improved signal-to-noise ratio above threshold.

Nems-Clarke Co., Div. of Vitro Corp. of America, Dept. ED, 919 Jesup-Blair Drive, Silver Spring, Md.

CIRCLE 143 ON READER-SERVICE CARD

Capacitors

Variety of terminals

These bathtub-style capacitors come in a variety of terminals and have optional mountings. The terminals may be on any side of the unit and may be plug-in or solder-lug type. Produced in a wide range of capacities, the line offers a choice of dielectric materials.

Condenser Research Corp., Dept. ED, P.O Box 161, Seymour, Ind.

CIRCLE 144 ON READER-SERVICE CARD

Pressure Switch

For aircraft hydraulic systems

The 6512 is a snap action, spdt switch for aircraft and other hydraulic systems that need a pressure sensor to actuate electrical apparatus. Operating point is adjustable from 500 to 2000 psi and 2000 to 3500 psi.

Consolidated Controls Corp., Dept. ED, Bethel, Conn.

CIRCLE 145 ON READER-SERVICE CARD

NEW PRODUCTS

Silicon Rectifier

Low reverse leakage

Type T encapsulated silicon rectifier is a diffused junction unit designed for 85 C ambient. The design allows low reverse leakage current and low forward voltage drop. Maximum piv is 400 v. Maximum dc load current is 500 ma. Forward voltage drop at max dc load is 0.5 v. Maximum reverse leakage current is 0.2 ma.

P. R. Mallory & Co., Inc., Dept. ED, Indianapolis, Ind.

CIRCLE 148 ON READER-SERVICE CARD

Power Supply

Airborne strain gage type

Two versions of the 2 to 300 power supply provide 1 or 3 amp at 5, 10, or 15 v. Output voltage varies less than ±0.1 per cent for line variations of ±0.1 per cent from −55 to +85 C. The unit will operate to these specifications under 20 g vibration and 50 g shock up to 70,000 ft.

Neff Instrument Corp., Dept. ED, 2211 East Foothill Blvd., Pasadena, Calif.

CIRCLE 149 ON READER-SERVICE CARD

Coil Assemblies

1-1/4 in. long

Ceramic coil forms 2480 through 2485 are 1-1/4 in. long and come with adjustable ring terminals or silicon Fiberglas terminal collars.

Cambridge Thermionic Corp., Dept. ED, 445 Concord Ave., Cambridge 38, Mass.

CIRCLE 150 ON READER-SERVICE CARD

Silicon Rectifier

1500 v at 150 C

Designated TM155, this silicon rectifier offers 1500 v, 400 ma ratings at 150 C. It may be used in high voltage power supplies requiring 600 v output or higher. Hermetically sealed, it comes in the standard 7/16 in. hex package.

Transitron Electronic Corp., Dept. ED, Wakefield, Mass.

CIRCLE 153 ON READER-SERVICE CARD

Spectrum Analyzer

0.5 cps to 300 kc range

The S-2 series makes possible spectrum and power density analysis of both discrete and random data from 0.5 cps to 300 kc. The system consists of a Panoramic spectral power density analyzer model PDA-1 plus a spectrum analyzer and chart recorder. Four different modes of analysis are selectable through front panel switching.

Panoramic Radio Products, Inc., Dept. ED, 520 South Fulton Ave., Mt. Vernon, N.Y.

CIRCLE 154 ON READER-SERVICE CARD

Terminal Blocks

Eliminate external wiring

In 1, 2, and 3, row units, these solderless terminal blocks accept standard AMP 53 taper pins. With internal buss connections to eliminate external wiring, units come in any combination of feed-through individual or shorting terminals.

DeJur-Amsco Corp., Dept. ED, 45-01 Northern Blvd., Long Island City 1, N.Y.

CIRCLE 155 ON READER-SERVICE CARD

NEW PRODUCTS

Time Delay Relay

Saves panel space

Available in 32 variations of five basic models, the type PMT time delay relay needs no extra vertical space for latch and timing mechanisms. Time delays up to 3 min are offered in some of these pneumatic, 10 amp units. Using modular construction, the relays have universal poles with isolated contacts so that two circuits per pole may be used, even at opposite polarity.

Clark Controller Co., Dept. ED, Cleveland 10, Ohio.

CIRCLE 158 ON READER-SERVICE CARD

DC Electrometer

Has 53 ranges

Model 600 dc electrometer has 53 ranges. It measures voltage from 10 mv to 10 v full scale; current from 10^{-14} to 3 amp full scale; and resistance from 200 to 10^{13} ohms full scale. It also serves as a dc preamplifier with precise gains from 0.1 to 100.

Keithley Instruments, Inc., Dept. ED, 12415 Euclid Ave., Cleveland 6, Ohio.

CIRCLE 159 ON READER-SERVICE CARD

Rotary Solenoid

Has ratchet drive

Motoroid ratchet drive solenoids provide rotary output without the use of linkages. Output torques can be selected from any part of their torque curve, and their rotation angle can be varied by stop adjustment.

Leetronics, Inc., Dept. ED, 30 Main St., Brooklyn 1, N.Y.

CIRCLE 160 ON READER-SERVICE CARD

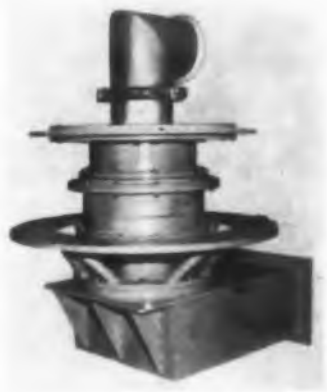
Environmental Test Chamber

Has wide temperature range

Having a temperature range from —100 to +800 F, this test chamber is accurate to ±2 F. The Freon 13-Freon 22 cascade type unit can dissipate 1600 BTU/hr at —85 F and 500 BTU/hr at —100 F. Internal capacity is 3.4 cu ft. Fiberglass is used as insulator.

Associated Testing Labs, Inc., Dept. ED, 112 Clinton Rd., Caldwell, N.J.

CIRCLE 163 ON READER-SERVICE CARD



Rotary Joint

Handles 100 kw

This rotary joint, used in antenna systems, can handle 100 kw average power. Its operating frequency is 400 to 450 mc. The unit has a vswr of 1:15 (max). Size: WR2100 to 9 in. coaxial.

G. B. Electronics Corp., Dept. ED, 711 Stewart Ave., Garden City, N.Y.

CIRCLE 164 ON READER-SERVICE CARD

Tube Tester

Offers multiplicity of peak conditions

For electronic and TV picture tubes, the 10-40 tube tester affords functional testing of voltage regulator tubes, ultrasensitive gas testing for amplifier tubes, and beam-current testing of TV tubes. Because the tubes under test are dynamically swept over a path of operation, on a sinusoidal time base, encompassing a wide range of plate family characteristic curves, they show their ability to operate at a multiplicity of peak conditions.

Precision Apparatus Co., Inc., Dept. ED, 70-31 84th St., Glendale, N.Y.

CIRCLE 165 ON READER-SERVICE CARD

NEW PRODUCTS

SPRAY CLEANER.—Vythene-E, purified grade of Vythene, 20 times less toxic than carbon tetrachloride. Has no flash point and is highly stabilized to all metals.

Tect, Inc., Dept. ED, Northvale, N. J.

CIRCLE 168 ON READER-SERVICE CARD

CENTRIFUGAL BLOWERS.—Series LP low pressure units with diameters from 2 to 9 in. Deliver 20 to 2000 cfm.

The Torrington Mfg. Co., Dept. ED, Torrington, Conn.

CIRCLE 169 ON READER-SERVICE CARD

ROTARY INVERTER.—Model 4617 for inertial guidance systems. Delivers 750 va from 28 v dc input. Voltage controlled to ±0.2 per cent, frequency to ±0.01 per cent.

Varo Mfg. Co., Inc., Dept. ED, 2201 Walnut St., Garland, Tex.

CIRCLE 170 ON READER-SERVICE CARD

POTTING COMPOUND.—Temporell No. 1500 adheres to metal, paper, and wood, but not to rubber. Temperature range of —65 to +1500 F.

Orell, Inc., Dept. ED, Box 527, South Gate, Calif.

CIRCLE 171 ON READER-SERVICE CARD

PHOTOJUNCTION CELL.—Miniature type 7224 for sound movie projector and computer use. Covers 3500 to 19,000 angstrom range and has illumination sensitivity of 0.7 μa per ft-c. Dissipates 0.03 w.

Radio Corporation of America, Electron Tube Div., Dept. ED, Harrison, N. J.

CIRCLE 172 ON READER-SERVICE CARD

MINIATURE CIRCUIT BREAKER.—Klixon 7274-1 manual reset thermal breaker 1.42 x 0.75 x 0.56 in. Ratings from 0.5 to 5 amp.

Metals & Controls Corp., Dept. ED, Attleboro, Mass.

CIRCLE 173 ON READER-SERVICE CARD

TANTALUM CAPACITORS.—Foil-type electrolytic units that withstand 2000 hr life test. End seal of TFE-fluorocarbon resin is virtually leakproof.

Sprague Electric Co., Dept. ED, North Adams, Mass.

CIRCLE 174 ON READER-SERVICE CARD

ACCELEROMETER.—Gas damped model A501 for accurate measurement of acceleration changes flat up to 500 cps. Operates from —65 to +200 F without heater jacket.

Statham Instruments, Inc., Dept. ED, 12401 W. Olympic Blvd., Los Angeles 64, Calif.

CIRCLE 175 ON READER-SERVICE CARD

TEMPERATURE CONTROL SYSTEM.—Model TLC-3297 3-channel warning and control system to monitor process-tube temperatures in nuclear reactors. Adaptable to any remote temperature monitoring application.

Arnoux Corp., Dept. ED, 11924 W. Washington Blvd., Los Angeles 66, Calif.

CIRCLE 180 ON READER-SERVICE CARD

DIGITAL VOLTMETER.—Model DVA-410 ac-dc 4-digit unit has a range of 0.0001 to 999.9 v; ac accuracy of 0.1 per cent or two digits; and dc accuracy of ±1 digit. Transistorized; modular construction.

Electro Instruments, Inc., Dept. ED, 3540 Aero Court, San Diego 11, Calif.

CIRCLE 181 ON READER-SERVICE CARD

PUSHBUTTON SWITCH.—Tri-Lite monitors three conditions with a three-color light assembly. Dual-purpose unit is for flush or subpanel mounting.

Electrosnap Corp., Dept. ED, 4230 W. Lake St., Chicago 24, Ill.

CIRCLE 182 ON READER-SERVICE CARD

ELAPSED TIME INDICATORS.—Series 53 units have self-starting synchronous motors and standard 5-digit registers. They are 3.5 in. round or square.

Marion Electrical Instrument Co., Dept. ED, Grenier Field, Manchester, N. H.

CIRCLE 183 ON READER-SERVICE CARD

REGULATED POWER SUPPLY.—Transistorized model SC-32-5 delivers 0 to 32 v, 0 to 5 amp. Under 0.01 per cent regulation for line or load.

Kepco Labs, Inc., Dept. ED, 131-38 Sanford Ave., Flushing 55, N. Y.

CIRCLE 184 ON READER-SERVICE CARD

RF CONNECTORS.—Type 3000 cable plug, 3001 cable jack, 3002 panel receptacle, 3003 panel jack, 3004 cable feed-through, and 3005 right-angle plug are added to ConheX miniature hexagonal line.

Sealectro Corp., Dept. ED, 610 Fayette Ave., Mamaroneck, N. Y.

CIRCLE 185 ON READER-SERVICE CARD

INSULATION.—Stanpreg P1 all-purpose glass fabric for use under MIL-R-7575A. Polyester resin preimpregnated. Supplied in roll form.

Standard Insulation Co., Dept. ED, 74 Paterson Ave., East Rutherford, N. J.

CIRCLE 186 ON READER-SERVICE CARD

MOTORIZED TAPE PUNCH.—For computers, data handlers, communication systems. Punches up to 8 columns on tapes up to 1 in. wide at speeds up to 27 cps.

Precision Specialties, Inc., Dept. ED, 1342 58th St., Kansas City, Mo.

CIRCLE 187 ON READER-SERVICE CARD

NEW PRODUCTS

MINIATURE AMPLIFIER.—Model 2618 for use with the company's piezoelectric accelermeters. Completely sealed, it provides variable gain, 6 to 20, and operates continuously at 250 F. Distortion and nonlinearity are under 1 per cent gain; stability is ±1 per cent.

Endevco Corp., Dept. ED, 161 E. California St., Pasadena, Calif.

CIRCLE 190 ON READER-SERVICE CARD

LIMIT SWITCHES.—Series HII for any exposed control or indicating application on aircraft or industrial machines. In 12 variations.

Electrosnap Corp., Dept. ED, 4230 W. Lake St., Chicago 24, Ill.

CIRCLE 191 ON READER-SERVICE CARD

LOW-TEMPERATURE PROBES.—Semiconductor 7XXXL units provide output in volts for a 20 F span in the LOX range. Can be used with almost any liquefied gas in the −240 to −320 F range.

Arnoux Corp., Dept. ED, 11924 W. Washington Blvd., Los Angeles 66, Calif.

CIRCLE 192 ON READER-SERVICE CARD

ELECTROSTATIC PROBES.—For use with the company's absorption analyzer. Envelope, T, straight, and miniature types trace signals through hard-to-reach circuits.

Kingston Electronic Corp., Dept. ED, Medfield, Mass.

CIRCLE 193 ON READER-SERVICE CARD

ENVIRONMENT CHAMBERS.—Dry-ice operated subzero cabinets with +200 to −120 F range. Constancy within units is ±0.5 at −100 F, ±1 F at +200 F.

American Instrument Co., Dept. ED, 8030 Georgia Ave., Silver Spring, Md.

CIRCLE 194 ON READER-SERVICE CARD

RF FILTER.—Bandpass/band-suppression unit for simultaneous ATC transmissions on adjacent channels in the lower kmc range from a single antenna. Channels are separated better than 30 db, and loss in the pass frequencies is under 1 db.

Microphase Corp., Dept. ED, Box 1166, Greenwich, Conn.

CIRCLE 195 ON READER-SERVICE CARD

MINIATURE TUBES.—Types 6DT5 and 12DT5 9-pin beam power pentodes conservatively drive 110 deg vertical deflection systems. Units feature controlled high zero-bias plate current and low zero-bias screen current at a specified low plate voltage.

Westinghouse Electric Corp., Electron Tube Div., Dept. ED, P. O. Box 284, Elmira, N. Y.

CIRCLE 196 ON READER-SERVICE CARD

RF CONNECTORS.—Series designed to prevent cable assembly contacts from disengaging in rapidly fluctuating ambient temperature.

Kings Electronics Co., Dept. ED, 40 Marbledale Rd., Tuckahoe, N. Y.

CIRCLE 201 ON READER-SERVICE CARD

RADIO TELESCOPE RECEIVER.—X-band radiometer EK/HII-X2C sensitive to noise radiation levels down to 0.01 Kelvin, with integration time constants down to 100 sec. Has 8 kmc operating frequency, 1 kmc bandwidth, 10 db noise figure, 86 db rf gain.

Ewen Knight Corp., Dept. ED, 206 A St., Needham Heights 94, Mass.

CIRCLE 202 ON READER-SERVICE CARD

DIGITAL VOLTMETER SYSTEM.—Model DVA-412 automatically measures ac-dc voltages and types results on electric typewriter. Over 0.0001 to 999.9 range, accuracy ac is 0.1 per cent or two digits; dc, ±1 digit.

Electro Instruments, Inc., Dept. ED, 3540 Aero Court, San Diego 11, Calif.

CIRCLE 203 ON READER-SERVICE CARD

TRANSISTORIZED POWER SUPPLIES.—From a 6 or 12 v battery, units provide outputs from 150 to 400 v dc up to 265 ma for operating radio receivers, transmitters, and mobile communication equipment. No moving parts.

Arnold Magnetics Corp., Dept. ED, 4613 W. Jefferson Blvd., Los Angeles 16, Calif.

CIRCLE 204 ON READER-SERVICE CARD

PHOTOCELLS.—Thirteen miniature cells together cover all the visible spectrum and more. Sensitivity to light flux is about 1 million times that of high-vacuum photoemissive tubes. Each has rectangular sensitive surface 3/16 x 3/64 in. Supplied with end or side view.

Clairex Corp., Dept. ED, 19 W. 26th St., New York, N.Y.

CIRCLE 205 ON READER-SERVICE CARD

POWER OSCILLATOR.—Model 150 supplies 160 va at a fixed frequency of 400 cps ±0.25 per cent or a variable frequency of 350 to 450 cps. Output is 0 to 120 v continuously variable; regulation is 1 per cent no load to full load.

Industrial Test Equipment Co., Dept. ED, 55 E. 11th St., New York 3, N. Y.

CIRCLE 206 ON READER-SERVICE CARD

PUSHBUTTON SWITCHES.—Series 850 normally off switches for alarm devices, high fidelity equipment, and relays. Rated at 3 amp, 120 v ac or 1.5 amp, 240 v ac.

Alcor Mfg. Co., Dept. ED, 4444 W. Roosevelt Rd., Chicago 24, Ill.

CIRCLE 207 ON READER-SERVICE CARD

NEW PRODUCTS

MINIATURE AMPLIFIER.—Model 2618 for use with the company's piezoelectric accelermeters. Completely sealed, it provides variable gain, 6 to 20, and operates continuously at 250 F. Distortion and nonlinearity are under 1 per cent gain; stability is ±1 per cent.

Endevco Corp., Dept. ED, 161 E. California St., Pasadena, Calif.

CIRCLE 190 ON READER-SERVICE CARD

LIMIT SWITCHES.—Series H11 for any exposed control or indicating application on aircraft or industrial machines. In 12 variations.

Electrosnap Corp., Dept. ED, 4230 W. Lake St., Chicago 24, Ill.

CIRCLE 191 ON READER-SERVICE CARD

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Clairex Corp., Dept. ED, 19 W. 26th St., New York, N.Y.

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PUSHBUTTON SWITCHES.—Series 850 normally off switches for alarm devices, high fidelity equipment, and relays. Rated at 3 amp, 120 v ac or 1.5 amp, 240 v ac.

Alcor Mfg. Co., Dept. ED, 4444 W. Roosevelt Rd., Chicago 24, Ill.

CIRCLE 207 ON READER-SERVICE CARD

IDEAS FOR DESIGN—*ENTRY BLANK*

To the *Ideas-For-Design* Editor of ELECTRONIC DESIGN —
830 3rd Ave., New York 22, N.Y. • PLaza 1-5530

Here is my design idea for possible publications in your *Ideas For Design* department. I can expect $10 for this idea if accepted for publication.

(Ideas suitable include: *1.* new circuits or circuit modifications, *2.* new design techniques, *3.* designs for new production methods, *4.* clever use of new materials or new components in design, *5.* design or drafting aids, *6.* new methods of packaging, *7.* design short cuts, or *8.* cost saving tips)

STATEMENT OF THE PROBLEM—

MY SOLUTION. AND WHY—(Please be explicit. Include sketches or photos that will help the idea across)

Signed_____
Title_____
Company_____
Address_____

(Place illustrations on separate sheet if necessary)

NEW PRODUCTS

HF POWER TRANSISTOR.—Diffused base pnp germanium type 2N1046 for horizontal and vertical crt deflection circuits. Provides 15 w dissipation and a typical 12 mc alpha cutoff frequency.

Texas Instruments Incorporated, Dept. ED, P O. Box 312, Dallas, Tex.

CIRCLE 209 ON READER-SERVICE CARD

HAND PYROMETER.—Portable model B measures temperatures of convex, rotating, or flat surfaces. For plastics, semifluids, liquids, gases, molten soft metals. Needs no power source.

West Instrument Corp., Dept. ED, 4363 W. Montrose Ave., Chicago, Ill.

CIRCLE 210 ON READER-SERVICE CARD

INDICATING LIGHT.—Incandescent type 855RE for edge-lighting Lucite panels. Jelly bean in size, it projects 0.125 in. in front of the panel.

The Sloan Co., Dept. ED, 4101 Burbank Blvd., Burbank, Calif.

CIRCLE 211 ON READER-SERVICE CARD

PAPER ELECTRICAL TAPE.—For identification of leads in stick wound coils, tape P comes in range of colors and standard widths.

Pee Cee Tape & Label Co., Dept. ED, 521 N. La Brea Ave., Los Angeles 36, Calif.

CIRCLE 212 ON READER-SERVICE CARD

GEIGER-MUELLER TUBES.—Range of alpha-beta-gamma end-window tubes with varying window thicknesses.

Nucleonic Corporation of America, Dept. ED, 196 Degraw St., Brooklyn 31, N.Y.

CIRCLE 213 ON READER-SERVICE CARD

AIRCRAFT CIRCUIT BREAKER.—Rated at 225 amp, 480 v ac, 400 cps, 3 phase; 500 amp, 250 v dc. Functions from −65 to +600 F up to 75,000 ft.

Westinghouse Electric Corp., Dept. ED, Lima, Ohio.

CIRCLE 214 ON READER-SERVICE CARD

COMMUNICATION RECEIVER.—Type 13A1 for high performance in the 55 to 260 mc range.

General Electronic Labs, Inc., Dept. ED, 195 Massachusetts Ave., Cambridge 39, Mass.

CIRCLE 215 ON READER-SERVICE CARD

POWER SUPPLY.—Transistorized model HY-CA1-10-10 is chopper stabilized with 1 mv regulation for line or load variation. Input, 105 to 125 v; output 1 to 10 v dc, 10 amp.

Hyperion, Inc., Dept. ED, 1447 Washington St., West Newton, Mass.

CIRCLE 216 ON READER-SERVICE CARD

CONTROL STATIONS.—Metagraphic type for use with process computer systems. Continuously record and indicate controlled variable.

The Bristol Co., Dept. ED, Waterbury 20, Conn.

CIRCLE 219 ON READER-SERVICE CARD

TRANSISTORIZED POWER SUPPLY.—Model SC-18-1 delivers 0 to 18 v, 0 to 1 amp. Regulation is less than 0.1 per cent.

Kepco Labs, Inc., Dept. ED, 131-38 Sanford Ave., Flushing 55, N.Y.

CIRCLE 220 ON READER-SERVICE CARD

DECADE COUNTERS.—Types DC-106-A and DC-106-B low cost, 110 kc units have 10 electrical outputs. Modular printed circuit construction.

Burroughs Corp., Electronic Tube Div., Dept. ED, P.O. Box 1226, Plainfield, N.J.

CIRCLE 221 ON READER-SERVICE CARD

CAPACITOR.—High voltage, low inductance units for thermonuclear equipment and fast discharge and energy storage applications.

General Electric Co., Capacitor Dept., Dept. ED, Hudson Falls, N.Y.

CIRCLE 222 ON READER-SERVICE CARD

BANANA PLUGS.—Silver plated swage 2000 and screw type 2020 plugs to fit 0.104 diameter holes.

Goe Engineering Co., Dept. ED, 219 S. Mednik Ave., Los Angeles 22, Calif.

CIRCLE 223 ON READER-SERVICE CARD

SELF-INSULATING FASTENERS.—Have plastic heads molded on threaded metal fasteners, combining mechanical advantages of metal with plastic insulation.

Gries Reproducer Corp., Dept. ED, 400 Beechwood Ave., New Rochelle, N.Y.

CIRCLE 224 ON READER-SERVICE CARD

TRANSMISSION BALANCER.—Symmetrapeak network SP-58-1A symmetrizes unequal audio wave peak energy about the zero axis. For am and fm transmitters, it improves power by 4 db.

Kahn Research Labs, Inc., Dept. ED, 22 Pine St., Freeport, N.Y.

CIRCLE 225 ON READER-SERVICE CARD

POWER TRANSISTORS.—Types 2N1021, 100 v, and 2N1022, 120 v. Germanium pnp alloy junction units that dissipate 50 w at 25 C.

Texas Instruments Incorporated, Dept. ED, P.O. Box. 312, Dallas, Tex.

CIRCLE 226 ON READER-SERVICE CARD

PANEL METERS.—Ruggedized ac and dc sealed indicating meters with external zero adjusters.

WacLine, Inc., Dept. ED, 35 S. St. Clair St., Dayton 2, Ohio.

CIRCLE 227 ON READER-SERVICE CARD

PRODUCTION PRODUCTS

Zone Scanner

For metal purification

This vertical floating zone scanner is designed for high purity semiconductor and metal production. With top and bottom holders horizontally and vertically adjustable, the mechanism allows easy material and seed centering. It handles quartz protection tubes with OD's up to 35 mm.

Lindberg Engineering Co., Dept. ED, 2450 W. Hubbard St., Chicago 12, Ill.

CIRCLE 230 ON READER-SERVICE CARD

Wire Cutter and Stripper

Processes over 9000 pieces per hour

All automatic, from unreeling insulated wire to stacking pieces in a trough, the Acme wire cutter and stripper processes over 9000 pieces an hour in 1 to 40 in. wire lengths. Rate for 80 to 120 in. lengths is 3000 pieces per hour. The machine handles stranded wires up to 10 gauge and solid wires to 12 gauge.

Jennings Machine Corp., Dept. ED, 3452 Ludlow St., Philadelphia 4, Pa.

CIRCLE 231 ON READER-SERVICE CARD

Screen Printing Machines

Automatic and Semiautomatic

In automatic and semiautomatic models, these accurate machines screen print ceramics and mica for capacitors, small printed circuit boards, dials, thermistors, and other small parts. Print areas and speeds vary with the model and the type of part to be handled. The maximum area is 8.5 x 15 in.; top speed is 15,000 cycles per hour.

Automation Equipment, Inc., Dept. ED, Pine at Forest St., Manchester, Conn.

CIRCLE 232 ON READER-SERVICE CARD

Thomas & Skinner's Orthosil® Wound Cores are ideal for special applications and can be specially tested to customer requirements prior to shipment.

These T&S Wound Cores meet and exceed customer requirements in respect to all magnetic characteristics.

Besides complete assurance of quality and specification conformity, T&S offers its highly qualified engineering assistance—based on more than 50 years of experience in the magnetic materials industry—to help you select the core best suited for any given application.

T&S's entire organization prides itself in anticipating a customer's problems in advance and providing the correct engineering recommendations to prevent such problems from materializing.

SPECIALISTS IN MAGNETIC MATERIALS

Permanent Magnets · Magnetic Tapes
Laminations and Wound Cores

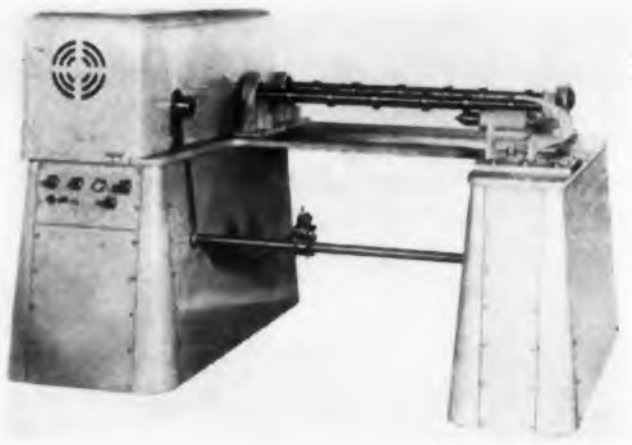
Thomas & Skinner, Inc.

1157 East 23rd Street, Indianapolis 7, Indiana

CIRCLE 234 ON READER-SERVICE CARD

Transformer Core Winder

Semiautomatic



Transformer core winder model 151, semiautomatic, winds cores in variable lengths to a maximum of 10 in. in multiples of three. Maximum core OD is 25 in.

Geo. Stevens Mfg. Co., Inc., Dept. ED, Pulaski Rd. at Peterson, Chicago 46, Ill.

CIRCLE 235 ON READER-SERVICE CARD

Automatic Sealing Machine

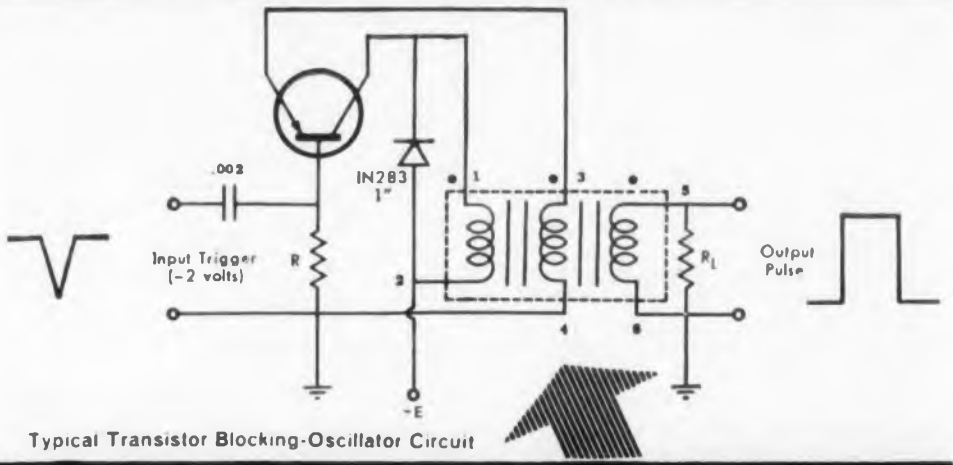
Mass-produces glass inner terminal units

Mass production of glass inner terminal units for electron tubes is possible with the 13844 8-position, 8-head automatic sealing machine. Besides completing the glassing sequence, the machine positions a pin. Normal production is 480 units per hour, but the machine can produce 1700 units an hour if parts can be loaded that fast.

Kahle Engineering Co., Dept. ED, 1310 7th St., North Bergen, N.J.

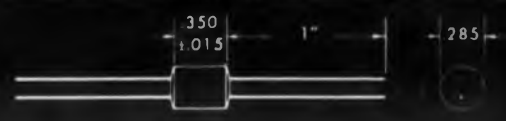
CIRCLE 236 ON READER-SERVICE CARD

ORDER THE PULSE TRANSFORMERS YOU WANT FROM STOCK



Typical Transistor Blocking-Oscillator Circuit

ALADDIN MICRO-MINIATURE TRANSFORMERS



Don't DO-IT-YOURSELF: Look it up in Aladdin's encyclopedia. We'll bet we've already designed the transformer you need—and that we've got it in stock.

Here's a sample of what we've got for this typical blocking oscillator circuit, in our 105°C (94-series) micro-miniature line:

Pulse Width μ sec.	Rise Time μ sec. Max.	Max. Rep. Rate KC	Minimum Load Impedance OHMS (R_L)	Output Volts	E Volts	R OHMS	Transistor	Aladdin Pulse Transformer Number
0.2	0.025	250	1000	6.5	— 5	1000	2N346	94-672
0.2	0.025	250	120	2.0	— 5	1000	2N346	94-675
*0.3	0.025	150	1000	6.5	— 5	1000	2N346	*94-677
0.3	0.025	150	33	1.0	— 5	1000	2N346	94-681
0.4	0.025	100	360	3.5	— 5	1000	2N346	94-684
0.5	0.025	70	680	5.0	— 5	1000	2N346	94-688
*0.5	0.025	70	120	2.0	— 5	1000	2N346	*94-690
0.5	0.10	40	2200	18.0	—15	470	2N123	94-737
*1.0	0.10	20	2200	18.0	—15	470	2N123	*94-742
1.0	0.10	20	33	2.0	—15	470	2N123	94-746
1.0	0.04	45	680	5.0	— 5	50	2N345	94-693
1.5	0.04	30	1000	6.5	— 5	50	2N345	94-697
1.5	0.04	30	33	1.0	— 5	50	2N345	94-701
1.5	0.10	15	1000	12.0	—15	470	2N123	94-748
2.0	0.10	10	470	8.0	—15	470	2N123	94-754
*2.0	0.04	20	1000	6.5	— 5	50	2N345	*94-702
3.0	0.04	15	360	3.5	— 5	50	2N345	94-709
*3.0	0.12	7	1000	12.0	—15	470	2N123	*94-758
4.0	0.12	4	2200	18.0	—15	470	2N123	94-762
4.0	0.12	4	470	8.0	—15	470	2N123	94-764
*4.0	0.05	10	680	5.0	— 5	50	2N345	*94-713
5.0	0.06	9	1000	6.5	— 5	50	2N345	94-717
5.0	0.06	9	33	1.0	— 5	50	2N345	94-721
5.0	0.12	3	2200	18.0	—15	470	2N123	94-767
*5.0	0.12	3	470	8.0	—15	470	2N123	*94-769
6.0	0.07	7	680	5.0	— 5	50	2N345	94-723
*6.0	0.07	7	120	2.0	— 5	50	2N345	*94-725
8.0	0.09	5	680	5.0	— 5	50	2N345	94-728
*8.0	0.09	5	33	1.0	— 5	50	2N345	*94-731
*10.0	0.09	4	1000	6.5	— 5	50	2N345	*94-732

*For lab use, you can buy a kit containing one each of the ten micro-miniature transformers marked with an asterisk—$49.95 complete.

NOBODY...BUT NOBODY—makes a more comprehensive line of low-power pulse transformers than Aladdin...

Commercial grades: −20° to 85°C • Military grades: −55° to 105°C • Military high-temp. grades: −55° to 130°C

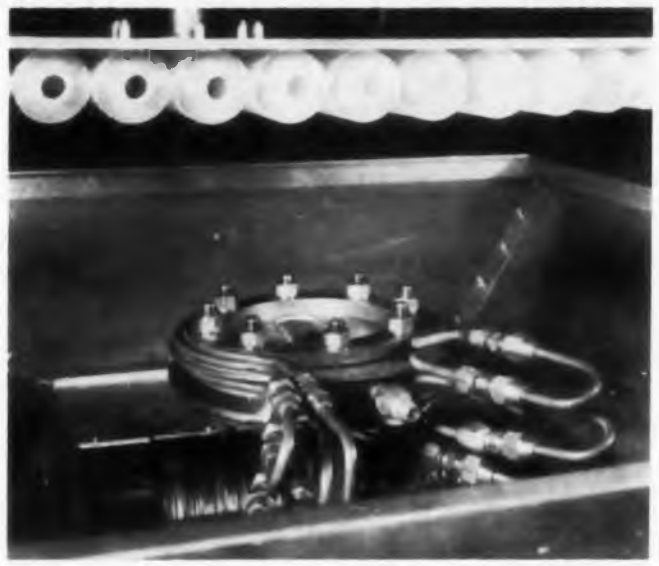
Free Aladdin Pulse Transformer Encyclopedia gives detailed engineering information on pulse transformers. Engineering bulletins also available on IF's and encapsulated inductors. Write on company letterhead.

Aladdin® ELECTRONICS, INC.
A Division of Aladdin Industries, Inc.
715 Murfreesboro Road • Nashville 10, Tennessee

CIRCLE 237 ON READER-SERVICE CARD

SERVICES FOR DESIGNERS

Radiation for Rent



At the Midwest Irradiation Center in Rockford, Ill., an 8 million volt linear electron accelerator can be rented by the hour. Available for both research and commercial radiation processing, the machine emits high energy electrons, X-rays, and neutrons. It can accommodate objects both thick and thin. It will irradiate materials of unit density up to 1 inch thick from one side, or sections over 2 inches thick from two sides. The picture shows polyethylene bottles passing under the accelerator window for irradiation that will increase their temperature resistance.

The installation is jointly operated by W. F. and John Barnes Co. and Applied Radiation Corp.

Applied Radiation Corp., Dept. ED, 2404 N. Main St., Walnut Creek, Calif.

CIRCLE 239 ON READER-SERVICE CARD

Air Gage Tooling

West Coast precision part manufacturers now have a nearby source for air gage tooling equipment. The Dahl-Harvey Corp. in Pasadena is producing a complete line. The company has lab equipment that can make measurements internally or externally directly to 5 millionths of an inch. It also is equipped to design and build special application tooling. The equipment now being produced meets all the requirements and is guaranteed to work on dial and column type amplifiers.

Dahl-Harvey Corp., Dept. ED, 1145 S. Fair Oaks Ave., Pasadena, Calif.

CIRCLE 240 ON READER-SERVICE CARD

ARNOLD transistorized power supply

. . . a regulated lightweight inverter, built to aircraft and missile specs.

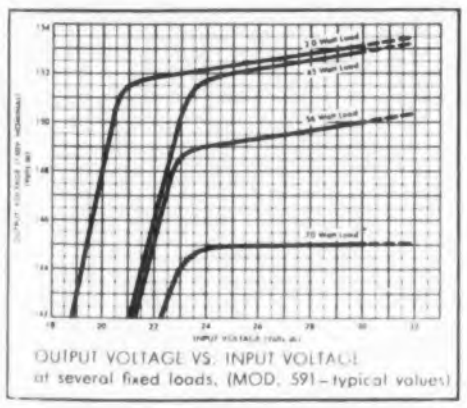
FEATURES

- Constant output voltage as battery discharges.
- 1/5 weight, 1/2 size of comparable dynamotors.
- Withstands short circuit indefinitely.
- Withstands input voltage transients of 70 volts for 0.1 sec. and 60 volts, indefinitely.
- Output voltage drift only 1.5% from −55° to +71°C.

SPECIFICATIONS

D. C. OUTPUT Model 591-A
Input Voltage: 24-30 VDC
Output Voltage: Any from 25-1200 VDC
Output Power: 60 watts regulated
Regulation: Line: ±0.5% for 6V variations
Load: ±1.0% for ½ L to FL
Ripple: 0.3% RMS
Size & Weight: 3" OD x 3 1/16" high; 22 oz.

A. C. OUTPUT Model 591-AC
Input Voltage: 24-30 VDC
Output Voltage: 115 VAC, 400 cps, 1 phase
Output Power: 50 V.A. square wave
Regulation: Frequency: ±0.5%
(line & load) Voltage: ±2.0%
Size & Weight: 3" OD x 3 1/16" high; 22 oz.



OUTPUT VOLTAGE VS. INPUT VOLTAGE at several fixed loads. (MOD. 591—typical values)

Write or phone for literature

ARNOLD MAGNETICS CORPORATION
4613 W. Jefferson Blvd.
Los Angeles 16, Calif.
REpublic 1-6344

CIRCLE 242 ON READER-SERVICE CARD

Cine-Radiography Probes Sealed Packages

Rototest has a cine-radiographic facility that gives engineers an inside look at sealed packages undergoing environmental tests. The X-ray movies often save weeks of failure analysis, and sometimes they are the only way to solve a problem at all. So that users may be sure an assembly will X-ray clearly, they are given a free still of it in advance. Thus they need spend nothing until they are satisfied the method will succeed.

Rototest Labs., Inc., Dept. ED, 2803 Los Flores Blvd., Lynwood, Calif.

CIRCLE 243 ON READER-SERVICE CARD

Ovens

Closely controlled vacuum

Semiconductor components can be outgassed and brazed or fused under closely controlled vacuum conditions in this oven. The vacuum baking oven has its own vacuum pumping system, heating equipment, and temperature regulating and indicating instrumentation. The vacuum chamber can be evacuated to a pressure of 10^{-6} mm and heated to approximately 450 C. Upon completion of the bake, vacuum is broken to the inert-gas atmosphere of the dry-box.

F. J. Stokes Corp., Vacuum Equipment Div., Dept. ED, Philadelphia 20, Pa.

CIRCLE 244 ON READER-SERVICE CARD

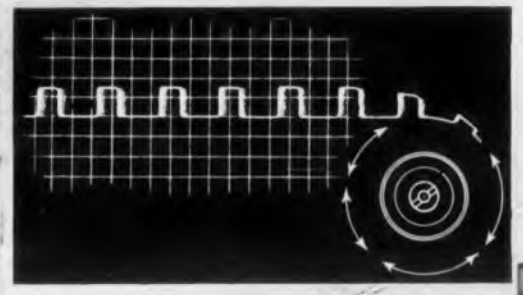
Servo Components in A Hurry

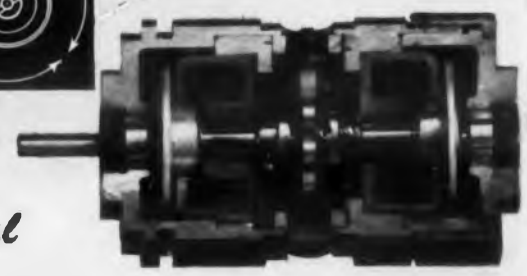
A 24-hour shipment program for standard servo components is announced by the Daystrom Transicoil Corp. The service applies to 100 servo motors and motor generators listed in the company's new catalog. All units, available either with plain or hobbed shafts, are supplied with Teflon insulated leads 8 inches long. Stock List 158 details the program.

Daystrom Transicoil Corp., Dept. ED, Worcester, Montgomery Co., Pa.

CIRCLE 245 ON READER-SERVICE CARD

STEPPER MOTOR





PROVIDES
Bi-Directional
PROPORTIONAL SHAFT ROTATION FOR A GIVEN PULSED INPUT

MODEL SM-300-1

- Angular increment per pulse — 36°.
- Stepping rate — up to 15/second.
- Voltage requirement — 28 V. D.C.
- Duty cycle — $\left(\frac{\text{on time}}{\text{on time \& off time}}\right)$ 56% max.
- Weight — 8 oz.
- Shock — 15 G's for 11 milliseconds duration each way along three major axes.
- Reliability — shall not fail to convert more than one pulse in 1,000,000 into equivalent angular rotation.

OTHER MODELS AVAILABLE WITH VARIATIONS FROM THE ABOVE SM-300-1 SPECIFICATIONS.

The two rotary solenoids contained in each motor produce the incremental motion of the output shaft in either direction. Energizing either of these solenoids produces a combination of linear and rotational motion which moves a ratchet gear axially into engagement with its mating ratchet gear and thus imparts a constant amount of rotation to the output shaft. The detent roller assembly insures constant, reproducible angular shaft rotation increments in either direction and maintains the output-shaft position while the motor is at rest with the power off.

Stepper Motors are adaptable to routine jobs such as driving mechanical counters. They also find excellent use in positioning devices that will set up a controlling voltage and/or a phase shift such as potentiometers and autosyns. They are widely used as a positioner for guided missiles to adjust heading, fuel flow, altitude, and circuit sampling for telemetering purposes. In one adaptation as a heading controller, two Stepper Motors are used to position a differential autosyn in steps of either vernier degree or coarse degrees per input pulse, bi-directionally, through a suitable gear train.

Write for more details—available upon request.

STEPPER MOTORS CORPORATION
Subsidiary of California Eastern Aviation, Inc.
7443 West Wilson Avenue • Chicago 31, Illinois

CIRCLE 246 ON READER-SERVICE CARD

NEW LITERATURE

Plug-In Limit Switch 248

A precision limit switch which can be replaced in seconds is described in Bulletin No. 20, now released. All five actuator types available are included. Dimension drawings, mounting information, and prices are covered. Minneapolis-Honeywell Regulator Co., Micro-Switch Div., Freeport, Ill.

Shaft Couplings 249

Couplings that are used where units are spaced apart and one bearing only is provided for one of the units are described in a 4-page brochure (Form No. 99), now available. Thomas Flexible Coupling Co., Warren, Pa.

Precision Finishes 250

A 20-page brochure on precision finishes on metals is now available. Particular emphasis is placed on the "Hardas Process" which is one method of hard anodizing. Anachrome Corp., 10647 Garfield St., So. Gate, Calif.

Thermal Elements 251

Selection of thermal elements for maximum resistance to corrosive atmospheres is made easy with a folder recently published. Called "Thermal Element Selection Guide for Corrosive Atmospheres," it lists more than 400 separate corrosive atmospheres into which temperature control elements are often immersed. Partlow Corp., 505 Campion Rd., New Hartford, N.Y.

Tough Bolts 252

The fastener described in this brochure combines simplicity of design with superior strength and endurance. It was specifically designed for use in high performance aircraft and missiles. The brochure is well illustrated and gives detailed information on this bolt. Rivet Tool Co., 2600 W. 247 St., Torrance, Calif.

Resistance Winder 253

Technical details on Model 209 Fully Automatic Continuous Resistance Winder which requires no operator are given on catalog page now released. Included are dimensions, types of windings, typical applications for round and flat material, and provision for adhesive application. George Stevens Mfg. Co., Pulaski Rd. at Peterson, Chicago 30, Ill.

Selenium Rectifier Ratings 256

High current density Petti-Sel industrial type selenium rectifiers are described in bulletin No. 248A. The bulletin gives the ratings and dimensions, as well as data on uprating the rectifiers when cooled by forced air. Radio Receptor Co., Inc., Semiconductor Div., 240 Wythe Ave., Brooklyn 11, N.Y.

Clutch Catalog 257

This 28-page, illustrated catalog covers a complete line of miniature and sub-miniature electromagnetic clutches and brakes. Information on each type of clutch and brake produced includes cutaway drawings, engineering data, schematic diagrams, dimensional data, minimum performance curves, oscilloscope readings, and other technical information. Autotronics, Inc., Rt. 1, Box 812, Florissant, Mo.

Plastics 258

An illustrated 6-page brochure describes the physical and chemical properties of six special clear plastic materials, and a coating material for emergency repairs. The products offer many advantages including superior resistance to corrosion, abrasion, crazing, temperature, and shattering, as well as machinability. They can be used for television faces, instrument dial covers, and plotting boards. One type is permanently antistatic; another will not support combustion. The Homalite Corp., Wilmington 4, Del.

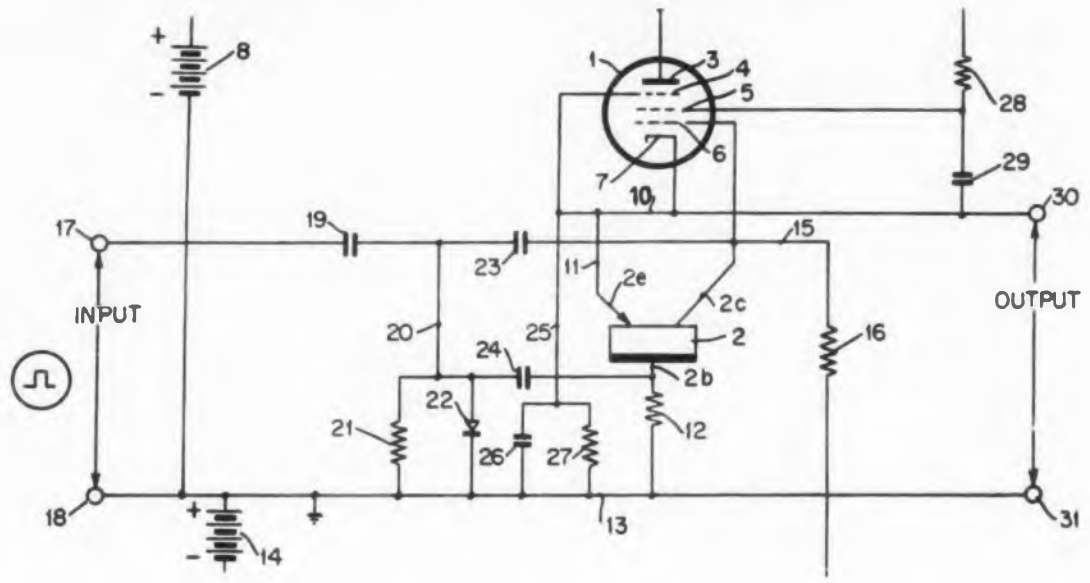
Variable Transformers 259

The 100-page Powerstat variable transformer Bulletin P258G, an invaluable reference manual-catalog, is designed for those who specify or who want to know more about variable transformers. This comprehensive, easy-to-read, file-fitting guide is filled with product information, engineering data, outline drawings, connections, ratings, charts, and illustrations on all standard 50/60 cycle autotransformers plus some special use types. The Superior Electric Co., Dept. P258G, Bristol, Conn.

Cathode Ray Tubes 260

Engineering data on Rayonic cathode ray tubes, including applications, characteristics and general information, is available. Complete electrical and mechanical data is supplied and a large variety of popular types and custom designs. Waterman Products Company, Inc., 2445 Emerald St., Philadelphia 25, a.

PATENTS



Transistor Trigger with Tube Controlling Emitter

Patent No. 2,825,806. Carl A. Bergfors. (Assigned to International Business Machines Corp.)

A transistor and a vacuum tube connected in series are used to scale high frequency pulses in a binary counter. The circuit is particularly designed so that when the transistor and tube are both "on", the tube will respond to negative pulses to cut both off; when both devices are "off", the transistor can be triggered by negative pulses to make both tube and transistor conductive. Scaling or frequency division is thereby achieved.

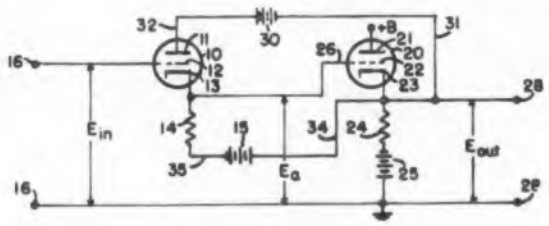
To illustrate the operation, assume the tube and transistor are both "off". A negative impulse applied to the input will be coupled to base 2b, and, since emitter 2e is clamped to ground potential by condenser 26, the transistor will conduct and make the voltage on electrode 6 less negative. The tube will conduct through emitter 2e and cause the transistor to conduct more current and thus bias the tube for increased conduction. The action is cumulative to saturation with both tube and transistor quickly triggered to "on". A second negative impulse does not effect the emitter-base current since the transistor is at saturation. However, the negative voltage applied to electrode 6 causes the tube to conduct less, causing the emitter-base current of the transistor to be reduced. This results in less current at collector 2c and a more negative bias at electrode 6. Again the action is rapid, causing a fast trigger. In this instance, however, both tube and transistor are triggered to "off".

High Input Impedance Signal-Monitoring Apparatus

Patent No. 2,839,618. William J. Heacock Jr. (Assigned to Hazeltine Research, Inc.)

Cathode followers in cascade with current and voltage feedback comprise an impedance converter having an input impedance of 1,000,000 meg. 12AT7 in the circuit measures 100 v with negligible loading on the signal source.

The circuit is designed to select an operating point such that the grid current (input current) is of the order of



0.001 μa. This is achieved by maintaining the tube current at about 60 μa and by restricting variations in the instantaneous operating point within a very small area.

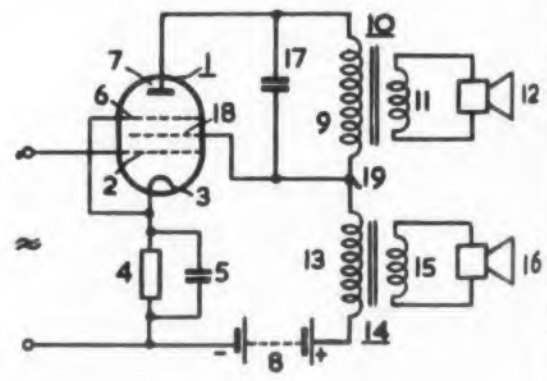
As shown, plate II is tied to cathode 23 such that voltage changes in load impedance 24 are fed back. The plate and cathode of tube 10 change in the same sense with the input voltage. In effect the plate to cathode voltage remains at the quiescent value.

Cathode 23 is tied back to cathode 15 through resistor 14 and the voltage at either end of this resistor is the same. This insures constant current in tube 10 with high dynamic input impedance over a wide range of input voltages.

Output Stages for Low-Frequency Amplifiers Comprising Two Loudspeakers

Patent No. 2,846,503. Johann Kump. (Assigned to North American Philips Company)

The circuit applies to advantage known concepts that triodes inherently produce less distortion, that a lf speaker will not reproduce harmonic distortion and that the subjective impression of sound is unaffected if the low and intermediate frequencies are reproduced satisfactorily. Accordingly, the invention lies in a power output stage in which the amplifier tube is driven as a pentode for low frequen-



cies and as a triode for the high frequencies.

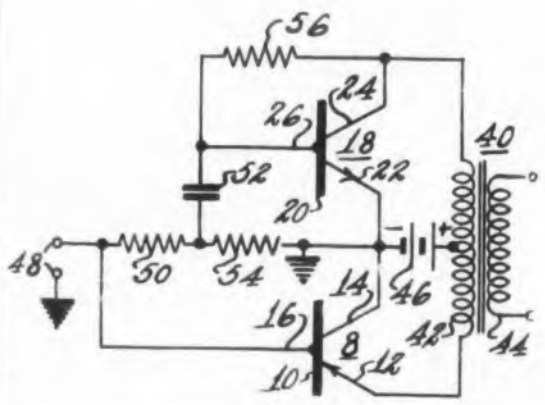
The illustration circuit consists of pentode power amplifier tube *1* connected in series with the primary of lf speaker *12* and the primary of hf speaker *16*. At low and intermediate frequencies, the tube operates as a pentode with the screen electrode at the plate supply voltage since the impedance of primary winding *13* is low. Speaker *12* does not reproduce hf distortion. At high frequencies, primary winding *9* is shorted by capacitor *17* and the tube operates as a triode to deliver low distortion hf power to speaker *16*.

Transistor Amplifier Circuits

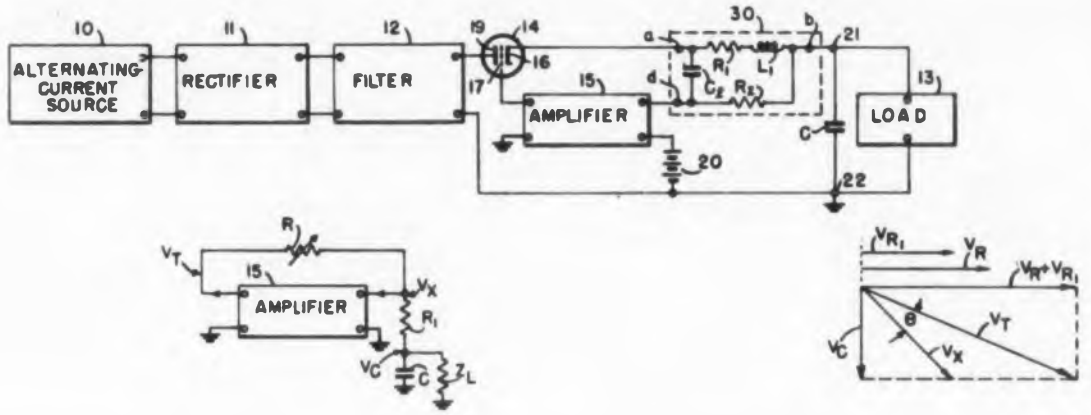
Patent No. 2,839,620. Frederick D. Waldhauer (Assigned to Radio Corporation of America.)

Complementary symmetry transistors directly produce amplified push-pull power output from a single phase voltage input.

In the circuit shown a single phase voltage is applied at input terminals *48* producing a push-pull output across transformer *40*. Npn transistor *18* and pnp transistor *8* are connected with their



emitter-collector paths in series with the transformer winding. The junction of emitter *22* and collector *14* are grounded. A positive signal applied simultaneously to bases *16* and *26* causes collector *24* current to decrease while emitter *12* current increases. With change in polarity of the input signal, collector *24* and emitter *12* currents reverse. Resistor *56* is required to reduce the voltage gain of transistor *18* and to stabilize the circuit operation.



Voltage Regulator Circuit

Patent No. 2,826,735. William J. Heacock, Jr. (Assigned to Hazeltine Research, Inc.)

The circuit is designed to prevent high frequency oscillation of a dc voltage regulator which has circuit capacitance coupled across the output terminals.

In the conventional regulator, the high gain amplifier degeneratively couples back to the regulator a signal proportional to the difference of the reference voltage and the actual output voltage. At high frequencies, however, the phase of the voltage of the capacitance across the output may shift sufficiently to cause regenerative feedback, resulting in circuit oscillation.

The equivalent circuit indicates that since, at higher frequencies, the reactance of condenser C_2 is low, the amplifier input is the resultant of the voltages of the resistor R_1 and condenser C in series. This reduces the phase of the amplifier voltage such that even a high gain amplifier will not oscillate. In addition, the inductance L_1 contributes a leading phase shift to reduce the tendency of the circuit to oscillate at still higher frequencies.

It is to be noted that the normal low frequency characteristics of the regulator are unaffected by the voltage drop across resistor R_1 since the voltage across the output condenser C is coupled directly to the amplifier input through resistor R_2.

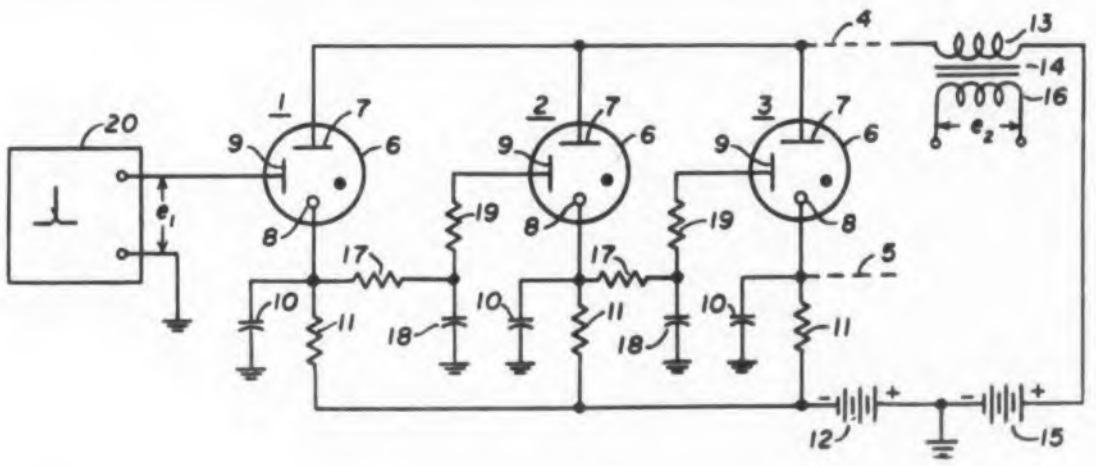
Pulse Generator

Patent No. 2,831,972. Howard L. Foote. (Assigned to General Dynamics Corp.)

Cold cathode discharge tubes connected in cascade generate a train of pulses in response to a single initiating pulse.

The circuit uses three tubes in cascade having a common output connection to the transformer primary. Each stage has an individual cathode load comprising integrating resistor 17 and condenser 18.

An impulse to stage 1 causes this stage to fire and the change in current in the transformer primary induces an impulse in the secondary. Stage 2 is fired after the predetermined delay in the cathode coupling integrator and a second impulse appears in the transformer secondary. Similarly, stage 3 is fired subsequent to the second delay and a third impulse couples to the output. However, conduction of stage 3 lowers the plate voltage common to all stages such that conduction can no longer be sustained. All tubes cut off and the circuit is reset to multiply the next impulse from the pulse source.



BOOKS

Physics and Mathematics in Electrical Communication

Dr. James Owen Perrine, John F. Rider Publisher, Inc., 116 West 14 St., N.Y. 11, N.Y., 268 pp, $7.50.

This book offers a probing explanation of what happens in electrical circuits. The text contains numerous explanatory diagrams. On a foundation of associated mathematics made completely understandable and replete with numerical examples, the author ties together physical concepts and electrical communication. An entirely new approach is used in analyzing hyperbolic functions, exponential equations, and related functions.

Transistor Technology Vol. 2

F. J. Biondi, Editor, D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N. J., 701 pp, $17.50.

This volume brings together much of the recent literature on the technology of materials and principles of transistor design through the efforts of many contributors. The technology of materials focuses on the basic physical properties, the preparation of material, and the effects of processing treatment on materials properties. A number of papers take up the control of lifetime in germanium and silicon, and the removal of impurities from silicon. They introduce work on recombination centers in silicon, methods for growing germanium, and present a discussion of a chemical etching technique for finding dislocations in silicon.

Transistor design topics include a discussion of diodes emphasizing avalanche mechanism, large-signal behavior and switching design as well as principles related to frequency response of transistors in junction triodes. Other aspects covered are: base-layer design; complex switching devices; tetrodes; and radiation sensitivity device design including a discussion of the silicon solar energy converters.

Engineering Electromagnetics

William H. Hayt, Jr., McGraw-Hill Book Co., 330 West 42nd St., New York 36, N.Y. 328 pp, $8.50.

This book offers an introduction to electric and magnetic fields. The material includes electrostatics, the steady magnetic field, time-varying fields and Maxwell's equations, and includes a number of examples illustrating the applications of Maxwell's equations. Vector analysis is used throughout.

In order to illustrate and clarify the use of Maxwell's equations, the final two chapters provide an introduction to skin effect, wave motion, circuit concepts, radiation, and relativistic effects. The sections on relaxation and iteration methods of experimental mapping are another unique feature of this book.

Oscilloscope Techniques

Alfred Haas, Gernsback Library Book Co., 154 West 14th St., New York 11, N. Y. 224 pp, $2.90 paper, $4.60 bound.

The book features photographs of 'scope patterns—many uncommon—explaining how to obtain these waveforms, and what they indicate. It is handy reference for anyone who uses the 'scope professionally or experimentally, and will suggest many new and varied uses beyond those in routine bench work.

Better Report Writing

Willis H. Waldo, Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y. 231 pp, $4.75.

This desk guide presents ideas on scientific composition, style, division of reports, tables, illustrations, and use of words. It is written as a reference instead of a classical exposition of technical English. Three appendices condense information on abbreviations, symbols, and hyphenation. This is a guide in book form for anyone concerned with scientific report writing.

Electronic Components Handbook, Volume Two

Keith Henney and Craig Walsh, McGraw-Hill Book Co., Inc., 330 West 42nd Street, New York 36, N. Y. 368 pp, $12.50.

The second volume of the handbook for designers of military and commercial electronic equipment furnishes data on: power sources and converters; fuses and circuit breakers; electrical indicating instruments; printed wiring boards; solder and fluxes; choppers; blowers; rf transmission lines and waveguides. It is intended as an aid in selecting and applying the best unit for a particular job so that maximum reliability of the end product results.

The book lists the effect on each of unfavorable environment such as heat, humidity, altitude, pressure, shock, vibration, etc. Like Volume One, which covered resistors, capacitors, relays, and switches, this book concentrates on those kinds of component parts for which a coordinated tri-service military specification has been written. In addition, it also covers other component types for which only single-service specifications or industrial specifications are available. A digest of the military specifications covering each kind of each component is given.

Color TV Principles and Practices

Prepared by General Electric Co., Owensboro, Ky. 135 pp, $5.00.

Here are the three fundamentals necessary to service color: Colorimentry, the science of measuring and analyzing color; the standard color specifications of the National Television System Committee adopted by the FCC; and special receiver circuitry which translates colorimentry into electronics. The book covers the basic concepts of hue, saturation, luminosity, and the use of a chromaticity diagram—and clearly explains how relatively simple sub-circuits implement those principles.

The text is profusely illustrated with clearly-arranged diagrams explaining circuitry; humorous but pointed drawings which illustrate functions without tedious technical written explanations; and 18 color plates demonstrating service problems.

Part 4 of Professor Kharkevich's nomograph includes his Sections 6 and 7. In these sections, he discusses frequency multiplication, linearization, and nonlinear distortion. ELECTRONIC DESIGN's serial translation of this work has been a bi-weekly presentation since September 17th.

Nonlinear and Parametric Phenomena in Radio Engineering

Part 4

A. A. Kharkevich

(Translated by J. George Adashko)

Chapter 1

Nonlinear Circuits and Fundamental Nonlinear Processes

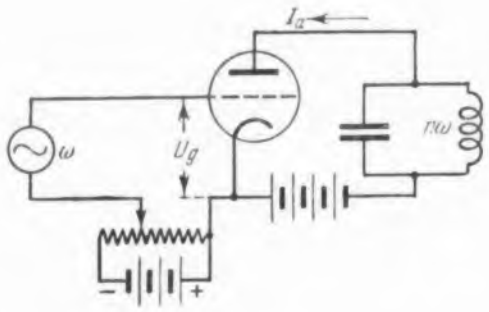


Fig. 9. A typical frequency multiplier. The tank circuit is tuned to the n'th harmonic of the signal applied to the grid.

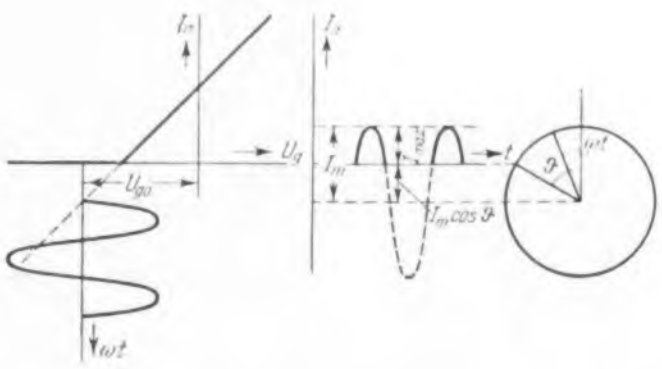


Fig. 10. An approximation of the characteristics of the triode used for the frequency multiplier in Fig. 9.

6. Frequency Multiplication

A nonlinear system can be used for frequency multiplication, to obtain a frequency that is a multiple of an available one. Frequency multiplication is resorted to when direct generation of the required frequency is for some reason not feasible.

Multiplication is based on an exceedingly simple scheme. Voltage of the original frequency is applied to a nonlinear network to produce a current of high harmonic content. The harmonic of the desired frequency is separated by a filter.

One such circuit is shown in Fig. 9. A sinusoidal voltage of radian frequency ω is applied to the grid of the triode; the tank in the plate circuit is tuned to the n'th harmonic, which is selected by the tank circuit. The remaining harmonics, to which the tank-circuit presents little impedance, are filtered out. An adjustable negative bias, sufficient to cut off the triode, is applied to the grid. The result is the so-called "cut-off mode."

Let us approximate the characteristic of the triode by means of a broken line, as shown in Fig. 10. This approximation is sufficient for our purpose. We choose the operating point to the left of the bend in the characteristic. When the operating point is in this position and if the applied grid voltage is sinusoidal, only short current pulses will flow in the plate circuit. The remaining portion of the sinusoidal current (shown dotted) will be cut off—hence the name of this operating mode. The mode is fully characterized by the cutoff angle, i.e., by the value of the argument ωt, at which the current vanishes (reckoned from the instant of time when the plate current is maximum). Knowing the cutoff angle, it is possible to expand the expression for the plate current into a Fourier series. The plate current can be represented as a function of time in the form

$$I_a = I_m (\cos \omega t - \cos \theta) \quad [I_a > 0]$$

(The symbols are shown in Fig. 10). For the amplitude of the n'th harmonic we have, from the known relation

$$I_n = \frac{1}{\pi} \int_{-\pi}^{\pi} I_a (\omega t) \cos n\omega t \, d\omega t =$$

$$= \frac{2}{\pi} I_m \int_0^{\theta} \cos nx (\cos x - \cos \theta) \, dx =$$

$$= \frac{1}{\pi} I_m \left[\frac{\sin (n+1)\theta}{n+1} + \frac{\sin (n-1)\theta}{n-1} - \frac{2 \cos \theta \sin n\theta}{n} \right]$$

$$= I_m F_n(\theta).$$

In practice one can specify not I_m (determined by the amplitude of the grid voltage) but I_{max} the peak value of the plate current. These two quantities are obviously related by

$$I_{max} = I_m (1 - \cos \theta).$$

Expressing now the amplitude of the n'th harmonic of the plate current in terms of the peak value of the plate current, we have

$$I_n = I_{max} \frac{F_n (\theta)}{1 - \cos \theta} = I_{max} f_n (\theta).$$

Functions of the cutoff angle for various values of n are shown graphically in Fig. 11. These curves show how to select the cutoff angle to obtain the maximum amplitude of the desired harmonic. Thus, for example, we must use $\theta = 40$ deg for frequency tripling, and so on.

7. Linearization and Nonlinear Distortion

Nonlinear relations play a double role in radio engineering. In many cases the nonlinearity determines the very nature of the process and is

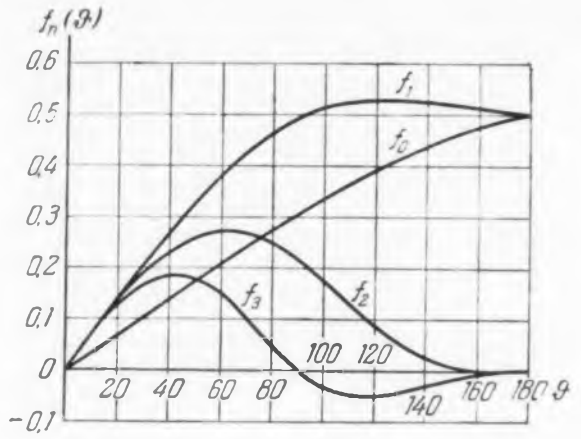


Fig. 11. Functions of the frequency multiplier cutoff angle for various harmonics.

used to obtain the desirable result. This takes place, for example, in frequency multiplication, in detection, and in many other important applications. But sometimes nonlinearity is not only unnecessary, but is harmful and undesirable. This occurs, for example, in amplification.

Waveform distortion and the resultant spectrum enrichment which are typical of a nonlinear system, are essential for frequency multiplication. In amplification, however, we deal with the inverse problem, that of retaining the initial waveform of the oscillations as much as possible. Any change in the waveform, resulting from the nonlinearity of any circuit element, is called nonlinear distortion. It is necessary to reduce this distortion, i.e., to eliminate the nonlinearity effect.

Strictly speaking, no system is linear. So-called "linear" systems are merely those whose nonlinearity can be neglected under the circumstances. The possibility of neglecting nonlinearity depends not only on the characteristic of the system, but also on the operating conditions. For example, in the case of amplification, the operating point is best placed at the center of the straight-line section of the tube characteristic, and the amplitude of the control voltage is best held within the limits of its straight portion. Actually, the characteristic is always curved, and when we speak of a straight portion, we mean one having a sufficiently small curvature.

Replacing a nonlinear relation by an approximate one, together with any measure aimed at improving the approximation, is generally called linearization.

The linearization concept will be explained first with a particular example. Consider the quadratic characteristic

$$I = aU^2.$$

This nonlinear relation cannot be represented by an approximate linear one in any manner whatever. But suppose that the voltage U consists of

NEW Automatic Electronic Cable-making Machine Announced

(Los Angeles, California) After years of development, The Zippertubing Company announces production of a machine which automatically makes cables at speeds up to 900 feet per hour. This machine, occupying only 24 square feet of floor space, produces cables with up to 108 conductors and is so simple to operate that inexperienced personnel can make cables to any specification.

This new equipment utilizes the revolutionary Zippertubing cable jacketing, which is fed into the machine along with the required number of conductors. The Zippertubing then is automatically wrapped around the conductors, zipped closed and, if required, permanently fused with a chemical sealer. The completed cable automatically is wound on the take-up reel for storage or shipping. The machine will produce cable from ⅜" to 2½" O.D. with larger sizes on special order.

Complete unit with wire reels in place.

MULTI-JACKETED CABLES IN ONE STEP

By using Zippertubing laminated materials, cables which require jackets of several different materials can be made in one step without costly re-handling. Available jackets include copper, aluminum or Co-netic steel in combination with such materials as vinyl, Mylar,* or fiber glass. Other laminates for high temperature exposure, abrasion protection, etc., also may be used in the machine.

SUBSTANTIAL SAVINGS

Up to 90% of the labor costs formerly involved in fabricating cables are eliminated through the use of the Zippertubing Cable Machine. Only limited floor space is necessary for long-run continuous lengths, and material waste, skilled labor investment and expensive extruding equipment no longer are required. Expensive "minimum" orders for custom extruded cabling as well as delay in deliveries also are eliminated. Because of the flexibility of Zippertubing, small cable runs for R & D work are economically feasible. Zippertubing cables can be re-opened for additional work on conductors, virtually eliminating the great costs formerly incurred in correcting mistakes in prototype development.

Close-up of head showing Zippertubing jacketing and conductors being formed into cable and automatically sealed.

MEET MIL SPECS

Cables produced on this new equipment meet all necessary MIL specs, depending on the jacketing material and the purpose for which it is to be used.

CABLE MACHINE FREE

One of the purposes of this new machine is to help manufacturers reduce their capital investment and inventory in electronic cables. A special plan has been developed whereby manufacturers who use 10,000 feet or more of Zippertubing jacketing per month will be provided with one of these machines at no cost. For those with more modest requirements, the machine may be leased very inexpensively with option to buy, or it may be purchased outright. A 100% lifetime guarantee is available under all plans. When ordering, allow three weeks for delivery.

AVAILABLE IN THREE PARTS

The Zippertubing cable machine may be ordered in three units: basic unit, which includes the head and sealing device; wire payoff unit, which contains the "tree" and spindles for holding the wire reels; power unit, which has the take-up reel spindle, frame and 115 V AC/DC motor that pulls the cable through the complete process.

For complete catalog information or field engineering service, write to the manufacturer: The Zippertubing Company, 752 So. San Pedro St., Los Angeles 14, California. TWX LA 840. Sales offices and warehouses are located in all principal cities.

(advertisement)

**Trademark of duPont.*

CIRCLE 269 ON READER-SERVICE CARD

a dc component U_0 and an ac component ΔU. We are interested in the latter only. Then

$$I = aU^2 = a\,(U_0+\Delta U)^2 = a\,(U_0^2+2U_0\Delta U+\Delta U^2).$$

The current thus has three components: a dc component

$$I_0 = aU_0^2$$

a linear component

$$I_1 = 2aU_0\,\Delta U$$

and a quadratic component

$$I_2 = a\Delta U^2.$$

The dc component is usually of no interest to us. We write the increment of the current in the form

$$\Delta I = I_1 + I_2 = 2aU_0\Delta U + a\Delta U^2$$
$$= 2aU_0\Delta U\left(1+\frac{1}{2}\,\frac{\Delta U}{U_0}\right).$$

We are justified in discarding the second term provided

$$\frac{\Delta U}{U_0} \ll 1,$$

i.e., the smaller ΔU and the greater U_0, the better the linearization approximation. This result is illustrated graphically in Fig. 12, from which it is seen that by increasing U_0, the working point is shifted towards a section of the parabola with a smaller curvature, and at the same time, with a greater slope.

Reduction of ΔU permits linearization of any nonlinear dependence.*

To demonstrate this, let us assume that we are given a nonlinear characteristic in general form

$$I = f\,(U).$$

Let us expand the expression for the current in a Taylor series about the point U_0:

$$I = f\,(U_0) + f'\,(U_0)\,\Delta U + f''\,(U_0)\,\frac{\Delta U^2}{2}$$
$$+ f'''\,(0)\,\frac{\Delta U^3}{6} + \ldots$$

If ΔU is sufficiently small, the higher-order terms can be neglected, and the linearized expression for the current becomes

$$I \cong f\,(U_0) + f'\,(U_0)\,\Delta U.$$

The dc component is determined by the ordinate of the characteristic at the operating point, and the slope is determined by the derivative at this point.

*However, a linearized description of phenomena occurring in certain systems, has no physical meaning. We shall not encounter these exceptional cases.

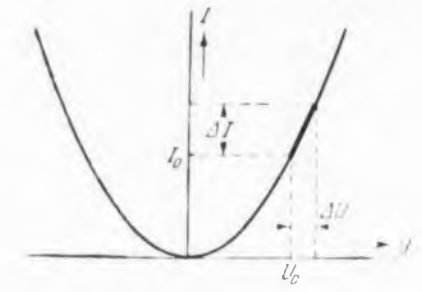


Fig. 12. In this parabola, as ΔU decreases, or U_0 increases, the $\Delta I/\Delta U$ relationship becomes more linear.

The tangent to the characteristic at the operative point may turn out to be horizontal, i.e., $f'(U_0) = 0$. In this case it is necessary to shift the operating point by changing U_0. Thus, in the quadratic example above we had

$$f\,(U) = a\,U^2, \quad f'\,(U_0) = 2aU_0$$

and had we taken $U_0 = 0$ we would have obtained $f'(0, = 0.$

Nonlinear distortion in an almost-linear system must be estimated and measured by several methods, all based on the spectrum enrichment due to the nonlinearity. The first method consists of applying a sinusoidal voltage to the input of the system and determining the effective values of all output harmonics but the first. The ratio of this quantity to the effective value of the first harmonic (fundamental frequency) is called the harmonic distortion

$$k = \frac{\sqrt{I_2^2 + I_2^2 + \ldots}}{I_1}$$

where I_1, I_2, etc. denote the amplitudes of the harmonics. Nonlinear distortion is assumed negligible if the harmonic distortion does noth exceed one per cent. Commercial apparatus usually is specified to contain a harmonic distortion not exceeding five per cent.

The second method consists of applying simultaneously to the input of the system two sinusoidal voltages of different frequencies. In this case, as shown in Section 5, a rich spectrum of combination frequencies is formed. The coefficient characterizing the nonlinear distortion is determined in the same manner as the harmonic distortion.

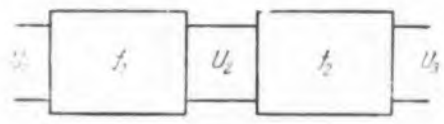


Fig. 13. A nonlinear two-port network with a second two-port correcting network.

Recently a new method was proposed for determining the nonlinear distortion. It is based on measuring the total power in a certain frequency band, produced in response to an input with a continuous spectrum, from which the same frequency band is first eliminated by means of a filter. If the tested system is linear, the frequencies eliminated from the input are absent from the output. Owing to nonlinearity, however, combination frequencies and harmonics, the so-called nonlinearity products, are produced within the eliminated band. It is this product that is measured. The new method corresponds more closely to actual operating conditions of the apparatus and gives a more correct estimate of the nonlinear distortion.

It should be pointed out that nonlinear distortion can be corrected in the same manner as frequency distortion. Let us assume that there is a nonlinear two-port network with a characteristic

$$U_2 = f_1(U_1).$$

Let us add to this two-port network a second network, serving as a corrector (Fig. 13). Its characteristic

$$U_3 = f_2(U_2)$$

should be chosen in such a way as to eliminate the nonlinear distortion, i.e., as to make

$$U_3 = AU_1.$$

This condition yields

$$\frac{U_3}{U_1} = \frac{U_3}{U_2}\,\frac{U_2}{U_1} \qquad \frac{f_2[f_1(U_1)]}{U_1} = A$$

$$f_2[f_1(U_1)] = AU_1,$$

i.e., the function f_2 should be the inverse* of the function f_1.

For example, if

$$f_1(U_1) = aU_1^2,$$

then we should have

$$f_2(U_2) = b\sqrt{U_2}.$$

With these relations we obtain

$$U_3 = b\sqrt{U_2} = b\sqrt{aU_1} = AU_1.$$

*Let us recall the definition of an inverse function. If

$$y = f(x),$$

then, solving this equation for x, we get

$$x = \phi(y).$$

The function ϕ is the inverse of the function f. Furthermore

$$\frac{\phi[f(x)]}{x} = \frac{f[\phi(y)]}{y} = 1.$$

ELECTRONIC DESIGN

Angular to Digital Conversions

Daniel Levine
Consulting Engineer
Glendale, Ariz.

THESE TWO tables are handy compilations of data for engineers making angular-to-digital conversions. The first table consists of binary bits which can be transferred to digital computer notations, thusly:

Bits	Circle Parts	Notation
0	1	1
1	2	10
2	4	100
3	8	1000
	—etc.—	

The bits, therefore, represent powers of two.

The second table divides a circle by powers of ten. The decade block represents the power. Parts of a circle and the angular measure follow, respectively.

A useful addendum of angle to radian conversions ends the tables.

Shaft-to-digital encoding can find special application for the tables. In an encoder, the number of binary or decimal digits will indicate the angular accuracy in reading the shaft position. For example, if a technique of encoding employs 15 binary bits the shaft is divided into 32,768 parts and the angle can be read within 39.551 seconds.

Engineering Data

Angular-to-Digital Conversions

Bits	Parts of Circle	Angular Measure
0	1	360°
1	2	180°
2	4	90°
3	8	45°
4	16	22.5°
5	32	11.25°
6	64	5.625°
7	128	2.8125°
8	256	1.40625°
9	512	42.1875′
10	1,024	21.09375′
11	2,048	10.546875′
12	4,096	5.2734375′
13	8,192	2.63671875′
14	16,384	1.318359375′
15	32,768	39.55078125″
16	65,536	19.7753900625″
17	131,072	9.8876953125″
18	262,144	4.94384765625″
19	524,288	2.471923828125″
20	1,048,576	1.2359619140625″
21	2,097,152	0.61798095703125″

Decades	Parts of Circle	Angular Measure
0	1	360°
1	10	36°
2	100	3.6°
3	1,000	21.6′
4	10,000	2.16′
5	100,000	12.96″
6	1,000,000	1.296″

Angle-to-Radian Conversions	Angle	Radians
	1 deg	0.0174532925
	1 min	0.0002908882
	1 sec	0.0000048481

IDEAS FOR DESIGN

Get $10.00 plus a by-line for the time it takes you to jot down your clever design idea. Payment is made when the idea is accepted for publication.

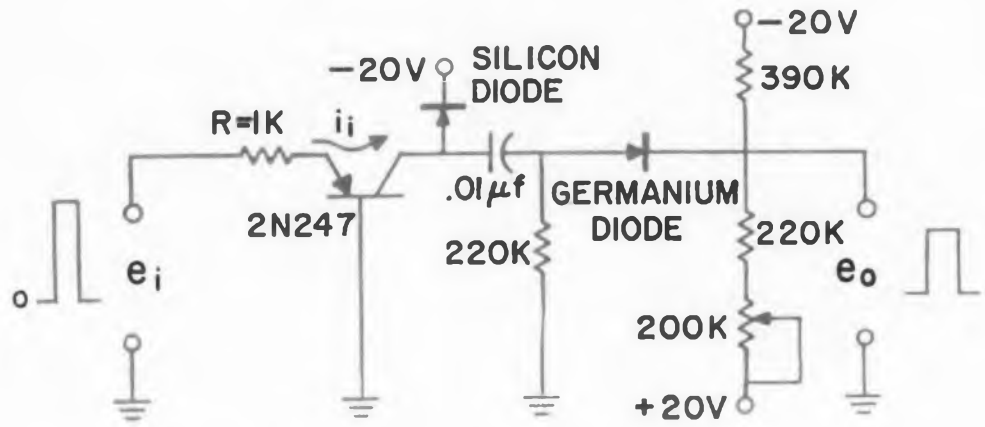


Fig. 1. Logarithmic video amplifier.

A Logarithmic Pulse Amplifier

IT WAS necessary to design a pulse amplifier whose output was a logarithmic function of the input pulse amplitude over a wide dynamic range of input signal variation.

A high speed silicon diode served the purpose very well, as is shown in the circuit diagram in Fig. 1.

A curve showing e_o versus e_i for the circuit is shown in Fig. 2.

Since the plot in Fig. 2 is a semilog presentation, it can be seen that $e_o = k \log e_i$ very closely over a 100 to 1 range of input voltage (40 db).

The circuit is based on the forward V-I characteristics of an ideal semiconductor diode as shown in eq (1).

$$I = I_s \left[e^{(KT/q)V} - 1 \right] \qquad (1)$$

where I = diode current

I_s = saturation current of diode

V = diode voltage

K = Boltzmann's constant

T = Absolute temperature

q = Charge on an electron

Rearranging terms and taking the logarithm of

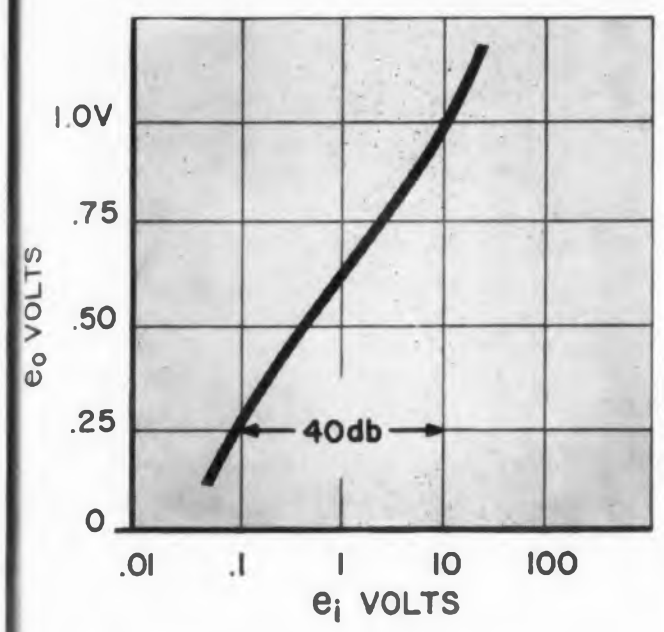


Fig. 2. Output voltage versus input voltage for log video amplifier shown in Fig. 1.

both sides of eq (1) results in eq (2).

$$(I + I_s) = I_s\, \epsilon^{(KT/q)V}$$

$$log_\epsilon\,(I + I_s) = (KT/q)V + log_\epsilon I_s \qquad (2)$$

If $I \gg I_s$ (which is the case for $I > 10\ \mu a$) then

$$V = K_1\, log_\epsilon\, I + K_2 \qquad (3)$$

where $K_1 = KT/q$

$K_2 = log_\epsilon\, I_s$

The low input impedance and high output impedance of the 2N247 grounded base amplifier make $i_i = (1/R)\, e_i$ (for $e_i = 100$ mv). Then:

$$e_o = K_1\, log_\epsilon\, i_i + K_2 = K_1\, log_\epsilon\, (e_i/R) + K_2$$

$$e_o = K_1\, (log_\epsilon\, e_i - log_\epsilon\, R) + K_2$$

$$e_o = K_1\, log_\epsilon\, e_i + K_3 \qquad (4)$$

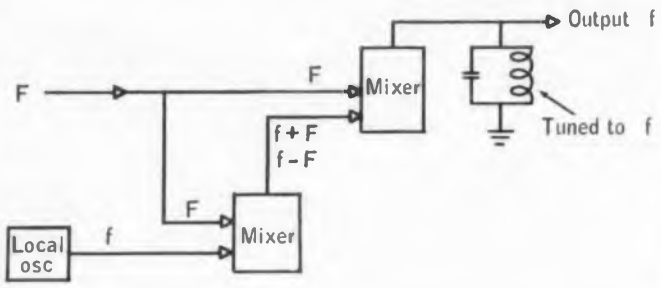
where $K_3 = (K_2 - log_\epsilon\, R)$

Eq (4) is the desired relationship except for the constant term K_3. This constant term is subtracted from the output by the back biased germanium diode and resistive network shown in Fig. 1.

For short pulse lengths, (1-10 μsec), the Transitron S10G and SG226 silicon diodes work very well because of their low shunt capacity and fast switching time. For longer pulses a general purpose type 1N483 will perform very well over an even larger dynamic range than that shown in Fig. 2.

Eugene P. Hoyt, Motorola Research Lab., Riverside, Calif.

IDEAS FOR DESIGN



From Many—One. This arrangement provides a single, known output frequency, regardless of the input frequency.

One RF Frequency From Many

We needed a circuit to accept rf at any frequency and, without tuning, deliver a known and constant rf frequency, despite any input frequency change.

The block diagram shows the solution. The local oscillator is tuned to the desired output frequency f. This is mixed with any incoming frequency F in mixer 1. The output of mixer 1 is $f+F$ and $f-F$. These are heterodyned against the incoming F in mixer 2. Mixer 2 provides $f+2F$, $f-2F$, and f. A tank at the mixer output can assure that the output frequency will always be f, regardless of the input frequency.

The local oscillator can be crystal controlled, so the output frequency can be as stable as if it were crystal controlled.

J. Frank Brumbaugh, Senior Marine Eng., Heath Co., Benton Harbor, Mich.

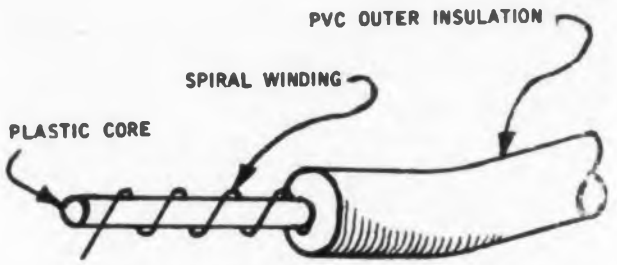
Noise Suppression in Automobiles

Automobile ignition interference is mainly due to shock-excitation, by each spark, of the wires connecting the ignition coil, the high voltage distributor, and the spark plugs.

The other sources of automobile interference, namely the sparks due to bad contacts or poor connections in the electrical equipment, are easily silenced by the use of standard anti-interference capacitors connected right across the spark sources, and due care.

However, ignition interference, which affects radio and television, is a different problem. The usual solution has been to insert, in each high voltage conductor, a special low value resistor to damp out the oscillations. There is generally one resistor on each spark plug and one in the wire connecting the ignition coil to the distributor.

A new and better way has been found by the French firm PIA. Instead of a lumped resistor,



ANH-intereference High Voltage Wire

the damping resistance is distributed along the length of the wire. This is obtained by spiral-winding a resistant wire around a plastic core (see figure). Besides a distributed resistance, this process provides a distributed self-inductance in a circuit where capacitance usually prevails.

A two-fold advantage issues. On the one hand, the resonant frequency is lowered and easier to eliminate. On the other hand, the amplitude and form of the sparking voltage are improved and make for better ignition. This has been born out by trials on the road.

Finally, the spiral winding acts as an rf choke, and tends to confine the spark voltage where it belongs—across the spark gaps.

A. V. J. Martin, Carnegie Institute of Technology, Pittsburgh, Pa.

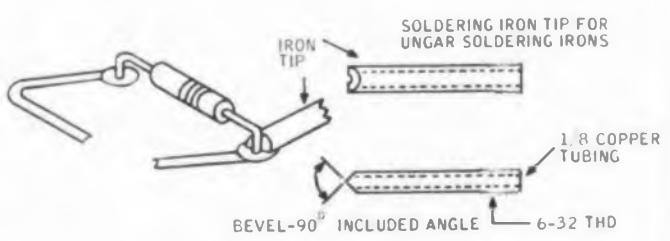
Better Soldering For Printed Circuits

In soldering components to printed circuit boards, the best joints are made if the component lead and eyelet (or pad) are heated simultaneously, with uniform heat, and, of course, quickly.

A short length of 1/8 in. copper tubing can be threaded at one end, and filed at the other end, to make an excellent soldering iron tip for Ungar type soldering irons.

With this soldering iron tip, one can heat the component lead and the eyelet at the same time. Faster solder joints result with no damage from excess heat and long soldering dwell times.

R. A. Wyman, Group Eng., Lockheed Aircraft Corp., Palo Alto, Calif.



Copper tubing makes excellent printed circuit soldering tip.

What the Russians Are Writing

J. George Adashko

MEASUREMENTS

Measurement of Peak and Instantaneous Values of Periodic Voltages and Currents by A. D. Kratirov. EC 2/58, pp 65-70, 5 figs.

Describes how to measure peak and instantaneous periodic voltages or currents with the aid of detector instruments and with the aid of d'Arsonval meters with rectifiers of other types. Fundamentals of the procedure are given along with the basic diagrams of the measuring instruments and the possible field of their application. Measuring the alternating component (pulsations) of rectified voltages and currents with the aid of pointer-type voltmeters and ammeters is shown possible.

Prototype of an Instrument for Checking UHF Standard Signal Generators by Measuring the Coefficient of the Depth of the Amplitude Modulation by P. A. Shpan'on. Izmeritel'naya tekhnika 3-4/58 pp 78-82, 3 figs.

The instrument is based on the method of measuring the coefficient of depth of modulation of a small amplitude-modulated uhf voltage. The nonlinearity of the amplitude characteristic of the i amplifier does not affect in principle th error of the measurement.

Measurements by Means of a Broadband Indicator in the Presence of Nonlinear Distortion by V. A. L'vov. EC 3/58, pp 54-57, 2 figs.

The errors involved in the attenuation of a two-port network with nonlinear distortion in the oscillator or in the two-port network is made as a function of the type of the measured frequency characteristic of the attenuation. A formula is obtained for the necessary attenuation in the measuring filter, connected at the oscillator output, to insure a specified measurement accuracy. The specific case of the measurement of attenuation in the rejection band of the high frequency filter is considered.

Measurement of the VSWR of a Generator by Means of a Phase Shifter by L. N. Bryanskiy. Izmeritel'naya tekhnika. 3-4/58, pp 87-88, 2 figs.

In the case of a generator with waveguide output the vswr can be measured in a simpler manner than with the usual slotted line technique. This can be done

by replacing the slotted line with a phase shifter and a probe. The same accuracy is obtained, although the cost of a probe and phase shifter is usually half of the cost of a slotted line. See Fig. 1.

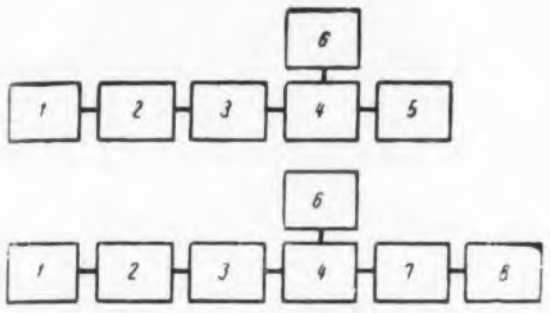


Fig. 1. Block diagram of two equivalent methods of measuring vswr. 1—generator; 2—decoupling attenuator; 3—phase shifter; 4—probe; 5—short-circuiting pluner 6—indicator; 7—auiliary phase shifter; 8—stationary short circuit.

TRANSISTORS

Approximate Transient and Frequency-Phase Characteristics of the Intrinsic Current Gain of a Junction Transistor by T. M. Agakhanian. RE 2/58, pp 3-13, 7 figs.

An exact solution of the transfer function for the intrinsic current gain of a junction transistor is quite complicated. The customary simplification is to replace the transfer function by two functions, one applicable for the initial instant of time, the second beyond this time. Even this approximation involves certain mathematical difficulties. The author proposes another simplified expression. The transfer function (t) is represented by a single expression, and yet sufficient accuracy is retained. All three types of transistor connections are considered. Reference is made to many American articles on the subject.

Contribution to the Theory of the Transfer Characteristic of a Transistor by A. A. Grinberg. RE 2/58, pp 51-53.

The transfer characteristics are obtained for various transistor connections. The analytic form of the transfer characteristics makes it possible to account for the collector capacity and the load impedance of the transistor.

Influence of the Dependence of the Frequency Properties of a Transistor on Its Electric Operating Conditions on the Duration of the Wave Fronts by I. I. Litvinov. RE 2/58, pp 53-58, 5 figs.

Experience in the use of semiconductor relaxation oscillators with a single reactance has shown that if the peaks of the generated pulses are not steep, the duration of the trailing fronts turn out to be at times considerably greater than those of the leading fronts. This phenomenon cannot be explained by means of a pulse-shaping analysis that assumes the transistor frequency properties to be independent of its operating conditions. The reason for this contraction of the trailing front is the accumulation of minority carriers in the germanium during saturation. So far, only few attempts have been made to take this effect into account analytically.

Equivalent Circuits of Transistors for a Broad Frequency Band by K. Shul'gin. R 3/58, pp 52-55, 6 figs, 1 table.

Continuing a previous article in the November 1957 issue of "Radio," where only low-frequency equivalents were considered. In the present article equivalent circuits are developed for some Russian transistors for a wider range of frequencies.

On the Parameter h_{11}/z_{11} of a Transistor and Generalized Characteristics of Impedances and Gains by V. K. Labutin. RE 2/58 pp 59-68, 7 figs, 1 table.

A new transistor parameter, a ratio of the short-circuit to open-circuit input impedance, is used in the article to derive generalized characteristics and impedance and gain diagrams, which permit a lucid description of the amplifying properties of a transistor under small-signal conditions at low frequencies.

Regeneration and Neutralization of Transistor Stages by A. A. Rizkin. EC 2/58, pp 12-19, 11 figs.

The author indicates that certain concepts and formulations available in the literature concerning the internal feedback of a transistor stage and its neutralization are incorrect. The concepts of the internal feedback and the connection between the input and output circuits of the stage are delineated.

(Continued on following page)

RUSSIAN TRANSLATIONS

CIRCUITS

Direct Coupled Transistor Amplifiers by N. S. Nikolayenko. RE 2/58 pp 14-22, 8 figs.

The article analyzes ac transistor amplifier with direct coupling between stages. The circuit has many advantages, being simple to construct, containing a minimum number of parts, and permitting transistorized amplifiers to operate at temperatures up to +100 C.

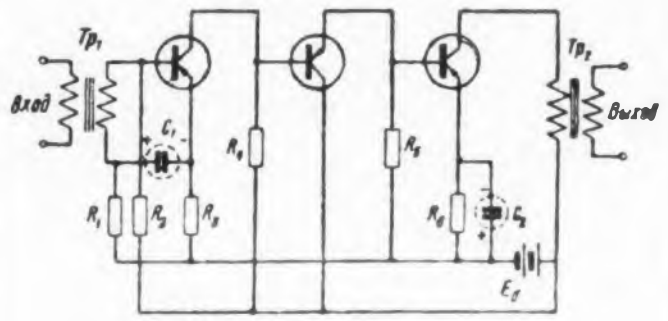


Fig. 2. Direct coupled transistor amplifier.

Determination of the Parameters of Transistors by K. Shul'gin. R 5/58, pp 58-60, 5 figs.

A continuation of previous articles on equivalent circuits of transistors, (Radio, November 1957 and March 1958). In this article it shows how, using equipment normally available to a radio amateur, the required parameters of transistors can be determined for evaluating the equivalent circuits.

Group Mode of Multiphase Multivibrator by Ya, Ye. Belen'kiy and A. N. Svenson. RE 3/58, pp 61-65, 5 figs.

The multiphase multivibrator was first described by the same authors in the August 1956 issue of Radiotekhnika. In the ordinary operating mode, the multiphase multivibrator generates sequences of pulses such as are used in electronic commutators. This article investigates an operating mode, in which each stage generates not one, but a group of pulses. The mechanism

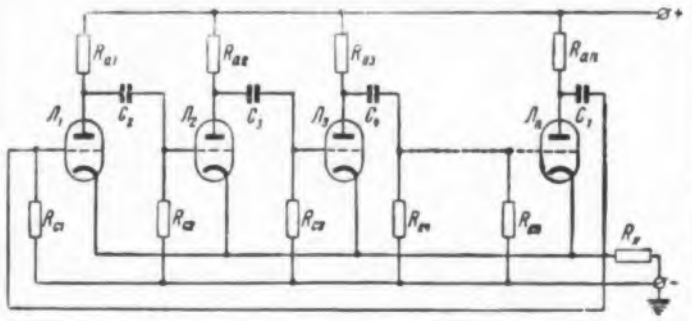


Fig. 3. Multiphase multivibrator.

of operation of a multivibrator is described, and fundamental calculations and relations are given for this mode. See Figs. 3, 4 and 5.

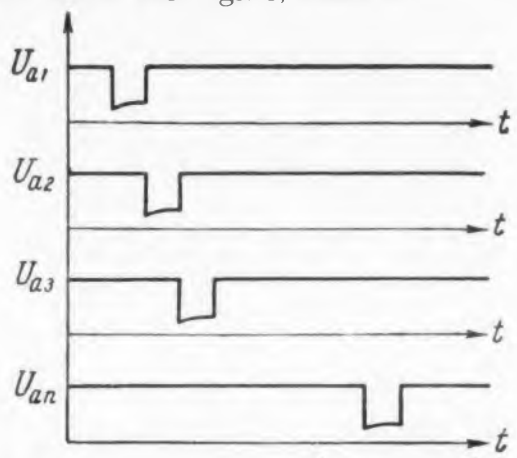


Fig. 4. Pulses produced by multiphase multivibrator in normal operation, and in group operation.

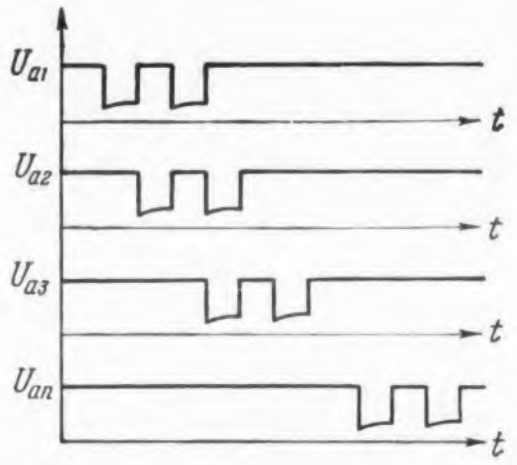


Fig. 5. The voltages are developed across the resistors bearing the same marking.

of operation of a multivibrator is described, and fundamental calculations and relations are given for this mode. See Figs. 3, 4 and 5.

On the Measurement of the Asymmetry of the Input of Radio Receivers by A. V. Fradin and V. A. Olendskiy. EC 4/58, pp 30-45, 3 figs, 3 tables.

An analysis of the equivalent circuit of the input of a radio receiver and of its fundamental parameters. A procedure is examined for the measurement of the asymmetry coefficients of the receiver input on the basis of the measured impedances and voltages. Values of the input parameters are given for certain commercial receivers, experimentally obtained. The value of the reception coefficient of the feeder is discussed.

Temperature Stabilization of Transistor Voltage Amplifiers by Yu. R. Nosov and B. I. Khazanov. RE 2/58, pp 28-35, 1 fig, 2 tables.

The authors determine the condition of gain stability in a grounded-emitter circuit under temperature changes. They show the influence of the circuit parameters and of the transistors themselves on the satisfaction of these conditions. The theory proposed is applicable for both sili-

RUSSIAN TRANSLATIONS

con and germanium transistors. They describe the change in the emitter current and analyze the cause of this change.

For thermal stability of the voltage gain, it is necessary that the voltage increments of the absolute temperature and of the emitter current be equal. The change in the emitter current should be due to a shift in the voltage-current characteristic. The effect of the change in the collector current should be reduced to a minimum. To accomplish this, it is advisable to use a low-resistance divider in the base circuit.

ELECTROMAGNETIC THEORY

Secondary Diffraction of Electromagnetic Waves by a Ribbon by P. Ya. Ufimtsev. JTP 3/58, pp 569-582, 13 figs.

Secondary diffraction involves internal currents that flow at different elements of the surface of a body. In the case of diffraction by a ribbon, the role of this interaction becomes most substantial for directions of observation close to the plane of the ribbon, and also for glancing incidence of the illuminating wave. The approximate expressions obtained for the scattered field are suitable for all directions of illumination and observation. The results of the rigorous and approximate theories are compared.

Axially Symmetrical Electrostatic Problems for a Conductor in the Form of a Semi Infinite Tube With Thin Walls by N. N. Lebedev and I. P. Skal'skaya. JTP 4/58, pp 792-800, 6 figs.

An exact solution is obtained for the distribution of the potential near a thin semi-infinite cylinder (tube) located in an arbitrary axially-symmetrical external field. A new method is developed for the solution of one class of static problems. It is analogous to the method used to investigate a similar class of boundary problems in the theory of diffraction, encountered with problems of radiation of acoustic and electromagnetic waves from the open end of cylindrical and flat waveguides.

Distribution of Electric Charges on Linear, Flat, Closed Conductors by L. A. Druzhkin. RE 3/58, pp 3-7, 2 figs.

The author considers the distribution of electric charges on linear conductors, using a specially introduced linear-density function. It is shown that the solution proposed not only makes possible finding the potential and fields, but also leads to a substantial simplification of the analysis.

PROPAGATION

Scattering of Electromagnetic Waves by Sinusoidal and Trochoidal Surfaces With Finite Conductivity by V. I. Aksenov. REE 4/58, pp 459-466, 1 fig.

Using the Kirchhoff approximations, a solution is obtained for the problem of the scattering of electromagnetic waves by limited portions of a sinusoidal or trochoidal surface with finite conductivity. The solution makes it possible to calculate the scattered field in the far zone. A method is proposed for determining the amplitude of the wave in the maxima of scattering lobes. By way of an example, the author calculates the scattering of electromagnetic waves by a sinusoidal surface.

Asymptotic Solution of the Problem of Diffraction of a Plane Electromagnetic Wave by a Conducting Cylinder by A. S. Goryainov. REE 5/58, pp 603-614, 7 figs.

The diffraction by a round cylinder is first solved rigorously, and the resultant series are summed asymptotically. Simple formulas are obtained which give good agreement with the strict formulas at sufficiently close distance to the diffracting cylinder.

Determination of the Internal Field in the Perturbation Method With the Aid of the Solution of the Diffraction Problem by V. V. Nikol'skiy. REE 5/58, pp 690-697, 5 figs.

The perturbation method has recently solved problems involving gyrotropic bodies placed in waveguides and in resonators. The limitation is that its accuracy depends entirely on the way the perturbed field is determined (the internal field) from the known value of the initial field. This requires an independent method, for which the quasi-stationary approximation is ordinarily used. This imposes substantial limitations on the dimensions of the perturbation region. This article gives an example whereby this limitation is overcome. The method uses the diffraction of a plane wave by the perturbing body to determine the perturbed field in the closed system. The specific example is a dielectric cylinder in a rectangular waveguide, as being the simplest and most amenable to comparison with already-published works.

Induction Through Neighboring Third Circuits, Caused by Structural Irregularities in the Line by P. K. Akul'shin. EC 11/57, pp 73-82, 6 figs, 1 table.

The author has written several articles on the subject, the latest of which was published in the July 1957 issue of *Elektrosvyaz'*. It is shown in

RUSSIAN TRANSLATIONS

this article that the structural irregularities of the line are the main cause of induction through third circuits, and limit the degree of shielding between circuits.

Diffuse Propagation of UHF Waves in the Troposphere from Antennas With High Directivity by D. M. Vysokovskiy. EC 5/58, pp 16-22, 4 figs.

The author has shown in a previous article (Geometrical Characteristics of the Scattering of Radio Waves by Turbulent Irregularities in the Troposphere, Elektrosvyaz', September 1957) that the basic characteristics of diffuse propagation are determined by the properties of the effective scattering volume. In particular it is determined by the ratio of the angular dimensions of this volume to the width of the directivity pattern of the antennas used at the terminal point of the communication route. Since in practice the antennas have directivity patterns that are narrower than the effective scattering volume, the net result is usually a reduced antenna gain in the reception of scattered radiation. Furthermore, the possible bandwidth of a given line is affected by the directivity of the antennas. The author therefore derives expressions for the scattering power for inhomogeneous turbulence, for the antenna-gain losses, and for the broadening of the directivity patterns in diffuse propagation.

INFORMATION THEORY

Phase Correlation Properties of Signals and Gaussian Noise in Two-Channel Phase Systems by V. V. Tsvetnov. RE 4/58, p 53-62, 5 figs.

The author considers the correlation properties of the phase differences in two-channel phase systems under the influence of Gaussian noise. Relations are derived for the correlation functions of the phase differences for the case of pure noise and for the case of strong signals. The correlation properties of the phase differences are compared with the correlation properties of the envelope of the Gaussian noise.

Statistical Properties of Sets of Messages by D. S. Lebedev. RE 1/58, p 3-10.

The connection between the statistical properties of sets of messages and the problems of transmitting messages from this set over a communication system is developed within the framework of the discrete case. Messages are classified and an attempt is made to create a new statistical model for facsimile and television communication.

Contribution to the Theory of the Carrying Capacity in Binary Transmission by B. A. Varshaver. RE 1/58, pp 11-21, 7 figs.

The general relations of communication theory derived by Shannon (The Mathematical Theory of Communications) and the theory of maximum interference immunity by V. A. Kotel'nikov are used to determine the carrying capacity of the binary channel under various methods of manipulation. It is assumed that the channel is under the influence of fluctuation noise.

Response of a Time Delay Pulse Detector to a Sequence of Pulses Modulated by a Random Process by G. P. Tartakovskiy and Yu. M. Sergiyenko. RE 1/58, p 62.

The authors show the equivalence of time delay pulse detector to a linear pulse circuit with negative feedback. Transfer functions of the latter network are derived. The spectral density of the random processes at the output of the detector is determined from known statistical characteristics of the pulse signal at the input of the detector.

Suppression of Pulsed Noise by Nonlinear Transformation of the Form of Their Frequency Spectrum by A. A. Gorbachev. RE 1/58, pp 56-61, 8 figs.

The various versions of linear transformation of the spectrum ahead of the amplitude limiter in a system designed for the separation of a signal from a noise background are investigated. The advisability of using tuned converters is indicated. Results of theoretical and experimental investigation are cited. Essentially the method is based on separating the signal from the noise by using the two differences (in amplitude and in spectrum) between the pulse noise and the signal.

MICROWAVES

Perturbation of the Natural Frequency of Electromagnetic Resonators by Ferrites by Yu. N. Dnestrovkiy. REE 5/58, pp 675-589.

The method of successive approximations (the vector analog of the Kellog method) is used to investigate the problem of large and small perturbations to the natural frequencies of electromagnetic resonators induced by ferrites. A convergence of the successive approximations follows from the general theorems for the systems of integral equations. This method estimates the accuracy of the results obtained by other investigators.

Effect of Radioactive compounds Co^{60} and Po^{210} on the breakdown power and on the statistical delay of microwave pulse discharge in

RUSSIAN TRANSLATIONS

air was investigated. It is shown that the breakdown power remains unchanged over a wide range of compound activity.

Electric Discharge in Air at 3.2 cm by V. Ye. Mitsuk, G. S. Solntsev, M. Z. Khokhlov, P. S. Bulkin, and G. M. Zastenker. REE 5/58, pp 698-703, 7 figs.

A procedure is proposed for determining the breakdown voltage of the electric field and the statistical time delay at a wavelength of 3.2 cm. The experimental set-up is described, as are the devices that makes it possible to automatize the statistical measurements. The breakdown voltages were measured at pressures from 0.1 to 300 mm Hg. The results obtained are in agreement, within experimental accuracy, with those obtained by Posin ("The Microwave Spark," Physical Review, 1948, 73, 496) but the authors disagree with his conclusions.

Approximate Method of Calculating the Induced Current in Cavity Magnetrons by S. I. Bychkov. REE 4/58, pp 530-536, 2 figs, 2 tables.

The fundamental relations are derived for the induced current in a cavity magnetron. Starting with the assumed distribution of the radial velocities of the electrons, the dependence of the first harmonic of the induced current on the mode and the parameters of the magnetron are determined.

MISCELLANEOUS

Radio Equipment for Simultaneous Translation of Speeches into Eight Languages by S. G. Kalikhman. CJ 5/58, pp 8-11, 8 figs.

Block diagram and description of principal apparatus used for simultaneous translation of speeches and their translations in large halls. A fixed wavelength at 85, 100, 150, 130, 145, 40, 55 and 70 kc was used. No wires are used for transmission, although the system can be converted for such purpose. The equipment is capable of serving participants in a conference in a hall with an area up to 3000 m^2. No indication is given as to where this equipment is actually installed.

Pulsed Method for Determining the Location of Improper Pairing of Conductors in Cables by V. O. Shvartsman. CJ 2/58, pp 7-9.

The author considers the theoretical fundamentals, the measuring apparatus required, and the results obtained when using a pulse method

for determining the points of incorrect pairing of conductors in municipal telephone systems. It is indicated that this method can also be used to locate faults of other types.

Four-Electrode Piezoelectric Resonator for the Frequency Range from 250 to 600 kc by V. Ya. Gel-mont. CJ 3/58, p 12.

Invertigates four-electrode piezoelectric resonator, operating at the second harmonic, in filters. This circuit makes it possible to reduce by one half the number of resonators in quartz filters used to separate the group carriers in type V-12 high frequency carrier apparatus.

Nonstationary Processes in a Waveguide by A. A. Kovtun. REE 5/58, pp 660-674, 6 figs.

Investigates nonstationary processes in a cylindrical waveguide of round cross-section, excited by an elementary dipole. The method of incomplete separation of variables is used to obtain an exact solution to the problem. The solution is analyzed for cases when the conductivity of the waveguide wall is a large finite quantity or an infinite quantity.

Design of Grounded-Grid Stage in the Critical Mode by Yu. V. Bogoslavskiy. EC 4/58, pp 36-40.

A procedure is developed for the design of a grounded-grid stage in the critical mode. One of the initial parameters for the design is chosen to be the amplitude of the plate current, the oscillation power P_1, or the tank-circuit resistance.

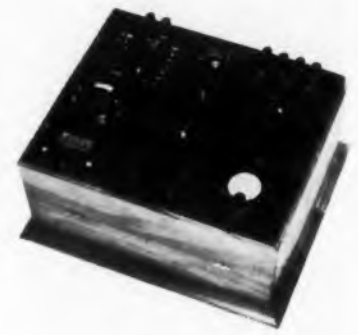
KEY

The sources of the Russian articles and their dates of issue follow the authors' names. Here is the key to the names of the journals in which the articles originally appeared.

AJ	Acoustic Journal *(Akusticheskiy Zhurnal)*
AT	Automation and Telemechanics *(Avtomatika i Telemekhanika)*
CJ	Communications Journal *(Vestnik Svyazi)*
EC	Electrical Communications *(Elektrosvyaz)*
IET	Instruments and Experimental Techniques *(Pribori i Tekhnika Eksperimenta)*
JTP	Journal of Technical Physics *(Zhurnal Tekhnicheskoy Fisiki)*
ME	Measurement Engineering *(Izmeritel'naya Tekhnika)*
R	Radio
RE	Radio Engineering *(Radiotekhnika)*
REE	Radio Engineering and Electronics *(Radiotekhnika i Elektronika)*

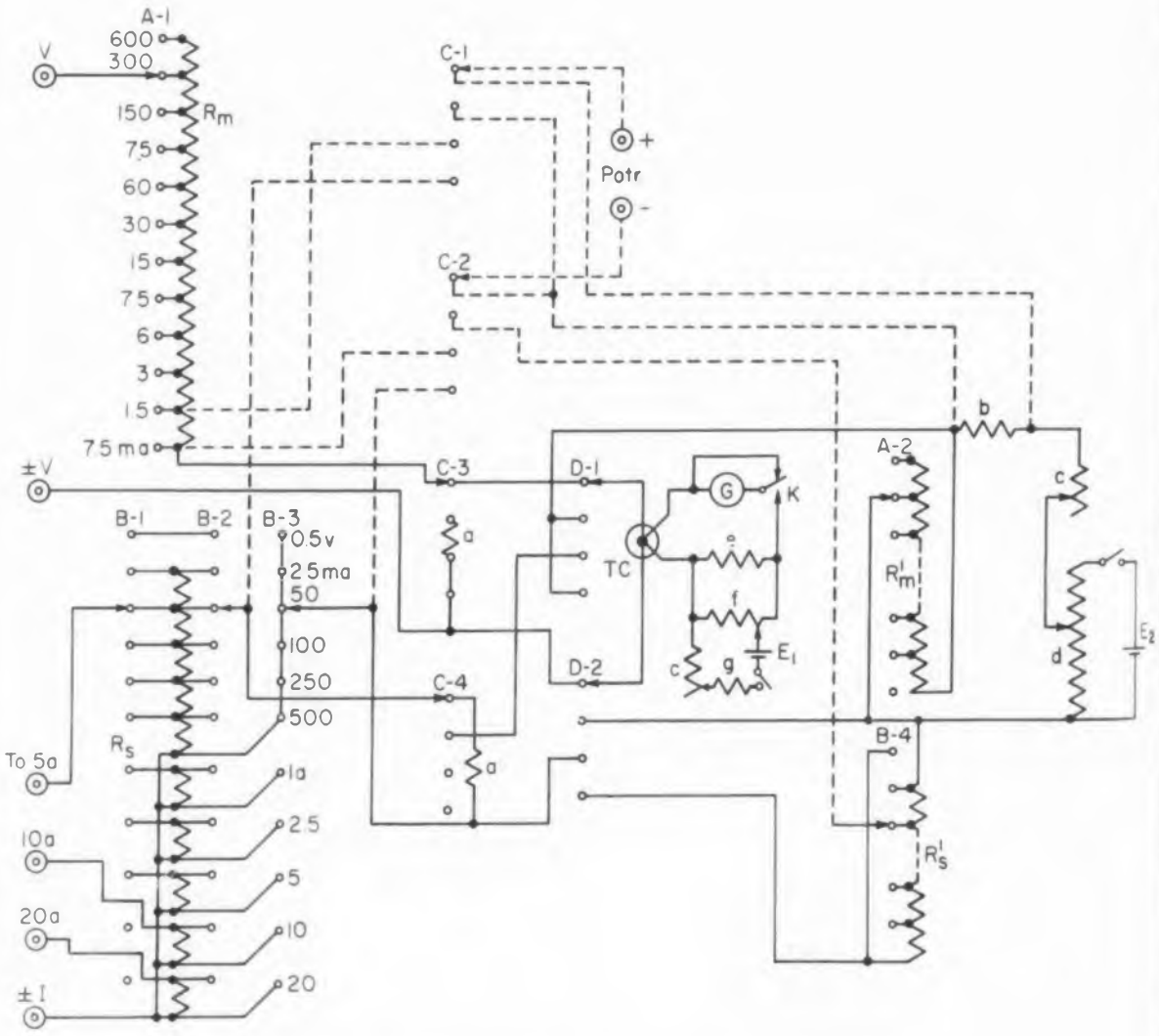
ABSTRACTS

Audio-Frequency Volt-Ammeter



INCREASING use of audio frequencies, especially in airborne devices, has made necessary the development of special equipment and transfer standards for tests of instruments operating in this range. Toward this end the National Bureau of Standards has developed a self-contained, portable volt-ampere converter which measures voltage and current from 5 to 50,000 cps. As the primary electrical units are maintained by dc standards, all ac measurements of voltage, current, and power are actually based on transfer instruments, which are standardized on dc and then used on ac. Twelve voltage ranges from 0.5 to 600 v and 11 current ranges between 7.5 and 20 amp have been designed. These ranges may be used either for dc or ac measurements with a 1.5 v potentiometer or for ac-dc transfer tests of instruments.

Like other transfer instruments for accurate standardization at the higher audio frequencies, the volt-ammeter, based on an earlier, more limited prototype, uses a thermal converter as the sensitive component. The thermal converter consists essentially of a conductor, heated



Wiring diagram of the volt-ampere converter for use in audio-frequency calibration work.

by the ac to be measured, and a thermocouple, thermally attached near the center of the heater. The output electromotive force produced in the thermocouple is first balanced against the voltage from an internal dc bucking circuit to obtain a null reading on a built-in galvanometer. Then the heater is switched to an internal dc circuit, which is adjusted to give the same output emf and therefore equivalent heater current and voltage drop. A simple multiplication of the voltage measured across a portion of this dc circuit yields the unknown alternating voltage or current. The 7.5 ma thermal converter used has excellent transfer characteristics, its ac-dc difference being less than 0.01 per cent at audio frequencies. Changes in heater resistance are compensated by connecting additional resistors in the circuit. Accuracy of the instrument is dependent only on the poteniometer used to measure the voltage and on the highly stable internal resistors. A function selector switch is used to connect the thermal converter circuit to the shunts for ac measurements and to the series resistors for alternating voltage measurements. For direct voltage measurements the 1.5 v section of the series resistors is connected directly to the potentiometer, and for dc measurements the shunt voltage is connected directly to the potentiometer. This relatively simple switching permits the same resistors and shunts to be used for dc as well as ac measurements, thus greatly increasing the usefulness of the instrument.

Binding posts on the panel make possible the inclusion of a millammeter in the balancing circuit to measure the thermal converter output voltage. With these data and a converter characteristic curve, ac-dc difference tests can be made of voltmeters and ammeters with an accuracy of 0.02 per cent. In such tests the voltampere converter is connected in series with the test ammeter, or in parallel with the test voltmeter. Alternating and direct current are then applied successively to the arrangements. By using a more sensitive external galvanometer in place of the built-in galvanometer, the ac-dc difference of the test instrument can be obtained. Special precautions were taken to minimize reactance.

Abstracted from National Bureau of Standards Technical Report, Audio Frequency Volt-Ammeter.

Spurious Radiation

•

EFFICIENT rf spectrum utilization and mutual interference reduction requires the imposition of limitations on harmonic and other spurious radiations from microwave electronic equipment. An experimental program was undertaken to extend the limits of existing interference specifications to cover the range 1 to 10 kmc, and to establish techniques for radiated interference measurements.

The following conclusions were reached:

- With horn-type directional antennas, it is feasible to make repeatable cw field intensity measurements in a shielded enclosure from 1 to 10 kmc.
- The optimum distance range for interference testing is 3 to 6 ft from the equipment in the frequency range.

The paper also proposes a method for near-field antenna calibration which gives good correlation between theoretical and experimental values.

Abstracted from the article Measurement of Spurious Radiation from Missileborne Electronic Equipments *by A. L. Albin and C. B. Pearlston, Jr., Filtron Co., Inc., delivered at 1958 IRE Convention.*

MEETINGS

Calendar of Events

OCT. 1958

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

30-31 Electron Devices Meeting, Washington, D. C.*

NOV. 1958

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

3-8 International Plastics Standards Meeting, Washington, D. C.

5-7 Soc. for Applied Spectroscopy joint meeting with ASTM Materials Comm., New York, N. Y.

6-7 5th Annual National Meeting Professional Group on Nuclear Science, San Mateo, Calif.*

10-12 2nd International Symposium on the Physics and Medicine of the Atmosphere and Space, San Antonio, Tex.

17-18 IRE Region 3 Convention, Atlanta, Ga.

17-20 Conf. on Magnetism and Magnetic Materials, Phila., Pa.*

17-21 8th National Plastics Exposition, Chicago, Ill.*

19-20 Northeast Electronics Research and Engineering Meeting, Boston, Mass.*

19-21 Elec. Tech. in Medicine and Biology, Minneapolis, Minn.

DEC. 1958

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

2-4 Reliable Electrical Connections, Dallas, Tex.*

3-5 Eastern Joint Computer Conf., Phila., Pa.

3-5 Symp. on Global Communications, St. Petersburg, Fla.

*Indicates meetings described in the following columns.

Electron Devices Meeting, Oct. 30-31

Shoreham Hotel, Washington, D. C. Sessions to cover important new developments in devices and techniques essential to defense, industrial, and commercial electronics. Major aspects of recent electronic advances to be discussed: "Controlled Fusion," "P-N Junctions," "Panel Display Devices," "Parametric Amplifiers."

5th Annual National Meeting Professional Group on Nuclear Science, Nov. 6-7

Villa Motel, San Mateo, Calif. The conference will comprise four sessions: Electronics for Particle Accelerators; Electronics for Controlled Fusion Research; Reactor Instrumentation; Nuclear Radiation—Effects, Detection, and Measurements. Technical papers to be presented will cover applications of electronics to the problems of nuclear detection, measurement, and control. New developments covered at the Geneva and Paris Conventions will be discussed.

Conference on Magnetism and Magnetic Materials, Nov. 17-20

Sheraton Hotel, Philadelphia, Pa. Sponsored by the Basic Science Committee of AIEE. For further information write C. J. Kreissman, Remington Rand Univac, 1900 W. Allegheny Ave., Phila. 29, Pa.

8th National Plastics Exposition, Nov. 17-21

International Amphitheatre, Chicago, Ill. To be held concurrently with the API Annual Conference at the Hotel Morrison. Sponsored by the Society of the Plastics Industry, Inc. Theme to be stressed: Plastics for Profits. Will cover materials, methods, machines, and techniques.

Northeast Electronics Research and Engineering Meeting, Nov. 19-20

Mechanics Hall, Boston, Mass. Sponsored jointly by the Boston, Connecticut, and Western Massachusetts Sections of the IRE. R. R. Leonard, Datamatic Div., Minneapolis-Honeywell Regulator Co., Newton Highlands, Mass., has more information.

11th Annual Conference on Electrical Techniques in Medicine and Biology, Nov. 19-21

Nicollet Hotel, Minneapolis, Minn. Sponsored by IRE, AIEE, and ISA. The theme this year

is Biology and Computers. Sessions will cover possible applications of electronic computers in the fields of electrocardiography, electroencephalography, and biological logics. Further information may be obtained from Mr. Robert Erskine, Minneapolis-Honeywell Co., 2753 Fourth Ave. South, Minneapolis, Minn.

3rd EIA Conference on Reliable Electrical Connections, Dec. 2-4

Dallas, Tex. For information write W. O. Richards, 224 Cedar St., Syracuse 3, N.Y.

1959 Solid State Circuits Conference, Feb. 12-13, 1959

Philadelphia, Pa. Sponsored by IRE, AIEE, and Univ. of Pennsylvania. Devoted to transistor circuit technology, applications, and circuit techniques of a variety of solid state devices.

Sections

A series of lectures on Space Technology, co-sponsored by the LI Section of IRE and the American Rocket Society are being held at the Garden City High School, Garden City, N.Y. Nationally recognized authorities in important areas of space engineering will discuss latest developments in space research and the problems which still remain to be solved.

Seminars

R & D: American Management Assoc. to present five seminars. **Nov. 10-14,** Organizing and Controlling Research and Development; **Nov. 19-21,** Effective Utilization of Outside Research Facilities; **Nov. 19-21,** Effective Supervision of Engineering Projects; **Nov. 19-21,** Creating and Evaluating Research Projects; **Nov. 19-21,** Administering Salary Programs in the Technical Organization. Address enquiries to Registrar, AMA, 1515 Broadway, New York 36, N.Y.

Paper Deadline

November 30: Deadline for papers (in triplicate) to be considered for inclusion at the International Convention on Transistors and Associated Semi-Conductor Devices to be held in London May 25-29, 1959. Before submitting papers, authors are asked to send a short summary of each paper of about 200 words, giving title and range of subject matter covered. Address enquiries to Industrial and Trade Fairs Ltd., Drury House, Russell St., London, W. C. 2.

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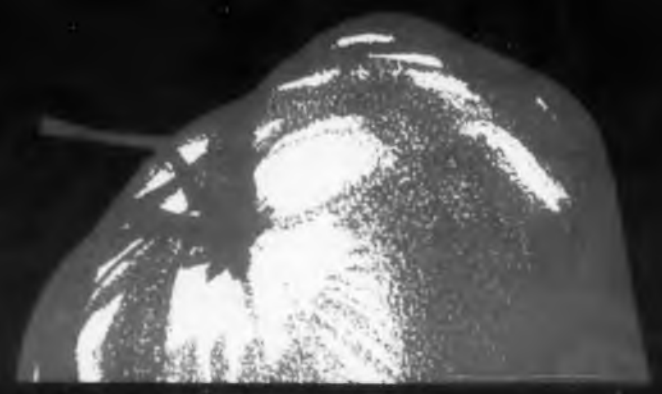

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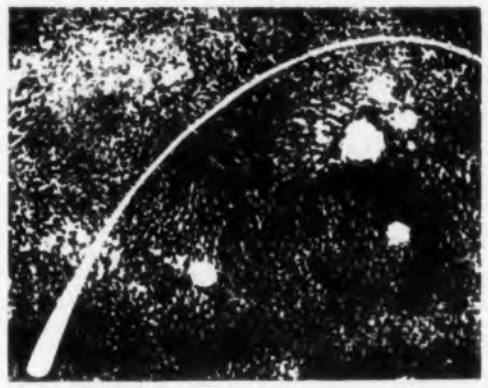

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STANDARDS AND SPECS

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Transistor Symbols

AIEE No. 426, Proposed Standard for Graphical Symbols for Semiconductor Devices, April 1958

The first section of this standard sets forth the basic rules and symbol elements for the construction of graphical symbols for semiconductor devices. The second section is a glossary of device symbols. In this section, a listing is made of some semiconductor devices, together with their graphical symbols. It is recognized that in many cases it is possible to develop other device symbols using the standard symbol elements of section one. In general, the angle at which a connecting lead is brought to a symbol has no particular significance. Copies of this proposed standard are available without charge from the American Institute of Electrical Engineers, 33 West 39 Street, New York 18, N.Y.

Cores

AIEE No. 430, Proposed Recommended Practice for Toroidal Magnetic Tape Wound Cores, April 1958

It is recommended that the nominal dimensions for toroidal strip-wound cores made from magnetic tape be between 0.014 and 0.005 inch in thickness and without regard to the type of magnetic material used. Bobbin-wound cores of ultra-thin magnetic tapes are not included. Also excluded from consideration are recommendations on dimensional tolerances, space factors, number of wraps of tape, core case shape or size, and particular values of strip thickness. Copies of this publication are available without charge from the American Institute of Electrical Engineers, 33 West 39 Street, New York 18, N.Y.

Fuseholders

MIL-F-21346, General Specifications for Block and Plug Type Fuseholders and Associated Electrical Clips, 24 April 1958

Fuseholders for use with instrument, power, and telephone fuses and other widely used fuses are covered by this spec. Block and plug type fuseholders, and associated equipment such as electrical clips and electrical-clip assemblies are covered. The type designation for a typical fuseholder meeting this spec is FH20AM.

ADVERTISERS' INDEX

October 29, 1958

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