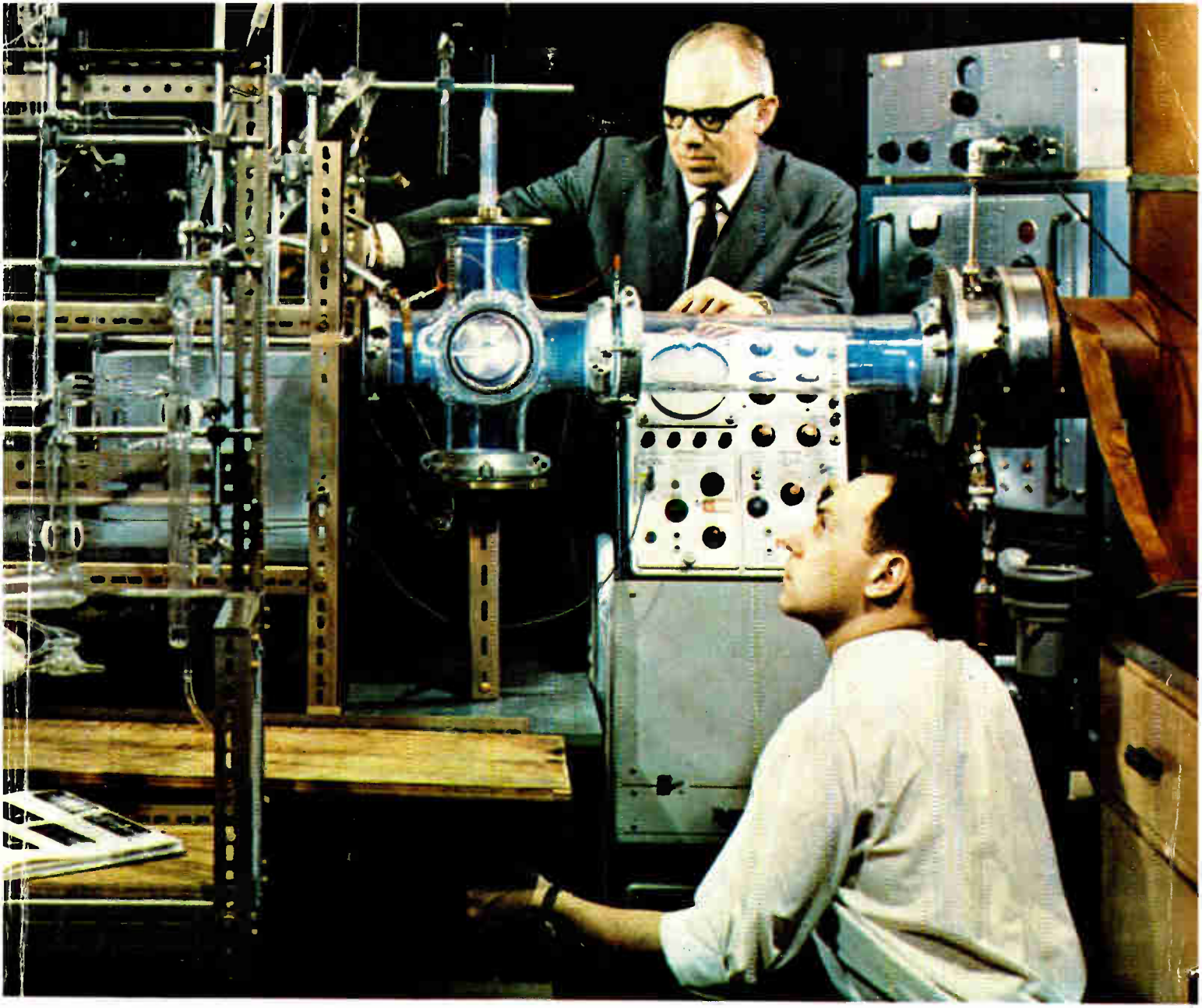


Plasma physics research at RCA-Victor Montreal (See Cover Story, Page 5)

Canadian Space Electronics — Special Issue

Ten top articles, commencing on Page 29

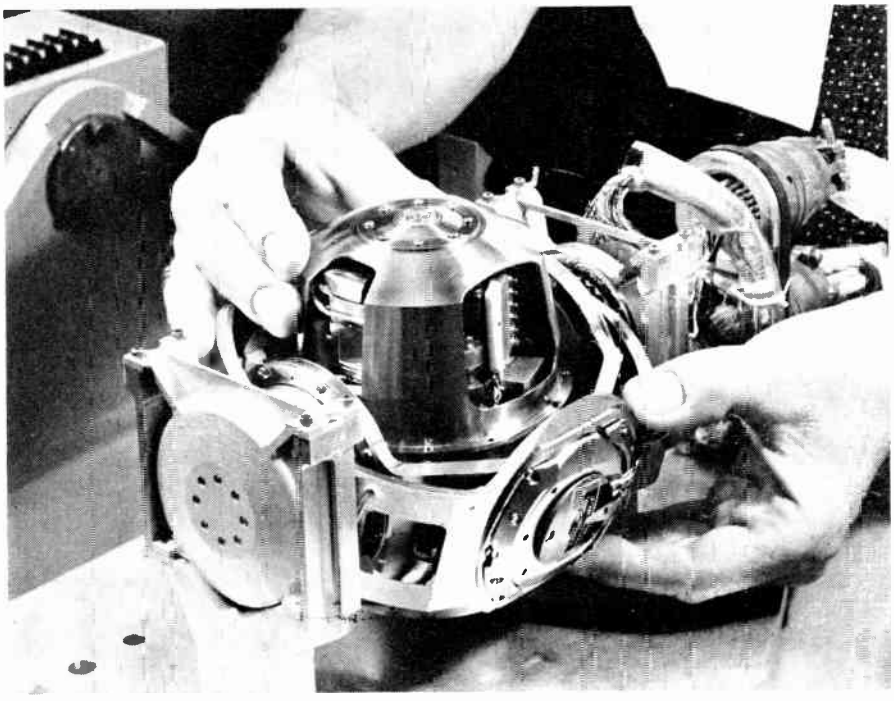
MARCH 1962

electronics & communications

The engineering journal of the Canadian electronics industry

FROM SMALL TO SMALLER IN INERTIAL PLATFORMS

Litton P-300 containing two new gyros, three improved accelerometers, four gimbals, and an advanced, irrotational vibration mount compacted into a 0.245-cubic foot, 15-pound unit for missile and space applications.



The Litton P-300, a miniaturized inertial reference platform that rests comfortably in one's two hands, is the result of a program aimed at developing a small, light, reliable unit for orbital and suborbital vehicles. The challenge presented by the P-300 project at its outset was the formidable one of taking an already small production platform (the 30-pound Litton P-200) and chopping it in half without sacrificing performance.

As in the P-200, floated, two-degree-of-freedom gyros were selected to minimize the number of gyro rotor assemblies and to simplify the stabilization servo loops. The gyros were made smaller and their performance increased through the reduction of minor error torques, such as those from flex leads making electrical interconnection between float and case. The gyro wheel, float, and gimbal were constructed primarily of beryllium, greatly improving the stiffness-to-density ratio and reducing the mass shifts caused by anisoelasticity under acceleration. Despite the smaller size of the gyro rotor, high angular momentum was obtained by distributing the rotor mass in a manner that provides a large radius of gyration.

Gas-lubricated bearings are another and particularly noteworthy improvement in the small (2.1″ by 2.9″), light (under 2 pounds) gyros. These bearings use 1/20th of the clearance between bearing surfaces normally associated with oil-lubricated assemblies and offer other advantages that improve gyro performance by an order of magnitude.

The accelerometers in the P-300 were scaled down (to 0.8″ x 0.8″ x 1.5″) through similar imaginative engineering techniques without decreasing performance. Small and greatly improved, these accelerometers contain a sensitive element that is a floated pendulum mounted on a pair of jewel-and-pivot bearings and equipped with an electromagnetic pickoff and torquer. The relative motion of the pendulum is kept to a small fraction of a milliradian even at an acceleration of over 20 g.

Another feature of the P-300 is the use of direct drive gimbal torquing. By incorporating this type of torquing, the weight penalty paid in motors and gear trains has been greatly reduced. In addition, direct torquing significantly increases accuracy of the attitude readout.

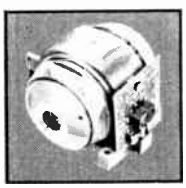
Attractive positions are available in the following areas:

Electronic Engineers and Technicians for Systems Checkout and Testing

Field Service Representatives

Mechanical Technicians for assembly of Gyros and Accelerometers

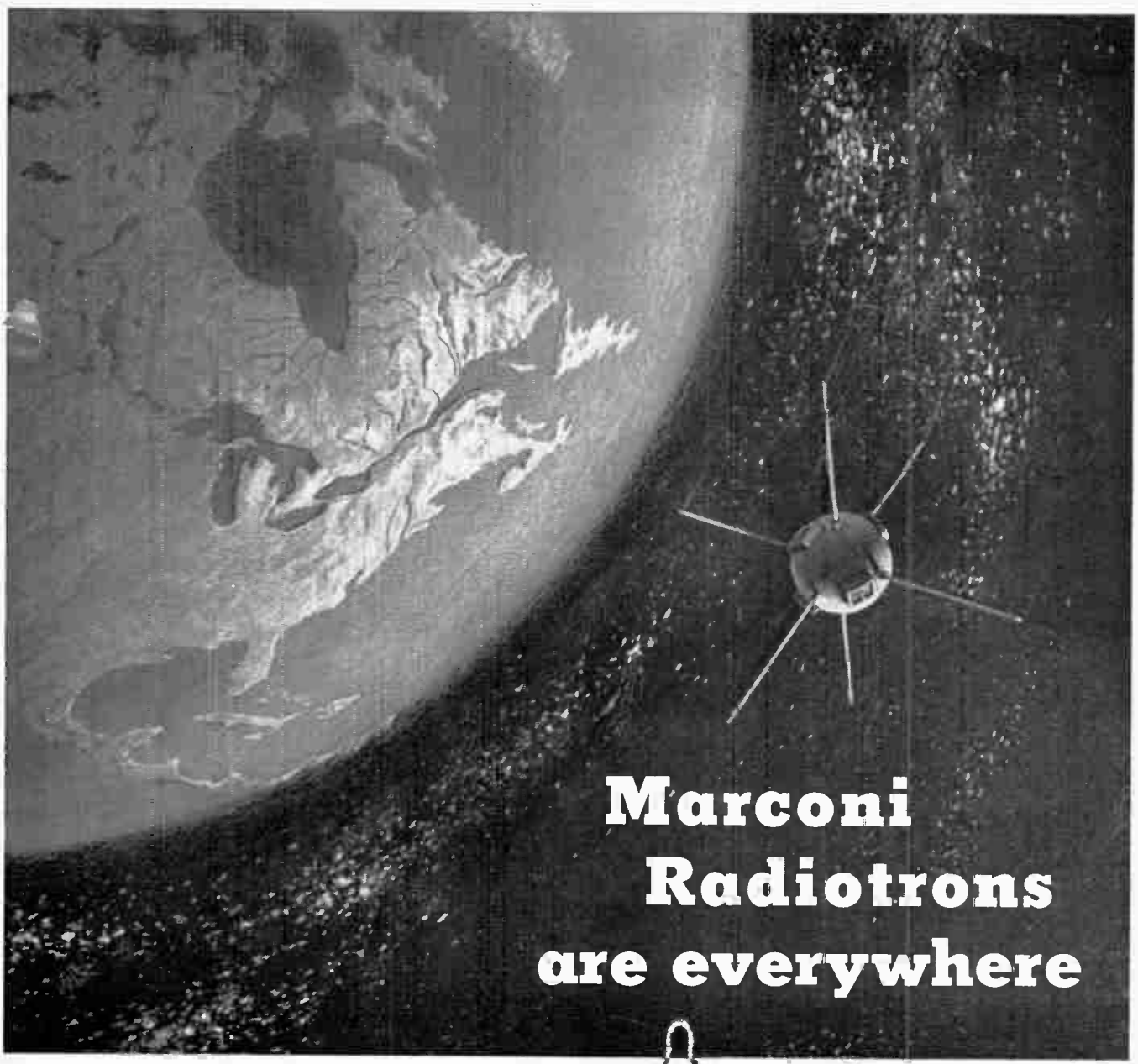
These are permanent positions in a long term programme using the most advanced techniques and equipment. Write, phone or drop by for a visit. Personnel Manager, Litton Systems (Canada) Limited, 123 Rexdale Blvd., Rexdale, Ontario.



LITTON SYSTEMS
(CANADA) LIMITED
Rexdale, Ontario

DIVISION OF LITTON INDUSTRIES
BEVERLY HILLS, CALIFORNIA

For complete details check No. 63 on handy card, page 79



Marconi Radiotrons are everywhere

The complicated electronic equipment used in today's far reaching scientific experiments requires dependable, precision-made components which must function under the most critical of operating conditions. Marconi radiotrons are used in many of these applications because they meet—and surpass—these quality requirements. And this same quality is built into *all* Marconi tubes for *all* types of installations . . . for radio and television stations . . . for home receivers. Marconi tubes assure superior performance—greater power—longer life. Be sure to recommend Marconi—greatest name in radio and television.

ELECTRONIC TUBE AND COMPONENTS DIVISION

CANADIAN **Marconi** COMPANY

830 BAYVIEW AVENUE, TORONTO, ONTARIO

Branches: Vancouver • Winnipeg • Montreal • Halifax

For complete details check No. 15 on handy card, page 79

Resistors?

STACKPOLE matches every requirement

If you have a burning yearning for improved resistor dependability coupled with on-time deliveries, here's a hot tip:

In Performance Stackpole Coldite 70+ fixed composition resistors go well beyond MIL-R-11 requirements—with added dividends in load life, moisture resistance and humidity characteristics. For extra reliability, their carbon resistance elements and outer insulating shells are cold-molded of similar materials. These are formed by a new process into a solid, homogeneous structure that remains free from catastrophic failure or erratic changes in resistance in severe environments.

In Production Stackpole Coldite 70+ Resistors remain one of the easiest components to solder either by dip or iron. They're the only resistors having leads that are solder dipped—not once, but twice—in addition to the usual tin coating. That's why leads stay smooth and tarnish free even after months in storage.

In Appearance it's hard to match their smooth, glossy finish and uniform, easily-read color codes. And this attractive appearance lasts even after scrubbing with solvents.

Stackpole Coldite 70+ Resistors are available in MIL-R-11 Type RC-20 (½-watt), Type RC-32 (1-watt), and Type RC-42 (2-watts) . . . in all standard resistance values, and at ordinary resistor prices.

CANADIAN STACKPOLE LIMITED
550 Evans Avenue, Toronto 14, Ontario
Telephone: CLifford 5-2373

CERAMAG® FERRITE CORES • VARIABLE COMPOSITION RESISTORS • SLIDE & SNAP SWITCHES • CERAMAGNET® CERAMIC MAGNETS • FIXED COMPOSITION CAPACITORS • BRUSHES FOR ALL ROTATING ELECTRICAL EQUIPMENT ELECTRICAL CONTACTS • GRAPHITE BEARINGS, SEAL RINGS, ANODES • HUNDREDS OF RELATED CARBON & GRAPHITE PRODUCTS.

For complete details check No. 16 on handy card, page 79

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electronics & communications

The engineering journal of the Canadian electronics industry

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CCAB

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contents

MARCH, 1962 Vol. 10, No. 3

CANADIAN SPACE ELECTRONICS

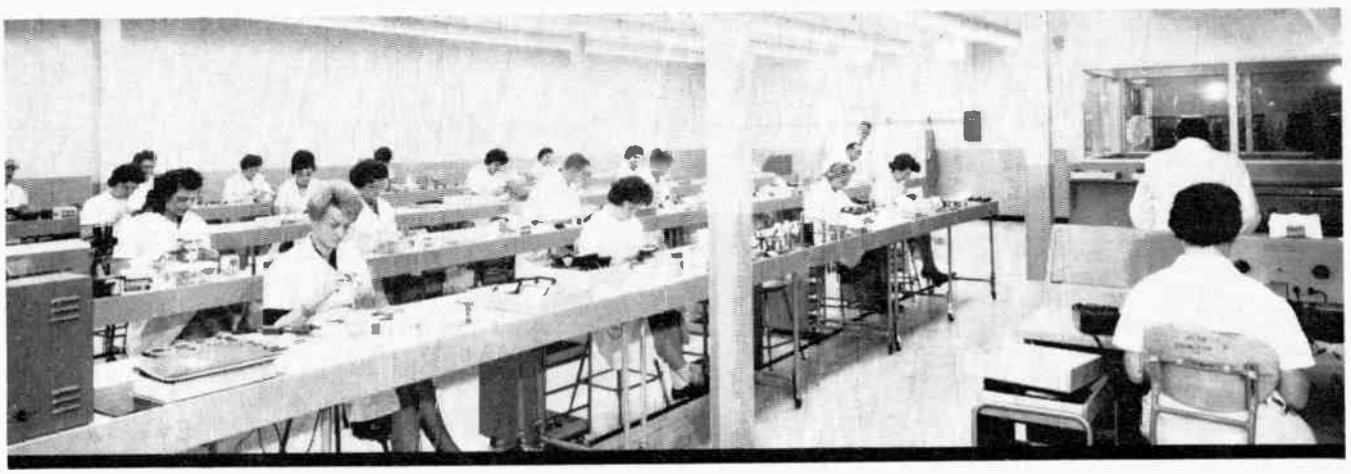
COVER STORY

Investigations in the RCA Victor Research Laboratories of a plasma moving at supersonic velocities past a particle simulating the conditions of a space vehicle re-entering the earth's atmosphere. In the background is Dr. J. R. Whitehead, Director of Research, and in the foreground, Dr. M. P. Bachynski, Director of the Microwave Physics Laboratory.

departments

BACH-SIMPSON EXPANDS LONDON PLANT...

Maybe this isn't news . . . . Bach-Simpson has been expanding steadily since 1946. In the last ten years the present modern plant has been enlarged eight times. The facility now includes nearly 50,000 square feet of space, houses 350 skilled employees, and provides in-plant almost every service, from design and tooling to environmental test, essential to the production of widely varied lines of precision electrical components. Bach-Simpson produces meters and accessories, both military and commercial, test equipment, and a variety of special electrical and electronic items too numerous to describe for Canadian and Commonwealth markets. Sister company Welwyn Canada Limited, under the same roof, is a major supplier of precision resistors to both Canadian and U.S. users.



PROVIDES ADVANCED CLEAN ROOM FACILITY

While expansion has come about through the growth of both Canadian and Export markets, parallel improvement of the facility has been in response to the demands of todays' technology for the best possible products at the lowest possible cost. The biggest news, therefore, is inside where it doesn't show, except in improved quality and service.

The new Clean Room is air-conditioned and sealed, and accessible only through an air-lock entrance. All fixtures have been designed for maximum cleanliness and efficiency. From the tiled floor to the fluorescent-lighted ceiling, this bright, and substantially enlarged assembly area provides the optimum in working conditions for critical operations.

A bigger and better Bach-Simpson Limited may have the answers to some of your problems. Your inquiries are invited.

Bach-Simpson
LIMITED
1255 BRYDGES STREET, LONDON, ONTARIO

For complete details check No. 9 on handy card, page 79

For the vital telemetry link of the Agena Launch system, Lockheed chose HELIAX. The requirements of this launch complex link, typical of careful missile range instrumentation, illustrate the advantages of HELIAX.

No RF Noise: The unique Andrew connector design captivates inner conductor to outer conductor, eliminating RF noise from sliding connector contacts.

No RF Leakage: The continuous copper outer conductor protects the circuit from other RF signals.

Low Loss, Low VSWR: Insures maximum circuit reliability, minimum signal distortion.

Flexible, Rugged: The corrugated outer conductor of HELIAX makes it the only flexible air dielectric cable. This corrugated outer conductor withstands high crushing forces and heavy vibration.

Easy to Install: Andrew connectors are easily attached in the field, even by inexperienced personnel. HELIAX flexibility makes it much easier to pull into place on the tower and through ducts.

No Corrosion Problem: HELIAX, made of copper, is less affected by corrosive fumes and fluids present in launch areas.

These advantages make HELIAX the preferred coaxial cable for all RF transmission.

Andrew 606 Beech Street • Whitby, Ontario • MOhawk 8-3348

ANTENNAS • ANTENNA SYSTEMS • TRANSMISSION LINES

For complete details check No. 6 on handy card, page 79

Look for the "hidden extras" when you specify connectors

Electrical connectors, made to identical specifications by different manufacturers, may look much alike. In operation, however, great differences may develop. At altitudes of 100,000 feet, depths of 30 fathoms—or even in a machine shop—it is reassuring to know the connector has complete dependability.

Our goal, at Scintilla Division, is to provide this dependability by building extra quality into every connector we make. Our engineers are not content merely to meet specifications; they provide "extras"—by design. And, they have the right to say "no" to the smallest deviation in quality. To assure this kind of quality control, we maintain one of the highest ratios of inspectors-to-production-workers in the industry.

These "hidden extras"—quality, integrity, dependability—make Bendix® Electrical Connectors most often specified for the most demanding jobs. In fact, the only thing that isn't extra is the price. It's competitive.

Look for these values when you specify connectors. Let us tell you about them. Write us at Sidney, N. Y.

Be sure to visit the Scintilla Exhibit at the New York I.R.E. Show.

Scintilla Division

THE Bendix CORPORATION

Canadian Affiliate: Aviation Electric, Ltd., 200 Laurentien Blvd., Montreal 9, Quebec. Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.

For complete details check No. 10 on handy card, page 79

WEIGHT, SPACE PROBLEMS?

REPLACE

ALMOST ALL SUBMINIATURE GLASS TYPES

WITH TRANSITRON'S EXPANDED LINE OF SILICON MICRODIODES

Since it introduced the first all-glass packaged silicon microdiode with TRUE hermetic sealing, Transitron has continued to expand its line until today it offers, in quantity, the widest variety of high-quality silicon microdiodes in the industry.

While Transitron still remains an exclusive source for micro "zeners", further developments have made possible the introduction of a series of very fast switching, low capacitance microdiodes particularly well-suited for use in extremely high speed transistorized computer circuitry. The family includes Transitron's TMD-50, and TMD-914 and TMD-916 — microequivalents of the popular subminiature glass 1N914 and 1N916.

The rugged all-glass construction and true hermetic sealing of Transitron's microdiodes provide exceptional long-term reliability over a wide range of environmental extremes. Their compatibility with conventional semiconductor circuitry can help you miniaturize your existing design through replacement of standard subminiature glass types with microdiode equivalents. All are available in quantity and are especially recommended for critical computer applications where small size, light weight and excellent stability are required . . .

For further information, write for Transitron's "Microdiode" bulletins.

Watch for still further significant developments in microminiaturization from Transitron. Soon to be announced.

RECOMMENDED REPLACEMENT CHART

MICRODIODE TYPES		SUBMINIATURE GLASS TYPES
Very Fast Switching Types		
TMD-50	replaces	1N993 (S266G)
TMD-914	replaces	1N914
TMD-916	replaces	1N916
Fast Switching Types		
TMD-24	replaces	1N625, 1N626 1N659
TMD-25	replaces	1N627, 1N658 1N662, 1N663
TMD-27	replaces	1N628, 1N629 1N661, 1N643
High Conductance Types		
TMD-41	replaces	1N456, 1N456A 1N461, 1N461A 1N482 thru 1N482B
TMD-42	replaces	1N457, 1N457A 1N462, 1N462A 1N483 thru 1N483B
TMD-45	replaces	1N458, 1N458A 1N459, 1N459A 1N463, 1N463A 1N464, 1N464A 1N484 thru 1N485B
Micro Voltage Regulator Types		
TMD-01	replaces	1N705, 1N751
TMD-02	replaces	1N708, 1N752
TMD-03	replaces	1N709, 1N753
TMD-04	replaces	1N710, 1N754
TMD-05	replaces	1N711, 1N755
TMD-06	replaces	1N712, 1N756
TMD-07	replaces	1N713, 1N757
TMD-08	replaces	1N714, 1N758
TMD-09	replaces	1N715
TMD-10	replaces	1N716, 1N759

NOTE: The MICRODIODE types listed above are similar to their conventional-size counterparts within the limitations of power dissipation . . . Transitron engineers will be glad to discuss with you comparative specifications as they affect your particular replacement designs.

MEET US AT THE IRE SHOW — BOOTHS 1720 - 1724

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Transitron

electronic corporation of Canada, Ltd.

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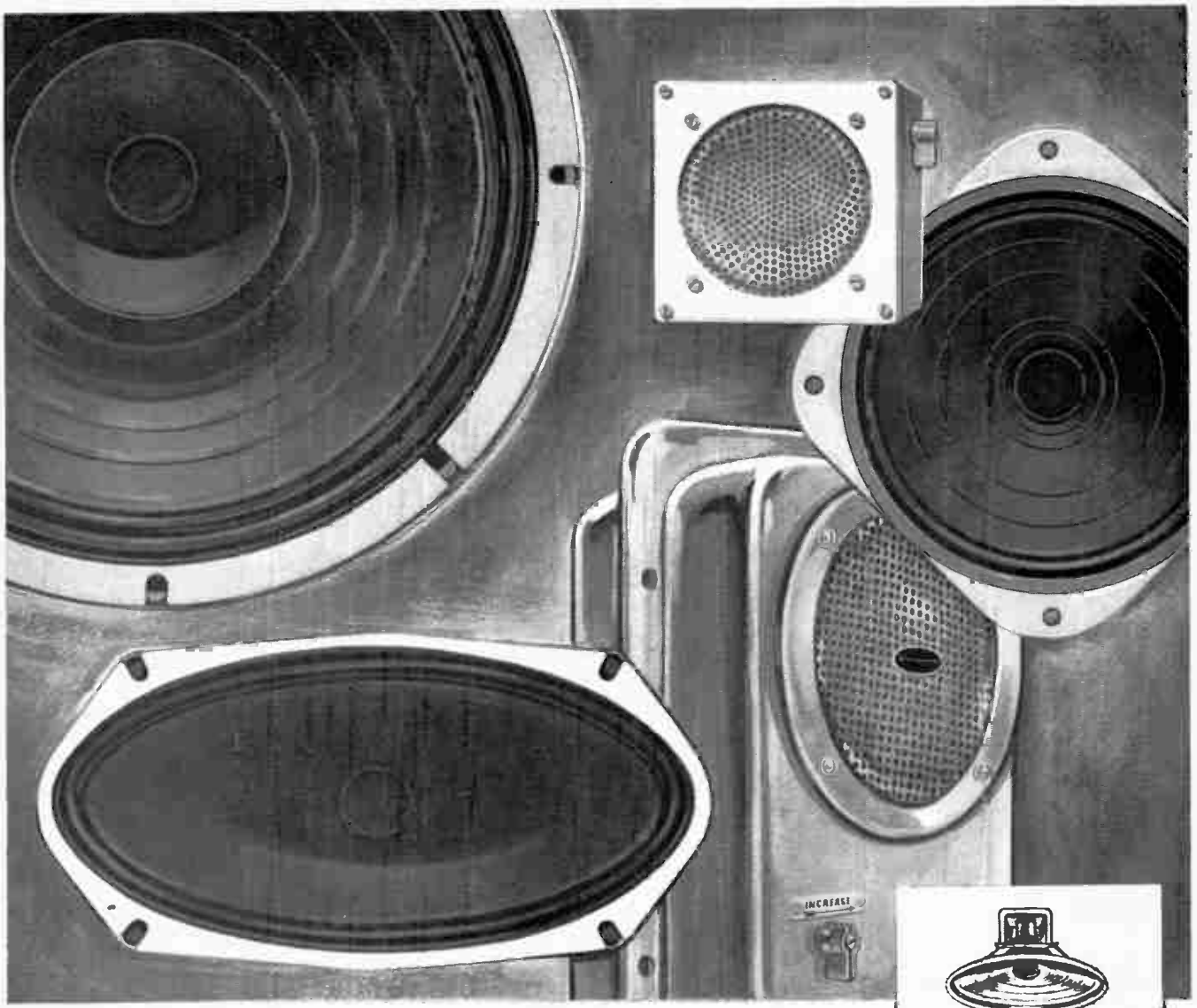
For quantities 1-999 call your nearest Transitron Industrial Distributor.



Single Speakers

Elliptical Automotive Speakers

Combination Speakers

Blast-proof Speakers and Enclosures

- **70 DIFFERENT STANDARD MODELS**
- **SPECIALS BUILT TO ORDER**

Marsland permanent magnet loudspeakers are manufactured in round, square and elliptical shape and in sizes from 2″ to 12″, with all conventional Alnico 5 magnet weights in the magnetic structure.

Standard lines provide voice coil diameters of 9/16″, 3/4″ and 1 1/4″ with impedances of 3.2 and 6 ohms. Higher impedances up to 45 ohms are available to special order.

Marsland has built millions of economical, high quality loudspeakers suited to all types of commercial applications. Stock models include: the "Imperial" line, particularly noted for faithful sound reproduction; moisture-proof models for outdoor or special inside installations; blast-proof speakers and enclosures for specialized tasks in industry and for military applications.

Detailed Information Available On Request

MARSLAND LOUDSPEAKERS

M/5

Associate Company

MARSLAND ENGINEERING LTD. KITCHENER, ONTARIO CANADA **MARSLAND PRECISION EQUIPMENT LIMITED** WATERLOO, ONTARIO

For complete details check No. 36 on handy card, page 79

ASSURES PROTECTION from Severe Mechanical Shock

• *Positive protection* against retaining-ring slippage is now yours with Texas Instruments 2N332A series grown-junction transistors.

The retaining ring *stays put* in TI's exclusive CRIMP-LOCK design, preventing short circuiting and assuring fail-safe performance under extreme mechanical abuse.

• *Guaranteed high-temperature stability* plus added mechanical reliability is provided with TI's ceramic base feature.

• *Immediate delivery in production quantities* . . . applications assistance . . . data sheets . . . complete statistical reliability data . . . all are yours for the asking. Call your local TI sales office or authorized TI distributor today.

TI Grown-junction Transistors with *Crimp-Lock* Design *Exceed* Military Requirements for Shock, Vibration, and Centrifuge Tests.

Improve Your Circuit Reliability with *Long-term Proven Performance* of TI Grown-junction Transistors.

- *Only TI offers over five years of life test data,* from lots that have been continuously on test for over 5 years, showing an extremely low average failure rate of less than 5×10^{-6}!
- *Over six-million life test hours* provide your greatest source for *predicting* transistor reliability.
- *Thousands of successful circuit applications* over the years testify to the *consistent* high performance of TI devices.

All at low cost, because industry's wide acceptance and use of these units enables TI to provide fast, cost-saving production in large quantities.

Immediate Delivery Anywhere in Canada from **CESCO ELECTRONICS LTD.**

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the industry's business

As part of $500,000 contract fiberglass reinforced plastic radome for CF-104 Starfighter is positioned on grinding equipment at Brunswick of Canada's Dixie plant.

TV sales continue to climb

Television sales in November continued the upward trend which had been evident in Canada since August.

At November 30, 1961 the increase in television sales for the 11 months, compared to the same period last year, was 2.5% — 266,071 units compared to 259,580. November was the third highest month, ranking only behind September and October.

Stereophonic and high fidelity radio phonograph combinations continued their healthy climb, reaching record monthly totals in November. Their sales for 11 months of 70,312 units were 36.8% ahead of the 51,393 units sold in the corresponding period of 1960.

The pronounced interest in FM radio is shown by the fact that 52% of all radio phono sales now include this desirable broadcast band coverage.

APEO registers 1,027 members during 1961

A total of 1,027 persons were registered as professional engineers during 1961 by the Association of Professional Engineers of Ontario.

Some 1,500 applications for membership were received during the year by the 20,000-member organization which serves as the licensing body for the engineering profession in Ontario. Of the 1,500, 475 applications were from non-graduates in engineering or persons who had graduated from schools not accredited by the APEO. Most of them hailed from countries other than Canada, with about 250 from the U.K. and parts of the Commonwealth.

Also reported was the fact that there now are about 1,600 certified engineering technicians and technologists working closely with the engineering profession in the province.

Sprague-TCC (Canada) Ltd. formed

A controlling interest in the Telegraph Condenser Company (Canada) Ltd., of Toronto, has been acquired by the Sprague Electric Company of North Adams, Mass. This was announced jointly by Robert C. Sprague, chairman of the board of Sprague Electric, and W. C. Handley, chairman of the board of the Telegraph Condenser Company of London, England, of which TCC-Canada was previously a subsidiary. The British company retains a minority interest in the Canadian concern, which now will be known as Sprague-TCC (Canada), Ltd.

Sprague-TCC (Canada) Ltd., has manufactured a limited number of types of electrolytic and tantalum capacitors for sale in Canada and other British Commonwealth markets. The Toronto facilities will be supplemented by a small operation in Walkerton, Ontario.

Radionics moves Toronto office

Radionics Ltd. has announced the move of their office in Toronto to new and larger quarters at 4938 Yonge Street, Willowdale, Ontario. E. S. Zieba, who has been with Radionics Limited for approximately 10 months calling on customers in the central and western Ontario area, will remain in charge of this office.

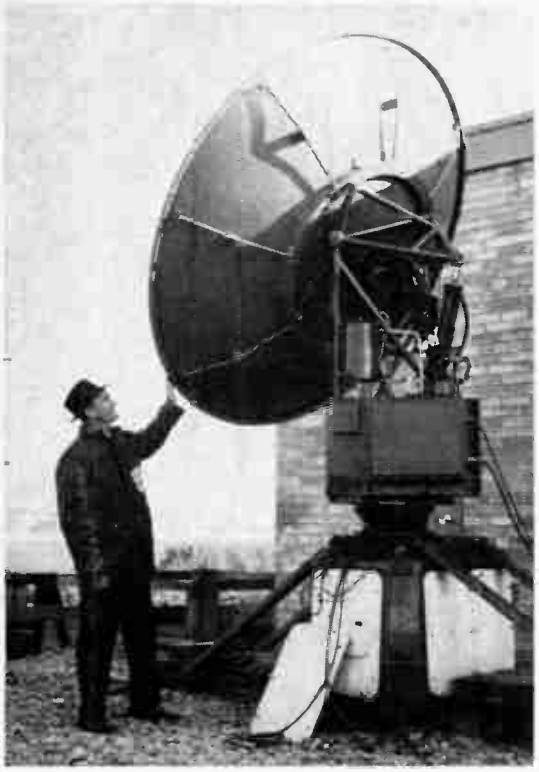
Conway extends franchise to B.C. firm

Conway Electronic Enterprises Ltd., manufacturers and distributors of precision electronic instruments, devices, and systems, have announced that an agency franchise has been extended to Frederick Goertz Limited, 1328 West Pender Street, Vancouver, British Columbia. Frederick Goertz Ltd. will offer the same specialist sales and service facilities as offered by Conway Electronic Enterprises Ltd., and will handle many of the Conway agencies for British Columbia.

Canadian Research Institute to represent Elmeg counters

The German firm of Elmeg Elektro-Mechanic have announced the appointment of Canadian Research Institute, 85 Curlew Drive, Don Mills, Ontario, as their Canadian sales and service representative. Elmeg manufacture a complete line of electrical impulse counters, including panel mounting and portable types, high speed models, telephone toll counters, predetermining types, miniature models, and print-out counters.

Flight Lieutenant R. H. Mitchell (left), officer commanding No. 3 RCAF Communications Unit, Winnipeg, accepts the Air Force's telecommunications efficiency trophy from Air Vice Marshal H. M. Carscallen, Air Officer Commanding, Training Command. Trophy was awarded to the unit with the highest yearly record of accuracy, speed of traffic, serviceability of equipment, in addition to military turnout.



Canadian weather radar actuators for DOT

The Department of Transport has recently taken delivery of four weather radars equipped with a new Canadian developed antenna tilt actuator for use at major airports to provide improved pilot weather briefing. Found Brothers Aviation Limited is the developer and builder of the new actuator system.

The antenna rotates continuously in azimuth on the Decca MR 75 and at the completion of each revolution the "dish" is tilted 1° in elevation. Upon completion of 30 discreet tilt motions, the antenna is returned in one continuous down sweep to the starting point and the cycle is repeated. An antenna elevation indicator is located adjacent to the display tube on the console so that the weather and its altitude can be determined simultaneously.

Predicts TV sales increases will continue

A continuation in 1962 of the higher sales of television receivers recorded in the second half of 1961, was forecast early in 1962 by Stuart D. Brownlee, president of Canadian Admiral Corporation, Limited.

In a year-end statement, he forecast an increase of approximately 10 per cent in the TV industry sales.

Mr. Brownlee added that Canadian Admiral's 1961 TV receiver sales were

Continued on page 89

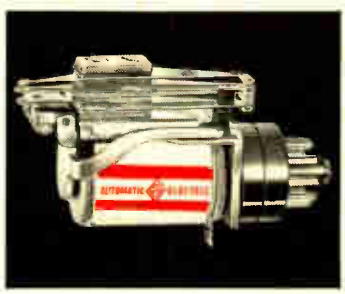
Time from the fire station was three minutes flat. And all the people were rescued. Patricia and Billy, Aunt Lucy, Mom and Dad. And the neighbours, too . . . above and below and on either side. Yet calls like this are routine for firemen everywhere.

In apartments, offices, hospitals and schools, fire alarm systems by The Standard Electric Time Co. of Canada Ltd. are standing by constantly. Ten minutes or 20 years from now their relays will click and more lives will be saved.

The key factor is unfaltering reliability. And a key component in the vital control unit of every system is a special relay made by Automatic Electric.

"Automatic Electric", say Standard engineers, "is *our* first choice of relay manufacturers. We cannot afford to have a Standard system fail."

When *you* definitely want relays that will never let you down, choose from the vast range at Automatic Electric. Automatic Electric Sales (Canada) Limited, 185 Bartley Drive, Toronto 16, Ont. Branches across Canada.



SPECIAL FOR STANDARD TIME

Shown here is the type of custom relay developed for The Standard Electric Time Co. of Canada Ltd.

Relays designed to YOUR specifications can be supplied by Automatic Electric quickly and at moderate cost.

For the very broad range of more usual applications, Automatic Electric relays are available right off the shelf.

AUTOMATIC ELECTRIC

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

6208

AN ORGANIZATION SERVING CANADIAN INDUSTRIES WITH COMMUNICATION AND CONTROL SYSTEMS

For complete details check No. 8 on handy card, page 79

industry personnel


G. D. Garbutt


A. A. Rowan-Legg


A. Lavendel


R. Bennett

Six position changes announced at Aviation Electric

A. Bandi, president, Aviation Electric Limited, recently announced the following appointments and changes in title, effective January 1, 1962: **D. R. Taylor** from vice-president to senior vice-president; **A. Lavendel** from director, overhaul division to vice-president, overhaul division; **C. D. Garbutt** from sales & service manager to director of sales & service; **R. S. Bennett** from production manager to director of manufacturing; **E. Wall** from manager, planning & development to director of engineering; **A. H. Davis** from assistant quality control manager to quality control manager.

Canada Illinois Tools selects new vice-president

The election of **Fred Ballentine** as vice-president of Canada Illinois Tools Limited was announced by Harold Byron Smith, president of the company and its parent, the Illinois Tool Works Inc., Chicago.

Mr. Ballentine, a Canadian by birth, has been associated with C.I.T. since 1937. He began in sales and rose to direct the sales programs of both Shakeproof and Citco products in Canada. He was named Shakeproof Division manager in 1957 and general manager of C.I.T. in 1960. He will continue as general manager, assuming the duties of vice-president in addition.

Rowan-Legg elected Garlock vice-president

Allan A. Rowan-Legg has been elected vice-president and general manager of Garlock of Canada Ltd. He succeeds Edwin W. Reese who terminated his service because of health reasons. Since 1957 Mr. Rowan-Legg has been president and a director of both Superior Propane Ltd. of Toronto and Northern Superior Propane Ltd. Mr. Rowan-Legg will have complete responsibility for marketing and manufacturing.

Thomas to lead Muirhead sales

R. W. Watler, P.Eng., general manager of Muirhead Instruments Ltd., Stratford, Ontario, has announced that **A. G. Thomas** will lead the Muirhead Sales Organization in future. Before coming to Canada, Mr. Thomas spent five years with the parent company in England as a sales engineer.

In addition, **R. A. Oliver** has been appointed sales representative for the Montreal area.


F. Ballentine


K. T. Boddy

Kruger organization elects top personnel

The Kruger Organization Ltd., Montreal, has announced the election of **Gene H. Kruger** as chairman of the board, **B. J. Kruger** as president and chief operating officer, and **John T. Dodds** as senior vice-president.

In addition to the purely honorary position of chairman, Mr. Gene H. Kruger will remain a director of the company.

Boddy becomes executive assistant at Electric Chain

The appointment of **K. T. (Ken.) Boddy** as executive assistant has been announced by B. R. Ekblad, managing director of The Electric Chain Company of Canada Limited, 86 Bathurst Street, Toronto.

Mr. Boddy joined the company in 1957 and has been connected with the sales activities of their specialized industrial products and services. He will take charge of the sales and development work of the precious metal precision plating division which serves the electronics industry in a variety of ways, in his new capacity.


A. G. Thomas


J. D. Buchanan

Buchanan appointed as Mallory president

Mallory Battery Company of Canada Limited announced the appointment of **John D. Buchanan,** formerly vice-president of Marketing, as president and chief executive officer.

The Board of Directors are: **Stanley Stilwell,** president of Johnson, Matthey & Mallory Limited, Toronto; **G. Barron Mallory,** president of P. R. Mallory & Co. Inc.; **M. E. Christiansen,** President Mallory Battery Company, U.S.A.; and **John D. Buchanan.**

Mallory moved into a new million-dollar head office and factory located on a 10-acre site at Clarkson, Ontario, on January 27.


B. D. Vallillee


B. Deacon

Erie sales staff changes

Bruce D. Vallillee has joined the sales staff of Erie Resistor of Canada Ltd. Mr. Vallillee has been associated with the Canadian Electronic component field for many years, and takes over the Ontario territory.

Bill Deacon will assume coverage of the Eastern Ontario and Quebec territories working out of the head office in Trenton.

Continued on page 91

BURNDY

MAKES ALL TYPES OF ELECTRICAL CONNECTORS

From the simplest terminal to the most complex multi-disconnect device — solder or solderless — you can rely on BURNDY's 38 years of experience. Whether you use standard wire, coax or miniature coax cable, BURNDY answers your connection problem for terminal blocks, miniature round and rectangular connectors, rack and panel, printed circuit, unique modular connectors, or hermetically sealed requirements. When examining your needs, remember — BURNDY makes all types of electrical connectors. We welcome your inquiries.

BURNDY Toronto, Ontario

DESIGN WITH ARNOLD 6T CORES . . .

SAME-DAY SHIPMENT OF STANDARD DELTAMAX CORE SIZES

Arnold 6T tape cores (aluminum-cased and hermetically-sealed) offer you three very important design advantages. *One:* Maximum compactness, comparable to or exceeding that previously offered only by plastic-cased cores. *Two:* Maximum built-in protection against environmental hazards. *Three:* Require no supplementary insulation prior to winding and can be vacuum impregnated after winding.

Now we've added a fourth vital advantage: Maximum availability. An initial stock of approximately 20,000 Deltamax 1, 2 and 4-mil tape cores in the proposed EIA standard sizes (See AIEE Publication No. 430) is ready on warehouse shelves for your convenience. From this revolving stock, you can get immediate shipment (*the same day order is received*) on cores in quantities from prototype lots to regular production requirements.

Use Arnold 6T cores in your designs for improved performance and reduced cost. They're guaranteed against 1000-volt breakdown . . . guaranteed to meet military test specifications for resistance to vibration and shock . . . guaranteed also to meet military specifications for operating temperatures. The 6T hermetic casing method is extra rigid to protect against strains.

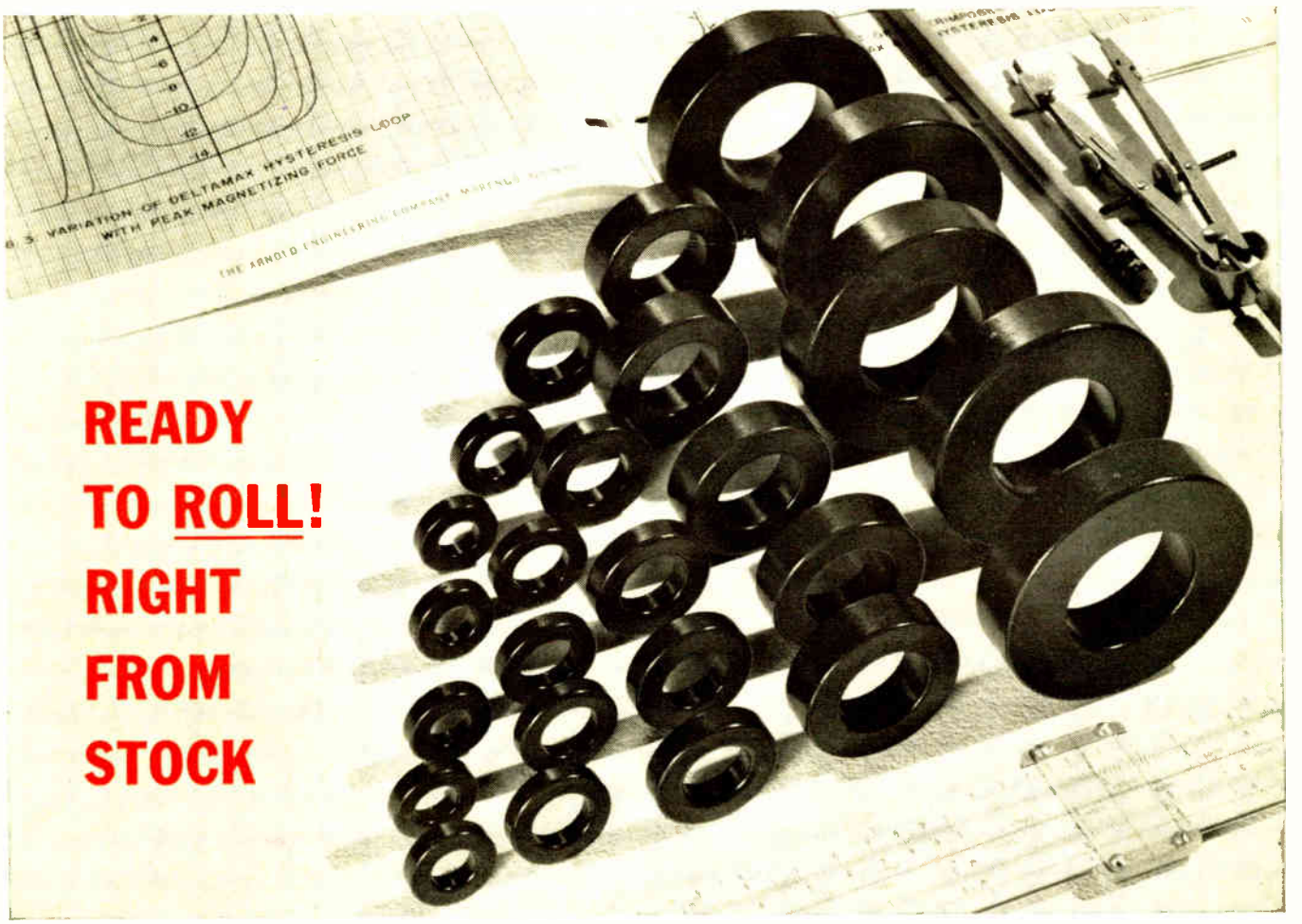
Let us supply *your* requirements. Full data (Bulletin TC-101A and Supplements) on request. • Write *The Arnold Engineering Company, Main Office and Plant, Marengo, Ill.*

ADDRESS DEPT. EC-3

ARNOLD
SPECIALISTS in MAGNETIC MATERIALS

CANADIAN Representatives: Bayly Engineering Ltd., First St., Ajax, Ont. Telephone (Toronto Exchange): 925-2126

1539



For complete details check No. 7 on handy card, page 79

MUCH MORE THAN A SALESMAN

Your Phillips representative is much more than a cable salesman. His products cover the most complete range of electrical wire and cable conductors in Canada. His markets include almost every modern industry. As a result, his breadth of understanding of wiring needs gives him a better appreciation of your particular problems.

The next time you have a problem, take advantage of his knowledge, and his Company's 72 years of experience. Call . . .

Phillips Electrical Company Limited, Head Office—Brockville, Ontario. Branches—Dartmouth, Montreal, Ottawa, Toronto, Hamilton, Winnipeg, Edmonton, Vancouver. The Canadian affiliate of the BICC Group.

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WIRE & CABLE

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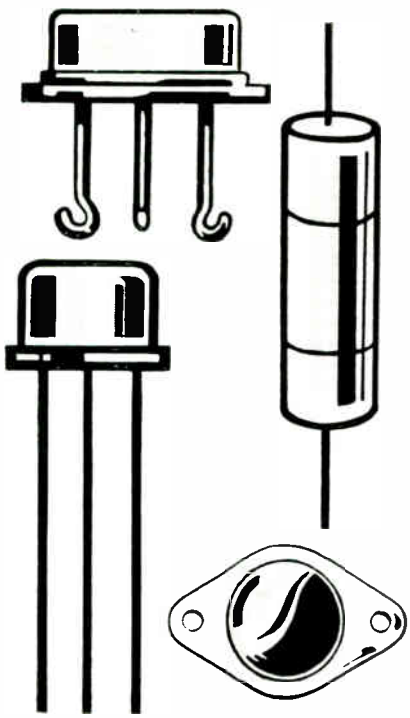

For the utmost latitude in circuit design and component procurement, refer to Raytheon's great range in semi-conductors.

Silicon transistors . . . germanium transistors . . . gold bonded or point contact diodes . . . diffused junction silicon rectifiers . . . everything for a modern designer's most advanced semi-conductor requirements.

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- Silicon Diffused Junction Sub-Miniature Glass Diodes
- Silicon Bonded Junction Sub-Miniature Diodes
- Silicon Sub-Miniature Glass Diodes
- Silicon UHF Mixer Diodes
- Silicon Diffused Rectifiers
- Germanium Sub-Miniature Transistors
- Silicon Sub-Miniature Transistors
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- TRANS-SIL Stud Mounted Power Rectifiers
- TRANS-SIL Rectifier Assemblies
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Consult your local authorized Raytheon Distributors for up-to-date information on all Raytheon semi-conductor products . . . or write:

Ask for the latest Raytheon Semi-Conductor catalogue.

RAYTHEON CANADA LIMITED

WATERLOO, ONTARIO

RAYTHEON

EXCELLENCE IN ELECTRONICS

62-2

For complete details check No. 48 on handy card, page 79

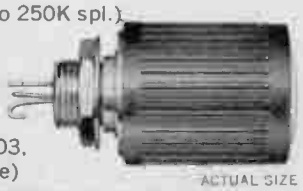
New Bourns Knobpot*—Precision Potentiometer, Dial and Knob—All in Front of the Panel!

With the new Bourns Knobpot, nothing is behind the panel but the solder hooks and the bushing. Everything else is out in front, integrated into a single, compact unit. (Just ¾" in diameter by 1" long, the easy-to-mount 10-turn Model 3600 Knobpot is shorter by 1½" than comparable potentiometers alone—to say nothing of the space it saves by incorporating its own turns-counting dial.)

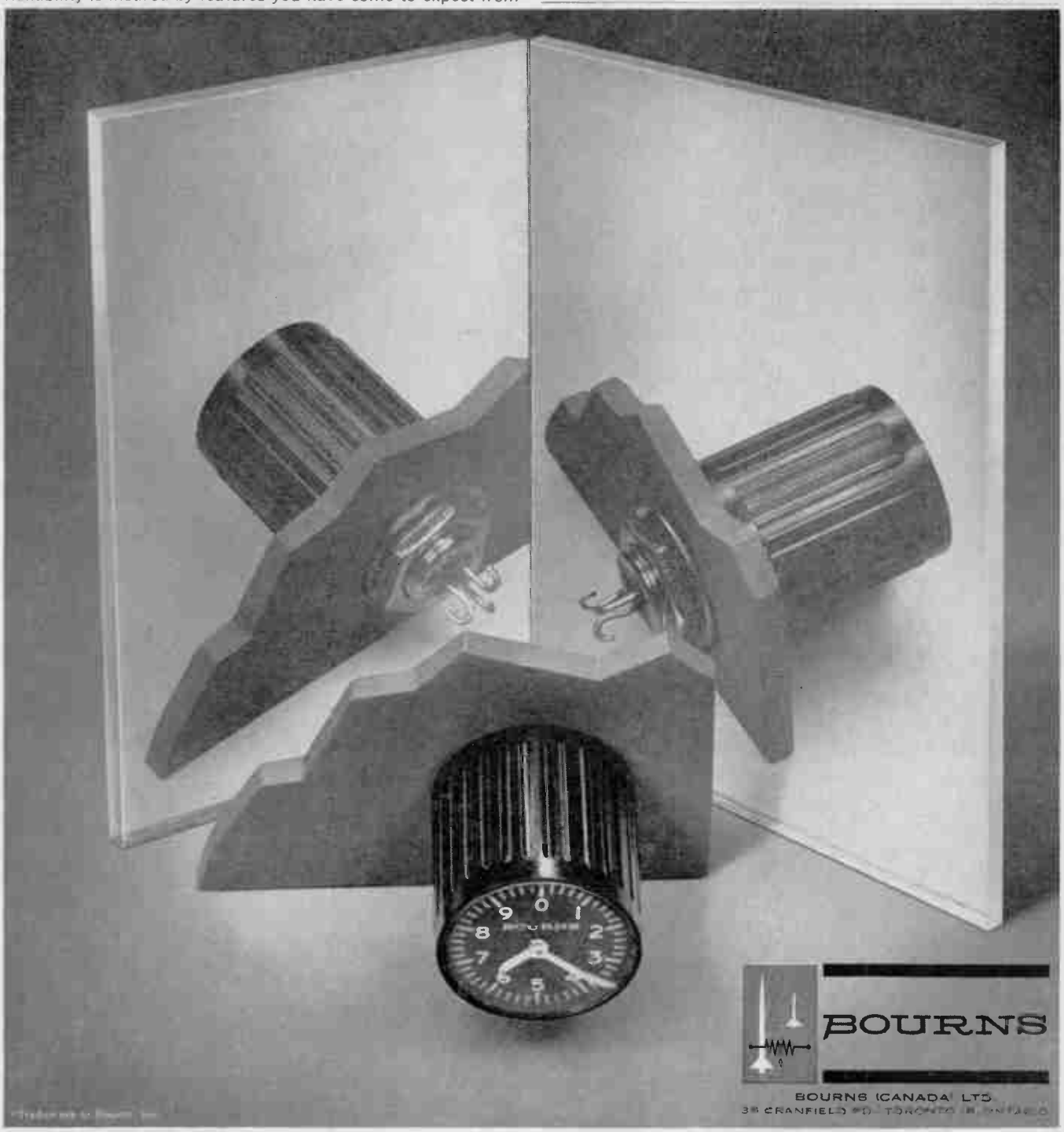
Settings are easy to make and permanent. The clear-reading dial lets you adjust to 0.5% of the unit's total resistance value, and the knob's self-locking feature keeps your adjustment steady even under 10G vibration or 50G shock.

Reliability is insured by features you have come to expect from Bourns: exclusive, indestructible Silverweld® multi-wire termination; 100% in-process and final inspections; Bourns' Reliability Assurance Program—the most extensive in the industry. Write for complete data.

Resistances: 1000Ω to 100K std. (to 250K spl.)
Linearity: ±0.5%
Power rating: 1.5W @ 25°C
Max. operating temp.: +85°C
Mech. life: 200,000 revolutions
Humidity: MIL-STD-202, Method 103, Condition B (steady state)



ACTUAL SIZE



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

For complete details check No. 11 on handy card, page 79

"Keep in Contact . . ."

Collins new 32MS-1A single sideband transceiver *keeps* you in contact with vehicle operators and offices throughout your organization. The Collins 32MS-1A gives constant communication with distant facilities and units on the move. This Collins transceiver gives communications reliability available only with single sideband, regardless of climate or terrain. ■ It offers both SSB and compatible AM operation on any of four preset frequencies in the 1.6-15 megacycle range. All functions, including channel selection, are push-button operated. Power output is 100 watts PEP (50 watts average AM). Plug-in power supplies permit 32MS-1A operation from 12 v dc, 28 v dc, or 115/230 v ac, 50-400 cps single-phase power sources. ■ As the basic radio in your network, the 32MS-1A serves fixed station, mobile and airborne requirements — simplifying maintenance as well as stocking of spare parts. ■ Learn *all* the advantages of using Collins 32MS-1A transceivers. Mail the coupon today.

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Toronto, Ontario, Canada

Gentlemen, please send me your 32MS-1A brochure and names of nearest Collins dealers.

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Street_____

City_____ State_____ Country_____

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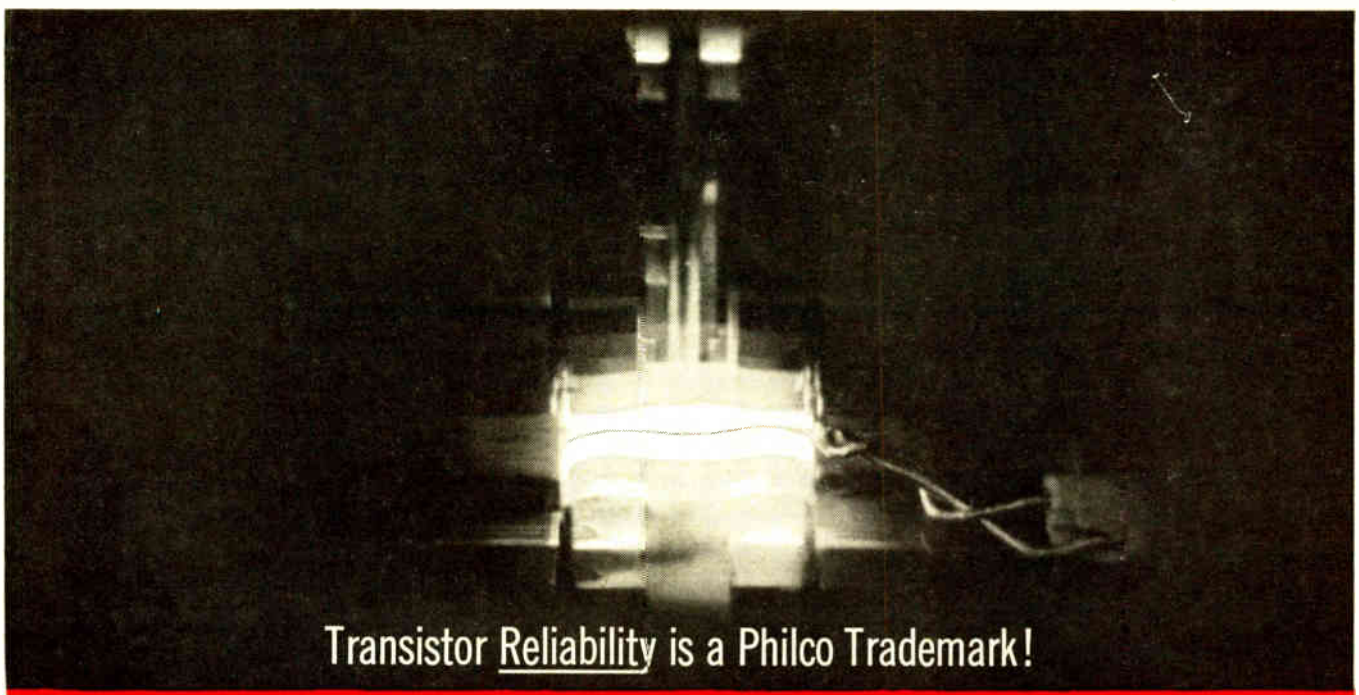
COLLINS

For complete details check No. 18 on handy card, page 79

Why can't Philco Transistors Fail?

Because they're the only transistors in the world produced by full automation. No chance for human error. **Because** every one of them is tested. Not one dud in a million. **Because** every fourth Philco employee works only on reliability. **Because** we log two million hours of transistor life tests a week. **Because** we have already spent over five million dollars solely on a transistor reliability assurance program!

Compare these facts with the production and testing techniques of any of Philco's competitors. Then you be the judge. We think you'll agree that...



Transistor Reliability is a Philco Trademark!

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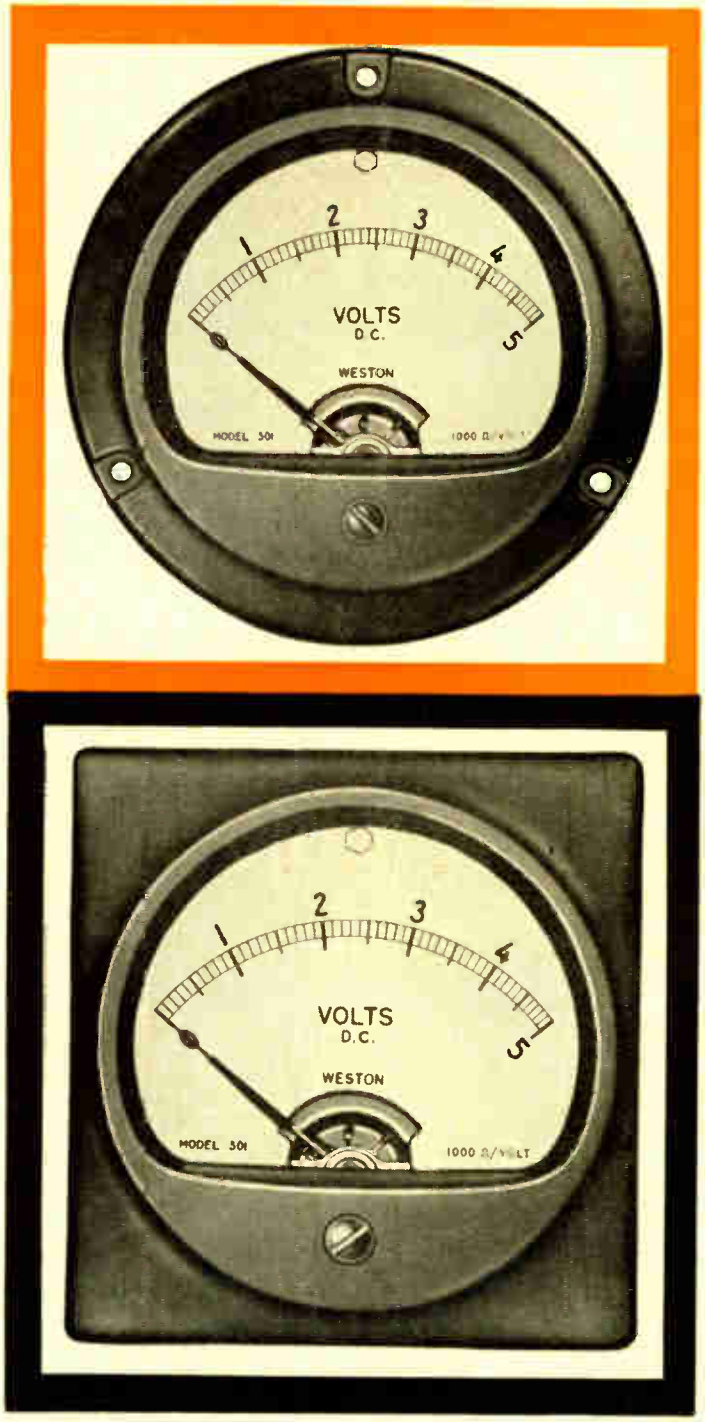
For complete details check No. 43 on handy card, page 79

"LIFE-INSURED"* PANEL INSTRUMENTS by WESTON

...NOW MADE IN CANADA!



201/301 group—available in round and square 2½" and 3½" cases

The accuracy and dependability of WESTON Panel Instruments are acknowledged throughout the world. Now this outstanding product group is *made in Canada*—precision manufactured to last a lifetime in any installation!

- **Spring Back Jewels with Locking Nuts for fine Adjustments**
- **Specially Treated Alnico 5 Magnets Provide Long Term Stability**
- **CORMAG Mechanism Fully Shielded from Magnetic Effects**
- **New Styled Bakelite Cases Sealed Against Dust**
- **Die Cast Parts in Critical Structural Members Assure Complete Interchangeability, Permanent Alignment**
- **Designed for Minimum Power Consumption—Minimum Response Time**
- **Available in Matching A-C, D-C, Rectifier and Thermo Types**

*Extended 3-year warranty.

For detailed information on the Weston 201/301 Group of Panel Instruments, write Daystrom Limited,
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5430 Ferrier Street, Montreal 9, Quebec.
A subsidiary of Daystrom, Incorporated.
Or any office of Northern Electric Co. Ltd.

6132

CANADIAN PLANT—COOKSVILLE, ONT.

DAYSTROM LIMITED

WORLD LEADERS IN MEASUREMENT AND CONTROL

For complete details check No. 23 on handy card, page 79

Spaulding FIBRE FACTS FOR ENGINEERS NUMBER 5

How to Achieve Permanence at Low Cost

by K. H. Alverson, Product Standards Director

Seldom is a high degree of permanence found associated with the characteristics of dielectric strength, rugged structural strength and arc resistance at such low cost as in Vulcanized Fibre. This permanence and strength allows the engineer to use Vulcanized Fibre to replace more expensive plated or coated parts even where insulating or arc resisting properties are not required.

The reason for Vulcanized Fibre's agelessness lies in the chemical action of its production which arrests the natural tendency of cellulose to deteriorate. This renders Vulcanized Fibre more stable than the hardest wood. (Corrosion, such as attacks metals, is completely precluded since Vulcanized Fibre has a non-mineral base.)

The permanence of Vulcanized Fibre in use is well illustrated by its application as insulation in transformers, switchgear, and circuit breakers. Parts such as corrugated duct spacers, arc chutes and barriers are subjected to terrific arc exposure and must maintain their form, strength and electrical properties for years under continuous operation in hot oil. Lightning arresters and high voltage fuses, made from Fibre tubing for protecting power line transformers, are still in service and operation, in satisfactory condition, after more than twenty years of use.

Industrial fuses with a fibre case and replaceable fuse link are one of the best known uses for Fibre tubing. If the fuse blows, the link is simply replaced and the fuse case used over and over again.

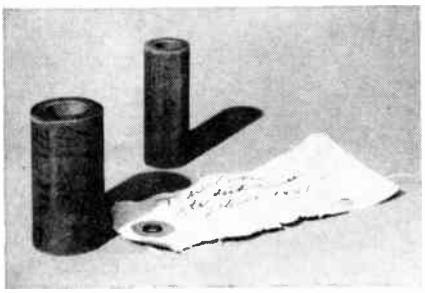
Fibre grommets are used to form a permanent locked-in-place insulator in metal assemblies, such as clocks, motors, etc. They will not deteriorate and fall out as will rubber. Fibre grommets for such applications are approved by the Underwriters' Laboratories.

Fibre is non-corroding, unaffected by oils, greases, solvents, etc. It withstands the pounding of heavy trains when used as track insulation under outdoor exposure. Easily formed into complex shapes for use in athletic equipment, welding helmets, etc., all of which must withstand harsh usage without failure.

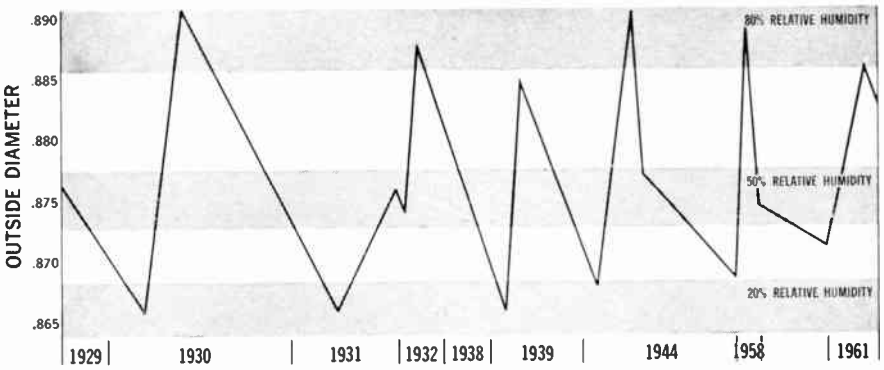
Trunk coverings, sample cases, factory trucks and waste baskets have been made for years of Vulcanized Fibre to take advantage of the light weight, abrasion resistance and permanence of the material.

Because of its many unique characteristics, Vulcanized Fibre offers a virtually endless variety of applications.

Spaulding Engineers who have been trained in Value Analysis can help you take advantage of the wide range of possibilities in designing to reduce costs through the use of Vulcanized Fibre parts. They also make available to you Spaulding's extensive fabricating facilities and experience in working with this extraordinary material.



While many materials deteriorate over the years, Vulcanized Fibre maintains its essential properties for decades. Note how the linen tag attached to Fibre tube samples in 1929 shows age, but Fibre tubes look and act as they did 32 years ago.



Long term test of fibre, which has been going on since 1929, shows that fibre still responds to wide humidity changes in the same way it did when test began. Predictable changes in dimension occur when fibre tubing is subjected to extremes of humidity. Tests such as these prove that there is no change in Vulcanized Fibre characteristics over long periods of time.

Be sure to add this FREE Literature to your reference files. *WRITE TODAY.*

New Value Analysis Brochure a detailed review of the Spaulding Value Analysis technique together with case histories of design improvement and cost reductions that have been accomplished through Spaulding's Value Analysis of customer products. 12 pages.

Vulcanized Fibre Engineering Data — a design reference book which comprehensively covers all the application specs of Vulcanized Fibre. 10 pages.

GENERAL CIRCUITRY AND QUICK DISCONNECT MS Series, MS Types, K Series. MS plugs meet MIL-C-5015; include environmental resistant types, and feature low cost, uniform quality, interchangeability, and wide variety of contact arrangements. A wide variety of shell sizes and types are available to meet all general-purpose applications. The K Series are lightweight, rugged, all-purpose plugs—have many of the features of the MS Series. The K line features a special Acme threaded coupling. Crimp snap-in contacts are available in some MS types.

RACK/PANEL Dual panel rectangular plugs have a wide variety of contact arrangements and shell sizes. Rectangular shape increases insert area utilization, simplifies assembly, provides maximum flexibility for module or unit plug-in applications. Available in environmental resistant types; coaxial and high voltage contacts, solder or crimp snap-in.

AUDIO AND LOW LEVEL CIRCUITS P, XLR, XK, O, UA Series for all low level sound requirements. Full line of plugs for all requirements of microphone, radio, television, tape recorders, computers, control devices, and many other applications. In many shell sizes and contact layouts, coaxials. Latch-lock types, wall mounting, panel, locknut mounting, and adapter receptacles. Line includes the deluxe streamlined XLR Series.

MINIATURE SERIES KQ/KR, KM, K-Miniature, DPA, DPX, Golden-D. *Circular Miniature Plugs* designed for aircraft, missile and other applications where space and weight are critical. Include environmental resisting, crimp snap-in contacts, quick-coupling devices, monobloc construction, hermetically sealed versions.

Miniature Rectangular Plugs meet weight and space limitations in rack/panel installations. Range from lightweight sub-miniatures to small plugs of great strength. Coaxial layouts, hermetically sealed versions, crimp snap-in contacts.

CANNON PLUGS FOR ANY APPLICATION OR ENVIRONMENT

HERMETICALLY SEALED Available in most popular plug lines. Includes the first Series approved to MIL-C-25955, which requires leakage rates of less than .001 micron cubic foot per hour (1.5×10^{-8} cc/sec.). Plugs for all hermetic applications—standard or custom designs, with some series designed to withstand extreme thermal shocks, temperatures from —100°F to 1000°F, pressures above 2000 psi.

COAXIAL RF SERIES Available in a wide variety of types from subminiatures to large cable applications. For use in thousands of military, industrial, and commercial applications. Meet extreme environmental conditions. Hermetically sealed versions, weight-saving aluminum versions available. Full line of RF plugs meets all requirements from ground based equipment through outer space.

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MAGNETIC DEVICES A wide range of magnetic actuating devices for military, industrial, and commercial applications. AC and DC solenoids; linear, rotary and reciprocating actuators for computers, business machines, environmental, and special design. Push, pull, Push-Pull; high temperature, potted, hermetically sealed. Broad power ranges, input voltages in 6, 12, 24, 36, 115, and 230 dc and ac.

For more than four decades Cannon has been solving critical plug problems for every conceivable military and industrial application. Our wide variety of plugs—more than 27,000 designs—are available to meet such problems of modern technology as *shock, vibration, acceleration, temperature, altitude, moisture,* and *miniaturization*...Cannon plugs are the standard of the industry for use in aircraft, missiles, ground support equipment, computers, data processing devices, business machines, radio, television, and many other standard and special applications. For additional information on the typical designs illustrated, or other types to meet your individual requirements, write to:

CANNON ELECTRIC CANADA LIMITED 160 Bartley Drive, Toronto 16, Ontario
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CANNON PLUGS

For complete details check No. 17 on handy card, page 79

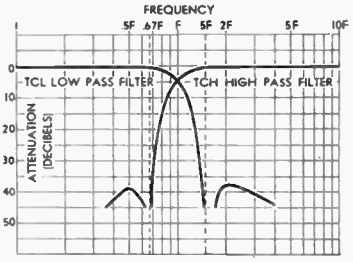
Current Reference
FOR LOW COST FILTERS

Each time circuit design calls for low pass, high pass, interstage or band pass filters in communications, guidance and control, it's the reliable, economical filter that counts. For filters that are right up there in front of you when you need them, order these and other filters from the Burnell & Co. standard catalog.

STANDARD

TCL—LOW PASS— TCH HIGH PASS FILTERS

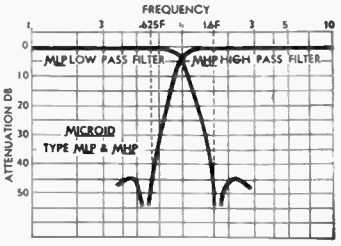
These popular low cost filters find many useful applications. A band pass filter results when cascading a TCL with a TCH filter. Standard impedances are 500/600 ohms and 10K. For 60 cps to 300 cps, case size is 1¾ sq. x 3, 400 cps and up 1-3/16 x 1-11/16 x 2¼ H.



MICROID®

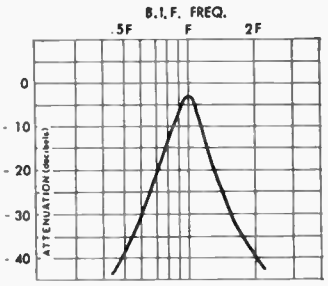
MLP —LOW PASS— MHP HIGH PASS FILTERS

The MLP and the MHP are micro-miniature counterparts of the TCL and TCH low pass and high pass filters. Standard impedance is 10,000K. Case sizes are as follows: 400 cps to 1.9 kcs, 11/16 x 15/16 x ½, 2 kcs to 4.9 kcs, 11/16 x 1⅝ x ½, 5 kcs and up, ⅝ x 15/16 x ½ H. Wt. of both MLP and MHP Microids, approximately .3 ozs. each.



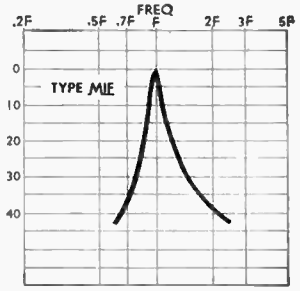
BIF—BAND PASS INTERSTAGE FILTERS

These economical Burnell band pass interstage filters are designed for a wide variety of applications. Input impedance is 10K output to grid with a voltage gain of approximately 2:1. Any frequency between 60 cps and 100 kc is available. 3 DB bandwidth nominally 8%. Size as above.



MIF—INTERSTAGE FILTER

Input impedance for the MIF micro-miniature interstage filter is 10,000K to grid with a voltage gain of approximately 2:1. The 3 db band width is nominally 8%. Covering frequencies from 7.5 kcs to 100 kcs these interstage filters are provided in the same case sizes as the MLP



F_o CPS.	TCL 10K	TCL .6K	MLP 10K	TCH 10K	TCH .6K	MHP 10K	BIF 10K	MIF 10K
60 ~	59079	65950		55853	55579		17550	
100 ~	61367	63915		62942	55580		17228	
120 ~	64129	65951		65962	65975		17551	
200 ~	19971	61740		55759	65977		21391	
400 ~	65938	55370	71028	64419	29877	71015	17230	71000
500 ~	50176	29562	71029	55760	26174	71016	17231	71001
750 ~	50177	20310	75242	55993	75244	75243	17232	71002
1000 ~	50178	29563	71030	31724	65978	71017	17233	71003
1500 ~	50179	65953	71031	75245	66283	71018	17234	71004
2000 ~	50180	65954	71032	65963	62608	71019	17235	71005
3000 ~	50182	29566	71034	31725	59292	71021	17237	71007
4000 ~	50183	20312	71035	75246	66278	71022	24720	71008
5000 ~	50184	22400	71036	36826	23324	71023	17238	71009
10000 ~	50187	29569	71037	31726	22122	71024	17239	71011
20000 ~	50771	75247	71038	50774	75248	71025	21169	69613

If your filter needs can't be met from our large stock catalog, we'll be glad to manufacture to your specifications

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For complete details check No. 25 on handy card, page 79

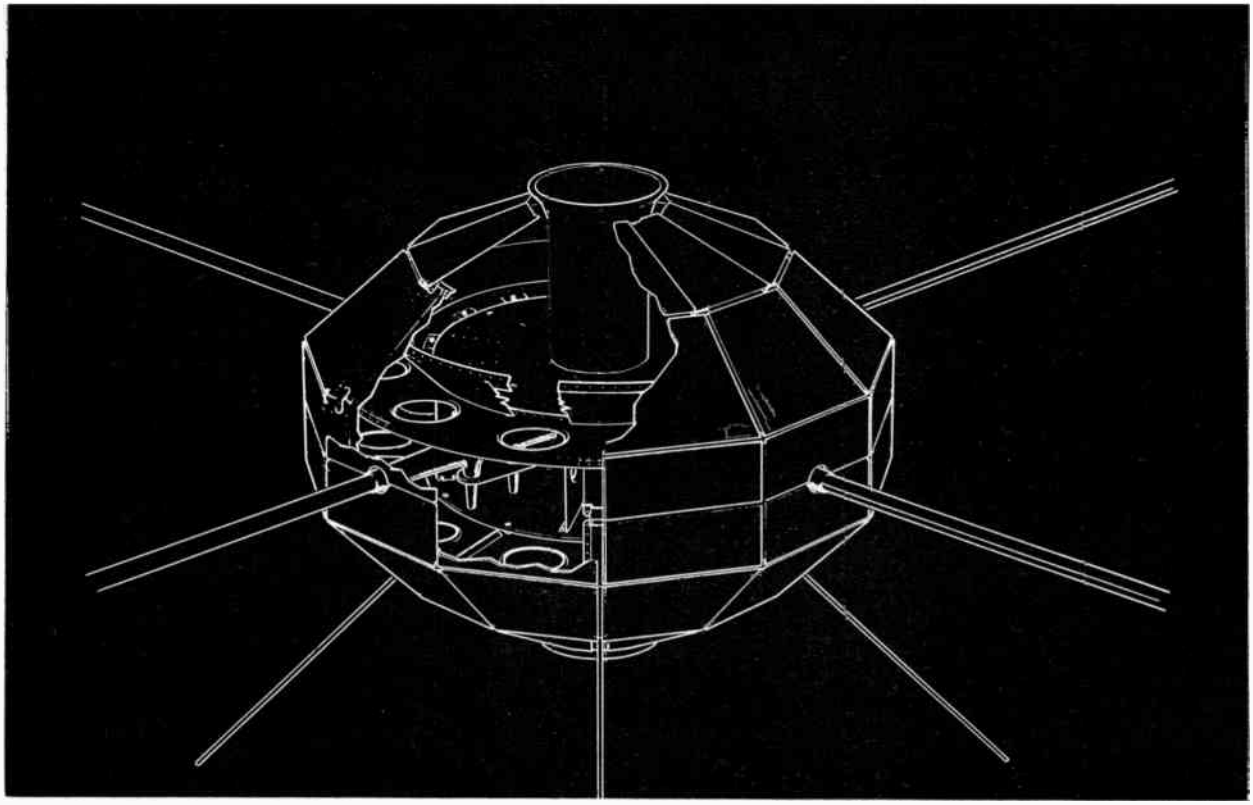


Figure 1. The S27 Spacecraft for the ionosphere sounding experiments — cutaway view.

CANADIAN SPACE ELECTRONICS

The Canadian swept-frequency ionospheric sounding satellite

. . . . this article from the Defense Research Telecommunications Establishment reveals details of the electronic system of the S-27 satellite . . .

by R. K. Brown*

Introduction

Scientists of the Telecommunications Establishment of the Defense Research Board (DRTE) have been studying the earth's ionosphere for many years. These studies have been directed toward both a better understanding of the fundamental properties of the ionosphere and the application of this knowledge to communication problems. Perhaps the most widely used experimental method for making such studies is the swept frequency ionospheric sounder. This method provides a wealth of information at all altitudes up to that of maximum ionization (the F_2 layer maximum) but not beyond.

This limitation suggested the desirability of instrumenting a satellite to sound the ionosphere from above and when the United States invited suggestions for satellite-born experiments, the Canadian Topside Sounder proposal was made. Final arrangements were made with the National Aeronautical and Space Administration (NASA) and it was agreed that DRTE would provide the spacecraft (satellite) with complete instrumentation, Canadian telemetry stations for receiving and recording data and a data reduction center to convert the recorded data to suitable ionograms. NASA has agreed to provide technical consultation and assistance, final environmental acceptance testing, the use of the world-wide Minitrack chain for satellite tracking, and the recording of ionospheric data outside Canada, and the rockets and range facilities necessary to place the spacecraft in orbit.

This report will be concerned mainly with the Topside Sounder satellite with only brief references to other DRTE responsibilities.

Spacecraft electronics

In addition to the ionospheric sounder which will carry out the primary experiment, the instrumentation includes several other electronic sub-systems. Two telemetry systems will transmit data directly to ground

*See page 30

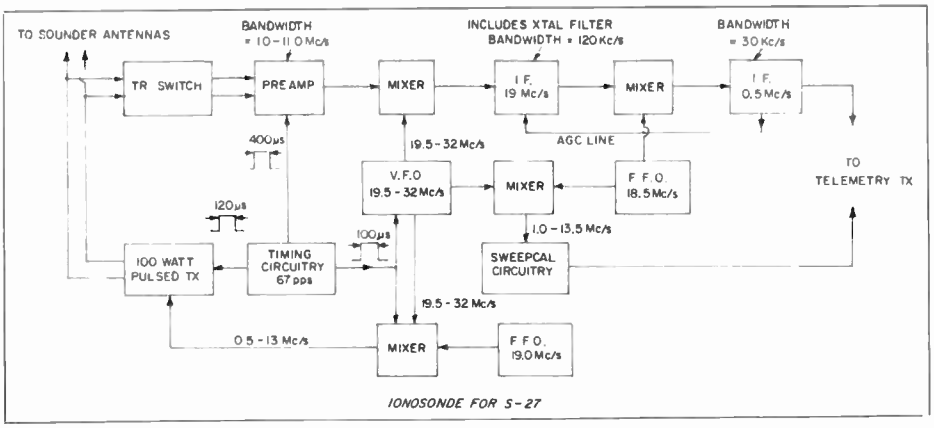
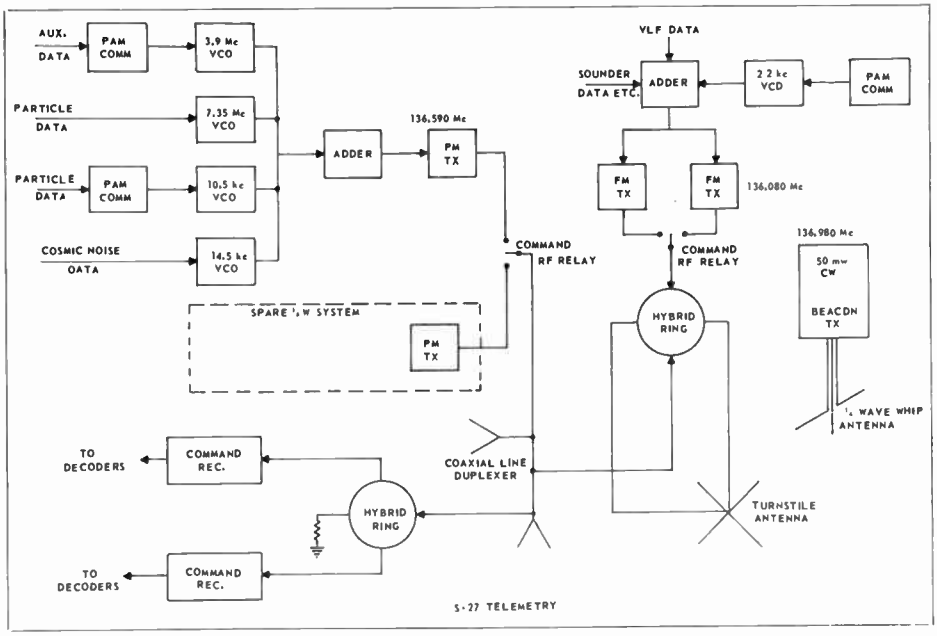


Figure 2. *(left) Block diagram of the ionosonde system of the S-27 satellite*
Figure 3. *(lower left) Diagram showing the satellite's telemetering system.*

stations, an unmodulated beacon transmitter, operating continuously, will enable the satellite to be tracked, and a command receiver and decoder also operating continuously, will provide control of the satellite electronic system. Power will be supplied by solar cells and storage batteries. Monitoring circuits will provide information on currents, voltages and temperatures.

Three other experiments, cosmic particle measurements, a very low frequency receiver and cosmic noise measurements are also housed in the spacecraft. These are significant experiments, the results of which are expected to complement the main experiment, but their description is beyond the scope of this report and they



The Author

R. K. Brown *received his BA and MA from the University of B.C. where he was later a lecturer. After some years with the B.C. Research Council he joined DRB as a Scientific Officer. At* **DRTE** *he has made significant contributions to the S-27 satellite project.*

will not be discussed in detail.

The proposed orbit of the satellite, the characteristics of the ionospheric sounder, and of the command and the telemetry systems are shown in Table I. (See page 68)

The Sounder

The sounder is a swept frequency pulsed sounder covering the frequency range 1.6 to 11.5 Mc. A 100 μsec pulse is repeated at a rate of 67 pulses per second and the rate of frequency sweep is approximately 1 Mc per second. The sweep linearity requirements are relatively easy to meet, as will be discussed later. All the essential components are shown in Figure 2. A variable frequency oscillator (VFO) sweeping from 19.5 to 32 Mc is mixed with a 19 Mc fixed frequency oscillator to produce the required frequency sweep. It should be noted here that it is desired to operate the sounder receiver over the frequency range 0.5 to 13 Mc even though the antenna matching networks are efficient only over the frequency range 1.6 to 11.5 Mc. This is done to provide for the reception of cosmic noise over an extended frequency range although the response falls off very rapidly below 1.6 Mc, being approximately 40 db down at 0.9 Mc. The increased cosmic noise intensity at the low-frequency end of the spectrum will partially offset this decrease in the overall sensitivity of the receiving system.

In the receiver the incoming signal is mixed with the swept frequency oscillator and translated in frequency to 19 Mc. An IF amplifier provides 40 db gain with a crystal filter setting a bandwidth of 120 kc. Following the 19 Mc amplifier the ionospheric signal is mixed with the output of a crystal controlled local oscillator operating at a frequency of 18.5 Mc. This results in a second frequency translation to 500 kc. The 500 kc amplifier has a bandwidth of 30 kc and a gain of 60 db. Amplitude limiting is provided to ensure that the signal reaching the wide-band telemetry channel does not exceed a specified value. An envelope detector at the output of the 500 kc amplifier provides the low frequency signal (sounder pulse plus cosmic noise level). Low frequency amplifiers following the detector provide an AGC voltage to control the gain of the 19 Mc amplifier and a cosmic noise telemetry voltage (not shown in Figure 2) proportional to the AGC voltage. This AGC is designed to provide measurements of cosmic noise over a dynamic range of 40 db. The pulse derived from the signal reflected from the ionosphere is passed directly from the envelope detector to the wide-band telemetry channel (see Figure 2).

The low level stages of the transmitter are wide-band transformer coupled amplifiers using the common base connection. A filter with a pass band of 1 - 12 Mc/sec is included. This is followed by a cascade of four class B push-pull emitter follower stages, the last

of which uses four 2N1709 in push-pull parallel.

The final amplifier consists of four class A pairs in push-pull parallel using the common base connection providing 100 watts into a 400 ohm load. This performance is maintained over the temperature range −50°C to +85°C. Stability requirements call for a low impedance drive which is obtained from the class B cascade described above. The power consumption is 4.3 watts the overall power gain is 46 db and the power gain of the final stage is 7 db.

A free running, capacity-coupled multivibrator sets the basic system rate at 67 pulses per second. Capacity-coupled monostable circuits are used to produce fixed time delays and to generate gating and synchronizing pulses.

The frame and line synch pulses are negative-going with pulse widths of 7 msec and 200 microsec respectively. The zero range, transmitter gate and receiver gate pulses are positive-going and have widths of 100, 120, and 400 microseconds respectively. The video format is shown in Figure 5.

Two dipoles, one with a tip-to-tip (including satellite) length of 150 ft., operating over the range of 1.6 - 4.5 Mc and one at right angles to the above, 75 ft. tip-to-tip and operating in the range 4.5 to 11.5 Mc will be used.

These will be driven by balanced wide-band matching networks with insertion loss not in excess of 11 db. Balanced drive will be utilized in order to avoid any unbalance, and hence ensure that the orthogonal dipoles are electrically orthogonal.

In the cross over region around 4.5 Mc/sec radiation will take place from both antennas and the radiated wave will not be plane polarized as for a single dipole, but may be circularly or elliptically polarized depending upon the relative phases of the currents in the two antennas. It is not expected that this phenomenon will seriously degrade the ionograms.

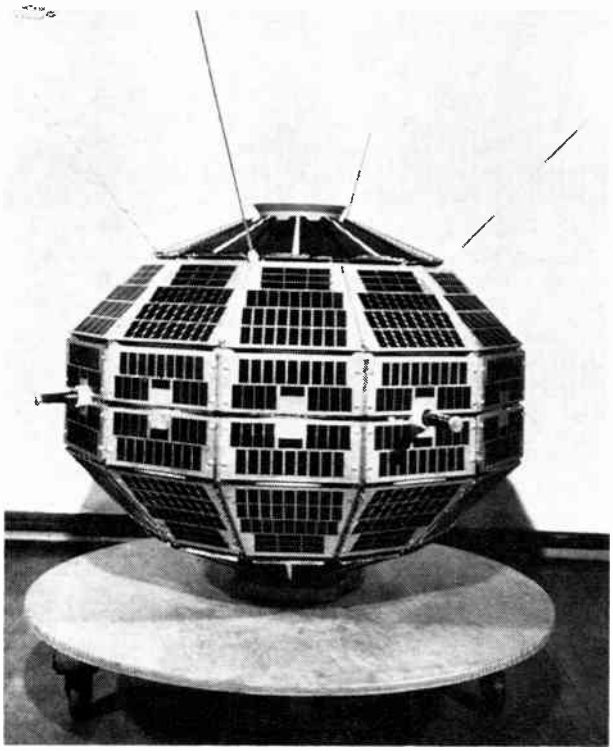


Figure 4. Photograph of the S-27 "Top-side Sounder" satellite.

Figure 5. Video format of the S-27 ionosonde.

Telemetry and Beacon — see figure 3

Two telemetry transmitters are to be used, one operating at a power level of 0.25 w at a frequency of 136.590 Mc, and a second with a power output of 2.0 w at a frequency of 136.080 Mc (see Table I). Both transmitters are operated on command only, to conserve battery power. The lower power transmitter is modulated in such a way that it may, in an emergency, be used as a tracking beacon. Both transmitters are duplicated in order that a spare unit may be switched in, on command, in case of failure.

The 0.25 w, 136.590 Mc transmitter is phase modulated by four standard IRIG subcarrier oscillators at 3.9, 7.35, 10.5 and 14.5 kc respectively. The 7.35 and 10.5 kc subcarriers are to be used for the cosmic particle experiment. The 14.5 kc subcarrier will monitor the cosmic noise level during the sounder sweep. The 3.9 kc subcarrier will monitor battery voltages, solar cell charging currents and temperatures. Data inputs to the 3.9 kc, and the 10.5 kc subcarriers are time multiplexed (PAM) using solid state commutators. Total phase deviation of this transmitter is ±0.8 rms radians.

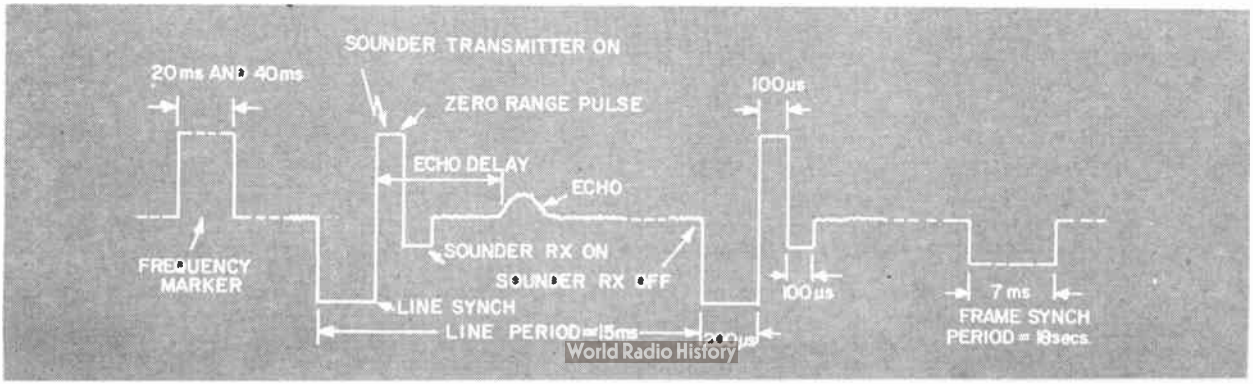
The 2.0 w, 136.080 Mc transmitter will be frequency modulated by the ionospheric sounder echo signals plus marker and synchronization pulses. Signal bandwidth for the above is from ½ cps to 10 kc. A 22 kc subcarrier has been added to this transmitter and will carry information redundant to that on the 3.9 kc subcarrier on the low power transmitter. Peak frequency deviation of this transmitter is ±40 kc.

The telemetry antenna consists of four whips in a turnstile configuration (see Figures 1 and 4). They are driven by a hybrid ring isolator. This antenna is shared by the two telemetry transmitters and by the two command receivers (see Figure 3). The command receivers are isolated by means of a hybrid ring cut to the command frequency which in turn is isolated from the ¼ w 136.590 Mc transmitter by a coaxial line duplexer. All inputs to the antenna will have a maximum VSWR of 1.4:1.

A 50 mw, 136.980 Mc tracking beacon transmitter has been provided for use by the NASA Minitrack network. This transmitter is unmodulated and radiates continuously via a single ¼ wavelength whip mounted on the "top" of the satellite.

Command System

With the exception of the beacon transmitter and command receiver, all electronic equipment in the



satellite will be normally off. When the satellite comes within range of the ground telemetry station, the appropriate spacecraft equipment can be turned on by command. The full electronic system can be turned on with automatic turn off in 10 minutes, or one or more of a number of individual sub-systems depending upon the measurements desired. Command is achieved by the transmission of a radio frequency signal which is modulated by discrete audio tones. Combinations of seven tones are used to achieve a total of 12 commands. The spacecraft contains two command receivers, for redundancy, and appropriate decoding networks. This equipment operates from the "best" battery so that as long as one of the six batteries is operative command can be achieved.

Monitoring Circuits

Battery current measuring circuits permit measurement of the charge or discharge currents of the six battery packs used in the power supply system of S-27. A resistor of approximately 0.5 ohms is inserted between the negative terminal of each battery pack and earth. The voltage developed across this resistor due to the passage of current is amplified by a balanced pair of NPN transistors, the voltage outputs of which are fed to the two commutators for redundant telemetry of battery current information back to the ground. These current measurements provide not only quantitative data on the charge and discharge rates, but also serve to monitor the command operation of the battery pack switching circuit by indicating which battery packs are in use at any given time.

The voltages of the four working packs will be monitored by telemetering the voltages appearing at the four outputs of the battery switching circuit. In order to provide a higher accuracy in the telemetered readings than could be obtained by simple voltage division from these points to the commutator inputs, two six-volt zener diodes are employed in series to subtract a substantially constant 12 volts from the battery pack voltages before telemetry. An appropriate voltage divider then limits the voltage variations of the battery packs to the useful dynamic range of the commutator inputs. The four voltages measured are transmitted redundantly on the 250 milliwatt and 2 watt telemetry transmitters.

The temperatures of 22 points within the satellite will be monitored. The basic measurement technique relies on the change of resistance with temperature of disc-type thermistors. A zener diode regulated voltage is impressed across a resistor is series with each thermistor to obtain an output voltage which varies approximately over the dynamic range of the commutator inputs for the expected temperature range of the satellite. Eleven thermistor circuits have outputs feeding the 250 milliwatt telemetry transmitter via commutator #1, and the remaining 11 will feed the 2 watt telemetry transmitter via commutator #2.

Power Source

Early in the system design a decision was made to use a single voltage level, 15 volts, for all batteries and to derive the voltage rails needed for the various circuits from DC-DC static converters. Consequently, the power source consists of six nickel-cadmium batteries (four operating plus two spares) recharged by silicon solar cells. Four DC-DC converters, one associated with each operating battery, provide the necessary DC voltage levels.

A total of 6480 solar cells, arranged in 144 series groupings of 45 cells each, provide the charging power for four separate 12 battery Ni-Cd battery supplies. The solar cell efficiency (9 per cent), arrangement (aspect ratio 4.25), operational temperature (0°C), together with factors for micrometeorite damage, transmission losses, and safety margin supply an input to the batteries that has a design minimum of 22 watts.

One of the four battery supplies is to provide power for most of the continuously operating circuitry. The remaining three are to operate the command part of the instrumentation. These three supplies have capacities proportionally much larger than necessary when considered in the light of charging power per orbit. This excess capacity will be used to supply sounding power for the greater part of two successive orbits, recharging taking place over many following orbits. Construction techniques developed for presently orbiting satellites have been used in all phases of the power source construction. However, thicker (0.012 inch) than average solar cell cover glasses have been used to protect against higher energy electron damage.

Mechanical design

Spacecraft Design

The shape and general structure of the spacecraft are shown in Figures 1 and 4. Figure 1 shows the internal arrangement. The four sounding antenna modules and the batteries (not shown) are located in the central cylindrical section. The electronic packages (not shown) are mounted on the decks above and below the central section in the space between the thrust tube and the stiffening flange shown cut away in Figure 1. Both figures show the four sounding antennas extending in the equatorial plane and the telemetry turnstile whips. The beacon antenna, not shown here, is a whip mounted at one end of the thrust tube along its axis.

The spacecraft shape approximates an oblate spheroid and the design is a compromise between two requirements: first that the electronic packages be accessible and easily removed; and second that the solar aspect ratio be constant. The aspect ratio is the effective fraction of the total surface area illuminated. A constant aspect ratio is desirable to maintain constant solar cell output power.

Attached to the periphery of the central structure are two half-shell aluminum spinnings which form the satellite shell. Onto this spun shell are attached the solar cell panels and both heat-control end caps. The central structure is attached to the thrust tube through which the entire load is transmitted.

The spacecraft is 42 inches in diameter, 34 inches high and weighs 320 lbs. Roll and pitch moments of intertia of the vehicle prior to sounding antenna extension are 7.9 and 5.5 slug-feet^2 respectively. These values increase to 577 and 255 slug-feet^2 with antennas unfurled.

Sounding Antenna Design

The sounding antenna system consists of crossed dipoles one of which measures 150 ft. tip-to-tip and the other 75 ft. tip-to-tip. Individual poles are therefore approximately 75 ft. long and 37½ ft. long, and are 0.90 inches in diameter. The novel feature of this antenna design is the matter in which it is stowed within the spacecraft in a relatively compact volume. *(see article commencing on page 46, and in particular, Figure 10 on page 48.)*

All four antenna poles are driven out in unison during extension by a single motor and gear train. The shorter poles are declutched from the drive when fully extended while the longer two continue to drive out. The rate of extension of each tube is 0.17 ft. per second.

Continued on page 63

Canadian Black-Brant rockets for space research

. . . . article describes a family of Canadian designed and built research rockets with special emphasis on the electronic and instrumentation aspects

by W. R. Bullock and A. W. Fia*

The Black Brant family

The world is recording the efforts of many to produce bigger, faster and more lethal means of airborne destruction so it is perhaps a refreshing change to consider some of the ways rockets and missiles make useful contributions to basic scientific knowledge. With the IGY program in the background and orbiting satellites and "men in space" well in the foreground, there is much of great interest to report in the field of research in the upper air.

We need to chart the upper air for a variety of reasons; to understand its structure better, to provide data for space and inter-planetary flight, and to learn how it influences our own earth, its weather, its magnetism and perhaps even its shape.

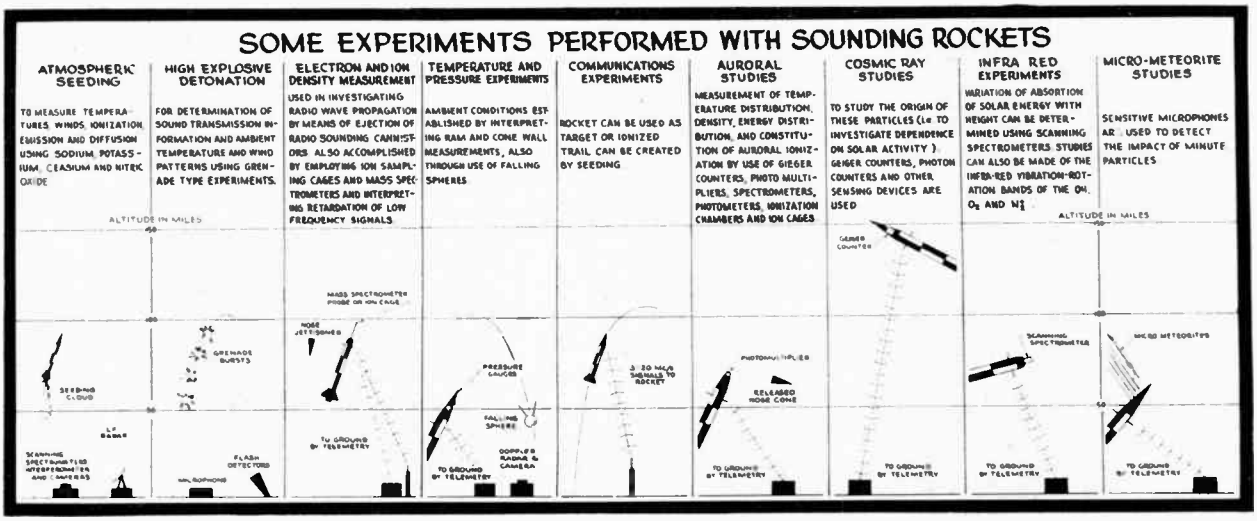
Increasing interest in space for both peaceful and military purposes is demanding greater investment and participation in research. Canada, with the magnetic pole lying within her boundary and the largest land mass directly under the auroral zone, is a natural laboratory for this research. It was for this reason that the United States installed a large launch complex at Ft. Churchill from which many United States and some Canadian rockets have been flown. It is for this reason also that many Canadian scientists have stated that Canada has a responsibility to the rest of the world to provide space data which can be more easily obtained from Canadian soil than from almost any other region.

The cost of launching satellites and men into space is very high indeed, but the cost of failure to do so is even higher, which is undoubtedly the reason that the two giants in the business today are leaders of two opposing ways of life. There is, however, a great deal to be learned about the region which can be successfully probed by the use of rockets. Scientists in Canada, the United States, and in certain European countries have indicated, that for them, the zone of interest extends from 100,000 feet to 5,000,000 feet (approximately, 1,000 miles) and that the less costly rocket would serve their needs better even than satellites.

Above the limits of balloons and through the "middle layer" of the ionosphere these "sounding rockets" can carry instruments to measure tempera-

*See page 36

Figure 1. A sampling of typical experiments carried out using the Black Brant III, IVa and V research rockets.



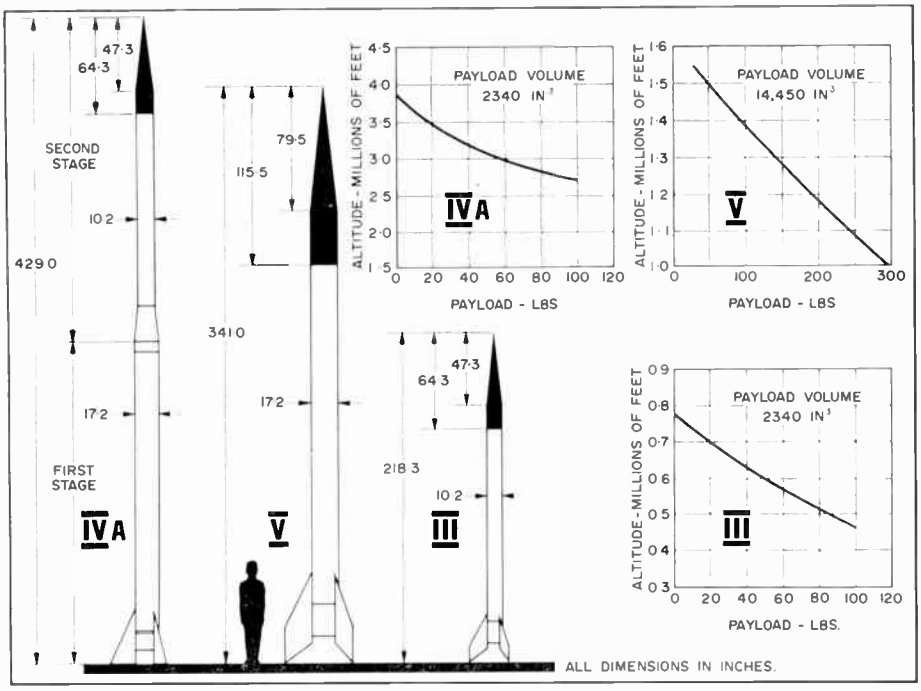


Figure 2. Three members of the Black-Brant family of rockets showing payload/altitude performance. Black area at the rocket nose shows the payload compartment.

ture, density, pressure, the character and composition of the ionized D, E, & F layers, solar activity, cosmic radiation, night air glow, dynamo currents, magnetic storms, the nature and extent of the aurora, the distribution of ozone and many more. A sampling of such experiments is shown in Figure 1.

The success of the CARDE propellant test vehicle, named the Black Brant I, suggested that Canadian sounding rockets could be designed and built to compete with any in the free world. The location and potential of the range at Churchill further indicated a sizeable long-term market for rockets if they could be made to meet the requirements of the researchers in terms of cost, payload and altitude.

It is clear that a wide choice of motor sizes, methods of launching, attitude control and staging is available to the rocket designer who wishes to meet the demands of the scientist. Any of the many combinations of these would result in a vehicle differing from others in cost, complexity, performance and reliability. The selection made by Bristol Aero-Industries Limited working with the Canadian Government can be clearly seen in the Black Brant III, Black Brant IV and the Black Brant V rockets. These are being designed and developed by Bristol Aero-Industries Limited under contract to the Department of Defense Production and in co-operation with the Canadian Armament Research Development Establishment who are supplying, not only the solid propellant fuel but technical assistance in the design and flight proving; the National Research Council who are assisting in the design of the instrumentation and providing user information; and the Defense Research Telecommunications Establishment whose input as users adds to the general utility of the final product.

Although there is a general requirement to cover the altitude from 100,000 feet (30 kilometers) to 5,000,000 feet (1500 kilometers), the main interest is in the region up to 3,500,000 feet (1000 kilometers). By accepting this limitation and using as a basis for design, the motor and propellant of Black Brant I, a small family of three high altitude rockets is being developed which can be used either singly or staged to blanket the desired zone.

► Black Brant III — A small rocket of 10" diameter, which could be instrumented easily by one establishment, capable of carrying 40 lbs. to 116 miles.

► Black Brant V — A single stage rocket of 17" diameter, to carry a heavier payload of 150 lbs. to at least 200 miles.

► Black Brant IV — A boosted rocket to carry a minimum of 25 lbs. to at least 600 miles.

Figure 2 shows this Black Brant Family coverage.

Black Brant III

Figure 2 also gives the general characteristics, configuration, and performance expected of the Black Brant III rocket.

Nose Cone — With average payload densities of 40 to 50 lbs. per cubic foot, a useful payload volume of 1½ cubic feet was selected for the Black Brant III. This would allow a minimum of 60 to 75 lbs. of payload to be carried.

The nose cone is divided into two major sections:

(1) A separate igniter compartment

(2) A pressurized instrument compartment.

In order to reduce the effect of aerodynamic heating which could result in a minimum nose cone skin temperature of 1400°F, a radiant shield is provided on the inner surface and an ablative of fiberglass on the nose cone outer skin. With this insulation, the maximum temperature in the instrument compartment due to all causes is expected to be confined to less than 165°F.

Performance — Although the original design aim was to provide a rocket which would carry 40 lbs. to 110 miles, recent material and propellant development indicates that the rocket will be capable of carrying this weight to 120 miles.

Black Brant V

Figure 2 shows the general characteristics, configuration and performance expected of the Black Brant V. This is a rocket with the external configuration of its engine identical to Black Brant I and Black Brant II. Therefore, motors may be interchangeable.

Nose Cone — Following the practice of Black Brant III, the igniter compartment is similarly separated from the instruments. The remainder of the nose cone is made in two parts.

(1) An aluminum parallel section which may be varied in length as desired from '0' to 28 inches.

(2) An ogive fairing of fiberglass.

The parallel section is made of metal to allow for

a more efficient ground plane for the antennas which will be mounted on this surface. The effect of the fiberglass ogive which will cover the bulk of the instrumentation is to reduce the temperature rise resulting from aerodynamic heating. The additional bulkhead separating the parallel and ogive sections will provide for instrument support and pressure sealing between compartments if desired.

Performance — The design aim was to produce a rocket to carry 150 lbs. to 200 miles. It is now considered that this will be exceeded and Black Brant V is expected to carry 150 lbs. to 240 miles.

Black Brant IV

The original concept of the Black Brant IV was the use of the Black Brant V as a boost vehicle for the Black Brant III. However, since the motor configuration of Black Brant I, II and V are identical, Black Brant IV will be designed in two phases, A and B. Black Brant IV-A will use a Black Brant I engine with simple fins as a booster for the Black Brant III. The configuration and performance is indicated in Figure 2. Black Brant IV-B may use the Black Brant V motor as a boost vehicle. Since the configurations are identical, boosters will be interchangeable.

In its two stage role, therefore, Black Brant III (with fins replaced by a conical stabilizer) will be attached to either the Black Brant I or the Black Brant V engine. Fins, to provide adequate stability will be added to the booster.

Instrumentation for Black Brant III Flight proving

Six Black Brant III rockets are scheduled to be flight proven at Wallops Island in May-June of this year, prior to making the vehicle available for general use.

The instrumentation used for these, falls naturally into two categories — telemetry and transducers, each with related equipment. As each must be tailored to meet the requirements of the other, many people dislike the classification. However, for purposes of this paper, the two will be discussed separately.

Because of the necessary complexity of the instrumentation, little detail will be given — rather, an overall view will be presented.

The telemetry system

The basic type of telemetry used is a 5 channel FM-FM system, with PAM time multiplexing (commutation) on one channel. The information capacity requirements for the dynamic firings are such that the full capability of the telemetry system will not be used. This implies that a simpler telemetry system would have been adequate. However, one of the objects of the dynamic firings is to flight prove various types of instrumentation which may assist people who wish to use the rocket in the future. The five channel FM-FM telemetry system is believed to be one which will be generally useful for upper atmosphere exploration with a rocket the size of Black Brant III, so is being used for the present firings.

The telemetry for the first two flights differs from that used for the last four firings in two respects:—

(1) Vacuum tube telemetry components are used

(2) Two transmission systems are used.

Vacuum tube components are being used for the first two firings because the 75 lb. payload allowance on those flights makes the weight penalty acceptable. In addition to this, the instrumentation team at BAIL has had previous experience with the type of components being used, and feels that they are very reliable. Naturally, the fact that they are considerably cheaper than their transistorized counterparts is an influencing factor also.

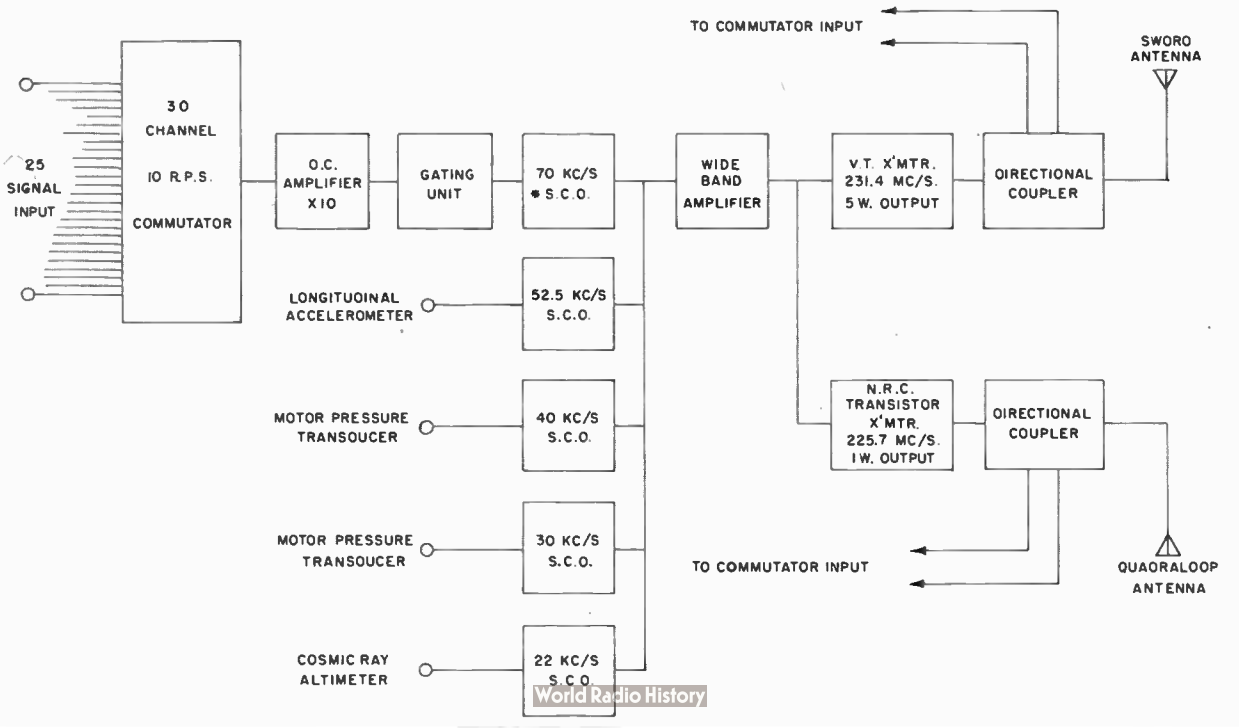
Two transmission systems are being used for three reasons:

- The redundancy makes the overall system more reliable,
- The payload allowance permits the extra installation,
- The transistorized transmitter and quadraloop antenna, which have been developed by N.R.C. for the Black Brant III rocket have never been flight proven.

The use of an extra transmission system permits in-flight monitoring of transmitter and antenna performance, and should provide reasons for failure, if it occurs.

In the last four firings, the payload allowance is 40 lbs. In general, it is desirable to have the majority of this available for instrumentation other than the telemetry systems, so the use of transistorized com-

Figure 3. Block diagram of telemetering system. System is flexible and can be arranged to suit special requirements.



ponents is mandatory to reduce telemetry weight and volume. It should be pointed out that the greatest savings effected are not in the components themselves, but by the reduced power and voltage requirements which permits the use of lower capacity batteries and removes the necessity for equipment to produce high voltages. Figure 3 shows a block diagram of the telemetry system for the first two firings. The only deviation from standard practice is the use of a DC amplifier between the commutator and the gating unit. The amplifier is required because some of the temperature gauges used cannot produce a 0 to 5 volt output as is required by the standard sub-carrier oscillators.

The positioning of the amplifier between the commutator and the gating unit eases drift stability requirements because two inputs on the commutator provide 0 volt and 0.5 volt signals which are used for calibration of that loop of the telemetry system. Thus, small drifts with time and temperature are permitted, provided they are not severe enough to cause the output of the 70 Kc/s sub-carrier oscillator to drift from its passband of 70 Kc/s $\pm 7\frac{1}{2}\%$.

The DC amplifier used is a transistorized unit, with an input impedance of ½ megohm $\pm 6\%$ over the operating temperature range of 25°C to 60°C. The zero drift at the output is less than 2% over the temperature range for all input conditions. The input operating point is stabilized so that the current available for feedback to transducers is less than 1 microamp for all operating conditions.

following nine parameters:

(1) Motor chamber pressure.
(2) Longitudinal acceleration (in the direction of flight).
(3) Lateral acceleration (in two perpendicular planes)
(4) Spin rate about the longitudinal axis
(5) Relative magnitude of lateral acceleration in the nose cone due to lateral displacement of the center of gravity of the rocket, and that due to rotational movement about the center of gravity. In general, these accelerations both occur simultaneously, so the lateral accelerometers must be separated longitudinally to give all the required information.
(6) Aerodynamic heating of the nose cone, motor wall, and fin surfaces.
(7) Payload compartment temperature.
(8) Performance of the newly developed transistorized transmitter and quadraloop antennas.
(9) Effectiveness of the nose cone pressure seal during flight.

The first six of the above measure the performance of the rocket during flight and are therefore, the most important. Consequently, they utilize most of the information capacity of the telemetry system because duplication is considered necessary to increase reliability.

The last three present information about the instrumentation environment and operation.

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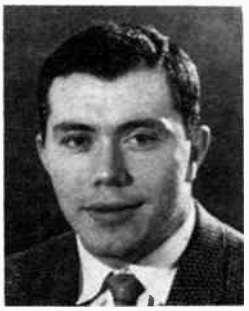
The Authors



Bullock

Fia

Transducers

Before transducers for flight can be selected, the parameters to be measured must be chosen.

As the firings are for the purpose of flight proving the rocket, the majority of the instrumentation must be used for measuring the performance during flight. In general, the parameters actually measured are in the areas where the design predictions are most uncertain, or where the results will be of particular interest to those who wish to use the rocket in the future.

As the information which may be collected and transmitted back to earth during flight is limited, a great deal of thought is necessary before deciding just what should be measured.

Factors such as ease of measurement, availability and cost of suitable transducers, usefulness of results, and complexity of support instrumentation all affect the decision as to whether or not a particular measurement should be made.

For Black Brant III, it was decided to measure the

In addition to the above mentioned flight objectives, several recently developed instruments will undergo flight proving. These include:

- A cosmic ray altimeter device.
- A magnetometer for measuring rocket roll rate.
- Several telemetry components, including the transistorized transmitter and quadraloop antennas developed by N.R.C.
- DC amplifiers for amplifying transducer outputs.

The above mentioned instruments are described in later sections.

The transducers selected follow directly from the types of measurements being made. For example, standard pressure transducers and accelerometers are used for (1), (2), (3) and (5).

The separation of accelerations in (5) is accomplished by using another set of lateral accelerometers located at a different point from the regular accelerometers with respect to the rocket center of gravity. Both will provide identical results in the case of a lateral

displacement of the rocket center of gravity, but will provide different results depending on their location in the case of rotation about the center of gravity.

As indicated above, the spin rate of the rocket is to be measured using a magnetometer which measures the movement of rocket with respect to the earth's magnetic field. This ought to be particularly effective at Wallops Island in the United States where the magnetic lines of force have a large component parallel to the earth's surface, which is in the correct direction for maximum sensitivity of the magnetometer. It should be noted that D.R.T.E. scientists have successfully measured rocket spin rate at Churchill using a magnetometer.

Black Brant III uses a motor which has a short burning time. Because of this, it must have high acceleration so that it can reach high altitudes. This means that aerodynamic heating effects are very severe, and a great many precautions must be taken to reduce their impact on structural strength and on instrumentation.

A considerable amount of uncertainty exists in the calculations of aerodynamic heating and its effects, so measurements of skin temperatures assume considerable importance.

For measuring the rise of skin temperature due to aerodynamic heating, platinum wire transducers are being used in most places. Where the maximum expected temperatures are low enough, thermistors are being used, in spite of their inherently long time constants. In places where very fast response times to high temperatures are required, thermocouples are being

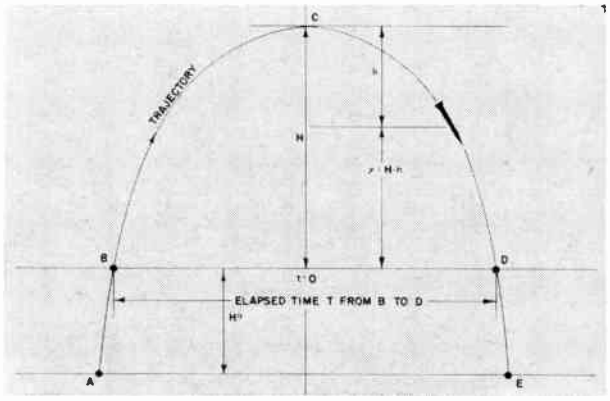


Figure 4. Diagram showing the computation of peak altitude.

installed to confirm the results from the platinum wire gauges. The difficulty in the use of thermocouples, and to a lesser extent platinum wire gauges is the limited output available even over large temperature ranges. The largest output from the platinum wire gauges that can be obtained without using excessive bias currents or resorting to bridge techniques is about 0.5 volts. This is the factor that necessitated a DC amplifier in the telemetry system. Thermocouples are even more restricted in output. A suitable metal wire thermocouple, such as copper-constantan will provide only a few millivolts at the maximum expected nose cone temperature of 1200°F. In the cases where thermocouples are used a chopper stabilized DC amplifier is utilized to bring the output up to the 0.5 volt maximum required by the commutator. The cold junctions are attached to a heat sink which is thermally isolated from the instrumentation compartment and which has its temperature monitored by a thermistor.

Special instrumentation

Roll Rate Magnetometer

The development of a magnetometer suitable for measuring rocket roll rate was undertaken for the following reasons:

- ► Gyros normally used for this function are comparatively expensive.
- ► Many scientists in Canada expressed the desire for a sensitive magnetometer suitable for measuring magnetic fields at high altitudes.

Consequently, an instrument capable of measuring rocket roll rate, which may be one part of an attitude determining system, and which is also capable of forming part of a system for measuring magnetic fields may prove to be a useful tool for many experimenters.

Normally, the sensitivity requirements for a magnetometer suitable for measuring roll rate and one suitable for measuring magnetic fields differ greatly. This is because the roll rate magnetometer must measure and present a full scale output for a field strength equal to twice the full value of the earth's field, and Q is the direction of look with respect to a north-south magnetic line. Cos Q may assume all values between ± 1, so that the magnetometer may see a change in field proportional to $2H_E$), whereas the magnetometer used for measuring the earth's field normally measures only the change in field with respect to a fixed level, thus permitting much greater resolution, and requiring greater sensitivity.

The BAIL rollrate magnetometer uses a saturable core type of head, operating on the second-harmonic principle. This basic type of magnetometer can be made sensitive to changes in magnetic field strength of 1 or 2 gammas, with proper feed back techniques. Use of this magnetometer in a rocket is complicated by the motion of the vehicle, so that special feedback systems must be used if high resolution measurements are to be made.

As the present, techniques to make the instrument suitable for magnetic field measurements have not been perfected, and the effort to date has been to produce a magnetometer of the same basic type but with reduced sensitivity so that it is adequate for roll rate measurements.

One of these magnetometers will be used on each of the first six firings.

Cosmic Ray Altimeter

There is a need for an inexpensive, medium accuracy altimeter device which can present altitude information through the telemetry system of a rocket, independent of radar tracking, in cases where precise altitude information is not required.

One method that may be employed for determining altitude is to measure the length of time that is required for the rocket to fall from maximum altitude to some known lower altitude, as long as this reference level is above regions of appreciable drag — that is, above 20 km.

One way to measure the time elapsed is to choose an altitude in the upper atmosphere where a unique upper atmospheric event occurs. Then the time that elapses between passing this altitude on the way up and again on the way back down may be measured, and used to determine the altitude as a function of time.

Figure 4 represents the geometry.

The equation of motion is given by

$$g = \frac{d^2h}{dt^2}$$

where $h = H - y$

So:

$$g = \frac{-d^2y}{dt^2} \qquad (1)$$

The force of gravity is not a constant over the

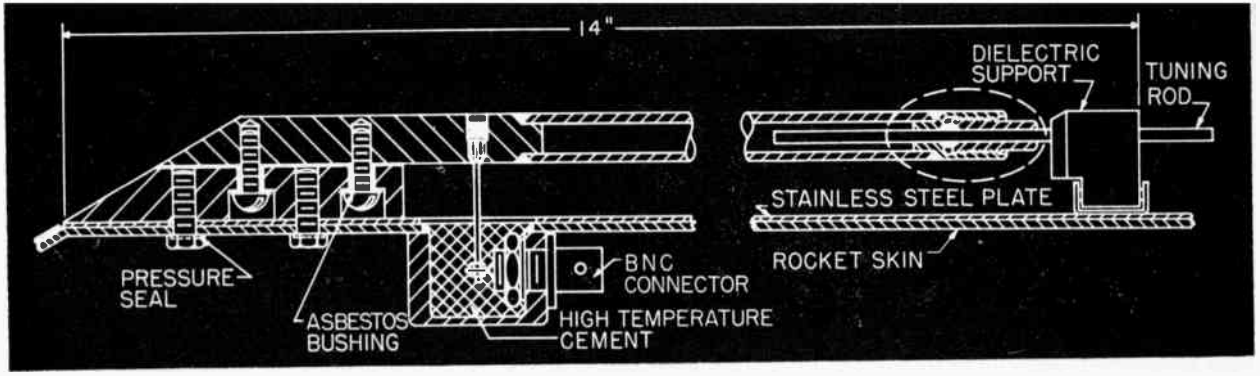


Figure 5. Diagram of the NRC designed rocket antenna.

altitude regions in question, but it does vary linearly, so g may be replaced by:

$$g = g_o - m\,(H_o + y) \quad (2)$$

where g_o is the force of gravity at the launch site, and m is the change in g with altitude in $\frac{\text{ft./sec.}^2}{\text{km}}$

Substitution into (1) yields:

$$\frac{d^2y}{dt^2} - my = mH_o - g_o$$

which has a solution:

$$y(t) = H \operatorname{Cosh} m\,t + \frac{(H_o - g_o)}{m}(\operatorname{Cosh} m\,t - 1) \quad (3)$$

The maximum altitude $Z = H + H_o$ may be found by substituting

$$y = 0 \text{ at } t = T/2$$

This yields:

$$Z = \frac{\frac{g_o}{m} - \frac{g_o}{m} - H_o}{\operatorname{Cosh} \frac{m}{2} T} \quad (4)$$

Substituting (4) into (3) in the form

$H = Z - H_o$ permits the calculation of altitude as a function of time from peak altitude. The only requirements are to know H_o and to measure T.

H_o may be found in a number of ways. Several suitable layers are available in the upper atmosphere, one of which is the cosmic ray Pfotzer maximum, which occurs at an altitude of about 20 km. This is particularly attractive, because it involves the measurement of the concentration of particles with sufficient energy to penetrate the nose cone, thus permitting the use of a geiger tube counter located in the instrument compartment without having the necessity of looking through a window. In the altimeter developed at BAIL, five geiger tubes are used, all operating in parallel so as to increase the effective area and produce a sufficiently high counting rate to give good resolution of the height H_o.

The accuracy of altitude determination depends on the knowledge of the height and stability of the reference layer. It is hoped that results correct to ±1 or 2 km can be achieved using the Pfotzer maximum, which has been determined from previous rocket measurements. The results are expected to be more accurate in cases where the rocket can be radar tracked up to H_o.

**The authors are indebted to the Rocket Instrumentation Group of N.R.C. under the supervision of Mr. W. L. Haney for the following report on the work which they have undertaken on behalf of the Black Brant Rocket Program.*

Introduction

NRC telemetering components

The Radio and Electrical Engineering Division of the National Research Council has undertaken, in co-operation with the Black Brant III technical steering committee, to design certain of the telemetry components. These included an antenna, a solid state transmitter and the associated power dividing and phasing networks connecting one to the other. Later the inclusion of a second transmitter and antenna system called for the provision of a facility for cross monitoring of telemetry performance.

Quadraloop antenna

Since there was considerable doubt as to the ability of the blade antennas as used in Black Brant II to withstand higher temperatures and larger mechanical forces encountered on the Black Brant III rocket, a new telemetry antenna was designed. An antenna with frontal area less than one square inch with a suitable radiation pattern and capable of handling five watts was desired. The antenna had to be insensitive to aerodynamic heating, mechanical forces and the partial removal of the ablative coating on the rocket.

The antenna system consists of two L-transmission line antennas mounted on opposite sides of the rocket and fed 180° out-of-phase. A λ/2 difference in the length of the feed cables provides the phase shift.

The antenna configuration is shown in Figure 5. The length of the radiator determines the frequency at which the reactance of the input impedance is zero while the distance of the feed point from the grounded end determines the resistive component. A thicker radiator gives a broader bandwidth but conflicts with the low drag. A narrow bandwidth was accepted in exchange for easy tuning. Radiation patterns were checked on a model rocket and indicated uniform coverage, ±2 db, in 60° cones fore and aft with two very narrow nulls in the radial direction.

The power handling capacity of the antenna, with a negative DC bias voltage, is about 2½ watts. The weight is less than two pounds.

The materials selected are believed to be capable of withstanding the severe aerodynamic heating expected on a Black Brant III flight and differ markedly from those used in antennas operating in more favorable environment.

Transistor telemetry transmitter

A telemetry transmitter must, from the nature of its use, be made as reliable as possible taking into account the environment in which it is to operate and at the same time be small in size and have a high efficiency.

Most solid state UHF transmitters use a crystal controlled oscillator at a frequency below 130 mc/s followed by a chain of amplifiers and multipliers. The number of stages is governed by considerations of power output, reliability and efficiency.

Continued on page 87

The role of the Defense Research Board in space-oriented research – a survey

(abstracted from a report prepared by DRB Headquarters)

by C. A. Pope *(DRB Public Relations Officer)*

Because of the association of many space problems with defense systems, it is necessary for the Board to maintain competence in space fields so that it can fulfill its advisory role to the Minister of National Defense and to the Armed Forces.

Typical items of space-oriented research current in DRB laboratories are investigations relating to re-entry physics, communications and the biosciences.

Research aimed at detecting missiles during their launch and mid-course phases is in progress in the U.S.A. The DRB's efforts are concentrated on contributing to the detection of high-velocity objects re-entering the earth's atmosphere.

Canada's defense scientists are seeking specific knowledge about the re-entry reactions which take place in the atmosphere by obtaining measurements of atmospheric electro-magnetic and physico-chemical disturbances.

A number of aerophysics and aerodynamics test facilities at the Canadian Armament Research and Development Establishment (CARDE), Valcartier, permit scale models of a wide size-range to be launched into free flight hypersonic firing ranges.

These re-entry phenomena studies include measurements of the chemical constitutents of the upper atmosphere and the background radiation in which or through which detection sytems must operate.

Some measurements are needed at altitudes higher than those which can be achieved by employing aircraft or balloons. Because of this requirement the Board has developed high-altitude rockets capable of carrying instrumented packages to the desired heights. These research rockets, called Black Brant 2s, are a further development of rocket vehicles designed at CARDE for testing the performance of new or improved solid propellant engines. The Black Brant 2 is suitable also for the upper atmosphere research programs of the National Research Council, Canadian universities and for the research needs of some U.S. agencies.

The presence of the visible auroral belt, stretching from the Alaska border Churchill to the northern tip of Labrador, makes Canada unique insofar as auroral effects are concerned. Because the visible aurora is a manifestation of disturbed conditions in the upper atmosphere, it has followed that Canadian research, and particularly that of the Defense Research Telecommunications Establishment (DRTE), of Ottawa, has concentrated mainly on the atmosphere regions affected.

In addition, DRTE scientists have established experimental communications links employing ionospheric scatter and meteor burst techniques and the Board's 80-foot diameter research radar at Prince Albert has played an important role in conducting direct auroral echo studies. Both of these programs relate directly to the Board's communications research.

More recently, ground-based investigations have been augmented by a research rocket program designed to obtain high-altitude measurements of the composition of the upper atmosphere and of the absorption of radio waves in the ionosphere.

The DRB Topside Sounder satellite, entirely designed and built in Canada and which will probe the upper side of the ionosphere, will be launched at the Pacific Missile Range in California in a co-operative program with the U.S. National Aeronautics and Space Administration (NASA).

Many defense research projects in the biosciences suggest potential applications toward the solution of space problems. Studies relating to man's responses to his environment and the search for improved methods of keeping him alert and efficient appear to be particularly promising.

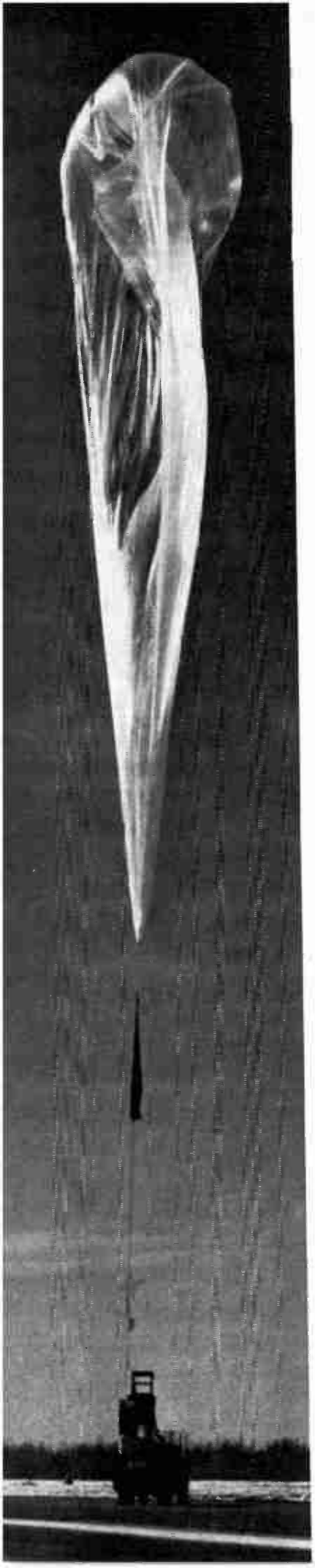
Studies on vigilance, perception, changes in blood circulation and respiration as affected by variations in posture, and the assessment of errors made in critical tasks are all examples of research with potential significance to space as well as to terrestrial environments.

Typical of this twofold application are the motion sickness and disorientation studies which have been in progress for many years at the Defense Research Medical Laboratories (DRML), in Toronto.

The obvious implications for space travel in this research was recognized early in the program. A working partnership has resulted between DRML and the USN School of Aviation Medicine at Pensacola which is involved in Project Mercury studies.

DRB scientists feel that continuing importance will be attached to research related to the defense of North America and particularly, to those problems associated with the Arctic. It appears to be essential therefore, that as Canadians continue investigating the upper atmosphere relevant to communications and to ballistic missile detection, contributions in techniques and component development allied with the employment of satellites and research rockets will continue.

Further research on the disturbed upper atmosphere by means of ground-based and rocket-borne equipment is expected as well as the employment of scientific data obtained from the Topside Sounder satellite for related studies. Meteorological and communications satellites are of world-wide interest to scientists and Canadian research may move into these fields. ●



Upper atmosphere and near-space research at CARDE

by G. B. Spindler and A. Laflamme *(See page 42)*

Introduction

Upper atmospheric research at CARDE is centered upon the measurement of the absorption and emission of electromagnetic radiation by the atmosphere, the measurements ultimately yielding information on atmospheric chemistry, physics, constituent photo-activity, and constituent concentrations. In past investigations the visible and infrared regions of the spectrum have been of greatest interest; work now in progress on microwave systems will however extend the spectrometric coverage to millimeter wavelengths.

Virtually all measurements are carried out in situ with instruments that are inaccessible during the measurement period, and consequently the success of the experiment depends upon the successful operation of generally complex measurement, control, data recording, and data transmission instrumentation. It can be appreciated that the task of the electrical, mechanical and optical designer is seldom simple; when the limitations imposed by restricted vehicle payload capacities and the often severe vehicle and ambient environments are considered, it is clear that the designers' basic problems are compounded.

The altitude at which an experiment is to be carried out determines the type of vehicle required and obviously has a bearing on the design of the necessary instrumentation. For reaching altitudes up to 40,000 ft., aircraft are used, payload capacity is typically 1000 lbs., and flight duration about two hours. Up to 100,000 ft. balloons with a payload capacity of 650 lbs. and a flight duration of four hours are employed. Rockets with a payload capacity of 100 - 400 lbs. and a flight duration of 5-10 minutes can reach altitudes of half to one million feet (100 - 200 miles).

The first aircraft measurements were carried out by CARDE four years ago, with the purpose of determining the concentrations of some atmospheric trace species (H_2O, CO_2, CH_4, O_3, N_2O) by means of recording solar spectra. A spectrometer and a servo-optical device for maintaining an image of the sun on the entrance slit of the spectrometer

Figure 1. RCAF CF-100 aircraft with instrumented tip-tank being prepared for

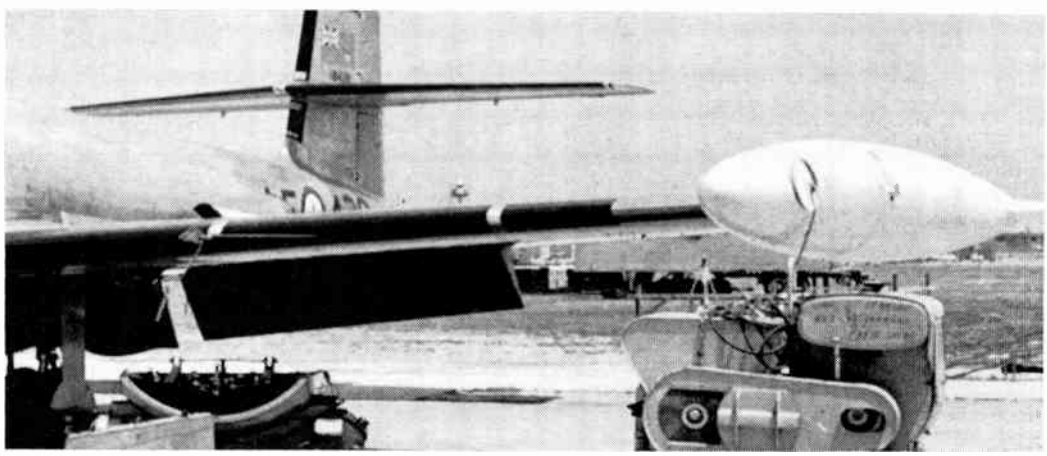
Figure 2. High-altitude balloon at lift-off, Quebec. Balloon is made from 40 micron polyethylene and expands to about 130 feet diameter at altitude. Instrumented gondola is recovered by parachute.

. . . . article describes the instrumentation and techniques applied by scientists of The Canadian Armament Research and Development Establishment in their research program dealing with the upper atmosphere and the near reaches of space.

were mounted in a wing tip-tank of a CF-100 aircraft supplied and operated by RCAF as shown in Figure 1. These measurements continue, and are being carried out at altitudes from arctic to equatorial regions.

The program of atmospheric investigation using balloons, illustrated in Figure 2 as instrument platforms began in 1958 and is continuing. Several gondolas have been built and flown; for example, one consisting of a scanning spectrometer has been flown some dozen times using various infrared detectors to examine radiation emitted sponstaneously by active atmospheric constituents; another gondola has been built in conjunction with the University of Toronto to serve a similar purpose, but uses a Michelson interferometer in place of a dispersive-element spectrometer to improve sensitivity. Still other gondolas have been built and flown by CARDE, or by CARDE in conjunction with the University of Saskatchewan, and are instrumented with spectrometers to study airglow phenomena[1] or radiometers to measure integrated radiation backgrounds (Figure 4). A gondola consisting of a sunseeker — spectrometer pair similar to that used in the aircraft has been built to extend solar spectral measurements to almost 100,000 ft. altitude. In about a year's time, atmospheric trace constituent concentrations will be determined by measurements in the millimeter-wavelength region using a microwave spectrometer now under development.

The use of rocket platforms began during the IGY with the construction of two nose cones, shown in the photograph, Figure 5 designed to measure the altitude profiles of emission from atmospheric OH and sodium. The two nose cones were fitted to Nike-Cajun rockets supplied by a U.S. agency and launched from the range at Fort Churchill in late 1958. A new rocket was made available subsequent to the successful development and flight firings (1959) by this Establishment of a propellant test vehicle in the form of the Black Brant I sounding



flight. Airborne experiments reveal composition of upper atmosphere.

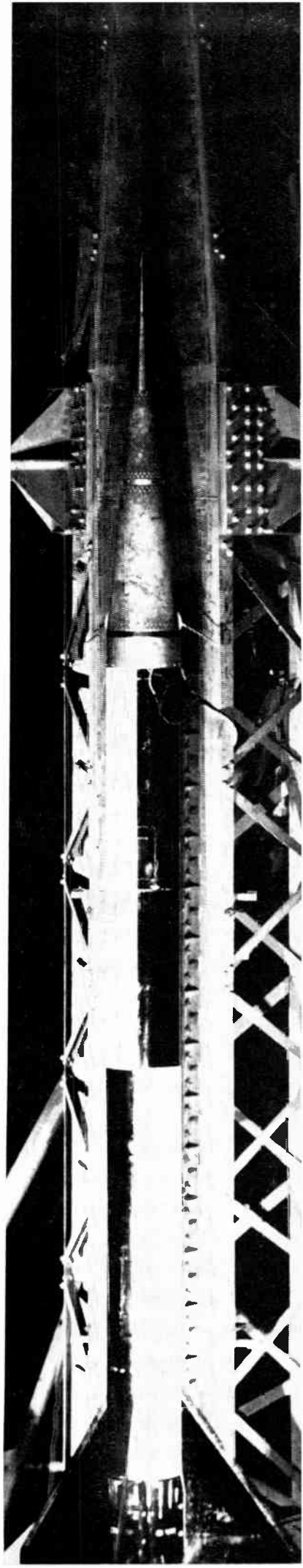


Figure 3. Black-Brant I rocket with seeding nose-cone on launcher at Fort Churchill, Manitoba. Motor produces a thrust approaching 25,000 lbs. for 20 seconds giving 20g acceleration to rocket. Motor was designed and developed at CARDE.

Figure 4. (left) Balloon being filled with helium. Radiometer instrumented gondola is mounted on the launching deck of truck.

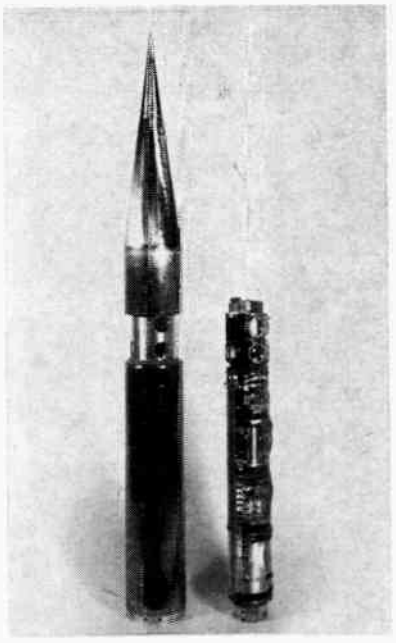


Figure 5. (right) Nose cone structure and instrumented package for Nike-Cajun IGY firings. Package includes two photometers, four radiometers, amplifiers, power supplies, gyro, telemetry and tracking beacon.

rocket, shown in Figure 3, two of which were used to carry a "chemical seed" to the release altitude of 100 km. (approx. 63 miles) (1960). The experiment has been described elsewhere[2]. Briefly, it had as one of its primary objectives the determination of radiation effects associated with the reaction of the seed gas and the atmosphere. This experimental program is continuing with the current preparation of additional nose cones, shown diagramatically in Figure 6.

Concurrently, investigations are being carried out in the laboratory to support atmospheric field measurements. The first laboratory support work was carried out five years ago[3], and taken up again (1961) on a somewhat larger scale to investigate the radiation and recombination processes that occur when a gas is excited or dissociated by RF discharge and mixed with a second gas in a hypersonic nozzle.

Aircraft tests — solar spectra

Solar spectra provide basically a plot of the irradiance of the emitting source (the sun) as a function of wavelength, the irradiance curve being modified by the band absorption of atmospheric trace constituents such as water vapor, carbon dioxide and ozone. The wavelength at which the absorption bands occur are a characteristic, and generally known, function of the absorber, and the extent of absorption a function of the amount of absorber source and spectrometer; thus spectra taken at various altitudes permit an identification of the constituents, and a determination of their concentration and altitude profiles. The instrumentation necessary for taking spectra are mounted in the wing tip tank of a CF-100 aircraft, as shown in Figure 7.

Solar radiation is focussed by a lens mounted in the skin of the tip tank onto the entrance slit of a spectrometer in which it is chopped by a rotating disk and dispersed by a lithium fluoride prism. To compensate for aircraft angular movements and obtain uninterrupted spectra, a sunseeker is used to maintain the solar flux on the slit within tolerable limits. It consists of a mirror gimballed about two axes, servo amplifiers and motors to position the mirror, and a selenium cell array to produce an error signal whenever the radiation beam is displaced from a predetermined position. A cryostat using nitrogen at 2200 psi and consisting of a compressor, a regulator and a cooling head, keeps the lead-telluride photo-conductive cell mounted at the exit slit of the spectrometer at liquid nitrogen temperature. The signal from the detector is amplified, demodulated, and fed to an oscillograph recorder mounted in the armament bay of the aircraft.

A number of other measurements have to be recorded simultaneously to permit interpretation of the spectrometer signal. These include environmental conditions such as outside air temperature and pressure, temperature and relative humidity inside the pod; aircraft motion parameters such as pitch rate, roll rate, heading, latitude and longitude, and monitors on the operation of the equipment including gimbal position angles, error signals and power supply voltages.

Various other detection systems are presently being flown, some with recording capacity requirements exceeding the capabilities of ordinary paper recorders, because of either the high number of channels to be accommodated or the frequency response required. In these cases, time-multiplexing, frequency-multiplexing, or a combination of both techniques are used in conjunction with magnetic tape techniques to cope with the amount of data to be collected.

All this instrumentation must meet aircraft safety standards and be capable of operating over a wide range of environmental conditions; in this respect, special attention must be given to the tip tank-mounted packages, since vibration, temperature changes and humidity variations are particularly severe. Because some measurement programs must be carried out in tropical zones, precautions also have to be taken against corrosion and fungus growth.

Balloon-borne tests — airglow spectrometer

Some chemical reactions occurring in the atmosphere are photo-emissive; a spectral study of the emissions can yield information on the responsible

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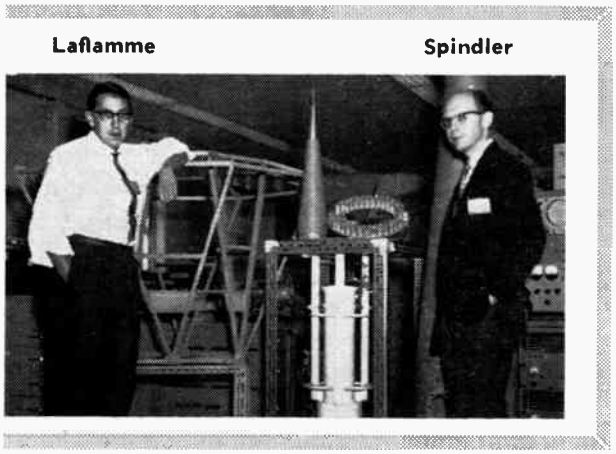
reactions, concentrations of the reactants, and so on. The gondola instrumentation described below was designed to study these airglow phenomena.

Figure 8, shows the optical layout of the spectrometer. Radiation from the source (day or night sky) is reflected through the entrance slit by a three-bladed mirror chopper onto the collimator. After being dispersed by the grating, the radiation is collected by the camera mirror and focussed in the plane of the exit slit. A field lens forms an image of the camera mirror on the detector. When the chopper blade is *not* in front of the slit, the spectrometer sees radiation reflected by the reference mirror from the low-temperature source.

The chopper disk is made of Perspex aluminized on one side and is 25 cm in diameter and 6 mm thick. It is driven at 1600 rpm by an induction motor, thus chopping the radiation at 80 cps. The grating is driven by a synchronous motor through a gear train which provides a scan in wavelength from 2 to 10 microns in four minutes; a latching relay operated by limit switches reverses the direction of rotation of the motor at each limit of the scan. Two continuous rotation potentiometers incorporated into the gear train provide a grating angular position signal for the telemetry.

The sensitivity of the detector is greatly dependent upon its temperature. If a usable signal from such a



low level source of radiation as the night airglow is to be obtained, the detector must be cooled to liquid oxygen temperature. A dewar flask is used to carry enough coolant to last for six hours. With the dewar left open to the atmosphere, the decrease in ambient pressure as the balloon ascends is reflected in a decrease of the boiling point of the coolant and the added sensitivity thus obtained is utilized when qualitative results will suffice. When quantitative measurements are the prime objective, some sensitivity is sacrificed in favor of a more constant performance by venting the dewar through a pressure regulator. The low temperature source used as a reference is also a dewar flask blackened inside and filled with liquid oxygen.

The detector output has to be amplified by a factor of about half a million before it is of a sufficient level to be fed to telemetry. To reduce the power drain and hence the weight of the power supply, a transistorized amplifier has been designed which consists of six identical stages in series, each stage being stabilized by negative feedback to obtain a gain figure practically constant over the range of temperatures at which the amplifier operates. The amplitude of the signal also varies over wide limits from one part of the spectrum to another. In order to obtain a complete coverage, the last four stages are each connected to a synchronous demodulator, the latter feeding four separate telemetry channels, providing a dynamic range of 20,000 to 1 without the use of special encoding equipment. The slight increase in work required to interpret the records is well compensated by the reliability resulting from a much simpler airborne installation.

The reference wave necessary to operate the phase sensitive demodulators is derived from a lead sulphide detector mounted near the edge of the chopper and opposite a small light bulb. The signal thus obtained is amplified to the required level and fed to the demodulators. It is also applied to a frequency sensitive circuit whose output is telemetered as a chopper speed monitor.

The telemetry package is made up of commercially available units. It is a PDM-FM system, providing thirty information channels each sampled thirty times per second; the frequency response of each channel is thus about 5 cps. The transmitter frequency is 226.5 megacycles and the radiated power 4 watts. This equipment contains a DC motor, a high speed commutator and circuits, such as the transmitter, where voltages as high as 250 volts are used. As the efficiency is rather low and a large portion of the supplied power has to be dissipated in the form of heat and since the equipment must operate for hours in a rarified atmosphere there is a definite danger of arcing in some of the units and of overheating because of the reduced convection. These problems are solved by using an airtight container

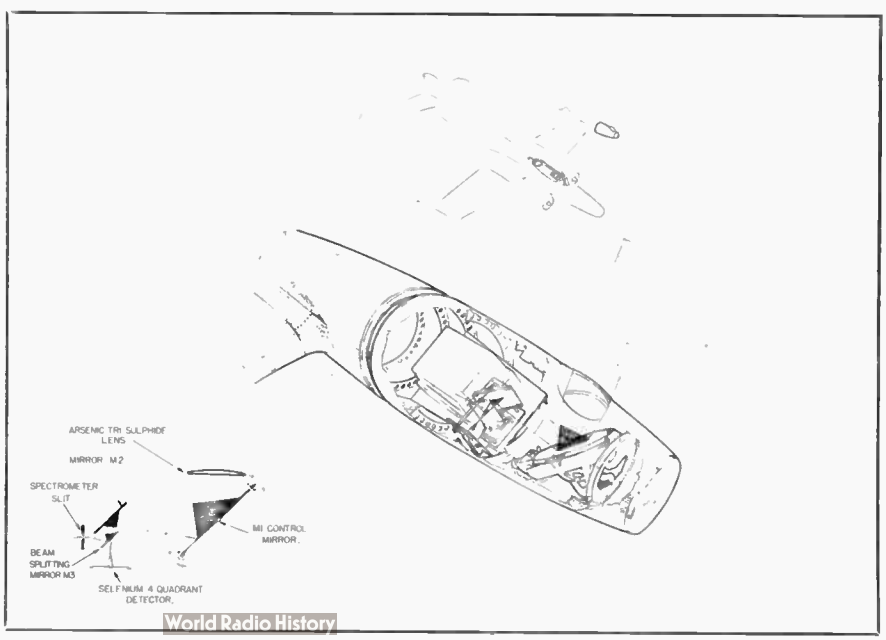


Figure 7. Diagram showing arrangement of sun-seeker equipment for keeping sun's image on slit of spectrometer. (Diagram courtesy De Havilland Aircraft of Canada.)

sealed at atmospheric pressure before launch. A small fan is included to circulate the air inside the container to equalize the temperature of the components and to obtain a better transfer of heat from the units to the case. Since at 30 km altitude the convection is reduced by about 90 per cent, the radiation from and onto the

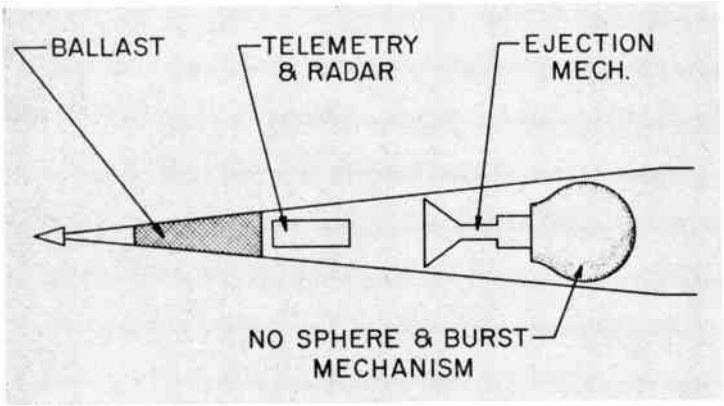


Figure 6. Layout of Nitric Oxide (NO) seeding nose-cone.

container is not negligible. This is especially true when the flight takes place during the day; it then becomes important to paint the container white to minimize the input of heat from solar radiation.

The antenna is a two-element turnstile hung under the gondola. Designed at CARDE[4], it possesses a radiation pattern which is circular in azimuth and a flattened cardioid in elevation. The special elevation pattern stems from the desirability of decreasing the radiation upwards and producing maximum antenna gain in the direction of greatest range (for a depression angle of a few degrees) while retaining some radiation straight below to allow for the possibility of the balloon passing directly over the receiving station.

The power supply consists of 20 silver peroxide-zinc cells capable of supplying 28 volts to the 6 ampere load for 6 hours. These were chosen because they occupy only half the volume and are four times lighter than equivalent lead-acid batteries, and provide excellent inherent regulation. Since the efficiency of batteries decreases as the temperature is reduced, the aluminum container is lined with styrofoam. The heat generated when the batteries are under load is sufficient to keep their temperature above the freezing point.

The telemetry units contain their own converter and regulators and are fed directly from the batteries. A transistorized inverter produces the 115v 60 cps for the chopper and the grating motors. Regulators and converters are used to produce the various other voltages required by the amplifier.

The gondola also contains the following units:

- Two magnetometers mounted at right angles in a horizontal plane to indicate the azimuth look-angle of the spectrometer.
- Automatic cut-down circuits and red flashing light to comply with DOT regulations.
- Radar beacon to permit tracking of the balloon.
- Command receiver to terminate the flight when desired.

The total weight of the gondola is about 450 lbs. A 40-meter balloon (Figure 2) lifts this load at an ascent rate of 15 ft/sec to an altitude of 30 km. The gondola is released on command and descends at 25 ft/sec on a 30 ft. diameter parachute.

One other environmental condition which applies to the whole gondola is that it should be capable of surviving recovery by parachute. The landing shocks are rather difficult to predict since the gondola could be dragged on the ground by the parachute, fall into water or be caught on the branches of trees by the parachute lines. For this reason, enough styrofoam is attached to the sides and to the bottom of the gondola to keep it afloat, where it also serves as padding to absorb part of the shock on landing. It is interesting to note here that the particular gondola described has been flown a number of times and that no dewars or optical elements have been broken. In some cases, it was not even necessary to realign the optics.

Rocket-borne tests — seeding nose cones

In this experiment, unlike the IGY rocket experiment, the great bulk of the data-producing instrumentation is ground-based, the function of the nose cone instrumentation being limited to ensuring release of the seed gas at the appropriate altitude, to monitor by telemetry the various operations involved in the release sequence, to monitor certain vehicle performance parameters, and to provide trajectory data. Since a discussion of the ground instrumentation falls outside the scope of this paper, it will be mentioned only briefly here. Further information is given in reference (2).

The object of the experiment is to study the photoreaction between the nitric oxide (NO) seed and ambient atomic oxygen, and to infer the concentration of the latter from the radiation emitted by the reaction. Nitric oxide reacts with ground-state atomic oxygen to

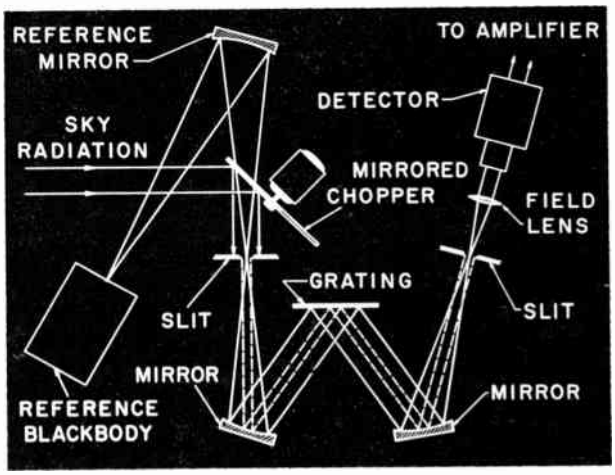


Figure 8. Arrangement of spectrometer for airglow experiments.

produce excited nitrogen dioxide:

$$NO + O \longrightarrow NO_2^*$$

The excited NO_2 then decays spontaneously to a lower energy level by emitting radiation, the latter forming a continuum extending across the visible spectrum and into the near infrared:

$$NO_2^* \longrightarrow NO_2 + h\nu$$

The appearance of the light emitted from the seed-atmosphere reaction zone is not unlike that of an aurora (although quite different in origin), producing a luminous 'cloud'.

Since the concentration of atomic oxygen is expected to peak at about 300,000 ft., that altitude is chosen as the release point. Because it is desirable to avoid pre-contamination of the atmosphere in the neighborhood of the release point by rocket exhaust gases and gases associated with the nose cone, it is necessary first to separate the cone from motor so that each assumes a different trajectory, then to eject the nitrous

oxide (NO) container from the cone, in order that the cone and container are well separated at the time of gas release. The flight profile for the experiment is given in Figure 9. To ensure that the gas is released from the container almost instantaneously rather than trailed out, it is maintained under pressure in a relatively brittle steel sphere which contains a disruption mechanism capable of shattering the sphere in about one millisecond. The gas is thus released from a 'point' to expand essentially in a spherical manner to a visible maximum diameter of many hundreds of feet.

As shown in the layout diagram, Figure 6, the nose cone consists of the following items, reading aft from the tip of the cone:

- Aerohead transducer
- Lead ballast
- Telemetering gear
- Radar beacon
- Power supplies (not shown)
- NO gas container and ejection mechanism
- A series of flashbulbs (not shown)
- Radar and telemetry antennas (not shown)
- Separation mechanism (not shown)

The aerohead transducer is a small cone gimballed with two degrees of freedom mounted on the tip of the nose cone (Figure 3) and maintains a pointing direction parallel to the trajectory while the vehicle is sensibly within the atmosphere; it thus provides a measure of vehicle pitch and yaw attitudes relative to the trajectory.

Approximately one hundred pounds of lead ballast is carried in the forward portion of the cone to keep the center of gravity of the cone/vehicle combination safely forward of the center of pressure (arrow-type stabilization) throughout trans- and supersonic velocity regimes and to stabilize the cone itself during separated flight.

The telemetry is a 28-channel PWM/FM unit which radiates at 226.6 mc through three blade antennas mounted 120° apart just forward of the cone-cylinder separation plane (Figure 3). The output of transducers monitoring, for example, pitch/yaw, NO gas temperature and pressure, motor pressure, and the separation-ejection sequence are applied to separate channels. Each channel is sampled thirty times per second by the commutator, giving a frequency response of about 5 cps/channel. If a telemetered function requires a higher frequency response, channels are paralleled.

To provide a real-time plot of trajectory, a CARDE-built transistorized radar beacon is included in the nose cone. The beacon is keyed to radiate when it receives a signal from a ground-based 10-cm radar, thus returning to the radar a much larger amplitude signal than would have been returned from skin reflection alone. The beacon radiates though two antennas mounted 180° apart on the nose cone skin. The position of the vehicle is displayed in real time on two automatic plot boards, one giving altitude as a function of north-south displacement from the launcher, the other altitude as a function of east-west displacement.

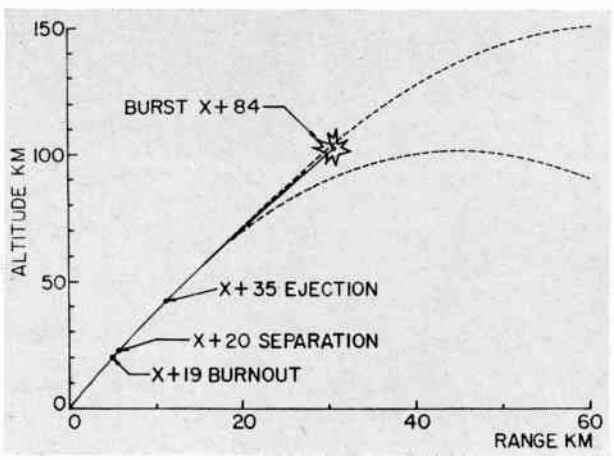
The NO container is a spherical steel bottle of 35-cm diameter machined from a solid billet and contains 15½ lbs. of NO under pressure of 250 atmospheres. The container is ejected from the nose cone by compressed air at a separation velocity of 6 ft/sec, and is disrupted by an internal squib-driven steel spike.

The flashbulbs are included to give the ground instrumentation operators some means of tracking the nose cone wtih the instrument heads, so that the gas release point is within the fields of view of the relatively narrow-field instruments before gas release, thus ensuring that transient phenomena occurring during the first few seconds of the 15-minute life of the NO cloud are recorded. Since the angular separation between cone and sphere at burst is small compared to the smallest instrument half-field, a negligible error is incurred by tracking the cone rather that the sphere. The use of flashbulbs for tracking rockets has been described in the open literature[5].

The separation mechanism consists of two semi-circular clamps holding the nose cone to the short nose cylinder. The clamps are held in position by two explosive bolts, and in turn hold retracted two drag doors hinged to the nose cylinder, which on release of the clamps fold outward to increase the drag of the motor, and hence increase the rate at which cone and motor separate.

The extent of the ground instrumentation coverage justifies very much more than a single paragraph in its description, but the scope of this paper does not, unfortunately, permit a lengthier treatment. Instrumentation coverage was extensive, comprising spectrometers, photometers, cameras, radiometers, RF ionosonde, 600-cm auroral radar, RF radiosonde, 10- and 70-cm tracking radars, and acoustical ranging networks. A great deal of the instrumentation, especially the non-optical equipment, was supplied and operated by agencies outside CARDE. Their contributions are gratefully acknowledged.

Figure 9. Programmed seeding vehicle trajectory. Numbers refer to time in seconds after launch.



References

1. J. F. Noxon and A. Vallance Jones "A Balloon-borne Spectrometer for Study of the Airglow Beyond Two Microns" Can. Jour. Physics, 39, 8, p. 1120 Aug. 1961.
2. G. B. Spindler "Techniques and Instrumentation involved in a D-region Chemical Seeding Experiment" Manuscript submitted for publication in Can. Aeronaut. Jour.
3. D. Cohen, R. Lowe, J. Hampson "Infrared Emission from High-Frequency Discharges in CO_2" Jour. App. Physics. 28, 6, p. 737, June 1957.
4. A. Dion "Design of a Turnstile VHF Antenna Having Unusual Pattern Requirements" CARDE Technical Memorandum 217/58.
5. G. B. Spindler "The Visibility of Flashbulbs and Their Application to Rocket Tracking" to be published in Applied Optics, March 1962.

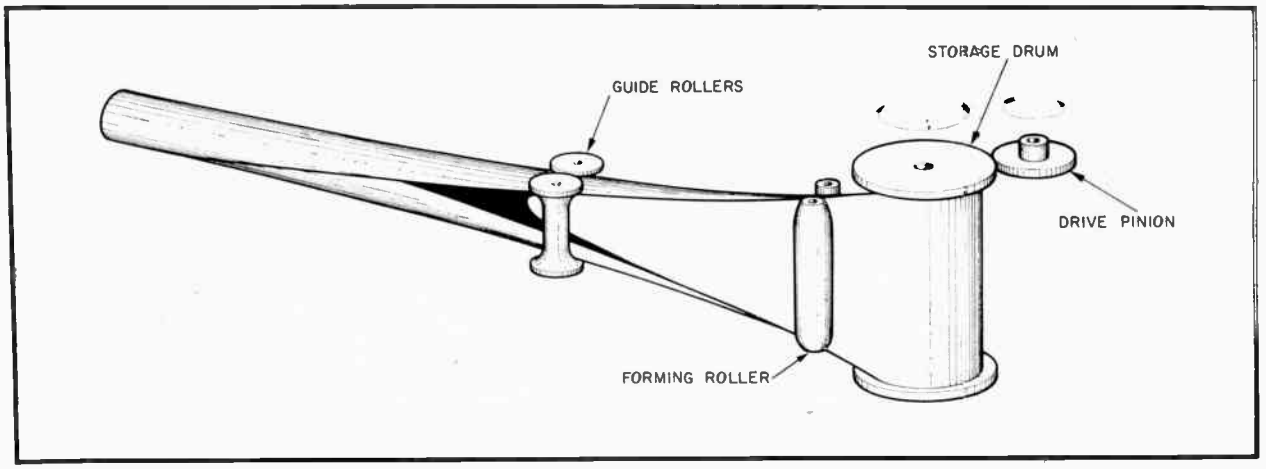


Figure 1. Diagram showing basic principle of operation of the extensible tube.

CANADIAN SPACE ELECTRONICS

A family of self-erecting space structures

. . . . a revolutionary, all-Canadian design permits compact storage of long antennas for space-vehicle applications . . . .

by Austen B. Barnes*

Introduction

The STEM Stored Tubular Extensible Member — is a means of producing long rigid tubular elements from a compact mechanism and is suited to a wide variety of applications, ranging from whip antennas to masts and structures.

The concept of a tubular element which could be stored in the form of a flat coiled ribbon was originally investigated by Canada's National Research Council during World War II as a means of erecting a small transmitting antenna, and the principle was further improved by the Canadian Army Development Establishment, utilizing spring steel as the element material. Later, The De Havilland Aircraft of Canada, Limited, Special Products Division, embarked on a comprehensive research and development program, culminating in the present wide range of STEM products. The elements may be made of a great variety of materials including spring steel, stainless steel, and beryllium copper, and work on new materials is progressing continuously.

Basic principle

The basic mode of operation of the device is shown in Figure 1. Metal tape, having been heat treated to assume the tubular shape, is flattened and wound on a drum for storage purposes, in a similar manner to a carpenter's measuring tape. The heat treatment results in the unrestrained tube adopting a tubular shape with the two edges overlapping by almost 180 degrees, giving virtually the same strength as a seamless tube of the same diameter and wall thickness.

When extension is required the element is payed off the storage drum into a special mechanical guide which allows it to revert to the tubular configuration and gives it sufficient support at the base to form a rigid cantilever member.

During this process, some means of constraint or support is provided for the tape element around the periphery of the storage drum. Dependent upon the type of unit, this can take various forms such as metal spring belts, rubber belts, as shown in Figure 2, or even merely storage drum cheeks conically dished on the inner faces, holding the flat element in place as indicated in Figure 3. The partly formed material, with its reduced width, is not so constrained, and is led off the drum with no difficulty.

On the early units, interwound Mylar tape was used to provide the costraint but this has been superseded by improved techniques. As the Mylar always had to be kept in tension, it was necessary to wind the tape onto a separate drum during extension, and this actually pulled the tape element off the storage drum and into the guide sleeve. To rewind, the drive had to be transferred to the storage drum, respooling the tape element and the interwound Mylar.

The later designs, dispensing with the Mylar tape and using the belts permit extension and retraction by simply driving the storage drum in the appropriate direction.

Operation — manual, motorized, or automatic

Retraction or extension of the belt-constrained units may be effected by a manual or motorized reversible

***The Author**

Austen B. Barnes *is a Senior Mechanical Design Engineer with the Special Products Division of* **De Havilland Aircraft of Canada Ltd.** *He has been deeply involved in the various designs described in this article.*

drive applied to the storage drum. The manual drive has some advantages in certain ground applications, but a reversible electric motor drive is the most usual means of operation. Power requirements are very low and are usually less for extension than for retraction, due to the inherent spring energy in the material itself which is released during reversion to the tubular shape. This property is fully utilized in the self-erecting types, described later.

Various types of mechanism have been developed for different applications, with length capabilities ranging from a few feet to nearly 1,000 feet. However, in cases where more than about 20 feet of element is ejected, some means must be used to compensate for the changing diameter of the material on the storage drum, as the material is led off or respooled. It is important that constant geometry be maintained between the guide mechanism and the take off point of the element from the spool.

This may be accomplished by moving the storage drum relative to the fixed frame and guide mechanism, or by moving the guide mechanism relative to the fixed frame and storage drum.

As the storage drum is usually gear driven, it must be arranged to move — if it moves at all — in an arc around the gear to maintain constant meshing; consequently, constant guide geometry is possible only if the element is led off tangentially as in Figure 1.

In the other case, where the guide moves, it must move radially with respect to the drum to accommodate the changing stored material diameter, and radial take-off is employed. This is arranged generally as in Figure 4, with the curved "shoe" and idler roller guiding the element material to a radial position.

Where "one-shot" operation is desired, with no retraction, the inherent spring energy of the un-reeling element may be used as its sole source of extension force. The unit shown in Figure 3 is provided with this capability, the free end of the element being tethered, the spool unreeling the material and travelling along the produced element until it finally flies off the end. Units have also been developed employing two of these spool arrangements back-to-back with a centrifugal brake acting differentially between them, such that the rate of ejection is within the allowable limits of the system with which the elements are being used. This automatic self-ejecting feature is useful in applications where weight and power are at a premium and retraction is unnecessary.

A further type of self-ejecting automatic unit has also been developed, known as the "jack-in-the-box". In this arrangement the element is ejected sideways in the form of an expanding spiral as shown in Figure 5.

The scope of the STEM devices is therefore very broad, embracing a variety of mechanisms, each of which has an area of preferred application.

Special features:

Many special features can be incorporated into most of the units, some of which are listed below:

- ► Electrical circuit made or broken to remotely signify full extension or retraction.
- ► Automatic drive motor shut-off at full extension or retraction.
- ► Potentiometer indication of length extended or retracted.
- ► Special construction techniques available for prolonged life in vacuum (space) environment.

These add greatly to the application scope of an already versatile device.

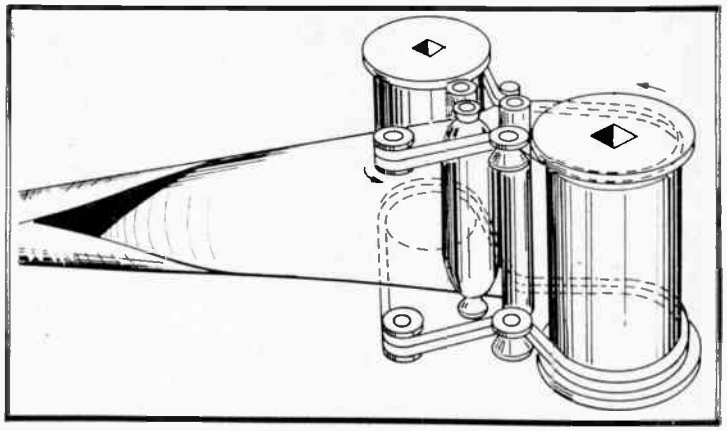


Figure 2. Diagram showing principle of tube extension for designs employing spring or rubber belts.

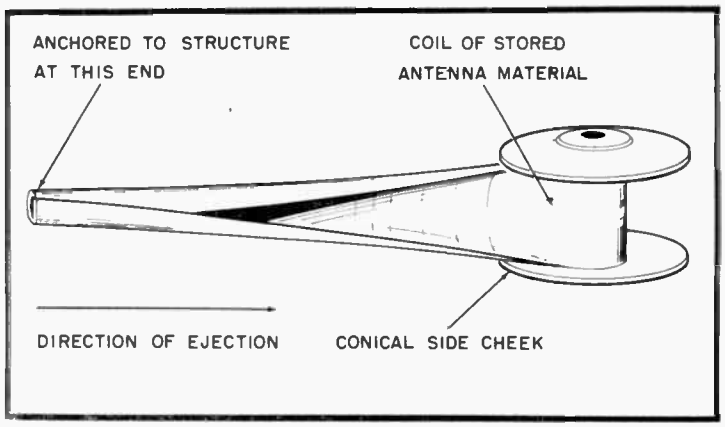


Figure 3. Design employing conical drum cheeks to provide constraint for un-winding strip.

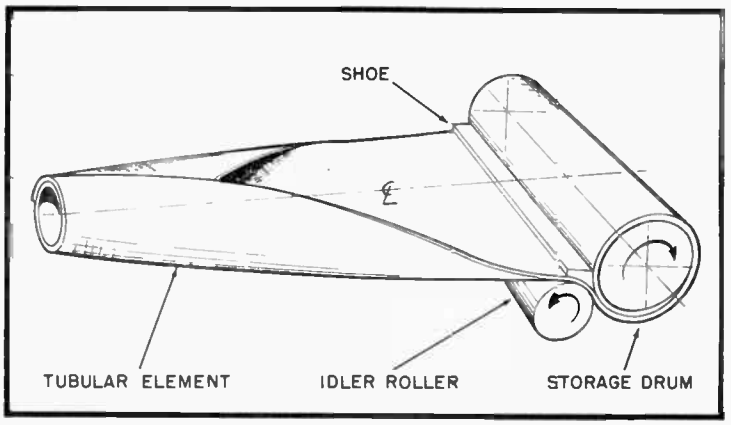


Figure 4. Design using the principle of radial lead-off using curved shoe idler roller.

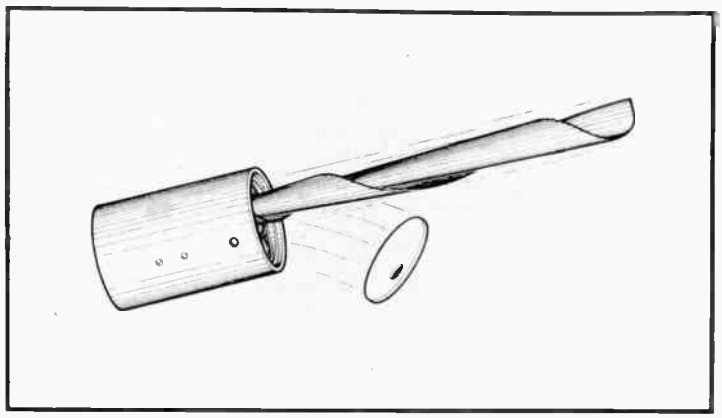


Figure 5. The self-extending "Jack-in-the-box" side-ejecting design.

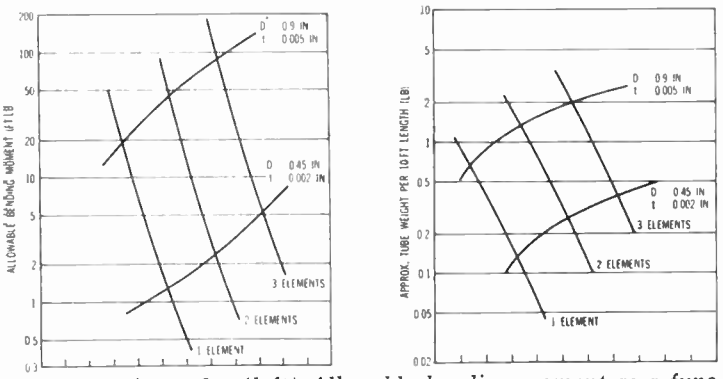


Figure 6. (left) Allowable bending moment as a function of tube dia. and (right) tube dia. versus weight.

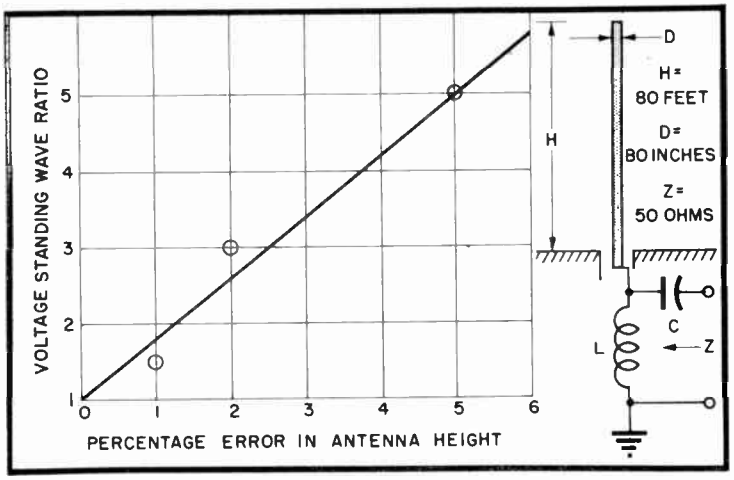


Figure 7. Relationship between mast height mis-match and VSWR for the tubular antenna.

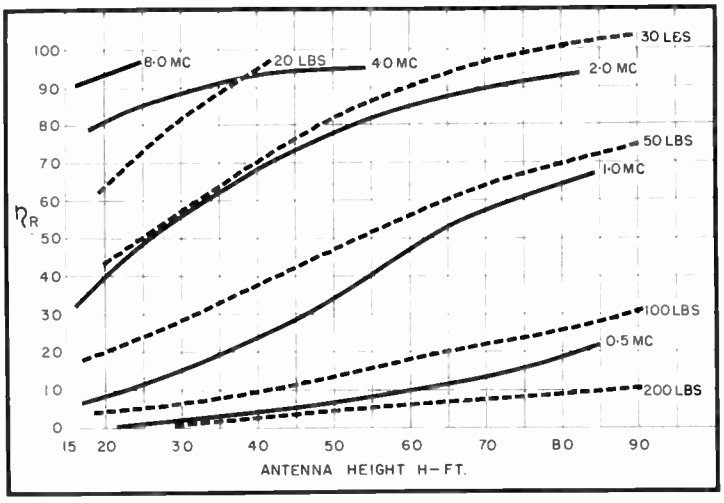


Figure 8. *(above) Efficiency against antenna height for antenna lengths less than λ/4. Chart also shows weight of inductive matching unit.*

Figure 10. *(below) Extensible antenna designed for the Canadian S-27 "Top-side Sounder" satellite.*

Strength and rigidity

The strength and rigidity of extended tube is governed by the material type, wall thickness, diameter, and number of element layers. If required, several layers of element material can be ejected in tandem such as to combine and overlap to form a very rigid yet resilient set of nested tubular elements. This practice has some advantages, when it is considered that the main stresses acting on the element are:

(a) Stresses generated in opening out and flattening the tubular element for storage.
(b) Bending moments and/or centrifugal forces sustained in use.

The flattening stress is given by the equation:

$$S = \frac{Et}{D}$$

where:

D = tube diameter
t = thickness of material
E = Young's modulus of elasticity for the material

For an allowable stress with a given material, therefore, the tube diameter and material thickness are directly proportional.

As mere thickness of element cannot be increased without increase of diameter, and consequent increase of material width — it is convenient to use multi layers of element. In this manner, the mechanism can be kept compact, yet the element strength is greatly increased, enabling it to withstand much higher bending moments.

The actual bending moment and centrifugal forces sustained depend upon the application environment and are dealt with in later sections. However, included in Figure 6 is a chart of permissible bending moments versus tube diameter and number of nested elements, together with the element weight in terms of number of elements and overall diameter. All the figures are based upon an overlap of 180°.

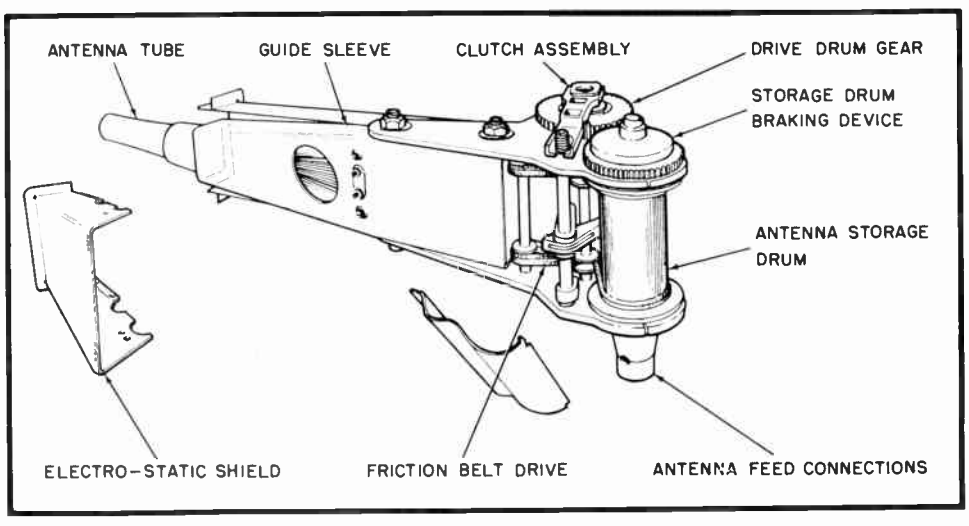
Bending moments caused by wind forces

In the case of ground applications, wind imposes a bending moment as follows at the base of the mast:

$$M = \tfrac{1}{4} \rho V^2 C_d D L^2$$

where M = maximum bending moment
ρ = mass density of air
V = wind velocity
C_d = drag coefficient $\approx$ 1.2
D = tube diameter
L = tube length

Wind induced oscillation can be a more serious problem in some circumstances, but the high damping



of the elements due to the material overlap gives the STEM devices a performance superior to seamless tube in this regard.

Bending moments and centrifugal forces related to extension rate

The rate of extension may be designed anywhere from a fraction of an inch to many feet per second. In some instances the rate of extension is a critical factor; for example, in the case of spinning earth satellites and rockets. Here the extending antennas increase the overall moment of inertia of the spinning satellite and as a result the system slows down in order

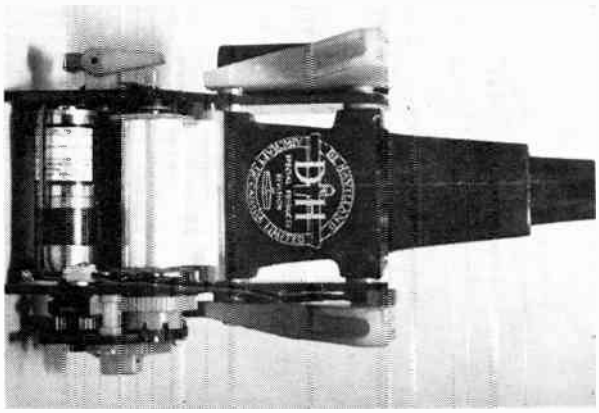


Figure 9. *The Model A2 antenna designed for use with the LOFTI spacecraft.*

to conserve angular momentum. The slowing down effect appears as a bending moment at the roots of the antennas and this, together with the Coriolis and centrifugal forces, imposes severe limitations on the permissible rate of ejection of these systems. Similarly, in spinning rockets with antennas or booms ejected radially from mechanism packages, the ejection rate must be such as to keep the forces below the breaking point of the element. Mounting the elements in a staggered formation, i.e. part tangential, part radial and arranging the direction of rotation accordingly, it is possible to relieve some of the bending moment by the cancellation of Coriolis and centrifugal effects. This permits a much higher ejection rate from spinning vehicles than would otherwise be possible.

Electrical performance

The electrical performance of the units is very high if tuned to one quarter wavelength, and the facility of the mechanisms to extend or retract on command is a great advantage in achieving this in variable frequency

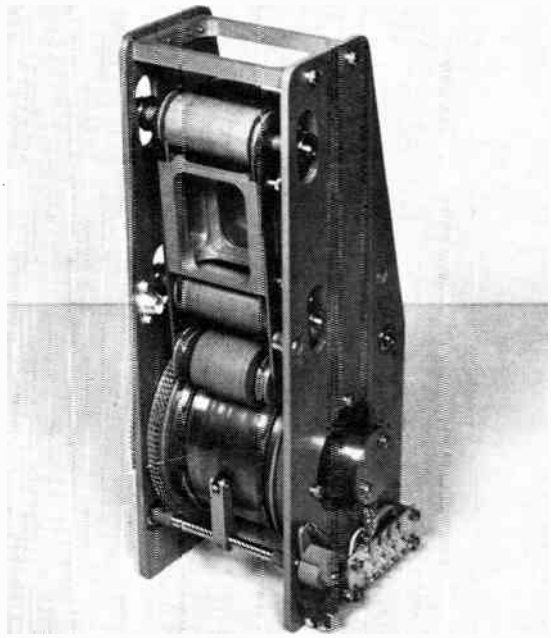


Figure 11. *All-metal design presently in orbit in the APL "TRAAC" satellite.*

systems. Sinclair Radio Laboratories Limited have been responsible for solving some of the matching problems associated with the STEM devices; in particular, the DRTE S.27 satellite project, the Javelin rocket S.27 system try-out, and some projected ground based antenna applications.

Figure 7 and 8 (by Sinclair) show the influence of mast height mismatch on voltage standing wave ratio, and how the efficiency at low frequencies may be improved at antenna lengths less than one quarter wavelength using suitable inductive matching. A plot of the inductive matching coil weight is also included in Figure 8.

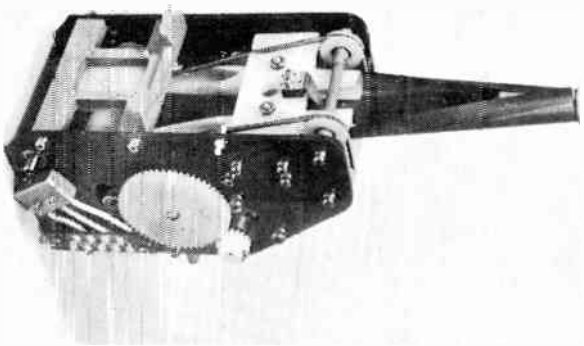


Figure 12. *30 ft. A-18 antenna designed for the S. 48 satellite. Unit is of advanced design and only weighs 1½ lbs.*

The plot in the latter figure assumes the use of a good ground counterpoise, and where this is not available, a significant drop in efficiency inevitably occurs.

Applications

Some of the characteristics of the various units are shown in Table I.

The earliest design of successful unit, the Model A.2 antenna is shown in Figure 9, and is being used in the LOFTI satellites by the United States Naval

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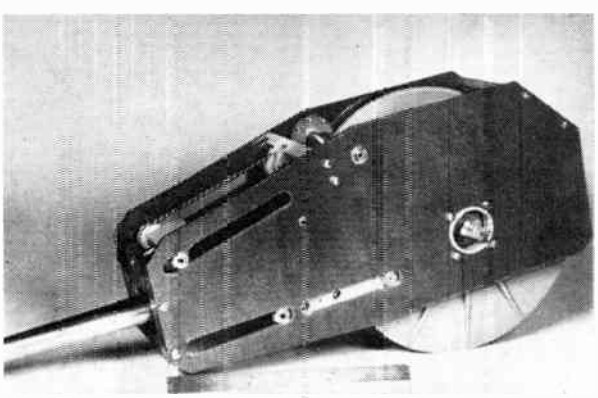


Figure 13. *Model A.21 for the U.S. Navy ejects 1,000 ft. of tube. Presently being investigated is a 5,000 ft. design.*

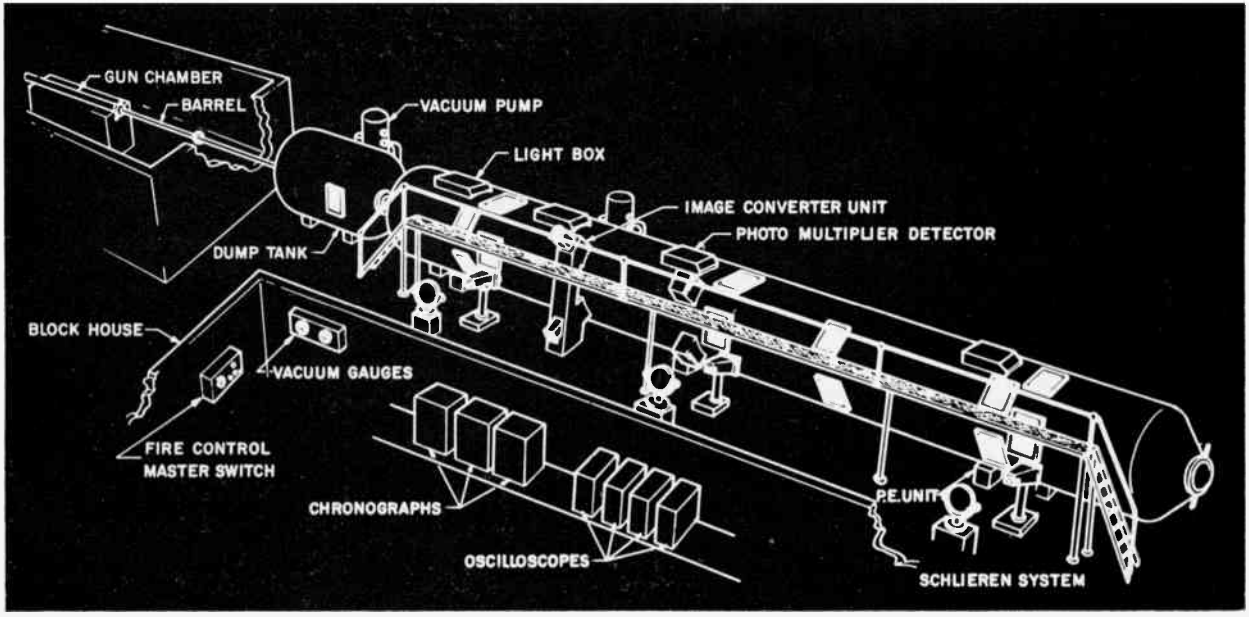


Figure 1. Layout and instrumentation of a hypervelocity range facility.

CANADIAN SPACE ELECTRONICS

Radiation measurement techniques in hypervelocity research

. . . . radiation measurements performed in microsecond intervals are carried out at CARDE's hypervelocity ranges using new instrumentation . . . .

by Dr. A. Lemay, L. Tardif and J. G. G. Dionne*

Introduction

Hypersonic ballistic ranges have demonstrated in the past few years[1] [2] [3] that they can be of considerable value in our effort to establish an effective defensive system against intercontinental ballistic missiles. These ballistic ranges have served mainly for the study of the elementary physico-chemical processes occurring along the missile trajectory and especially during the re-entry phase. Among the phenomena that are studied, the aerodynamic behavior of models and the radiation emitted from these models and their surrounding atmosphere have direct implications in any current defensive system.

The hypersonic range facilities simulate the conditions of altitude and velocity for re-entry missiles and permit a correlation of the observations with the data collected during actual re-entry of missiles such as those launched from Cape Canaveral.

Such a facility is illustrated in Figure 1. It consists of a light gas gun launcher, a dump tank to absorb the gun gases followed by the range itself, consisting of a large tank equipped with a proper pumping system to evacuate it to pressures corresponding to altitudes up to 250,000 feet (approx. 50 miles).

One of the ranges presently in operation at CARDE is 400 feet long by 10 feet in diameter. In most of our firings, projectiles of various shapes and dimensions (spheres, cones, etc.) are mounted in a carrier, called a sabot which has a double purpose: first, it provides a very good seal in the bore of the gun and secondly it prevents the projectile from pre-heating due to friction during the acceleration phase taking place in the barrel of the gun. This second property is most important for radiation observations since it prevents pre-initiation of the ablation phenomenon. This sabot is either trapped or left behind the projectile due to the large drag forces determined by its aerodynamic shape. Current launching techniques permit velocities up to 25,000 feet per second for a model ½ inch in diameter and up to 19,000 feet per second for a 1½ inch diameter model.

Origin of radiation phenomena

It is well known that a shock wave is formed ahead of bodies travelling at supersonic velocities for instance an aircraft breaking the sound barrier. A similar shock wave will obviously be formed ahead of the models at hypersonic velocities for altitudes where the atmospheric pressure corresponds to a flow regime above the free molecular flow. Very high temperatures in the order of 5000° - 10,000°K are reached immediately

*See page 53

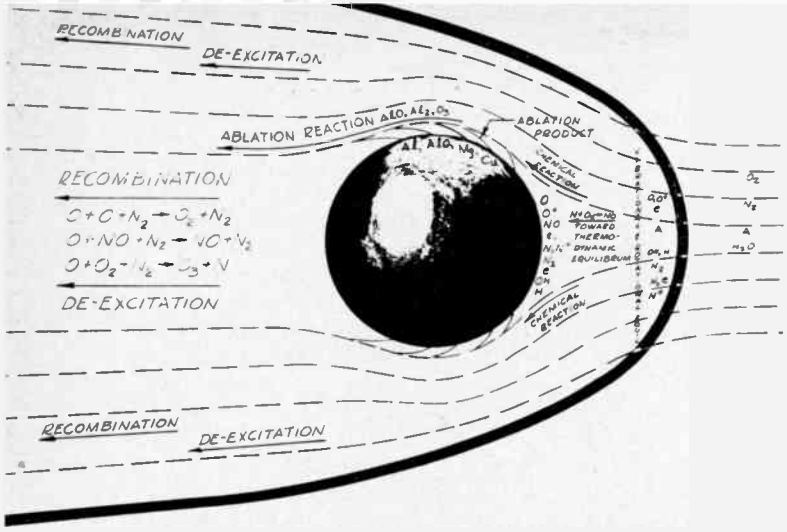


Figure 2. Diagram showing the various processes occurring in the luminous volume surrounding hypersonic bodies.

behind the shock wave, which generates a plasma by dissociating and ionizing the air molecules.

This phenomenon is well illustrated in the sketch shown in Figure 2. The hot gases formed react chemically between themselves and then relax to equilibrium by emitting ultra-violet, visible and infra-red radiation.

Moreover, a large amount of energy is transferred to the body, especially to its front surface where the reacting gases are hottest and most luminous. This process heats up the surface of the body and induces ablation. The ablation products are mixed with the gases in the long wake following the projectile. This long wake emits radiation, principally in the infra-red region.

As a first approximation, it may be stated that the intensity of the emitted radiation follows the black-body radiation law, i.e. it varies as the fourth power of the temperature with a wavelength distribution peak shifting towards the blue as the temperature increases. The highest temperature region in the case of a hypersonic projectile of nose radius R is a very small volume ($0.1R^3$) surrounding the stagnation point which is located at the very front of the body. We may assume for small bodies that this region is a point source with strong emission in the ultra-violet and visible regions of the spectrum. This point source is easily detectable with photomultiplier detectors and their signals are often used to trigger our radiation recording instruments, chronographs, shadowgraph and schlieren stations. The chronographs accurately measure the velocity of the projectile. Both shadowgraph and schlieren stations give useful information on the physical condition of the projectile and the schlieren units also photograph the associated shock waves.

Radiation instrumentation

As previously outlined, the emitted radiation covers a very wide spectral range and, for our observations, suitable detectors sensitive in the various regions of the spectrum are chosen.

In order to give useful information, time resolution is necessary since the radiation intensity fluctuates widely with different positions relative to the model on the trajectory axis. This time resolution is limited by the radiation level, detector rise time, model dimensions and velocity. These conditions determine the field of view which has to be used with a detector of given sensitivity and its associated optics. A practical field of view would have to be approximately half the size of any region to be resolved. A rectangular field of view is usually defined in the plane perpendicular to the axis of the trajectory, with the smallest dimension along this axis. (See Figure 4). Since the stagnation region is about 20 times smaller than the projectile and up to one thousand times more luminous, a relatively large field of view yields useful information even with small projectiles for this region of great interest.

Optical designs

Various optical designs can be used to determine such a field of view and these will now be described in more detail.

The first of these designs[4] achieves a narrow rectangular field of view geometrically defined by a series of slits. A diagram of this construction is shown in Figure 3a. Such an arrangement however is limited in the narrowness of the field of view due to Fresnel diffraction problems which become important when the slit dimensions are reduced below approximately 1/16

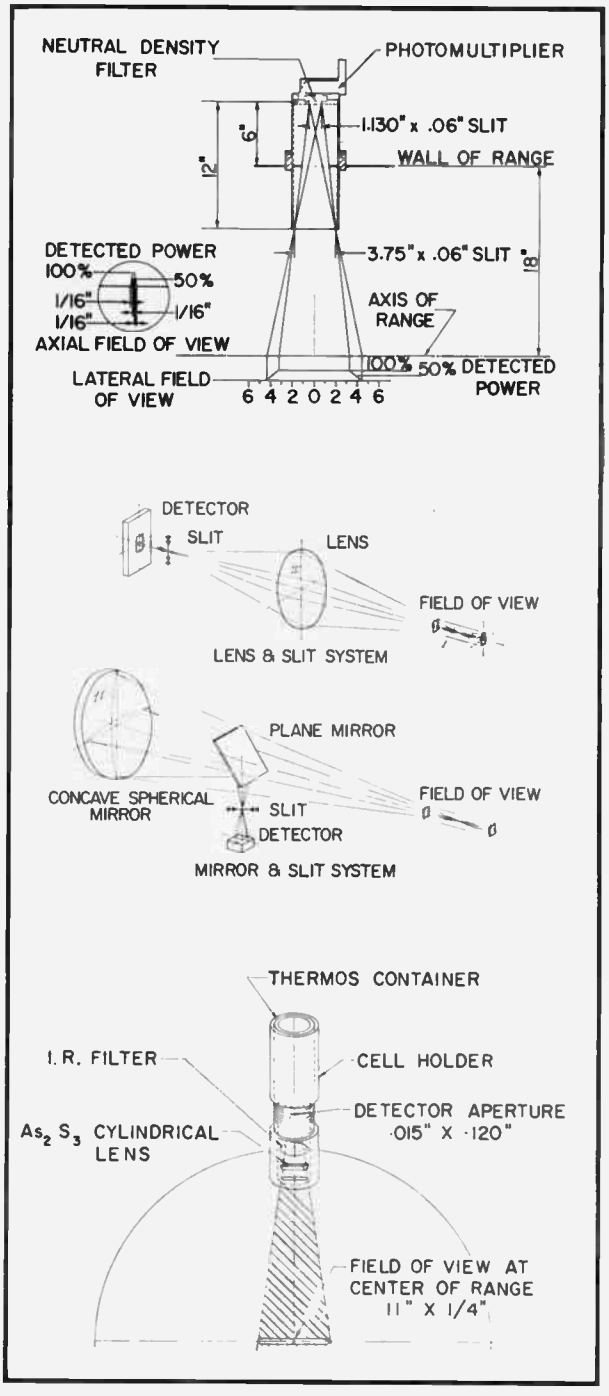


Figure 3a. (top) Schematic of photomultiplier assembly using geometrically defined field of view; (b & c) Two narrow field optical systems; (d) (bottom) Sketch of P-type Au-Ge Cell Assembly.

of an inch. Nevertheless, this simple, sturdy and inexpensive construction has many qualities which render it attractive for stagnation point radiation studies and as a trigger initiator. These qualities consist of high transmission which is practically independent of wavelength, a high aspect ratio field of view and an infinite depth of field, which is especially advantageous when used as a trigger generator.

In order to obtain a narrower field of view, an optical system of spherical or cylindrical lenses or mirrors is required. The numerical aperture (solid angle subtended) defines the amount of light collected by the optical system and also determines the depth of the field of view. The slit, as seen though the optics, determines the width and height of the field of view (Figure 3b and 3c). With such systems, a field of 1/16 of an inch by two inches at a distance of seven feet from the focal plane has been achieved. The limited height of this field of view necessitates the use of many modules mounted in a fence arrangement in order to allow for the dispersion of the projectile. This also permits a coarse transverse resolution for large projectiles. A fence arrangement using lenses is shown in Figure 4.

The amount of chromatic aberration which may be tolerated dictates the use of one of the following three systems:

► *Chromatic spherical or cylindrical lenses* (uncorrected ordinary lenses.)

This lens system, the least expensive of all, is adequate when used in conjunction with interference filters defining narrow wavelength bands in the spectrum. This system provides the advantage of easy positioning of the field of view inside the range by varying the distance between the lens and the detector. An arrangement of this type, shown in Figure 3d, is used in the infra-red region with gold-doped germanium photoconductive detectors. The lens material in this case is an arsenic tri-sulfide glass possessing very good transmission characteristics up to 12 microns in the infra-red. A visible and ultra-violet module[5], designed and built to CARDE specifications by De Havilland Aircraft Co. and incorporating a fused quartz lens is shown in Figure 5a.

► *Achromatic spherical lenses* (corrected for a very wide spectral region: 2400 to 6000A°.)

A lens system of this type[6], designed and used for ultra-violet and visible sensitive modules, has been built by the Perkin-Elmer Corporation under contract DA-19-020-ORD-5249 from the U.S. Army Ordnance Missile Command for the CARDE hypersonic range facilities. A calcium fluoride lens inserted between two quartz lenses provides adequate chromatic correction over the above mentioned spectral region while simultaneously offering excellent transmission characteristics. A photograph of one of these modules is shown in Figure 5b. This system also offers the versatility of a lense arrangement (variable focal plane). However, in the infra-red region, because of the large variation in index of refraction over the wavelength band which must be covered (0.6 up to 10 microns), it seems very impractical to even attempt the design of an achromatic infra-red lens system, but reflective optics offer an adequate solution to this problem.

► *Spherical or cylindrical mirror system*

A reflective optical system eliminates transmission problems while offering exceptionally good achromatic properties over the complete part of the spectrum of interest to us. However, these systems present complex mechanical design and difficult alignment problems. In order to focus on different planes it is more practical to use interchangeable mirrors with the appropriate radii of curvature. One module[7] built around a mirror system by the Perkin-Elmer Corporation is shown in Figure 5c.

Associated electronics

It has been previously noted that a spatial resolution of the emitted radiation is required. If a projectile travelling at 20,000 feet per second is observed through a hypothetical field of view of 1/16 of an inch in width,

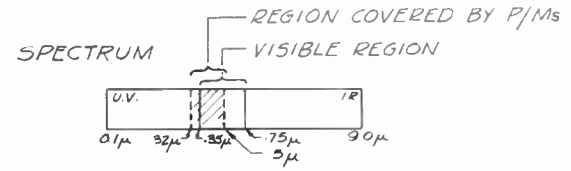
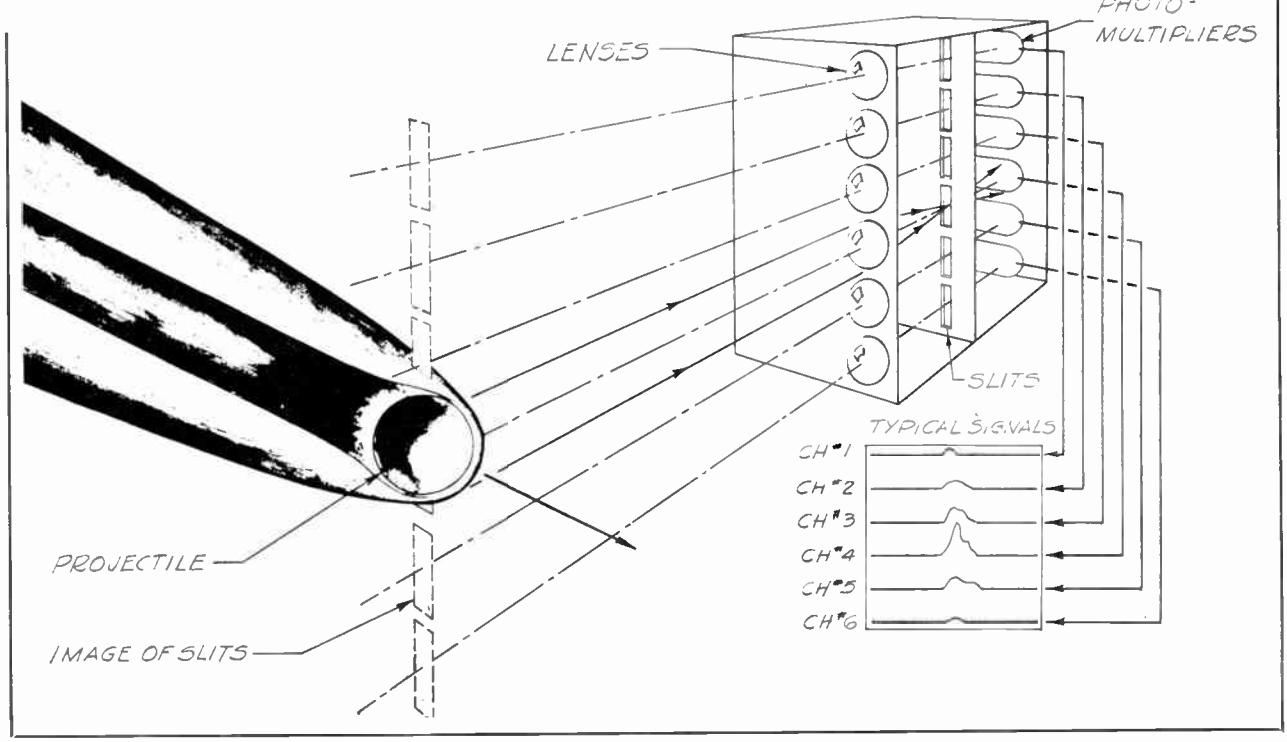


Figure 4. A series of photomultiplier modules mounted in a fence arrangement forming a measuring station along the range.



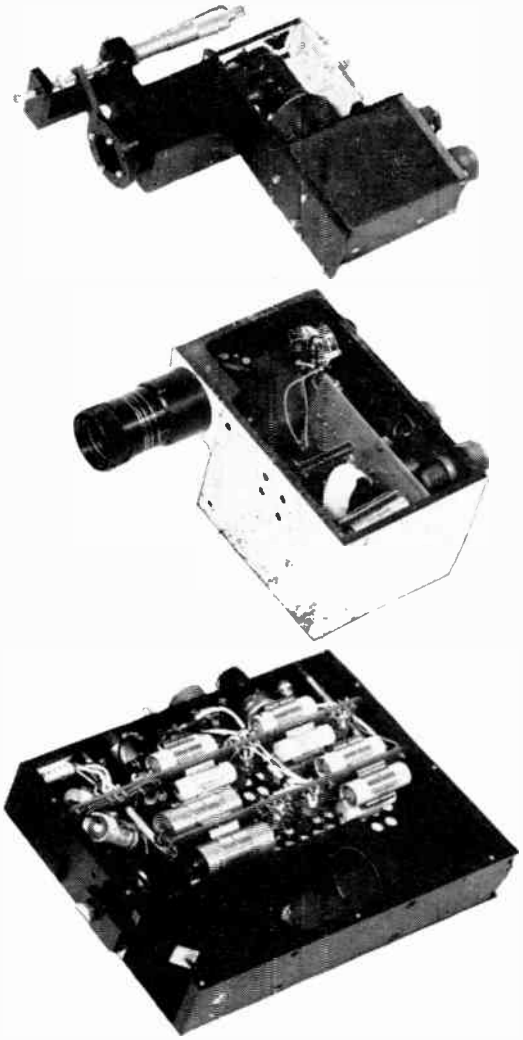
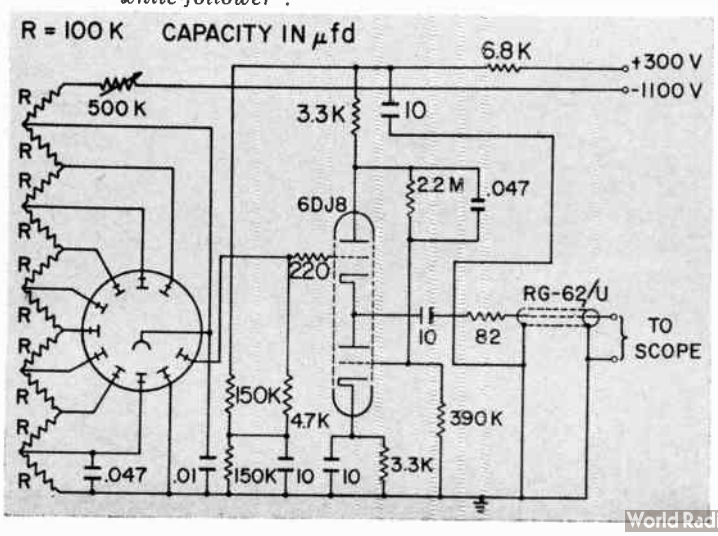


Figure 5. (top-a) ultra-violet and visible measuring module (De Havilland Aircraft Co.) (center-b) ultra-violet module (Perkin Elmer Corp.) (bottom-c) Infra-red measuring module (Perkin Elmer Corp.).

a minimum of 0.04 microseconds rise time will be required from the detector and recording electronics. As for the recording aspects of our operations, such a requirement is, at present, conveniently fulfilled with oscilloscopes and, in the near future, suitable magnetic tapes may become available. As the oscilloscopes provide a wide band multi-range gain amplifier, no linear amplifiers or preamplifiers are needed. In conjunction with the detector, a "White follower"[4] matching device is used as illustrated in Figure 6. The oscilloscope traces are photographically recorded on Polaroid 3000 ASA film which allows a fast writing speed and eliminates the film processing. Typical traces from two photomultipliers and their interpretation are shown in Figure 7.

Figure 6. Circuit diagram of photomultiplier and "white-follower".



It can be noticed from these traces that no wake signal is recorded behind the sphere, and the wake recorded behind the sabot which is used to launch the projectile does not extend to the anticipated distances. This is due to the large ratio between the luminous intensities of the stagnation region and the wake. Obviously, a choice has to be made between recording either the peak intensity or recording the wake where the peak intensity is off-scale. In order to circumvent this difficulty and to observe these two regions on the same trace, a twenty channel three decade logarithmic amplifier[8], designed and built to CARDE specifications by Computing Devices of Canada Ltd. or a three decade compressed gain amplifier (Perkin-Elmer design) is used.

Spectroscopic techniques
Time-integrated spectroscopy

Spectroscopic techniques are currently used to study the physico-chemical processes taking place around hypersonic projectiles and they permit a better resolution than the resolution attainable with interference filters (80-100A°). Conventional spectrographs used in general spectroscopy work would give time-integrated spectra providing that enough light enters the instrument. Our initial experiments have demonstrated that, in our case, the light entering the spectrograph, when dispersed over the spectrum, is not intense enough to impress a photographic plate. Collecting mirrors to gather the radiation are now used with locally designed large numerical aperture spectrographs. These mirrors integrate the radiation over a long time interval in the order of 200 microseconds and the spectrographs in this case give valuable information on the ablation processes which occur.

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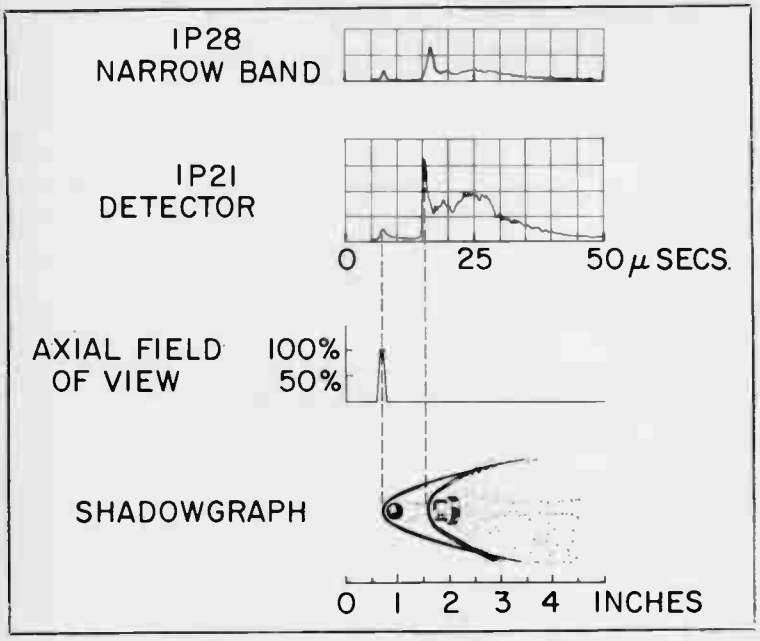


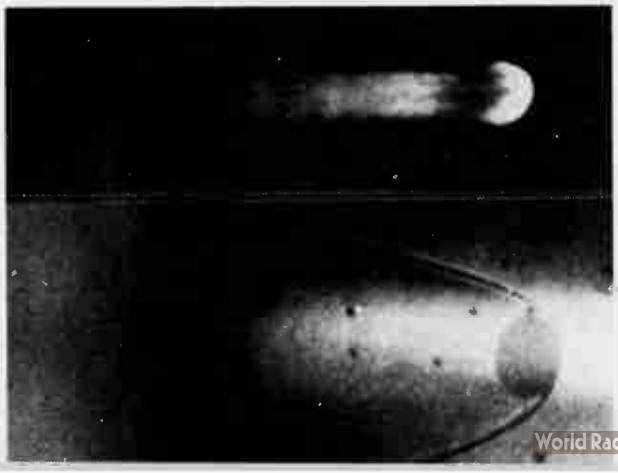
Figure 7. Diagram showing interpretation of radiation detector signals.

Time-resolving spectroscopy

The ideal experimental instrument would be a high resolution narrow field of view time-resolving spectrograph recording the intensity variations displayed over a wide spectral range as the different sections of the luminous volume pass through the field of view. One such instrument, incorporating a rotating drum carrying the film as the time-resolving element has shown only limited usefulness up to this point, especially because of the very short exposure time for each point on the film and the small incident energy density.

The most promising instrument to achieve this is a time-resolving spectrograph built around an image converter tube (RCA C73435B). It is now in its final stage of development. This image converter tube provides light amplification and a very fast shutter action electrostatically controlled by a grid bias. It also permits an electrostatic deflection of the image without impairing the focus sharpness. The image may be gradually swept across the phosphor face during the "ON" period of the tube. As the luminous volume passes through the narrow field of view of the instrument, the incident radiant energy is spectroscopically resolved and focussed on the photosensitive cathode. When the portion of the volume to be studied enters the field of view the tube is turned "ON" and the image of the spectrum is linearly swept across the phosphor face. The image formed will show wavelength along the X axis and the time (related to different sections of the radiating volume) along the Y axis of the phosphor.

Figure 8. Photographs of a model in flight. (top) using emitted light (bottom) by means of shaddowgraph techniques.



In flight photography of projectiles using available light

When the image converter tube is coupled with a photographic objective focussing the luminous projectile on the photo-cathode, a very short exposure time (< 1 μsec) enables us to take a still picture of the projectile in flight. The shutter speed is determined by considering the field of view and the photo-cathode size which limit the optimum resolution. The minimum exposure time required is one half the time needed for the projectile to travel a distance equivalent to the optimum resolution. The optical system uses an f/1.9 camera objective to focus the image on the photo-cathode and an f/1.9 lens to focus the phosphor image on the film. The complete optical system has an image/object ratio of 1/20 and its optical gain is high enough to photograph on Polaroid 3000 ASA film a tungsten filament at a temperature of 2000°K with an exposure time of 0.15 μsec. This image converter camera easily resolves 12 line pairs per mm of photo cathode. A photograph of a hypersonic projectile taken with this camera at an exposure time of 0.4 μsec is shown at the top of Figure 8. A shadowgraph of this same projectile and its associated shock wave is also shown on this figure.

Conclusion

In this article we have presented a brief summary of the methods employed in studying the radiation phenomena associated with hypervelocity projectiles.

It must be emphasized that the important qualities required for our radiation instruments are adequate accuracy, high detectivity, together with ease of construction, alignment and serviceability. Furthermore, the instruments must be as versatile as possible since they have to be adapted to various sizes of hypersonic ranges and projectiles. The detectors must also operate over a wide range of radiation levels in order to allow for pressure and velocity variations.

This work on radiation observations is expanding rapidly and many techniques are in the process of development for obtaining further information leading to a better understanding of the re-entry problem.

Acknowledgments

The authors are grateful to Dr. A. Dm-Kokline who is responsible for the time-integrated spectroscopy aspects of the work.

References

1. Bull, G. V., *Re-Entry Studies in Free Flight Ranges (1959) IAS Paper No. 59 - 143.*
2. Bull, G. V., Tidy, G. H., *Les Techniques Hyperbalistiques en recherche Aerophysique. Presented at II Congres International des Fusees et des Satellites (June 1959).*
3. Maiden, C. J., *The CARDE Hypersonic Range One Facility and Associated Research Instrumentation CARDE report TM/AB 49.*
4. St. Pierre, C. A., *Results from the Third Radiation Program in CARDE Hypersonic Range 1 using 0.40 inch Diameter Spheres. CARDE report TM-611-61.*
5. De Havilland Aircraft of Canada Ltd., *VUVT2 Radiometers and Ancillaries, DHC-SP-TN-148.*
6. Perkin-Elmer Corp., *Instruction Manual Photomultiplier Module Engineering Report No. 5814.*
7. Perkin-Elmer Corp., *Instruction Manual ARGMA — Range Instrumentation Engineering Report No. 7048.*
8. Computing Devices of Canada Ltd., *Operating Instructions for Logarithmic Amplifier TL A-1. Report No. TLA1-OMI.*

Figure 1. Experimental set-up for producing SF_6 negative ions for charge neutralized ion engine.

CANADIAN SPACE ELECTRONICS

Electric propulsion for spaceflight – the ion engine

. . . . research at RCA-Victor is aimed at employing heavy-negative-ion charge neutralization in ion engines thus avoiding the many problems using electrons . . . .

by Dr. G. G. Cloutier*

(condensed from a comprehensive research report written by Dr. Cloutier)

Introduction

The thrust of a chemical rocket is produced by expanding through a nozzle the hot gases generated in a combustion chamber. The maximum velocity at which the gases can be ejected from the rocket is limited ultimately by the temperature of the gases in the combustion chamber and the heat resistance of the structure. As a result, high thrusts are attained at the expense of very large mass flow rates. For space applications it is highly desirable to keep the fuel consumption to a minimum so that the weight of the propellant is not too great a fraction of the total weight of the rocket. One way of reducing the fuel consumption while maintaining the desired thrust in a rocket is by expelling the propellant at higher velocities. It is this feature which makes the electric rocket attractive.

In an electric rocket the propulsion is achieved by launching at extremely high velocities a jet of electrically charged particles. This can be done by subjecting these charged particles to strong electric or magnetic fields.

The electric rocket being a low thrust device, a chemical rocket will be required to put the space vehicle, including the electric rocket, into a satellite

*See page 59

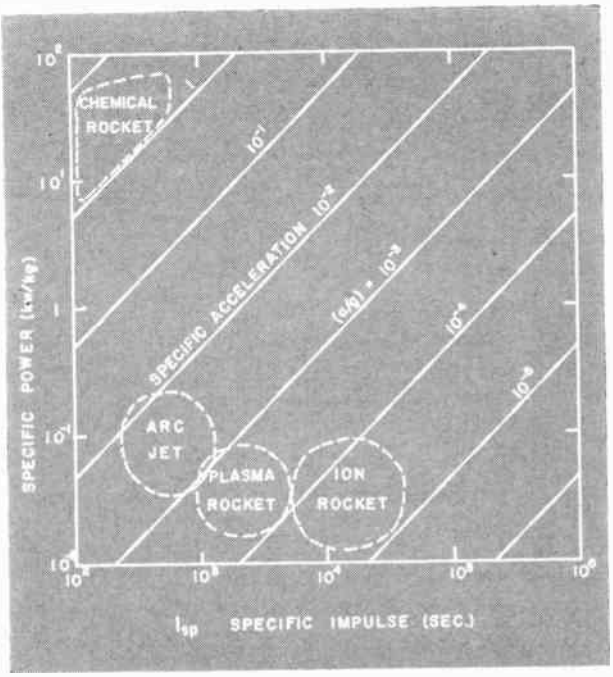


Figure 2. Performance regions in terms of specific power and impulse for various propulsion systems.

orbit. Therefore the electric rocket will not supersede the chemical rocket but will simply complement the latter in the fulfillment of a space mission.

Among the interesting characteristics of the electric rocket are the continuous control of thrust, the long operating period, the low fuel consumption and the capacity of carrying large payloads for deep-space missions. These characteristics will be discussed in this paper and descriptions of various electric propulsion systems presently under investigations will be outlined.

Basic concepts of rocket propulsion

A number of fundamental relationships serves to describe the behavior of a propulsion system and a brief review of these will illustrate the requirements for electrical propulsion.

Thrust — Based on Newton's laws of motion, the thrust of a rocket can be described by the equation:

$$F_s = \dot{M} v_{ex} \qquad (1)$$

where $\dot{M}$ is the mass flow rate of the propellant ejected from the rocket and v_{ex} is the exhaust velocity of the propellant.

It is thus evident that for a constant thrust, a reduction in the fuel consumption is achieved by increasing the exhaust velocity. In fact this is one of the major factors which has lead to the development of electric rockets since in an electric propulsion system the exhaust velocity can be made very high.

Specific Acceleration — The acceleration of the rocket due to its thrust is given by

$$a = Fa/M_o$$

where a is the acceleration of the rocket and M_o is the total weight of the rocket.

A useful parameter is the specific acceleration which is defined in terms of the acceleration due to gravity "g" at the surface of the earth, that is,

$$a/g = \frac{F_s}{gM_o} = F_p/M_o \qquad (2)$$

where (a/g) is the specific acceleration and

$$F_p = \frac{\dot{M} v_{ex}}{g}$$ is the thrust in units of weight.

In a chemical rocket, the specific acceleration is larger than unity so that the vehicle may escape from the earth's surface. On the other hand, an electric rocket will have a specific acceleration much less than unity but still useful for interplanetary travel.

Specific impulse — Another basic parameter is the specific impulse I_{sp} which is defined by:

$$I_{sp} = \frac{F_p}{\dot{M}} \qquad (3)$$

This quantity has the dimensions of time, and is normally expressed in seconds: it may be interpreted as the thrust produced by the rocket per unit of propellant flow rate. Combining equations (1) and (3) it can be seen that it may also be expressed by

$$I_{sp} = \frac{v_{ex}}{g} \qquad (4)$$

This last definition points out the fact that the specific impulse is essentially a function of a single parameter, the exhaust velocity. When considering fuel consumption, it is found that a given increment of velocity is achieved more efficiently if the specific impulse of the rocket is increased. On this basis, for space travel, one should attempt to design rockets with as high a specific impulse as possible. However this is not the case because none of the basic parameters defined above takes into account the power requirements.

Power — The power transferred to the exhaust of the rocket is given by the basic equation:

$$W = \tfrac{1}{2} \dot{M} v_{ex}^2 \qquad (5)$$

It is realized that while the thrust and the specific impulse increase linearly as function of the exhaust velocity, the power necessary to propel the rocket increases as the square of the exhaust velocity. The power requirements will thus impose an upper limit to optimum specific impulse of a given rocket.

Specific power — Since the weight of any electrical power supply is approximately proportional to the output power, the weight of the electrical power plant will thus be an important factor in the evaluation of an electric propulsion system. Another important parameter, the specific power, is thus introduced. It is defined as the ratio W_s of the useful propulsion power W to the total weight of the rocket M_o.

$$W_s = W/M_o \qquad (6)$$

If a nuclear reactor is to be used as the power supply in an electric propulsion system, it is estimated that the specific power of the rocket will range from 0.1 to 1.0 K Watts/K gm, two orders of magnitude less than the chemical rocket.

For any given space mission where the distance, the payload and the flight time are predetermined, optimum values for the specific impulse, the thrust and the specific power are found to apply. In general, it is found that the optimum specific impulse is larger, the longer space mission. For example, the optimum specific impulse for a round trip to the moon ranges from 1500 to 5000 seconds while for interplanetary missions, the specific impulse will vary from 6000 to 20,000 seconds. In a given space mission the payload and the flight time are also important factors to be considered since they are both functions of the specific impulse and the specific power. The data of Table I illustrates the dependence of these two parameters on the specific impulse. The values presented have been computed[1] for the situation where a 5000 pound earth satellite is to be transferred from a 150 mile orbit to a 24 hour orbit (approximately 22,000 miles). It is seen that as the specific impulse is increased by a factor of 10, the ratio of the payload to the total weight of the

vehicle increases by 50 per cent; the time required to accomplish the mission passes from 19 to 131 days.

TABLE I

Specific Impulse (seconds)	Payload/Total Weight	Initial Weight (pounds)	Flight Time (days)
1100	.602	8300	19
2000	.765	6540	28
5000	.893	5570	64
10,000	.948	5280	131

Electric rockets can generally be grouped in two classes: those using electric fields for the acceleration and those using magnetic fields. In the former case particles of opposite signs (positive ions, electrons or negative ions) must be accelerated separately since in a given electric field, charges of opposite signs are accelerated in opposite directions. Therefore the systems using electric field acceleration are called ion propulsion systems.

The propulsion by means of magnetic fields is based on the J x B force which causes an acceleration in the same direction to charges of opposite signs. This type of force is therefore useful for the acceleration of a plasma containing free electrons and ions. As a result, the name plasma accelerator is given to the propulsion systems based on this concept. A propulsion system (Arc jet accelerator) using the heating of a gas by means of an electric arc is often considered as an electric propulsion system. Although this system operates by means of an electric current and consequently requires the presence of an electric power-plant its

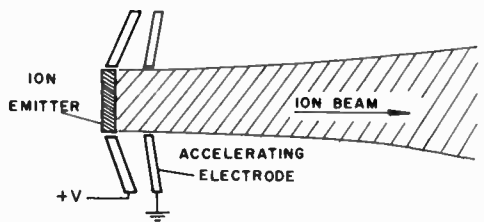


Figure 3a. Basic ion-engine structure.

thrust is produced, as in chemical rocket, by expansion of the gases through a nozzle. Such a propulsion system must thus be regarded as a system intermediate between a chemical and an electric rocket.

In Figure 2, a chart is shown relating the basic parameters discussed for the different propulsion systems and indicating their regions of applicability. The chemical rockets characterized by a large specific acceleration and a high specific power are however limited to a specific impulse in the region of 500 seconds. The ion propulsion system may produce a specific impulse between 5000 and 40,000 sec but is limited to very low specific acceleration and specific power. The specific power of a plasma propulsion system falls in the same range as that of the ion rocket. However with a plasma accelerator a higher specific acceleration can be obtained with a specific impulse between 1000 and 5000 seconds.

Ion propulsion

In an ion rocket the ions are accelerated from an emitting surface by applying a large voltage between the emitting surface and an accelerating electrode (See Figure 3a). This electrode is shaped in such a way as to allow a well focussed beam of ions to be launched into space. Basically, the ion engine can be regarded as an ion diode, and analysis of this structure yields the following propulsion parameters.

Thrust

$$F_p = \frac{\dot{M} V_{ex}}{g} = 1.47 \times 10^{-5} A^{\frac{1}{2}} PiV^2 \qquad (7)$$

$$F_p = 8.01 \times 10^{-13} s/d^2 V^2 \text{ (Kgm)}$$

Exhaust velocity

$$V_{ex} = \frac{2eV}{Mi}^{\frac{1}{2}} = 1.38 \times 10^4 \frac{V}{A}^{\frac{1}{2}} \text{ m/sec} \qquad (8)$$

Specific impulse

$$I_{sp} = \frac{V_{ex}}{g} = 1.417 \times 10^3 \frac{V}{A}^{\frac{1}{2}} \text{ (sec)} \qquad (9)$$

Power transfer to beam

$$W = VI = P_i V^{5/3} \qquad (10)$$

and for a planar diode:

$$W = 5.47 \times 10^{-8} \frac{s}{d^2} \cdot \frac{V_{5/2}}{A^{\frac{1}{2}}} \text{ (watts)} \qquad (11)$$

where:

V_{ex} = exhaust velocity (m/sec)
A = atomic weight of ions (AMU)
P_i = perveance of the ion diode
V = applied voltage (volts)
s = emitting area of diode (m^2)
d = inter-electrode distance (m)
e = charge of the electron (coulombs)
M_i = molecular weight of the ions (Kgm)

It is seen that the thrust, the specific impulse and the power increase with the voltage. However, the power required to propel the rocket increases more rapidly than the thrust and the specific impulse. On the other hand it is interesting to note that the thrust for a given structure factor (s/d) and voltage (V) is independent of the molecular weight of the ions while both the specific impulse and the power are reduced as the molecular weight of the ions is increased. This result is particularly interesting since it shows clearly the advantage of using ions of a large molecular weight for ion propulsion.

It can be shown that the propellant flow rate is limited by space charge effects in the ion diode. In fact this is a fundamental limitation of the ion propulsion system. One approach which has been proposed by Seitz and Raethers[5] to improve this situation is the use of an "Accel-decel" system as shown in Figure 3b. Here, an additional electrode is included such that a large voltage is applied between the emitter and the first electrode to increase the ion current from the

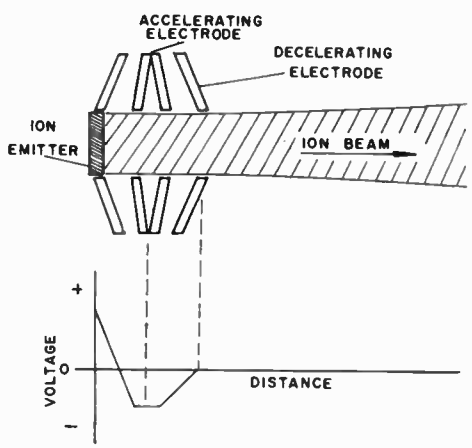


Figure 3b. The "accel-decel" ion-engine structure and diagram showing voltage distribution.

emitter. The ions are then decelerated by the second electrode to launch them with the appropriate velocity. This arrangement has also the advantage of providing better collimation of the ion beam. Consequently erosion of the electrodes due to ion bombardment can be kept to a minimum.

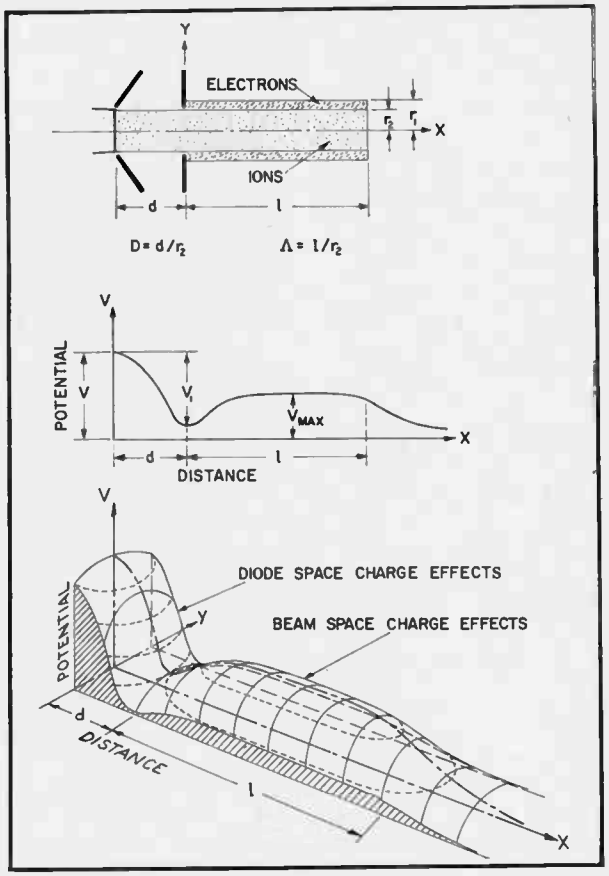


Figure 4. Diagram showing potential variation contours in the exhaust of an ionic rocket.

Charge neutralization

A fundamental problem which arises in the operation of an ion rocket is that of the neutralization of the ions after their ejection from the rocket. If positive ions are launched from the rocket, it is necessary to eject negative charges (electrons or negative ions) to prevent electrical charging of the space vehicle.

The space charge problem in the exhaust of the ion rocket is illustrated in Figure 4, where a sketch of the voltage distribution due to space charges in the exhaust of the ion engine is presented. In this case the ions are ejected through a circular aperture and the neutralizing electrons are launched from the periphery of the exist aperture. The electrons are attracted towards the center of the ion beam by the large space charge voltage created by the presence of the positive ions. As a result the electrons oscillate through the beam and their presence contributes in reducing the space charge potential. However, a certain time will elapse before the electrons become uniformly distributed throughout the ions and consequently complete charge mixing will take place some distance behind the rocket. The presence of this large space charge potential just outside the rocket will slow down the ions coming out from the diode, and may result in a drastic loss of thrust and power efficiency.

The need for neutralization can be illustrated by an example. Consider the following conditions in an ion rocket based on the model shown in Figure 4.

Ion current density:	J = 10 ma/cm
Ion beam radius:	r_2 = 0.50 cm
Electron Injector radius:	r_1 = 0.75 cm
Singly charged Ion (Cesium):	A = 133
Applied Voltage:	V = 6.8 KV.

For these parameters, the specific impulse is approximately 10,000 seconds, and the space charge voltage in the center of the ion beam in the presence of the electrons is approximately 925 volts. This voltage depression represents a deceleration of the ions from the applied (6.8 KV) voltage and corresponds to a thrust and power reduction of 3 per cent and 6 per cent respectively. If (as might seem desirable) higher ion current densities are generated the loss of efficiency increases rapidly.

There are serious dfficulties inherent in the use of electrons for neutralizing a positive ion beam. Firstly because of their very large mobility in comparison with the ions, the electrons move through the ion beam without causing appreciable effects on the movement of the ions. Secondly, the large velocity spread associated with the emission of electrons by a thermionic cathode results in good fraction of the electrons emitted having a higher velocity than the exhaust velocity of the ions thus producing spatial unbalanced of charges along the ion beam.

However, several refined approaches to this problem have been investigated and laboratory tests indicate that electron beam neutralization is in fact, feasible and effective. Nonetheless, it is generally admitted that because of the vicinity of other charges and conductors in the laboratory environment actual tests in space will be needed to prove the systems . . . . such tests are planned for the near future.

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Dr. G. G. Cloutier *received his B.A. and B.A.Sc. (physics) at Laval University and later, his M.Sc. at McGill. In 1959 he received his Ph.D. at McGill for his work in mass spectrometry. Some time was spent at CARDE doing rocket fuel research and later he joined RCA-Victor where he is presently carrying out research into ionic propulsion.*

Another possible method of neutralizing the positive ions from an ion rocket is by ejection of negative ions. If adequate sources of negative ions could be produced it should then be possible to operate an ion rocket by using adjacent diodes of positive and negative ions. The mixing of the positive and negative ions in the exhaust of the rocket should then take place more readily than if electrons were used since the mass of the particles present would be nearly the same and the velocity of the negative ions could be well matched to that of the positive ions.

Research along these lines is being carried out at the RCA Victor Research Laboratories, Montreal, P.Q., and is aimed at developing a high intensity source of negative ions using sulfur hexafluoride (SF_6).

This molecule is particularly attractive since its mass (146 AMU) matches well the mass (133) of the cesium (positive) ion. Another interesting feature of this molecule comes from the fact that SF_6 is characterized by a very high probability of electron capture for electrons of very low energies. This implies that if sufficient ionization could be attained, little power would be required to generate an intense beam of SF_6 negative ions. A negative ion source characterized by a high power efficiency would be available to neutralize the positive cesium ion sources already in

operation. A photograph of the experimental setup used in these studies is shown in Figure 1.

Ion sources

One of the basic problems in the realization of an ion rocket is the ionization of the propellant prior to its launching from the vehicle. The prime objectives in the development of ion sources for electric propulsion are the attainment of large ion concentrations and a high efficiency for converting neutral atoms or molecules into ions. Both these objectives are of prime importance; the first one because large ion current densities are required for obtaining useful thrusts and the second because any fraction of the propellant not converted into ions constitutes a dead load for the rocket. It is generally admitted that the efficiency of propellant utilization in an ion rocket should be above 90 per cent. In addition, the conditions for minimizing the power requirements must, of course, be considered. There exist two basic methods of ionization: surface ionization and electron bombardment. Both these methods have been extensively used in the design of ion engines.

Surface ionization — Surface ionization is obtained when an atom of a low ionization potential comes into contact with a metal having a higher work function than the ionization potential of the incoming atom.

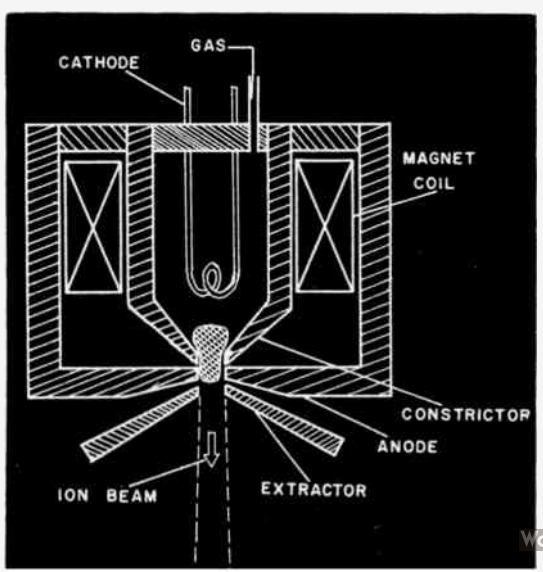
In a cesium ion engine the vapors of cesium are allowed to flow through a porous tungsten plug which is held at a temperature in the range of 1500°K. In their passage through the porous tungsten the cesium atoms lose one electron and emerge from the tungsten plug as positive ions. The ions are then accelerated by a large negative voltage applied to the accelerating electrode of the ion diode.

Ionization by electron bombardment

When an electron of sufficient energy hits an atom, it may dislodge one electron from the atom and form a positive ion. Generally, in ion engines, the electron bombardment ion source operates as a hot-cathode gas discharge, since this device largely eliminates the undesirability of double ionization when properly proportioned and operated.

Most electron bombardment ion sources designed for electric propulsion use electric and magnetic fields to trap the electrons in the plasma. In this way the electrons are forced to remain in the plasma for a longer period and thus have a higher probability of producing ions. A large number of ion sources using this principle have been proposed and tested, but only two of the most promising ones will be briefly discussed here.

Figure 5. Schematic diagram of the "Duo-Plasmatron" ion source.



Penning discharge ion source

A high degree of ionization of a gas can be obtained in a Penning discharge in which magnetic and electric fields are used to trap the electrons. One model which has been particularly studied[3] as a possible source for an ion engine is an arrangement wherein the electrons are emitted on the axis of the system and accelerated towards a cylindrical anode. A small magnetic field is applied along the axis of the cylinder in such a way that the electron emitted on the axis follow a spiral path in their transit to the anode. In this way the path length of the electrons between the cathode and the anode is sufficiently long to increase the probability of ionization and a plasma with a high degree of ionization can be produced. Extraction of the ions, which are not appreciably affected by the small magnetic field, is accomplished by applying a large voltage between two grids located at one end of the cylindrical anode. Such an ion source has been studied experimentally using mercury vapors. With a 10 cm diameter ion source, a current of 125 ma of Hg + ions was obtained[3] at an accelerating voltage of 3 KV. (I_{sp} = 5500 seconds.) A propellant utilization of over 80 per cent was obtained in the cited case.

The duoplasmatron ion source

Another method of ionization by electron bombardment which is being seriously considered as a possible source for an ion engine is the duoplasmatron[4]. A schematic diagram of this source is shown in Figure 5. In this source a low pressure arc discharge is produced between a hot cathode and the anode. A constricting electrode located close to the anode serves to compress the discharge and increase the plasma density. A magnetic field applied between the constricting electrode and the anode also serves to constrict the plasma. A high ion current density is then extracted from the plasma by applying a large voltage on the accelerating electrode. With such a source, Burton[4] has reported the extraction of a current of 60 ma of Argon ions at a voltage of 5.0 KV. This represents an extremely high current density of approximately 1 amp/cm^2. Some of the limitations of this source are found in the small size of the ion beam necessary to attain high plasma density, and in the erosion caused by the ions impinging on the accelerating electrode.

References

1. *M. Camac, A. Kantrowitz and H. E. Petschek,* "Plasma Propulsion Devices for Space-Flight". IRE Trans. Military Electronics, 3, 34(1959).
2. *M. P. Ernstene* et al, "Multiple Beam Ion Motors", American Rocket Society Meeting, Monterey, Calif., Nov. 1960, Paper No. 1373-60.
3. *H. R. Kaufman and P. D. Reader,* "Experimental Performance of an Ion Rocket Employing an Electron Bombardment Ion Source", American Rocket Society Meeting, Monterey, Calif., Nov. 1960, Paper No. 1374-60.
4. *B. S. Burton,* "The Duoplasmatron: Theoretical Studies and Experimental Observations", ARS Meeting, Monterey, Calif., Nov. 1960, Paper No. 1372-60.
5. *R. N. Seitz and M. J. Raethers* "A Pierce Gun Design for an Accelerate-Decelerate Ionic Thrust Device" Paper No. 884-59.

Figure 1. The instrumented helmet for measuring linear and angular accelerations.

An instrumented helmet for aero-space-medical research

by M. R. Howat and Dr. W. H. Johnson*

Introduction

Motion sickness and disorientation (false perception of position in space) have long been recognized as difficulties besetting aircrew during aerodynamic flight in conventional aircraft. However, now that man is involved in space flight, these medical problems are of oustanding significance since these undesirable effects would not only reduce the astronaut's efficiency but might indeed jeoparcize his very survival.

It has been well established that both motion sickness and disorientation can readily result from angular accelerations of the head[1, 2, 3], and possibly to a lesser extent from linear accelerations also. Experimental research has clearly demonstrated that head movements, whether voluntary or otherwise, involve accelerations different from those of the vehicle in which the subject is travelling, whether this be a laboratory device, a car, ship, aircraft or space vehicle. The need therefore arose for a means of measuring the movement of the head directly in order to determine the resultant accelerations acting on the organ of balance located within the head.

This paper describes an electronic head movement recorder which has been developed in these laboratories. The instrument may be useful to others interested in the effects on the human of various types of acceleration experienced in vehicles (laboratory devices, aircraft, space capsules, etc.)

Apparatus

Movements of the head can be measured by attaching to it suitable linear and angular accelerometers in

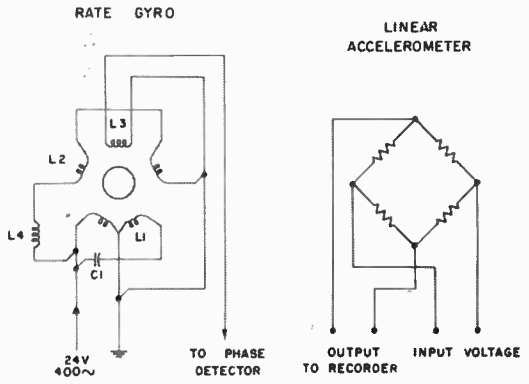
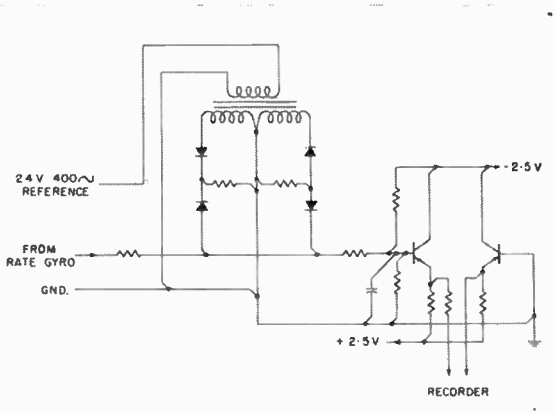


Figure 2. (above) Diagram of helmet gyro and linear accelerometer. Figure 3. (below) Circuit diagram of the phase sensitive detector.



***The Authors**

Mr. Howat *is the supervisor of the electronics section of The Defense Research Medical Laboratories, Downsview, Ont.* **Dr. Johnson,** *of the same establishment, a graduate of McGill University, is in charge of acceleration research.*

each of three orthogonal planes. The angular acceleration sensing devices employed are rate gyroscopes (United States Time Corporation) while the linear accelerometers are G-meters (Statham Transducers), all of which are attached to an RCAF anti-buffeting helmet (Figure 1). The output of each sensing element (six in all) is fed into one of six channels of a recorder; from the record the components of acceleration in each of the three planes are determined. The recorder is attached to the vehicle itself.

The three gyroscopes are mounted on the helmet at right angles to each other so that each responds only to rotation in one of the three orthogonal planes. The gyroscopes are energized by a 24 volt 400 cycle AC supply, and their output signals are demodulated in an "analyser" before being fed into three channels of a Heiland mirror galvanometer recorder (type A-401-R6).

The linear accelerometers, also mounted orthogonally in conjunction with the gyroscopes, are energized by an 8 volt DC supply. These accelerometers are a standard wire bridge type of transducer and have a full scale range of 10g. All arms of the bridge act as sensing elements thus providing maximum sensitivity. The output signals from these accelerometers are fed directly into the remaining three channels of the recorder.

Figure 2 shows the electrical circuit of the linear accelerometers and the gyroscopes. L1 is the motor drive for the gyro rotor, which rotates at 24,000 rpm. Pick-off coils L2 and L3 constitute a rotary differential transformer, in which the phase difference between the primary and secondary currents is always 90°. Because of the multiple pole design of the pick-up transformer, a high output voltage is obtained for a small gimbal deflection. The 400-cycle output voltage from coil L3 is proportional to the angular velocity input of the gyroscope, leading the excitation current by 90° for positive input and lagging by 90° for negative input.

The analyzer (demodulation) unit, suspended on the chest of the subject (Figure I), converts the information from the sensing elements on the helmet into a form usable by the recorder. The phase detector circuits required for the gyros are located in the analyzer and are shown in Figure 3. They consist of four instrument diodes connected in a half-wave switch demodulator circuit which delivers positive and negative output pulses corresponding to the phase differences in the gyro output signal. From the demodulator circuit the signal is fed to a low pass filter which changes the pulsating 400-cycle signal to a varying DC voltage. A balanced emitter follower is used to match the output of the filter to the low impedance galvanometer recorder. Mechanical and temperature stability is obtained by potting each phase detector in a foam rubber compound. Power for the phase detectors is supplied by two mercury cell batteries which, having a capacity rating of 1000 milliampere hours, furnish 150 hours of operation. Provision is included on the front panel of the analyzer for measuring the battery voltages.

The portable six channel Heiland recorder used with this equipment employs six mirror galvanometers (Heiland type 100-350). These galvanometers are electromagnetically damped and have a resonant frequency of 100 c/s. The sensitivity of the galvanometers is approximately 35 microamperes per inch of deflection; one-eighth inch deflection on the record chart corresponds to 1g of linear acceleration (32 ft/sec^2), and to 12°/sec., 24°/sec. and 48°/sec. of roll, pitch and yaw motion respectively (Figure 4). The recorder holds 100 feet of recording paper; with a chart speed of 0.35 inches per second, approximately one hour of continuous recording time is available.

Summary

By the attachment of an array of six accelerometers to a helmet, the angular and linear accelerations of the head can be determined. Such measurements allow more accurate studies of the forces acting on the organ of balance and lead to a better understanding of the physiological problems involved in trajectory and orbital flight by astronauts.

References

1. *Johnson, W. H.*, Head Movements and Motion Sickness, Int. Rec. Med. and G. P. Clinics, December 1954.
2. *Johnson, W. H., Stubbs, R. A., Kelk, G. F. and Franks, W. R.*, Stimulus Required to Produce Motion Sickness, J. Aviat. Med., October 1951.
3. *Johnson, W. H. and Taylor, N. B. G.*, A Review of the Physiological Effects of Angular Acceleration. "Bio-Assay Techniques for Human Centrifuge", Bergeret, P., Pergamon Press, 1961.

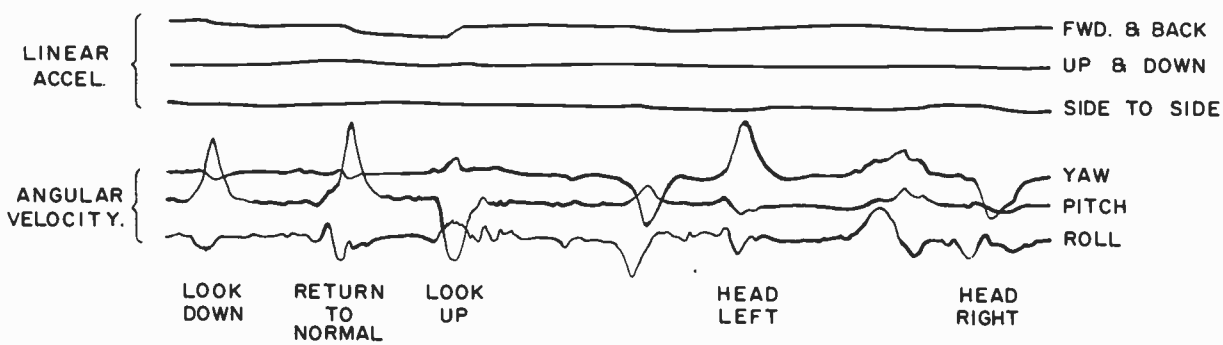
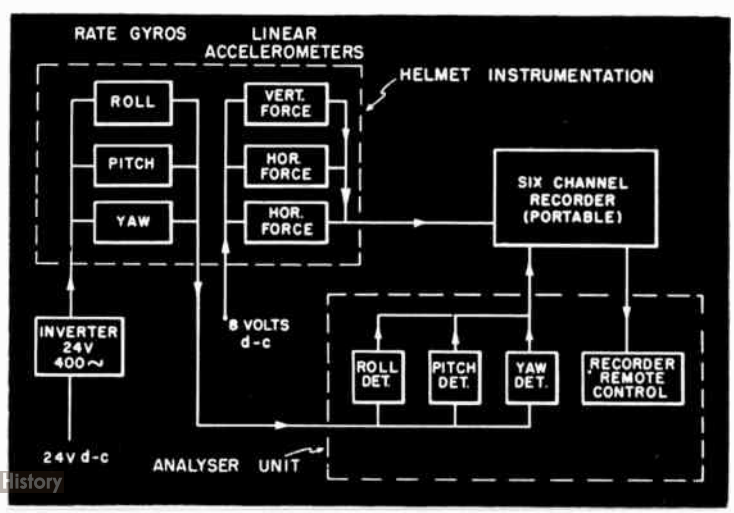


Figure 4. (above) Typical chart recording obtained from the recorder. Shown below is a block diagram of the whole system.



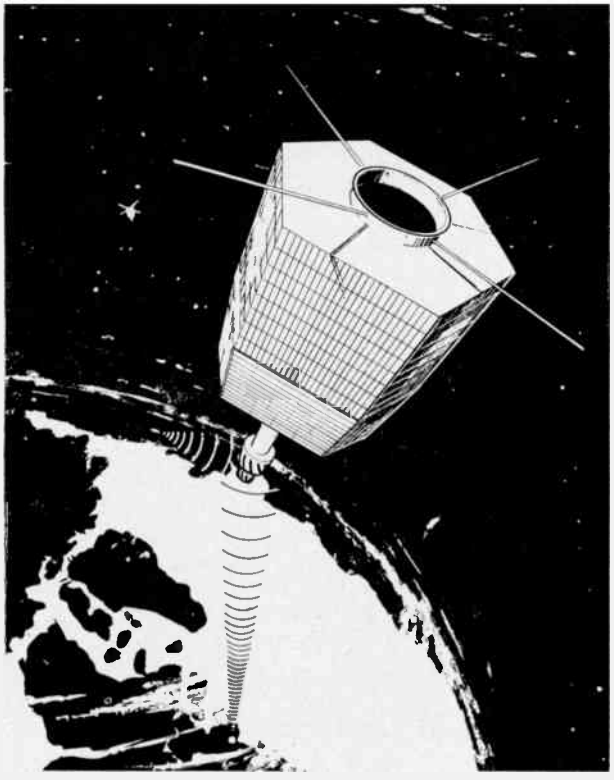


Figure 1. Impression of the RELAY satellite in orbit passing over the Atlantic and linking Europe with North America by line of sight communication.

The project RELAY communication satellite system

(based on material supplied by RCA-Victor, Montreal, P.Q.)

Introduction

One often hears remarks to the effect that space research is all very well but what are the tangible benefits of such activity? In many instances it is not easy to give an immediate and all-encompassing reply to questions of this kind, but in the field of communications by orbiting satellites we are able not only to show that this technique parallels other methods, for example, submarine cable and conventional radio, but for future requirements far outclasses these competitors both in regard to technical performance and sheer economic factors.

Explanation for this derives from the conflicting requirements of ever-increasing communication traffic density on the one hand and restricted bandwidth and frequency allocations on the other. Communication by satellite, as indicated in Figure I is by line of sight and consequently very much higher frequencies can be used giving much greater channel capacity.

The need for this bandwidth expansion can be judged from the fact that in 1960, approximately three million overseas telephone calls were made in the United States. This number is expected to reach twenty-one million by the end of the present decade and perhaps one hundred million by 1980. Satellite systems are the only way known to meet the requirements of this "communication explosion".

In the case of the final system arising from project RELAY, and using telephone capacity as the criterion it is expected that the total system cost will be about one fifth of equivalent submarine telephone cables.

Of particular importance is the fact that satellites will enable world-wide television to be accomplished on a high quality reliable basis, existing communication channels being entirely inadequate for achieving this type of transmission.

Project RELAY — objectives

Project RELAY is a system of ground stations and satellites, designed as an experiment in world-wide communications. It is sponsored and paid for by the National Aeronautics and Space Administration (NASA), an agency of the U.S. Government, with the exception of ground stations being built and paid for by other national governments.

The main objectives of the program are:

1. To accelerate the development of communication satellite technology.
2. To develop a working system of wide-band microwave communication for distances over, say, 3,000 miles.
3. To develop ground station operational techniques.
4. To increase our knowledge of spacecraft design.
5. To increase our knowledge of the space environment.

Particular achievements expected from the RELAY I system are television transmission between North America and Europe and one-way and two-way simultaneous telephony, between North America and South America.

Booster system and Orbital elements

Three or four satellites are planned for RELAY I. The first should be launched early in the summer of 1962 from Cape Canaveral, Florida. The launch vehicles will be Thor-Delta 3-stage rockets, built by Douglas Aircraft.

The satellite will be launched from Cape Canaveral at an inclination of 54° to the equator. The orbit will be elliptical, with an apogee (highest point) of 3,000 miles and a perigee (lowest point) of 800 miles.

The period, or time taken to complete an orbit, will be 163 minutes and the satellite will be "visible" for use between any two ground stations for roughly 30 minutes. By injecting more satellites into the same orbit it will be possible to maintain almost continuous contact between stations by switching from the satellite "setting" to the next one "rising".

The life of the satellite is expected to be one year,

although it will be considered a success if it continues to operate electrically for three months. The orbit passes through the severe radiation of Van Allen belts.

Project RELAY I Satellite

Figure 2 shows the general arrangement of the satellite. External construction resembles an eight-sided barrel, about 32" long and 29" diameter, with eight flat faces. Including the main antenna, which protrudes from the end pointing towards the earth, it is about 4½ feet long. The outside is covered with solar cells, to provide electrical power from the sun's rays. The internal structure is a space-frame constructed from aluminum alloys, and the internal equipment consists of the communications electronics, storage batteries, telemetry equipment, and some apparatus for radiation experiments. The total weight of the satellite will be about 135 pounds, of which the basic structure represents only 10%.

To stabilize its position in space, thus ensuring correct antenna pattern orientation relative to the earth, the satellite has a spin rate of 120 r.p.m. and is equipped with a magnetic ring controlled from the ground which allows small corrections of attitude to be made.

Vital parts of the satellite electronics, designed and built by **R.C.A. Victor, Montreal,** include the Wideband-Narrowband Repeater and the CW Beacon. In addition, the company has been called upon to design and build a Satellite Simulator and to perform overall systems engineering studies and analyses to help determine ground station requirements and satellite component performance.

The Wideband-Narrowband Repeater is the heart of the satellites electronics. This unit receives the weak signals from the ground station, amplifies them, and sends them back to earth to the receiving station. It will handle television, telephony, and data-transmission signals.

Design and development of this unit brought about several significant "firsts" e.g. The first microwave repeater designed in less than one year. The first microwave repeater designed for an airborne environment. One of the first entirely solid-state heterodyne microwave repeaters with the exception of the TWT. The first microwave repeater achieving this degree of miniaturization.

The C.W. Beacon sends out a continuous signal at a discrete frequency. It will be used to locate and track the satellite. Without this facility, it would be impossible to locate the satellite with sufficient accuracy for the ground stations to operate, and is consequently a very vital unit.

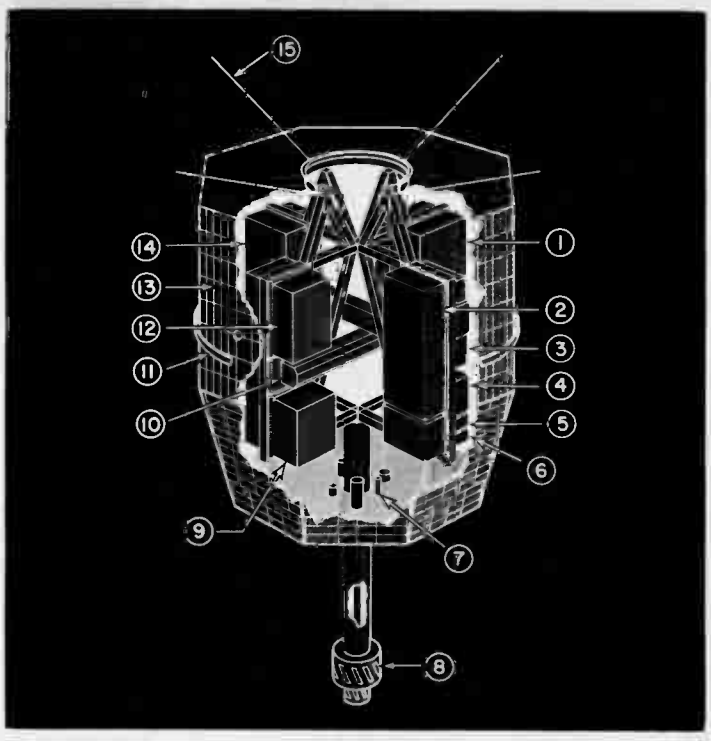


Figure 2. Diagram showing main components of the RELAY I satellite:
(1) Travelling wave tube power supply.
(2) Radiation effects experiment.
(3) Receiver exciter.
(4) Encoder.
(5) Decoder.
(6) Receiver and subcarrier demodulator.
(7) Radiation sensors.
(8) Wide-band antenna.
(9) Receiver and travelling wave tube exciter.
(10) Travelling wave tube.
(11) Attitude control coil.
(12) Travelling wave tube power supply.
(13) Solar cells.
(14) Batteries.
(15) Telemetry antenna.

The Satellite Simulator. This is a piece of ground equipment used by the Ground Stations to check out their equipment prior to contacting the satellite. The units produced will be distributed around the world to the various governments participating in the project.

Canadian satellite

Continued from page 32

Sounding program

Arrangements have been made to turn the satellite on and carry out topside ionospheric soundings at 13 ground telemetry stations located in Canada and around the world.

When all equipment is on, the satellite power consumption is 35 watts. Since the solar cells provide about 10 watts (averaged over 24 hours) when the satellite is in a minimum sunlight orbit the equipment can be operated for only five hours in 24 hours. However, this allows sufficient time for all passes within good telemetry range of all the ground stations. The condition of the batteries will be closely monitored and if necessary the sounding program will be adjusted accordingly.

Each station has a command transmitter and receivers for both the FM and PM telemetry systems. All information, along with a suitable satellite time code, will be recorded in seven channels on half inch magnetic tape. The tapes will be sent to DRTE at Ottawa where a data reduction center will convert the stored information to photographic ionograms and paper chart records (for temperature and battery currents and voltages) as required by the users. The design life of the satellite is one year and since, during the lifetime of the satellite, tape records will arrive at Ottawa at a rate requiring eight hours of processing a day, a very large amount of data will be accumulated. It may be desirable to direct future effort toward some form of automatic or semi-automatic data analysis.

Conclusion

The S-27 is a complex spacecraft containing two primary experiments, the topside sounder and the cosmic particle equipment, and two secondary experiments, the very low frequency receiver and the cosmic noise measurements. Auxiliary equipment includes temperature, voltage and current monitors, power supply batteries and converters, telemetry and command systems

Continued on page 68

Magnetohydrodynamics – an introduction

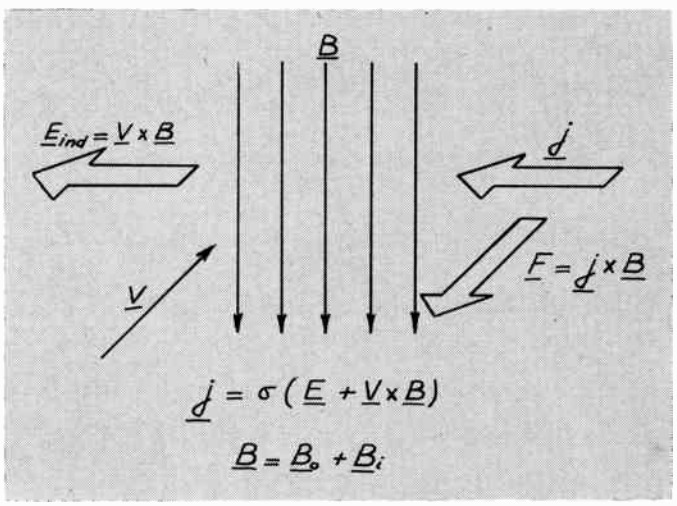
. . . . article outlines basic considerations relating to the interaction of a conducting gas and electromagnetic fields. This subject is of vital importance to spacecraft design . . . .

by Dr. J. D. De Leeuw*

The subject of this paper has all the appearances of being a young one. The fact that we have this special Space Electronics issue is a sign in itself and in addition one might see some indication for it in the existence of a confusing multitude of names for the subject which overlap to a very large extent. We have plasmadynamics, magnetofluid, aero or gas dynamics and even hydromagnetics. However, as is so often the case, the subject was already known in principle for quite a long time. Just about 130 years ago, Faraday did some experiments in this field and speculated that the large scale motion of the oceans might be responsible for the changes in the earth's magnetic field. Around the turn of the century some designs for magnetogasdynamic power generators had already been proposed, and in 1909 Larmor suggested that the earth's magnetic field and that of the sun might be due to a self-generating magnetogasdynamic action.

The recent sudden increase of interest took place originally in astrophysics when it was realized that most matter in the universe is a conductive medium. In addition, the higher speeds of flight attained in the last few years in which enough flow energy is present to ionize the air and so provide conductivity, hinted at the possibility of influencing the flow field, hopefully in a controlled and desirable manner. Then there is the vast field of problems associated with nuclear fusion research and the very attractive possibility of accelerating conductive fluids to high velocities which could well result in feasible space propulsion units.

Figure 1. Diagram showing directions of force components in ionized flow in the presence of a magnetic field.



It is clear that in the space available only a small selection from the large amount of material can be discussed and in this paper only some general concepts of magnetogasdynamics will be dealt with in which a conductive fluid in the classical sense is considered, i.e. the microscopic structure is ignored, rather we think of a continuous medium which possesses the property of electrical conductivity. In that way we hope to evade the complications of having to consider the different particles, like electrons and ions, separately. However we shall see a little later that to be realistic we have to modify this view to a certain extent.

After the discussion of the general concepts, a few examples of magnetogasdynamic flows will be given as they have been obtained in the laboratory with plasmas that were produced by heating the gas through a shock wave.

The basis for magnetogasdynamics is the simple fact that an observer moving in a magnetic field will measure an induced electric field in addition to the electric field that exists for an observer at rest. If the magnetic field of strength B is vertical and directed downward, and for simplicity a velocity at right angles to this field of magnitude V is considered, then this induced electric field will have a magnitude of V times B and is directed perpendicular to both velocity and magnetic field. In this case it will be pointing to the left, as shown in Figure 1. In mathematical vector notation $\underline{E} = \underline{V} \times \underline{B}$. If we have a conductive medium moving in this way through the magnetic field, this induced electric field will tend to cause an induced current to flow in the same direction if there is no other source for an electric field. At this stage it will be assumed that the conductive medium can be characterized by a simple conductivity σ, i.e. a current will flow in the direction of the total electric field.

The magnetic field exerts now a force on the current carrying medium, which is perpendicular to the magnetic field and the current. This force will point for the simple example in Figure 1 in the direction opposite to the velocity, and in vector notation $\underline{F} = \underline{j} \times \underline{B}$. It may be noted that this is a very familiar result. The induced electric field corresponds to the voltage of a

*See page 65

generator and the force in the direction opposite to the motion leads in the case of a generator to the need for a driving torque.

In general there will also be other sources for the electric field, so the law for the current flow should be written:

$$\underline{j} = \sigma(\underline{E} + \underline{V} \times \underline{B})$$

Now, unlike the case of the solid conductor moving in a generator, the situation is more complicated because the velocity V is that of the fluid and its motion is influenced by the Lorentz force j x B. Furthermore the value of B in the expression has to take into account the magnetic field due to the induced currents in the fluid as well as a possible imposed magnetic field, say from magnets situated outside the fluid. So to oversee the entire situation in some detail each of the interactions will be discussed separately.

First, the influence of the currents on the magnetic field is considered. It is convenient to think of two separate contributions to this field: that due to magnets external to the fluid region, B_0, and that induced by the currents in the fluid, B_i. For simplicity it may be assumed that the external field does not vary with time.

The Author

Dr. J. D. De Leeuw *is an Assistant Professor at the University of Toronto (Institute of Aerophysics) and lectures in the subject of plasma physics. He is also conducting research work in the field of extremely low density plasma.*

The magnetic field associated with the induced current satisfies the well-known theorem that a line integral of this magnetic field is equal to the total enclosed current times the permeability, which is expressed by

$$\oint \underline{B} \cdot \underline{dl} = \mu \int_s j \cdot d\underline{S}'$$

If we estimate the magnitude of the two sides of the equation in terms of a typical length L, we get the expression

$$B_i L = \mu j L^2$$

We can go a step further by estimating the induced current by using Ohm's law and introducing a typical velocity V, which gives

$$B_i = \mu\sigma VBL$$

or expressing the total magnetic field in terms of its two parts

$$\frac{B_i}{B_0 + B_i} = \mu\sigma VL$$

When B_i is rather small in terms of the external magnetic field we may in approximation write

$$\frac{B_i}{B_0} = \mu\sigma VL = Re_m$$

This quantity is called the magnetic Reynolds number and as was just demonstrated, when it is smaller than unity, it gives an indication of how much of the total magnetic field differs from the externally imposed magnetic field. If the value of Re_m in a problem is much smaller than unity, the magnetic field will be close to the usually accurately known external magnetic field, and one of the basic magnetogasdynamic interation mechanisms is inoperative.

On the other hand, when the magnetic Reynolds number is much larger than unity, the foregoing simple interpretation is no longer meaningful. The induced magnetic fields will be of major importance and it can be shown that the behavior of the conductive fluid is much like that of an ideal conductor.

It is well known that such a conductor successfully protects its interior from changes in the magnetic field and the same holds for the behavior of the motion of a conductive fluid when it is characterized by a large magnetic Reynolds number. The magnetic flux through a small imaginary loop in the fluid that moves with the fluid particles will not change and we may describe this loosely by saying that the magnetic field lines are firmly attached to the fluid particles.

It is of interest to have a look at the values of the magnetic Reynolds number for a few typical cases:

1) molten core of the earth

$$\left.\begin{aligned} \sigma &= 10^6 \text{ mho/m} \\ V &= 10^{-4} \text{ m/sec} \\ L &= 10^7 \text{ m} \end{aligned}\right\} Re_m = 10^3$$

2) nuclear fusion exp't — dynamic pinch.

$$\left.\begin{aligned} \sigma &= 10^7 \\ V &= 10^4 \\ L &= 10^{-2} \end{aligned}\right\} Re_m = 10^3$$

3) Hot ionized — hypersonic flow

$$\left.\begin{aligned} \sigma &= 10^2 \\ V &= 10^4 \\ L &= 10^{-2} \end{aligned}\right\} Re_m = 10^{-2}$$

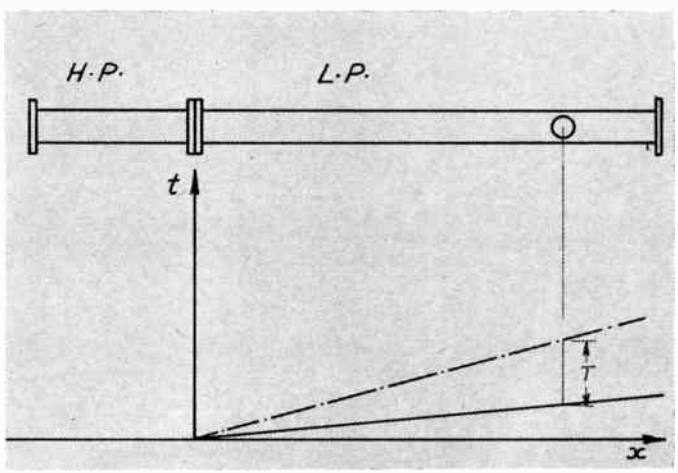
4) Flow of Hg.

$$\left.\begin{aligned} \sigma &= 10^6 \\ V &= 1 \\ L &= 10^{-2} \end{aligned}\right\} Re_m = 10^{-2}$$

5) Shock Tube — Laboratory

$$\left.\begin{aligned} \sigma &= 7 \times 10^3 \\ V &= 5 \times 10^3 \\ L &= 10^{-2} \end{aligned}\right\} Re_m = 3.5 \times 10^{-1}$$

Figure 2. Basic principle of the shock-tube. Diagram below shows the shock position (solid line) and the boundary between the two gasses (broken line) both as a function of displacement.



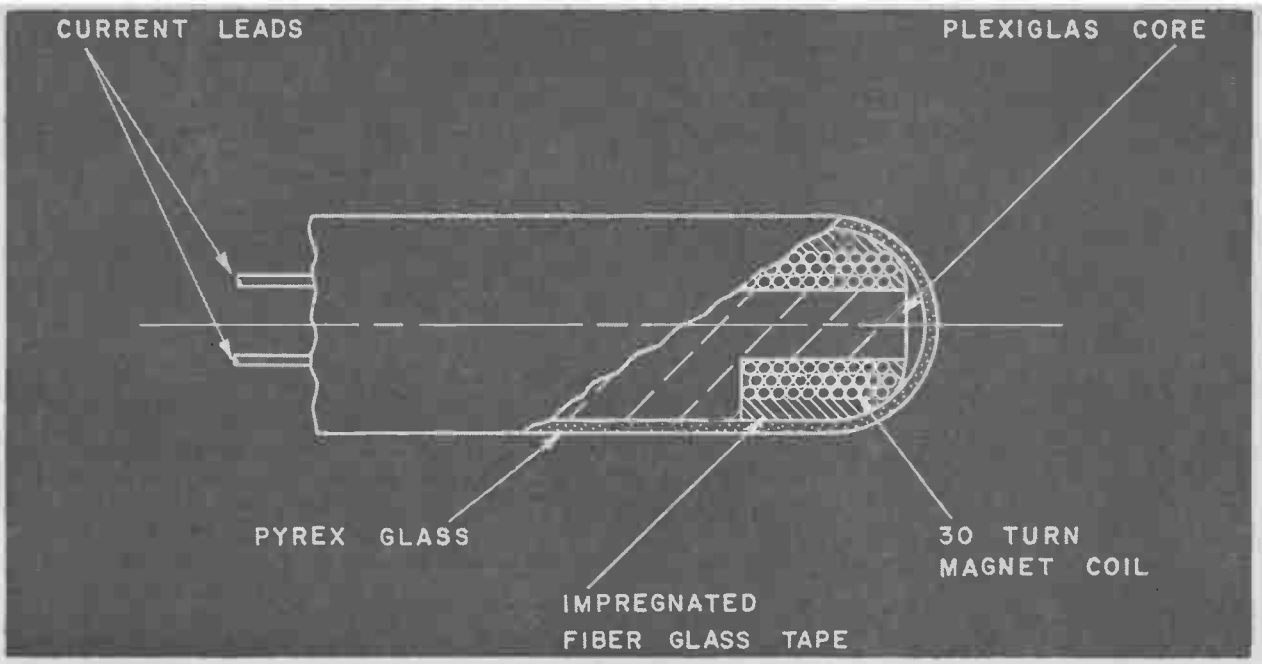


Figure 3. Diagram showing a hemispherical-nosed hypersonic flow model which contains a coil for generating a magnetic field.

From these examples, it is seen that in situations which involve large lengths, like that of the earth's core and problems of gas clouds in the universe the magnetic Reynolds numbers is large and the magnetic field lines and fluid are constrained to move together. The same situation is true for the conditions of dynamic nuclear fusion experiments. However, here only those cases of interest to the aerodynamicist are considered where the magnetic Reynolds number has a relatively small value, a situation which fortunately can be reproduced with laboratory equipment of moderate cost.

Next the magnetic influence on the fluid flow will be examined. The fluid flow equation of motion has the following typical form:

$$\rho \frac{D}{Dt} \cdot \underline{V} = -\nabla p + j \times \underline{B} + \eta \nabla^2 \underline{V}$$

where ρ = fluid density
p = pressure

Essentially this equation states that mass x acceleration equals pressure forces + Lorentz forces + viscous forces. We shall ignore the viscous forces in our discussion and make an estimate of the magnitude of the inertia forces and the Lorentz force through which the magnetic field influences the flow.

For this purpose we express a typical time in the flow field in terms of the velocity and a typical length

$$t = \frac{L}{V}$$

In this way we obtain the interaction parameter S

$$S = \frac{\text{Lorentz force}}{\text{inertia force}} = \frac{j \times \underline{B}}{\frac{\rho V^2}{L}}$$

Now the magnitude of j x B can be estimated in two ways. To be consistent we choose the one appropriate to a relatively small magnetic Reynolds number. In that case we use Ohm's law and get j x B = σVB^2. So that we find for the interaction parameter

$$S = \frac{\sigma B^2 L}{\rho V}$$

We see that the parameter S depends strongly on the magnetic field and a decrease of the density will be helpful to make S large. In most cases it is necessary as a result of the small sizes of equipment of reasonable cost to use both as large a value of B and as small a value of ρ as possible and unfortunately this brings in an additional complicating factor. Our basic assumption so far was that the conduction process could be described by a simple, linear Ohm's law. However, one might have been suspicious about this, because solid conductors in a magnetic field show a Hall effect and the same is true for a conductive gas. This is caused by the fact that in a magnetic field charged particles do not on the average travel along electric field lines but have a tendency to describe curved paths around the magnetic lines which makes their mean positions move at right angles to the electric field. The time for a complete cycle of a charged particle around a magnetic field line $\frac{1}{\omega}$, is inversely proportional

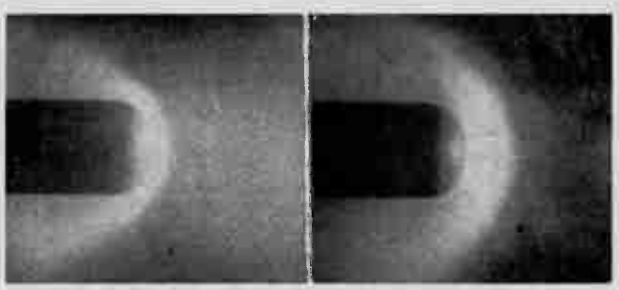


Figure 4. (left) Flow distribution without a magnetic field. (right) Flow with a magnetic field. Note that hot plasma is pushed away from the model thereby reducing heat transfer from the gas.

to the magnetic field strength. Now, if the density of the gas is high the mean time between collision of electrons and the ions and other gas particles, τ, may be much shorter than the time for a complete cycle with the result that the curved paths are frequently interrupted and the electrons pretty well follow the electric field lines. The simple Ohm's law is then a good description of the conduction process. However, when the density is low and the magnetic field strength is high, the electrons describe appreciable portions of their curved trajectories or even may complete several between collisions and an extra term has to be included in Ohm's law. The detailed derivation has to be based on a more general theory for a plasma in which electrons and ions are considered as separate gases. The derivation is complicated, but the generalized Ohm's law would be of the form

$$\underline{j} = \sigma\left[\underline{E} + \underline{V} \times \underline{B} - \frac{\omega\tau}{\sigma B}(\underline{j} \times \underline{B})\right]$$

expressing the fact the last term, describing the Hall effect, is only important when the ratio of collision time to the time for a completed turn as indicated by $\omega\tau$ is appreciable compared with unity.

As a result of the desire to make S large in the experiments, it often happens that $\omega\tau$ is not negligible and of course the more complicated current pattern will show its influence on the resulting flow field.

The experiments that will demonstrate some magnetogasdynamic effects were performed in a shock tube. A shock tube consists essentially of a long pipe which is separated by a diaphragm in two sections as shown in Figure 2. One of these is brought to a high pressure, the other one is usually at a very low pressure, something like a hundredth of an atmosphere. The pressure difference between the two sections is supported by the diaphragm until this is broken by some device. Then there is a large pressure unbalance and the high pressure gas on the left will flow into the section at the right and in so doing it will compress the gas in that section. This compression is not a gradual process. Actually it takes place through a shock wave which instantaneously brings the low pressure gas to a pressure somewhat lower than that originally present in the high pressure section and at the same time imparts a high velocity towards the right. This shock wave moves very rapidly and a typical speed in the experiments would be 16,000 ft/sec. The gas that was originally in the high pressure section will also move rapidly into the other section, somewhat behind the shock wave. We can represent these phenomena in a distance-time diagram in which we plot the paths of the shock wave and the boundary of the gas that was originally to the left of the diaphragm. In Figure 2, the heavy black line represents the shock position, the dashed line the boundary between the two gases.

The experiments are usually performed near the downstream end of the tube and at that location the diagram indicates that there will be a length of time T, perhaps of 100 microseconds duration during which the compressed low pressure gas flows in a steady fashion past the test station. Since the compression ratio for this gas can be made to be as high as several hundred, the gas is strongly heated. Temperatures of 10,000°K, i.e. twice the surface temperature of the sun, can be readily obtained. As a result of the high temperatures the gas becomes a (luminius) plasma and it is therefore conductive. The length of time it exists is sufficient for the experiments.

The first experiment was done at the Ramo-Wooldridge Corporation. It concerned the flow near the front end of a hemispherical body. The model that was used is shown in Figure 3. A small magnet was placed in the interior of the body and could be pulsed to give a peak magnetic field at the nose of 40,000 gauss. The values of the interaction parameter were as high as 60 by working at very low densities. The magnetic field lines are roughly perpendicular to the body surface and since the flow has to move in a radially outward direction, the induced electric field will be in a circumferential direction, producing forces trying to restrain this radial motion of the gas flow.

Figure 4 shows a picture of the flow without and with the magnetic field. Without the magnetic field the flow is slowed down by a bow wave near the nose and in losing kinetic energy the gas becomes hotter which shows up as a region of increased luminosity behind the bow wave. When the magnetic field is on, the radial constraint on the flow makes the region of retarded flow considerably larger as shown in the photograph to the right. It may be noted here that the increased distance of the bow wave is associated with a decrease in heat transfer at the nose, which is a desirable feature for re-entering bodies.

The second experiment was performed at the AVCO Research Laboratories. In this case a loosely wound solenoid was placed directly in the stream. Figure 5 shows the solenoid from the side and the magnetic field is perpendicular to the page inside the solenoid and almost zero outside. The flow is coming from the left. The induced electric field is in the vertical direction in the interior of the solenoid and virtually zero outside. The currents will therefore move almost in a vertical direction inside the solenoid in one way and will close outside the solenoid. The forces on the flow are against the direction of flow and decelerate the gas. Again the loss of kinetic energy heats the gas and we see it as an increase of luminosity. In Figure 5 the interaction parameter $S = 0.3$, $\omega\tau = 0.6$ and the magnetogasdynamic effect is not very large. When interaction is somewhat stronger say, $S = 1.7$ the magnetic field is quite effective in slowing down the flow in the open spaces between the wires of the solenoid.

Figure 6 shows a moderately strong interaction ($S = 1$) with a value of $\omega\tau = 5$ and it is seen that the Hall effect seriously disturbed the symmetry of the flow pattern, indicating the need for considering this effect.

It is hoped that this short paper has served the purpose of introducing some of the concepts of magnetogasdynamics. The present period is one of further experiment, theoretical work and development and it may be anticipated that this effort will result in a number of important engineering applications.

Figure 5. Solenoid directly in flow field: $S = 0.3$ and $\omega\tau = 0.6$. (photograph courtesy of The AVCO Manufacturing Corp.)

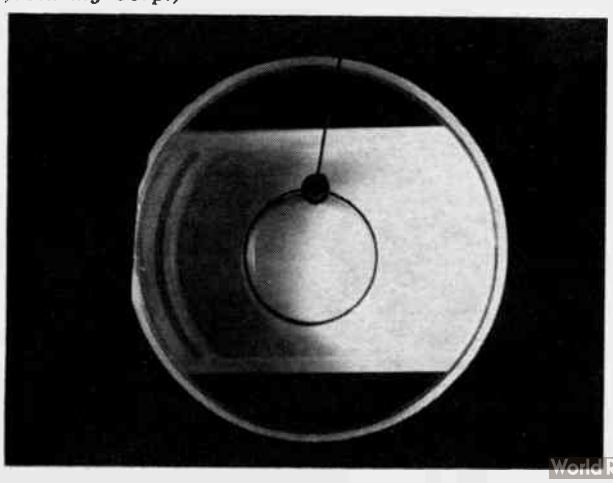
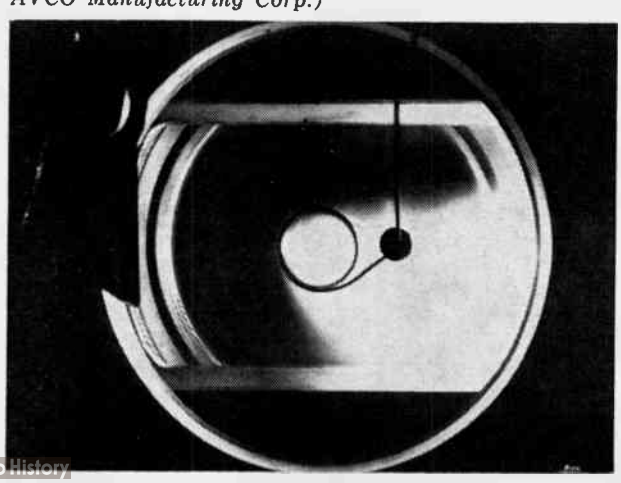


Figure 6. Same conditions as for Figure 5 except $S = 1.0$ and $\omega\tau = 5.0$. (photograph courtesy of The AVCO Manufacturing Corp.)



Canadian satellite

Continued from page 63

and the beacon. All this equipment is carried in a structure which must be accurately dynamically balanced and must withstand extensive vibration and high accelerations. Finally, an antenna of novel mechanical design must operate successfully in the space environment. Ultra conservative design and extensive and rigorous testing have been used wherever possible to ensure the maximum probability of success.

This project has been made possible through the provision by the National Aeronautical and Space Administration of the Thor-Agena launching rocket and associated range facilities which will be used to inject the S-27 Topside Sounder into orbit in the third quarter of 1962.

TABLE I

S-27 Satellite Characteristics

Orbit	
Circular	625 miles (1000 km)
Inclination	80° toward the east
Sounder	
Transmitter Frequency Sweep	1.6 to 11.5 Mc
Receiver Frequency Sweep	0.5 to 13.0 Mc
Transmitter Power	100 watts pulse
Modulation	100 μsec pulse with 67 cps prf
Telemetry #1	
Frequency	136.080 Mc
Transmitter Power	2.0 watts nominal
Modulation	FM ±40 kc max. deviation
Data inputs	(1) Sounder receiver output (2) Sounder line and frame sync pulses plus frequency markers (3) 22 kc subcarrier carrying redundant data
Telemetry #2	
Frequency	136.590 Mc
Transmitter Power	250 milliwatts
Modulation	PAM/FM/PM ±0.8 radians rms deviation by 4 IRIG subcarriers
Data inputs	(1) Channel 9 - 3.9 kc, 35 point PAM commutator, battery voltage, temperatures, charging currents (2) Channel 11 - 7.35 kc particle detector (3) Channel 12 - 10.5 kc Cerenkov detector (4) Channel 13 - 14.5 kc cosmic noise data, frequency marker pulses
Beacon	
Frequency	136.980 Mc
Transmitter Power	50 milliwatts
Modulation	None
Command Link	
Seven tone AVCO system	12 commands

Acknowledgments

The Sinclair Radio Company, Toronto, Ontario, carried out the electrical design of the sounding antennas and associated matching network, and the telemetry antennas and multiplexer.

The De Havilland Company of Canada, Downsview, Ontario, in close association with the DRTE mechanical design group, carried out the design of the spacecraft structure and the long antennas and extension mechanism.

Antennas

Continued from page 49

Research Laboratories. This unit uses the original Mylar pull-out tape system.

The Model A.1 MK11 unit designed and built for DRTE is shown diagramatically in Figure 10 (See article on page 29, and is being used as an antenna system in the Canadian S.27 Topside Sounder satellite, due for launching late in 1962. Rubber belt-driven, the A.1 MK11 is capable of antenna lengths up to 75 ft., using 0.9 ins. diameter steel element.

The forerunner of the more recent STEM designs is however the Model A.16, 60 ft. erectable boom, a moving guide unit with an element of 0.5 ins. nominal diameter beryllium copper shown in Figure 11. This all metal unit uses no lubrication outside the electric motor package, and has operated satisfactorily after two weeks in a vacuum. These were built for the Applied Physics Laboratory of Johns Hopkins University, and one unit is presently in orbit in the APL TRAAC satellite. The radio lead-off boom is designed to eject a 7 lb. weight attached to its end to operate as a gravity gradient stabilizer*, ensuring that the satellite is correctly oriented in relation to the earth's surface.

*Gravity gradient stabilization may provide a remarkably simple and reliable solution to the satellite attitude control problem. This method could eliminate the involved array of horizon scanners, reaction jets and control systems which possess limited life and reliability.

Figure 12 shows a 30 ft. Model A.18 antenna unit, six of which will be used in each of the S.48 satellites being designed and built by Airborne Instruments Laboratories Inc. These units use a moving drum, tangential lead-off design with 30 ft. of element. The unit weighs 1.5 lbs., and represents a great advance over the original A.2 type.

The Model A.21 unit, presently under construction for the United States Naval Research Laboratories and shown in Figure 13, is the first superlength unit, and is capable of ejecting 1,000 ft., of 0.5 ins. diameter element. However, even longer units up to 5,000 ft. are being considered for space use.

Also under development is an extensible space boom suitable for use with magnetometers and other instruments for the Jet Propulsion Laboratory of The California Institute of Technology.

Conclusions

The STEM family is rapidly expanding into new areas, and there seems no doubt that this new application of a relatively simple concept has enormous potential. Technically, it fulfills a function nothing else can, and innately, who has not wanted, at one time or another to witness the artistry of someone truly succeeding at the Indian rope trick?

Acknowledgments

Acknowledgments are due to the writer's colleagues at De Havilland, Sinclair Radio Laboratories Limited, and to The De Havilland Aircraft of Canada, Limited, for giving permission to publish this article.

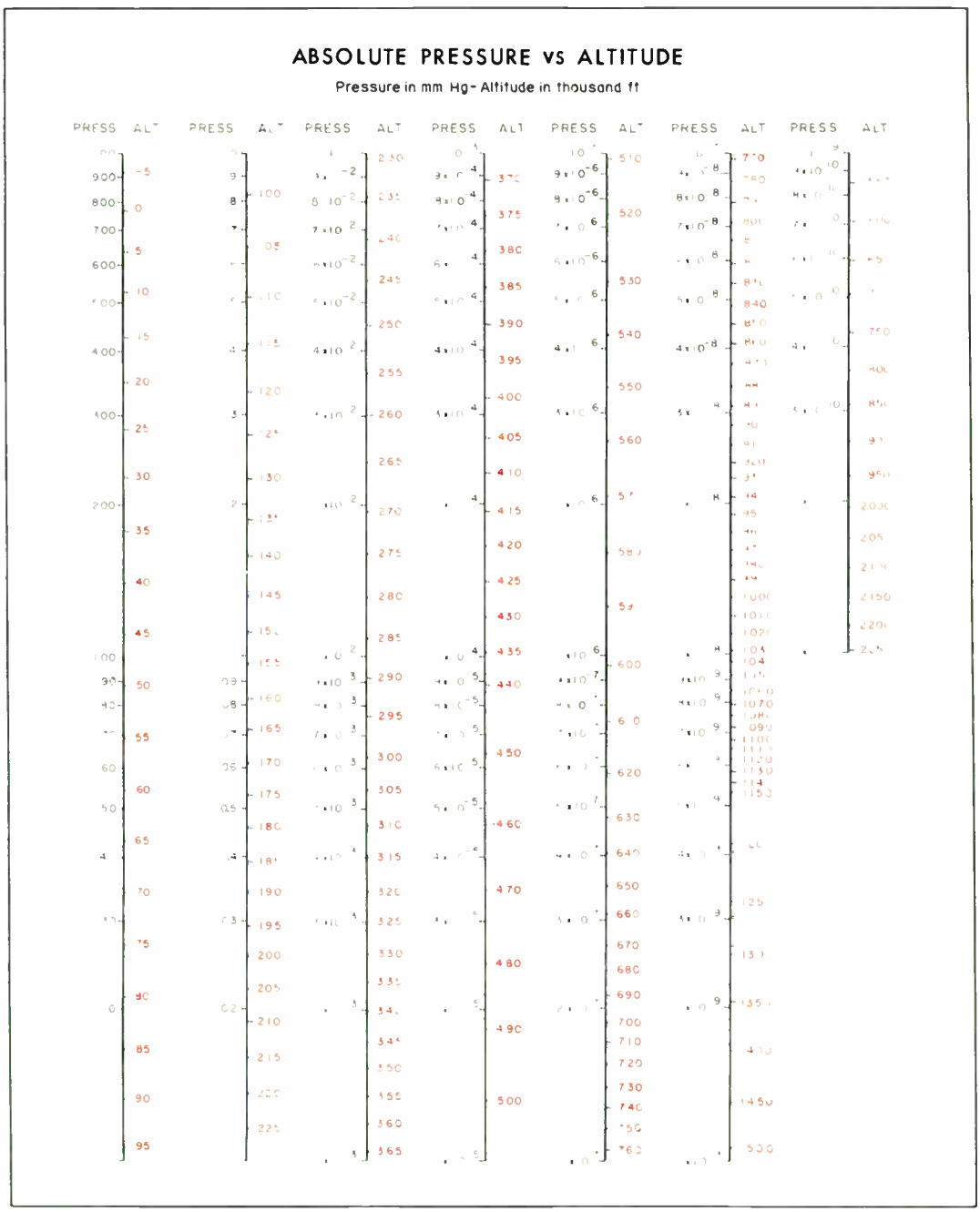
**in gravity gradient stabilization the boom, with or without an added mass effectively re-distributes the mass of the total satellite to make it appear like a long beam. In time, usually after about 10 orbits, the unbalance gravity forces acting about the beam result in the alignment of the long axis of the system with a line passing through the center of the earth.*

Absolute Pressure/Altitude Chart

. . . . this chart is based on the ARDC Model Atmosphere but has been corrected to reflect actual data from rockets and satellites . . . . chart is most up-to-date presentation known

by Gene Byrnes

(this chart reprinted through the courtesy of Scientific Engineering Laboratories Inc., Woodland, California, U.S.A.)



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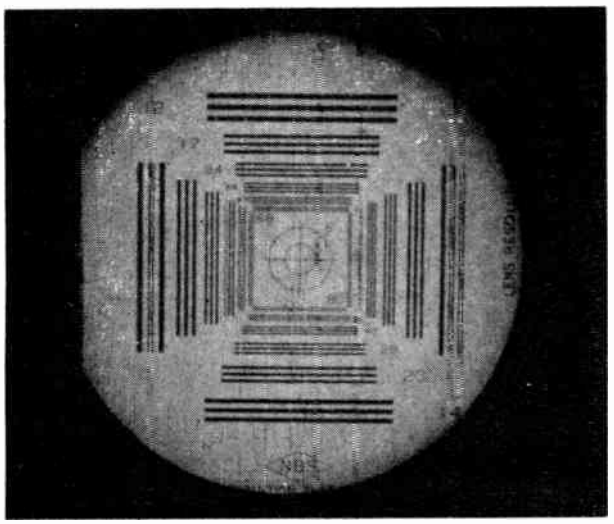
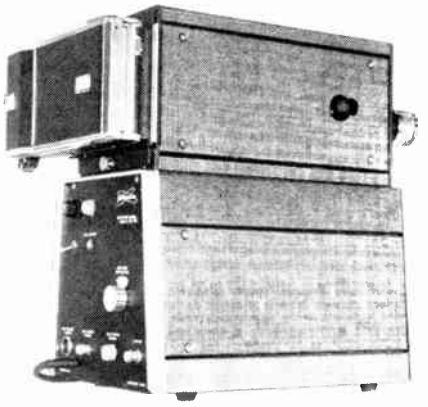


This is an actual size portrait of an NBS resolution chart taken at 0.1 microsecond with an Abtronics electronics framing camera

Announcing the Model 2 SINGLE FRAME ELECTRONIC CAMERA



The Model 2 Electronic Camera uses an Abtronics IC 1.2 image converter diode to provide a single frame exposure with provisions for combining any number of units in a system for multiple frame applications. For focusing and alignment of the image a D.C. voltage is applied to the image converter tube, the anode image may then be viewed through a conveniently located port. A mechanical shutter on the recording camera prevents exposing film while focusing and adjusting.

The basic camera comes complete with objective lens and Polaroid type roll film recording back. An interchangeable 4" x 5" back is available. Priced at only $2,925, the new camera offers highest performance at lowest price.

SPECIFICATIONS — Exposure times, 0.01, 0.1, 0.3, 1.0 microseconds; image size at film plane, 2.5" dia.; resolution, 10 line pair/mm; size overall, 10" x 15" x 16"; weight, 30 lbs.

New FOUR CHANNEL TIME DELAY UNIT

Abtronics Model 100 is a general purpose laboratory delay unit designed for use with the Model 2 camera to trigger delayed shutters or fire such auxiliary equipment as flash guns. It is also useful in camera systems where a number of photos are being taken at remote points and/or in sequence. Combining the delay unit with the new low price Model 2 camera offers the user exceptional flexibility and economy in the design and construction of camera systems.

SPECIFICATIONS—Number of channels, 4; time delay per channel, 1-10,000 microseconds; time delay main dial, calibrated from 1 to 3.5 microseconds; smallest scale division, .05 microsecond; outputs: front, ± 50 volts — into 50 ohms, rear, ± 500 volts — into 100 ohms or 250 volts (jumper change), pulse width, 2 microseconds, other output levels available; repetition rate, single pulse — 1 pulse per sec. max.; size, 7" x 19" standard panel with enclosed chassis; weight, 24 lbs.; price, $1,395.

Model 1 ELECTRONIC CAMERA

Abtronics Model 1 Framing Camera is the most advanced electronic high speed framing camera on the market today. Features include an all electronic shutter capable of operating at 0.1 microsecond, independent time delay for each of the 4 frames adjustable from 1-1000 microseconds, independent focus and aperture adjustment for each channel. Self contained and ready to operate, the camera weighs only 80 pounds. The Model 1 takes pictures in black and white and color, including self-illuminated objects such as explosives and electrical discharges. Applications include ordnance studies, shock wave studies, electrical discharge studies, high speed laboratory photography, missile launching, and combustion studies.

Other key features are: Exposure time per frame, 0.1, 0.3, 1, 3, 6 microseconds; effective resolution, 10 line pairs per millimeter; time delay accuracy, 3%; price, Model 1 with lenses, two camera backs, 4 extension tubes, and 6 rolls of Polaroid type film ready to take pictures—$9,275 f.o.b. Livermore, California. Also available with 4 separate recording heads, $11,000.

For complete information, please address

abtronics inc.

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Represented in Canada by ALLAN CRAWFORD ASSOCIATES LTD., 4 Finch Ave. W., Willowdale, Ontario, Canada; 225-7771. In Montreal: RE. 9-6776.

For complete details check No. 20 on handy card, page 79

product panorama

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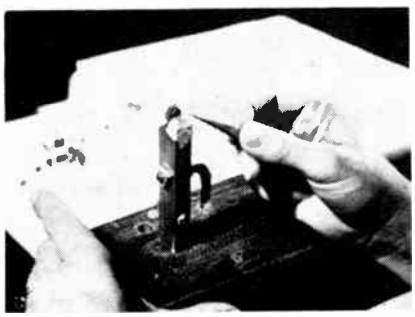
Precision tweezers

Item 267

Range of 75 Hunter precision tweezers for electronics and miniature instrument assembly are available. Called Hunter Erem tweezers, they include all Dumont and Boley styles and also specially-developed types which are now stock items. Most



styles available in regular carbon steel, special Eremite anti-acid and antimagnetic stainless and certain types are stocked in nickel, silver and brass.

Len Finkler Ltd., 2 Tycos Drive, Toronto, Ontario.

Miniature portable power source

Item 268

Designated MP 40-0.5 this unit is designed for convenient bench use to provide bias and other voltages. DC output is 0 to 40 volts at 0 to 500 ma, regulation 0.05 per cent. Use can also be made of it as a component of an automatic system since it can be programmed at 500 ohms/volt from a distant point. The narrow width (6") allows several units to be placed side-by-side on a bench or shelf. At no additional cost units can be mounted three across on a rack panel. Two meters are standard.

Willer Engineering & Sales Co., 676 Richmond Street West, Toronto 3, Ont.

Complex ratio bridge

Item 269

An all solid-state complex ratio bridge which combines small size and high accuracy is announced by Gertsch Products, Inc. This precision voltage and phase comparator measures both in-phase and quadra-

ture voltage ratios of any 3- or 4-terminal network. Accuracy of in-phase measurements is greater than .01 per cent of range. Quadrature accuracy is greater than .1 per cent of range (plus calibration error and .0002 Rx).

Allan Crawford Associates Ltd., 4 Finch Ave. West, Willowdale, Ont.

Output power meter

Item 270

Newly-designed output power meter, Type 1840-A, a passive instrument, serves as a load and can be used to measure the output power and impedance of oscillators, amplifiers, etc. It provides 48 impedance settings, 0.6 ohms to 32 kilohms. Five de-

cade power ranges are available from 0.1 mw to 20 w. An auxiliary scale reads from —10 to 43 db re 1 mw. This meter has a quasi-rms response.

General Radio Company, 99 Floral Parkway, Toronto 15, Ont.

Light source apparatus

Item 271

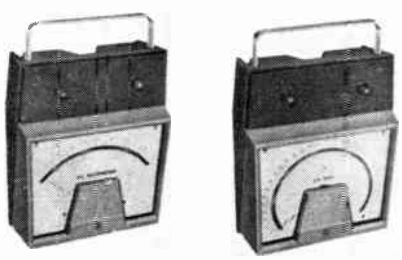
Kit includes a 150 watt light bulb covered with a special heat-resistant opaque paint except for apertures which provide point and line sources of light. Also included is a 40 watt, straight filament show case bulb which provides a sharp line source for light interference experiments. Some recommended applications for this kit are in the following experiments: pulses in a ripple tank, periodic waves, refraction of waves, Young's experiment, resolution, law of equal areas, interference and phase.

Stark Electronic Instruments, Ajax, Ont.

Taut-band suspension instruments

Item 272

Canadian Westinghouse has available taut-band half-per cent portable instruments — types P-151 and P-161 — as AC and DC milliammeters, ammeters, and voltmeters. In-



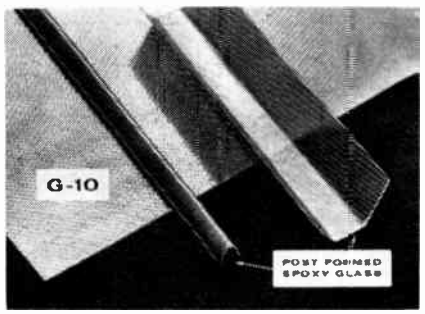
corporation of taut-band suspension mechanisms eliminates pivots and jewels, the most expensive instrument maintenance factor. Repeatability of readings is better than 0.05 per cent since friction is entirely eliminated.

Canadian Westinghouse Co. Ltd., 286 Sanford Ave., Hamilton, Ont.

New epoxy glass laminates

Item 273

These two grades are continuously produced epoxy resin laminates with polyester film facing on both sides for higher reliability of electrical properties. Thickness tolerances are provided closer than NEMA specs, and excellent uniformity over large



numbers of sheets and long strip lengths are reported. It may be readily post formed into channels and other shapes as required.

H. P. Ruggles and Co., Ltd., 88 Caroline Street, Hamilton, Ont.

Relay contact cleaner

Item 274

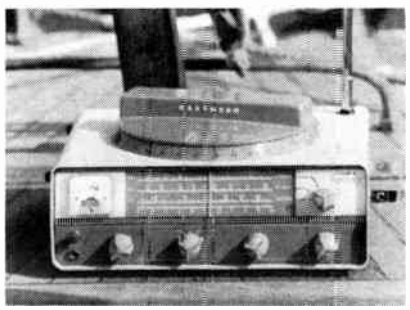
Called the Diacrom Spatula, this device consists of diamond particles, as the abrasive, which are so effective in cleaning that very little pressure is required to do a perfect job. It removes only about ½ micron of material and leaves the normal gap unchanged. This precision tool is designed to be non-clogging, long-lasting and has a color-coded Nylon shaft for flexibility in hard-to-reach areas. This new Diacrom Diamond Spatula is specifically designed to clean relays and contacts of every type.

Abbey Electronics Ltd., 555 Wilson Ave., Downsview P.O., Toronto, Ont.

Radio direction finder

Item 275

This transistorized unit, Model 356 Ranger II, operates from six standard flashlight batteries and has been designed to receive long-range Consolan direction finding signals. It has a built-in beat frequency oscil-



lator and covers the Consolan band to receive lines of position from various stations. The Ranger II also covers the regular beacon, marine, and broadcast bands; and is fitted with a top-mounted rotating loop antenna.

Raytheon Canada Ltd., P.O. Box 8, Waterloo, Ontario.

Continued on page 76

The preference for Sylvania tubes has two causes—performance and reliability. Sylvania designs these vital features into every tube, using advanced concepts in electronic engineering, made practical realities through incredibly high standards of production.

■ Take the new Sylvania Bikini Cathode Subminiature, for example. The cathode is a flat sleeve, bonded on two sides only with a uniform film of precast emissive material, producing an even temperature and ion emission. Used with the Sylvania Strap Frame Grid, the Bikini Cathode allows exact grid-cathode spacing for improved performance. High db gain, unusually low noise and exceptional ratio of Gm per mA of plate current are the consistent advantages of the new Sylvania Bikini Cathode Subminiature. For technical data on Sylvania electronic tubes, contact your supplier or write to Sylvania Electric (Canada) Limited, 6233 Cote de Liesse Road, Montreal 9.

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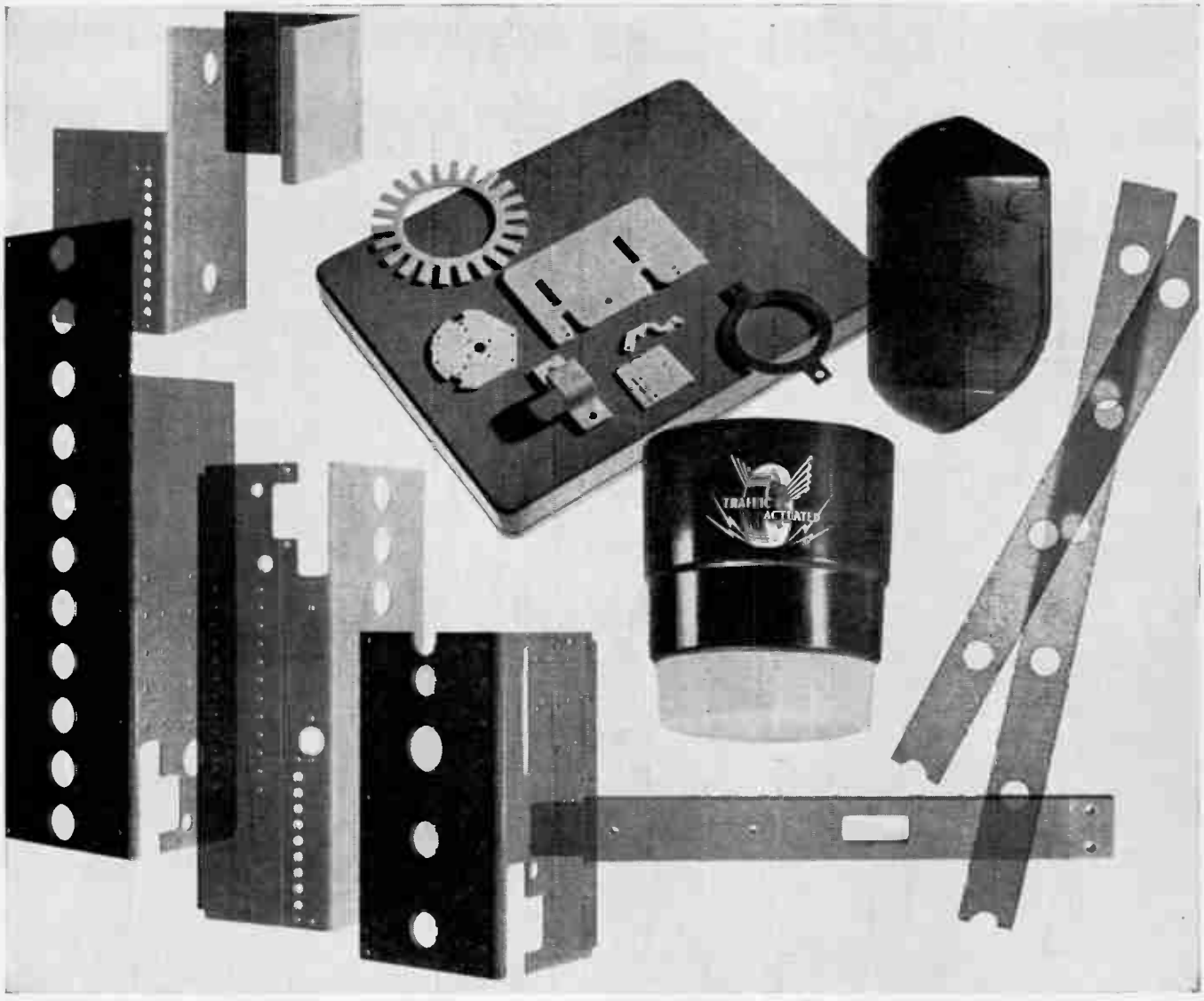

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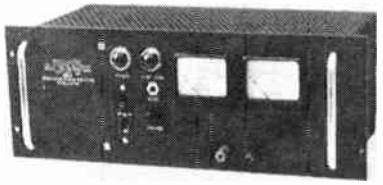


Regulated DC power supply

Item 276

Model TRP-36 Regulated Power Supply, an all-transistorized device delivers from 25 to 32 volts of pure, filtered DC at currents from 0 to 2.5 amperes, fully regulated against variations both in line and in load. It's powered from 115 volt, 60 cycle line and delivers output with a regulation of 0.15 per cent against line changes of from 105 to 125 volts AC and also against loads of 0 to 2.5 amperes.

Canadian Research Institute, 85 Curlew Drive, Don Mills, Ont.

Compactron sockets

Item 277

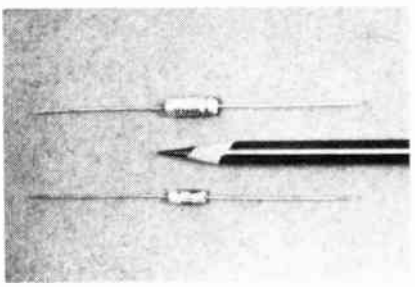
To aid electronic experimenters and hobbyists, CGE has available a package of two 12-pin sockets for Compactron devices. Several of the six types of Compactron devices are appearing in consumer TV and radio sets in lieu of conventional tubes and transistors. The pair of sockets, packaged in a plastic bag, is offered at a suggested user price of 50 cents. The sockets call for chassis holes 1⅛" diameter and mounting holes spaced 1 5/16 inches center-to-center. A new feature is a raised "key" ridge between pins 1 and 12 to help insert the Compactron device in hidden locations.

Canadian General Electric Co. Ltd., 214 King St. West, Toronto, Ont.

Aluminum electrolytic capacitors

Item 278

Two new sizes in Sprague Type 30D Littlytic Capacitors are believed to be the smallest yet offered in hermetically-sealed aluminum electrolytics. Their dimensions are 3/16" diameter x ½" long and ¼" diameter x ½" long. Tiny yet dependable, they



offer ultra-low leakage current which means minimum drain and long battery life when used in battery bypass applications.

Sprague-TCC-(Canada) Ltd., 50 Bertal Rd., Toronto 15, Ont.

Transistor video distribution amplifier

Item 279

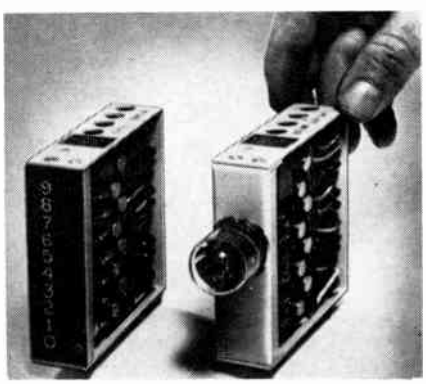
The R5900A is a plug-in module having its own regulated power supply and operating from 117V AC line voltage. Designed for use in either color or monochrome video chains and incorporates two outputs each giving 1.4 volts composite video signal. It's a compact unit with 16 amplifiers in seven inches of rack space. Frequency response is 60 cycles to 8 mc. + 0.1 db to — 0.2 db, and — 0.5 db maximum at 10 mc.

Northern Electric Co. Ltd., 1600 Dorchester Street W., Montreal, P.Q.

Decade counting units

Item 280

Complete line of transistorized decade counting units covering ranges from DC to 35 mc has been announced by Computer Measurements Co. Five basic plug-in units are available covering ranges from DC to 300 Kc, 2 mc, 12 mc, 20 mc, and 35 mc.



Requiring only 3¾" panel space, these lightweight, compact units consume only a fraction of the power of their vacuum tube counterparts.

Atlas Instrument Corp. Ltd., 50 Wingold Ave., Toronto 19, Ont.

Continued on page 85

NORDEN MAKES MICROGON

Norden's new MICROGON provides digital encoding of angular displacement and angular rate with continuously available pure binary or binary-coded decimal output in parallel or serial form. A new electronic technique for coarse angle data acquisition allows all angular information to be carried over only two wires from the transducer. Standard resolutions are 360,000 counts per turn 2^{19} cpt.

plus

THE KETAY LINE OF ROTATING COMPONENTS

These Norden components are recognized throughout industry and military agencies for outstanding accuracy and reliability. Advanced designs and rigorous quality control techniques provide performance and reliability to satisfy the most exacting requirements.

SYNCHROS. Control and torque transformers; transmitters and receivers; torque and control differential transmitters to MIL-S-20708A. Sizes 05 to 31.

RESOLVERS. Size 08 to 23 resolvers available offering functional accuracies to .03%, stability over a range of −55°C to +125°C, high input impedance. Vernier resolvers available with null spacing accuracy of 10 seconds.

SERVO MOTORS. Featuring high ratio of stall torque to power input at maximum rpm. A wide variety in frame sizes from 05 to 23. Exceed environmental requirements of MIL-E-5272A.

MOTOR TACHOMETERS. Integrating and damping types. Size 15 integrating model requires no warm-up time, meets environmental requirements of MIL-S-17806. Size range from 08 to 18.

CANADIAN PRATT & WHITNEY AIRCRAFT

COMPANY, LIMITED • LONGUEUIL, MONTREAL, QUE.

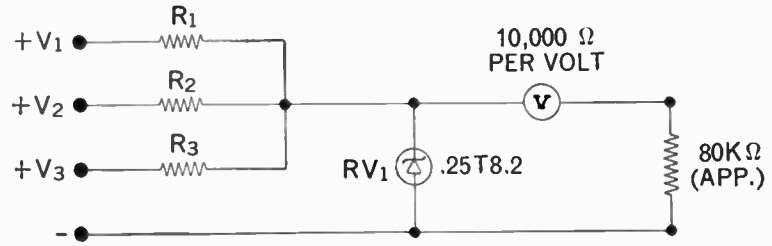
SUBSIDIARY OF UNITED AIRCRAFT CORPORATION

PRATT & WHITNEY ENGINES • SIKORSKY HELICOPTERS • HAMILTON STANDARD PRODUCTS • NORDEN ELECTRONICS

For complete details check No. 62 on handy card, page 79

TARZIAN DESIGN IDEAS

Regulator Diodes–useful devices in electronic circuits

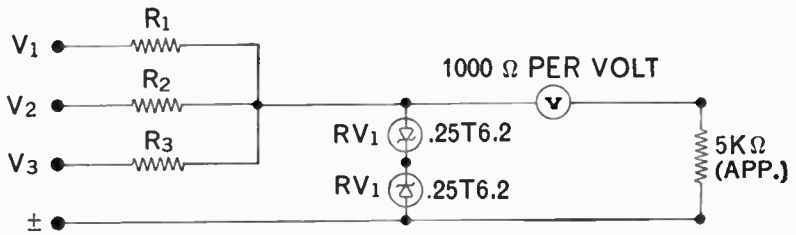


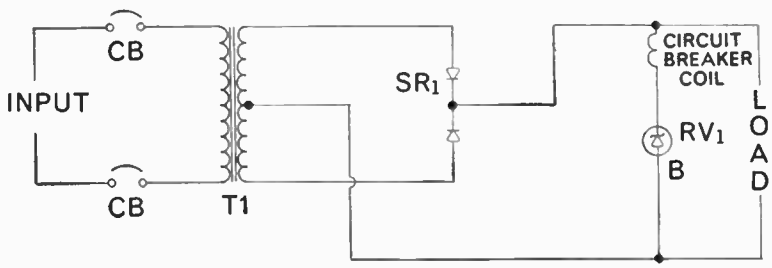
PROTECTION OF DC METER MOVEMENTS

R_1, R_2, and R_3-Meter Multipliers.
RV_1-Sarkes Tarzian Type .25T8.2 Regulator.
V=100 Microampere Meter Movement.

PROTECTION OF AC METER MOVEMENTS

R_1, R_2, and R_3-Meter Multipliers.
RV_1-Sarkes Tarzian Type .25T6.2 Regulators.
V=1 Milliampere Meter Movement.



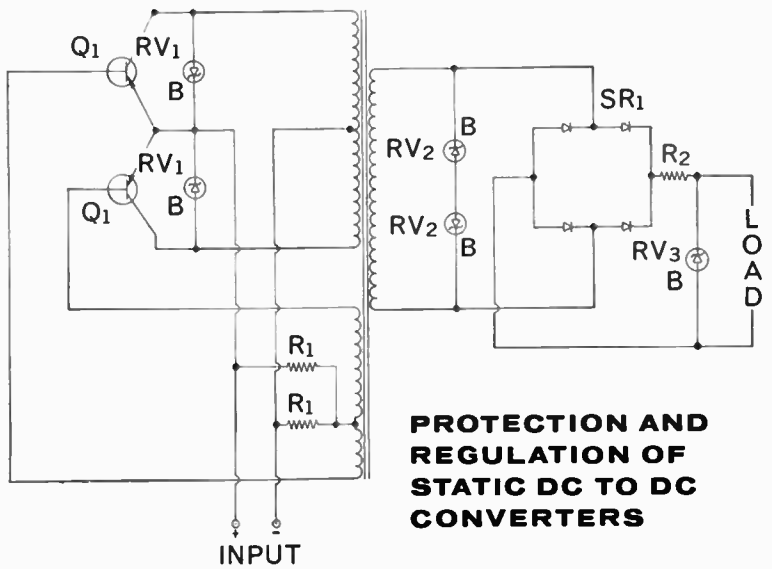


OVERVOLTAGE PROTECTION FOR SENSITIVE LOADS

RV_1-Selected to Avalanche at Critical Voltage and Cause Circuit Breaker to Open.

■ Not too long ago, the regulator diode (Zener) was considered a "luxurious" component, to be used only in the most sophisticated circuit. Progress in processing techniques and predictable voltage yields has made almost any application economically practical. The small size, inherent ruggedness, and physical simplicity of these devices—and their clipping, limiting, and protecting functions—can now be put to work widely.

The four applications shown here, while typical, can only suggest the usefulness of the silicon voltage regulator. We hope they will also suggest some useful answers to your problems, or new ways to improve reliability and performance. Our new catalog, 61-VR-11, contains data on five Tarzian series of silicon voltage regulators, plus design and test information. We will include prices. (You may be pleasantly surprised!) Prompt engineering service is also available.



PROTECTION AND REGULATION OF STATIC DC TO DC CONVERTERS

RV_1-Transistor Protectors.
RV_2-Transient Voltage Suppressors.
RV_3-Voltage Regulator-Transient Suppressors.

TECHNICAL LITERATURE BRIEFS

Radio frequency interference: 4-page color brochure entitled "RFI Control" is available. In addition to explaining how time and money can be saved by early anticipation of RFI problems, the brochure gives a comprehensive list of the company's RFI testing equipment, engineering personnel backgrounds and corporate experience. **Electro International Inc., Box 391, Annapolis, Md.**

Item 289

"Testing and Test Equipment": A new addition to the Technical Information for the Engineer series of publications has been announced. It describes in detail the various types of tests applied in industry. **Kearfott Division, General Precision, Inc., 1150 McBride Avenue, Little Falls, N.J.**

Item 290

Selenium photovoltaic cells: bulletin No. 03-200, discusses the features and specifications of the Models 856 and 594 photovoltaic cells, which use barrier-layer, self-generating Photronic components. **Weston Instruments Division, Daystrom Inc., 614 Frelinghuysen Avenue, Newark 14, N.J.**

Item 291

Technical heat sink manual: prepared especially for use by engineers is available for rapid selection of the proper heat sink to meet specific conditions. **Astro Dynamics, Inc., Second Avenue, Northwest Industrial Park, Burlington, Mass.**

Item 292

Analytical procedures with radioactive isotopes: a collection of papers which serves to introduce practical isotope procedures to the analytical chemist, educator and student. **Nuclear-Chicago Corp., 359 East Howard Avenue, Des Plaines, Ill.**

Item 293

Power supply provides .0001% regulation: 4-page bulletin No. 101, describes a very high precision power supply. The all transistorized instrument provides plus or minus .001% eight-hour stability and better than .0001% regulation. **Princeton Applied Research Corp., P.O. Box 565, Princeton, N.J.**

Item 294

Microwave instrumentation: special catalog has been developed and deals with the generation, transmission, and measurement of microwave phenomena. Included is a review of basic microwave measurements and photographs of typical equipment set-ups for these measurements appear throughout the catalog. **Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif.**

Item 295

White noise diode manual: 16-page manual containing specifications operating characteristics, and performance curves of the Sounvister white noise diode, also includes a discussion of the theory and effect of white noise. **Solitron Devices, Inc., 500 Livingston St., Norwood, N.J.**

Item 296

Two-phase Eicor servo motor: bulletin No. 119, gives data on the precision motor tachometer recently introduced, which features long life design and close speed control. **Eicor Division, Indiana General Corp., 517 W. Walnut Street, Oglesby, Ill.**

Item 297

Condensed solenoid catalog: 6-page catalog provides detailed specifications on more than 70 different types of linear solenoids, rotary solenoids and electromagnetic devices. **IMC Magnetics Corp., Western Division, 6058 Walker Avenue, Maywood, Calif.**

Item 298

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Company Nature of Business
(State, when applicable, whether electronic equipment or components are manufactured, sold, or used in manufacturing, etc.)

ARE YOU AN ENGINEER? Yes ☐ No ☐

Signature Position
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INDEX TO ADVERTISERS

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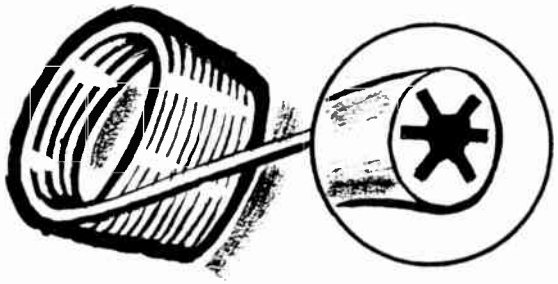
A REVOLUTIONARY NEW CORED SOLDER FOR ALUMINUM COMPLETELY EFFECTIVE WITH AN ORDINARY HAND-SOLDERING IRON . . .



A unique product designed specifically for use in the electrical, electronics and allied industries, in the same manner as conventional rosin-cored solders. Outstanding results may be obtained if particular attention is given to the following points of procedure:

1. Always heat the solder directly in contact with the surface being soldered.
2. Make sure the Tip of the soldering iron has a sufficiently high heat input and thermal capacity.
3. Surfaces to be soldered must be heated rapidly to the working temperature of the cored solder.

Ungar-Enthoven Aluminum Solder and flux products now make it possible to successfully join light-gauge aluminum sheet, wire, tube, pressings, stampings, and impact extrusions. Thin foils are readily soldered, but it is necessary to keep the time of heating as short as possible to avoid dissolution of the foil into the solder. No special preparation of aluminum surfaces is normally required before soldering, provided that the material is in bright condition following cold-working. Dirty surfaces should be cleaned by abrasion.

This solder is produced in grade AS.20 at 16 s.w.g.

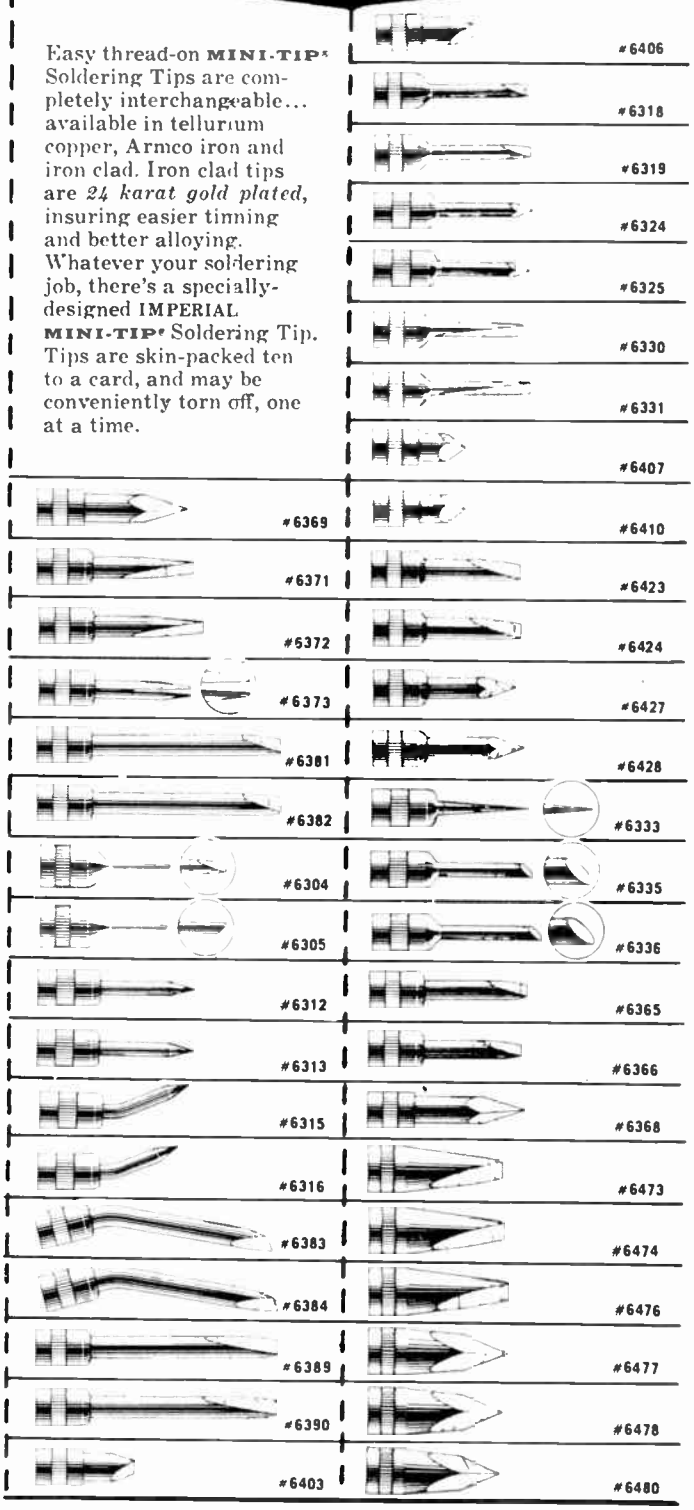
PERFECT SOLDERING WITH ADVANCED Ungar EQUIPMENT

Imperial "SAFETY-GUARD" HOLDER. Specially-designed for the Imperial... avoids damage while protecting the operator from hot tip burns. Attaches quickly to the top or underside of the work bench.
#6800

Imperial HEAT SEAL. Heat Seal on threads of heat cartridges and **MINI-TIP**® insures optimum heat transfer...protects threads, reduces oxidation and seizing. Convenient 3-oz. can.
#6801

42 MINI-TIP® SOLDERING TIPS TO CHOOSE FROM FOR USE WITH YOUR IMPERIAL Ungar IRON

Easy thread-on **MINI-TIP**® Soldering Tips are completely interchangeable... available in tellurium copper, Armco iron and iron clad. Iron clad tips are *24 karat gold plated*, insuring easier tinning and better alloying. Whatever your soldering job, there's a specially-designed IMPERIAL **MINI-TIP**® Soldering Tip. Tips are skin-packed ten to a card, and may be conveniently torn off, one at a time.

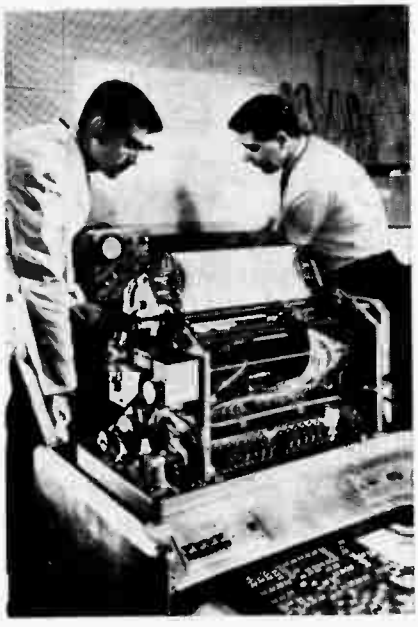


IMPERIAL Ungar

ELDON INDUSTRIES OF CANADA LIMITED
44 DANFORTH ROAD, SCARBOROUGH, ONTARIO
electronics division

For complete details check No. 26 on handy card, page 79

international scene



Creed & Company engineers check the new Model 1000 output printer whose speed — 1,000 words per minute — is 10 times that of the fastest teleprinters now used for computer output printing.

First civil secondary radar for Continental Europe

The first civil ground secondary surveillance radar in Continental Europe is to be installed in France early in 1962. The equipment has been ordered by the French Secretariat General a l'Aviation Civile for its Service Technique de la Navigation Aerienne from Cossor Radar & Electronics Limited of Harlow (Essex, England). It consists of an interrogator-responsor and an aerial system. These will be associated with an existing primary radar located at the French Northern Air Traffic Control Centre adjacent to Orly, the airport of Paris.

The equipment will be used by the Service Technique de la Navigation Aerienne to evaluate the air traffic control radar beacon system and to gain operational experience with this new tool for the air traffic controller.

TV outside broadcast vehicle for New Zealand

Marconi's Wireless Telegraph Company Limited has received an order through Amalgamated Wireless (Australasia) Limited to supply to the New Zealand Broadcasting Service a television outside broadcast vehicle. Initially it will contain two Mark IV camera channels, although it is wired for four. The vehicle, which will be the only one operating in New Zealand, is being shipped to Auckland.

CAE to pool talent with French firm

Canadian Aviation Electronics Ltd. will enter a joint bid with Le Matériel Téléphonique of Paris, France, for contracts for simulators for anti-submarine warfare airplanes for NATO countries in Europe. If successful in their bid, the two companies will pool their technical resources to develop and manufacture the simulators in Montreal and Paris.

It is expected that the governments of France, Germany, Holland and other European countries will order the airplanes, and a number of simulators will be required.

CAE has already produced an operational flight trainer and a tactical crew procedures trainer for the Argus airplane for the RCAF, and is currently working on orders for simulators for the F-104 Starfighter airplane for the RCAF and NATO countries in Europe. LMT is producing simulators for the French-built Mirage III.

BOLSA to install English Electric computer

The Bank of London and South America have placed an order worth about $600,000 with The English Electric Company for a KDP10 data processing system. BOLSA will be the first overseas bank in England to use an electronic computer for its foreign operations.

The KDP10 system is to be installed next June in the Bank's London branch in Queen Victoria St., where it will revolutionize the present bookkeeping systems by converting them to automatic processing and recording of accounts on magnetic tape. The handling of current accounts and statements will be the first to be affected by the changeover, as well as all dealings of the Bank's foreign exchange department, which has a large annual turnover in exchange and deposit transactions.

Pye landing system for France

The French Aviation Authorities have selected the Pye Instrument Landing System, incorporating a direc-

tional localizer, for installation at their research and development center at Bretigny, near Paris, where work on military and civil aircraft landing systems is carried out. The system is for bringing aircraft safely to touchdown under all weather conditions.

Sweden orders 82 Marconi transmitters

The Royal Board of Swedish Telecommunications has placed yet another big order for television and sound broadcasting transmitters with Marconi's Wireless Telegraph Company Limited.

The new contract calls for the supply of 21 vision transmitters, 21 sound transmitters, 40 frequency-modulated sound transmitters and a considerable quantity of program input, paralleling, feeder and ancillary equipment.

A solar-powered radio-public address system, designed by Hoffman Electronics Corp., was demonstrated for Indian government and military representatives in Faridabad, India. Solar cells convert sunlight into electric power to operate this unit.

British firm supplies detection equipment to West German Army

First Green Archer mortar-locating radar equipment has been supplied to the West German Army by EMI Electronics Ltd.

A high proportion of army casualties in the last war was caused by mortar fire, due largely to the extreme difficulty of locating these weapons.

EMI's Green Archer is able to pinpoint the mortar's position within a few seconds, by an advanced technique using radar in conjunction with an electronic computer. This information can be used immediately for artillery counterfire.

CANADA METAL

Exceptional SOLDERS and FLUXES

There just isn't a better stock of better Solders and Fluxes available in Canada. And, Canada Metal did not win its supremacy in the Solder and Flux field overnight.

Decades of creative metallurgical research and rigid quality control, followed by unending and diligent on-the-job testing by our Technical Service Department . . . that's the unspectacular secret.

Nowadays, industries in Canada are hardpressed to uncover a soldering job which cannot be handled by a Canada Metal stock-item Solder or Flux. But, when that does happen, the long-experienced experts in our Technical Service Department are able to quickly recommend a suitable, special Solder and Flux.

Delivery? Well, we have plants and stocks right across Canada. This means you can get stock items and special products fast.

If you want Tin-Lead Solders, Silver Solders, Silver Brazing Alloys and Fluxes . . . Canada Metal has All Forms for All Uses, All Users.

Consult our Technical Service Department

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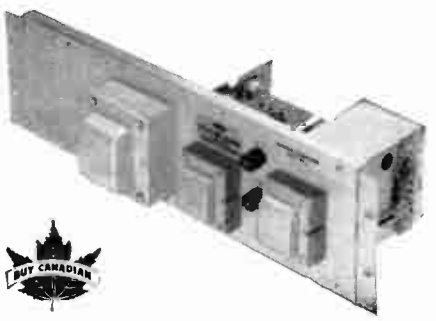
THE CANADA METAL CO. LIMITED

MONTREAL TORONTO SCARBOROUGH WINNIPEG CALGARY VANCOUVER

For complete details check No. 14 on handy card, page 79

BATTERY-POWERED 20 C/S RINGING SUPPLY



BUY CANADIAN

PYLON RINGING GENERATOR
TYPE RG-1

- 24V or 48V battery input
- Dependable transistor circuitry
- No maintenance or adjustments needed
- Shipment from stock

PYLON

PYLON ELECTRONIC DEVELOPMENT company, ltd.

Communications Systems and Equipment

161 CLEMENT ST., LASALLE, MONTREAL 32, QUE.

For complete details check No. 46 on handy card, page 79

IT'S NEW!

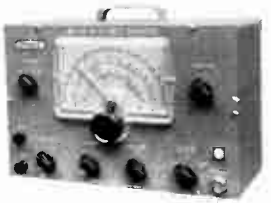
MHG-48

A factory wired and calibrated, compact, accurate, marker generator frequency 3.5 mc to 250 mc in 6 ranges accuracy ± 1%.
Internal crystal oscillator 4.5 mc useful for frequency checks (crystal accuracy 0.01%) other crystals may be used. Internal modulation frequency of 720 c/s and 250KC for production of Horizontal and vertical bars. A versatile unit designed especially for use in alignment and servicing of T.V., F.M. and VHF receivers. Write for New Starkit Catalogue.

WIRED AND CALIBRATED
ONLY **$87.95**

SWG-58

Wired and calibrated for use in the alignment of R.F. and I.F. circuits, traps and discrimators, etc. Accurate response curves when used in conjunction with the Starkit MHG-48 and oscilloscope. Frequency coverage in two bands 3 mc to 120 mc and 140 mc to 260 mc. Variable sinusoidal sweep deviation 0-12 mc by means of vibrating capacitor. Provision is made for blanking the return "scope" trace, also a phase controlled horizontal sweep for the oscilloscope.
These features plus many more—write for complete specifications.



WIRED AND CALIBRATED
ONLY **$97.95**

STARKIT

STARK ELECTRONIC INSTRUMENTS LTD.
AJAX, ONTARIO

For complete details check No. 54 on handy card, page 79

product panorama

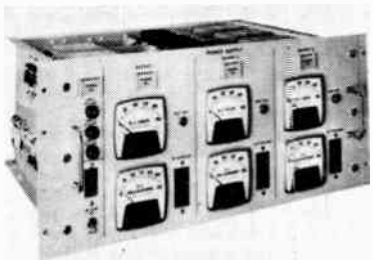
For further information on Products use Readers' Service Cards on pages 79 and 80.

Continued from page 76

Multi-output power system

Item 281

A new militarized highly sophisticated Power System for the missile and space vehicle field, has completely solid state design with the following specifications: Input — 105-125 VAC, 60-400 cps, single phase; Outputs (completely floating and isolated) include — 300 V at 300 ma, 150 V at 300 ma, 6.3 VAC at 18 amperes; Regulation —



0.2 per cent combined line and load; Ripple — 3mv, rms; Size — 24" panel, 10½" high. Manufactured by Mid-Eastern Electronics, Inc.

Willer Engineering & Sales Co., 676 Richmond Street West, Toronto 3, Ont.

Matched diode assemblies

Item 282

Four new matched diode assemblies made from the GE ultra high speed and controlled conductance PEP silicon switching diodes have been announced. The two matched pair assemblies, MP-1 and MP-2, and the matched quads MQ-1 and MQ-2 are available in large quantities for mass production requirements. The diodes composing each assembly have been matched within the narrow voltage range of 10-millivolts over a broad current range of 100-microamperes to 10 milliamperes, and to within 20 millivolts from 10-milliamperes to 50-milliamperes.

Canadian General Electric Co. Ltd., 214 King St. West, Toronto, Ont.

Power resistor decade

Item 283

Clarostat Manufacturing Co., Inc., has announced the availability of its power resistor decade box in a rack mounted version. Designated Model 250, it provides a power resistor of any required ohmage from 1 to 999,999 ohms — in one-ohm increments. It

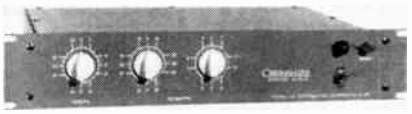
has a power rating of 225 watts at 1000 volts maximum, features Clarostat Greenohm Power Resistors throughout, click-in detent bar knobs for pronounced selected ratings.

Tri-Tel Associates Ltd., 81 Sheppard Ave. West, Toronto, Ont.

Digital clocks

Item 284

Chrono-log clocks are designed to serve as a time source for data loggers, data handling systems, computers, digital time displays and other applications. Their output is a non-ambiguous, parallel, decimal contact closure pattern representing 24 hour time. The output of the clock can



be used to program system functions so as to initiate log cycles at periodic intervals, start and stop process equipment, etc.

Glendon Instrument Co. Ltd., 46 Crockford Blvd., Scarboroug, Ont.

Replacement pressure pads

Item 285

A package of felt pads designed to replace worn pads on virtually every tape recorder and eliminate this cause of playback distortion, has been announced by Robins Industries. A package of 40 pads (cat. No. PP-1) lists at $1. Felt pressure pads are standard equipment on virtually every reel-to-reel tape recorder made today. Their purpose is to keep pressure on the tape and hold it firmly and uniformly against the head during the record and playback function, otherwise serious impairment of performance may occur.

E. S. Gould Sales Co. Ltd., 19 le Royer St. West, Montreal, P.Q.

Continued on page 86

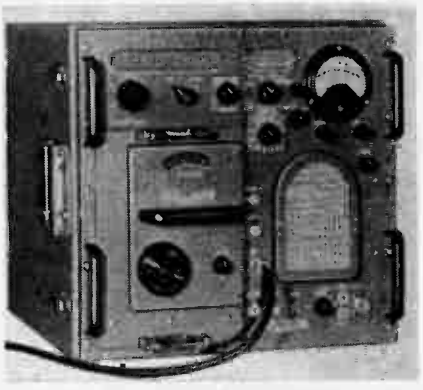
product panorama

For further information use Readers' Service Cards on pages 79 and 80.
Continued from page 85

RFI measurements extended

Item 286

Frequency range of Noise and Field Intensity Meter NF-112 has been extended to 15,000 Mc with the addition of new plug-in tuner Model T-5/NF-112, produced by Empire Devices, Inc. As a result the NF-112 now covers the entire frequency range from 1.0 to 15.0 KMC in a single in-



strument, by means of five plug-in tuning units. The basic design techniques used in lower frequency heads have been retained.

Instronics Ltd., P.O. Box 100, Stittsville, Ontario.

High voltage selenium cartridges

Item 287

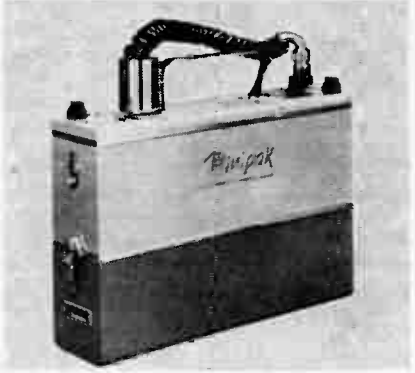
An advanced line of selenium high voltage rectifiers pack more power to the inch than standard cartridge rectifiers, and are available over a peak reverse voltage range from 48 to 28,800. This complete series of Altosel half-wave cartridges will provide forward currents of 5 ma at 35°C, and have a max. RMS input ratings ranging from 33 to 18,100 volts (res. load). Advanced techniques in manufacturing account for a substantial size reduction, as well as reducing forward power losses per cell to a point where the internal temperature rise remains essentially the same.

Douglas Randall (Canada) Ltd., 126 Manville Road, Scarborough, Ont.

Portable FM 2-way radio phone

Item 288

Minipak, a dependable, practical and portable FM transceiver has been engineered not only to consider the practical aspect



encountered by the man in the field who must use the equipment, this set also features long battery life, extreme dependability in the face of hard usage, and light weight to offer more comfort when carrying. Frequency range is 150 - 174 Mcs; sensitivity is .75 microvolts for 20 dB.

Canadian Marconi Co., 2442 Trenton Ave., Montreal 16, P.Q.

Bristol Black-Brants

Continued from page 38

In the transmitter developed for Black Brant III reliability is secured by using a very simple circuit with a very minimum of components. The basic transmitter consists of a crystal controlled transistor oscillator operating at 55 mc/s feeding a varactor quadrupler which gives an output of 1 watt at 220 mc/s. High efficiency is obtained by operating the transistor at a relatively low frequency and using a high Q varactor diode.

The only other circuits required in the transmitter unit are a current regulator to keep the current to the transmitter constant despite changes in battery voltage and a video amplifier-modulator to provide modulation by means of a variable capacitance diode.

Cross-monitoring unit

In order to provide increased reliability to the telemetry from the Black Brant III for the first two firings it was decided to use two separate transmitter antenna combinations in each rocket. The first link will consist of the transistor transmitter feeding the quadra-loop antennas while the second will be a tube transmitter feeding blade antennas similar to those employed in Black Brant II.

The cross-monitoring unit provides a means whereby the power output of each transmitter and the power reflected by each antenna system may be sampled and the resultant voltages used to modulate four channels in the telemetry system. Thus if either the transmitter or the antenna system of one link fails or deteriorates in flight, an indication of the type of failure will be transmitted over the other link. In addition, by means of a common modulator all telemetered information will be passed by both links at the same time.

The cross-monitoring unit consists essentially of two dual directional couplers, the coupled outputs of which feed four matched detector units. The four outputs of the detectors will give DC voltages proportional to the voltage amplitudes of the four quantities to be measured.

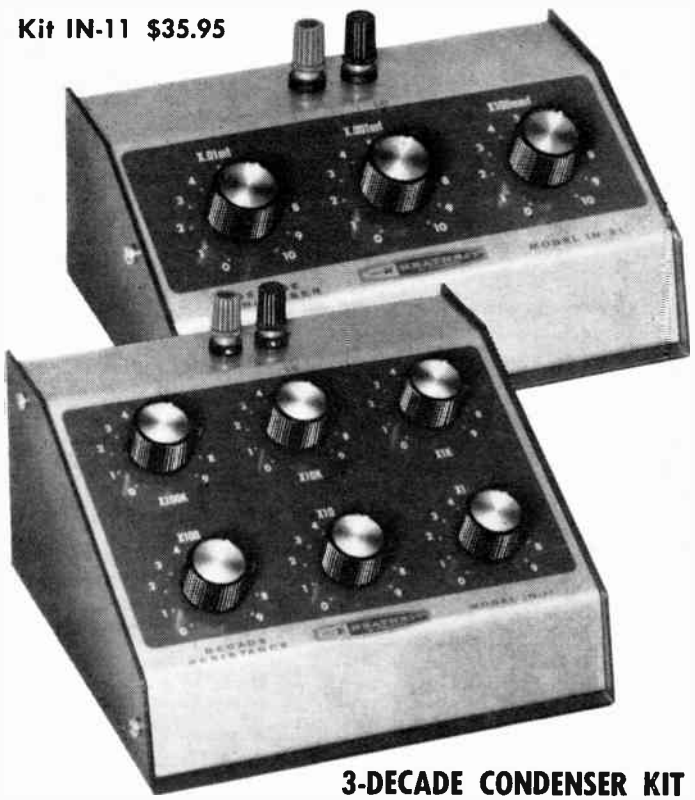
The cross-monitoring unit outputs may also be used in pre-flight checks to assist in alignment of the transmitters and tuning of the antennas.

TWO NEW HEATHKIT DECADE KITS FOR LABORATORY OR ELECTRONIC WORKSHOPS...

6-DECADE RESISTANCE KIT

Ideal for laboratory use in countless experimental applications, this precision Decade Resistance kit provides easy switch-selection of any resistance value from 1 ohm to 999,999 ohms in one ohm steps. Terminals are placed on top for convenient connection to circuitry. Sloping front panel design makes it easy to read and operate. Uses 54, ½% 1 watt precision resistors. Measures only 7⅛" W x 5" H x 6⅝" D. 4 lbs.

Kit IN-11 $35.95



3-DECADE CONDENSER KIT

Use this in any application requiring precision capacitor values. Provides capacitor values from 100 mmfd to 0.111 mfd in 100 mmf steps. Capacitors are precision 1% silver mica types rated at 350 volts DC, continuous; 500 volts DC, intermittent; and 1000 volts DC test. Switches are high quality low-loss ceramic wafer types with positive detent action. 3 lbs.

Kit IN-21 $25.95

DAYSTROM LIMITED

1480 DUNDAS HWY. EAST, COOKSVILLE, ONT.

6209

For complete details check No. 22 on handy card, page 79

The most complete range of electro-mechanical VIBRATION GENERATORS

2lb. to 22,000lb. thrust force

Environmental testing at each stage of development—simulating the severest field conditions of vibration—gives modern components and equipment 'built-in' mechanical and functional reliability.

Goodmans Vibration Exciters and Oscillator Power Amplifiers provide the means for this analytical approach.

GOODMANS

the vibration specialists

GOODMANS INDUSTRIES LIMITED, AXIOM WORKS, WEMBLEY, MIDDLESEX, ENGLAND
Wembley 1200 (8 lines) Cables: Goodaxiom, Wembley, England

NICKAM INSTRUMENTS & SUPPLY LIMITED

99 Floral Parkway, Toronto 15, Ontario

For complete details check No. 41 on handy card, page 79

Industry's business

Continued from page 13

up over 1960 by more than 10,000 sets and except for a shortage of wood cabinets in November and December, this figure would have been at least 15,000.

The Admiral president predicted Canadian industry sales volume of 385,000 TV receivers in 1962, compared with 350,000 in 1961 and 340,000 in 1960.

Wholesale Radio extends services

Another new branch of Wholesale Radio and Electronics Limited is open at 365 Wilson Street, in Hamilton, Ontario. A balanced inventory of electronic requirements for industry and the serviceman is carried in stock.

Len Finkler named National Radio rep.

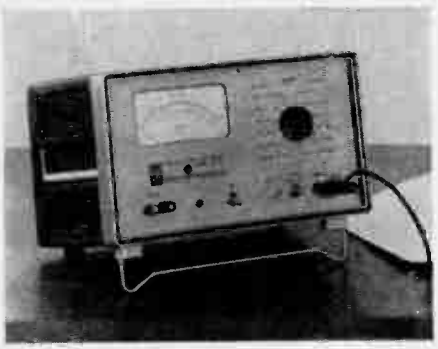
William Menezes, sales manager of the Component Division of National Radio Company, Melrose, Mass., announced the appointment of a Canadian sales representative. This appointment was made to give National greater coverage in the OEM field. The new sales agent will represent National Component lines only, which includes chokes, captive hardware, commercial and Mil spec knobs, coil forms, dials, drives, vernier mechanisms and elasticable. Len Finkler Ltd. is the new Canadian representative, with offices and warehouse facilities located at 2 Tycos Drive, Toronto 19, Ontario.

RCA Victor shows greatest sales since 1955

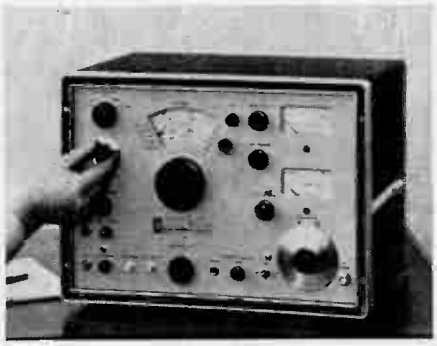
"1961 was a year of conspicuous success for RCA Victor Consumer Products," said G. L. Mansour, vice-president of the company's Consumer Products Division. "Our optimism for 1962 is based on the favorable results achieved in 1961, the greatest sales increase since 1955, as well as on the continuing growth of our various product lines. The recovery of the Canadian economy in the last quarter of '61 should continue in 1962 with a promise of increased volume."

The high sales are accounted for by TV replacements, second-set purchases, and the introduction of FM stereo combinations.

ATLAS INSTRUMENT *is proud to announce the addition of the following new high-performance electronic instruments—*

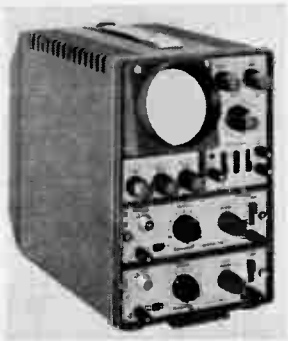


Sierra Electronic Corporation, division of Philco Corporation, Model 127A Solid State Selective Voltmeter. Covers 2-350 Kc/s, —80 to +22 DBM, accuracy ± 1 db, built-in crystal calibrator, rechargeable battery, light and portable.



Borg-Warner Controls Model G-201 RF Signal Generator 10 to 420 Mc., 0.1 microvolt to 0.5 volt output into 50 ohms. ½% frequency calibration plus built-in crystal calibrator.

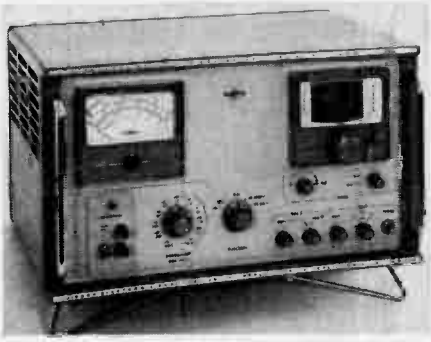
Borg-Warner Controls Model M-101 Vacuum Tube Voltmeter, 1 millivolt to 300 volts, 10 cps to 4 Mc/s, high input Z, amplifier output terminals.



Telequipment Ltd., Model D33 dual beam Oscilloscope features plug-in amplifiers for extreme versatility. Bandwith to 6 Mc., fully calibrated triggered time base.

PRD Electronics, Inc., Model N630 Calorimetric Power Meter measures DC to 18 Kmc RF power 10 microwatts to 1 watt accuracy 3% or better direct reading.

H. H. Scott Sound Level Meter Model 412, a rugged and dependable instrument covering a wide range of sound levels accurately. Accepts a wide range of accessories. Calibrated to latest ASA standard.



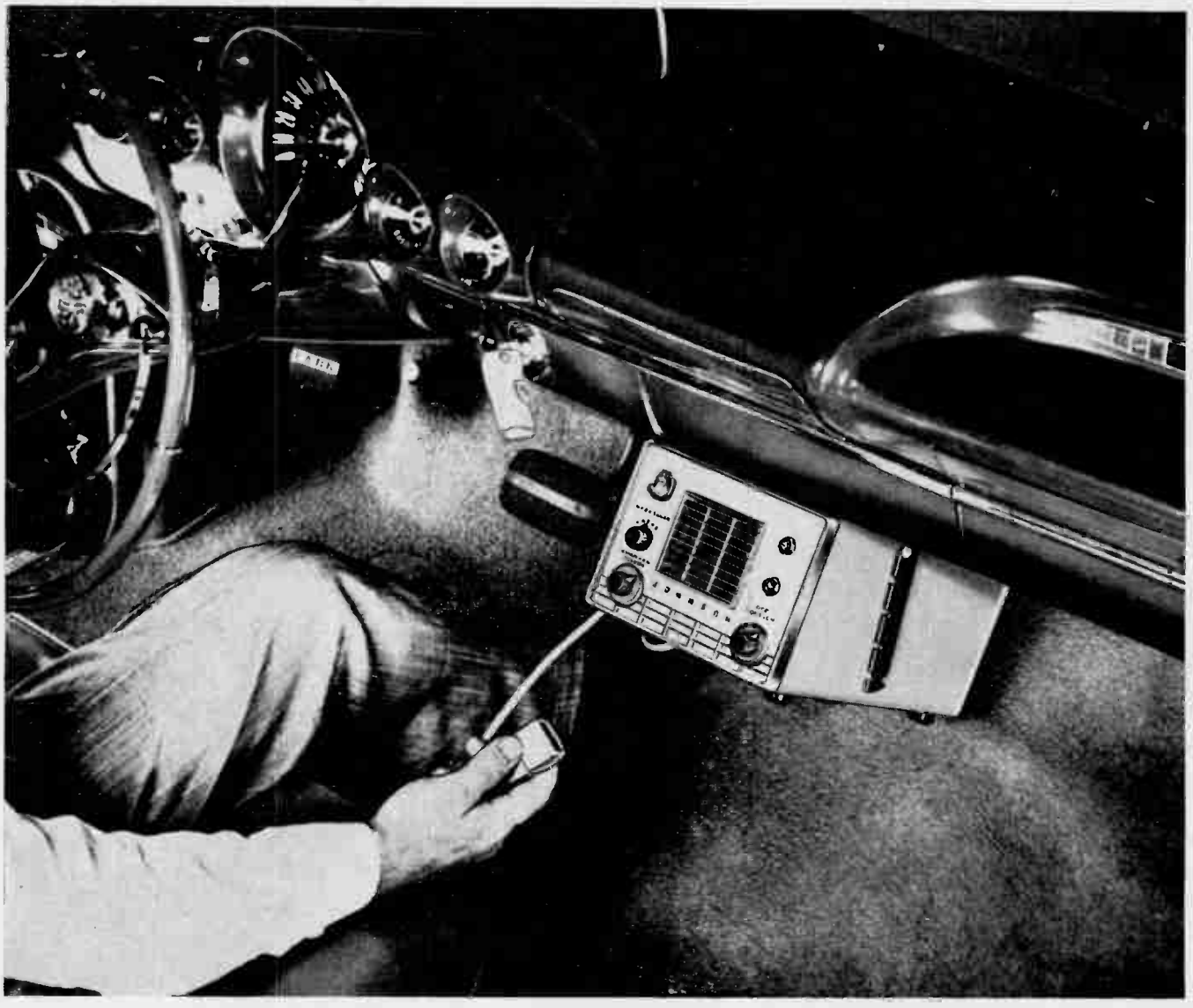
Electro Instruments Inc. Model 4010 Digital Voltmeter, 1 millivolt to 999.9 volts DC automatic ranging and polarity highly reliable solid state circuitry accuracy ± 1 digit + .002%/degree C.

Sierra Electronic Corporation, Div. of Philco Corporation, Model 126A Frequency Selective Voltmeter 5 to 1620 Kc/s, —90 to +32 DBM dual selectivity, carrier reinsertion and crystal calibrator built-in.

For complete information on new measurement instruments, and any other equipment manufactured by these companies, please contact our Representative in your area. Our fully trained sales and service staff is ready to assist you with any of your instrument requirements.

ATLAS INSTRUMENT CORPORATION LTD.
50 Wingold Avenue, Toronto 19, Canada
BRANCHES IN: MONTREAL · OTTAWA · VANCOUVER

For complete details check No. 4 on handy card, page 79



How Electro Sonic Can Make GRS Work for Your Company

The new 27 Megacycle Canadian General Radio Service Band, open April 1, 1962, will have many industrial uses for short-range work where the cost of larger equipment cannot be justified.

Our new General Radio Service Division has a staff with the training and experience to help you choose the right equipment for the job, and get the most out of it.

An item in point — the Johnson "Messenger" 5 Channel General Radio Service Transceiver illustrated above. Here is a rugged unit that offers the finest performance of any equipment available! Can be used as a base station, or in a car or boat. The effective range is 5 to 25 miles, depending on location and antenna system. Measures only 5⅝" x 7" x 11⅜".

Available in five different models — furnished complete with microphone and cord, crystals for one channel, and necessary power cords.

Model		Net Price
242-126	115 VAC only	$199.95
242-127	115 VAC & 6 VDC	214.95
242-128	115 VAC & 12 VDC	214.95
242-129	115 VAC & 24 VDC	224.95
242-138	115 VAC & 230 VAC	224.95

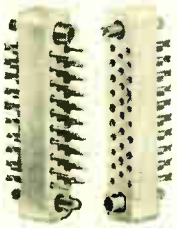
ESSCO

ELECTRO SONIC SUPPLY CO. LTD.

543 YONGE STREET · TORONTO 5, ONTARIO · 924-9301

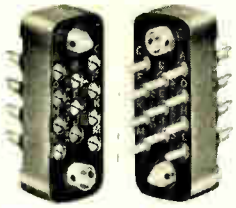
DIRECT ORDER DESK PHONE 924-9251

For complete details check No. 27 on handy card, page 79



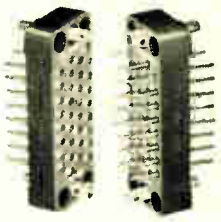
UMI SERIES. Ultraminiature Draw-Pull & Screwlock

Number of contacts
5, 7, 9, 11, 14, 20, 26, 29, 34, 44, 50
Maximum wire size .....#22 AWG wire
Current rating .....3 amps.
Also available in UMI-SL-Series



SMI SERIES—Subminiature

Number of contacts
5, 7, 11, 14, 20, 26, 29, 34, 42, 50,
Maximum wire size .....#20 AWG wire
Current rating .....7.5 amps.
Also available in SCREWLOCK SMI-SL-Series



MI SERIES—Miniature

Number of contacts
7, 12 (8-4), 14, 18, 20, 21, 26, 34, 41, 50, 75
Maximum wire size .....#20 AWG wire
Current rating .....7.5 amps.
Also available in SCREWLOCK MI-SL-Series

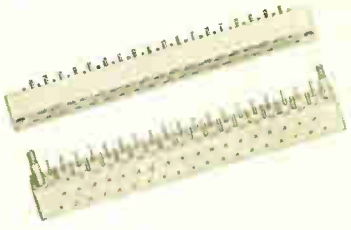
REMI SERIES
Standard and Screwlock

Number of contacts
7, 12 (8-4), 14, 18, 20, 21, 26, 34, 41, 42, 50, 75
Type of contact....crimp style, removable with "snap-in, snap-out" feature.
Wire sizes accommodated
#18, #20, #22, #24, #26 , #30, AWG wire
REMI counterparts of our MI, MI-SL, MI-KSL, MI-BSL and MI-BMSL SERIES can be provided

the only complete source for your...

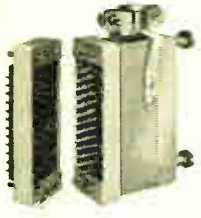
ULTRA-RELIABLE ELECTRONIC CONNECTORS

AUTOMATION
COMMUNICATION
CONTROLS
INSTRUMENTATION
MISSILES
PORTABLE EQUIPMENT
PRINTED CIRCUITS
TEST APPARATUS



MPC SERIES
Printed Circuit Connector

Number of contacts 15, 23, 33, 37, 49
Maximum wire size .....#24 AWG wire
Current rating .....3 amps.



MI-BSL "FBI" SERIES
Miniature Bracket Screwlock

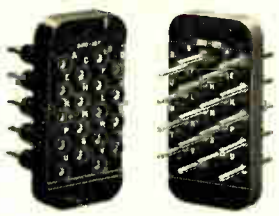
Number of contacts
34, 41, 50, 75, 123, 150, 225,
Maximum wire size .....#20 AWG wire
Current rating .....7.5 amps.

UPCC SERIES
Printed Circuit Connector

Number of contacts 7, 11, 15, 19, 23, 32
Maximum wire size .....#20 AWG wire
Current rating .....7.5 amps.
Also available in Screwlock UPCC-SL & UPCC-SLH Series

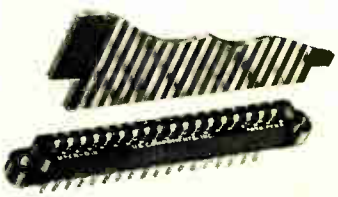
MH SERIES—Miniature Hex

Number of contacts 4, 5,7, 9
Maximum wire size .....#20 AWG wire
Current rating .....7.5 amps.



990 and 990S POWER SERIES
Standard and Short Contacts

Number of contacts 7, 10, 15, 18
Maximum wire size .....#16 AWG wire
Current rating .....13 amps.
Also available in Screwlock 990-SL-Series



UPCR & UPCR-D
Printed Card receptacle

Number of contacts
(Beryllium Copper) 6, 10, 15, 18, 22 per row
Current rating .....5 amps.
Type of contact—Solder type, Taper tab, Wire wrap

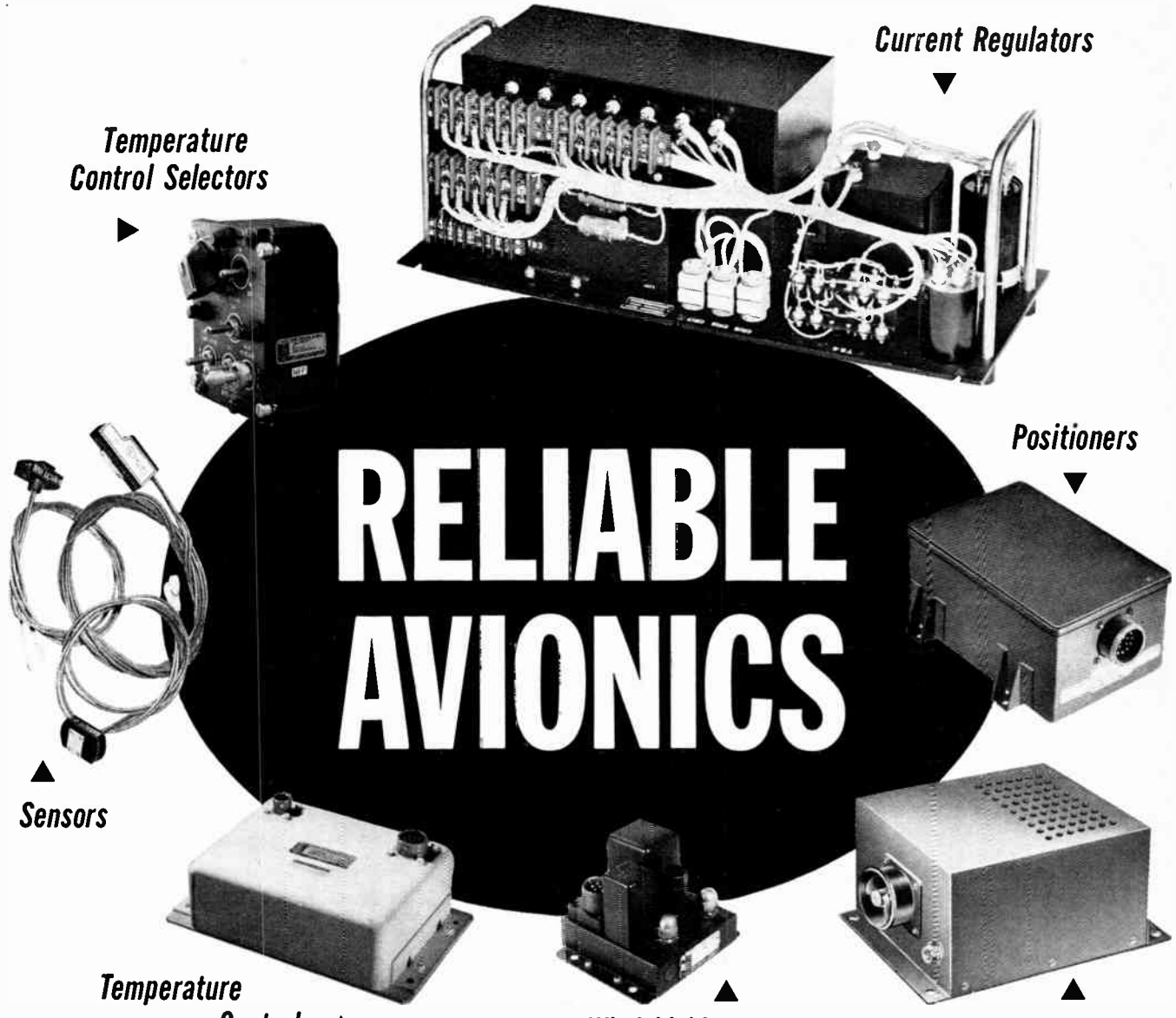
SPECIAL FEATURES: Side or rear cable entrance hoods available. Alkyd, Melamine or diallyl phthalate molding compounds.

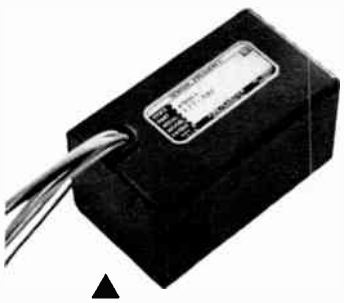
- Other U.S.C. products are available such as pressure seals, adapters, mounting brackets.
- Over 7000 stock sizes and types for standard and special applications.
- Special types custom-designed to meet micro-miniaturization and performance requirements.
- All connectors meet or surpass MIL-C-8384B, MIL-C-21097A and NAS 713, 714, 715. Rigid quality control with 100% inspection and testing per MIL-Q-9858. Crimping tool meets MIL-T-22520 (WEP).

U. S. COMPONENTS, INC. 1320 Zerega Avenue, N. Y. 62, N. Y. • TA 4-1600

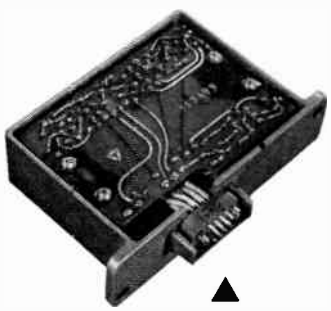
The above items are covered by U.S. Pat. 2,658,182; 2,761,108; 2,845,603; 2,845,604; 2,853,689; 2,933,713; 2,848,702; 2,979,689; 2,909,755; 2,953,767. Additional pats. pending.

For complete details check No. 60 on handy card, page 79





Frequency Monitors



Amplifiers

Garrett Manufacturing Limited

has assumed complete responsibility for a specialized line of avionic products and systems formerly produced in the U.S.A. by The Garrett Corporation's AiResearch Manufacturing Division.

The products depicted here are typical of those available to meet your avionics requirements. They are backed by Garrett's outstanding facilities and personnel in the areas of research, development, engineering, testing, manufacturing and support services. Your inquiries are invited.

GARRETT

GARRETT MANUFACTURING LIMITED / ***4 RACINE ROAD, REXDALE, ONTARIO***

Research, development, manufacturing and sales engineering of systems and components for aircraft, missile, spacecraft, electronic, nuclear and industrial applications

For complete details check No. 28 on handy card, page 79

Industry personnel

Continued from page 16

Oldershaw moved to managerial post at Varian

B. H. Breckenridge, president and general manager of Varian Associates of Canada Ltd., has announced the appointment of **Malcolm J. Oldershaw**, P. Eng., as manager, Applications Engineering. In this capacity Mr. Oldershaw will be concerned with the sales and application of the company's extensive line of microwave tubes, gas switching devices, mixers and high vacuum products.

Lovely joins Benco engineering staff

Benco Television Associates Limited announced the appointment to their engineering staff of **John D. Lovely.** Born and educated in England Mr. Lovely came to Canada in 1955 and was chief engineer of consumer products for Canadian Aviation Electronics in Montreal. Before joining Benco Mr. Lovely was chief development engineer with Rediffusion Incorporated a division of the English Rediffusion Group.

M. J. Oldershaw

J. D. Lovely

Canadian corporation formed by ITT

A new corporate name — ITT Canada Limited and the regrouping of facilities and functional control of three Canadian associate companies of International Telephone and Telegraph Corporation on January 1, was announced recently.

Two Montreal firms, Standard Telephones & Cables Mfg. Co. (Canada) Ltd., changed in name to ITT Canada Limited, and ITT Electronics Service Co. of Canada Ltd., will be joined. A third company Royal Electric Mfg. Co. (Quebec) Ltd., in suburban Pointe Claire, will retain its name and be a subsidiary of the Canadian formation.

ITT Canada, with headquarters in Montreal, as a corporate member of the ITT System will exercise auto-

Continued on page 96

Industry personnel

Continued from page 95

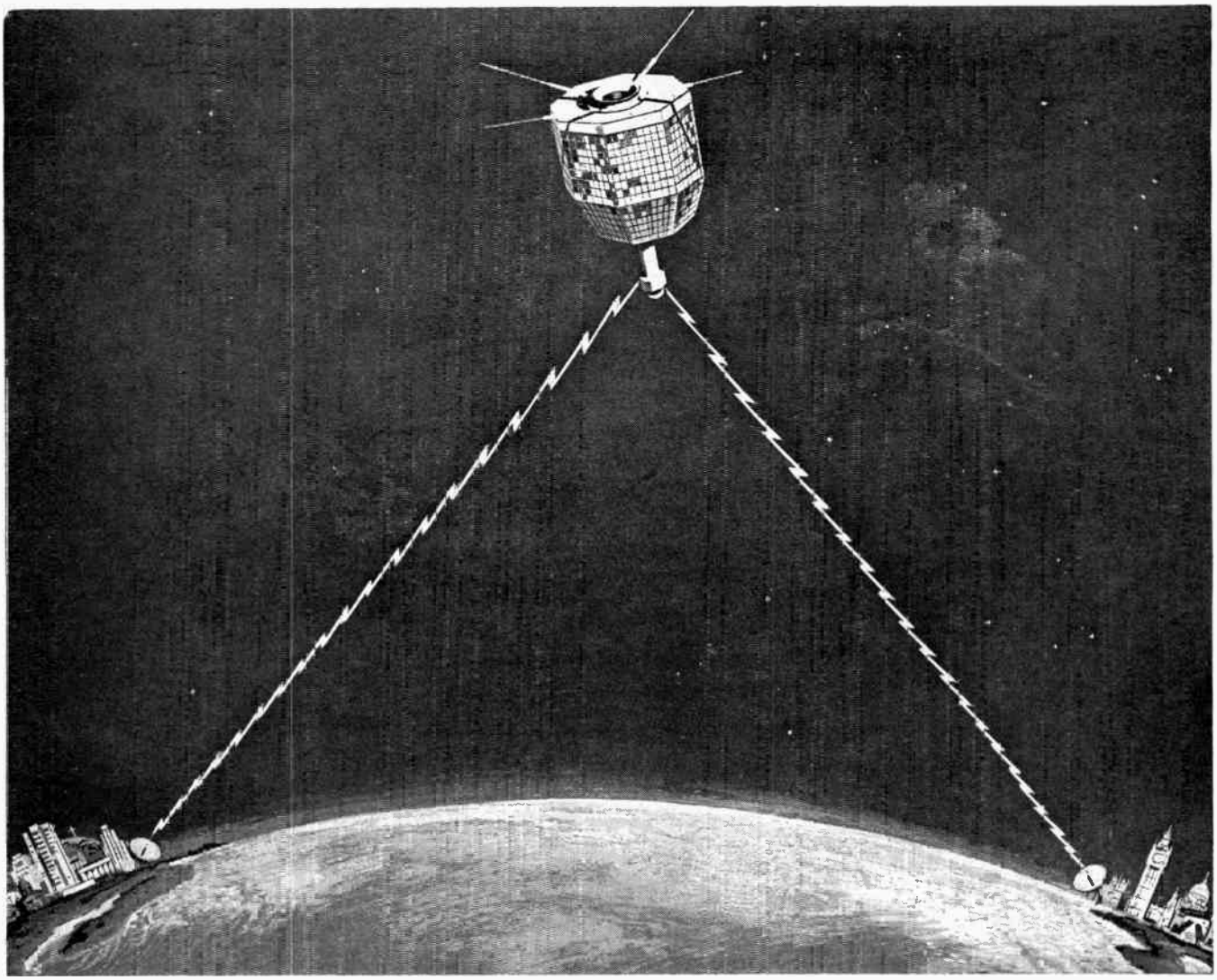
nomous control in Canadian operations.

Heading up the new formation as president and general manager is **W. J. Cheesman,** former area general manager ITT Canadian Operations. Other appointments are **H. J. Barker,** vice-president engineering; **R. R. B. Hoodspith,** vice-president and general manager Service Division; **E. O. Bridges,** vice-president, manufacturing; and **C. Desjardins,** vice-president and general manager Royal Electric.

"The object of the re-organization," said Mr. Cheesman, the newly elected president, "is improved customer service, and the expansion of Canadian engineering, design and manufacture to encompass a wider range of ITT system products for both the Canadian and export markets.

Telecables & Wires Ltd. elects new officers

The election of **L. G. Lumbers** as president and **H. O. Coish** as vice-president of Telecables & Wires Ltd. has been announced. Telecables & Wires Ltd. is a subsidiary of Canada Wire and Cable Company Limited of which Mr. Lumbers is also president.



CAREER OPPORTUNITIES IN ADVANCED ELECTRONICS...

RCA Victor in Canada is building the Receiver/Transmitter for the communications satellite shown in the artist's impression above. Scheduled to go into orbit late this summer, Project Relay is being built for the United States' National Aeronautics and Space Administration, and will pioneer a new realm . . . global television.

Diversification in Design and Development Engineering is the keynote at RCA Victor. At our Montreal plant extensive engineering programmes are conducted on a wide variety of projects wholly Canadian in design and development.

At RCA Victor, opportunities exist at all experience levels for graduates in Electrical Engineering and Engineering Physics to work with distinguished technical teams on advanced engineering and research projects. To engineers and scientists RCA Victor offers excellent starting salaries . . . plus a comprehensive employee benefit programme.

Our wide range of activity includes theoretical and practical work in:

- Microwave and Scatter Communications
- Military Systems
- Antennas
- Installation and Service
- Radar
- Systems and Reliability Studies
- TV and AM Broadcast
- Microwave Physics
- Solid State Physics
- Semi-Conductor Applications

Applicants interested in a career with the Company should contact:

Technical Employment Manager

RCA VICTOR COMPANY, LTD.

1001 Lenoir Street, Montreal 30, Quebec

THE MOST TRUSTED NAME IN ELECTRONICS

For complete details check No. 47 on handy card, page 79

opportunities

These classified advertisements are published to assist those in the industry who have articles for sale, positions available, positions desired, sales agency openings or business opportunities. Charges are 25c per word or figure, not including heading or box number. Minimum charge is $5.00 payable on submission. No agency commission paid. There is absolutely NO CHARGE for "positions desired" advts.

Send all material to the attention of the Classified Editor of ELECTRONICS AND COMMUNICATIONS, 450 Alliance Ave., Toronto 9, Ontario.

HELP WANTED

SALES ENGINEERS

with a good basic background in either Electronics or Electrochemical equipment required at once.

For interview phone RU 3-6576.

Also Technicians and Sales Technicians entertained.

Conway Electronic Enterprises Reg'd
1514 Eglinton Ave. West
Toronto 10, Ontario

Sinclair Radio Laboratories Ltd.

has set up facilities to carry out approval tests on 27 Mc/s General Radio Service Band equipment as per DOT Specification 136 and Standards Procedure 100.

Inquiries should be directed to:

Sinclair Radio Laboratories Ltd.
P.O. Box 179 - Downsview, Ontario
Telephone: MElrose 5-1881

HELP WANTED

PART TIME EDITOR

is required for a small Ontario bi-monthly technical journal.

Box 5100

Electronics and Communications
450 Alliance Avenue, Toronto 9, Ont.

APPLICATION ENGINEER

Experience with circuitry associated with electronic components including special purpose tubes and semi-conductors.

Salary commensurate with experience.

Write or apply:

Radio Valve Company Limited,
189 Dufferin Street, Toronto 3, Ontario
534-6311

ELECTRONICS ENGINEER

Well known electronics manufacturer with over 30 years in Canada requires graduate design engineer for electronics development. This is not temporary work. Salary in keeping with training and experience. Location South-Western Ontario.

Box 5101,

ELECTRONICS AND COMMUNICATIONS,
450 Alliance Avenue, Toronto 9, Ontario

HELP WANTED

SALES ENGINEER

ITA Electronics Corporation, a major U.S. manufacturer of AM, FM & Studio Equipment, is establishing a Canadian subsidiary. A vacancy exists for an aggressive, knowledgeable sales representative, desirous of presenting the Canadian Broadcast Industry with a quality line of equipment at realistic prices and supported with an unmatched servicing philosophy.

Contact:

Al Timms, Broadcast Sales Manager
ITA Electronics Corporation
Lansdowne, Pa., U.S.A.

All applications will be held in confidence.

APPLICATION ENGINEER

experienced with the manufacture of radio and TV coils as well as associated circuitry and coil design.

Salary commensurate with experience.

Box 5103,
Electronics and Communications
450 Alliance Avenue, Toronto 9, Ontario

HELP WANTED

Coil winding machine set-up man, experienced in the production of radio and TV coils.

Salary commensurate with experience.

Box 5104,
Electronics and Communications
450 Alliance Avenue, Toronto 9, Ontario

QUALITY CONTROL SUPERVISOR

Science graduate with eleven years experience in the electronic component industry seeks new position. Quartz crystal, semiconductor photo-cell, microwave tubes. Military and commercial applications.

Box 5102
Electronics and Communications
450 Alliance Avenue, Toronto 9, Ontario

Computer Programmer

Male or Female with University degree or equivalent ability required: Mathematical aptitude essential. Previous experience in computer programming desirable.

Alcan is currently operating a tape 650-1401 system which is scheduled to be replaced by a larger system in 1962.

Please apply in writing to:

ALCAN

ALUMINUM COMPANY OF CANADA, LIMITED
Staff Personnel Division
Box 6090,
Montreal 3, P.Q.

editorial

Aerospace in Canada – the birth of an industry

It may come as a surprise to many Canadians to find, as this special issue shows, quite an extensive activity in Canada concerning the space sciences. Indeed, one of the objects in preparing this special space electronics presentation has been to demonstrate the very real existence of this capability here in Canada. Though manifestly not in the same category as space developments in the United States it is evident that the very first elements of an aerospace industry now exist in this country. Examination reveals that Canadian endeavors do not overlap those of the giants in the business but instead are complementary to them. Rather than a little competence in the whole field, Canadians are achieving great competence in highly specialized areas. Unique Canadian antennas are projected for a dozen U.S. satellite projects, Canadian research rockets are offered to world-wide markets. Canadian aeroballistic and plasma physics research provide a vital link in military space programs in the western world; there are many other examples. Though only a small part of Canada's scientific and engineering effort has been committed to these activities the results are excellent and those directly involved merit our sincere admiration.

So far so good, but the future looms ahead and if Canada is to retain her label in world affairs as a technologically advanced nation it is clear that the special capabilities presently in existence should be developed and expanded. Within the time scale foreseen in the Gordon report we would hope to see a well-founded aerospace industry in Canada . . . . once again, not sending men to the moon, but otherwise deeply involved in many branches of space activity both in regard to research and manufacture.

To assist in the attainment of this advanced industry it is necessary to plan a course of action at government level right now. In particular, government agencies should assist Canadian companies in participating in U.S. and possibly European programs in much the same way that help is given in connection with joint defense projects.

Secondly, alignment of Canada with one of the satellite communications projects should be proceeded with on an urgent basis. This is one aspect of space work that promises substantial financial returns. At least let us build the ground stations and not be wholly dependent upon our American friends for high capacity trans-Atlantic communications channels and TV broadcast direct from Europe. In a somewhat similar vein, we should take a serious look at satellite weather prediction techniques and as a minimum, prepare our own data reduction centers.

Finally we would like to see the emergence in Canada of a vigorous and reasonably well funded government agency dealing with all non-military aspects of space research. Such an agency, initiating projects in the national interest, co-ordinating geographically far-flung space-oriented activities and acting in a scientific advisory role to the cabinet would provide the binding force the emergent industry requires.

As this special issue shows, Canada has the brains and resources to contribute significantly in these exciting research frontiers . . . . let us try and keep these in Canada . . . . they are part of our heritage.

Only "KEMET"

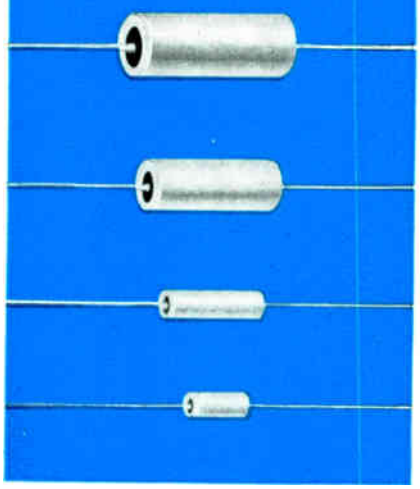
The SPECIALIST in SOLID TANTALUM CAPACITORS

has the widest choice of high-voltage types

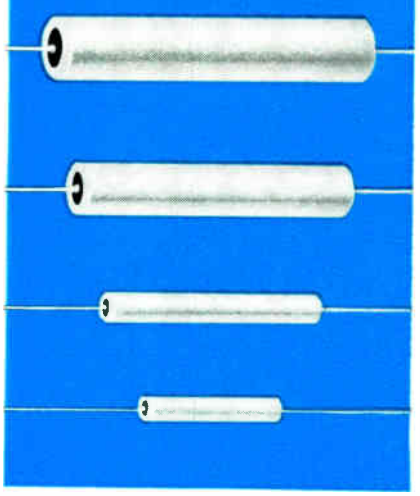
—also available in low capacitance values!

75 V
60
50
35
20
15
10
6

J-SERIES
(Polar Type)
.0047 to 330
MICROFARADS
Temperature Range:
−55 to +125° C



N-SERIES
(Non-Polar Type)
.0024 to 160
MICROFARADS
Temperature Range:
−55 to +105° C



J-Series meets or exceeds MIL-C-26655A

KEMET offers you the only full line of high-voltage solid tantalum capacitors for a multitude of military/industrial applications. J-Series and N-Series are available in working voltages of 75, 60, 50, 35, 20, 15, 10, and 6—in standard E.I.A. values with ±5%, ±10%, and ±20% tolerances. Low leakage characteristics are excellent. Four J-Series case sizes conform to MIL-C-26655A—with or without insulating sleeve. Leads are solderable and weldable. All KEMET capacitor types have passed approved environmental tests. Whatever your solid tantalum capacitor needs, meet them with KEMET's complete line! Kemet Company, Division of Union Carbide Corporation, 11901 Madison Avenue, Cleveland 1, Ohio.

Write for technical data on the complete line of "KEMET" Solid Tantalum Capacitors!

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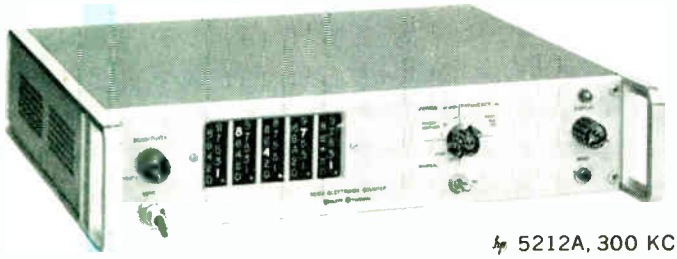
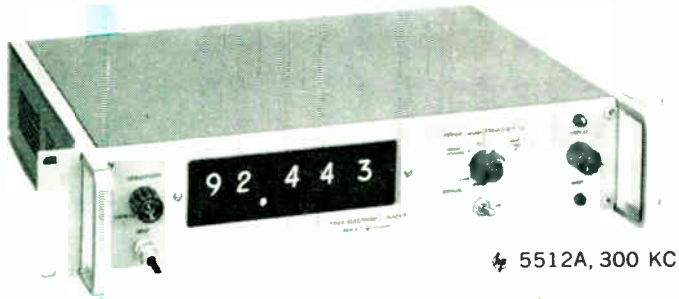
For complete details check No. 37 on handy card, page 79

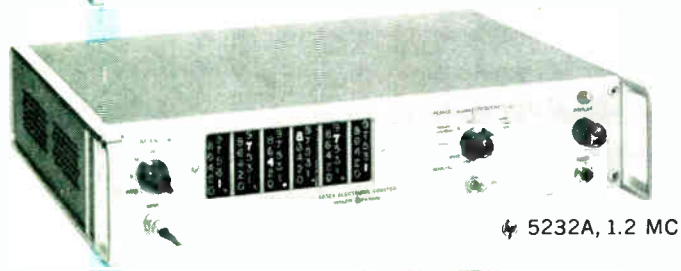
4 hp SOLID STATE COUNTERS



hp 5212A, 300 KC



hp 5512A, 300 KC



hp 5232A, 1.2 MC

hp 5532A, 1.2 MC

Measure frequency, period, ratio, quickly, accurately . . . Compact, easy-to-use instruments with unique storage feature for continuous display, no "blinking" between measurements . . . 0.1 volt sensitivity . . . Solid state dependability . . . Unique low frequency accuracy . . . Operation −20° to +65° . . . Prices comparable to vacuum tube counters!

These ultra-modern, easy-to-use counters have maximum counting rates of 300 KC or 1.2 MC, with a choice of Nixie or columnar readouts. Only 3½" high, the counters are engineered in the new hp modular design—ideal for both bench use and easy rack mounting. High sensitivity permits low level measurement without accessories, and multiple period average measurement (to 100,000 periods) gives higher accuracy in lower frequency ranges, even for noisy signals. Self-check is provided for both frequency and period measurement modes. Solid state design gives you the advantages of low heat dissipation, fast warm-up, low power consumption and high reliability. Counters include a four-line BCD output.

Call or write your hp representative today for information and a demonstration!

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

Counter	Max. Counting Rate, Registration	Period and Multiple Period Average Measurement		Frequency Measurement		Ratio Measurement			Price
		Range	Accuracy	Range	Gate Time	Reads	Range	Accuracy	
5212A	300 KC, 5 digits columnar	2 cps to 300 KC	± one count ± time base accuracy ± trigger error/ periods averaged	2 cps to 300 KC	10, 1, 0.1, 0.01 sec.	(f_1/f_2) x period multiplier	f_1: 100 cps to 300 KC (1 v rms into 1,000 ohms) f_2: same as period	± 1 count of f_1 ± trigger error of f_2	$ 975.00
5512A	300 KC, 5 digits Nixie								1,175.00
5232A	1.2 MC, 6 digits columnar	2 cps to 1.2 MC	± 1 μs ± time base accuracy ± trigger error/ periods averaged	2 cps to 1.2 MC			f_1: 100 cps to 1.2 MC (1 v rms into 500 ohms) f_2: same as period		1,300.00
5532A	1.2 MC, 6 digits Nixie								1,550.00

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