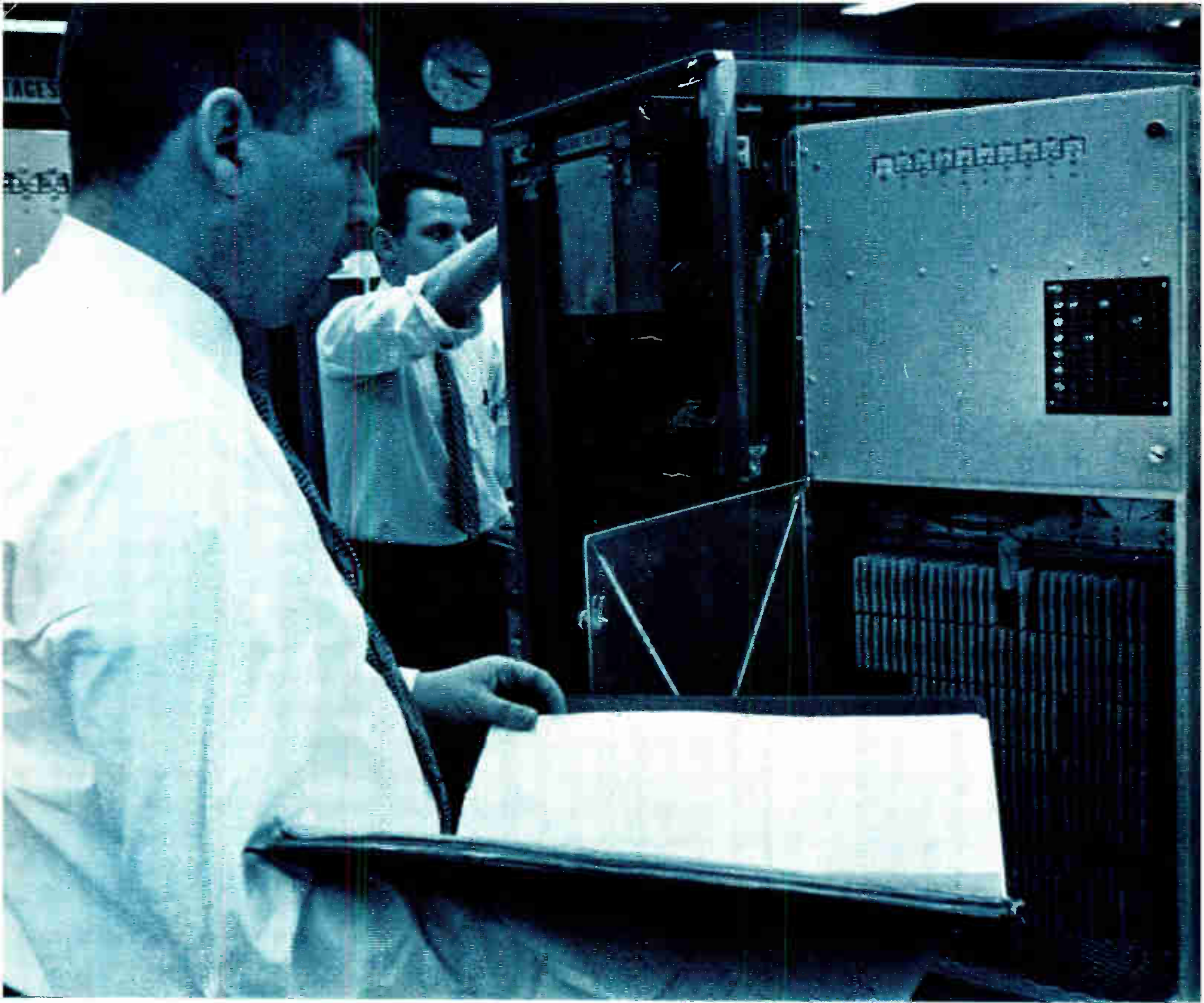


See description page 5

electronics and communications

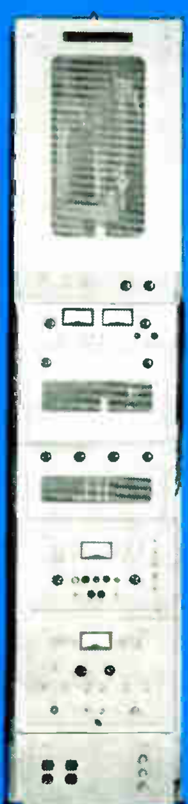
an age publication

JANUARY 1961

up to 960 telephone channels to...

specifications

The DQ58C Wide Band Trans-continental Radio Relay is the Latest Product of the Telecommunications Department.



For over six years the Canadian Marconi Company has maintained an advanced, well-equipped laboratory for designing and developing radio relay equipment. There are few laboratories in the world with the same specialized experience. The Canadian Marconi Company has produced a range of medium and wide band high performance equipment for use in currently approved frequency bands. The DQ58C is one of the latest additions to the wide band equipment meeting CCIR recommendations for standards of performance.

Some of the major advances in the design of the DQ58C have been the application of an improved Travelling Wave Tube, offering an exceptionally WIDE BANDWIDTH with HIGHER GAIN and POWER OUTPUT, a new VARACTOR mixer circuit, and the extensive use of PRINTED CIRCUIT BOARDS, SLIDE - IN CHASSIS and components of high performance figures such as new microwave ferrite devices.

- ★ **Maximum capacity 1200 channels**
- ★ **Either monochrome or Colour TV**
- ★ **Frequency range 1700-2300 MCS**
- ★ **Power output 10 watts**
- ★ **Baseband 10 c/s to 8 mc/s**
- ★ **Full drop and insert**

For further information on this and on our complete line of radio equipment please write or phone

CANADIAN MARCONI COMPANY
— Telecommunications Department

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For complete details check No. 11 on handy card, page 35

at Canadian Marconi

the only complete **Image Orthicon** testing lab in Canada

factory tested and sealed

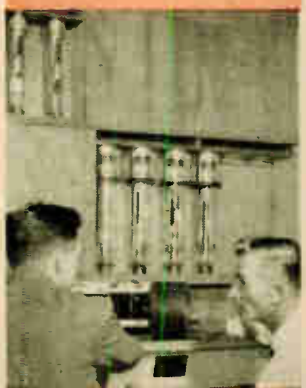
Before they leave the factory, all Marconi Image Orthicons undergo extremely critical testing.

studio conditions duplicated

Acceptance tests are conducted when the tubes arrive in Canada. Marconi has built a special lab where the image orthicons are tested under Canadian studio conditions.

"total" testing

An extensive series of tests check every detail. Once it has passed these tests, the camera tube is shipped to the studio, sealed and protected by the Marconi guarantee.



tests vary

Each of the six types of image orthicons undergoes its own special tests. To test each tube thoroughly takes 30 to 50 minutes.

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visiting studio personnel

Studio engineers and technicians are invited to inspect and make use of these facilities.

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CANADIAN Marconi COMPANY

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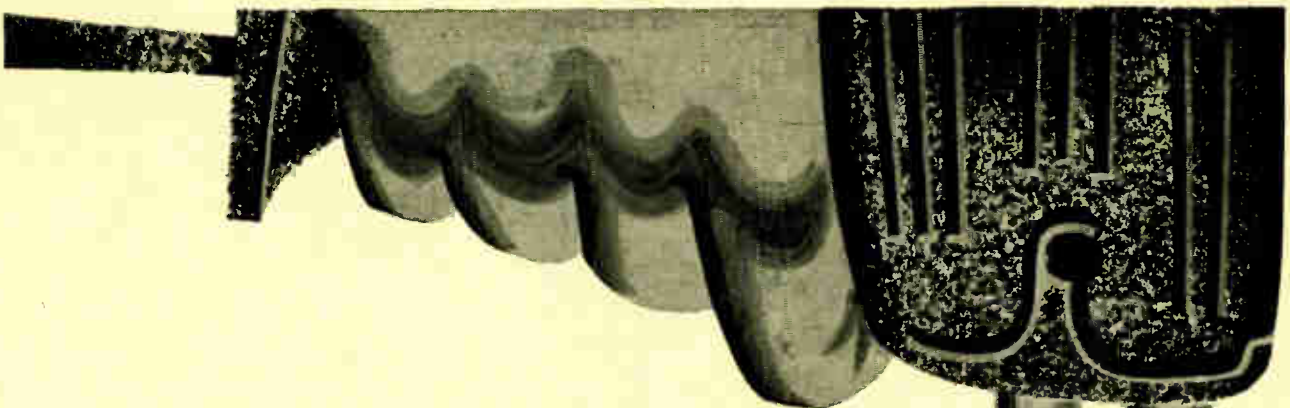
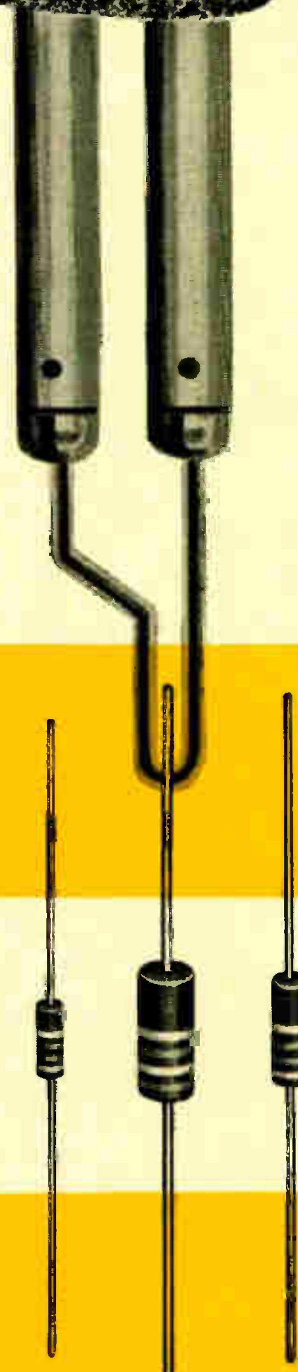
For complete details check No. 10 on handy card, page 35



Would you buy fixed resistors just because they're the **easiest to solder?**



Of course you wouldn't!

But when you add the highest degree of "solderability" of any resistors on the market to top-notch reliability in other physical and electrical characteristics — well, that's something else. Like a lot of other cost-conscious producers, you'll then be using Stackpole Coldite 70+ Resistors!

Stackpole Coldite 70+ "solderability" saves time and money in your production. It assures perfect connections that eliminate a lot of possibilities for costly field service later on.

Coldite 70+ performance fully matches the "solderability" of the leads. They're designed to meet or excel MIL-R-11 in every respect. And they're tops in load life, humidity and moisture tests!

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fixed composition resistors

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For complete details check No. 12 on handy card, page 35

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60

electronics and communications

Canada's pioneer journal in the field of electronics and communications engineering

contents JANUARY, 1961

Vol. 9, No. 1

departments

COVER STORY

As part of its reliability philosophy, IBM incorporates service aids into its equipment like the small lighted "trouble" panel on the face of the 729-III magnetic tape unit shown on our front cover illustration undergoing study at IBM's Product Test Laboratory.

EIA report

by R. T. O'Brien

Educators Ask for School TV Receiver

The Education Television Association of Metropolitan Toronto has asked the manufacturers to produce the specifications for an educational television receiving system for schools.

At a special meeting of the Receiver Division Engineering Committee, Eric Palin, vice-principal of Ryerson Institute of Technology, outlined the results of a carefully controlled study by the Metropolitan Educational Television Association (META) and the Toronto Boards of Education which clearly showed that educational television is rapidly gaining national acceptance as an indispensable visual training aid and that Canadian receiver manufacturers are being offered an excellent opportunity to tap a potential market.

Television is opening up a completely new opportunity in the field of education. A number of programs are already being videotaped for early presentation in the Metro Toronto Area. Teachers are attending special courses in programming, video scriptwriting, and production techniques. Visual aids representatives on the many Boards of Education are busy with the development of facilities such as exist at Ryerson which will ensure that production of programs is adequate and that the content is geared to Canadian curricula.

Emmett Freestone, representing the Toronto Board of Education, Visual Aids Department, told the meeting that there are nearly 28,000 schools in Canada and that his department has received a number of inquiries from Boards of Education across the country seeking information on the work being done in promoting educational television in the Metropolitan areas of Ontario, clearly demonstrating the need for Canadian manufacturers to get into the position of being able to provide suitable receiving systems.

The EIA Receiver Engineering Committee wasted no time. A special group has been assigned the big task of writing a specification for school television receiving systems. The only characteristics specifically asked for by the educators are good picture and adequate sound in a set suitable for use in the average Canadian classroom. The engineers are given a free hand to work out the details of configuration, portability, mounting, and the safety and cabinet protection aspects. Reliability to ensure minimum servicing requirements; input provisions for UHF and VHF; and the capability of the receiver to be adequate in a variety of signal strength climates will be just a few of the problems to be worked out.

Both Mr. Palin and Mr. Freestone expressed confidence that the engineers will quickly produce the specifications and the equipment. Educational TV for Canada is well on the way to reality.

Advanced TV Servicing Techniques Courses

The Receiver Service Committee, under Chairman Jim Sands, reports on the success of the Advanced Television Servicing Techniques Course. One class is enrolled at the Ryerson Institute in Toronto, one at the Vancouver Vocational Institute, and a third one in London, Ontario. Mr. Sands reports that the Committee now feels sure that the various schools are interested in carrying on with the program and several service organizations throughout the country have been asking more questions about the training.

It is evident there will be sufficient students to maintain adequate classes for the schools involved.

A new graduation certificate has been designed. This will be printed in the near future, and will be issued to last year's graduating class so that there will be uniformity from now on across the country.

In addition a Directory of Graduate Accredited Technicians of the EIA approved Advanced TV Servicing Techniques Course is being prepared and will be distributed shortly. The Directory will give the name and graduation year of the technicians who have successfully completed the course. The purpose of the Directory is to have available a list showing successful graduates that the manufacturer can recommend to perform service on his product.

For complete details check No. 5 on handy card, page 35

Lenkurt Electric Co. of Canada assumes complete sales autonomy

Carman R. Hughes, vice-president of General Telephone & Electronics International Incorporated, announces that, effective January 1, 1961, Lenkurt Electric Co. of Canada Limited directly assumes the responsibility for the sale and service of all their products. This function has heretofore been the responsibility of Automatic Electric Sales (Canada) Limited.

Lenkurt Electric and Automatic Electric have had close business associations for many years and both companies are members of the General Telephone & Electronics Corporation. Key sales personnel, formerly with the Carrier and Radio Sales Division of Automatic Electric, have been transferred to Lenkurt Electric so that a continuity of service to customers will be provided. This sales personnel group has been combined with the Lenkurt sales engineering staff to provide a concentrated sales and service organization.

The reason for this change is to increase efficiency and to furnish even better service through direct access to the factory by sales personnel.

Lenkurt Electric and Automatic Electric will continue to work in close cooperation, particularly on projects involving the products of both companies. Assurance is thus given of a complete service for all communication requirements.

The modern, well equipped factory of Lenkurt Electric, located in Vancouver and staffed by an experienced Canadian engineering group, has established the design and manufacture of high quality carrier and radio equipment for all Canadian requirements.

Bourns (Canada) Ltd. announce production of potentiometers

Marlan E. Bourns, president of Bourns, Inc., Riverside, California, has announced the opening of a new facility in Canada to operate under the name of Bourns (Canada) Ltd. This new facility will supply the Canadian military and commercial electronics market with Bourns Trimpot® leadscrew actuated potentiometers made in Canada by Canadians with maximum Canadian content.

Bourns (Canada) Ltd. has entered into a long term lease for a 7,000 square foot building at 36 Cranfield Road, East York, Ontario, Canada. In charge of this operation is John A. Law, supervisor of administrative services. Key Bourns personnel are presently in Canada checking facilities and setting up manufacturing procedures to assure that the Canadian-made units will meet the same rigid specifications as those made in the United States. A quality control and reliability assurance program will be put into operation immediately whereby production lots will be sent to Riverside on a monthly basis for complete environmental testing to all specifications.

New testing facility for Marconi

A new laboratory for testing special purpose tubes has been established by the Electronic Tube and Components Division of Canadian Marconi Company in Toronto. It is believed to be the first time such facilities have been available in Canada. A similar testing lab for camera tubes has been in operation at Marconi for over two years and the value of this facility prompted extension of the testing operations to include special purpose tubes.

Most special purpose tubes used in Canada are imported. When the tubes are just re-shipped to the customer in Canada, shortcomings in them may not be discovered until after they are in service. Delays incurred while the defective or damaged tube is returned to the European or U.S. manufacturer are a serious inconvenience to the Canadian customer. By pre-testing the tubes before they are shipped to the customer, delays and inconvenience will be eliminated; for shipments to customers will be made only from an inventory of tested tubes.

CFCF-TV, channel 12 opens on schedule

CFCF-TV, Channel 12, will make its debut to 2,500,000 viewers in the Montreal area at 4.00 p.m., Friday, January 20, 1961.

Just nine months after being recommended a license to operate Montreal's second English-language television station by the Board of Broadcast Governors, CFCF-TV is now fully geared to commence continuous daily transmission with programming initially from 4.00 p.m. to approximately 12.30 a.m.

L. J. Bardwell Canadian rep.

L. J. Bardwell Company have announced their appointment as the Canadian representative of Parker Electrical Instrument Corp., of Connecticut. Among the lines to be handled by Bardwell will be Electrical Instrument Corporation's panel meters.

Exterior view of the new 7,000 square foot manufacturing facility in which Bourns (Canada) Ltd. will produce potentiometers for the Canadian military and commercial market.

CANADIAN RADIO TECHNICAL PLANNING BOARD: **Front row l. to r.:** *T. S. Dutton, J. M. Richardson, R. R. Robertson, E. A. Frith, J. E. Hayes. R. C. Poulter, C. J. Bridgland, F. H. R. Pounsett, President, CRTPB; D. Geiger, G. P. Adamson, F. W. Radcliffe.* **Back row l. to r.:** *J. C. Cline, Staff Insp. G. H. Long, J. L. Wilson, N. Redsell, W. B. Smith, G. H. Stewart, E. L. Palin, W. A. Caton, W. J. Wilson, Lt. Col. J. C. Garnall, F. G. Nixon, P. R. G. Cahn, C. Eastwood, F. G Stiles, S. Bonneville. E. H. Hayes, A. Reid, C. Harris, G. A. Muir, J. H. Fletcher.* **Absent:** *W. Ornstein, Chairman, Land Fixed and Mobile Committee.*

IRE Canadian Electronics Meet planned for October 2-4, 1961

The 1961 Canadian Electronics Conference sponsored by the Institute of Radio Engineers will be held in Toronto October 2, 3 and 4. Theme for the meeting will be "Progress through Electronics".

In announcing dates and theme, Fred J. Heath, general chairman of the new Conference Executive Committee, said papers, discussion and displays would center on up-to-date electronics developments in industry, commerce, medicine and defense.

Fred J. Heath

A. R. Low, chairman of the Technical Program Committee, said calls are now going out for technical papers by authorities on such subjects as electronics exports and imports with particular reference to the Japanese industry, electronics in other countries, communications systems. Canada's satellite program, solid state electronics, engineering management, traffic control, industrial electronics, nucleonics, medical electronics, plasma physics, data processing in business, and educational aspects of electronics.

On the display side of the conference, special emphasis will be given to new electronics products and developments, according to G. C. Eastwood, chairman of the Exhibits Committee.

This fifth biennial conference, explained Grant Smedmor, conference manager, is intended not only to provide a forum for the dissemination of electronics information and for the display of the latest electronics equipment. A showcase is being provided for engineers and businessmen to get an over-all detailed appreciation of every phase of electronics. The conference enables leaders in all phases of the industry to get together conveniently. A printed program is being made available from IRE headquarters, 1819 Yonge Street, Toronto, early in 1961. Exhibit space at the Automotive Building in the Canadian National Exhibition grounds is now being made available on a first-come-first-served basis.

"The fantastic progress being made in Canada and the rest of the world through electronics will be portrayed at this conference," Mr. Heath stated. "To ensure that a complete report is given on all developments, the help of an advisory committee composed of leaders in related fields is constantly being obtained."

Dial program for SGT

Details of the 1961 dial conversion program of Saskatchewan Government Telephones, whereby close to ten thousand telephones will be converted to automatic dial operation within the next eighteen months, was announced in Regina by the Minister of Telephones, the Hon. C. C. Williams.

Mr. Williams said that the program called for the conversion to automatic dial service next year of twenty-one manually operated exchanges throughout the province. He said that construction on the buildings to house the automatic switching equipment in these communities would start next summer, and that all offices were expected to be in operation by the spring of 1962. The Minister said that the twenty-one dial conversions in the 1961 program were the first of some three hundred to be carried out in the next ten years. Mr. Williams announced last October that the corporation was aiming for complete dial telephone service for the province by 1971 under a stepped-up program of dial conversions.

Personnel exchange locations

John H. Cole has been appointed manager of the Leaside, Ontario, plant of Corning Glass Works of Canada.

Mr. Cole succeeds **A. Russell Arnold** who has been named assistant to the manufacturing manager of the Consumer Products Division of Corning Glass Works at Corning, N.Y.

Mr. Cole has been with Corning Glass Works since 1951. He has served as an industrial engineer, process engineer, and, since 1956, as production superintendent of one of the company plants in Corning, N.Y.

J. A. Fellows joins Burlec Sales

B. W. Richardson, president of Burlec Sales, recently announced the appointment of **J. A. Fellows** to their staff. Mr. Fellows is to head the new Onan division for their recently acquired central Ontario franchise for Onan engine generating equipment.

Mr. Fellows brings a wide range of experience to his new position. Originally entering the sales field as manager of the Industrial Division of Canadian Aviation Electronics he moved to Pye Canada Ltd. as manager of its Telephone Division. Prior to his latest appointment he was sales manager for Tele-Radio Systems Ltd.

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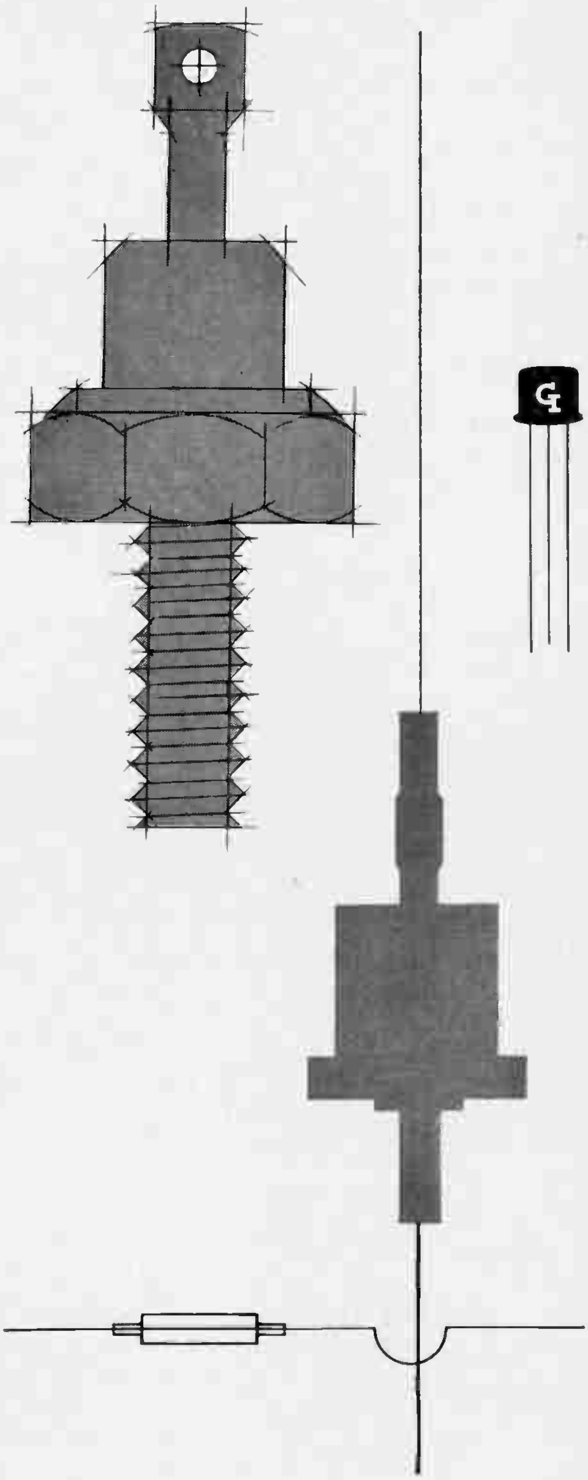

G. I. SEMICONDUCTORS are now manufactured in Canada, to the highest standards of quality and reliability. In the General Instrument plant at Waterloo, Ontario, where 50,000 square feet of floor space is devoted to the manufacture of electronic components, facilities are as modern as any on this continent.

Here, in dust-free air, skilled operators perform the delicate task of producing high quality G. I. Semiconductors for the Canadian electronics industry.

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Technical assistance and the facilities of our research laboratories are always available to you.

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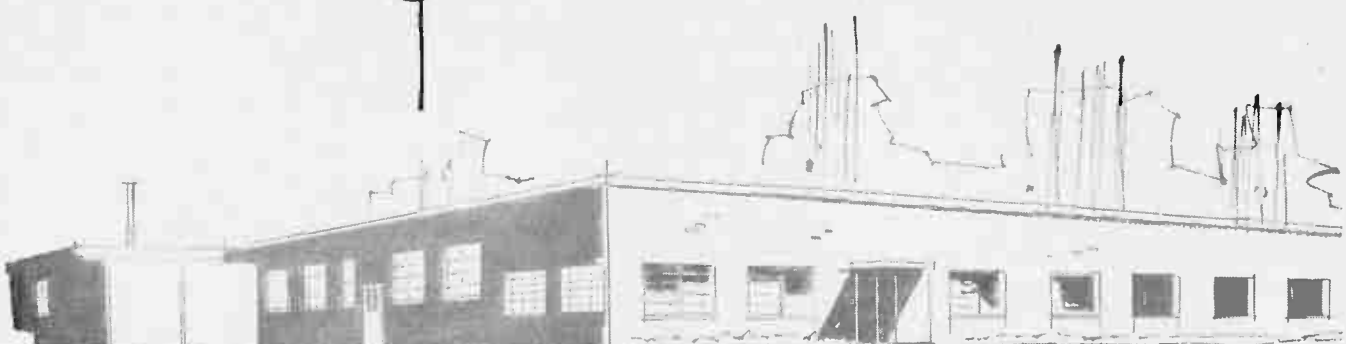
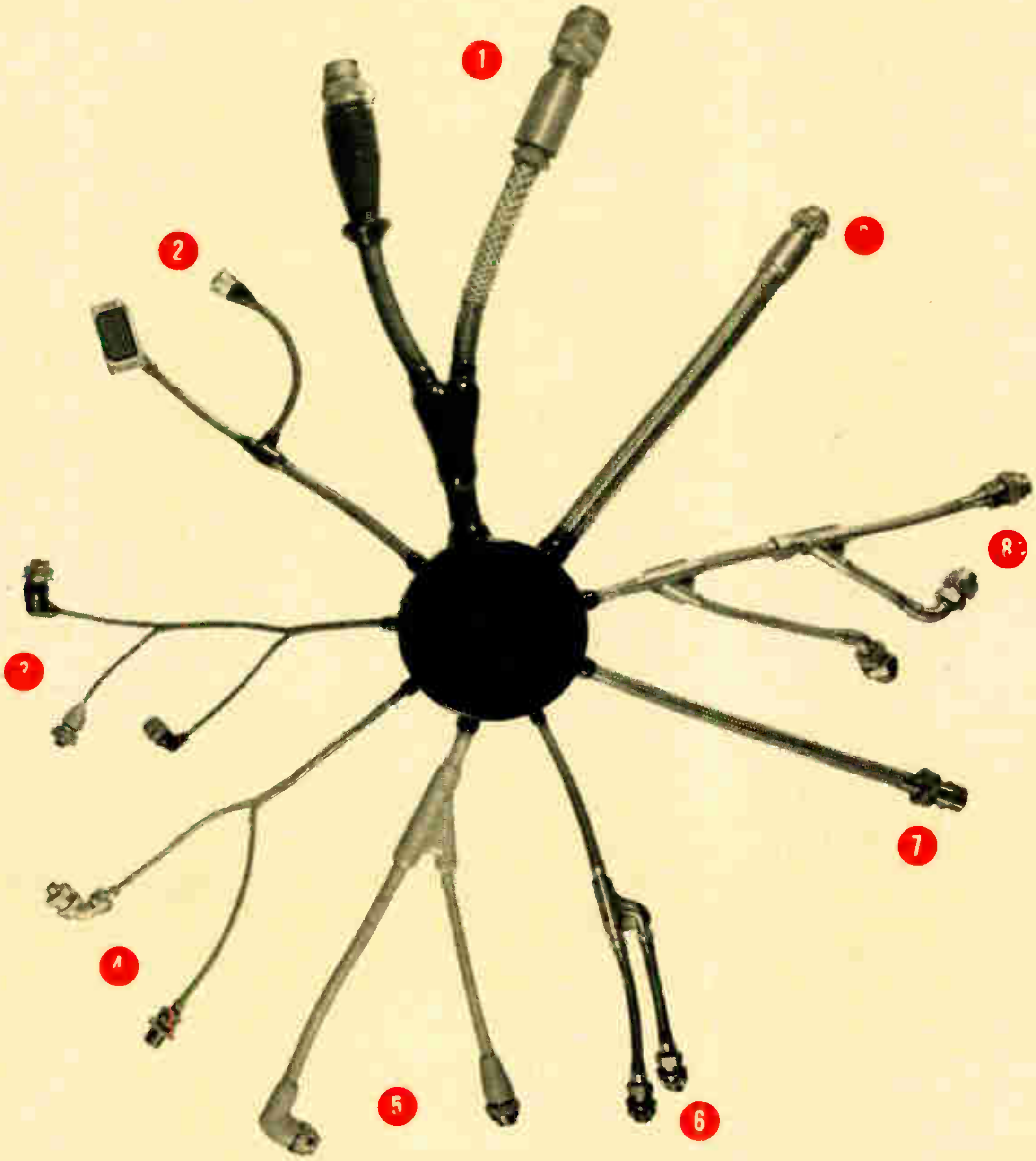


For complete details check No. 17 on handy card, page 35



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industry personnel


R. Spencer Soanes


L. C. Sentance


R. H. Smith


Peter Bas


J. H. Innes


D. S. Simkins


F. J. Martin


R. A. Lapetina

Philips Electronics organization changes

D. C. F. van Eendenburg, president, Philips Electronics Industries Ltd., Toronto, announces a change in the organization of the Rogers Electronic Tubes and Components Division.

The division is re-oriented into two independent departments, each under a departmental manager, reporting directly to the president. The two new departments will be responsible in their respective markets, which are: Equipment Manufacturers, Distributors, Equipment Users, Government, Universities, Research and Development Establishments, Export, Contacts with Industry Associations, for all aspects connected with progressive marketing.

Customers in the field of consumer products will be primarily served by the entertainment semi-conductor, tube and component department. The manager is **Mr. Peter Bas.**

Customers in the field of professional products will be primarily served by the professional semiconductor, tube and component department. The manager is **Mr. Donald S. Simkin, P.Eng.**

The division's reorganization will allow the company to give better service to customers in view of the expected, future rapid growth of the electronics industry in Canada.

M. C. Patterson, general manager (marketing) of the former Rogers Electronic Tubes & Components Division, has been given a new assignment which will permit our company to benefit from his past experience and background. He will report directly to the president.

L. C. Sentance heads professional engineers

A 47-year-old Saskatchewan-born mechanical engineer, **Lawrence Crawley Sentance** of Burlington, has been elected president of the 20,000-member Association of Professional Engineers of Ontario. He succeeds Dwight S. Simmons, Toronto, as chief executive of the organization which serves as the licensing body for all engineers practising in the province.

Born in Melville, Sask., Mr. Sentance is manager of the Defense Apparatus Division of Canadian Westinghouse Ltd., Hamilton. He has been with that company since 1937 when he left an instructor's post with his alma mater, the University of Saskatchewan, to take a two-year engineering apprenticeship course with Westinghouse. He graduated in mechanical engineering, and also holds his masters' degree in the same branch.

Canadian Research Institute sales appointment

The announcement was recently made by R. Spencer Soanes, president of Canadian Research Institute, of the appointment of **John H. Innes, P.Eng.,** as sales manager of that organization. Mr. Innes joined the company after having ten years' experience with United-Carr Fasteners Company Limited and the Shell Oil Company of Canada.

Mr. Innes will be responsible for all sales, advertising, publicity, and market research for Canadian Research Institute, and the many other companies they represent.

With a backlog of 22 years' experience and with new laboratories in Don Mills, Canadian Research Institute is planning for a 100 per cent volume increase during the next twelve months.

Edo (Canada) appointment

R. R. Hind, vice-president and general manager of Edo (Canada) Limited, has recently announced the promotion of **R. A. (Bob) Lapetina** to the position of vice-president — engineering of the company's Cornwall operation.

Mr. Lapetina will be responsible for the design and development of military and commercial electronic systems, specializing in the field of sonar and associated underwater acoustics.

Mr. Lapetina is a graduate of Columbia University and spent twelve years with Edo Corporation, New York, before becoming chief engineer of Edo (Canada) Limited two years ago.

F. J. Martin joins General Instrument

J. McK. McLean, vice-president and general manager, General Instrument of Canada Limited, announces the appointment of **F. J. Martin, MIRE, AM Inst.E,** as sales manager for government products.

Mr. Martin will be responsible for establishing and developing a military and specialized equipment sales facility for all government departments, utilizing the wide and varied resources and experience of the General Instrument Corporation Group.

Mr. Martin has a wide background in the field of electronic instrumentation, both in London, England, and in Canada. For the past eighteen months he has been instrument division manager for E.M.I.-Cossor Electronics Limited.

Hysol (Canada) Ltd. names vice-president

The appointment of **Russell H. Smith** as vice-president of Hysol (Canada) Ltd. has been announced by G. H. C. Smith, president.

High energy electrons in solid state physics

Released to Electronics and Communications for exclusive Canadian publication by High Voltage Engineering Corporation, Burlington, Massachusetts.

Studies of radiation effects are vital to physicists in developing the theory of the solid state. For example: high-energy particles have been used extensively to produce defects in crystalline materials. The resulting vacancy-interstitial pair alters the mobility of the charge carriers, and therefore the electrical characteristics of the material. In conductors, this will result in decreased conductivity. In semi-conductors, the defects, which are primarily of the Frenkel type, will act as carrier traps and decrease the carrier lifetime. A knowledge of these effects which can be easily measured has been invaluable in extending the theory of crystal structure.

Lattice bonds

Theoretical studies in ionic and co-valent crystals have shown that the lattice binding energy is about 25 ev. The energy of an electron which can cause a single displacement is therefore of the order of 0.4 Mev. This figure is confirmed by a number of experiments with electrons from Van de Graaff accelerators. Reports of these experiments have come from Purdue University using the University of Notre Dame accelerator[1], North American Aviation, Inc.[2], Bell Telephone Laboratories[3], and others. All confirm the theory within the experimental errors. More refined measurements on such aspects as crystal orientation by Bell Laboratories[3], and minority carrier lifetime, by R.C.A. Laboratories[4], are under way and will serve to extend even further our understanding of the crystal structure.

Type of particle

Many different particles can be used for radiation studies. Their effects differ mainly in the momentum transferred to the lattice atom. Heavy particles transfer a large amount of energy. The ejected atom may have enough kinetic energy to cause subsequent displacements and produce a thermal spike in which a large number of atoms are involved. This type of damage is hard to analyze because of its complexity.

Light particles, such as electrons, can be accelerated to energies where only a single displacement will occur. It is possible to measure the binding energy of the atom in the lattice by suitable measurements following this type of bombardment.

The source of these particles can be an accelerator or a nuclear pile. The need for precise control of certain variables and the necessity for knowing the particle energy makes the accelerator a superior source. The Van de Graaff has been used extensively in these studies because its precision and energy stability best meet the requirements.

Applications

Studies of radiation effects can be applied to current problems. Nuclear pile designers must know how much radiation a material can withstand before failure, and how well important instruments will stand up under particle bombardment. In particular, sensitive electronic systems must operate safely in high-intensity radiation fields. This is particularly true for nuclear-powered aircraft and guided missiles. Much work is now going on in testing components in radiation fields provided by particle accelerators.

There have been reports of high-frequency diodes being produced by irradiating semi-conductor materials to reduce the carrier lifetimes. While these have not been produced commercially, it appears that this is a simple method of producing traps in semi-conductors where they are needed.

Accelerator versatility

The studies described above are being carried out principally with the Van de Graaff®. Capable of accelerating charged particles such as electrons and protons, this versatile source of synthetic radiation can also produce monenergetic neutrons and high-intensity x-ray fields. The primary particle energy is continuously variable over wide ranges, and can be accurately measured for threshold studies.

[1] *E. E. Klontz, K. Lark-Horowitz, Phys. Rev. 86, 643, 1952*

[2] *D. T. Eggen, M. J. Laubenstein, Phys. Rev. 91, 238, 1953*

[3] *W. L. Brown, Bull APS, 2, 156, 1957*

[4] *P. Rappaport, Phys. Rev. 94, 1409, 1954*

Selling to the Canadian Government

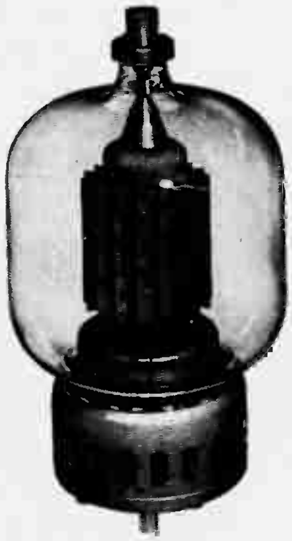
The Canadian Government, the largest single buyer of goods and services in Canada, has just issued a manual on its requirements. Prepared by the Small Business Branch of the Department of Trade and Commerce, **Selling to the Canadian Government** was distributed to businessmen attending the recent Export Trade Promotion Conference in Ottawa.

The manual details the methods and procedures of Federal Government procurement, with information about tenders and contracts. Services are divided into professional and commercial, with a complete analysis by type. Most construction, it is explained, is handled by the Department of Public Works, but four other departments have the authority to contract in some measure, on their own, for public works.

This manual describes how purchasing is handled by the nine departments which handle 90 per cent of all Federal Government procurement. The purchasing offices of each department are listed.

An appendix notes 72 categories of goods and services purchased, with a breakdown of each into as many as 20 individual items and a clear indication as to which are used by the various departments.

Copies of **Selling to the Canadian Government** are available from the Editorial and Art Services Division, Trade Publicity Branch, Department of Trade and Commerce, Ottawa.



EIMAC TYPE 4-1000A TETRODES HELP PROVIDE

COMMUNICATIONS FOR CANADA'S REMOTE AREAS

The Type 4-MRE-3C radio transmitter, now helping provide Canada's remote areas with reliable all-weather communications, contains a pair of Eimac Type 4-1000A tetrodes as final RF amplifiers. Companion SK-500 sockets and SK-506 glass chimneys are also supplied by Eimac. The tetrodes are operated push-pull Class C in conjunction with a specially designed broad-band R.F. transformer that covers the range 100 to 200 kilocycles.

The Type 4-MRE-3C is manufactured for the Department of Transport by Standard Telephones and Cables Manufacturing Company (Canada) Limited, and can be remote controlled over a single telephone pair to a distance of 30 miles. If antenna icing raises the Voltage Standing Wave Ratio above 2.5:1, output power is reduced automatically by 50%.

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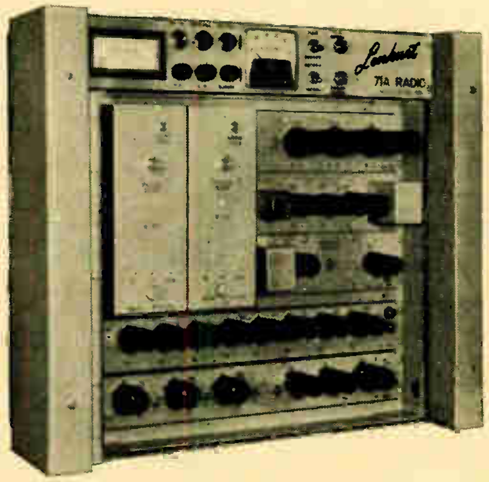
a new family of light-route radio systems by *Lenkurt*



The new Lenkurt Type 71 light-route radio equipment is available for operation in the 150 mc, 450 mc and 900 mc bands. It provides toll-quality transmission of up to thirty multiplexed voice channels over distances of up to ten hops. Greater channel capacity can be obtained over shorter distances.

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Transmitter power output and receiver noise alarms are provided including both local indication and facilities for connection to remote equipment.

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This new Lenkurt light-route radio equipment was designed and manufactured in Canada.

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CRTPB newsletter

Prepared by Canadian Radio Technical Planning Board

Relaxes Radio Licensing Requirements

Transport Minister Leon Balcer has announced that licenses for private mobile radio systems will now be available to a much wider range of applicants than before.

Because private systems operate on very high frequencies and the number of channels available is necessarily limited licenses have so far been restricted to those who could prove an essential need.

Technical advances have now resulted in a more economical use of frequencies through closer spacing of channels. As a result the Department is able to relax its requirements and permit more general licensing.

As certain frequencies will still have to be reserved for such essential services as police, fire, utilities, etc., general licensees will have to share with others the frequencies assigned to them.

Also, to meet public demand, the licensing of public radio dispatching systems will be broadened so as to permit a greater number of such systems to operate on a competitive basis in these large centers.

Licensing Land Mobile Systems

Since April 1, 1958 the Department of Transport has been licensing stations operating in the 150.8 - 152 mc/s band on the basis of 30 kc channel spacing. On September 1, 1960 because of a lack of available channels in the 152 - 174 mc/s band, the Department extended their split-channel licensing policy to cover the band 152 - 174 mc/s.

In conjunction with this policy, on September 1, 1960, the frequency coverage of Radio Standard Specification 126, was extended to cover the full band 150.8 - 174 mc/s. This meant that on and after this date all VHF radiotelephone to be used in new systems in the specified areas had to be type-approved under Specification 126.

One development of the implementation of this policy was that the Department has been asked by several licensees now using wide-band equipment if they would be permitted to add narrow-band equipment to their systems. After due consideration it was decided that there would be no objection to this request although it was realized that a small degradation in system performance would undoubtedly occur. The Department believes that this action will assist in expediting the transition from wide-band to narrow-band operation.

16th Annual Meeting

Frank H. R. Pounsett, Philips Electronics Industries Limited, was returned as President of the Board at the 16th Annual Meeting held in Ottawa on November 24. C. J. Bridgland, Canadian National Telegraphs, was re-elected Vice-President.

Ralph A. Hackbusch, President of Hackbusch Electronics, has been appointed to continue as General Technical Co-ordinator. Mr. Hackbusch, on the advice of his doctors, did not attend this meeting, the first he has missed since the Planning Board was organized in September 1944. Because of his reduced activity for health reasons Mr. Hackbusch has been appointed to carry on in an advisory capacity and R. T. O'Brien of the Electronic Industries Association has been named to assist him.

Other appointments re-affirmed were: R. C. Poulter, Radio College of Canada, Director of Public Relations; Fred W. Radcliffe, Electronic Industries Association, Secretary-Treasurer; and Cowan Harris, Electronic Industries Association, Assistant Secretary.

Study on Telephone Channel Parameters

At a joint CRTPB/EIA Microwave Committee meeting in April 1957 there was expressed the need for a mutually acceptable system standard, including a common technical language, for discussing radio relay requirements and as a result a task force was set up to report on communications systems parameters paying attention to the definitions and methods of measurement.

During the course of the studies data was to be collected on generally accepted levels of performance for common carrier and general communication services which are in use.

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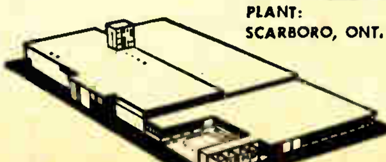

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briefing the industry

A consulting engineering firm in Colorado is using a Toronto installed computer in the design of a hingeless arch in the field of civil engineering. The complex calculations, which might take up to one week for an engineer to do manually, are being done electronically in Toronto in three minutes with no chance of error. The computer, manufactured in England by Ferranti Ltd., is called Pegasus (Winged Horse) and is installed at Ferranti-Packard in Toronto specifically for scientific and engineering applications.

British equipment will light Canadian TV studios when a new commercial television service (Channel 9) starts operating in Toronto on January 1. On December 1 the first of BOAC's DC7F freighter aircraft left London carrying the equipment to Toronto. The cargo arrived in Toronto on December 1 and was part of a $500,000 order won by a Toronto firm, Strand Electric Ltd., in the face of keen American competition.

"Buy Canadian" is no empty slogan at Canadian Admiral Corporation. In introducing three new television models, Ed. Whittaker, vice-president sales, pointed out that 94.7 per cent of the components in a new 23" table model were of Canadian manufacture. The percentage rises to 95.0 per cent in a 23" console and 95.2 in a 23" lowboy model. This high Canadian content is not unusual in Admiral sets. since several models in the current television line. introduced last June, are well over 96 per cent Canadian in components. These figures do not include labor cost in the TV sets. which is 100 per cent Canadian.

More than 90 per cent of the thousands of electronic component manufacturers, are doomed to disappear from the American business scene within the next 10 years. "Accelerated by the relentless demand for standardized products. custom manufacturing houses will either convert to standardized product lines or fall by the wayside," according to Bernard M. Goldsmith, president. Nytronics. Inc. Nytronics, Inc., consisting of Essex Electronics Division, Berkeley Heights, N.J., Automation Products Division, Lexington, Ky., and a Canadian subsidiary. is one of the nation's leading producers of custom and standardized components for the electronics, missile, communications and computer industries.

"The output of the American electronics industry for the coming decade will triple," according to Theodore Rossman, chairman of the board of the Pentron Electronics Corporation. One of the underlying factors of the growth of America's electronics industry is the shift from radio and television manufacture as these markets reach saturation, to industrial equipment. Industrial electronics, the Pentron Electronics executive said, is the field where growth in the next 10 to 15 years will probably be quickest.

A survey shows the Canadian Electronics Industry has suffered a 28 per cent reduction in employment from 1955 to end of 1959. This included people in research, engineering, production, administration and factory sales and service. It did not include distribution and service employees. Further reductions have been reported in 1960. Based on a survey of radio receiver and supporting component manufacturers of transistorized sets in Canada, from which was determined the number of hours of Canadian production in a typical transistorized receiver, it has been calculated that the 395,000 transistorized sets imported from Japan in 1959 represented 1,185 jobs lost to Canadians in our industry.

In the second year of the Canada-U.S. defense sharing program there has been a significant decline in production sharing contracts. For the first six months of 1960 members of the EIA (Canada) have reported total production sharing orders of less than an average of $1,000,000 (one million dollars) a month. This is considerably less than one half of the average for 1959 and indicates a reverse trend to the one which had been anticipated.

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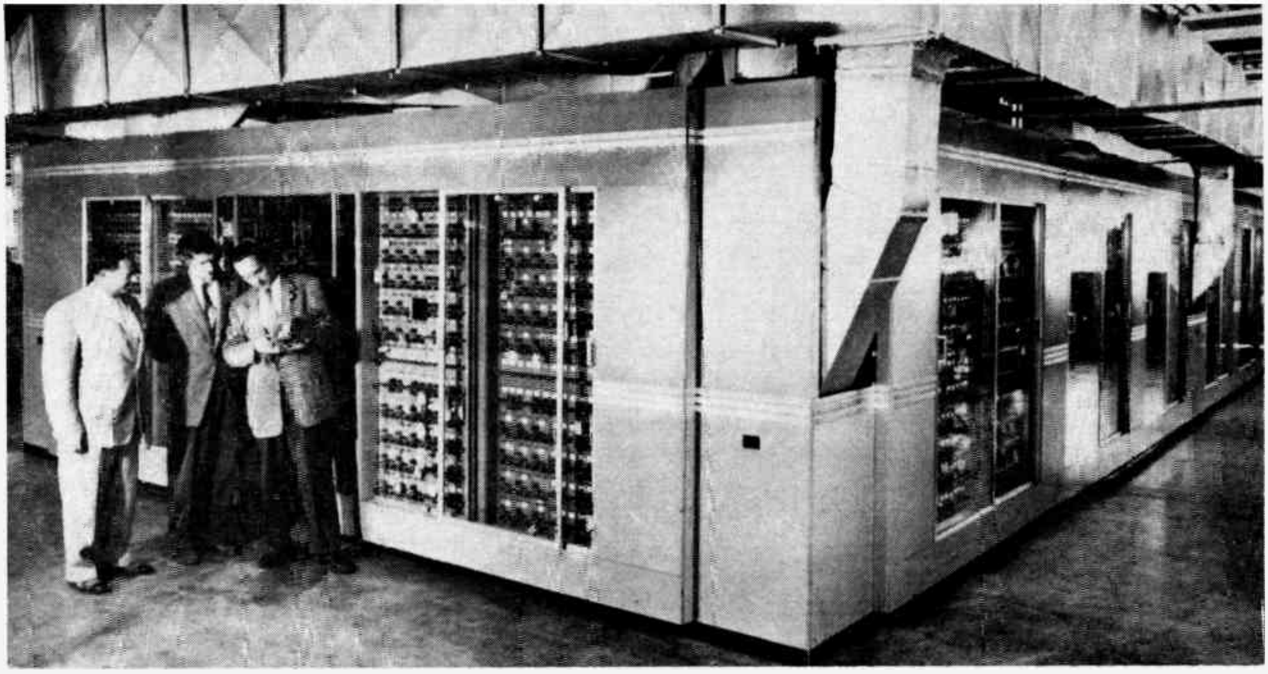


The naval tactical trainer at the time of its cancellation in 1956 was one of the largest computers in existence. Design and development were entirely Canadian.

DEFENSE MARKET ANALYSIS

What's ahead in defense electronics?

Long range planning in the Canadian electronics industry can be based on only one assumption — that our government will strongly encourage and assist the industry in finding a place for itself under the Canadian sun.

by W. S. Kendall *

For the first five years after the outbreak of the Korean war in 1950 defense equipment requirements provided a renewed technological demand on the Canadian electronics industry. A remarkable spectrum of new ideas, combined with the 1950-55 climate of requirements, led to the initiation of such advanced developments as: naval tactical data processing, naval tactical trainer, naval plotting tables, variable depth sonar, Doppler airborne navigation. Rho Theta airborne navigation computer, PHI airborne navigation computer, UHF airborne communications, ground mobile communications, mobile radar, flight simulators, CAGE semi-automatic data processing. CF-100 missile and missile auxiliaries and the ASTRA fire control and navigation system.

The changing defense emphasis after the end of the Korean war, coupled with rising costs, led to the termination of many of these developments in the years 1956 and 1957. As time passed and the cold war changed from the local contest of Korea to a situation of intercontinental challenge, defense requirements changed to one of large scale systems. Costs again increased beyond the limits originally envisaged and Canada withdrew from major systems development. The final stage in this process was reached on September 23, 1958 when the ASTRA development was cancelled and on February 20, 1959 when the ARROW weapon system was cancelled.

This has had a profound effect. To the electronics defense industry it has meant the virtual disappearance of its market and the immediate necessity of finding new markets for continued existence. Production sharing has been offered and worried businessmen are now asking themselves these questions:

Will production sharing provide the answer?

Will I be able to compete in other markets?

Will I be able to maintain steady plant loading and technological growth?

Management in the defense industry has two major problems today, one being the short term need of maintaining plant and facility, the other the longer range problem of determining where the company is to go in the years ahead. There seems little doubt that in the short term at least, production sharing is the only answer. To make production sharing work effectively we must know and understand the characteristics of our new market, for only by knowing the market in detail will we be able to plan effectively for results.

These are some of the things we should know about the United States defense market:

It is a large market

There is a popular understanding that the United States defense market runs just over 40 billion dollars because this is the figure most often quoted in the press. This figure however, is the total Department of Defense budget and includes the salaries and administrative costs of the Armed Services. Of the 40 billion

* *Managing Director, Computing Devices of Canada Ltd.*
The author has noted that facts used in this article have been obtained from official sources and are believed to be accurate. The opinions expressed in this article are strictly those of the author.

dollar total budget approximately 14 billions are spent on the purchase of military hardware with around five billion dollars of this earmarked for electronics. This is still an impressive total. By contrast Canadian electronics defense expenditures over recent years have been averaging approximately 100 million dollars annually — or about two per cent of the United States total.

Electronics is a rapidly growing market by reason of the fact that it is taking over more and more of the complex control and communications systems of modern weapons and this market will continue to outgrow the general economy by a significant factor in the decade ahead.

It is a technically advanced market

The money spent for research, development and production in the United States today is for equipment that is literally forcing the frontiers of the art. In the defense business technical breakthroughs are not uncommon — indeed they are almost an expected part of every defense contract.

It is a technologically fast-paced market, always moving ahead and paying high premiums for advanced and creative engineering.

It is a highly competitive market

Before Korea the United States defense market was highly cyclical reacting like a barometer to every swing in the political climate. Since Korea, defense expenditures have settled down to a remarkably steady 40 billion dollar per year average. This post-war market stability has attracted many companies interested in carving out for themselves a permanent place in defense contracting.

The defense market differs from any other in that sales aggressiveness cannot extend total market volume. The upper limit has been established and has remained virtually unchanged over the past nine years. Any financial ceiling such as this is subject to intense pressure. Inflationary trends alone reduce the dollar value level by perhaps four per cent each year. Along with this there is the increasing cost of maintaining existing weapons in the field; but perhaps most significant of all is the ever rising cost of the technical development of today's complex weapons systems.

Theoretically offsetting these pressures to some extent are the savings made possible by reduction of combat stocks and personnel. But this alone is insufficient. The military services are demanding — and getting — more and more value for their defense dollar. Making this possible is the competitive buying policy of the United States government which encourages any company having capability to bid for defense business. Countless companies have accepted the challenge which has resulted in an unbelievably organized, intensely competitive market with more and more peoples scrambling for the same dollar.

Through production sharing Canadian companies have an opportunity to enter this market, the only requirement being to provide equal or better quality and delivery — *and at a better price.*

It is a geographically dispersed market

In Canada our market was at our back door. Business was done in Ottawa with Department of Defense Production. In the United States, although the Department of Defense is the only customer, there are numerous agencies from coast to coast with authority to place contracts. In addition there are prime contractors and major sub-contractors who can place millions of dollars worth of business. This means that Canadian companies can no longer send one man to knock on one door looking for business. Today it is necessary to have a number of people knocking on a number of doors many miles from home. Sales costs therefor will be dramatically higher.

Direct person to person contact and personal selling will be the order of the day. Canadian companies attempting to develop business possibilities by mail will find it a barren exercise. It must be remembered that in defense marketing we are not primarily selling

Department of Defense Expenditures For Procurement and Research, Development, Test and Evaluation

Fiscal Years 1959-1961
(Millions of Dollars)

	1959 Actual	1960 Estimate	1961 Estimate
Total DOD Budget	$41,233	$40,945	$40,995
Procurement			
Missiles	3,339	3,500	3,479
Aircraft	7,658	6,670	6,027
Ships	1,493	1,651	1,644
Electronics and Communications	942	898	1,067
Other	979	1,223	1,384
Total	$14,410	$13,943	$13,602
Research, Development, Test and Evaluation (RDT & E)	2,859	3,680	3,917
Total Procurement and RDT & E	$17,269	$17,623	$17,519

Source EIA 1960 Fact Book.

Increasing electronic missile dollars is a prime factor behind the remarkable growth of the U.S. electronics industry during recent years. In fiscal 1955, somewhat more than $300 million of $718 million in missile expenditures was absorbed by electronics. Of the three and one half billion dollars spent for missile production in fiscal 1959, approximately $1.6 billion consisted of electronics.

Signposts for the road ahead

- **"Strong political pressures and cross currents will make life difficult."**
- **"We will need to alter our outlook and methods."**
- **"Sales costs will be dramatically higher."**
- **"It will be necessary to develop a new breed of second level management in the company. This will be the defense salesman although he may be called by another name."**
- **"Canadian companies obtaining the greatest measure of success in the United States market will be those having a high degree of engineering capability."**
- **"Probably the most serious problem to face Canadian defense industry in the decade ahead will be the shortage of engineers."**
- **When we consider the extent to which the production sharing concept must be accepted in depth on both sides of the border before it can be regarded as a fully workable system, we will recognize the long term nature of the scheme."**

a product, but rather a capability. This type of selling cannot be accomplished by remote control and wishful thinking.

It is a foreign market

No matter how equal the opportunity may be theoretically it must be remembered that without complete economic and political integration, the United States market is not ours by natural right. It is ours by concession only. We can never expect all the rights and privileges of the home market. Strong political pressures and cross-currents will make life difficult, particularly if we obtain large dollar contracts. The United States defense purchaser will have a hard time placing business in Canada when the U.S. small business administration demands preference, or if there is unemployment in his own area. The security clearance will always provide a selective device for favoring home suppliers. Monetary exchange problems will continue to be a psychological as well as a procedural irritant.

Let us accept the fact that we do *not* have equal opportunities in the United States market and we never will have as long as we wish to remain Canadians.

This then is our market. No one will claim that the task ahead will be easy. To compete in this highly technical, intensely competitive market, Canadian companies will need to alter completely their outlook and methods. It will not be surprising if some fail to make the grade. The successful companies will be those unafraid of adapting to tougher marketing conditions. This will inevitably call for a greater emphasis on marketing.

"Marketing" defense products

To be successful in a highly competitive market one must utilize all the tools of efficient management, in engineering, production, and marketing. Increasingly, United States companies are setting up marketing divisions having complete planning responsibility ranging from the earliest stages of developing customers needs, through to the final deliveries of a satisfactory product, on time, and within costs. It is interesting to note that just over one year ago the American Management Association turned its attention to the defense market for the first time with a defense marketing seminar held in New York followed by a second one in Los Angeles. The theme of these conferences was the necessity for highly efficient and planned marketing in the increasingly competitive defense business.

We are competing then with United States companies, highly customer oriented, and seeking in every way to determine, encourage and develop the customer's needs and to establish ability to meet these needs. Companies unwilling to go along with this concept are finding themselves hopelessly outclassed.

Personal selling and the defense salesman

In Canada, where we had one customer at one location, there was little need for highly qualified defense sales staffs. In most cases senior and top management personnel were primarily responsible for the government contact. Because our markets are now highly dispersed and more competitive it will be necessary to develop a new breed of second level management in the company. This will be the defense salesman, although he may be called by another name. He will be a senior, capable marketing man with a broad technical and business background. He will be able to make contact at all levels with the customer and must know how to call on the resources of his company to meet customer needs. Men with this kind of capability will be hard to find, and this could turn out to be one of the major limiting factors in the Canadian production sharing sales effort.

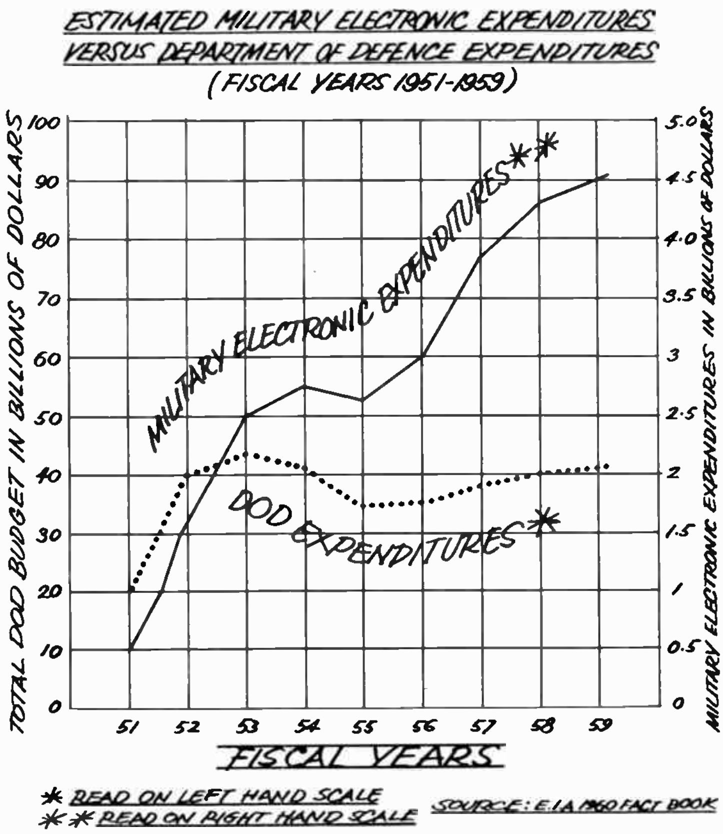
High degree of engineering specialization necessary

Canadian companies obtaining the greatest measure of success in the United States market will be those having a high degree of engineering capability. In many cases they will be able to offer a unique solution rather than attempting to compete across the board with countless others for straight production. With a good engineering approach, contracts can often be negotiated and competition restricted or even eliminated. The secret will be in selecting a narrow market segment for specialization and developing the highest possible degree of technical competence in that area.

Although there is no guarantee that production will automatically follow successful completion of an engineering development, there is no question about the competitive edge the developing company will have in bidding for it.

Shortage of engineers

The most serious problem to face the Canadian defense industry in the decade ahead will probably be the shortage of engineers. Over 700 Canadian engineers and technical staff have left for Britain or the United States in the last two years. Although the exodus is now perhaps halted the damage has been incalculable. One Canadian company president recently pointed out that a technical proposal prepared by his company could not have been written six months later because in such an interval of time he had lost the necessary key engineering talent. The lack will be felt more and more as production sharing business starts to develop. Everyone will be looking for engineers and



From the accompanying chart the rapid growth rate of electronics as compared with the total DOD budget may be clearly seen. This is primarily attributable to expanding missile programs (including detection and defence), the increasing electronic content of sophisticated aircraft, and increasing command and general communications activity.

there won't be enough. This factor, more than any other, will slow the growth of defense production sharing.

The difficulties ahead for Canadian industry are numerous. They are different for each company and in some cases may require an adjustment in head office policy. There will be several difficult years as Canadian companies fight their way out of the situation they now find themselves in and adjust into new markets. As yet there has been no significant success in production sharing but the climate seems brighter. In expecting quick results we have not been realistic. Even to re-orient company thinking towards the new markets, new competitiveness, and new management methods is a long and gradual process. When we consider the extent to which the production sharing concept must be accepted in depth on both sides of the border before it can be regarded as a fully workable system, we will recognize the long term nature of the scheme. Production sharing can be made to work, but we must equip ourselves with the best marketing and technical people we can get and set out to learn the tricks of wresting business from a tough and reluctant market. *We are overly optimistic if we expect this can be fully accomplished in less than five years.*

The long range future

Production sharing alone cannot be the final answer to the problems of the Canadian defense industry. If it were, we could only expect to see control of this industry pass from Ottawa to Washington as Canadian productive and engineering capacity became fully committed on United States military programs. Clearly then, over the long term, we must have a broader plan for new markets, new skills and new products. Although production sharing is a purely bi-lateral arrangement between the United States and Canada there are numerous political pressures today calling for an increase in secondary manufacturing in Canada and an increase in export sales. Defense products and the industrial and commercial products resulting from the build up of technical skills could contribute substantially to this aim. There will be some problems. A good part of the technical know-how of Canadian companies at the moment is provided by United States or British parent companies. Can we expect to continue receiving this technical assistance if we are to use it in direct competition with those who supply it?

This highlights the necessity of our government assisting in developing uniquely Canadian technical skills so that we can compete in any market. There are obvious reasons why Canadian and American defense technology should be molded in the common aim. But the growth of export business in other than United States markets could offer Canadians the "best of two worlds" opportunities. It would tend to offset the growing worry in the minds of many that integration of our defense economy may be just another step towards a more complete integration.

The Canadian defense industry is confronted by an immense challenge. We stand squarely at the crossroads. One road will lead to technical dependence, the other will allow Canada's electronic industry to recreate itself on a far stronger, more diversified and highly technical basis, taking its full part in world affairs and contributing to better living standards for Canadians.

Our long range planning can be based on only one assumption — that our government will strongly encourage and assist our industry in finding a place for itself under the Canadian sun.

Plasmas and the communications engineer

The past few years have seen a tremendous surge of interest in a subject known as plasma physics. What exactly is plasma physics? Why has this sudden interest developed? What has it to do with the communications engineer? The following article answers these questions.

by Dr. T. W. Johnston *

"Plasma" is the term adopted by Irving Langmuir in his gas discharge investigations to denote the state of the gas in what is called the positive colunm in a d.c. discharge.

The essential characteristics of the plasma are the following:

(1) The plasma is a gas with positively charged particles (positive ions), negatively charged particles (electrons and perhaps negative ions) and possibly including an un-ionized neutral background gas.

(2) It has enough charged particles at sufficiently low velocities that the positive and negative volume charge densities are very nearly equal so the gas has little excess charge of either sign.

(3) There are enough charged particles to have noticeable electromagnetic effects.

Langmuir named and defined the plasma from studies of laboratory discharge tubes, but most plasmas occur naturally. In fact most of the material in the Universe is plasma. Only the relatively cold and solid planets, asteroids, meteors and the interstellar dust clouds are *not* plasma. The stars, which make up most of the matter in the Universe, and the interstellar gas clouds, which include most of the balance, are completely ionized plasmas. That is to say they have a negligible fraction of un-ionized gas. The ionosphere is a transition region, a weakly-ionized plasma between the un-ionized lower atmosphere and the completely-ionized interplanetary gas. See Figure (1). Occasionally short-lived plasmas are produced even in the lower atmosphere by nature with meteors and lightning.

Far from being a laboratory curiosity, the plasma, the so-called "fourth state of matter" is the usual state for the existence of matter in the Universe.

This being the case, why has this intense interest in plasmas not developed long ago? The answer is that since the end of the nineteenth century there has been a great deal of work on accessible plasmas in discharge tubes and the not-quite-so-accessible ionospheric plasma. Until recently, work on the inaccessible astrophysical plasma had to remain almost purely theoretical and interest in dense plasmas was quite limited. The single key factor which is responsible for the present intense development is atomic energy, especially energy from the fusion of hydrogen isotopes — H-bomb energy.

The effect has been felt in two ways.

The destructive power of a comparatively light H-bomb made the development of the ballistic missile and its large rockets an essential part of military strategy. This has resulted in the design and launching of satellites which can now investigate interplanetary space directly. Satellite recovery also involves plasma physics, since the re-entering vehicle forms a hot atmospheric plasma around itself, just like a meteor.

On the other hand there is a possibility that the hydrogen bomb reaction can be tamed and controlled and that man will be able to produce energy from matter in a way similar to the sun and stars. To do this entails the creation of a very hot gas plasma, hotter than the interior of the sun, and holding it together long enough to produce energy. This is the most challenging problem of all in plasma physics.

Other possibilities are that the electrical properties of the plasma may lead to the use of plasmas in an electromagnetic rocket of very high exhaust velocity. The high frequency resonating properties of the plasmas may enable it to be used as a source of power at very high microwave frequencies.

To understand how the plasma can be used in these bewilderingly different ways the simplest concepts must be considered which relate the plasma and the electromagnetic field.

Plasmas and the electromagnetic field

The electrically active components of the plasma are of course the charged particles. Of these the ions and their motion can often be neglected owing to their mass which is so much greater than the electrons. This leaves the electrons as the most important part of the mixture. The ions provide a constant charge-neutralizing background and, with the neutral particles, scatter the coherent electron motion to give a viscous drag and power-absorbing effect. The electrical effects

RCA Victor Research Laboratories, Montreal.

are provided by the net currents which flow in the plasma — essentially the electron average flow. For an exposition it is easier to consider the motion of a large number of average electrons with an average viscous drag, but very similar results can be obtained by much more advanced rigorous theory.

Under the influence of an a.c. electric field the plasma current flows as if the plasma were a lossy inductor. This can be easily seen by comparing the average electron motion equation with that for a lossy inductor.

Average Electron Motion

$$\frac{e}{m}E = \frac{dv}{dt} + \nu v$$

where e, m and v are the electron charge, mass and velocity E is the electric field and ν the viscous term (with dimensions of frequency)

Lossy Inductor Equation

$$V = L\frac{dI}{dt} + RI$$

remembering that I is proportional to electron velocity v.

The a.c. current density in the plasma due to a field E of angular frequency ω is then

$$J = nev = ne\frac{e}{m}\frac{E}{\nu + j\omega} = \frac{ne^2}{m}\frac{E}{\nu + j\omega}$$

When we consider electromagnetic waves we must also consider the capacitive free space displacement current ϵ_0 dE/dt and the inductive effects.

This leads us to the lossless transmission line analogy for free space plane waves shown in Figure 2.

The characteristic phase velocity of the line is $1/(L_0C_0)^{\frac{1}{2}} = 3 \times 10^8$ m/sec., the velocity of light, and the impedance is

$$(L_0/C_0)^{\frac{1}{2}} = 120\pi \cong 377 \text{ ohms/square (metre)}$$

The addition of the plasma is to provide a shunting lossy inductor as shown in Figure 3.

An important parameter, called the plasma frequency, is the resonant frequency of the shunt branch which for a low loss (low ν) plasma is very nearly

$$\omega_p = 2\pi f_p = \frac{1}{(L_pC_0)^{\frac{1}{2}}} = \left(\frac{ne^2}{\epsilon_0 m}\right)^{\frac{1}{2}} \text{ radians/sec.}$$

Putting in the numerical factors this becomes

$$f_p \cong 9n^{\frac{1}{2}} \text{ (n in electrons/metre}^3\text{)}$$
$$\cong 9000n^{\frac{1}{2}} \text{ (n in electrons/cm}^3\text{)}$$

Above this frequency the capacitive term dominates the shunt branch for a low-loss plasma $(\nu^2 << \omega_p^2)$ and the plasma transmission line is only slightly mismatched to the free space transmission line. Below the plasma frequency the shunt branch is inductive and the plasma is very badly matched to free space and almost all energy incident from free space is reflected. At very low frequencies (much less than ν) the resistive term will dominate and the plasma will behave as a conductor, still reflecting almost all the incident energy.

A low-loss plasma $(\nu << \omega_p)$ is equivalent to a high-Q circuit. Highly-ionized gases are low-loss plasmas. Weakly-ionized gases with too much neutral background gas correspond to low-Q circuits and for them the transition at the plasma frequency is very broad and is "washed out" by the strong loss effect.

Magnetic fields complicate this picture a great deal. Briefly it can be said that, owing to the action of the magnetic field in making charged particles orbit around magnetic field lines, an incident plane wave becomes split into two waves travelling at different velocities, generally with elliptic polarization and with some field along the direction of propagation. At a certain frequency for each charged particle resonant effects may occur if the collision frequency is much lower than

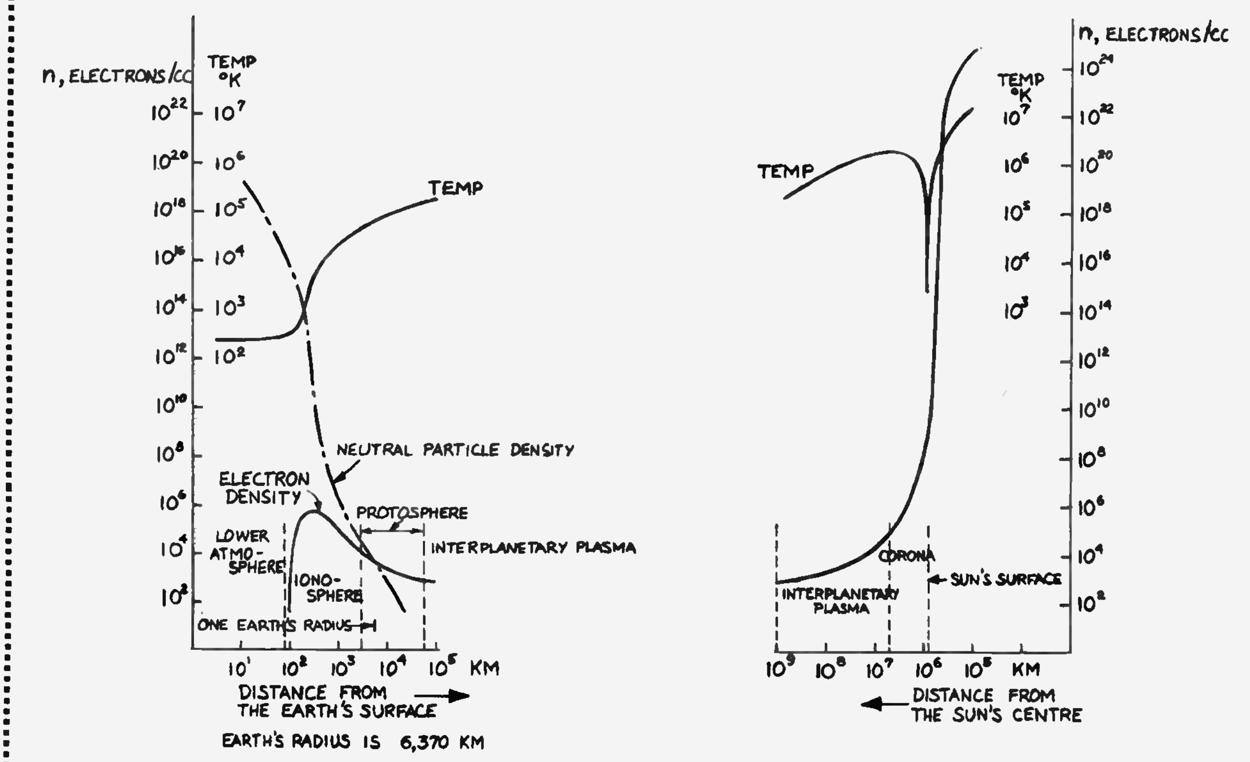


Figure 1 — Plasma between earth and sun.

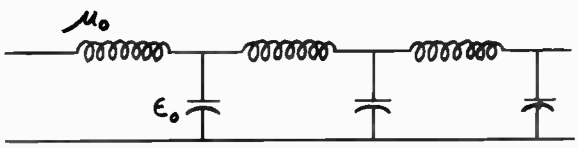


Figure 2

Free-space-plus-plasma transmission line analogy

$R_p = \frac{m\nu}{ne^2}$ ohms/metre $\qquad L_p = \frac{m}{ne^2}$ henries/metre

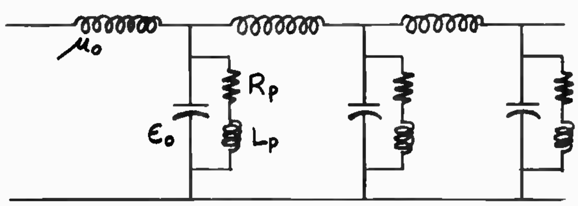


Figure 3

Free-space transmission line analogy.
$L_0 = \mu_0 = 4\pi \times 10^{-7}$ henries/metre
$C_0 = \epsilon_0 = (1/36\pi) \times 10^{-9}$ farads/metre

that frequency. This frequency is the gyro or cyclotron frequency for the particle. The particle will orbit around the field lines at that frequency. For electrons the cyclotron frequency is

$$f_c = \frac{\omega_c}{2\pi} = \frac{1}{2\pi}\frac{e}{m} B = 2.8 \text{ Mc/s per gauss}$$

If one attempts to apply a d.c. or slowly-varying electric field to a plasma the ions and electrons will separate to cancel the field, so moving a plasma by a d.c. electric field is not effective. However, the plasma at low frequencies and d.c. is a good conductor of electricity and, as such, it can be moved by induction, like the armature conductors of a motor. This is the essence of the pinch tubes, magnetohydrodynamic accelerators and the like. A usual refinement is that the magnetic field can be produced by the currents flowing in the conducting plasma.

Because of the use of the magnetic field and because the plasma acts as a hydrodynamical fluid with magnetic effects, the study of this low frequency behavior of the plasma in the magnetic field is given the jaw-breaking name of magneto-hydro-dynamics often abbreviated to MHD. Incidentally, the theory was highly developed by astrophysicists before it came to be applied to man-made systems.

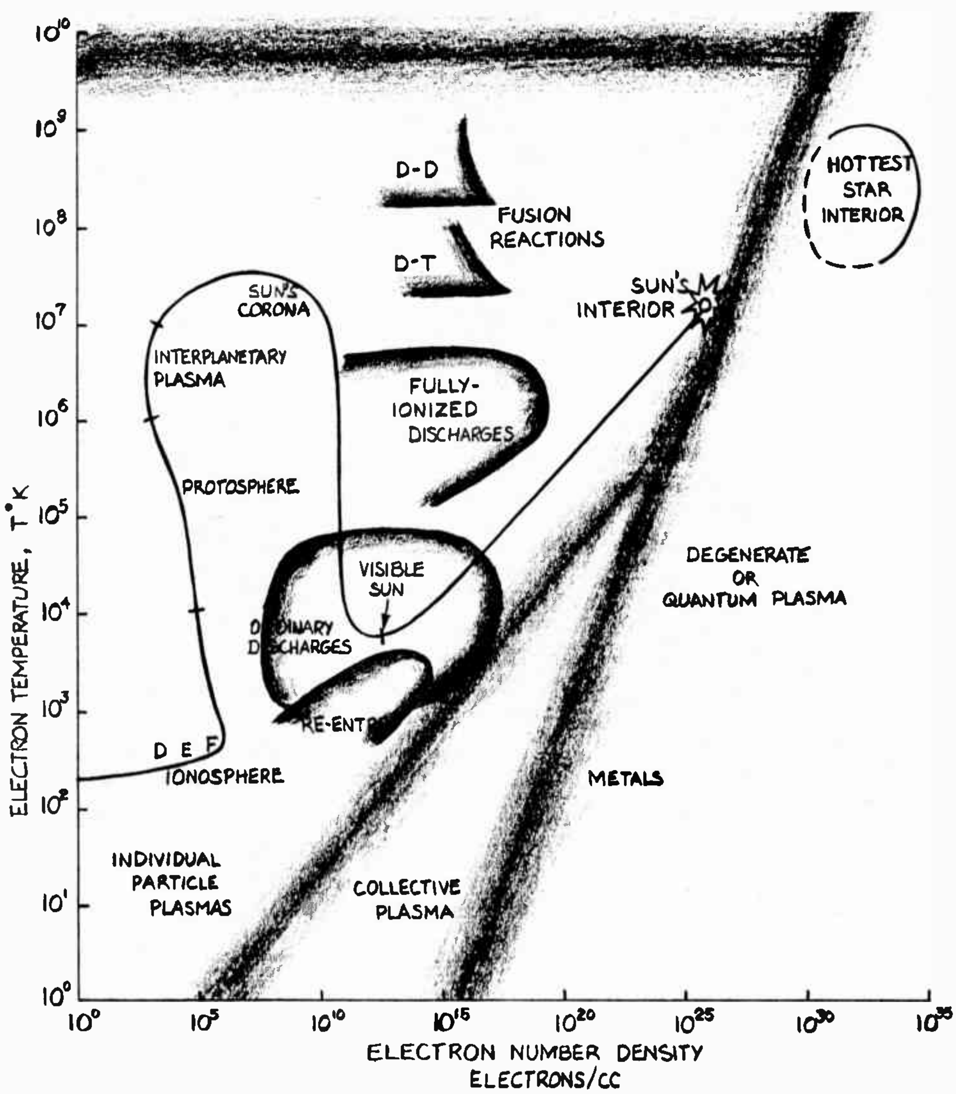


Figure 4a — Plasma electron temperature and electron number density Relativistic (electron) plasma

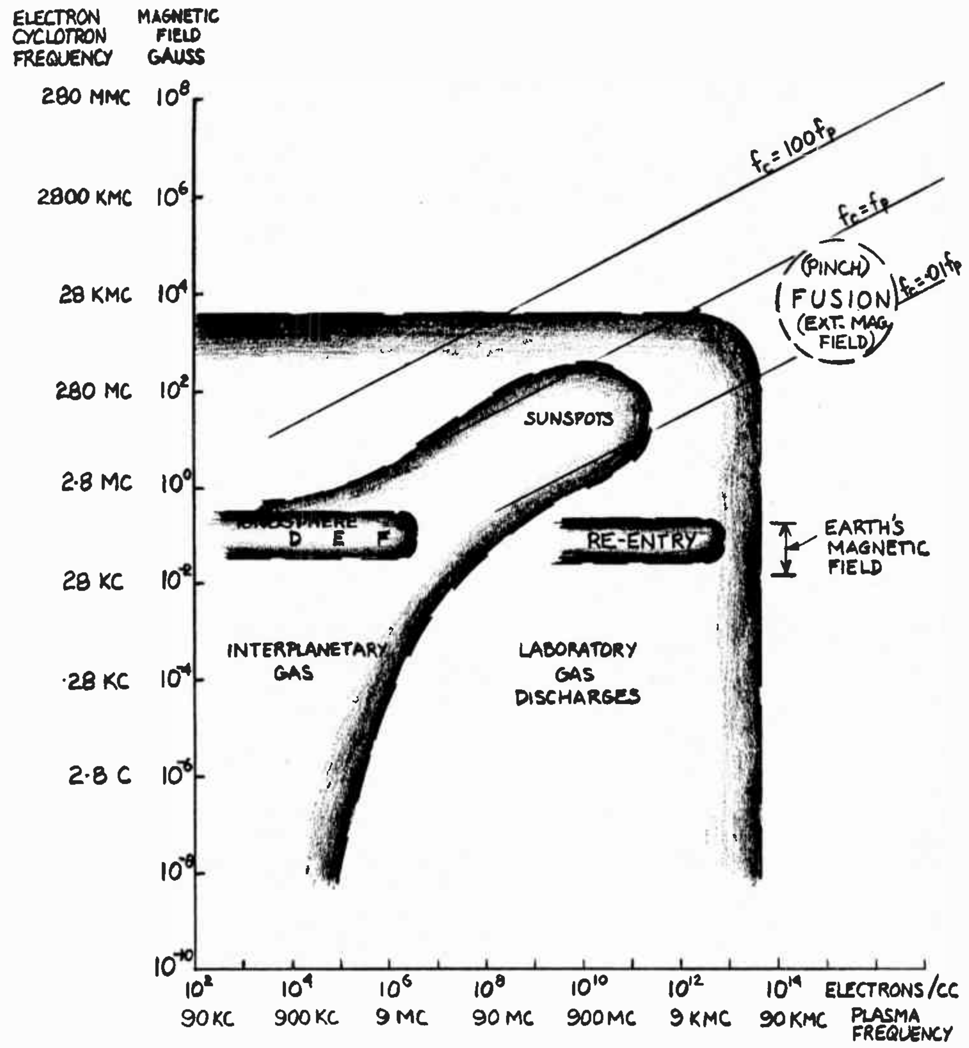


Figure 4b — Magnetic field and plasma electron density

Where and how plasmas are formed

There are three ways to make a gas plasma; namely by electric field particle acceleration, by radiation and by thermal particle collisions.

The Electrical Method is the one employed in the laboratory. An electron from an ionization pair, usually produced by an ultra-violet or X-ray, is accelerated by an electric field until it gains enough energy to make an ionizing collision to produce an extra electron and so on. The result is called a breakdown avalanche and the process is only limited by the gas and the environment. The energy needed to produce all the ionization after the initial pair comes from the electric field. For very intense plasmas the electric field is usually produced by induction.

Sufficiently short-wavelength radiation produces ion-pairs directly. This process is not a cumulative one and the plasma density will depend only on the balance between the rate of production and loss. The sun's corona, the interplanetary and interstellar gas are ionized in this way. These gases are so thin that particles rarely meet to recombine and hence they are nearly completely ionized. Another effect is that the gas particles rarely meet anything to which they can give energy and so their average energy is equivalent to a gas temperature of hundreds of thousands of degrees. Near the earth the gas density increases and the sun's intensity is not enough to ionize the gas completely. As earth is approached recombination becomes more effective. While the plasma density increases, the neutral particle density increases more swiftly and the gas is less completely ionized. (See Fig. 1). At sufficiently low altitudes nearly all the energetic radiation has been expended in maintaining the ionospheric plasma at higher altitudes, so that no further ionization takes place. In addition to being a reflector of radio waves whose frequency is below the ionosphere plasma frequency, the ionosphere is a good ultra-violet-absorbing shield, making animal life possible.

The thermal motion and collisions of its own particles can produce enough ions and electrons to make any sufficiently hot gas a plasma. As the temperature rises more of the random collisions are energetic enough to produce electron-ion pairs. Air, for instance, at 5,000°C is quite noticeably ionized. Temperatures of this magnitude are produced in rocket exhausts and around objects entering the earth's atmosphere, be they meteoric or man-made. These entry and exhaust plasmas are sufficiently dense to affect radio waves thus allowing detection (for exhausts) and even signal propagation (meteor trail scatter propagation). Around the nose of a re-entering satellite the plasma becomes so dense (and its plasma frequency so high) that it easily reflects the highest frequency waves that can be conveniently

Continued on page 39

The advent of TV Microwave Pick-Up Units represents a further step forward in Bell's continuing policy of providing such specialized customers as the TV broadcasters with speedy economical service tailored to fit their specific requirements.

The author of the following article is shown in the above illustration at the monitoring position of the TV Microwave Pick-Up Unit system.

TV MICROWAVE

Pick-up units provide facilities for remote television coverage

by John Rhodes *

The Bell Telephone Company of Canada is rightly associated by many Canadians in Ontario and Quebec with the latest and increasingly colorful versions of Alexander Graham Bell's invention which grace the home. Within the organization of that company, however, are groups devoted to the provision of all kinds of specialized communications services to the public and industry. One such service offered to TV broadcasters is the transmission of television video and audio signals from an outside broadcast location to the broadcasters studio.

In metropolitan areas, and in many towns and cities Bell has networks of video and audio cables to connect studios to transmitters, and arenas and stadiums to studios. All these facilities have access also to the Trans-Canada TV Network leased by the CBC and operated by the Trans-Canada Telephone System of which Bell is a member. However, many outside broadcasts occur in urban or rural areas where cable facilities are not available. In these cases Bell will provide portable microwave links to transmit the broadcasters video and audio to a convenient point where cable is available, and by this means deliver the program to the studio or wherever required. This type of service is commonly called TV Pick-Up Service.

With a view to providing speedy, economical, and efficient TV Pick-Up Service the Customer Services Engineer's group of the Bell Telephone Company's Toll Area has recently obtained three TV Microwave Pick-Up Units of special design. Each unit consists of a vehicle specially equipped with all the necessary microwave and ancillary equipment. The vehicle can thus be driven to any point at which service is required and speedily set up. In most cases ample warning of a TV Pick-Up requirement can be given by the broadcaster, but in those cases where a request for service is given at short notice the use of the units will greatly

**Special Services Engineering Department, The Bell Telephone Company of Canada, Montreal.*

reduce setting up time. Where the nature of the terrain at the Pick-Up location is such that access to vehicles is impossible, the unit can be driven to the nearest possible place, and the design permits the rapid removal of equipment for transportation by any available means to the location.

The design requirements for the vehicles specified sufficient space to contain two RCA TVM1A Microwave Systems together with all necessary ancillary equipment. The vehicle chosen to house this equipment is a 12'7" International AM 150 Flat Back Van. The body of this vehicle has 6' of headroom and sufficient space to permit easy access to the equipment racks. The wall and roof cavities are filled with fiberglass insulation.

Another requirement was that the main equipment should be of a portable nature and so housed that it could be quickly demounted from the vehicle complete in portable cases. To provide for this, each piece of microwave equipment is strapped to a rubber padded shelf by means of webbing straps with quick release fasteners. Each shelf is part of a rack, formed by four metal angle uprights to which the shelves are bolted. The racks are mounted on all-metal shock mounts specifically designed for all-round control of vehicular disturbances. A non-linear spring rate prevents bottoming of the load under impacts as great as 20 'g'. All equipment is grounded to a common bus, and all vehicle panels are bonded to the same point. A main ground terminal on the exterior of the vehicle is used to connect the ground bus to a suitable external ground. In addition to the microwave equipment, the vehicle contains monitoring facilities, cable equalizers, a video clamper, audio terminations, cable storage, antenna and tripod storage, a propane heater, small parts storage and ventilation fan.

Equipment layout

The plan view shows the general layout of the fittings within the body of the truck. At the right hand side a pair of sliding doors separate the vehicle cab from the equipment section. Immediately behind the doors are racks 1 and 2 which house two RCA

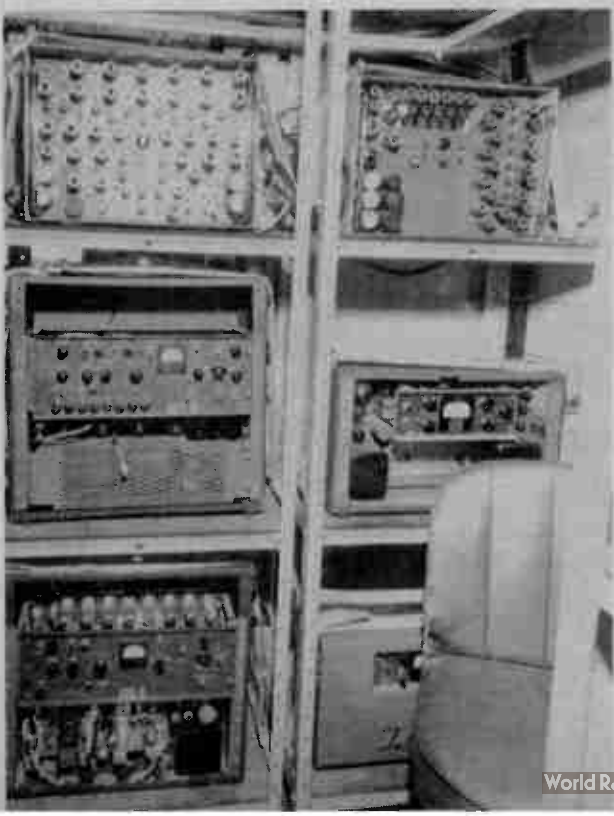
Rack 3 showing clamper and receiver power supply — power entrance in rear.

TVM1A microwave transmitter and receiver control units, together with a set of Telechrome portable signal generator equipment. Rack 5 houses a Stedivolt P39 voltage regulator which regulates all AC power used in the truck, a VHF communications trans-ceiver and the receiver power supply of one of the two RCA units.

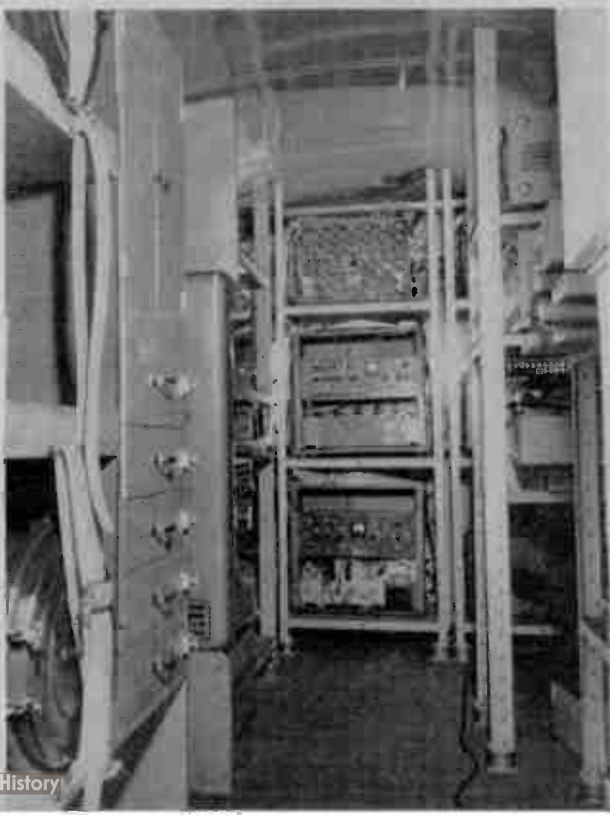
Rack 4 houses the monitoring equipment, and, in front of the rack, is a floor mount which accepts the removable passenger seat from the cab of the vehicle to provide an operator's seat. The monitor rack houses a video picture display tube, a TV waveform monitor oscilloscope, an audio amplifier and VU meter, a jack mounting and an equalizer panel. The operator can examine up to two incoming and outgoing video signals

Continued on page 37

Racks 1 and 2 showing Telechrome and RCA equipment.

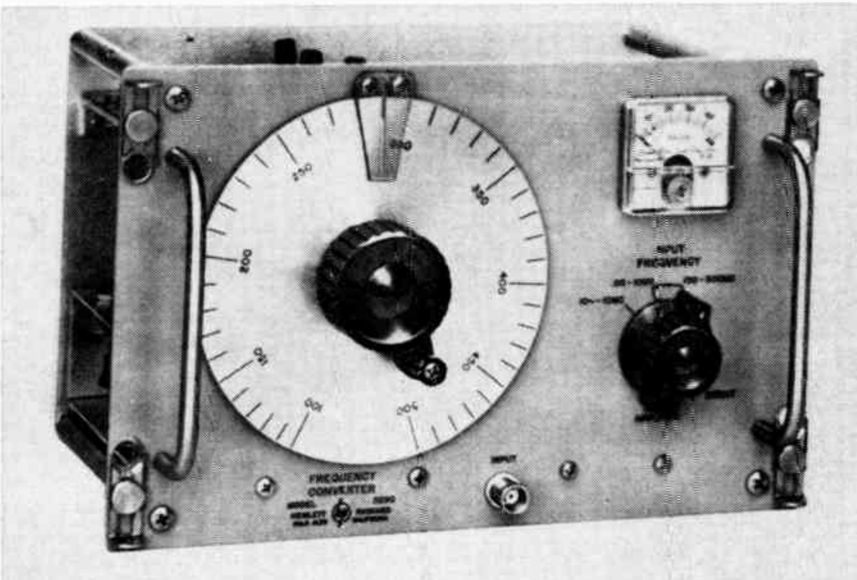


Interior view from the rear door.



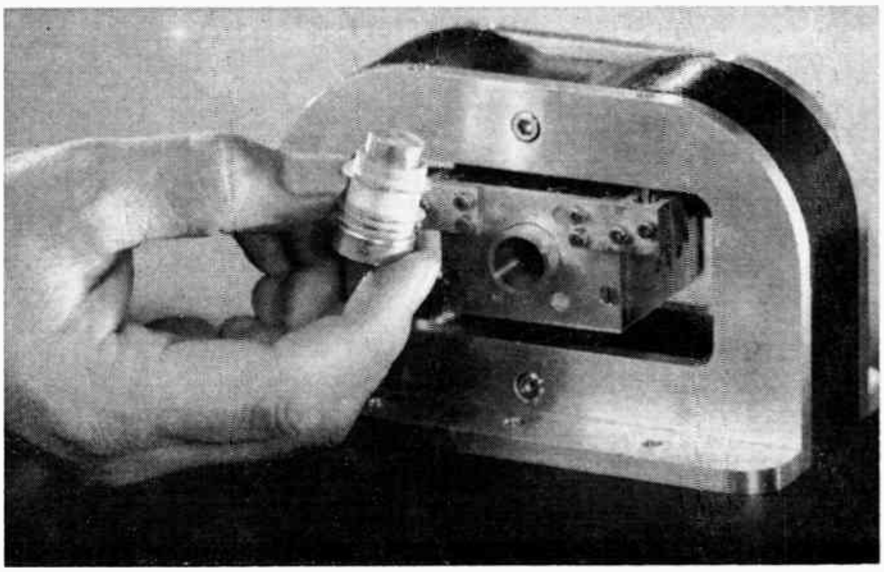
product panorama

For further information on New Products use Readers' Service Cards on pages 35 and 36.

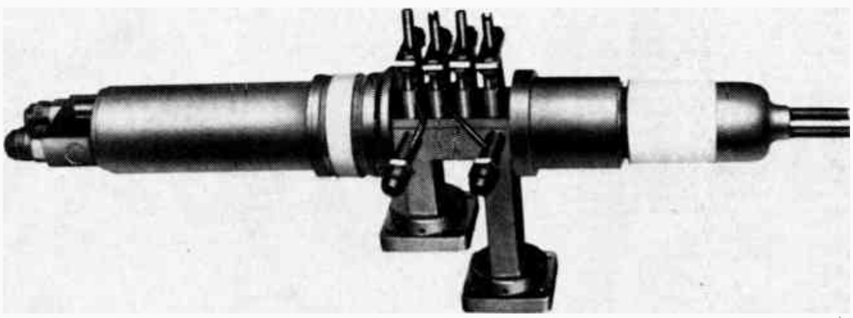


Model 525C Frequency Converter

Item 660



Item 661



Item 662

Electronic counters

Item 660

A new versatile plug-in unit which increases the measuring capability of -hp- Model 524 Electronic Counters to 510 MC is now available from Hewlett-Packard Company.

The frequency converter unit, Model 525C, can be used in the -hp- Model 524B, C or D counters 1) to measure frequencies between 100 and 510 MC with 100 mv sensitivity, 2) to amplify signals between 50 KC and 10.1 MC with 20 mv sensitivity. All Model 524 features are retained including stability of 5 parts in 10^8 per week for the Models 524C and D, frequency indications to 10.1 MC directly, time interval from 1 microsecond to 100 days, period from 0 CPS to 100 KCS and maximum resolution of 100 nanoseconds.

Model 525C contains a capacity-loaded cavity for frequency determination and a highly-efficient diode harmonic generator plus a transistorized amplifier.

Further information from Atlas Instruments Ltd., Toronto, Ontario.

Voltage tunable magnetron

Item 661

This new tube, shown here with its magnet and cavity, can be electronically tuned over the range of 400-1200 megacycles with a nominal output power of 100 milliwatts.

Eimac's X-747 is a reliable, wide-range Voltage Tunable Magnetron available for immediate delivery. The X-747 can easily be adapted to the designer's specific need.

For complete product data, write Eitel-McCullough, Inc., San Carlos, California.

Amplifier klystrons

Item 662

The highest CW power ever offered at X-band is available in the new VA 849 series of amplifier klystrons announced by Varian Associates.

The new tubes are rated at 20 kilowatts, cover a frequency range of 7.125 to 8.5 kilomegacycles, and are tunable over a 60 megacycle range. The VA 849 four-cavity tubes have been tested to more than 25 kilowatts. The series was designed for applications requiring very low AM and FM residual noise.

For further information write **Tube Division, Varian Associates, 611 Hansen Way, Palo Alto, California, U.S.A. or Georgetown, Ontario.**

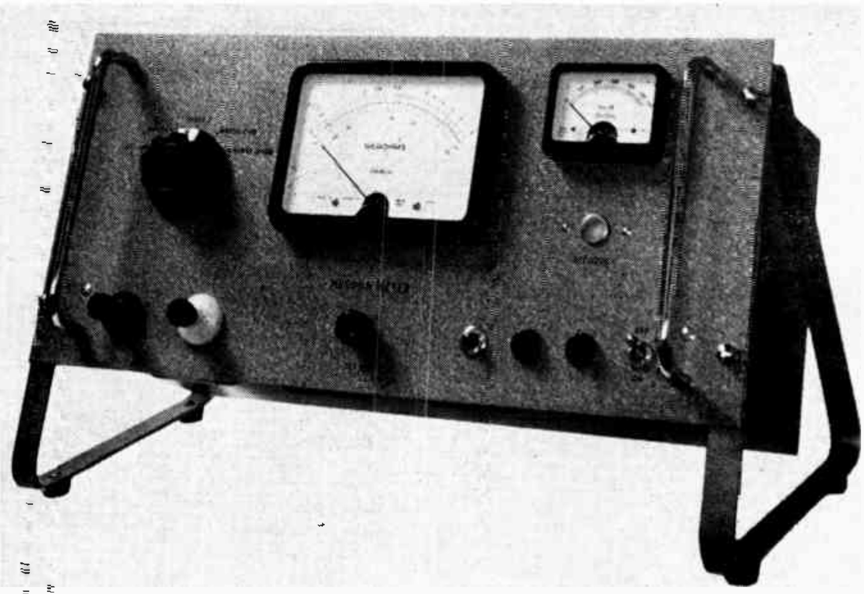
Megohm meter

Item 663

Here is an AC-operated, self-contained instrument designed for insulation leakage testing at 500V applied DC. It can also be used for the direct measurement of high value resistances at a similar applied voltage. The instrument is suitable for bench or standard 19-inch rack mounting, for laboratory or production testing.

Range: 0-10,000 megohms in four ranges. Accuracy: better than 4% of FSD after 15 minutes warm-up period. Operates on 115 volt 60 cycle supply; finished in hammer grey enamel.

R. H. Nichols Ltd., Box 500, Downsview, Ontario.



Item 663

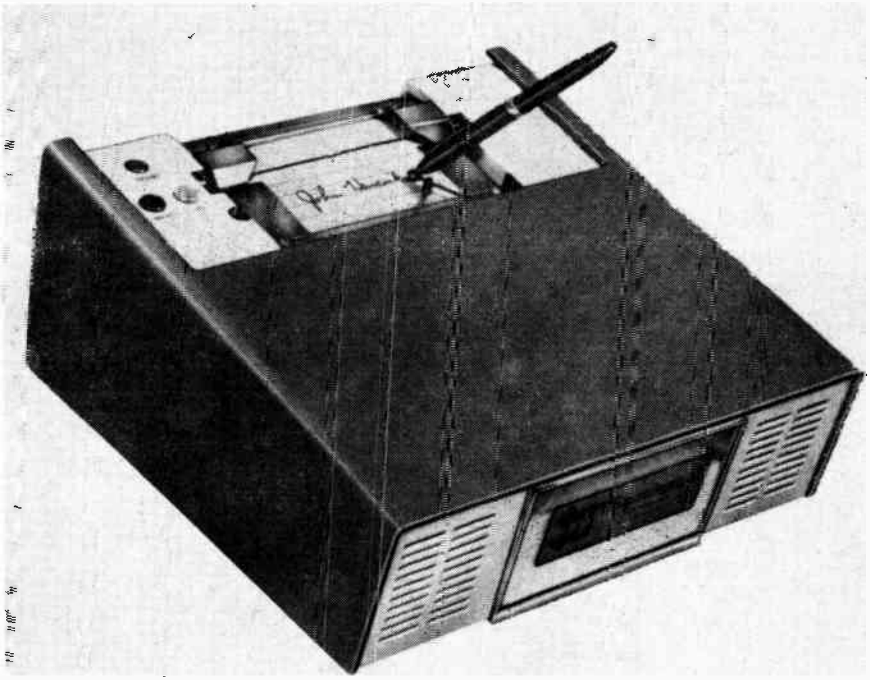
Quartz Sealcap trimmer

Item 664

The newest development of the JFD Electronics Corporation, Brooklyn, N.Y., is the miniature high voltage, high temperature quartz Sealcap. The new trimmer offers excellent reliability under high temperature operation, and other severe environmental conditions.

Model VCJ337, for example, embraces the following features: Capacitance range of 2. to 10 pf.; 3000 VDC working voltage; 5000 volts dielectric strength; 2 x 10^6 megohms insulation resistance; wide operating temperature range (—55° to +200°C); temperature coefficient of ± 50 ppm/°C.; Q of 1500 at 1 MC; Sealcap sealed interior construction locks out atmospheric effects as well as increases insulation resistance and dielectric strength.

Complete technical information is available upon request from **JFD Electronics Corp., 6101 Sixteenth Avenue, Brooklyn 4, New York.**



Item 665

Telautograph transmitter

Item 665

Automatic Electric Sales (Canada) Limited, announces the new TELautograph Direct Writer Model D, a new compact version of the well known TELautograph transmitter that features direct writing with a ball point pen on paper and increased transmission distances.

The direct writing feature eliminates writing in one place while watching another, and allows the use of multi-carbonized forms. There is no stylus and no messy ink.

The Direct Writer Model D, which is AC operated, uses a DC amplifier and allows the user to write to as many as 50 receivers simultaneously within a radius of up to 50 miles with increased transmission accuracy. Maximum power consumption is 50 watts.

For full information write **Automatic Electric Sales (Canada) Limited, 185 Bartley Dr., Toronto 16, Ontario.**

Reed relays

Item 666

New Reed Relays just announced by Struthers-Dunn, are based on an unusual design incorporating a short pole piece with a longer moving reed. This permits higher operating speeds, with less contact bounce than obtainable with conventional reed switches. The relays provide approved dependability and performance for computers, data, processing equipment, transistor drive and other applications.

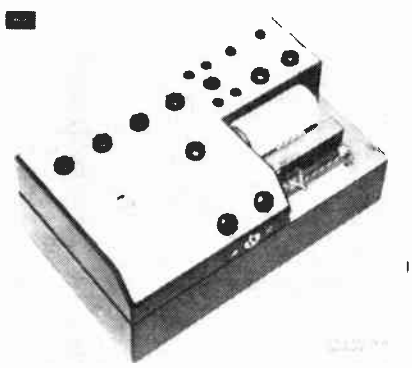
A hermetically sealed, glass encapsulated magnetic reed switch is surrounded by an operating coil to provide SP-ST normally-open relay action. It is well suited for low level switching or for low power switching of loads up to 15 watts and 250 volts. Maximum operating current is 1 ampere. Load life at ¼ of maximum rating is on the order of 200 million operations. Minimum operating power is approximately 100 milliwatts.

For further information write **Struthers-Dunn Relays, Division of Renfrew Electric Co. Limited, 349 Carlaw Ave., Toronto 8, Ontario,** manufacturers of Struthers-Dunn Relays in Canada.

Level recorder

Item 667

The Type 2305 Level Recorder covers the frequency range 10-200,000 c/s within 0.2 db as well as DC and will record any voltage level between 5 mV and 100 volts. A foremost innovation has been the inclusion of three full-wave rectifier circuits enabling true R.M.S., average and peak detection of the input signal to be obtained whereas the Type 2304 only gives half-wave peak rectification. Another new feature is the incorporation of two writing widths of 100 mm and 50 mm.



By an increase in the number of lamallae on the potentiometer from 108 to 216 a higher resolving power has also been achieved, and from the nine writing speeds of the Type 2304 the number has been enlarged to 15 covering the two paper widths with speeds from 2 mm/sec. to 2000 mm/sec. The inclusion of a simple to use arrangement allows the direct recording of polar diagrams without the necessity of additional equipment.

A mechanical arrangement enables the pen to be lifted from the paper and a marking button will "event-mark" the outer rim of the paper with a dip when pressed. These latter features, along with the paper drive motor clutch, can be remotely controlled. Within the Type 2305 there are two built-in switches, one to control the electro-mechanical drive of the B & K Spectrometer Type 2111 and the other to give successive switching of two different inputs into a single output, when this is required.

For further information contact either A/S Brüel & Kjaer, Naerum, Denmark or **R-O-R Associates Limited, 1470 Don Mills Road, Don Mills, Ont.**

Metalized ceramic components

Item 668

A complete line of metalized ceramic components for use in electronic devices such as transistors, diodes, rectifiers, resistors, capacitors, and transformers is now available from Metalizing Industries, Inc.

The metalizing of ceramic, glass and mica prepares an electronic component for permanent bonding to metal through production soldering or brazing methods. Using special techniques, Metalizing Industries, Inc. is now offering electronic manufacturers metalized insulators which can be hermetically sealed into a finished assembly.

Metalizing Industries, Inc. offer on their components conductive coatings of silver and platinum with electroplated coatings of copper, nickel, silver and tin. Components include both steatite and alumina ceramics in tubes, plate rods, and custom shapes.

For further information: **Prime Electronic Components Limited, 868 Dundas Highway East, Dixie, Ontario.**

Slide switch

Item 669

A new model slide switch, with a four-pole, double-throw circuit, has been added to the switch line at Continental-Wirt Electronics Corporation, Philadelphia manufacturer of resistors and other components for the electrical and electronics industries.

The new switch, designated type SW-742, is useful in hundreds of multiple switching applications related to audio systems, electronic measuring devices, home appliances, and various industrial controls.

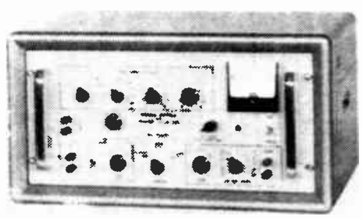
For easy assembly in end products, the new four-pole switch is designed with all terminals in a common plane. Users find this provides for more convenient fit in the chassis, and avoids short circuits. All terminals and contacts are silver plated, and standard units feature the "short" terminal, with overall distance from mounting surface to extreme tip of terminal being .575 in. nominal.

Lake Engineering Co. Ltd., 123 Manville Rd., Scarborough, Ontario.

Phase meter and phase shifter

Item 670

The Model 341 is a combination Phase Meter and Phase Shifter intended for operation at 400 cps. This instrument has been designed especially for high accuracy phase measurements between fundamental components in the presence of severe harmonic distortion. For example, the



Model 341 will measure the phase difference between two signals with an absolute accuracy of 0.1° in the presence of 200% 3rd harmonic content. All harmonics are rejected by more than 80 db. The instrument performs with full accuracy and resolution at signal levels as low as 10 mv with useful operation at 1.0 mv. The null meter sensitivity may be set for 1°, 10°, or 100° for full scale indication. Additional features of this instrument include a 10 megohm input impedance, direct reading of phase angle in degrees, and continuous 0° to 360° phase coverage.

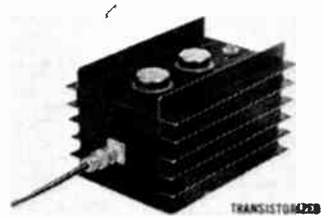
Allan Crawford Associates, Ltd., P.O. Box 214, Willowdale, Ontario.

Power packs

Item 671

A new series of high voltage, low current power packs has just become available according to Plastic Capacitors, Inc., Chicago manufacturer.

The series consists of three types. First is 6-28 VDC Input-transistorized type. These are available from 2 to 50 KVDC output and are especially suitable for portable equipment because of the light weight, also ideal for other applications including military, radar, guidance systems, field image scopes, etc.



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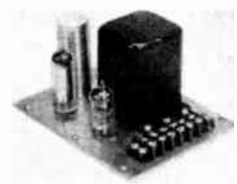

TUBE OSCILLATOR TYPE

The second type is the tube oscillator type which operates from 200 to 300 VDC, with 2 to 30 KVDC output available. These are designed for use with radar indicators, scopes, airplane guidance systems and other applications.

The third type includes a large number of line voltage 60-400 cycle power packs which are used in laboratory equipment, on shipboard, in electrostatic precipitators, paint sprayers, and electron microscopes. Voltages from 2 to 100 KV available.

All types are available as solid encapsulated units, epoxy dipped, light weight, or sealed oil filled units. Excellent for special military or commercial uses, these plastic capacitors power packs will meet your needs. For additional information, write to:

Lake Engineering Co. Ltd., 123 Manville Rd., Scarborough, Ontario.

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Pick-up units

Continued from page 31

from the picture or waveform point of view and can measure levels of or listen to the associated audio feeds. The rack provides equalizing arrangements for the various lengths of video cable which may be used to connect the broadcasters equipment to the unit, and has terminating repeating coils for the audio pairs. The operator can also feed such test signals as stair-step or multiburst into the microwave link for test purposes, and can examine received waveforms on his waveform monitor. All video, audio and monitor equipment connections in the vehicle have appearances at the jackfield on the monitor bay to permit full flexibility in interconnection.

The remaining rack, rack 3, houses the second receiver power supply, and a clamper for the video signal. It also provides storage on its upper shelf for one of the four RF heads associated with the two RCA TVM1A microwave equipments.

The remaining three RF heads are housed in the storage wall, adjacent to the locker for small parts. Up to four parabolic antennas, either 4′ or 6′ in diameter, can be strapped against the storage wall in transit.

A propane heater is provided for use in winter, and a ceiling exhaust fan allows forced ventilation in winter or summer. A wooden box, ventilated through the floor and sealed by a gasket from the interior of the vehicle, provides storage for the propane bottle. The choice of gas heating as against electric heating was dictated by the lack of large capacity power supplies in many remote locations.

The audio and video and the power entrances are located at the rear curb-side of the vehicle. The audio and video cabling is distributed by means of cable troughing secured close to the roof, and strategically padded with foam rubber where it might present a hazard to the operator. The mains wiring is effected throughout with Pyrotenax wiring.

When the rear doors of the vehicle are opened access is obtained to two banks of cable reels, in which are housed video, camera, power and audio cables. By with-drawing safety pins the reels can be removed from their mountings. A crank is provided which engages with lugs in the hub of each reel so that cable can be removed or wound on with the reels in position. Attached to the wall of one of the cable reel banks is a fold-down workbench for use if minor field repairs should become necessary.

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this issue to a business associate (you may require it for reference) — just tear out and send along the free subscription card on page 35.

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PRODUCTS LIMITED
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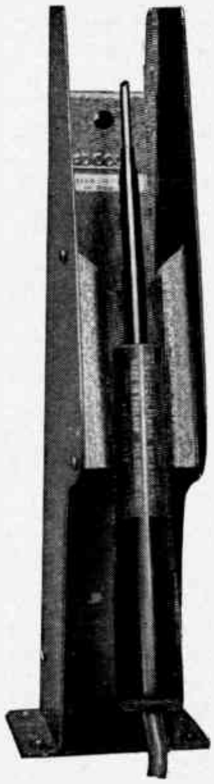

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For complete details check No. 1 on handy card, page 35

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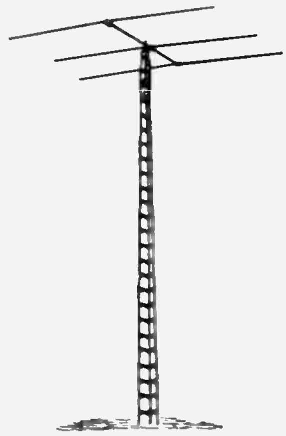

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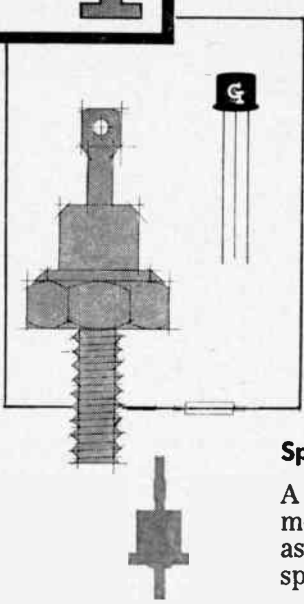

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For complete details check No. 31 on handy card, page 35

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For complete details check No. 28 on handy card, page 35

Plasmas

Continued from page 29

produced. This is the "blackout" problem, so called because the telemetry system is "blacked out" during a possibly critical phase of the entry.

A far more important hot gas plasma than any discussed so far is our own sun, whose outside temperature appears to be about 6000°C and whose inside temperature has been calculated to be 20 million degrees centigrade. The sun radiates heat at the enormous rate of 3.8 x 10^{23} kilowatts, and this energy is supplied by thermonuclear fusion in the very hot core. The protons, neutrons and nuclei flying about in the core at very high speeds can collide with sufficient energy to stick together and react and eventually to produce helium nuclei and energy. Very high temperatures are needed to produce these reactions.

Recently man has begun the attempt to parallel this feat in a controlled manner rather than in the uncontrolled hydrogen bomb. The chief difficulty is the containment of the hot plasma which is far too hot to allow materials walls to be used. The sun uses gravity, but for a much smaller man-sized system gravity is too weak and the attempt is being made to use suitable magnetic fields. Because of its high conductivity and complex behavior in a magnetic field the theory is very difficult and the plasma displays exasperating ingenuity in escaping. One might say that one round of sparring between scientists and the plasma is over, and further theory and experiments are being prepared for round two.

The prize is not just atomic power — that is available already through fission. In the same way that the earth's coal and oil must eventually be exhausted, so must the usable fission elements, in time. The fission radioactive waste problem would become acute with widespread fission power. Fusion power requires hydrogen isotopes which can be readily obtained from the sea and leaves little radioactive source — if it can be made to work. The only other serious competitor as an *ultimate* power source would be solar power conversion.

One further plasma should be mentioned — the solid state plasma, often called the quantum plasma. The free electrons and holes in solids can behave in a plasma-like manner and many plasma concepts can be applied, with due respect for quantum mechanics. Studies of avalanche breakdown, plasma and cyclotron oscillations, even the familiar diffusion mobility and recombination in the solid state are all concepts taken from plasma theory.

The range of plasma parameters is shown in Figure 4.

Plasmas and the communications engineer

Now that plasma physics has been very briefly reviewed, it is not hard to see where the communications engineer enters the picture.

For the engineer who is interested in communication across the earth's surface, plasma physics is vital to the study of the role of the ionosphere and to meteor trail scatter propagation, and has great potential for possible future application to prediction of radio storms. In detection the parameters of the exhaust and re-entry plasmas must be known. Space vehicle communication involves the upper ionosphere and even the interplanetary plasma, not to mention the re-entry plasma difficulties.

Continued on page 40

Plasmas

Continued from page 39

Plasma concepts are being applied to semi-conductors and new interest is being generated in the production of millimeter wave power by plasma oscillations at the plasma frequency.

Apart from the direct work in the field of communication and detection, the use of radio wave effects as a diagnostic tool for laboratory plasmas is still developing rapidly and is an essential part of plasma science. These techniques are vital in the development of plasma systems for controlled thermonuclear fusion and MHD energy conversion, as well as for experiments on basic physics in the fields of astrophysics, ionospheric physics and low energy particle interaction.

In Canada, the Defense Research Board has been working on ionospheric physics for many years. A notable project should be the Project Farside, an American-launched Canadian satellite to take radio soundings from the other side of the ionosphere. The University of Toronto's Institute of Aerophysics has done some theoretical and experimental work on plasmas. At the RCA Victor Research Laboratory in Montreal, theory and experiments on a wide range of gas plasma topics are under way, as well as solid state plasma research in avalanche breakdown in semi-conductors. The RCA Victor Research Laboratory gas plasma research includes theoretical work on radio wave propagation and radiation and on basic plasma theory, while the experimental program consists chiefly of microwave propagation studies, investigation of negative ion properties (for application to ion rockets) and on experiment on the interaction of a modulated electron beam with a plasma.

The interest in plasmas is growing rapidly and it is hard to predict the future. One thing can be said. Plasma physics is a vital and growing science and the advanced communications and electronics engineer will have a lot to contribute and learn from it.

Where to read more about:

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L. Spitzer Jr., "Physics of Fully-Ionized Gases", Interscience 1956.

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Elementary — P. Parker, "Electronics", Chap. 15, Edward Arnold 1950.

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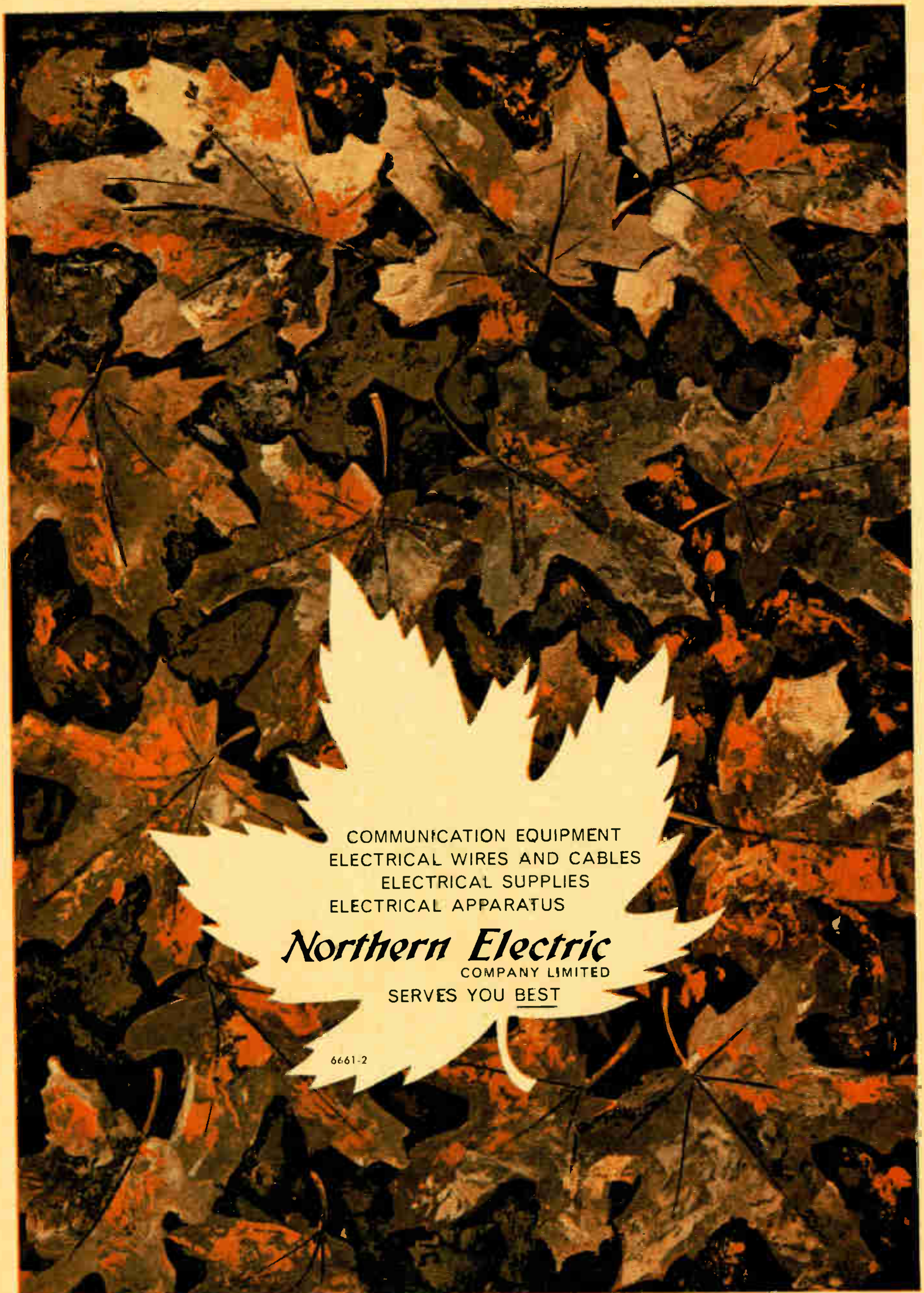

For complete details check No. 24 on handy card, page 35

DDP contracts awarded

Following is a list of unclassified electronic defense contracts for $10,000 or more awarded during the period November 1 - 30, 1960 to Canadian firms by the Department of Defense Production.

- Ahearn & Soper Co. Ltd., Ottawa, Ont., electronic tubes, $29,986.
- Aviation Electric Ltd., Montreal, Que., aircraft flight instruments, $1,086,146.
- Canada Wire & Cable Co. Ltd., Ottawa, Ont., telephone cable, $236,874.
- Canadian Applied Research Ltd., Toronto, Ont., spares for aircraft navigational equipment, $10,101.
- Carriere and MacFeeters Ltd., Scarborough, Ont., repairing, overhauling and modification of ground rectifiers, electrically powered auxiliary generating sets and associated equipment, $29,-617
- A. Deskin Sales Co., Montreal, Que., connectors, $16,776.
- Edo Canada, Ltd., Cornwall, Ont., sonar modification kits, $11,526.
- ITT Electronics Service Co. of Canada Ltd., Town of Mount Royal, Que., calibration teams, $15,577.
- Instronics Ltd., Stittsville, Ont., spectrum analyzers, $12,235.
- E. G. Lomas, Ottawa, Ont., electronic components, $53,399.
- R. N. Nichols Ltd., Downsview, Ont., insulation breakdown test sets, $12,688.
- Northern Electric Co. Ltd., Ottawa, Ont., supply and construction of transmitting antennae, $43,905.
- Philips Electronics Industries Ltd., Toronto, Ont., electronic tubes, $12,199.
- Radionics Ltd., Montreal, Que., radiacmeters, $19,807.
- R-O-R Associates Ltd., Don Mills, Ont., electronic tubes, $68,269.
- Sperry Gyorscope Co. of Canada Ltd., Montreal, Que., computer units, $26,922.
- Sperry Gyroscope Ottawa Ltd., Ottawa, Ont., aircraft navigational equipment, $90,184.

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For complete details check No. 6 on handy card, page 35

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