CARL

Where Ingenuity Is a Business

Wm. Miller of Topographical Surveys Br. discusses CARL Airborne Profile Recorder with Vic O'Leary, proj. eng.

THE AMAZING success story of Canadian Applied Research Ltd., the company whose greatest asset is brain-power, continues to attract attention. From the company's inception in 1951 until the present time, it has never stopped expanding, never stopped churning out new approaches to old problems.

CARL is a member of the A.V. Roe Canada Limited group of companies which has interests in almost every major industry in Canada. At the present time CARL operates from three plants in the eastern section of Toronto and one in the north.

Employing some 500 highly-trained people, CARL is a small but specialized firm devoted primarily to the design and manufacture of instrumentation equipment. Another major part of CARL's operation is the environmental testing laboratory. This lab, approved by the RCAF for testing to military specifications, also handles work for industrial and commercial interests.

Diversification: Although incorporated in 1951 as basically a defence industry, CARL has in recent times begun a diversification program aimed at the commercial market. Says J. M. Bridgman, vice president & general manager: "We intend to broaden out into non-defence lines, but still in precision instruments." One such item presently in production at CARL is the automatic tri-film processor.

This transportable equipment is designed to process and dry, automatically, 16 mm, 35 mm, and 70 mm film. The film is drawn from a light-tight magazine, formed into loops in the successive process tanks, transported at pre-selected speed and dried in a forced hot air chamber. To complete the cycle, the film is wound on take-up spools. No lower rollers are used, as the upper roller system of the equipment automatically forms loops of the correct length in each tank. Processing is controlled by a mechanical program unit after the film is loaded into the machine.

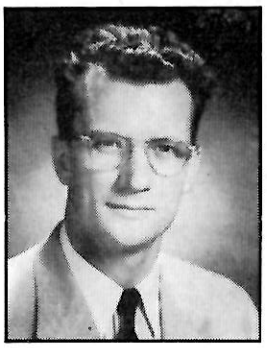
As normally supplied, the first two tanks are used for developing, the second pair for fixing and the last two for washing. However, many combinations of tanks and processing solutions, as for stabilization, special hardening or combined development-fixation, may be obtained by changing Saran conductors on the liquid distribution system. Separate temperature control of the processing solutions is possible on each tank over the range 60°F to 110°F, within plus or minus 1 degree. This Mark 3 processor used in industry, hospitals and laboratories, is one of CARL's best-selling products. Orders for the 400-lb., transportable processor have been received from places as far removed as Japan and Australia.

Navigation Aid: Another foreign export item of the company's is the already famous R-Theta navigation computer system. The R-Theta, (R for range, Theta for bearing) is a dead-reckoning device receiving information electrically from other aircraft instruments which give true airspeed and compass heading. The ground speed end interception computer solves the basic wind triangle in analogue form and feeds ground miles and true heading to the computer. This latter unit uses precise mechanical resolvers to produce a result in terms of distance and bearing from the initial reference point.

Electro-mechanical methods are used in this computing system. Transistor amplifiers are used in the servo loops, thus permitting a compact over-all system. The over-all accuracy is better than 2% of the distance flown. That is, in a flight of 1000 miles the indicated position would be within 20 miles of the true position. Further, the R-Theta is compatible with and complementary to the various approach navigation aids

P. C. JEFFREY
Dir. of Sales & Service

ERIC MOSS
Dir. of Eng. & Mfg.



J. M. BRIDGMAN
Vice Pres. & Gen. Mgr.

5767

such as TACAN and VOR/DME.

Another item of airborne precision equipment manufactured by CARL is the Type T232 Mk. 8 aerial camera using 35 mm film. With this camera, each frame is identified by a number as it is exposed, giving a positive correlation between exposures and simultaneous readings of other aerial survey instruments. The film transport and exposure interval depend on aircraft speed, height, and overlap desired. These are adjustable by means of interchangeable gears giving exposure times of ¾, 1½, 2½ and 5 seconds. Mounted on the camera is the exposure counter which is a mechanically driven 5 figure counter, resettable to zero, which counts each exposure and is recorded on each photograph.

Blood Brother: A near-relative is Mk 7 instrumentation camera, designed for industrial purposes and used in radar and oscilloscope recording, instrument panel recording, aerial survey positioning, and plotting records. The camera mechanism provides a basic unit with separate electrical circuits for opening and closing the shutter and actuating the film transport. Thus a wide variety of remote control applications is possible. Quick change film magazines in 100 foot and 400 foot capacities are available. A rigid quick release mount is provided for either tripod or fixed mounting. The shutter is a focal plane type, the basic exposure speed of which is 1/100 second. The camera may be cycled from 3 frames per second to any desired longer interval. In addition, it is capable of being fitted with most types of lenses commonly used for both motion picture and still 35 mm cameras, from wide angle to telephoto types.

Ilustrative of CARL's diverse interests is its line of aircraft dual probe ice detection systems. The dual probes and associated pressure switch are contained in one small unit which thus eliminates interconnecting pneumatic tubing and reduces the electrical cable requirements. The two probes, approximately 3" long and 5/16" in diameter, extend into the air-stream; under non-icing conditions the detector probe produces pressure and the reference probe at all times a true datum pressure. When subjected to icing conditions, definite changes in pressure differential occur between the detector probe and the reference probe, thus actuating the enclosed pressure switch; heat is automatically supplied to the detector probe, thus restoring normal pressure, at which time heat is removed.

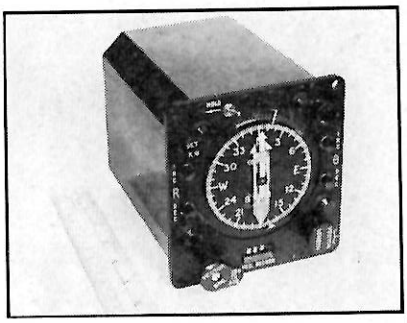
Continued icing conditions cause this cycle to occur repeatedly, each time signalled by flashing a warning light in the cockpit and/or automatically controlling an ice prevention system. The reference probe does not ice up at any time since it is always maintained above 32°F, both probes are thermostatically controlled to prevent overheating.

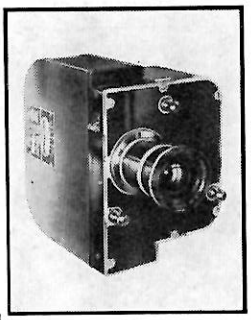
Interpretations: To take full advantage of this ice detector, its signals should be properly interpreted, and to this end Canadian Applied Research Limited has engineered and built a number of de-icer controllers, which assume complete control of a de-icing system and render its operation completely automatic. With an ice detector and a de-icer controller, therefore, the burden of watching for ice accretion and operating a protection system is entirely removed from the aircrew, who are advised, by indicator lights, that the aircraft is in icing and that the protection system is operating.

These de-icer controllers are all custom designed to meet the particular requirements of the aircraft in which they are to be installed, since no two aircraft types have identical ice protection systems. The controllers are basically electromechanical devices, with a fair amount of electronics being introduced into controllers being currently developed; they can be designed to control hot gas, electrothermal or pneumatic de-icing systems for engines, airframes and propellers, and can be used to coordinate the operations of a mixed ice protection system.

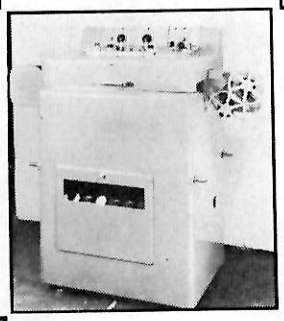
In the same field is the type T401 static ice detector for use in the detection of icing on radar antennae and similar installations. The detector operates on the principle of interference, by ice accretion, between a feeler assembly and a fixed head, in such a manner that an accretion of .030" or less will result in a signal. A thermostat, operated by ambient air temperature, renders the entire unit inoperative above temperatures at which icing can occur.

Keeping Track: Another piece of ground equipment built by CARL for use in Canada's north country is the type T609 auroral recorder, which

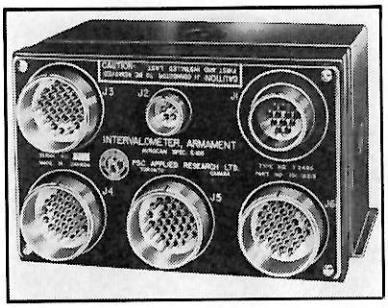


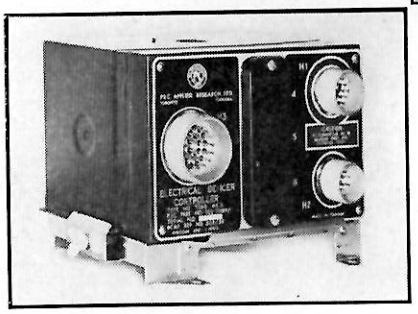


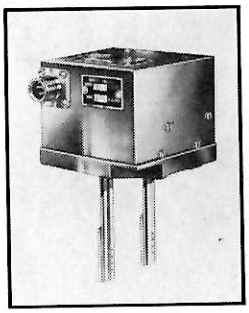
At far left is CARL's well-known R-Theta navigation computer instrument. To immediate left is the company's Mk. 7 instrumentation camera.



To the immediate right is CARL's Mk. 3 automatic tri-film processor; far right, armament intervalometer, used to control firing of aircraft weapons.







Immediate left, dual probe, nerve end of CARL's ice detection system. Associated equipment far left is de-icer control which interprets dual probe signals.

was widely used in connection with the IGY. Developed by Dr. D. Hunten, University of Saskatchewan, the auroral recorder is designed to produce a photo-electric recording of auroral phenomena. The tabulated results are obtained directly in the form of a punched tape, and indicate the brightness of the auroral display and the position on a particular mention of the sky. The punched tape output also indicates the time of measurement of the phenomena and the presence of cloud or haze which might tend to obscure the aurora.

Something of more immediate application to the aviation field is the Airborne Profile Recorder Mk. 5, an improved precision radar altimeter designed for air survey work to determine the relative heights of land along the flight path of an aircraft. This instrument is capable of measuring terrain clearance from 1000 to 35,000 feet with a high degree of accuracy.

Two simultaneous and continuous records are supplied by the system on a paper chart recorder. One is the terrain profile as provided by the radar altimeter referred to sea level and corrected for deviations from the barometric flight altitude; the other record is the terrain clearance, or distance between aircraft and ground. One of the problems associated with air survey work is the necessity for keeping the aircraft at a constant barometric height during a photographic mission. Based on the height deviation hypsometer circuitry used in the APR Mk. 5, the company designed a new survey instrument, the Hypsometer Statoscope. This new survey instrument supplies the camera operator and pilot with height deviation information with an accuracy of plus or minus 5 feet.

Less spectacular, but nevertheless important items being produced at CARL's Toronto plant are the Gamble Stereo Plotter for tracing contour lines, the Station Magnetometer which records the three orthogonal components of the earth's magnetic field, and the High Speed Impulse Recorder. This last-mentioned instrument records rapid impulse sequences and determines the duration of "live" and "dead" periods. CARL presents Canada's electronics industry with a comprehensive service for the manufacture of microwave plumbing and associated precision assemblies in the current wave lengths. The Company offers Canadian customers the benefit of special manufacturing techniques which enable economical fabrication, even in small quantities, as well as rapid delivery.

The Strong Team: The Manufacturing Division of the Company is backed up by a strong Engineering Division, which, among its other facilities has an excellently equipped RCAF approved Environmental Test Laboratory. These facilities are more than adequate for the Engineering Division, so they are also made available to industry in general, and they are able to carry out qualification tests to Military Specifications or to run particular tests for customers' requirements under completely confidential conditions.

In dealing with their various customers whose interests are often competitive, CARL employs rigid security measures to prevent any leakage of test results to other than the company paying for the service. This code of ethics is so closely adhered to that when exclusive tests are being carried out for one company or another, only lab workers are allowed to approach the test area.

The lab, while not the biggest in Canada, is certainly one of the best. It

(Continued on page 62)

line includes semi-conductors, cathode ray storage tubes, microwave tubes and test instrumentation. R-O-R is located in suburban Toronto and has a branch office in Montreal.

PHOTOGRAPHY

(Continued from page 40)

print and one unmarked print for retouching.

Handling and Packing Photographic Artwork: Every precaution must be taken to avoid risk of damage to originals when handling and packing, both before and after printing.

The photographs should be mounted to prevent creasing. As the surface of a retouched photograph is particularly sensitive to fingermarks and other blemishes it should be protected by a tissue overlay.

Photos, mounted or unmounted, must not be packed for transit without some form of rigid protective packing material. Small unmounted photographs should be packed flat between pieces of stiff board.

APPLIED RESEARCH

(Continued from page 35)

contains a wide variety of electrical and mechanical testing instruments, including such things as horizontal and vertical mechanical vibrators, and an electromagnetic shaker with a frequency range of 5 to 2000 cycles/second. There is a shock tester with a 50 lb. capacity load, which is capable of a maximum acceleration of 220 G.

All Weather: There are a variety of installations such as a sand and dust chamber, an explosion chamber, and a salt spray and humidity chamber. There are temperature chambers of various types, a high temperature oven capable of 1000°F, pressure chambers and a fungus growing chamber. CARL also has a wind tunnel in his lab, equipped with water spray for icing tests and capable of max indicated airspeed of 400 fps. One corner of the lab is taken up by the copper mesh radio interference testing room where specimen pieces of equipment are tested to determine the amount of radio interference they generate.

Since being incorporated in 1951, CARL has incrased its sales volume more than 15 times. Presently with almost 500 employees and anticipating further growth in 1959, the company appears to be continuing its meteoric expansion. Today, throughout the entire organization can be felt the prevailing spirit of a team that wholeheartedly believes in the three fundamental qualities of a top engineering development firm: imagination, production and service. This is what they sell at CARL.

TWENTY-FIVE YEAR MAN: American Airlines Inc. last month held a presentation banquet marking 25 years with American for R. W. McDonald (second from left), Toronto manager of operations for AAL. At left is W. H. Miller of AAL's New York regional operations office. Others are F. J. Robinson, AAL's first Canadian sales manager in 1941; and P. E. Priestman, of Toronto, present sales manager for Canada.

MORE ON STOL

(Continued from page 14)

vised) this contraption would rise vertically, the transition problem would be prohibitive — and payload negligible. Anyway, a tilt-wing would be more comfortable for pilots and passengers.

It may be of salutary interest to note here that two airplanes, to my knowledge, had the deflection of their high-lift flaps reduced because the trim and drag forces involved would have put an excessive burden on the pilot. I believe that in the case of the Twin Pioneer the original full flap position caused too great a trim change. In the Fokker Friendship there was to have been an almost vertical position for the slotted double flap over the hedge. This was found to involve both drag and trim changes that would have been trickier to handle than the gains warranted. By contrast, the flap system on production aircraft is simpler and lighter.

Thus, another criterion for STOL is the amount of tail which can be permitted as a payload penalty.

The Jet Flap: In this device, which I own has been a personal predilection since I saw the initial demonstration model at the 1955 SBAC Display and enthusiastically reported it in AIRCRAFT, one has the present ultimate idea in integrated lift for STOL. Characteristically, Britain has been laggard in developing the invention and, almost equally characteristically, the NACA has done a deal of tunnel work with free-flying models.

The jet flap emanated from the NGTE, being the inspiration of Dr. B. S. Stratford who, while working on simple jet deflexion thought of a remark of his Director, Mr. Hayne Constant that "since the propulsive jet of modern aircraft is a very powerful entity, it ought to be combined 100% with the wing in flight near the ground."

Theory was put into practice with special two-dimensional models devised by Mr. N. A. Dimmock, and Mr. I. M. Davidson was chosen to lead the three-man project and development team. Note that the jet flap was the conception of turbojet aerodynamicists and therefore its functional problems, the practicability and efficiency of the ducting and jet slit were accepted at the start by experts in just these techniques.

Although it has obvious afinities

with both supercirculation and jet deflection, relationships which have been emphasized by the layouts investigated by NACA, the jet flap should be regarded as a new *flight system* — a method of flying as different from the airplane as is the helicopter. The NGTE must also accept some blame for the general misconceptions which surround the jet flap in that the name is itself misleading.

True Integration: The jet flap is a true integration of the aerodynamic forces, the circulatory airflow over the wing, with the thrust of the power plant. In its elemental form the system consists of the downward ejection of the jet engine efflux through a slit spanning the trailing edge of the wing. This "jet sheet" has two distinct actions: it forms a physical barrier below the wing, as solid in effect as and far greater in area than any practical extension flap; and it entrains a vast airflow over the top of the wing. Fantastic lift coefficients, as great as 15 in the extreme case, were recorded for the NGTE two-dimensional models. Furthermore, there were indications that the system could be made unstallable.

The mechanics of the ducting in the wing—the subject of more than 50 Power Jets (R & D) Ltd. patents in fifteen countries—are too detailed for discussion here, but numerous practical suggestions have been made. The proposed method of deflection is by a tiny movable flap of not more than 5% of the wing chord. This flap would work by Coanda effect, that is to say the boundary layer would adhere to the curved surface and carry with it the main airflow.

It is envisaged that an airplane with the jet flap system would look pretty conventional, but it would require a slab tail with a range of possibly 45 degrees to meet the large downwash changes.

Outline of Flight: The flight plan is envisaged something like this. Open the throttles with the jet sheet deflected about 40 degrees (a greater angle than this would almost certainly exceed the practical limit for induced drag) and after the short roll required to accelerate to, say, 50 mph the airplane would unstick. As soon as it was clear of ground effect, say twice the wing chord, it would be sucked up steeply and rapidly. Throughout this phase the vertical flight path would be controlled directly by the throttles and the slab tail would provide longitudinal trim, with the differential variation of small sections of Coanda flap for roll and perhaps also yaw.

For cruising, the jet sheet would be ejected horizontally—with an estimated loss in propulsive efficiency of about 5% compared with conventional orifices of similar area. The slit offers one incomparable advantage however; it is *quiet* and at no time should it generate a noise level greater than, say, approach idling for the same engines with circular nozzles. During the cruising condition the slab tail would be used as an elevator.

On descent, the pilot would reduce speed and lower the Coanda flap to deflect the jet sheet; thereafter controlling his descent by throttle, with the slab tail set to give automatic trim. The approach angle should be widely variable and very easy to control—just a final burst of power to cushion the touchdown as ground interference with the jet sheet took effect to reduce lift by about 20%.

That is the elemental system as envisaged for by-pass jet operation, the by-pass being chosen because its relatively cool efflux would simplify duct fabrication. If turboprops were used, the system would become a VSTOL one—but never a practical VTOL device.

Like *all* powered-lift systems, the safety aspect must be approached from the practical angle of designing to put the possibility of a catastrophic engine failure beyond reasonable chance. Even so, although it would land fast, a jet-flap airplane ought to be no more dangerous and unwieldly than an autorotating helicopter. Safety in partial engine failure would be assured by using a larger number of smaller engines than usual and cross-ducting the efflux to eliminate asymmetry—which would be disastrous because of the first-order effect of power on lift.

Price Tag: The price for this form of STOL? Instead of elaborate mechanically hinged extension flaps, heat resistant wing ducting of some complexity. A small loss in cruising propulsive efficiency (none in the case of a free shaft turboprop), which means more fuel per mile, but a clean airplane without excrescences and a small wing. Although the downwash angle change would be large, the centre of lift does not move much and the tail surfaces might well be far smaller than those usual with STOL airplanes. Ground effect would suggest a high-wing layout, but this is common anyway with STOL bushplanes.

Power requirements, it should be noted, would be greater than for a conventional airplane, perhaps 50% greater. This would be used, of course, only during the integrated-lift stages of the flight, but one must admit that some excess engine weight in cruising flight would impose a larger penalty than usual with conventional airplanes, as between take-off and economical cruise power.

I have enthused about the NGTE jet flap because I believe it offers something which no other system can. It is, however, obviously in an elementary state of the art, still requiring much basic research. Unfortunately, although it arrived at a time when the aeronautical purse strings were unloosed, but almost solely for immediate military necessities and for few long-term projects. Now the situation is even worse, with, apparently, no money for anything except missiles—and "space-trickery." Furthermore, there is today such a vested interest in concrete that the true STOL market may in fact be too small to "justify" the necessary research expenditure. Timing is as paramount in the success of an invention as is its genuineness and in the case of the jet flap I think the environment is critical.

COMING EVENTS

January 26-29—IAS Annual Meeting, Sheraton-Astor Hotel, New York.

February 4-5—Annual Meeting, Air Cadet League of Canada, Siegniory Club, Quebec.

February 14-18—RCFCA Annual Meeting, Queen Elizabeth Hotel, Montreal.

February 23-24—CAI Special Meeting, 50th Anniversary of Powered Flight in Canada, Queen Elizabeth Hotel, Montreal.

March 12-13—Canadian Aircraft Industry Instrumentation Symposium, Toronto, sponsored by the Toronto Section, Instrument Society of America.

March 31-April 3—SAE National Aeronautic Meeting, Aeronautic Production, Forum & Aircraft Engineering Display, Hotel Commodore, New York.

April 12-19—First World Congress of Flight, Las Vegas, Nevada.

May 4-8—National Industrial Production Show of Canada, Exhibition Park, Toronto.

June 12-21—23rd International Air Show of France, Le Bourget Airport, Paris.

June 13—Air Force Day across Canada.

June 15-17—CAI Annual General Meeting, Keltic Lodge, Ingonish, N.S.

August 8-16—International Aviation & Air Industries Fair, New York Coliseum.