An Approach to Test Instrumentation

By J. E. SMITH*

THE EVOLUTION of modern aerial weapon systems has resulted in a significant increase in the amount of flight testing necessary to prove the aircraft, the weapons and the combination of these into a weapon system. The increase in the number of elements to be tested under normal operational conditions and the increase in the complexity of these elements is reflected in corresponding increases in the quantity and types of test instrumentation to be fitted to the aircraft designated for the development program.

Flight test instrumentation may be required for two general classes—new or prototype and current squadron aircraft. When prototype aircraft are to be used for tests during their development, the installation of special test equipment is phased into the program and the units are wired and installed during the construction of the aircraft. This work is normally done by members of the manufacturing firm so that an optimum installation can be achieved most efficiently. The second class of instrumentation presents several different problems. In this case we have an aircraft in squadron service which is already completely fitted with one form of weapons system. This aircraft must be modified to fill a development role in which it must carry special instruments and for which it may or may not require the components of its present armament system. This article outlines a method, successfully applied by Computing Devices of Canada Limited, for the solution of flight instrumentation problems falling within this second trials class.

The problem in Canada was to develop a versatile test equipment package for use on a standard CF100 all-weather fighter during armament component and weapon trails. One of the prime requirements was that the equipment should be capable of being fitted to any squadron aircraft by squadron personnel without the necessity for factory rework on the aircraft. The assembly should also require a minimum time for installation and removal.

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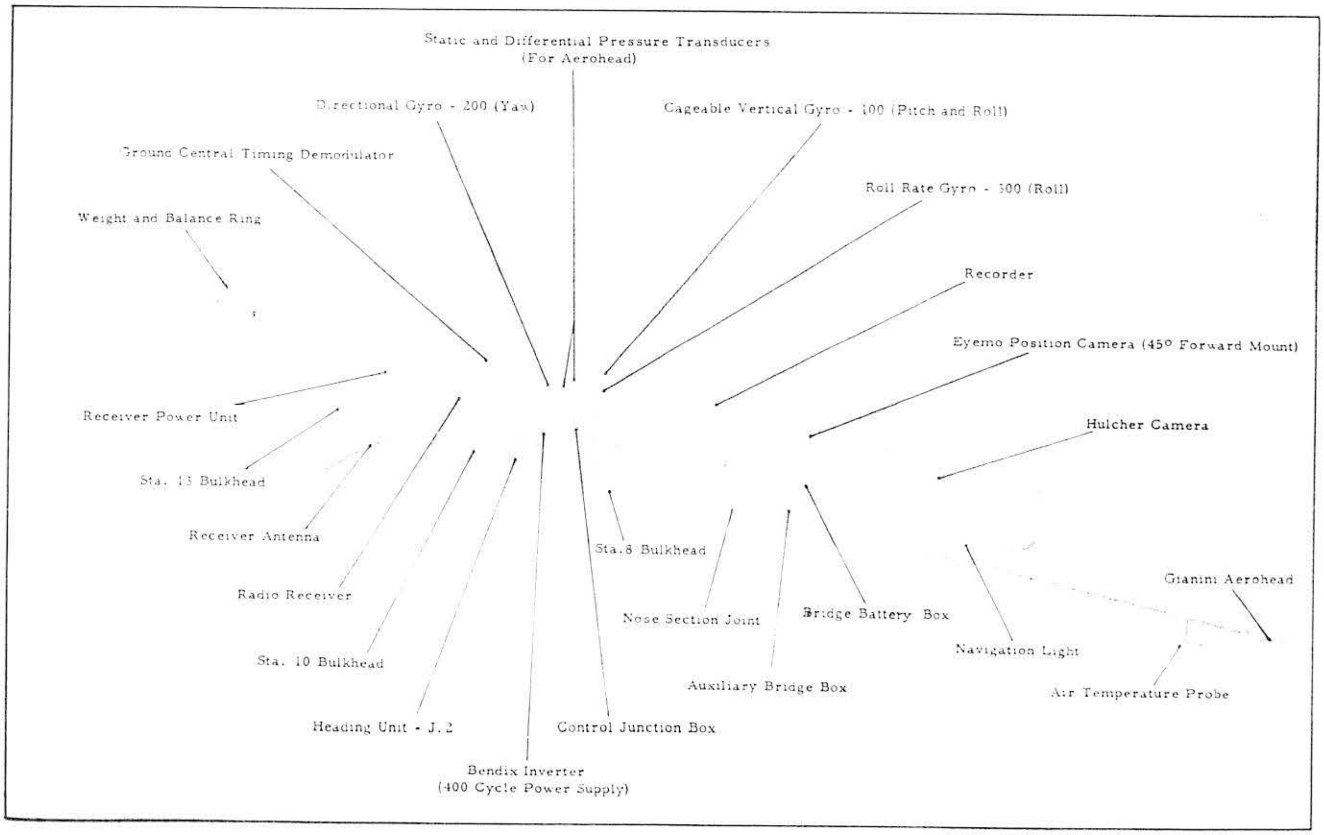
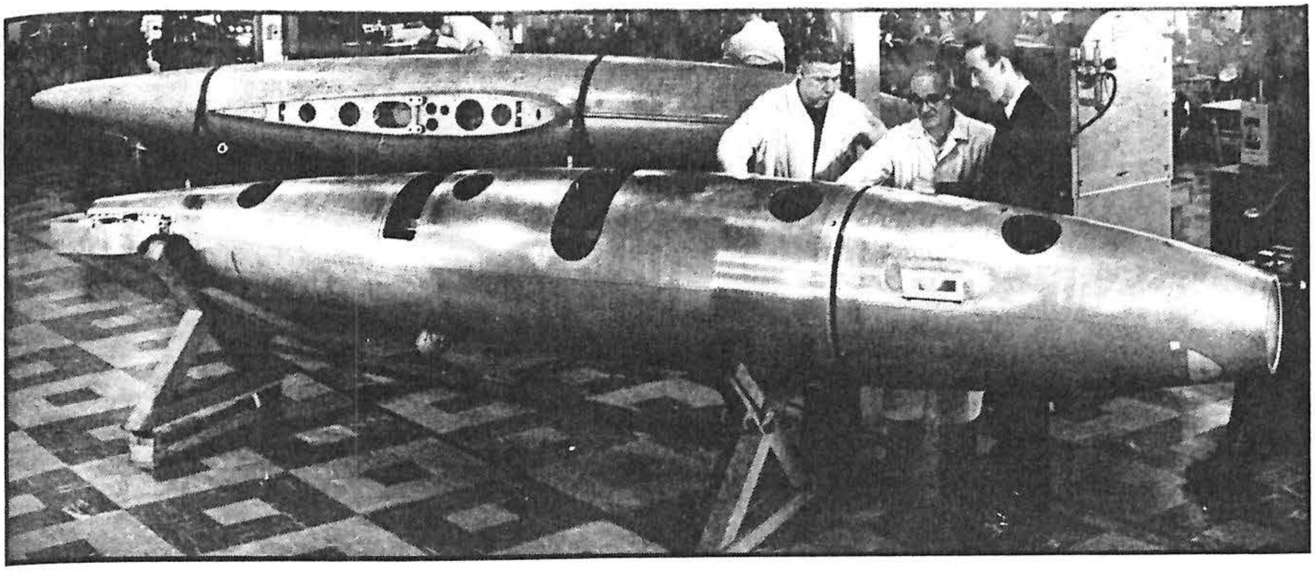
After some investigation into the various possible configurations for this equipment, it was decided that the best answer lay in the modification of the wing tip fuel tanks which are fitted to this aircraft for ferry flights. Experience with this assembly has shown that this decision was sound. Several installations of photographic equipment in tip tanks were known to exist in the U.S.A. and in the United Kingdom but this was the first time, within our knowledge, that the extensive instrumentation planned here was to be fitted in a standard tank. The chief unknowns in the installation were, of course, the effects of wing twist and tip vibration on equipment performance.

Parameters Covered: The first units to be developed would be used to equip the aircraft as a trials pacer. The 14 parameters to be detected and recorded in application were as follows:

1. Pitch Position
2. Roll Position
3. Yaw Position
4. Heading
5. Indicated Airspeed
6. Altitude





The author (R) discusses modifications made to structure of tanks with two of the technicians on the project.

7. Outside Air Temperature
8. Central Time
9. Normal Acceleration
10. 70 mm. Camera frame count
11. 35 mm. Camera frame count
12. 16 mm. Camera frame count
13. Angle of Attack
14. Angle of Sideslip

Instruments: The many available recording mediums were reviewed with regard to availability, accuracy and complexity. Since the assembly was intended for ultimate use by squadron personnel, it was decided that a system should be adopted which required a minimum of ground equipment for calibration and data reduction. On this basis, it was decided to standardize on a proven galvanometer recording system and to use D.C. detection circuits. The consolidated Electro-dynamics Corporation 18-channel 5-114 P-3 recorder was selected.

The air data requirements were met using a nose boom extending forward from the lower half of the tank. This boom was fitted with a Giannini Aerohead and Air Temperature Probe.

Position information was derived from a pair of Minneapolis-Honeywell gyros, one of which supplied pitch and roll position signals and the other of which supplied directional data. To reduce the errors in the vertical gyro due to false erection during maneuvering, a rate gyro was installed containing a switch to cut off the erection motors during turns.

The cameras selected for this application were the Model 70 Hulcher 70 mm. motion picture camera, the Training Aids Model 71TA high speed 35 mm. camera and the standard AN-N-6 16 mm. G.S.A.P. Since channels were available in the recorder, it was decided to record frame counts for camera synchronization rather than use one of the more complex film frame identification systems.

A standard An/ARC-3 VHF receiver was selected as the medium for receiving and translating timing signals to synchronize the recorded data with that being recorded in other aircraft or at ground radar, telemetry or cinetheodolite sites. A demodulator unit was provided to produce signals acceptable to the galvanometer circuits from the output stage of the ARC-3 receiver.

All of these instruments were combined into a recording system containing the necessary 400 cycle inverter for the gyro motors, the pressure transducers, the accelerometer, the D.C. bridges and the control, sequencing an automatic in-flight calibrating circuits.

Structural Modifications: One of the main considerations in the location of equipment within the tank was that of providing direct and easy access to the cameras and recorder to facilitate the unloading and reloading of this equipment. While the tank is of monocoque construction carrying the normal air and fuel loads through the skin, it was decided that the equipment to be carried should be fitted into a box structure within the tank surface and that this structure should be designed to pick up on the three main tank bulkheads which are attached to the wing spar anchor points. As may be seen in the attached figure, the tank was cut just ahead of the tank-wing leading edge junction. One additional access panel was fitted between the second and third anchor bulkheads. A box structure was constructed inside the tank with its main corner spars extending from the nose section aft to the rear spar bulkhead. This design formed three compartments—a rear section containing all the radio and demodulation equipment associated with the air-to-ground radio link; a central

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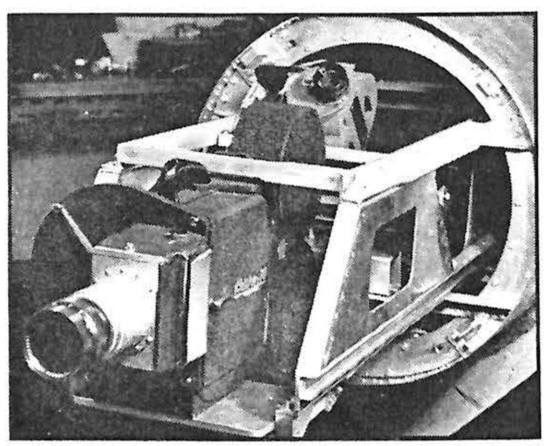

With the nose pieces removed, the channels on which the nose slides can be seen, as well as the two cameras which were installed in the UIP.

tions between this and other aircraft. The two ports provide flexibility in stationing below or beside other aircraft with angular adjustments possible in the horizontal position. Lenses from 1 to 10 inch focal length can be accommodated.

The completely instrumented tank weighs roughly one-third that of the tank with a full fuel load. Care has been taken to ensure that the centre of gravity of this tank falls within the longitudinal limits of the normal tank empty and full. To provide lateral trim, a ballasted tank is fitted to the other wing tip. This tank has also been modi-

"35,000 ft. up and Harper has to leave the room!"

fied to a flat nose section equivalent to that on the instrumented tank. This was done to eliminate any amount of yaw trim unconsciously supplied by the pilot when flying with one clean and one flattened tank. The equipment has been flown over the complete speed and altitude range for the aircraft and has produced no noticeable change in the aircraft handling characteristics.

Installation: The design objectives concerning facility of installation have been achieved with this equipment. Mechanically, the tank is attached to the aircraft in exactly the same way as a normal fuel tank. The time for the necessary electrical connections from existing wing wiring to the instrument control box replaces and is equivalent to the time required to couple the fuel lines for a standard tank. Within the fuselage, the only requirement is the connection of the fuselage end of normal tip wiring through a circuit breaker to the aircraft D.C. supply circuits.

All control circuits for selected operation of the tip tank equipment not intended for automatic sequencing are provided by existing circuits from the cockpit panels to the wing tip. All the necessary switches existed in the cockpit so that no wiring, other than the power pumper noted above, was required during installation.

Proving lamps have been mounted in the tip tank in a location just ahead of the wing leading edge permitting the pilot to check the operation of the equipment following the selection of appropriate switches within the cockpit.

The applications of this versatile form of flight test instrumentation have increased considerably since the first units were flown. The number of parameters which may be recorded from fuselage mounted equipment is only restricted to the number of leads available in the wing and the number of recorder channels allocated for a specific trial.

The elimination of the necessity for aircraft down time pending the installation of special instrumentation with a corresponding reduction in preparation time and total project cost has resulted in the use of this equipment for many different trials normally rejected due to cost or time limitations. The removal of the cameras in the nose section produces a mounting area large enough to accommodate most air-to-air missile components or systems for performance and environmental tests.

Any modifications to the nose section necessary to meet specific test requirements can be made with the tanks stored in the laboratory. Equipment unserviceabilities do not ground the aircraft and aircraft unserviceabilities do not ground the equipment.

Summary: This article has outlined a method of flight test instrumentation applied to a specific aircraft series in Canada by personnel from Computing Devices of Canada Limited. The exact equipment configuration recorded here is not considered to be applicable to other programs on other aircraft types.

However, the general approach is forwarded for consideration by those faced with the problem of using squadron level aircraft for the testing of new aircraft or armament equipment. The concept of instrument packages suitable for installation on any aircraft of a specific type utilizing existing aircraft electrical circuits and existing mounting fixtures can result in considerable savings in project development time and cost. This approach provides a measure of independence from aircraft serviceability and will, in general, result in an increase in the amount of test data produced per project dollar.

gone many alterations, including the change-over from water to air. At IAM's Flying Personnel Medical Establishment headed by Squadron Leader R. A. Stubbs, two new models have been developed. Still classed as experimental, they are presently in evaluation use with the RCAF. The X-Mark I is a G-suit built into a summer flying suit; the X-Mark II is a model incorporated in a pair of pants.

There are other FPME development projects all aimed at preserving the lives and health of RCAF aircrew members. One of these is a new type of waterproof flying boot designed along the mukluk principle. There are refinements to oxygen masks and innovations in survival equipment. What items would you include in a single forty-five pound seat pack? That's the total allowed for a single-seat fighter aircraft.

Wrong Pack: The urgency of this problem was pointed up last year when an American F-84 pilot was forced to bale-out of his burning Thunderjet over the wilds of eastern Labrador. Considering that the season was late winter, imagine his feelings when he opened his survival pack to find a bright yellow dinghy. His three-day wait for rescue in a sub-Arctic blizzard would have been more bearable had that dinghy been a sleeping bag. However, over-water flights call for dinghy packs. This is the situation in all RCAF jet operations too.

The answer is being evolved by the FPME at Toronto. It consists of a combination dinghy-sleeping bag. The details of this particular development project are still swathed in security.

Less spectacular at IAM, but none-the-less important, is the Central Medical Establishment under Flight Lieutenant T. M. Carey. Based on the RAF counterpart unit, the CME takes care of medically borderline aircrew cases, acting as a sort of Court of Last Appeal. To assist in this work, they have a board of consultants and when necessary, call upon leading Toronto specialists. "The greater part of our work," said F/L Carey, "is with vision problems and rising blood pressures in older types being returned to flying duties."

All of these RCAF officers who are exchanging ball-points for pistol-grip control columns are sent to CME for check-up. They get what the doctors at CME call their "Desk-to-Jet Overhaul". It is the most extensive physical overhaul that any of them will have to undergo in their entire service career. It is another aspect of the work done by aero-medical people.

While men of science are reaching for the horizons of speed and altitude, these other men such as Johnson, de Candole, Bromiley and Stubbs are searching for the human's place in it all. A few years ago the world accepted the assumption that the average human frame was universally the same. Now science is discovering that every man is physiologically individual, just as every man is psychologically individual. That single fact has enormously complicated the already complex problems of how to put Man into Man's new machines.

INSTRUMENTATION

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section containing the gyros, inverter, bridge supply, accelerometer, transducers and master control and switching box and a forward section containing the recorder and cameras.

To provide rapid servicing for the cameras, new bulkheads were inserted on either side of the station where the nose had been separated and four pairs of anchor blocks were fitted in such a way that the nose of the tank was held in place by four large pip-pins. The instrument box structure projected well forward inside the removable nose section so advantage was taken of this fact by providing a track on either side of the structure and rollers on the nose so, on removal of the pins, the nose section can be rolled forward exposing the cameras and recorder.

The front cone of the nose section was replaced by an optically flat glass to provide a port for the forward facing 70 mm. camera and two ports, one on the side (outboard) and one on the top, were supplied for the 35 mm. camera.

The 70 mm. camera selected for this application may be set up for operation in single (2¼ x 2¼ in. frame) or double (2½ x 5 in. frame) modes. Sufficient space is available to install this camera with its long axis in the double frame mode either vertically or horizontally using its standard 100 foot fill magazine or a special 400 magazine. Lenses with focal lengths varying between 7 and 27 inches can be accommodated.

The 35 mm. camera, in some applications, may be considered as a position camera to record the relative posi-