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INSTRUMENTATION FOR THE ARROW FLIGHT TEST PROGRAM

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Special Assistant to Chief Experimental Engineer.

DATE June 17th, 1958.

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PROJECT

INSTRUMENTATION FOR THE ARROW FLIGHT TEST PROGRAM

SUMMARY

The flight test instrumentation program arising from Brochure AD-51 "Statement of Work (Issue 2) - Arrow Program", dated May 22, 1958, is analysed. The total cost of airborne recording instrumentation, ground data handling equipment, and laboratory support approaches $2.5 million, in excess of present orders placed. Extra personnel and accommodation are also necessary.

PROJECT

INSTRUMENTATION FOR THE ARROW FLIGHT TEST PROGRAM

CONTENTS

C O N T E N T S (continued)

1.0 INTRODUCTION

The obligations of Avro Aircraft Ltd. are defined broadly in the Arrow Statement of Work, Brochure AD-51, and in detail by agreements within the company, and between the company, the R.C.A.F. and the other associate contractors. This report deals with the resulting actions which must be taken with respect to flight test instrumentation, and the requirements thus arising.

A brief review of the equipment to be used, and its technical characteristics is included, to facilitate a better understanding of the issues. There follows a qualitative analysis of Brochure AD-51, and then an analysis of the essential factors involved in the various tasks thus disclosed. Equipment, staff and space requirements are summarised in separate sections, and, where necessary, the details are set out more fully in Appendices. Graphs are included where appropriate, to facilitate appreciation of the data presented.

2.0 TYPES AND CHARACTERISTICS OF INSTRUMENTATION SYSTEMS

2.1 Airborne Recording

Airborne recording of data is achieved by the use of continuous trace magnetic oscillographs, magnetic tape recording systems, and photo-observers. Oscillographs are fairly restricted as to the number of data channels which can be accomodated without causing confusion. Their data is recorded in continuous analogue form, which is convenient for rapid qualitative inspection of cause-and-effect-relationships, but the extraction of accurate numerical data is time consuming manual operation. Magnetic tape recording systems offer either analogue or digital recording facilities, and permit the recording of many more data channels, all in electronically recoverable form. The records may be played back either into visual analogue display equipment, for inspection and editing, or into electronic data handling equipment for direct derivation of the ultimately desired informatioh. Photo-observers are useful when the parameters to be measured are few, and when the greatest accuracy and convenience is obtainable only from the direct observation of calibrated visual-display instruments of well established design. The photo-observer arrangement entails the least possible complication which still provides for automatic simultaneous recording of a few dozen readings.

Several techniques are employed in magnetic tape recording, each with its own characteristics. The C.E.C. Datatape equipment used in the earlier aircraft uses both P.D.M. and C.M. recording, while the I.R.I.G. equipment used in later aircraft uses both P.D.M. and F.M. recording. The P.D.M. (Pulse Duration Modulation) system is a method of commutating a number of data channels (usually 40 or 85) into time sequence on a single magnetic track. The time duration of each pulse represents the amplitude of the signal being recorded. The low commutator rotation speed (20 or 10 revolutions per second in the above cases, respectively) results in relatively low frequency response, and the method is limited to the recording of quasi-static data.

2.1 (continued)

F.M. recording is a method whereby a number of sub-carriers recorded on a single tape track are each frequency-modulated by a separate signal. The sub-carriers can be separated during ground playback, by suitable tuned filters. This system allows about 8 data channels per tape track, in a typical case. The frequency response is much better than with P.D.M. recording, with the higher frequency sub-carriers, but is about the same with the lower frequency sub-carriers. A 14 track tape recorder is used in the I.R.I.G. system, and after allocating two tracks to system service duties, about 80 to 100 parameters can be recorded on such a machine, by the F.M. system. The C.M. (Compound Modulation) system is applicable to signals arising in bridge-type transducers, which are accordingly energised from a 1,500 c.p.s. A.C power. The resulting output is a 1,500 c.p.s. signal which represents, in magnitude and phase, the magnitude and sense of the transducer stimulus. This output modulates a 10,500 c.p.s. sub-carrier which is recorded on the tape, one to a track. The zero 1,500 c.p.s. output corresponding to zero stimulus affords a safeguard against zero drift, and the high value of the energising frequency gives a good frequency response. The latter is achieved, of course, at the cost of allocating a separate track to each channel, which disadvantage is partly offset by the use of a large number of tracks (28) on Datatape recorders.

Both the Datatape and the I.R.I.G. tape systems handle the data in analogue form for a considerable part of the processes involved, and entail reconversion on the ground to analogue form, before the data can be handled in other ways. In this form the data is subject to both zero drift and scale errors, which are impossible to avoid altogether with equipment on the scale involved in the Arrow programs. Developed equipment is now available which permits the early conversion of all signals to digital form, and the subsequent handling of the data without reconversion to analogue form. It is planned to introduce this system into the Arrow program at a later stage.

2.2 Airborne Telemetry

A telemetry system consists of a radio transmitter whose basic carrier is frequency modulated by a number of discrete sub-carriers, each of which is frequency modulated by a separate signal, as in the case of F.M. tape recording. Due to the avoidance of limitations which apply to tape recording, more sub-carriers can be used with telemetry, and 12 may be employed in a typical case. The highest standard sub-carrier frequency available is capable of carrying a P.D.M. pulse train with acceptable accuracy, and consequently a telemetry system may handle 40 or 85 P.D.M. commutated quantities as well as 11 or so continuous quantities.

2.3 Ground Equipment

In the case of each system referred to in the previous section, certain ground equipment is needed. The photo-observers require only film viewers for inspection of the film under magnification, and the data is extracted by manually recording the instrument dial readings. Oscillo-graph records are in the form of long rolls of paper, which require suitable long tables for qualitative viewing. For quantitative evaluation of data, the rolls are mounted in a machine in which the records can be traversed across an illuminated screen. The operation of movable measuring scales causes the display of readings in digital form on an indicator, and the machine may be adapted to operate an electric typewriter directly. By whatever method, data must be extracted point by point.

All magnetic tape systems require a ground play back tape transport, with which is associated equipment to ensure that playback speed corresponds exactly with the recording speed. P.D.M. data must first be decommutated into separate data channels, and then "Translated" from pulse duration back to amplitude form, each data channel requiring a separate translator. F.M. data must first be passed through tuned filters to separate the sub-carriers on each track, and then through discriminators to convert the frequency modulation of the sub-carriers back to amplitude variations. For P.D.M. or F.M. information, the equipment described may be provided in multiple, so as to enable all tracks to be played at once, or the tape may be separately played back for each track.

2.3 (Continued)

C.M. data must be passed through C.M. demodulators, one per track, and it is reasonably convenient to provide as many demodulators as there are tracks carrying C.M. information. As already noted, P.D.M., F.M. or C.M. data is converted back to analogue form, and as such may be displayed on continuous trace direct writing oscillographs, whose records may be qualitatively evaluated by inspection, or edited to determine the time periods over which other processing may be required. Other processing, at Avro, is digital processing. P.D.M. information can be fed directly from the play-back tape unit into the C.E.C. Millisadic digitising equipment, which decommutates and digitises information directly. F.M. or C.M. information must be reduced to final analogue form by the means already described, and may then be fed into the Millisadic equipment, which will either digitise repeatedly from a single input, or will scan up to 20 inputs sequentially at a somewhat lesser rate. In any event, the output of the Millisadic equipment is a magnetic tape bearing the digital information, and this may be played back at reduced speed so as to operate an I.B.M. card punch, whose output is in the form of digitally punched cards, or it may be played back into a tape conversion unit which converts the peculiar digital coding and format of the Millisadic tape into the coding and format required for direct input into the I.B.M. 704 digital computer. The output tape may then be used for digital computing purposes. When digital tape recording is used, the recorded tape is played back in a unit which can either transform the information into analogue form for visual display and inspection on direct-writing oscillographs, or directly produce an output tape with coding and format suitable for use in the I.B.M. 704 computer.

3. ESTABLISHMENT OF INSTRUMENTATION REQUIREMENTS

3.1 Allocation of Aircraft

The allocation of aircraft throughout the contractor and R.C.A.F. flight test programs is shown in figure 1. Aircraft 1 through 8, including aircraft 3 while allocated to Avro Phase 1 testing, and aircraft 16, are fitted with instrument packs, replacing the weapon packs to be carried in service,

3.1 (continued)

and all the airborne recording and telemetry equipment will be carried in these packs. In its subsequent phases, aircraft 3 will carry a development weapon pack which will not afford recording instrumentation space. However, no radar or other electronic equipment will be carried in the radar nose, and a limited quantity of recording instrumentation will be installed there. Aircraft 9 thro' 15, 19, 20, 22, 26, and 27 will carry weapon/instrument packs in which half the space will be taken up by a reduced weapon installation, and the other half will be available for recording instrumentation. Aircraft 17 and 18 are scheduled to be fitted with weapon packs, and only the radar nose will be available for recording instrumentation, in this case.

3.2 Responsibilities of Avro Aircraft Ltd.

Under the terms of the Statement of Work (Issue 2) for the Arrow Program (Brochure AD-51), Avro Engineering Division is responsible for the following duties falling within the general description of instrumentation:-

(a) Design and/or specification, installation, check-out and calibration of airframe sensing and airborne telemetry and recording instrumentation for the Avro flight test programs.

(b) The recording, reduction and analysis of data resulting from Avro flight test programs.

(c) Maintenance of and changes to instrumentation referred to in (a) above, after R.C.A.F. acceptance of the aircraft concerned. This includes provision of replacement or extra items.

(d) Design and/or specification and installation of sensing instrumentation required for Avro airframe development, in aircraft allocated to other associate contractors, i.e. aircraft 4, 5, 7, 9, 10, 12, 13 and 22.

(e) Design and/or specification (to contractor's requirements) of airframe sensing and contractor's system instrumentation, required for contractor's programs, and of airborne recording instrumentation, in aircraft allocated to other associate contractors, excluding the provision of instrumentation items.

3.2 (continued)

(f) Check-out and calibration of airframe instrumentation in aircraft allocated to Orenda Engines Ltd. and Canadair Ltd..

(g) Assistance to all other associate contractors with maintenance of and changes to instrumentation in their aircraft after R.C.A.F. acceptance, whether at Malton or at Cold Lake, excluding the provision of replacement or extra items.

(h) Operation of aircraft 3 during Canadair C.T.V.and E.T.V. programs at Malton, including the provision of ground telemetry facilities, and supply to Canadair of recorded data. (Note: Canadair will not actually require ground telemetry facilities at Malton).

(i) Supply of data reduction facilities and service to all other associate contractors operating at Malton except in the case of aircraft 3 as defined in (h) above. (Note: Orenda will not actually require data reduction for aircraft 7).

(j) Provision of ground telemetry facilities for Orenda Engines. Ltd. program with aircraft 7.

(k) Provision to R.C.A. at Malton, of office, storage and laboratory facilities, including laboratory test equipment, and assistance with its operation, but excluding facilities for the maintenance and repair of Astra I equipment.

(l) Provision to Canadair, Ltd. at Malton of office, storage, and laboratory facilities, including the use of and assistance with the operation of available laboratory test equipment, and the supply of one (only) set of Sparrow missile test equipment.

(m) Design and/or specification (to R.C.A.F. requirements), installation, check-out and calibration of airframe sensing and airborne telemetry and recording instrumentation for aircraft allocated to R.C.A.F. Phase 2 and Phase 4 thru 8 programs. This includes photo panels for Phase 2 aircraft, but not the instruments contained in the panels. It is assumed that no instrumentation is required in Phase 6 or Phase 8 aircraft.

3.2 (continued)

(n) Servicing, maintenance, calibration and operation of airborne instrumentation, for R.C.A.F. Phase 2 programs, at Malton.

(o) Provision, manning and operation of facilities for ground telemetry (including readout), magnetic tape playback and readout, data processing and computation, for R.C.A.F. Phase 2 programs, at Malton.

(p) Design and/or specification, installation, check-out and calibration of airframe sensing and airborne recording instrumentation for the Weapons System Demonstration aircraft 14 and 15.

(q) Maintenance, check-out, calibration, and changes to airborne instrumentation referred to in (p) above, after R.C.A.F. acceptance of the aircraft, for the purposes of the Weapons System Demonstration at Cold Lake. This includes provision of replacement or extra items.

(r) Analysis of data derived from the Weapons System Demonstration, and processed through an R.C.A.F. operated data reduction facility.

In addition to the foregoing items specified in the Statement of Work, there is to be established, at Malton, a combined Missile System Evaluation Facility and Engineering System Evaluation Facility, the purposes of which are respectively to provide for maintenance, set-up and checking of missiles and fire control system units for test program purposes, and to provide for engineering evaluations of these systems and developments thereof.

3.3 Responsibilities of Other Agencies

In order to clarify the assessment of Avro's responsibilities, reference is made below to items of particular interest which are defined in Brochure AD-51 as the responsibilities of other agencies.

3.3 (continued)

The Government of Canada is responsible for:

(a) The supply of instruments for photo panels to be used in Phase 2 programs.

(b) The supply of telecommunications equipment for ground telecommunications required for the Arrow flight test programs at Malton.

(c) The supply of capital-type equipment necessitated by Avro's services to other associate contractors, and to fulfill coordinating contractor responsibilities, including computing and simulating equipment, data processing equipment, and ground telemetering installations.

(d) Office and laboratory space, and living quarters at Cold Lake for Avro personnel.

(e) Data reduction services at Cold Lake.

(f) Maintenance and operation of instrumentation in aircraft 17 thru 20 and 23 thru 37, after R.C.A.F. acceptance.

The Radio Corporation of America is responsible for:

(a) The provision and operation of maintenance facilities and services for Astra I at Malton and at Cold Lake, for all associate contractor requirement.

(b) Provision, pre-flight testing, maintenance and changes for all airborne instrumentation in aircraft 4, 5, 9, 10 and 22, except for sensing instrumentation installed solely for airframe development purposes. (Note: Avro are to render assistance to R.C.A. in respect of maintenance and changes, as stated in paragraph 3.2 item (g)).

Canadair Limited are responsible for:

(a) The provision of airborne telemetry in missiles.

(b) Operation and maintenance at Malton and Cold Lake of Sparrow missile check-out and maintenance facilities, and provision of services and spares for the missiles and associated ground support equipment. The facilities are provided by Avro at Malton (paragraph 3.2 item (b)), and by the R.C.A.F. at Cold Lake.

3.3 (continued)

(c) Provision, pre-flight testing, maintenance and changes for all airborne instrumentation in aircraft 12 and 13, except for sensing instrumentation installed solely for airframe development purpose. (Note: Avro are to render assistance to Canadair in respect of maintenance and changes, as stated in paragraph 3.2 item (g)).

(d) Provision of ground telemetry and recording facilities at the firing range, for aircraft 3.

Orenda Engines, Ltd. are responsible for:-

(a) Provision, maintenance and changes for airborne engine data telemetering adaptation equipment and special airborne instrumentation in aircraft 7.

(b) The supply of three government furnished Iroquois engines with full instrumentation for aircraft 7.

4.0 PROGRAM RESULTING FROM ESTABLISHED REQUIREMENTS

4.1 The following paragraphs translate the requirements enumerated in section 3.0 into specific tasks which are discussed individually. The earlier paragraphs deal with the provision of instrumentation in the aircraft throughout the program, and the later sections deal with the required ground facilities and services.

4.2 Airborne Instrumentation in Airframe Development Aircraft 1, 2, 6 and 8.

These aircraft are or will be equipped with C.E.C. Datatape systems as the primary data gathering means. Additionally, they will each carry a telemetry package, and aircraft 1 and 2 will carry continuous recording oscillographs. Due to operational difficulties which have been encountered in the early stages of the Arrow flight test program, it has been necessary to define a three-stage development of the systems contained in packs 1 and 2. Stage A consists of the operational use of telemetry on 12 continuous channels and an oscillograph recording up to 20 continuous items. It does not include the operational use of the tape recorders or of the P.D.M. systems. Stage B adds two operational Datatape

4.2 (continued)

recorders, allowing the recording of 45 continuous channels, but still excludes operational P.D.M. systems. Stage C brings into operation in each pack two Ascop P.D.M. systems, having a total capacity of 80 commutated data channels for tape recording, 40 of which will be available for telemetry. In accordance with a policy which has been accepted within Avro, no more than 100 parameters will actually be recorded or telemetered in any one flight. Accuracy and reliability are seriously compromised by attempts to activate the instrumentation on too large a scale in the limited pre-flight time available, and the maximum level of 100 signals has been chosen as giving a reasonable balance. The three-stage development applying to aircraft 1 and 2 includes the location and cure of electrical faults which initially interfered with the successful operation of the tape transport machines. It also includes the location and cure of several faults which interfered with the reliable operation of the P.D.M. system. In this area, an extensive engineering and laboratory investigation into the operation and characteristics of the P.D.M. equipment is being made, and improvements are being developed. The scheduling of packs 1 and 2 during this period of development is shown in figure 2.

The sensing instrumentation installed in airframe 1 and 2 was designed as prescribed in Technical Design Department report "C-105 Insturmentation" (later known as CF.105/F.A.R.(1). Much of the sensing instrumentation, and most of the associated wiring throughout the aircraft, had to be installed while the aircraft were being built, because of inaccessibility of the areas concerned after final assembly. An exception occurs in the case of the patch panels, which are being assembled and wired by the Instrumentation Laboratory, after acceptance of the aircraft. These patch panels are located in the airframes above the packs, and enable suitable selections of the total sensing instrumentation available, to be made for recording purposes. The scheduling of the work involved is shown in figure 2. It may be mentioned that early flights have been made with direct wiring of selected sensing instrumentation to the pack disconnects, without a patch panel.

The packs for aircraft 6 and 8 will be similar in principle to those for aircraft 1 and 2, except that no oscillograph will be fitted, and only one Datatape recorder will be fitted in each. The P.D.M. system will be enlarged from two 40-channel

4.2 (continued)

sets, to two 40-channel and two 85-channel sets. Various equipment items, including the P.D.M. units, will be changed from the types used in packs 1 and 2, to take advantage of improvements now available. A telemetry package will actually be fitted only to pack 6, although identical provisions for it will exist in pack 8 in case telemetry is needed.

The sensing instrumentation in airframes 6 and 8 has been designed to the requirements of Technical Design Department report 72/FAR/6.

4.3 Airborne Instrumentation in Airframe Development Aircraft 3 for Phase 2 Testing

That area of the Avro Phase 1 testing for which aircraft 3 has been allocated (see figure 1) is coincident with the testing required by the R.C.A.F. for Phase 2 testing on Mark 1 aircraft, and is to be undertaken jointly by the company and the R.C.A.F. For convenience, it is designated now purely as Phase 2 work. The aircraft will make its first (acceptance) flight with no operational instrumentation, and a pack containing only ballast (pack 5). The recording instrumentation to be installed in its own pack will consist of a photo panel carrying about 35 instruments, and an oscillograph recording about 7 parameters. Figure 2 shows the scheduling of these pack arrangements. Airframe instrumentation is included in this aircraft as defined by the previously mentioned Technical Design Department report applicable to aircraft 1 and 2, except for the omission of accelerometers which were installed in aircraft 1 and 2 as structural integrity instrumentation. The instrumentation required for the Phase 2 testing is defined by Technical Design Department report 71/FAR/29, and includes some of the already installed instrumentation. Additionally, instrumentation is to be fitted to determine pressures and temperatures in the engine ejector and bypass areas, and it will be necessary to run piping through the aircraft to conduct the pressure signals to the photo-panel instruments. The instruments for the photo panel are defined in Brochure AD-51 as Government Furnished, but are in fact being procured by Avro because of R.C.A.F. inability both to supply them, and to agree that the supply is an R.C.A.F. responsibility. The contractual implications are in the hands of the Engineering Project Management Services Department.

4.4 Airborne Instrumentation in Astra Development Aircraft 4 and 5

The instrumentation installations in these aircraft are identical to each other. A small quantity of sensing instrumentation is required by Avro, for what are in effect airframe development purposes (i.e. monitoring in the interests of airframe problems). To the extent that this instrumentation is not also required by the Astra system contractor (R.C.A.), it is specified and provided by Avro, specification being via Technical Design Department report 71/FAR/2. The installation and wiring design of this instrumentation has been carried out by the Flight Test Instrumentation Design Group, and the actual installation and wiring is being carried out during the building of the aircraft. The two aircraft are allocated entirely to R.C.A.'s programs, after R.C.A.F. acceptance, and the total sensing instrumentation requirements of R.C.A. were defined in R.C.A. document R.E.L.4 (Engineering Letter to R.C.A.F., serial # 4). This document is now stated by R.C.A. to be obsolete, and will be replaced by a series of A.E.L.s (Engineering Letters to Avro), none of which have been received, but all of which were promised to Avro by June, 30th, 1958 (reference memo 1292/01/GEN - E.J. Lynch to S.E. Harper, dated June 16, 1958). Assurance has been given that the new definition of requirements will not exceed the original definition. The instrumentation in question can be divided into three categories. Firstly, there are voltage tappings within the Astra system itself, for which wiring between connectors on Astra units and the patch panel is the only Avro provision necessary. Secondly, there are other measurements within the Astra system for which R.C.A. will supply transducers and internal wiring, and for which the only Avro provision necessary is wiring between the Astra unit connectors and the patch panel. Thirdly, there are measurements to be made within R.C.A. - specified Avro - designed systems directly supporting the Astra system. The required instrumentation is being specified and supplied by R.C.A. and fitted by Avro. All of the design work associated with all three categories is being carried out by the Product Design Department. Not all of the information in the third category has yet been received from R.C.A.

The provision, installation design, and installation of the patch panels in aircraft 4 and 5 is the responsibility of the Test Department, and the design awaits receipt from

4.4 (continued)

R.C.A. of pin-to-pin wiring information, the production of which R.C.A. has in progress. The mechanical installation of the panel is similar to that for aircraft 1 and 2.

The recording instrumentation within the packs is entirely specified by R.C.A. and all the equipment required is to be supplied by R.C.A. The detailed installation design and the work of installation is to be carried out by Avro. The required design information from R.C.A. is now practically complete, although receipt of it was up to one month later than required by Test Department schedules . Building and Activation scheduling for the packs is shown in figure 2, although this will be somewhat dependent upon sufficiently early receipt of equipment from R.C.A., who are unable to give an entirely satisfactory undertaking in this respect. There is also some prospect of R.C.A.'s requiring design changes to the packs at a very late date, arising from bench tests of the equipment after receipt by R.C.A. Provision is being made for design liaison with R.C.A. to meet this possibility. Reference may be made to memorandum 1292/01/GEN previously quoted.

The first flight of aircraft 4 will be made without instrumentation, using pack 5 carrying only ballast. Pack 5 will then be fitted with an oscillograph, and used for surveys of the air-conditioning system in the early flights of aircraft 5. Following this, it will be built up to its final configuration, similar to pack 4.

Initial check-out and calibration of the R.C.A. -specified instrumentation in aircraft 4 and 5 is excluded from Avro's responsibility in Brochure AD-51, and has been agreed with R.C.A. to be their responsibility. The necessity for R.C.A. to begin this check-out by December 15, 1958, creates the necessity for Avro to have an operational I.R.I.G. tape ground facility by that time. The recording system is designed around two I.R.I.G. tape recorders, one running at low speed, and accepting low frequency F.M. and low speed P.D.M. data, and the other running at high speed, accepting higher frequency F.M. data. No oscillographs or telemetry are used. Four P.D.M. commutators are used, all of them accepting high level signals except one, which accepts the low level signals originating from the Avro airframe development sensing instrumentation.

4.5 Airborne Instrumentation in Airframe Development Aircraft 3 For Missile Launching and Weapon Pack Testing

For these programs the aircraft will be fitted with a development weapon pack, and the only space available for instrumentation will be in the radar nose. Only an I.R.I.G. magnetic tape system will afford the required capacity in the available space. One I.R.I.G. recorder plus an oscillograph will be carried, and there will be one 40-channel P.D.M. commutation system associated with the recorder. Flights with this system are scheduled to begin in Mid-April 1959, and it will require the use of the I.R.I.G. ground facility by the end of February 1959. No telemetry equipment will be installed. Preliminary design work has commenced.

The sensing instrumentation required for these programs is defined in Technical Design Department report 71/FAR/10 in respect of the missile launching tests being carried out by Avro for Canadair, Ltd. and in report 71/FAR/11 for the strictly Avro weapon pack operational tests. Reference has already been made to the airframe instrumentation already installed in this aircraft similar to that in aircraft 1 and 2. The extra sensing instrumentation required is to be in the weapon pack and in the missile. In the case of the pack, the measurements involve hydraulic pressures, mechanism displacements, temperatures and differential pressures, and design work for these has yet to be started. In the case of the missile (Canadair Environmental and Control Test Vehicles) the instrumentation will be internally contained, and Avro recording wiring will be taken to the Canadair connectors.

4.6 Airborne Instrumentation for Iroquois Engine Development Aircraft 7.

Practically all of the sensing instrumentation to be carried in this aircraft is specified by Orenda Engines, Ltd. and supplied with the Iroquois engines which will be used. Only two parameters are required by Avro in the interests of airframe development. The Product Design Department is producing all drawings for the airframe and engine sensing instrumentation with its wiring and piping through the airframe; the Flight Test Department is responsible for technical liaison between Product Design and Orenda Engines, Ltd. concerning instrumentation.

4.6 (continued)

Similar responsibilities apply to the recording instrumentation, which is located in the pack. This consists of one Datatape recorder and two oscillographs, plus two telemetry systems. The equipment is completely specified and supplied by Orenda, except for telemetry systems which are being specified by the Flight Test Department, and supplied by Avro.

4.7 Airborne Instrumentation for Aircraft with Weapon/Instrument Packs

The aircraft which will be fitted with these packs are 9-15, 19, 20, 22, 26 and 27, and are allocated as shown in figure 1. The R.C.A.F. has requested that these aircraft be fitted with standardized sensing instrumentation in the airframes, and standardized recording instrumentation in the packs. This proposal is based on the essential similarity of the instrumentation requirements for the programs of these aircraft, and the desirability of a high degree of interchangeability. It also reduces enormously the engineering and design work for the programs, and the necessary provision of spares. It is probable that the standardised airframe instrumentation will be applied to all R.C.A.F. aircraft from 17 to 37, in order to maximise flexibility in the program.

The proposal for standardised airframe instrumentation is based upon the acceptance as a standard of Technical Design Department report 72/FAR/14, originally issued in respect of aircraft 10 only, but now under review as a standard, plus the acceptance as standard of the Astra and associated systems instrumentation to be requested by R.C.A. for aircraft 9. R.C.A. have promised to submit their comments on report 72/FAR/14 together with their requirements for aircraft 9 by June 30th. The proposal has not been submitted to Canadair, but their requirements for aircraft 12 and 13 have been communicated to Avro (Technical Design Department report 72/FAR/28 - not yet issued) and they are within the scope of the standard proposal. It will be submitted to the R.C.A.F. as soon as the final revision of report 72/FAR/14 becomes available.

The proposal for standard recording instrumentation is contained in a brochure prepared by the Flight Test Department and has been submitted to R.C.A. for comment, which has been promised by June 30th, 1958. A schematic diagram is shown

4.7 (continued)

in figure 3. It is currently being submitted to the R.C.A.F. for comment, and it more than adequately covers the known requirements of Canadair, to whom it must yet be submitted for approval.

The recording system is based on the use of I.R.I.G. tape recording, as agreed some time ago by all parties, and it provides for a generous number of recording channels, with a high degree of flexibility regarding the signal level and the speed of P.D.M. commutation. The basic standard would be invariable as to design, although certain alternative choices and certain arbitrary quantity limitations could be applied in the call up. Extra functions could be called up outside the basic standard area, and for some of these a standard subsidiary design would be created. Others would be designed only as and when required.

In view of the early start which must be made on design work for aircraft 9, it will probably become necessary for Avro to proceed very shortly on the basis of the above proposals, and to assume that the acceptance of these proposals by the other parties, as a standard, will follow. Determination of policy in this regard will be between the Flight Test Department and the Project Engineering Manager. It is to be noted that Brochure AD-51 requires all instrumentation equipment for aircraft allocated to other associate contractors to be specified and supplied by the contractors in question, except for airframe development instrumentation. Consequently, formal approval of the standard proposals by these contractors is necessary.

4.8 Airborne Instrumentation for Airframe Development Aircraft 16

This aircraft is allocated to the performance of Structural Integrity testing to substantiate theoretical airloads used in calculations and ground tests. It has been agreed by the R.C.A.F. and the National Aeronautical Establishment that this shall be done using strain gauges as the principal sensing instrumentation. The complete sensing instrumentation requirements are defined by Technical Design Department report 72/FAR/8. and design work for its installation is in progress in the Flight Test Department.

From the viewpoint of the program, it would be practical and convenient to record the data by the use of an I.R.I.G.

4.8 (continued)

tape recorder, employing mainly P.D.M. commutation. However, as discussed later in paragraph 4.12, it is desirable for separate reasons to develop an airborne digital recording system, and to further this objective economically, it is convenient to employ the proposed system in aircraft 16. Consideration of this proposal by the R.C.A.F. has been denied, pending submission of sufficient supporting argument. However, it is felt that a sufficient justification exists, and a report is being prepared which it is hoped will secure the necessary approval. Such approval is anticipated for the purposes of the present report, but this should not be construed as representing any actual intention to proceed without approval.

4.9 Airborne Instrumentation in R.C.A.F. Phase 4 Aircraft

Aircraft 17 and 18 are allocated to R.C.A.F. Phase 4 performance and handling tests, and, as previously noted, are scheduled to have active weapon packs, leaving only the radar nose area available for instrumentation. The required recording system has not yet been defined by the R.C.A.F., but preliminary discussions with C.E.P.E. indicate that it may be of sufficient extent to preclude its installation in the limited space available. It will possibly be necessary to substitute an instrument pack or a weapon/instrument pack for the weapon pack, in one or both aircraft. A meeting has been arranged with the R.C.A.F. to try to resolve this question very shortly, and for the purposes of this report it is meanwhile assumed that each aircraft will carry the equivalent of the standard I.R.I.G. pack, including the optional second tape recorder, plus a telemetry system, plus a photo panel.

As already noted, these two aircraft will probably carry standard sensing instrumentation, although this is another matter requiring R.C.A.F. confirmation.

4.10 Ground Facilities for Datatape Systems

The essential equipment for a Datatape playback system includes a playback tape transport, a P.D.M. decommutator, a set of P.D.M. translators, and a set of C.M. demodulators, together with a patch panel for routing the resulting signals to the visual read-out or digitising equipment.

4.10 (continued)

Such a facility is in operation at Avro now, and experience in operating it to date indicates that the equipment can be expected to be in use for 5-10 hours for processing data from each typical flight, when the program develops (see Appendix A). Figure 4 shows the expected number of flights per month during the program with each type of primary data-gathering system. The expected maximum with Datatape is 28 flights per month, which is about 1.35 per working day, and it is expected that a single facility will be able to provide sufficient service, if operated, when necessary, on a two-shift basis.

4.11 Ground Telemetry Facilities

The principal use of radio-telemetry is in test programs in which it is necessary to direct the progress of each flight on the basis of information which can be evaluated on the ground as it arises, but which cannot be evaluated aboard the aircraft. Instances exist in programs probing into stability and control of the aircraft, or into the boundaries of safe operation of the engines. Secondary uses are as a preview of information recorded on board, and as a possible indication of the cause, if the aircraft is lost by accident. Use of telemetry for these reasons alone is hard to justify, since the recorded data must in any case be viewed by playback in order to establish its satisfactory quality for further processing, and a telemetry system would be unlikely to add significantly to the evidence in the case of a crash, unless it were a fairly extensive installation. For these reasons, it has been decided that telemetry will be used only in aircraft 1, 2, 6, 7, and possibly 8, as far as flying from Malton is concerned.

Figure 5 shows the expected number of flights per month with these aircraft. Analysis of the operations associated with preparing for, executing and terminating a telemetry flight shows that the equipment is thus occupied for $3\frac{1}{2}$ hours for each flight. Even in winter, when only two flights per day would thus be possible due to lack of daylight, it would seem that the required maximum number of 28 flights per month could be achieved with a single facility, whose capacity would at that time be effectively 60 flights per month, assuming that any fine day would be a flying day.

The facility presently in use consists of duplicate radio-telemetry receivers (one active and one on stand-by), tape

4.11 (continued)

recorders for the mixed sub-carrier signals, narrow-band filters, narrow-band discriminators, and supporting equipment. The use of the tape recorders is fully justifiable while the special risks associated with early flights remain significant, and until the on-board tape recording systems are functioning properly. At a later stage, it will become acceptable to discontinue their use. The facility makes use of the P.D.M. decommutation and translation equipment listed in the previous paragraph as part of the Datatape facility, but since it is planned to separate flight operations facilities from data-reducing facilities at a future date (see paragraph 4.18), this P.D.M. equipment will have to be duplicated. The capacities of the systems, as noted in this report, are based on full-time availability of equipment for a single purpose. The visual-display analogue recording equipment which now is associated with the Datatape facility, but is also used for display of telemetry data, is more than sufficient for telemetry purposes. However, it is not sufficient for the fully developed data reducing facilities which will be required, in addition to the telemetry facility.

In order to cater for the Orenda requirements for aircraft 7, it is necessary to operate two receivers actively at the same time and it will therefore be necessary to acquire a second antenna, and a third receiver for stand-by use. It will also be necessary to acquire wide-band filters and discriminators to handle the Orenda data, as well as oscilloscopes to display the data to the monitoring engineers. These extra units are identifiable as requirements arising solely out of Avro's obligations to serve another associate contractor, and are accordingly chargeable to the Government of Canada, as stated in section 3.3.

Not listed in Equip requirements.

4.12 Development of Airborne I.R.I.G. System

Aircraft 3, in its second program, will be the first Avro aircraft to carry this system, and its equipment should be ready for post-installation check-out by mid-February 1959. Prior to its assembly, which must start at about January 1, 1959, the same equipment is to be used for familiarisation and any necessary development work.

4.12 (continued)

It will be delivered by September 1958, and will be operated throughout October, November and December in a "breadboard" assembly. The self-contained playback facility in the tape recorder, together with a small quantity of reproduction and discrimination equipment being purchased for the purpose, will render this work largely independent of the creation of the I.R.I.G. ground facility. By means of this preliminary breadboard work, it is planned to avoid the problem of development troubles arising after initial use, as has been the case with the Datatape systems.

4.13 Ground Facilities for I.R.I.G. Tape Systems

The handling of data with this system will be very similar to that with a Datatape system, except that recovery of information from the F.M. tracks will require more playback runs. The superior recording capacity of the F.M. system (see paragraph 2.1) will be utilised fairly heavily by R.C.A. particularly. It is estimated that it will be possible to reduce all of the data required in 7 to 15 hours per flight (see Appendix 'A'). Figure 4 shows that a maximum of 52 flights per month will be made with I.R.I.G. recording systems, and it is concluded that two complete sets of ground equipment are necessary to handle the data. Each will be required to handle about 1.25 flights per day, which can be done by operating on a two-shift basis when necessary. The first system must be ready for operational use by March 31, 1959, and the second by October 31, 1959.

The earliest use of the system will be by R.C.A. who will perform preparatory check-out work with pack 4 beginning by mid-December, 1958, and sufficient equipment should be on hand by that time to serve this purpose.

The functional and traffic requirements of R.C.A. and Canadair are now known, and a broad specification for the proposed system was submitted to R.C.A. on June 9th, for comment, if so desired. The Canadair requirements are slight, and submission to them is superfluous. Procurement investigations have proceeded to an advanced stage, and a formal specification is about to be sent out for tender, for the complete system, except for the tape transport machine. The latter will be obtained independently in order to provide for R.C.A.'s early check-out requirement, and will be supported by a small

4.13 (continued)

quantity of subsidiary equipment already available, during the early check-out phase. The system to be contracted for covers the necessary band-pass filters, discriminators, and P.D.M. decommutation and translation equipment, as well as all power supplies and cables, but does not include visual-display or digitising equipment. The choice of tape transport will be agreed with the system supplier, and it is intended that the supplier should initially staff the equipment for the purpose, firstly, of proving to Avro satisfaction that it operates reliably, and, secondly, of instructing Avro personnel in its use. This will extend sufficiently to cover a period of actual use in the flight test program. It is expected that the first system will be delivered by the end of 1958.

4.14 Development of Airborne Digital Tape Recording

As was mentioned in paragraph 2.1, the analogue Datatape and I.R.I.G. systems are subject to errors due to the difficulties involved in holding constant such factors as amplifier gains, oscillator frequencies and tape speeds, over periods of time long enough to cater for pre-flight calibration, flight recording and ground playback. These particular difficulties are overcome completely if the signals are converted immediately into a digital code, since the preservation of the code is independent of the behaviour of processing equipment, as long as it continues to operate. There remain the inaccuracies due to the variation of transducer properties with time, and to errors in calibration. The use of an airborne digital tape recording system, with s uitable associated ground equipment, should result in the reduction of the probable error of 3 to 4% associated with analogue systems, to less than 1%. These matters of accuracy are the subjects of independent reports presently being prepared by the Flight Test Instrumentation.Engineering Group.

Inaccuracies of the order of 3-4% are quite unacceptable for certain purposes, e.g. for the measurement of static, total and differential pressures in flight performance programs, where photo panels are the unquestioned preferred choice. It is likely that such performance will also be found unacceptable for the proper evaluation of fire control systems and navigation systems where photo panels could not be used, and that a demand will arise for the improvement which

4.14 (continued)

would result from the use of a digital system. A proposal is being prepared which sets out detailed reasons for the development of such a system, and a plan for its development ,and it is intended to request R.C.A.F. endorsement of the proposal. As mentioned in paragraph 4.8, the development would include employment of the system in the Structural Integrity Program aircraft, 25216.

The airborne multiplexing and digitising unit contemplated for this system should be procured in time to permit its operation in the laboratory, using simulated signal sources by February 1959. Familiarisation and development on it should be complete by May 1959, to enable design work on pack 16 to begin.

4.15 Ground Facilities for Digital Tape System

The ground facility required is a unit comprising an input tape transport, on which the airborne tape is played back, a processing unit capable of converting the signals to analogue form for the operation of visual-display oscillographs, or of converting the signals into digital coding suitable for direct input to the I.B.M. 704 computer, and an output tape transport, which produces a tape bearing the information in I.B.M. 704 code, and format. This unit should be procured for delivery at the same time as the airborne equipment, and would be used during the familiarisation phase.

4.16 Ground Facilities for Digitising Analogue Information

Of all the information gathered by the airborne analogue data-gathering system employed in aircraft flying at Malton (essentially aircraft 1-11), some will be put aside for future reference, some will be reproduced in analogue form only (on Sanborn oscillographs, or the like) and some will be digitised for computer use. The time required for digitisation is estimated in Appendix 'A', on the assumptions that the time periods over which digitisation will be required are very small, and that nearly all of the recorded parameters would require digitisation. The employment time for the digitising equipment has been estimated from the data derived in Appendix 'A', by applying the further assumption that digitisation would be

4.16 (continued)

required for only two of the five flights assumed to be flown each month with aircraft devoted to electronics systems development, and only three of the seven flights per month for other aircraft. The aircraft involved are, according to presently known requirements, those involved in stability and control programs, and in Astra system programs, viz., aircraft 2, 4, 5, 6, 8, 9, 10 and 11. The resulting utilisation time for the digitising facility is shown in figure 6.

It would at first appear from figure 6 that a single facility (i.e. the existing Millisadic equipment) would be sufficient, since maximum utilisation is only about 160 hours per month. However, it must be realised that the digitising facilities cannot be operated independently of the play-back facilities, and consequently must be provided on a scale compatible with the utilisation of the playback facilities. It was concluded in paragraphs 4.10 and 4.13 that the two-shift capacity of each playback facility was about 25 to 30 flights per month. Earlier in this paragraph, the assumption was made that only 40% of the flights would create a need for digitisation. These data lead to the conclusion that, with infinitely flexible scheduling, it would be possible to have one digitising facility cater for a total flight frequency of about 65 to 70 per month. A more practical estimate would be about 50 flights per month. Reference to figure 4 shows that this intensity is reached in November 1959. Further reference to figure 6 shows that, at that time, the Datatape and I.R.I.G. playback facilities will be about equally responsible for the digitising traffic.

From the foregoing argument, it is concluded that the existing Millisadic facility will be capable of handling all required analogue-to-digital conversion traffic until late in 1959, and that our diminishing ability to schedule playback traffic suitably will then compel us to install a second conversion facility. It is recommended that the second facility be operational by October 1959, and it is concluded that two facilities will suffice for the entire program. It will always be necessary to schedule playback runs requiring digitising, to some extent.

The equipment presently available consists of the C.E.C. Millisadic unit, an I.B.M. card punch, and a tape conversion

4.16 (continued)

unit. The functions of these units are described in paragraphs 2.3. It is not expected that the card punch will be used to a significant extent, since its operation is comparatively slow. The second digitising facility has not yet been considered, but it most probably will not be another Millisadic Unit (for one reason, its effective frequency response is rather low). If it were, however, this would not create the need for a second tape conversion unit, since the total utilisation time is quite evidently within the capabilities of the existing unit. There is a clear implication that if a different type of unit is procured, its output tapes should be suitable for direct input into the I.B.M. 704 computer.

4.17 Computer Traffic

Flight Test program traffic on the I.B.M. 704 computer is generated by the digitisation of flight test results, as discussed in the last paragraph. Figure 7 shows this traffic, in flights per month, based upon the assumptions already applied. The extent to which computation will be carried out on Avro flight test results is not yet clear, but discussions which have already taken place between R.C.A. and the Avro Digital Computing Section have led to the conclusion that the average computer time required for R.C.A. programs will be about 6 hours per month. The R.C.A. requirements will be defined in document AR-4, the second issue of which will be submitted to Avro very shortly.

4.18 Organization of Flight Control and Data Reduction Establishments

It has been concluded that it is necessary to establish the ground telemetry facility at Avro so as to be completely independent of the data-reducing facilities (see paragraph 4.11). Accordingly it is proposed that there should be established:-

(a) A self-contained flight control facility including telemetry, with its associated recording and display equipment, and Avro Flight Test two way radio communication with the test aircraft, and

4.18 (continued)

(b) a self-contained data reducing facility including the Datatape, I.R.I.G., and digital tape playback equipment, analogue display units, analogue-to-digital conversion equipment, and oscillograph and film processing and analysis equipment.

It is anticipated that the present difficulties experienced with some of the equipment, of the category to be included in these two facilities, will subside to the point where the equipment can be utilised effectively as a business facility, without constant attention by skilled electronics technicians. The services of the latter should be reducible eventually to daily check-out routines, and servicing of faulty units. Similarly, it should be possible to eliminate the present practice of adjustment of the telemetry read-out or playback equipment by Flight Test engineers. All operation should be possible by suitably trained, non-technical personnel. The radio communication with the aircraft will naturally remain with the Flight Test Operations Engineer concerned, as at present.

Although no program or obligation of which we now have knowledge would require Avro to operate a telemetry ground station elsewhere than at Malton, it would be unwise to terminate the mobility now afforded by the present telemetry trailer, in case such a requirement should arise.

The entire flight control facility should comprise the following:

(1) Existing two telemetry receivers and additional spare (see para. 4.11).

(2) Existing telemetry antenna, plus one extra (see paragraph 4.11).

(3) Existing tape recorders.

(4) Existing sub-carrier filters plus additional units required for Orenda program on aircraft 7 (see para. 4.11).

(5) Existing discriminators, plus additional units needed for the Orenda program on aircraft 7.

4.18 (continued)

(6) Existing P.D.M. decommutator and set of 40 translators.

(7) Existing patch panel.

(8) Four of the eight existing Sanborn eight-channel direct writing oscillographs.

(9) Existing Ascop P.D.M. display oscilloscope. — Re para 4:11.

(10) Existing (R.C.A.F. supplied) communication receiver and transmitter.

(11) Existing (or shortly to exist) radio control console.

(12) Existing communication antenna.

(13) Miscellaneous equipment required directly to support the above.

The data-reduction facility should include eventually:-

(1) Present Datatape playback machine.

✓(2) New P.D.M. decommutation and translation equipment, equivalent to the existing equipment, and allocated to Datatape use alone.

(3) Present C.M. demodulators.

✓ (4) Two I.R.I.G. tape playback machines.

✓ (5) Two sets of F.M. sub-carrier filters.

✓ (6) Two sets of F.M. discriminators.

✓ (7) Two sets of P.D.M. decommutation and translation equipment, allocated for use with the I.R.I.G. equipment alone.

(8) One digital tape playback and conversion unit (subject to approval of the digital recording proposal).

(9) Existing Millisadic analogue-to-digital conversion equipment.

4.18 (continued)

(10) One additional set of analogue-to-digital conversion equipment.

(11) One new P.D.M. display oscilloscope. Is this the one referred to in para 4:11? (as such it should be part of Flt Control Facility)

(12) Four existing and eight new Sanborn 8-channel direct-writing oscillographs.

(13) One Consolidated continuous-trace oscillograph paper developer.

(14) Existing manual oscillograph reader.

(15) Existing film reading equipment.

(16) Display tables for continuous trace records.

(17) Patch panels and other miscellaneous equipment required directly to support the above.

The data reduction facility should be so arranged as to permit visiting engineers to perform editing functions without interfering with other reduction in progress, and should be staffed not only with operating personnel, but also with administrative personnel with a proper system of documentary control.

4.19 Provision of Instrumentation Spares for Flight Test Program

The company is required to maintain and modify as necessary the instrumentation installations in R.C.A.F. aircraft allocated to the company's own test programs, and this is interpreted to include the provision of adequate spares, to prevent undue delays due to breakdown. The major items in question are included in the estimates of section 5.0 of this report. No spares are to be provided for aircraft allocated to other associate contractors, or retained by the R.C.A.F.

4.20 Canadair Laboratory at Avro

The company is obliged to supply to Canadair, Ltd. office, laboratory and storage space and facilities, including laboratory test equipment and one set of Sparrow missile

4.20 (continued)

test equipment for the purpose of maintenance and pre-flight checking of Sparrow missiles. Details of the equipment and the space required have been received from Canadair, and finalised after discussion with them. The equipment to be provided is listed in Appendix 'B' to this report.

The specification of the facility within the company is being undertaken by the Instrumentation Laboratory, which is now preparing space layouts and details of the plant services required. It is proposed to locate the Canadair Laboratory near the combined M.S.E.F. and E.S.E.F. location, so as to permit the use of common power supplies, although the success of this proposal rests to some extent on space availability. The location proposed is at the south end of the ex-Orenda experimental engine test cells. Space requirements are detailed in section 7.0. There are no Avro staff requirements.

4.21 R.C.A. Laboratory at Avro

It is anticipated that R.C.A. instrumentation personnel will arrive at Avro by December 15th, 1958, for the purpose of beginning check-out work on the instrument pack for aircraft 4 (refer to para. 4.4), and the instrumentation laboratory which Avro is to provide for R.C.A. must therefore be available by that time. The Production Division is now constructing the necessary accommodation in Building D.3, and expects to have it ready for occupation by October. Despite the statement of Brochure AD-51 (para. 8.1.6) to the effect that the laboratory is to be equipped by Avro, it is widely understood at Avro that R.C.A. will supply both the laboratory test equipment and the furniture. Neither the Engineering Division nor the Production Division at Avro has budgeted for such equipment, and an assurance is to be sought from R.C.A. that they will supply it. The matter is in the hands of the Project Engineering Manager.

4.22 R.C.A. Astra Facility at Malton

Brochure AD-51 does not hold Avro responsible for any contribution to the facility which R.C.A. are to establish at Malton for the maintenance and repair of Astra equipment, in support of associate contractors' programmes. To the

4.22 (continued)

extent that R.C.A. wish to contract for any facilities to be provided by Avro, the matter is being negotiated directly between R.C.A. and Avro Production Division, and the Engineering Division is not involved. There is no reason to doubt that the facility will be available by the time Avro becomes directly involved in tests with the Astra system.

4.23 Other Services to the R.C.A.F. and Associate Contractors at Malton.

Earlier paragraphs have dealt with the design of airborne instrumentation in the aircraft with which the R.C.A.F. and the associate contractors will be involved at Malton. Further, the paragraphs dealing with telemetry and data-handling facilities have been based on the inclusion of the work which Avro is obliged to perform for the other parties. Other services which have not been specifically mentioned earlier in section 4.0 are listed below:-

(1) Construction of recording instrumentation installations, in aircraft 4,5,7,9,10,12,13 and 22 for associate contractors, and in aircraft 3,17,18,19,20,26 and 27 for the R.C.A.F.

(2) Check out and calibration of instrumentation in the same aircraft, except R.C.A. aircraft 4,5,9,10 and 22, for which R.C.A. agree to be responsible. In the case of aircraft 7, these services are to be provided to Orenda Engines, Ltd. throughout the program (figure 1). with some assistance from Orenda technicians. Such assistance is assumed to be confined to the Orenda-supplied equipment with which the Avro laboratories are unfamiliar. In the case of aircraft 3, the reference is to the Phase 2 test period only, during the whole of which Avro will continue to supply the services in question. In all other cases, these services relate only to initial check-out and calibration meant to prove the acceptability of the instrumentation. No definition of the necessary work exists, and Canadair, Ltd. and the R.C.A.F. must be invited to submit their requirements.

(3) Assistance with maintenance of and changes to instrumentation after R.C.A.F. acceptance of aircraft 4,5,7,9, 10,12 and 13. This service is construed as maintenance

4.23 (continued)

assistance (except for aircraft 7) to the extent of the provision of Experimental Department help in performing removal or assembly work which custom or union policies do not permit to be performed by technicians, and change assistance including engineering design and laboratory or Experimental work of a character similar to that for which Avro was responsible up to the time of R.C.A.F. acceptance. These services necessitate the establishment of Flight Test liaison services in respect of the aircraft concerned, exactly as if they were allocated to Avro. In respect of aircraft 12 and 13, these services, at Malton, terminate when the aircraft leave for Cold Lake. In respect of aircraft 7, maintenance also includes laboratory work to support the continued check-out and calibration services mentioned in item (2).

(4) Operation of aircraft 3 for Canadair E.T.V. and C.T.V. purposes. This entails a continuation of all services provided during the Avro programs on this aircraft, except data-reduction. It has already been noted that Canadair have chosen not to require ground telemetry at Malton.

(5) Operation of aircraft 3 and aircraft 6(or 8) instrumentation for R.C.A.F. Phase 2 testing. Since the testing concerned is of equal interest to Avro, the work concerned amounts to continuation of all services normally provided, throughout flying periods by the R.C.A.F.

The above obligations have been taken into account in the staff and space requirement estimates of this report.

4.24 Engineering and Missile System Evaluation Facilities

The necessity for these facilities arises from the Statement of Work for C-100 Mark 5M aircraft, which calls for the establishment of a facility at Avro for the maintenance, repair and check-out of Sparrow missile auxiliaries. Mention is made of the facilities in this report partly because of their proposed partial integration with the Canadair laboratory (para 4.20) and partly because the programs directly concerned are ultimately for the support of the Arrow project. Appendix 'C' contains a listing of the equipment and building services required, but the cost of these items is excluded from consideration elsewhere in this report.

4.25 Avro Instrumentation Establishment at Cold Lake

The duties of the Cold Lake instrumentation detachment include:-

(1) Assistance with the maintenance of and changes to airborne instrumentation in Canadair aircraft 12 and 13 to the extent defined in para 4.23 item 3.

(2) Operation, maintenance, set-up and calibration of airborne instrumentation in Avro aircraft 14 and 15.

(3) Design and execution of changes to airborne instrumentation in Avro aircraft 14 and 15.

(4) Supply of instructions to R.C.A.F. data-reduction personnel re handling of Avro data, and survey of reduced data to determine its acceptability.

Procurement of instrumentation equipment, for change purposes, or as spares, will be a Canadair responsibility for aircraft 12 and 13, and an Avro responsibility for aircraft 14 and 15. Procurement of bought out items other than instrumentation equipment, required for change purposes, will be an Avro responsibility for aircraft 14 and 15, and for aircraft 12 and 13 where Avro is responsible for change support to Canadair. An arrangement must be made with the R.C.A.F. under which they will undertake light manufacturing and assembly operations for Avro. The design record of the airborne instrumentation will be maintained by suitable sketches and order records.

In order to support the operation of aircraft 14 and 15 it will be necessary to have at Cold Lake a complete set of spare equipment for the weapon/instrument packs, and it will be advantageous to have this electrically assembled in an operable manner, so as to provide a check-out-facility for faulty units removed from the aircraft.

The staff, laboratory test equipment and space required for this facility are listed in the appropriate sections of this report. The facility must be in operation by June 1st, 1960, and will remain in operation for the duration of the programs, estimated to be in excess of a year. The R.C.A.F. are expected to supply both laboratory space and living quarters for the Avro detachment, and this should be taken to include

4.25 (continued)

living quarters for their families. The company should also consider whether to pay travelling and other expenses for families.

5.0 EQUIPMENT REQUIREMENTS

This section is concerned only with the major airborne and ground equipment needed to satisfy the requirements detailed in section 4.0 and not already purchased. In respect of airborne equipment only, various detailed statements have been issued on requirements, from time to time, for the first eight aircraft. These statements have naturally been approximations, and in some respects they are now outdated. There is understood to be a total funding of $1.3 million to cover these aircraft. In addition, there is understood to be a funding of $3.5 million for similar purposes for aircraft 9 to 37. The present statement will include portions of the equipment falling within these fundings, plus other equipment which is of an Avro capital nature, or may fairly be regarded as due for provision by the Government of Canada.

Appendix 'B' lists the equipment concerned under the following classifications:

(1) Airborne Recording Instrumentation.
(2) Ground Flight Control and Telemetry Facility.
(3) Data Handling Facility.
(4) Instrumentation Laboratory.
(5) Canadair Laboratory.
(6) Avro Instrumentation at Cold Lake.

The approximate cost and required delivery date of each item is noted, together with the identity of the agency presumably to pay for it, in accordance with Brochure AD-58. The accumulated costs, for each agency, are depicted graphically in figure 8. The Capital Budget recommendations which have been submitted for the year 1958/59, do not necessarily reflect the costs listed herein as Avro Engineering Division responsibility, since the acceptance of such responsibility is a matter which it is understood is still subject to confirmation.

6.0 STAFF REQUIREMENTS

6.1 Instrumentation Design

The manpower budget in effect for the year 1958/59 was intended to include known work for that year on all aircraft up to and including the Structural Integrity aircraft, which then was aircraft 15. It is now apparent that R.C.A.F. Phase 4 aircraft 17 and 18 will require considerable new design work on sensing and recording instrument installations, according to an R.C.A.F. document only just received. It was previously assumed that the amount of new design work would be very small, and would not arise until the following year.

The work has not yet been evaluated, but for the purposes of this report, it is assumed that it will give rise to a maximum requirement of eighteen men, all additional to the present 1958/59 budget. The requirement will be distributed as follows:-

July 1958	2
August	4
September	8
October	12
November	16
December	18
January 1959	18
February	14
March	10

6.2 Instrument Laboratory

The personnel presently budgeted for the year 1958/59 are sufficient to provide for the maintenance, check-out and calibration of airborne instrumentation in the first three aircraft only. Additional personnel are needed for this purpose in the following budget years, to provide for the additional aircraft. A two-shift 5-day week is assumed, and four additional men per shift, per aircraft, are required. On this basis an additional eight men will be required beginning in each of April, May and July 1959, and an additional 16 in February 1960. These will provide for aircraft 6, 7, 8, 11 and 16, to be flown at Malton. In addition, two extra men are required to provide assistance to R.C.A. with aircraft 4, 5, 9 and 10, beginning

6.2 (continued)

in April 1959, and two extra men are required to render similar assistance to Canadair, Ltd. with aircraft 12 and 13, beginning in April 1960.

6.3 Data Handling Facility

This facility is assumed to operate on a two-shift five-day week. It will require ten new men effective February, 1959, and ten further new men effective August, 1959.

6.4 Instrumentation Detachment at Cold Lake.

There are two Avro aircraft to be directly supported at Cold Lake, and two Canadair aircraft requiring some assistance, as defined earlier. This will require the following personnel on location at Cold Lake by May 1st,1960.

1 Senior Flight Test Engineer
1 Instrumentation Engineer 'A'
4 Electronics Technicians 'A'
4 Laboratory Technicians 'A'

In order to permit this, ten replacement personnel must be acquired at Malton during February, March and April, 1960.

6.5 Summary

All the foregoing requirements are depicted graphically in figure 9, in which is added an approximate allowance of 10% for temporary indirect personnel, and extra supervision.

7.0 SPACE REQUIREMENTS

The most recent statement of Test Department space requirements is that of Mr. S.E. Harper's memo dated May 29,1958 to Messrs. Lindley and Adey, covering the period up to March 31, 1959. This memorandum, and the associated graph, are reproduced in this report as Appendix 'D'.

In order to accommodate personnel and facilities as described in this report, the following space will be needed, in addition to that stated in Mr. Harper's memorandum:-

7.0 (continued)

(1) Data Handling Facility

An eventual total of 3,500 square feet is necessary for this facility, as compared with the allowance of 1,000 sqare feet mentioned in Appendix 'D'. The whole 3,500 square feet must be in one continuous area, although it can be brought into use in two stages. In December 1958, 2,000 square feet, rather than the previously requested 1,000 square feet are required, and the remaining 1,500 square feet should be added by June, 1959.

(2) Instrumentation Design Staff

Paragraph 6.1 lists the additional personnel required. An allowance of 50 square feet per man amounts to a total of 800 square feet extra, required by September, 1958.

(3) Instrumentation Laboratory Staff

Paragraph 6.2 lists the additional personnel required. These are to cover two shifts, and an allowance of 60 square feet each, for only half of the total personnel, is considered sufficient. Thus 720 square feet of extra laboratory space is needed by April, 1959, and another 480 square feet by February 1960.

(4) Cold Lake

No previous submission has been made concerning this requirement. Ten men are involved , requiring 500 square feet of bench and desk space, plus 1,000 square feet for the accommodation of the spare set of instrumentation,and working space for weapon/instrument pack maintenance, check-out and calibration. This space must be available by May, 1960.

(5) Summary

Figure 10 presents the already requested space, plus the extra space detailed above, in graphical form.

AVRO AIRCRAFT LIMITED

RESEARCH & DEVELOPMENT (AIRFRAME)

PROJECT

REPORT No. RD.87

FILE No.:

No. OF SHEETS 5

TITLE: APPENDIX 'A'

DATA PLAYBACK AND DIGITISING TIME REQUIREMENTS

UNCLASSIFIED CONFIDENTIAL

PREPARED BY E.J. Lynch
Special Assistant to Chief Experimental Engineer

DATE June 17th, 1958.

AVRO EA 1368

DATA PLAYBACK AND DIGITISING TIME REQUIREMENTS

This appendix estimates the time required to play back, edit, and digitise data acquired by means of Datatape and I.R.I.G. Magnetic recording systems. The times for each process are based upon actual experience to date, but the amount of data to be closely examined or digitised can only be estimated at the present time.

The total information recorded will not be capable of display or digitisation in a single play-back run. It is assumed that the first play-back run will cover the entire flight, and will include the data most likely to reveal the points of most interest, and the occurrence of any unexpected phenomena. Subsequent play-back runs with the remaining data would be restricted to the periods of particular interest. All play-back runs would be repeated as necessary to permit digitisation of the data over the periods of interest, having regard to the capacity of the digitising unit. It is assumed that the periods of interest, plus the time required for operating procedures, would not exceed 30 minutes, during the repeat runs.

The principal time components involved are now evaluated as follows:-

First Play-back Run

Patching (Signal routing)	30 mins.
Setting up demodulators, F.M. discriminators and P.D.M. equipment	15 mins.
Setting up Sanborn Oscillographs	1 hr. 0 mins.
Play back (full flight time)	1 hr. 0 mins
Total	2 hrs. 45 mins.

Repeat Run of First Play-back

Notes: (a) No changes to patching are required (by definition).

(b) Repeat runs are necessary for every 20 C.M. or F.M. parameters to be digitised.

Total time: 30 mins.

Subsequent Play-back Runs

Note: Digitisation would be included the first time.

Patching	30 mins.
Setting up G.M. demodulators, etc.	15 mins.
Setting up Sanborn Oscillographs	1 hr. 0 mins.
Playback	30 mins.
Total	2 hr.15 mins.

Repeat Run of Subsequent Play-back

Total (as before)	30 mins.

These time components are now applied to the various aircraft in the program, as follows:

DATATAPE AIRCRAFT

Aircraft 1 and 2

Each aircraft carries two recorders, each of which carries one set of P.D.M. data and about 20 C.M. channels. All data on one tape can be played back at once, so that one initial run and one subsequent run are required. Each run must be repeated to digitise the P.D.M. and C.M. data separately.

Initial run (1st tape)	2 3/4 hours.
Repeat to digitise P.D.M. data	1/2 "
Repeat to digitise C.M. data	1/2 "
Subsequent Run (2nd tape) (including digitisation of P.D.M. data)	2 1/4 "
Repeat to digitise C.M. data	1/2 "
Total time	6 1/2 hours

Total digitising time:	3 3/4 hours.
Total time if no digitising required:	5 hours.

Aircraft 6 and 8

Each aircraft carries one recorder, with 4 sets of P.D.M. data, and about 20 C.M. channels. All the C.M. data and one set only of P.D.M. data can be played back simultaneously. Two repeats of this run are necessary for digitisation. Three subsequent runs, including digitisation, are required to play back the remaining P.D.M. data.

Initial Run	2 3/4 hours
Repeat to digitise P.D.M. data	1/2 hour
Repeat to digitise C.M. data	1/2 hour
Subsequent Run for 2nd set of P.D.M. data	2 1/4 hours
Subsequent Run for 3rd set of P.D.M. data	2 1/4 hours
Subsequent Run for 4th set of P.D.M. data	2 1/4 hours
	10 1/2 hours
Total digitising time:	7 3/4 hours
Total time if no digitising required:	9 1/2 hours

I.R.I.G. AIRCRAFT

Aircraft 3

The aircraft carries one recorder with one set of P.D.M. data, about 60 narrow-band F.M. channels and four wide-band F.M. channels. The last are for Canadair purposes only, and Avro's obligation is terminated with delivery of the recorded (not reduced) data to Canadair. However, this involves copying the tapes, since we shall wish to retain the originals. The P.D.M. data and 20 of the F.M. channels can be played back simultaneously, and two subsequent runs will be needed for the remaining F.M. data. No data will have to be digitised, for this program.

Initial Run (P.D.M. and 20 F.M.)	2 3/4 hours
Subsequent run (20 more F.M.)	2 1/4 hours
Subsequent run (last 20 F.M.)	2 1/4 hours
Total time:	7 1/4 hours
Add to above time required to copy tape, if necessary, for Canadair, Ltd.	2 hours

Aircraft 4 and 5

These aircraft each carry two recorders, one having 42 FM channels, and the other having four sets of P.D.M. data plus 40 F.M. channels.

Initial run (1st set of P.D.M. + 20 F.M.)	2 3/4 hours
Repeat to digitise P.D.M. data	1/2 hour
Repeat to digitise F.M. data	1/2 hour
Subsequent run (2nd set of P.D.M. and 20 F.M.) including digitisation of F.M. data)	2 1/4 hours
Repeat to digitise P.D.M. data	1/2 hour
Subsequent run (3rd set of P.D.M. data, including digitisation)	2 1/4 hours
Subsequent run (4th set of P.D.M. data, including digitisation)	2 1/4 hours
Subsequent run (2nd tape - 20 F.M. including digitisation)	2 1/4 hours
Subsequent run (2nd tape - last 20 F.M. including digitisation)	2 1/4 hours
Total time:	15 1/2 hours
Total digitising time:	12 3/4 hours
Total time if no digitising required:	14 hours

Aircraft 9, 10 and 11

These aircraft each carry two recorders with only three sets of P.D.M. data, but otherwise identical to aircraft 4 and 5. By elimination of the inapplicable subsequent run for P.D.M., the following times are obtained:-

Total time:	13 ¼ hours
Total digitising time:	10 ½ hours
Total time if no digitising required:	11 ¾ hours

AVRO AIRCRAFT LIMITED

RESEARCH & DEVELOPMENT (AIRFRAME)

PROJECT

REPORT No. RD.8 7

FILE No.:

No. OF SHEETS 6

TITLE: APPENDIX 'B'

EQUIPMENT LISTINGS

UNCLASSIFIED CONFIDENTIAL

PREPARED BY E.J. Lynch
Special Assistant to Chief Experimental Engineer

DATE June 17th, 1958.

AVRO EA 1368

AVRO AIRCRAFT LIMITED

RESEARCH & DEVELOPMENT (AIRFRAME)

REPORT NO. RD.87

SHEET NO. B.1 of 6

PROJECT

INSTRUMENTATION FOR THE ARROW FLIGHT TEST PROGRAM

DATE June 17th 1958.

PREPARED BY E.J. Lynch

EQUIPMENT LISTINGS

1. AIRBORNE RECORDING INSTRUMENTATION

Description	Aircraft	No. Off	Total Cost $	Delivery required	Payable BY
Continuous Trace Oscillograph	? 3	1	15,000	July/58	Avro Prod.
I.R.I.G. Tape Recorder with all supporting equipment.	✓3	* 1	25,000	Jan/59	" "
	✓4	2	132,000	Oct/58	R.C.A.
	✓5	2	132,000	Dec/58	"
	✓9	2	80,000	June/59	"
* Tape Recorder already purchased minus supporting equipment.	✓10	2	80,000	"	"
	✓11	* 1	45,000	Nov/59	Avro Prod.
	✓12	1	60,000	Dec/59	Canadair
	✓13	1	60,000	"	"
	✓14	1	60,000	Jan/60	Avro Prod.
	✓15	1	60,000	Dec/59	" "
	✓17	2	80,000	"	" "
	✓18	2	80,000	Jan/60	" "
	? 19	2	80,000	Feb/60	" "
	? 20	2	80,000	"	" "
	✓22	2	80,000	Mar/60	R.C.A.
	✓26	2	80,000	May/60	Avro Prod.
	✓27	2	80,000	"	" "
Telemetry Equipment	6	1	18,000	Dec/58	" "
	7	2	25,000	Feb/59	" "
	8	1	15,000	Apr/59	" "
	17	1	15,000	Dec/59	" "
	18	1	15,000	Jan/60	" "
			# 1,397,000		
Digital Tape Recorder, with electronics	16	1	100,000	Oct/58	" "
Photo Panel	8	1	5,000	Apr/59	" "
	17	1	5,000	Dec/59	" "
	18	1	5,000	Jan/60	" "
			115,000		

2. GROUND FLIGHT CONTROL AND TELEMETRY FACILITY

	No. Off	Total Cost	Delivery Required	Payable By
Telemetry Receiver (Spare)	1	✓2,500	Jan/59	Government
Telemetry Antenna	1	✓1,000	"	"
Wide-band sub-carrier filters	1 set	✓1,500	"	"
Wide-band F.M. discriminators, including power supplies	1 set	✓5,000	"	"
		#10000		
		@ 1,522,000		

AVRO EA 1569

2. (continued)

N.B. The above requirement arises solely from Avro's obligation to provide service for Orenda Engines, Ltd., and is therefore to be provided by the Government of Canada.

3. DATA HANDLING FACILITY

Description	No. Off	Total Cost	Delivery Required	Payable By
P.D.M. Decommutator and Translators, with power supplies (For Datatape)	✓1 set	100,000	Jan/59	Avro Eng.
I.R.I.G. Play-back Tape Transports complete with F.M. sub-carrier filters, discriminators, P.D.M. decommutators & translators, and all necessary power supplies	✓1 set	300,000	Dec/58	" "
	✓1 set	300,000	July/59	" "
Analogue to Digital Conversion Equipment. N.B. Delivery req'd Feb/59 if next item is needed.	✓1 set	128,000	July/59	" "
Modifications to above item to permit playback and conversion etc. of airborne digital tape.	1 set	25,000	Feb/59	" "
P.D.M. Display Oscilloscope	✓1	7,000	Dec/58	" "
Sanborn, or other 8-channel	✓4	40,000	July/59	" "
direct-writing oscillograph	✓4	40,000	Dec/59	" "
		$940,000		

4. INSTRUMENTATION LABORATORY

The following equipment is estimated to be necessary for the use of laboratory technicians to be added to existing staffs for the purpose of checking out, maintaining and calibrating airborne instrumentation in aircraft 6, 7, 8, 11, 12, 13, 14, and 15, while any of these aircraft are at Malton. Present facilities are sufficient only for aircraft 1, 2 and 3. Additional equipment is needed for the maintenance support of the expanded data handling facilities.

4. (continued)

Description	No. Off	Total Cost	Delivery Required	Payable By
Oscilloscope	2	3,000	March/59	Avro Eng.
	2	3,000	Feb/60	" "
Eput Meter and Auxiliaries	2	3,000	March/59	" "
	1	1,500	Feb/60	" "
Antenna Checking Equip't	1 set	500	March/59	" "
	1 set	500	Feb/60	" "
Calibration Trolley	1	1,500	March/59	" "
	1	1,500	Feb/60	" "
Miscellaneous Equip't	-	4,000	1959	" "
Pulse Generator	1	700	March/59	" "
Oscillators	1	400	March/59	" "
	1	400	Aug/59	" "
		$20,000		

5. CANADAIR LABORATORY

Brochure AD-51 specifies that Avro will provide Canadair with the use of, and "assistance" with the operation of, "available" laboratory test equipment, and the supply of 1 set of Sparrow missile test equipment. However, no equipment is "available" in the sense that it does not have to be purchased, nor is any but nominal "assistance" possible within the presently budgeted staff limitations. The first three items listed below were considered to be "available" from Avro equipment at Point Mugu, but the extension of operations there has now made their removal to Malton impracticable, and they will have to be procured. It is not expected that Canadair will require any significant "assistance". The total equipment needed is listed below. All this equipment is assumed to be provided on Canadian Government financial responsibility, and it is all needed by March, 1959.

5. (continued)

Description	No. Off	Total Cost
Missile Test Set, 1835AA	1	Unknown
Power and Control Test Set 1835 BA	1	"
Guidance Test Set 1835 CA	1	"
Radar Test Set AN/UPM-42	1	15,000
Oscilloscope (Tektronix 545)	2	3,500
Pre-Amplifier 53/54C	2	600
" " 53/54L	2	400
Oscilloscope Trolley 500/53	2	250
Viewing Hoods, Filters and Bezels	2 sets	25
Oscilloscope (Dumont 410A)	1	700
Trolley	1	75
Multimeter (AVO Model 8)	1	125
Power Supply (0-500 volt)	1	1,000
Oscillator (H.P. # 205A.G.)	1	350
V.T.V.M. (H.P. # 410B)	2	600
V.T.V.M. (Ballantine 316)	1	400
Tube Checker (Hickok 53GA)	1	425
Milliammeter	1	307
Decade Box (100 K)	3	510
Transformer	1	50
Impedance Bridge	1	615

PROJECT

INSTRUMENTATION FOR THE ARROW FLIGHT TEST PROGRAM

5. (continued)

Description	No. Off	Total Cost
Insulation Test Set AN/P5M-2A	1	300
Thermal Voltmeter	2	700
Pulse Generator (H.P. # 212A)	1	724
Differential Voltmeter	1	1,000
Stroboscope (G.R. # 631 BL)	1	155
Standard Gain Horn	1)	
Flap Attenuator P.R.D. 190 F.I.	1)	
Waveguide Stand P.R.D. 387 A	3)	5,000
Tunable Crystal Mount P.R.D. 621 A.F.1.	1)	
Airtron Direct Coupler	1)	
Desks and Chairs	10 ea.	1,500
Benches	6	1,200
Power Supply (400 cps - 30 KVA) (including installation)	1	9,000
60 cps Regulated Supply	1	1,000
28 V DC Supply, including installation	1	4,500
		$50,011

+ first 3 items of unknown cost

1,397 000 Airborne IRIG
115 000 Airborne Digital
10 000 Gnd Telemetry
915 000 Gnd Data Handling, IRIG
25 000 " " " (Digital)
20 000 Rob. AVRO
50 000 Rob Canadair

2,532 000

AVRO EA 1369

UNCLASSIFIED

6. AVRO INSTRUMENTATION AT COLD LAKE

Accomodation provided by the R.C.A.F. at Cold Lake is assumed to include all furniture required. This is to comprise:-

2 Desks (Single or Double Pedestal)
2 Chairs
1 Drafting Board
8 Work Benches, suitable for instrumentation work, and with lock up storage space.
9 Stools

Laboratory and Special Test equipment to be provided is listed below, and will be required to be available at Cold Lake by May 1960.

Description	No. Off	Total Cost
Oscilloscope	2	1,800
Oscillator	1	400
Frequency Converter (60 to 400 cps. - 1½ K.W.)	1	1,000
Miscellaneous Equipment	-	2,500
Complete Spare Set of Data Recording Equipment	1 set	60,000
		$65,700

Brochure AD-51 specifies that laboratory and special test equipment at Cold Lake shall be provided by the R.C.A.F.

AVRO AIRCRAFT LIMITED

RESEARCH & DEVELOPMENT (AIRFRAME)

PROJECT

REPORT No. RD.87

FILE No :

No. OF SHEETS 5

TITLE :

APPENDIX 'C'

EQUIPMENT AND BUILDING SERVICES REQUIRED FOR M.S.E.F.

PREPARED BY E.J. Lynch
Special Assistant to Chief Experimental Engineer.

DATE June 17th, 1958.

REPORT NO. RD.87

SHEET NO. C.1 of 5

PROJECT

INSTRUMENTATION FOR THE ARROW FLIGHT TEST PROGRAM

DATE June 17th, 1958.

E.J. Lynch

EQUIPMENT AND BUILDING SERVICES REQUIRED FOR M.S.E.F.

The following power supplies are common to the Canadair laboratory, and have been listed in Appendix 'B' under that heading:-

400 c.p.s. Supply - 30 K.V.A., including installation	$ 9,000
60 c.p.s. Regulated Supply	$ 1,000
28 V D.C Supply, including installation	$ 4,500
	$14,500

The following building alterations and services will provide also for the Canadair Laboratory, but were not included in Appendix 'B' under that heading:-

In 'A' Engine Test Cell

Partitions

Doorway

Heat

Light

Power

In Annex to 'A' Engine Test Cell

Partitions

3 Radomes installed in wall

Dust-free room

R.F. Screening

Heat

Light

Power

The total cost of all the above is estimated to be $10,000.

PROJECT

INSTRUMENTATION FOR THE ARROW FLIGHT TEST PROGRAM

The following is an incomplete list of the test equipment required. The missing items are presently unknown. The proposed source of each item is indicated by a code, as follows:-

M Obtainable from Point Mugu (Avro property).

R To be lent to Avro by R.C.A.F.

A To be ordered at Avro expense

H Avro property available at Hughes Tool Co.

B Avro property available at Bendix

Fire Control Units & Maintenance Gear (All relevant handbooks and drawings must be included)

Code	Item
M	R.S.U. -- 2
M	A.S.U. -- 2
M	O.E.U. -- 2
M	P.C.U. -- 2
M	A.P.S. -- 2
M	M.L.C. -- 2
M	Boresight Computer -- 2
M	Reference Generator -- 3
M	Isolation Amplifier -- 2
M	R.S.U. Test Set -- 1
M	A.S.U. Test Set -- 1
M	O.E.U. Test Set -- 1
M	P.C.U. Test Set -- 1
M	A.P.S. Test Set -- 1
M	M.L.C. Test Set -- 1
M	1835 CA Guidance Units Test Set -- 1
M	1835 EA Parent Aircraft Test Set -- 1
R	Type D Captive Missiles -- 2
M	XN-3 Guidance Units -- 2
R	Complete MG-2 Fire Control System -- 1
R	Complete set of service maintenance gear for the MC-2 -- 1

COMMERCIAL ITEMS

Microwave Test Gear.

Code	Item	Equipment	Catalogue No.	Supplier
A	1	K-Band Spectrum Analyser		
A	2	X-Band Spectrum Analyser (suggest the following since the two plug-in units cover X and K bands)		

CONFIDENTIAL

PROJECT
INSTRUMENTATION FOR THE ARROW FLIGHT TEST PROGRAM

Pulse Generators

Code	Item	Equipment	Catalogue No.	Supplier
1 M 1 A	1	2 Pulse Generators (Note: 4 needed if auxiliary test sets are not available to us)	212A	
B	2	Pulse Programmer (2)	RP 375 Bendix (1)	Remanco, Inc. 128 Broadway Santa Monica, California

Power Supplies

B	1	1 "invertron" 4 K.C. power supply	Model 651 - 451 SC4000-1	Behlmar Eng. Co. Burbank. Calif.
A A A	2 3 4	3 Regulated Power Supplies	Model D3-150B	Dressden - Barnes Corp. Pasadena, Calif.

Misc. Test Gear

A	1	1 Multi-range Test meter (AVOMETER)	Model 40	Canadian Agent
A A A	2 3 4	3 Multi-range Test meters	Model 262	Simpson
A	5	1 Berkely EPUT meter	Model 554	Berkely Instruments

Microwave Generators

A	1	X-Band Test Set	Model 624 C	Hewlett-Packard 275 Page Mill Road Palo Alto, Calif.
A	2	K-Band Test Set	TS 223/AP	Aircraft Radio Corp. Boonton, N.J.

Note: 1. Both the above sets are relatively cheap, reliable and may be external pulsed.

2. Handbook of Maintenance & instructions for Model TS 223/AF is available as NAVSHIPS Publication 900.797 (CO-AN 35 TS 223-3).

AVRO AIRCRAFT LIMITED

RESEARCH & DEVELOPMENT (AIRFRAME)

PROJECT

REPORT No. RD.87

FILE No :

No. OF SHEETS 2

TITLE :

APPENDIX 'D'

PREVIOUSLY ESTABLISHED SPACE REQUIREMENTS

PREPARED BY E.J. Lynch
Special Assistant to Chief Experimental Engineer.

DATE June 17th, 1958.

PREVIOUSLY ESTABLISHED SPACE REQUIREMENTS

Reproduced below is a memorandum dated May 29, 1958, from Mr. S.E. Harper to Messrs. R.N. Lindley and R. Adey, summarising Test Department space requirements, as then known. The following table and graph were appended to this memorandum.

May 29, 1958
Messrs. R.N. Lindley, R. Adey.
S.E. Harper

The attached table summarizes the rate at which we require space. This is further to my letter dated May 9th and the item numbers used on the table are the same as those used in the letter.

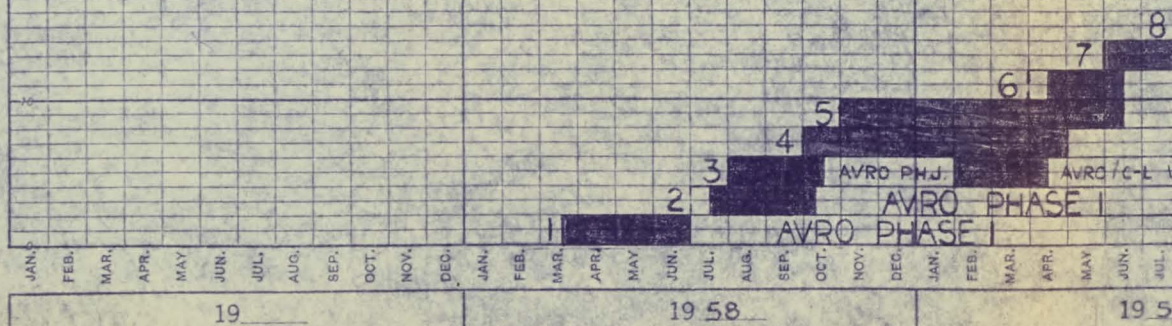
There is one small difference between what was said in my letter dated May 9th and the table, and this is in respect to our immediate requirements. It will be observed that 2,500 sq.ft. have been requested by July for the M.S.E.F. - in my previous letter this was assumed to be required later.

Temporary arrangements are being made for allocating our immediate overflow but these should be ignored and treated as temporary, i.e. new space should be provided immediately in accordance with the attached table.

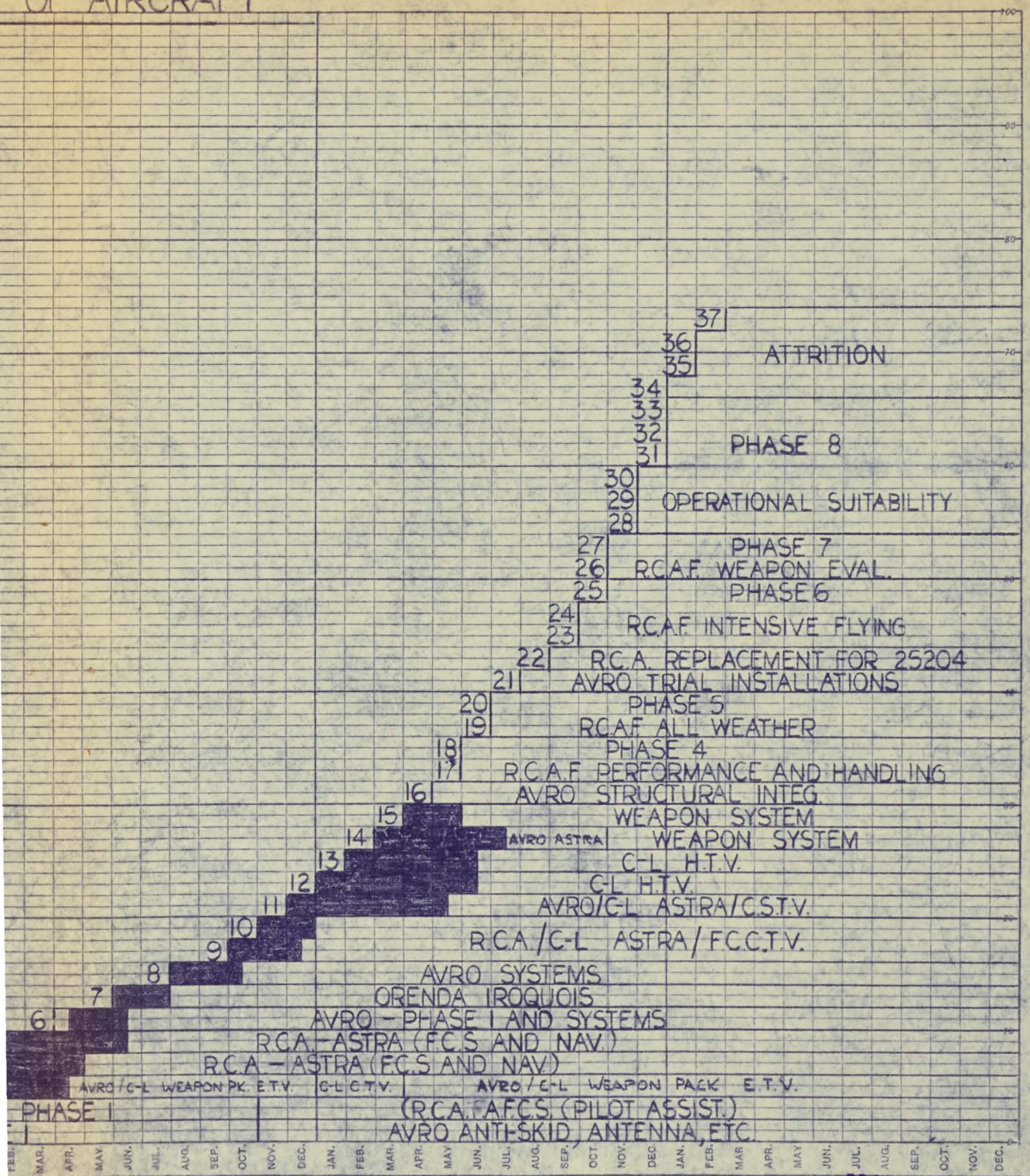
lc
cc Messrs. FRichardson
JBGale

ALLOCATION OF AIRC

DURING SHADED PERIODS, AIRCRAFT ARE BEING MODIFIED AND BOUGHT UP TO A STANDARD WHERE THEY ARE READY TO COMMENCE THEIR PROGRAMMES.



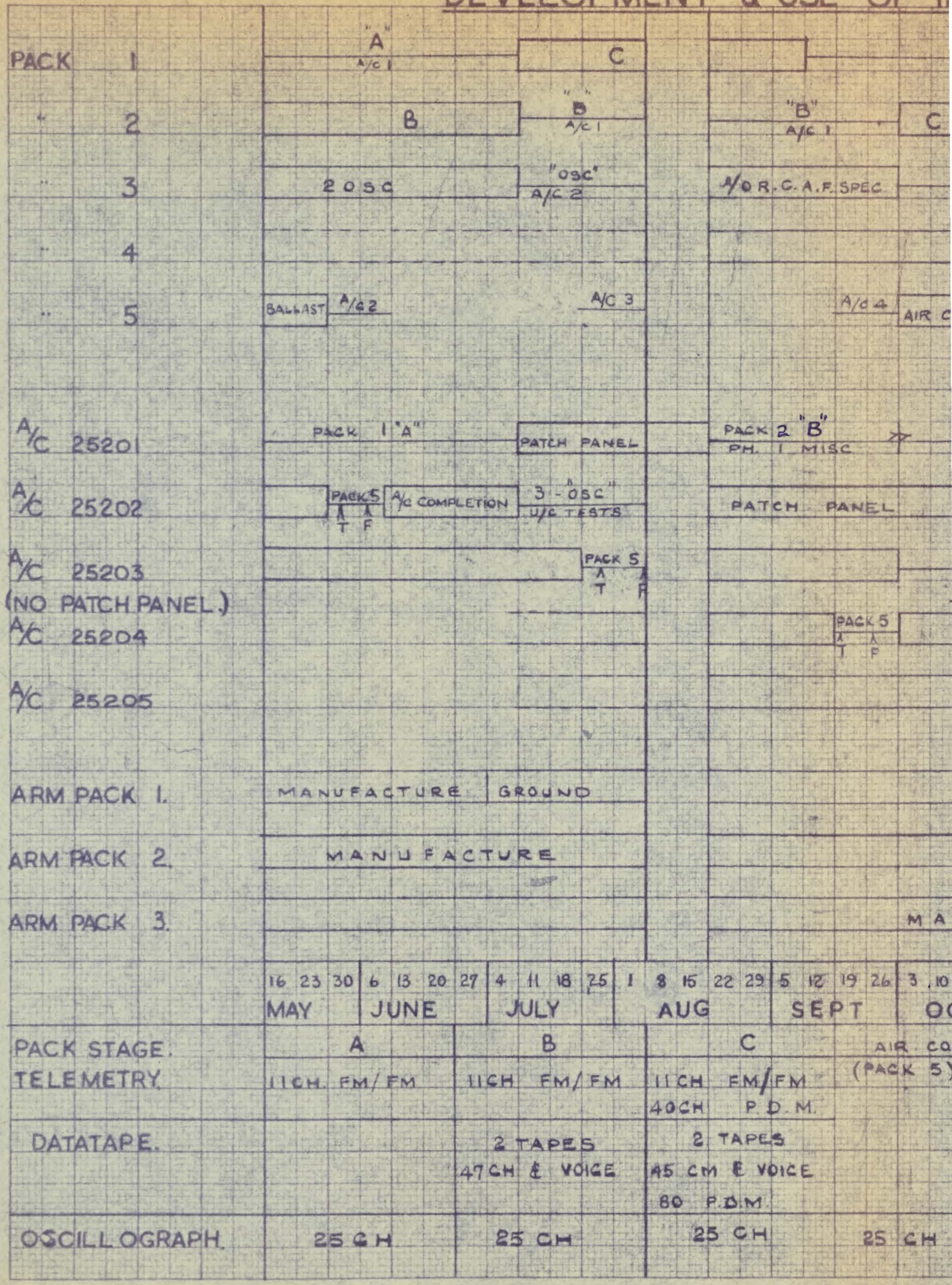
OF AIRCRAFT



UNCLASSIFIED CONFIDENTIAL

FIG. 1

DEVELOPMENT & USE OF I



OF INSTRUMENT PACKS.

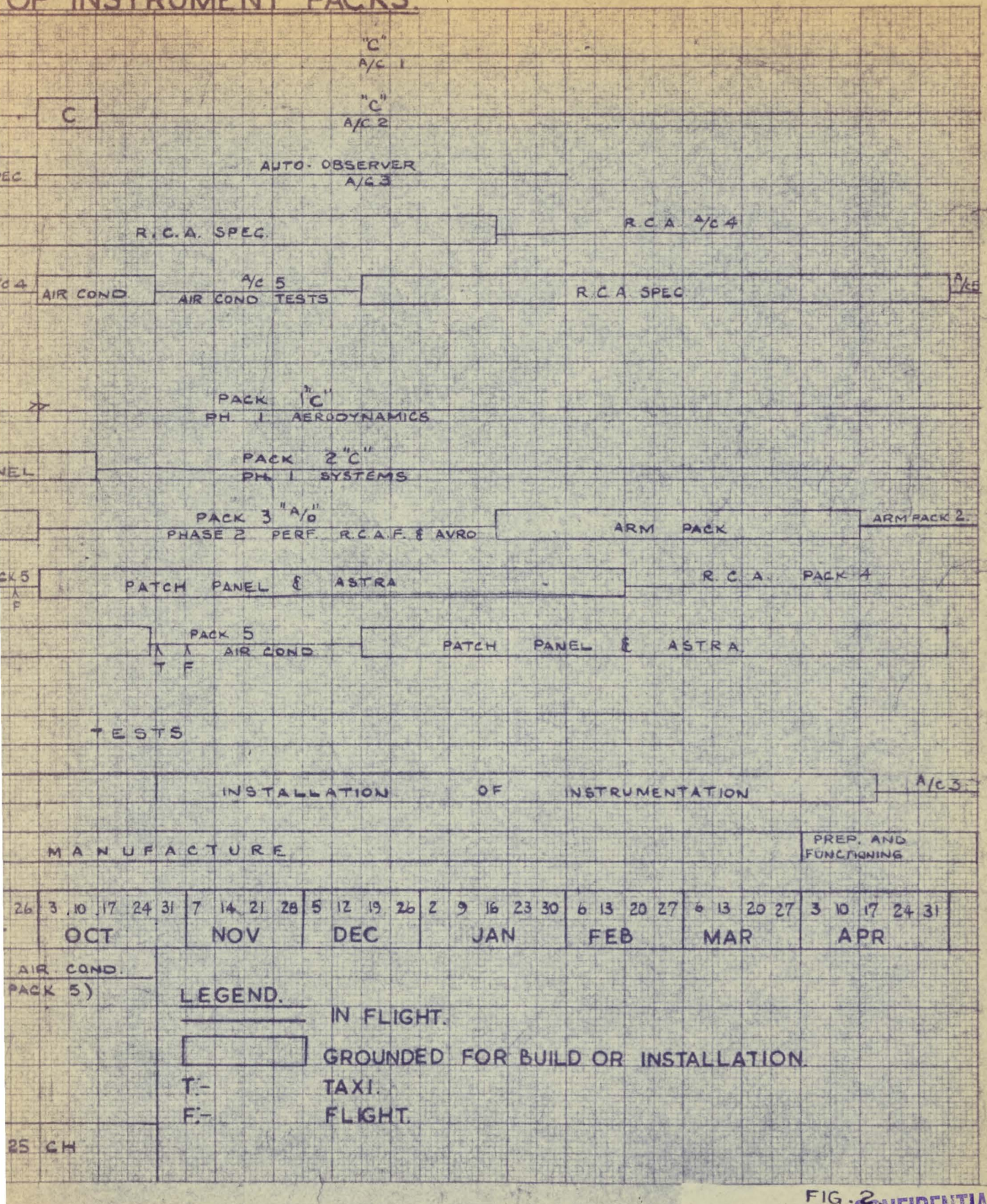
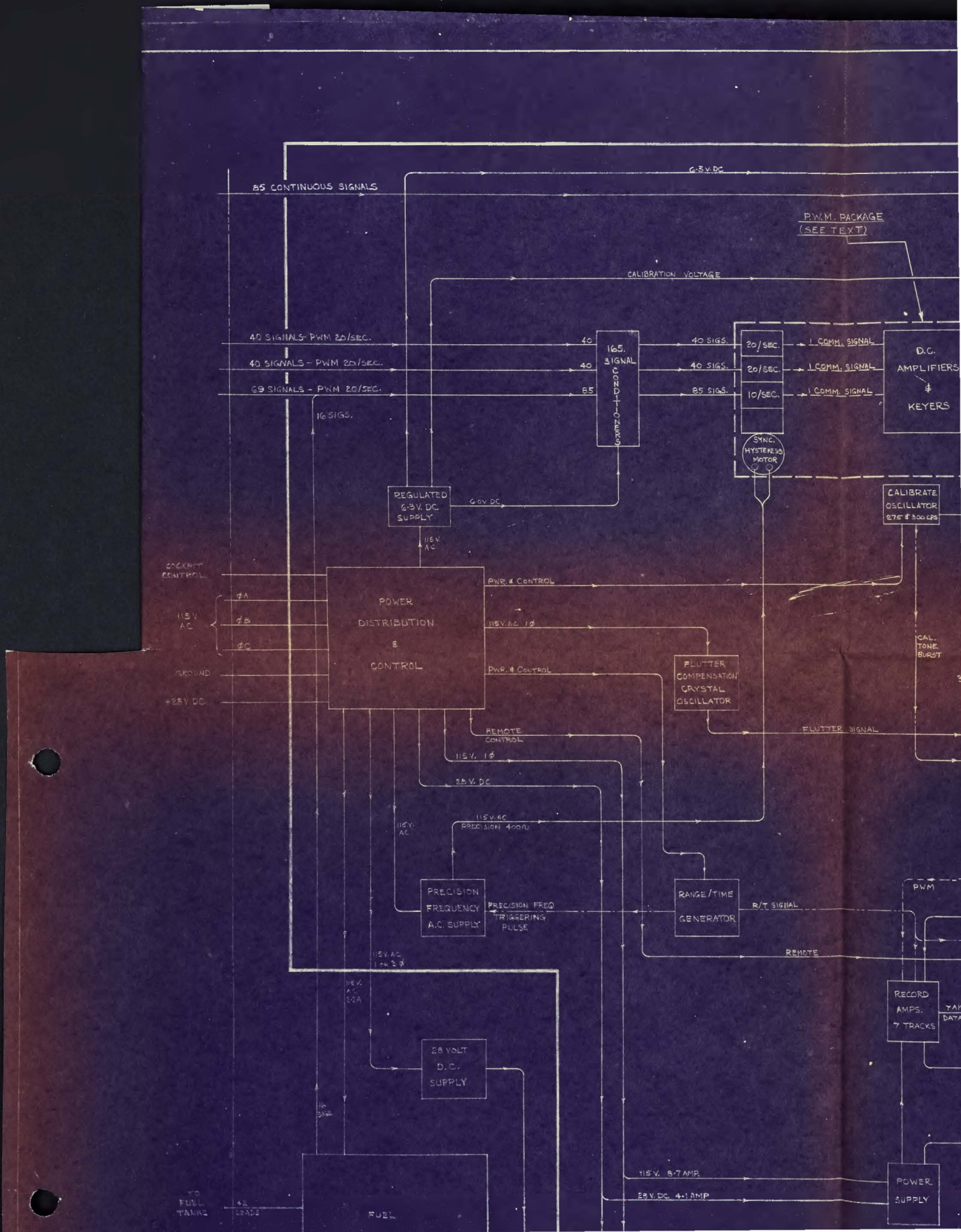
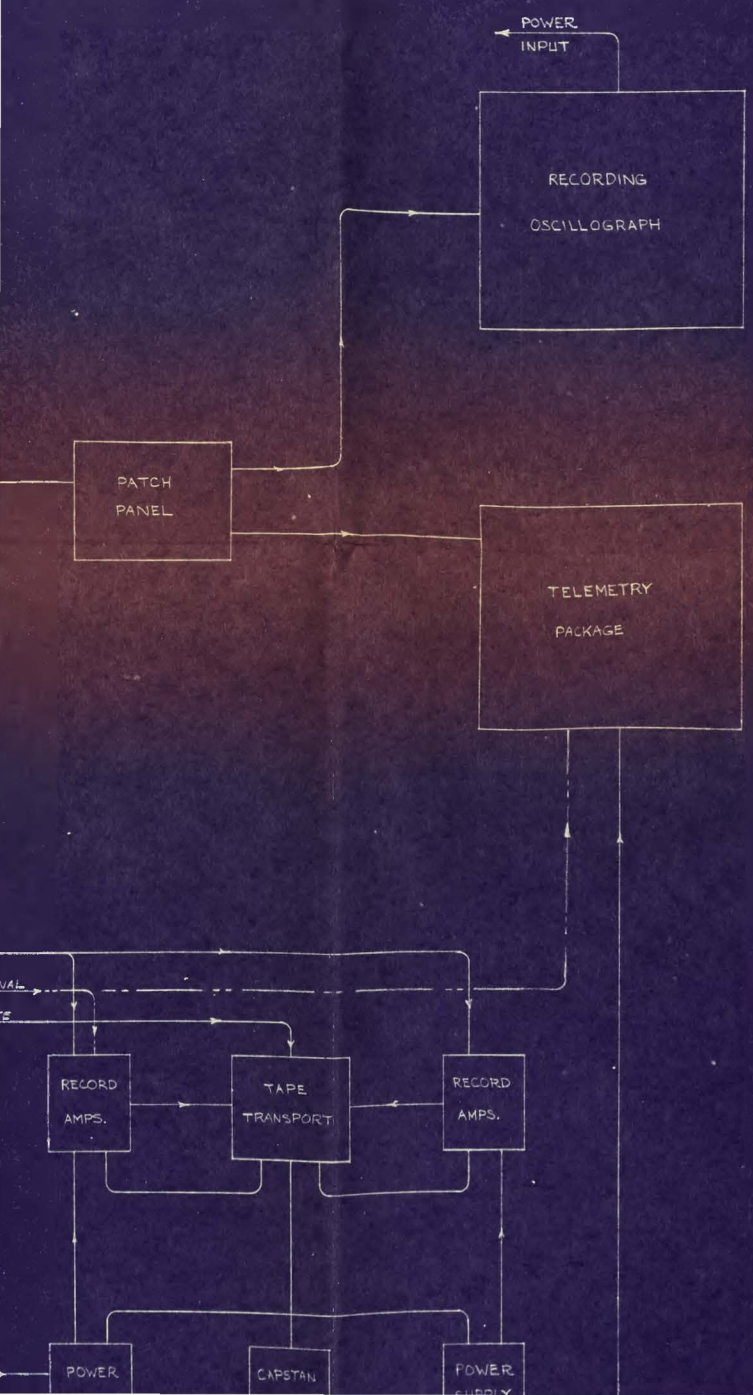


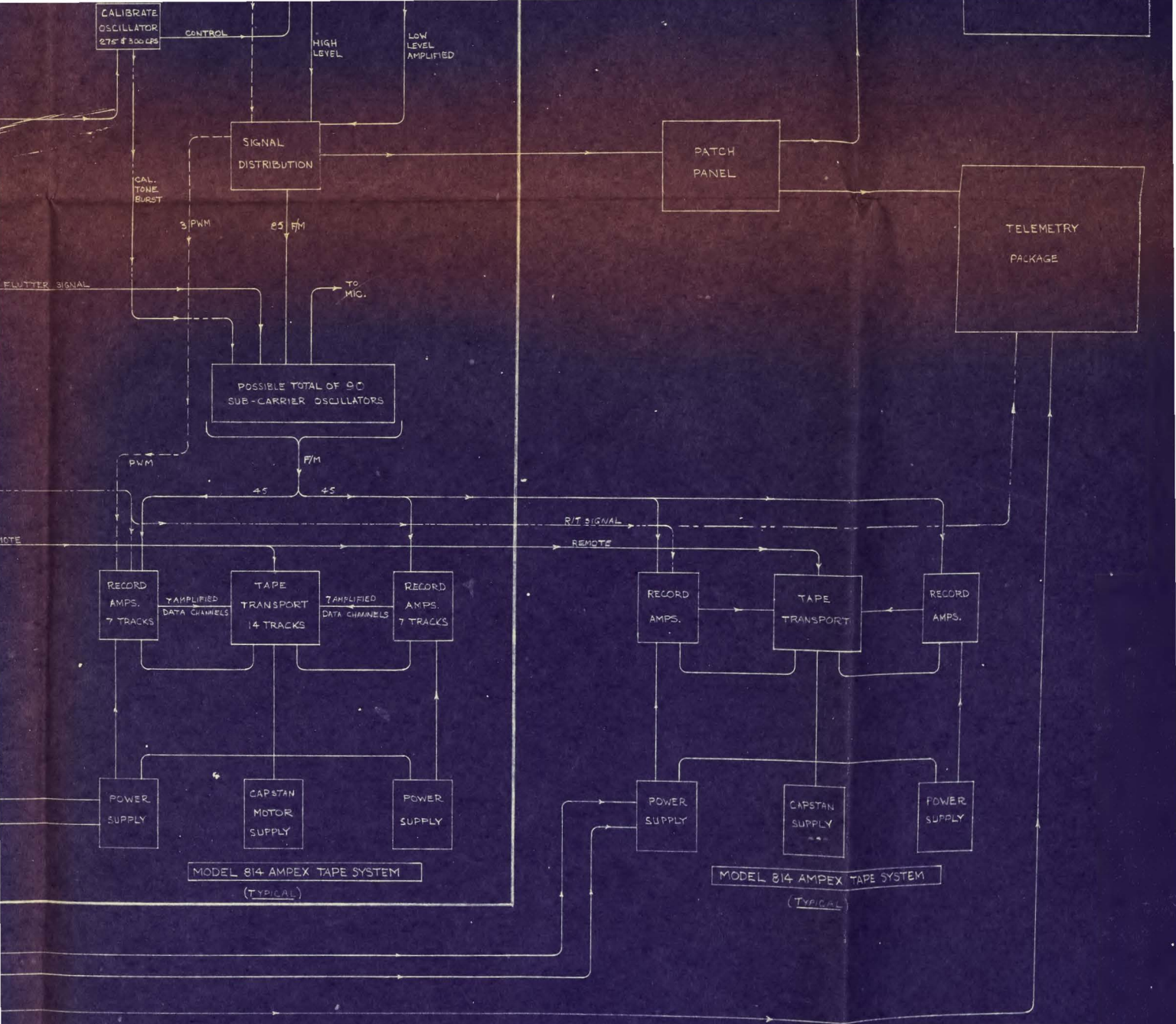
FIG. 2


85 CONTINUOUS SIGNALS
6.3 V. DC
P.W.M. PACKAGE
(SEE TEXT)
CALIBRATION VOLTAGE
40 SIGNALS - PWM 20/SEC.
40 SIGNALS - PWM 20/SEC.
69 SIGNALS - PWM 20/SEC.
16 SIGS.
40
40
65
165 SIGNAL CONDITIONERS
40 SIGS.
40 SIGS.
85 SIGS.
20/SEC.
20/SEC.
10/SEC.
1 COMM. SIGNAL
1 COMM. SIGNAL
1 COMM. SIGNAL
D.C. AMPLIFIERS & KEYERS
SYNC. HYSTERESIS MOTOR
REGULATED 6.3 V. DC SUPPLY
6.3 V DC
115 V. AC
CALIBRATE OSCILLATOR 275 & 300 CPS
COCKPIT CONTROL
115 V. AC
ØA
ØB
ØC
GROUND
+28 V. DC
POWER DISTRIBUTION & CONTROL
PWR. Ø CONTROL
115 V. AC 1Ø
PWR. Ø CONTROL
CAL. TONE BURST
FLUTTER COMPENSATION CRYSTAL OSCILLATOR
FLUTTER SIGNAL
REMOTE CONTROL
115 V. 1Ø
28 V. DC
115 V. AC
115 V. AC PRECISION 400 ~
PRECISION FREQUENCY A.C. SUPPLY
PRECISION FREQ TRIGGERING PULSE
RANGE/TIME GENERATOR
R/T SIGNAL
PWM
REMOTE
115 V. AC 1 & 3 Ø
115 V. AC 2Ø
28 VOLT D.C. SUPPLY
RECORD AMPS. 7 TRACKS
16 SIGS.
TO FUEL TANKS
46 LEADS
FUEL
115 V. 8.7 AMP.
28 V. DC. 4.1 AMP.
POWER SUPPLY

BASIC SYSTEM SHOWN INSIDE THIS FULL LINE



SPARE WIRING AND MOUNTING PROVISIONS ARE TO BE MADE FOR ANY ONE OF THESE SPECIAL ORDER ITEMS.



PROPOSED STANDARD I.R.I.G. INSTRUMENT PACK

AIRCRAFT Nos. 25209 TO 14

HALF SIZE

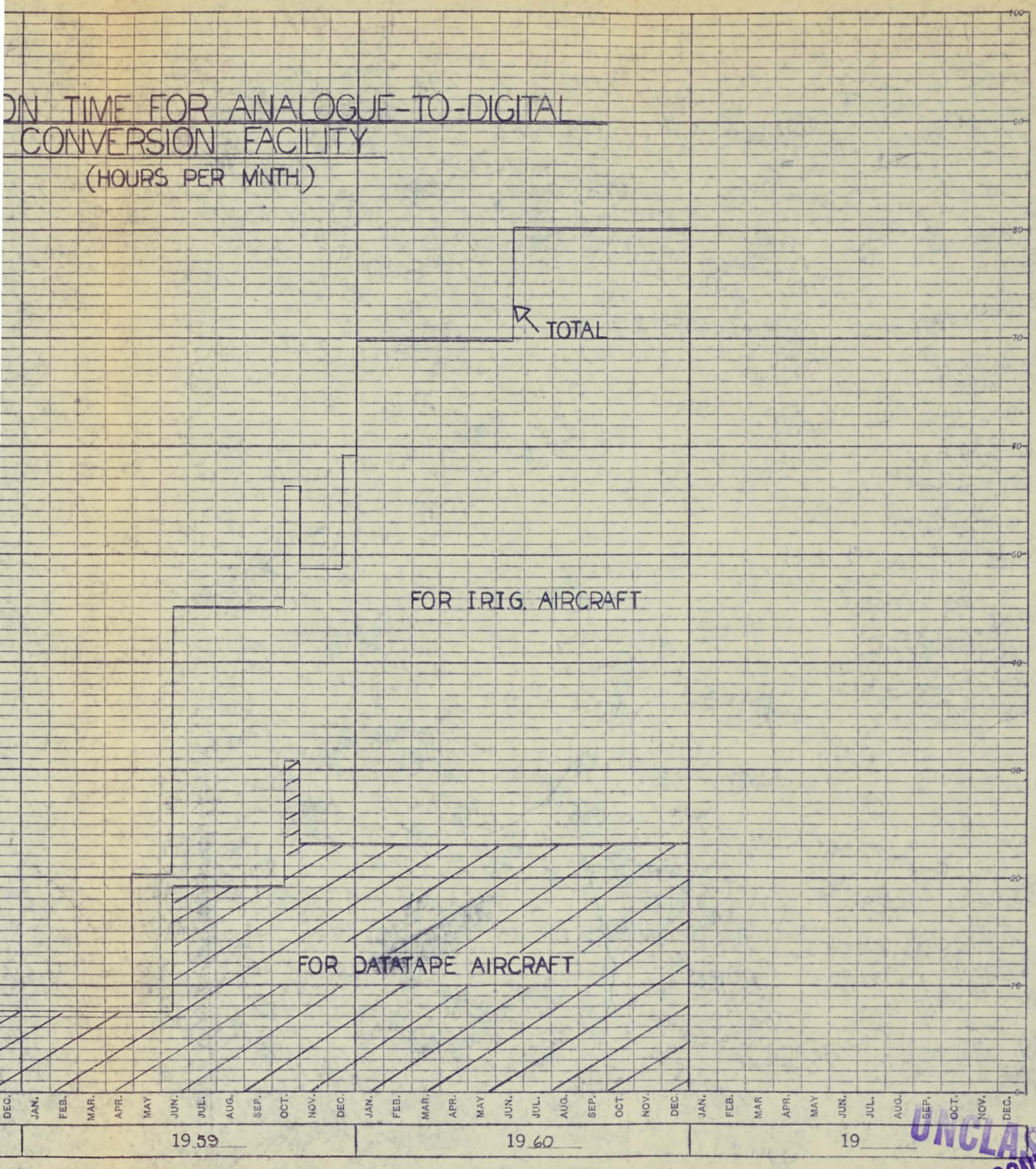
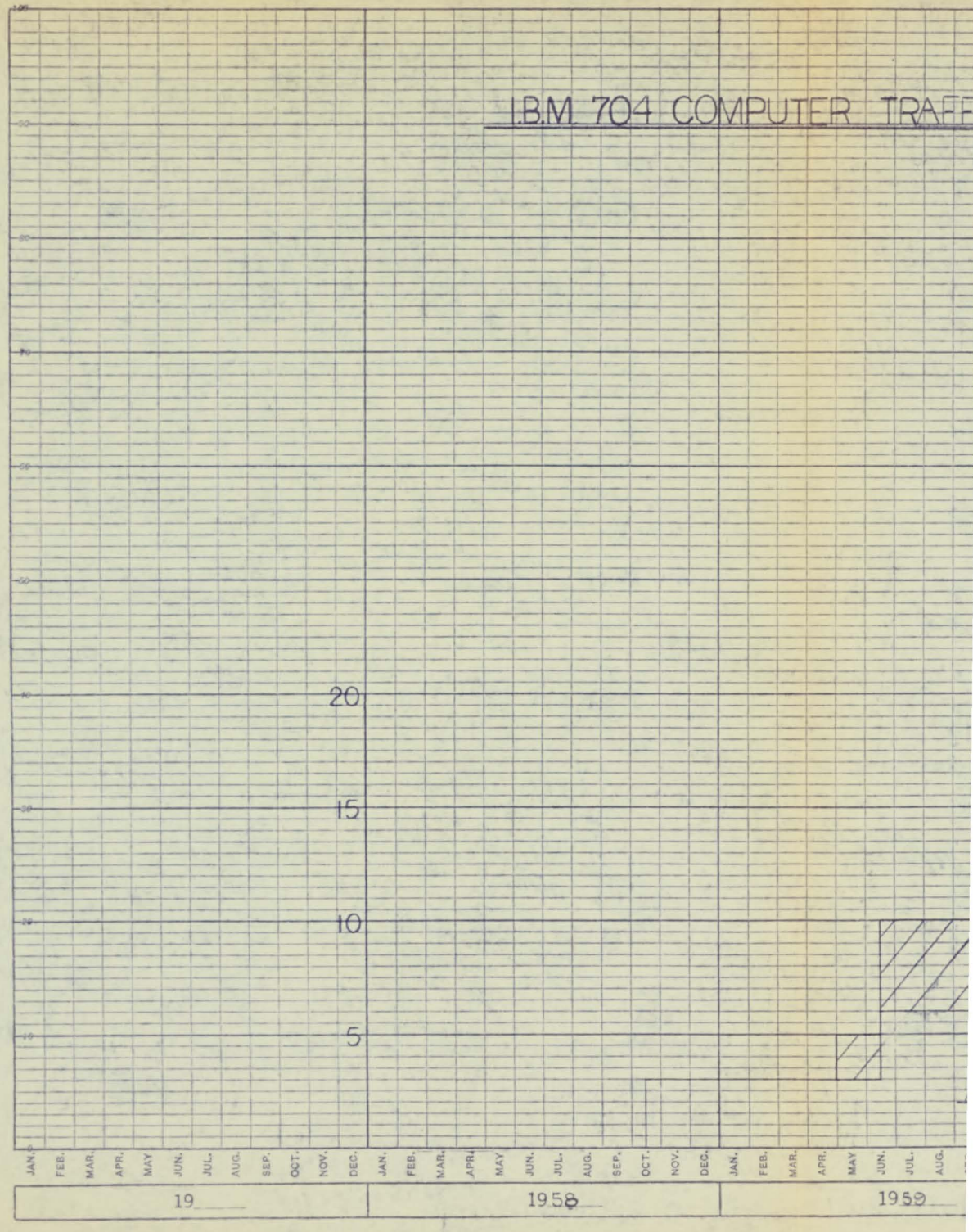
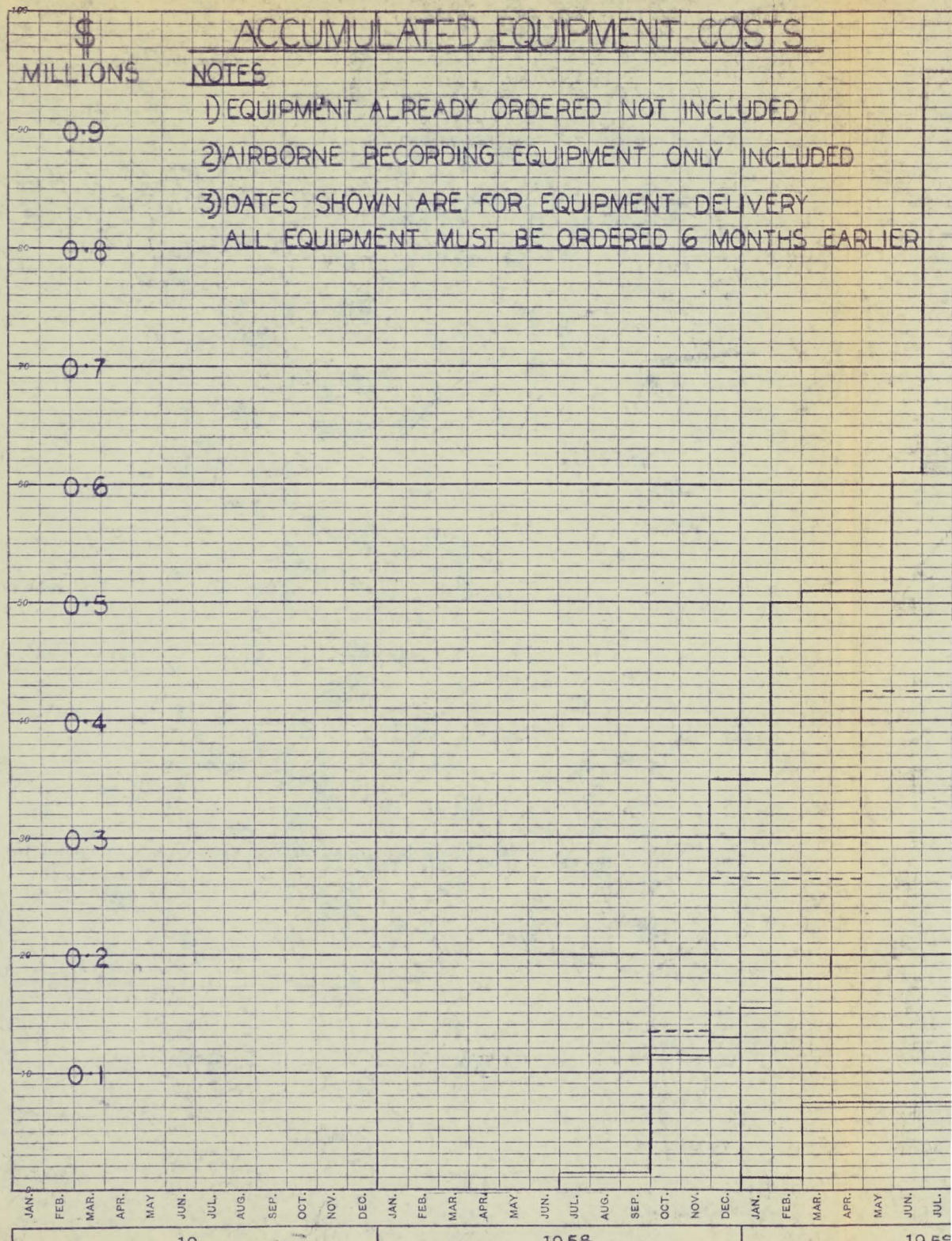
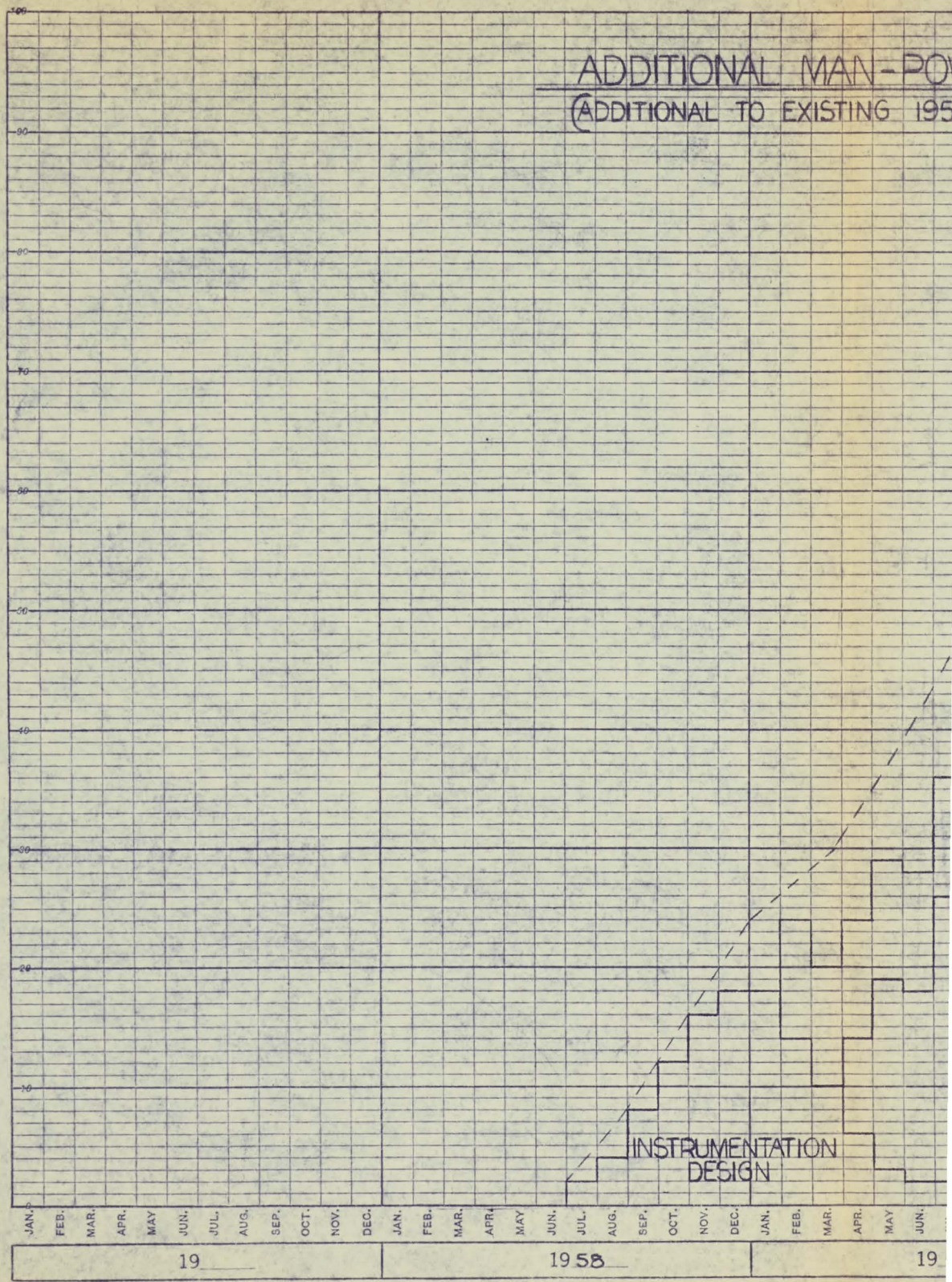
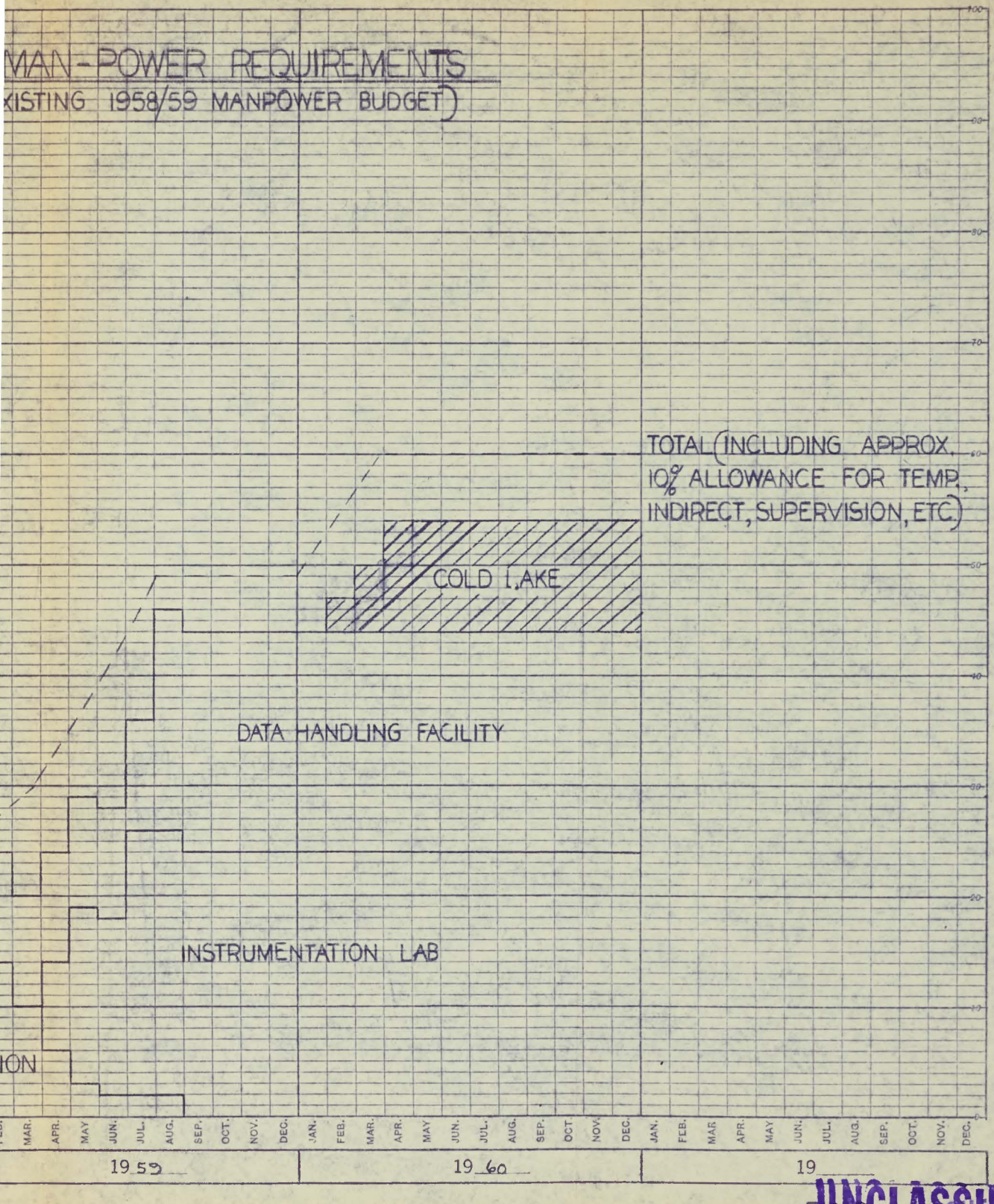


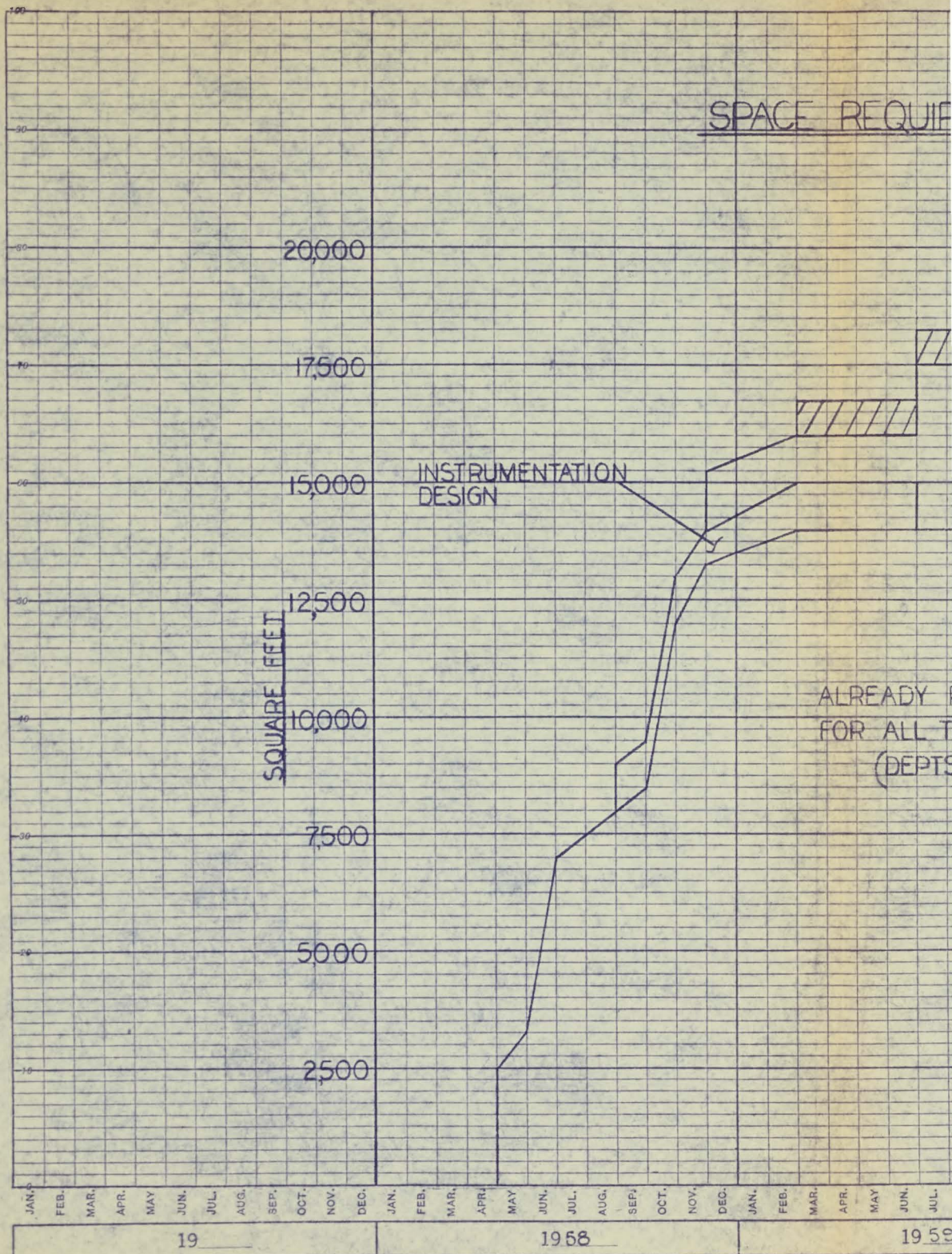
FIG. 6











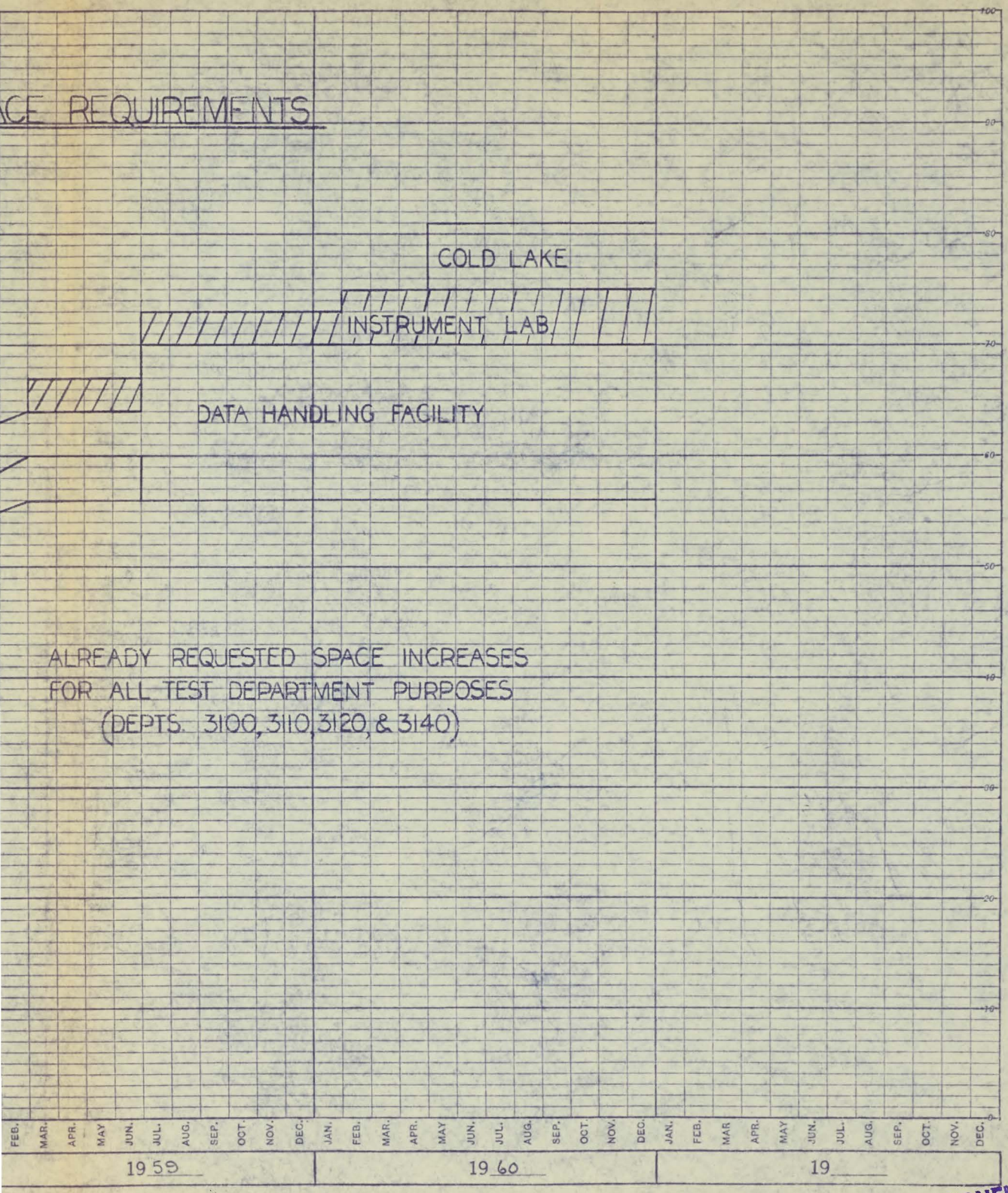


FIG. 10

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