APPENDIX 1

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Mr Deegan

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WEAPONS RESEARCH ESTABLISHMENT

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AIRBORNE HIGH FREQUENCY DIRECTION FINDING FOR TACTICAL USE BY THE AUSTRALIAN MILITARY FORCES

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S U M M A R Y

A rotatable crossed ferrite rod antenna system is used to provide h.f. d.f. from a light aircraft.

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1. INTRODUCTION

The Australian Army has been faced with the situation where it often happens that the only current information on the enemy forces is obtained from locating the source of their radio signals. The problem is that of locating high frequency (h.f.) transmitters to within a mile. The transmitter, as a rule, is of very low power. Ground based direction finders working on skywaves do not give this accuracy, even with consolidation of a number of separate observations, and there is no guarantee that consolidation could be used as the transmitter might be mobile. Ground-wave direction finding is ruled out as it is to be used in tropical areas and the range of a high frequency ground wave in jungle is very short.

The decision to use an airborne method placed further restrictions on the techniques and equipment used. The only aircraft available for the purpose were light aircraft, with limited space and payload, which cruised at about 100 knots. As the aircraft could be required for other roles the equipment had to be capable of being installed and removed in a matter of an hour or so.

The system of airborne direction finding (A.R.D.F.) adopted is particularly effective since the time taken to obtain bearings is short. Many bearings, from different aircraft positions, may be observed, giving the equivalent of a multi-station direction finding network, see figure 1. As a result the productivity of the system is high. Only two men are needed, the pilot and the operator, so operating costs are low.

Two other A.R.D.F. systems are in use, in both of which aerials are fixed to the aircraft; in the first system the whole aircraft must be turned to obtain the directional readings and in the second system a very costly and elaborate computer system and a crew of five or more is required in the aircraft. In the Australian system (High Divine) only the aerial itself is turned and a very effective and economical system results. A new principle of h.f. direction finding was developed by W.R.E. to overcome interaction between the d.f. aerial and the airframe so that a rotatable aerial could be used.

2. PRINCIPLES OF OPERATION

In the Australian airborne h.f. d.f. system the directive properties of a ferrite rod aerial system are used to give the bearing of a transmission relative to the aircraft heading. The polar diagram of a single ferrite rod aerial has two null positions. However, when installed in an aircraft these nulls appear to be influenced by currents in the airframe and are not sufficiently well defined to be used for an accurate aural or visual indication of direction. To overcome this limitation, two ferrite aerials are used; these are mounted at an angle of 60° to each other (figure 1) producing a polar diagram as shown in figure 2. This arrangement produces four positions (A, A', B, B') in which the aerials will produce equal signals if directed to a source of transmission. By using a suitable display system, an indication of direction may be obtained by rotating the aerial until equal signals are obtained, and noting the direction of the aerials (relative to the aircraft heading) by use of a scale and pointer. This system appears to be less dependent on currents in the airframe than does the null system.

To display the signals the two aerials are remotely tuned to achieve maximum sensitivity, their outputs switched sequentially to a common receiving system and displayed on an oscilloscope, a simplified schematic diagram and a typical display are shown in figure 3.

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To achieve operational requirements relative bearings must be measured to an accuracy of $\pm 1^{\circ}$. In practice this means that the two channels, before combination by a diode switch, must be carefully matched to better than 1 dB (typically ½ dB) over the entire frequency range.

Several timing circuits are contained in the system to give one second elapsed time readout, 60 second and 10 second time markers. These timing signals are used to obtain the ground position of the aircraft when a bearing is taken, the aircraft being flown, under visual condition, along a straight and level path.

Included in the equipment is a 'back-up' field strength type direction finder. This makes use of a separate whip aerial, a receiver and Rustrak recorder. The strength of a signal is continuously recorded and the maximum field strength is obtained at the closest approach to a transmitter i.e. when bearing of transmitter is at right angles to the track. This provides a useful check on results obtained from the main system.

The installation in Cessna aircraft of the Australian Army is shown in figures 5 and 6.

3. PERFORMANCE

The first development trials were carried out in South Australia in February 1965 and successful operational trials were made in August 1967. Although intended for experimental demonstration only the Australian equipment was so successful that it has been pressed into operational service ever since.

Ninetyfive percent of targets located successfully were found with useful accuracy. These figures compare more than favourably with the productivity and accuracy of similar units. The radio equipment has survived one crash landing (due to engine failure) and has continued to perform a twice-daily service. During 1968 a total of 1347 hours were flown, producing 1501 fixes. Arrangements for the engineering development of three units for Cessnas and two for Pilatus Porter Aircraft are underway in Engineering Wing, W.R.E.

4. FUTURE DEVELOPMENTS

Further development work is in hand at W.R.E. to extend the frequency range of the system and to improve its accuracy and all-weather performance by incorporating aircraft navigational aids.

A single station ground based locator (Short Cell) has been developed to complement the aircraft by providing less accuracy but supplementary tasking information to optimise the operation of the aircraft.

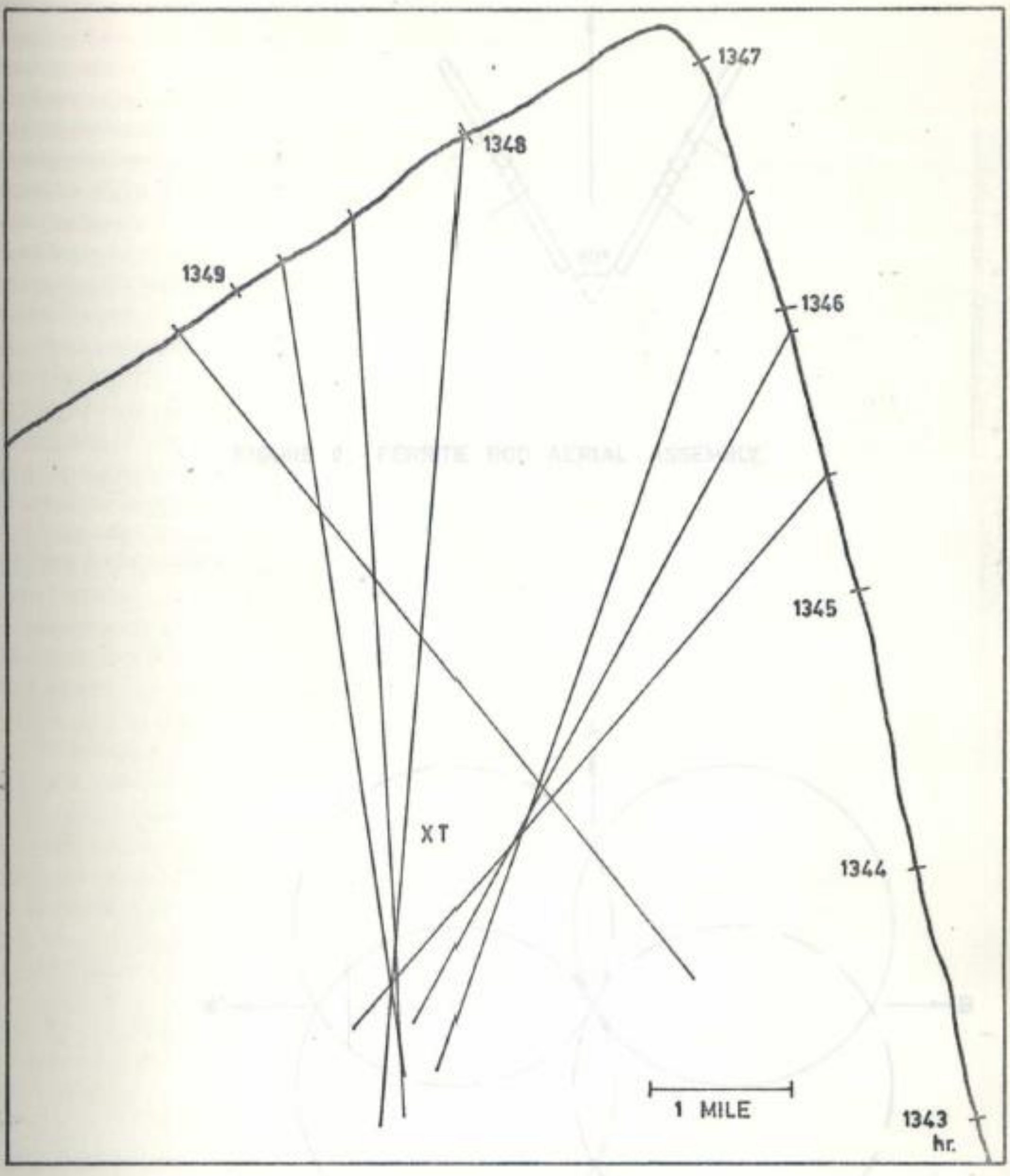

FIGURE 1. TRACK—STRAIGHT RUNS.

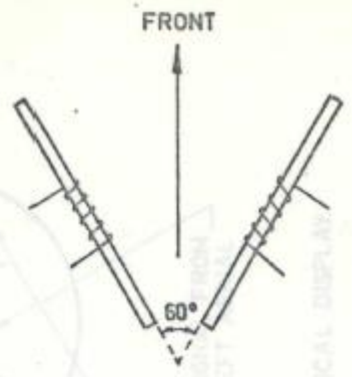

FIGURE 2. FERRITE ROD AERIAL ASSEMBLY.

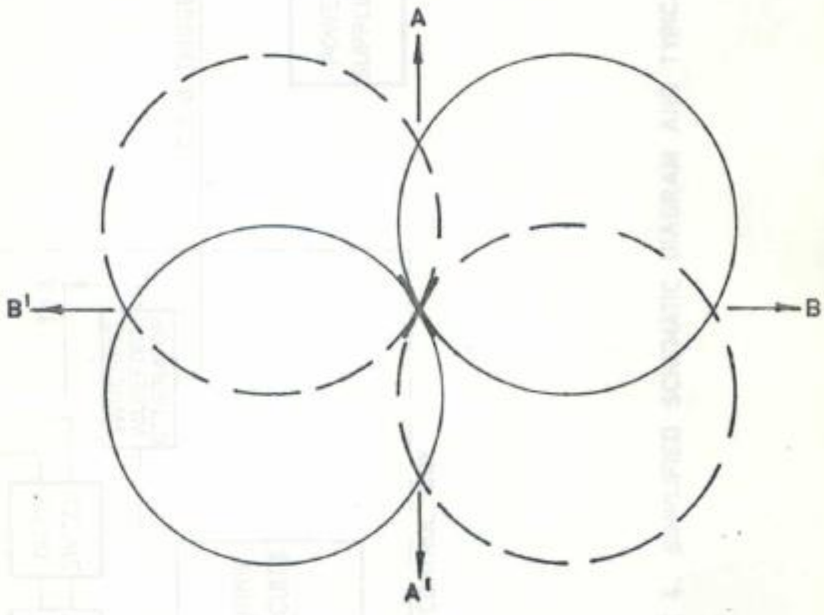

FIGURE 3. POLAR DIAGRAM OF ROD ASSEMBLY.

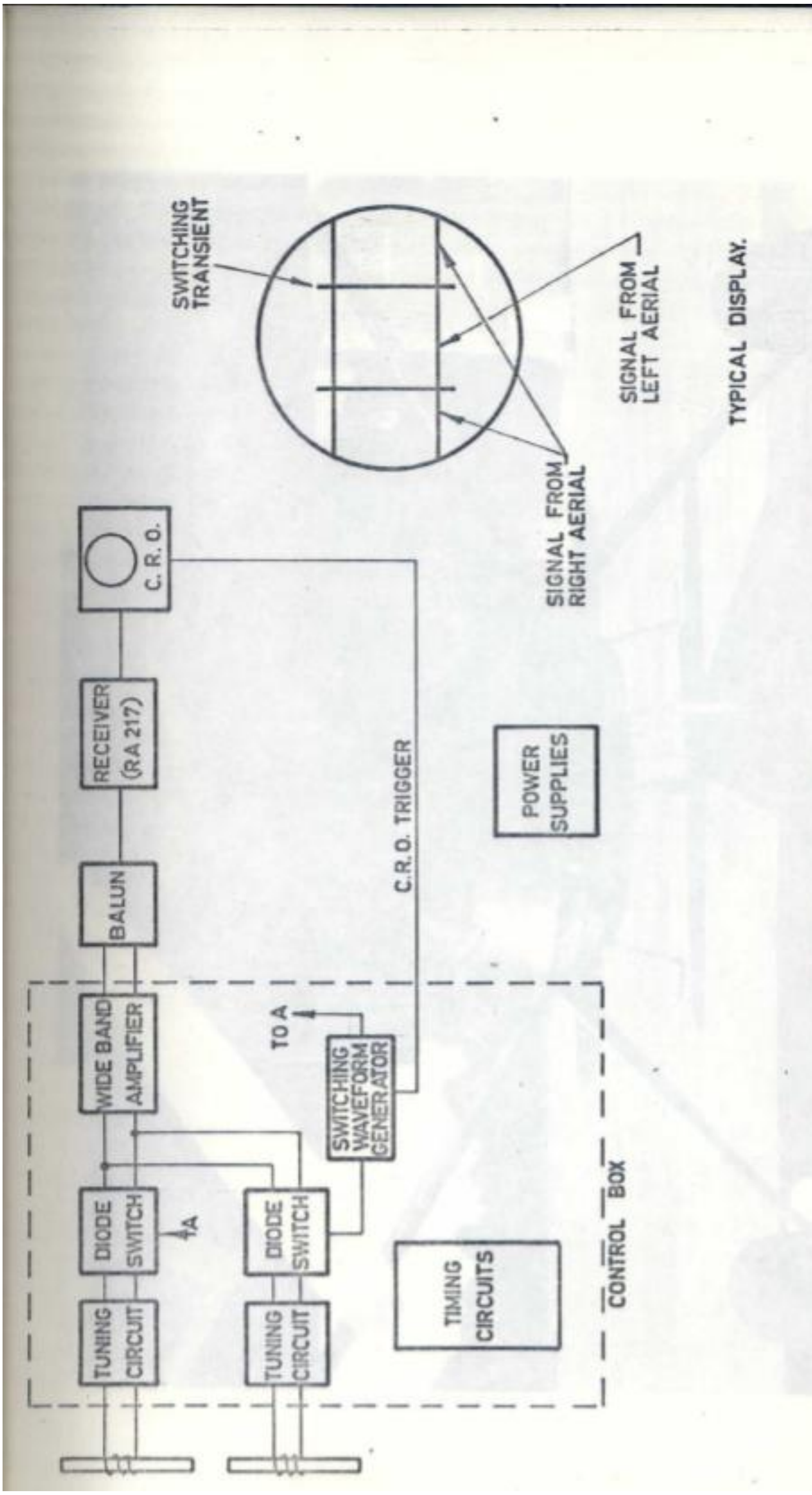

FIGURE 4. SIMPLIFIED SCHEMATIC DIAGRAM AND TYPICAL OSCILLOSCOPE DISPLAY.

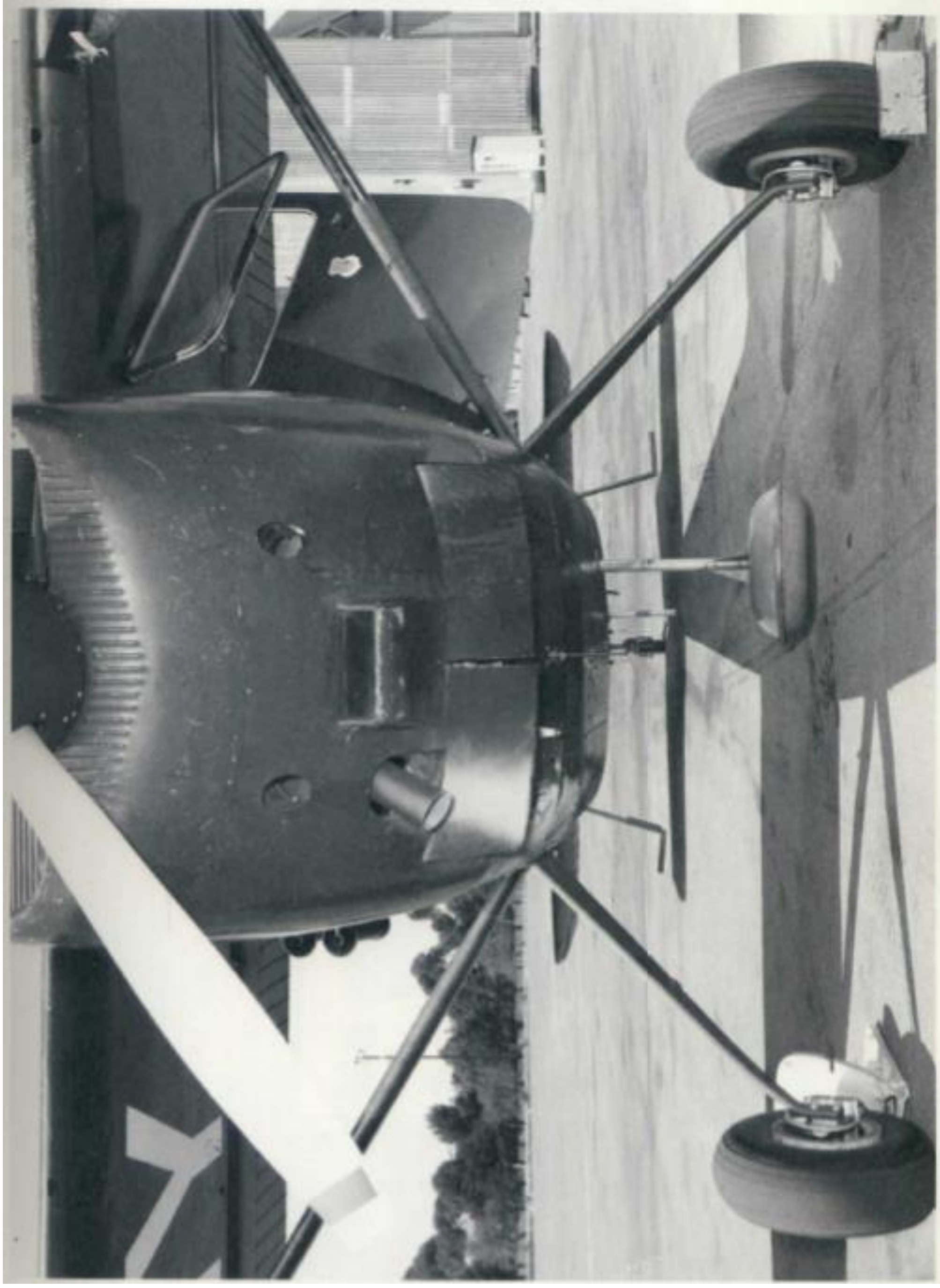

FIG. 5

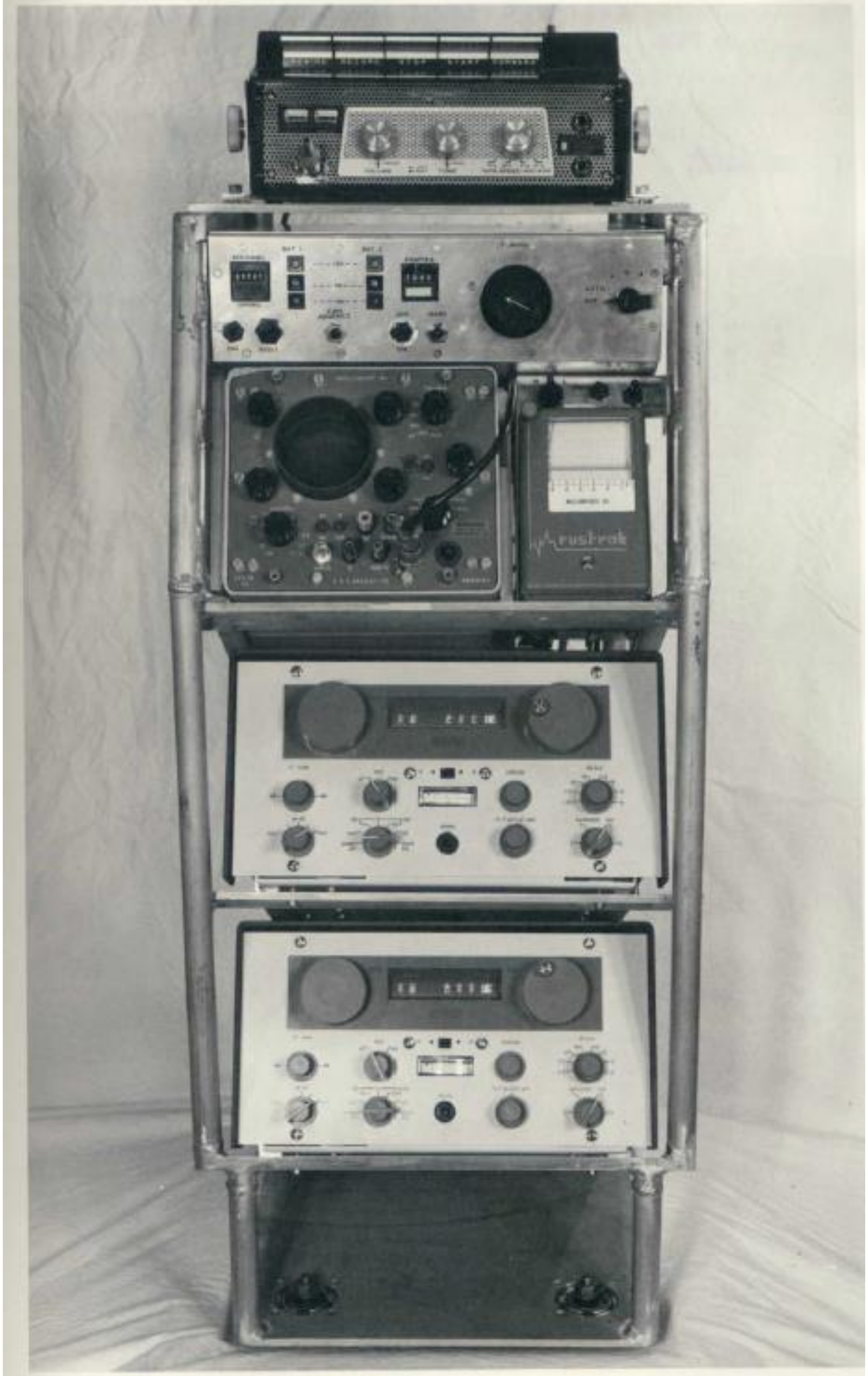

FIG. 6.

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