CANADA

A RADIOACTIVE DIAL MARKER FOR THE DECCA NAVIGATIONAL AID

by

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ABSTRACT

A small auxiliary unit has been designed for use in conjunction with a Decca Navigational System on survey flights. The unit is intended to trigger a relay system which actuates an aerial camera every time the dial pointer on the Decca dial passes through zero. For this purpose, the pointer tip has been coated with radioactive caesium-137 whose activity is detected by a Geiger tube located above the dial face. Details are given of the mechanical arrangement and of the design of the circuit which is fully transistorized.

CONTENTS

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INTRODUCTION

In connection with the aerial survey flights carried out by the Geophysics Division of the Geological Survey of Canada, it seemed desirable to obtain photographic exposures automatically by connecting the camera release in some way to the dials of the Decca Navigation System used. It was essential to do this without interfering in any way with the operation of the dials and without adding appreciably to the weight of equipment in the aeroplane. In addition, it was necessary for any such system to be very reliable and to require practically no maintenance in the field. This requirement was placed before the Radioactivity Division of the Mines Branch by Mr. L.A. Collett and Mr. S. Washkurak of the Geological Survey of Canada, and the unit described here was developed, with their co-operation, during April and May, 1958; in time for the start of the field season.

Several possible systems, mainly of an optical nature,were discussed at first, but it was decided to use a scheme based on detecting the radioactivity of a coated dial pointer. This scheme seemed to be the simplest to construct, and most convenient in view of the limited time available, because several of the circuits required had been under development already for other purposes.

The problem, then, was to produce an electrical pulse to close a relay every time the dial pointer passed through the zero position. The pointer could move either clockwise or anti-clockwise and with speeds varying from 15 rpm to 0.5 rpm. For compactness a thin, end-window type, Geiger-Mueller tube was chosen which would actuate a transistorized ratemeter circuit. As 28 volts D.C. were available from the aircraft generator all circuits, including the high-voltage supply for the Geiger tube, were designed for that voltage.

The complete unit had to be compact, light, able to withstand aircraft vibrations and able to tolerate temperature variations. The unit described here may be considered to be a possible prototype. It consists of a Geiger detector, a transistor amplifier and integration circuit, a transistor switch circuit, and the high-voltage supply. The equipment can operate from a D.C. source which may vary from 22 to 28 volts and it requires a maximum current of 300 milliamperes.

CHOICE OF RADIOACTIVE SOURCE

To avoid frequent replacement it was necessary to choose a radioactive isotope of long half-life. In addition, its application had to be such as to place no drag on the dial pointer itself; in fact, it was stressed from the start that even a very small mass might unbalance the pointer For these reasons, early plans to insert a tiny piece of radioactive cobalt wire into the pointer tip were abandoned in favour of activation by dipping the tip into a radioactive solution. The solution contained caesium -137 which has a half life of 30 years. It emits gamma rays of 0.66 MeV energy, as well as some beta rays. To get good collimation for this energy, the dial cover was replaced by a plastic disc which had a narrow slot cut in just above the zero. The total activity on the pointer was about 6 microcuries.

THE DETECTOR

An end-window Geiger tube, Amperex type 230N, was selected as the detector. This is a halogen-quenched tube operating at 900 volts. This tube was housed in a thin lead cylinder which had a slit cut into its closed face to provide additional collimation. They were mounted inside a Lucite holder with the two collimating slits carefully lined up. Figure 1 illustrates the mounting of the detector above the dial and the external appearance of the system. The bottom half of the box shown houses merely the Decca indicator.

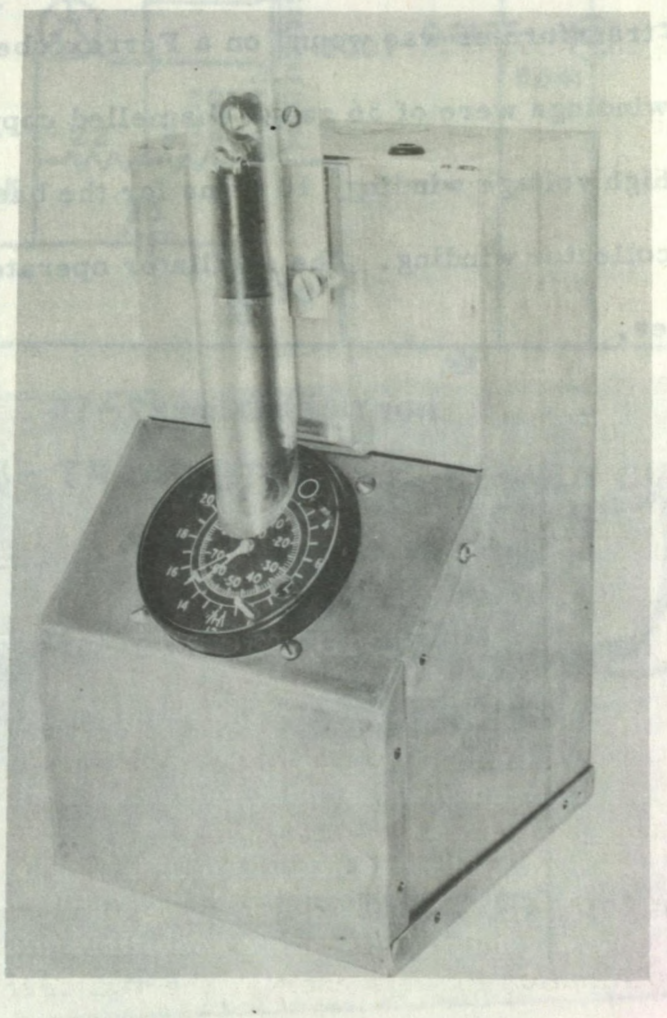


Fig. 1 - View of Marker System

ELECTRONIC CIRCUITS

The electronic circuits were housed in the upper part of the box and consisted of two parts: the high voltage supply circuit, and the integrator and switch circuit. To avoid interference these two parts were assembled separately and shielded as shown in Figure 2. The high voltage circuit is on the left and the switch circuit on the right.

The high voltage circuit is shown in Figure 3 and consists of an R/F transistor oscillator and a half-wave rectifier circuit. It supplies 900 volts to the Geiger tube, stabilized by a corona regulator type 5841. The transformer was wound on a Ferroxcube pot core, 36 mm O.D. All windings were of 36 gauge enamelled copper wire, 1200 turns for the high voltage winding, 10 turns for the base winding, and 50 turns for the collector winding. The oscillator operates at approximately 6000 cycles.

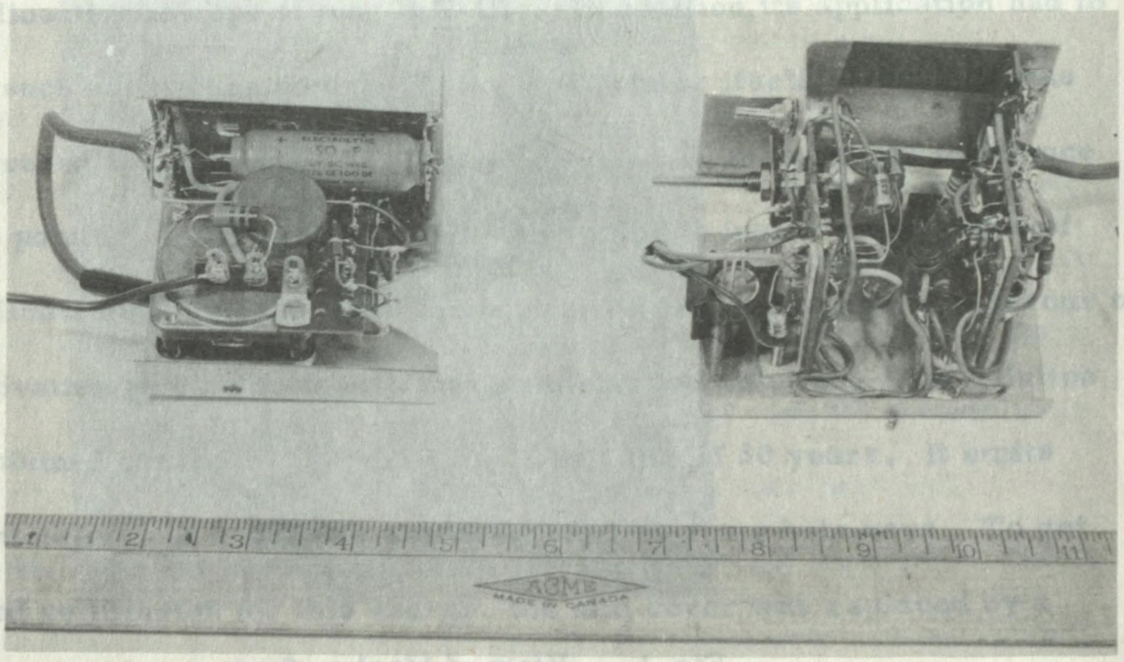
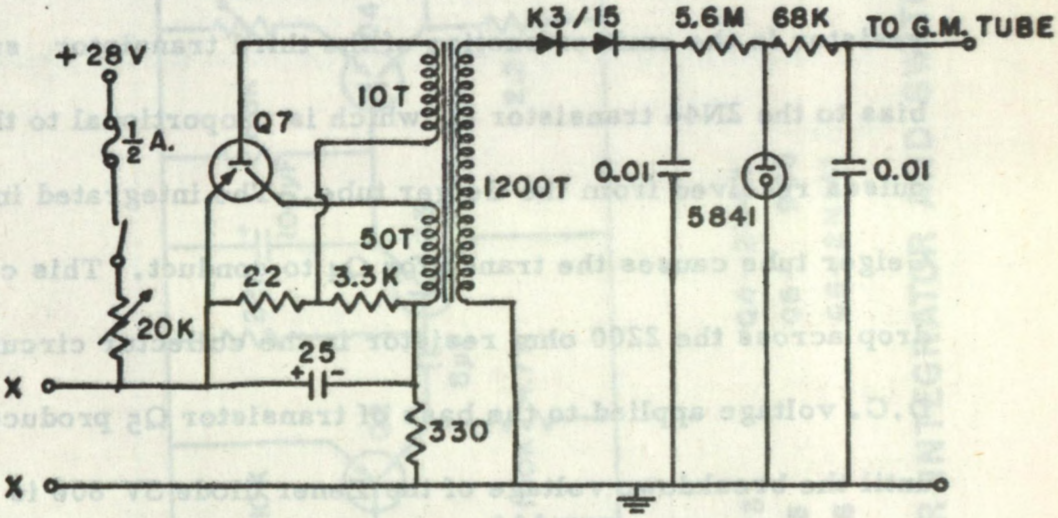


Fig. 2 - View of Transistor Circuits (Disassembled)



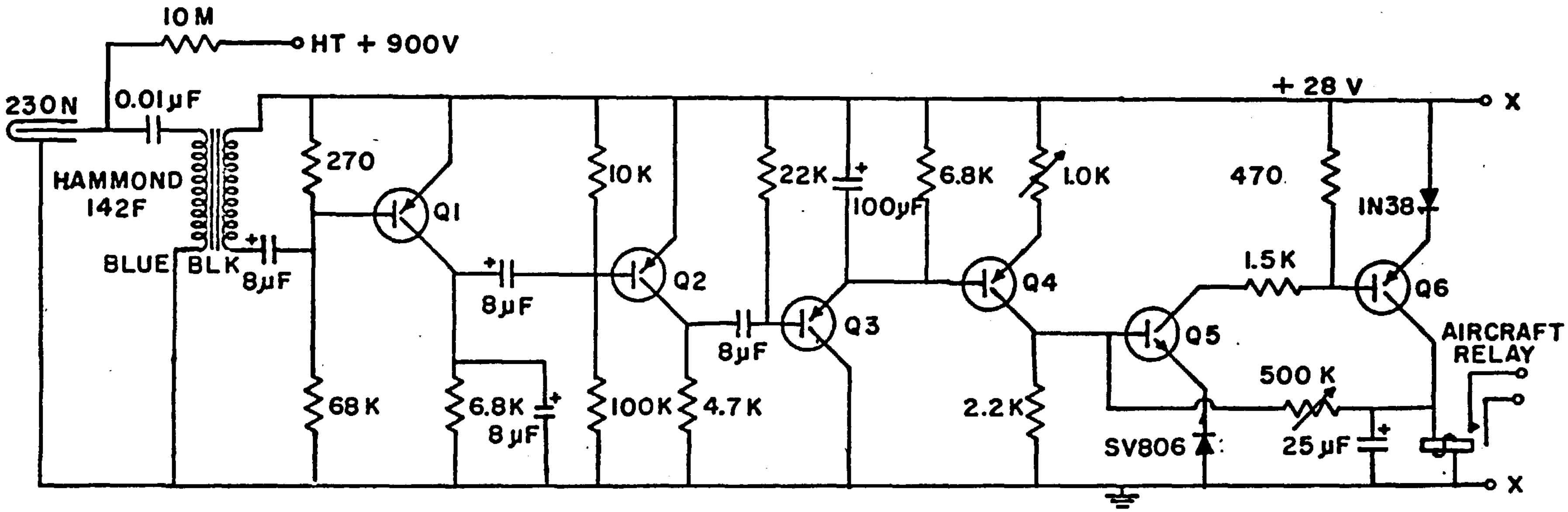
Q7 - 2N86 TRANSITRON

FIG. 3 - TRANSISTOR H.T. SUPPLY CIRCUIT

INTEGRATOR AND SWITCH CIRCUIT

This circuit presented most of the problems, as it was important to minimize the possibility of accidental closing of the relay and yet choose time constants such that the circuit would operate both at fast and slow pointer revolution rates. The final circuit is shown in Figure 4.

The first three transistor stages amplify and integrate the pulses from the Geiger tube. The 100 μF condenser and the 6800 ohm resistor in the emitter section of the third transistor, supply a variable bias to the 2N44 transistor Q_4 which is proportional to the number of pulses received from the Geiger tube. The integrated input from the Geiger tube causes the transistor Q_4 to conduct. This creates a voltage drop across the 2200 ohm resistor in the collector circuit. The rise in D.C. voltage applied to the base of transistor Q_5 produces no input until the breakdown voltage of the Zener diode SV 806 is reached at 6 volts. At that point, current flows in the base circuit of the transistor Q_6. The collector of Q_6 then becomes positive. This positive voltage is fed back to the input trigger stage through the 500 kilohm potentiometer and causes the 2N141 to drive to saturation, thus placing the full input voltage across the relay and closing the contacts. The diode in the emitter circuit of Q_6 offers a high impedance from emitter to ground when the trigger circuit is not conducting. This protects the transistor against thermal runaway. When the trigger circuit is switched on, the diode becomes a low impedance and offers little inverse feedback.



Q1 – 2N123
Q2 – 2N 86
Q3 – 2N 86
Q4 – 2N44
Q5 – 903
Q6 – 2N141

FIG. 4 – TRANSISTOR INTEGRATOR AND SWITCH CIRCUIT.

Provision was also made for triggering additional units.

The system was tested at supply voltages varying from 22 to 28 volts. It was installed in a Commander aircraft and appeared to be at least as reliable as the main Decca equipment.

ACKNOWLEDGMENTS

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