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AIRBORNE RADIO DIVISION - ENGINEERING TEST SECTION

23 August 1945

PROPOSED NEW TYPE OF RANGING AND HOMING SYSTEM

By R. C. Miedke

- Report R-2623 -

[redacted]

FR-2623

* * *

Approved by:

S. Riccobono - Assistant Section Head

Raymond A. Gordon
Acting Supt., Airborne Radio Division

Rear Adm. A. H. Van Keuren, USN (Ret.)
Director, Naval Research Laboratory

Preliminary Pages . . .	a-c
Numbered Pages	4
Plates	2

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ABSTRACT

The need for a new Naval Aircraft homing system that will give the pilot range and azimuth indications is becoming very acute with the ever increasing and changing use of Naval air tactics. The system now in use does not give sufficiently accurate azimuth indications, does not give any range indications, and is not adequate from a standpoint of security. This report describes, briefly, a new proposed type of aircraft ranging and homing system which incorporates the above features which are not available in the present system. This system will require a number of new circuits but no major difficulties are expected in the design or construction of these circuits. It is recommended that this system be thoroughly investigated to determine its potential possibilities for future use in Naval Aircraft.

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INTRODUCTIONS

1. The ranging and homing system proposed here, in compliance with the request from Bureau of Aeronautics (1), is to incorporate such features as simplicity of operation, simplicity of construction, minimum amount of equipment, use by a large number of aircraft and to have a useable range of approximately line of sight. The operation of this system is, briefly, as follows: The plane sends out a pulse which is received by the home station and which actuates circuits sending back two pulses so arranged that the time difference between the pulse sent out by the plane and the first return pulse received by the plane gives the pilot range indication and the time difference between the two pulses received by the plane gives the pilot azimuth indication.

GENERAL DESCRIPTION

2. The ranging and homing system being proposed here is shown in a block diagram on Plate 1. The time sequence of the various pulses transmitted and received are shown on Plate 2. The system operates as follows:

(a) All action is initiated by the pilot when he closes a spring operated switch for approximately 10 seconds (switch returns to normal when released). This switch triggers a coding circuit which keys the transmitter, sending out a series of pulses similiar to those shown in Figure 1, Plate 2. The last pulse (trigger pulse) starts the range indicator circuits operating. The output of the transmitter is fed to a non-directional antenna. The coding circuit consists of keying tubes so arranged that any combination of seven pulses can be used as the code for any given airplane. This then allows 127 planes, each with a separate code, to operate from any carrier or home base. By using more pulses still more planes can operate from a given base as the total number of combinations of n things is equal to 2^n-1. Following the seven coding pulses is one long pulse used to trigger the range and azimuth circuits. The sequence of these pulses are shown on Plate 2.

(b) The series of transmitted pulses are received by the home station on a directional antenna rotating approximately 5 rpm and then pass through a conventional superheterodyne pulse receiver. Each pulse received is applied to the first trigger tube which keys the transmitter sending out pulses identical to those received. The last or triggering pulse performs the following:

(1) It disables the receiver until the second trigger tube has functioned.

(2) It keys the fixed pulse delay circuit which delays the pulse 50 microseconds. The fixed delayed pulse is then fed to a variable pulse delay circuit which further delays the pulse from 0 to 3600 microseconds. This delay circuit is controlled by the ships master compass and the position of the directional antenna so that the time difference between the two transmitted pulses will vary continuously from 50

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1. BuAer ltr. AER-E-3114-JRE F42-9/69 of 12 April 1945 to Director, NRL.

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microseconds at north, or zero degrees azimuth, to 3650 microseconds at the end of one revolution or 360 degrees rotation. This gives a change in the time between pulses of 10 microseconds per degree rotation. This pulse keys a second trigger tube, which pulses the transmitter again for one pulse and also restores the receiver to operating condition.

(c) The pulses transmitted by the home station, see Figure 2 of Plate 2, are received at the plane by a conventional superheterodyne pulse receiver. If the code pulses follow the proper sequence the trigger pulse performs the following three functions:

(1) Disables the plane transmitter.

(2) Keys the range indicator circuit which stops this circuit and gives range by the time difference between the initial transmitted trigger pulse and the first received trigger pulse.

(3) Starts the azimuth indicator.

The last pulse (azimuth pulse) stops the azimuth indicator and gives the bearing the pilot should fly to return to the home station by the time difference between the received trigger pulse and the azimuth pulse.

SIMPLICITY OF OPERATION

3. The operation of this equipment is intended to be extremely simple. The only operation thus far anticipated, once the proper r.f. channels and coding are selected, is that the pilot in the plane close a switch when he desires range and azimuth information. All further action will be automatic. Both range and azimuth presentation will be on meters or on selysn driven indicators similar to those used in D.F. systems.

ACCURACY OF PRESENTATION

4. By measuring the time difference between two pulses, it is believed that range measurements can be made with an accuracy of ±5% and azimuth presentation can be made with an accuracy of approximately ±2% of 360 degrees at 100 miles range. It is expected that this system will be usable at ranges slightly greater than line of sight.

CARRIER FREQUENCIES

5. This system is intended to operate at frequencies between 400 and 750 Mc. It is believed that operation at frequencies in this range is desirable both from the standpoint of availability of tubes and size of antenna required. If tubes can be made available for efficient operation at frequencies up to 1500 Mc, these frequencies would be preferable because of the smaller antenna requirements.

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ANTENNA REQUIREMENTS

6. The only antenna necessary on the aircraft will be a single half-wave vertical dipole. The antenna necessary at the home base will be a rotating beam antenna with a beam-width of approximately 15°. Narrower beam-widths would give greater accuracy in azimuth indications but would limit the number of aircraft able to use the system in any given period of time. From the above it can be seen that the higher frequencies have the advantage of requiring smaller antennas.

SECURITY

7. The above system is considered reasonably secure as very few transmitted pulses are necessary to give range and azimuth information. The fact that the home station gives out azimuth information is not considered serious as this information is given only when requested and then it is transmitted only in the direction of the requesting plane. Even if the enemy were in line with the home station and the plane he would have to know the system to know that the time between the pulses were an indication of azimuth. To offset this even further, the system could be coded so that azimuth indications could be started from east, west or any other direction instead of using north as a reference or starting point. This would make it nearly impossible for the enemy to use the signals except by a straight homing "DF" system. Letting the home station give azimuth indications will require considerably less equipment in the plane helping to keep the weight requirements low.

POSSIBILITY OF JAMMING

8. The possibility of this system being jammed is believed to be quite small as only a few transmitted pulses are used at any one time and these pulses are only transmitted occasionally; that is, when range and azimuth indications are asked for by the pilot. It would be difficult for the enemy to determine the frequency and purpose of such few pulses. If the enemy were to try jamming by sending out a series of pulses that would actuate the home transmitter, the pilot need only fly a short distance to port or starboard and he will be able to get satisfactory signals as the jamming would be effective only in a line from the home base to the jammer. If the enemy were to use noise jamming the pilot could simply switch to another R.F. channel where reception would be clear. It is also possible that anti-jam circuits could be incorporated.

POSSIBILITY OF OVERLOADING THE SYSTEM

9. This system is designed to accommodate a large number of aircraft. Since the maximum time required for one challenge is 6000 microseconds and the antenna rotates at a rate requiring 33,333 microseconds per degree rotation and the antenna beam-width is 15 degrees, the system can handle approximately 375 challenges per minute from any given direction.

CONSTRUCTION, SIZE AND WEIGHT

10. It is intended that the equipment be built in units or on sub-assemblies to permit ease in production testing and assembly and to facilitate ease in field maintenance. The entire aircraft equipment could be housed in a one unit ATR rack and it is estimated that the unit would weigh approximately 50 pounds. With the possible use of new, small, lightweight components the weight could be reduced considerably.

TIME REQUIRED TO BUILD MODEL

11. It is estimated that a demonstratable model can be designed and built in one years time. Approximately nine months more would be required to design and build a prototype model. This estimate is dependent upon the priority assigned the problem. If the priority is such that a large number of men can be assigned to this problem on a full time basis it can no doubt be finished in less time.

OTHER POSSIBILITIES OF THE SYSTEM

12. A number of modifications to this system which would incorporate different operating features are possible. One such modification, which would require considerably less equipment, would give continuous azimuth indications only and would be somewhat less secure. However, any system giving continuous indications means there must be a transmitter operating somewhere, thereby reducing the security and increasing the possibilities of being jammed. It is also believed possible that the present system could be designed to use a range sweep voltage, similar to that used in the AN/APG-5 system, that could be locked on the desired return pulse, thereby giving the correct range information to the right aircraft, instead of using a series of coding pulses as described above.

CONCLUSIONS

13. This proposed ranging and homing system is believed to be entirely feasible and while it requires a number of new circuits no major troubles are expected in the design or construction of these circuits. Some of the features of this system are that it will require a minimum amount of equipment especially in the aircraft, will be very simple in operation and can be used by a large number of aircraft at ranges of approximately line of sight.

RECOMMENDATIONS

14. It is recommended that a problem be set up authorizing an investigation of the above proposed ranging and homing system including the construction of an experimental demonstratable model.

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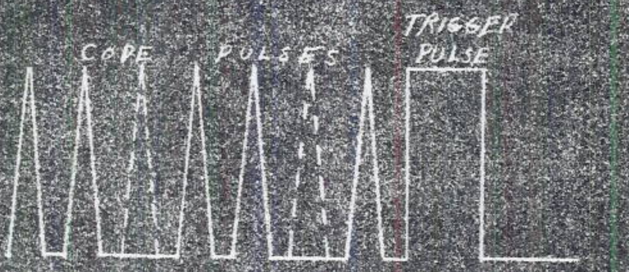
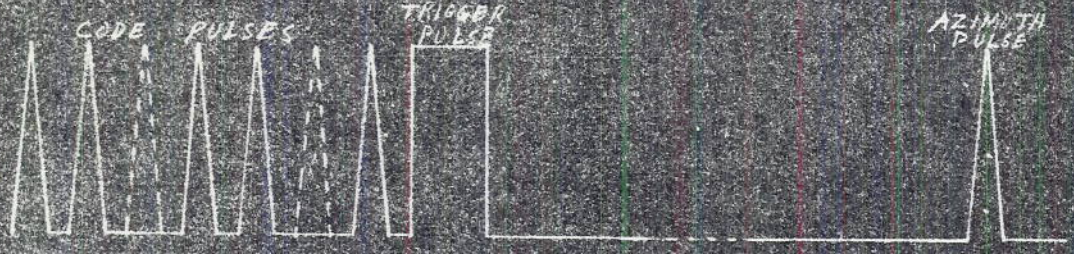


SIGNAL TRANSMITTED BY AIRCRAFT AND RECEIVED BY HOME STATION

FIG. 1



SIGNAL TRANSMITTED BY HOME STATION AND RECEIVED BY AIRCRAFT

FIG. 2

PROPOSED RANGING AND HOMING SYSTEM

PLATE 2