STATUS REPORT

PROJECT 2039

DROP ZONE BEACON PROGRAM

31 JANUARY 1956

STATUS REPORT - PROJECT 2039

DROP ZONE BEACON PROGRAM

I. INTRODUCTION

1. In connection with [redacted] operations, there is a requirement for a means of locating or identifying arbitrary areas to permit accurate airdrops or landings without compromising the selected sights or even permitting the existance of locally unauthorized electronic radiations to alert local authorities to the presence [redacted]. This type of operation requires the navigation of the supply aircraft for hundreds of miles, usu- [redacted]

25X1 25X1 25X1

II. HISTORICAL REVIEW

1. Project 2039 was established in the Research and Development Branch, Engineering Division, Office of Communications, on 7 April 1952 for the purpose of studying the problem of air navigation and drop zone location. The study was aimed at a review of known systems using presently available equipment. The confines of the problem were established in the following references:

   a. Chief, EUCA, Staff Study, dated 3 March 1952.

   b. Acting Chief, Policy and Plans Staff, Memorandum to the Chairman, Research, Development, and Production Review Board, dated 7 April 1952.

2. A number of basic systems were investigated during the early phases of the project. These systems included:

   a. British Gee and Consul and American Systems of Loran and Shoran.

   b. VOR Omnirange.

   c. S & X Band Radar Transponders.

   d. Rebecca-Eureka Systems.

   e. Infrared Beacon, Viewers, and Metascopes.

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f. AN/ARA-8 vs. AN/URC-4 (VHF)

g. AN/ARA-25 vs. AN/URC-4 (UHF)

h. AN/CRT-3 (Gibson Girl) and other small transmitters.

3. [redacted] 25X1

4. The AN/URC-4, along with the ground plane antenna modification and pictorial assembly instructions, are illustrated in Figures 1, 2, and 3 attached. It will be noted that assembly required the suspension of the battery by its connecting cable under the tripod stand for proper operation.

5. The following exerpts from reports on the operational evaluation of the AN/URC-4 with ground-plane antenna modification will tend to indicate the results of the testing of the URC-4 ground plane equipment.

a. From Chief, Communications, [redacted] dated 16 September 1952: 25X1

"The ground equipment operated satisfactorily. Range of the AN/URC-4 is excellent for the purpose intended. The ground-plane modification is satisfactory. The cone of silence seems to be satisfactory and further tests are mandatory to establish an operating SOP using modified AN/URC-4 equipment for homing purposes."

b. From Project 2039 Progress Report, dated 21 September 1952:

"Although it is admitted that sufficient flight testing has not been performed to prove the complete suitability of the system, those tests which were accomplished indicate that the URC-4 beacon is superior to any existing system. Consequently, the URC-4 beacons are going into operation at present."

6. Thus, in September 1952 there was an available homing beacon for the drop zone operation. For approximately the next year, activity consisted of further testing, training, and fabrication of additional units for operational use. During late 1952, two new developments started the second phase of this program.

[redacted] d- 25X1

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III. BACKGROUND OF PRESENT PROGRAM

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1.

2.

3. During September 1954 it was determined that there was a requirement for a visual indicating adapter for the ARA-8 homing equipment. The requirement for visual indication stems from the fact that the regular aural indication in the AN/ARA-8 is not adequate for critical direction indication, nor does it indicate relative degrees of departure from the on-course as does visual homing indication. In addition to this, there is the requirement for recognition of a signal null in order to know when the drop zone is reached. The aural recognition of a null is sometimes rather difficult, whereas when the null is presented visually, there is seldom any difficulty encountered in its recognition. Coincident with the creation of the 5/8 wave antenna indicated in Figure 4, there is the requirequirement for differentiation between the warning null and the over-target null, which is a great deal deeper. With the visual indicator this differentiation is entirely feasible.

IV. DESCRIPTION OF SYSTEMS

1. The SARAH system consists of a beacon which, when properly erected and powered, transmits pulses at a predetermined rate. These pulses are received in a Yagi aerial system, which must be composed of two aerials angled outward from the center line of the aircraft so that the direction of the beacon is apparent from the increased signal received in that aerial which points most directly toward it. The received signal is presented on a cathode ray tube having a vertical trace line. If the larger signal is to port, then the aircraft or ship must turn to port until the signal is equal on each side of the trace line. It is then facing directly at the beacon. The beacon signal is received at a distance which is dependent upon height of both the beacon and the receiving aerials. Thus when the aircraft is flying at 1000 feet and the beacon is at ground level in flat terrain, the signal is received at about 12 to 15 miles. With the aircraft at 8000 feet, the signal is received at about 30 miles. The beacon aerial is so designed that there is no break in received signal when the aircraft is homing toward the beacon until the aircraft is within about 800 yards of the beacon at a height of about 600 feet. At this time there is a slow

collapse of the signal, lasting about 1 1/2 seconds, followed up by a rapid buildup and after seven seconds a short collapse lasting about two seconds, when the aircraft is flying about 200 mph. This pattern collapse is used for air supply dropping at night or in poor visability without the aid of ground lights or ground markers. A speech facility has been incorporated into the beacon with a range of about 80% of the beacon range, depending upon height and terrain conditions. The operating frequency is approximately 220 megacycles. The beacon consists of a self-pulsing oscillator generating paired pulses at a 5 millisecond interval, and by using different pulse repetition frequency, five different groups of beacons are possible with identification between beacons due to the different DRF. Figure 5 attached represents the airborne portion or beacon portion of the SARAH system and Figure 6 represents the beacon portion of this system.

2. The AN/URC-4 vs. AN/ARA-8 system consists of a ground unit made up of a standard AN URC-4 VHF/UHF transceiver incorporating miniature tubes and two crystal-controlled frequencies, 120-130 mc in the VHF band and 240-260 mc in the UHF band. The transmitter is capable of either continuous or on-and-off tone modulation and voice transmission. The tone may be locked on to permit unattended operation of the beacon. The unit is self-powered by a small mercury battery, the BA/1264-U. The antenna has been designed to give a warning null prior to the over-target null indication. The airborne unit consists of a standard AN/ARC-3 transceiver working with an AN/ARA-8 DF homing adapter. The AN/ARA-8 consists of two alternately keyed antennas, one on each wing of the aircraft. A modulating device provides the pilot with an aural signal indicating course direction. When the ground beacon is properly placed, a pattern is radiated which effectively creates a warning a few seconds prior to the over-target null. Flying against this beacon using an AN/ARA-8 homing adaptor, the pilot will hear a U or D, depending upon whether he is to the right or the left of the beacon. When the plane is headed directly to the beacon, the U and D signals converge into a solid tone, indicating "on-course." As the pilot approaches about 1000 yards from the target zero, the signal fades slowly and then returns with a rather rapid buildup. After the buildup, the signal lasts for a few seconds, depending upon aircraft speed and altitude, and then rapidly drops to zero signal, which is an indication of being directly over the target area. In order to attain the accuracy required for blind dropping, it is necessary to make the radius of the cone of silence over the target at the dropping altitude as narrow as the maximum accuracy required for the drop zone; that is, if the drop zone accuracy is to be 50 yards, a maximum diameter of the cone of silence must be no more than 100 yards. This calls for critical flying, due to the fact that missing the over-target area by more than 100 yards will eliminate the drop zone cone of silence completely. The critical flying required, the "crabbing" for wind, as well as the indication of null depth, can be greatly improved by the addition of visual presentation of on-course and signal strength information.

3. The AN/ARA-22 is an experimental visual homing adaptor which has been utilized successfully in connection with the AN/ARA-8 vs. AN/URC-4 DZ system to provide a visual presentation of homing information. The system effectively keys the right and

left antennas of the AN/ARA-8 system very rapidly and transmits the presence of signal on either antenna to a standard left-right indicating vertical needle on an ISL type of meter. It is simply necessary then to fly to center needle to remain on course. This also provides the pilot with a capability for partial correction of winddrift by crabbing into the wind as he approaches the drop zone beacon. The signal level being received is applied to the horizontal needle of the ILS meter and creates an exceptionally good indication of null passage. Through the use of the horizontal needle, it is quite possible to discriminate between the warning null, say approximately 10 db depth, and the over-target null with approximately 15 db depth. This indication of signal level is accomplished by attaching the automatic gain control voltage to the horizontal needle of the ISL meter, which gives accurate indication of signal strength available at the receiver.

V. STATUS AN/URC-4 BEACON

1. Prior to delivery of the 5/8 wave DZ antenna for the AN/URC-4, the contractor conducted a number of tests to measure the radiation pattern under conditions of different terrain and weather. These tests indicated the following: At 500 feet, the fairly wide and deep warning null is about 3500 feet in diameter. Approaching the target on course at 500 feet a warning null is obtained about 1200 feet out, the signal gradually decreases 10-15 db with the null easily detectable. The signal then builds up sharply and remains fairly constant through the inner zone. The main null at 500 feet is fairly sharp and approximately 15-20 db deep.

2. In accordance with the contract, one prototype of the new antenna (see Figures 7 and 8) was delivered on 15 December 1954 for evaluation by Government engineers prior to completion of the six prototypes ordered. Preliminary evaluation of this antenna, using the AN/ARA-8 with aural indication, indicated that the antenna radiated the basic pattern which was required of it. The aural indication of the AN/ARA-8, however, was not cirtical enough to consistantly interpret the dropping information available from the antenna. The following chart indicates the maximum ranges obtained with the equipment for consistant reliable homing:

ALTITUDE	MAXIMUM RANGE
4000 ft.	25 naut. miles
2000 ft.	14 " "
800 ft.	7 " "
300 ft.	5 " "
Clipping Tree Tops	4 " "

In all instances, ground communications with the beacon was acceptable, but the on-course information was critical. The warning and target zero nulls were unreliable as received aurally, due to the difference depending upon terrain and quadrant from which the beacon was approached. The general conclusions available from this evaluation indicate that a visual presentation of null and on-course information is highly desirable.

3. Further evaluation of the 5/8 wave antenna conducted a [redacted] 25X1
using an AN/ARA-8 modified with an AN/ARA-22 for visual on-course and null indications proved that the modified AN/URC-4 antenna radiates a pattern which gives definite warning and target zero nulls. These nulls are broad and deep enough at an altitude of 500 feet or more to be easily recognizable on a visual null indicator when the plane is flown accurately over the target area. It is possible through visual null indication to differentiate between warning and over-target nulls. In order to obtain accuracy to within 50 yards of the beacon, it is necessary to make the diameter of the null no more than 100 yards at the dropping altitude. Due to this fact, rather critical accuracy is required in flying over the beacon, since an error of 100 yards or more will eliminate the target zero null.

4. The 5/8 wave drop zone AN/URC-4 antenna is considered to be acceptable, and the contractor has been instructed to finish the fabrication of six prototype models to be used for operational evaluation. These antennas will be available during January 1956.

5. Due to the transition of the Air Force to UHF and the development of the AN/URC-11 as a UHF replacement for the AN/URC-4, it was deemed desirable for the contractor to develop and fabricate UHF versions of this antenna which may be used with the AN/URC-4 on the UHF range or adapted to the URC-11 when applicable. The six prototype UHF DZ antennas will likewise be available in January for operational evaluation in connection with the AN/URC-4 and the AN/URC-11 when available. The AN/URC-11 has been requisitioned for testing in connection with this program and is expected to be available early in 1956.

6. In conclusion then, there is available for operational evaluation an AN/URC-4 drop zone beacon which has been tested and approved from an engineering point of view. The 5/8 wave antenna modification for this equipment may be placed in production in a rather short time and in quantities required for operational needs. The AN/URC-11 should be available in quantity in early 1956 and may be adapted in the same fashion as the AN/URC-4 for DZ application. The AN/URC-11 is considered to be an improved UHF version of the AN/URC-4 in that engineering evaluations have proven that it provides equal or greater ranges, but is less than half the size of its predecessor.

VI. STATUS OF THE SARAH BEACON

1. Of the three SARAH airborne units received for evaluation during November 1954, one has been installed in an Agency aircraft and

received an engineering evaluation. One of the SARAH airborne units and two ground beacons have been loaned to the United States Marine Corps for installation in a helicopter and operational evaluation in connection with Marine Corps operations. The third unit is ready for installation in an Agency C-47 when permission is received from the Air Materiel Command for this installation. In addition to the engineering evaluation performed by OC-E, this equipment has been evaluated by the United States Air Force and the United States Navy. Technically speaking, the SARAH airborne homing receiver is a well-constructed and reliable unit capable of homing on the SARAH beacon, and in other respects performs as claimed by the manufacturer.

2. [redacted] 25X1

3. [redacted]

VII. STATUS OF THE AN/ARA-22

1. The AN/ARA-22 has been tested as a visual homing and null presentation in connection with the AN/ARA-8 vs. AN/URC-4 drop zone system. It has been determined that this equipment is technically satisfactory for this type of operation and that it could be produced for incorporation in aircraft homing systems with a small amount of redesign.

2. Preparations are presently being made to install this experimental AN/ARA-22 visual indication adaptor on an Agency C-47 in order that operational evaluation of this system may be accomplished to determine whether the Agency wishes to produce this equipment for inclusion in the interim system.

VIII. COMPARISON BETWEEN SYSTEMS

1. From an engineering point of view, both systems require critical alignment of the balance between left and right airborne antenna elements. This is due to the fact that both systems depend for their homing information upon keying alternately each of the antenna elements. The signal strength at each antenna is an indication of the side from which the signal is originating. A

weak antenna element on either side, in either system, would obviously be detrimental to the accuracy of that installation. See Figure 9 for a tabulated comparison.

2. The airborne SARAH receiving equipment is more complex than the AN/ARA-8 equipment and would require special training for servicing personnel. The AN/ARA-8, on the other hand, is a relatively simple and standard piece of homing equipment which operates in connection with the AN/ARC-3 VHF Command Receiver. Due to visual information presentation, the SARAH airborne equipment gives a much better indication of the passing of a null than that given with the aural indication of the AN/ARA-8. The addition of the AN/ARA-22 visual presentation to the AN/ARA-8 system, however, overcomes this deificency. Voice communications have proven to be very poor in the SARAH system, probably due to the pulse repetition frequency technique used for modulation. The AN/URC-4 vs. AN/ARA-8 system has always proved to be capable of satisfactory voice communications. The SARAH equipment does have the feature, however, whereby the various ground beacons may be set to trigger the scope presentation in a different timing sequency and therefore provide for identification of different beacons. This feature is not included in the AN/URC-4 system.

3. The ground equipment or beacons for the two systems differ somewhat electronically, but their basic operating principle is about the same. Each beacon has a specially designed DZ antenna capable of radiating the pattern illustrated in Figure 4 and each has been designed for extreme simplicity of operation and ease of assembly. The beacons differ principally in the radiated signal and in the type of power supply. The SARAH beacon is equipped with a vibrator power supply enabling this equipment to operate with any 6-volt battery with 12 amp. hours or more capacity, whereas the AN/URC-4 is supplied with a specially designed mercury battery, the BA 1264-U dry cell. In either case, the equipment will operate 20 hours or more on one battery. The signal emitted by the SARAH beacon consists of very short paired pulses from a self-pulsing oscillator. This type of emission is required in order to key the special visual cathode ray tube display in the SARAH receiver. This special type of signal creates the capability of radiating a UHF signal with rather high peak power, in the order of 15 watts, but the relative average power is still similar to the AN/URC-4; that is, about 50 milliwatts. At the same time, this special signal precludes successful operation against this beacon with other than the special SARAH airborne receiving equipment. The AN/URC-4 beacon operation consists of the transmission of a continuously tone-modulated carrier in the VHF or UHF range. This type of signal may be utilized for homing with most regular radio homing equipment operating in the proper frequency range.

4. The AN/URC-4 is being replaced in the near future by the new AN/URC-11, which is a UHF transceiver with the same power and basic characteristics as the AN/URC-4. The AN/URC-11, however, is about half the size of the AN/URC-4. This equipment is now in production and should be available in quantity in the near future. By operating this transceiver with the special 5/8 wave drop zone antenna and flying against it with the UHF ADF homing adaptor, the AN/ARA-25, a UHF drop zone system comparable to the VHF AN/ARA-8 vs. AN/URC-4, is obtained. The new UHF system would include a more advanced type of airborne homing equipment with visual ADF indication and a much smaller, more advanced, beacon design. The frequencies of this equipment are in the high VHF range and are compatible with (200 mc) those used in the SARAH equipment.

IX. THE COMPATIBILITY PROBLEM

1. [redacted] 25X1

2. In order to fulfill the first requirement; that is, compatibility with the U. S. Air Force, it is necessary to utilize a beacon of the continuous carrier type, such as the AN/URC-4 or the AN/URC-11. In addition, it is necessary to employ equipment operating in the proper frequency range, 120-130 mc or 240-260 mc. The U. S. Air Force is presently in a period of transition between VHF and UHF. The following excerpt from a letter from Acting Director of Communications, USAF, Brigadier General Alvin L. Pachynski, should indicate the U. S. Air Force position:

> "Our planning calls for installation of a considerable number of AN/ARA-25 (UHF/ADF) equipment in certain types of aircraft. Initial equipping will be accomplished through retrofit programs established by the Air Materiel Command. A majority of the installations will be completed during FY 55 and 56 with some carrying out as far as the 2nd quarter of FY 58."

In accordance with this planning, the equipment utilized in the future should be in the UHF frequency range.

3. In order to fulfill the second problem; that is, compatibility with the Allies, there is the need for Tri-partite standardization. Here again, standardization among the intelligence organizations would involve only the choice of a system and the in- [redacted] 25X1

4. [redacted]

X. CONCLUSIONS

1. [redacted] 25X1

2. Additional evaluation should be performed considering the two basic systems from an operational point of view in order to determine the most desirable system to be chosen for the interim application.

3. There are available two basically different systems which may be considered for the interim drop zone application. Both systems, the SARAH and the AN/ARA-8 vs. AN/URC-4 type, have received a complete engineering evaluation and operate more or less reliably in accordance with previous discussion.

4. Both systems seem to have about the same number of basic advantages and disadvantages. Both systems have approximately the same range and drop zone indication capabilities. The difference then between the two systems is primarily operational.

5. The choice of a system for interim beacon use will depend upon a number of factors including the following:

   a. The use for which the beacon is intended in its primary application; that is, is it for cold war limited operation, or is it for caching and other types of preparation for hot war?

   b. Is standardization with [redacted] Allies to be considered? If standardization is a factor and the beacon is to be used for hot war application, then which air force will supply the majority of the support equipment? 25X1

c. Other factors being equal, the operational techniques of the two systems may be considered. The SARAH technique requires a third party in the aircraft, perhaps the navigator, to read the scope and direct the pilot as to course and drop point. In the case of the AN/URC-4 technique, the pilot flies the plane to center needle of the visual indicator and indicates the drop point in accordance with the visual null indication. Both course and signal strength indication are available directly to the pilot or co-pilot.

6. The characteristics which have been considered to be the basic requirements for a drop zone system are enumerated below. These requirements may be modified to incorporate any later plans of policy in connection with air operations of this type.

a. The ground unit must be compact, rugged, and easily assembled. It should be self-powered and capable of operation for at least 15 hours without the necessity for replacing or recharging the batteries. It must be capable of directing a plane flying at low altitudes and in inclement weather from a distance of about 10-15 miles to the drop point. The drop point must be defined and indicated to within about 50 yards of the beacon. The antenna should be so designed that it will radiate in accordance with the pattern indicated in Figure 4. The beacon should incorporate some method of identification or authentication.

b. The airborne equipment should be capable of receiving the beacon signal and presenting it in such a manner that the pilot will be able to steer a course directly to the drop point. The system may incorporate some method of semi-automatic winddrift correction. The method of presentation of the null information should be visual in order that the presence of a null may be more easily detected. It is desirable that the aircraft be completely passive; that is, that there be no radiation from the aircraft in connection with the use of this system.

XI. RECOMMENDATIONS

1. It is recommended that the Air Maritime Division initiate a program of operational evaluation of both systems; that is, SARAH and the AN/URC-4 type, so that a decision may be reached as to the type of system to be chosen for the interim drop zone beacon application. It is further recommended that the Office of Communications, Engineering Division, personnel provide engineering support in the form of maintenance of the prototype equipment, but that the complete operational evaluation be conducted primarily by air operations personnel. In connection with the combined evaluation, it is recommended that a test be initiated to determine the feasibility of homing on the SARAH beacon with the AN/ARA-25 ADF homing adaptor.

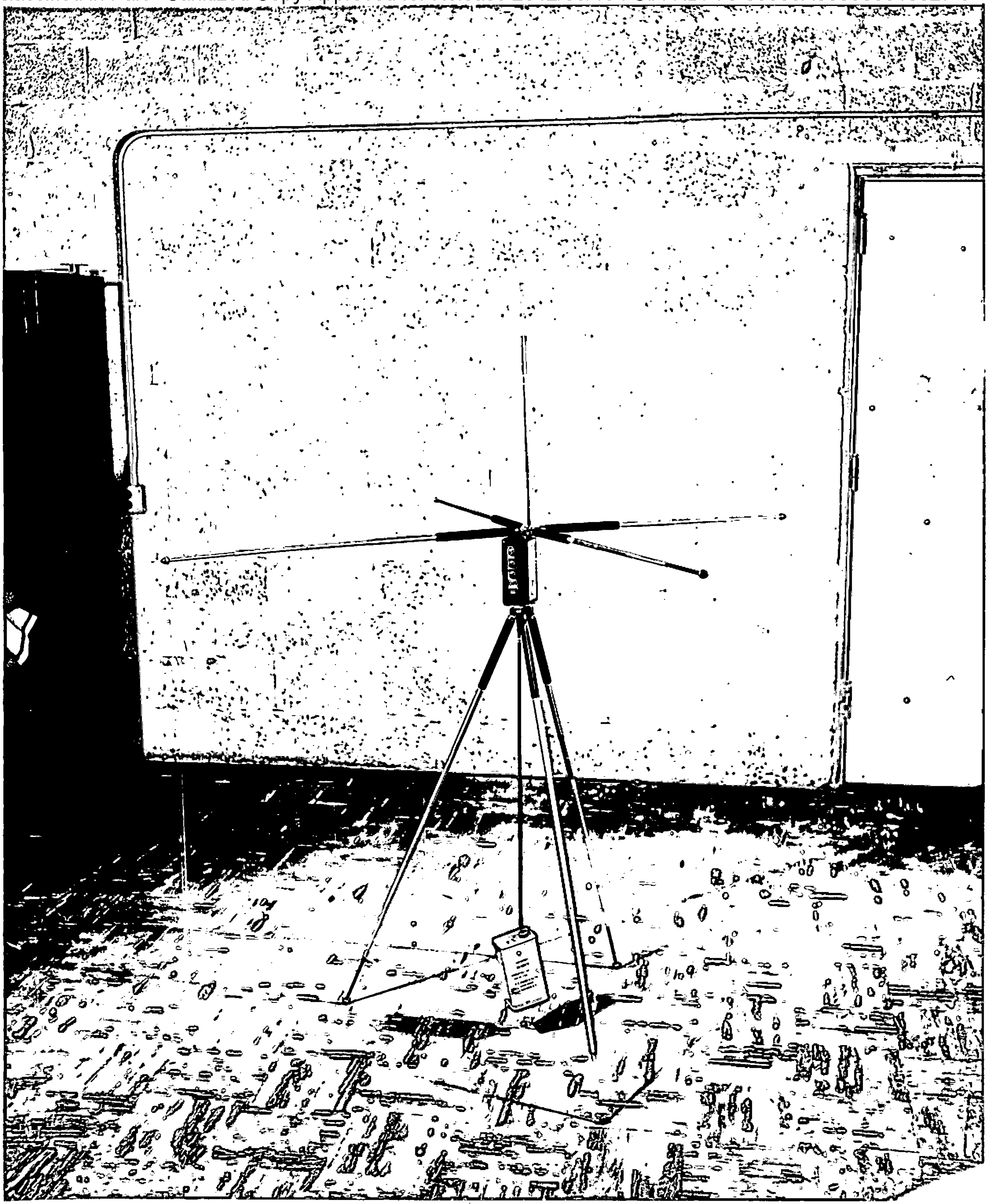

FIGURE 1

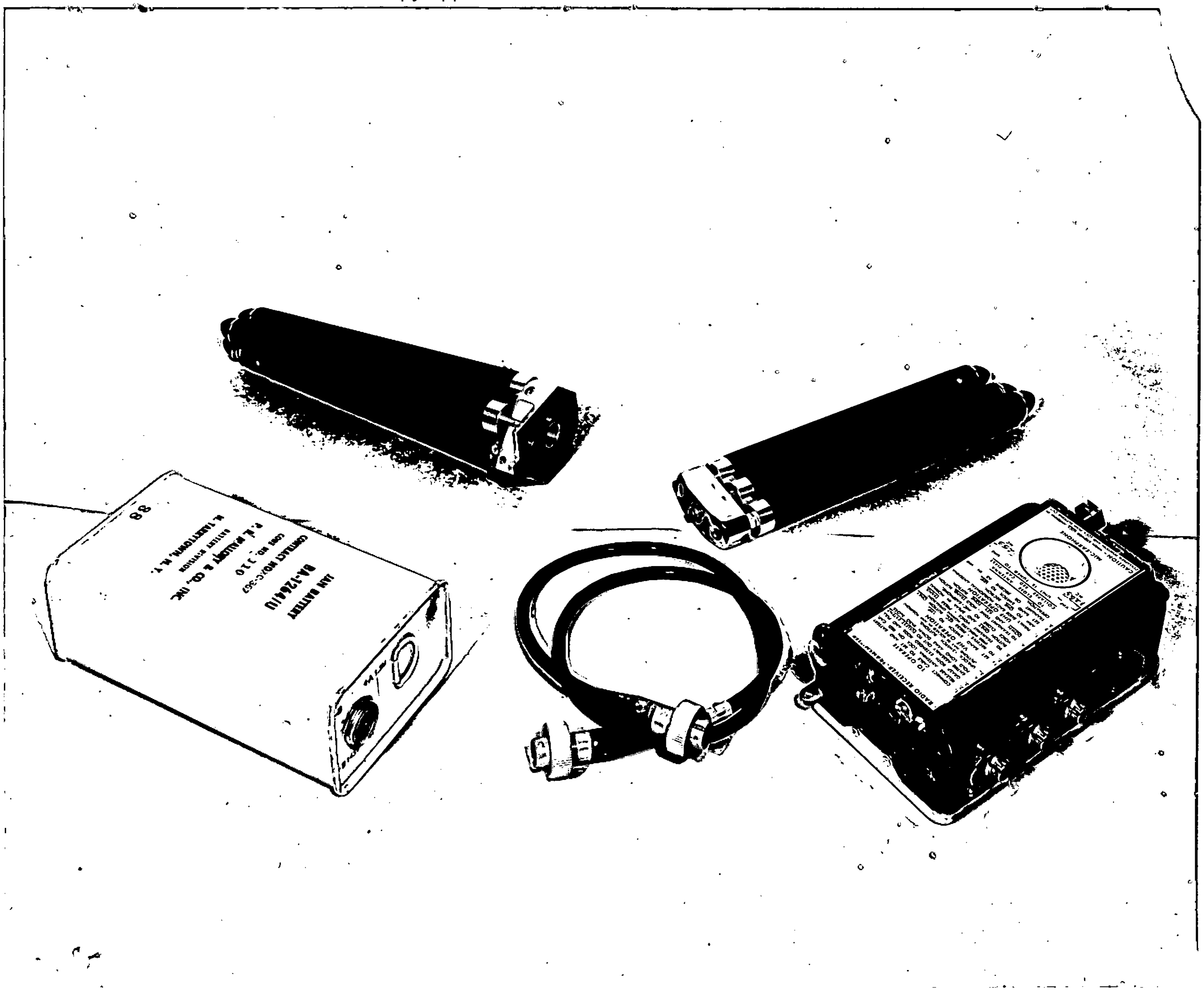

FIGURE 2

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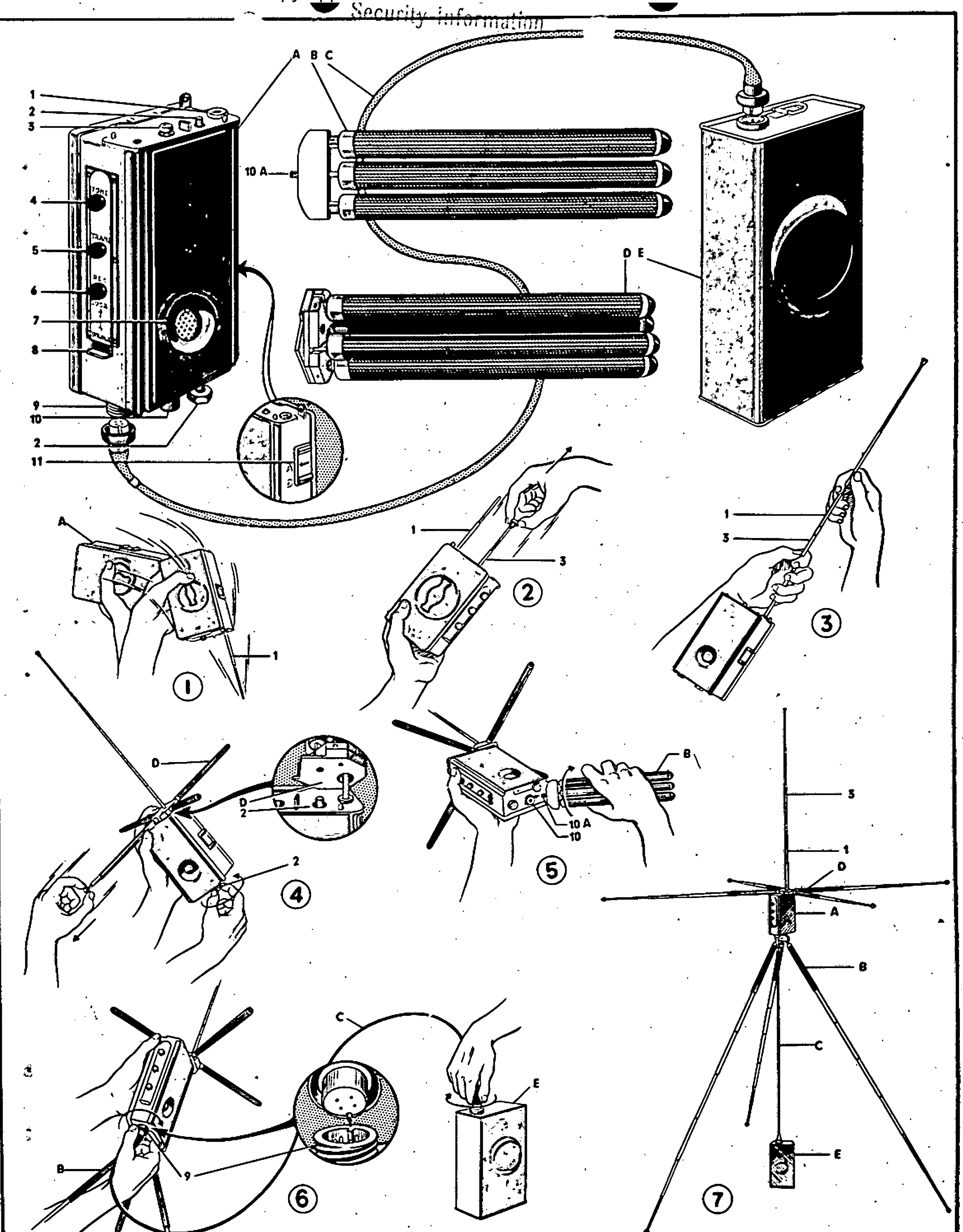
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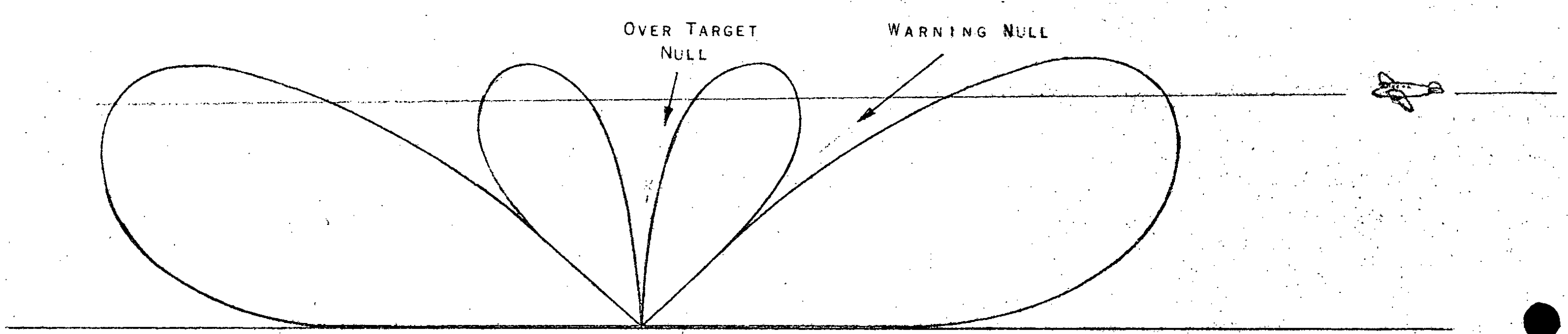
FIGURE 3



RADIATION PATTERN - AN/URC-4 D.Z. ANTENNA

Figure 4

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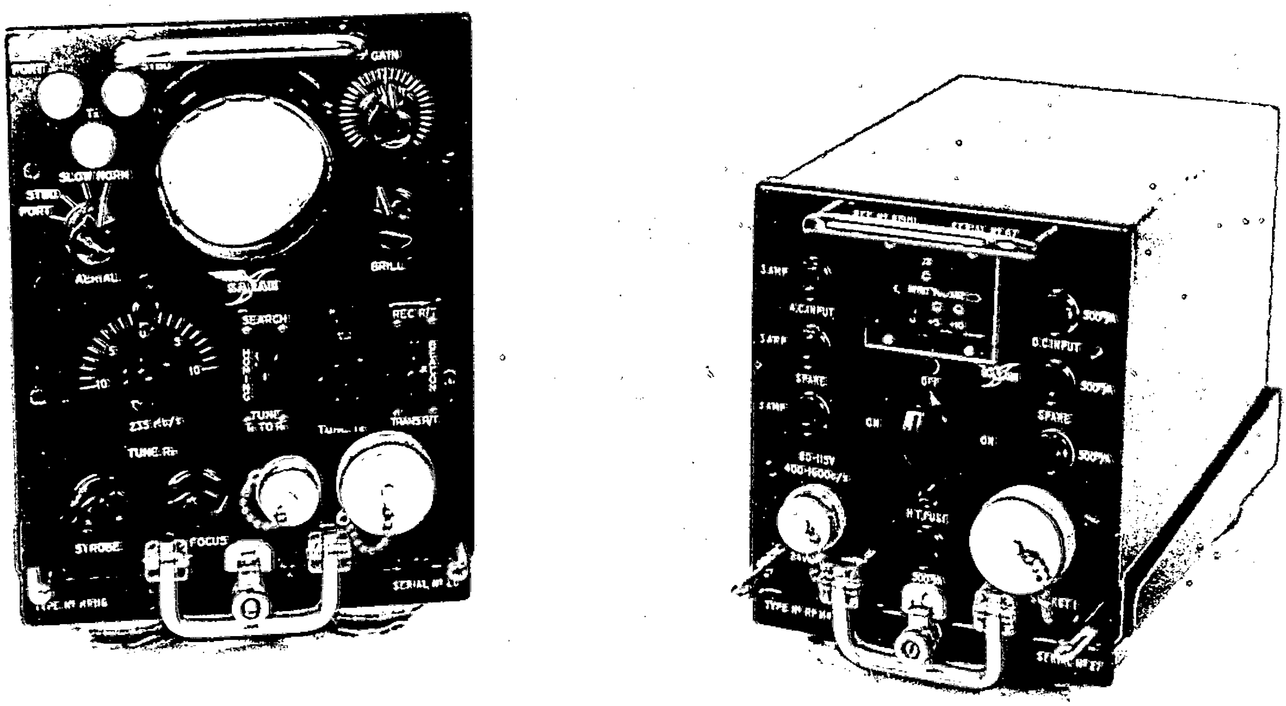
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STBD
PORT
AERIAL
BRILL
SEARCH
REC R/T
TUNE Rx
TRANS R/T
STROBE
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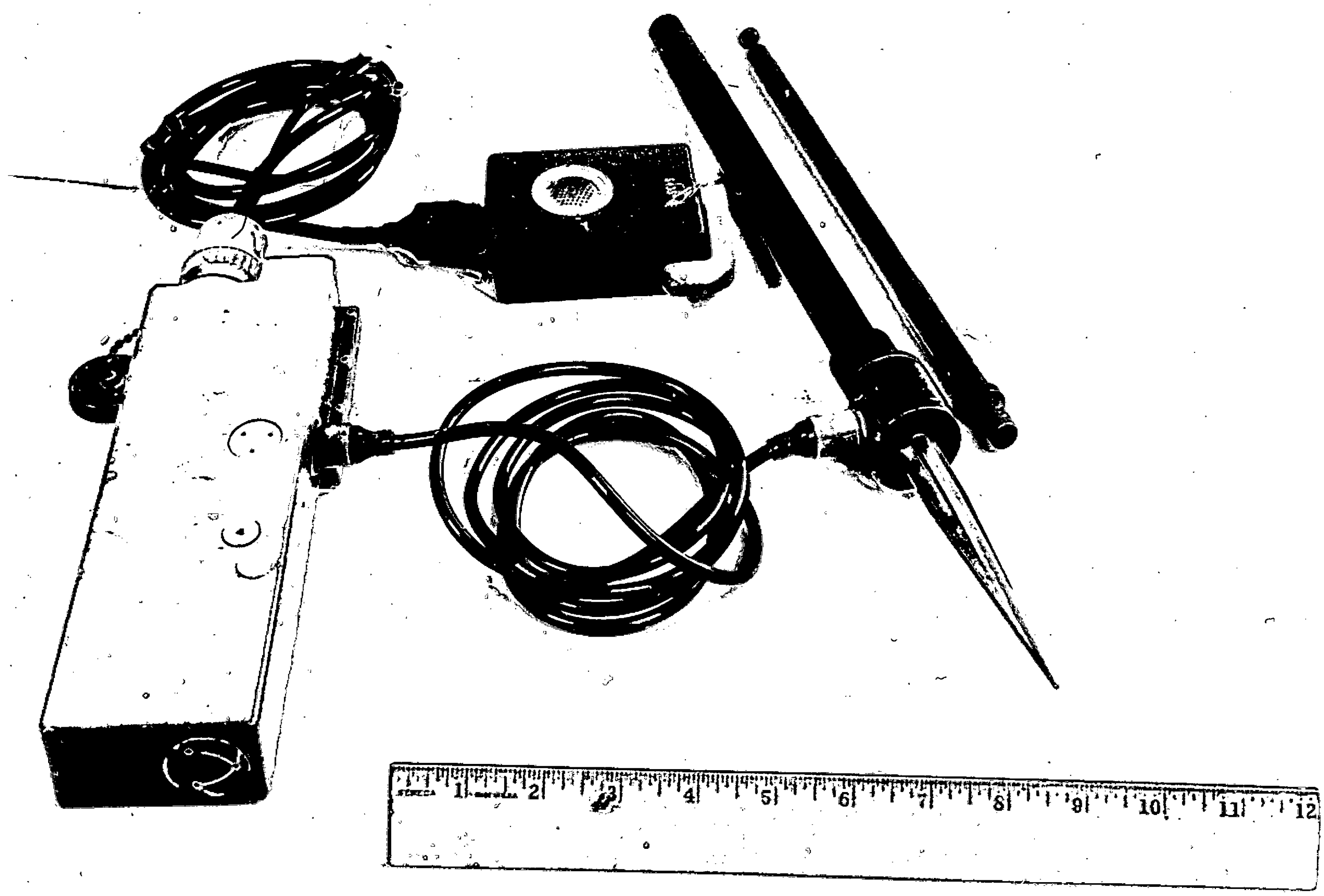
D.C.INPUT
SPARE
OFF
ON
H.T.FUSE

FIGURE 5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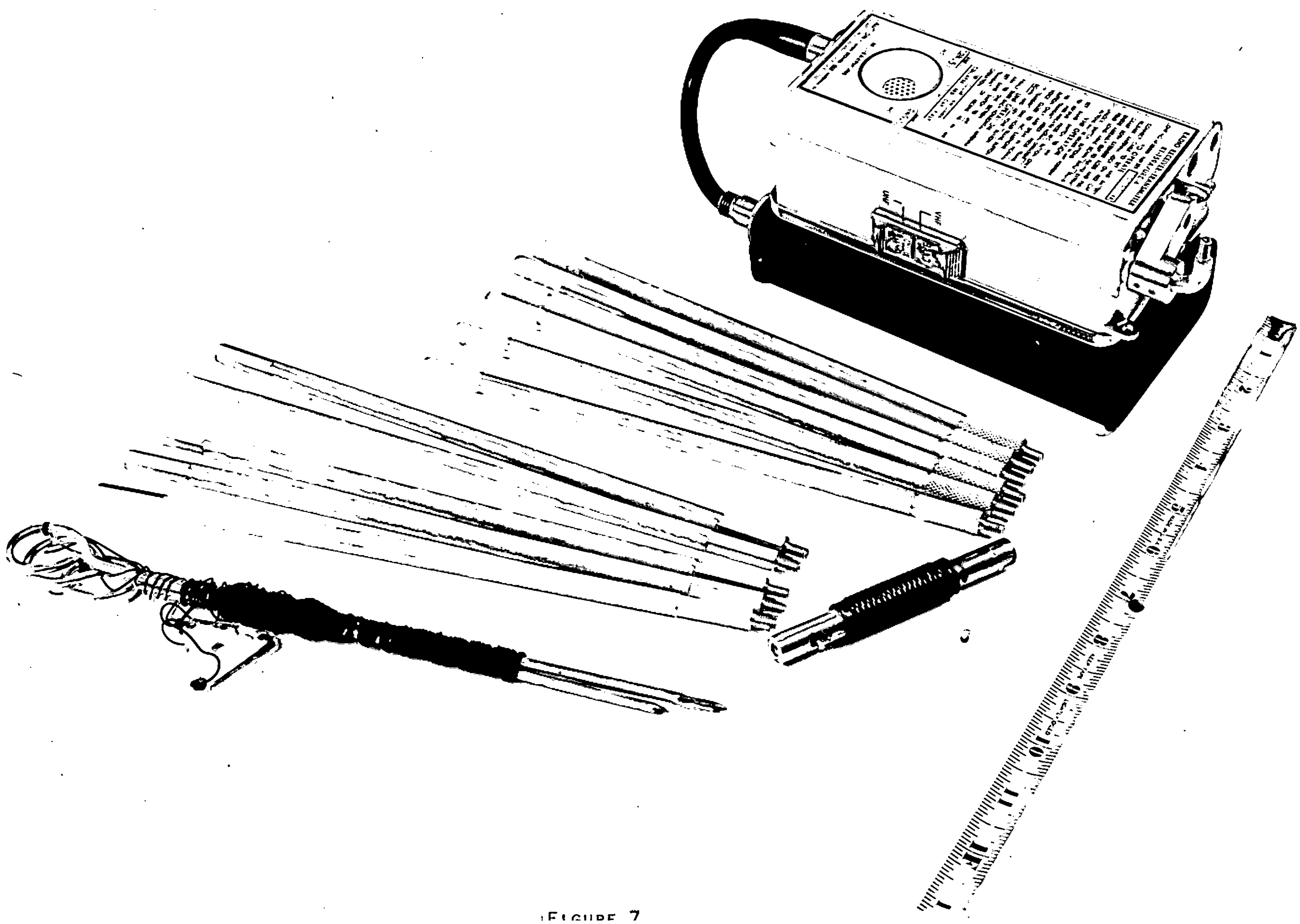

FIGURE 7

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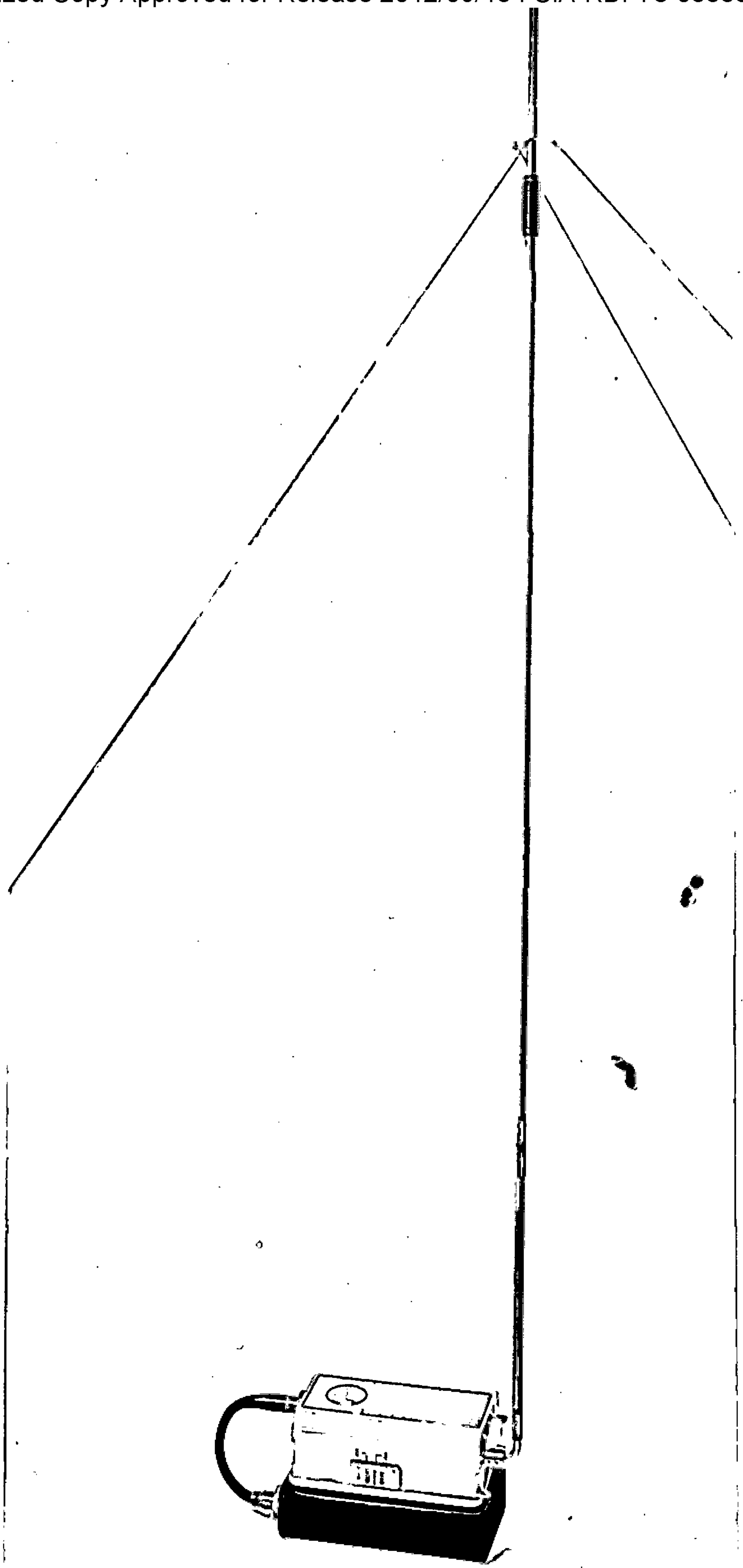

FIGURE 8

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COMPARISON OF DZ BEACON EQUIPMENT

CHARACTERISTICS	OLD SIS	NEW SIS	AN/URC-4	AN/URC-11
Frequency Range	235 Mcs.	220-240 Mcs.	120-130 & 240-260 Mcs.	238-263 Mcs.
Output Power	12-15 W peak (1)	18 W peak	50 MW	50 MW
Power Source	6 V Battery	6 V Battery	BA/1264U Dry Cell	BA/1264U Dry Cell
Battery Life	(2)	(2)	20 Hours	20 Hours
Size	Beacon: 9 3/4 x 3 x 1 3/4 in. Speech Unit: 4 3/4 x 2 1/2 x 1 1/4 in.	?	6 1/4 x 3 1/2 x 2 in.	3 1/2 x 2 1/2 x 1 5/16 in.
Weight	5 lb. 11 oz.	?	2 lb. 10 oz.	13 oz.
Air Receiver	"SARAH"	"SARAH"	ARA-8 or ARA-25	ARA-25
Op. Range at 500 ft.	4 miles	?	4 miles	?
1,000 ft.	15 miles	?	15 miles	?
10,000 ft.	60 miles	?	50 miles	?
Cost	$1,032.66	?	$177.67	$491.26
On Hand	5	1 (3)	590	5 (3)
Beacon Emission	Self-pulsed 7 μs paired pulses	self-pulsed 7 μs paired pulses	CW with 1 kc tone	CW with 1 kc tone
Voice Modulation	PRF Mod.	none ?	AM	AM

(1) Estimated (30 MW average power)
(2) Depends on particular 6 V battery used. Approximately 20 hours, with lead acid battery measuring 4" x 5" x 6 1/2"
(3) Due this month

FIGURE 9

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