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Report on
Detection and Location of Concealed
Microphone Wires

for

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NAVAL RESEARCH LABORATORY
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ABSTRACT

Two methods and apparatus for detecting concealed wires are described. The first method consists of detecting a change of distributed capacity to ground of a search electrode caused by the proximity of extensive, metal objects. The second method consists of setting up an exciting AC field and detecting the presence of metallic bodies by picking up some of the energy transferred to those bodies by electrostatic coupling. Design details and results of tests are given.

I. INTRODUCTION

A. Authorization.

1. This problem was authorized by the Director of the Naval Research Laboratory.

B. Statement of Problem.

2. The problem is to devise a method for detecting the presence of and locating small wires, specifically microphone wires concealed in the walls of a room. Such wires may be either grounded or floating, shielded or unshielded, single conductor or twisted pair. The apparatus must be easily portable, rugged, and should consist of easily replaceable components wherever possible.

C. Known Pertinent Facts and Original Work.

3. The problem of detecting the presence of metallic objects is an old one, and the techniques used in its solution are well known. These include measurements of a change in capacity between two electrodes, one of which may be grounded, measurement of change in the electro-magnetic coupling between two coils and measurement of a change in the magnetic field, all of these changes being due to the presence of a metallic body. The last two methods mentioned are ruled out by the nature of the immediate problem since they are useful only in detecting conducting bodies of large effective area or magnetic bodies of appreciable volume. The wires to a microphone fall in neither of these two groups and consequently the capacitive method was chosen as the most promising.

4. Several variations of the above method were tried and two adopted. The first of these makes use of the heterodyne principle, using two r-f oscillators beating with each other to produce an audible note. The frequency of one of these oscillators is fixed, while the frequency of the other is determined by the capacity of a variable air condenser plus the capacity between a search electrode and ground. Any change in this capacity causes a change in the oscillator frequency and is manifest by a change in the pitch of the audible note. A suitable instrument was built to embody this principle and qualitative tests were made to find out how various objects affected the audible beat note. The search electrode, a wire 12" long, was carried along 1" from and parallel to the surface of a 3/4" plywood board. Definite signals were obtained when the electrode passed a wire attached to the rear of the plywood. A longer wire gave rise to a greater frequency change with a change of about 2,000 cycles when the electrode was parallel

to and opposite a 4 foot length of wire. The size of wire had no apparent effect. Grounding the wire at one end made little difference in the result unless the instrument itself was actually grounded. A wire screen, 1/2" mesh, grounded or ungrounded, completely masks the effect of the wire if placed in front of or immediately behind the wire.

5. This instrument is sensitive to all changes in electrode-to-ground capacity and therefore also responds to any changes in dielectric. As a result the search electrode must be held a substantially constant distance from any surface scanned or a change in the beat note will result as the electrode approaches that surface. Similarly, any variations in the material and thickness of the wall will cause a change in beat note. In general, none of these causes has as great an effect as a wire. The instrument has an effective range in air of about 8 inches.

6. The second method makes use of a transfer of energy by means of a capacitive coupling. If an oscillator is connected to a short length of antenna electromotive forces appear in nearby conducting objects, caused by electrostatic induction. These electromotive forces can then be detected by means of an exploring or "search" probe, amplifier, and headphones. Suitable apparatus was constructed, and again qualitative tests were run to determine its applicability. The search electrode was this time about an inch of wire protruding from a grounded shield and protected by a bakelite cap. The antenna was strung up about a foot from the length of wire to be detected and the search electrode or probe carried about in the neighborhood of the wire. It was readily apparent when the probe was near the wire, this condition being indicated by a large signal. The probe even had some directional qualities, giving the largest signal when pointing directly to the wire. The probe cannot be used near the antenna, the direct transfer of energy from the antenna being large enough at 8 feet to mask any signal received from the wire. However, it is easy to follow a wire at greater distances from the antenna. Some stray 60 cycle signal may be picked up but will interfere in no way with detecting and tracing the wire. If a wire screen of 1/2" mesh is placed either directly behind, or in front of, the wire, a signal is received over the whole surface of the screen if the screen is not grounded. In such a circumstance the instrument is practically useless for locating the wire accurately. If the screen is in front of the wire and is grounded, no signal at all is received, the wire being effectively shielded. If the screen is immediately behind the wire and is grounded, the signal is only slightly decreased and the wire can still be readily detected and traced. The instrument has an effective range in air of about 1 foot.

II APPARATUS

A. Hetrodet

7. The heterodyne detector, christened the "Hetrodet", consists of the circuit of Plates 1, housed in an aluminum box as shown in Plate 4. The probe, or search electrode, is held on a bakelite plate 6 inches in front of the aluminum box and protected by a semi-cylindrical cover, which serves also to keep the electrode a constant distance from any surface scanned. The only controls are a power switch and a variable air condenser to provide for tuning in the beat note. A second variable air condenser can be adjusted by a screw-driver through an opening in the housing, providing a wider range of tuning. Once the second condenser is set there should be no reason for changing it. Power for the Hetrodet is provided from a 45 volt B battery and a 1.5 volt dry cell housed in another unit. Connections are made through a cable which enters the housing through the handle. The Hetrodet weighs 5 pounds.

B. Electrodet

8. The detector utilizing the capacitive transfer of energy and called the "Electrodet" consists of an audio oscillator and an audio amplifier in separate units as shown in Plate 5. Plate 2 shows the circuit of the amplifier, Unit A. It is a two stage resistance-coupled audio-frequency amplifier for use with headphones and powered by a 45 volt B battery and a 1.5 volt dry cell. The exploring probe is an unshielded piece of wire about an inch long, protected by a bakelite cap and attached to a brass handle. It is connected to Unit A by a shielded cable. On Unit A will be found a power switch and a volume control. The latter may be left full on (clockwise) in normal use. Unit A of the Electrodet weighs 8 pounds.

9. Plate 3 shows a circuit of the Electrodet, Unit B. It is a power-line operated audio-frequency oscillator with an amplitude control tubes and amplifier. It is especially designed for constant tone and output, regardless of reasonable changes in line voltage and for low power consumption. The antenna is an insulated flexible conductor, about 20 feet long and is connected to the high potential side of the oscillator. This unit will operate from a line giving 105 to 120 volts a.c., 50 to 60 cycles. It weighs 15 pounds.

III METHODS OF USE

A. Hetrodet.

10. The battery cable should be plugged into the socket in the top of the Electrodet, Unit A. The power switch on the latter should remain in the "off" position while the Hetrodet is being used. When the headphone plug is inserted and the power switch on the Hetrodet turned on, a slow rotation of the single adjusting knob will locate a whistle or beat note. The probe should be placed

against the wall or surface to be scanned, and the control adjusted for a note of low pitch. Of the two positions of the control giving such a low pitch, that one should be used which causes a rise in pitch when the hand is passed near the sensitive electrode. The unit should now be passed in a regular fashion over the surface to be searched. The presence of a concealed wire is indicated by a rise in pitch. Some alteration in pitch will also be observed when the construction or density of the surface changes. The Hetrodet remains sensitive to metallic objects even though they are grounded.

B. Electrodet.

11. In using the Electrodet, the antenna should be supported by any convenient means near the wall to be searched, say, near a corner. The probe is then passed in a regular manner over the surface. Passage of the probe near a concealed wire which also passes near (within a few feet of) the antenna, is indicated by a tone in the headphone. This tone will be heard loudly when the probe is brought near the antenna, which is a good overall test of the system. Because of this direct pickup from the antenna, the region near it cannot be explored. The antenna must be moved, and that region then searched. If a signal is received while searching the wall, there are concealed wires of some sort, and they must pass near the antenna. If no signals are received, there still may be wires concealed, but none which pass near the antenna. Thus, before an investigation of a wall with the Electrodet can be considered complete, the antenna must be hung in several positions and a thorough search made with the probe in those regions where the direct pickup from the antenna is not excessive. For instance, in investigating one wall the antenna should be strung up in three vertical and three horizontal positions and a search with the probe made for each separate position. If the wire to be found is grounded, or is covered by a shielded grounded covering, the efficacy of the Electrodet is greatly reduced. If the conductor is not grounded, it may be traced for considerable distances.

IV CONCLUSIONS AND RECOMMENDATIONS

A. Facts Established.

12. The detection of concealed wires may be considerably facilitated by use of the Hetrodet and the Electrodet. The Electrodet has an effective range in air of about 1 foot while the Hetrodet is effective to about 8 inches.

13. If the wire to be found is grounded or covered by a grounded shield, the Electrodet is of little value in locating it, while the Hetrodet is still effective.

14. If the wall or surface to be scanned contains a metal shield or screen, such as the metal lath in plaster walls, the Hetrodet is of little value in detecting or locating the conceal-

ed wire whether the screen is grounded or ungrounded. If the screen is ungrounded the Electrodet is of little value, while if the screen is grounded the Electrodet will detect and locate a wire concealed in front of a screen, but not behind it.

15. AC power lines can be distinguished from other wires by the characteristic power frequency hum picked up by the Electrodet.

16. The size of a concealed wire is unimportant.

B. Opinions.

17. With sufficient practice an operator can be aided considerably in the location of concealed wires by the combined use of the Hetrodet and the Electrodet.

C. Recommendations.

18. Further work might profitably be done on the Electrodet. First, the audio oscillator could be replaced by an r-f oscillator modulated by a suitable audio note. This would require a corresponding change in Unit A, namely, the introduction of a detector stage. This would probably increase the use of the Electrodet in locating grounded wires or shields.

19. A filter could be included in Unit A of the Electrodet to eliminate interfering noise if desired.

20. Unit B could be made to operate on DC or AC.

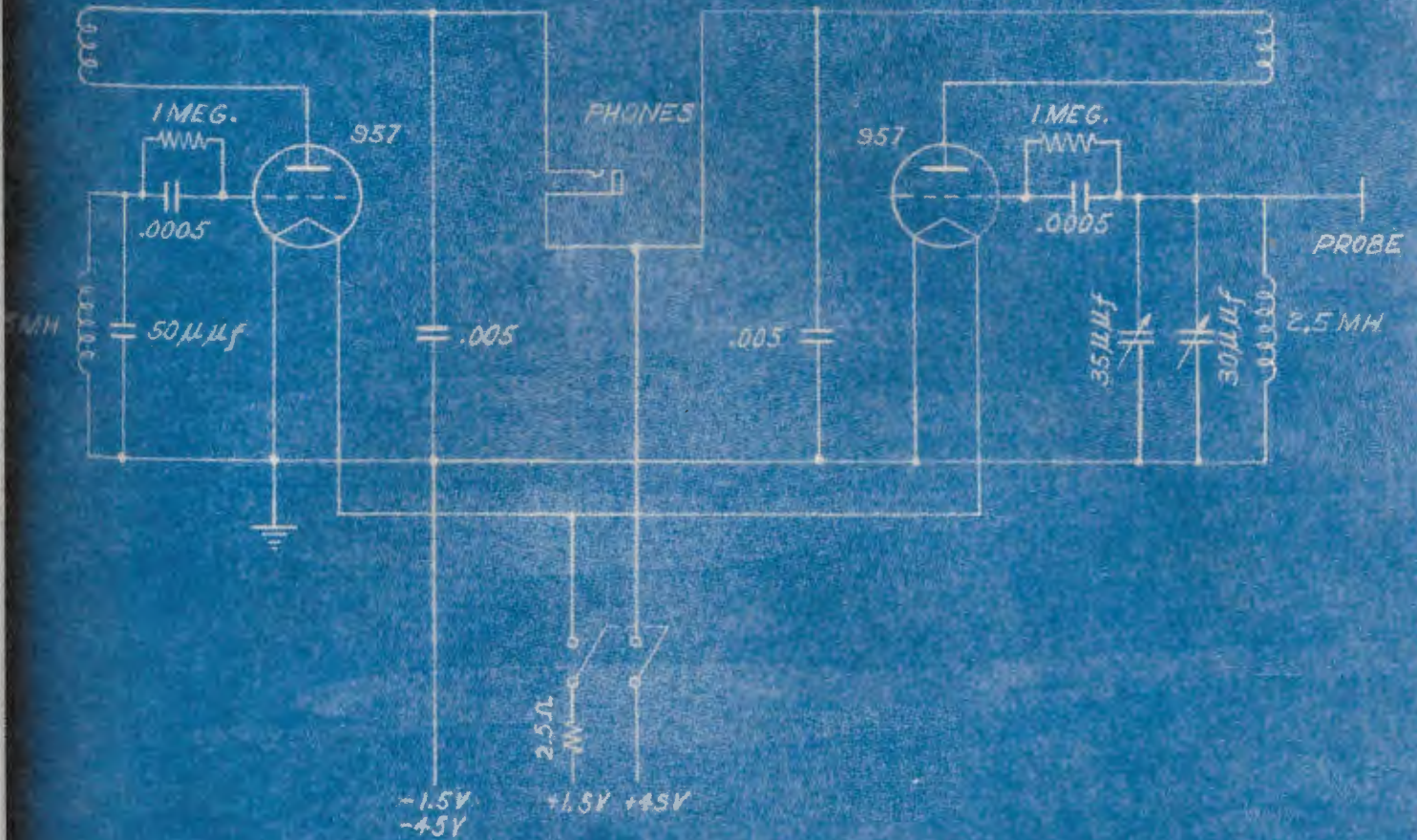
V SUMMARY

21. Various methods for detecting and locating concealed wires were investigated and two chosen for further development. One of these makes use of change of the capacity between a "search" electrode and ground in the vicinity of a wire. The other depends on the transfer of energy by electrostatic induction from an antenna to nearby conducting bodies.

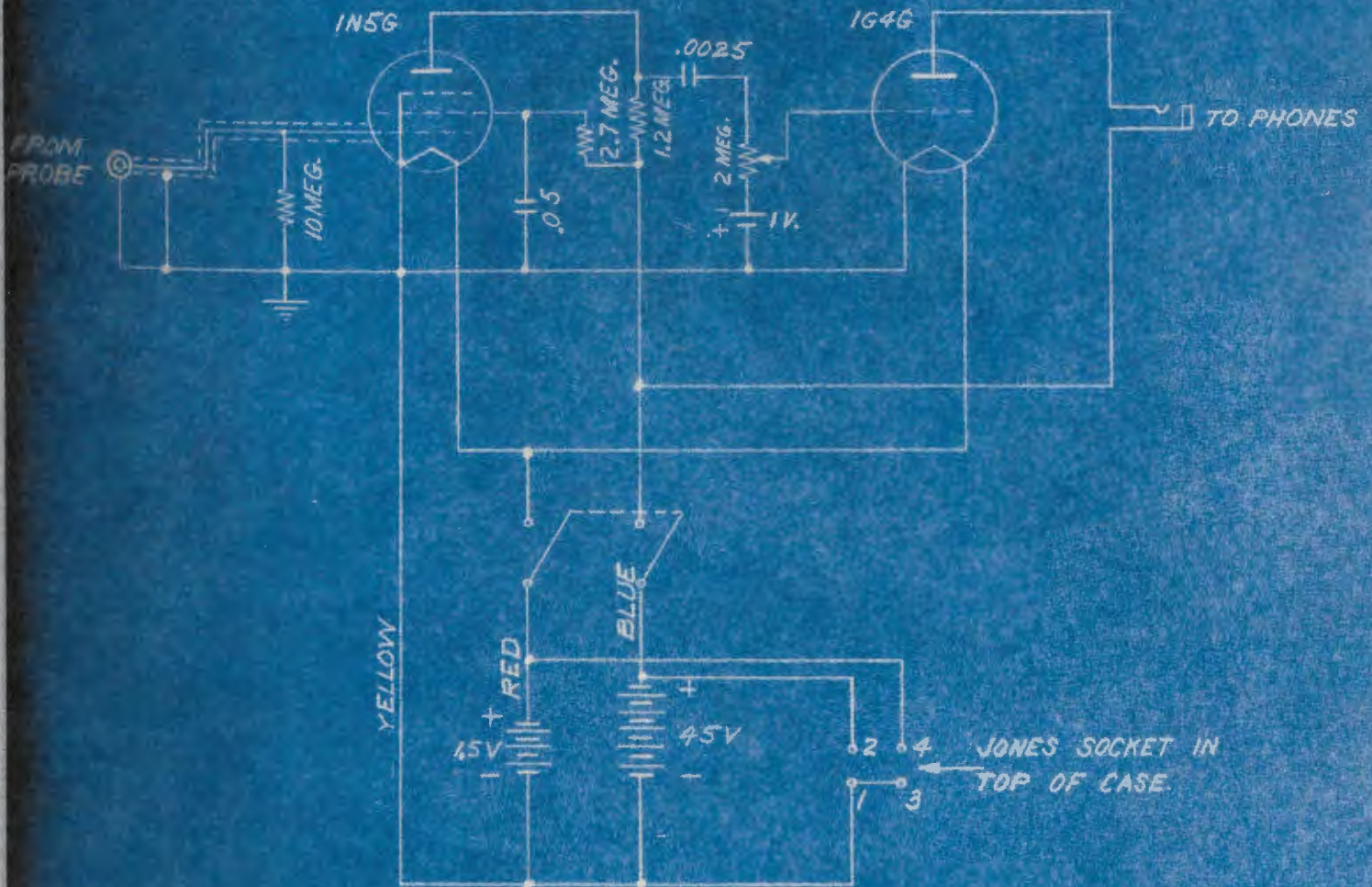
22. Instruments were built to embody these principles. The Hetrodet is sensitive to a change in electrode-ground capacity and indicates such a change by a change in pitch in the headphones. The Electrodet is sensitive to induced electromotive forces in conducting bodies and indicates such electromotive forces by a tone in the headphones.

23. These instruments were found to be useful in locating wires in ordinary walls, while in walls having a metal screen built in they were not very useful.

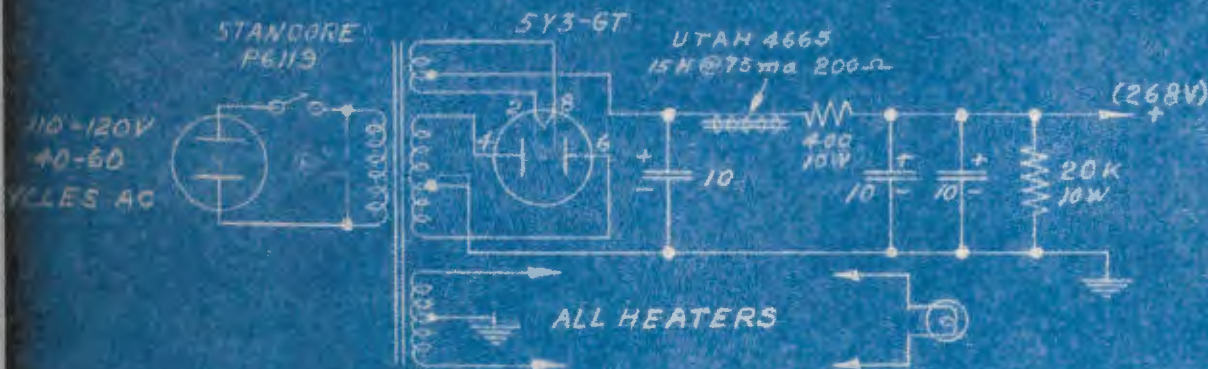
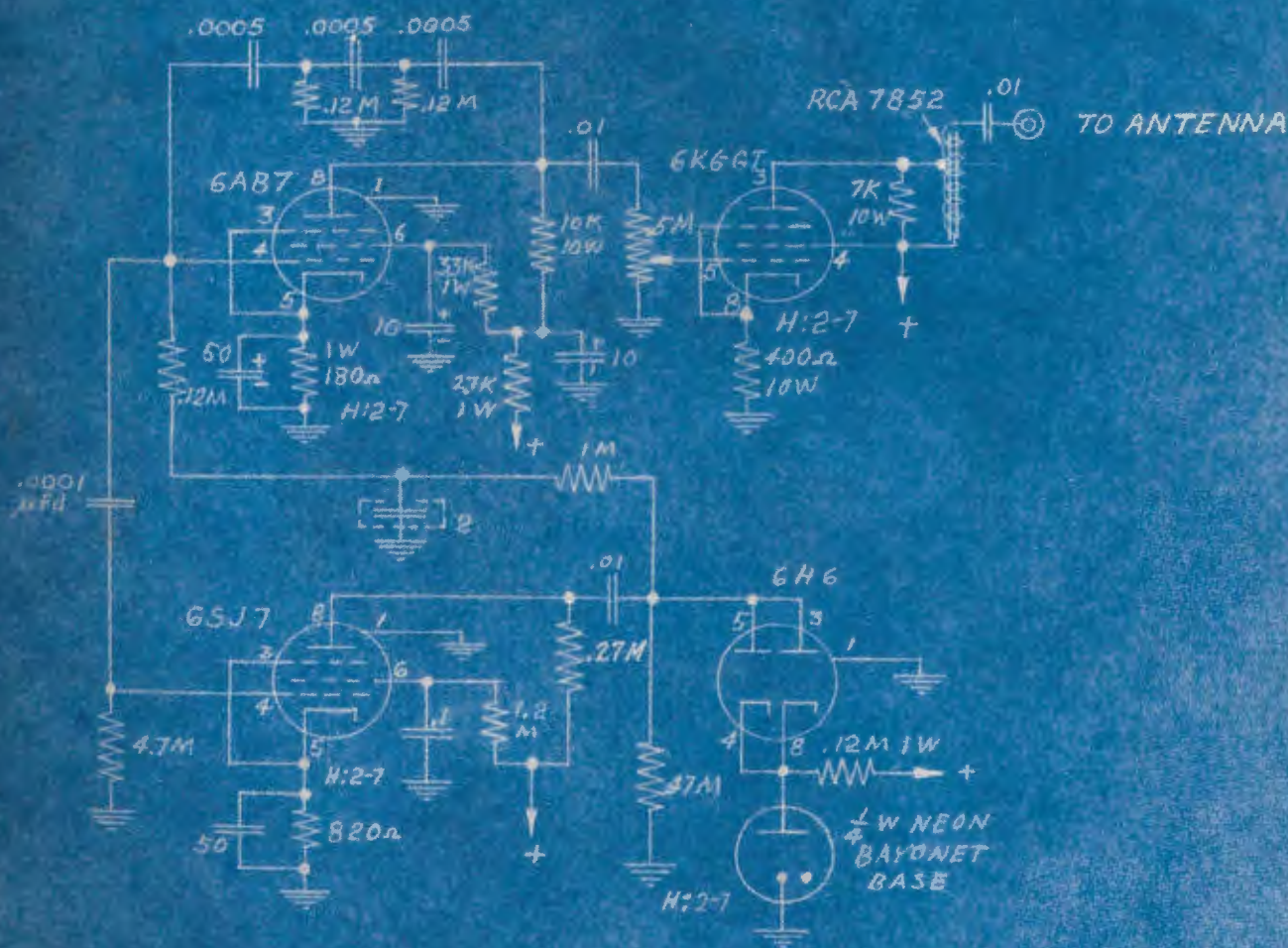
HETRODET

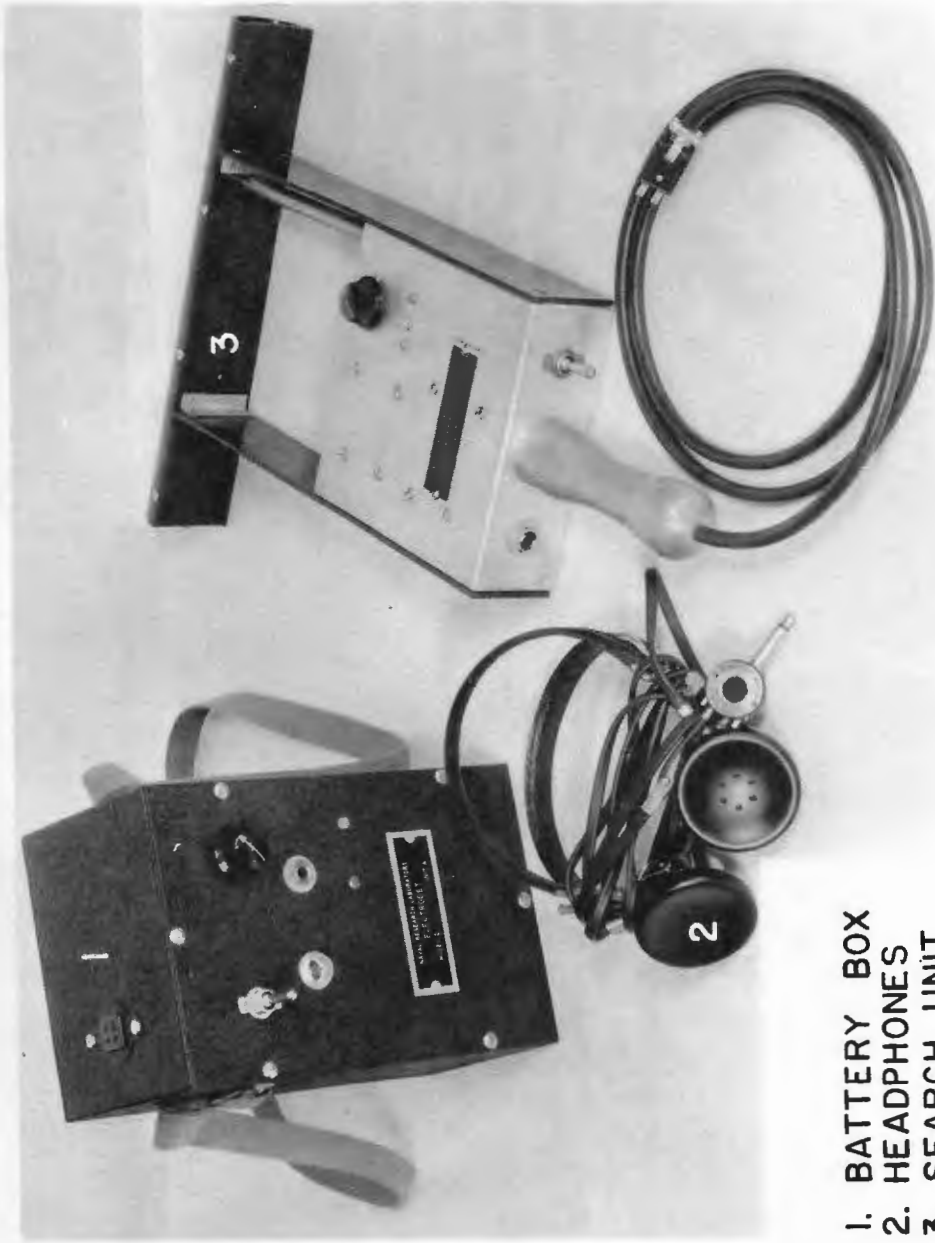


ELECTRODET - UNIT A
MODEL 2



MODEL 2





- 1. BATTERY BOX
- 2. HEADPHONES
- 3. SEARCH UNIT

HETRODET

PLATE 4

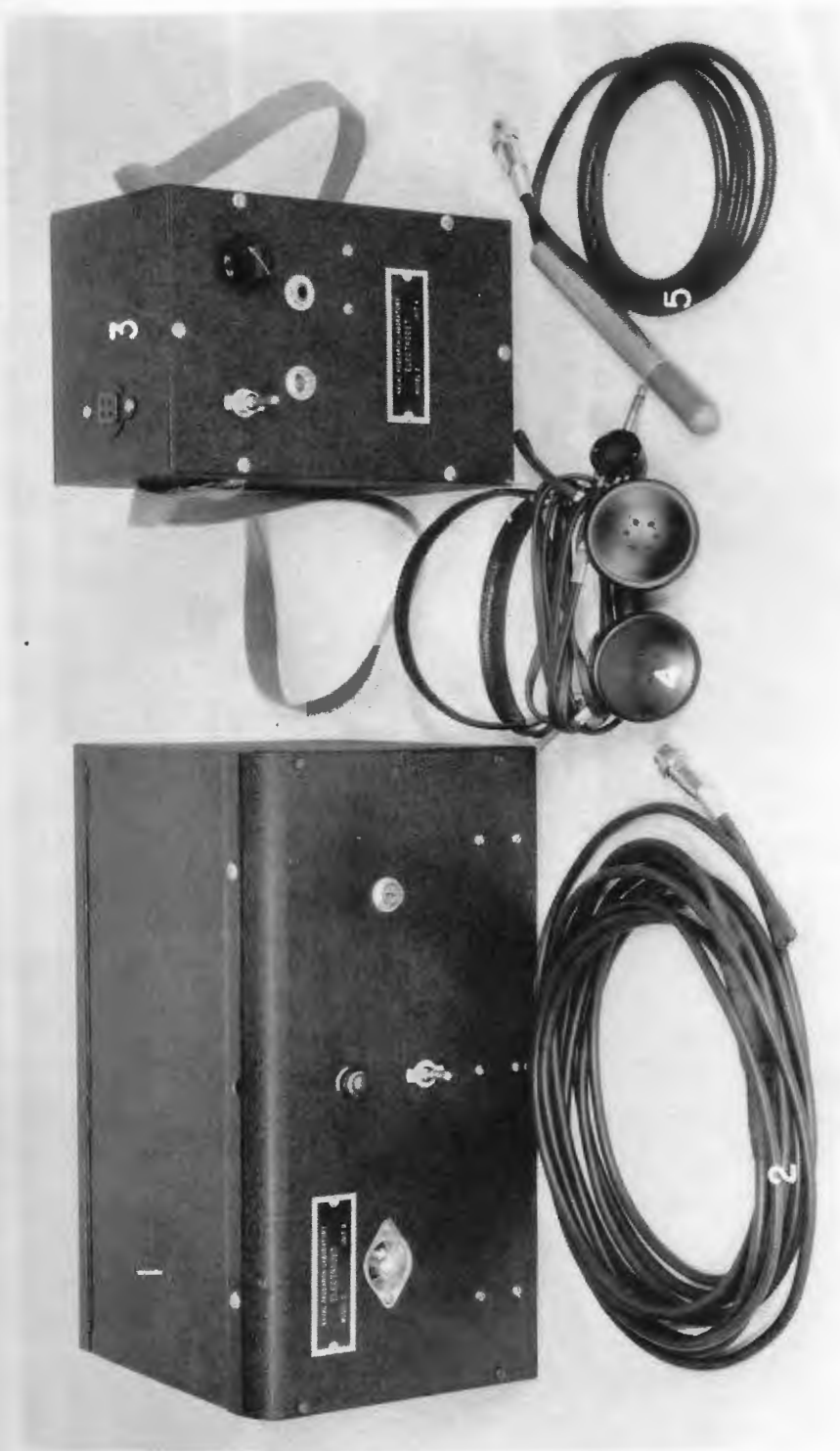


PLATE 5

- 1. OSCILLATOR UNIT
 - 2. ANTENNA
 - 3. AMPLIFIER & BATTERY UNIT
 - 4. HEADPHONES
 - 5. PROBE
- ELECTRODET**