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Research Order #1
Phase I - Progress Report #1

28 December 1953

OBJECTIVE:

To study and evaluate the factors and components involved in the design of a portable infrared communicator.

GENERAL DATA:

The work to be performed according to Bid Proposal #76-1, Phase I may be summarized as follows:

A. Evaluation of sources and sensitive elements

B. Determination of beam width requirements and evaluation of "find-operate" systems

C. Study of modulation methods and attendant optical systems

D. Evaluation of power sources

E. Study of required circuit characteristics

The results of these studies will be used as the basis for recommending a system to be developed.

DETAILED DATA:

A. Preliminary considerations of performance and physical characteristics

In order that the efforts of the investigation would be most efficiently directed, information regarding the approximate desired performance and physical characteristics was obtained in discussion with representatives of the agency. Two possible sizes of equipment were originally considered.

The first unit suggested would have an average clear weather (ACW) range of 6 miles and a size of 12" x 18" x 8"

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weighing about 18 lbs. with fuel for 9 hours operation.

The second proposed unit would have an ACW range of 10 miles and a size of 18" x 24" x 10" weighing about 42 lbs. with fuel for 9 hours operation.

The Appendix indicates the basis on which these proposals were made. It should be understood that these proposals were used as a starting point and a guide for future thinking regarding reguired equipment size.

After further discussion with representatives of the agency, they indicated that the unit with an ACW range of 6 miles would be preferred because of size and weight considerations. Other factors are that the unit should be packaged so that it may be carried in a suitcase; that the power source, if an engine generator, must be very carefully silenced for maximum aural security. The unit must be capable of being buried in the ground for long periods without adverse effects on performance. It is desirable that the daylight operational range not be markedly less than the night range. It is necessary that a high degree of visual security be maintained for both night and day operation.

B. <u>Evaluation of sources and sensitive elements</u>

It is thought that the most useful and realistic study of various sources and sensitive elements can be made by actual tests of such elements in a dark room using a vacuum range optical attenuator to simulate long ranges.

The laboratory's new dark room which has been under construction for several months is now nearing completion. In conjunction with this a vacuum range optical attenuator will be constructed and installed. This unit will be similar to the one designed and built by [redacted] 25X1
ment under contract [redacted] 25X1

A mechanical chopper will be provided for sine wave modulating the source under test at any one of a number of audio frequencies so that the audio response of the sensitive element under test may be evaluated. Infrared filters suitable for the items under test will be interposed so that source and sensitive element can be tested under correct conditions of spectral radiation and response.

For sources that are capable of electrical modulation, suitable electrical equipment will be provided to modulate them.

To supplement and check the empirical data obtained with the above methods, sensitivity calculations will be made from available published data.

Cesium vapor sources as well as some tungsten lamps are presently on hand. Information is being obtained on high pressure Xenon lamps made by the Hanovia Chemical and Mfg. Co. Of the sensitive elements to be tested, some thalofide and lead sulfide cells are on hand, and also an infrared photomultiplier with S-1 cathode.

C. Investigation of beam width requirements

Since the transmitter and receiver beam widths in the "find" and "operate" modes of operation will be important factors in determining the ease of operation of the equipment in the field, considerable study is being made of this problem. In this connection a "find-operate" transceiver beam simulator is being designed. Parts for this will be fabricated as soon as detail drawings are ready. This should be within two weeks. Purchased parts are on order, and delivery is expected by the first of the year.

The simulators consist of two transceiver units designed of such a size as to reproduce in the rather limited space of the laboratory dark tunnel the conditions that may be expected when two communicators in the field are trying to locate one another and establish communication.

The receiver portion of the simulator will have provisions for acceptance angles of about 0.3°, 0.6° or 1.2°. The transmitter will have a beam continuously adjustable from less than 1° to about 8°. Provision is being made so that the receiver may be mounted coaxially with the transmitter or to one side as desired. It is thought that with these simulators the minimum practical beam widths for the "find" and "operate" modes can be determined.

As an alternative to increasing the beam width during "find" by increasing the source power, the possibility of causing the transmitted beam to scan rapidly through a relatively wide angle is being considered. Thus, a hand cranked mechanical scanner might possibly be arranged to cause the narrow beam to scan in such a way as to duplicate the effect of a wide beam.

D. Study of modulation methods and optics

Although modulation methods are being given some thought, active study of this problem will be deferred until more information has been obtained on the relative merits of the various IR sources and until the required beam characteristics have been investigated.

The lightweight plastic Frenelens made by the Bolsey Corporation of America is being considered for possible use in the optical system. Samples are being obtained. Again, most of optical study will be dependent on the results of investigation of sources and sensitive elements and beam requirements.

E. Power source

Much of the thinking regarding power sources has been in regard to engine generator sets. However, as was brought out in discussion with the agency representatives, the cost for development of a suitable unit could be very high. In addition the problem of achieving the necessary aural security could be serious.

[redacted], 25X1
has been contacted regarding the development of an engine generator set. They have indicated that a unit operating at 10,000 rpm and producing about 50 W at 900 c.p.s. could be made weighing about 3 to 4 lbs. The life would be from 100 to 200 hours. They consider the problem of silencing the unit to

be not too serious. Their estimate of cost for a development and tooling program is about $30,000 for generator manufacture and $55,000 to $60,000 for the engine.

Because of the high cost of such a development, the possible modification of an engine of the model-airplane type with the necessary changes to give reliable operation, sufficient life, and adequate silencing is being considered. Technical information has been requested from a number of manufacturers of this type of engine. An attempt will be made to locate a less costly generator also.

Since the development of a suitable engine-generator set does present a number of problems, the use of batteries of the Yardney Silvercel type will be seriously studied. Data regarding shelf life, discharge, and cycling characteristics will be requested from the manufacturer.

F. Circuit characteristics

Circuit characteristics will be largely determined by the source, sensitive element and modulation method. However, information on components and techniques that may be applicable to this problem is being obtained.

A study of the optimum speech band pass for maximum intelligibility will be made. This study will be based on a review of the technical literature as well as actual confirming tests. The information thus obtained will be used in setting up circuit performance specifications to achieve an optimum overall performance of the transmitter and receiver units.

PROGRAM FOR NEXT INTERVAL:

Final completion of the dark room and tunnel will be expedited. Construction of the vacuum range optical attenuator and the "find-operate" simulators should be completed, and the accessory equipment for use in performing the tests will be constructed. Further information will be obtained for study of the power source problem.

Report prepared by [redacted]

Report approved by

25X1

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APPENDIX

The two suggested possible communicator sizes were based on known performance of previously developed equipment. The Type W Hand Held Optical Telephone developed during World War II by the University of California under Contract OEMsr-1073, Project Control AC-226.03 was used as a starting point for performance calculations.

This unit had a transmitter beam of about 4 x 5 degrees using a 4-1/4" diameter mirror. The source was a 100 W tungsten lamp operating at a color temperature of 3400° K. Mechanical modulation by means of a vibrating mirror in conjunction with a grid mirror was used giving a modulation efficiency of 0.5. A type A thalofide cell was used in a 4-3/4" diameter mirror of 3" focal length. The resultant field of view was 10 x 10 degrees. The estimated ACW night range of this unit was 3 land miles.

The corresponding vacuum range may be calculated from the relation

$$R_{1.0}^2 = \frac{R_T^2}{T^{R_T}}$$

where $R_{1.0}$ is vacuum range in sea miles, R_T is operational range in sea miles for an atmospheric transmission factor of T per sea mile. For ACW the transmission is taken as 0.6 per sea mile. Thus,

$$R_{1.0}^2 = \frac{(3 \times .864)^2}{.6^{(3 \times .864)}} = 25.2$$

or, $R_{1.0} \simeq 5.0$ sea miles = 10,000 yards.

Similarly, if an ACW range of 6 land miles is required, the required vacuum range is about 39,000 yards; and for an ACW range of 10 miles, a vacuum range of 158,000 yards is needed.

For a first approximation in determining the size of the equipment required for these ranges, it was decided that the source brightness and modulation efficiency would be considered the same as the Type W as would the receiver sensitivity. The gain in range was to be achieved by increasing the area of the mirror for transmitting and receiving; the same mirror would be used for both functions.

Since vacuum range is proportional to the square root of the mirror area of either receiver or transmitter; when the same mirror is used for both functions, vacuum range is directly proportional to mirror area (assuming identical transceivers, communicating with one another).

For an ACW range of 6 miles, the new mirror diameter would be

$$D \simeq \sqrt{\frac{39{,}000 \times 4.75^2}{10{,}000}} = 9.4 \text{ inch.}$$

For an ACW range of 10 miles, the new mirror diameter would be

$$D \simeq \sqrt{\frac{158{,}000 \times 4.75^2}{10{,}000}} = 18.9 \text{ inch.}$$

It was estimated that with the much narrower beam width contemplated the power requirements for the source could be so reduced that the overall power requirements would be about 50 to 60 watts for the 6 mile unit and, because of possible larger modulator and larger source, 80 to 100 watts in the 10 mile unit.

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The size and weight estimates were as follows:

	6 Mile Unit	10 Mile Unit
Optics, electrical components	4 lbs.	12 lbs.
Case	5	12
Engine-generator	4	8
Accessories and miscellaneous	1	2
	14 lbs.	34 lbs.
Fuel for 9 hours	4 lbs.	8 lbs.
	18 lbs.	42 lbs.
Size	12" x 18" x 8"	18" x 24" x 10"

Since these estimates of range and size were based only on improvements resulting from use of single larger mirror instead of two and decreased beam width, any other improvements in receiver sensitivity, etc., may be expected to result in either decreased size and weight or increased range.

DW/t