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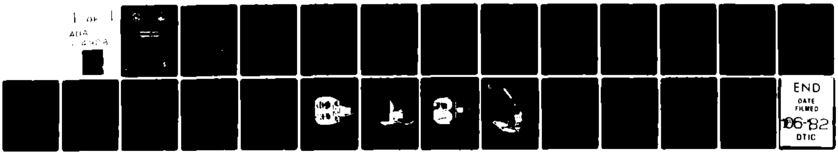

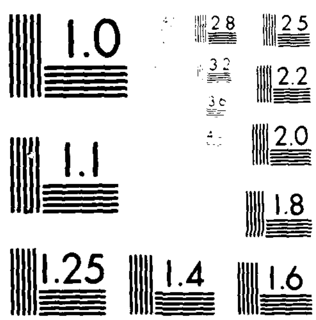

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INFRARED DATA COMMUNICATIONS

OPERATIONS ANALYSIS DEPARTMENT

NAVY FLEET MATERIAL SUPPORT OFFICE
Mechanicsburg, Pennsylvania 17055

Report 149

INFRARED DATA COMMUNICATIONS

REPORT 149

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ABSTRACT

This report provides an introduction to the technology of infrared data communications. The Navy is greatly increasing its use of distributed data processing techniques. Telephone lines are normally used to provide the required short range data communications between the host computer and remote terminals and other peripheral equipment. However, installation of additional telephone lines often involves delays, inconvenience and considerable expense. Infrared communications have proven to be an economical and reliable alternative technology for short range data communications requirements. Use of a single infrared communications unit at the Navy Fleet Material Support Office (FMSO) resulted in savings of approximately $90,000 during Fiscal Year 1980. Savings in subsequent years were similar, but not as large due to reduction in rate schedules.

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I. INTRODUCTION

Advances in communications technology coupled with an increased emphasis on distributed processing techniques have greatly increased the Navy's use of remote terminals and other peripheral Automated Data Processing (ADP) equipment located at a distance from the host computer. In most applications, telephone lines are normally used to provide short range communications between the host computer and remotely located terminals and other peripheral equipment. However, delays are frequently encountered in obtaining installation of telephone lines and considerable expense and inconvenience are often involved in installing telephone lines under existing buildings and roads. These problems have prompted the Navy to seek an alternative short range communications capability. The use of infrared communications has proven to be a viable alternative technology for providing the required data transmission capability. The Navy has been successfully using infrared communications for approximately five years. Infrared communications equipment is simple, easy to install, and has proven to be extremely reliable and virtually maintenance free.

II. BACKGROUND

The Navy Fleet Material Support Office (FMSO) became involved in the area of infrared communications technology in 1976 when a Research and Development (R&D) contract was entered into with the University of Colorado. The purpose of this contract was to investigate the potential application of infrared technology to the Navy's data communications requirements. Installation and evaluation of infrared communications equipment was planned in conjunction with the contract.

A prototype infrared communications system was installed at FMSO in August of 1977 by University of Colorado and Navy personnel. This system linked remote terminals located in the FMSO applications development offices to a BURROUGHS 4700 central processor located in an adjacent building. The distance involved is approximately 400 yards. The system consists of dual optical transceivers located on the tops of the two buildings. This system has been in successful use since initial implementation in 1977. Through multi-drop techniques, as many as 10 remote terminals located in the applications development offices have been in concurrent communication with the host central processor. A cost analysis conducted during the 1980 Fiscal Year indicated approximate annual savings of $90,000 resulting from this prototype installation.

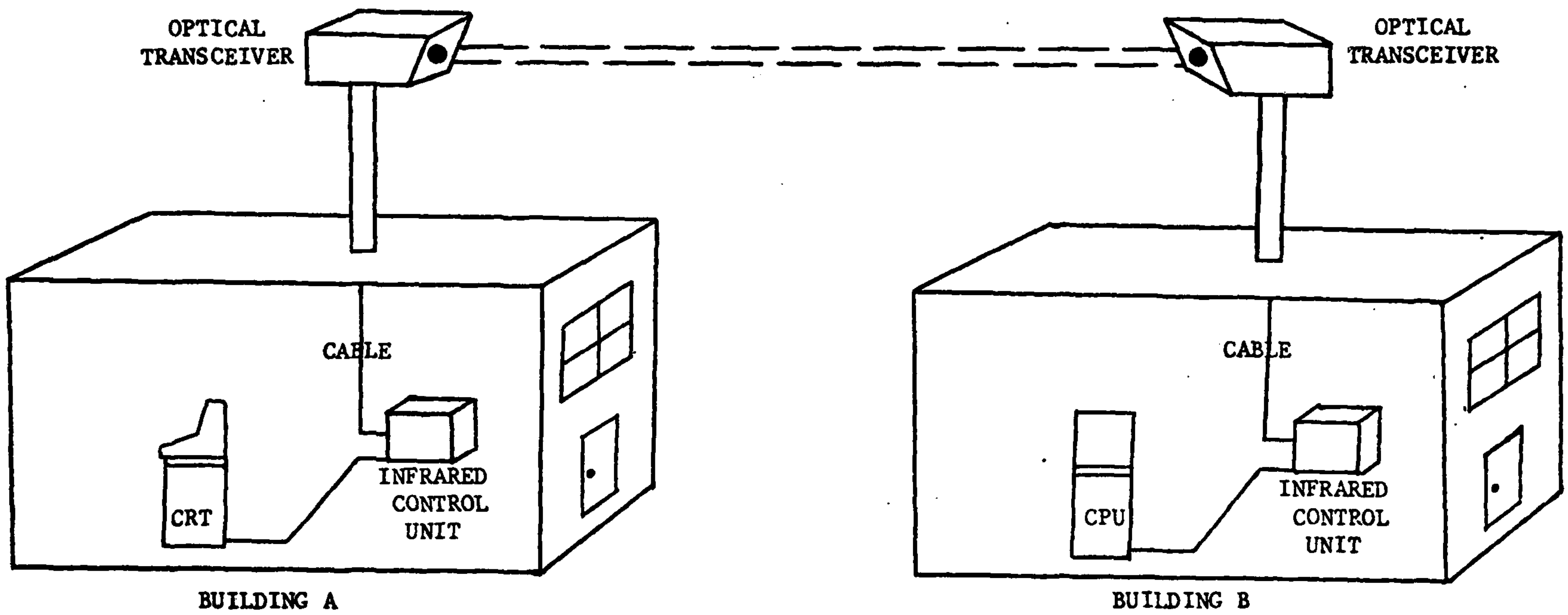
Based on the success of the prototype installation, in 1980 FMSO decided to initiate a procurement action for competitive acquisition of infrared communications equipment. Specifications were developed and advertised and proposals were received from three commercial firms. The equipment selected fully met the Navy's requirements for a reliable short range data communications capability. Since that time, FMSO has been involved in the implementation of additional infrared systems which were commercially acquired. Clearly, infrared communications is no longer a R&D experiment. Off the shelf commercial systems are now available to meet a variety of short range data communications requirements.

III. EQUIPMENT CHARACTERISTICS

Infrared communications is effected via an optical signal in the infrared range of the light spectrum which is transmitted through the atmosphere in a line of sight manner. Actual transmission of digital type computer data is accomplished through modulation of the infrared carrier signal. The carrier signal for Navy systems operates at a wavelength of approximately 9000 Angstroms. The infrared beam is generated by a light emitting diode and is incoherent in nature. The system does not employ lasers and does not present any type of health or radiation danger. Data transmission rates range from 1200 to 9600 baud for asynchronous transmission, and 1200, 2400, 4800, 9600, or 19,200 baud for synchronous transmission.

FIGURE 1 provides a graphic portrayal of the simplest type of infrared communications system. The FIGURE 1 system consists of dual optical transceivers located on the tops of two buildings housing ADP equipment between which communications is desired. The range of this system is approximately one mile. Current commercial cost of the system is less than $10,000. Complete specifications for a system of this type are provided as APPENDIX A.

One of the most important evaluation criteria utilized in the Navy acquisition of infrared equipment was ease of installation and maintenance. Installation of the system shown in FIGURE 1 can be accomplished in approximately one half day. No special skill in electronics is needed by the installer. The optical transceivers are physically mounted on the tops of the two buildings. Alignment of the transceivers is achieved by sighting through a telescope that has been bore-sited to the barrels of both the transmit and receive sides. The infrared control unit is installed either in a rack or self standing in the proximity of the ADP equipment. A cable approximately one fourth inch in diameter connects the optical transceiver to the control unit. After the system has been installed, a full system test can be performed within minutes. System loopback capabilities facilitate troubleshooting procedures which quickly identify failures in any of the infrared components. Normal maintenance practice is to replace the entire transceiver unit and return it to the vendor for repair in the case of any type of system failure.



BASIC INFRARED COMMUNICATION SYSTEM

FIGURE 1

IV. SUMMARY

Infrared communications have progressed from an experimental technique to a viable commercially available technology for short range data communications. The Navy Fleet Material Support Office is currently utilizing infrared communications at its offices in Mechanicsburg, Pennsylvania. FMSO has also assisted in the installation of infrared communications equipment at the Marine Corps Air Station, Cherry Point, North Carolina. Other installations of infrared equipment are planned. In all cases, infrared equipment has proven to be highly reliable.

The use of infrared communications equipment is recommended in any situation where installation of telephone lines may be inconvenient, expensive or precluded by some geographical constraint such as a body of water. Additional information or assistance regarding the use of infrared communications equipment can be obtained by contacting the author through the Operations Analysis Department of the Navy Fleet Material Support Office, Post Office Box 2010, Mechanicsburg, Pennyslvania 17055.

APPENDIX A

SPECIFICATION FOR AN:

INFRARED OPTICAL COMMUNICATIONS SYSTEM

APPENDIX A: SPECIFICATION FOR AN: INFRARED OPTICAL COMMUNICATION SYSTEM

1. Background/System Description.

a. The purpose of this system is to provide short range communications between various pieces of Automated Data Processing (ADP) equipment. The system is generally used to link remote terminals or other peripheral ADP equipment to a host computer, but it should also be capable of computer-to-computer linkage. The communication medium will be a digital signal emitted in the infrared range of the spectrum and transmitted through the atmosphere.

b. The system will consist of dual optical transceivers, control units and cables. One optical transceiver will be installed at each end of the communications link. The control units will be located in the proximity of the ADP equipment needing communications linkage. The cables will be used to connect an optical transceiver to its respective control unit.

c. These specifications are based upon a prototype system developed by the University of Colorado for the Navy Fleet Material Support Office, Mechanicsburg, Pennsylvania. The prototype is being used in an operational mode and the photographs in this specification are of the prototype system.

2. Optical Transceiver.

a. The optical transceiver is the component of the system which emits an infrared signal at one end of the communication link and receives infrared signals at the other end of the communication. The signal is emitted by a LED (Light Emitting Diode) installed behind an optical lens used to focus the infrared beam. The signal is received by a photosensitive element installed behind an optical lens used to collect the signal being transmitted by the other optical transceiver. The system must be capable of simultaneous transmitting and receiving, i.e., full duplex communication. The photographs in enclosure (1) show two different types of optical transceivers currently being used by the Navy.

b. Physical Characteristics. The dimensions of the optical transceiver (excluding the mounting bracket) should be less than nine inches in height, 16 inches in width and 20 inches in length. It must be sufficiently compact and capable of being moved from one installation site to another by one person; consequently, it must weigh less than 25 pounds. The casing in which the transmitting and receiving units are installed must be made of corrosion resistant material so as to withstand salt air and other corrosive atmospheric conditions. The casing must be covered with a brushed aluminum or stainless steel shield to protect the transceiver components from solar heat. The shield must extend sufficiently over the top of the casing to protect the optical lens from rain or snow. The base of the optical transceiver must contain a mounting bracket designed to screw directly onto a two inch diameter pipe with standard pipe threads. The cable connector on the optical transceiver must be placed in such a way as to allow the cable connecting the transceiver to the control unit to run through the two inch diameter pipe which will be used as a mounting mast. The optical transceiver will have an azimuth adjustment allowing 360 degrees of movement and elevation adjustment allowing 30 degrees of movement above and below the horizontal. A 4x (four power) riflescope must be permanently mounted in the casing parallel to the line of transmission of the light beam. This riflescope is required for the proper alignment of the transmitter and receiver units. The optical transceiver must be adequately sealed so as to prevent moisture from entering the unit and condensing on the optical lens or electronic parts. The optical transceiver must be constructed so it can withstand conditions of severe weather that can normally be expected in a roof top installation.

c. Performance Requirements. The optical transceiver must be capable of generating, emitting and receiving a digital signal in the infrared part of the light spectrum, i.e., 7800-10,000 Angstroms. Laser systems are not acceptable nor will any other device be accepted which may be harmful to the health and well being of persons that may pass through or be required to work in the light beam, as deemed unsafe by this organization. The range at which the optical transceiver must be capable of transmitting and receiving the infrared signal is one foot to one mile measured by line of sight. At these distances, the data transmission rates will be 1200 bps (bits per second), 2400 bps, 4800 bps, 9600 bps and 19,200 bps synchronously and up to 9600 bps asynchronously. The data error rate shall not exceed one error in every million bits (10^{-6} error rate). The system must have full operational capability under any weather conditions (i.e., rain, snow, fog, smog, etc.) as long as the naked eye visibility is equal to the distance between the two optical transceivers.

3. Control Unit.

a. The primary purposes of the control unit is to: (1) serve as a data set to interface with ADP equipment with the optical transceiver, (2) to generate and control digital signals going to and from the optical transceivers, (3) to furnish Automatic Gain Control (AGC) to the receiver part of the transceiver, and (4) to provide a power supply for the transceiver. The control unit will be designed to accept bits of data from ADP equipment, generate a signal to activate the LED in the optical transceiver, accept signals from the photo-sensitive element in the transceiver and produce bits of data as input to ADP equipment. Integral to the control unit are the electronic circuits, indicator lights and switches that are needed to test all of the functions of the system.

b. Physical Characteristics. The volume of the control unit should be less than 1.7 cubic feet. On the front of the unit and easily accessible will be the controls and indicator lights of the test circuits, and controls for adjusting the data transmission rates. At the rear of the control unit will be the electrical connections for the optical transceiver and the ADP equipment. The system will be required to interface with ADP equipment via Electronic Industries Association RS232 standards (see enclosure (2)) and the BURROUGHS two wire connection. The pins relating to the secondary send/receive circuits of the RS232C standard are not required. The control unit base and covering must be constructed so as to adequately protect the electronics and permit either rack mounting or stand alone installation. The control unit will be installed indoors and, therefore, does not need all weather protection.

c. Performance Requirements. The control unit will be a single channel system with adjustable data rates and asynchronous or synchronous transmissions at all speeds. The following features are required to be an integral part of the control unit.

(1) Data Rates. Must have a selector dial installed on the front of the unit which permits the selection of the following rates of data transmission: 1200 bps, 2400 bps, 4800 bps, 9600 bps and 19,200 bps.

(2) Mode of Transmission. Must be capable of asynchronous or synchronous transmission at all data rates.

(3) ADP Equipment Interface. EIA RS232C standard and the BURROUGHS wire connector as specified in enclosure (2).

(4) Strapping Options. The control unit must have the capability to have (a) the request-to-send/clear-to-send functions should be held active, (b) to select either an internal or external clock, and (c) to hold the data-set-ready function active at all times.

(5) Test Features. The control unit must have built in circuits to test the ability of the system to transmit and receive in both directions of the optical transceiver. Test circuits must be available to determine whether the system is operating properly and to identify any component of the system that is inoperative.

(6) Indicator Lights. Indicator lights will be installed on the control unit to show operational status of the system transmit clock, receive clock, transmit data, receive data, request-to-send, clear-to-send and data-set-ready functions.

(7) Voice Intercom. The control unit will include a telephone hand set and the capability to use the system as a voice intercom so that a person at each end of the system can communicate via the infrared light beam. This feature is required for aligning the optical transceivers and testing the system.

(8) Power Supply. Must be capable of furnishing not more than 24 volts DC power to the optical transceivers.

4. Cables.

a. The purpose of the cable is to electrically connect the control unit to the optical transceiver.

b. Physical Characteristics. The length of the cable will depend on the individual installation, but will be between 50 and 500 feet. The total cable diameter can not exceed 3/4 of an inch. All leads in the cable must be properly shielded to prevent cross talk and the introduction of extraneous signals into the system. The cable must be enclosed in a weatherproof covering. The electrical connectors at either end of the cable must be small enough so that they can easily slip through a two inch diameter pipe that will be used as a mounting mast for the optical transceiver. The connectors at the optical transceiver end of the cable must be weather tight. The cable must be flexible and easily coiled when installed.

c. Performance Requirements. Must be capable of carrying at least 24 volts DC power from the control unit to the optical transceiver. Must meet standards for Class II wiring.

Evaluation Criteria for Single Channel Infrared Communications System

1. The evaluation of proposals received on the single channel infrared system will be based upon the following mandatory performance requirements.

a. System must be full duplex.

b. Optical transceiver must be weatherproof for outdoor installation.

c. Optical transceiver must have 360 degree aximuth adjustment and 30 degrees above and below horizontal elevation adjustment.

d. Optical transceiver must have an optical alignment system for easy installation.

e. System must be able to transmit/receive synchronously at data rates of 1.2, 2.4, 4.8, 9.6, 19.2 kilobits per second and asynchronously at 1.2, 2.4, 4.8, 9.6 kilobits per second.

f. System must have full self test capabilities built into the units.

g. System must have telephone intercom to be used while testing or installing.

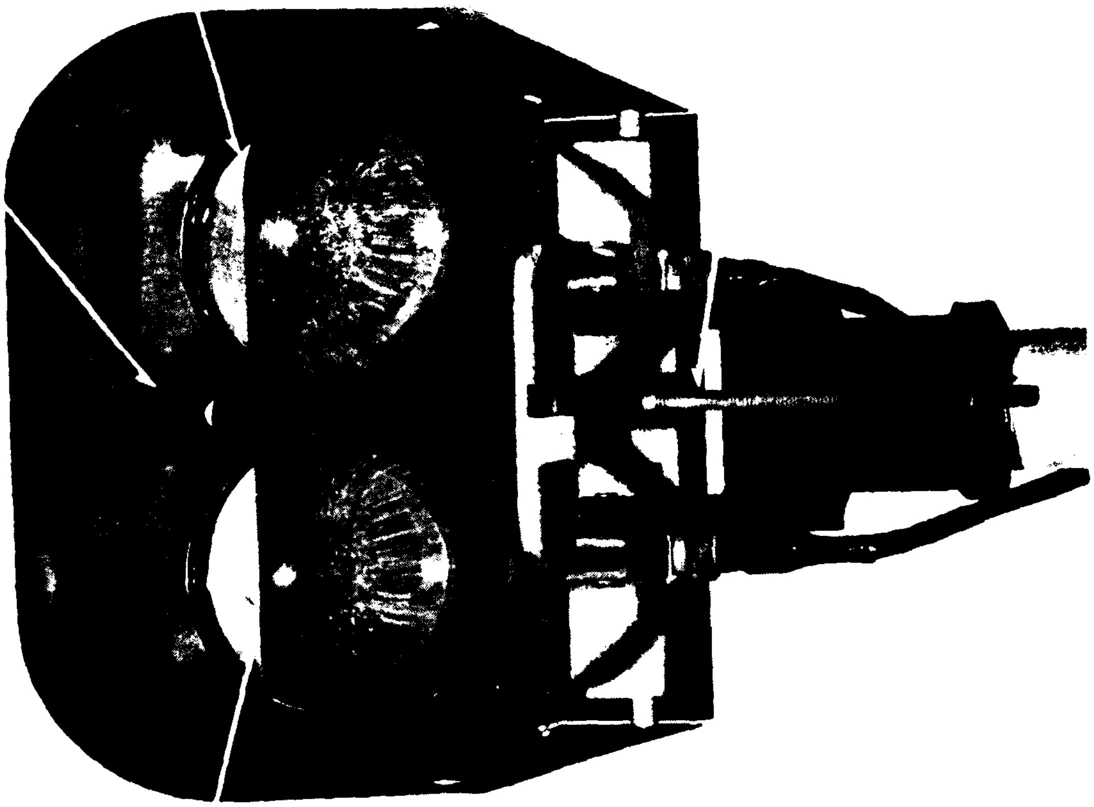
h. System must have a range up to one mile in distance.

i. System must comply with EIA RS232C standards for equipment interface and must have option for BURROUGHS two wire interface.

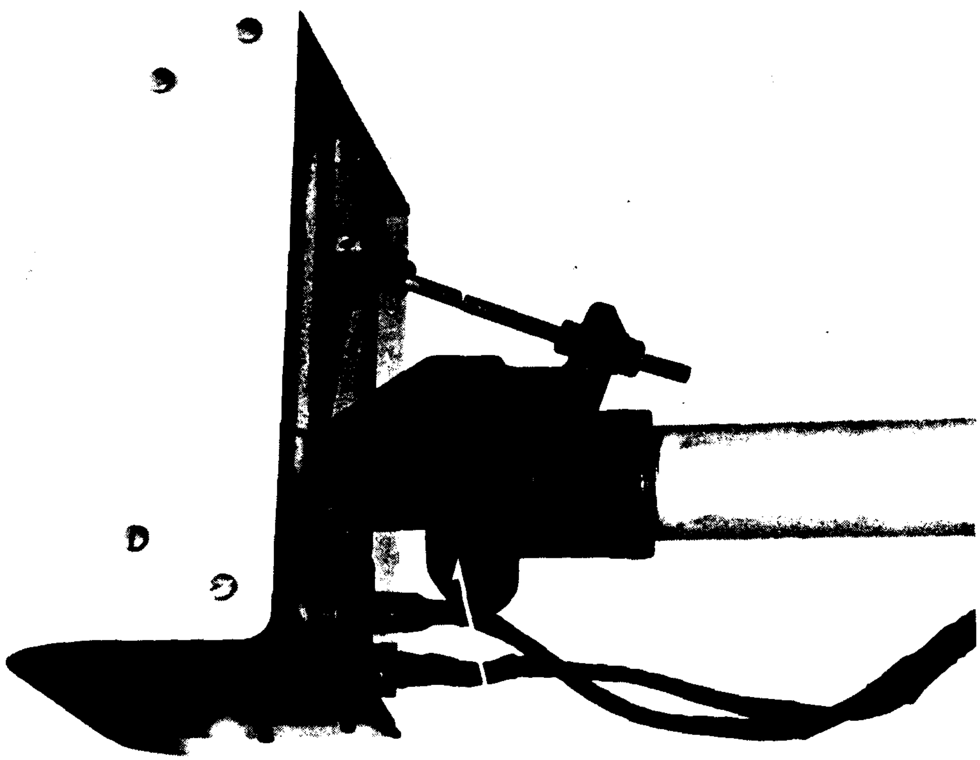
j. System must meet Class II electrical installation specifications for connecting the optical transceiver to the control unit.

k. Must have system status indicator lights indicating conditions of transmit clock, receive clock, transmit data, receive data, request-to-send, clear-to-send and power on/off.

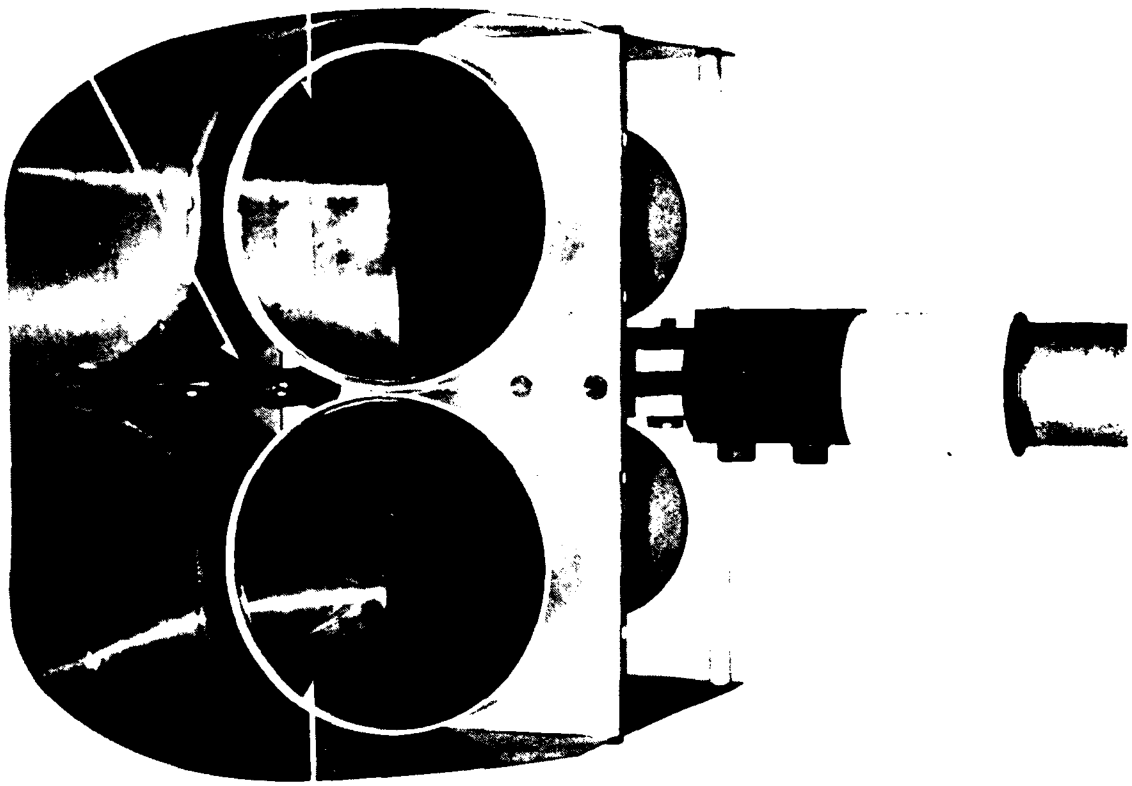
2. In addition to the above mandatory requirements, consideration will be given to design enhancements, technical improvements and maintenance/reliability features.



Enclosure (1) to
APPENDIX A



Enclosure (1
APPENDIX A



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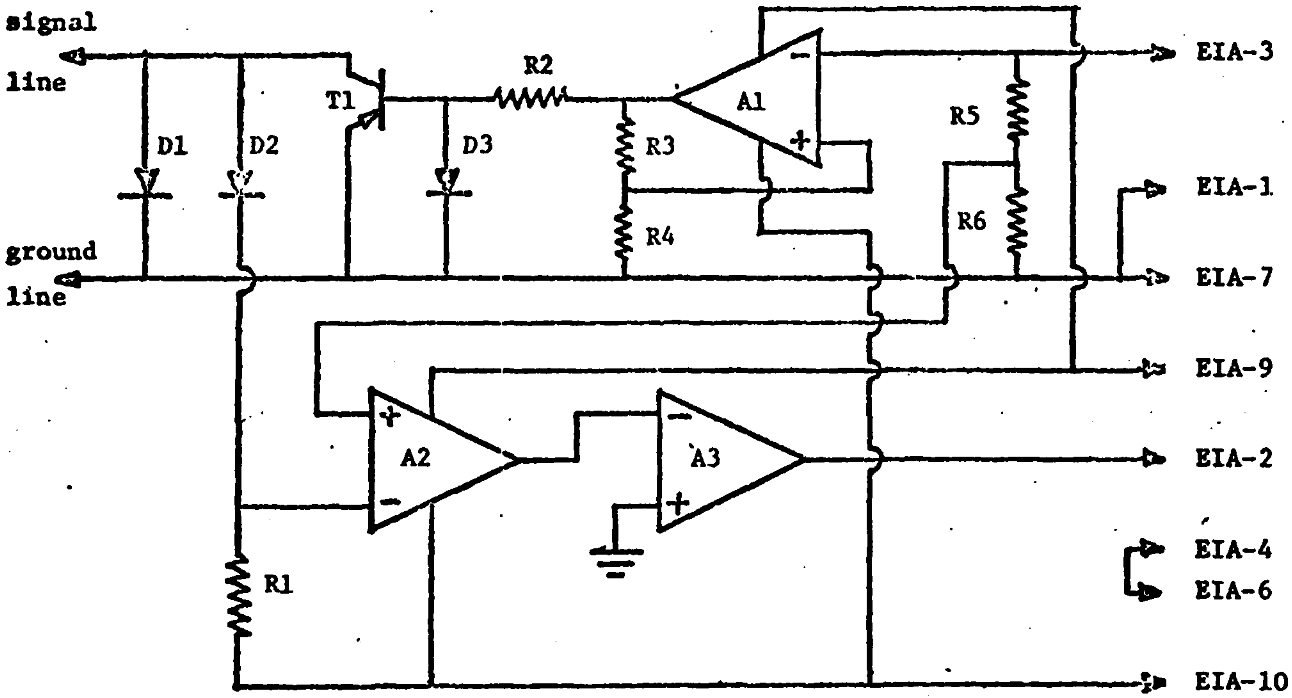

A1	748TC
A2	748TC
A3	748TC
D1	1N914
D2	1N914
D3	1N914
T1	2N2904
R1	5.6 KΩ on local loop 390 Ω 1/2 watt on remote loop
R2	10 KΩ
R3	8.2 KΩ
R4	3.3 KΩ
R5	2.2 KΩ
R6	2.2 KΩ

EIA-1	case ground
EIA-2	xmit data to data set
EIA-3	receive data from data set
EIA-4	request to send
EIA-6	data set ready
EIA-7	signal ground
EIA-9	+12 volt supply from data set
EIA-10	-12 volt supply from data set

Figure 2

Burroughs TDI-1 to RS-232 Interface Adapter

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13. ABSTRACT

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