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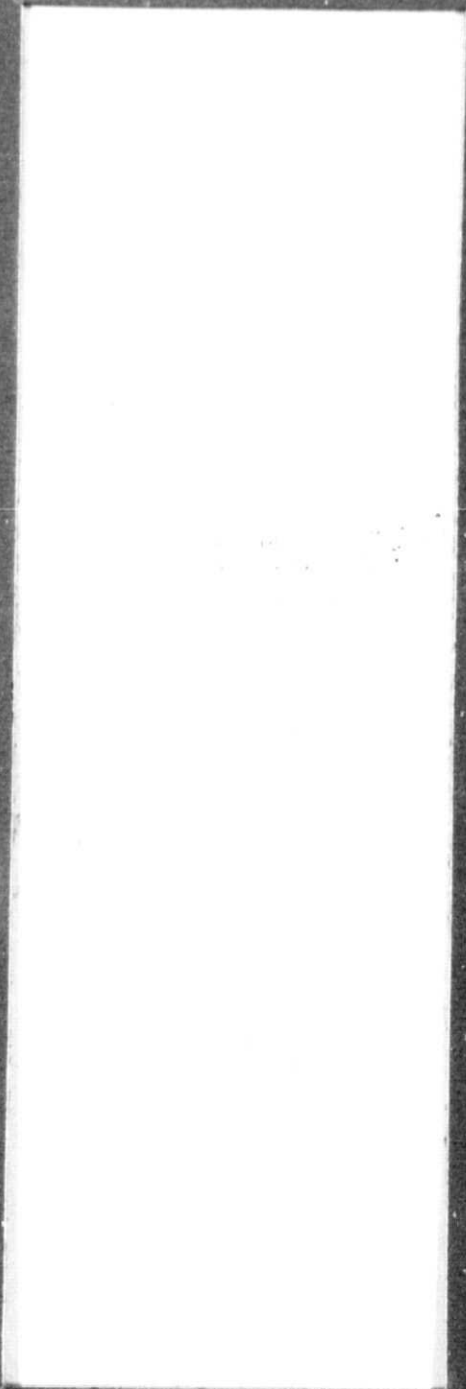
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**Flight Systems
Division**

MULTIPURPOSE PANEL
DISPLAY DEVICE
INVESTIGATION

FINAL REPORT

PREPARED FOR:
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ADMINISTRATION

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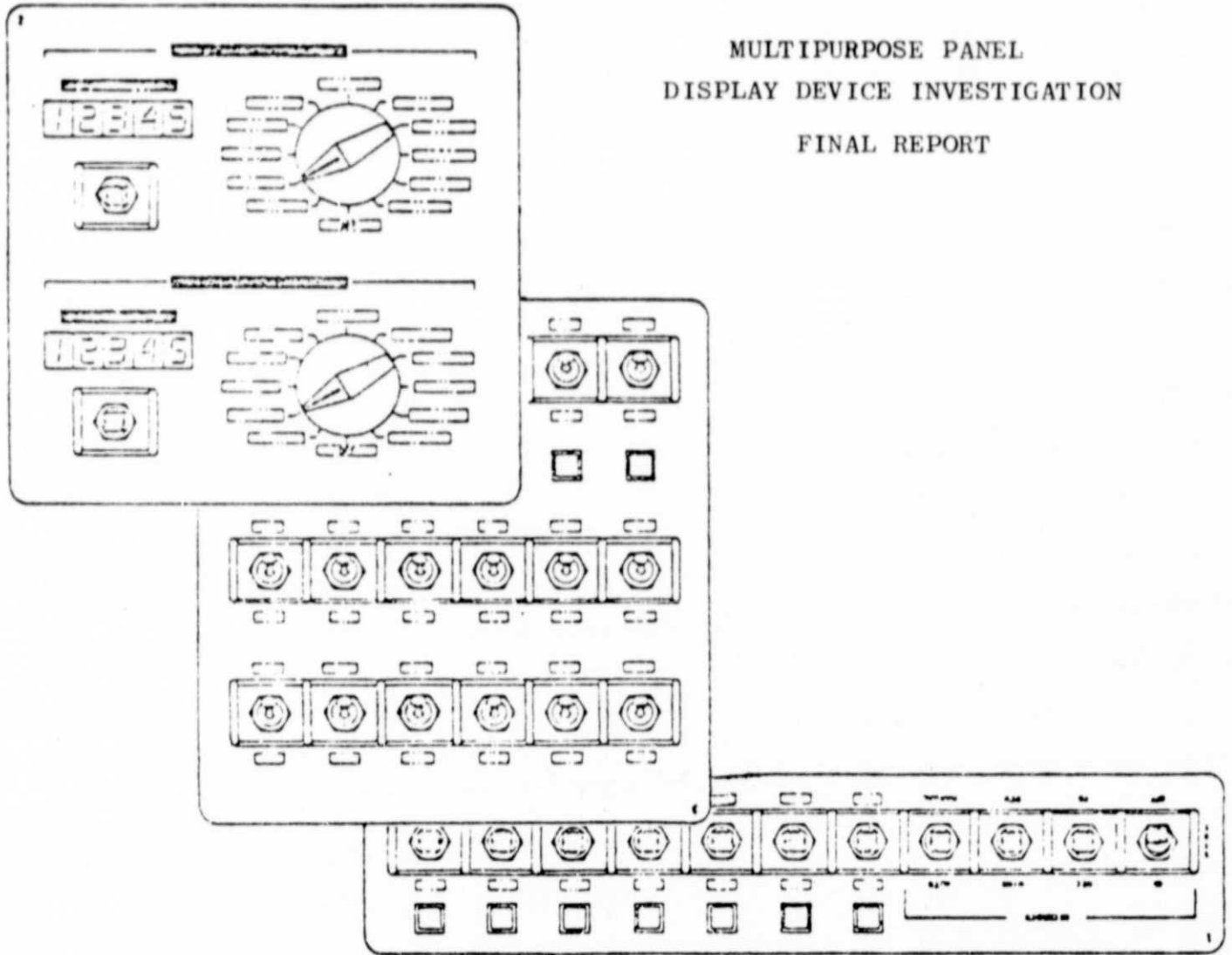
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MULTIPURPOSE PANEL
DISPLAY DEVICE INVESTIGATION
FINAL REPORT



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ABSTRACT

This report documents the results of a study to investigate display devices with the purpose of finding a device to replace the light emitting diode (LED) displays presently used in the Multi-purpose Panel. It is submitted to the Marshall Space Flight Center by the Bendix Corporation, Flight Systems Division in compliance with the report requirements of Contract NAS8-32361.

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SECTION 1
INTRODUCTION

1.1 BACKGROUND

The Multipurpose Panel, developed for Marshall Space Flight Center under Contract NAS8-31286, provides a flexible control and display panel with easily changeable nomenclature. The nomenclature is displayed by LED devices controlled by a stored program (PROM) within the panel. The Multipurpose Panel is useful in applications where panel space is limited, but a number of similar subsystems must be controlled, or where basic panel nomenclature and functions must be changed rapidly, as in the case of between mission changes of Space Shuttle payloads. In the first application, panel area limitations are overcome by time sharing a central control panel among several subsystems. In the latter case, entire control panel changes are effected by simply replacing a memory module, thereby reducing the extent of installation and checkout procedures between missions. A photograph of the panel is given in Figure 1.

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MULTIPURPOSE PANEL

FIGURE 1

1.2 PURPOSE

The purpose of this investigation is to find, if possible, a suitable replacement for the LED display currently employed on the Multipurpose Panel. If there is no device currently available, which offers substantial improvement over LED display, the investigation will include promising devices undergoing laboratory development.

The criteria for evaluation include the following:

1. High brightness to Control Station.
2. Visible under both high and low ambient lighting conditions.
3. Low power dissipation per character.
4. Full alphanumeric capability.
5. Character heights of 1/4" and 1/8".
6. Small package size consistent with character height.
7. Availability considering both procurement time and cost.

SECTION 2
INVESTIGATION

2.1 BACKGROUND MATERIAL

Before querying individual manufacturers on their specific products, a literature search was performed. A bibliography of the literature researched is found in Appendix 1.

The investigation yielded several types of display technologies (other than LED's) which had possible potential in meeting several of the previously mentioned criteria. They are:

1. Incandescent
 - a) Direct view
 - b) Piped light - fiber optic
2. Gas Discharge
 - a) Plasma panels
 - b) Individual characters
3. Liquid crystal

In addition, the following technologies are presently in the laboratory development stage, however it will be some years before they are commercially available.

1. Colloidal light valve
2. Electrochromic display
3. Moving foil display
4. PLZT display
5. Electrophoretic display

- 6. Elastomer display
- 7. Plated silver electrode display

These displays make the presentation of alphanumeric characters in the form of sixteen segments. In most cases, these segments overlap to produce a pleasing display. Typical display patterns are illustrated in Figure 2.

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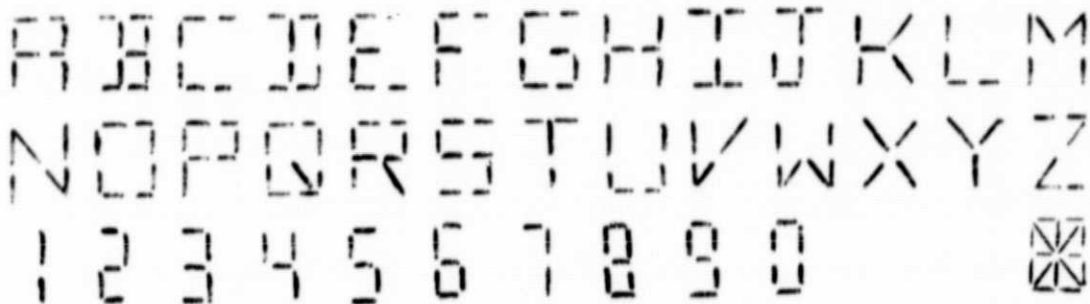


FIGURE 2
TYPICAL DISPLAY PATTERNS

2.2 MANUFACTURER CONTACT

Next, manufacturers representative of the various technologies were contacted for product information and demonstrations:

<u>Manufacturer</u>	<u>Technology</u>
Beckman Instruments, Inc. Information Displays Operation 350 North Hayden Road P. O. Box 3579 Scottsdale, Arizona 85257	Gas Discharge
Burroughs Corporation Electronic Components Division P. O. Box 1226 Plainfield, New Jersey	Gas Discharge, Plasma Panel
Chicago Miniature Drake Manufacturing Co. 4433 N. Ravenswood Ave. Chicago, Illinois 60640	No Alphanumeric
Digital Electronics Corp. 2126 Sixth St. Berkeley, California 94710	Fluorescent
Hamlin Incorporated Lake and Grove Streets Lake Mills, Wisconsin 53551	Liquid Crystal Display
Industrial Electronic Engineers, Inc 7740 Lemona Ave. Van Nuys, California 91405	Incandescent Liquid Crystal Display Plasma
Itek Corporation Applied Technology Division 645 Almanor Ave. Sunnyvale, California 94086	Liquid Crystal Display
National Electronics Varian Division Geneva, Illinois 60134	Out of Plasma Panel Business

Manufacturer

Owens Illinois
Electro/Optical Display Operations
Toledo, Ohio 43666

REFAC Electronics Corporation
P. O. Box 809
Winstead, Connecticut 06098

Wagner Electric Corp.
Tungsol Division
1006 Misty Lane
Parsippany

Technology

Selling Plasma Panel
Business

Incandescent

Incandescent

SECTION 3
EVALUATION

3.1 COMMERCIALY AVAILABLE DEVICES

3.1.1 Incandescent Displays

No manufacturer at this time offers an 1/8" alphanumeric display. In the direct view type, REFAC Electronics currently manufactures an alphanumeric display with 1/4" character height and seven segment numeric display with 3/16" character height. In addition, a 3/16" alphanumeric display has been designed, but is not in production. If this design is ultimately selected, a tooling charge would have to be paid.

Displays using "piped" light are available with a 1/4" minimum height. A unit, manufactured by IEE, uses a fiber optic light pipe with three light dots for each of sixteen segments, See Figure 3.

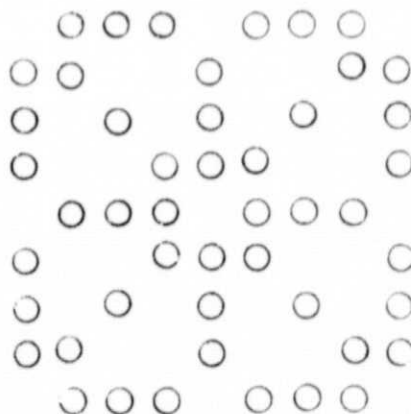


FIGURE 3
IEE SIXTEEN SEGMENT FORMAT

A display made by Tungsol is slightly larger (.32" in character height). In this unit the light is piped with plastic wedges to form bar segments as shown in Figure 1. At this time, Tungsol is not working or planning to work on a smaller alphanumeric display.

The high intensity white light of incandescent displays allows filtering to any desired color and to improve contrast ratio.

A comparison of the capabilities of incandescent displays with the requirements in the statement of work is given below:

1. High Brightness to Control Station

Incandescent displays can provide a brightness up to 9000 F.L. This is more than adequate in any controlled environment situation.

2. Visible in High Ambient Lighting Conditions

Incandescent displays are capable of being read in direct sunlight. Two methods are employed to accomplish this. One is brute force, lamp filament brightness is increased until it is readable. The other method makes use of contrast enhancement filters to reduce surface and internal reflections allowing greater differentiation between lit and unlit segments.

3. Visible in Very Low or Dark Ambient Conditions

Brightness of incandescent displays is easily controlled by reducing the filament voltage. This type of operation produces the need for a dimming control, either fixed steps or continuously variable.

4. Low Power

The incandescent are not low power devices, consuming between 3/4 to 1 - 1/2 watts per character with all segments lit. The direct view type consumes the least power (equivalent to an LED display) and the piped light display consuming approximately twice as much power.

5. Full Alphanumeric Capability

Displays with full alphanumeric capability are in the minority. The majority are numeric only, for use with calculators and wrist watches and these devices do not use the high power incandescent readouts. The devices selected have full alphanumeric capability in the form of a 16 segment display. The segments consist of the direct view incandescent wire filament, three dot fiber optic segment, or bar segment plastic light pipe.

6. Standard Character Height 1/4" and 1/8"

Two manufacturers were found who produce 1/4" displays, REFAC and IEE. In addition, REFAC can produce a 3/16" character height unit if an initial tooling charge is paid. No manufacturer was found who could or would produce a 1/8" display.

7. Minimum Package Size

For a REFAC 1/4" display, the package dimensions are 0.375" H x 0.335" W x 0.312" D. An IEE 1/4" display is 0.5" H x 0.4" W x 1.0" D. The REFAC 3/16" display is approximately 0.305" H x 0.272" W x 0.312" D.

8. Availability

The 3/16" REFAC display is available after lead time for tooling. The others are off-the-shelf items.

3.1.2 Gas Discharge Displays

3.1.2.1 Plasma Panels

These panels, as manufactured by Burroughs, IEE, and Owens-Illinois, are not suitable for displays only a few characters in length. They are made as an alternate to the CRT display. Other features which make this display unusable or undesirable are the large package height with respect to character size (1" for single line 1/4" characters) and the high power supply voltage (250 V).

3.1.2.2 Individual Characters

This display is a fourteen segment gas discharge type where all the segments are in a single plane. The appearance of the lighted characters is pleasing. Unfortunately, the smallest alphanumeric character height is 0.55 inches with two characters in a unit 1.120" H x 1.062" W x 0.255" D, which is too large for this application. This unit is made by Beckman Instruments.

3.1.3 Liquid Crystal Displays (LCD)

Liquid crystal displays come in a variety of form factors, individual character, string of characters in a strip and a custom panel. The individual character displays as typified by Hamlin, Inc. have a minimum character height of 1" and a package size 1.75" high which preclude their use. Because manufacturers find LCDs difficult to multiplex, one electrical connection must be made for each segment in the display.

On the multipurpose panel, the display around the rotary switch contains five groups of eight characters, with fourteen segments per character for a total of five hundred and sixty pin connections. Spacing of connections with a 0.050" pitch yields 28" of lineal periphery on the panel. This clearly will not fit in the area available.

In an effort to alleviate the pin limited packaging of these displays, Applied Technology (Division of Itek Corporation) has packaged CMOS integrated circuits chips integral with the LCD assembly. These integrated circuits accept serial clock and data, latch the data, and provide an output to each segment.

A comparison of the capabilities of this liquid crystal display with the requirements in the statement of work is given below:

1. High Brightness to Control Station

The LCD relies on reflected light rather than emitted light. In a controlled environment situation, the brightness which is a function of the ambient light, will be adequate for easy readability.

2. Visible in high ambient lighting conditions

The contrast ratio of 20:1 ensures readability in high ambient lighting conditions.

3. Visible in very low or dark ambient conditions

LCD's are not visible in dark ambient conditions. To resolve the problem, this device includes lamps and light traps to provide sufficient light for readability.

4. Low power

The average power per character is 25 microwatts. This does not include heater power when the temperature falls below +5°C or the lamp power under dark conditions.

5. Full alpha numeric capability

The display consists of eight, fourteen segment starburst characters capable of full alpha numeric capability.

6. Standard character height 1/4" and 1/8"

At present, only the standard character height of 5/16" is available. Special units with character heights of 1/4" and 1/8" can be built with a tooling charge of approximately \$50,000. A large part of this is for re-packaging the CMOS electronics packaged integrally with the display. The display is not sold without the electronics.

7. Minimum package size

The package size for the standard 5/16" character height unit is 0.6" H X 3.08" W X 1.0" P.

8. Availability

The standard 5/16" character height unit is available in eight weeks. The special units would require a design and fabricate lead time of about six months.

3.2 DEVICES IN LABORATORY DEVELOPMENT

Contact with Mr. George W. Goodrich of Bendix Research Labs produced the opinion that most of the previously mentioned devices now in the laboratory development stage had little potential of becoming commercially available. The exceptions to this are the colloidal light valve and the plated segment display. Mr. Goodrich and Mr. G. H. Azarbayejani recently completed a study on digital displays (Reference 15).

3.2.1 Colloidal Light Valve

This device is similar in structure to the LCD with a different material for the liquid crystal (Reference 15, section 2.7). It is felt that this device has a greater potential than the LCD for overcoming temperature and multiplexing problems. Owens Illinois Research Center and Frontier Research Inc. have been working on this type of display recently. It is predicted that a practical device will be available in one and a half to two years.

3.2.2 Plated Segment Display

An additional device which may have potential is being developed by the French Atomic Agency's Laboratory for Electronic and Computer Technology. It consists of electrolytic cells wherein a silver solution is plated on an electrode to produce a reflective segment. The duration of the display is 10 minutes at which time the character must be refreshed. If it is desired to erase the character, the action is reversible. The description appeared in: *Technical Insights*, 60 E. 42nd St., New York (212) 687-4185.

3.3 SUMMARY

The characteristics of the representative display technologies are summarized in Table I. The LED displays are included as a basis of comparison. The 0.147" LED used on the panel (HP 5082-5661) is no longer being manufactured. The characteristics of a similar device (HDSP-2000) is included instead. These two devices do not have 1/4 and 1/8 inch high characters, however, the 0.27 and 0.147 inch heights are very close approximations.

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TECHNOLOGY	INCAND. DIR. VIEW	INCAND. PIPED LIGHT	LCD	INCAND. FILTER OPTIC	LED	LED
MANUFACTURER	REFAC	TUNGSOL	APPLIED TECHNOLOGY	IEE	H.P.	H.P.
PART NO.	0-45	-	LCD 100-8	Series 2409	Series 3092	HDSP-200
HIGH BRIGHTNESS TO CONTROL STATION	YES	YES	YES	YES	YES	YES
VISIBLE IN HIGH AMBIENT	YES	YES	YES	YES	NO	NO
VISIBLE IN DARK AMBIENT	YES	YES	WITH AUX. LAMPS	YES	YES	YES
LOW POWER (7 SEC. ON) CHAR	420 mw	630 mw	25* w/o LAMPS	700 mw	140 mw	225 mw
FULL ALPHA NUMERIC	YES	YES	YES	YES	YES	YES
CHARACTER HEIGHT	1/4"	5/16"	5/16"	1/4"	.270	.146
1/4 INCH	AVAIL.	NOT AVAIL.	SPEC. ORDER	AVAIL.	AVAIL.	AVAIL.
1/8 INCH	3/16" AVAIL ON SPEC. ORDER	NOT AVAIL.	SPEC. ORDER	NOT AVAIL.	-	-
MINIMUM PKG SIZE HxWxD	.375"x.335"x.312	.615x.297x1.35	600"x3.08"x1.00"	.5x.4x1	.6x1.3x.3	.31x.7x.3
NO. OF CHARACTER IN ASSEMBLY	1	1	3	1	5	4
AVAILABILITY/PRICE(CATALOG ITEM OR TIME)	CAT./\$35	CAT./\$100	CAT./\$400	CAT./\$115	CAT./\$90	CAT./\$33
RECOMMENDED FOR REPLACING LED DISPLAY	NO- HIGH POWER NO 1/8" CHAR	NO- HIGH POWER HIGH PRICE LARGE PKG NO 1/8" CHAR	NO- WOULD HAVE TO DEVELOP NEW UNIT	NO- HIGH POWER NO 1/8" CHAR	-	-

DEVICE COMPARISON
TABLE 1

SECTION 4
CONCLUSION

4.1 GENERAL

At the present time, there is no device sufficiently superior to the present LED display to warrant recommending it's replacement.

The incandescent displays do not have a 1/8" character and have too high a power consumption.

The gas discharge displays have too large a package size to incorporate in the panel.

The LCD in the form of individual characters or panels have too large a package size to incorporate in the Multipurpose Panel. Applied Technology's "DynascotTM" display comes close to being a substitute, however, at present, it is only available with characters 5/16" high with a package height of 0.600". This is not suitable for panel mounting. A special design with the desired 1/8" character height would entail approximately \$50,000 development charges and take approximately four to six months without complete assurance in the success of the endeavor. Therefore, this approach is also not recommended.

Of the devices in the laboratory stage which show promise of being commercially available in the future their status is such that they are not presently available for this project.

SECTION 5
RECOMMENDATIONS

5.1 GENERAL

While at this time there are no display devices which meet the criteria established as a prerequisite for modifying the existing Multipurpose Panel, it is felt that several devices now in the laboratory stage merit further observance.

The two devices specifically warranting observance are the collodal light valve and the plated segment display. These devices will be reaching a stage of practicality within about one year. It is recommended this study be continued at that time to take advantage of advanced technology.

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