SAND79-0186
Unlimited Release

COMMERCIALLY AVAILABLE VIDEO MOTION DETECTORS

DEPARTMENT 1730

Sandia Laboratories

SAND79-0186
Unlimited Release
Printed January 1979

COMMERCIALLY AVAILABLE VIDEO MOTION DETECTORS

Information Systems Department 1730
Sandia Laboratories
Albuquerque, NM 87185

ABSTRACT

A market survey of commercially available video motion detection systems was conducted by the Intrusion Detection Systems Technology Division of Sandia Laboratories. The information obtained from this survey is summarized in this report. The cutoff date for this information is May 1978. A list of commercially available video motion detection systems is appended.

ACKNOWLEDGMENTS

Technical inputs to this report were made by J. D. Williams, F. L. Schow, D. E. McGovern, and P. M. VanPraag, all of Sandia Laboratories. The material in the Principles of Operation section draws heavily on the document listed as Reference 2; additional material submitted by manufacturers of video motion detectors is mentioned in References 3 through 10.

CONTENTS

	Page
Introduction	7
General	7
Principles of Operation	8
Analog Techniques	8
Digital Techniques	9
Special Features	9
Multicamera Monitoring	9
Video Monitoring	10
Sensitized Areas	10
Alarms	10
Other Special Features	10
Performance	10
Detection Capability	11
False/Nuisance Alarms	11
Commercially Available Equipment	11
References	12
APPENDIX A -- Letter of Inquiry and Questionnaire	15
APPENDIX B -- Summary of Video Motion Detector Specifications and Capabilities	21
APPENDIX C -- List of Manufacturers	25

TABLES

Table		
B-I	Specifications for Video Motion Detectors	23
B-II	Video Motion Detector Features	24

COMMERCIALLY AVAILABLE VIDEO MOTION DETECTORS

Introduction

The Intrusion Detection Systems Technology Division of Sandia Laboratories, Albuquerque, New Mexico, funded by the U.S. Department of Energy, Office of Safeguards and Security, has conducted a market survey of commercially available video motion detection systems. For the survey, questionnaires were mailed to a number of video motion detector (VMD) manufacturers. A sample of the questionnaires is included in Appendix A. Although a concerted effort was made to identify and contact all of the known manufacturers of VMD systems, undoubtedly some companies were omitted from this survey. In addition, some manufacturers either did not respond to the questionnaire or provided only minimal data regarding their product.

The results of the survey are summarized in this report. The main purpose of this report is to provide security personnel with insight into the types of equipment currently available, the capabilities and limitations of this equipment, and a list of sources for obtaining further information about the equipment. The cutoff date for the information contained in this report was May 1978.

General

The potential threat of terrorists or other malcontents to steal valuable material from, or sabotage, public or privately owned facilities has brought about an increased interest in physical security. To improve physical security, greater emphasis is being placed on the type of security equipment used. The use of security equipment for military applications alone is expected to increase from the present $78 million per year to over $300 million per year by 1983.[1]

An essential function of every physical security system is the early detection and assessment of any unauthorized activity. As it is used in this report, assessment is defined as the means of determination of the cause of an alarm. The state of the art in sensor technology is presently not sufficiently advanced to allow adequate assessment without visual inspection. This inspection can be done with roving patrols, guards located in guard towers, quick response guards, or closed-circuit television (CCTV). Because of the costs associated with the use of guards for continuous coverage, the use of CCTV has become widespread. Since most video motion detectors can be added to conventional CCTV systems, a better understanding of the capabilities and limitations of these systems is needed before they are incorporated into existing physical security systems. The following sections describe the operational principles of video motion detectors and summarize the specifications and features of several commercially available systems.

Principles of Operation[2]

Video motion detection systems are based on the detection of a change in t' video signals from all or part of the field-of-view* of the imaging system being used. A picture frame or sections of it are temporarily stored as a reference and then compared with a subsequent sample frame. Changes in the brightness or contrast with respect to time are used for detection. These changes are detected through continuous comparison of the video signal samples to the reference. If any changes occur, the difference between the two signals is recorded, and, when this difference exceeds a threshold, an alarm is activated.

The reference signal is continuously updated to prevent slow changes in the scene illumination from producing an alarm. Environmental factors such as rain, fog, or snow can cause false/nuisance alarms. In addition, rapid changes in the illumination level or electrical interference (60-Hz noise, transients, etc.) can also cause false/nuisance alarms.

The major differences among the video motion detectors are the methods of processing and recording the video signals. Analog techniques and digital techniques are the principal approaches used to provide signal processing.

There are three basic categories of VMD devices. The first category uses either a video disk recorder or digital memories to store entire video frames. Comparisons are made using entire TV frames for both the reference and sample signals. The second category of equipment compares only certain sections of the TV frame with identical sections of a subsequent frame. The size and position of these sections are usually adjustable. Video storage requirements are substantially reduced for this category of equipment. The third category compares video amplitudes obtained at either fixed or adjustable small sample positions.

Analog Techniques

Analog techniques commonly used for video processing include fine grain or detailed processing and processing of integrated video signals. For fine grain processing, each frame of a TV picture is recorded on a magnetic disk or tape. A line-by-line comparison is then made between the recorded video data and sample video signals from the camera. Up to 30 or more video frames are often compared to the stored reference frame before an alarm is generated. This procedure prevents false alarms caused by a momentary burst of electrical interference. Gradual variations in scene illumination can be compensated for by frequent updating of the reference signals and by the use of automatic light control circuitry in the TV camera system.

Integrated signal processing techniques rely on a comparison of an integrated video signal of a whole or a part of a TV frame with a reference signal. The reference signal is also integrated and recorded during quiescent periods. The

*The viewing area or field-of-view is determined by the focal length of the lens used.

total energy of each sampled integrated signal is compared with the total integrated energy of the reference. A significant (preset) total energy change of the sampled signal from the reference signal will cause an alarm to be activated. To prevent slow changes in normal illumination from causing an alarm, the reference signal is continuously updated to reflect the trend of the change.

Digital Techniques

Video motion detectors which use digital techniques function on the same basic principle as those using analog techniques. Video analog signals are converted to digital signals for processing, recording, and comparison. Typically, digital detectors use several small fixed spots evenly distributed over the field of view. These points (spots) are continuously sampled, monitored, and compared. Any significant change in the video level of one or more points (number of points selectable) per time interval (preset or selectable) will activate an alarm.

Reference signals from each point are digitized and normally are stored in random access memories (RAMs) or registers by four-bit code numbers. The code numbers represent the signal level of the spot. The reference signals undergo a continuous update to accommodate change in signal illumination. The update prevents the equipment from registering false alarms for normal changes in illumination.

Special Features

There are certain special features incorporated into many of the VMDs which serve to enhance the equipment's adaptability and utility. It is not uncommon to find all or some of these special features incorporated into commercially available equipment. The most desirable special features in a VMD include

1. Multicamera monitoring,
2. Video monitoring,
3. Sensitized areas, and
4. Alarms.

Multicamera Monitoring

In most security systems utilizing CCTV, more than one camera is necessary to give adequate coverage. Since most VMDs will provide a multicamera monitoring feature, a separate VMD for each camera is usually unnecessary. Both automatic and manual switching controls are available. In the automatic mode, camera sequential switching is often accomplished on a time-sharing plan. The order of electronically switching cameras is internally controlled by the VMD equipment, but camera hookups control the physical sequencing. The manual switching mode allows an operator to select, at random, any camera desired. Commercially available VMD systems can accommodate from 1 to 50 cameras.

Video Monitoring

A feature which allows video monitoring of the area under surveillance is incorporated into most VMDs, although such a feature is not a necessary part of the equipment. Any standard video receiver/display may be used. When more than one camera is used, automatic or manual switching displays are available.

Sensitized Areas

All CCTV systems use a field-of-view which has a vertical to horizontal ratio of 3:4. The area of the field-of-view is determined by the focal length of the lens. In some cases, surveillance of the entire area of the field-of-view is unnecessary and, for this reason, VMDs may possess the ability to provide a sensitized area which is less than the field-of-view. To adapt to special security problems, various shapes may be selected for the sensitized areas. Among the various shapes that can be sensitized are "L"s, "C"s, "U"s, rectangles, and squares. Normally, the size of all shapes except squares is predetermined by the equipment according to a percentage of the field-of-view. Square sensitized areas in all equipment and the various other shapes available in some selected systems can be adjusted manually from a minimum of 5 percent to 100 percent of the field-of-view. In addition, certain VMDs may provide a feature which allows detection of movement into or out of a sensitized area while it excludes motion within the sensitized area and the remainder of the field-of-view.

Alarms

All VMD systems incorporate an alarm feature that is audio, video, or both. The audio alarm is normally a two-tone, one-octave, low-frequency signal. The visual alarm is either a steady or a flashing red light. In some systems, when detection occurs and the area is being visually monitored, the sensitized area may flash on and off.

Other Special Features

Other special features which may be or already have been incorporated into some VMD systems are listed below:

1. Zoom, iris, and focus control,
2. Remote pan and tilt control,
3. Time and date generator,
4. Video recording capability for late time retrieval, and
5. Remote alarm capability.

Performance

The performance of VMD systems is based on their detection capability, their ability to suppress false alarms, and, to a lesser extent, the other functions they perform.

Detection Capability

VMD systems utilize the principle of changes in illumination to detect motion within an area under surveillance. A difference between total integrated energy or illumination signal strength and a reference signal is measured electronically. When this difference exceeds a certain percentage, detection occurs. In most systems, the minimum discernible threshold of detectability is around 5 percent. A capability for adjusting the sensitivity of this threshold is incorporated into all systems. Under low-contrast conditions, point sampling or fine-grain processing provides better detection capability than does integrated video signal processing.

False/Nuisance Alarms

The quality of performance of a VMD system is largely dependent upon its ability to perform with few false/nuisance alarms. These types of alarms are caused by objects in the field-of-view which under normal operation have an illumination change, usually periodic, that is above the detection threshold. Operators may tend to become complacent when continually subjected to these alarms and may ignore them or adjust the detector's sensitivity to cancel them, thus overlooking genuine alarms. To improve the detection capability of a VMD system subjected to these alarms, the system must be able to suppress them. Systems which utilize a longer sampling time for obtaining a reference signal provide one means of suppressing these false alarms; the periodic changes in illumination become an average value rather than a discernible change in value. Selected use of sensitized areas can eliminate or mask the false-alarm generators. An external approach to the problem would be removal of the false-alarm generator, where practical.

Commercially Available Equipment

Appendix B is a synopsis of the commercially available video motion detector systems, as determined from the market survey. Representative characteristics, performance, physical data, and cost range are presented for comparison. No attempt has been made to select a most favorable system since the various surveillance needs must be determined on a case-by-case basis.

References

1. International Military Intrusion Detection Market, Report No. 505, Frost and Sullivan, Inc., New York, New York, 1977.
2. Summary of Intrusion Detection Sensors, Closed Circuit Television and Video Motion. Stanford Research Institute (SRI) Special Report for Sandia Laboratories under Sandia Laboratories Document 02-0034 Amendment 3 (SRI Project 4188), September 1975 (No longer available).

Supplier-Furnished Literature
(See Appendix C for address and telephone number)

3. Colorado Video
   a. Data sheet on Model 304 Motion Detector.
   b. Instruction Manual, Model 304 Motion Detector.
4. Information Processing Systems
   "SCANGUARD: A Review of the System," March 1978. (An 18-page report prepared in response to the Sandia Laboratories inquiry of Appendix A.)
5. Javelin Electronics Division
   a. Brief summary of Javelin's history and the highlights of Javelin's J314MD Motion Detector. (A half-page memo prepared in response to the Sandia Laboratories inquiry of Appendix A.)
   b. Data sheet on Model J314MD Video Motion Detector.
6. RCA
   Data sheet on Model TC1460/2, TC1460/4 Video Motion Detectors.
7. Vicon Industries Inc.
   Data sheet on Model V222MD Motion Detector.
8. Video Applications Company
   a. A 6-page report. (Prepared in response to the Sandia Laboratories inquiry of Appendix A.)
   b. Multi-Camera Motion Detection Television System Processor--TELESENTRY.
   c. Video motion detector specifications for multiple-camera high sample point density applications.
9. Visual Communication Specialists
   Technical Report--Visual Communication Specialists, Model IMD--200 Intrusion/Motion Detector. (A 26-page report prepared in response to the Sandia Laboratories inquiry of Appendix A.)
10. Video Tek, Inc.
    a. A 3-page letter and a 10-page report. (Prepared in response to the Sandia Laboratories inquiry of Appendix A.)
    b. Application Notes
       AN1 Outdoor Area Security
       AN3 High-Rise Building Security
       AN5 "Nuisance" Alarms
       AN6 Automated CCTV Security System
    c. Data sheets on the MDU-2 and MDU-3 Digital Intrusion Detector Analyzer.
    d. "Digital Video Sharpens On-Line Observations," Control Engineering, November 1975.

e. "Computer-Based Video Security," Security Distributing and Marketing, 7, No. 8, (August 1977) pp. 22-27.

f. U.S. Patent 3,988,533: Video-Type Universal Motion and Intrusion Detection System.

g. *System Theory of Operation (an 84-page report).*

APPENDIX A

Letter of Inquiry and Questionnaire

Sandia Laboratories
Sandia Corporation
Albuquerque New Mexico 87115

February 7, 1978

The Intrusion Detection Technology Division at Sandia Laboratories is funded by the U.S. Department of Energy (formerly ERDA's Division of Safeguards and Security) to provide DOE facilities with technical information and assistance to upgrade their security systems. I am preparing a survey report on commercially available video motion detectors. This report will be distributed to the personnel at DOE and other government facilities who are responsible for specifying and procuring security systems. The main purpose of this report is to provide security personnel with an insight into the type equipment that is currently available, the capabilities and limitations of this equipment, and a list of sources for further information or price quotations. You may have been contacted by phone by Mr. Doug McGovern of our Laboratories. This report is a continuation of the same effort. The enclosed outline is used to give all reports a uniform treatment.

I am soliciting your assistance and cooperation in providing material for the preparation of a report of your video motion detection system. Specifically, I need detailed technical information that clearly explains each topic of the enclosed outline.

I wish to thank you in advance for providing the requested material and hope you will keep me informed of future developments and announcements.

Thank you very much for your attention to this request. If possible, we would like to have your response by March 10, 1978.

Yours truly,

Philip M. VanPraag
Intrusion Detection Technology
Division 1739
(505)-264-6082

PVP:mh

1.0 GENERAL DESCRIPTION
- 1.1 Company background
- 1.2 Overall approach to security (e.g., role video motion detection plays in a total security system)
- 1.3 Overall approach to video motion detection
- 1.4 System capabilities
- 1.5 Significant features

2.0 HARDWARE
- 2.1 Video motion detection - general
- 2.2 System configuration including block diagram
- 2.3 Does the system include camera and signal processing equipment? Describe the processing system (e.g., digital and/or analog. Explain operation.)
- 2.4 Is a photo detector externally attached to monitor screen?
- 2.5 Does the system include the video monitor?
- 2.6 Discuss monitoring selection process over the raster area (e.g., specific areas to be monitored are selected by positioning electronic cursors on raster).
- 2.7 Is a video recorder required (tape or disc?)? What are the video recording response requirements to work with your system? Describe replay capabilities, if any.
- 2.8 What is the system capacity (number of cameras, etc.)?
- 2.9 Is the system available from stock? If not, what is the normal delivery time after an order is received?
- 2.10 Is an isolated video output available?
- 2.11 Does the system have variable sensitivity?
- 2.12 Does the system have a provision for producing a remote alarm signal?
- 2.13 Does the system have a remote reset capability?
- 2.14 Does the system require external sync capabilities for either cameras or monitors? If so, does it require separate H and V drive? Does it require locking capabilities that deviate in any way from RS170 sync standards?
- 2.15 Will the system operate with a low light level camera?
- 2.16 Are the alarm contacts (a) normally open, (b) normally closed or (c) can be selected to be either normally open or normally closed?
- 2.17 Describe the multi-camera input sequencing process, if available.
- 2.18 Is the system self-supervised for (a) tampering and (b) video presence? If answer to (a) and/or (b) is "yes," please explain how.
- 2.19 Does the system have an audio alarm signal?
- 2.20 Does the system have a video alarm signal?
- 2.21 Can the system be used for either interior or exterior applications?
- 2.22 Is the system capable of detecting fire and smoke?
- 2.23 Describe the relation between the number of cameras and the number of monitors (e.g., does each camera require a separate monitor?).

2.24 What are the power requirements?
2.25 Is an auxiliary power source available?
2.26 Please list the model(s) number(s).
2.27 Please list the system cost (or price range, if necessary) for one complete system as of 2/1/78. (This information may not be included in our published report.)

3.0 RELIABILITY
3.1 Special features (e.g., hardware redundancy, etc.)
3.2 Special techniques
3.3 Backup capabilities

4.0 MAINTENANCE
4.1 Warranty provisions (length of time for both parts and labor)
4.2 Maintenance arrangements

5.0 CUSTOMERS
5.1 Government (list persons to contact if possible)
5.2 Commercial (list persons to contact if possible)

APPENDIX B

Summary of Video Motion Detector
Specifications and Capabilities

TABLE B-I

Specifications for Video Motion Detectors

	Video Motion Detectors							
	CVI Model 304	IPS Scanguard	Javelin Model 3314MD	RCA Model TC1460/2	VICON Model V222MD	VIDACO Telesentry	Visual Comm. Spc. Model IMD-200	VTI Model MDL-2
Performance Data								
Probability of Detection (%)	Unavailable	95[a]	Unavailable	Unavailable	Unavailable	Unavailable	Unavailable	>99[b]
False Alarm Rate (no./camera/day)	Unavailable	2	Unavailable	Unavailable	Unavailable	Unavailable	Unavailable	Unavailable
Nuisance Alarm Rate (no./camera/day)	Unavailable	Unavailable	Unavailable	Unavailable	Unavailable	Unavailable	Unavailable	Unavailable
Sensitivity	%	%	20	Unavailable	2	6.25%	Unavailable	Unavailable
Physical Data								
Size (h x w x d in cm)	4 x 19 x 8	Unavailable	4 x 21 x 25	5 x 21 x 26	5 x 21 x 26 8 x 48 x 26	7 x 17 x 19.75	Unavailable	7 x 19 x 13
Weight (kg)	Unavailable	22.7	1.7	0.5	1.6	Unavailable	Unavailable	20.4
Power (primary/ secondary)	117 VAC at 60 Hz	117 VAC at 60 Hz 230 VAC at 50 Hz	11 - 26 VAC at 60-50 Hz 11 to 18 VAC	95 to 115 VAC at 60 Hz 230 VAC at 50 Hz	95 to 115 VAC at 60 Hz 240 VAC at 50 Hz	117 VAC at 60 Hz 240 VAC at 50 Hz	115/230 VAC at 60/50 Hz 12 VDC	95 to 130 VAC at 60 Hz 190 to 260 VAC at 50 Hz
Power Consumption (watts)	Unavailable	Unavailable	5	5	4	300	Unavailable	Unavailable
Window Shape	4 variable position small squares	Variable polygons	Variable line widths	Variable rectangles	Horizontal or vertical rectangle or square	1352 points	Variable rectangles	Up to 16,000 points
Window Size	Small squares	Variable	Adjustable from 2 to 100 of area	% of total area	% of total area	Point windows	Adjustable from 2 to 100% of area	Point windows and rectangles
Emplacement	Rack mounted			Desk top or rack mounted	Desk top or rack mounted		Desk top or rack mounted	Desk top or rack mounted
Video Input (interlace)	Random, 2:1	2:1	Random, 2:1 or EIA sync	Unavailable	Random, 2:1 or EIA sync	2:1	Unavailable	Random or 2:1
Temperature (°C)	Unavailable	0 to 120° F	Unavailable	Unavailable	Unavailable	Unavailable	Unavailable	Unavailable
Humidity (%)	Unavailable	0 to 95	Unavailable	Unavailable	Unavailable	Unavailable	Unavailable	Unavailable
Analog or Digital	Analog	Analog	Analog	Analog	Analog	Digital	Analog	Digital

[a]Based on 5% nondetection over 100% field-of-view or 100% detection of 5% sensitized area

[b]Statistics based on testing

TABLE B-II

Video Motion Detector Features

Features	Manufacturers							
	Colorado Video Inc. Model 304	Information Processing Systems Scan-guard	Javelin Electronics Model J314MD	RCA Model TC1460/2 or 4	Vicon Industries Model V22MD	Video Applications Co. Telesentry-16	Visual Communications Specialists Model IMD-200	Video Tek Inc. Model MDU-2
Includes camera and signal processing electronics	No	No	No	No	No	No	No	No
Photo detector externally attached to monitor screen	No	No	No	No	No	No	No	No
Includes video monitor	No	No	No	No	No	No	No	No
Requires video monitor	No	Yes	No	No	No	No	No	No
Number of sensors	1	10[a]	1	1 to 4	1	4 to 16	1	4 to 16
Isolated video output available	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Variable sensitivity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No[b]
Provision for remote alarm signal	Yes	Yes	Yes	Yes	Yes	Yes[c]	Yes	Yes
Remote reset	Yes	No	Yes			Yes[c]	Yes	Yes
In external sync required		No	No	No	No	Yes	No	Yes
Can use low light level camera	Yes	Yes				Yes	Yes	Yes
Normally open alarm contacts	Yes		Yes		Yes	Yes	Yes	No
Normally closed alarm contacts	Yes		Yes		No	Yes	Yes	Yes
Multicamera input sequencer	No	Yes	No	No	No	Yes	No	Yes
Self supervision	No	Yes				Yes	Yes	Yes
Audible alarm signal	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Video alarm signal	Yes	Yes			Yes	Yes	Yes	Yes
Smoke and fire detection capability	Yes	Yes				Yes	Yes	Yes
Requires one monitor for each camera	Yes	No	Yes	Yes	Yes	No[d]	No	No
Cost	≠1,000	~30,000	~1,000	<1,000	<1,000	~15,000	<1,000	~5,000[e]

[a]Expandable to 50 cameras.
[b]On-site sensitivity controlled digitally by setting the number of sensitized locations necessary to cause an alarm.
[c]Optional feature.
[d]Requires 2 monitors regardless of the number of video inputs.
[e]Other models range up to 50,000 depending on options.

APPENDIX C

List of Manufacturers

The names, addresses, and telephone numbers of the commercial companies who responded to the survey are listed below:

1. CVI Colorado Video Incorporated
   Box 928
   Boulder, CO 80306
   (303) 444-3972

2. Information Processing Systems of California, Inc.
   70 Glenn Way
   Belmont, CA 94002
   (415) 572-1742

3. Javelin Electronics
   6357 Arizona Circle
   P.O. Box 45002
   Los Angeles, CA 90045
   (213) 641-4490

4. RCA Electro-Optics & Devices
   Closed-Circuit Video Equipment
   New Holland Avenue
   Lancaster, PA 17604
   (717) 397-7661

5. Vicon Industries, Inc.
   130 Central Avenue
   Farmingdale, NY 11735
   (516) 293-2200

6. Video Applications Company
   P.O. Box 1598
   701 E. New Haven Avenue
   Melbourne, FL 32901
   (305) 727-8640

7. Visual Communication Specialists
   7162 Convoy Court
   San Diego, CA 92111
   (714) 560-9156

8. *Video Tek Inc.*
   8 Morris Avenue
   Mountain Lakes, NJ 07046
   (201) 335-1628

DISTRIBUTION:

U.S. Department of Energy
Office of Safeguards and Security
Washington, DC 20545
Attn: George Weisz, Director (10)

J. P. Crane, Director, Safeguards and Security Division, AL (10 copies)
D. R. Smith, Director, Safeguards and Security Division, CH (5 copies)
C. J. Barry, Director, Personnel and Security Office, GJ (2 copies)
H. J. Argyle, Director, Safeguards and Security Division, ID (5 copies)
T. H. Blankenship, Director, Safeguards and Security, NV (3 copies)
W. T. Sergeant, Director, Safeguards and Security Division, OR (5 copies)
M. L. Von Grey, Director, Security Division, PNR (5 copies)
R. T. March, Director, Materials Management & Safeguards Division, PNR (1 copy)
K. H. Jackson, Director, Safeguards and Security Division, RL (4 copies)
R. L. Daley, Director, Safeguards and Security Division, SAN (7 copies)
N. H. Seebeck, Jr., Director, Safeguards and Security Division, SR (5 copies)
W. M. Walsh, Director, Security and Safeguards Division, SNR (3 copies)

1700 W. C. Myre
1711 M. R. Madsen
1730 C. H. Mauney
1731 E. R. Julius
5432 F. V. Thome
1734 W. N. Caudle
1739 J. D. Williams (100)
1739 F. L. Schow
1739 J. L. Rife
1739 P. C. Maes
1750 J. E. Stiegler
1754 I. G. Waddoups
1758 C. E. Olson
1759 M. J. Eaton
1760 J. Jacobs
1761 T. A. Sellers
1762 H. E. Hansen
1763 J. J. Baremore
1763 D. E. McGovern
1764 J. E. Hinde
8266 E. A. Aas
3141 T. L. Werner (5)
3151 W. L. Garner (3)
For DOE/TIC (Unlimited Release)
DOE/TIC (25)
(R. P. Campbell 3172-3)