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RADAR DETECTION OF BIRDS HAZARDOUS TO AIRCRAFT (PHASE II)

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DATA REPORT

APRIL 1981

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16. Abstract

A portable photographic radar recording system developed by the Technical Center Photographic Laboratory was evaluated to determine its capability to monitor and record bird movements as detected by an airport surveillance radar. This system was developed for use by U.S. Fish and Wildlife Service (USFWS) biologists for study of bird hazards problems at airports. The system was designed for photographing an automated radar terminal system (ARTS) II or ARTS III display with range and video selection available to the biologist. The design is such that interference with air traffic control equipment is kept to a minimum. Time and date documentation are provided. System operating instructions and technical data are contained in the appendices.

Tests performed to demonstrate system capability included time lapse photography of various roosting area and migratory bird phenomena. These tests showed that the system was suitable for use by USFWS biologists for the study of bird movements hazards at airports.

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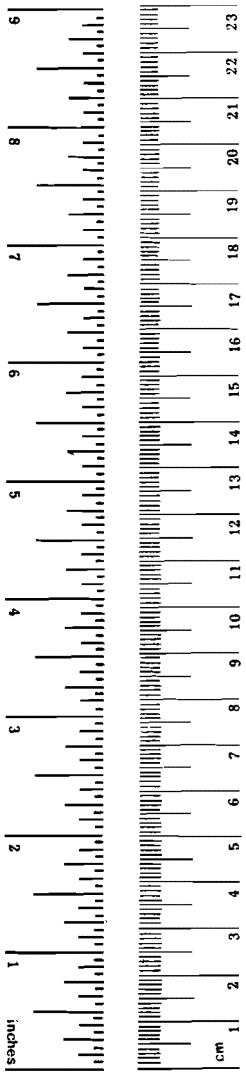
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

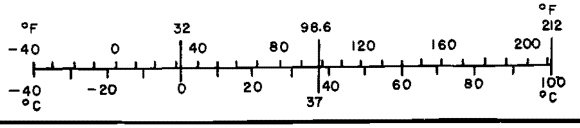
Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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INTRODUCTION

PURPOSE.

The purpose of this project was to design and develop a portable radar data recording system for monitoring and recording bird movements using information from Airport Surveillance Radar (ASR) systems. This equipment will be used by United States Fish and Wildlife Service (USFWS) biologists studying bird hazards to aircraft at airports.

This report discusses the results obtained from testing a photographic recording system developed at the Federal Aviation Administration (FAA) Technical Center by the Photographic Laboratory.

BACKGROUND.

Work under this project was in response to a request for a research, development, and evaluation effort (FAA form 9550-1), AAS-300-79-1, dated May 25, 1979, "Radar Detection of Birds Hazardous to Aircraft."

The first phase of the project consisted of demonstrations and discussions with Airport Standards (AAS-320) personnel at the FAA Technical Center of suitable radar recording techniques available for detecting and recording bird movement data.

In Phase II, the subject of this report, the FAA Technical Center ASR-8/Automated Radar Terminal Systems (ARTS III) Test Bed System was outfitted with the photographic equipment described below. This equipment, if satisfactory for AAS-320 needs, could serve as a preliminary unit for AAS-320 work on bird data recording and as a prototype for a technical data package (TDP) (appendix A) to be issued for future equipment procurement by AAS. Radar doppler techniques have also been discussed and will be investigated under Phase III of this project. The investigations are to be performed in response to FAA form 9550-1, No. AAS-300-80-11, and are scheduled to be completed in April 1982.

DESCRIPTION OF EQUIPMENT.

A Beatie Coleman 35 millimeter (mm) automatic recording camera and associated film cartridges, a camera shutter timer, a delay timer, and the ARTS III's plan position indicator (PPI) display camera supporting cone, designed to mask the ambient light when photographing, were chosen to perform the initial recording task (figures 1 and 2).

The camera timing control was used to open the camera shutter for some fixed period of time each frame. The delay control unit was used to set the period of time between frames. The ASR-8 radar controls provided for selection of parameters to obtain the desired radar video for display.

The camera timing control was provided without using radar signals (trigger or synchro). This was done to enable personnel without a radar background or training to more easily interface the equipment with field radar sets.

The camera support cone used in these tests was made for use with ARTS III PPI's. Additional cones for use with most of the other PPI's in the FAA inventory have been made for use at the Technical Center.

Independent controls of radar antenna polarization and moving target indicator (MTI) velocity response settings were requested by AAS-320. Subsequent discussions with their personnel pointed out that these functions were already available in the ASR equipment but could not be used without air traffic control approval. If the test radar were capable of diplexed (dual channel) operation, one channel could

be provided exclusively for data collection and channelized functions such as sensitivity time control. MTI canceller velocity response could be independently varied as desired. The range of the data collected can be set as desired since each PPI has an individual range control which permits the selection of any range of information from 0 to 60 miles for display.

The photographic system is compact enough for air shipment and requires little training for use. Instructions are provided in appendix B.

DISCUSSION

GENERAL.

The basic philosophy followed in testing was to set the radar system parameters to optimize bird movement detection and to periodically (lapse time photography) record the resulting data on film. Data were taken in clear weather in the early morning hours (near sunrise) and in the early evening hours (near sunset). Concentrated bird movement is at its peak during these times. For data reduction and analysis, the data were subsequently projected on a screen at an accelerated frame rate to facilitate detection of bird movements.

TEST METHOD.

The data were collected under the following conditions:

1. Radar video was obtained from the ASR-8 MTI receiver to minimize ground clutter effects.

2. The receiver sensitivity time control (STC) was turned off to provide maximum system sensitivity.

3. A 15-nautical-mile (nmi) maximum range was selected for the video display since most bird activity is detected within this range.

4. To optimize the bird target returns while minimizing ground clutter echoes, a 30-decibel (dB) subclutter visibility velocity response curve was selected for the MTI canceller.

5. The radar antenna was operated on low beam to enhance low altitude targets.

6. The camera shutter was kept open for 4.7 seconds (one ASR antenna scan time) for each data frame.

7. Pictures were taken every 10 seconds. Data corresponding to longer delay times could, if desired, be obtained by selecting frames with the desired time separation.

TEST RESULTS.

The following photographic data were selected from over 2,000 single-scan photographs of the PPI display to show typical system detection and recording capability. All data were collected during the month of April 1980. Time, date, and photographic frame number are provided on each photograph. The photographs show various bird movements detected by radar such as migration pattern and roosting locations.

The data films were examined by an ornithologist from AAS-320 who identified the types of bird movements discussed in the following.

Figure 3 shows an example of bird movement in the morning from a roosting area. While figure 3 (frame a) shows no indication of bird activity to the west, figure 3 (frames b and c) photographed shortly thereafter (Note camera time clock.) show a large population of birds dispersing to their feeding grounds. Subsequent data taken but not presented here showed succeeding dispersions from the same roosting area over a short period of time.

Figure 4 shows a line of migrating birds approaching the radar site. During the period of data collection, bird movement direction varied and was not always in a northerly direction as might be expected in the spring season.

Figure 5 shows an example of bird migration movement in the evening hours. The bird concentrations (songbirds) are shown to be increasing during the interval between frames a and b of figure 5.

In figure 6, a large movement of birds is shown along the coast.

SUMMARY OF RESULTS

1. The photographic system tested on this project provided recording of information on bird movements as detected by an ASR-8 radar. An ornithologist was subsequently able to classify the bird data into groupings such as roosting birds and migrating birds.

2. The system tested is portable, provides time and date documentation, and provides display range selectability up to 60 miles.

3. Radar set control functions such as MTI velocity response curves and antenna polarization are selectable using ASR controls when permitted by air traffic control personnel.

4. The photographic equipment can be interfaced with various types of PPI's by using camera support cones made for them.

5. To the maximum extent possible, the photographic system is independent from air traffic control equipment.

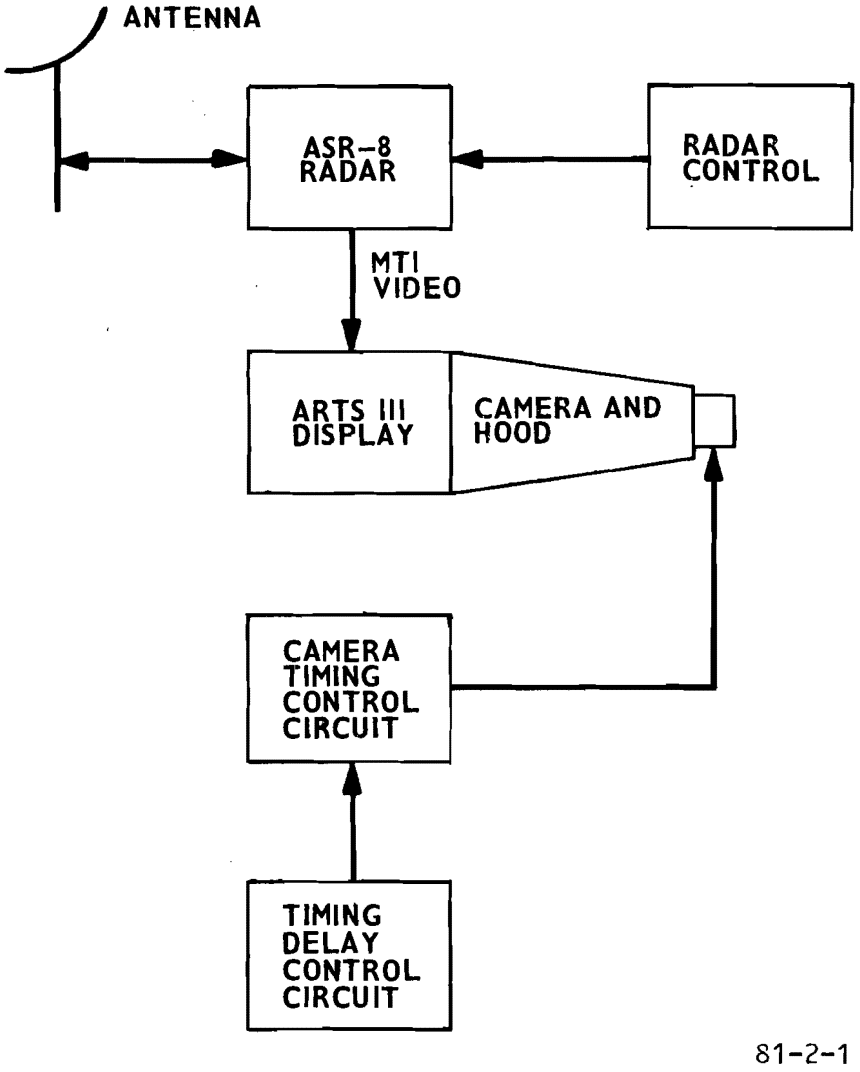


FIGURE 1. DATA COLLECTION EQUIPMENT BLOCK DIAGRAM

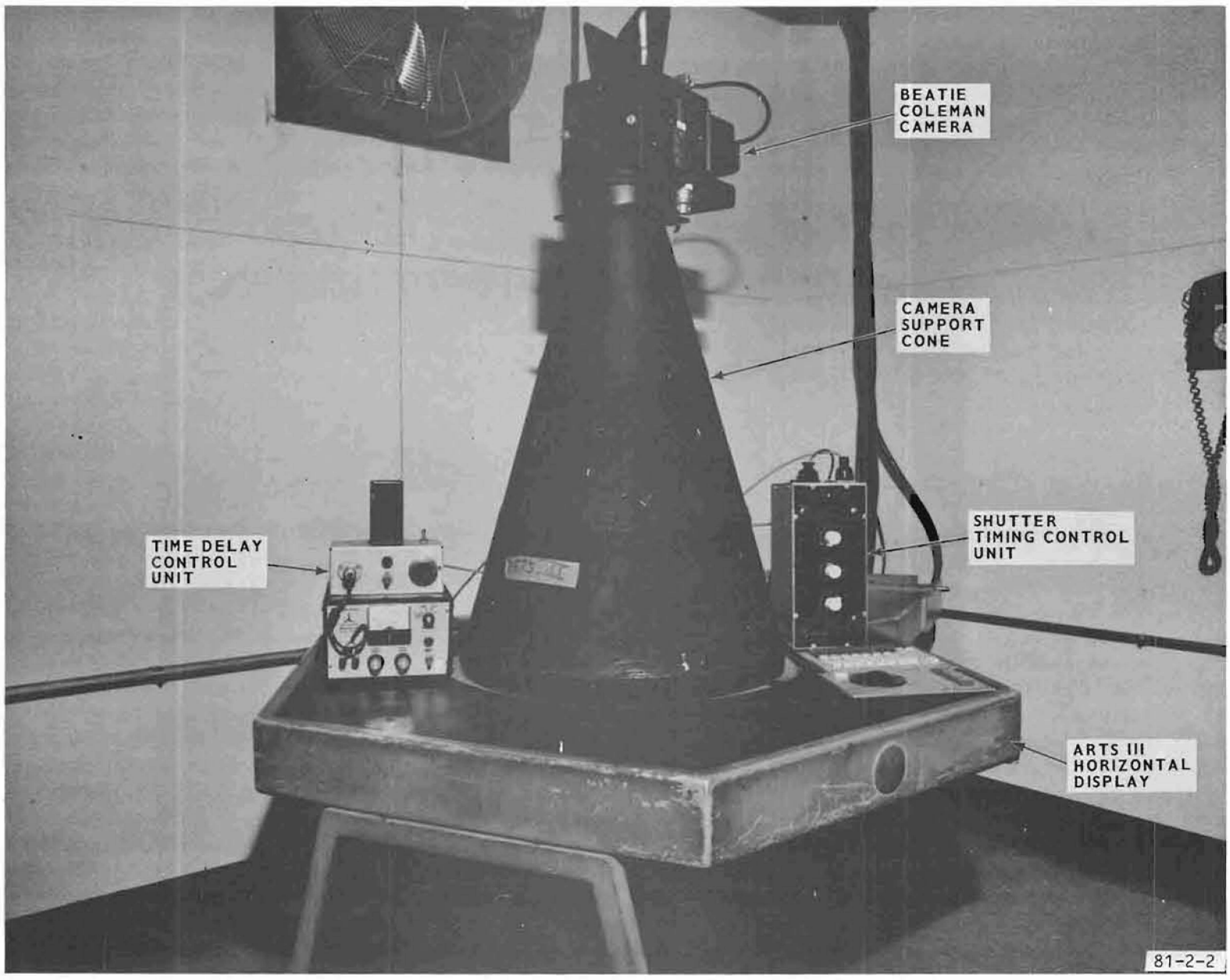
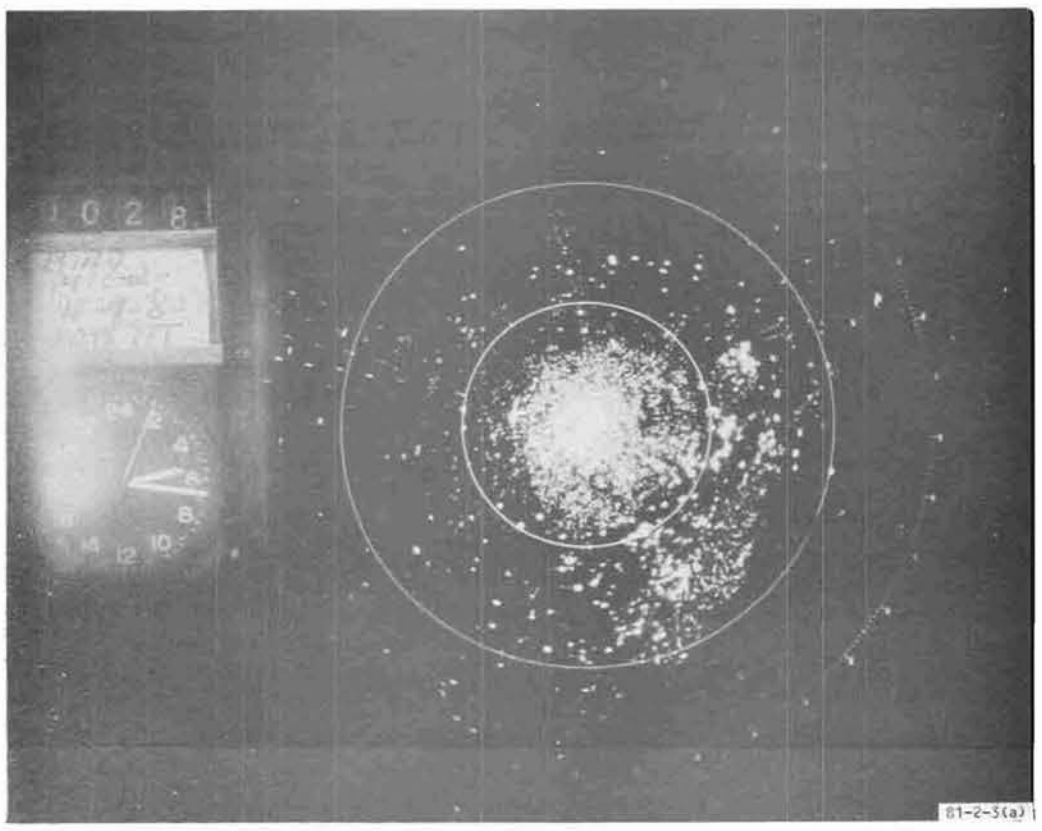
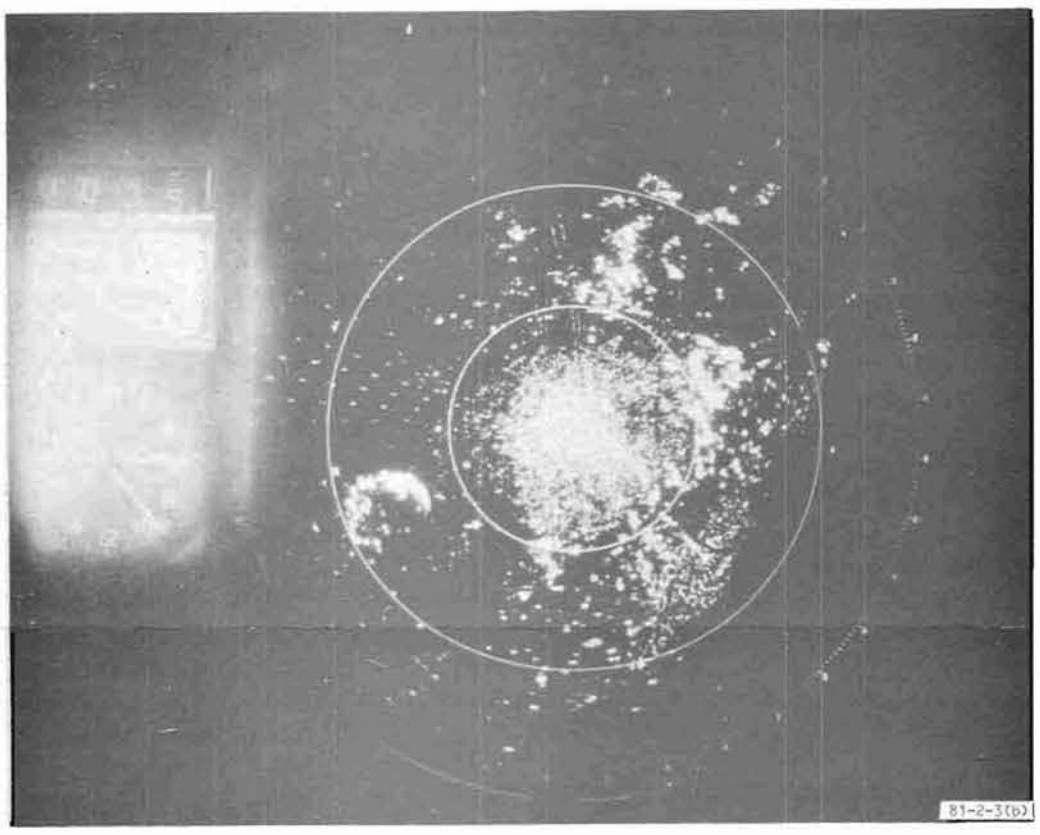


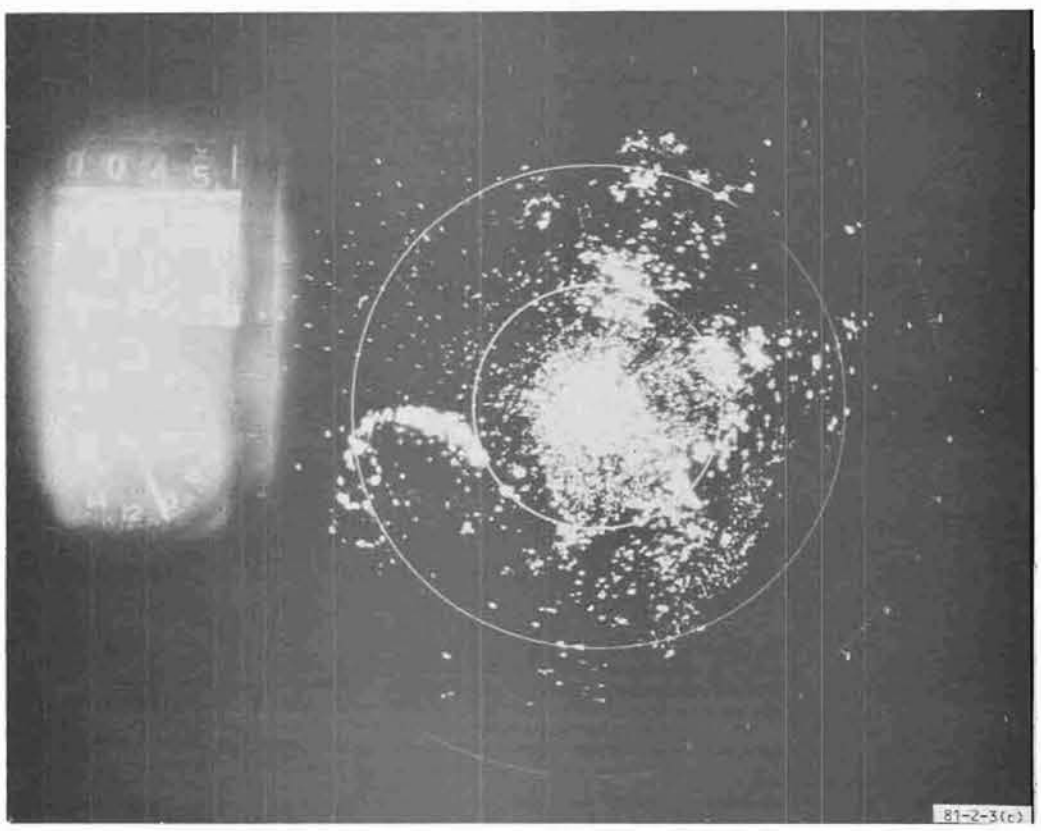
FIGURE 2. DATA COLLECTION INSTRUMENTATION



(a) BEFORE DISPERSION



(b) EARLY DURING DISPERSION



(c) LATER DURING DISPERSION

FIGURE 3. BIRD DISPERSION FROM ROOSTING AREA (5-MILE RANGE MARKS)

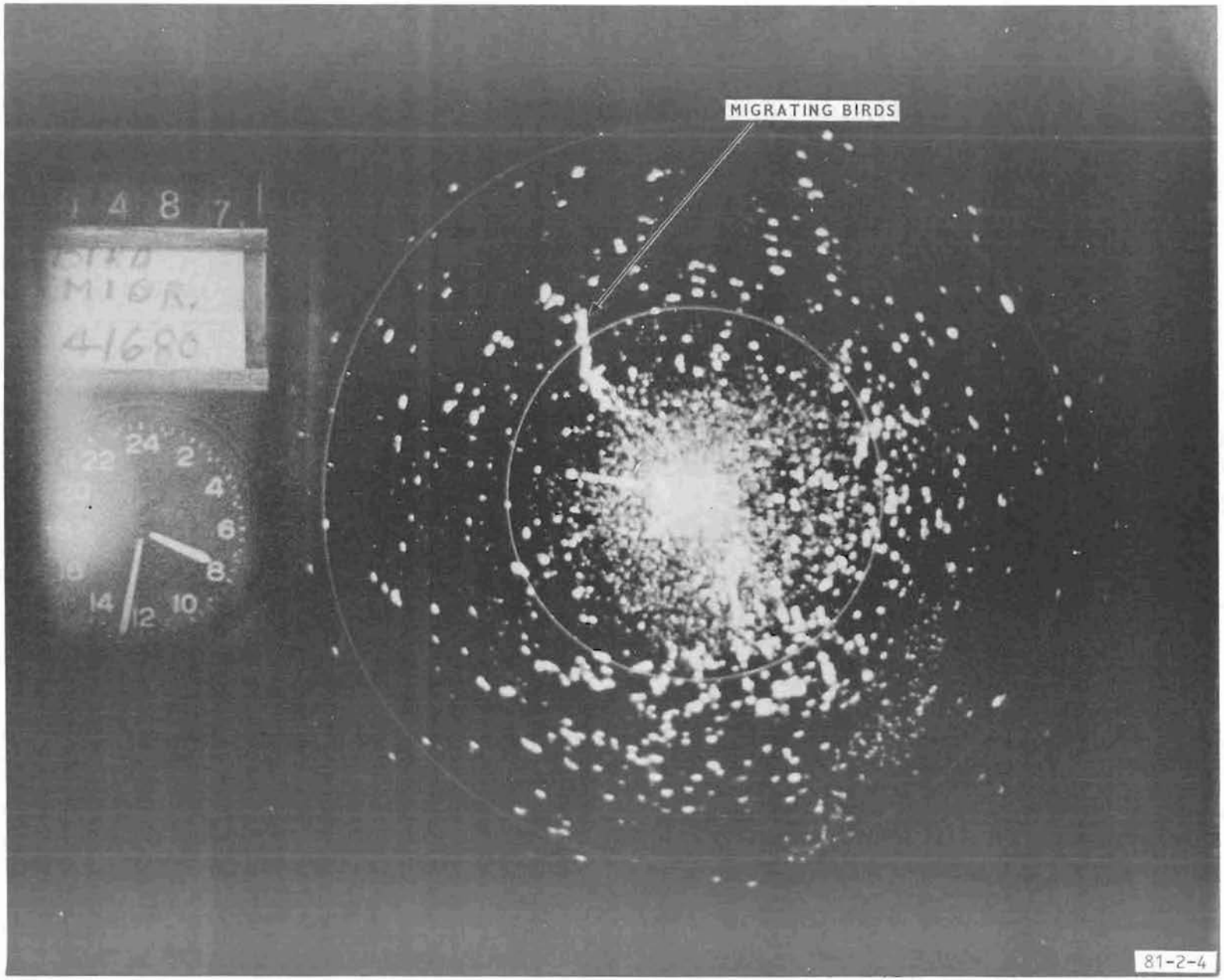
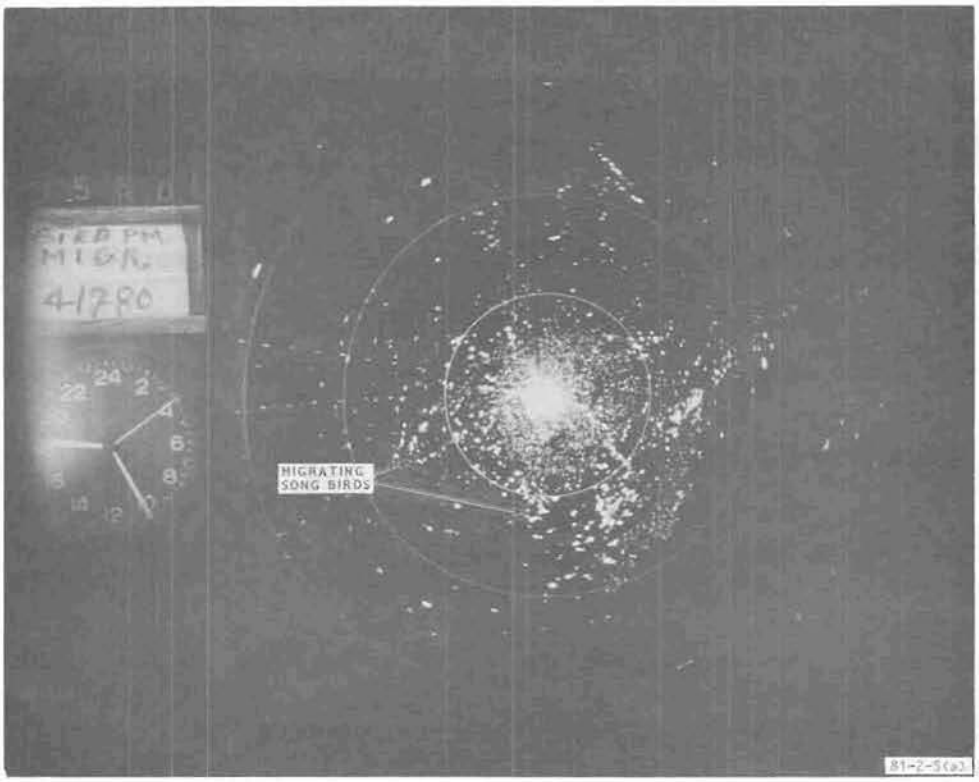
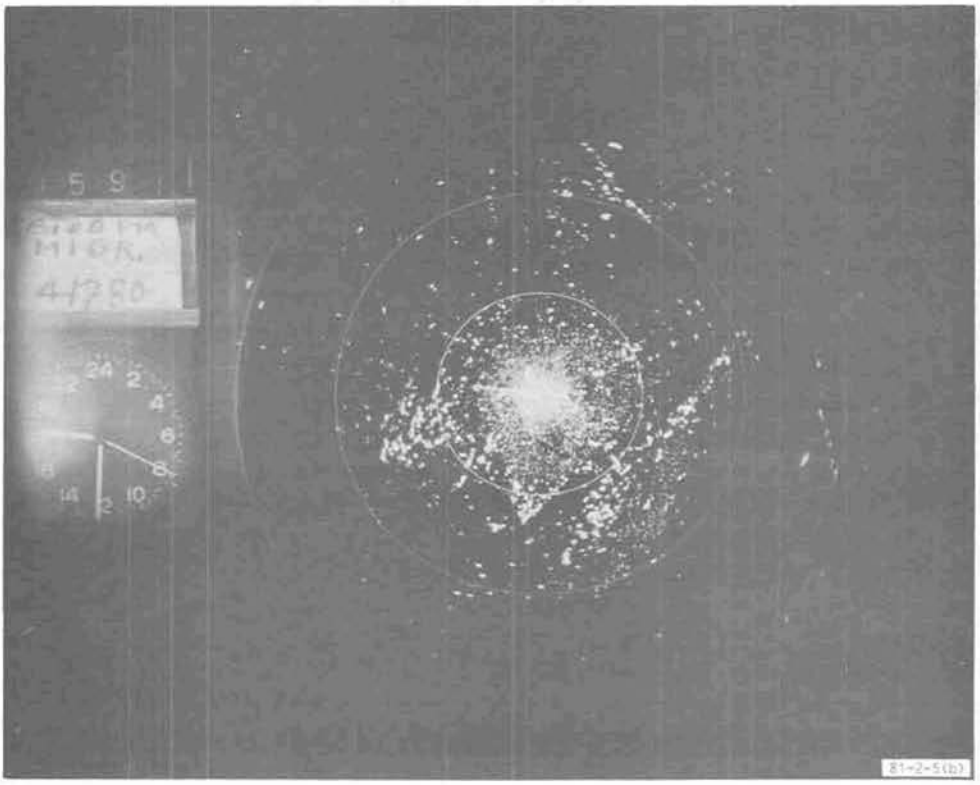


FIGURE 4. LINE OF MIGRATING BIRDS (5-MILE RANGE MARKS)



(a) NEAR BEGINNING OF MOVEMENT



(b) 5-MINUTES LATER IN MOVEMENT

FIGURE 5. EVENING MIGRATION OF SONGBIRDS (5-MILE MARKS)

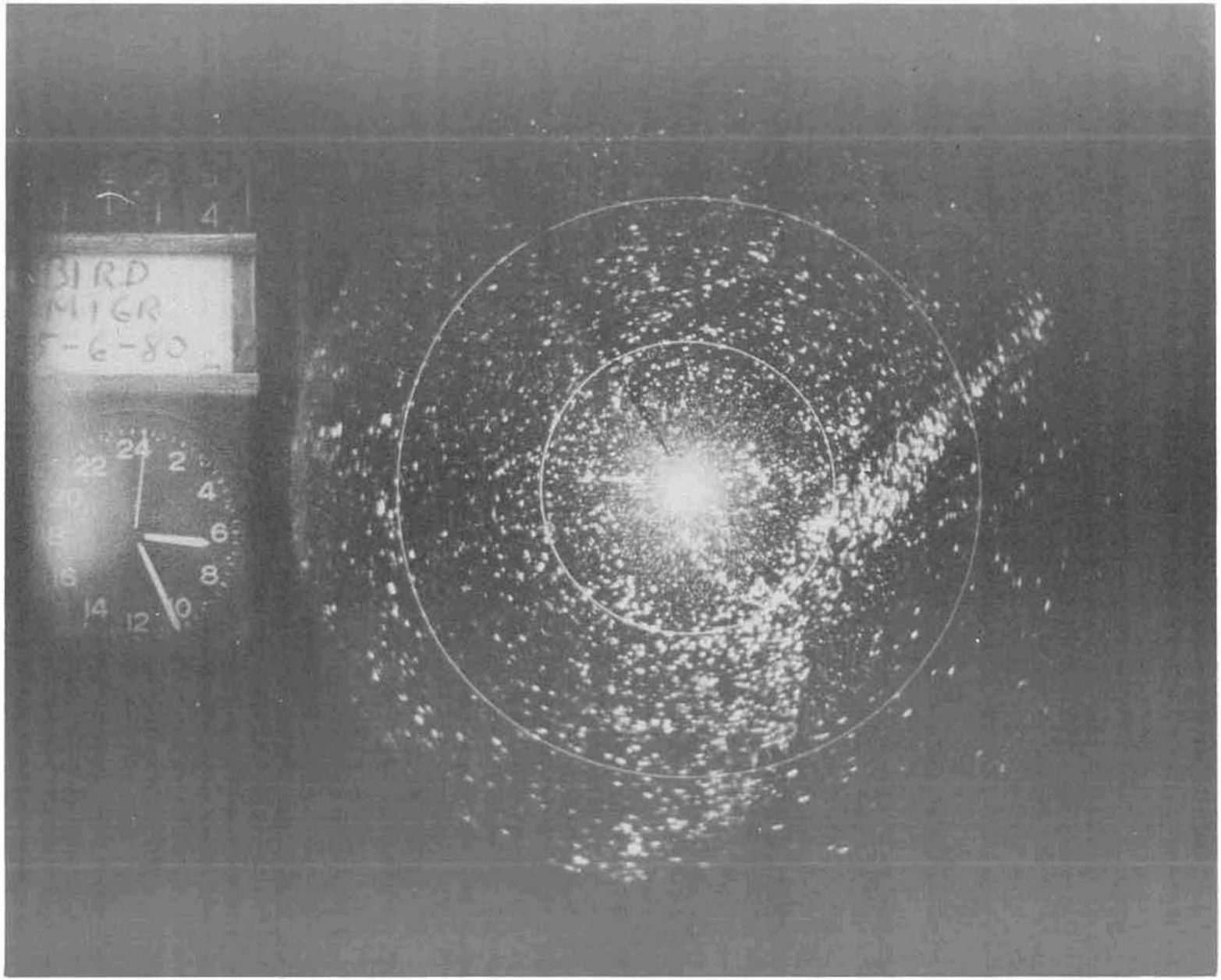


FIGURE 6. HEAVY BIRD MIGRATION ALONG THE COAST (5-MILE RANGE MARKS)

APPENDIX A

TECHNICAL DATA PACKAGE FOR PROCUREMENT OF PHOTOGRAPHIC SYSTEM

The following data are provided to aid in procurement of a photographic radar data recording system. Technical information on the FAA Technical Center system discussed in the body of this report is also included for reference.

The system should include a camera, shutter timing control unit, time delay unit, and a photographic cone. Technical data on each are given below.

CAMERA.

A 35mm camera is recommended to provide the resolution required; the camera should have:

1. Focusing from 1 foot to infinity.

2. An electronic external shutter control which allows holding the shutter open for periods of up to 100 seconds.

3. A data chamber to place on each frame of film exposed, a data tag, clock (time), and the frame number.

4. Focal length stops — F3.5 to F22.

5. Capability of photographing the entire ARTS II or ARTS III display area (20-inch diameter) from a distance of approximately 30 inches.

The specifications of the Technical Center system camera are as follows:

Manufacturer: Beatie Coleman, Anaheim, California
Type : 35mm
Model : KD-5
Weight: 10 pounds
Lens : Angineaux 28mm retrofocus type R11 (to provide wide angle photography)

SHUTTER TIMING CONTROL UNIT.

This unit should have timing selector switches which provide shutter open times of combinations of:

1. 0 to 1 second in 0.1-second steps
2. 0 to 10 seconds in 1-second steps
3. 0 to 100 seconds in 10-second steps

It should have sufficient power output to drive the shutter solenoid of the camera selected. It should accept timing signals from the time delay unit (discussed below) which provides the timing between frames.

The specifications of the Technical Center timing control unit are as follows:

Manufacturer: Lektra Laboratory, Inc., New York, New York
Model : TM-8
Weight: 5 pounds
Size : 12 inches by 5 inches by 5 inches
Timing: digitally selectable intervals

1. 0 to 1 second
2. 0 to 10 seconds
3. 0 to 100 seconds

TIME DELAY UNIT.

The time delay unit should have the following capabilities:

Timing selectability: 1 second to 15 minutes
Output: signal compatible with shutter timing control unit

The specifications of the Technical Center time delay unit are as follows:

Manufacturer: Solid State Controls, Inc., York, Pennsylvania
Part Number : 1050
Timing Range: 0 to 1 minute
Weight : 15 pounds
Dimensions : 11 inches by 5 inches by 8 inches
General : External power requirements are 110 volts alternating current (a.c.). The interconnecting cable between the camera and the timing units should be 10 feet long to allow positioning the timing units as desired.

PHOTOGRAPHIC CONE.

The cone must be rigid enough to support the camera and must keep out all ambient light. ARTS III cones in use at the Technical Center are constructed of 1/16-inch aluminum and painted with off-the-shelf flat black paint. This paint provides sufficient absorption of spurious light (reflection or leakage) to prevent it from degrading photographing capability. Supporting surfaces for attachment to the display and camera are of 1/8-inch aluminum for increased strength. Dimensions of the ARTS III cone are shown in figure A-1. The cone is made in three sections for portability. Sections overlap by 1/2 inch and are fastened together by sheet-metal screws. A viewing port with hinged cover is in the second section as shown. Mounting holes for the camera will be determined by the camera selected. For display mounting, four screws (8/32-inch by 1-1/6-inch counter sunk flat head phillips) are used as shown in figure A-2. They are located on the top, right, left, and bottom of the ARTS III display cathode ray tube holding ring. Figure A-1, view E, shows the corresponding cone mounting brackets.

An ARTS II display cone is not included in the Technical Center inventory. However, its construction should be identical to the ARTS III cone except for the display interface. Figure A-3 shows pertinent display dimensions. The diameter of the cone at the display should be 22-1/2 inches with mounting flanges (similar to those of ARTS III cone) corresponding to a sufficient number of screws shown in figure A-3 to provide the necessary support. The support bracket arrangement used

with the ARTS III cone is recommended. However, for additional strength, the two display ring holding screws at the display top should both be used. The bracket holes should be 3/16 inch in diameter. Care must be exercised in this area of fabrication since a concentric circle of display azimuth mark lights (1/2 inch in height) with an outer diameter of 22-1/4 inches limits the inner dimension of the cone.

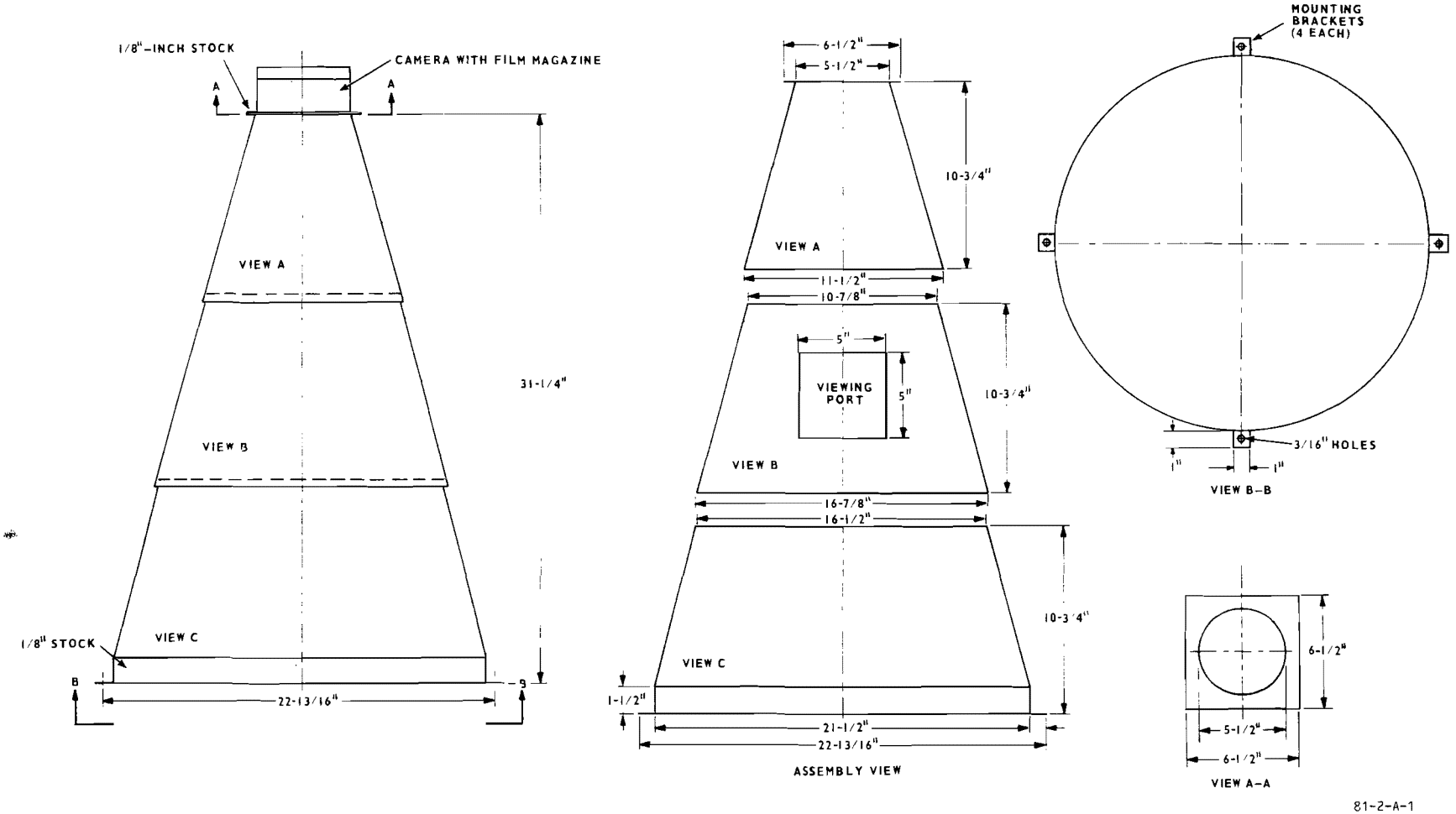


FIGURE A-1. ARTS III DISPLAY CONE WITH SECTIONAL VIEWS

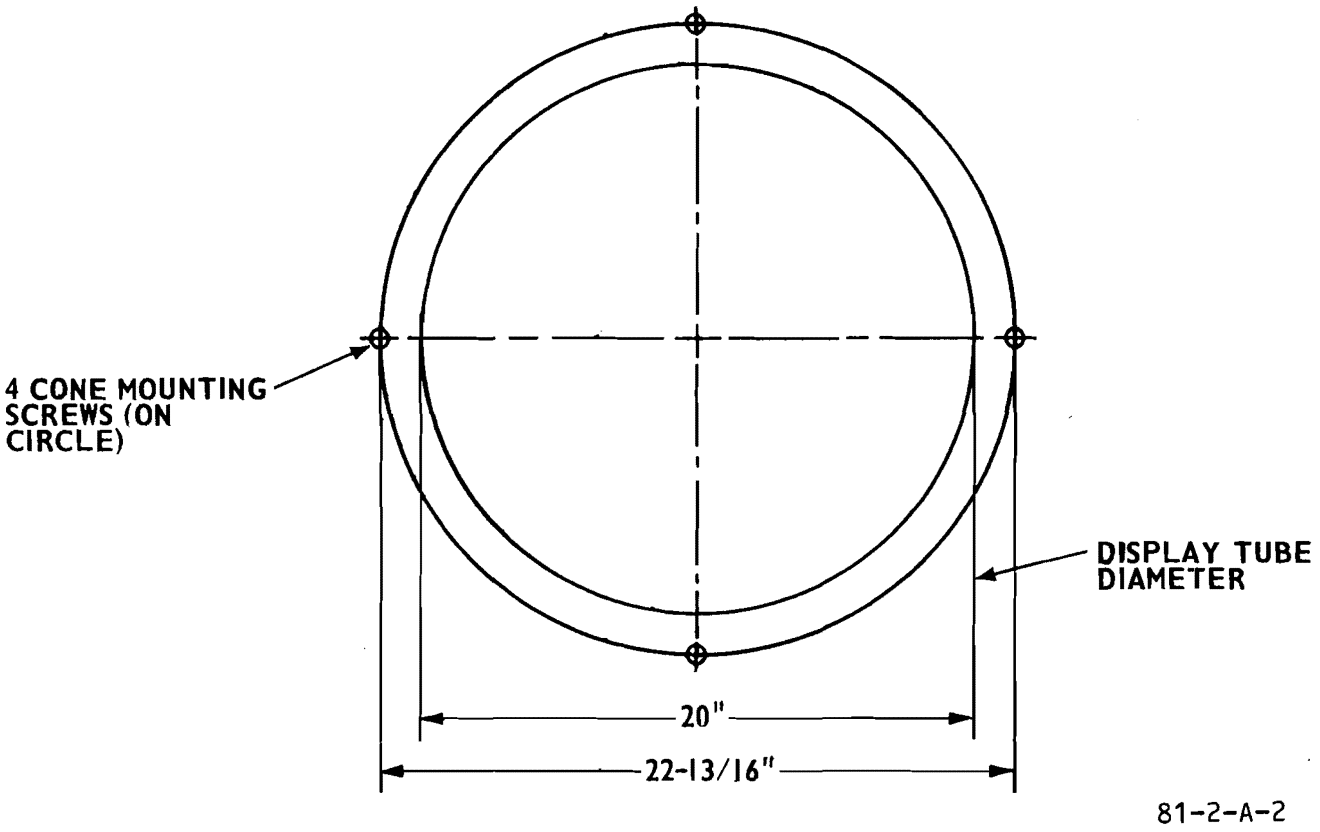


FIGURE A-2. ARTS III DISPLAY CONE MOUNTING SCREWS DIAGRAM

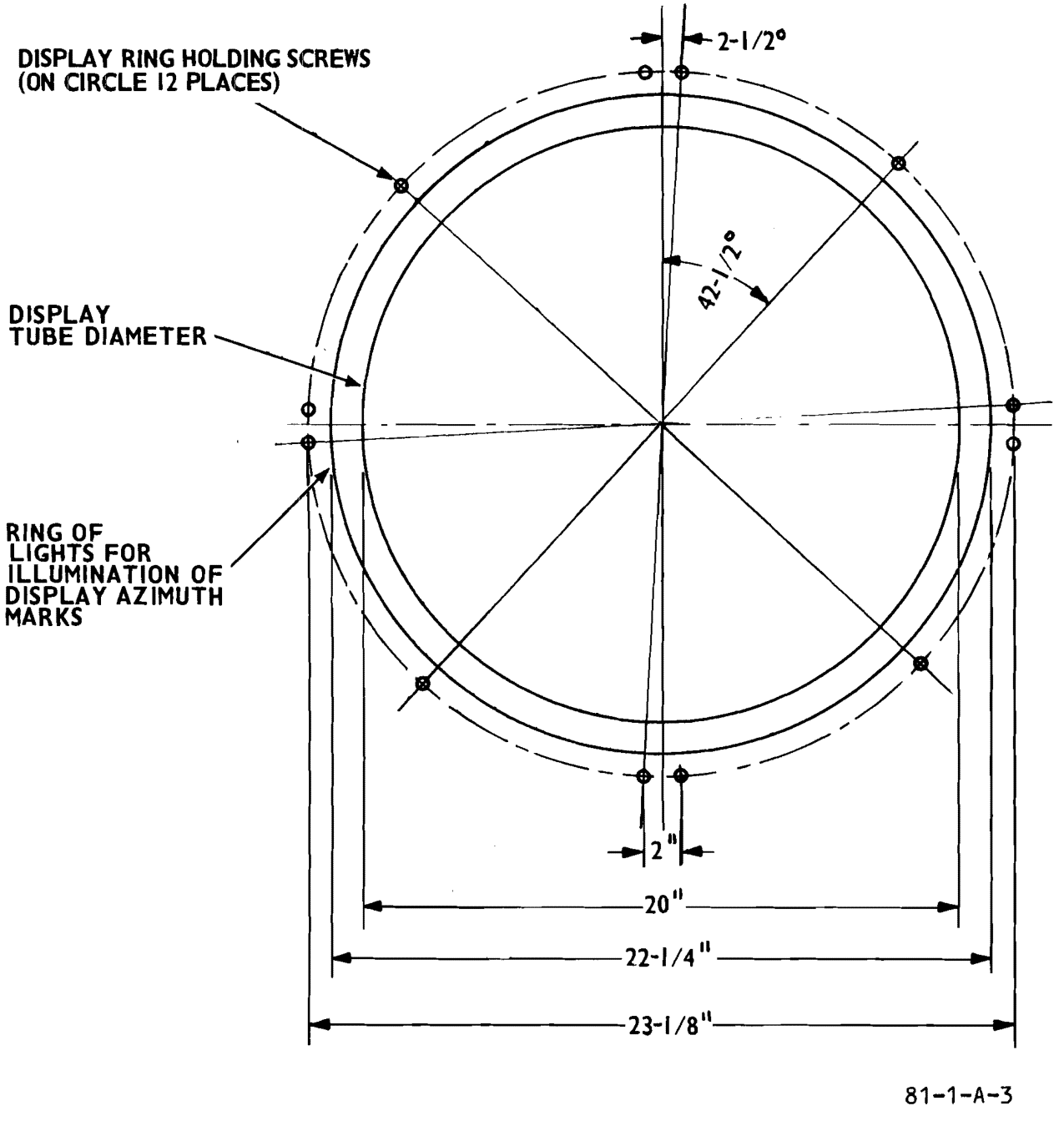


FIGURE A-3. ARTS II DISPLAY CONE MOUNTING SCREWS DIAGRAM

APPENDIX B

OPERATING INSTRUCTIONS FOR FAA TECHNICAL CENTER RADAR DISPLAY PHOTOGRAPHIC SYSTEM

The listed steps should be followed for system set-up and operation. Figure B-1 shows the electrical connections to be completed as discussed below.

1. Mount the photographic cone on the PPI by removing the display tube holding ring screws corresponding to the holes in the cone mounting brackets. While holding the cone in position, reinsert the screws. For horizontal displays simply position the cone over the display area.

2. Mount the camera to the plate on the top of the photographic cone with the screw provided. Check that the camera is correctly set (F-stop, focus).

3. Slide the interchangeable film magazine into the back of the camera (For loading and unloading of film, refer to the manufacturer's operating instructions manual. Copies are available at the FAA Technical Center and will be provided with the camera.). The magazine is inserted in the track on the camera back and the attached four-pin connector plugged into the mating connector on the camera body.

4. The camera operating cable is plugged into the mating nine-pin connector on the other side of the camera. There are two cables branching off from the connector. One of them has an "off-on" switch with a two-prong male plug. This cable should be connected to the receptacle which is labeled "switch" in the shutter timing control unit. The other one is a three-prong plug which should be connected to a 110-volt a.c. receptacle. An extension cord may have to be used depending on the distance from photographic area to the a.c. power source.

5. There are two cables in the delay timing control unit. One is used for 110 volts a.c. supply; the other (two-prong) is used to connect to the receptacle which is labeled "remote" in the shutter timing control unit.

6. Turn on the system and set the delay timing control unit (provides between-frame timing) to the desired value. Set the shutter timing control unit to the desired value (usually equal to antenna scan time). System operation is audible and can, thereby, be monitored for correct timing.

7. Set the display video control to the MTI position and select the desired range (0 to 60 miles).

8. Set display sweep intensity to desired level.

9. Coordinate with FAA site personnel to obtain the desired radar parameters during the test period. The subject parameters are receiver sensitivity time control, MTI canceller velocity response, and antenna polarization.

Note: It is advisable that personnel using this system receive initial training from FAA Technical Center Photographic Laboratory personnel. This training is particularly important in setting display sweep brightness and in camera focusing.

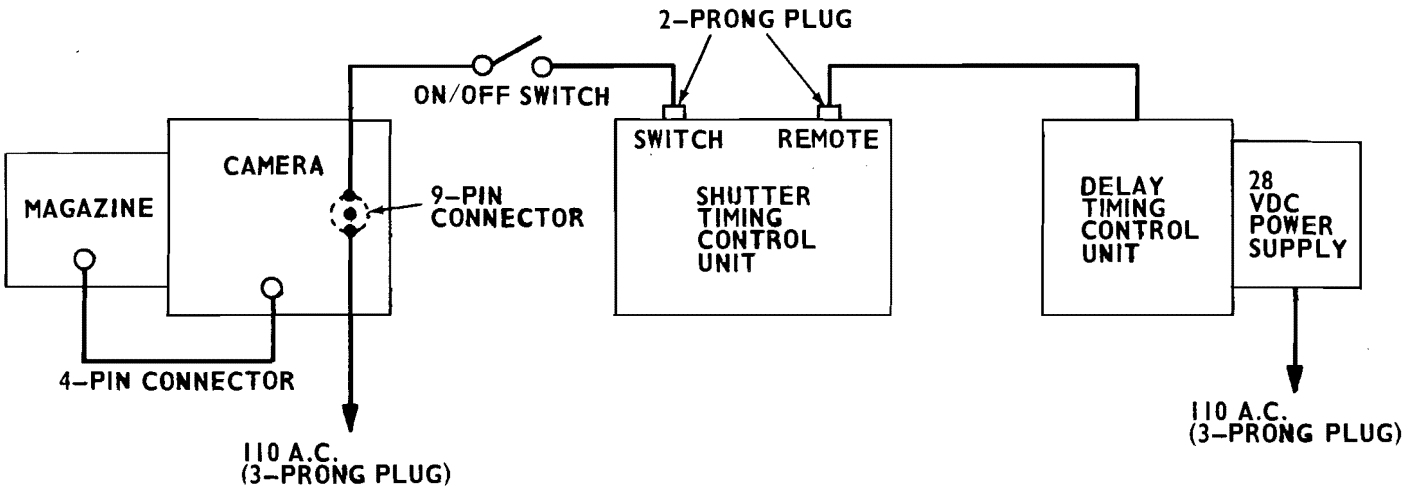


FIGURE B-1. PHOTOGRAPHIC SYSTEM INTERCONNECTION DIAGRAM