AFWAL-TM-85-258-FIBG

RAPID RUNWAY REPAIR TEST DESCRIPTION

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DECEMBER 1985

1 October 1985 – 21 October 1985

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FLIGHT DYNAMICS LABORATORY
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES
WRIGHT-PATTERSON AIR FORCE BASE, OH 45433-7750

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
DECEMBER 1985	FINAL	1 OCTOBER 1985 – 31 OCTOBER 1985

4. TITLE AND SUBTITLE
RAPID RUNWAY REPAIR TEST DESCRIPTION

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
David Banaszak
Earl Rogers

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Structural Vibration and Acoustics Branch
Structures and Dynamics Division
Flight Dynamics Laboratory
Wright-Patterson AFB, OH 45433

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
FLIGHT DYNAMICS LABORATORY
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES
WRIGHT-PATTERSON AFB, OH 45433

10. SPONSOR/MONITOR'S ACRONYM(S)
AFWAL/FIBG
NOW: AFRL/VASM

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
AFWAL-TM-85-258-FIBG

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for Public Release; Distribution Unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

This report describes instrumentation used during Rapid Runway Repair (RRR) tests with a C-141B and C-5A at RAF Wethersfield during October 1-21, 1985. The RRR test objectives were to validate the Precast Concrete Slab (PCS) and Fiberglass Mat (FGM) repairs for use with strategic airlift aircraft, to collect data on the performance of the two repair types under sustained airlift trafficking, to determine necessary modifications to the repair methods to support sustained airlift aircraft operations, and to provide additional data for the (TAXIG) HAVE BOUNCE Program.

15. SUBJECT TERMS
Rapid Runway Repair (RRR); Precast Concrete Slab (PCS); HAVE BOUNCE PROGRAM

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			David Banaszak
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR	54	**19b. TELEPHONE NUMBER** *(include area code)* 937-904-6859

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. 239.18

FOREWORD

This effort was performed by the Structural Vibration and Acoustics Branch (AFWAL/FIBG) and Structural Integrity Branch (AFWAL/FIBE), Structures and Dynamics Division (AFWAL/FIB), Flight Dynamics Laboratory (AFWAL/FI), Air Force Wright Aeronautical Laboratory (AFWAL), Wright-Patterson Air Force Base , Ohio. The effort supported Project AFES8502, Rapid Runway Repair which was sponsored by HDQTRS AFESC/RDCR at Tyndall Air Force Base , Fl. Capt Martin Lewis was the AFESC project officer. FIB provided instrumentation to ensure that aircraft limit loads were not exceeded during testing of a C-141B and a C-5A at RAF Wethersfield, United Kingdom(UK) operating over a precast slab and fiberglass mat repairs.

The work was performed by David Banaszak, Earl Rogers, Larry Dukate, Janice Chinn, and Lowell Vaughn of AFWAL/FIBG and Tony Gerardi and John Riechers of AFWAL/FIBE. Messrs Banaszak, Rogers, Dukate and Gerardi were at the test site during the period of 1 October 1985 to 21 October 1985. Special appreciation is extended to Mr. Rogers for his excellent job of fabricating camera and instrumentation brackets. He implemented the designed instrumentation package in a rapid matter. Mr. Dukate provided aide at RAF Mildenhall and RAF Wethersfield by fabricating cable, laying speed tape and providing helpful insights. With these personal efforts, all the project deadlines were successfully met.

This manuscript was released by the authors in February 1985 as a FIBG Test Report. The report has been reviewed and approved.

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CONTENTS

1 INTRODUCTION

This report describes instrumentation used during Rapid Runway Repair(RRR) tests with a C-141B and C-5A at RAF Wethersfield during October 1-21, 1985. The instrumentation was used to ensure aircraft limit loads were not exceeded during operation over a Precast Concrete Slab(PCS) and a Fiberglass Mat(FGM) repair. The instrumentation included two systems. The primary system measured and monitored the accelerations listed in Table I. A secondary video system displayed the motion of three landing gear during test runs over the repairs. The equipment used is listed in Table II. Identical equipment were on both aircraft, except for different accelerometer serial numbers. The C-141B had twelve accelerometers, eight on pylons, two on wings and two inside the aircraft. On the C-5A, six interior accelerometers were used in the primary system. Three video cameras and monitors were used on both aircraft to observe the landing gear during each test run.

The RRR test objectives were to validate the PCS and FGM repairs for use with strategic airlift aircraft, to collect data on the performance of the two repair types under sustained airlift trafficking, to determine necessary modifications to the repair methods to support sustained airlift aircraft operations, and to provide additional data for the (TAXIG) HAVE BOUNCE Program. The test plan detailing the RRR project was written by Headquarters AFESC/RDCR. Tables III and IV summarizes the C-141B test events during which acceleration data and video data were recorded respectively. Tables V show the acceleration data and

Table VI shows the video data recorded during the C-5A test events. During test events the aircraft taxied over the PCS and FGM repairs. During back taxi events, the aircraft travelled over the repairs in the reverse direction.

Figures 1 and 2, taken from the test plan, show cross sections of the two repairs. Photos of the two repairs are shown in Figures 3 and 4. The FGM repair was anchored every 18 inches. The PCS repair consisted of 7 slabs by 7 slabs for a total coverage of 14 meters by 14 meters. Figure 5 shows the C-141 on the fiberglass mat and Figure 6 shows the C-5A taxing over the precast slab repair.

2 SYSTEM OVERVIEW

The major instrumentation components are shown in the block diagram in Figure 7. The primary system included an instrumentation recorder and a 19 inch rack full of test equipment. The equipment for the secondary video system was mounted in a second 19 inch rack. Equipment layout for the two racks is shown in Figure 8. The racks could be mounted independently or as a two rack wide unit. Aircraft cargo straps were used to to secure the two racks, tape recorder and power converter to a standard type 463L pallet as shown in Figure 9. The instrumentation was shipped to RAF Mildenhall on the test C-141B and returned by military aircraft to Wright Patterson AFB,OH after test completion.

2.1 Aircraft Power

The instrumentation was powered from a Unitron PS-62-66D Static Frequency Converter. Aircraft power required for the converter was 115VAC,400 Hertz,3 phase,30 amps per phase. The converter could supply 4100 Watts of 115VAC, 60 Hertz power. On each aircraft a power cable was routed from a service outlet in the cargo area to the converter. Standard power cables were used between the converter output and the equipment racks.

2.2 Primary Measurement System

The primary measurement system consisted of twelve accelerometers for the C-141B and six accelerometers for the

C-5A. The accelerometers were connected to the measurement equipment rack and tape recorder as shown in the block diagram of Figure 10. Wire routing between the accelerometers and the primary measurement system was as shown in Figure 11 for the C-141B and Figure 12 for the C-5A. C-141B accelerometer wires were routed thru the cryogenic plugs behind the wing trailing edge at fuselage station 1046.

Accelerometer locations and IDs (e.g. A1) are identified in Table I. Right wing accelerometers on the C-141B are shown in Figure 13. The C-5A had no external accelerometer wiring. Photos of the accelerometers mounted in the C-5A are shown in Figures 14 and 15. All accelerometers were attached to small mounting blocks or plates which were bonded directly to painted aircraft surfaces using Loctite Depend no-mix adhesive. The pallet and equipment were located as shown in Figures 11 and 12 for each aircraft.

2.3 Primary System Calibration And Setup

The accelerometers had a range of -15g to +15g. A typical laboratory frequency response for an accelerometer is shown in Figure 16. The system sensitivity for each acceleration depended on the final gain resistors selected for the signal conditioning amplifiers. These amplifiers are described in Reference 1.

A potentiometer was connected to each accelerometer for recording shunt calibrations on tape by flipping a switch on the front panel of the measurement rack. The resistances were adjusted to simulate 1g above ambient for low cal and 2g above ambient for high cal.

Before and after testing on each aircraft, a three point static calibration (dump cal) was performed through the system. The three point static calibration technique is described in Reference 2. Whenever possible a low cal and high cal shunt calibration was performed for later verification of the overall system calibration. Table III for the C-141B and Table V for the C-5A include the calibration data that were recorded on tape.

2.4 Video System

The block diagram of the video system is shown in Figure 17. All components were in the video rack shown in Figure 8 except for the three cameras located on the aircraft exterior as shown in Figures 11 and 12. The cameras provided an optimum view of the gear motion, tire rotation and repair movement during each test run. C-141B camera power and video cables were routed to the rack through the nose, left and right hand wheel well inspection windows. On the C-5A, cables were routed through access holes under the aircraft. A typical camera mount is shown on the C-141B in Figure 18. The cameras were mounted each day after arrival at RAF Wethersfield and were removed at the end of each day. Camera mounting brackets remained on the aircraft for the duration of each test. Two cameras viewed the main landing gears and the third viewed the nose landing gear. On the C-5A, the cameras looked at the forward left main and aft right main landing gear. An operator turned the Video Cassette Recorders(VCRs) on prior to repair encounter and turned them off after completion of the test run. Since video timers were not available, the IRIG-B time code generator output was recorded on the VCR's audio tracks as shown in the block diagram in Figure 17.

On the C-141B, one VCR was used and cameras were switched as shown in Table IV. For the C-5A three VCRs were used and video tape records were made as shown in Table VI.

2.5 Other Considerations

All external wiring was secured to the aircraft with aluminum tape(FSN 7510-00-81-8077). A thin layer of silicone sealant(RTV) was applied to the tape's leading edge to prevent it from coming off due to airflow during taxi and flight. The tape stayed on with no problems and was easy to remove.

All instrumentation, except the cameras, were installed at RAF Mildenhall. All test runs were performed at RAF Wethersfield. Since cable routing from outside to inside the aircraft was via normally closed openings, the aircraft flew unpressurized and no higher than 5000 feet on the 20 minute flights between Mildenhall and Wethersfield.

An instrumentation engineer, instrumentation technician, and loads engineer were on the aircraft to monitor the accelerometer and video data during each test run.

3 FIELD EFFORTS ON C-141B

3.1 Installation

C-141B Tail Number 67-954 arrived at RAF Mildenhall on October 1st. The installation was completed in five days. Cables were fabricated, checked and installed. Accelerometer mounting blocks were bonded to the aircraft pylons. Aircraft power was connected to the instrumentation. The Base Sheet Metal Shop modified and mounted the three camera brackets. After mounting accelerometers, the aluminum tape was applied over the accelerometer wires. Three coax cables and three 5-wire cables were fabricated, checked and installed between the video cameras and video racks. Accelerometer wires were connected to terminal strips in back of the instrumentation rack. Accelerometer outputs were wired into the amplifier inputs via BNC connectors on back of the instrumentation racks.

3.2 Calibrations

Voltages were checked at accelerometer outputs, amplifier outputs, recorder inputs and recorder playback outputs. These voltages were compared to laboratory accelerometer sensitivities. Using data from a quick look dump cal of the accelerometers, end to end sensitivities and offsets were computed and evaluated for use in setting up accelerometer cal resistors and the oscillograph recorder.

Several accelerometers had larger than expected offsets. The offsets were found to be proportional to cable length! Later laboratory tests showed that these offsets could be reduced considerably by using larger size wire between the accelerometers and their signal conditioning.

Final calibrations were recorded on instrumentation tape as shown in Table III. Scaling and offsets were used for setting up the oscillograph recorder for 1g per inch or (1/2)g per inch as desired. Passive 1 Hertz filters were connected between the amplifier outputs and the instrumentation recorder inputs. Offsets on the oscillograph trace changed. This was temporary and probably due to water seeping into the base of the accelerometers. For testing, the filters were placed after the reproduce output as shown in Figure 10.

3.3 Setup, Procedures And Results

Acceleration data were recorded on instrumentation tape and oscillograph paper during each test event. Data on oscillograph paper were evaluated before proceeding to the next test event. The instrumentation recorder and oscillograph were started ten seconds before beginning of taxi and turned off after the aircraft passed over the repairs.

The C-141B left Mildenhall and landed at Wethersfield on October 7th. Recorded data are tallied in Table III. Twenty eight light gross weight events were made before returning to Mildenhall. A RCA portable VCR was used to record seven events on the right main landing gear while taxing over the repairs. The cameras were not used in the morning because of the rain. A summary of video records is included as Table IV.

On October 8th crew members loaded the aircraft with heavy vehicles. Fifteen heavy weight test events were recorded on instrumentation and video tape. Usually the right main gear was recorded on video, but when requested, the VCR was switched to the nose or left main gear. At times the left wing elastic accelerometer(A3) looked bad on the oscillograph trace.

The final nine heavyweight test events on the C-141B were recorded on October 9th. Eight events were recorded on video tape for the left or the right gear as requested. At the end of testing at Wethersfield, the aircraft returned to Mildenhall. A post three point calibration was performed on all accelerometers.

Where possible, all three video cameras were mounted and viewed by the on board test personnel. One camera signal was recorded on a portable VCR whenever possible.

4 FIELD EFFORTS ON C-5A

The C-5A Tail Number 690004 arrived on October 9th. Because of the low acceleration measured on the C-141B and previous experience from the C-5 HAVE BOUNCE test, a proposal was made to reduce the C-5A instrumentation to triax accelerometers at the pilot seat and at the center of gravity. Approval was received to reduce the instrumentation on the C-5A to six accelerometers inside the aircraft and three cameras under the aircraft. This decision to eliminate exterior accelerometers, plus experienced gained in setting up the instrumentation on the C-141B, reduced the time to modify the C-5A to two work days.

4.1 Installation

The equipment pallet, cameras and accelerometers were transferred from the C-141B to the C-5A. Cables used on the C-141B were cut for use on the C-5A. Aircraft power at the service outlet located at FS 630 was connected to the static power converter. The crew chiefs routed camera cables and mounted brackets. The three VCRs ordered for this project were received and installed in the video rack.

4.2 Calibration

The team completed accelerometer calibrations, setup of accelerometer cal resistors and setup of the oscillograph recorder. Several checks were made to make sure no offset changes occurred.

4.3 Setup, Procedures And Results

Acceleration data were recorded using the procedures used for the C-141B as described in Section 3.3. The six accelerometer signals on the oscillograph paper were reviewed after each test event to ensure there were no high acceleration level.

Testing started October 15th at Wethersfield. Fourteen light weight test events were recorded on the instrumentation recorder and the three VCRs. Video recordings were made of all three landing gear. After the last run, the fiberglass mat came loose so the plane was flown back to Mildenhall.

On October 16th the cloud ceiling at Wethersfield was 500 feet, so the mission was postponed. On October 17th the C-5A was flown to Wethersfield and loaded with heavy vehicles. A VCR power supply on the aircraft went bad so the RCA portable VCR was substituted for the bad one. The day finished with fourteen heavyweight test events recorded on the instrumentation tape and video tapes.

On October 18th heavyweight testing resumed. During the 80 knot deceleration test event (36), ground observers saw the fiberglass mat coming up. Ground video also showed the mats coming up. Two aircraft video tapes were viewed to try to see mat upheaval during the run. Viewing the aircraft video tapes was inconclusive, so a new 80 Knots deceleration event(49) with no braking was added to check for mat reaction. During event 49, the fiberglass mat came apart and pieces caused some aircraft damage, especially in the left hand wheel well. A flying part severed the coaxial cable to the aft camera and caused video failure during the run. The crew spent the rest of the day preparing the aircraft for return to Mildenhall. This included unloading all the cargo, patching damaged wheel well areas and changing several flat tires. C-5A video tapes were duped and a final three point accelerometer calibration was accomplished. Data recorded on instrumentation tape are listed in Table V. All three landing gear were recorded on video tape as tabulated in Table VI.

5 LABORATORY ANALYSIS OF DATA

5.1 Quick Look Playback Of Data

After return to Wright Patterson, all data were played back on a laboratory tape recorder. The reproduced data were low pass filtered at a frequency of 10 hertz and recorded on paper with the laboratory oscillograph recorder. The laboratory setup shown in Figure 19 was similar to the field setup except for use of 10 Hertz active filters rather than 1 Hertz passive filters. Random noise data recorded in the field were played back with a 10 Hertz filter and no filter to check the frequency response of each channel. Typical responses are shown in Figures 20 and 21.

5.2 Calibration Of Data

The oscillograph was set up for a sensitivity of 10 mv/mm by inserting 0 and 250 mvdc voltage levels. Data from the precal and postcal records were used to determine sensitivities in g/mm. A typical shunt calibration is shown in Figure 22. The results of these oscillograph calibrations are shown in Table VII.

5.3 Data Reduction

Oscillograph records were made at .1 ips for all data on both instrumentation tapes. Data were manually read for highest peak to peak change in millimeters for each of the parameters. The records with the highest changes were then recorded on oscillograph paper at 1 ips for closer study. The selected records are shown in Table VIII for the C-141B and Table IX for the C-5A.

The C-141B data were played back in two passes. During pass 1 A1,A2,A5,A7,A9 and A11 were recorded on oscillograph paper. During pass 2 the other six accelerometer signals were recorded. The C-5A data were played back in one pass.

5.4 Data Results

For the records in Tables VIII and IX, peak to peak changes were read in millimeters as shown on trace A6 for a typical time history in Figure 23. For each accelerometer, the maximum peak to peak changes are marked by an asterisk and then listed below the dashed line in the tables. These maximums are then multiplied by oscillograph sensitivities to obtain the maximum differential g peak to peak for each accelerometer. The maximum g's for each accelerometer are listed on the bottom line of Tables VIII and IX.

Using Table VIII for the C-141B, it is seen that the maximum g peak to peak for non pylon accelerometers(A1,A2,A3 and A12) was 1.28 g's for the pilot seat location(A1). For vertical pylon accelerometers(A4,A6,A8 and A10), the maximum was 3.33 g's for the left inboard pylon(A6). The maximum for lateral pylon accelerometers(A5,A7,A9,A11) was 5.52 g's for the left inboard pylon(A7). Based on previous HAVE BOUNCE tests, these g levels were insignificant. The levels on the pylons are not of concern because they occurred at higher frequency ranges.

By using Table IX, it is found that the maximum peak to peak acceleration on the C-5A was 1.026 g's for the vertical accelerometer at the pilot seat(A1). Again, based on previous HAVE BOUNCE tests, this level was not significant.

5.5 Video Results

Logs of video tape records are included as Tables IV and VI for the C-141B and the C-5A respectively. In the laboratory, the video tapes were audio dubbed on track 2 with record remarks shown in the tables. Time code on track 1 was not disturbed.

6 CONCLUSIONS

During testing with both aircraft, no high level accelerations were observed at low frequencies. This indicated aircraft design limit loads were not exceeded.

The video cameras worked well in a location where humans or transducers could not perform. The real time video was an excellent tool to evaluate gear motion during the actual test events.

The accelerometer's increase offset as a function of cable distance was caused by using small size wire to connect the accelerometers. The offset did not affect test results, but the offset could cause data loss on tests requiring long cable lengths.

The overall data quality was good. Future tests should include video timers, a smaller instrumentation recorder and better filters.

7 REFERENCES

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2. Banaszak, David, "Automating Transducer Calibrations for Users", Thirteenth Transducer Work Shop, Sponsored by Vehicular Instrumentation Committee of Range Commanders Council at Monterey CA, June 1985.

APPENDIX A

TABLES

A.1 TABLE I RAPID RUNWAY REPAIR PARAMETER LIST

AIRCRAFT TYPE: C-141B

ID	ACCELEROMETER DESCRIPTION	MAX RANGE(g)	FREQ(HZ) REQUIRED	ESTIMATED ACCURACY
A1	Vertical at Pilot's Station	-5 to +5	10HZ	+_.25 G
A2	Vertical at A/C c.g.	-3 to +3	10HZ	+-.05 G
A3	Vertical at Left Wing Elastic Axis	-10 to +10	10HZ	+-.5 G
A4	Vertical at Left Outboard Pylon	-5 to +5	10HZ	+-.3 G
A5	Lateral at Left Outboard Pylon	-6 to +6	10HZ	+-.3 G
A6	Vertical at Left Inboard Pylon	-5 to +5	10HZ	+-.3 G
A7	Lateral at Left Inboard Pylon	-6 to +6	10HZ	+-.3 G
A8	Vertical at Right Inboard Pylon	-5 to +5	10HZ	+-.3 G
A9	Lateral at Right Inboard Pylon	-6 to +6	10HZ	+-.3 G
A10	Vertical at Right Outboard Pylon	-5 to +5	10HZ	+-.3 G
A11	Lateral at Right Outboard Pylon	-6 to +6	10HZ	+-.3 G
A12	Vertical at Right Wing Elastic Axis	-10 to +10	10HZ	+-.5 G
C1	Video Left Main Gear			
C2	Video Nose Gear			
C3	Video Right Main Gear			

AIRCRAFT TYPE: C-5A

A1	Vertical at Pilot's Station	-5 to +5g
A2	Vertical at A/C c.g.	-3 to +3g
A3	Lateral at Pilot's Station	Unknown
A4	Lateral at A/C c.g.	Unknown
A5	Longitudinal at Pilot's Station	Unknown
A6	Longitudinal at A/C c.g.	Unknown
C1	Video Left Main Gear	
C2	Video Nose Gear	
C3	Video Right Gear	

A.2 TABLE II EQUIPMENT USED ON RRR PROJECT

PRIMARY MEASUREMENT SYSTEM EQUIPMENT

DESCRIPTION	QTY	WT(lbs)	WATTS(EA)
Honeywell 101 Instrumentation Recorder	1	100	480
Honeywell Model 1858 Oscillograph Recorder	1	72	480
Frequency Devices 12 Channel Low Pass Filter Box	1	15	
Signal Conditioning Shelf (Datel Amps, Power Cube and Time Code)			~140
Norland Digital O-Scope	1	44	200
Power Supply	2		
19" Rack(22(W)X72(H)X24(D)) 63(H) OPENING 34(D) with base			

SECONDARY VIDEO SYSTEM EQUIPMENT

JVC Model TM-22U Portable Color Video Monitor	3	9.0	27
JVC Model BR-6200U Portable (VHS) Video Cassette Recorder	3	13.0	9
Power Supply for CPD Color Camera WV-C120	3	2.9	26
AA-P26VAC Power Adapter/Battery Charger			
19" Rack			
Unitron PS-62-66D Static Freq Converter AC in 115/200+-20 VRMSL-L 3 phase wye or delta AC out 115VAC, 3 phase, 60HZ, 3500VA	2	95	
Setra Model 141A Accelerometers .88(W)x.875(H)x.880(D)	12	0.1	DC 15V, 7.5MA
Panasonic CPD Color Camera WV-CD120	3	3.0	DC 10.5VC 600MA

A.3 TABLE III DATA TAPE RECORDS ON C-141B(T/N 67-954)

(Page 1 of 3)
Recorder Type: Honeywell 101 Tape Speed: 15/16 ips

Track 1-12: A1-A12 mbfm Track 14: Time Code-Direct Record Track 16:Voice

REC	FOOTAGE	DATE	TIME	REMARKS
0	0-161	10/5		Tape Operation Check
1	161-184			White Noise DC-1KHZ
2	184-193			A1 +1g Cal and Shunt Cal
3	193-200			A1 0g Cal and Shunt Cal
4	200-208			A1 -1g Cal and Shunt Cal
5	208-217			A2 +1g Cal and Shunt Cal
6	217-226		1909	A2 0g Cal and Shunt Cal
7	226-235			A2 -1g Cal and Shunt Cal
8	235-244			A3 +1g Cal and Shunt Cal
9	244-253			A3 0g Cal and Shunt Cal
10	253-262			A3 -1g Cal and Shunt Cal
11	262-271			A4 +1g Cal and Shunt Cal
12	271-280			A4 0g Cal and Shunt Cal
13	280-289			A4 -1g Cal and Shunt Cal
14	289-298			A5 +1g Cal and Shunt Cal
15	298-307			A5 0g Cal and Shunt Cal
16	307-316			A5 -1g Cal and Shunt Cal
17	316-325			A6 +1g Cal and Shunt Cal
18	325-334			A6 0g Cal and Shunt Cal
19	334-343			A6 -1g Cal and Shunt Cal
20	343-352			A7 +1g Cal and Shunt Cal
21	352-361			A7 0g Cal and Shunt Cal
22	361-370			A7 -1g Cal and Shunt Cal
23				Start/Stop Record
23A	370-379			A7 +1g Cal and Shunt Cal Repeat
24	379-391			A8 +1g Cal and Shunt Cal
25	391-400			A8 0g Cal and Shunt Cal
26	400-409			A8 -1g Cal and Shunt Cal
27	409-418			A9 +1g Cal and Shunt Cal
28	418-424			A9 0g Cal
29	424-430			A9 -1g Cal
30	430-435			A10 +1g Cal
31	435-440			A10 +1g Cal and A12 +1g Cal
32	440-445			A10 0g Cal and A12 0g Cal
33	445-450			A10 -1g Cal and A12 -1g Cal
34	450-455			A11 +1g Cal
35	455-460			A11 0g Cal
36	460-465			A11 -1g Cal
	465-461	10/6	0930	Checking out Time Code
37	481-489		1308	Aircraft being towed
38	489-493			More aircraft being towed
	493-516			Setting Time Code track 14
	516-631			Setting up oscillograph ambient levels
	631-653			Filters between Datel amps and Recorder

TABLE III DATA TAPE RECORDS ON C-141B(T/N 67-954)
(Page 2 of 3)
Recorder Type: Honeywell 101 Tape Speed: 15/16 ips
Track 1-12: A1-A12 mbfm Track 14: Time Code-Direct Record Track 16: Voice

REC	FOOTAGE	DATE	TIME	REMARKS
	653-664	10/7	0723	Filters removed before Leave Mildenhall Filter between 101 and oscillograph
	664-675			Record gap before test records
1A	675-824			Taxi-Takeoff from RAF Mildenhall
2A	824-841		0850/0854	Landing at RAF Wethersfield Short On/Off Record
3	841-852		1111-1114	(0A) 5 Knot Back Taxi
4	852-859		1120-1122	(1) 5 Knot Taxi
5	859-868		1142-1145	(1A) 5 Knot Back Taxi
6	868-874		1146-1148	(2) 10 Knot Taxi
7	874-882		1200-1202	(2A) 5 Knot Back Taxi
8	882-889		1204-1205	(3) 20 Knot Taxi(Acceleration)
9	889-900		1216-1218	(3A) 5 Knot Back Taxi
10	900-905		1220-1222	(4) 20 Knot Taxi(Braking)
11	905-914		1240-1242	(4A) 5 Knot Back Taxi
12	914-923		1246-1248	(5) 40 Knot Acceleration
13	923-931		1250-1256	Shunt Cal
14	931-939		1306-1308	(5A) 5 Knot Back Taxi
15	939-956		1313-1315	(6) 40 Knot Braking Aborted
16	956-958		1315-1316	(6) 40 Knot Braking
17	958-981		1335-1339	(6A) 5 Knot Back Taxi
18	981-985		1343-1345	Engine Runup on fiberglass mats
19	971-975		1613-1615	(7) 60 Knot Acceleration
20	975-988		1627-1630	(7A) 5 Knot Back Taxi
21	988-992		1637-1638	(8) 60 Knot Braking
22	992-1004		1651-1654	(8A) 5 Knot Back Taxi
23	1004-1012		1659-1700	(9) 80 Knot Acceleration
24	1012-1028		1714-1717	(9A) 5 Knot Back Taxi
25	1028-1034		1724-1725	(10) 80 Knot Deceleration(no brake)
26	1034-1040		1738-1739	(10A) 5 Knot Back Taxi
27	1040-1046		1748-1749	(12) 100 Knot Accel Deleted Takeoff from Wethersfield
28	1046-1056		1752-1753	(13) Landing at Wethersfield
29	1056-1062		1810-1811	Takeoff from Wethersfield
30	1062-1072		1821-1823	Landing at RAF Mildenhall
31	1072-1079		1828-1830	Shunt Cal

TABLE III DATA TAPE RECORDS ON C-141B(T/N 67-954)
(Page 3 of 3)
Recorder Type: Honeywell 101 Tape Speed: 15/16 ips
Track 1-12: A1-A12 mbfm Track 14: Time Code-Direct Record Track 16: Voice

REC	FOOTAGE	DATE	TIME	REMARKS
32	1079-1098	10/8	0756-0802	Taxi and Takeoff from Mildenhall
33	1098-1105		0822-0824	Landing at Wethersfield and Taxi
34	1105-1033		1031-1033	Shunt Cal
35	1108-1125		1050-1055	Taxi into position for event(27A)
36	1225-1144		1100-1103	(27A) 5 Knot Back Taxi
37	1144-1152		1108-1109	(28) 10 Knot Taxi
38	1152-1166		1127-1130	(28A) 5 Knot Back Taxi
39	1166-1172		1134-1135	(29) 20 Knot Taxi
40	1172-1186		1147-1150	(29A) 5 Knot Back Taxi
41	1186-1191		1154-1155	(30) 20 Knot Braking
42	1191-1205		1208-1211	(30A) 5 Knot Back Taxi
43	1205-1213		1221-1223	(31) 40 Knot Acceleration
44	1213-1226		1243-1246	(31A) 5 Knot Back Taxi
45	1226-1231		1250-1251	(32) 40 Knot Braking
46	1231-1244		1258-1301	(32A) 5 Knot Back Taxi
47	1244-1247		1500-1502	(33) 60 Knot Acceleration
48	1247-1262		1519-1522	(33A) 5 Knot Back Taxi
49	1262-1269		1545-1547	(34) 60 Knot Braking
50	1269-1286		1609-1612	(37A) Taxi Turns at 5 Knots
51	1286-1289		1709-1711	Takeoff from RAF Wethersfield
52	1289-1305		1724-1727	Landing at RAF Mildenhall
53	1305-1307		1738-1740	Shunt Cal
54	1307-1321	10/9	0718-0721	Shunt Cal
55	1321-1325		0812-0814	Takeoff from RAF Mildenhall
56	1325-1333		0827-0829	Landing at RAF Wethersfield
57	1333-1355		1014-1020	(34A) 5 Knot Back Taxi
58	1355-1368		1025-1028	(35) 80 Knot Acceleration
59	1368-1382		1045-1049	(35A) 5 Knot Back Taxi
60	1382-1388		1127-1131	(36) 80 Knot Deceleration
61	1388-1434		1146-1154	(36A) 5 Knot Back Taxi
62	1434-1441		1326-1328	(38) Takeoff from RAF Wethersfield
63	1441-1450		1332-1334	(39) Landing at RAF Wethersfield
64	1450-1465		1352-1355	(39A) 5 Knot Back Taxi
65	1465-1472		1406-1407	(47) 60 Knot Braking on mat
66	1472-1491		1432-1436	Taxi Turn 1st mat
67	1491-1506		1438-1441	Taxi Turn 2nd mat(fiberglass)
68	1506-1511		1449-1453	A2 +1g, 0g, -1g Cal
69	1511-1520		1453-1455	A2 +1g, 0g, -1g Cal
70	1520-1524		1652-1654	A3 and A12 +1g, 0g, -1g Cal
71	1529-1538		1706-1708	A10 and A11 +1g, 0g, -1g Cal
72	1538-1547		1713-1715	A1 +1g, 0g, -1g Cal
73	1547-1557		1716-1719	A8 and A9 +1g, 0g, -1g Cal
74	1557-1566		1727-1729	A4 and A5 +1g, 0g, -1g Cal
75	1566-1575		1736-1738	A6 and A7 +1g, 0g, -1g Cal

A.4 TABLE IV VIDEO TAPE RECORDS ON C-141B(TN 67-954)

Recorder Type: RCA Portable   Tape Speed: EP
Video Track: Camera out Audio Track: Time code

Date	JVC Counter	(Event) Description
10/6	0000-0427	Aircraft inside hangar and equipment inside
	0477-0642	C-141 leaving hangar and inside aircraft
	0688-0692	Still of Right Main Gear
10/7	0696-0705	Still of Right Main Gear-Practice
	0705-0707	Gap before LIGHTWEIGHT RUNS
	0707-0719	(7) 60 Knot Acceleration
	0724-0764	(7A) 5 Knot Back Taxi
	0767-0778	(8) 60 Knot Braking
	0784-0826	(8A) 5 Knot Back Taxi
	0827-0844	(9) 80 Knot Acceleration
	0844-0896	(9A) 5 Knot Back Taxi
	0896-0915	(10) 80 Knot Deceleration(no braking)
10/8	0915-1023	Gap Before HEAVYWEIGHT RUNS
	1023-1083	(27A) 5 Knot Back Taxi
	1083-1105	(28) 10 Knot Taxi
	1105-1143	(28A) 5 Knot Back Taxi
	1143-1157	(29) 20 Knot Taxi
	1157-1159	Still of Right Main Gear
	1159-1190	(29A) 5 Knot Back Taxi
	1190-1204	(30) 40 Knot Braking(just before mat)
	1203-1253	People checking brake and tire temperatures
	1253-1279	(30A) 5 Knot Back Taxi
	1279-1299	(31) 40 Knot Acceleration
	1299-1322	(31A) 5 Knot Back Taxi
	1322-1334	(32) 40 Knot Braking
	1334-1366	(32A) 5 Knot Back Taxi-Left Main Gear
	1368-1384	(33) 60 Knot Acceleration-Left Main Gear
	1384-1414	(33A) 5 Knot Back Taxi-Left Main Gear
	1414-1423	Still of Nose Gear
	1423-1439	(34) 60 Knot Braking-Nose Gear
	1439-1452	Turning around-Nose Gear
	1452-1502	(37A) Taxi Turn
10/9	1507-1553	(34A) 5 Knot Back Taxi
	1553-1567	(35) 80 Knot acceleration
	1567-1610	(35A) 5 Knot Back Taxi-Left Main Gear
	1610-1628	(36) 80 Knot Deceleration-Left Main Gear
	1628-1662	(36A) 5 Knot Back Taxi-Left Main Gear
	1662-1695	(39A) 5 Knot Back Taxi
	1695-1707	(47) 60 Knot Braking
	1707-1760	Taxi Turn over Pre Cast Slabs
	1760-1804	Taxi Turn over fiberglass

NOTE: All records are of right main gear unless otherwise described.
Audio dubbed Right channel for all test events on 11/13/85
Time Code recorded on site on Left and Right channels for all events.

A.5 TABLE V DATA TAPE RECORDS ON C-5A(TN 690004)

(Page 1 of 2)
Recorder Type: Honeywell 101 Tape Speed: 15/16 ips
Track 1-6: A1-A6 mbfm Track 14: Time Code-Direct Record Track 16: Voice

REC	FOOTAGE	DATE	TIME	REMARKS
1	2000-2011	10/11	1446-1448	A2 +1g, 0g, -1g Cal
2	2011-2022		1448-1450	A4 +1g, 0g, -1g Cal
3	2022-2033		1451-1453	A6 +1g, 0g, -1g Cal
4	2033-2044		1501-1503	A1 +1g, 0g, -1g Cal
5	2044-2055		1504-1506	A3 +1g, 0g, -1g Cal
6	2055-2067		1507-1509	A5 +1g, 0g, -1g Cal
7	2067-2093		1615-1621	Oscillograph Setup Record
8	2093-2108		1727-1730	Shunt Cal
9	2108-2117	10/13	1420-1422	Shunt Cal
10	2117-2125	10/15	1103-1105	Shunt Cal
11	2125-2285		1224-1258	Takeoff Mildenhall/ Landing Wethersfield
12	2279-2290		1359-1401	(1A) 5 Knot Back Taxi
13	2290-2297		1405-1406	(2) 10 Knot Taxi
14	2297-2308		1423-1425	(2A) 5 Knot Back Taxi
15	2308-2313		1428-1429	(3) 20 Knot Taxi
16	2313-2328		1445-1449	(3A) 5 Knot Back Taxi
17	2328-2334		1451-1452	(4) 20 Knot Braking
18	2334-2347		1509-1512	(4A) 5 Knot Back Taxi
19	2347-2354		1515-1516	(5) 40 Knot Acceleration
20	2354-2363		1535-1537	(5A) 5 Knot Back Taxi
21	2363-2372		1538-1540	(6) 40 Knot Braking
22	2372-2380		1556-1558	(6A) 5 Knot Back Taxi
23	2380-2387		1559-1601	(7) 60 Knot Acceleration
24	2387-2394		1620-16212	(7A) 5 Knot Back Taxi
25	2394-2398		1630-1631	60 Knot Braking
26	2398-2571		1743-1820	Takeoff Wethersfield/Landing Mildenhall
27	2571-2518		1822-1824	Shunt Cal
28	2578-2580		1824-1826	Shunt Cal
29	2580-2590	10/16	1123-1125	Shunt Cal

TABLE V DATA TAPE RECORDS ON C-5A(TN 690004)
(Page 2 of 2)
Recorder Type: Honeywell 101 Tape Speed: 15/16 ips
Track 1-6: A1-A6 mbfm Track 14: Time Code-Direct Record Track 16: Voice

REC	FOOTAGE	DATE	TIME	REMARKS
30	2590-2610	10/17	0959-1001	Shunt Cal
31	2610-2793		1042-1121	Takeoff Mildenhall/Landing Wethersfield
32	2793-2749		1359-1400	(28) 10 Knot Taxi
33	2749-2809		1406-1408	(28A) 5 Knot Back Taxi
34	2809-2813		1425-1426	(29) 20 Knot Taxi
35	2813-2816		1430-1432	(29A) 5 Knot Back Taxi
36	2816-2823		1454-1456	(30) 20 Knot Braking
37	2823-2834		1500-1502	(30A) 5 Knot Back Taxi
38	2834-2838		1520-1521	(31) 40 Knot Acceleration
39	2838-2846		1524-1526	(31A) 5 Knot Back Taxi
40	2346-2349		1546-1547	(32) 40 Knot Braking
41	2849-2864		1549-1552	(32A) 5 Knot Back Taxi
42	2864-2875		1615-1617	(33) 60 Knot Acceleration
43	2875-2879		1621-1622	(33A) 5 Knot Back Taxi
44	2879-2884		1710-1711	(34) 60 Knot Braking
45	2884-2894		1713-1715	(34A) 5 Knot Back Taxi
46	2894-2904		1727-1729	Shunt Cal
47	2905-2918	10/18	0718-0720	Shunt Cal
48	2918-2925		0823-0824	(35) 80 Knot Acceleration
49	2925-2941		0826-0829	(35A) 5 Knot Back Taxi
50	2941-2946		0849-0850	(36) 80 Knot Deceleration
51	2946-2966		0939-0943	(37A) Taxi Turns
52	2966-2972		1128-1129	(49) 80 Knot Decel(no brakes) Repeat(36)
53	2972-		1516-1518	A2 +1g, 0g, -1g Cal
54			1521-1524	A2 +1g, 0g, -1g Cal
55			1525-1528	A4 +1g, 0g, -1g Cal
56			1528-1531	A6 +1g, 0g, -1g Cal
57			1537-1548	A1 and A3 and A5 +1g, 0g, -1g Cal

A.6 TABLE VI VIDEO TAPE RECORDS ON C-5A(TN 690004)

Recorder Type: JVC Portable Tape Speed: EP and SP
RCA Portable Tape Speed: EP

Video Track:Camera Audio Track 1:Time Code Audio Track 2:Audio Dub

Gear Shelf DATE	Right Fwd Top VCR 3 COUNTER	Nose Middle VCR 2 COUNTER	Left Rear Bottom VCR 1 COUNTER	REMARKS
10/15	0000-0009	0000-0009	0000-0009	Still of Landing Gear
	0009-0058	0009-0058	0009-0056	(1A) 5 Knot Back Taxi
	0058-0076	0058-0076	0056-0075	(2) 10 Knot Taxi
	0076-0136	0076-0135	0075-0135	(2A) 5 Knot Back Taxi
	0136-0149	0135-0149	0135-0148	(3) 20 Knot Taxi
	0149-0158	0149-0158	0148-0158	Checking Brake Temperatures
	0158-0255	0158-0255	0158-0256	(3A) 5 Knot Back Taxi
	0255-0278	0255-0277	0256-0279	(4) 20 Knot Braking
	0278-0316	0277-0316	0279-0315	(4A) 5 Knot Back Taxi
	0316-0345	0316-0344	0315-0344	(5) 40 Knot Acceleration
	0345-0375	0344-0374	0344-0375	(5A) 5 Knot Back Taxi
	0375-0408	0374-0407	0375-0408	(6) 40 Knot Braking
	0408-0435	0407-0434	0408-0434	(6A) 5 Knot Back Taxi
	0435-0461	0434-0460	0434-0460	(7) 60 Knot Acceleration
	0461-0488	0460-0488	0460-0488	(7A) 5 Knot Back Taxi
	0488-0505	0488-0504	0488-0502	(8) 60 Knot Braking
10/17	0505-0509	0504-0514	0502-0509	Blank Screen-VCRs Switched to SP
	0509-0559	0514-0561	0509-0557	(28) 10 Knot Taxi
	0559-0677	0561-0704	0557-0695	(28A) 5 Knot Back Taxi
	Missed	0704-0737	0695-0727	(29) 20 Knot Taxi
	Missed	0737-0763	0727-0753	(29A) 5 Knot Back Taxi
	-----	-----	-----	VCR 3 Changed to RCA Portable
	-----	-----	-----	Time Code Not connected to VCR 3
	0677-0733	0763-0817	0753-0804	(30) 20 Knot Braking
	0733-0890	0817-0940	0804-0927	(30A) 5 Knot Back Taxi
	0890-0943	0940-0988	0927-0974	(31) 40 Knot Acceleration
	0943-1032	0988-1062	0974-1049	(31A) 5 Knot Back Taxi
	1032-1057	1062-1085	1049-1070	(32) 40 Knot Braking
	1057-1143	1085-1163	1070-1150	(32A) 5 Knot Back Taxi
	1143-1234	1163-1252	1150-1237	(33) 60 Knot Acceleration
	1234-1267	1252-1279	1237-1267	(33A) 5 Knot Back Taxi
	1267-1299	1279-1307	1267-1294	(34) 60 Knot Braking
	1299-1341	1307-1345	1294-1331	(34A) 5 Knot Back Taxi
	1341-1395	1345-1394	1331-1379	Turning C-5A Around
10/18	1395-1466	1394-1448	1379-1433	(35) 80 Knot Acceleration
	1466-1508	1448-1485	1433-1470	(35A) 5 Knot Back Taxi
	1508-1589	1485-1564	1470-1549	Aircraft Standing Still
	1589-1643	1564-1614	1549-1600	Aircraft Turning
	1643-1685	1614-1653	1600-1638	(36) 80 Knot Deceleration
	1685-1796	1653-1758	1638-1742	(37A) Taxi Turns
	1796-1836	1758-1758	1742-1818	Tapes 3 and 1 Removed for Review
	1836-1879	1758-1790	1818-1844	(49) 80 Knot Decel(no brakes) Repeat(36)
				Lost VCR 3 on this Record over mat
	1879-1967	done	done	Aircraft Stills after Event (49)

NOTES: Events (28) thru (34A) have best light. Can compute speed from tire rotation or repair crossing time. Can copy video frame onto video copier.

A.7 TABLE VII LABORATORY OSCILLOGRAPH CALIBRATIONS

ID	C-141B CALIBRATIONS PRE CAL g/mm	POST CAL g/mm	%change
A1	.0513	.0513	0.0
A2	.0417	.0400	-4.1
A3	.105	.1176	+11.4
A4	.0506	.0506	0.0
A5	.0615	.0588	-4.4
A6	.0513	.0482	-6.0
A7	.0563	.0571	+1.4
A8	.0526	.0526	+0.0
A9	.0541	.0541	+0.0
A10	.0435	.0430	-1.1
A11	.0556	n/a	
A12	.0952	.0909	

ID	C-5A CALIBRATIONS PRE CAL g/mm	POST CAL g/mm	%change
A1	.0513	n/a	
A2	.0417	.0417	0.0
A3	.0476	n/a	
A4	.0526	.0519	-1.3
A5	.0435	n/a	
A6	.0455	.0460	+1.1

A.8 TABLE VIII C-141B PEAK TO PEAK VALUES READ FROM OSCILLOGRAPH

Peak to Peak Values in Millimeters for Each Accelerometer and Event

EVENT/Accel. ID=>	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
19(7) 60k Accel	11	8	7	12	50	17	<10	9	>10	1	>10	5
21(8) 60k Brake	11	8	4	11	12	13	5	15	7	23	8	8
23(9) 80k Accel	8	8	7	13	25	17	15	13	15	15	22	8
25(10)80k Accel	10	8	6	16	15	17	12	10	15	18	16	7
28(13)Ldg Weth	12	15	10*	32	37	26	50	24	73	35*	63	12*
49(34)60k Brake	13	6	6	13	65	13	18	10	30	17	48	6
58(35)80k Accel	<10	<10	5	18	<10	16	<10	13	<10	22	20	8
60(36)80k Decel	15	11	5	20	38	13	21	13	17	19	60	6
63(39)Ldg Weth	25*	21*	9	47*	83*	65*	98*	26*	65*	31	97*	9
64(39A)5k BT	<10	<10	3	9	<10	8	<10	7	<10	9	<10	3
65(47)60k Brake	17	10	5	23	37	13	21	12	24	20	60	6
Max mm p-p	25	21	10	47	83	65	98	26	65	35	97	12
x g/cm	.513	.417	1.05	.506	.615	.513	.563	.526	.541	.435	.556	.952
Maximum g p-p	1.28	0.88	1.05	2.38	5.10	3.33	5.52	1.37	3.52	1.52	5.39	1.14

NOTE: Maximum g p-p on pylons(A4 thru A11) occur at frequencies higher than about 5 Hertz. Further analysis requires removal of Higher Frequency data.
* Maximum peak to peak event.

A.9 TABLE IX C-5A PEAK TO PEAK VALUES READ FROM OSCILLOGRAPH

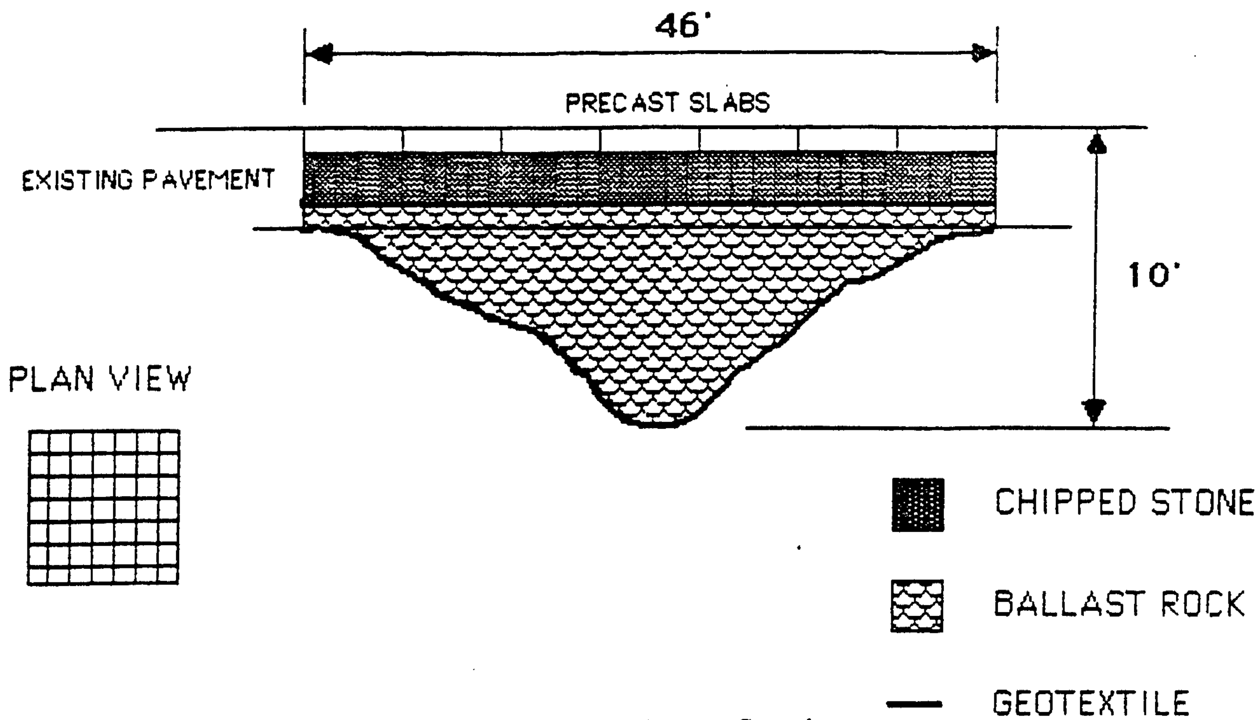
Peak to Peak Values in Millimeters for each Accelerometer and Event

REC	EVENT	A1	A2	A3	A4	A5	A6
15	(3)20k Taxi	14	8	<10	<10	<10	<10
19	(5)40k Accel	15	10*	<10	<10	15	15
20	(5A)5k Back Taxi	<10	<10	<10	<10	<10	<10
21	(6)40k Braking	9	<10	<10	<10	17	17*
23	(7)60k Accel	15	10*	<10	<10	15	10
25	(8)60k Braking	20*	10*	8	8	18*	16
34	(29)20k Taxi	<10	<10	<10	<10	<10	<10
38	(31)40k Accel	15	10*	<5	<5		
40	(32)40k Braking	12	5	<10	<10	<10	<10
42	(33)60k Accel	13	8	<10	<10	<10	<10
44	(34)60K Braking	10	8	<10	<10	<10	<10
48	(35)80k Accel	18	10*	<10	<10	<10	<10
50	(36)80k Decel	15	8	<10	<10	<10	<10
52	(47)(36Again)	15	8	<10	<10	<10	<10
Max mm peak to peak		20	10	<10	<10	18	17
x Cal g/cm		.513	.417	.476	.526	.435	.455
Max g peak to peak		1.026	0.417	<.476	<.526	0.783	0.774

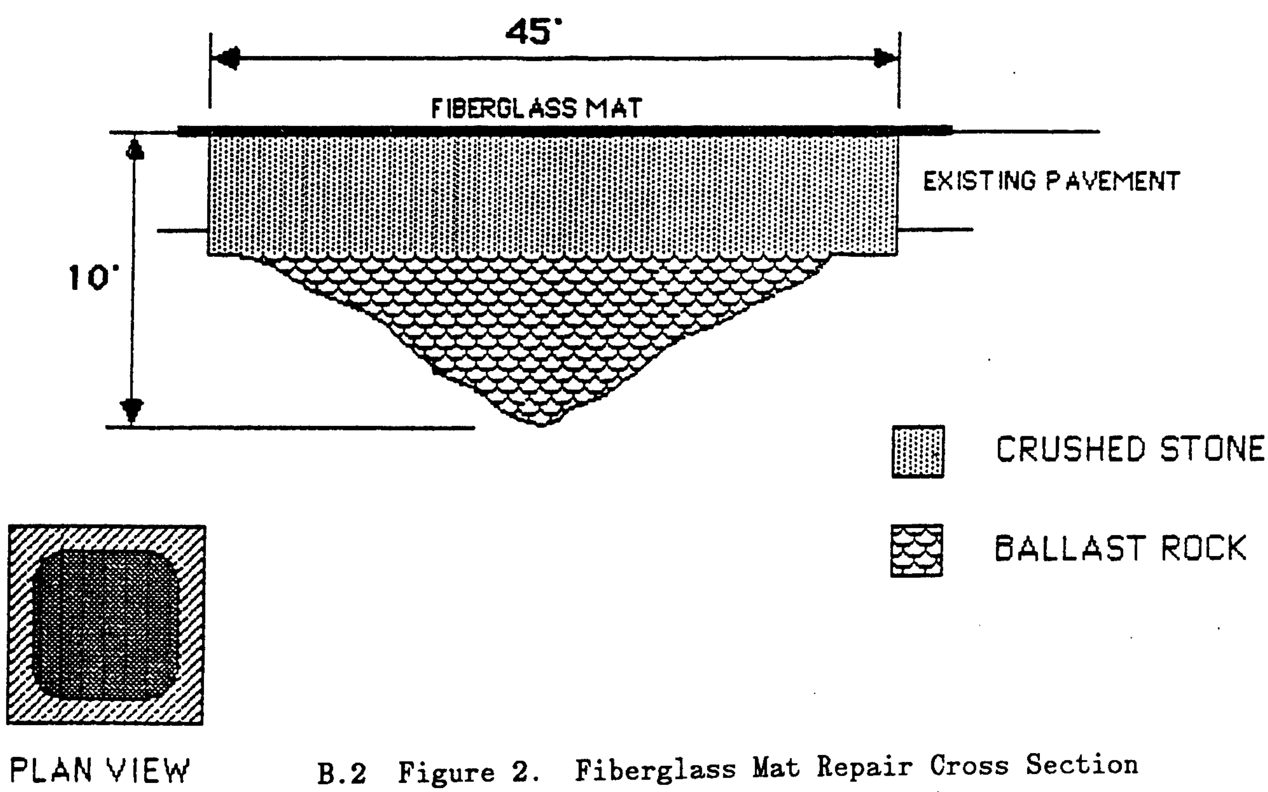
NOTE: * Maximum Peak to Peak event.

APPENDIX B

FIGURES



B.1 Figure 1. Precast Slab Repair Cross Section

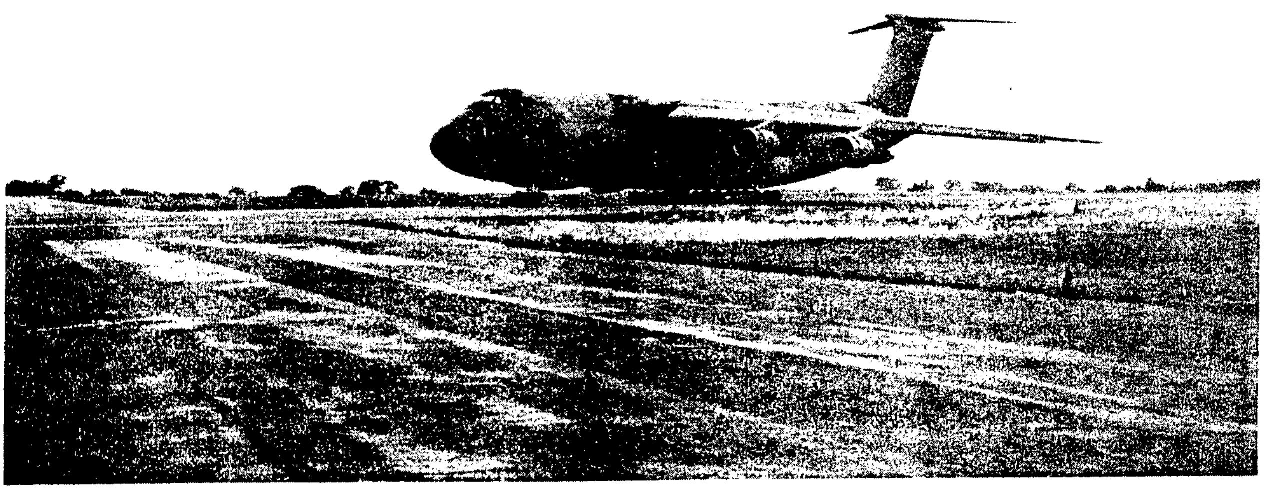


B.2 Figure 2. Fiberglass Mat Repair Cross Section

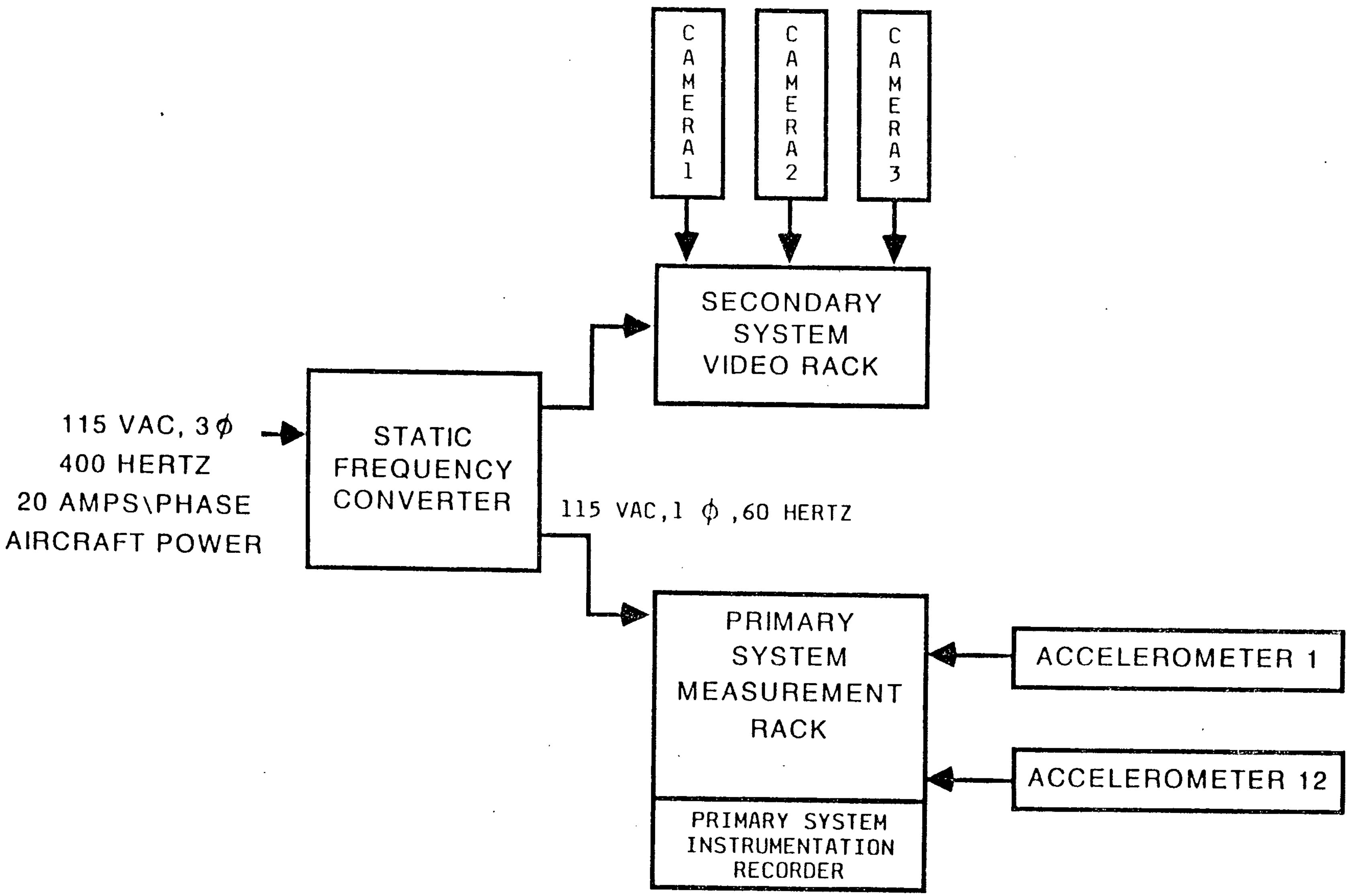
B.3 Figure 3. Precast Slab Repair at RAF Wethersfield

B.4 Figure 4. Fiberglass Mat Repair at RAF Wethersfield

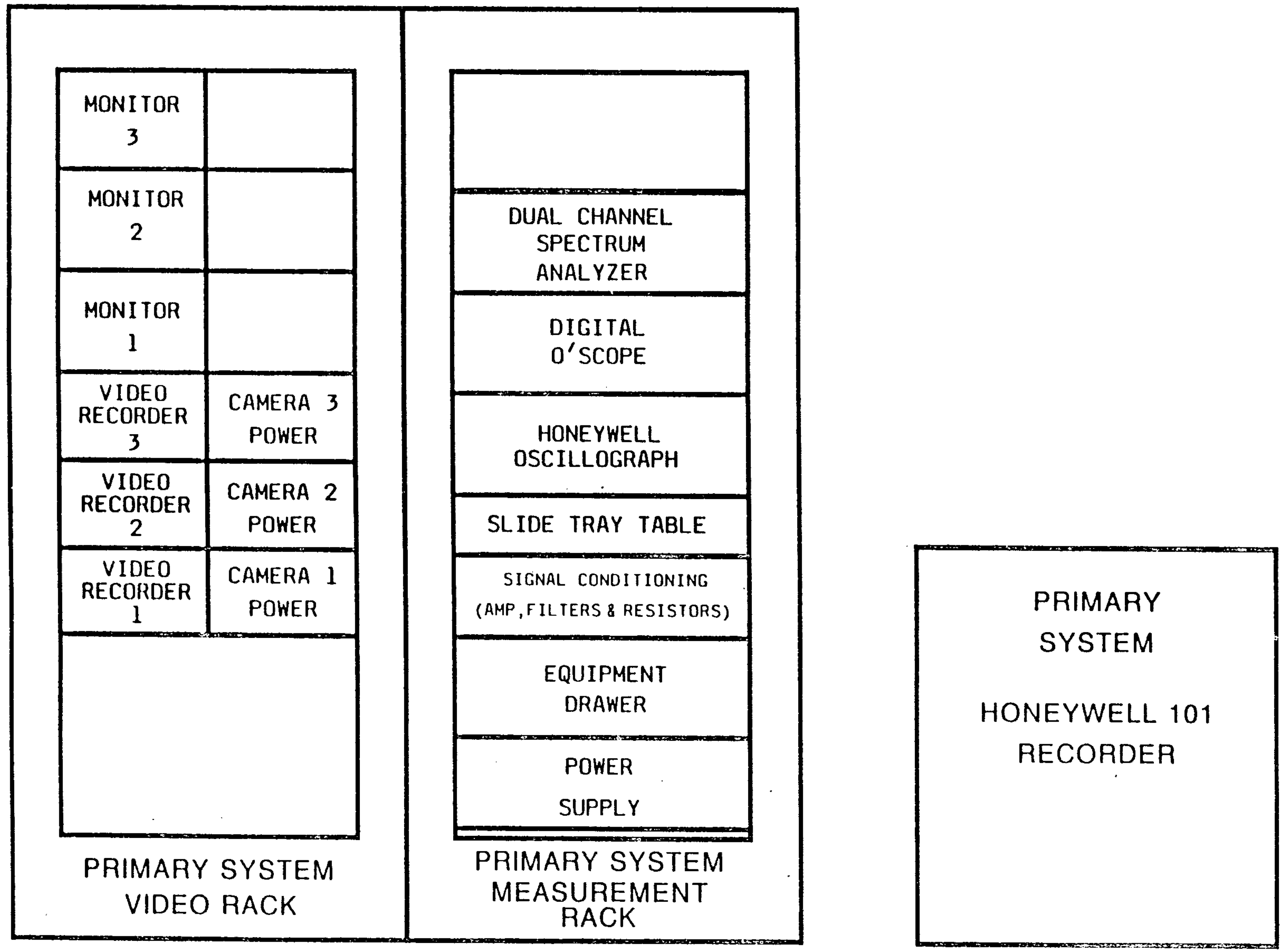
B.5 Figure 5. C 141 on Fiberglass Mat at RAF Wethersfield



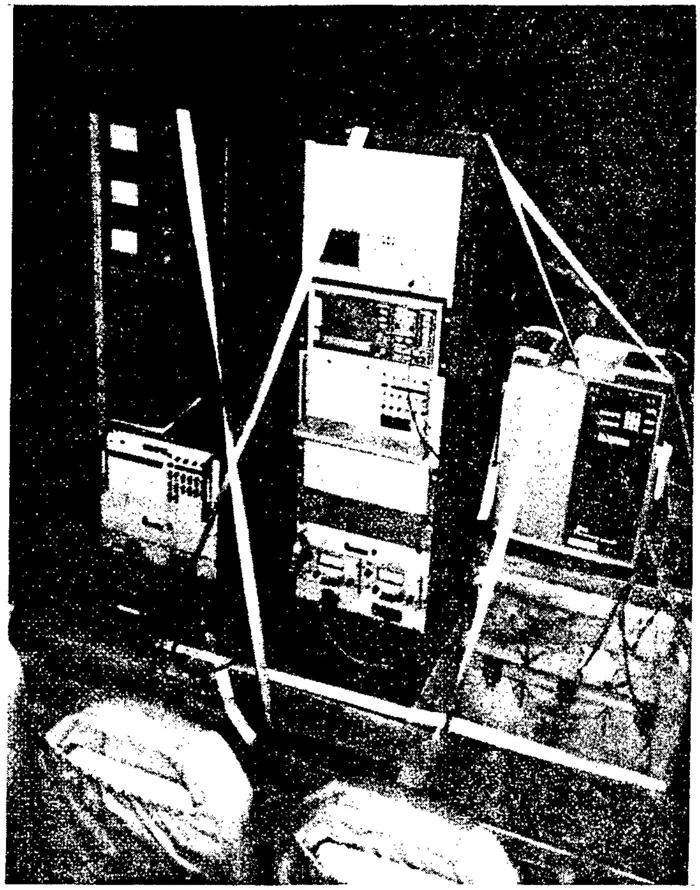
B.6 Figure 6 C 5A on Pre Cast Slab at RAF Wethersfield



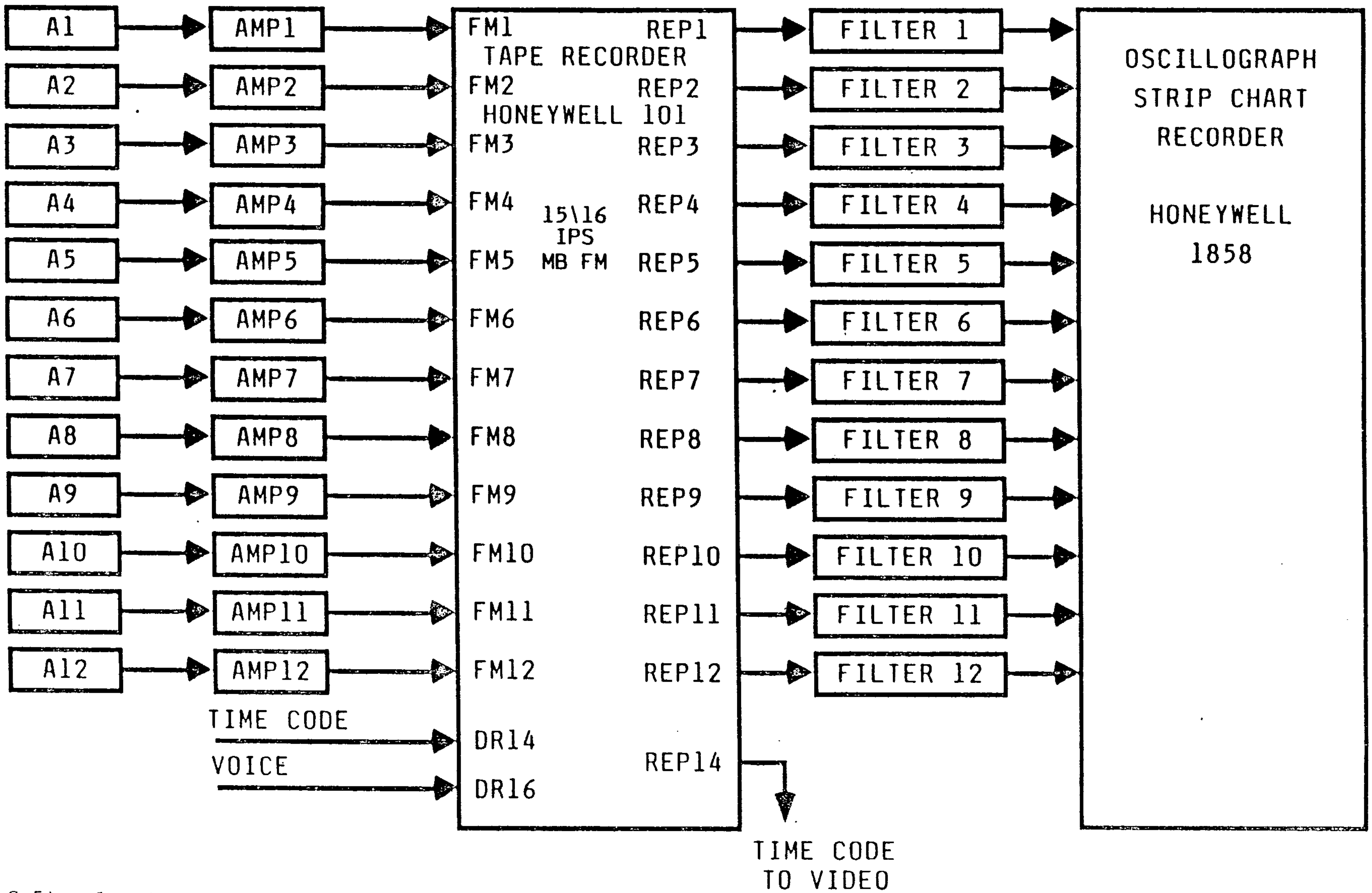
B.7 Figure 7. Block Diagram for Rapid Runway Repair Instrumentation



B.8 Figure 8. Equipment Layout for Project Rapid Runway Repair

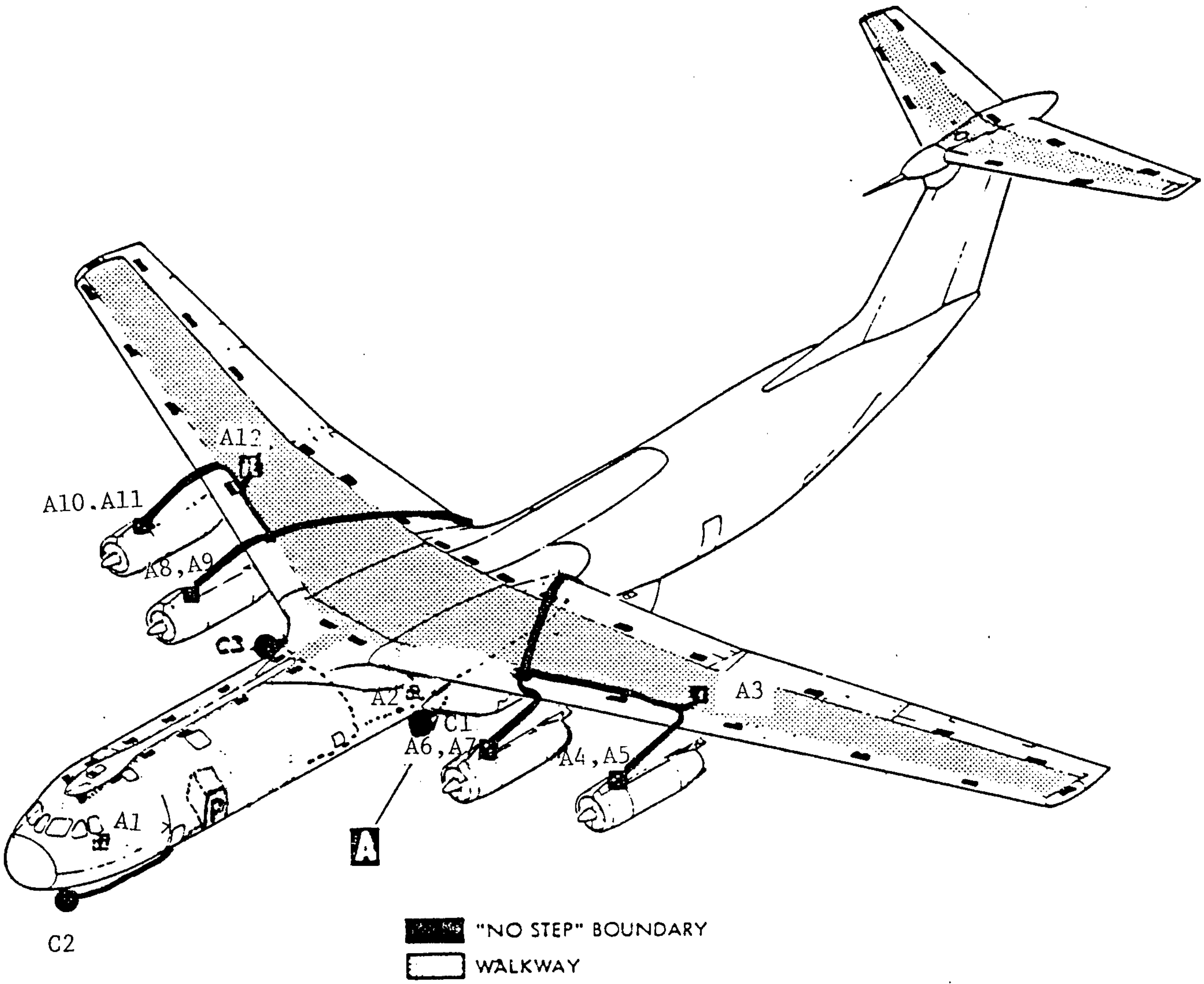


B.9 Figure 8. Equipment on 463L Pallet in C-5A



NOTE: On C-5A only A1 thru A6 were used.

B.10 Figure 10. Primary Instrumentation System Block Diagram



SYMBOLS:

P Pallet with Honeywell 101 Recorder, Measurement Rack, Video Rack, and Power Converter

● C1 Camera 1 Looking at Left Gear

● C2 Camera 2 Looking at Nose Gear

● C3 Camera 3 Looking at Right Gear

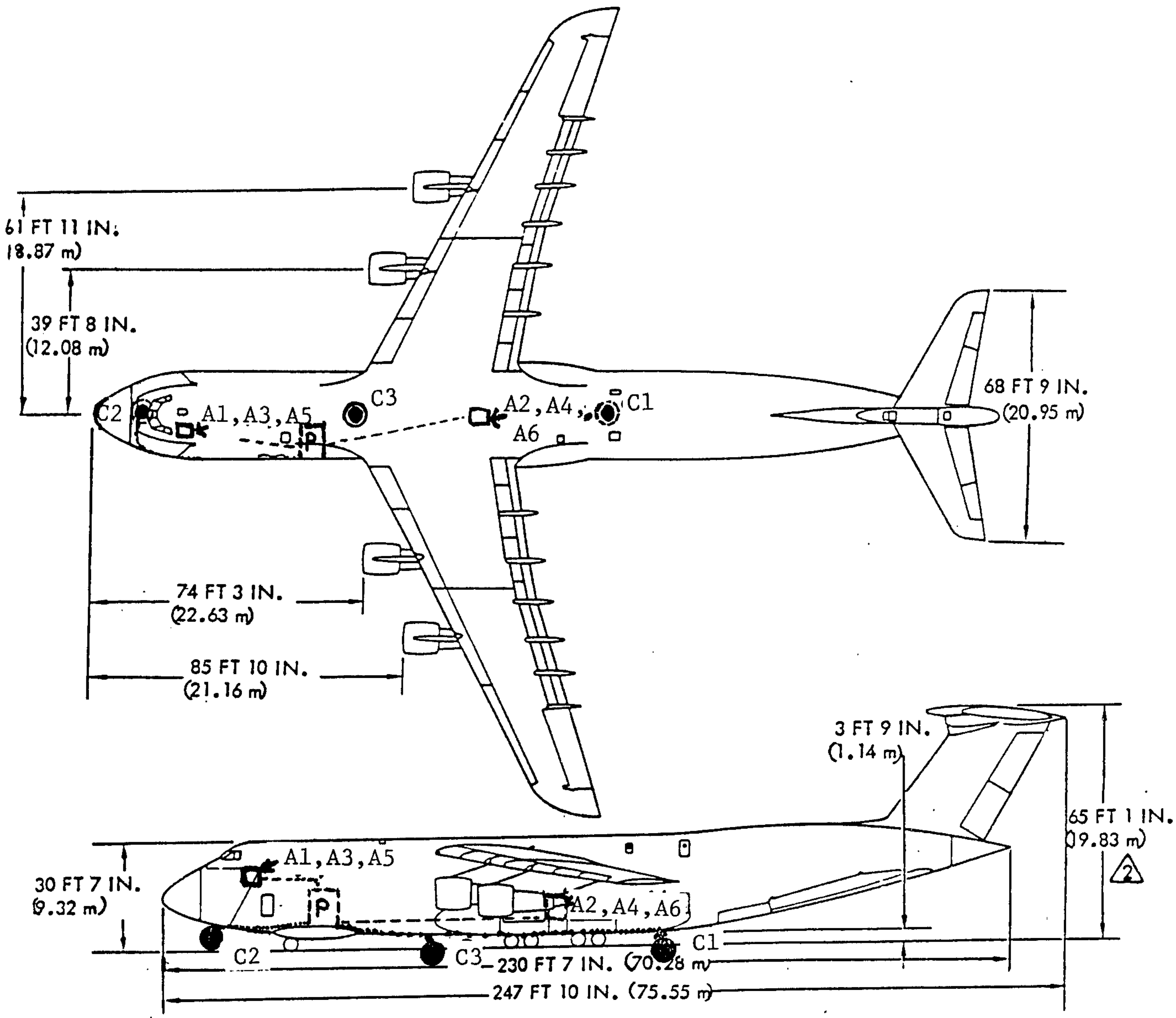
⊞ Accelerometer (1 axis) A1,A3,A12

⊠ Accelerometer (2 axes) A4,A5 A6,A7 A8,A9 and A10,A11

NOTES:

FS 497	Service Outlet on Left Side of Aircraft 115VAC,400 Hertz,3 phase, 20 amps/phase
FS 428-500	Equipment on Type 463L pallet
FS 930	C.G. Accelerometer
FS 1020	Main Wheel Well Inspection Windows
FS 1045	Cyrogenic Plug Locations

B.11 Figure 11. C-141 Instrumentation Locations



SYMBOLS:

P Pallet with Honeywell 101 Recorder, Measurement Rack, Video Rack and Power Converter

● C1 Camera 1 Looking at Left Gear

● C2 Camera 2 Looking at Nose Gear

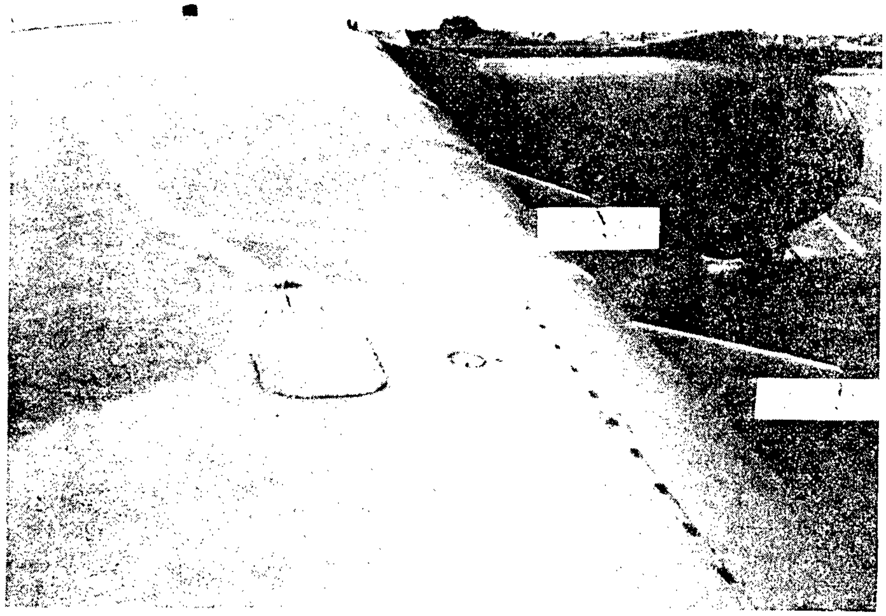
● C3 Camera 3 Looking at Right Gear

□ Accelerometers (3 axes) A1,A3,A5 and A2,A4,A6

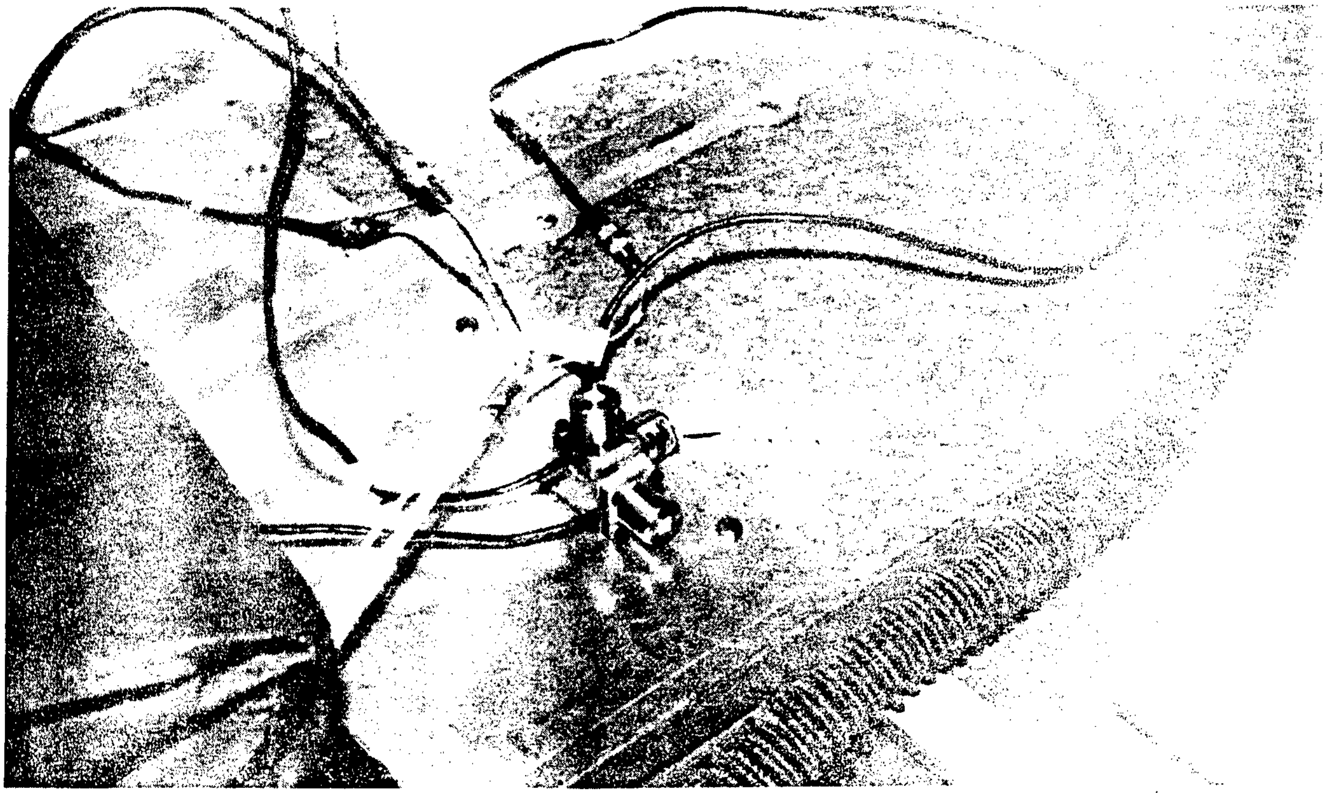
NOTES:

FS 615-700	Equipment on Type 463L pallet
FS 630	Service Outlet on Left Side of Aircraft 115VAC, 400 Hertz, 3 phase, 35 Amps/Phase
FS 1165	C.G. Accelerometers
FS 1340	Front Wheel Well Inspection Windows
FS 1560	Aft Wheel Well Inspection Windows

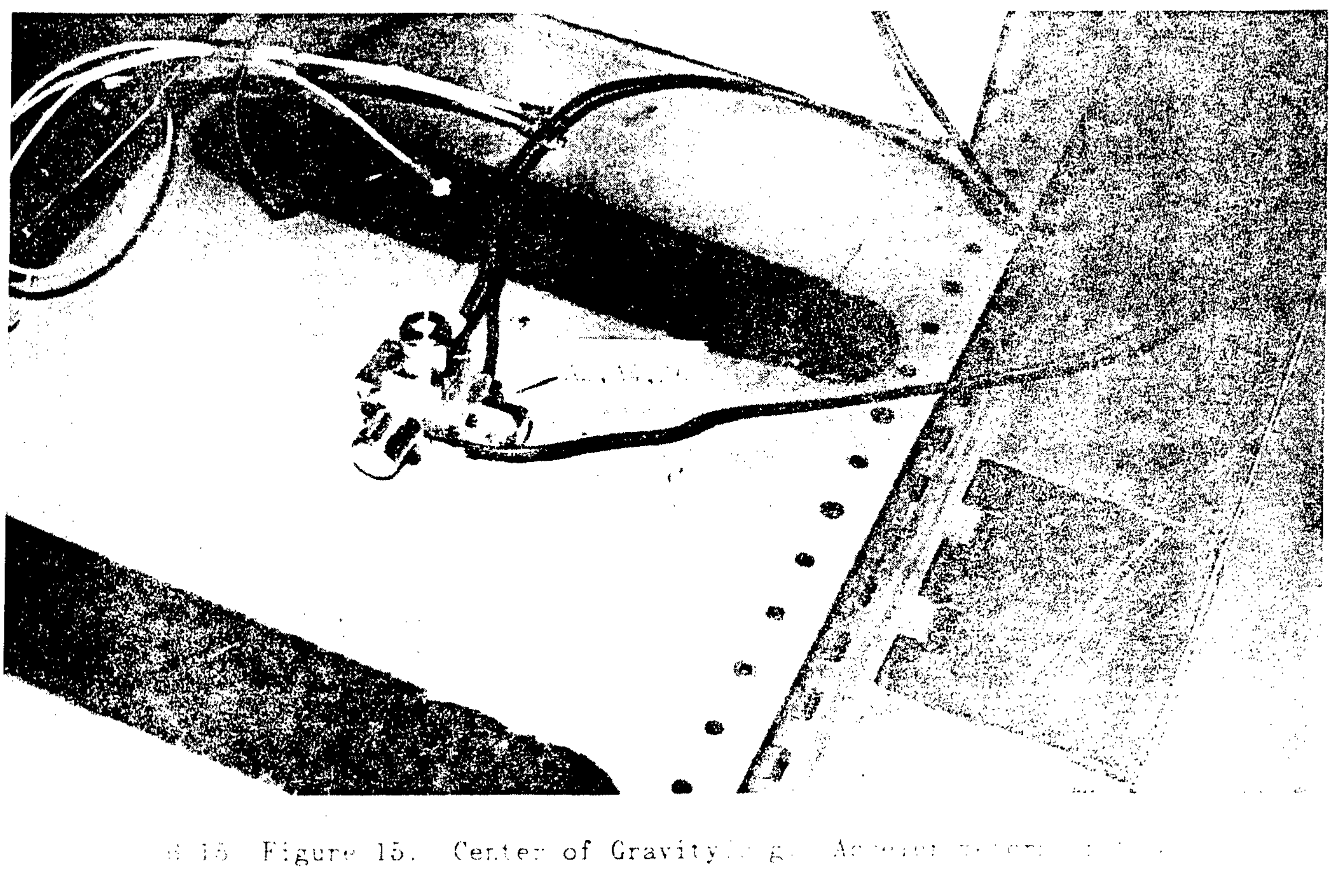
B.12 Figure 12. C-5A Instrumentation Locations



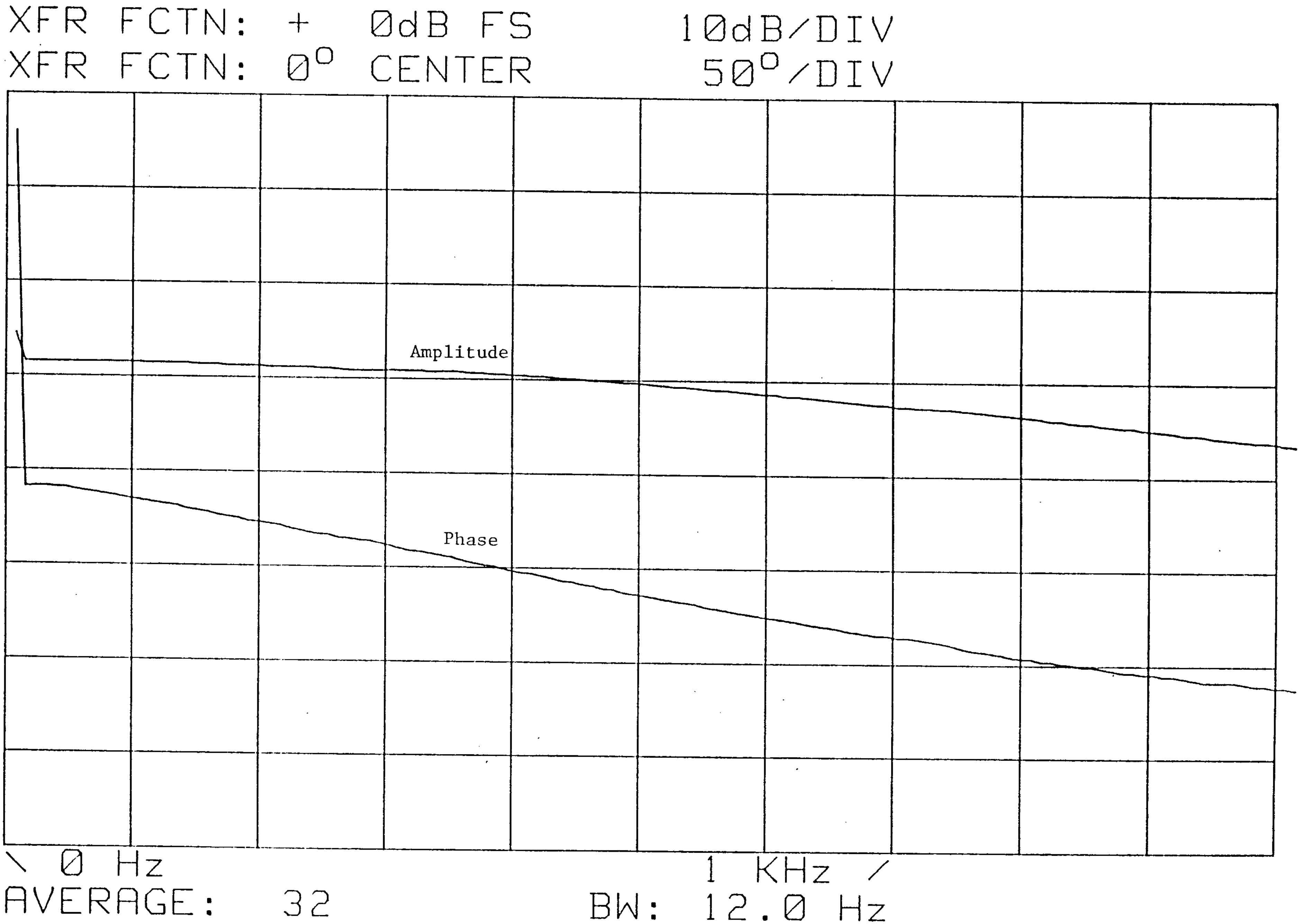
B.13 Figure 13. Right Wing and Pylon Accelerometers on C-141



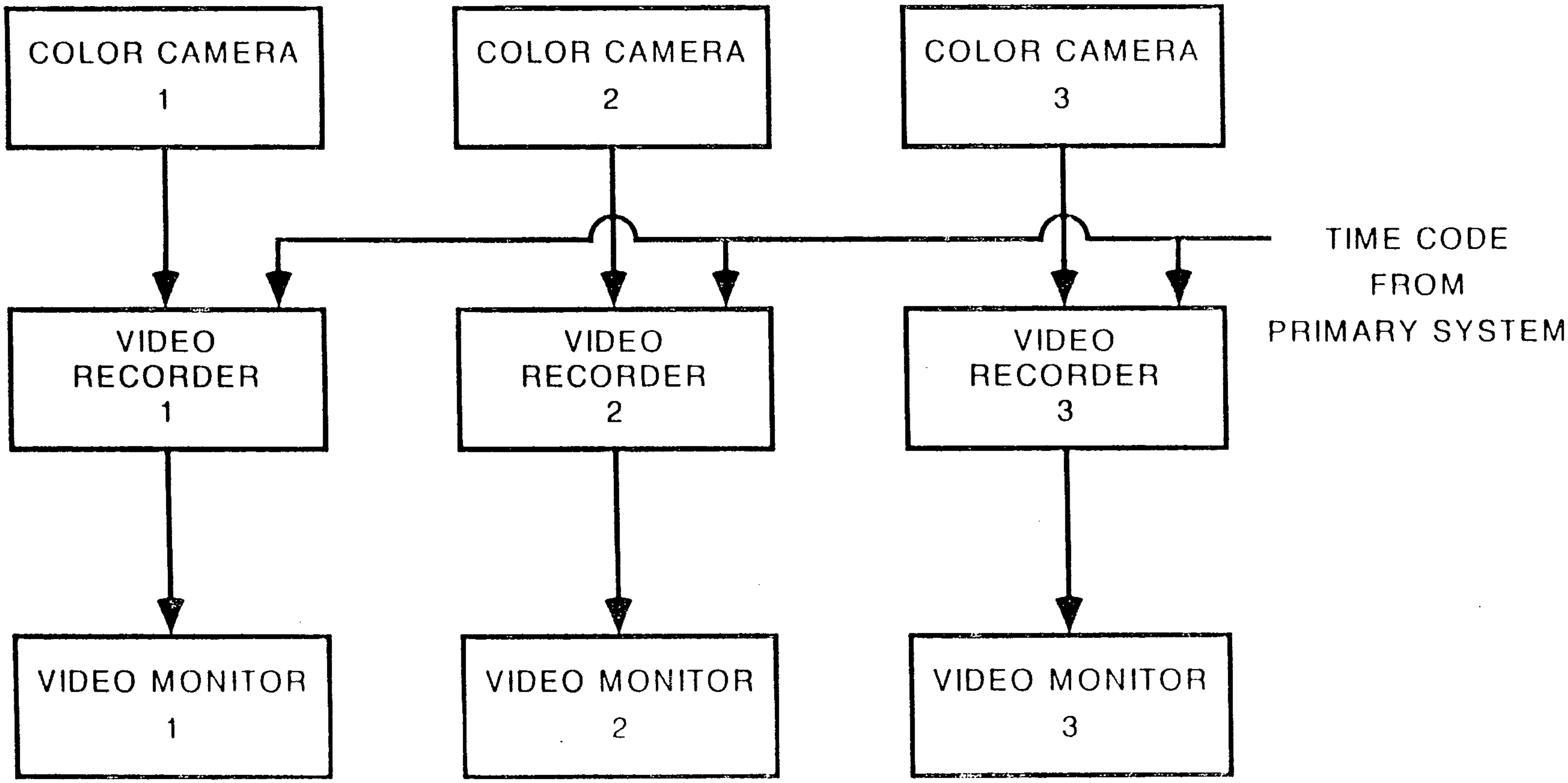
B.14 Figure 14. [illegible] Station Accelerometer [illegible]



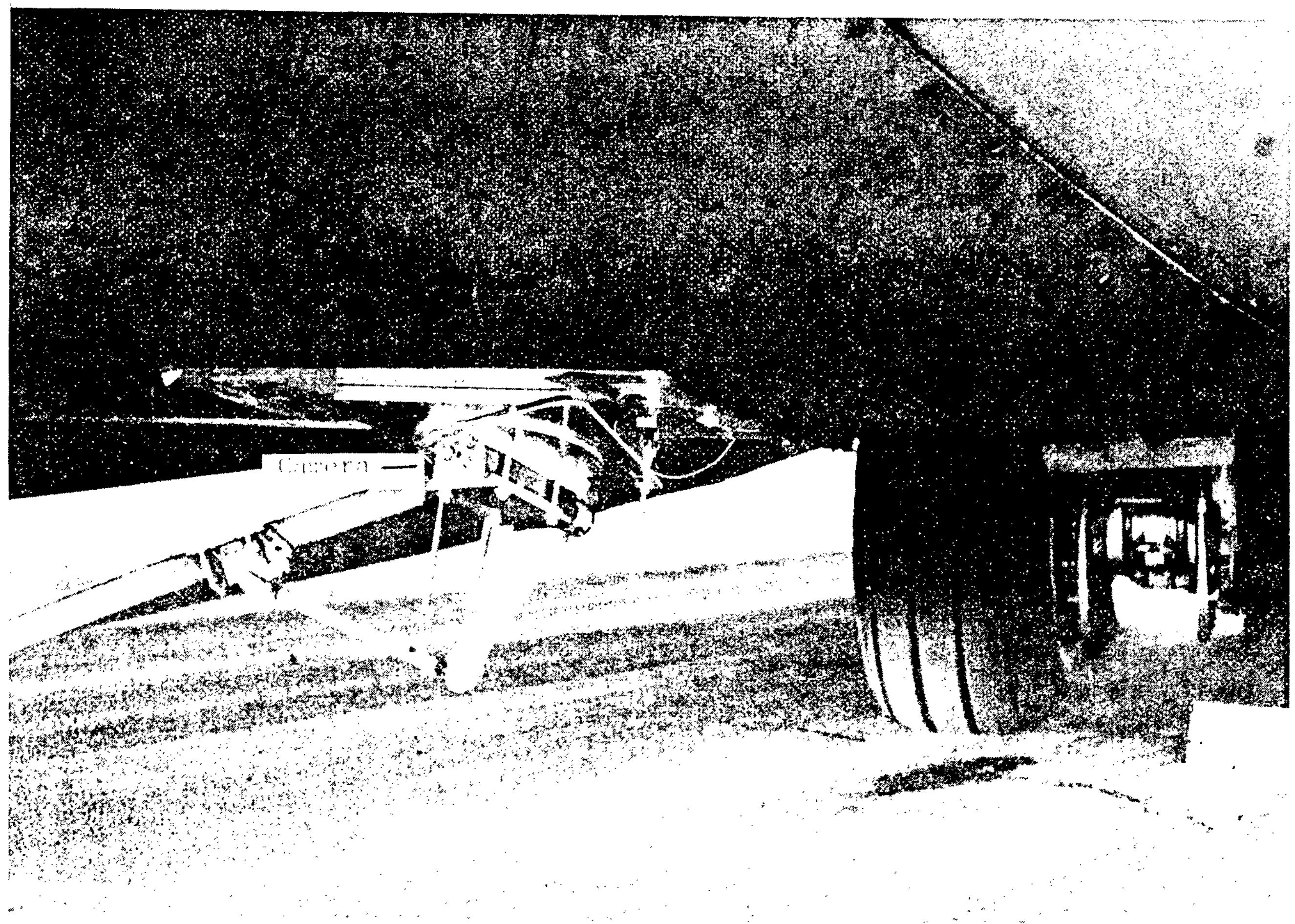
B.15 Figure 15. Center of Gravity [illegible] Accelerometer [illegible]



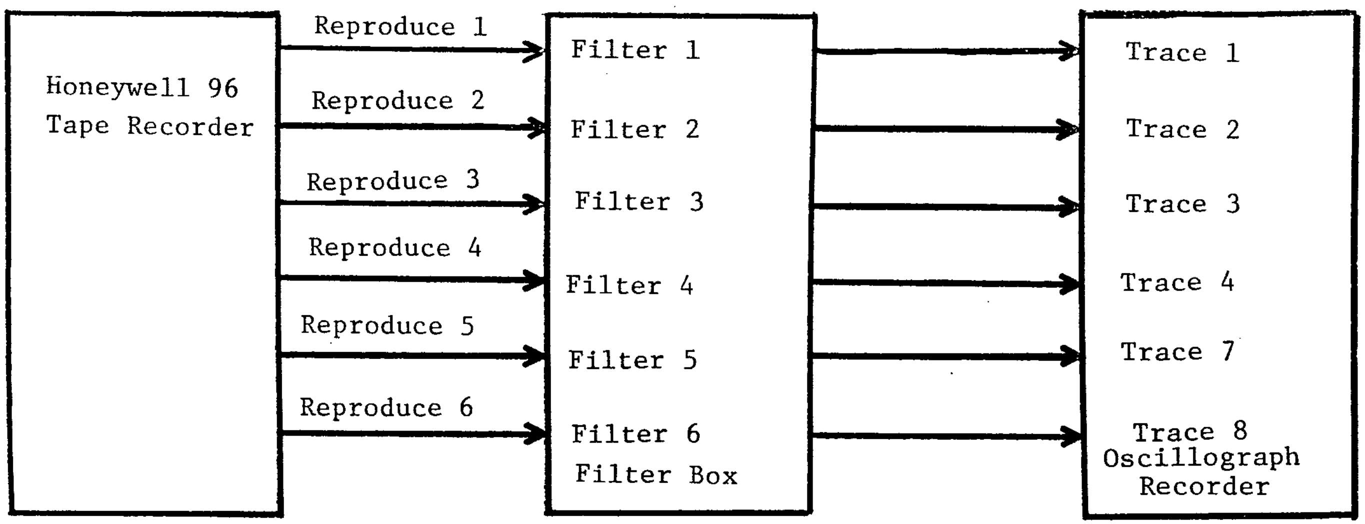
B.16 Figure 16. Typical Accelerometer Frequency Response



B.17 Figure 17. Secondary Video System Block Diagram

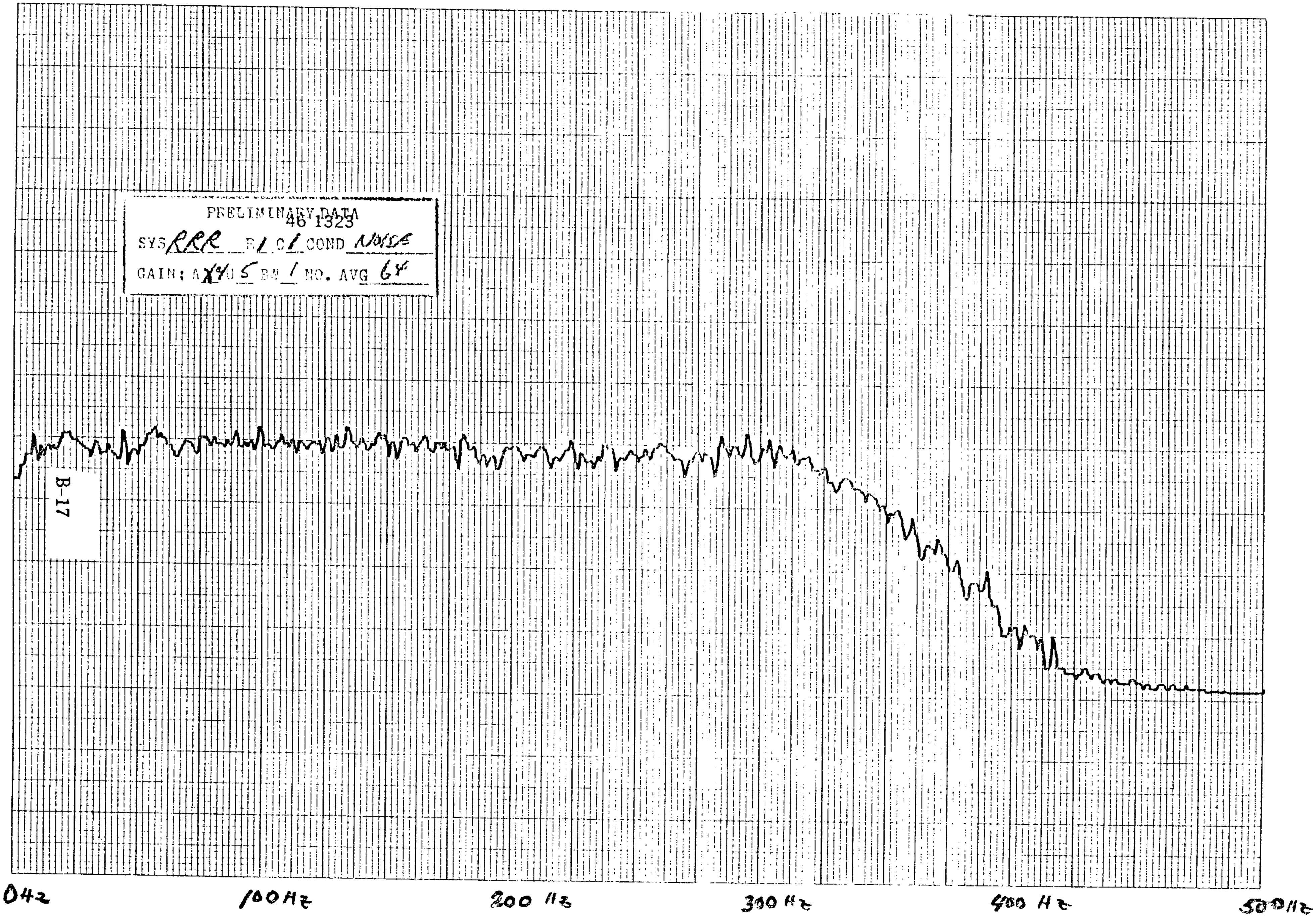


B 18 Figure 18 Left Camera Mounted on C 141

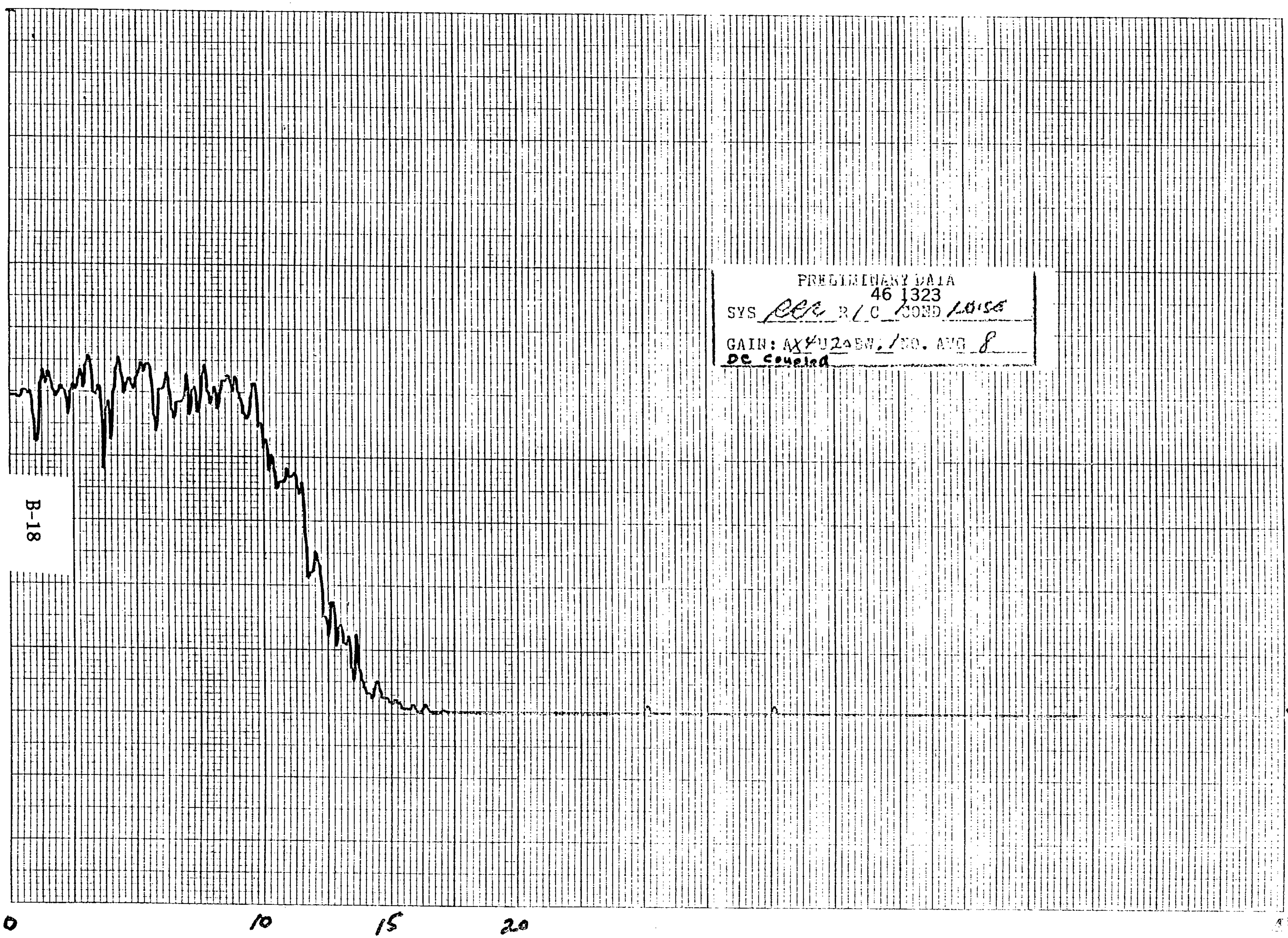


NOTE: Filters are 10 Hertz Low Pass

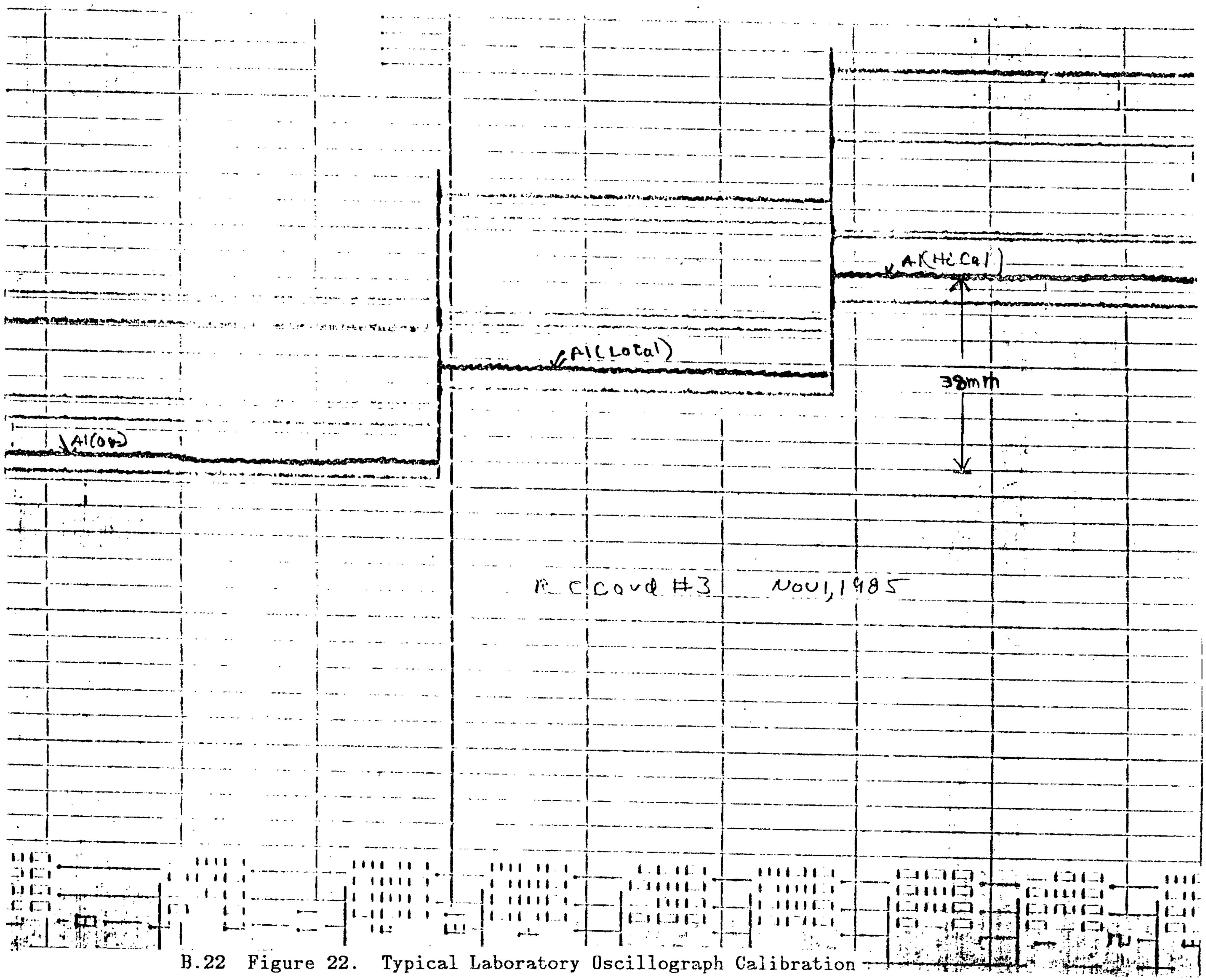
B.19 Figure 19. Laboratory Playback System Block Diagram



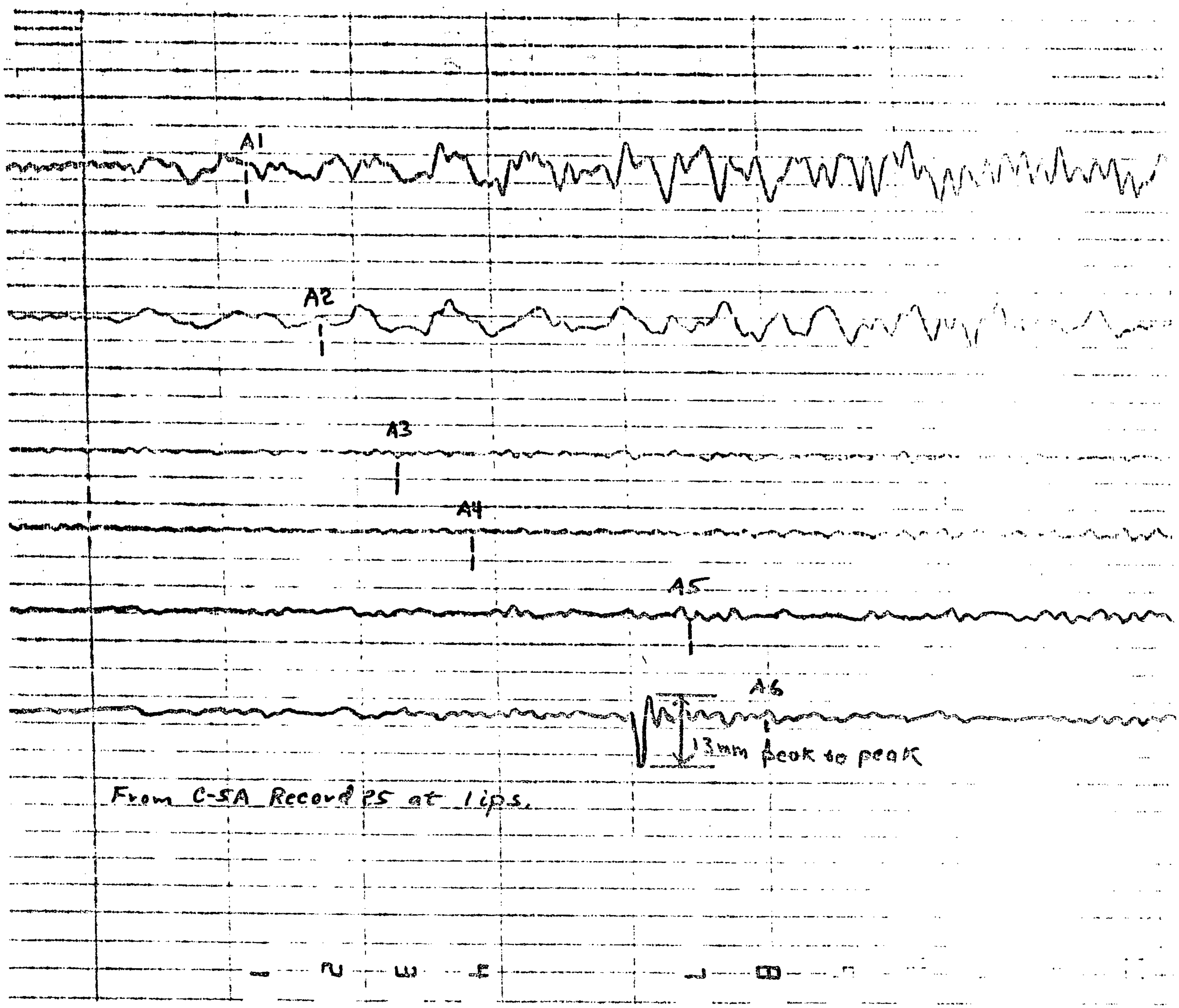
B.20 Figure 20. Frequency Response of System Channel 1



B.21 Figure 21. Frequency Response of Filtered Channel 1 on Playback



B.22 Figure 22. Typical Laboratory Oscillograph Calibration



B.23 Figure 23. Typical Laboratory Time History Oscillograph Record