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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA PROGRAM APOLLO WORKING PAPER NO. 1216

APOLLO SLOW SCAN TV TRANSMISSION TESTS OVER COMMERCIAL LONG LINES

[redacted]

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

February 2, 1967

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APOLLO SLOW SCAN TV TRANSMISSION TESTS
OVER COMMERCIAL LONG LINES

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Chief, Flight Support Division

Authorized for distribution

C. C. Kraft, Jr.
Director of Flight Operations

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APOLLO SLOW SCAN TV TRANSMISSION TESTS
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By Matthew J. Quinn, Jr.

PURPOSE

The purpose of this report is to document the results of the Apollo Slow Scan TV transmission tests performed on November 23, 1966, between the Merritt Island Launch Area (MILA) and Houston. The data collected during the tests are presented as monitor and oscillograph photographs because of the highly subjective nature of these data.

INTRODUCTION

Background

The Apollo spacecraft contains a slow scan television system to provide the video data to the Unified S-Band (USB) Manned Space Flight Network (MSFN) stations using frequency modulation techniques. The slow scan TV format consists of 320 lines at 10 frames per second while the normal EIA standard format consists of 525 lines at 30 frames per second interlaced scan.

The slow scan TV has two different formats: (1) the block I format has an amplitude sync and (2) the block II format has a burst sync. For a more complete definition of the two formats, refer to appendix F.

Current planning provides for video tape recording of the television signal at each USB site for subsequent playback and data reduction. Various proposals have been advanced for real-time use of the television picture signal for both mission operations and PAO. The current requirements are for real-time display capability in MCC-H from MILA, Goldstone, and Madrid. This requirement has been documented in the PSRD, and Goddard Space Flight Center (GSFC), in the fall of 1966, was actively engaged in the engineering of a system to provide for the required display. In essence, the problem in the system design was the nonstandard line and frame rate of the Apollo TV picture, which made the frequency content incompatible with existing commercial carrier facilities and which rendered all normal carrier monitoring and restoral procedures unusable. The design then proposed to change the nonstandard picture to one which met the United States EIA standard, and it further proposed to do this conversion at the USB station. This would allow normal operation of transmission facilities throughout the world under existing tariffs.

Other engineers, in reviewing the GSFC plans, concluded that the frequency incompatibility was not serious and could be compensated in terminal devices, and that the operating problems were not insurmountable. Following this reasoning, they concluded that one, rather than three, scan converters would suffice and this one could be located at MCC-H. Therefore, a test was devised by NASA Headquarters to test the feasibility of transmission of nonstandard television picture signals over commercial facilities designed for standard EIA television picture signals.

Reason For This Test

This transmission test was conducted at the request of NASA Headquarters. The request for the transmission tests is included as appendix A.

TEST RESULTS

The test results are presented as photographs of TV monitors and test oscilloscopes.

The test was conducted with a test conductor at MCC-H in charge. All block I formats were received and the block II sequence started. (Refer to K and L, appendix B.) The gray scale signal was received and a preliminary picture was taken (fig. G-18). The picture then began breaking up, which prevented proper operation of the scan converter at Houston. The test group at the MSOB at KSC did not immediately report trouble in their equipment, which indicated to the test conductor a possible transmission facility problem. This could not be verified immediately because the signal, being nonstandard, could not be monitored by the carrier. The test conductor then requested that the MSOB switch in an EIA-standard test generator so that the transmission facility could be checked by the carrier. The picture received at Houston of this standard signal is shown in figure G-20.

After comparing the final picture with the initial pictures, the test conductor felt that the comparison indicated that the circuit was essentially the same as it had been at the beginning of the test.

The MSOB group was asked to check their equipment, and since they could not immediately find any problem, the test conductor closed out the test. One hour and thirty minutes of transmission time was used on the commercial long lines. The performance of the signal generator is included as appendix E.

CONCLUSIONS

The test results are presented without any conclusions with regard to the original question of feasibility of transmission. It is obvious from the data that some kind of picture did arrive at Houston and was scan-converted. Subjective analysis is required to "score" the success of this part. It is also obvious that operational difficulties arose as a result of the inability of the carrier to monitor and restore; these are not subjective, and the test showed conclusively that these problems will arise and that they will require abnormal operations for correction.

Any questions regarding the test or this report should be directed to Matt Quinn, 713-483-5591, Flight Support Division, Manned Spacecraft Center, Houston, Texas.

APPENDIX A

REQUEST FOR TRANSMISSION TESTS

TO : Houston/Manned Spacecraft Center

FROM : NASA Headquarters Washington

INFO : KSC Florida/Kennedy Space Center
GSFC/Goddard Space Flight Center University Building

SUBJECT: TRANSMISSION OF THE APOLLO SLOW SCAN TV SIGNAL BY COMMERCIAL CARRIER

REF Your message R142007Z, November 1966, Subject: Apollo TV

In accordance with the referenced message and our telephone conversation on November 17, you are requested to proceed with the performance of the subject test. This test will determine the feasibility of transmitting the unconverted Apollo Slow Scan TV Signal over available commercial video circuits such as those between MSC and KSC.

The test should be performed at the earliest possible date, since the procurement of Apollo Slow Scan TV Converters for various tracking sites may be dependent upon the outcome.

A test plan has been drafted by this office, after coordination with both MSC and KSC engineering, which we feel will meet the basic test objectives. This test plan is available for your use as a guideline in preparing for the test, subject to modifications as necessary to satisfy your requirements. Mr. Engert, (MSC/EE-2), who has a scan converter suitable for use at MSC during the test, has a copy of the test plan.

Please keep this office informed of your plans to perform this test and the test results.

/S/EE CHRISTENSEN DIRECTOR MISSION OPERATIONS

APPENDIX B

TEST PLAN

TEST: SLOW SCAN TV TRANSMISSION, KSC TO MSC November 16, 1966

TEST TIME:

PURPOSE: TO AID IN DETERMINING OVERALL QUALITY OF TV WHICH CAN BE EXPECTED FOR MCC-H OPERATIONS AND PAO RELEASE -- TEST THE TELEPHONE CO. CAPABILITY TO TRANSMIT APOLLO SLOW SCAN TV SIGNAL OVER STANDARD TV VIDEO CIRCUITS.

TEST STEPS:

A. TEST SET-UP PRIOR TO TELEPHONE CO. VIDEO LINE CALL-UP.

    SET UP THE EQUIPMENT IN ACCORDANCE WITH THE ATTACHED BLOCK DIAGRAM.

    2. VERIFY EQUIPMENT CALIBRATION AND PERFORMANCE AT KSC AND MSC.

B. CONNECT STANDARD 525-LINE TEST PATTERN GENERATOR INTO LINE AT PATCH (A-1).

    ADJUST PATTERN GENERATOR FOR PROPER SIGNAL LEVEL AT SCOPE 2.

    2. VERIFY PROPER SIGNAL LEVEL IS BEING RECEIVED AT SCOPE 3.

C. CALL UP THE TELEPHONE COMPANY KSC TO MSC VIDEO LINE AND CONNECT TO THE EQUIPMENT SET-UP AT BOTH KSC AND MSC.

D. END-TO-END CIRCUIT VERIFICATION USING THE 525-LINE TEST PATTERN GENERATOR.

    1. CONNECT STANDARD VIDEO TV TAPE RECORDERS (PATCHES B-1 AND C-1) AND THE STANDARD TV MONITOR AT MSC (BUILDING 15, PATCH D-1).

    2. VERIFY PROPER SIGNAL LEVEL AT SCOPES 3 AND 4.

    3. OBTAIN PROPER SIGNAL LEVEL AT SCOPE 5.

    4. PHOTOGRAPH ALL SCOPES.

    5. PHOTOGRAPH 525-LINE STANDARD TV MONITORS IN THE MSOB ROOM 3416 AND BUILDING 15.

6. RECORD TEST SIGNAL ON THE STANDARD VIDEO TV TAPE RECORDER AT MSC AND KSC.

E. BLOCK I BLACK AND WHITE SIGNAL - TRANSMISSION OF STANDARD TV SIGNAL FROM MSOB SCAN CONVERTER OUTPUT.

1. CONNECT SCAN CONVERTER OUTPUT TO THE VIDEO LINE (PATCH A-4) AND ADJUST FOR PROPER SIGNAL LEVEL ON SCOPE 1.

2. PHOTOGRAPH SCOPES 1, 3, 4, AND 5.

3. PHOTOGRAPH STANDARD TV MONITOR AT MSC (BUILDING 15) AND ON THE SCAN CONVERTER AT THE MSOB (ROOM 3416).

4. RECORD CONVERTED STANDARD TV SIGNAL ON THE STANDARD VIDEO TV TAPE RECORDERS AT KSC AND MSC.

5. RECORD THE SLOW SCAN TV SIGNAL ON THE INSTRUMENTATION TAPE RECORDER AT KSC.

F. BLOCK I GRAY SIGNAL - REPEAT STEP E.

G. BLOCK I BURST PATTERN FOR RESOLUTION CHECK - REPEAT STEP E.

H. BLOCK I BLACK AND WHITE SIGNAL - TRANSMISSION OF SLOW SCAN TV SIGNAL FROM MSOB SLOW SCAN PATTERN GENERATOR TO MSC.

1. CONNECT SLOW SCAN PATTERN GENERATOR OUTPUT TO VIDEO LINE (PATCH A-3) AND ADJUST FOR PROPER SIGNAL LEVEL ON SCOPE 1.

2. CONNECT THE SLOW SCAN VIDEO SIGNAL INTO THE SCAN CONVERTER AT MSC (PATCHES D-2 AND E-1) AND CONNECT THE STANDARD TV RECORDER AND MONITOR TO THE SCAN CONVERTER OUTPUT (PATCH C-2).

3. PHOTOGRAPH SCOPES 1, 3, 4, AND 5.

4. PHOTOGRAPH SCAN CONVERTER TV MONITORS AT BOTH KSC AND MSC.

5. RECORD CONVERTED STANDARD TV SIGNAL ON THE STANDARD VIDEO TV TAPE RECORDERS AT BOTH KSC AND MSC.

6. RECORD THE SLOW SCAN TV SIGNAL ON THE INSTRUMENTATION TAPE RECORDERS AT BOTH KSC AND MSC.

I. BLOCK I GRAY SCALE SIGNAL - REPEAT STEP H.

J. BLOCK I BURST PATTERN FOR RESOLUTION CHECK - REPEAT STEP H.

K. BLOCK II 10 FRAMES PER SECOND BLACK AND WHITE SIGNAL - SET UP EQUIPMENT FOR BLOCK II SIGNAL. REPEAT STEP H.

L. BLOCK II 10 FRAMES PER SECOND GRAY SCALE SIGNAL - REPEAT STEP H.

M. BLOCK II 10 FRAMES PER SECOND BURST PATTERN FOR RESOLUTION CHECK - REPEAT STEP H.

N. BLOCK II .625 FRAMES PER SECOND GRAY SCALE SIGNAL - SET UP EQUIPMENT FOR BLOCK II .625 FRAMES PER SECOND SIGNAL. REPEAT STEP H.

O. BLOCK II .625 FRAMES PER SECOND BLACK AND WHITE SIGNAL - REPEAT STEP H.

P. BLOCK II .625 FRAMES PER SECOND BURST PATTERN FOR RESOLUTION CHECK - REPEAT STEP H.

TEST IS COMPLETE TERMINATE LEASE OF TELEPHONE CO. VIDEO LINE.

NOTES:

1. EVALUATING PERSONNEL

KSC	MSC
L. KNIGHT (TEST COND.)	T.E. POEL (TEST COND.)
J. JOSEPH (ASST. TEST COND.)	P. LIPOMA (ASST. TEST COND.
C. ROTH	M. ENGERT
J. RAMSEY	L. CROOM
S. GRAZIADIO	J. WINN (HQ)
R. NERCESSIAN (GSFC)	J. RALEIGH (BELLCOMM)
I. MASCON (HQ)	H. KRAUSE (BELLCOMM)
G. SPEAKE (BELLCOMM)	

2. TEST CONDUCTORS ARE AS NOTED ABOVE. COORDINATION OF THE TEST WILL BE PERFORMED BY I. MASON, WHO WILL BE LOCATED AT KSC, WITH ASSISTANCE FROM J. WINN, WHO WILL BE LOCATED AT MSC.

3. TELEPHONE NUMBERS:

   KSC MSOB ROOM 3416 - 305-867-3940
   MSC BUILDING 15 LAB. - 713-HU3-3465
   MR. ROTH'S OFFICE - 305-867-2790
   MR. ENGERT'S OFFICE - 713-HU3-5541

4. THE TEST CONDUCTORS WILL DETERMINE THE RECORDING TIME FOR EACH SIGNAL PLACED ON MAGNETIC TAPE.

5. THE TEST CONDUCTORS WILL ASSURE THAT MAXIMUM RESOLUTION IS OBTAINED ON PHOTOGRAPHS OF SCOPES AND TV MONITORS; FOR EXAMPLE, GOOD CONTRAST, CLOSEUP POSITIONS, UNIFORM SCOPE SETTINGS END-TO-END, UNIFORM TIMING OF PHOTOGRAPHS, ELIMINATION OF GLARE FROM LIGHTING, ET CETERA.

6. A POST-TEST DEBRIEFING WILL BE HELD AT BOTH KSC AND MSC.

MSC DIAGRAM

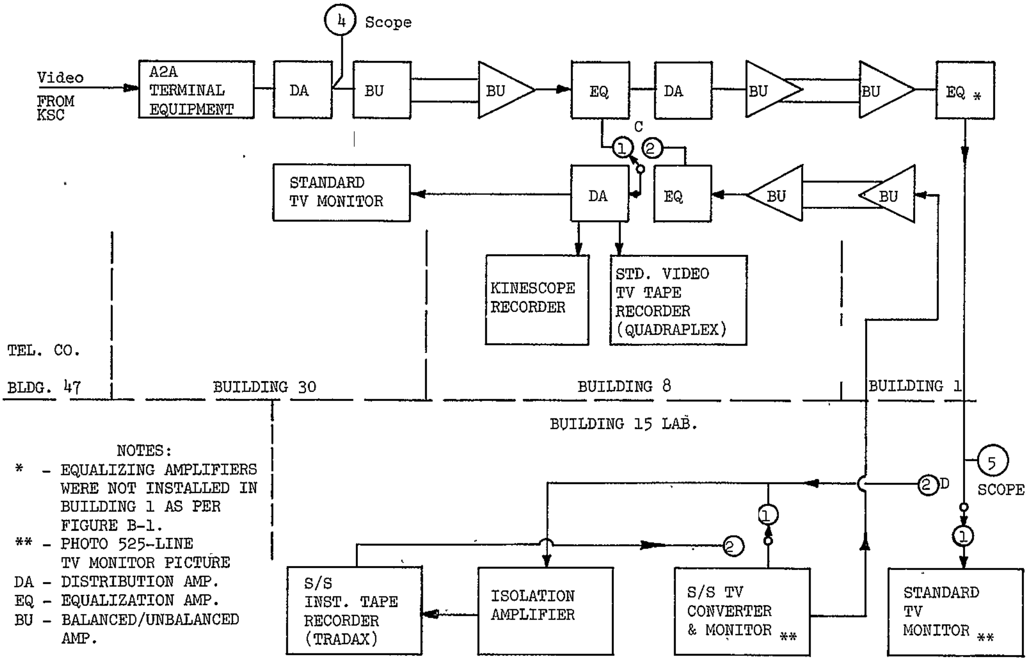


Figure B-1.- MSC diagram.

KSC DIAGRAM

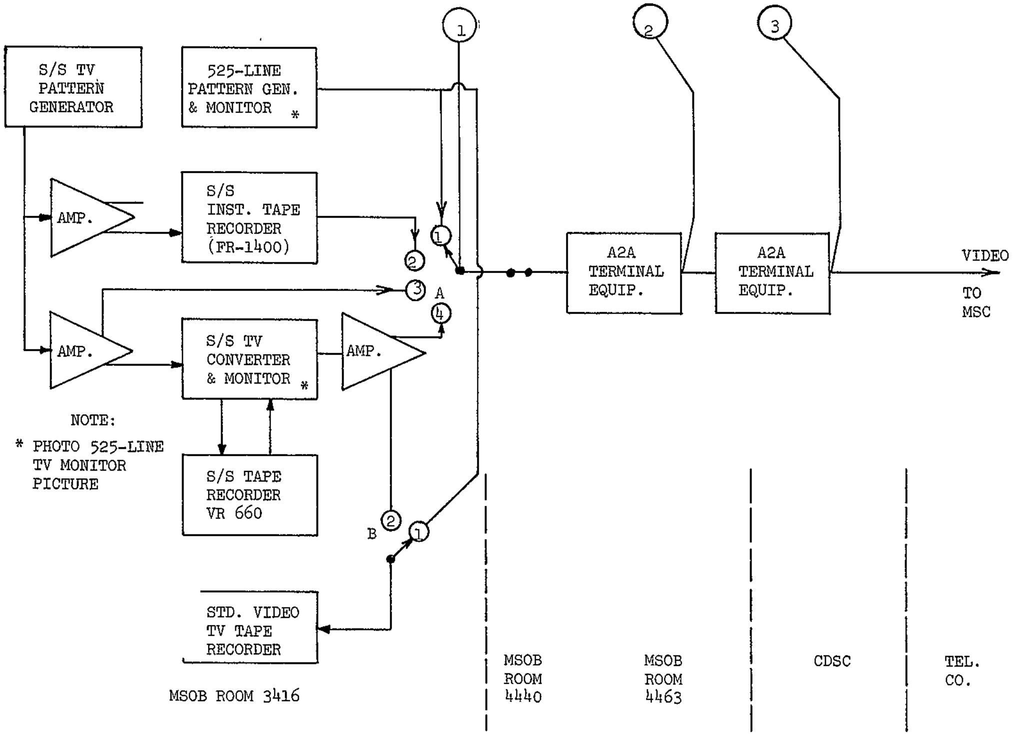


Figure B-2.- KSC diagram.

APPENDIX C

ROUTE OF TV TRANSMISSION

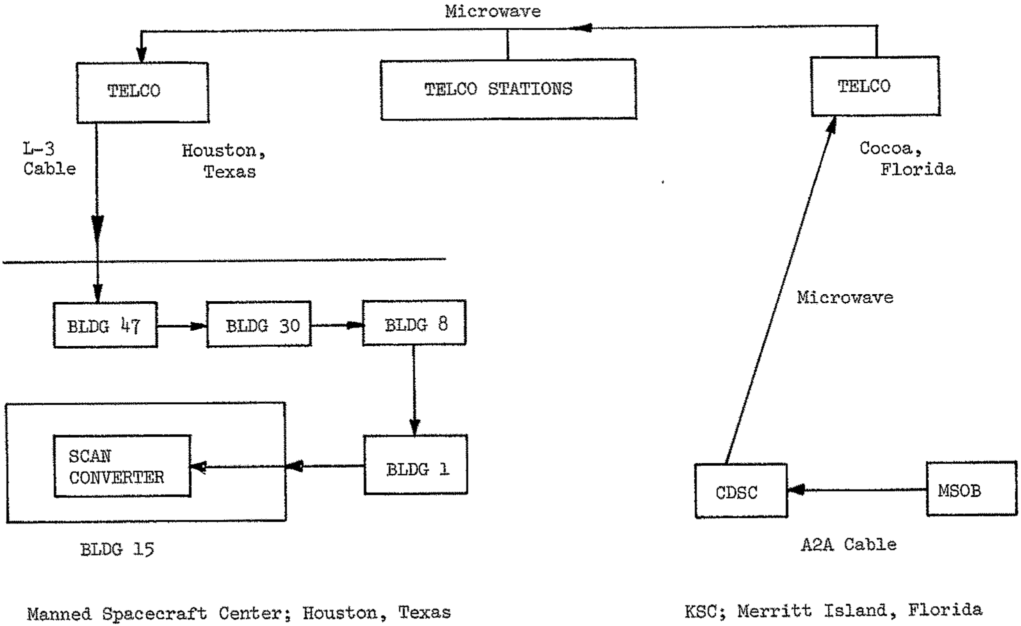


Figure C-1.- Routing of the television from MSC to KSC.

APPENDIX D

REFERENCES

1. Reich, Bruno; and Hondros, George: Performance Evaluation of the Video System at Kennedy Space Center for Transmission of Apollo Block I Television. Goddard Space Flight Center, Greenbelt, Maryland, October 1966.

2. Electronics Systems Test Program Report on Special FM Channel Performance and Evaluation Tests. Test Planning and Evaluation Section, NASA/Manned Spacecraft Center, Houston, Texas.

APPENDIX E

COMMENTS ON THE PERFORMANCE OF THE SIGNAL GENERATOR FROM THE CAPE KENNEDY TEST SUPPORT GROUP

No troubles were encountered throughout the KSC/MSC Block I Slow Scan TV test transmission at Room 3416, MSOB KSC. After completion of step J, the Slow Scan TV Test Generator and the Slow Scan TV Converter were re-configured for Block II Operation. Operation of the Converter was observed to be normal after the Block I to Block II set-up change. After a period of about two or three minutes, we noticed here that the Block II Slow Scan signal was approximately 0.5 volts peak-to-peak. At the moment we started to walk over to amplifier #4 so as to increase its output to 1.0 volt peak-to-peak into the A2A system, there appeared on the Slow Scan Converter Monitor a horizontal tear. The scope display of the video at the converter, with the slow scan HD pulse as a reference, was noted to have between 15 and 20 micro seconds horizontal jitter.

The output level of the Amp #4 was increased to 1.0 volt peak-to-peak but the horizontal tear remained. A quick check was made of the Slow Scan sawtooth sample time and the scope presentation showed the sample time to be in step with the horizontal jitter of the composite video into the converter. Immediately, Amp #3 and #4 were by-passed and the TV test set output was connected to the converter input only, but the horizontal tearing remained. We switched back to Block I operation for a quick check of the converter system and experienced again the same condition.

We were notified at this time that the test would be terminated. At no time during these few minutes of Block II transmission did we experience any irregularity other than that already mentioned. After termination of the test our equipments were powered down. An hour passed and the converter system was powered on again to determine a reason and solution to our problem but the system was again operating normally and all attempts to duplicate the horizontal jitter failed. It may be important to note that at the time of the problem, the horizontal tearing was much more pronounced with the Linearity and Resolution patterns than the Gray scale and Black and White patterns.

On our Friday, November 25, 1966, second shift, the converter system was powered on to attempt again a duplication of the horizontal jitter and after a period of time the problem did re-occur. In the belief that the reason was a temperature time function, the TV Test Set was turned off for 15 minutes and the converter left on. When the Test Set was turned on again - as luck would have it - all was normal. We did discover in Amp #4, the dc offset reference (ground) was fluctuating intermittently from 0 volts to +0.4 volts dc but this did not interfere with the Scan Converter operation.

On Saturday, November 26, 1966, I decided one more attempt to get a duplication of our problem. The TV test set and converter were powered up and we had our problem. This time I did not power off, but removed the covers of the test set. After about fifteen minutes of waiting and huffing and puffing on the power supply card, the problem slowly faded away, not to appear again for the next half hour.

The TV test set output during KSC Test #K 0231 was routed through the C14-175 camera test panel with the signal selector switch in the external position. Through this switch the C14-175 monitor input is also connected. During the problem duplication, the horizontal jitter from the test set was eliminated by disconnecting the cables from the Camera Test Panel to the C14-175 Monitor input; also by by-passing the C14-175 Camera Test Panel and connecting directly into our Video Patch Panel, where signal routing to MSC, the Scan Converter, and Tape Recorder inputs were accomplished. These checkouts were made while duplicating our Test #K 0321 patch set-up.

There is a strong indication that the reason for our problem is an accumulation of heat in the TV Test Set after a period of time which affects its loading capability. I might note, that voltage measurements made at the outputs of the power supply during the period of duplication were the same as when we had normal operation.

APPENDIX F

BLOCK I AND BLOCK II FORMAT DEFINITION

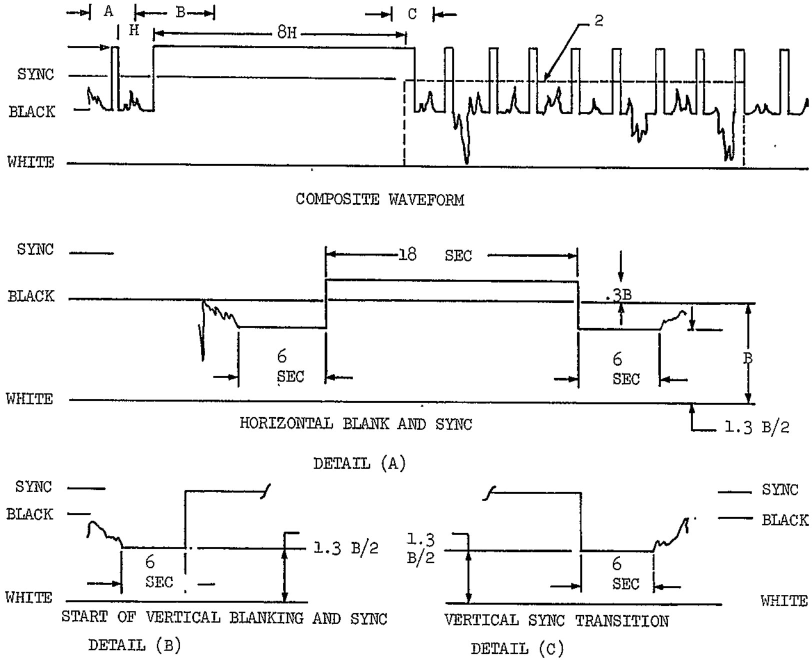


Figure F-1.- Apollo Block I format no. 1, camera output.

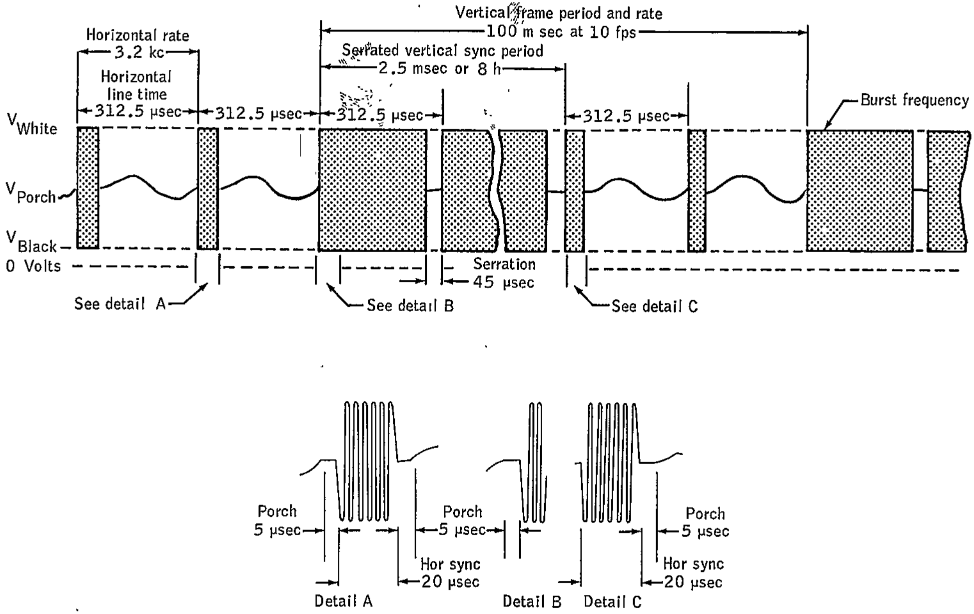


Figure F-2.- Block II, 10 frames per second 320 lines.

BLOCK II, 10 FRAMES PER SECOND

320 LINES SPECIFICATIONS

1. Burst frequency is 409.6 kHz ± 0.02%.

2. Period between consecutive leading edges of burst frequency is 312.5 μseconds.

3. Front and back porch periods are 5 μseconds ± 1 μsecond.

4. Black to white is 2 volts ± 0.1 volt peak to peak into 100 ohms and 1 volt ± 0.05 volts into 50 ohms.

5. White is positive and black is +0.3 volts ± 0.1 volts into 100 ohms load.

6. Bandpass filter down 3 dB maximum at 500 kHz and 20 dB minimum at 1 μHz.

7. Peak video with respect to ground shall be 2.4 volts maximum. Example: When black level equals 0.4 volts the peak to peak video shall be 2 volts + 0 volts or - 0.1 volts.

8. Positive sync tip shall be 2 volts + 0.1 volts or - 0.3 volts above the black level but shall not exceed the peak white video.

9. The porch level shall be 1/2 black to white voltage excursion ±0.1 volts.

10. The camera output stage is a current producing 2 volts peak to peak into a 100-ohm external load or 1 volt peak to peak into a 50-ohm external load.

11. The negative burst level is video black +0.1 volt or -0 volts. The black level is the minimum signal (video or sync) excursion.

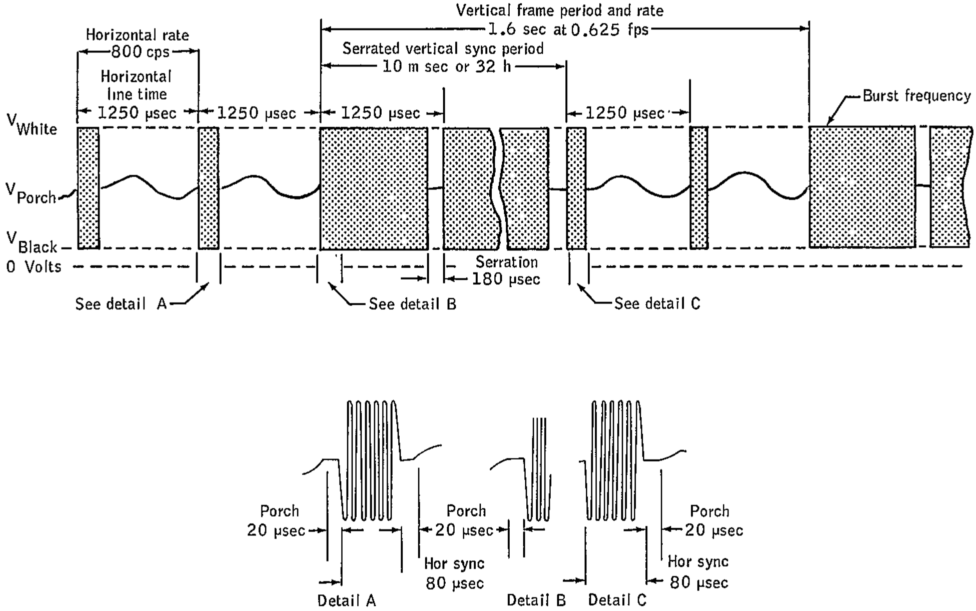
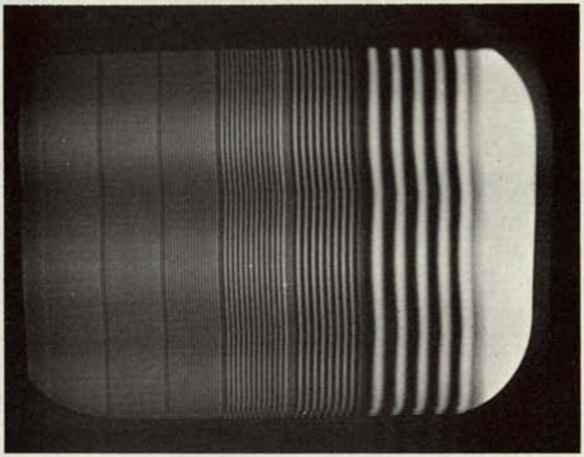


Figure F-3.- Block II, 0.625 frames per second.

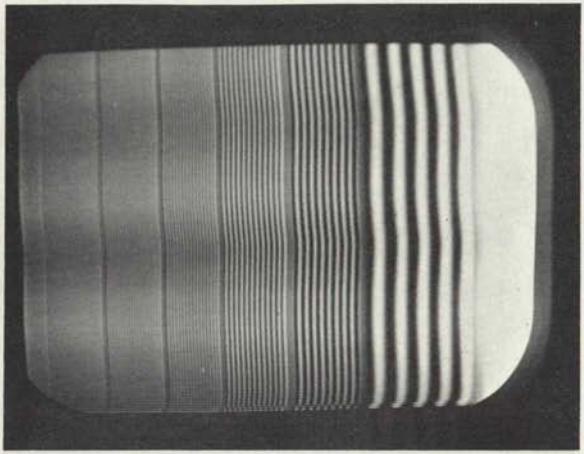
APPENDIX G

TEST RESULTS



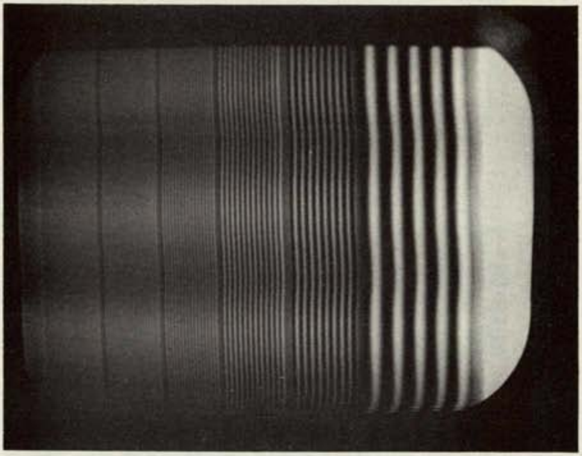
(a) Picture 1.

Figure G-1.- End-to-end circuit verification using 525-line pattern generator. (Refer to D of 3, appendix B.) Three pictures are included of the same monitor presentation.



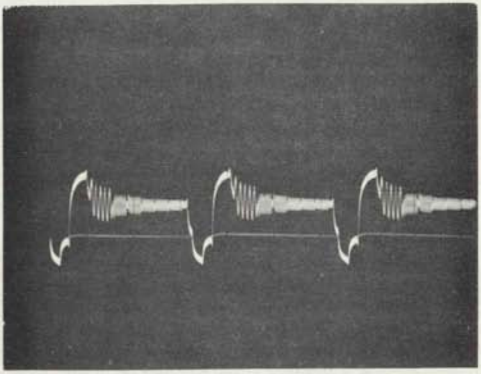
(b) Picture 2.

Figure G-1.- Continued.

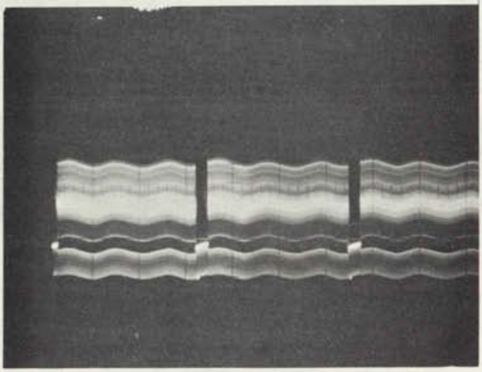


(c) Picture 3.

Figure G-1.- Concluded.

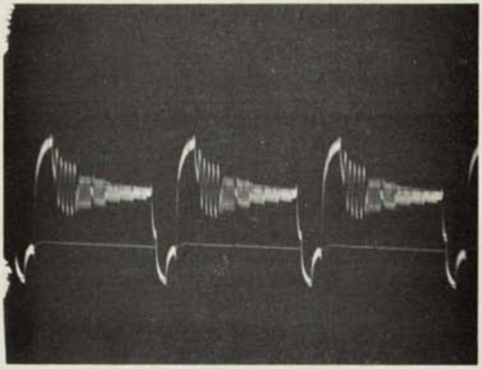


(a) Horizontal line (hor: 20µ sec/cm, ver: 1 volt/cm).

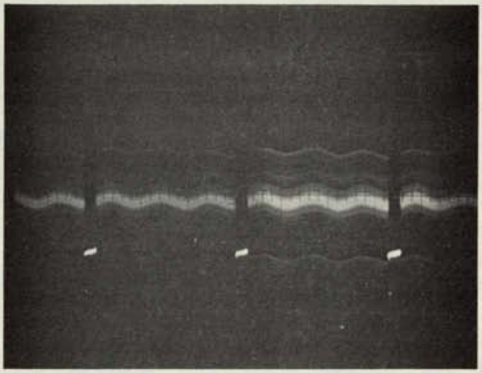


(b) Vertical field (hor: 5m sec/cm, ver: 1/2 volt/cm).

Figure G-2.- Oscilloscope pictures of end-to-end circuit verification using 525-line pattern generator. (Refer to D, appendix B.)



(c) Horizontal line (hor: 20μ sec/cm, ver: 1/2 volt/cm).



(d) Vertical field (hor: 5m sec/cm, ver: 1/2 volt/cm).

Figure G-2.- Concluded.

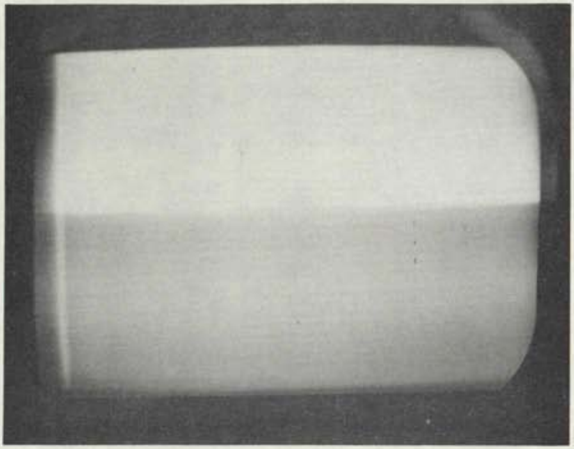
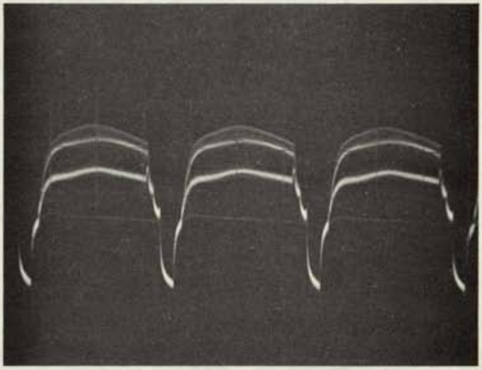
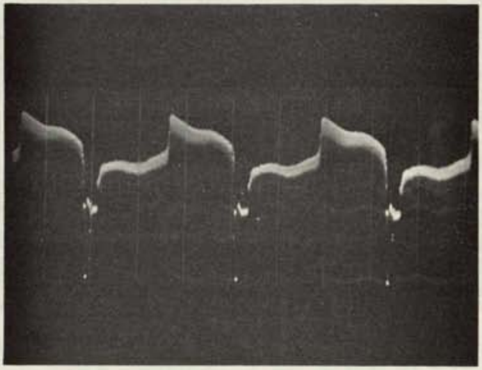


Figure G-3.- Block I black and white signal - transmission of standard TV signal from MSOB scan converter output. (Refer to E, appendix B.)



(a) Horizontal line (hor: 20μ sec/cm,
ver: 1/2 volt/cm).



(b) Vertical field (hor: 5m sec/cm,
ver: 1/2 volt/cm).

Figure G-4.- Oscilloscope pictures of block I black and white signal - transmission of standard TV signal from MSOB scan converter output. (Refer to E, appendix B.)

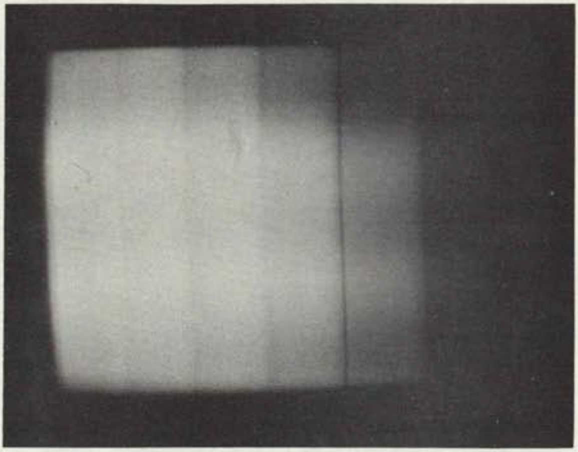
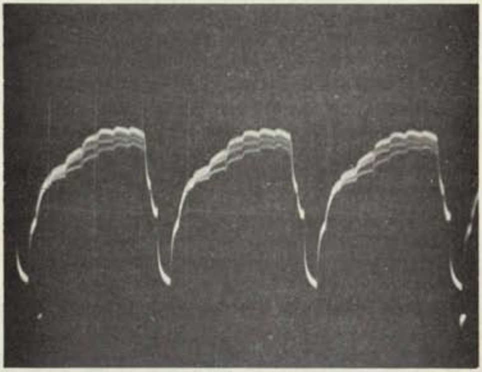
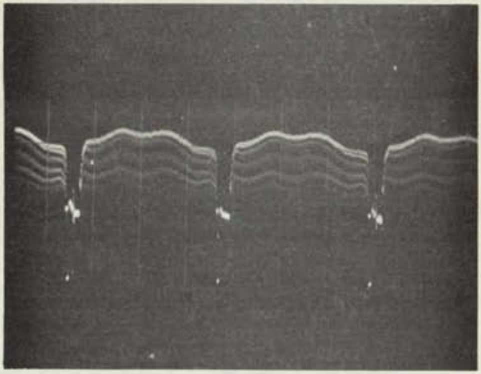


Figure G-5.- Block I gray scale signal - transmission of standard TV signal from MSOB scan converter output. (Refer to F, appendix B.)



(a) Horizontal line (hor: 20μ sec/cm, ver: 1/2 volt/cm).



(b) Vertical field (hor: 5m sec/cm, ver: 1/2 volt/cm).

Figure G-6.- Oscilloscope pictures of block I gray scale signal - transmission of standard TV signal from MSOB scan converter output. (Refer to F, appendix B.)

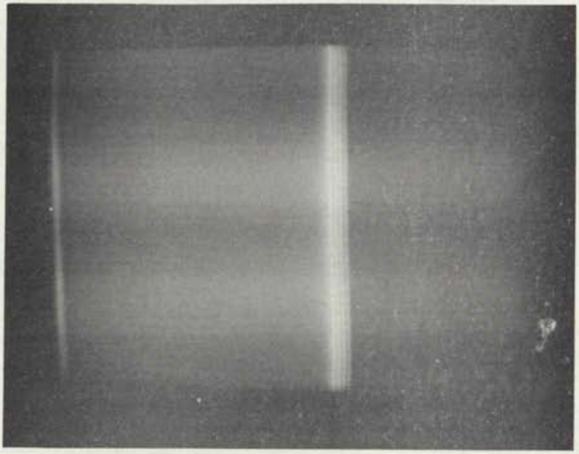
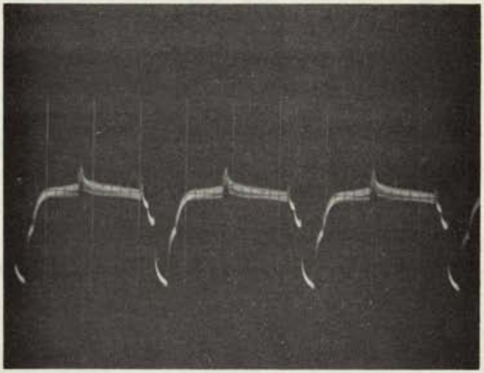
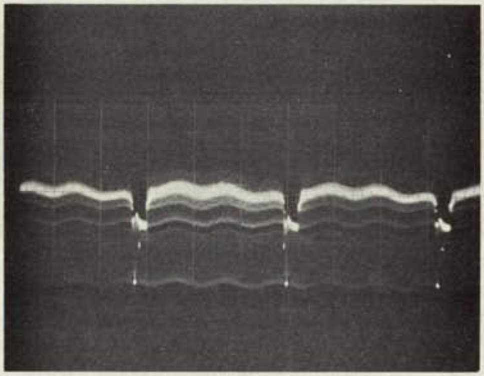


Figure G-7.- Block I burst pattern signal - transmission of standard TV signal from MSOB scan converter output. (Refer to G, appendix B.)



(a) Horizontal line (hor: 20μ sec/cm, ver: 1/2 volt/cm).



(b) Vertical field (hor: 5m sec/cm, ver: 1/2 volt/cm).

Figure G-8.- Oscilloscope pictures of block I burst patter signal - transmission of standard TV signal from MSOB scan converter output. (Refer to G, appendix B.)

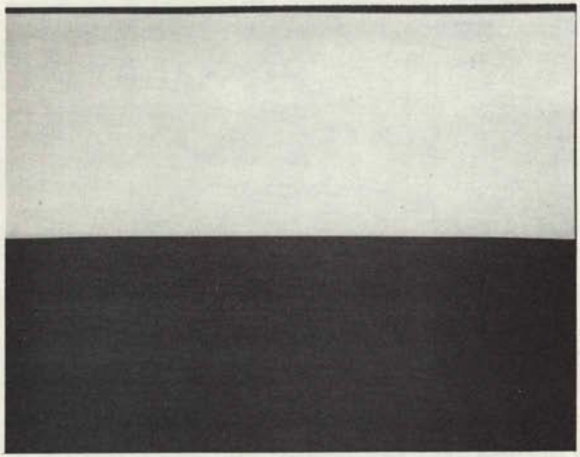


Figure G-9.- Block I - black and white signal slow scan monitor at Houston. (Refer to H, appendix B.)

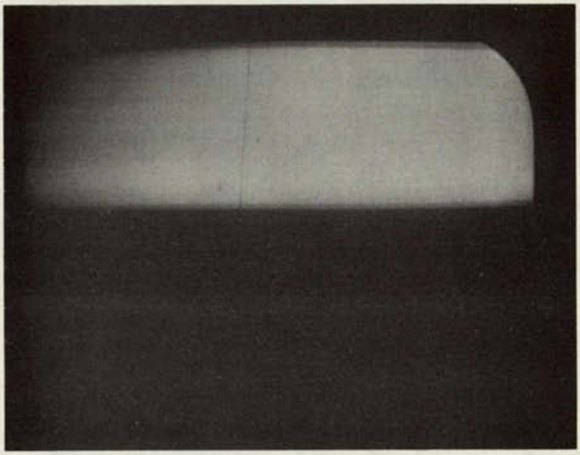
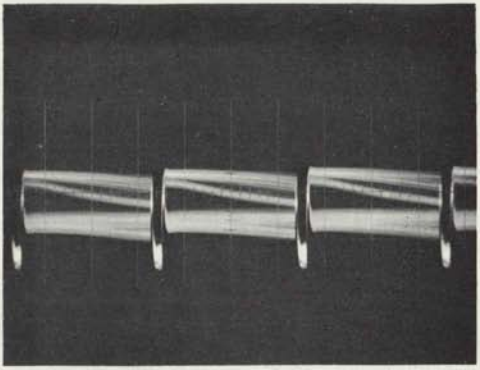
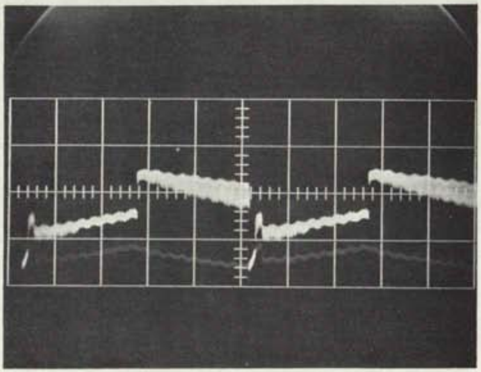


Figure G-10.- Block I - black and white signal scan converted at Houston. (Refer to H, appendix B.)



(a) Horizontal lines (hor: 100μ sec/cm, ver: 1/2 volt/cm).



(b) Two vertical frames (hor: 20m sec/cm, ver: 1/2 volt/cm).

Figure G-11.- Oscilloscope pictures of block I - black and white signal. (Refer to H, appendix B.)

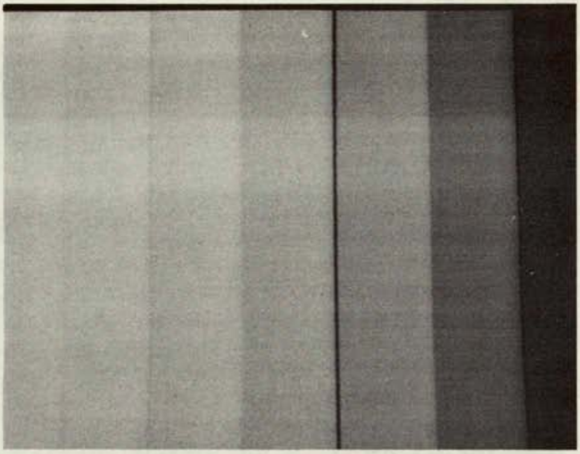


Figure G-12.- Block I - gray scale signal slow scan monitor at Houston. (Refer to I, appendix B.)

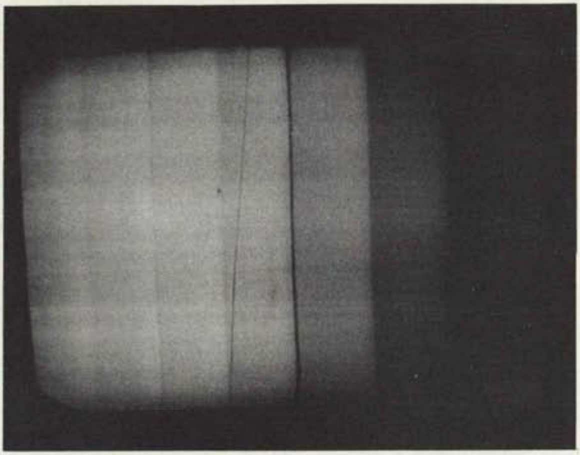
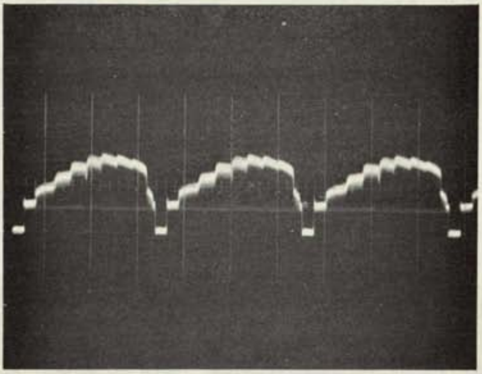
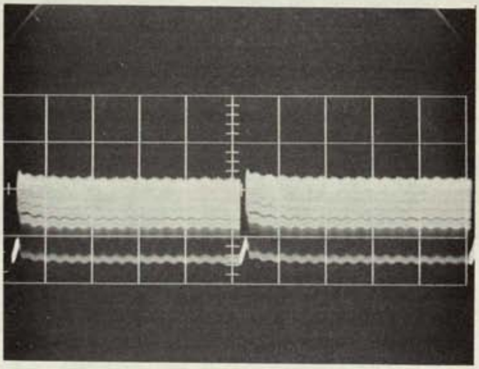


Figure G-13.- Block I - gray scale signal scan converted at Houston. (Refer to I, appendix B.)



(a) Horizontal lines (hor: 100µ sec/cm, ver: 1/2 volt/cm).



(b) Two vertical frames (hor: 20m sec/cm, ver: 1/2 volt/cm).

Figure G-14.- Oscilloscope pictures of block I - gray scale signal. (Refer to I, appendix B.)

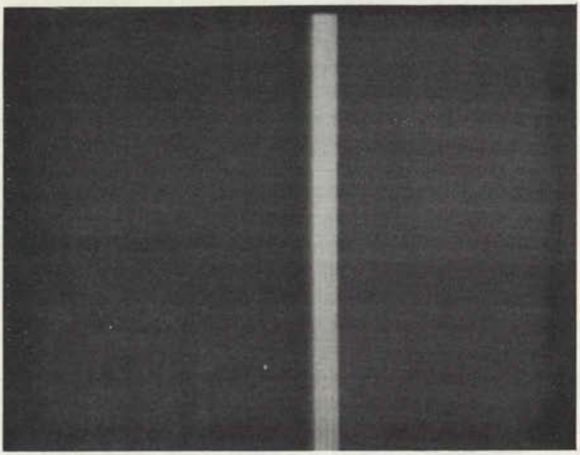


Figure G-15.- Block I - burst pattern signal slow scan monitor at Houston. (Refer to I, appendix B.)

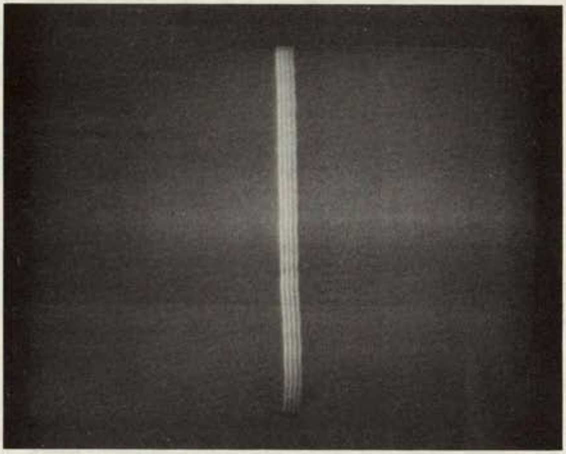
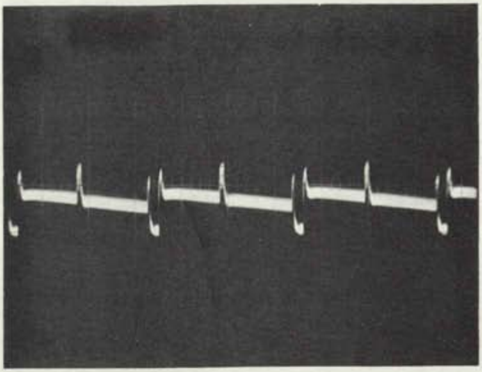
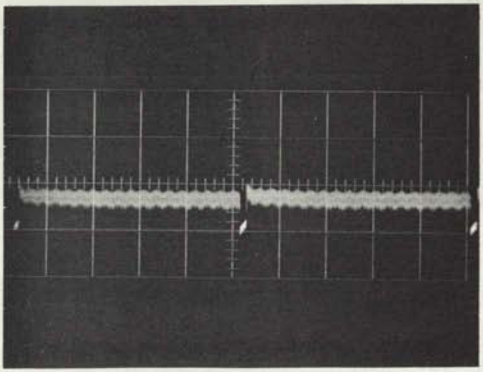


Figure G-16.- Block I - burst pattern signal scan converted at Houston. (Refer to J, appendix B.)



(a) Horizontal lines (hor: 100µ sec/cm, ver: 1/2 volt/cm).



(b) Two vertical frames (hor: 20m sec/cm. ver: 1/2 volt/cm).

Figure G-17.- Oscilloscope pictures of block I - burst pattern. (Refer to J, appendix B.)

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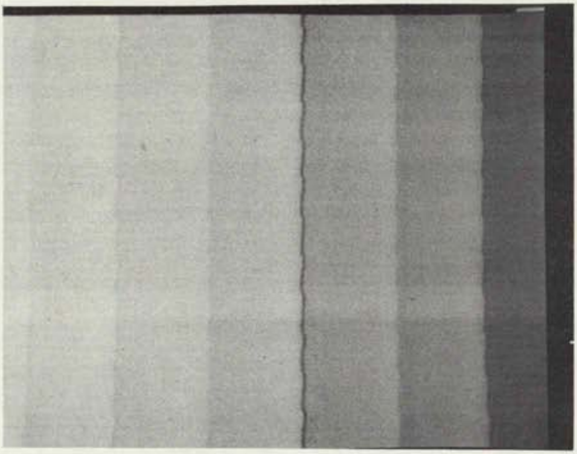
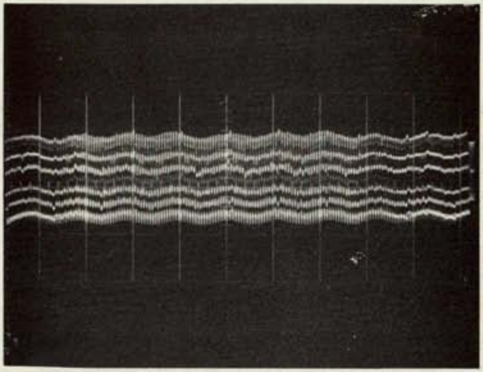


Figure G-18.- Block II - gray scale signal slow scan monitor at Houston. (Refer to L, appendix B.)



One vertical frame (hor: 10m sec/cm,
ver: 1/2 volt/cm).

Figure G-19.- Oscilloscope picture of block II - gray scale signal. (Refer to L, appendix B.)

NOTE:

The HORIZONTAL LINES picture is not available because the signal began breaking up before a picture of it could be taken.

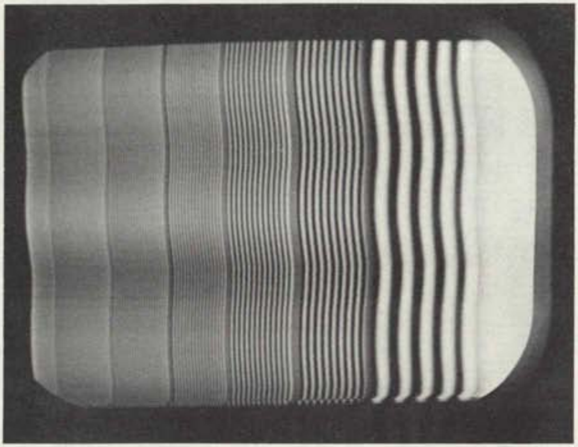
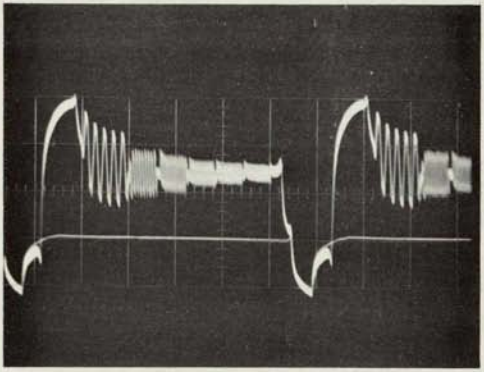
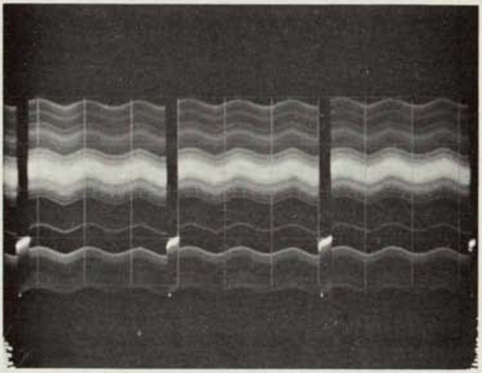


Figure G-20.- Final end-to-end circuit verification using 525-line pattern generator at the completion of the test.



(a) Horizontal line (hor: 50μ sec/cm, ver: 1/4 volt/cm).



(b) Vertical field (hor: 5m sec/cm, ver: 1/4 volt/cm).

Figure G-21.- Oscilloscope pictures of final end-to-end circuit verification using 525-line pattern generator. (Refer to D, appendix B.)