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In House Report
September 1979

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**EXPERIMENTAL IMAGE COMPRESSION
SUBSYSTEM (EICS) COMMUNICATION
TESTING**

Anthony R. Fanelli

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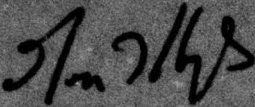
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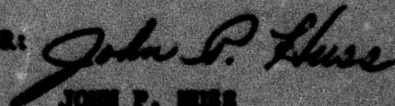
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The Experimental Image Compression System (EICS) was developed to effectively transmit intelligence and reconnaissance image data over narrowband links in minimum time. This report covers testing accomplished at RADC between March 1970 and July 1979 of the EICS. Testing was conducted over actual communications circuits in real time, with the most significant being the Troposcatter and Microwave links.		

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TABLE OF CONTENTS

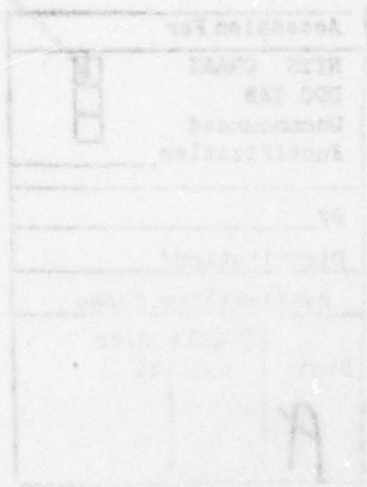
<u>SECTION</u>	<u>PAGE</u>
I. Summary	1
II. Test Imagery	2
III. Input Data	2
IV. Communications Channel Tests	2
V. Evaluation of the Results	5
VI. Imagery Evaluation	5
VII. Recommendations	9
VIII. Conclusions	9

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FIGURES

Figure No.	Title	Page
1	Test Pattern Original	3
2	Real Time Communications Channel Test	4

Table No.	<u>TABLE</u>	Page
1	Communication Channel	11



EICS COMMUNICATION TESTING

I. Summary:

This report covers testing of the Experimental Image Compression Subsystem (EICS) over various communications circuits provided by the RADC Digital Communications Experimental Facility (DICEF). The testing was accomplished in Building 240 by Anthony R. Fanelli/IRRE/3095, with assistance from Jim McEvoy of DICEF Laboratory, and Fred Huntington, Gordon Weatherup, Jack Prichard and Bill Schneider, who helped in TROPOSCATTER AREA.

The main objective was to test the EICS performance over nominal communications channels which are expected to carry image data through the military network. The net effect of the communications link on the image data is to produce errors with varying bit error rate and distribution.

A test was made over actual communication links available on base. The following is a list of communications channels used:

- a. Wire Line - Photos - 1-10
- b. Microwave - Photos - 11-12
- c. Troposcatter - Photos - 13-14

The tests used a specially prepared input image, Figure 1 which provided subjective and quantitative evaluation of the effects of various communication links. Some tests also demonstrated the redundant area coding¹ (REARCS) scheme. (See

Photo #12 Microwave and Photo #14 Tropo). All photos were then compared to Figure 1.

II. Test Imagery:

The test included two image subjects, one a standardize IEEE test pattern and a representative aerial recon photo. The test pattern provided a good quantitative measure of system performance while the aerial provided a subjective evaluation. The two subjects were pieced together to make a full size 8 x 8 inch composite photo as shown in Figure 1. A typical reconnaissance image was also used to demonstrate the REARCS¹ (see Photos 12 and 14). The composite photo was used for all transmissions, except Photos 12 and 14.

III. Input Data:

The test imagery in paragraph II was scanned on EICS, digitized and recorded on tape at 256/LPI. The tape data was then used to generate the 14 Photo hard copies of this report.

IV. Communications Channel Tests:

The test imagery defined in Paragraph II was tested over communication channels which are representative of those upon which imagery is to be transmitted in the military system. Table 1 shows a combination of links and variations in link quality which is a characteristic of those scheduled to be used for imagery. The test imagery was transmitted in real

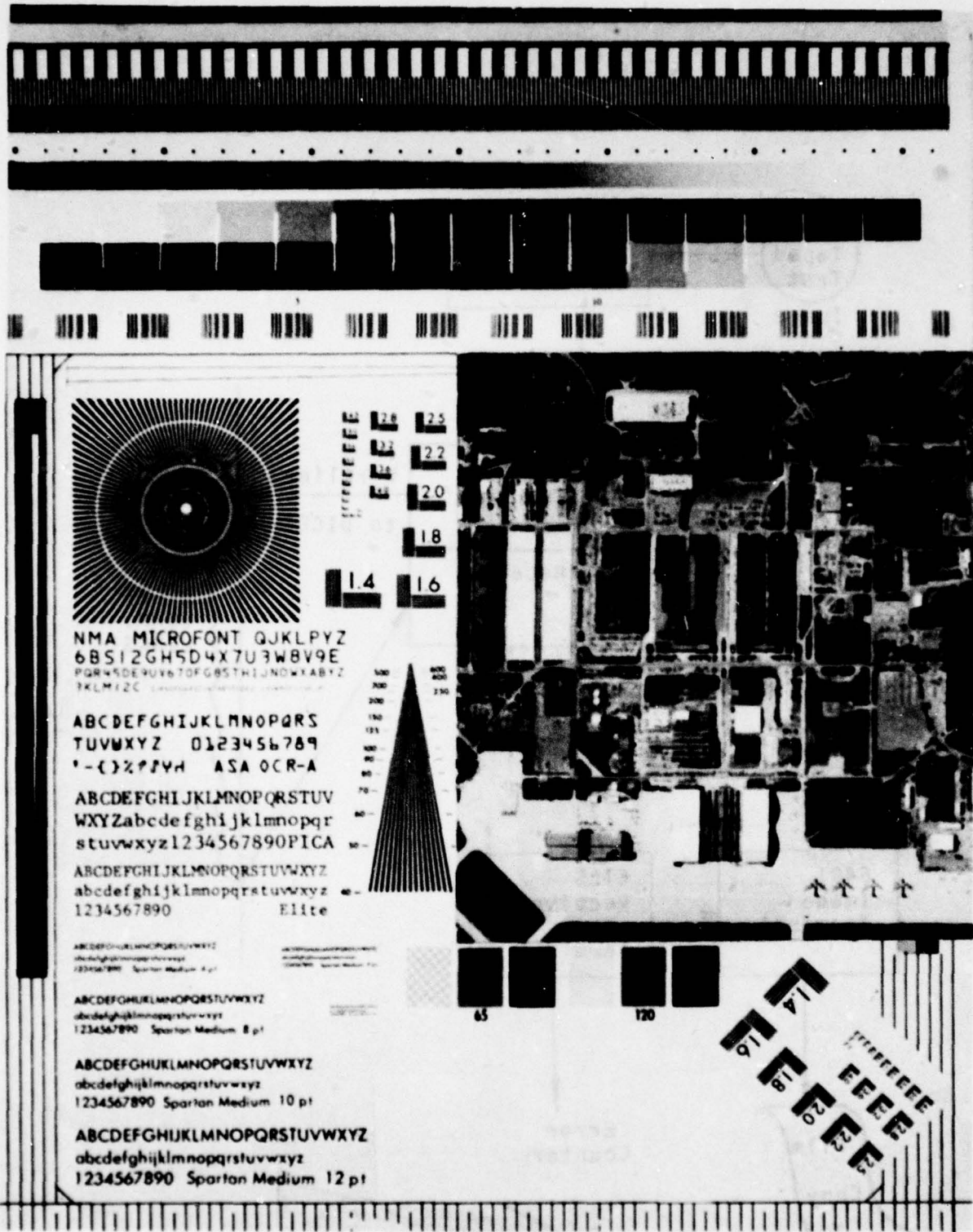


Figure 1 Test Pattern Original
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Pre Taped Test Image

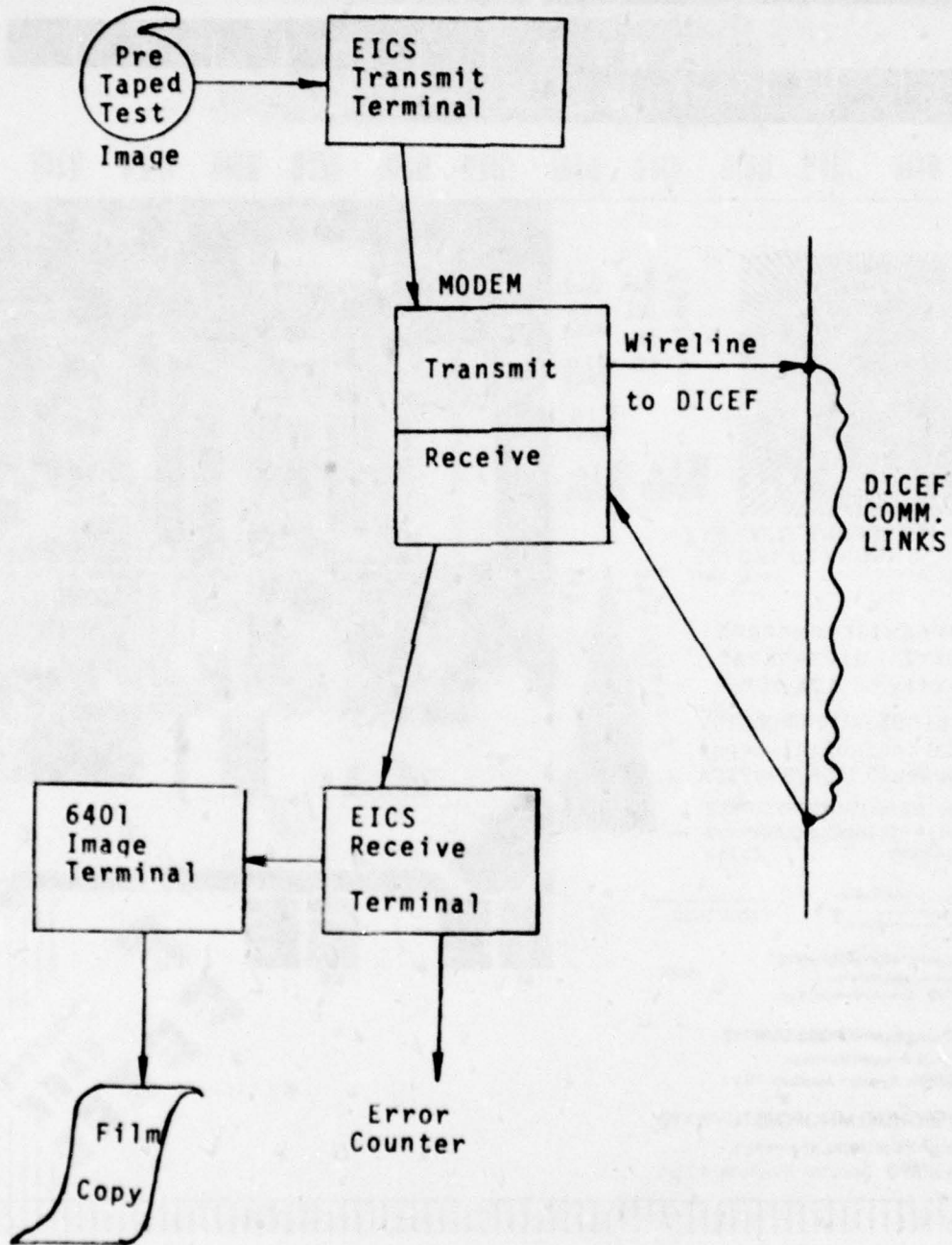


Figure 2 Real Time Communications Channel Test

time over those link combinations using the EICS system as shown in Figure 2.

V. Evaluation of the Results:

The methods for evaluating results in this particular test series are primarily subjective. The purpose is to evaluate the effects of errors. This being the case, the coding scheme is held constant. The result is that quantitative picture quality, resolution, MTF grey level response should not change from test to test. The only changes will be masking or altering data due to link errors. The IEEE test pattern was included in the test image as a means of verifying this fact. The masking or altering of image data can be determined subjectively.

Does the picture still convey useful information to the user? Which link combination provides better performance? Questions like these are answered using the subject test method. With the use of real links there was a question as to the actual overall error rate experienced during a given test. Simple testing with a counter prior to transmission provided a good estimate for bit error rate.

VI. Imagery Evaluation:

Photo #1 was transmitted over standard telephone line at a data rate of 9600 bps with a predetermined measured bit error rate of $.6 \times 10^{-4}$. The signal to noise ratio of the

telephone line was 22.5 db. The Pestrecov Star located at center left side is a good area of reference for evaluation of image distortion. Some image distortion can be seen, however, the reconnaissance image area is still usable.

Photo #2 was transmitted over standard telephone line at a data rate of 9600 bps with a predetermined measured bit error rate of 1.25×10^{-3} . The signal to noise ratio of the telephone line was 19.0 db. Review of the Pestrecov Star area shows a high degree of distortion compared to Photo #1. The reconnaissance image area is still highly usable.

Photo #3 was also transmitted over standard telephone line at a data rate of 9600 bps with a predetermined measured bit error rate of 2.5×10^{-7} .

Review of the Pestrecov Star area shows very little distortion, and the reconnaissance image area is of good quality, and highly usable.

Photo #4 was transmitted over an Autovon line between Rome Air Development Center, Rome, N.Y. and Tully, N.Y. and back to RADC at a data rate of 9600 bps. The signal level was -16db out and -10db back in, with a bit error rate of 1×10^{-6} . The Pestrecov Star and the reconnaissance image are of excellent quality.

Photo #5 was transmitted over an Autovon line between RADC, Rome, N.Y. and Tully, N.Y. and back to RADC at a data rate of 4800 bps. The signal level was -16db out and -10db

in, and had a bit error rate of 1×10^{-6} . There were no noticeable distortions in the Pestrecov Star. The transmission time was 55 minutes, with no image compression.

Photo #6 was transmitted over an Autovon line between two links, RADC, Tully, Potstown and back to RADC, and the data rate was 9600 bps. The signal was -11db out and -6db in, and had a bit error rate of 1.1×10^{-5} . Again, there seems to be little or no noticeable distortions in the Pestrecov Star.

Photo #7 was transmitted over Autovon line between four links, however, due to a tape read error only five minutes was recorded.

Photo #8 was transmitted over an Autovon line between four links, and the data rate was 9600 bps. The signal was -11db out and -9db in and had a bit error rate of 1.1×10^{-4} . Image evaluation of photo #8 shows little or no distortion of the Pestrecov Star. Transmit time was approximately twenty-five minutes.

Photo #9 was transmitted over an Autovon line with five links and the data rate was 9600 bps. This data rate proved to be high for a five link, and therefore Photo 9 did not transmit.

Photo #10 was transmitted over an Autovon line with five links, however, the data rate was reduced from 9600 bps to 7200 bps. The signal was -11db out and -12.5db in and had a

bit error rate of 1.1×10^{-4} .

Lowering of the data rate allowed for a successful transmission. The outlined area designated a programming error, and shows its result on the image.

Photo #11 was transmitted over Microwave between two links, and the data rate was 9600 bps. The bit error rate was 1×10^{-5} . The Pestrecov Star shows some distortion, however; the reconnaissance image is not affected by the distortion and is considered good image quality.

Photo #12 was also transmitted over Microwave with two links and the data rate was 9600 bps. The bit error rate was 1×10^{-5} . This photo utilized the REARCS scheme. The area outlined represents the area of high interest, and therefore, was transmitted at full resolution. The advantage of the REARCS scheme is to save transmission time. In this case transmission time was reduced by approximately fifteen minutes from the original 30-minute transmission time, required for a full 8" x 8" photo.

Photo #13 was an attempt to transmit over Tropo with two hops at a data rate of 9600 bps. This data rate proved too high as is evident.

Photo #14 was transmitted over Tropo with two hops at a data rate of 4800 bps. Lowering the data rate allowed for a successful transmission. This photo also utilized the REARCS scheme. The area outlined represents the area of high interest

and therefore was transmitted at full resolution. Transmission and reception time was approximately fourteen minutes for the full 8" x 8" photo.

Due to a computer failure the effects of adjacent channel interference in the imagery was not tested.

VII. Recommendations:

The quality of communications links vary at different times of the day, and several conditions have to be considered prior to transmission, these include hours of high use, which is generally 8 AM to 5 PM, a dedicated line, which is private, and the quality of the line, which is its condition.

It is recommended that conditioned lines or dedicated lines be used in order to improve the quality of the imagery, and dependability of transmission equipment.

It is also recommended that troposcatter transmission not be used because of the time involved in waiting for the right atmospheric conditions.

VIII. Conclusions:

1. Wire Line Test - Wire line test showed that data could be sent with little or no degradation, as can be seen by comparing the original input photo with Photo 1 through 10. Gaussian noise at various levels was super-imposed on the communications line to determine noise effect on the imagery. In the worse case the imagery was still usable.

2. Microwave -

Most of the test time was spent getting the communication channel set up for transmission.

Microwave transmission proved to be successful for two links at 9600 data rate.

Two photos were transmitted over microwave. The second photo used the REARCS scheme, which reduced the transmission time by fifteen minutes.

3. Troposcatter -

Only two photos were transmitted over troposcatter. More time was spent on tropo transmission than any other. The tropo equipment transmitted only the EICS imagery, and therefore it is not considered a true test, where the tropo equipment would be loaded down with other voice transmissions. Of the two images transmitted, only the 4800 data rate image was successful. The 9600 data rate proved to be too high.

Atmospheric conditions proved to be a big factor in image transmission. The noise level changed at different times of the day due to weather conditions.

Of the four communication channels tested, wire line proved to be more dependable and reliable for digital image transmission.

Table 1 Communication Channel

COMMUNICATION CHANNEL		DATA RATE	SNR OUT OF WIRE L. SIM.	BIT ERROR RATE MEASURED
PHOTO	STD TELEPHONE			
1.	Wire Line	9600B/S	22.5 db	$.63 \times 10^{-4}$
2.	Wire Line	9600B/S	19.0 db	1.25×10^{-3}
3.	Wire Line	9600B/S	Clean No Noise	2.5×10^{-7}
AUTOVON TESTING		DATA RATE	ROUTE	SIGNAL LEVEL
4.	0 Link	9600	RADC-Tully-RADC	-16db out
5.	0 Link	4800	RADC-Tully-RADC	-10db in
6.	2 Link	9600	RADC-Tully-Potstown-RADC	-16db out
7.	4 Link	9600	RADC-Arlington VA	-10db in
8.	4 Link	9600	RADC-Arlington VA	-11db out
9.	5 Link	9600	RADC-Tully-Rockdale	-6db in
10.	5 Link	7200	RADC-Tully-Rockdale	-11db out
MICROWAVE				
11.	2 Link	9600	RADC-Port Ontario & Return	-9db in
12.	2 Link	9600	RADC-Port Ontario & Return	-11db out
TROPO				
13.	2 HOPS	9600	RADC-Port Ontario & Return	Would not operate at 9600 Rate
14.	2 HOPS	4800	Same as above	2×10^{-4}

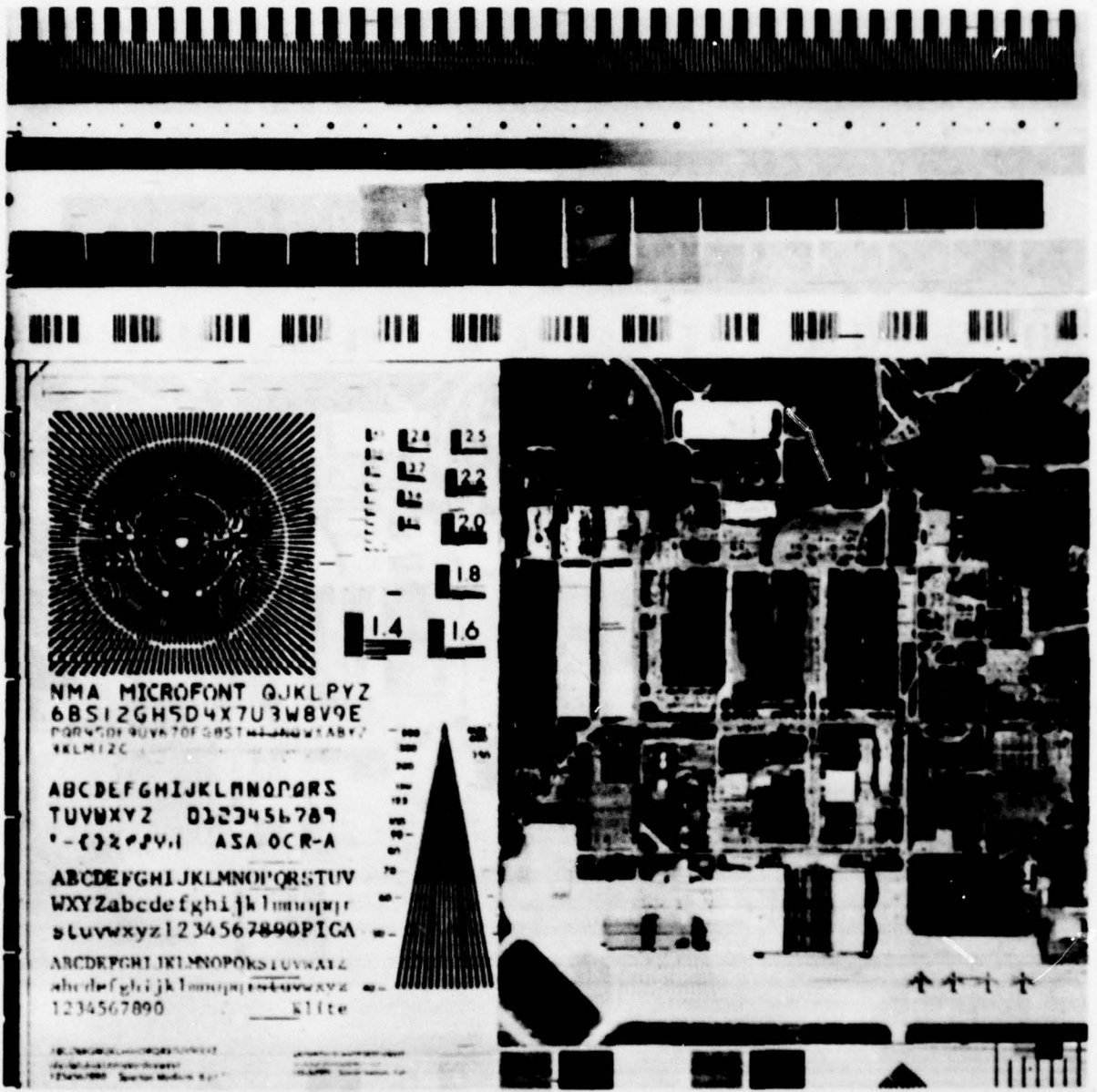
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¹William M. Sillers, "Redundant Area Coding Study," RADC-TR-71-192, September 1971 (888625), Rome Air Development Center, Rome, New York.

²Air Force Invention No. 6574, Redundant Area Coding System, 4 March 1970.

³L. Gardenhire and J. Maier, "Redundant Area Coding System," International Telemetry Conference, 1972.

⁴William M. Sillers, "Redundant Area Coding Image Link Simulation," RADC-TR-73-183, July 1973 (767568), Rome Air Development Center, Rome, New York.



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 2.2 2.0
 1.8
 1.4 1.6

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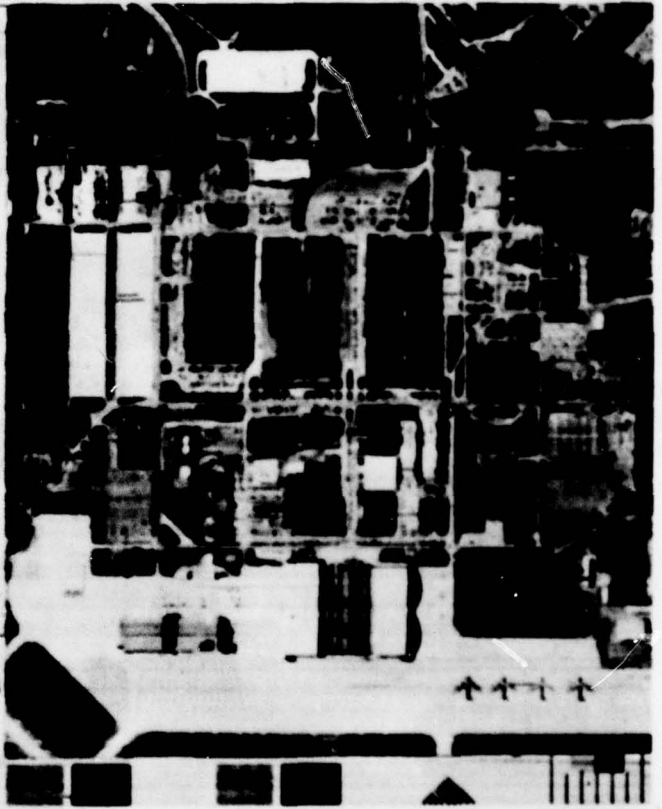


PHOTO 2
 STD Telephone Wire Line



PHOTO 3
 STD Telephone Wire Line

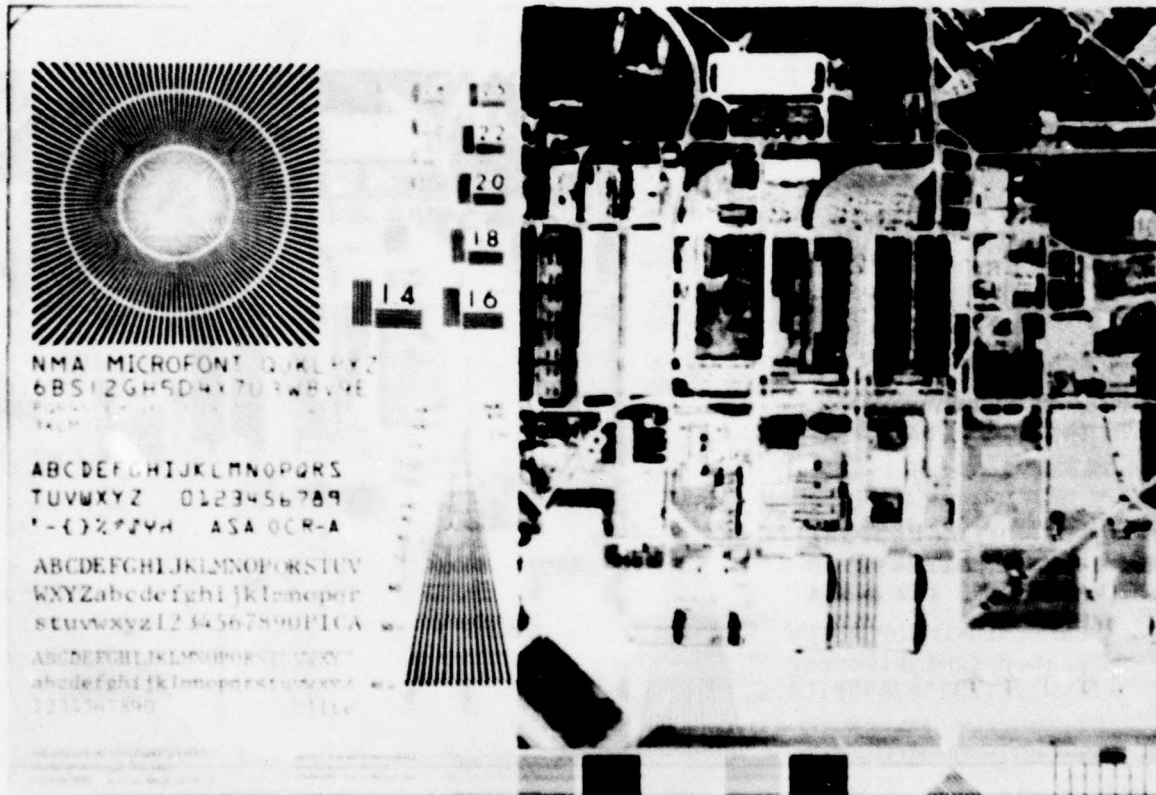
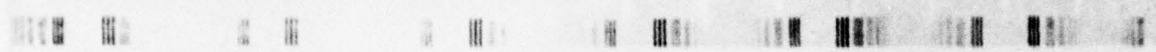


PHOTO 4
AUTOVON TESTING

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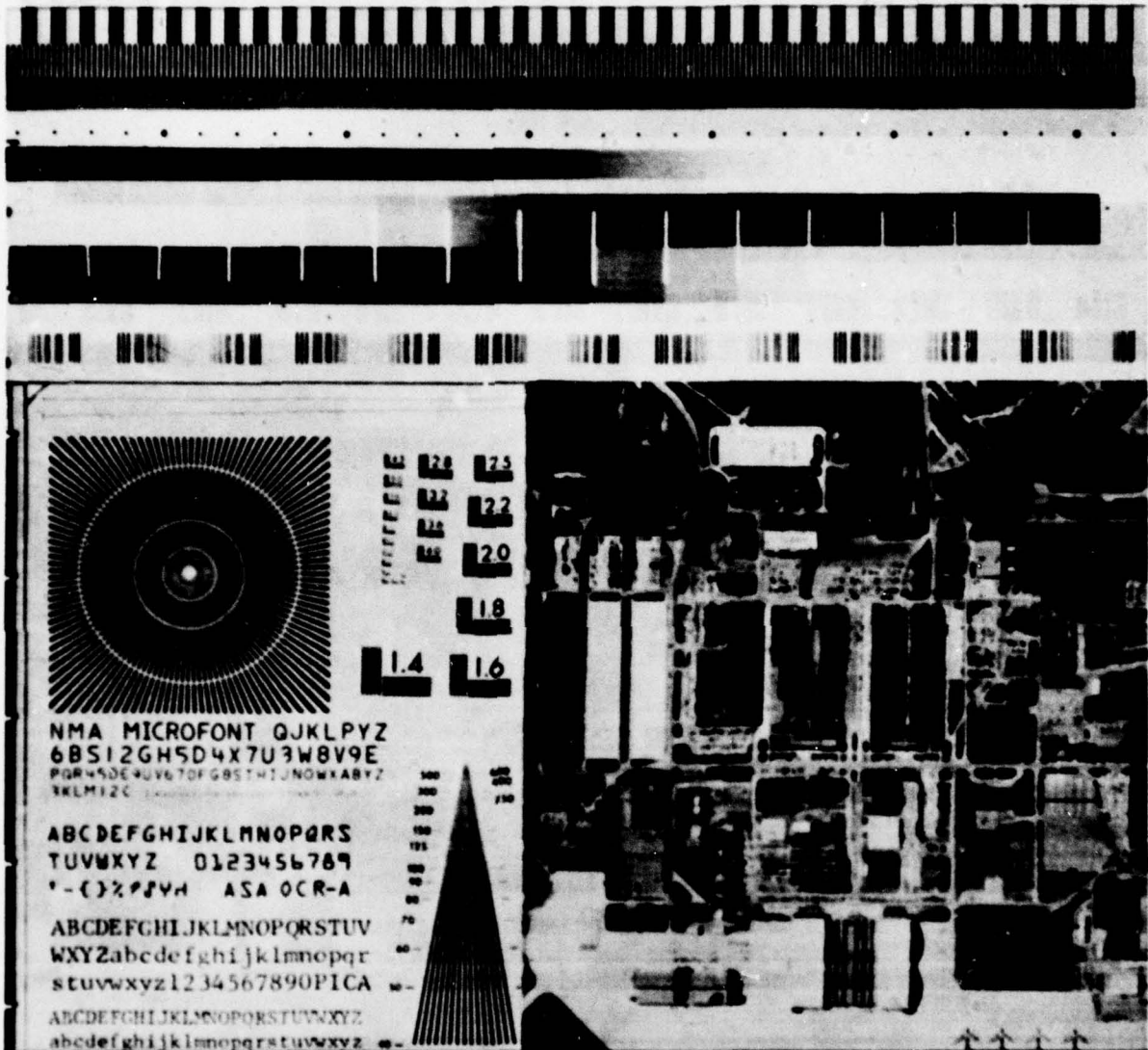


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 AUTOVON TESTING

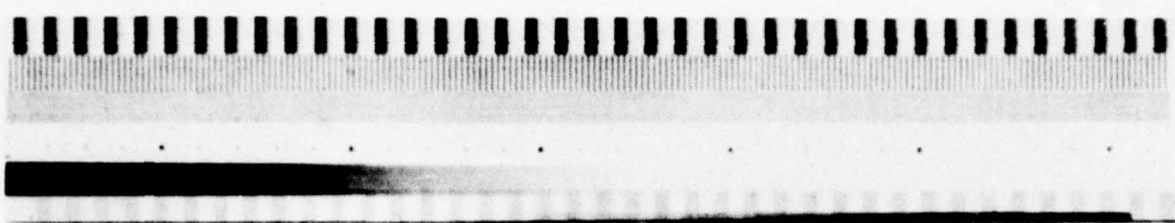
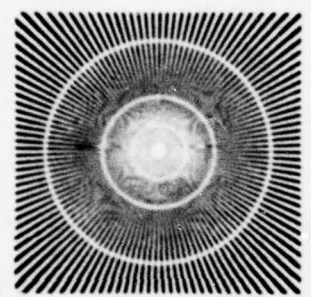


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AUTOVON TESTING



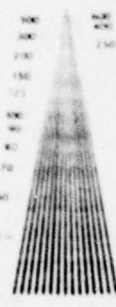
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PHOTO 8
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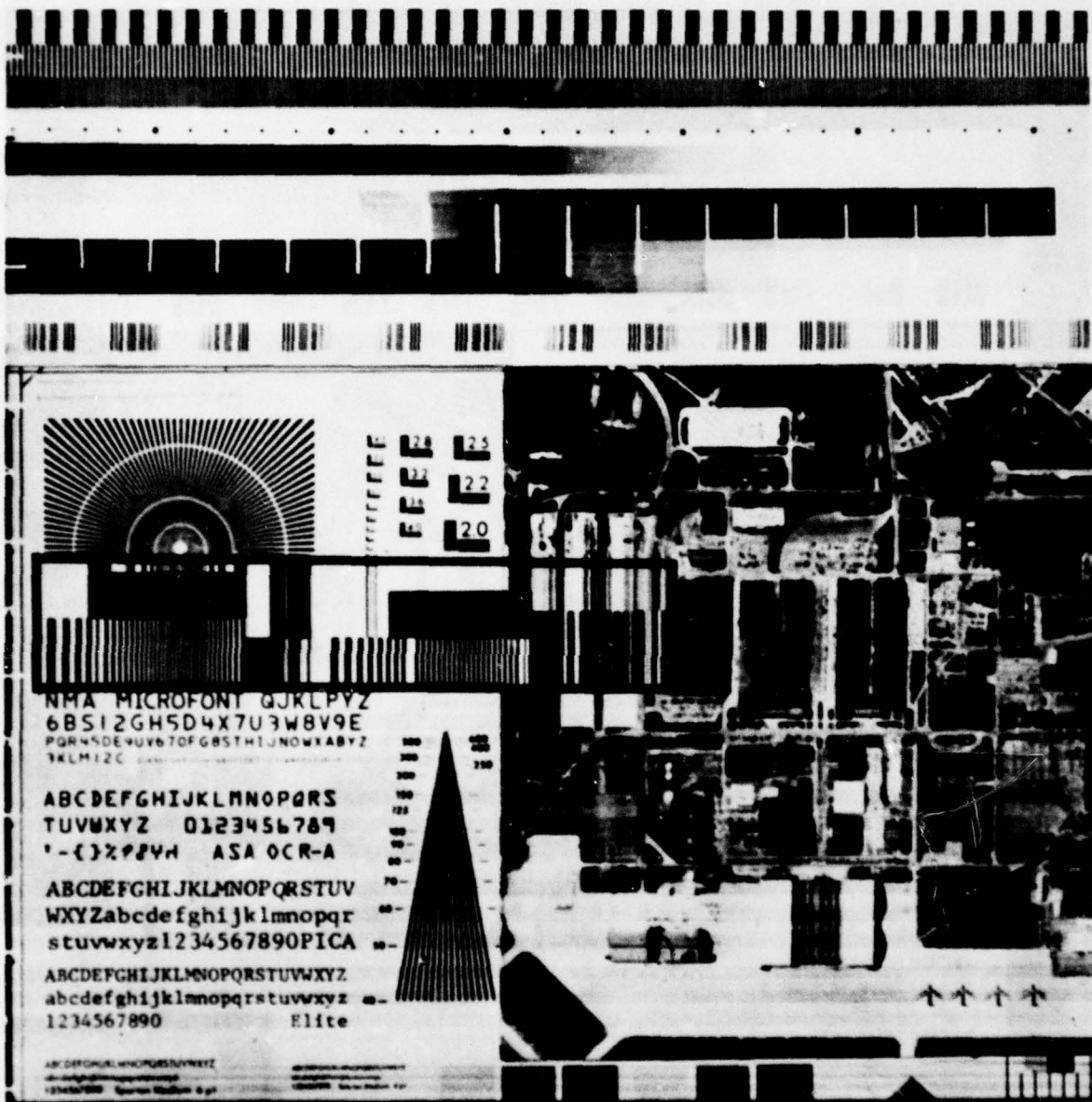


PHOTO 10
 AUTOVON TESTING

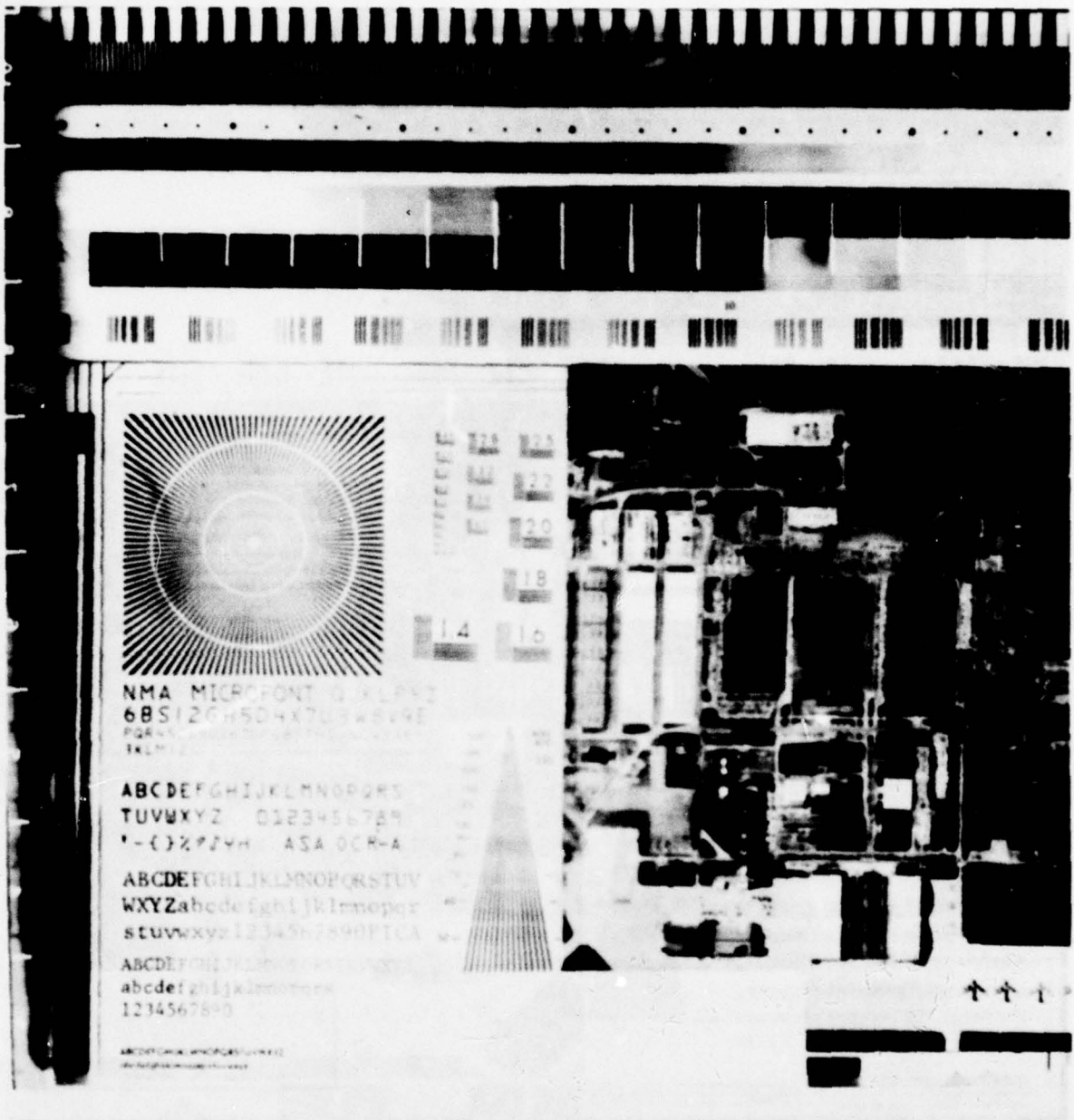
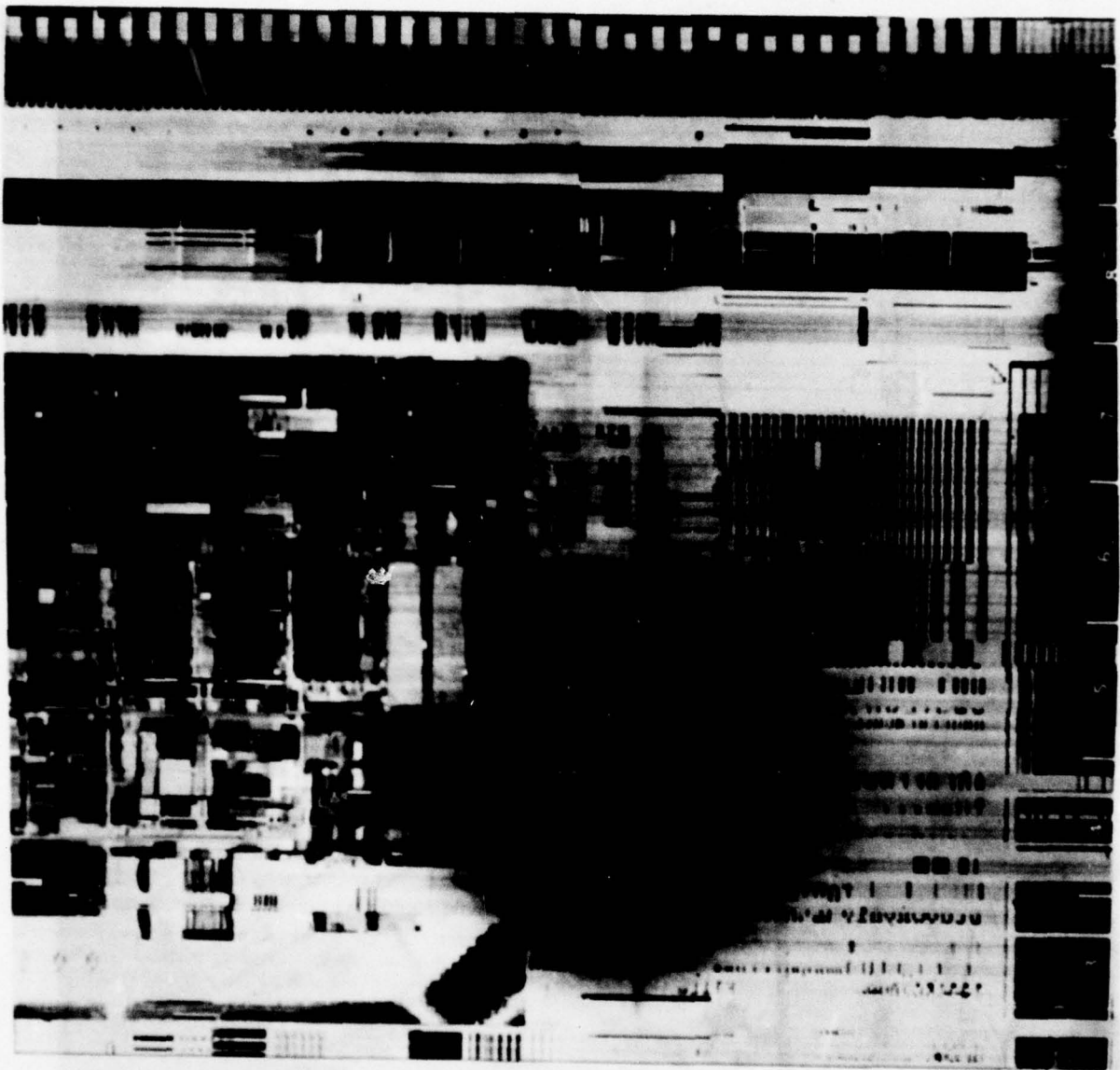


PHOTO 11
 MICROWAVE 2 LINK



PHOTO 12
MICROWAVE 2 LINK



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PHOTO 13

TROPO

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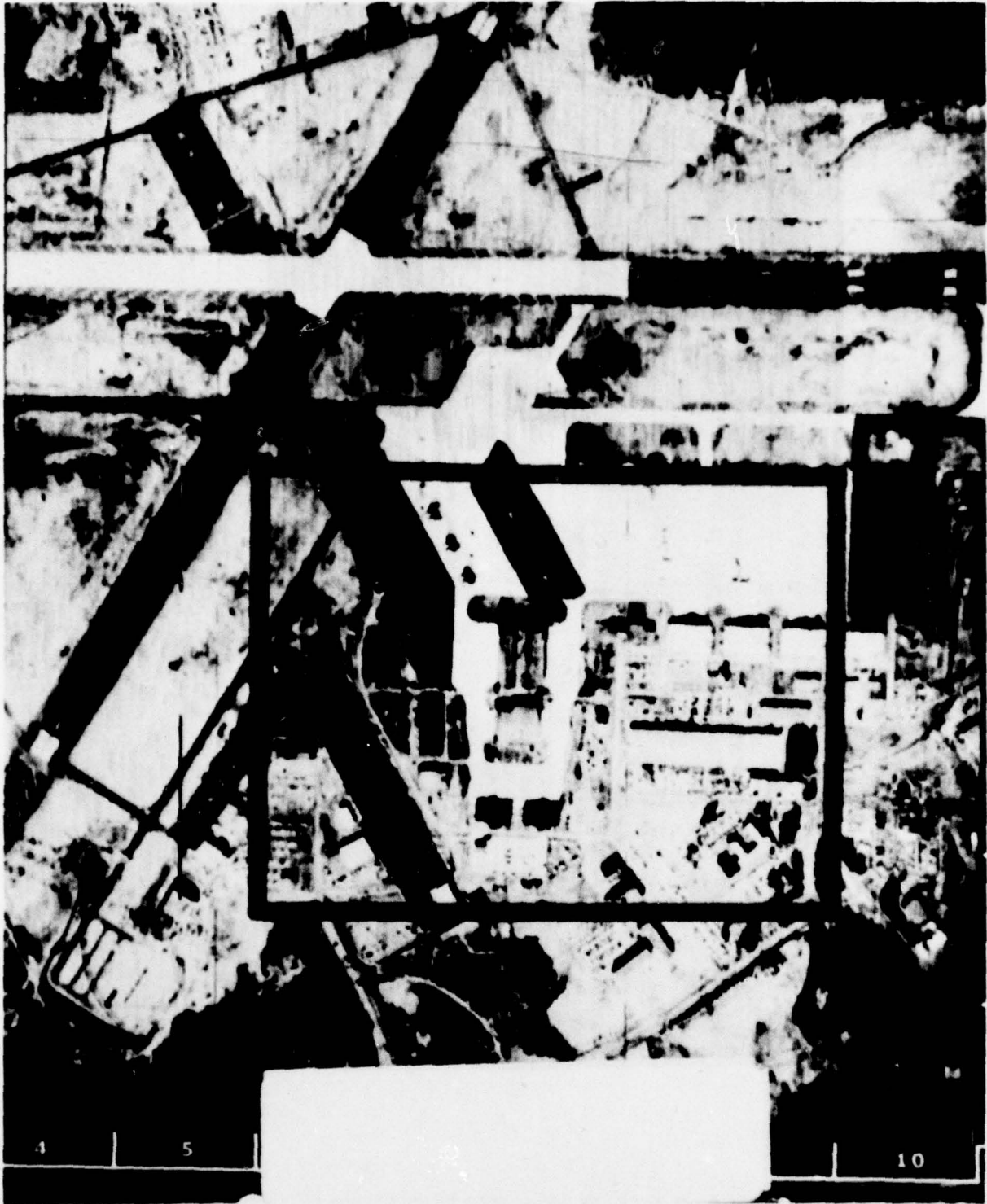


PHOTO 14

TROPO

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