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AIR FORCE CAMBRIDGE RESEARCH LABORATORIES

L. G. HANSCOM FIELD, BEDFORD, MASSACHUSETTS

Factors Affecting the APT Picture Quality

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METEOROLOGY LABORATORY PROJECT 6698

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Abstract

The Muirhead K-300A Recorder operation is analyzed and a daily quality control routine is suggested which permits evaluation of the photographic process, the light source, and the electronic function.

An objective technique for optimizing the image density range for a given weather satellite is presented, using the daily quality control data generated by recording a signal sequence and a densitometer measurement of the reflective density of the image.

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Factors Affecting the APT Picture Quality

1. INTRODUCTION

Research undertaken to improve the forecasting techniques for Southeast Asia used as one data source the tape-recorded signals from the APT (Automatic Picture Transmission) subsystem of satellites ESSA II, ESSA VI, and NIMBUS II. These taped signals were reproduced by an Ampex-500 tape deck and a Muirhead K-300A photofacsimile recorder to provide the satellite pictures used as raw data. It became evident that stringent control would have to be exercised over the picture production to ensure that the cloud and landmark information were of sufficiently high quality to be a positive contribution to the research effort.

The changes in signal strength and hence image brightness from tape to tape, noisy signals, and the variation between satellite cameras, all introduced variables which had to be compensated for in the playback and picture recording. In order to determine the limit of the performance of the Muirhead-Ampex equipment, tests were carried out to isolate the variables which affect the quality of the finished picture.

(Received for publication 25 September 1968)

2. DESCRIPTION OF THE APT SUBSYSTEM

The APT subsystem of a meteorological satellite consists of a vidicon camera (with suitable optics) which generates an electrical signal proportional to the brightness of the elements of the image formed on the active surface of the tube. This signal modulates an FM transmitter with a 2400-Hz carrier whose amplitude is a measure of the image brightness. This 2400-Hz video signal is recovered at the discriminator of the ground station and controls the intensity of a crater tube light source in the photofacsimile recorder (in a wet paper facsimile the marking current is proportional to brightness). The focused spot of light from the crater tube scans the photographic paper, producing an image of the earth and clouds as seen by the camera in the satellite.

It can be seen that in the APT subsystem, the scene image is:

(a) transformed into a voltage,
(b) which modulates an FM transmitter,
(c) whose signal is demodulated to reproduce a 2400-Hz sine wave of variable amplitude,
(d) which controls the intensity of a light source,
(e) exposing photographic paper,
(f) which is developed (activated and stabilized) to provide the desired picture.

If each of these transformations were linear, their combinations would be linear and a simple one-point calibration would provide the information to keep the brightness of the images consistent from picture to picture.

The relation of luminance to signal voltage for the two cameras of the ESSA VI satellite, as determined by prelaunch calibration, is shown in Figures 1 and 2.*

The data have been replotted on linear scales for signal (peak-to-peak voltage) and luminance in Figure 1 and on linear scales for signal (dbm) and luminance in Figure 2. The vidicon output voltage is approximately linear with respect to image brightness over a range from about 700 to 5,000 foot-lamberts.

The reflective density of the image produced by a photographic recorder is proportional to the logarithm of the exposure. Since the signal strength in dbm is a logarithmic function of the ratio of the peak-to-peak voltage to a reference voltage, the image density may be approximated by a linear function of signal level in dbm automatically compensating for the major portion of the characteristic curve of the photographic process.

If clouds having a brightness greater than 5,000 foot-lamberts are observed, the resulti signal amplitude will be greater than 0 dbm and in an APT receiving system, set according to the original instruction manual, the image has to be whiter than the paper. The result is a complete loss of texture and shape of the cloud in a "paper white" area in the print. Aircraft measurements of cloud brightness have given luminance values above 10,000 foot-lamberts for

*Alignment and Calibration Data for the TOS D Meteorological Satellite Report No. AED M-2151, Astro-Electronics Division, Defense Electronic Products, Radio Corporation of America, Contract No. NAS 5-9034, October 1967.

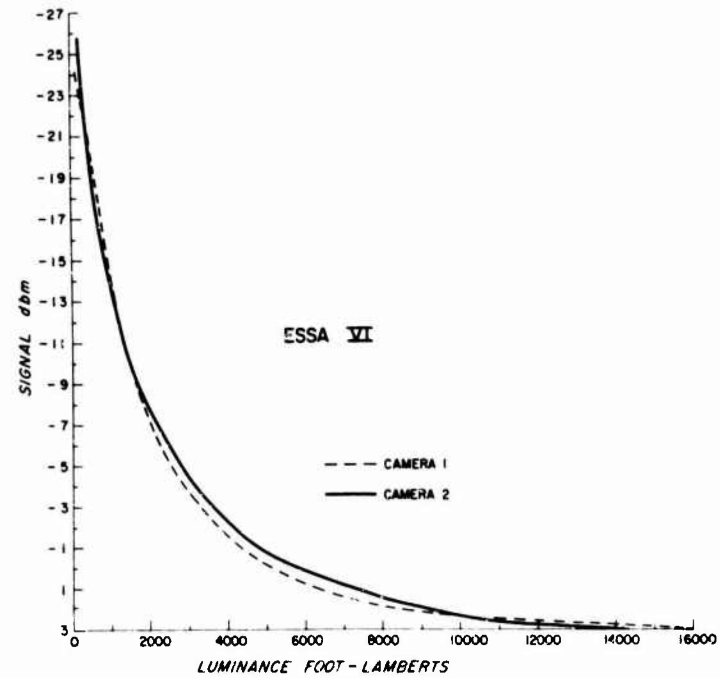

Figure 1. Relation of Luminance to Signal in dbm for the Two Cameras of the ESSA VI Satellite

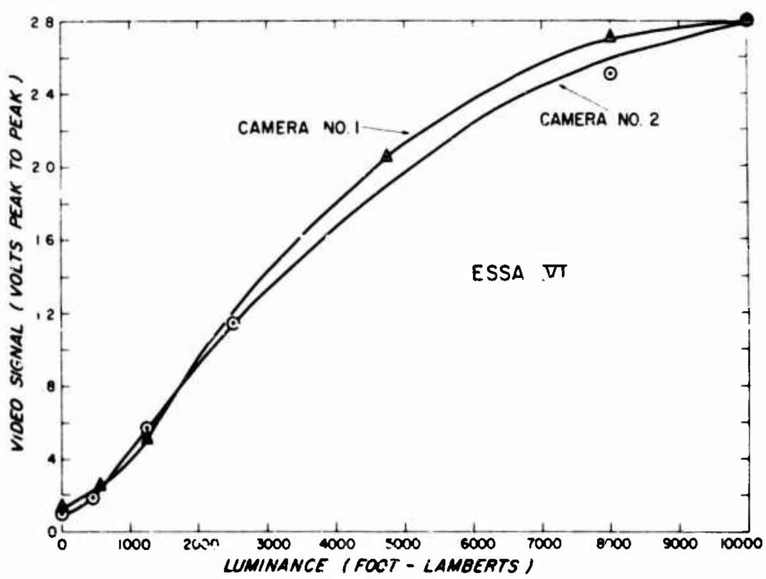

Figure 2. Relation of Luminance to Signal in Volts Peak-to-Peak for the Two Cameras of the ESSA VI Satellite

exceptionally thick cumulus type clouds. These extremely bright clouds are the very ones which are of maximum importance in many situations.

It is important to the meteorologist that the same image density on two pictures represents the same brightness of cloud image at the camera. Not all satellites have the same camera sensitivity nor does the camera in a given satellite necessarily remain constant with time. It is not usually possible to make, from the ground, sufficient exposure adjustments or contrast adjustments in the satellite to compensate for aging effects after launch. It is possible, however, to manipulate the gray-scale response in the Muirhead photofacsimile to obtain a linear relationship between the reflective density of the image and dbm signal strength over a wide dynamic range of signals.

The Muirhead Photofacsimile Recorder receives the amplitude modulated 2400-Hz carrier and performs several operations to make a picture as follows: (Figure 3)

(a) The photographic paper is scanned in synchronism with the image scan in the camera.

(b) The signal amplitude is converted to a drive current for the crater tube light source. The shape of this transformation function can be varied over wide limits by the gray-scale compensator. A typical gray-scale function is illustrated by the signal amplitude vs crater current plot of Figure 3.

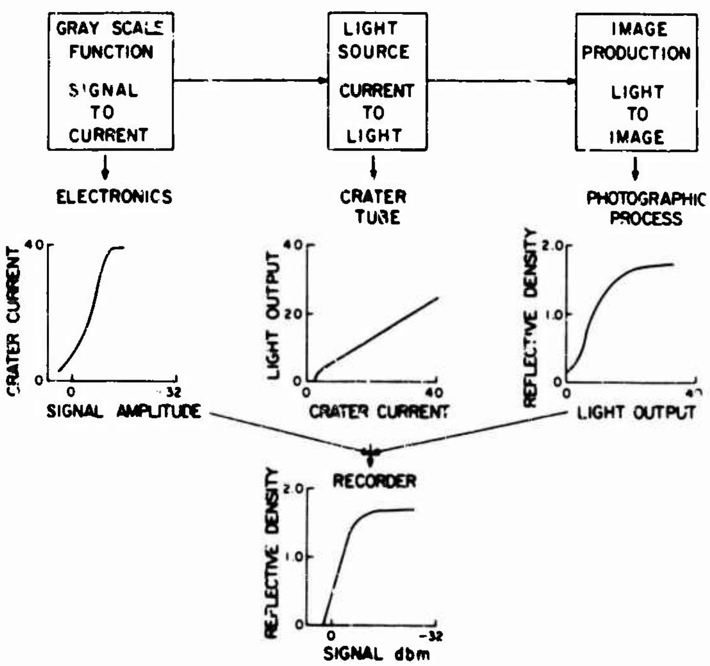

Figure 3. Characteristics of the Muirhead APT Photofacsimile Recorder

The crater tube converts the current input from the gray-scale compensator to light output as illustrated by the crater current vs light output plot of Figure 3.

The light output is used to generate the image on photographic paper which is developed and delivered as a print. The photographic process is quite nonlinear as shown in the plot of reflective density vs light output. The interaction of these three nonlinear functions results in the overall response of the recorder as shown in the bottom plot of Figure 3. The factors which cause a variation in the reflective density for a given signal amplitude can readily be identified and investigated.

Each APT picture transmission consists of a 3-sec start signal, illustrated by the oscillograms shown in Figure 4. The 2400-Hz carrier is switched 300 times per second from 2.17 V peak amplitude to 0 V amplitude. Figure 4 shows a start signal recorded at two sweep speeds of the oscilloscope, the upper being 2 msec/div and the lower trace 0.5 msec/div.

Following the 3-sec start tone, a 5-sec phase signal is transmitted as illustrated in Figure 5. The phasing is initiated by the 12.5 msec of 0 V breaking the constant amplitude (2.17 V peak-to-peak) 2400-Hz carrier. During this portion of the APT transmission, the recorder automatically adjusts its gain to make the signal level equal to the internal reference signal in the recorder assigned to "white."

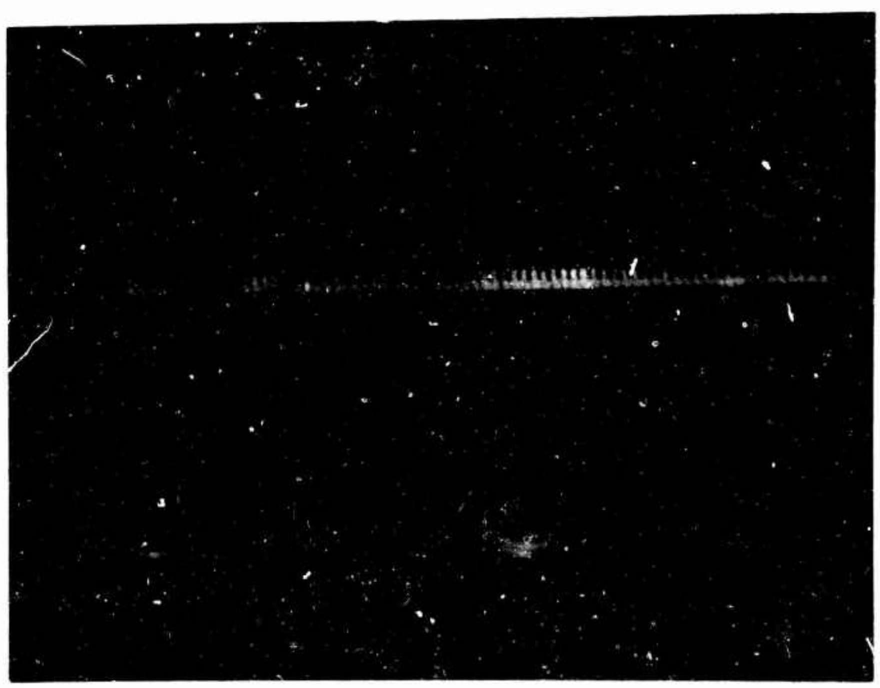

Figure 4. Oscillograms Showing 3-sec Start Signals for APT Picture Transmission at Sweep Speed of 5 msec/div (top) and 0.25 msec/div (bottom)

Figure 5. ESSA 5-sec Phase Signal at Sweep Speed of 20 msec/div (top) and 2 msec/div (bottom)

The signal for the next 200 sec consists of a 12.5-msec burst of constant amplitude (2.17 V peak-to-peak) followed by 237.5 msec of video information. Figure 6 illustrates two lines of a test pattern which will produce reflective densities proportional to the amplitude of the signal between the two phase-bar (white) signals. Figure 7 illustrates one line of an ESSA IV picture. The 2.17 V phase bar is visible at the beginning of the line followed by light clouds and a set of fiducial (dark) marks.

The importance of proper adjustment of levels in the receiving system is quite evident. In an amplitude system, only the sensor should be causing variation in the signal amplitude, not the operator or the receiving station.

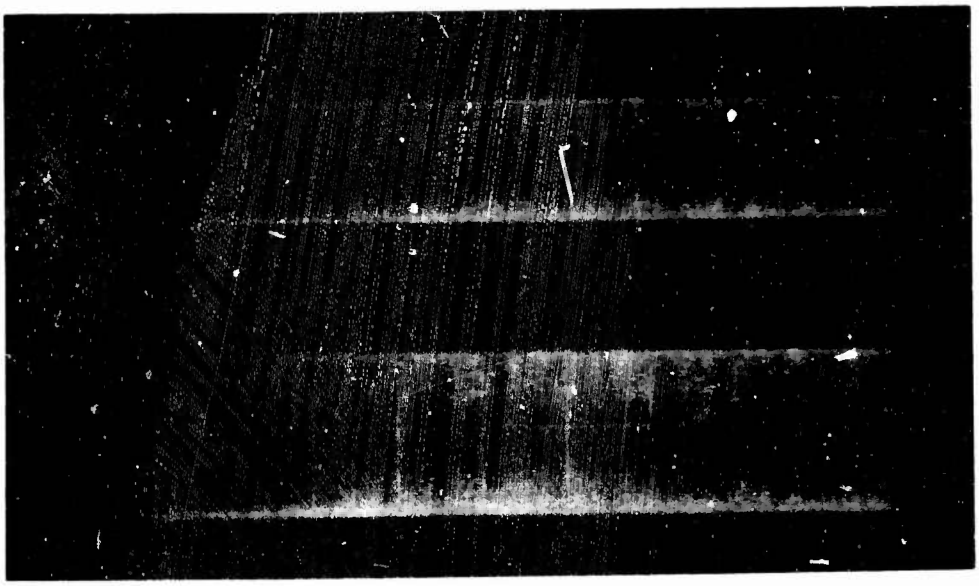

Figure 6. Oscillogram Showing Two Gray Levels

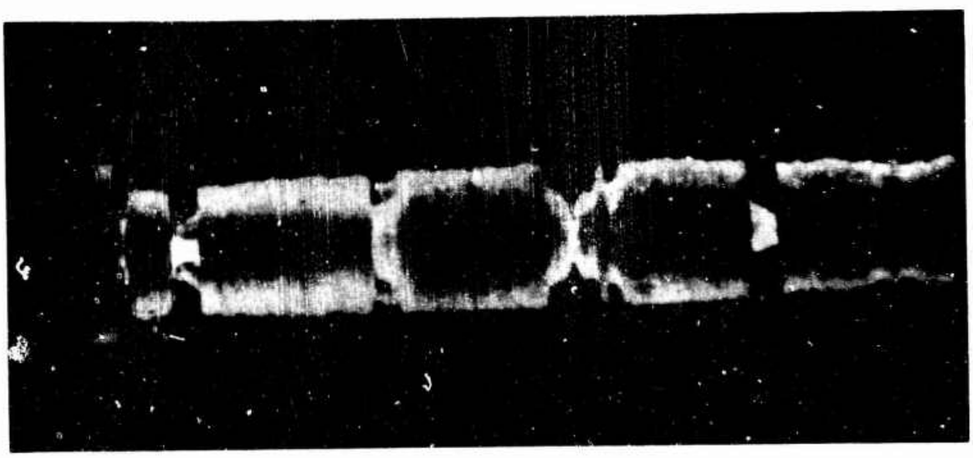

Figure 7. ESSA IV Phase Bar and Fiducial Marks

3. QUALITY CONTROL OF THE PICTURE REPRODUCTION

The following rules were set up for the guidance of the APT set operators:

(1) Set the receiver video output so that the peak-to-peak signal is measured to be approximately 2 V by an oscilloscope (0 ± 2 dbm in a 600-ohm line) during the phasing signal (5 sec duration) or during the beacon signal between pictures in the ESSA series of satellites.

(2) Do not tune the receiver during a picture. Tuning can introduce a level shift of as much as 1 dbm and should only be done on the beacon signal. If the receiver output level, facsimile recorder level control, or tape recorder level are changed during a picture, it will be almost impossible to obtain a picture whose gray scale is uniform over the time of the picture.

(3) Record the signals on tape (if needed for playback and additional copies) with the phasing signal or beacon signal level at or near 0 dbm.

(4) Playback from tapes to the Muirhead or other recorder should be set at a phase signal or beacon level as measured by the recorder at 0 dbm ± 2 dbm (31 to 49 on Muirhead meter). Within this range the automatic-level set circuit can set the gain to match the reference signal level in the recorder. If the recorder is not able to match the input signal level, the reflective density of all the picture elements will be increased or decreased but the dynamic range of reflective density will be either unchanged or decreased. Figure 8 illustrates the saturation of the cloud areas which results from a higher signal level than the recorder can compensate for. A picture was reproduced from a tape recording with the phasing signal amplitude set at 0 dbm and the Muirhead recorder in "auto" mode. The automatic-level set potentiometer was at the midpoint of its range. Replaying the tape with the phasing signal level reduced by 3 dB caused the automatic level set potentiometer to approach its upper limit. The resulting picture, identical to the original, is shown on the right side of Figure 8. The phasing signal level was increased to + 4 dbm, driving the automatic-level set potentiometer against its lower stop. The resulting picture is shown on the left side of Figure 8. The input signal level which corresponded to the whitest picture element was greater than the "paper white" level (0 dbm) causing the bright cloud areas to lose detail and degrading the picture quality. The variation that can be tolerated in the input signal level is about ± 3 dB. As long as the automatic level set is used (recording mode: "auto") operation within the ± 3-dbm signal level of the phase signal or beacon will not change the picture quality. In manual operation, the recorder level must be set at 0 dbm (corresponding to 40 on the Muirhead meter for the 5-sec phasing signal) if consistent picture quality is to be maintained.

It was found that when test patterns were made daily on the Muirhead K-300A recorder, a variation of 30 to 50 percent occurred in the reflective density produced by a given input signal strength. Figure 9 is a plot of reflective density vs signal level obtained from the daily test patterns during February 1968. The gray scale compensation was unchanged during this period.

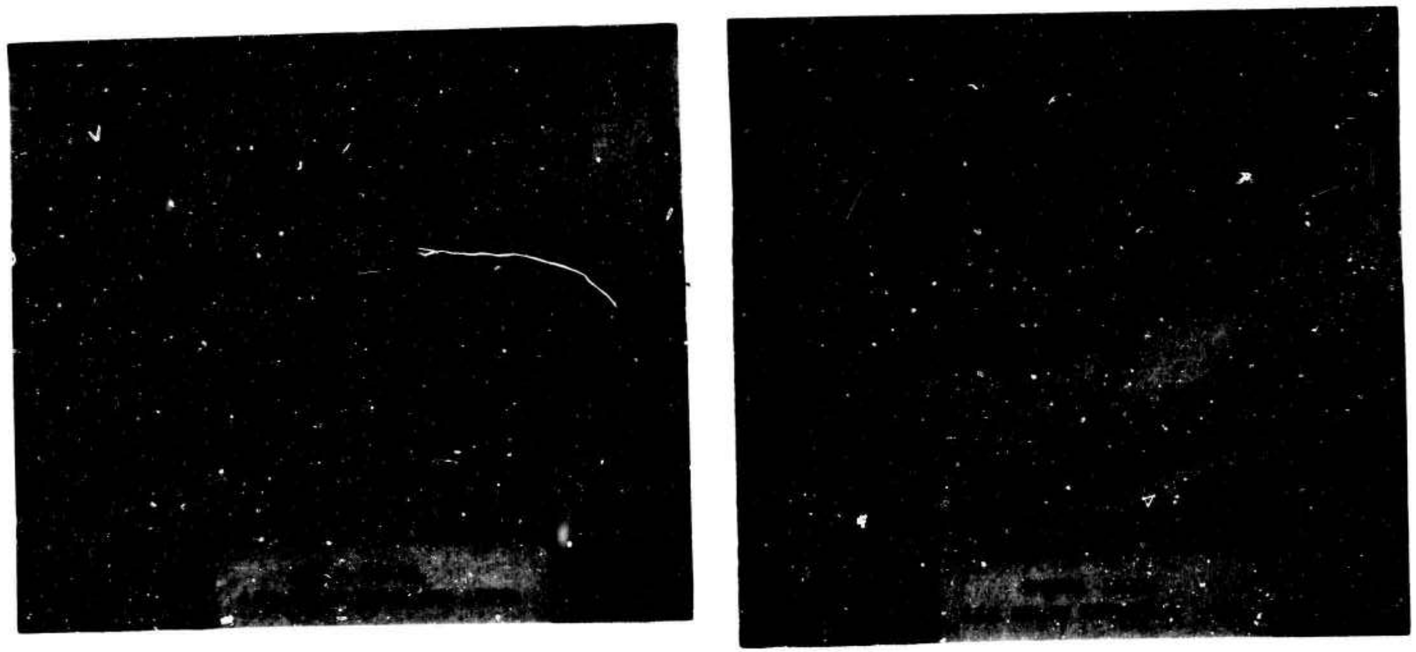

Figure 8. Saturation of the Cloud Areas Resulting From High Signal Level

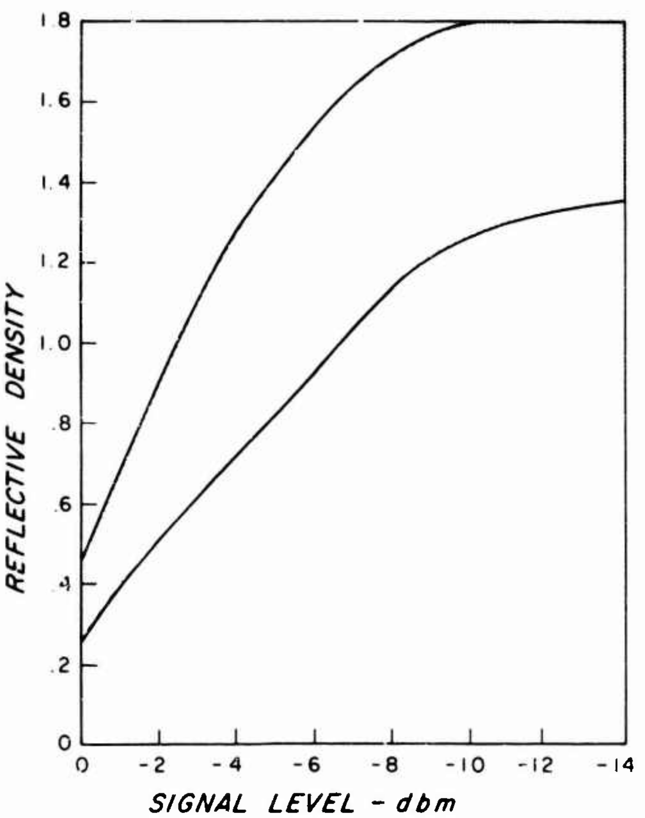

Figure 9. Envelope of Daily Test Patterns for February 1968

A microammeter was inserted in series with the crater tube monitor photodiode to give a quantitative measure of the light output of this light source. This measurement made it possible to separate the variables in the photofacsimile machine operation. The monitoring of the light output of the crater tube may be easily accomplished in those machines not incorporating the crater tube alarm by cementing a silicon solar cell (Tyce SS-12)* on the optical head where it is illuminated by the crater tube.

A form used to record the test data is illustrated in Figure 10. It is well suited for daily use in routine operation when a reflective densitometer is available and the light output can be monitored as described above.

The effect of temperature variation was measured by allowing the room to cool and the recorder temperature to reach equilibrium with the room.

Test data were taken at intervals as the temperatures of the room and the machine were slowly raised. A plot of reflective density vs signal amplitude in dbm is shown in Figure 11. A variation of 40 to 50 percent in reflective density resulted when the interior temperature of the recorder was changed by 16°F. Of even more importance to the satellite meteorologist, the slope of the function shifted and this has more fundamental effect on picture interpretation than a darkening or lightening of the whole picture.

By plotting the input signal against crater current, the effect of the temperature change on the electronics, including gray scale compensation, could be isolated from the contribution of the light source and the photographic process. The results are shown in Figure 12. The data show that the electronics are stable and reproducible over the temperature range tested. The long term variation over a period of 2 months was within the limits imposed by setting the reference level and reading the meter.

*Solar System Division-TYCO, 8241 Kimbal Ave., Skokie, Illinois, 60076.

APT DAILY QUALITY CONTROL

Date: 4-2-68 Time: 1430

dbm	Crater Current	Light output	Reflective density
0	6.4	5.4	.30
-2	7.5	6.1	.40
-4	8.5	6.6	.51
-6	9.4	7.1	.58
-8	10.0	7.6	.66
-10	11.0	8.1	.72
-12	11.8	8.6	.79
-14	12.8	9.2	.86
-16	13.9	9.8	.93
-18	15.1	10.6	1.02
-20	16.5	11.5	1.13
-22	18.2	12.6	1.23
-24	20.0	13.9	1.34
-26	22.1	15.2	1.44
-28	24.6	16.7	1.54
-30	28.0	18.3	1.64
-32	31.5	21.0	1.72
"normal" (black)			

Set white level	40.0
counter reading	234
crater tube no.	11
black start	440
black slope	736
grey start	767
grey slope	557
white start	729
white slope	823
Temperature	75°F

Procedure:

1. Turn on machine, set solution syphon for operation.
2. Set up "Manual," "Process" for 4 cycles to fill solution trays.
3. Set attenuator to 0 dbm, "Manual" mode "standby," select "carrier." Set door meter switches to "door" and "repeat."
4. Select "Set white" and adjust "level control" to read 40 on door meter. Record meter reading to tenths on form above.
5. Select "crater current" and record door meter readings for each 2 dbm increment of signal on form above. Return switch to "set white."
6. Select "Reload," "Start," wait 2 seconds, "Phase" then "Process" to remove fogged paper. Repeat procedure, check that last sheet is white.
7. Place the door switches to "Light output" and "Panel meter."
8. Set attenuator to 0 dbm. Switch to "Start" signal, select "Manual," then "Start," wait 2 seconds, press "Phase" while switching momentarily to "Normal" then to "Carrier." Press "Traverse."
9. Record a test pattern by switching the attenuator in 2 dbm steps from 0 to -32 dbm at approximately 10 second intervals, followed by 10 seconds of "start" and then "Normal" for the remainder of picture. Record the light output meter reading for each signal step
10. Write on back of print, time and date. Read reflective density and record above. Save print.

Figure 10. Form Used to Record Test Data

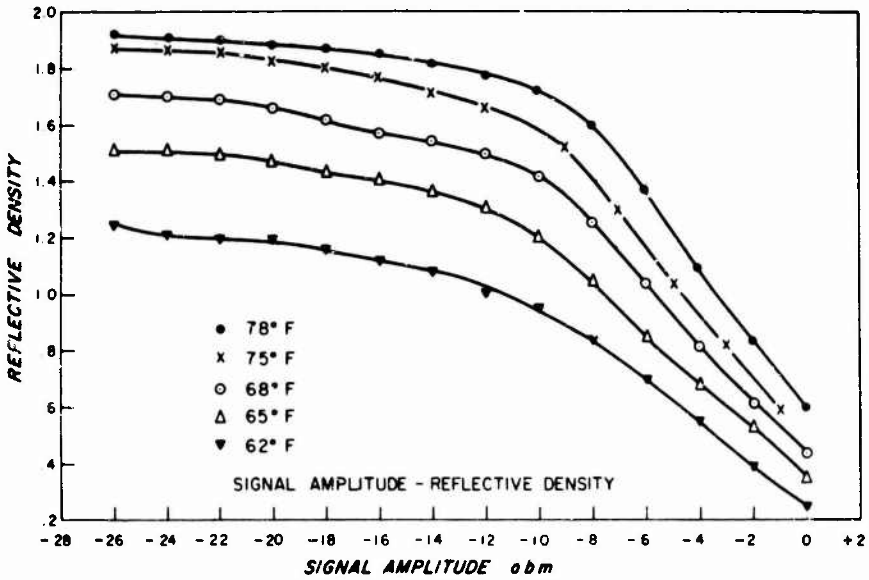

Figure 11. Variation of Reflective Density with Signal Amplitude as Function of Temperature

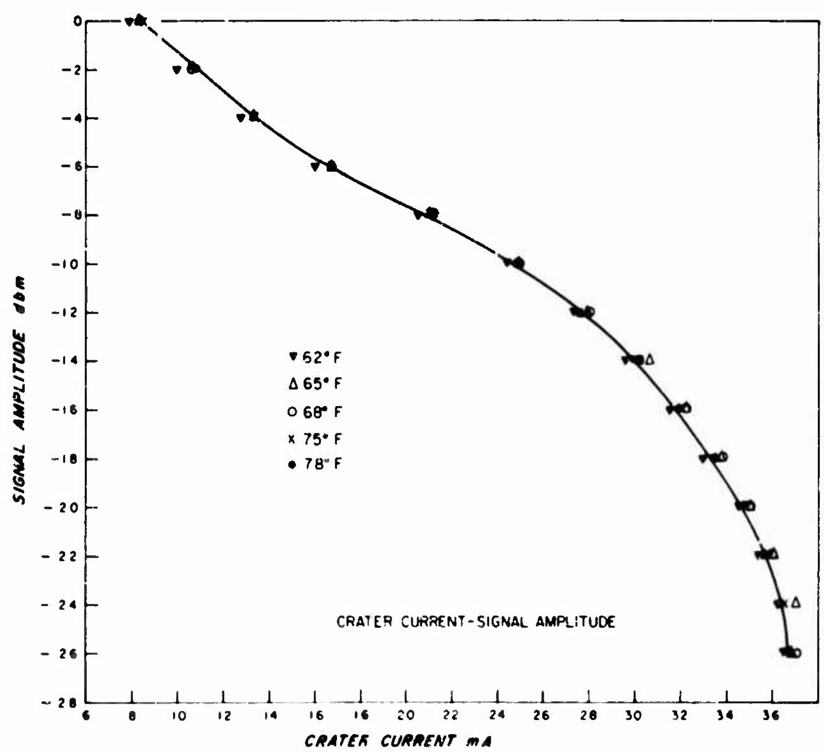

Figure 12. Variation of Crater Tube Current with Signal Amplitude as Function of Temperature

A plot of the light output of the crater tube as measured by the photodiode vs the crater tube current is shown in Figure 13. Some of the variation is a result of the temperature coefficient of the photodiode below 68°F. The light output of the crater tube is essentially independent of temperature.

The relation of light intensity to the reflective density of the image is shown in Figure 14 as a function of processor temperature. Any variability in the electronics, gray scale compensator, and crater tube are eliminated so that the relation shown is the product of the temperature characteristics of the paper, activator, stabilizer, and processor efficiency. The effect of increasing processor temperature in extending the range of reflection density is well known. As the temperature increases, a point is reached at which the blacks get very little blacker and the paper white is lost due to "chemical fog." The complex question of what increments of reflective density the eye and brain can perceive over the range from "white" to "black" will not be brought into this discussion. The research use of APT pictures indicates that a maximum reflective density of 1.4 to 1.6 was adequate for visual interpretation and little could be gained by achieving a "black" of 1.8 to 1.9 reflective density.

Conversations with Ilford, the manufacturer of the paper and chemicals used, indicate that a temperature of 80° to 85°F is permissible and gives the widest range of reflective density. It is obvious that the temperature should be held as constant as possible since even a temperature change of one degree is noticeable in the recorder transfer function when careful semi-quantitative work is being attempted.

Aside from the effects of changing temperature in the recorder, the light output of the crater tube did change as a function of time. This factor was investigated by plotting the light output as a function of crater tube current over a period of several months using a sample of six tubes. The machine was in use 8 hours a day and many hundreds of test patterns were run during this period. The data indicated that tubes initially give a nearly linear light output with respect to crater tube current as shown by the dashed line of Figure 15. As the tube ages, the light intensity will vary.

The light output from a crater tube may vary ± 5 percent from the original light intensity vs crater current curve before deterioration becomes serious.

Spectrograms were taken of two crater tubes. One was a new tube (type XL601F/T) and the other tube No. 6 which had failed after 15.5 hours of continuous operation at 26 mA. Figure 16 shows the spectrograms of these tubes taken with 10 mA of current. In general, the light output decreased over the whole spectrum but the ratios of the amplitudes of peaks varied across the spectrum. A shift of frequency of the peaks occurred which amounted to 3 nanometers. Spectrograms were made with the current in the new tube reduced until the major peak in the new tube matched the major peak in the used tube. The 3-nm shift was still observed. The major peak in the new tube at 10 mA current was matched by increasing the current in the used tube with the same 3-nm frequency shift. The spectra of both tubes were

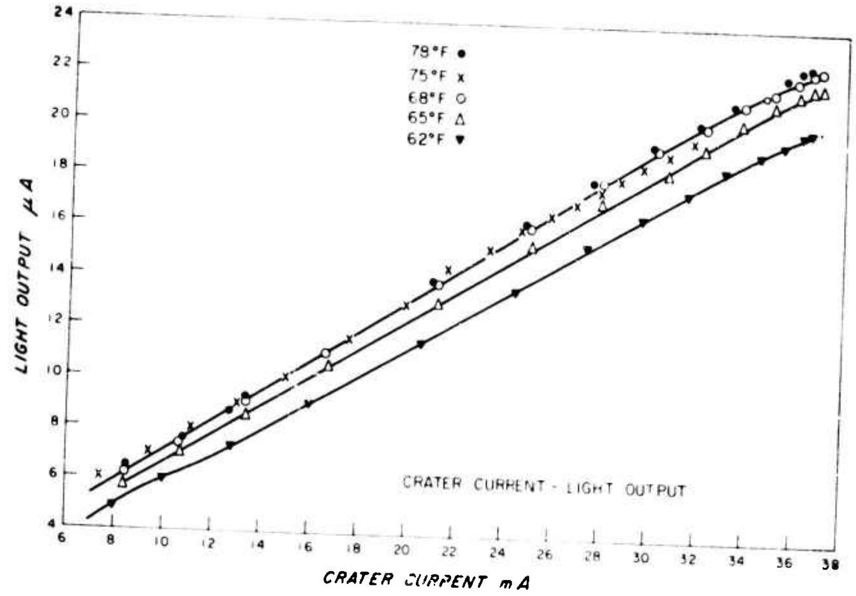

Figure 13. Variation of Light Output with Cr...er Tube Current as Function of Temperature

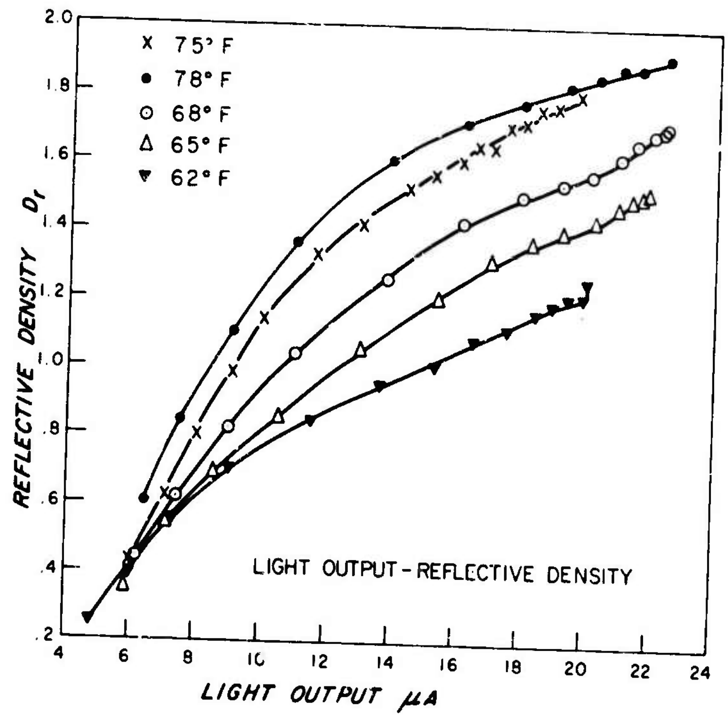

Figure 14. Variation of Light Output to the Reflective Density of the Image as a Function of Processor Temperature

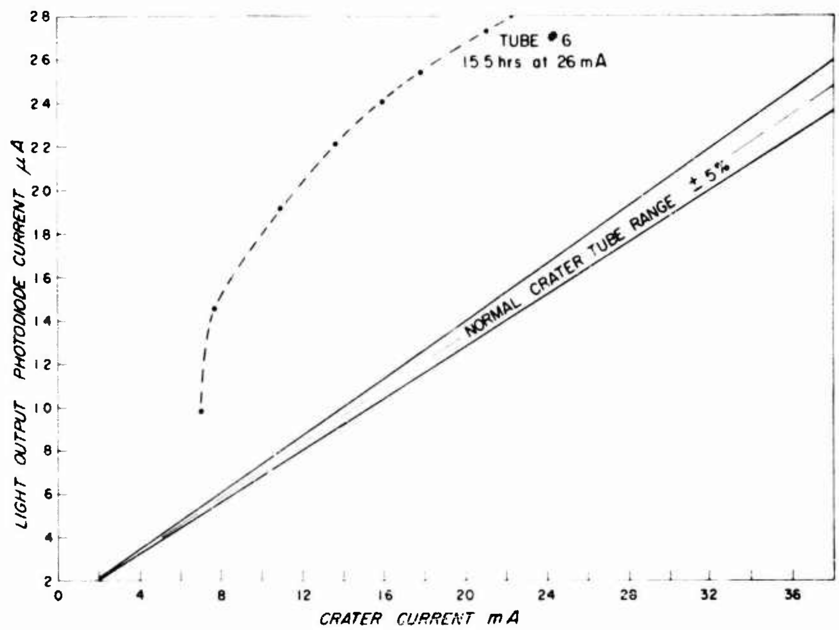

Figure 15. Variation of Crater Current with Light Output

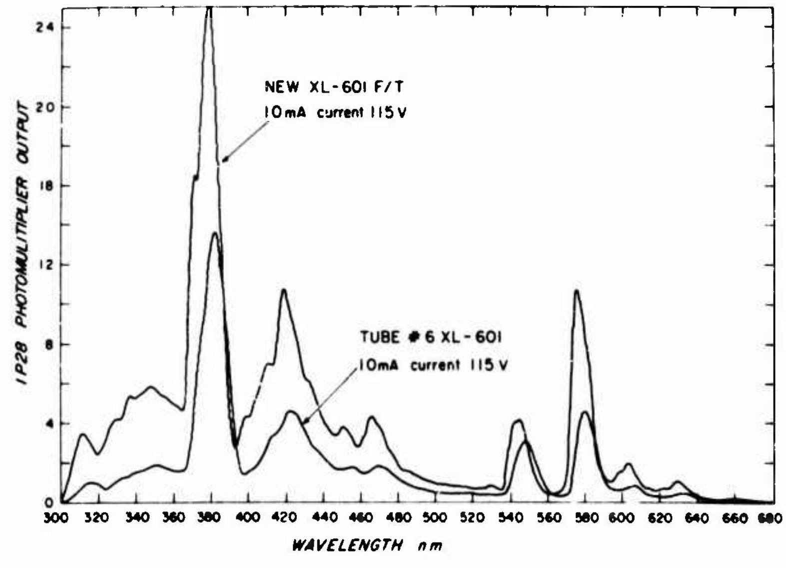

Figure 16. Spectral Response of Two Crater Tubes

unchanged in frequency as the currents were varied. The relative amplitude of the near ultraviolet and the blue were increased more than the other wavelengths by increased current flow, making the crater tube more efficient photographically at higher currents.

Both an increase and a decrease of the photodiode current can occur during the aging process. The photo sensor looks in diagonally at the crater arc and is not in the main beam used to expose the photographic paper. A growing deposit on the glass will initially decrease the light intensity reaching the paper. As the film thickens it reflects light back into the tube where a mica support plate can reflect additional light into the field of the photodiode. An extreme example of this is shown by the dotted line of Figure 15 where the light output was measured after 15.5 hours of continuous operation at 26 mA of a tube which had previously made about 100 pictures. At the end of this time, the highest reflective density that could be achieved was 0.82 although the light intensity seen by the photodiode was about 3 times normal. Table 1 gives the characteristics of the English Electric XL601 crater tube. It should be noted that the maximum peak cathode current is 45 mA with a maximum average current of 30 mA. The average life of 100 hours is obtained at 15 mA current corresponding to a reflective density of about 0.9. One hundred hours of operation corresponds to about 2,000 pictures or about 4 rolls of paper. In practice where the average picture current is larger than 15 mA, a tube will only last about 2 rolls of paper. In very cloudy areas where not much background is visible, the life will be greater since the failure depends on the milliampere-hours accumulated by the tube.

Table 1. Characteristics of the English Electric XL601 Crater Tube*

Maximum Breakdown Voltage	225	V
Maximum Operating Voltage (at 20 mA dc)	150	V
Maximum Average Cathode Current	30	mA
Minimum Average Cathode Current	5.0	mA
Maximum Peak Cathode Current	45	mA
Modulating Frequency Range	15 to 10^6	Hz
Minimum Luminous Intensity (at 30 mA dc)	0.27	candela
Minimum Luminance (at 30 mA dc)	8.52×10^5	nits
	550	candela/sq.in.
Color of Discharge		Blue-Violet
Average Life (at 15 mA dc)	100	hours
Mechanical		
Overall Length	3.060 inches (77.72 mm)	Max
Overall Diameter	1.253 inches (31.83 mm)	Max
Light Source		
Diameter	0.025 inch (0.635 mm)	Nom
Distance from end of bulb	0.312 inch (7.93 mm)	Max
Mounting Position		Any
Base	2 Pin International	Octal

*English Electric Company

Following these investigations, a temperature controlled oil bath was constructed to keep the machine at an internal temperature of 80°F. The stainless steel compartment was filled with a very light turbine oil and a small temperature control unit consisting of heater, thermostat, and stirrer was added. A rack was made with metal cans (BA-259 battery cans) to keep the bottles of chemicals out of contact with the oil.

A calibration pattern using the test form (Figure 10) was made to measure the performance of the recording system as a daily quality control procedure. The gray scale recorded for each 2-dB step of signal was measured with a MacBeth Quantalog RD107 densitometer to determine the reflective density. Adjustments were made to the gray scale compensation to match a standard signal-reflective density curve. Using these quality control procedures, the reflective density could be held to ± 0.10 for a fixed signal over extended periods of time.

Daily plotting from the data recorded on the quality control form of three functions proved to be a valuable aid in showing the existing relationships between the electronics, the light source and the photographic process. As illustrated in Figure 3, the plot of light output against reflective density defines the efficiency of the photographic process. The plot of light output against crater tube current gives a measure of the performance of the light source and the plot of signal in dbm against crater tube current defines the transfer function of the electronic section of the machine.

Master plots of these curves were made and covered with plastic so that the daily curve could be compared with the master and the previous day's data to keep track of the changing performance of the crater tube, the chemicals, paper, and processor so that proper maintenance could be initiated as required.

The recorded tapes from Southeast Asia had various kinds of noise present in the picture. Ignition noise, radio frequency interference, and tape head noise were identified at various times. Considerable improvement in the picture quality was obtained by inserting a band-pass or low-pass filter in the recorder input Figure 17 shows the improvement of the picture when various types of filters are employed. The cutoff frequency of the low-pass filter is not critical and a UTC Type LML 4000 was installed for routine use. This filter is available from Federal Stock as item 5915-810-9028. A band-pass filter as narrow as 2100 to 2500 Hz will pass the start modulation frequency and permit automatic operation of the recorder.

At one installation, insertion of a 10-dB attenuator in the preamplifier output prevented the receiver from overloading and generating nonlinear products in the mixer which were thought to be noise.

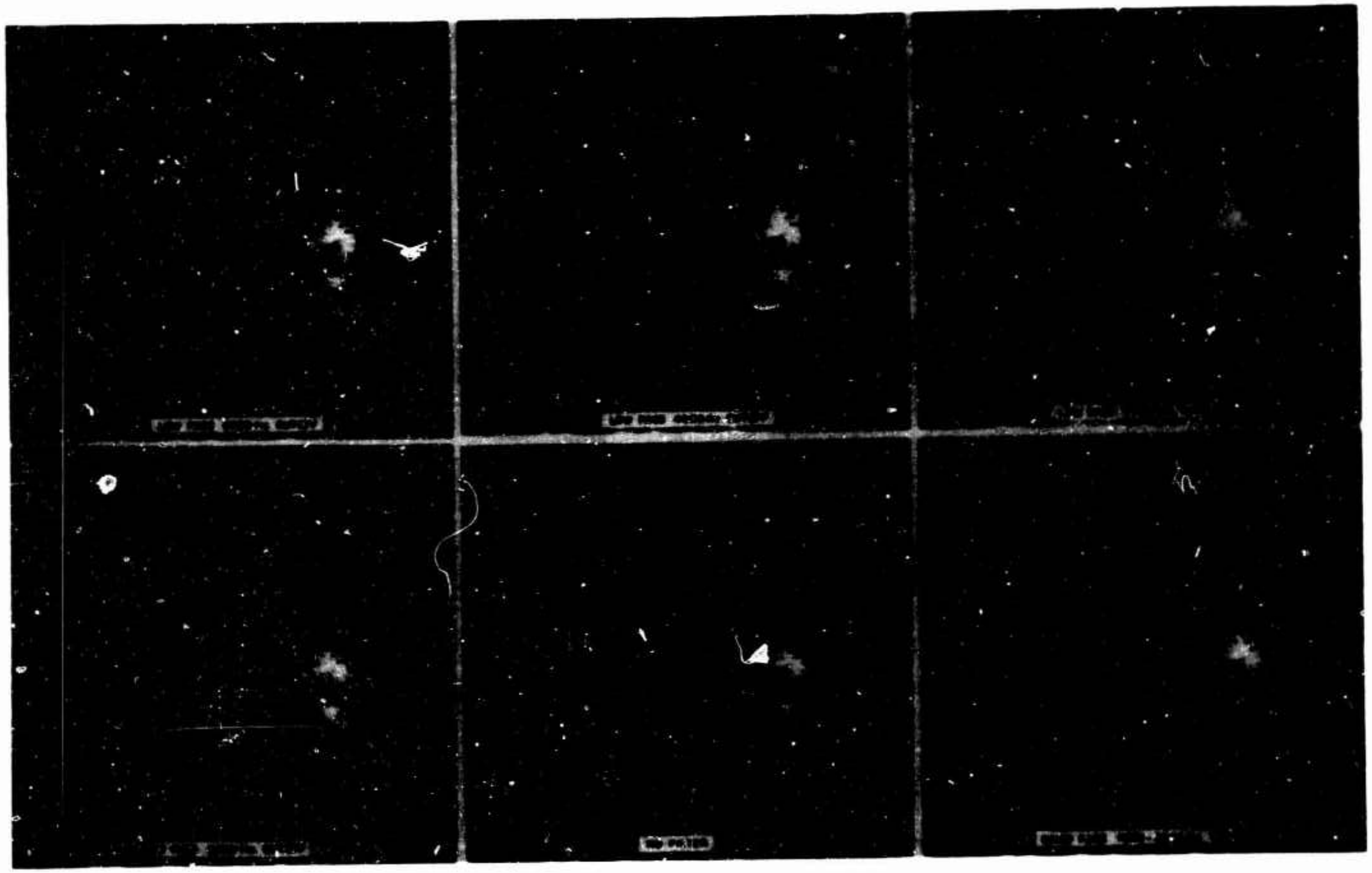

Figure 17. Effect of Input Filters

4. GRAY SCALE OPTIMIZATION

The achievement of a reasonable reproducibility of picture quality made possible use of an optimum gray scale for each satellite. The variation in camera characteristics between satellites generated pictures of widely varying contrast when a single gray scale setting was used in the recorder. Figure 18 illustrates typical gray scale transfer functions for the various data used in the AFCRL research effort. The use of the gray scale was considered optimum when a standard range of reflective density in the recorder was generated by the dynamic range of signals from a particular satellite. The same technique will apply to IR pictures as well. One problem is an adequate determination of the dynamic range of the signal without in-flight calibration of the camera system. As a first approximation, any picture which contains land-sea or sea surfaces free of clouds and an area of extraordinarily dense clouds can be used to derive a dynamic signal range. When the meteorologist knows from the synoptic situation that very bright clouds should be present in the picture area, a pass may be taped and the signal range determined. Such a situation is present off the New England coast in the spring months when a very active cold front moves off shore. The pictures of Figure 8 illustrate such a situation. Here the frontal clouds were bright enough to saturate the NIMBUS II camera. The transfer function from reflective density to signal strength is known from the recorder calibration and it is a simple matter to measure the reflective density of the sea surface and of the brightest cloud. In this fashion, the apparent dynamic ranges of the various satellites were measured in the spring of 1968:

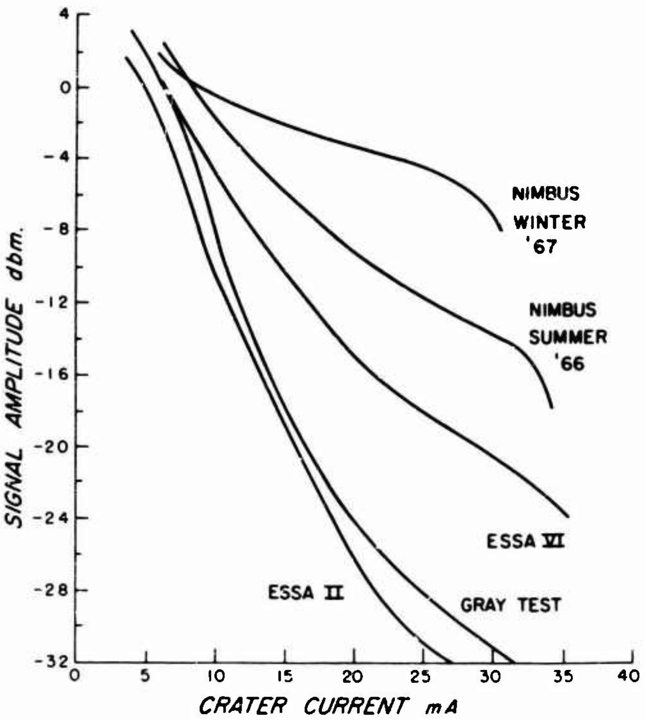

Figure 18. Typical Gray Scale Transfer Functions

ESSA VI	+ 0.5	to	-16	dbm
ESSA II	0	to	-32	dbm
NIMBUS II	+ 1.5	to	- 3.5	dbm

A gray scale setting was optimized for each of these satellites by setting a "black" reflective density of 1.4 and a "white" reflective density of 0.25 corresponding to the upper and lower limits of the dynamic range so that the reflective density is a linear function of signal strength in dbm in this range. Unexposed processed paper has a reflective density of 0.12.

To optimize the gray scale function for a given satellite, ten simple steps are followed:

(1) Put in a signal in steps of 2 dbm as called for in the daily quality control form and measure crater current, light output from the photodiode and reflective density.

(2) Plot reflective density against crater current (Curve P in Figure 19).

(3) Plot signal amplitude against reflective density (Curve A in Figure 19).

(4) Reproduce a taped picture with water surface and extra thick (white) clouds.

(5) Measure with the densitometer the reflective density of the water (D_W). Measure with a densitometer the reflective density of the brightest cloud (D_C).

(6) From Curve A determine dbm for reflective density of water (S_W). From Curve A determine dbm for reflective density of whitest cloud (S_C).

(7) Plot a straight line between S_C value at a reflective density of .25 and the S_W value at a reflective density of 1.40 (Curve L in Figure 8).

(8) Read from Curve L the reflective density for 0, -2, -4 dbm, and so forth.

(9) From Curve P determine the crater current to give the required reflective density for each 2-dbm signal step, from Scale S up to Curve L, over to Curve P and down to Scale C. (Steps 1, 2, 3 in Figure 19).

(10) Set up the gray scale compensator to give the dbm vs crater current scale derived in Step 9.

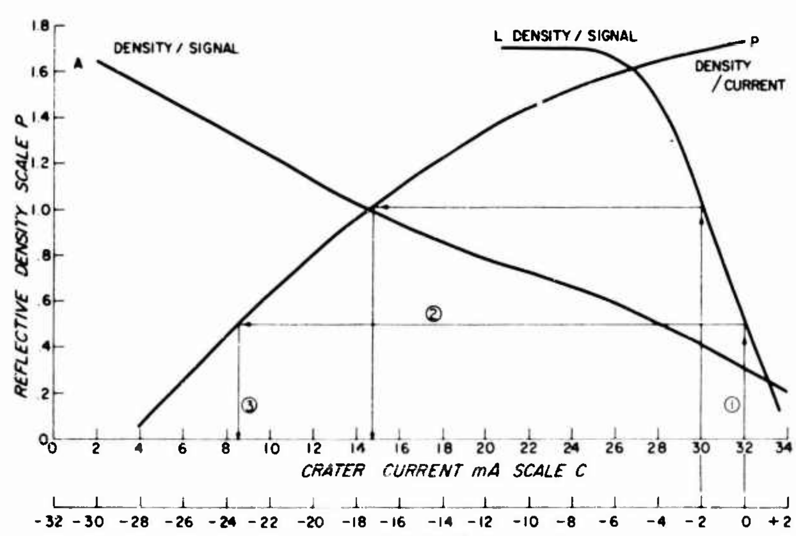

Figure 19. Optimum Use of a Gray Scale Compensator for a Satellite with Reduced Contrast

As the camera systems age, this check on satellite signal dynamic range should be repeated when synoptic situations are favorable or the reflective density of the sea surface has changed without a corresponding change in the recorder characteristics.

5. SUMMARY

Considerable improvement can be achieved in the pictures received from weather satellites by optimizing the use of available range in image density for the actual dynamic signal range of the satellite. By utilizing a picture with extremely thick clouds and with water surface not covered by clouds, the known signal-reflective density relationship set into the recorder can be used to monitor the camera sensitivity changes in the satellite. The signal-crater current relation can then be derived which provides a picture with optimum contrast. A daily routine calibration can improve the efficiency of the maintenance work and ensure a uniform picture quality.

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13. ABSTRACT

The Muirhead K 300A Recorder operation is analyzed and a daily quality control routine is suggested which permits evaluation of the photographic process, the light source, and the electronic function generator separately.

An objective technique for optimizing the image density range for a given weather satellite is presented, using the daily quality control data generated by recording a signal sequence and a densitometer measurement of the reflective density of the image.

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