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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 15 MISSION

TEMPORARY LOSS OF COMMAND MODULE TELEVISION PICTURE

ANOMALY REPORT NO. 4

LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS
MARCH 1973

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TEMPORARY LOSS OF COMMAND MODULE TELEVISION PICTURE

STATEMENT OF ANOMALY

The television picture from the command module color television camera was temporarily lost at the Mission Control Center ground station converter.

SYSTEM DESCRIPTION

The command module color television camera system consisted of a camera, lens, monitor, and two connecting electrical cables (one to connect the camera to the monitor and the other to connect the camera to the spacecraft console). The camera used the field sequential system of color pickup and transmission (as opposed to the standard simultaneous color field presentation). This provided a reliable, compact, low-powered unit which was compatible with the limited space and power availble in the spacecraft; although the simplicity of the camera resulted in a need for more ground station equipment to convert the video to a commercial standard presentation.

The camera consisted of a low-light-level imaging tube, video circuit, color wheel motor circuit, and high-and low-voltage power supplies. The imaging tube was an electron bombardment silicon tube which was highly resistant to burnout.

With normal lighting in the field of view of the television camera image-converter tube, the area of the tube face behind the mask (fig. 1), where the electron beam sweep from left to right begins, is black, and the signal level is zero volts (fig. 2a). As the sweep for each line progresses from under the mask and across the window, the signal varies from black (zero volt) to white saturation (-1.0 volt).

Black level for the signal is set at a 5-volt reference by the clamping circuit (figs. 2b and 2c) with the resulting signal varying from black level (5 volts) to white saturation (4 volts).

The white saturation level is a function of the video tube characteristics. The black level of the output signal is controlled by the black-level clipping circuit (figs. 2b and 2c) that conducts the portion of the signal above the clipping level through the diode to ground. The signal is clipped approximately 5 percent below the clamp level.

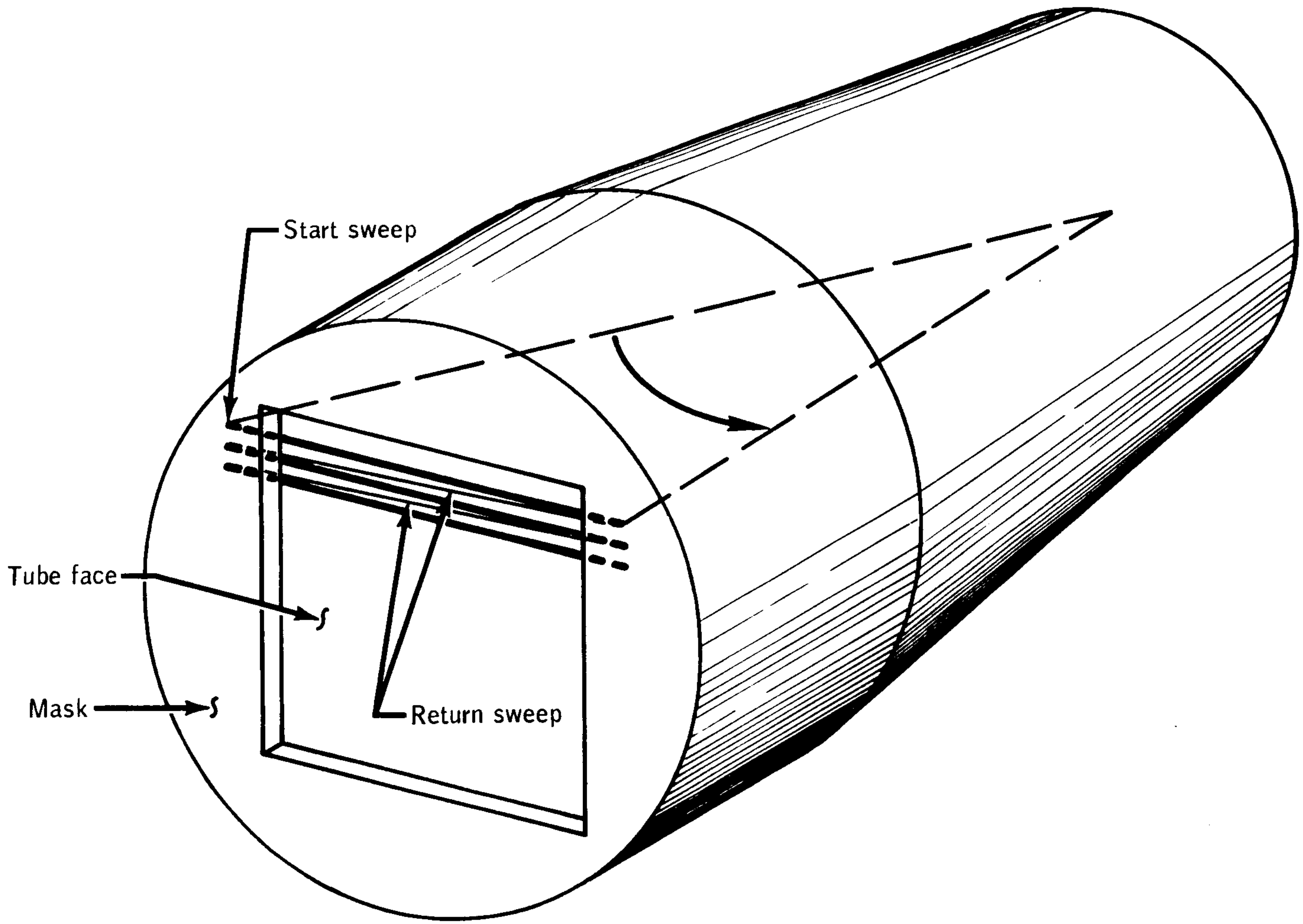

Figure 1.- Video image-converter tube (electron bombardment silicon tube).

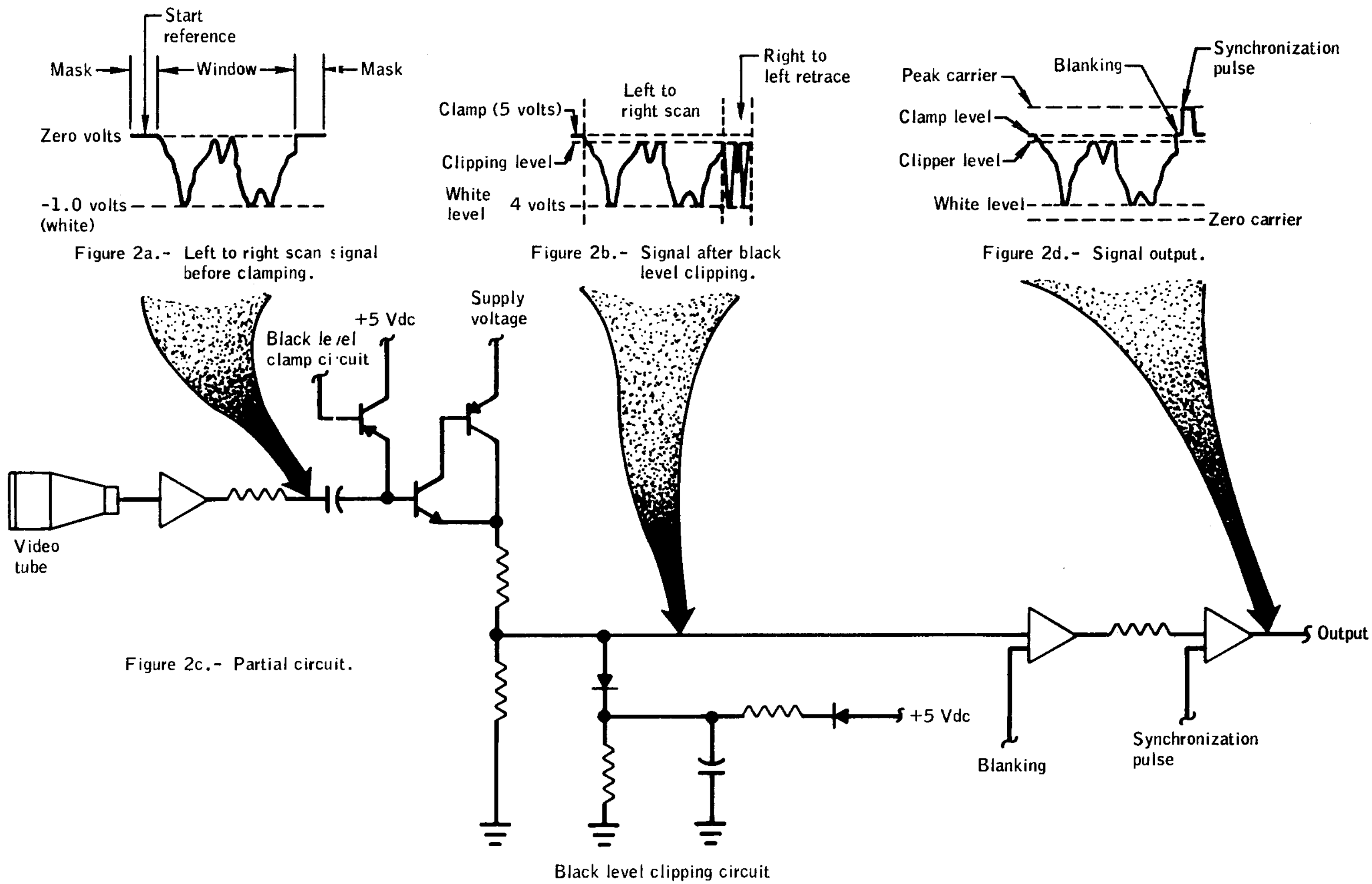

Figure 2a.- Left to right scan signal before clamping.

Figure 2b.- Signal after black level clipping.

Figure 2c.- Partial circuit.

Figure 2d.- Signal output.

Figure 2.- Generation of typical video signal with normal lighting in field of view.

The video signal that results from the fast return sweep from right to left for each scan line (fig. 1) is blanked out at the clamp level when the blanking circuit turns off the amplifier (figs. 2c and 2d), thus forcing the signal output to zero for that period.

The last video amplifier, shown in the partial circuit in figure 2c, adds the synchronization pulse to the video signal during the blanking period (fig. 2d). The synchronization pulse controls the start of the electron beam trace in the ground-receiver picture tube, providing the lock-on pulse for the ground station converter.

DISCUSSION

Investigation and examination of the video picture at the ground station showed that as sunlight came into the field of view, the ground-station converter lost lockup with the video downlink signal, and the picture was lost. When the camera was later pointed away from the sun, the ground-station converter locked up normally, and the picture returned.

Postmission analyses and tests with the flight camera showed that when a high intensity light, like direct sunlight, came into the field of view, the normally black area under the mask on the video tube was effectively illuminated by charge spreading. When the beam crosses this area, a signal is generated that corresponds to the illumination level. This signal is clamped to the black-level voltage. As a result, wherever the image darkened during the ensuing sweep across the tube, the increase in voltage above the starting reference appeared "blacker than black" (above 5 volts) after clamping (figs. 3a and 3b).

The large resulting voltage charged the clipper bias capacitor in the black-level clipping circuit (fig. 3c) and back-biased the clipping diode, preventing it from shorting the excessive signal to ground. As a result, high-amplitude excursions remained in the video signal output (fig. 3d) and were interpreted, by the ground signal converter, as synchronization pulses. The combination of the false synchronization pulses quickly followed by the normal signal synchronization pulse was rejected by the ground station converter and the picture was temporarily lost.

The black-level clipping circuit was modified to eliminate the diode which could be back-biased by a large charge on the bias network capacitor (fig. 4). The transistor which replaces the diode in the modified circuit isolates the bias capacitor so that it is not charged by the improper black level voltage. The transistor then continues to conduct the excess signal to ground, even in the case of high intensity light inputs to the video tube. In extreme cases (direct sunlight) the picture would go blank temporarily, with the modified circuit, but the normal synchronization pulse pattern would continue.

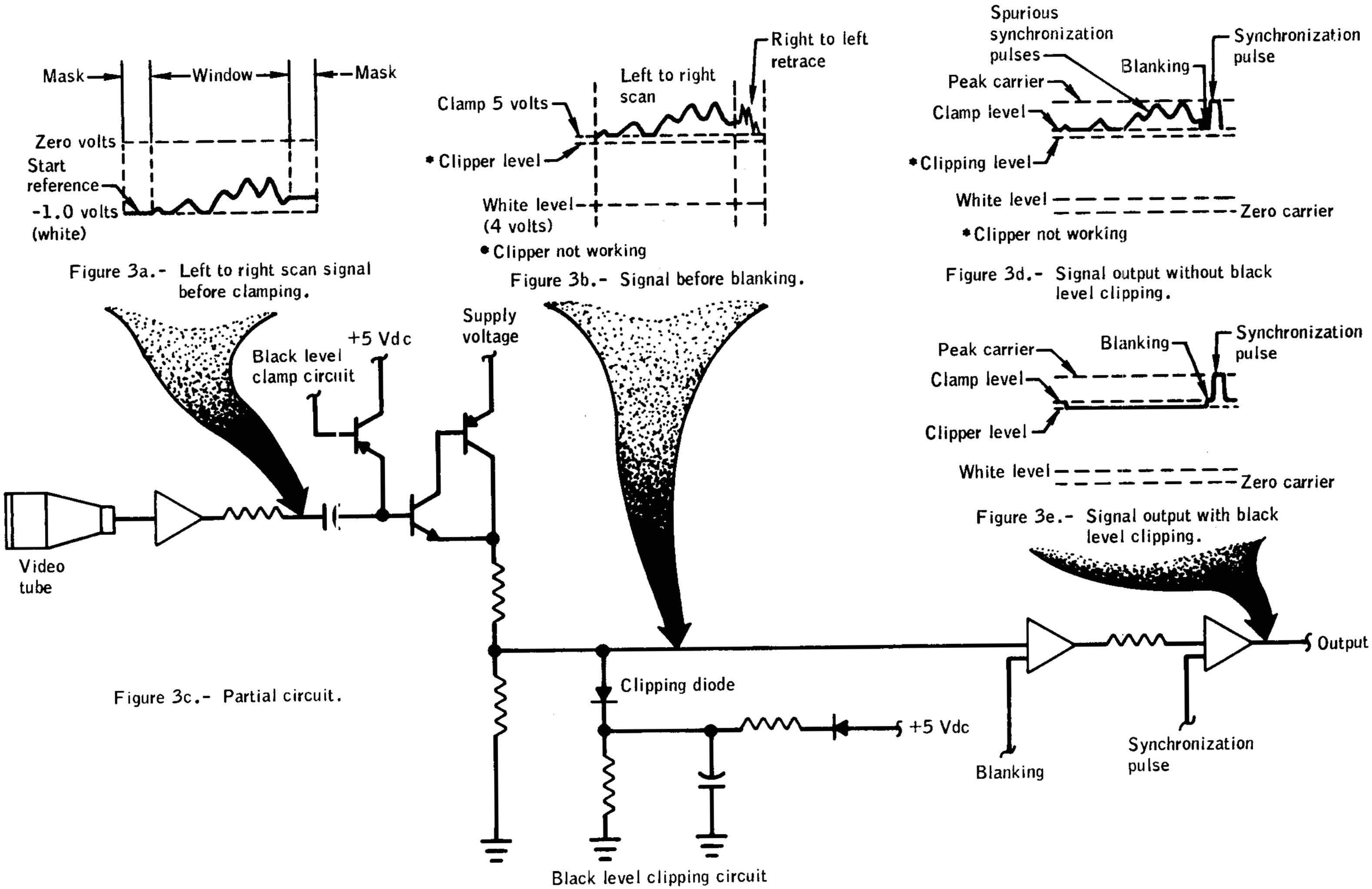

Figure 3a.- Left to right scan signal before clamping.

Figure 3b.- Signal before blanking.

Figure 3c.- Partial circuit.

Figure 3d.- Signal output without black level clipping.

Figure 3e.- Signal output with black level clipping.

Figure 3.- Generation of typical video signal with direct sunlight in the field of view.

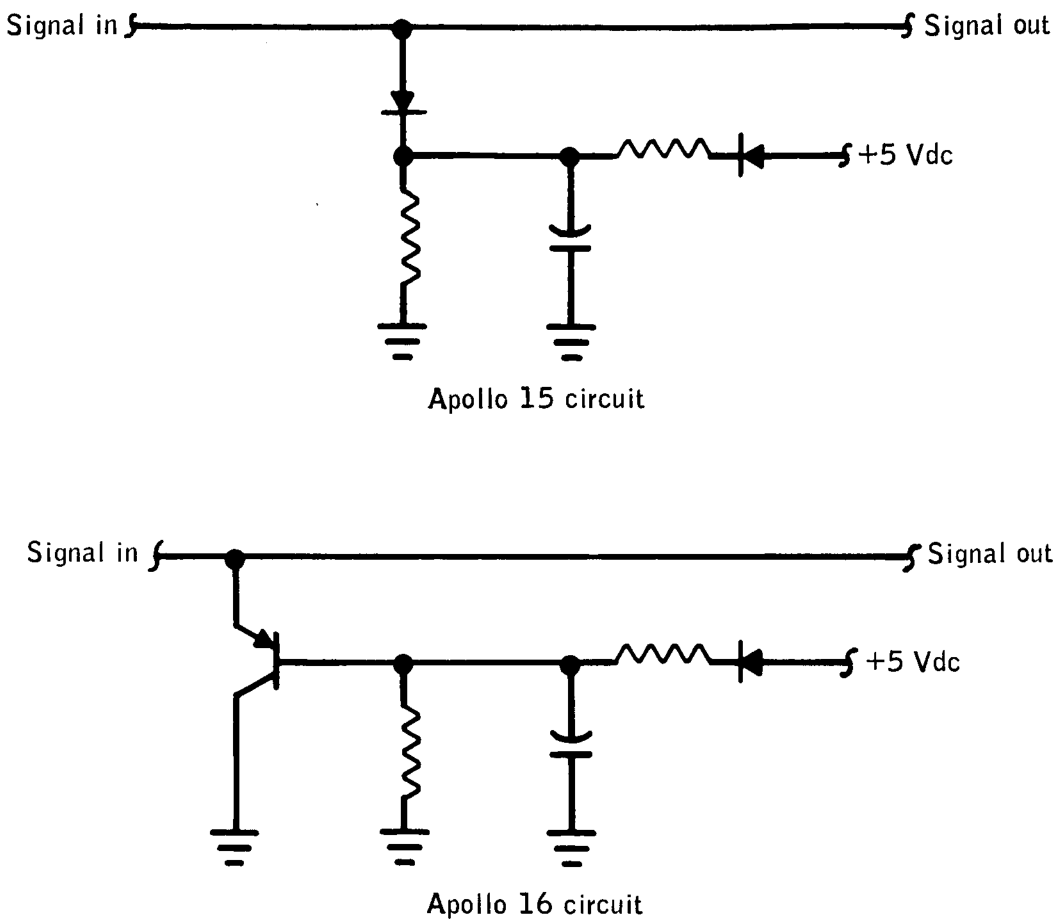

Figure 4.- Black-level clipping circuit modification for Apollo 16.

CONCLUSION

The temporary loss of the picture was caused by a false synchronization pulse that resulted from the inability of the black-level clipping circuit to respond adequately to the video signal when bright sunlight suddenly entered the camera's field of view. The clipper was not designed to operate with direct sunlight in the camera's field of view.

CORRECTIVE ACTION

The black level clipping circuit has been modified and its performance on the Apollo 16 mission was satisfactory.