The Space Congress® Proceedings | 1968 (5th) The Challenge of the 1970's

Apr 1st, 8:00 AM

Operational Television System for Launch Complex 39 at the John F. Kennedy Space Center

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Summary

Launch Complex 39 (LC-39) is located at the National Aeronautics and Space Administration's John F. Kennedy Space Center, Merritt Island, Florida, from where the manned Apollo Space Capsules will be launched. Many new approaches to the launching of space vehicles are incorporated and the extensive use of Closed Circuit Television (CCTV) for the surveillance of pre-launch and launch activities is considered vital in the Apollo/Saturn remotely controlled launch program. The use of closed circuit television has been used to varying degrees throughout the brief history of space vehicle launchings, however it is believed that this system, with its rather specialized requirements, is a major step forward in the constructive use of the powerful medium of television. The system was designed and installed under the supervision to the U. S. Army Corps of Engineers, and every attempt has been made to combine the lessons that have been learned in the TV broadcast, industrial, education, CATV, MATV, and long line transmission fields into a superior television system for use at LC-39.

Discussion

Introduction

This paper describes the LC-39 Operational Television System (OTV) in its role as a functional launch component, with emphasis on those areas considered unique or unusual in closed circuit TV systems. It is felt that many errors have previously been committed in this field of closed circuit TV. By presenting several of these specialized techniques and relating their functions as applied to the LC-39 system it is hoped that the use of television as a practical working instrument will be well established when similar applications are required. To gain insight into the reasoning behind the OTV system approach, a brief functional description of the operations concept of the LC-39 launch site is necessary.

Functions of LC-39

The assembly concept of the Apollo/Saturn spacecraft is such that the vehicle is completely assembled on a Mobile Launcher (ML) platform in the vertical position. The ML consists of a platform, on which the vehicle is assembled and a servicing tower which is permanently mounted on the platform. An elevator and several adjustable work platforms enable easy access to the vehicle during the assembly and servicing operations. The assembly of the vehicle on the ML occurs within the controlled environment of the Vehicle Assembly Building (VAB). This building will allow simultaneous final assembly and checkout of four such vehicles in the High Bay areas. Eight Low Bay areas provide facilities where the vehicle upper stages are assembled and readied for mating to the booster stage in a High Bay.

After the vehicle is assembled and initial checkout completed, the double load (ML and Vehicle) is picked up by a Crawler-transporter and moved along the crawlerway to one of two Launch Pads. (Preliminary plans included a third launch pad. The TV was designed to operate over the resulting 8-mile distance.)

At the Pad, the ML is moved to the launch location and the Mobile Service Structure (MSS) is moved from the park position, by the crawler transporter, to a position adjacent to the vehicle. The MSS is used to perform final installation and servicing of the vehicle and is then returned to the park position prior to launch.

By remote control from a Firing Room, located in the Launch Control Center (LCC), the vehicle is launched from the ML platform. The LCC includes four Firing Rooms, the Complex Control Center (CCC), and other related functional centers.

After the vehicle is launched the ML is returned to an area near the VAB where it is refurbished in preparation for assembly and checkout of another vehicle.

Operational Television Requirements

Many of the areas where activities occur during assembly, test, and launching of the vehicle are inaccessible to personnel because of remoteness or hazardous conditions of certain areas. To solve these problems, closed circuit television was selected to provide real time observation of many complex and precise operations requiring surveillance during critical times of countdown and launch. Television coverage is required during the following launch activities:

1. The assembly of vehicle stages and initial testing in the VAB.

2. General surveillance of the vehicle during transport between the VAB and the launch pad.

3. Monitoring of fueling operations and the surveillance of the fueling areas.

4. Monitoring functions in direct response to actual countdown and launch requirements.

The coverage of these activities has been provided for by the utilization of a television subsystem approach while, at the same time, maintaining very close integration between the individual operational area systems. The resultant OTV system operates in a manner permitting a maximum of flexibility for video switching, mixing, or key video insertion. For this discussion, the OTV system will be considered as being composed of five individual areas.

1. The VAB area is where assembly and initial tests of the Launch vehicle stage interfaces are made. The VAB television coverage areas consist primarily of the high bays and the ML, which during the vehicle assembly is located within the high bay area. To provide flexibility of camera coverage, compatable with the changing work elevations, camera cable trunk lines are routed vertically throughout the work towers and the ML's. Each of these trunk cables contain one or more camera distribution boxes spaced along its length, which allows the television camera to be connected into the cable system at various elevations as required. All camera cable trunk lines terminate in camera patch panels located in the VAB, and various combinations may be readily patched to the camera control units which, for the VAB cameras are permanently located in the LCC-CCR. By using this method of installation the maximum flexibility of camera locations can be obtained. At the same time, set up time has been minimized through the central location of camera control units in a controlled environment where technical and lineup facilities are readily available.

2. The Mobile Service Structure has two locations for normal operations. These are (a) the park position between Pad A and the LCC, from whence general surveillance pictures of the vehicle may be obtained, and (b) the launch pad position where it is placed adjacent to the vehicle to accomplish fueling and servicing of the vehicle prior to the vehicle launch.

The theory of camera locations on the MSS is the same as that for the VAB and the ML, in that camera cable trunks are routed vertically through the structure with camera breakout locations throughout the cable trunks. The trunk lines terminate in the MSS Communication Room.

The MSS system operates as an independent TV system with the sync generators locked to the master sync generator in the LCC. Camera control units, distribution amplifiers and the RF modulators are located on board the structure with full remote control capability at the LCC-CCR. The camera signals leaving the MSS are normally non-composite and are transmitted as single sideband RF Signals in groups of five, frequency multiplexed, so that 15 camera channels may be transmitted to the LCC-CCR on three coaxial cables.

3. The Launch Pads are the areas where the OTV cameras are used most. These areas provide surveillance of the fuel storage areas, multiple point viewing of the launch vehicle from the pad infield locations, and viewing of the vehicle for the orientation of the boresite photographic cameras. The pad is also the operational location for the ML and the MSS during launch activities. While at the pad location the MSS continues to operate as an independent system, however, all other cameras located at the pad are integrated into a subsystem with the camera control units, sync generators, pulse and video generators, modulators, etc., located in the Pad Terminal Connection Room (PTCR). There are approximately 50 cameras active at the launch pad area during prelaunch and launch activities. These are all remotely controlled from the LCC-CCR and normally operate in a noncomposite sync locked condition

with the LCC master sync generator. All camera signals from the pad are transmitted as single sideband RF signals multiplexed into 5-channel groups on coaxial cables.

4. The LCC-CCR area is the central remote control, video processing, and distribution area for the integration of the entire OTV system. The CCU's for the VAB cameras and Firing Room cameras are located in this area; as well as the countdown clock cameras and thier respective CCU's.

The LCC and CCR may be considered as individual subareas from a functional standpoint.

a. The VAB-PC area is where the signal processing for the VAB cameras occurs. This area contains a 12 by 12 video switcher, CCU's for the VAB cameras and FR No 3 surveillance cameras as well as the patching and distribution facilities for Firing Room No 3.

b. The Television Control Centers (TVCC) No 1 and No 2 are similar in operation. Only the operation of TVCC No 1 will be covered in this discussion. The TVCC is therefor the main signal processing, distribution and remote control center for the pad area cameras. The incoming RF camera signals are demodulated, routed through Distribution Amplifiers and Automatic Gain Controlled Amplifiers to the 60 by 100 video switcher, countdown information and sync is inserted and the resultant composite video is distributed to the assigned Firing Room monitors. The TVCC has full remote control capability for controlling up to 80 cameras on a patchable basis, thereby permitting cameras to be reprogrammed as desired. Line up monitoring facilities for 60 cameras and remote control capability for the OTV lighting system associated with the cameras assigned to an operation are provided.

c. The master sync system originates the locking sync signals used by all areas for the proper phasing of the entire television system.

d. The fault alarm system receives fault signals from each remote area indicating and sounding an alarm should the operational status of certain key elements in the system fail.

e. The Firing Rooms are the areas from which all operations associated with the launch program of a vehicle are controlled. The main purpose of the OTV system is to provide pictures, from throughout the launch complex, for the use of the technical operations personnel controlling the launch. Upon command from these controllers the viewing area of each camera is established, either before or during a launch sequence, and camera assignments to the various monitors are determined and switched at the proper moment in the launch countdown. There are four Firing Rooms, three of which are presently operational. The Firing Rooms each have 33 dual 8-inch monitors (66 active pictures), eight 27-inch monitors and five 14-inch monitors for the launch directors.

LC-39 Camera Chain Description

The basic description of a typical camera chain, in normal configuration at the Pad location in the LC-39 OTV system is as follows:

The television camera head assembly consists of an environmental housing, TV camera electronics, pan and tilt assembly, and the OTV lamp assembly. The head is mounted at the launch operational position and connected into the camera cable trunk by a 100-foot service cable to the camera cable trunk breakout connector. The camera cable trunk may be up to 3000 feet long terminating in, or patched to, a CCU where the video is developed and the camera identification number inserted. From the CCU the video signal is routed via distribution amplifiers to the RF single sideband modulator and multiplexed in a passive mixer with four other camera channels to one coaxial cable. This cable plant may be up to 8 miles long with RF wideband repeater amplifiers employed at approximate 1-mile intervals to equalize the frequency gain and restore the transmission losses resulting from the cable plant signal attenuation. At the LCC-CCR termination of the coaxial cable plant the signals are divided by a passive network and demodulated to recover the camera video signal. The video is routed via an AGC amplifier to the TVCC No 1 or No 2 video switchers. At the switcher the video may be routed to any one, or all, video monitor output channels as selected for use by the switcher operator. The output video channels from the switcher are routed to insert amplifiers where countdown clock and sync signals are mixed with the camera video signal. The composite signal is then routed via a patch panel to the firing room where it is used by the launch personnel in the LC-39 launch activity

Unique Features of the LC-39 System

1. Remote Control All cameras, except the countdown clock cameras, may be controlled locally at the CCU in the local operation area or remotely from the LCC-CCR. Remote control of the cameras located at the launch pads or the

MSS is accomplished over telephone cable pairs, eight pair being required for each camera. The control signals are transmitted in composite form and separated by selective filters at the PTCR on the pad or in the MSS communications room. The control signals transmitted are: ± 15 volts dc, 185 Hz or 650 Hz tones at a maximum composite signal level of 0 dbm.

The following camera functions may be simultaneously controlled from the LCC-CCR:

a. Electrical: power on-off, beam manual target, electrical focus, video setup and video gain.

b. Mechanical: camera pan and tilt, lens zoom, focus and iris.

2. Synchronization Under normal conditions all video signals at the LCC-CCR distribution areas are in phase and synchronous. This is accomplished through the use of redundant master sync generators which operate with line-lock reference. These generators originate the master sync signal which is distributed as reference sync to redundant slave sync generators located at each local area. These areas include the LCC-CCR, Pads A and B and the MSS. The distribution of the master sync reference signal to the local areas, some of which are 8 miles distant, is accomplished by using 7/8-inch air dielectric coax cable between the operating areas, with pulse repeater amplifiers spaced at approximate 1-mile intervals. To minimize failures in this portion of the system a redundant transmission system with automatic switchover to the backup loop has been provided.

Delay is interposed from a sync delay unit placed ahead of each slave sync generator at the local areas so that all resulting video signals to the LCC-CCR patch panels are in proper phase and time correctable to within 0.1 microsecond. When the MSS is in the park position a certain delay is added. However, when it is at the pad location no delay is added since, while there, the reference signal is locally generated by the pad slave sync generator, which has already been delayed by the pad sync delay unit.

Provision has been made for an emergency mode of operation in the event of failure of the Master sync generator signal to the local areas. Its use will be limited since the normal mode of operation is highly reliable. However, if the incoming reference sync signal is lost, the local sync generators transfer to line-lock condition and power is applied to the sync distribution amplifiers providing sync insertion in the camera control units; composite operation then occurs in that area. All signals throughout the system then would be transferred to composite mode and countdown clock information insertion would not be performed. Countdown clock insertion is possible, although not provided in the present mode of emergency operation, by genlocking the LCC-CCR slave sync generators to the incoming composite video.

3. Fault Alarm System To provide a means of monitoring equipment failures, or conditions in the remote areas that might affect the performance of the OTV system, a fault alarm system has been provided. This system senses and signals the presence, nature, and area location of failures relating to: room temperature, fire alarm, room humidity, flood level, out of tolerance line voltage, RF cable pressure, RF repeater amplifier, sync repeater amplifier, VHF carrier, master sync generator, and sync line lock.

4. OTV Lighting System To augment the existing lighting and to ensure 24-hour operational capability of the OTV system from a lighting standpoint, an OTV lighting system has been incorporated at the ML, MSS and Pad locations. The lighting system is remotely controlled from the LCC-CCR, either at TVCC No 1 or TVCC No 2. The lights are high intensity, quartz iodide type, mounted in explosion proof housings, which are pressurized with nitrogen. Two lights per camera are normally provided. These are mounted on a saddle arrangement attached to the camera housing in a manner, so the lamp lighting area tracks with the movement of the camera pan and tilt units. Three-position control of the light intensity is provided through the use of silicon controlled rectifiers. The positions are off, low intensity, and high intensity. High intensity provides a minimum of 50 foot candles of incident light throughout the viewing area of each camera. Each lamp pair has 2-wire remote control system. The control voltages used are 0 and ± 48 volts dc.

5. RF Transmission System To facilitate the transmission of high resolution video signals over distances of up to 8 miles, RF single sideband transmission techniques are employed with five separate camera channels multiplexed onto each coaxial cable. The coaxial cable plant installed between the launch pads and the LCC-CCR is 7/8-inch air dielectric coax with characteristic velocity propogation of 90 percent and an attenuation figure of 0.45 db per 100 ft at 100 MHz. The use of this cable permitted the spacing of RF repeater amplifiers at approximately 1-mile intervals. The RF repeater amplifiers are of wide

band design and provide constant loop gain through the RF system by the use of pilot carrier AGC techniques. This technique was necessary since with SSB transmission a steady state signal for sampling would not otherwise be present. The RF repeater amplifiers are designed to minimize the chance of single point failure by operating one half of an amplifier in parallel with the other. If one half fails, the gain of the other is increased automatically resulting in only a slight deterioration of signal to noise. A TRF mode of demodulation is utilized, thus eliminating the use of local oscillators in the demodulators. This has minimized the problems of SSB frequency stability.

6. Camera Identification A positive means for identifying the picture from any one of the approximately 65 cameras located throughout the OTV system, has been provided through assigning each camera, except the countdown clock cameras, a sequential number. These numbers are inserted at the CCU's and appear as white numbers on a black background in the upper left corner of the picture. This is accomplished through the use of flying spot scanner identification units which scan a 2 by 2-inch slide containing the identification number for the associated CCU. These slides are easily changed in the event a camera position is reassigned. The scanning is performed so as to place the resultant image in the upper left portion of the raster, (vertically occupying approximately 20 lines) (size is adjustable). An inverted window ensures that a black background always surrounds the white numbers, providing good contrast. The window is in the same relative position in the raster and mixed with the blanking signal within the CCU. The output of the scanner, with only the white numbers being present, is mixed with the output of the CCU.

7. Video Level Control With such a large number of cameras operating at any one time, every effort has been made to maintain relatively constant video levels. The objective was to keep sudden changes of video levels limited to only the amount permitted by the camera automatic light control action. To accomplish this objective the RF transmission system levels are controlled by the pilot carrier AGC technique, which provides essentially constant gain in the repeater amplifiers and AGC circuitry in the demodulators. An AGC video distribution amplifier is also provided in each camera channel ahead of the video switcher to eliminate long time constant variations in the video levels.

8. Environmental Protection Extreme environmental conditions are encountered in this application of an OTV system. In the LC-39 OTV system, noise levels, vibration, and mechanical shock were specified criteria for all equipment at the pad areas; criteria included survival through noise levels up to 172 db in the areas surrounding the Saturn V booster motors and full operational capability to 143db. Through the use of ruggedized vidicons, shock mounting of the camera chassis, and accoustical lining inside the camera housing the system was able to meet the performance specifications.

9. Operational Standards The EIA RS-170 standards of the television industry were selected for use in this system because minimum modifications to off-the-shelf items would be required. The degree to which procurement actually followed this route was somewhat minimized because of the specialized operational requirements developed for the system. However, the value of the selection has been confirmed by the relative ease with which the broadcast industry was able to use the pictures from the OTV system during the initial Saturn V launch.

Features of LC-39 OTV Equipment

The equipment furnished for the LC-39 OTV system was designed to incorporate the latest state-of-the-art and advances in transistorized, modular construction techniques. Some of the specialized features furnished in specific equipment are as follows:

1. Cameras The OTV cameras are designed for use in an explosive atmosphere in high noise and vibration areas. Special shock mountings and pressurized housings with accoustical lining were used in the cameras. The cameras, complete with Zoomar lense, were qualified by test for operation to 143 db above 0.0002 dynes/cm^2 over the frequency range of 0.0 Hz to 10,000 Hz in accordance with the procedures of MIL-E-5272C (modified for hydrogen atmosphere). The camera and zoom lense are remotely controlled from the CCU or the TVCC's at the LCC-CCR. The camera uses a type 4503 ruggedized vidicon and is capable of 750 lines horizontal and 340 lines vertical resolution with a signal to noise factor of 10 to 1 at 600 line horizontal resolution (peak to peak video to RMS noise) over TV-39 camera cable up to 2,000 feet in length with 20 foot-candles of incident light. The camera design provides for satisfactory pictures transmitted over cable up to 3,000 feet in length with a light level as low as 5 foot-candles. Automatic level control of the camera output signals to less than 1.5 db variation (as a function of impinging target light over a range of 20 to 60,000 foot lamberts) has been provided in the cameras.

2. Camera Control Unit These units are designed to provide pulse delay and video frequency compensation, permitting the use of up to 3, 000 feet of TV-39 camera cable between the CCU and the camera head. The delay and aperture compensation features are adjustable, thereby allowing compensation for changing camera cable lengths, as may occur when a camera is relocated. A remote control adaptor unit is incorporated in the CCU that provides for all operative functions (mechanical and electrical) to be controlled from the CCU, or by remote control from the LCC-CCR. Provision is made for the insertion of a white video identification signal and a black keyed out area in the camera raster where the number is to be inserted. Sync is added at the CCU when a sync signal is present at the sync input connector. However, the pulse distribution amplifiers that feed the sync signal to the CCU's are normally off, and the normal mode of operation provides non-composite video from the CCU.

3. Camera Identification Unit This unit uses a 2-inch cathode ray tube (CRT) in a flying spot scanner configuration. One unit is provided for each CCU where insertion of an identification number is required. The camera identification numbers are provided in the form of 2 by 2-inch transparencies (white numbers on a black background). These slides are inserted between the CRT face and a photomultiplier tube so that the slide may be easily replaced should the camera number be changed. The scanning is performed so as to place the resultant image in the upper left portion of the raster (vertically occupying approximately 20 lines). An inserted window insures that a black background always surrounds the white numbers, providing good contrast. The window is in same relative portion in the raster and mixed with the camera blanking signal within the CCU.

4. Sync Generator Dual sync generators with automatic transfer features are provided at each area. There are three modes of synchronization provided in each generator, these are: ac line lock, gen-lock, or crystal. The system master sync generators normally operate in the line lock mode and furnish reference signals, via two redundant coax cable circuits, to each local slave sync generator at the local operations areas. In the event one master generator fails, the outgoing circuits are transferred automatically to the redundant generator. The local area sync generators normally operate in gen-lock mode. If the primary generator loses gen-lock from the master generator, the output circuits transfer to the redundant slave generator and the primary generator transfers automatically to a line lock condition. Should the redundant generator also lose line lock, the primary generator would not transfer unless it was not functioning properly in the line lock mode. An auxiliary circuit is activated in the line lock mode to automatically turn on the sync adding distribution amplifiers at the camera control units. This results in a composite signal being transmitted from that area. All synchronizing signals generated or distributed in the LC-39 OTV system conform to EIA RS-170 standards.

5. Sync Delay Units These units utilize a lumped constant delay line technique, with pulse regeneration, to provide up to approximately 90 micro seconds total delay in 0. 1 micro second steps. (These units are placed in tandem with each slave sync generator to assure in-phase arrival of all video signals at the LCC-CCR. The sync delay unit in the LCC-CCR incorporates the greatest delay to counteract for the loop delay to launch pad B.) By utilizing the delay line approach, more than 10 nanosecond short term stability and 100 nanosecond long term stability was achieved.

6. VHF Carrier Modulator The modulators operate on one of five assigned frequencies in the 5 MHz to 95 MHz frequency range. The modulating input signal is a one volt, peak to peak, video baseband signal of 30 Hz to 8 MHz bandwidth. The modulator frequency stability is ± 0. 005 percent. The output signal is single sideband (vestigial), ± 50 dbmv as measured across a 75-ohm resistive load. The output bandwidth of the modulator is 8 MHz with 8-MHz input signal. Spurious signals are at least -60 db as referenced to the carrier output level. RMS hum and noise level within the 8-MHz carrier band width is at least 40 db below the RMS video signal level at 75 percent modulation.

7. VHF Repeater Amplifier These assemblies are designed to overcome transmission losses and provide frequency equalization of the RF signals transmitted from Pad A, Pad B, or the MSS park position to the LCC. These units are designed to provide wideband amplification over the bandwidth of 5 MHz to 95 MHz. The gain capability is 39 db for equalization over the pass band to within ± 0. 5 db for up to 6, 500 feet of 7/8-inch air dielectric coaxial cable. The rated minimum output level of the repeater amplifier is +50 dbmv. Automatic level control using a 92-MHz pilot carrier is provided, thus limiting level changes to less than ± 0. 5 db for input pilot carrier variations up to 10 db.

8. VHF Carrier Demodulator The demodulators are of TRF design. The output video level is adjustable from 0. 3 volt to 2. 0 volts peak to

peak for reference 1 volt (white) video input, and flat to within + 0.5 db for modulating frequencies between 30 Hz and 8 MHz. The video output tilt for a demodulated 60 pps square wave input is less than 2 percent, and the maximum delay in rise time is 0.1 microsecond. Spurious hum and noise within the video band width of 0 to 8 MHz is at least 40 db below the peak video level at 75 percent carrier modulation.

9. DA-AGC Amplifiers This is a combination distribution amplifier in tandem with an automatic gain control amplifier. The DA section adds sync to the non-agc input signal and provides composite signals to the lineup waveform monitor and the picture monitor and the composite signal for the offsite patch panel. The AGC section, utilizing relatively slow takeup and release times, of 1 second and 4 seconds respectively, maintains a relatively constant video level. Two such AGC outputs are provided, one is spare, the other is hard-wired to the switcher input. The amplitude frequency response of both the DA and AGC sections of the amplifier is flat + 0.5 db from 30 Hz to 8 MHz. The output level of the AGC amplifier remains constant to + 0.5 db for an input video level of 1 volt, peak to peak, + 6 db. The AGC action is controlled by video signals with frequencies below 1 MHz.

10. TVCC Video Switcher The video switchers are of the distribution type with 60 video inputs and 100 video outputs and not intended for use as programming broadcast units. The TVCC No 1 switcher converts the single ended coax input to a differential mode (cable shield floating), thence differential switching is performed by mechanical crossbar switches. The signal then passes through output amplifiers, which convert the signal back to single ended operation. No keyed clamping occurs in this unit, and either composite or non-composite signals may be switched. "Interrogate In" and "Interrogate Out" functions enable the operator to determine what conditions have already been made in the switcher. A preset technique of operation is employed whereby a complicated switch can be performed by the operation of a single button, selections may be changed without reprogramming other selections, multiple switch programs may be performed and a memory feature retains previously switched functions in the event of power failure to the switcher. At least 50 db of isolation at the sync crossover frequencies has been maintained.

11. Insert Amplifier The keyed insertion of the countdown clock information in all feeds from the switcher, and other direct feeds as selected, is performed by this equipment. Since keyed clamp is incorporated in the performance of this function, blanking reconstitution, and (as a by product, minimum set up) are incorporated in the output of the insert amplifiers. In addition, sync is normally added at the output. The sync add feature is remotely controlled and may be switched off when composite incoming signals are encountered.

A 1-volt level of blanking is used at the inserted signal, which can be varied producing any desired level of inserted information.

A byproduct of the keyed clamp is the essential elimination of any hum or other undesirable low frequency distortion added during the distribution operations. Since this is the last unit the signal passes through before passing to the terminating monitor, it was felt that the regeneration of blanking (removal of low frequency distortion) and the addition of sync should be performed here. This is in addition to the insertion of the countdown clock information.

12. Countdown Clock Cameras These units are separate analog cameras that scan a countdown clock readout, and are adjusted to clip off all black noise, with peak whites reaching the standard video level. Video set up above blanking is not provided. This signal is used as the feed to inputs of the insert amplifiers (one such amplifier is in tandem with each switcher output). The resultant output picture presents countdown clock information with the resultant white numbering adjustable to any level from black through well above normal video level. All such numbers will have the same video level, and will have been regenerated in the insert amplifier.