Record

LB-851

AN INDUSTRIAL TELEVISION SYSTEM

RADIO CORPORATION OF AMERICA

RCA LABORATORIES DIVISION

INDUSTRY SERVICE LABORATORY

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Approved

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Introduction

Ihis bulletin describes a closed-circuit television system for industrial and educational uses. It has been made simple, both mechanically and electrically, with no sacrifice in flexibility. A vidicon type of pickup tube is employed. Focus and alignment functions in the camera are accomplished by permanent magnet structures. A ten-inch monitor picture is presented and means are incorporated for supplying signals to conventional receivers, utilized as remote monitors with no alteration, over a distance of one mile.

The system has been in operation for several months and has proved to be simple in operation and very stable. It will provide a picture of 400-line resolution, comparable in quality to that received from a standard broadcast station.

General Description

This television chain is contained in two units connected by a multi-wire cable. The Vidicon camera contains a minimum of parts for weight reduction and so that in certain dangerous applications it might be considered expendable. The monitor-and-control unit contains all other required equipment including power supplies, deflecting circuits, video amplifier, monitor kinescope and a small r-f generator for driving remote receivers. Pertinent characteristics which are usually of interest in applications of such apparatus are listed below.

Case size (monitor-and-control unit) 12" x 15" x 19" excluding knobs, etc.
Weight of unit 60 lbs. (approximate)

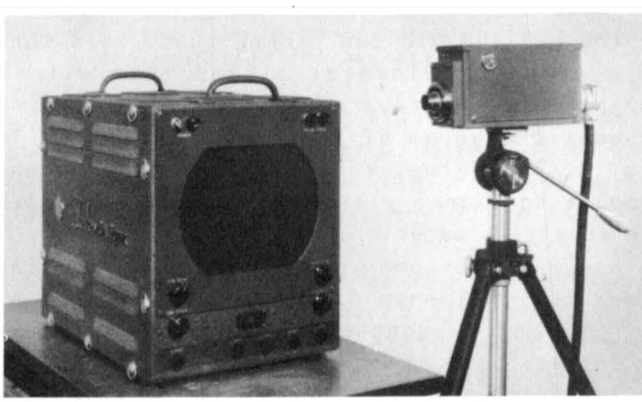


Fig. 1 - Complete industrial television equipment.

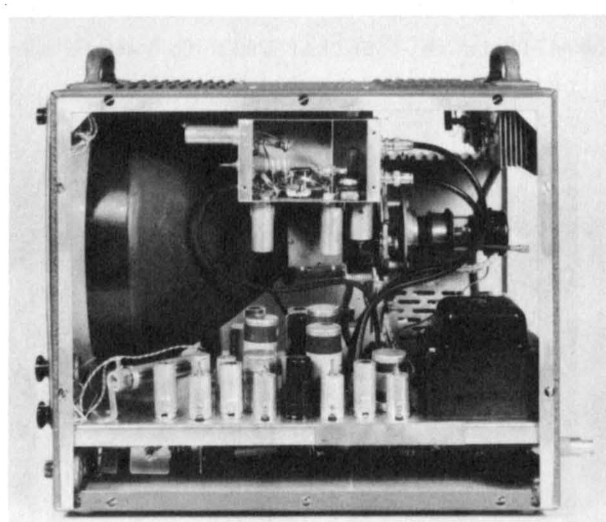


Fig. 2 - Side view of monitor-control unit showing modulated r-f oscillator with cover removed.

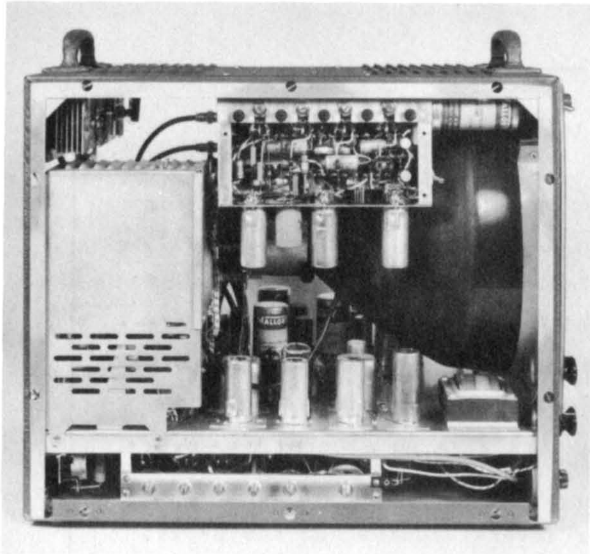


Fig. 3 - Deflection side of monitor-control unit showing synchronizing generator with cover removed.

Number of tubes in monitor unit, 22, (including kinescope)

Number of tubes in camera, 3, (including Vidicon)

Optical focus of camera adjustable remotely.

Power consumption, 200 watts.

Voltage range 105 to 130 volts by means of 3-tap switch.

Camera cable 5/8" diameter, 15 conductors, 3 coaxial.

Maximum length of camera cable 500 ft.

Monitor tube 10BP4A.

Remote monitors may be any unaltered television receivers.

Maximum distance, control unit to remote monitors, approximately 1 mile without booster amplifiers.

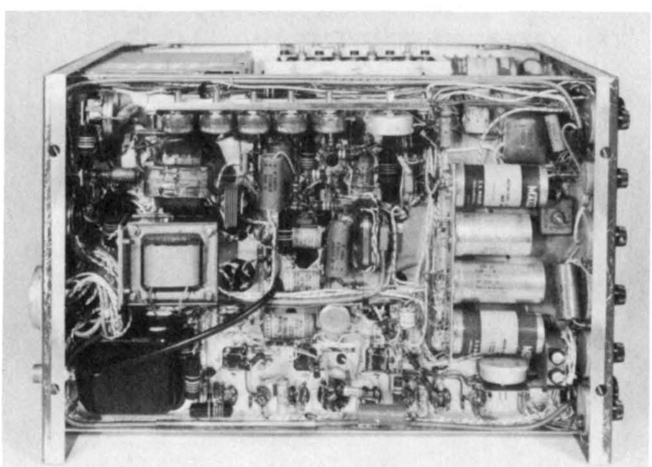


Fig. 4 - Bottom view of monitor-control unit.

Frequency response of amplifiers 5 Mc.

Scanning raster 525 lines, 60 fields interlaced. Provision for locking to 60-cycle power line.

Photographs of the unit are shown in Figs. 1 to 7.

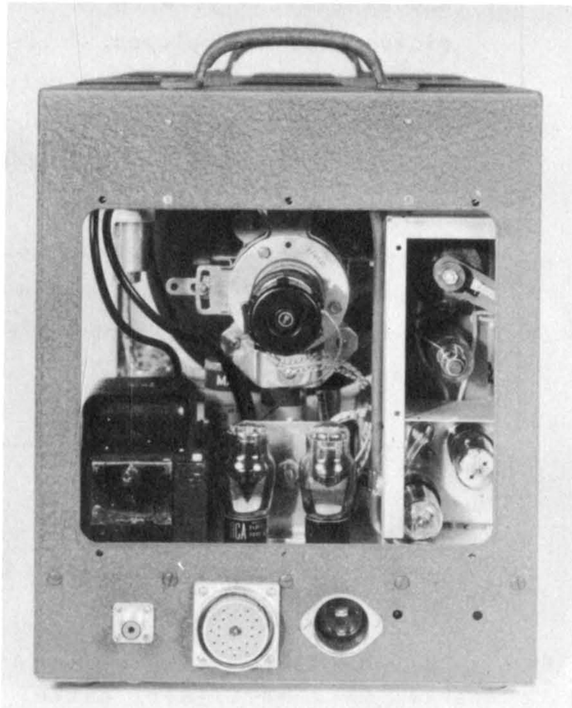


Fig. 5 - Rear view of monitor-control unit.

Electrical Description

The Industrial Television System is based on the C-73162 Vidicon pickup tube. This tube is a one-inch-diameter pickup tube with a photoconductive type of sensitive surface. A schematic diagram of the Vidicon is shown in Fig. 8. The target consists of a transparent conducting signal plate on which is deposited the sensitive material which is an insulator in darkness but becomes more or less conducting under the influence of light. The surface of this target is scanned by an electron beam. In darkness the surface is charged negatively by the beam until it reaches cathode potential and no more electrons can strike it. The con-

'ucting signal plate is made 10 to 30 volts positive with respect to the gun cathode so that a gradient is established through the material. Under the influence of light in the picture the material becomes semiconducting and the surface thus becomes more positive. The beam must then recharge the surface and this recharging current constitutes the video signal. A magnetic field for focus of the beam is set up by four Alnico rods set at the corners of square soft iron pole pieces. Deflection is accomplished by coils surrounding the Vidicon. Adjustment of the magnetic field for alignment purposes is made by adjusting the position of soft iron shunting sleeves on the four Alnico rods. By sliding the sleeves along the magnets the effect of each individual magnet is changed and thus the direction of the field lines in the vicinity of the Vidicon gun can be changed to compensate for slight misalignment of the gun in the magnetic field. Electromagnetic components for focus and alignment as well as a deflection yoke and a horizontal deflection transformer are available and may be purchased with the Vidicon.

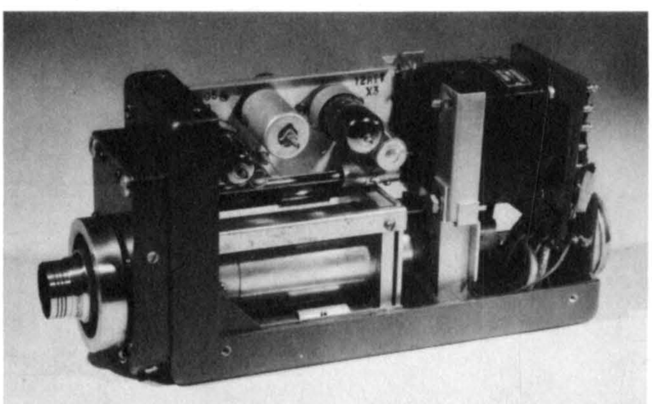


Fig. 6 - Side view of camera showing focus motor, video amplifier and magnetic structure.

A complete schematic diagram of the entire equipment is shown in Fig. 9. Referring to this diagram, the output of the Vidicon V1 is amplified by a high-gain video-amplifier stage V2 which in turn feeds a line driver stage consisting of ½ of a 12AT7 tube V3. The cathode of this tube drives a 50-ohm coaxial line in the cable and is terminated at the monitor end. The other half of V3 is used as a blanking amplifier to cut off the Vidicon beam during flyback periods. V4, V5, V6 and V7 make up the main video amplifier. The gain or contrast control is a 250-ohm potentiometer R17 which is part of the termination on the video cable from the camera. In the coupling circuit be-

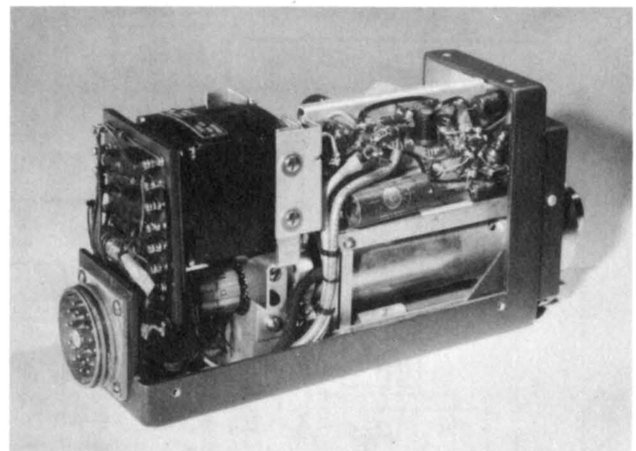


Fig. 7 - Side view of camera showing circuit side of video amplifier and cable terminal board.

tween V5 and V6 is inserted a compensating network consisting of L4, R30, and R31. This circuit has a rising characteristic with frequency and is adjusted to compensate the RC characteristic of the Vidicon capacity and the input resistor R9. A blanking signal is applied to the suppressor of V6 which serves to cut off this tube during scanning return. A crystal diode CR1 sets the d-c level of the grid of V6 in relation to black level represented by the period during which the Vidicon beam is biased off. The blanking signal is allowed to continue through the amplifier to the output where it is used as a synchronizing signal for remote receivers. For this reason the blanking must always exceed black level or be "blacker than black". This blanking level may be adjusted by control R32. Shunt and series crystals CR2 and

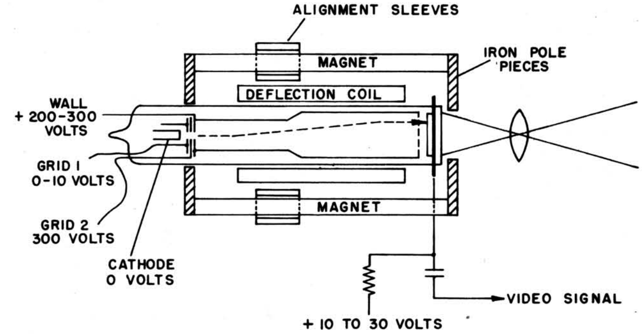
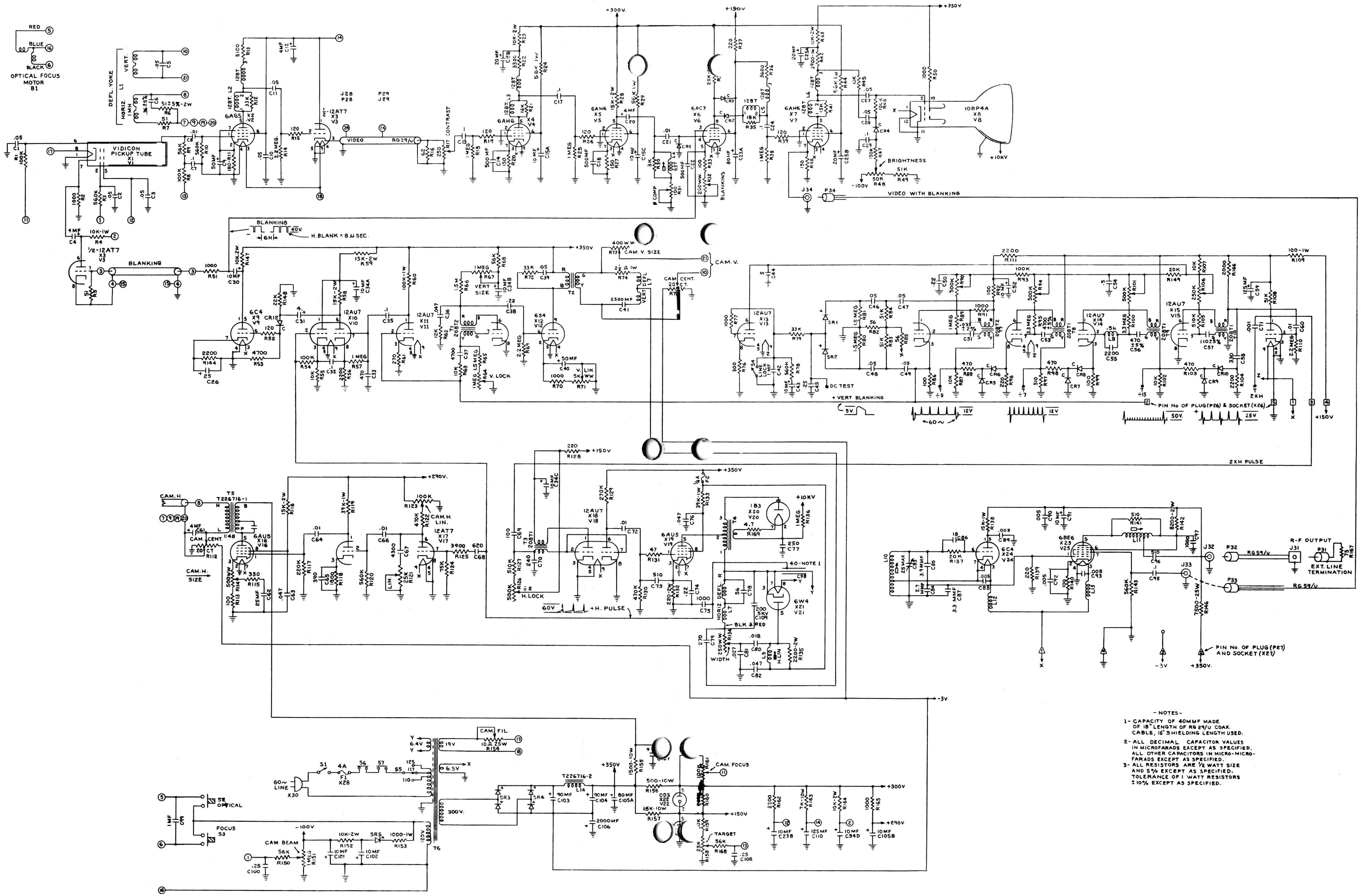


Fig. 8 - Schematic diagram of Vidicon pickup tube.



- NOTES -

1- CAPACITY OF 40MMF MADE OF 18" LENGTH OF RG 29/U COAX. CABLE, 16" SHIELDING LENGTH USED.

2- ALL DECIMAL CAPACITOR VALUES IN MICROFARADS EXCEPT AS SPECIFIED. ALL OTHER CAPACITORS IN MICRO-MICRO-FARADS EXCEPT AS SPECIFIED.

3- ALL RESISTORS ARE 1/2 WATT SIZE AND 5% EXCEPT AS SPECIFIED. TOLERANCE OF 1 WATT RESISTORS ±10% EXCEPT AS SPECIFIED.

Fig. 9 - Schematic of complete industrial television system.

CR3, properly biased, act as blanking clippers. Output from the plate circuit of V7 drives the monitor kinescope V8 while output from the cathode is used to modulate an oscillator for operating remote receivers.

The scanning raster employed is the standard interlaced 525 lines, 60 fields as used in commercial television. This standard raster has been retained primarily in order to provide a signal which could be used to drive unaltered commercial receivers as remote monitors. The necessary frequencies in proper relation are derived from a simplified synchronizing generator made up of V13, V14, and V15. One half of V15 is used in a blocking oscillator circuit to generate a frequency of twice the horizontal line frequency or 31,500 cycles (2H). The other half of this tube is a buffer amplifier supplying 2H pulses to the horizontal deflection circuit. One half of V14 is used as a blocking oscillator frequency divider, dividing the 2H frequency by 15. The other half is a similar blocking oscillator effecting a further division of seven times. One half of V13 likewise divides again by a factor of 5 giving a total division of 525 times to a frequency of 60 cycles. This 60-cycle frequency is compared to the power-line frequency in a phase detector made up of two selenium rectifiers SR1 and SR2. The output of the phase detector is amplified in the second half of V13 and the d-c voltage resulting is applied to the 2H oscillator as an a-f-c voltage to control its frequency. The same d-c control voltage is applied to the grid of the dividing blocking oscillators to adjust their natural period in relation to the a-f-c voltage. This feature greatly increases the stability when the generator is locked to the power line.

2H pulses are applied to one half of V18 in a blocking oscillator circuit which divides by two to give the horizontal frequency. The remaining half of V18, V19, V20 and V21 are connected in a conventional horizontal deflection and high voltage circuit to provide deflection and anode voltage for the monitor kinescope.

A pulse derived from the horizontal output through a capacity divider C98 and C75 is used to drive V17 as a sawtooth generator and amplifier for supplying horizontal deflection to the camera. V16 is operated as a class A amplifier to drive a 50-ohm terminated line through transformer T5. The proper waveform on the grid of V17 is obtained by adjusting sawtooth amplitude by means of control R123 and peaking control R121. The termination for the line is made up as shown in Fig. 10. Under the conditions of $R_1 = R_2 = \sqrt{L/C}$, this circuit is antiresonant at all frequencies and has a terminal impedance equal to $\sqrt{L/C}$. By impressing the proper waveform on the terminals of this network a sawtooth current can be produced through L which is the horizontal deflection coil. The important advantage of this circuit arises from the fact that the driving cable operates into an apparent pure resistive termination hence may be of any length without adjustments.

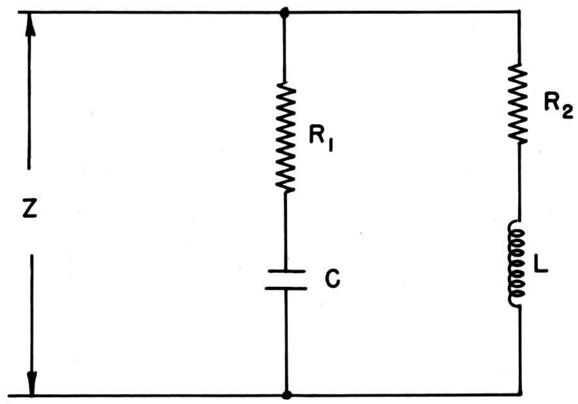


Fig. 10 - Schematic of aperiodic cable termination for horizontal deflection.

A vertical synchronizing and blanking pulse is provided across R86 in the cathode circuit of the 60 cycles half of V13. This pulse is applied to the grid of one half of V11 as an amplifier and also to the grid circuit of the second half of V11 connected as a blocking oscillator. A peaked sawtooth is developed across the network C36, R62 and is applied to the grid of the vertical output tube V12. The vertical output circuit is conventional with the camera vertical coils in series with a variable resistor R73 connected in parallel with the monitor coils.

The vertical pulse from the plate circuit of the amplifier half of V11 is applied to one grid of a mixer stage V10. Horizontal pulses from the circuit driving the camera horizontal deflection are applied to the second grid of the mixer. Mixed horizontal and vertical blanking then appears in the plate circuit. These pulses are amplified and clipped in V9 and applied to the camera cable to provide Vidicon blanking and also to the supressor of V6 to provide amplifier blanking.

In order to operate additional standard receivers as remote monitors a modulated r-f generator is included. This circuit provides a modulated signal which can be fed into the antenna circuit of any receiver. The frequency may be adjusted over channels 3 to 6. It will impress 0.1 volt of r.f. with 80 per cent modulation across a 75-ohm line. The oscillator is a conventional Hartley type using a 6C4 tube V24. A 6BE6 converter tube is used as a modulator, r-f voltage from the oscillator being applied to the first oscillator grid. Video signal from the cathode of the video output stage V7 is applied to the third or control grid. A broadly resonant autotransformer in the plate circuit of this tube is used to drive a terminated line to the receiver. Since the output voltage is high, an attenuator is usually used at the receiver. This is especially important when more than one receiver is used on the same line to provide proper isolation.

The power supply develops two basic d-c voltages, -100 volts and +350 volts. From the +350 volts is derived, by means of voltage regulator tubes, +300 volts and +150 volts. These latter voltages are used to supply the circuits which are critical as to voltage such as video amplifier and synchronizing generator and to supply operating voltage for the Vidicon. Selenium rectifiers are used in both supplies.

Location of Controls

All of the controls normally requiring adjustment are located on the front of the monitor, the four most frequently used being contrast, brightness, camera beam current, and camera focus. The remainder of the camera controls are arranged beneath a snap-on cover along the bottom of the monitor. Optical focus is adjusted by a motor driven lens mount operated by push buttons on the monitor.

Adjusting the Synchronizing Generator

The synchronizing generator is arranged to supply the necessary pulses to produce a 525-line 60-field interlaced picture. Defective operation of the synchronizing generator results in loss of interlacing, vertical jitter of the raster, horizontal bars in the picture, etc. To adjust the generator it is best to first set the 2H frequency to 31,500 cycles by comparing the output of the 2H jack with a signal generator output on an oscilloscope, first making sure the 60-cycle locking switch is in the free or unlocked position. A low capacitance (max. 20 μμf) input lead to the oscilloscope must be used. To adjust the 2H oscillator R106 is varied until the frequency is correct. Next the oscilloscope input is connected to the +15 test jack. The oscilloscope sweep is adjusted to a speed at which at least two complete 2H/15 intervals are visible. The 2H pulses may then be counted and R101 adjusted until fifteen 2H pulses are visible in each of two successive intervals. The input is then transferred to the next test jack (+7) and the sweep readjusted so that at least 2 of the next lower intervals are visible. R94 is set so that seven pulses are visible in each of two successive intervals. The oscilloscope input is then transferred to the next test jack (+5) and the sweep again readjusted to the proper speed to see the lower frequency intervals. R90 is set so that five pulses are visible in each of two successive intervals. With the oscilloscope input still connected to this point, the sweep deflection is connected to 60-cycle sine-wave input from the power line. If all previous adjustments are correct a slow drift of the lowest frequency pulse with respect to the 60-cycle line will be observed. If now the 2H speed control R106 is varied slightly, the drift can be made to be positive, negative, or nearly zero. If the 60-cycle locking switch is now put into the lock position the drift should stop and the generator remain locked tightly to the line frequency. The remaining test jack labelled DC TEST is provided as a check on the output of the phase detector. This voltage when measured with a voltohmyst should be zero plus or minus a few volts.

The usual horizontal and vertical lock controls are provided on the side of the main chassis and are so labeled.

Blanking Adjustment

The plate current in the 6AC7 tube V6 determines the amplitude of theblanking signal. This current is adjusted by R32. Since this signal is also used for synchronizing remote receivers it must be adjusted so that it will always exceed the black signal in the picture. If too great a blanking signal is used, the white portions of the picture will be clipped. This adjustment is best made by observing the signal on the cathode of the output video tube V7 with an oscilloscope. A video signal of approximately maximum amplitude should be present when this adjustment is made.

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