THE DAGE INDUSTRIAL TV CAMERA

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Fig. 1. One application for the Dage camera is the unattended monitoring of a machining operation. Picture can be observed on a standard TV receiver.

Its compact size, well-designed circuit, and the fact that it can be used with an unmodified, standard TV receiver has captured industry-wide attention. Here is data on how it is built and how it can be used.

THE inevitable expansion in use of electronic devices in industry is opening another doorway to opportunity. The new field of industrial or general "closed-circuit" television systems is on the verge of vast national enlargement, comparable only to the billions soon to be circulating in TV broadcast transmitters and receivers. The application of electronic "eyes" provides unlimited extension to the arms of industry, science, research, education, and business. A large share of the responsibility for proper servicing and maintenance of such systems will be charged to the independent television service industry.

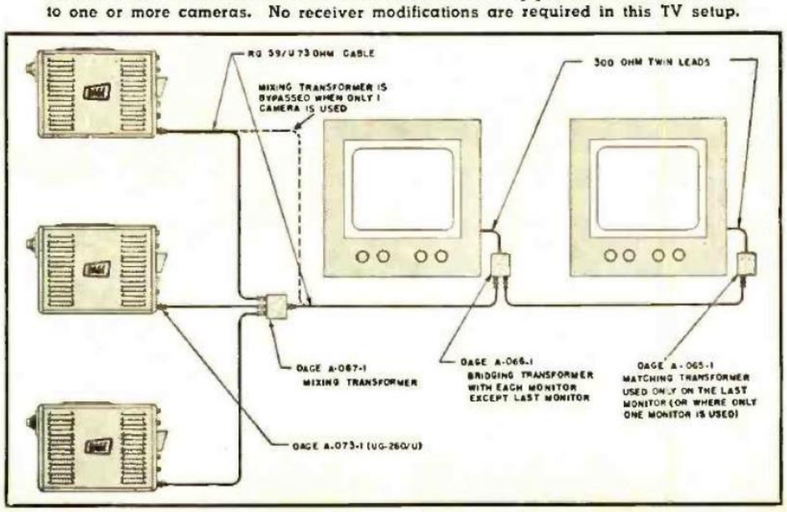
A recent development in this field is already resulting in the national interest needed to spark large scale activity in closed circuit TV systems. This development is the *Dage* ITV Camera (manufactured by *Dage Electronics Corp.*, Beech Grove, Indiana) technically described in this article. The low price and relative simplicity of setup and use are factors contributing to an assured broad utilization.

Fig. 1 shows the *Dage* camera in unattended operation allowing remote observation of functions. In the simplest installation, the a.c. cord is plugged into a 117-volt outlet and a single interconnecting 73-ohm cable is run from the camera output to the antenna terminals of any standard TV receiver. A simple matching transformer is used for 300-ohm input receivers. The picture from the camera is received on one of the television channels (2 through 6) and is selected and tuned in exactly the same way as a standard broadcast station is tuned. Any number of cameras at different locations can be fed into a single receiver, or a number of receivers at different viewing points can be connected to one or more cameras, as shown in Fig. 2. No modification of any kind is necessary in the receiver, making practical the purchase of inexpensive receivers where desirable.

The camera is a completely self-contained transmission system with only 17 tubes including the Vidicon pickup tube, video amplifiers, sync generator, regulated power supply, kinescope camera monitor, and composite modulated r.f. output. The unit is 9⅜" high, 4⅝" wide, 14" in length, and weighs only 18 pounds.

The miniature size of the *Dage* camera is achieved, in part, by use of

Fig. 2. How a number of cameras at different locations can be fed into a single receiver or how a number of receivers at different viewing points can be connected to one or more cameras. No receiver modifications are required in this TV setup.



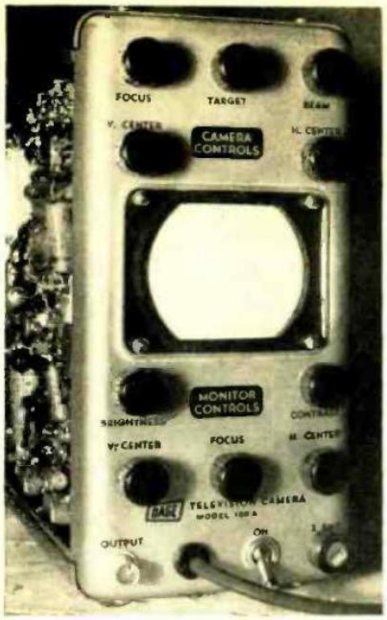


Fig. 3. Rear panel view of the Dage camera showing various camera and monitor controls.

the newly-developed *RCA* Vidicon pickup tube, type 6198. This pickup tube is only 6¼ inches long by 1 inch in diameter. Familiarity with operational characteristics is important to an understanding of camera operation. Since this tube has not been widely publicized in technical details, a very brief review follows of pertinent points. Fig. 4 is an exaggerated "functional" drawing to illustrate basic operation.

The scanning beam is supplied by a conventional electron gun with a 6.3 volt heater used to heat a thermionic cathode placed at ground potential. Four grids are used with the following functions: *Grid #1* (control grid) Picture cut-off value from −45 to −100 volts. *Grid #2* (accelerator grid) Ordinarily operated at a fixed positive voltage in the vicinity of 275 to 300 volts. *Grid #3* (focusing electrode) Current in the external focusing coil provides a uniform magnetic field through which the scanning beam is swept by the deflection coil saw-tooth currents. Grid #3 potential between plus 200 and plus 300 volts provides an electrostatic field in conjunction with the magnetic field to focus the electron beam at the photoconductive target. Current through the external focusing coil is fixed in the *Dage* camera, and grid #3 voltage is made variable to allow optimum electrical focus. *Grid #4* (decelerator electrode) This is a fine mesh screen adjacent to the photoconductive layer and attached to grid #3. This electrode is therefore maintained at the same operating potential as grid 3. The physical configuration provides a uniform field on the beam side of the target so that the beam strikes the photoconductive layer perpendicularly, irrespective of the angle from which approach is made. Decelerating action results from the fact that the signal electrode is operated at a much lower voltage of plus 20 to 30 volts. A low-velocity scanning beam results similar to that in the broadcast type image orthicon; but here the similarity ends.

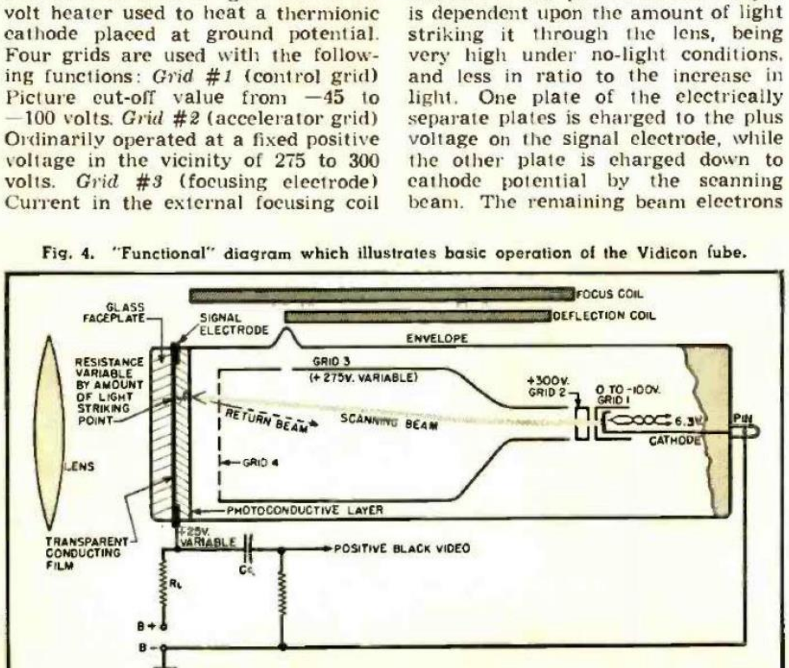
The light-sensitive element may be visualized as being comprised of two separate elements electrically; (1) a transparent conductive film coating on the inner surface of the glass faceplate, and; (2) a thin layer of photoconductive substance on the scanned side. This is obviously highly exaggerated in the drawing. A metal ring around the front end of the tube serves as the signal lead connection, to which the load resistor is connected in series with the "B plus" supply. The scanning beam is in series with the complete signal circuit. The resistance of the photoconductive layer is dependent upon the amount of light striking it through the lens, being very high under no-light conditions, and less in ratio to the increase in light. One plate of the electrically separate plates is charged to the plus voltage on the signal electrode, while the other plate is charged down to cathode potential by the scanning beam. The remaining beam electrons are turned back in the form of a return beam under the influence of the positive grids, but is not used in the Vidicon.

Under no-light conditions when the photoconductive element exhibits the characteristics of an insulator, very little current flows through the complete signal path. What little current does flow is termed the "dark current" which is a limiting factor in maximum signal electrode voltage. When light reaches the tube, the transparent conducting film on the inner surface of the glass faceplate begins conduction by an amount dependent upon the light intensity at that particular point, causing the corresponding point on the gun side to rise slightly toward the plus potential of the target supply. Thus the beam current increases at the points of the positive potential pattern created on the gun side of the target in accordance with the light distribution in the focused image. It is noted that the signal current through the load resistor increases for light portions and decreases for dark portions of the image, resulting in a positive black signal at the grid of the first preamplifier tube.

The scanning area of the Vidicon is only ½" wide by ⅜" in height. A 3" lens therefore is a "telephoto" type lens for a Vidicon tube, covering a field of 10 by 13.3 feet at a distance of 80 feet. A 1" lens is the general purpose type and a ½" lens is used for "wide angle" applications.

The spectral response under incandescent lighting is approximately the same as the human eye. Response may also be obtained in the infrared and ultraviolet regions. Only 50 to 100 foot-candles of incident illumination is required with a ½" or 1" lens (*f*1.5), and a readable picture can be obtained from the *Dage* camera with 10 foot-candles of light.

Fig. 4. "Functional" diagram which illustrates basic operation of the Vidicon tube.



Camera and Monitor Controls

External controls for the camera and built-in monitor are shown in Fig. 3. Fig. 5 shows the interior layout. The monitor uses a 3" kinescope (3RP1) with P1 phosphor. This serves as an excellent "range finder" for lens and camera adjustments where the monitoring receivers may be out of visual range of the camera setup.

The group of "Camera Controls" perform the following functions:

Focus—Varies voltage on grid 3 (focusing grid) of Vidicon. (See block diagram, Fig. 6). In practice the lens focusing collar is adjusted for proper distance to obtain sharp optical focus, then the "Focus" control is adjusted for maximum resolution of picture detail. A resolving power of 350 lines is possible in this camera.

Target—Adjusts voltage on photoconductive target of Vidicon. See Fig. 6. Variation of this control affects the quality of the picture in relation to amount of light on the transmitted scene. For a given operating voltage the sensitivity and dark current both tend to gradually change throughout the life of the tube, making mandatory an adjustable voltage to compensate for these changes. Under low light level conditions, the control may be operated toward full clockwise position (maximum voltage) for increased sensitivity. There is, however, a limiting value of target voltage beyond which the non-uniformity of the dark-current background in the picture reaches intolerable proportions. With sufficient light, the picture is improved by reducing the "Target" control setting.

Beam—Adjusts the negative potential of grid 1 (control grid) in the Vidicon. At a fully counterclockwise position (maximum negative voltage) the beam is cut off and no picture appears. As the control is adjusted clockwise, fixing amount of beam current by decreasing negative grid potential, the picture is observed to "wipe clean" with the brightest areas coming in last. The low-lights or dark portions of the scene appear first since the beam is sufficient to resolve the darker (less positive) areas, but insufficient to discharge the brighter portions (more positive) areas. The "Beam" control is left just clockwise of the point where there is enough beam current to resolve all highlights, since further rotation causes loss of resolution by the well-known spreading of an electron beam with too much beam current.

V. Center—A control in the camera vertical output stage V_{10B} which adjusts the magnitude of d.c. in the vertical deflection coil of the Vidicon. This centers the sweep vertically.

H. Center—A control in the camera horizontal output stage V_{12} which adjusts the amount of d.c. in the horizontal deflection coil for the Vidicon. This centers the sweep horizontally.

The camera "Monitor Controls" are self-explanatory with the exception of the "Contrast" control. This control is actually in the cathode of the second video amplifier stage (V_3) and determines the gain of the video amplifier. As such, it affects the contrast of the picture on the viewing receivers as well as the camera monitor. The gain is variable over a range of approximately 10 db. It is often found desirable in practice to set this control about ¼ to ½ open, and vary the contrast over a fine range by the "Target" control described previously. The "Contrast" control, however, provides a more flexible adjustment for meeting the requirements of different viewing receivers.

Video Amplifiers

As indicated in Fig. 6, four 6CB6 video amplifier stages are employed. Essentially uniform response to over 4 mc. is achieved by the use of combination series-shunt peaking circuits in all stages except the "high-peaker" stage V_3. Input stages between the pickup tube and first video amplifier are notably lacking in high-frequency response due to the inherently large shunt capacitances of such circuits. It is the purpose of the "high-peaker," V_3, in the *Dage* camera to compensate for this deficiency by a deliberate boosting of the high-end of the response curve in this stage. This is accomplished by using a very low value of plate load resistor (120 ohms) in series with an inductance. This arrangement provides an essentially inductive load at the higher frequencies in the desi d passband, resulting in the necessa y high-frequency boost for a flat ov r-all response curve.

The "Con ast" control mentioned before is a ..00 ohm variable potentiometer in the cathode of this stage, allowing a 10 db variation of stage gain. This control may actually be left in the minimum gain position and still provide sufficient contrast in most applications, with judicious setting of "Target" and "Beam" controls.

As noted from Fig. 6, the Vidicon grid #2 (accelerator grid) pin 5, is operated at a fixed plus potential of approximately 275 volts from the low voltage filter supply. The "Focus" control R_3, resistor R_2 and "Target" control R_1 form a voltage divider from pin 5 to ground. This provides the proper range of voltage adjustments for "Focus" and "Target" electrodes. The signal current variations through coupling resistor R_7 provide the signal voltage for the following first video amplifier stage through coupling con-

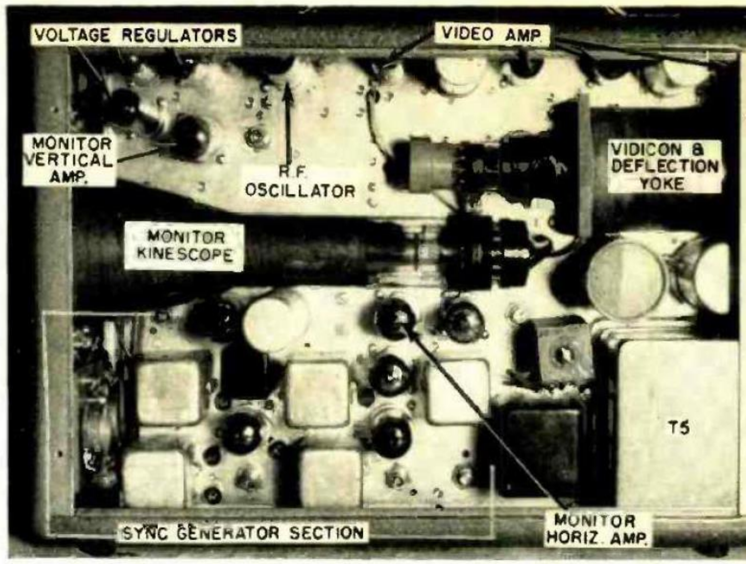


Fig. 5. Internal view of camera showing layout of chassis on the tube side of unit.

Fig. 6. Block diagram of the camera. An RCA type 6198 Vidicon pickup tube is employed.

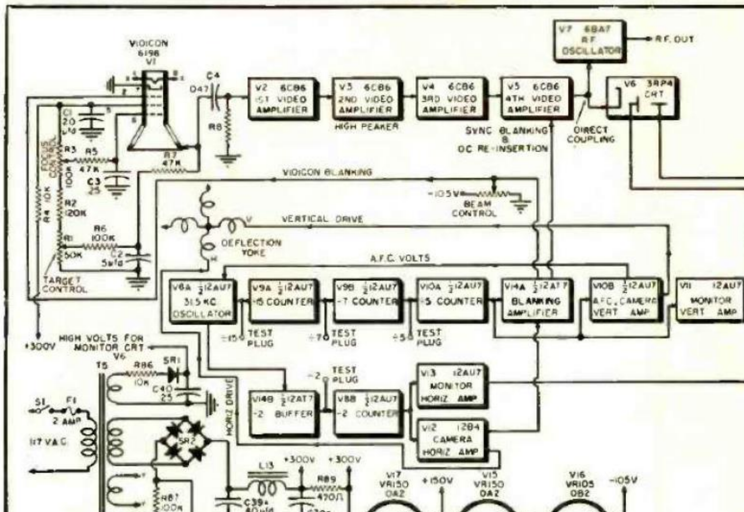


Fig. 7. "Divided by 2" counter pulses on scope when connected to "Test Plug ÷ 2." Every second pulse triggers ÷ 2 oscillator.

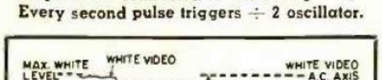


Fig. 8. The sync blanking and d.c. insertion circuit used in the Dage TV camera.

denser C_1. Condensers C_1, C_2, and C_3 provide adequate bypass of hum and stray field pickup and isolation from the common impedance of the power supply.

Blanking and Insertion

An important factor in the excellent results obtainable from this TV system is the simplified but effective method of injecting the sync-blanking pulses and re-inserting the d.c. component. The importance of proper d.c. insertion is emphasized by the fact that small shifts in black level have a noticeably adverse effect on dark tone rendition in the image. Sync-blanking insertion and d.c. re-insertion are combined in this camera by the use of two germanium crystal diodes in the circuit illustrated in Fig. 8. CR_8 serves to inject sync-blanking pulses and CR_7 inserts the d.c. component necessary to hold the blanking at a predetermined level irrespective of whether the video signal is in white or black regions at the moment of injection.

The picture signal is black negative polarity at the output of V_4, coupled to the grid of V_5 through C_{11} and grid return R_{25}. This return is made to a negative potential of 105 volts. During the active line scan (no sync-blanking pulses received) the V_5 grid is biased through R_{25}. At the end of each line, large negative sync-blanking pulses at 15,750 pps are injected at the junction of R_{26}-R_{27}. At the end of each field, the longer duration 60 pps sync-blanking pulses are injected. During these large negative excursions, CR_8 is driven into conduction inserting the pulses on the video signal.

Insofar as these control pulses are concerned, CR_8 and CR_7 are in series. The larger negative potential existing on the grid during the pulse injection drives CR_7 into conduction at the same instant. Thus the sync-blanking is continually referred to a constant bias reference, and the equilibrium charge on coupling condenser C_{11} appears as d.c. across diode CR_7 which holds the grid of V_5 at a constant level compared to blanking pulse amplitude. To this d.c. component is added the video a.c. component and constant background brightness relative to scenic content is restored. The direction of bias change is such that it compensates for the shift in the composite video waveform, as illustrated at the top of Fig. 8.

R.F. Oscillator Output

The composite, d.c. stabilized output of V_5 is black positive and is conductively coupled to the r.f. oscillator V_7 to retain the d.c. component. This stage is a miniature 6BA7 pentagrid converter used in a modified Hartley oscillator circuit to supply a double-sideband, amplitude-modulated video signal. It is tuned to any of the standard TV channels (2 through 6) by means of a slug adjustment in the Hartley coil, and provides a highly stabilized output.

Although the plate of V_5 is conductively coupled to the third grid of the oscillator V_7, this grid is returned to a point of negative potential and the effective voltage is about plus 5 volts. Grids 2 and 4 and the plate of V_7 operate at the relatively low positive potential of 82 volts.

Since the polarity of the applied composite video is positive, the amplitude of the r.f. carrier increases in the black sync-blanking region, and decreases with picture brightness, resulting in the standard negative modulation. Some beneficial limiting action occurs in V_7 on sync-blank peaks since the added positive potential on grid 3 and relatively low plate voltage causes the tube to be driven into the beginning of plate current saturation. This aids in holding the sync levels at the same height for successive peaks for efficient receiver sync control.

The Sync Generator

Both line frequency pulses (15,750 pps) and field pulses (60 pps) are derived from a common master oscillator operating at 31,500 cycles. This permits effective use of a line-lock stabilizing circuit which compares favorably in stability characteristics with commercial type broadcast equipment.

Blocking oscillators are used for the master oscillator and all divider circuits. The blocking type has an inherently greater stability than multivibrators when required to obtain greater frequency division than 2. The vertical sync-blanking is derived from the 15, 7, 5 chain of dividers. (The term "sync-blanking" is used since one pulse serves both purposes as shown in Figs. 9 and 10). A pulse from the grid side of the master oscillator is fed through a buffer stage to a single ÷2 counter for the horizontal sync-blanking. Equalizing pulses are not used in this system, greatly simplifying the circuit and maintenance requirements. Since the system is a closed circuit and the control pulses fed to the viewing receiver utilize the same driving pulses that scan the Vidicon pickup tube, ordinary transmission vagaries are precluded and no difficulty is experienced in the field with pairing of lines in a properly adjusted receiver.

The sync generator adjustment is straightforward and simple. The initial adjustment of the 31,500 cycle master oscillator is made by connecting one lead of a pair of headphones in series with a germanium diode to "Test Plug ÷2," and the other lead to

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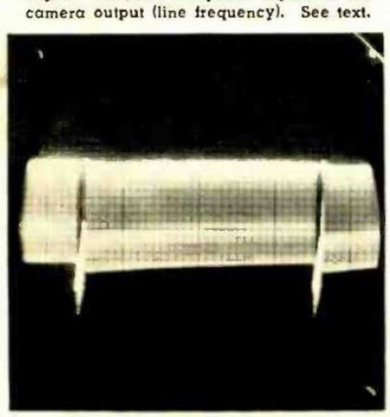

Fig. 9. Rectified composite signal at the camera output (line frequency). See text.

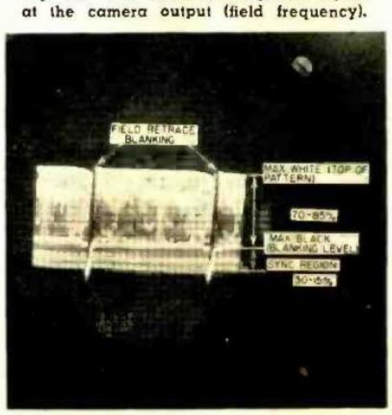

Fig. 10. The rectified composite signal at the camera output (field frequency).

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the high-side of an audio oscillator adjusted to 15,750 cps. In this way the audio oscillator beats with the second harmonic provided by the 31,500 cycle master oscillator and a zero beat may be obtained from the use of the germanium diode. Listening to the phones, the operator varies the 31,500 cycle "Adjust" control (screwdriver-adjust chassis control) in the grid circuit of the master oscillator for zero beat. Although a number of tones may be heard, depending upon how far out of range the 15,750 cycle "Adjust" control in the ÷2 circuit happens to be, variation of the master oscillator control allows the operator to distinguish the second harmonic beat from the others. After this zero beat is obtained, the 15,750 cycle "Adjust" control is varied for zero beat with the remaining tone. An oscilloscope connected to "Test Plug ÷2" will now show the pattern illustrated in Fig. 7. This indicates that every second pulse is syncing the ÷2 counter whose free-running frequency is close to 15,750 cycles.

Germanium diodes are employed in the interstage coupling networks of each vertical divider chain to bring the firing time into synchronism and for effective stage isolation to prevent interaction. Each divider is accurately adjusted by connecting the oscilloscope to the "Test Plugs" for that particular divider as noted in Fig. 6. Fig. 11 shows the pattern obtained at "Test Plug ÷15" indicating that every 15th pulse synchronizes the oscillator when the 2100-cycle "Adjust" control (31,500 ÷ 15) is properly adjusted. The same procedure is carried out through the remaining ÷7 and ÷5 counters. Tube V_{10A} is the final countdown for the vertical pulses, supplying 60 pps to the blanking amplifier V_{11A}, the camera vertical pulse amplifier V_{10B} and monitor vertical amplifier V_{11}.

The blanking amplifier V_{11A} receives the vertical pulses on the grid, while

Fig. 11. "Divided by 15" counter pulses on scope when connected to "Test Plug ÷ 15". Every 15th pulse triggers ÷ 15 oscillator.

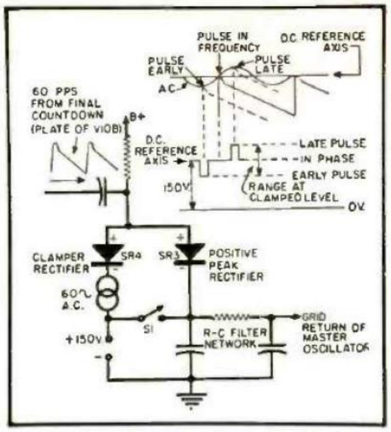

Fig. 12. The clamping-comparison line lock.

horizontal pulses are injected on its cathode from the V_{12} stage. In this manner the composite sync-blanking pulses of negative polarity appear at the plate and are injected into the grid of V_5 as described for Fig. 8. Fig. 9 shows the rectified composite output signal displayed at line frequency, and Fig. 10 illustrates the field frequency.

Horizontal and vertical size and linearity controls for Vidicon sweep are incorporated as screwdriver-adjustable chassis controls. The amplitude of vertical sweep ("Camera Height Control") is determined by the setting of a potentiometer in the grid excitation branch of V_{10H}. A separate potentiometer across the resistors which determine the bias on the V_{10R} grid serves to adjust the tube transfer-curve characteristics and is the sweep "Vertical Linearity Control". The two adjustments are obviously interdependent in action. The camera "Width Control" is an adjustable condenser between the ÷ 2 counter output (V_{8B}) and the camera horizontal output stage V_{12}.

The master oscillator can be locked in operation by the 60 cycle a.c. power line frequency by means of a unique clamping-comparison circuit. Two selenium diode rectifiers are used as indicated in the simplified schematic of Fig. 12. The action is based upon the fact that the blocking time of the oscillator is dependent not only upon the *RC* time constant of its grid circuit, but also upon a static grid potential which determines the extent to which the grid condenser may charge during the "on" time. Pulses from the final vertical countdown (60 pps) are combined with a fixed d.c. potential upon which is superimposed a 60 cycle a.c. line voltage, and the resultant clamped voltage is used to vary this static grid potential and automatically correct the master oscillator frequency.

The fixed reference d.c. potential is applied at the cathode of SR_4 in series with the a.c. filament winding *Y-Y* (Fig. 6). The anodes of SR_3 and SR_4 are parallel connected across a d.c. potential and pulses from the final countdown (hence dependent upon master oscillator frequency) are injected at this point. With the "Line-Lock" switch S_1 closed (unlocked position) the static grid potential is fixed by the d.c. potential of 150 volts. The comparison function is shorted out in this position of the switch. With S_1 open (line-lock position) the cathode of SR_1 is varied above and below the d.c. reference potential at the 60 cps line rate. Injection of the 60 pps from the final countdown to the anodes results in a clamped value at SR_1 dependent upon the relative frequency with the 60 cycle variation. SR_1 serves as the positive peak rectifier for the clamped pulse. If the master oscillator and all frequency dividers are exactly adjusted, the 60 pps coincide with the 60 cycle variations, and the voltage is clamped at the d.c. reference potential. (See waveforms, Fig. 12.) If the 60 pps from the final counter are early or late (too high or too low in frequency) the clamped level falls in the negative direction or rises in the positive direction. The level change is filtered to pure d.c. correction at the output of the filter network to which the master oscillator grid is returned. The direction of change is such that the cut-off period is shortened if the frequency was too low, or lengthened if the frequency was too high.

The author wishes to thank George Fathauer, inventor of this system and president of the *Dage Electronics Corp.*, for supplying the technical data on the camera and permission to publish this article.

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WIRELESS OPS OF "OLD"

FOR some time we have been considering a column dedicated to "Old Time Wireless Operators"—not "Radio Operators" for that appellation is too modern. We believe that we may have something along that line in the near future as our mail has brought us a reminder that 1952 was the 40th anniversary of the sinking of the "S.S. Titanic" in the North Atlantic and the subsequent employment of a large number of wireless operators for our American passenger ships.

It was in 1912 that our radio men put on long pants and became an integral part of American shipping. What has become of these men? Through this column we are going to try and find out what goes with the "Old Timers."

Our compliments to all "Old Timers" of 1912 and thereabouts and we would certainly appreciate your writing us as to when and where you first became a "commercial" operator, either ashore or afloat and by whom you were employed. We would also like to know how long you continued as a commercial radio operator and what you are doing now. A recent picture of yourself would also add interest to the column as would career highlights.

We feel that your story will be of interest to our readers, so you old brass pounders get busy and write us, in care of this column, and watch for its early appearance.

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