The Story of the DAGE Vidicon Camera

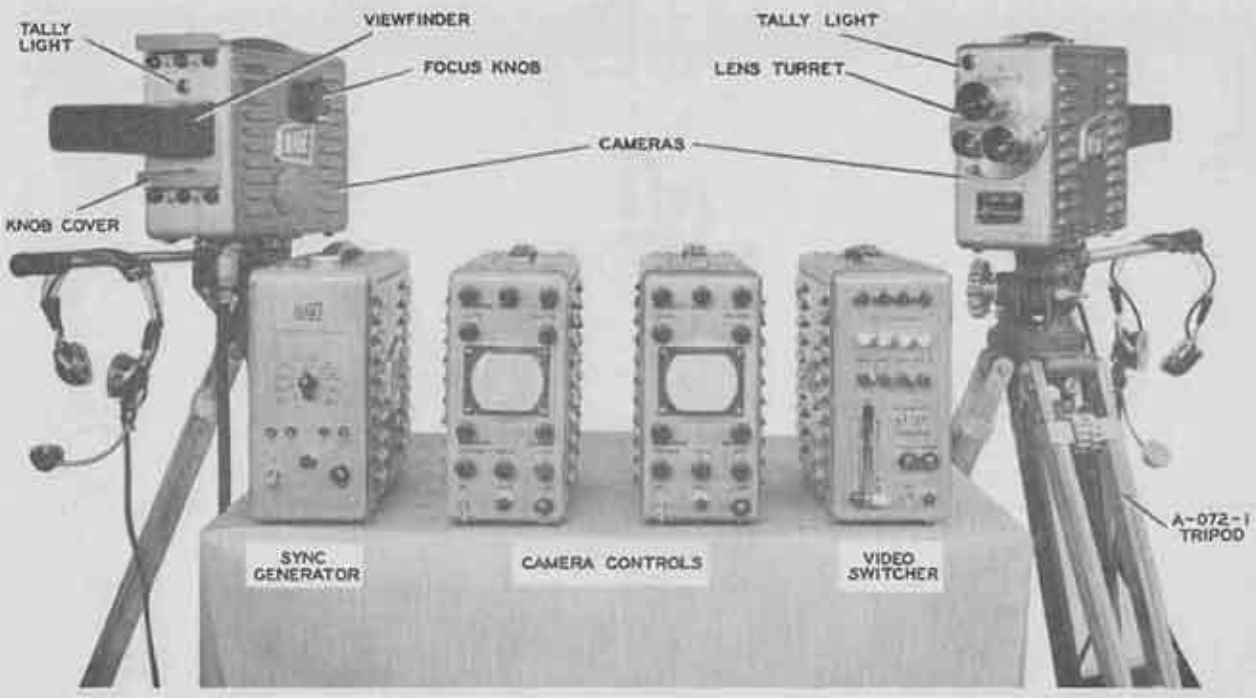


FIG. 1

MAJOR UNITS FOR A
DUAL CAMERA CHAIN
DAGE TELEVISION EQUIPMENT

THE DAGE CAMERA FOR FILM AND LIVE PICKUP

Originally, the Vidicon type pickup tube was designed for industrial purposes, and it was to this end that the original Dage cameras were developed. As the uniformity and overall quality of the Vidicon continued to improve, several broadcasters expressed interest in Vidicon equipment for station operation. A.B.C. enlisted the help of Dage engineers to convert one of the Dage Industrial Cameras to operate from RTMA sync with an RCA Camera Control. This equipment was used in a pickup of the Presidential Inaugural parade. The results were very satisfactory, and at that time Dage made the decision to go into the development and production of Vidicon equipment for studio and remote use. A completely original line of TV broadcast equipment was developed (See Fig. 1). The present line of equipment includes camera, camera control, switching system, and an RTMA sync generator. All units are packaged in the same size case, each weighing approximately twenty pounds, including its own self-contained power supply. The basic power requirement is 100 watts per unit.

To best understand the limitations and advantages of the Dage Camera, it is necessary to first cover the basic theory of operation of the pickup tubes. There are two present sources for this tube, RCA with its Vidicon and Cathodeon with its Staticon. The Vidicon (See Fig. 2) has a conventional heater cathode arrangement. Grid #1 is the control grid. Grid #2 is the accelerating anode, and Grid #3 is the focusing anode. Grid #4 is unusual, and some explanation is in order. It is a fine wire mesh, very close to the target area. It serves as a decellerating anode, creating an even potential adjacent to the target area, which in turn causes the electron beam to strike the target normal to the entire area. First consider the case of the lens being capped, when no light strikes the target area. At this point, the photo-conductive layer is essentially an insulator, exhibiting a very high resistance. As soon as the target charge is neutralized by the scanning beam, the only current flowing will be of very small value, which can be called "dark current." At this point it is important to note that the remaining electrons which are not needed to neutralize the target are returned. This return beam is not utilized in the Vidicon for a signal function as is the case with the Image Orthicon. Now consider what happens when light strikes the target area. At the point of illumination, the resistance is lowered and current flows in the photo-conductive target. This in turn causes a drop across the load resistor, proportional to the amount of light, and this signal is coupled through the coupling condenser to the grid of the first video amplifier. It is interesting to note at this point that the resultant signal from the Vidicon is black, positive.

Next, it is desirable to further discuss the relationship of target voltage, dark current and retentivity of the Vidicon. The residual signal lag after 1/20 of a second is approximately 10%, or a signal current drop from .2 micro amps, which is the average operation condition, to .02 micro amps. in 1/20 of a second when the Vidicon is operated at low target voltages. This is very close to the lag of the Image Orthicon operated at full storage conditions. Thus, at this operating point, the lag of the signal produced in the Vidicon is entirely satisfactory for film reproduction, and will reproduce all but extremely fast motion on live pickup. Since retentivity is proportional to target voltage, it is inversely proportional to available light. Actually, for best studio operation, there is only one value of target voltage for a particular Vidicon. This is approximately 20 to 30 volts, and can be properly determined by capping the lens and bringing up target and beam until edge flare is noticed or visible in the corners of the monitor. Target voltage should not be increased beyond this point.

Inasmuch as the dark current is constant with a fixed target voltage at the black level, the Vidicon sets its own black level and will maintain constant setup.

The spectral response of the Vidicon is similar to that of the human eye, however, it is broader and extends somewhat into the ultraviolet and infra red regions. This is comparable to the spectral response of the latest Image Orthicon.

The gamma of the Vidicon is particularly advantageous for film work. Its gamma is .65. This remains constant in the Vidicon while gamma in the Iconoscope and Image Orthicon vary with operating conditions. This value as you can see, produces a favorable overall gamma when combined with the gamma characteristic of the usual motion picture film which is approximately 1.4 to 1.7. Multiplying the gamma of the two together, assuming a median value of film as 1.55, we arrive at the unity of overall gamma. Multiplying the gamma of the Image Orthicon by film gamma of 1.55 gives an overall gamma of 1.55, which experience has shown to be excessive.

The Vidicon's .65 gamma, is even more important in the reproduction of kinescope recorded film where gamma often runs up to 1.9.

The .65 gamma combined with the extended gray scale of the Vidicon means that no white or black stretching circuits are required to produce a picture with accurate tone rendition. In addition, the Vidicon has a dynamic contrast range of about 200 to 1.

The Vidicon as operated in the Dage equipment will reproduce all ten shades of gray scale, as viewed on the test chart.

Now let us consider the resolution capabilities and required amplifier characteristics. The limiting resolution of a Vidicon approaches 600 lines. The resolution of the Vidicon, unlike the Image Orthicon or the Iconoscope, is not affected by anything but the dimension and shape of the scanning beam.

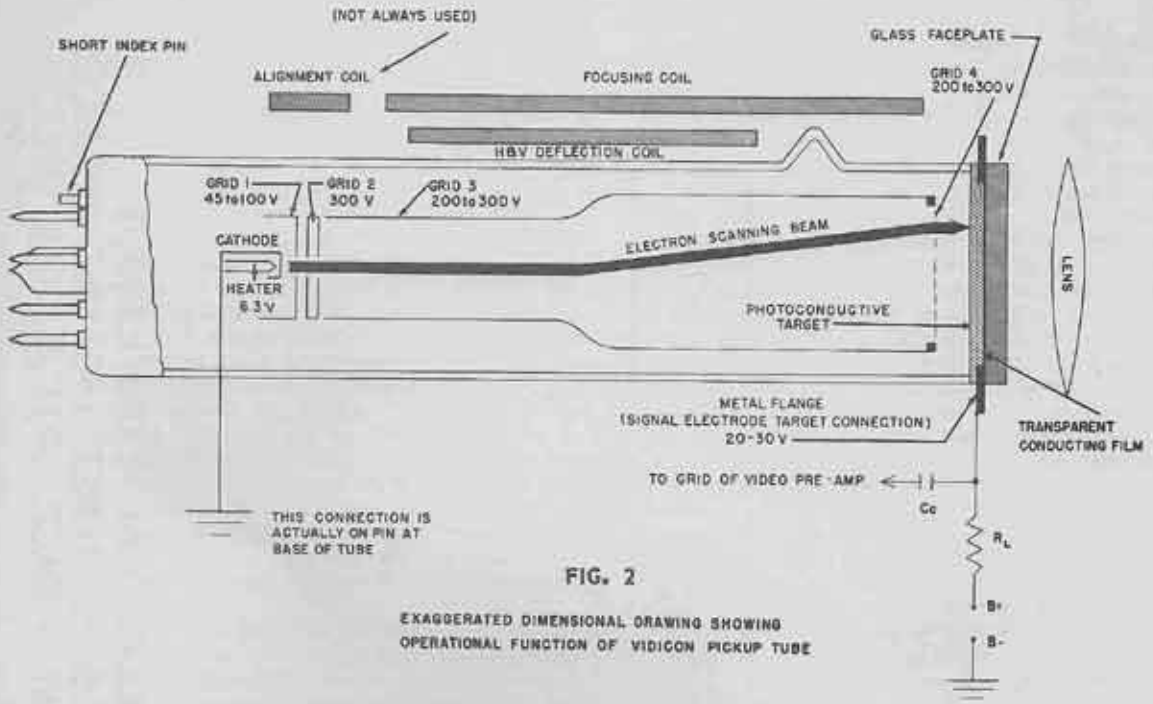
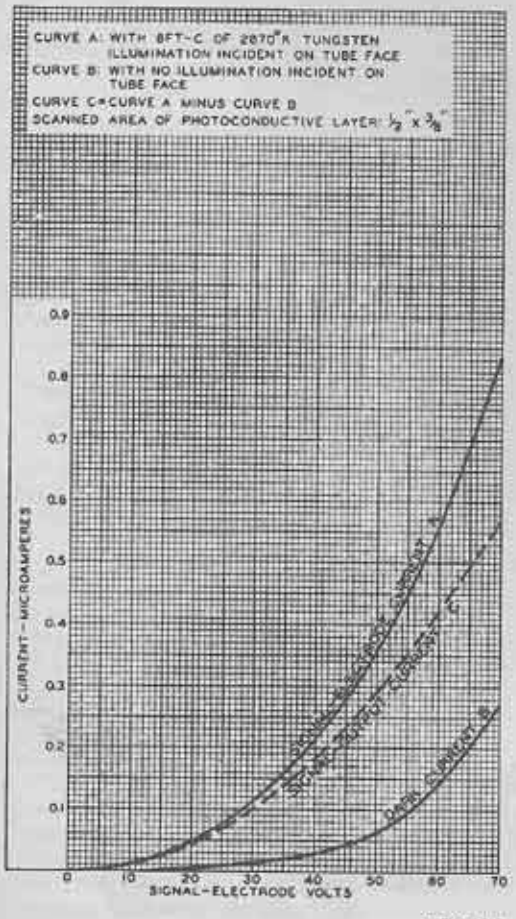
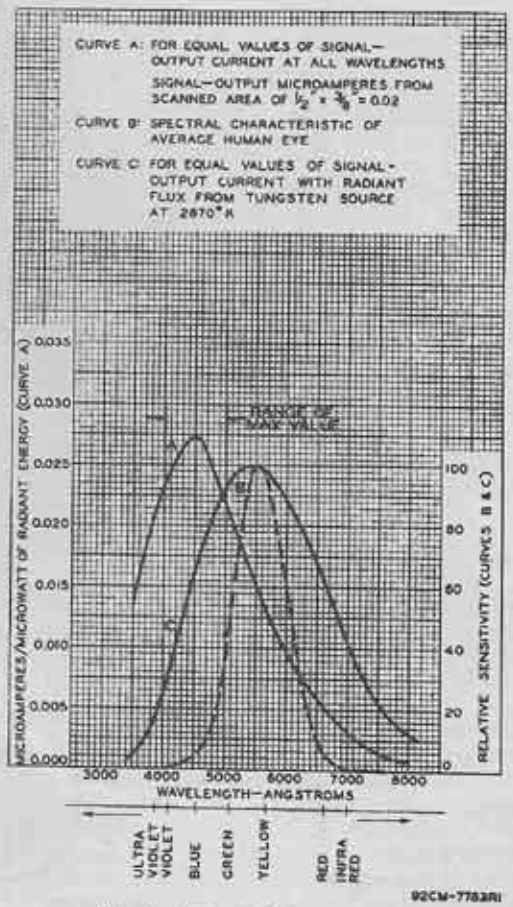


FIG. 2

EXAGGERATED DIMENSIONAL DRAWING SHOWING
OPERATIONAL FUNCTION OF VIDICON PICKUP TUBE



- Typical Characteristics of Type 6198.



- Spectral Sensitivity Characteristic of Type 6198.

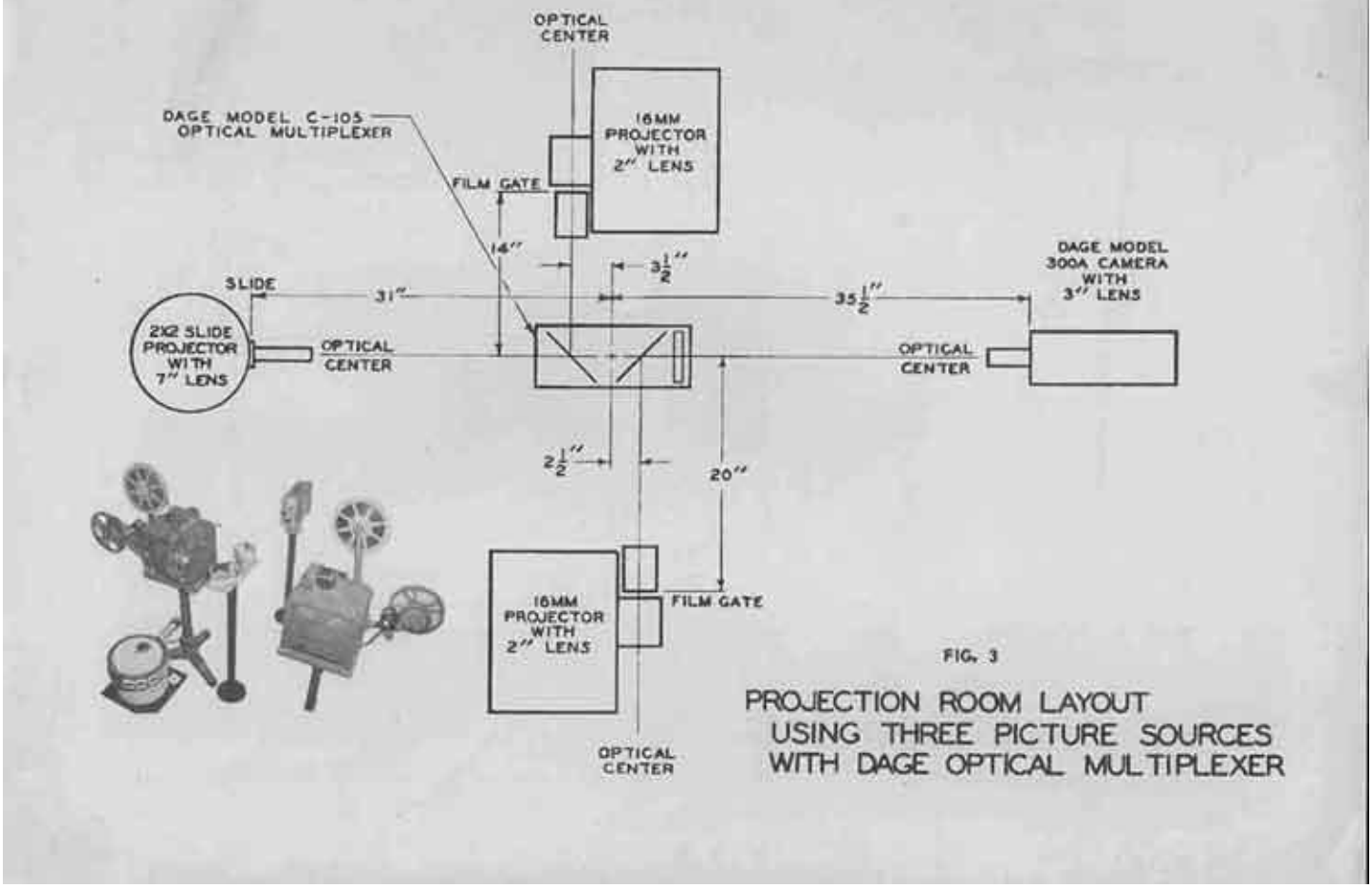


FIG. 3

PROJECTION ROOM LAYOUT
USING THREE PICTURE SOURCES
WITH DAGE OPTICAL MULTIPLEXER

The visual signal-to-noise ratio is approximately 300 to 1, which is higher than previous types of pickup tubes and enables the effective use of the technique known as aperture correction. The need for aperture correction in the Vidicon can be seen from the fact that the output at 450 lines is down 75% from the 50 line value. Aperture correction is obtained by means of a video amplifier with high frequency compensation for the 75% loss at 450 lines.

The overall video response in the Dage camera is flat out to 7 megacycles, with aperture correction. The camera is capable of producing more than 500 lines horizontal resolution. As noted previously, the Vidicon itself is capable of more than this. However if proper signal to noise ratio through the amplifier is to be maintained, further increase of bandwidth or high peaking would necessitate larger amounts of light in the studio. The present design requires a minimum of 200 to 250 ft. candles for satisfactory studio operation, which is a practical amount. One thing that must be kept in mind when considering the resolution of the Vidicon, is the fact that the useable target area of the Vidicon is only 1/2" x 3/8", thus resolving 600 line resolution in such a small target area is quite an accomplishment.

As previously mentioned, the Vidicon has a much extended gray scale and lower gamma than the Image Orthicon. In comparing pictures from the Vidicon with those from the Image Orthicon, it was found that there was less snap in the Vidicon picture. By introducing a circuit in the Dage camera control which compresses the whites, (which Image Orthicon does inherently), the Vidicon picture becomes more nearly compatible with the I.O. picture. This is particularly evident when the Vidicon camera is used with an Image Orthicon on comparative scenes.

The Dage Model 400A Synchronizing Generator will not be discussed in detail in this section. However, it is sufficient to note that it delivers a complete RTMA synchronizing signal, and is interchangeable directly, including cable connections, with the RCA field sync generator, all in the single, standard small package. The Dage Model 500A Video Switcher performs all the essential functions of sync mixing and camera switching complete with fade and dissolve controls. There are four video inputs, two of which may be remotes or other composite signals. The switcher also provides communications for four cameras.

The Dage Model 300C camera has conventional operating features in spite of its small size. It can be used with the RCA camera control by use of cable adaptors. The camera control unit is conventional as far as operational features are concerned, except that the 3" scope tube, through the use of a selector switch, displays horizontal or vertical wave form, or picture monitoring.

Let us now consider the Dage camera as used for film pickup. The combination of low gamma, extended gray scale and high signal to noise ratio in the Vidicon makes it the best pickup tube for film yet developed. The very small target area of the Vidicon makes direct projection a very difficult problem, not only as it requires special lenses in order to project an image of 1/2" x 3/8", but when reduced to that size, any vibration in the projector or camera is greatly magnified on the television screen. The use of conventional multiplexing equipment into a shadow box has two serious disadvantages. First, normally there is not enough light available. This necessitates too high a target voltage, which results in edge flare, caused by excessive values of dark current. The grain size of the screen itself limits the resolution capabilities of the system, to say nothing of hot spots common to this type of projection. Realizing that these two problems were going to seriously handicap the Vidicon as a medium of film pickup, Dage has developed a new optical multiplexing system, utilizing semi-transparent mirrors and a field lens. With the C-105 multiplexer, it is possible to use two 16 mm. movie projectors and one slide projector into a single camera (See Fig. 3). For proper operation of this system, two things are essential. First, all images must be on a common optical axis, and second, the proper focal length lenses must be used on the camera and all projectors. The field lens is 5" in diameter. The front mirror has approximately 40% reflection and 60% transmission. The rear mirror has a 50% reflection, 50% transmission, thus the efficiency factor for both movie projectors is within the tolerance of film densities. The slide projector's lamp voltage can be adjusted to balance its light output with the movie projector's.

The optimum lens combination for a three projector pickup is as follows:

A three inch lens on the camera, 2" lenses on the 16 mm. projector and a 7" lens on the 2 x 2 slide projector. The 16 mm. projector must have a standard three-two pull down for television use, and at least a 750 watt projection lamp. If the projector has a long duty cycle, this will eliminate the need for phasing the projectors with the synchronizing generator. This, incidentally, is a very important feature of the Vidicon. This multiplexing system as described, provides operation well under the maximum useable target voltage, and retentivity is well within tolerable values.

The Vidicon will maintain its own setup and with its unusually high brightness range of 200 to 1, it will operate virtually unattended over a wide range of film conditions.

As previously mentioned, the camera control has a white compression circuit. This circuit can be switched in or out, but should be out when used on film pickup so that the Vidicon's extended gray scale and brightness range capabilities can be utilized to its fullest extent.

The simplicity, low cost, and excellent technical characteristics of the Vidicon camera insure its wide acceptance for film reproduction. Where adequate amounts of light are provided it can do a very satisfactory job in studio and remote pickup applications. Its low cost, small size, and freedom from "burn-in" open the door for many ingenious new program ideas.