IRE PROFESSIONAL GROUP ONBROADCASTINGVolume PGBC-7 DECEMBER, 1961

NEW IMAGE ORTHICONS

G. W. Iler
Cathode Ray Tube Department
General Electric Company
Syracuse, New York

Summary
The use of video tape recording equipmenthas increased the requirements for higher quality performance from image orthicons. The GL -8093 and its characteristics are described as a3 -inch image orthicon to meet this need. TheGL -8092, a field -mesh version of the high sensitivityimage orthicon, is described for color applications.

Last year at this conference we talked abouttwo new image orthicons for broadcast service,the GL -7629 for high sensitivity and special applicationsand the GL -7293 for improved studioperformance. This year we have the privilege ofdescribing two additional types which representmodifications of these two for critical and specialrequirements in broadcast service.

A fact of life in the TV broadcast area forthe last couple of years is the change in studiopractices brought about by the video tape recorder. This new machine has wrought what practicallyamounts to a revolution in rehearsal, recording,commercial announcement, and maintenancetechniques, plus other changes about which theauthor is gratefully unaware, to be sure. Thevideo tape recorder has enjoyed such a tremendousboom and has found at least temporary favorover kine recording on film because the playbackquality is essentially indistinguishable from alive performance, at least on a home receiver, aswell as being available immediately after andeven during the recording process. All the advantages of live image orthicon quality and customaryTV studio practices can be exploited with more flexibility in scheduling facilities and talent.

VTR, however, as much as a boon as it hasbeen, is not a panacea for all of your problems,and has in fact brought with it its own particularset of problems. As another "aperture" or linkin the television system, it extracts its share ofquality from the video information and thereforeputs the onus on the rest of the system to perform
better.

The part of the system which has shown themost picture quality improvement recently hasbeen the camera chain where the 4-1/2" imageorthicon has been introduced. Whether or notyou use a video tape machine, the fact remainsthat the noise and edging effects are noticeablydecreased with this larger tube, and the resultingpicture even on our 525 line system has acrisper, more photo -like quality.

Like the video tape recorder, the use of the4-1/2" image orthicon introduces its own uniqueproblems along with its improvement in picturequality. Principal among these is the requirementfor more rigid lighting practices that mustbe followed if all the advantages of the 4-1/2"tube are to be realized. Since we are dealinghere not with manufacturingquality, but ratherwith basic design characteristics, in effect, weare trading some operating flexibility for improvementin picture quality. Actually doing thisis, for an experienced manufacturer of imageorthicons, not a difficult task; what is more difficultis to have a good, thorough understandingof what you as the representatives of the TV industryreally want and need.

It is quite evident at this point that at leastsome fraction of the industry both wants and needsthe 4-1/2" performance. It is also fairly evidentthat this fraction, although relatively small atpresent, will grow during

the next several yearsto form a substantial market. In the meantime,however, there are also a great many stationchief engineers and managers who would like tohave improved performance without having toeither invest heavily in new 4-1/2" camera equipmentor to trade so much operating flexibility,and at relatively economical cost as well. TheGL -8093 is, we believe, the answer to this situation.

The 8093 is a modification of the well-knownGL -7293. Its target -to -mesh spacing has beenreduced from the nominal 2. 2 mils in the 7293 toabout 1.4 mils to increase target capacitance. Asin the 4-1/2" tube, the net effect of increasingtarget capacitance is toimprove the signal-to-noiseratio, to reduce white edging effects fromimage side redistribution, and to increase gammasomewhat. The use of a field mesh behind thetarget as in the GL -7293 sharpens up the pictureby minimizing white edging due to beam bendingand by improving corner resolution. The fieldmesh also helps produce much flatter fields thanimage orthicons without it, and also eliminatesbackground interference from the firstdynodetexture and aperture.

Let us examine these characteristics insomewhat more detail.

The most significant improvement that the8093 brings to studio operation is the increasedsignal-to-noise ratio which is 50/1 on the averagecompared to 45/1 as a typical figure for the5820-type image orthicon. In decibels, theseratios are 34db for the 8093 and 33db for the5820. On paper, this does not sound like a verygreat difference, but in actual practice and operation,the difference in noise is quite noticeableon a monitor. Published figures for the 7295which is the most commonly used 4-1/2" imageorthicon are 56/1 or 35db. We therefore have animprovement in signal-to-noise ratio which althoughit does not quite match the 4-1/2" tube, isnevertheless a significant increase. The reasonsfor not going to higher ratios in a 3" image orthiconwill be explained shortly.

The second most significant improvement inthe 8093 is the further reduction of white edgingeffects. Those of you who have used the GL -7293 in the past have observed that the localizedwhite blooming around black areas has been reducedby the use of the field mesh. By reducingthe spacing between target and mesh in the 8093,redistribution effects which produce a very similarwhite border line are further reduced, givinga much cleaner black to white transition withoutover -shoots. It can be an advantage to start out with the least amount of over -shoot possible asoften -times various video amplifiers, cables andterminations are not adjusted properly and tendto introduce their own over -shoots. In comparison with a 5820, the combination of improvednoise figure and cleaner black to white edges producesa very clean, crisp picture.

And now, it would be well to discuss thereasons for choosing a target-to-mesh spacing of 1.4 mils which gives a signal-to-noise ratiosignificantly better than a 5820 but still not ashigh as a 4-1/2" tube. Certainly, a 3" tube canbe built with a closer target -to -mesh spacing, asexemplified by the 6474 and 7513 types which areabout 1 mil or slightly less. These tubes weredesigned for 3 -tube color cameras and the veryclose target -to -mesh spacing expands the lighttransfer curve below the knee so that the fullrange of scene contrast can beaccepted withoutpushing the highlights over the knee. In colorthis is necessary due to the color distortion ofhighlights over knee. Although these tubes offera signal-to-noise ratio more comparable to the4-1/2" class, there is a basic characteristic of
such close spacing which introduces limitationswhen used for studio black and white pickup. Thatis, the closer the target -to -mesh spacing becomesthe higher the effective gamma of the tube becomes,which in turn means the tube will not acceptas wide a range of scene contrast and willtend to compress black more readily. In thecolor camera, a gamma correction circuit isutilized to restore the curve out of the camera toa lower slope such as is experienced in normalblack and white set-up. The explanation for thiseffect is tied up, in a manner not completelyunderstood, with the efficiency of collection ofsecondary electrons from the target, but it isnevertheless an observable characteristic that asthe capacitance per picture element increases sodoes the dynamic gamma of the image orthicon.
Because of its higher capacitance, the 4-1/2"tube exhibits the same phenomenon.

The significance of this characteristic andthe reason an intermediate spacing was chosenfor the 8093 is that control of lighting and reflectancevalues of materials in the scene becomenoticeably more difficult with either a very close spaced 3" tube or any one of the 4-1/2" tubes.
The 8093 therefore is a design which is intendedto be an optimum considering theincreased demandsby broadcasters for improved signaltonoisefigures from 3" image orthicons on the onehand and the budgets, or lack of them as the casemay be, in a great many stations for lightingspecialists.

Figure 1 illustrates the light transfer characteristicof the 8093 compared to that of the 5820.Although it appears that the gamma is the sameas the 5820, this results from the curve beingtaken with a small highlight, and a dynamicgamma characteristic which would be more representativeof actual practice would show aslightly greater slope than the 5820.

In the case of the second tube to be describedwe can't say too much about signal-to-noise ratio.However, we can say a great deal about operatingflexibility, stability, and long life for colortelevision applications. There is a substantialamount of talk in the industry right now about thecoming of color television. Perhaps with all thissmoke, something will ignite and really burn.Whether color comes soon or slow, big or small, it is certain that flexibility will be an importantpart of any broadcasting activity. As horrible asit sounds to you chief engineers who will be responsiblefor doing it, it will probably be extremelyvital in many cases to be able to drag a pairof color cameras to remote locations and do pickupsunder a variety of conditions most of whichare likely to be very difficult.
The GL -8092 is essentially a marriage of thehigh sensitivity, magnesium oxide target of theGL -7629 and the field mesh construction of theCL -7293. The first use of the magnesium oxidetarget for broadcast television was in the GL -7629 introduced two years ago and although fairlywell known by now, some of its characteristicsmay be described to illustrate its applicabilityfor color as well as black and white.

Resolution sensitivity (Fig. 2) is perhaps themost significant performance characteristic. Atany light level the resolution from this tube issubstantially higher than that from a 5820, whichaccounts for the ability of this tube to portray detailedscene information at extremely low lightlevels. The large reduction in lateral leakage onthe target, due not only to the extreme thinnessof this target but also to the conduction mechanismof the magnesium oxide, is responsible forthis high resolution. As can be seen from the curves drawn on arbitrary axes, there is nocross -over point where the 5820 is higher in resolution.If we compare amplitude responses atthe higher light levels found in a typical black andwhite studio, we find the 7629 and 8092 to haveabout 48% response at 400 horizontal TV lines,compared to about 26% for the typical 5820.

Now a look at the transfer curve of the 8092related to that of the 5820 (Fig.3) will give us alittle insight into another characteristic of thisnew tube. At the lower light levels, the outputfrom the 8092 is substantially higher than thatfrom the 5820, although at the higher levels nearthe knee of the 5820 the signal output from the8092 is less. The reason for this is a widertarget -to -mesh spacing, and the result of thislower signal output at higher levels is a softergamma characteristic, somewhat like a vidicon,and a somewhat lower signal-to-noise ratio thanthe 5820. Despite the curve in the transfer characteristic,
these tubes are essentially no moredifficult to match dynamically in a color camerathan the normal close -spaced glass target tube.
The gamma characteristics are consistentenough from tube to tube so that with the aid of
neutral density padding filters, three tubes canbe made to track along a curved line as effectivelyas they would along a straighter gamma characteristic.
Furthermore, no gamma correctionis needed with the 8092. As is true in any image
orthicon used in color, however, the field meshconstruction contributes materially to the easeof setup as it eliminates shading problems which sometimes are mistaken for problems of dynamicregistration of grey scale strips. The 8092can be made to track quite faithfully over thewhole range of iris control which permits pickupof a very wide range of brightness values.

The signal-to-noise ratio of the 8092 when itis given an exposure close to the knee of the 5820,is about 34 to 1 peak -to -peak signal versus RMSnoise, compared to 45 to 1 for the 5820. In thelower region of the transfer curve where the signaloutput from the 8092 is higher, it will producean appreciably higher signal-to-noise ratio than a5820.

The life of the GL -8092, compared to thetypical life of the 5820, is theoretically muchgreater because of the complete difference inconduction mechanisms through the target of thecrystalline material, magnesium oxide. Thistube will not be retired for sticking.

By way of illustration, Figure 4 portrays thegeneral behavior characteristics of sticking during life of the 8092 vs. the 5820. The 5820 haspractically no stickiness when it is brand new.However, with life and hours the 5820 does developa degree of sticking which eventually leadseither to retirement or to progressively moredifficult operation. The 8092, on the other hand,starts with a small amount of after -image, butthis gradually diminishes with life, generallyrapidly at first, and reaches a point shortly afterinstallation where it is not objectionable or bothersomein operation. In other words, with thistube, an I.O. Guard would be useful primarilyduring the first few hours, and then of little usethereafter.

Because magnesium oxide is inherently avery stable secondary emitting material, othercharacteristics of this tube remain much moreconstant throughout life than they do in a 5820 black compression, resolution, sensitivity, andtarget cutoff voltages being notable examples.

These characteristics of magnesium oxidemake the GL -7629 and GL -8092 the most sensitiveimage orthicons for commercial televisionuse. The field mesh construction was incorporatedin the 8092 principally for use in colorcameras where flatness of field and dynamicmatch among all three channels is very essential.

Much can be said for analyzing and measuringimage orthicons on the basis of their individualperformance characteristics such as signaloutput, signal-to-noise ratio, and dynamic matchingproperties. As far as evaluating a color picture,however, nothing can really substitute forthe integrated response of the human observerviewing such a picture. I therefore submit thatthe results of a test of three magnesium oxidetubes in a G.E. color camera at 5-foot candles ofincident light on the scene, were remarkable. Theimpression of the observers was that this wastruly a very good color picture, but to describethese impressions it is again necessary to breakdown the picture into its componentcharacteristics.Although the picture at this very low lightlevel was noisy and the output video barely up to
1 volt, all colors were fully saturated and thedetail in the scene was hardly any less than atfull light level. Going to even lower exposures,video signal and color were lost before definitionwas. This demonstration is not described to proposein any sense that color sets be illuminatedto 5-foot candles in order that the GL -8092 maybe utilized effectively, but rather it is used to illustratehow sensitive the tube is and the degreeto which it can handle wide ranges of scene illumination,such as encountered outside on a
sunny day. A photograph of the results of thisdemonstration, if I had one, would truly be wortha thousand speeches.

Many television operations will be calledupon to install studio color facilities in the next
several years. In addition to long and stable lifeproperties, use of the 8092 allows color to be
broadcast from a black and white studio with excellentresults without having to go to the expense
and time of installing additional lighting facilities.In this application, a small sacrifice is made in
signal-to-noise ratio for the advantages of resolution,cooler sets, lower lighting and air conditioning
costs, and greater flexibility.

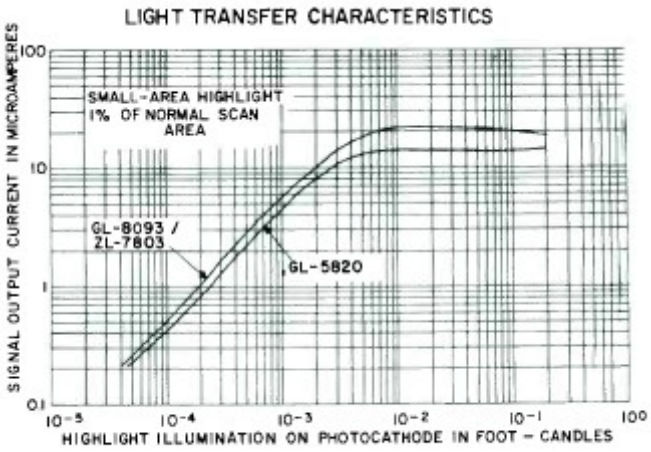

Fig. 1

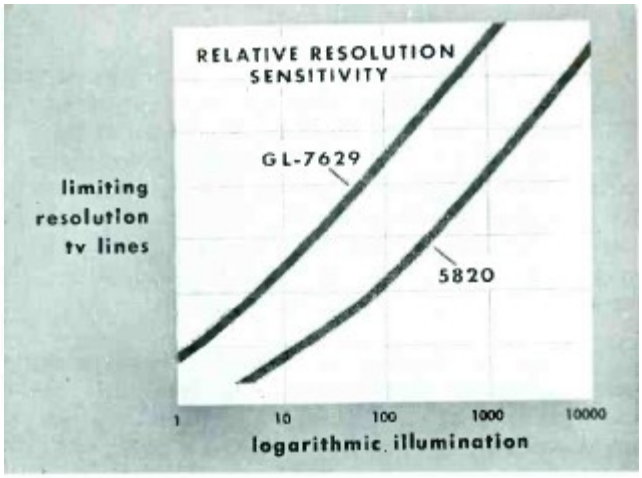

Fig. 2

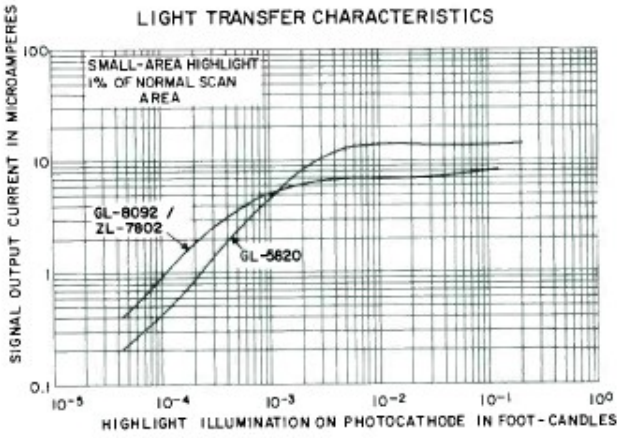

Fig. 3

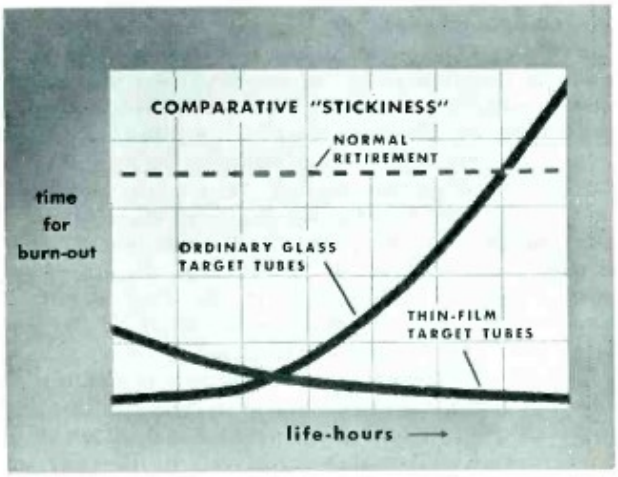

Fig. 4