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TELEVISION IMAGING WITHOUT VACUUM TUBES

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THE conversion of images into a series of electrical signals is performed by resolving (by prearrangement as a rule) the image receptor into elements FE (Fig. 1) that are then switched sequentially to load circuit R_L by commutator C.

The photoconductive effect is used for the transformation of energy of the light flux into the electric current energy. The operational capability of any solid-state switching method is determined by the physical process on which the method is based. Commutator K may either establish ohmic current through a photocell (PC) during the "on" part of the switching cycle, or merely charge its capacitor up to the source voltage. In the first case the load current reflects the illumination of the photocells during the "on" part of the switching cycle. Converters of the "instantaneous" type are characterized by low inertia. In the second case the image light flux causes leakage of charges from the capacitors of photocells during the "off" part of the switching cycle (i.e., during the time required to write one frame). Consequently the energy of the image light flux is stored and the load current reflects the illumination averaged over the frame transmission time. Converters of this type are based on the charge accumulation principle with the attendant significant increases of sensitivity.

1. CONVERSION METHODS WITHOUT CHARGE ACCUMULATION

These methods utilize either a fixed aperture (the leads from the photocells are connected to converter leads) or a shifting aperture (converter output is switched sequentially to the outputs of the FE elements).

The fixed aperture is a p–n junction collecting minority carriers. The outputs of the photocells are switched by the drift of nonequilibrium carriers in an electric field. The existence of recombination of nonequilibrium carriers in the course of the drift renders the signal dependent on the location of image details on the sensitive surface of the converter.

In order to commutate photocells with a fixed aperture the current lines of the nonequilibrium carriers are deflected by crossed magnetic and electric fields[1]

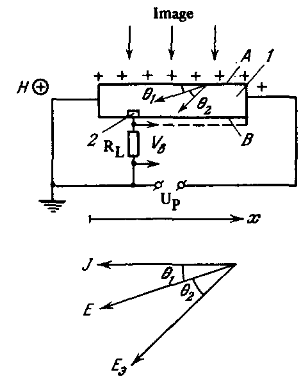


FIG. 2. Schematic cross section along the scanning line of a converter based on the Suhl effect.

(Suhl effect), by crossed electric fields in a crystal[2] (solid state analog of the dissector), or by an electric field pulling the profile of nonequilibrium carriers.[3]

These methods are realized in the following ways.

When the Suhl effect (Fig. 2) is used to scan the image the profile of the nonequilibrium carriers on surface A of semiconductor plate 1 due to the absorption of the image light flux is transferred to surface B; the transfer is effected by pulling voltage U_P and Hall voltage directed at an angle equal to the sum of Hall angles $\theta_1 + \theta_2$ of the majority and minority carriers, Some of the minority carriers fall into the field of p–n junction 2 setting up a videosignal current in load R_L. This current is proportional to the local intensity of the image light flux. As the magnetic field intensity H varies the carrier profile shifts along surface B giving rise to videosignal current in the load. The image scan is of the single-line type.

If the current lines are deflected by crossed electric fields in crystal 1 (Fig. 3) the nonequilibrium carrier profile moves from transparent electrode 2 to face 3 due to pulling voltage U_P. Some of carriers fall into the field of junction 5 in the center of cutout 4 of electrode 3, setting up a signal current in load R_L. Transverse fields due to voltages on electrodes 6, 7, and 8, 9 of the lateral faces of the crystal shift the profile of the nonequilibrium carriers along electrode 3 creating videosignal current in load R_L. Figure 4 shows a projec-

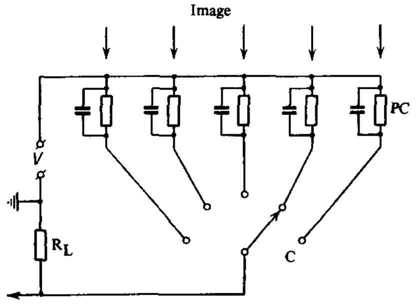


FIG. 1. Schematic diagram of a solid-state image converter.

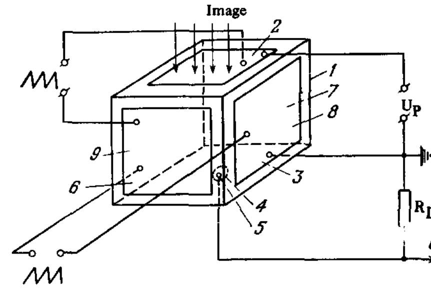


FIG. 3. Schematic diagram of a solid state dissector analog.

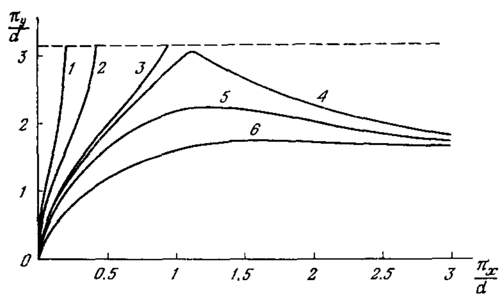


FIG. 4. Current line projection on a side face of analog dissector scanning electrode.

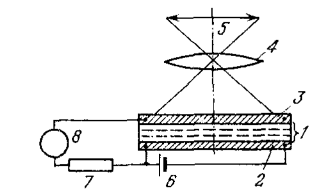


FIG. 6. Schematic cross section along a scanistor.

tion of the current lines on the lateral face of the crystal.[5]

In the image scanning method based on pulling the profile on nonequilibrium carriers, the converter consists of a semiconductor plate with ohmic contacts at end faces 1 and 2, and a number of p–n collector junctions 3 (equal to the number of lines of the image) along one of the ohmic contacts (Fig. 5). The profile of nonequilibrium carriers obtained in projecting the pulse image is pulled by a pulsed electric field to junction 3 whose circuit conducts the videosignal current. This method is relatively complex since it requires a line commutator and an image obturator.

In methods of image conversion without charge accumulation and without vacuum tubes the shifting aperture is represented by either the null voltage boundary in a triode structure[7,8] (the scanistor) or a scanning power supply.[9,10]

The null voltage boundary in a semiconductor triode structure (Fig. 6) is formed by balancing dc voltage 6 distributed along layer 2 and sawtooth voltage 8 of opposite polarity applied across structure 1. As the sawtooth voltage increases the null voltage boundary shifts and increases the area of the photodiode in load circuit 7. The rate of current increase corresponds to the distribution of image light flux intensity along layer 3. A single-line scan is used. The resolution of the scanistor can be increased approximately three times for the same length[11] by fabricating the base of triode sandwich 3 as a discrete structure.[8] A disadvantage of the scanistor is the need to apply differentiation to the output signal in order to detect the videosignal.

A photoelectric emf generated in a semiconductor strip by a scanning optical beam was proposed in [9] for a scanning power supply. The use of the strong field domain in a semiconductor crystal is more promising.[10] In this case the image converter is semiconductor strip 1 with a negative bulk conductivity (Fig. 7) supported by substrate 2. Photoconductive layer 3 is deposited on strip 1. Power supply voltage V is connected to strip 1 through load R_L. Strong-field domains appear in the semiconductor near one of the electrodes due to a drop in carrier mobility in the strong electric field; the mobility drop pulls the field into a local region. Electroacoustic domains moving relatively slowly in comparison to Gunn domains are of considerable interest to solid-state scanning. A breakdown of a domain at the opposite electrode causes automatically the appearance of a new domain. Therefore such converters have no need for sweep generators with a significant simplification of the design.

The domain field generates a current in a local region of photoconductive layer 3 corresponding to its illumination. Videosignal voltage appears in load R_L as the domain moves. Owing to the high field of the domain the amplitude of the videosignal can reach several volts.[16] Since the formation of a domain does not depend on the properties of photoconductive layer 3, the videosignal can be increased by virtue of a high internal amplification of the photocurrent, in turn increasing conversion sensitivity. This method can also be used to obtain a raster scan of the image, since strong field domains exist in subthreshold fields (but higher than maintaining fields). In such a case a domain is generated by a pulse at electrode 4 and transferred between the lines by an electrical pulse at electrode 5 synchronized with the passage of a strong field domain (via a capacitance formed by a layer of dielectric 6)[17]. As noted in [17], a strong-field domain has the properties of a nerve impulse. In a raster scan, however, the scattering power rises sharply, limiting the frame to several tens of lines. Crossed electric fields (the dissector analog) are more promising for the raster scan of images.

Image scanning without accumulation of charges may also be based on the single-element method[18] using an optical scanning beam and signal accumulation employing the photochromic properties of glass.

The sensitivities E (in luxes) and image frame (line) repetition frequencies (in Hz) computed by analyzing the physical processes involved are shown in Fig. 8 for single-line scans without charge accumulation. As we see from Fig. 8, the method of single-line scan based on strong field domains (lines G) has the highest sensitivity (minimum illumination from the image required to yield a signal-to-noise ratio of 30) with high resolu-

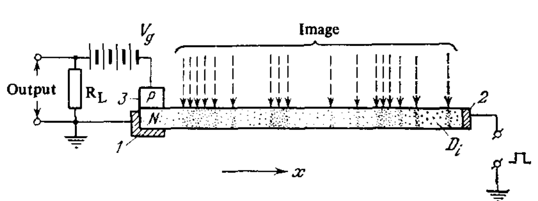


FIG. 5. Schematic cross section along the scanning line of a converter based on pulling the profile of nonequilibrium carriers.

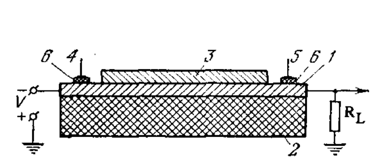


FIG. 7. Schematic cross section along a scanning line of a converter with strong field domain scanning.

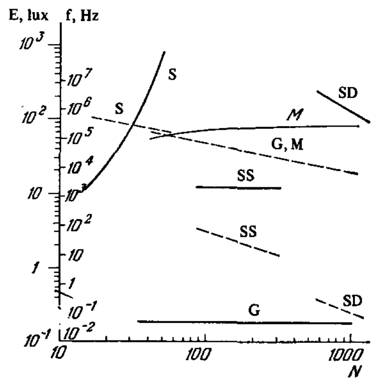


FIG. 8. Sensitivity E (solid lines) and line conversion frequencies (dashed lines) as functions of the number N of elements of image resolution, determined from a 20% dip between videosignal pulses for lines S and equal to the number of apertures along the line for other lines. S—Suhl effect conversion; SS and SD—scanistor solid and discrete bases; M—single-element resolution method; G—scanning by strong field domains.

tion. The resolution limits of solid-state imaging methods in relation to the scanning technique used are due to the following factors: (a) crossed electric and magnetic fields—maximum and minimum Hall angles (the maximum Hall angle is determined by the magnetic field intensity and the mobility of the majority carriers; the minimum Hall angle is determined by the mobility of the minority carriers causing leakage across the current lines[4]); (b) crossed electric fields—configuration of the force lines in the crystal[5]; (c) pulled profile of nonequilibrium carriers—the magnitude of the pulling field in the crystal.[6]

The sensitivities and conversion frequencies obtained with raster scanning solid-state videosignal generators are given in Fig. 9, showing that the scanning method based on the strong field domains in a crystal again has the best sensitivity. However it is difficult to utilize because of high scattering power. The dissector analog (lines Ds) is more promising for image scanning without charge accumulation. The limits of resolution of raster scanning methods are imposed by the following factors depending on the scanning method: strong field domains—scattering power level[16]; null voltage boundary—breakdown voltage of the collector junction of the triode structure.[11]

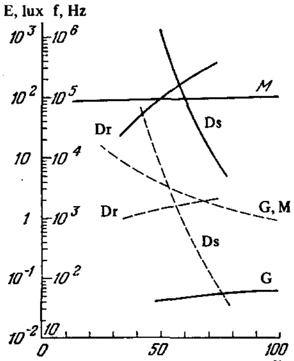
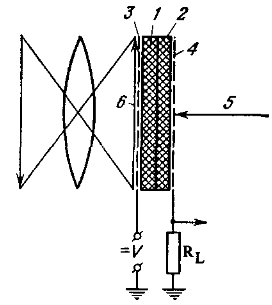


FIG. 9. Sensitivity E (solid lines) and frame conversion frequency (dashed lines) of raster scanning methods without charge accumulation as functions of the number of lines n determined from the number of elements in a line for 20% dip between videosignal pulses derived from bright image details for lines Dr and Ds and equal to the number of apertures per line for the remaining lines. Dr—resolution by pulling the profile of nonequilibrium carriers; Ds—solid state dissector analog; G—resolution by strong field domains; M—single element resolution into a videosignal.

FIG. 10. Schematic diagram of an optically switched converter.



The experimental results of investigating image scanning without charge accumulation have been reported in the literature only for scanistors.[12-14] A resolution of 100 lines was reached in the case of gold-compensated silicon as a base of the triode structure. The specific resolution is 10 lines/mm. Similar results were obtained with germanium.[15]

2. IMAGING METHODS WITH CHARGE ACCUMULATION

If charge accumulation is used, image conversion is accomplished by means of conducting channels in a highly resistive semiconductor structure, the channels serving to charge the photocell capacitances.

The conducting channel is formed by an optical beam,[19-22] a shock wave pulse,[23] a neuristor pulse,[24] or electrical timing pulses.[25] In this case the image converter (Fig. 10) is represented by capacitors formed by two semiconductor layers 1 and 2 between electrodes 3 and 4. Power supply voltage V is impressed on the electrodes through load resistor R_L. One of semiconductor layers 1 together with adjacent transparent electrode 3 represents the image receptor and is photoconductive. The second layer 2 of the semiconductor is used to establish a conducting channel for charging the capacitance of layer 1. This conducting channel scans the area of layer 2. In its absence in any local spot the power supply voltage concentrates in layer 2, creating conditions favorable for discharging the capacitance of layer 1. The discharge rate is stimulated by illumination on the layer 1 side. As a result, after a time period, a potential profile is established at the interface between layers 1 and 2, corresponding to the illumination profile at the surface of layer 1, i.e., the distribution of light flux in the image. The returning conducting channel restores the charge in layer 1. The current completing the full charge in layer 1 creates videosignal voltage in the load resistor R_L.

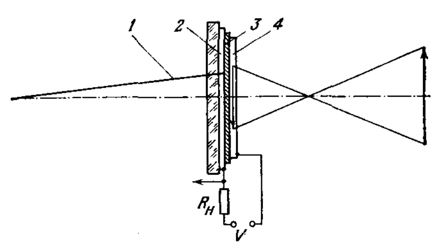


FIG. 11. Schematic diagram of a single-layer converter with optical switching.

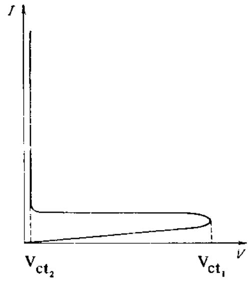


FIG. 12. Volt-ampere characteristic of a semiconductor device with a negative differential resistance.

If optical scanning beam 5 is used for the formation of the light flux conducting channel, switching layer 2 is photoconductive and the adjacent electrode 4 is transparent.[19] The converters described in [20,21] are distinguished by the fact that dielectric or metallic mosaics are inserted between layers 1 and 2 for optical decoupling purposes. The mosaic has a negligible practical effect and merely complicates the converter structure.

The structure of the optical switching converter is significantly simplified if photoelectret properties of semiconductors are used.[22] In this case the image converter consists of single layer 3 (Fig. 11) having photoelectret polarization and enclosed between transparent electrodes 2 and 4. Optical beam 1 penetrates a portion of the thickness of layer 3 charging the capacitance of the remaining portion of the layer. The charges settle in traps, generating a photoelectret condition. The photoelectret is depolarized by the image light flux in the the absence of a conducting channel. A second exposure to the optical beam restores photo-polarization of layer 3 and the resulting current creates videosignal voltage in load resistor R_L.

If the pressure of an elastic wave pulse is used for the formation of the conducting channel, layer 2 (Fig. 10) should have a barrier contact such as a p–n junction. The voltage pulse decreases the width of the forbidden band, creating the conducting channel in the inverse-biased p–n junction. Image scanning is structurally difficult because of problems in insulating the lines, in transmitting an elastic pulse from the end of one line to the beginning of the next, and also in quenching the reflected elastic waves.[30]

If a neuristor pulse is used for switching the elements of the photoconductive layer, layer 2 (Fig. 10) should have a negative differential resistance[24] (Fig. 12). The power supply voltage should be lower than cutoff voltage V_{ct_1} so that layer 2 has a high resistance in a normal state. Figure 13 shows a cross section along a line of a converter having planar thyristors (Fig. 10)

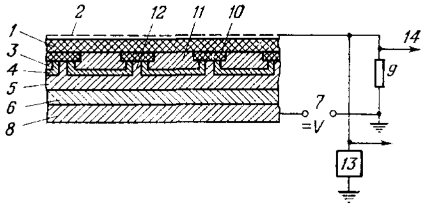


FIG. 13. Schematic cross section along scanning line of a neurocon with thyristors.

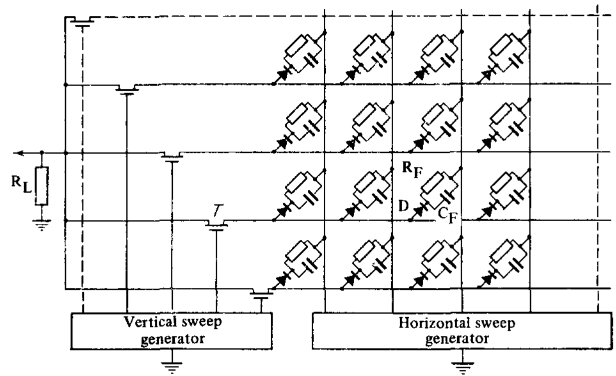


FIG. 14. Schematic diagram of a matrix converter.

as layer 2; the thyristors are formed by layers 3, 4, 5, and 6 of alternating conductivity on substrate 8. These generate regions 11 with negative differential resistance separated by regions 12 without negative resistance. In the figure, 10 is the dielectric layer and 13 is the synchronizing pulse generator. When a starting electrical pulse hits the end of a scanning line, as when it is impressed for example on layer 3 or 4 of the thyristor, the end stage of the thyristor goes into a low resistance state and charges the capacitance of photoconductive layer 1. As this capacitance is charged the current through the thyristor decreases and, when the maintaining voltage is reached, the thyristor switches to the high resistance state. However, by virtue of potential difference along layer 5, owing to heavy current passing through the thyristor stage in the low resistance state, minority carriers flow through the neighboring thyristor stage in a high resistance state; the minority carriers thus switch on the thyristor stage, etc. Consequently a region of transverse current propagates along the scanning line, resulting in sequential switching of layer 1 elements. Videosignal current 14 appears in load resistor 9. A converter of this type is known as a neurocon. The described neuristor line can also be made in a closed form. Then the scan can be started merely by starting the neuristor pulse at the time the

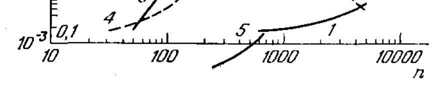


FIG. 15. Sensitivity E(solid lines) and frame scan frequency (dashed lines) as functions of the number of lines n of image scanned with charge accumulation: 1–matrix converter; 2–elastic wave pulse switching; 3, 4–optical switching when potential profile is formed in the photoconducting and photoelectret layers respectively; 5–neuristor pulse switching.

supply voltage is switched on. Consequently neurocons do not require sweep generators which significantly simplifies the design. A neuristor pulse can "jump over" technologically imperfect thyristor stages relaxing the requirements on the manufactured microcircuitry for neurocons.

If electrical timing pulses are used for image conversion (Fig. 14) photoresistors $R_F C_F$ are switched through blocking diodes D at intersections of mutually perpendicular bus lines by means of keying triodes T controlled by pulses from sweep generators. A special feature of matrix converters is the parasitic current from the neighboring elements. To remove parasitic current from load resistor R_L it is necessary to ground the idle bus lines; this in turn gives rise to the characteristics of a capacitive converter. A good design of a sweep generator feeding voltage pulses sequentially to the matrix bus lines and automatically grounding idle lines is given in [33]. A disadvantage of the matrix converter are the fairly stringent requirements on the technical specifications of the manufactured microcircuitry.

Figure 15 shows the results of evaluation of the expected parameters of imaging standards obtained by analyzing transients in the converter circuits and, in particular, the physical processes underlying the switching system. According to the diagram the greatest resolution (the number of elements of resolution equals the squared number of lines) is achieved by conversion methods based on the electrical timing pulses (lines 1) and neuristor pulses (lines 5). As noted above, neurocons have substantial advantages, having no need of sweep generators and relaxed requirements on the manufacture of the active elements of microcircuits on which they are based.

The maximum resolution is limited by the following factors in relation to the scanning method: optical beam and neuristor pulses—shunting effect of capacitor plates of the converter[27–29]; elastic wave pulse—shunting of the photoconductive layer by the low-resistance p-n junction jacket[30]; electrical timing pulses—technological capability to produce large integrated microcircuits.[34]

The results of experimental research on optical switching and switching by electrical timing pulses were described in the literature. The results of experimental optical switching converters based on the optical properties of amorphous selenium are reported in [22]. A resolution of 100 lines with a resolving power along a line of 120 lines and specific resolving power of 25 lines/mm was reached. Luminance at the electret layer (sensitivity) was 100 lux. This converter was the first in world practice to transmit a raster scanned image based on the application of physical phenomena in solid state. Better results were obtain from the development of converters of the matrix type.[35, 36] Solid state transmitter cameras using either monolithic or film microcircuits within the size of a narrow-film photographic camera and with power requirements of 1–3 W were designed and built. The largest number of lines (256) was obtained with thin film microcircuits, although at this time it is difficult to make a final conclusion as to their future in comparison to monolithic integrated microcircuits.[35]

3. IMAGE CONVERSION METHOD WITH INTERMEDIATE INFORMATION STORAGE

The existence of a potential profile of the image in conjunction with charge accumulation allows for the design of converters with intermediate information storage between writing and reading the image. The profile of ferroelectric or photoelectret polarization is used for information storage.[37–40] The information is read by means of an optical scanning beam that destroys the polarization profile and prepares the converter to write the next image frame. The design of the converter coincides with those in Fig. 10 except that a transparent ferroelectric or photoelectret is used as layer 2.

If ferroelectric properties are used for information storage, a voltage pulse delivered to electrodes 3 and 4 causes a preliminary polarization of the ferroelectric layer. A pulse of opposite polarity is applied for the writing cycle. This pulse charges the capacitances of the ferroeletric layer causing the appearance of partial polarization reversal. The magnitude of over-polarization is determined by local resistance of photoconductive layer 1, i.e., it corresponds to the distribution of illumination in the image. The obtained polarization profile is retained in the absence of power supply voltage. To read, an optical beam generates a photoconductive channel in layer 1. This channel restores a uniform ferroelectric polarization of layer 2.

The application of photoelectret properties of semiconductors placed between the electrodes to write, store, and reproduce information was suggested in [38]. The image light flux and power supply voltage generate a photoelectret polarization profile in the layer that is retained for up to 150 hours with shorted electrodes. In reading information the optical beam in the absence of power supply voltage produces photodepolarization whose current causes videosignal voltages to appear in the load resistor.

As a rule photoelectrets with long-term polarization storage are not sensitive. A two-layer variant of a converter (Fig. 10) was proposed in [39] to increase the photosensitivity of the image writing process. The increase in sensitivity is due to the high photo-sensitivity of photoconducting layer 1.

An original design of a converter was proposed in [40] (Fig. 16). Photoconductive (1) and photoelectret (2) layers are deposited on flexible tape 3 with a transparent electrode. A corona-emitting electrode 4′ is used to write and a conducting strip 4″ some distance l away

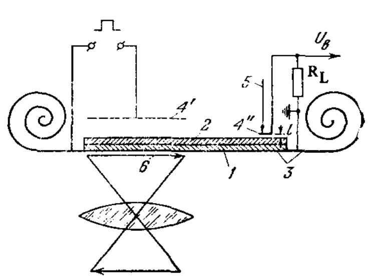


FIG. 16. Schematic diagram of image converter with a tape information carrier.

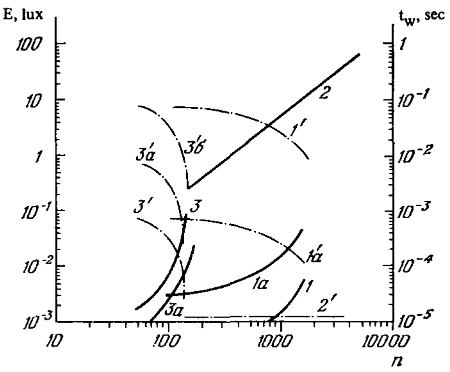


FIG. 17. Sensitivity E (solid lines) and frame write time t_w (dash-dot lines) as functions of the number of lines in conversion based on the method with intermediate information storage. 1—converter with tape information carrier; 2—information stored in ferroelectric layer; 3—information stored in photoelectret layer; 1, 1′—photoconducting layer resistivity of 10^{11} ohm-cm; 1a, 1′a—10^9 ohm-cm; 3, 3′—10^9 ohm-cm; 3a, 3a′—10^{10} ohm-cm; 3b′—10^{11} ohm-cm.

from the surface of layer 2 is used to read. The surface field of the electret profile on layer 2 induces charges in strip 4″. Optical beam 5 photo-depolarizes layer 2 and thus releases some charges that, leaking from strip 4″, cause videosignal current to flow in load resistor R_L. Thus a displacement current is used in the converter to read information. The use of a tape carrier increases the memory volume up to 10^8 bits and higher. In addition the converter can be used in a continuous transmission mode with a negligible delay (the time to write one image frame) by closing the tape carrier on itself (endless tape). The optical scan of course is required only in one dimension.

Figure 17 shows the results of evaluating the imaging parameters for the methods involving intermediate information storage. We note that frame writing time t_w denotes the length of the power supply pulse. The exposure time is significantly longer and equals the inertia of layer-1 photocurrent (Fig. 10). According to Fig. 17 the conversion method based on photoelectret properties and using tape carrier is the most sensitive at a high resolving power.

4. INFORMATIONAL ANALYSIS OF SOLID-STATE IMAGE CONVERSION INTO A VIDEOSIGNAL

Physical analysis of the methods of solid-state scanning allows us to determine their operational capability limits and to perform a comparative analysis of effectiveness from the viewpoint of information theory.

The information supplied to the input of the videosignal sensor can be measured from the relation

$$I_{in}=f_i N_{in}\log_2\left(\frac{\psi}{2\sqrt{2}}+1\right),\ \text{bit/sec}, \tag{1}$$

where f_i is the frequency of conversion of image frames (lines), N_{in} is the number of elements of resolution in a frame (line), and ψ is the signal-to-noise ratio of the image light flux.

$$N_{in}=nN_e, \tag{2}$$

where n is the number of lines and N_l is the resolution along a line determined by the maximum number of image details along the line, whose videosignal carries information concerning one gradation of brightness.[43]

The signal-to-noise ratio is determined by the number of photons incident on the sensitive surface S_e of the image receiver during the observation period:[44]

$$\psi=\sqrt{FS_e/f_i}; \tag{3}$$

F is the photon flow determined by converter sensitivity E.

The image conversion process is accompanied by loss of information expressed by reduced frequency of distinguishable images down to f_{eff} (time losses), reduced number of distinguishable image elements down to N_{eff} (geometric losses), and reduced number of distinguishable degrees of brightness in the reproduced image (contrast losses). Since the parameters of imaging standards were evaluated at a signal-to-noise ratio ψ = 30, the information at the output of the signal transmitter equal to its productivity is expressed by the relation

$$I_{out}=f_{eff}N_{eff}\log_2\left(\frac{30}{2\sqrt{2}}+1\right),\ \text{bit/sec} \tag{4}$$

The values of N_{eff} and N_l obtained from the computation of aperture characteristics of solid state videosignal transmitters[45] are given in the table.

N is the number of resolution elements and n is the number of lines (equal to the number of elements along the line) determined from the 20% dip between videosignal pulses arriving from neighboring bright details of the image with fixed aperture and equal to the number of apertures in a line with shifting aperture.

The effective frequency of image conversion is determined by the number n_1 of lost frames due to photoelectrical and switching inertias of the conversion methods:[30]

$$f_{\ni eff}=f_i/n_1. \tag{5}$$

In image conversion with intermediate storage the input information observation time equals frame write time t_w

$$t_w=1/f_i. \tag{6}$$

The effective frequency of image frame conversion is determined by exposure time t_e:

$$f_{eff}=\frac{1}{t_e}=\frac{1}{t_w+\tau}, \tag{7}$$

Scanning method	N_{eff}	N_e
Suhl effect	$0.2N$	$0.6N$
Carrier profile pulling	$0.95n^2$	$1.28n$
Current line deflection by crossed electric fields	$0.78n^2$	$1.05n$
Shifting aperture without charge accumulation	$1.2n^2$	$1.7n$
Shifting aperture with charge accumulation	$1.2n^2$	$1.8n$

N—number of resolution elements; n—number of lines (equal to the number of elements along a line) determined from a 20% dip between videosignal pulses from neighboring bright image details with fixed aperture and equal to the number of apertures in a line with a shifting aperture.

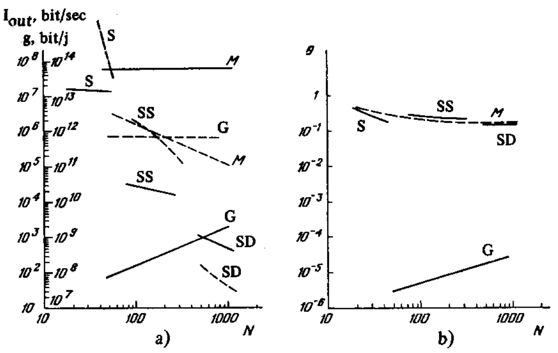


FIG. 18. Productivity I_{out} (solid lines a), informational sensitivity (dashed lines a), and relative sensitivity (b) of solid-state methods of single-line scanning without charge accumulation. Notation the same as in Fig. 8.

where τ is the inertia of the photocurrent of the photoconductive layer.

The most important characteristic of conversion is the informational sensitivity reflecting the energy loss of the image light flux in the transmission of a single bit:

$$g=\frac{I_{out}}{W},\ \text{bit/j} \tag{8}$$

The deviation of the conversion method from the ideal is characterized by the information transmission percentage:

$$\theta=\frac{I_{out}}{I_{in}}. \tag{9}$$

The informational characteristics of the television imaging techniques computed from the above relations and based on data in Figs. 8, 9, 15, and 17, are illustrated in Figs. 18–20.

As seen from Fig. 18, the highest informational sensitivity is obtained with the method based on the Suhl effect (lines S) at low resolution, the method of null voltage boundary scanning with a triode structure (lines SS) at medium resolution, and the method of strong field domain scanning (lines G) at high resolution. As noted above, the last method is the simplest in design and thus should be considered the most promising for single-line scanning without charge accumulation

Among raster scanning methods without charge accumulation (Fig. 19) the highest informational sensitivity is obtained from the single-element method (lines Me) and the strong field domain method (lines G). The single element method based on the use of an optical beam is difficult to use outside the studio. The strong field domain scanning is difficult to accomplish at high resolutions due to the large scattering of the power supply. The solid state dissector analog (lines Ds) is more promising for raster scanning without charge accumulation.

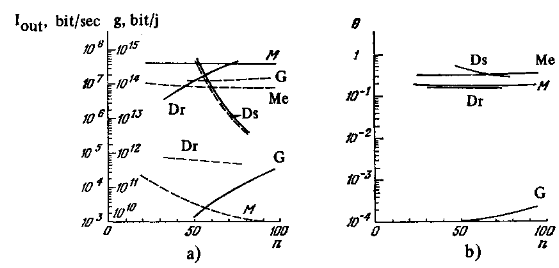


FIG. 19. Productivity I_{out} (solid lines a), informational sensitivity (dashed lines a), and relative sensitivity (b) of roster scanning methods without charge accumulation. Ml–multielement method of scanning with optical beam. Remaining notation the same as in Fig. 9.

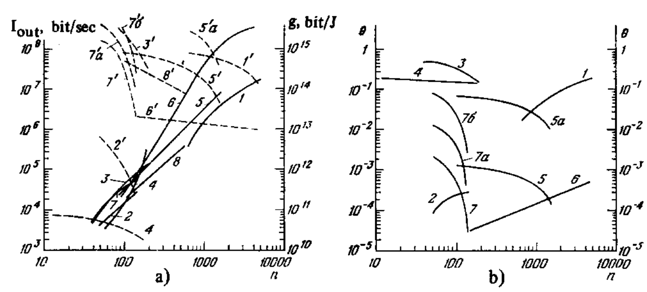


FIG. 20. Productivity I_{out} (solid lines a), informational sensitivity (dashed lines a), and relative sensitivity (b) of solid state imaging methods with charge accumulation. 1–matrix converter; 2–elastic wave pulse switching; 3, 4–optical switching when potential profile is formed by photoconductive and photoelectret properties respectively; 5–information written in the form of photoelectret polarization profile in conjunction with a tape carrier for photoconductive layer resistivity of 10^{11} ohm-cm (5, 5′) and 10^{9} ohm-cm (5a, 5′a); 6–information written and stored in ferroelectric layer; 7–information written and stored in photoelectret layer with photoconductive layer resistivity of 10^{9} ohm-cm (7, 7′), 10^{10} ohm-cm (7a, 7′a), and 10^{11} ohm-cm (7′b); 8–neuristor pulse scanning.

The highest informational sensitivity with charge accumulation (Fig. 20) is obtained with imaging methods using an optical beam (lines 3), electrical timing pulses (lines 1), and neuristor pulses (lines 8) for switching. Neurocons have significant advantages making sweep generators unnecessary and relaxing the technical specifications requirements of the microcircuits. This makes them a logical choice for imaging based on charge accumulation. Among the methods of imaging with intermediate information storage (Fig. 20) the highest informational sensitivity is obtained from the method of writing, storage, and recovery of information based on the use of photoelectret properties in conjunction with a tape carrier (curves 5). This method also yields the largest volume of memory and information storage time.

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