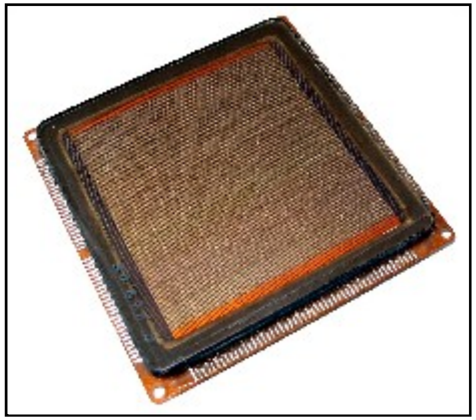
Gas-discharge indicators

(IGPS1-111/7, photo by SLvik)

Plasma TVs are familiar to everyone today. But not everyone knows that this technology appeared long ago, and moreover - displays based on it were produced in the USSR as well!



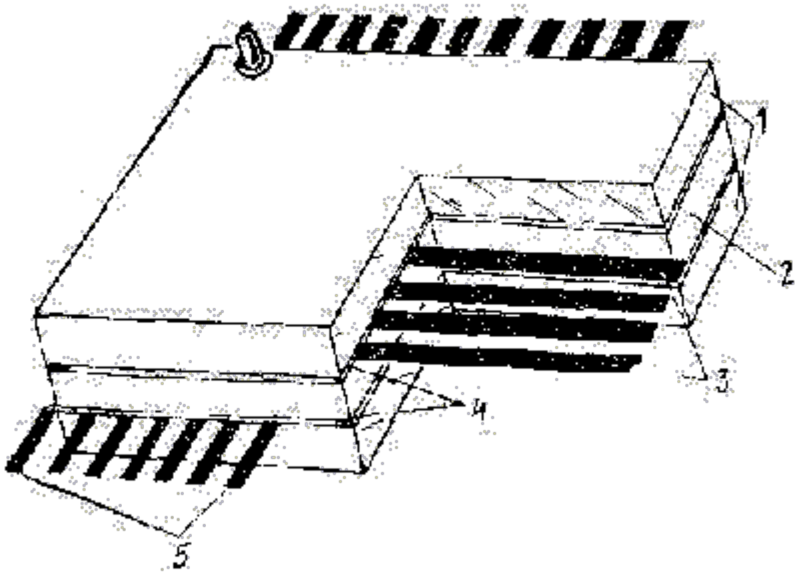
Principle of operation

In gas-discharge indicators, electrical energy is converted into light through emission of excited gas atoms.

Structurally, a gas-discharge graphic indicator consists of two glass plates forming a chamber filled, as a rule, with a neon mixture with other inert gases.

On each glass plate, a set of parallel conductors is placed (anodes on one, cathodes on the other), coated with a transparent dielectric and a protective layer. The plates are arranged so that the cathodes and anodes are perpendicular to each other.

For a certain value of the electric field created in the regions where the electrodes intersect, ionization and glow of the gas occur, electrons and ions move toward opposite electrodes, forming a discharge current. The glowing gas at the points of voltage application creates the points of displayed information.

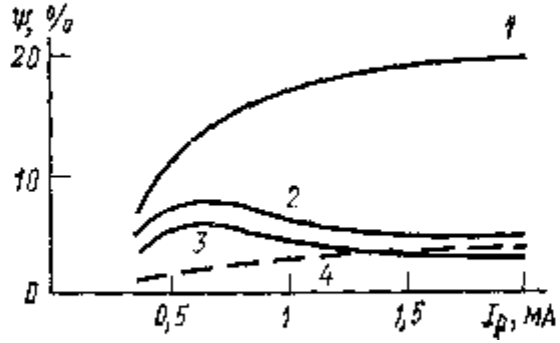


1 - glass plates; 2 - gas gap; 3 - anodes; 4 - protective coating; 5 - cathodes

It should be noted that the design of the light element is a capacitor with a triple dielectric (dielectric coating of the electrode — gas — dielectric coating of the second electrode).

UV emission dependence on discharge current (1-3 positive) column; 4 negative discharge; pressure 133 hPa)

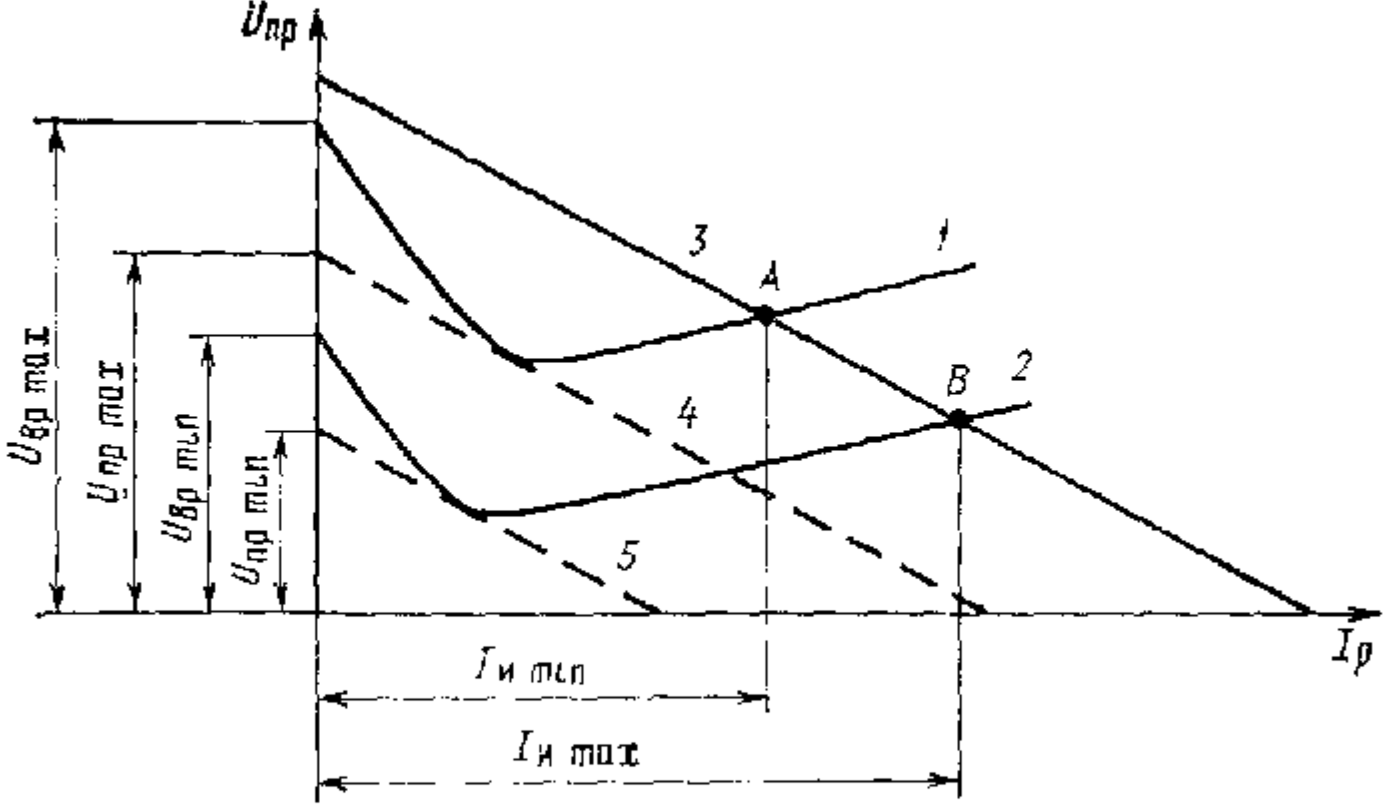
Gas discharge in the cell emits light, the color of which depends on the gas mixture. Neon mixed with an addition of 0.2% xenon gives emission of a negative discharge, the spectrum of which has a maximum at a wavelength of 0.585 nm, as well as a “positive column” with a maximum at a wavelength of 0.64 nm.



1.4 - He=Xe (1%)
2 - Ne=Xe (1%)
3 - Ar=Xe (1%)

In the spectrum of gas discharge radiation there is also a ultraviolet region. This allows excitation of phosphors placed in the discharge zone. In Soviet times, a fairly large number of types of gas discharge indicators with green glow were produced for almost all design solutions (AC and DC). Indicators of other colors of emission were created and developed, including two- and three-color.

Typical volt-ampere characteristic of a DC cell:

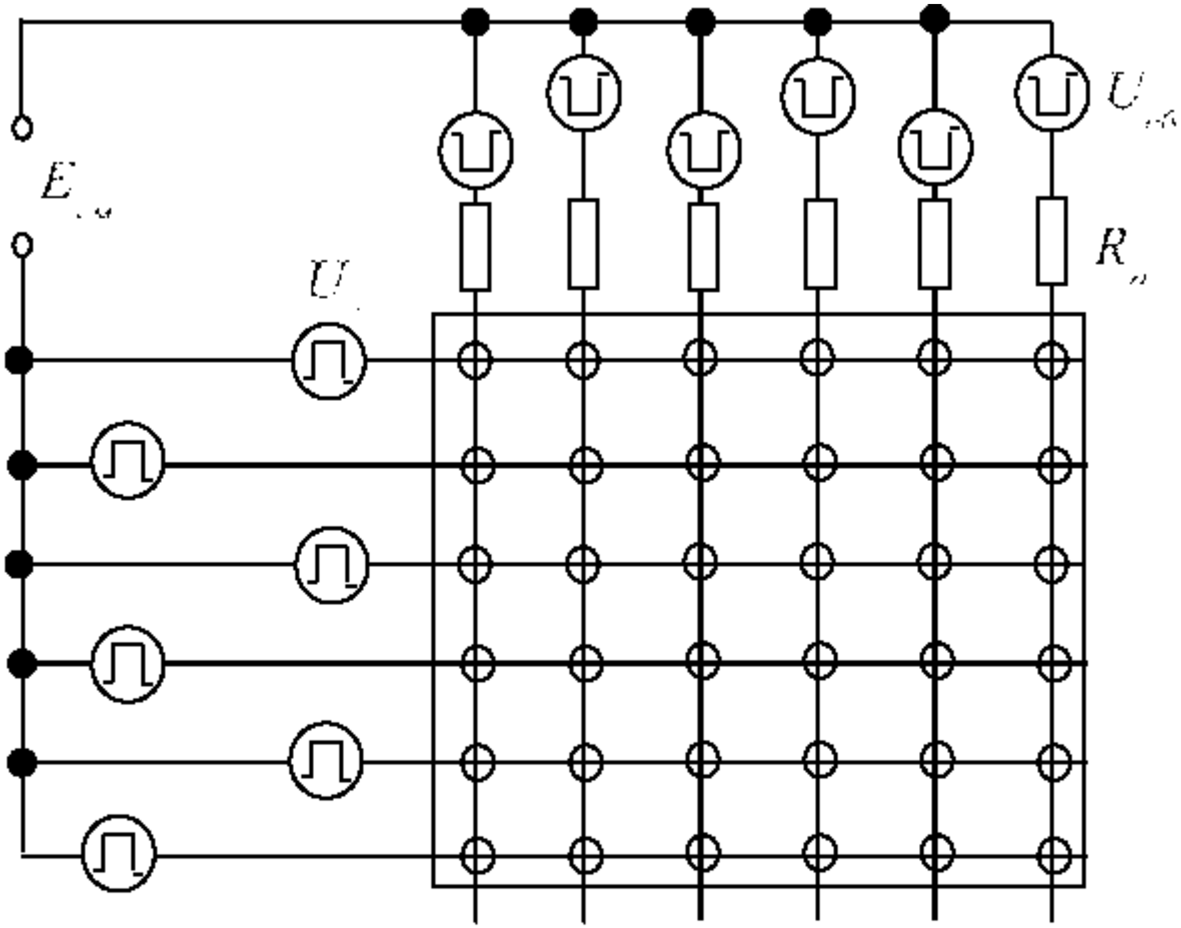


The characteristic has a falling section where the process of forming a spatial positive ion charge near the cathode ends, and a gently rising section of the glow discharge. Load characteristic 3, crossing the family of volt-ampere characteristics 1, 2 at intersection points A and B, shows the minimum and maximum (pulsed) indication current values. When moving the load characteristic parallel to itself downward (which is equivalent to decreasing the applied voltage), it occupies the extreme positions 4 and 5, and the points where it contacts the volt-ampere characteristics determine the regions where discharge ceases. Therefore, when the external voltage is reduced from Uvrmax to Uprmax, all cells will still glow. When the external voltage is reduced to Uprmin, all of them will extinguish.

The brightness of the elementary cell glow is determined not only by the supply voltage and its frequency, but also by the properties of the gas, the dielectric and protective coverings.

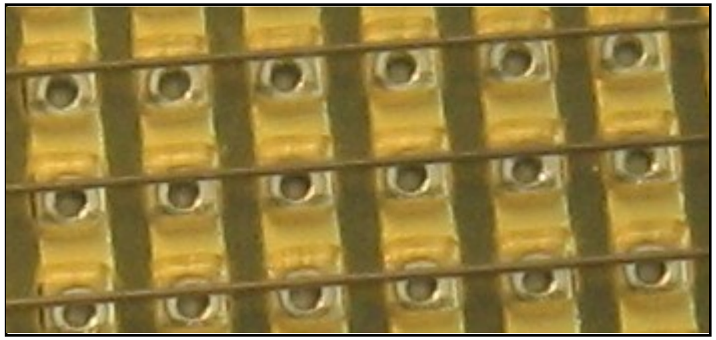
Most gas discharge indicators have a matrix construction. By physical principle, two large groups can be distinguished: alternating current indicators and direct current indicators.

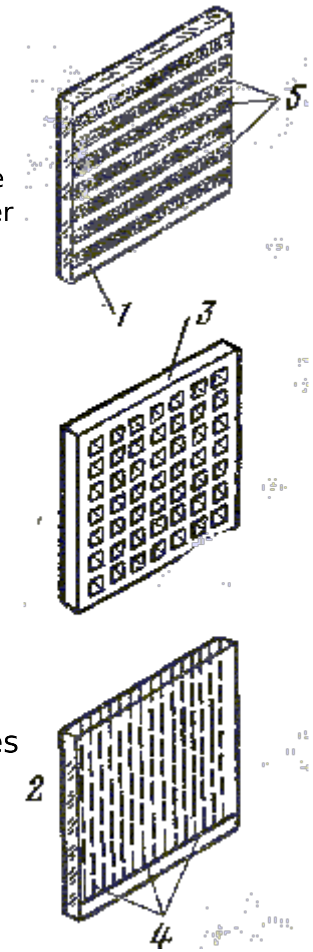
Memory in DC indicators can be implemented by a resistor built into each cell. In practice, DC indicators with external memory (for example, HIP-10000) or external discharge scanning are usually used. They do not have built-in resistors, and the memory is provided by the electrical mode of operation of the switching device.



There are three control modes for them:
- functional, when cells are polled one after another and extinguish with the cessation of polling impulse delivery;
- line-by-line, when the cells of a row (or column) are excited simultaneously with subsequent polling of all rows (or columns);
- functional with simultaneous memorization by switching limiting resistors. The use of this mode is limited, since for the duration of one frame in each row or column only one resistor can be connected. It is mainly used for displaying graphs.

Direct current panels with external addressing consist of two glass plates 1 and 2, separated by a dielectric matrix in the form of a grid 3 with holes. On the inner side of the glass plates are laid mutually perpendicular electrode systems: on one plate — cathodes 4, on the other — anodes 5. Holes in the insulating matrix are located exactly at the intersections of the cathodes and anodes. The internal volume of the device is filled with a mixture of inert gases, and the indicator basically consists of many elementary glow-discharge diodes, the number of which equals the product of the number of cathodes by the number of anodes. Each electrode (cathode or anode) has a separate electrical lead.





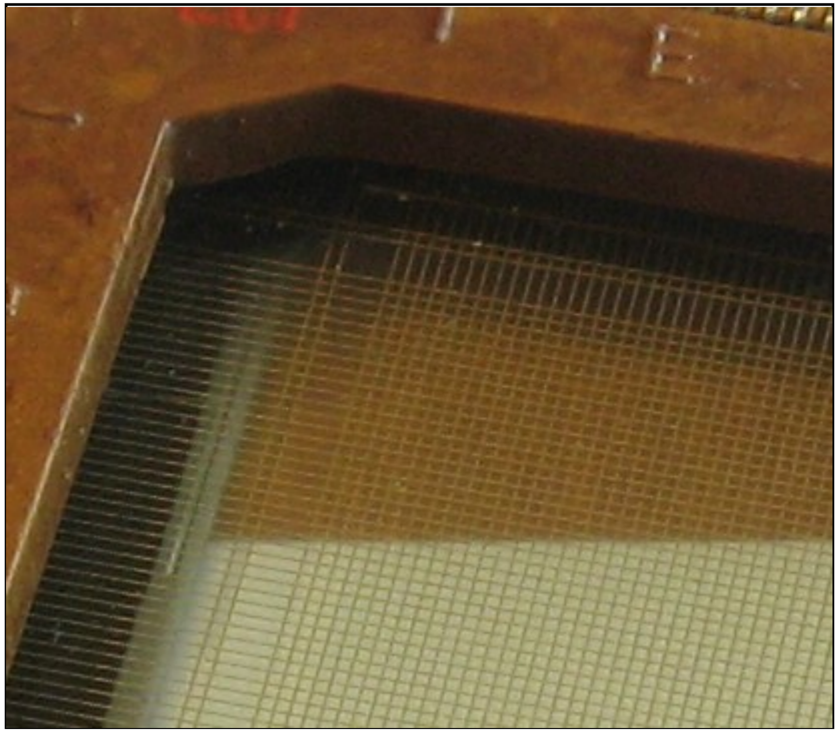
With external switching devices, voltage is applied to those vertical and horizontal electrodes at the intersections where glow discharge is desired, and the combination of glowing dots creates the necessary signs, letters, shapes. When the voltage is removed, the glow discharge ceases.

This construction is the simplest and most widely used in various information display devices, as well as in spectral analyzers, multi-channel measuring devices, chart recorders, and other electronic instruments.

The drawbacks of such indicators include:
- long delay time for the initiation of discharge in individual cells, caused by unequal levels of initial ionization at different points of the indicator field;
- a large number of external switching connections required to control the operation of the GIP;
- a decrease in cell brightness as the number of connected points of the indicator field increases.
However, based on them it is possible to create more efficient color LCDs (ZSI), especially in cases where phosphors excited by ultraviolet light are used.

To reduce the discharge onset time and minimize its deviations at different points of the indicator field, panels create blooming cells of the first cathode form a “mesh” in the form of 10–20 glowing lines arranged along the anodes with a pitch of 5–10 cells. In addition, an extra (above the main voltage) pulse with an amplitude of 50–100 V, duration 10–20 μs can be applied to the first cathode.

Matrix AC indicator (for example, GIP-16384) differs from DC indicators in that the electrodes are in direct contact with the gas medium of the discharge gap.



Two systems of metal electrodes are applied to the inner surface glass plates perpendicular to each other. A gap filled with an inert gas is created between the electrodes using spacers. The electrode surface is covered with a thin dielectric layer, onto which emitting and protective coatings with a high secondary emission coefficient under bombardment by positive ions are applied. The layered coating forms a capacitor structure capable of storing electrical charge. Each column and each row accordingly share the cathode and anode electrodes.

Ballast resistors are connected in series with the anodes. When voltage is applied simultaneously to all cathodes, breakdown can occur only in one low-voltage cell, because due to discharge in this cell the voltage is redistributed between the ballast resistor and the cell’s internal resistance and becomes insufficient to breakdown the other cells of the column.

From the physics of operation of gas discharge AC indicators, it follows that this device has image retention, since in any cell the gas discharge, once initiated by a recording pulse, remains until an erasure pulse is applied or power is turned off.

For matrix AC indicators there are three constructive options for applying the electrode system:
- in the form of thin films;
- by screen printing (thick-film electrode system);
- from molded micro-wire.

Thin-film electrodes are created by vacuum deposition, usually from gold-containing paste, thick-film — in the form of metal tracks using stencil photolithography. In all three constructions, the electrode system is covered with a thin layer of dielectric and a protective film. The dielectric layer (usually made of glass) forms a matrix system of separating capacitors, and the protective layer (magnesium oxide film) prevents sputtering of the surface that is the cathode. It should be noted that it is quite difficult to manufacture matrix indicators where the sizes of indicator elements would be the same. The spread in geometric sizes of the cells is determined by the tolerances of the starting materials, tools, fixtures, and equipment. In turn, the mismatch of constructive cell sizes leads to a spread of the electrical and optoelectronic parameters from cell to cell, from device to device. As the number of elements (cells) increases, solving this problem becomes more complex.

For all alternating current indicator constructions, due to the physical and design features mentioned above, there is a gap between the discharge initiation and the applied discharge pulse (recording). To reduce this time, a frame surrounding the working field of the indicator is introduced into the design. The frame is powered from a separate voltage generator. There is also another way to reduce the discharge delay time — by pre-exciting the cells to a level where their brightness to the eye is practically not noticeable. However, this method is used extremely rarely because of the complex form of supply voltages, strict requirements for voltage tolerances, and deterioration of contrast.

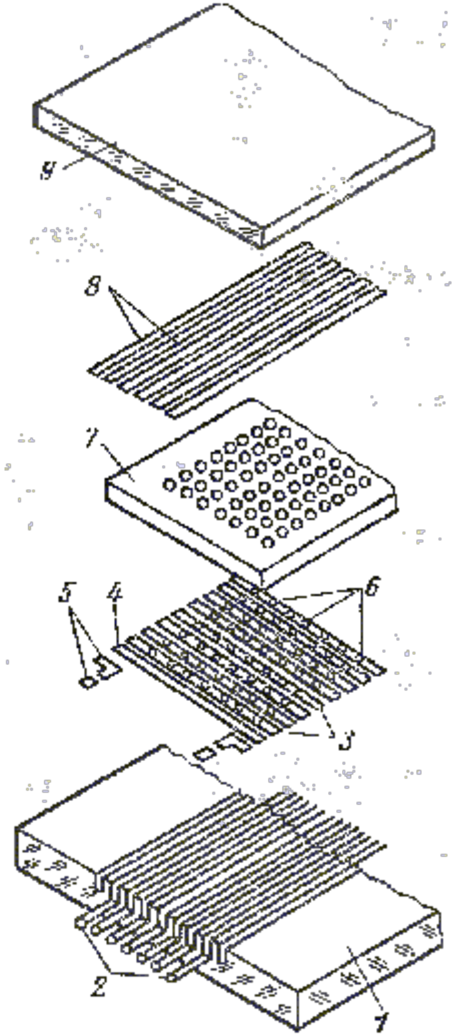
AC panels have a large information capacity; they can be used in modes with internal memory as well as with external storage devices.

Main parameters of gas-filled matrix AC panels:

1. Operating sustain voltage for discharge 90-120 V - minimum drive voltage of the write pulse (usually given at sustain discharge voltage of 170-200 V).
2. Minimum and maximum erase drive pulse values (usually given at sustain discharge voltage 80-100 V).

3. Front duration 0.1-0.3 µs; write pulse duration 3-5 µs.
4. Sustain discharge voltage pulse duration 4-6 µs.
5. Sustain discharge voltage pulse repetition frequency 25-55 kHz.

The operating principle of self-scanned gas-discharge indicators (e.g., IGPS1-222/7) is similar to decatrons.

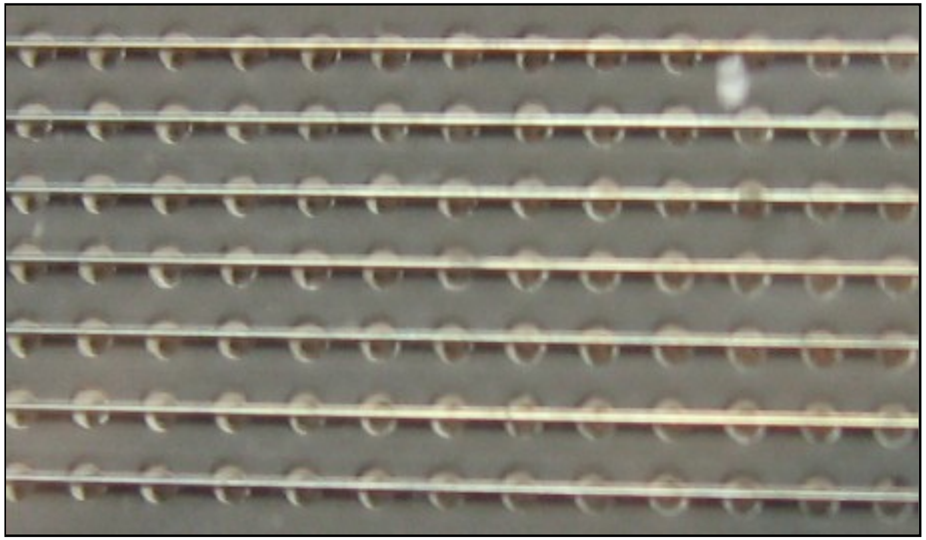


The indicator contains an auxiliary electrode system intended to create and sequentially move the auxiliary discharge along the indicator gaps. On the glass plate 1, scanning anodes 2 are arranged. Scanning cathodes 3 are located perpendicular to the anodes; in the same plane, a reset cathode 4 and two pairs of standby-discharge electrodes 5 are arranged. In the scanning cathodes, holes 6 with a diameter of 0,05—0,08 mm are made, positioned along the axes of the scanning anodes. Above the cathodes there is a dielectric matrix 7, whose holes are coaxial with

with the holes in the cathodes. On top of the matrix, above the holes, indication anodes 8 are placed,

made in the form of wire or film electrodes, parallel to the scanning anodes. On top

the panel is covered with a front glass 9.

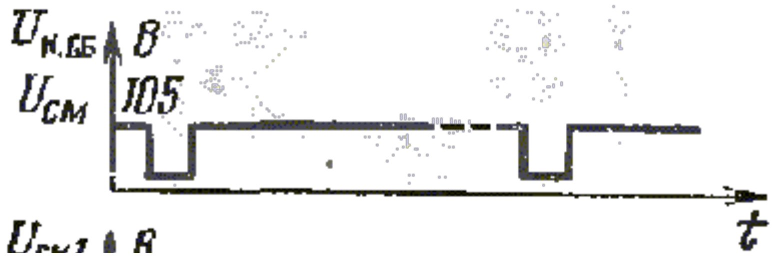


The scanning cathodes are electrically combined into several groups (three or more) and arranged in the following order: the cathode of the 1st group, next to it the cathode of the 2nd group, then the cathode of the 3rd group, and then again the cathode

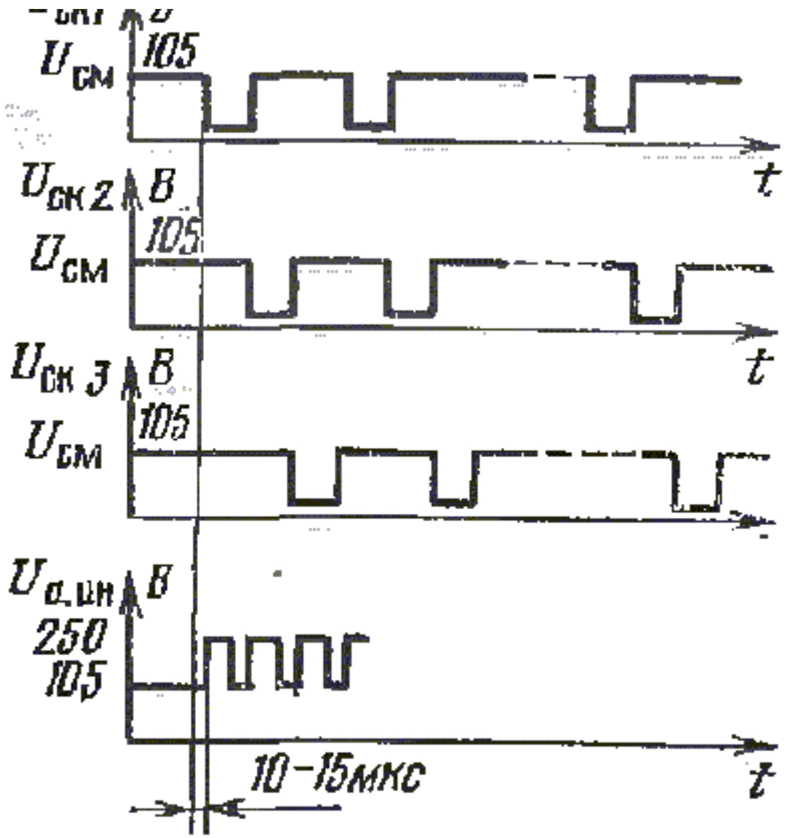
of the 1st group, etc.

The sequence of applying control voltages to the electrodes is shown in the figure.

The control circuit generates pulses in the cathode circuits Uск1, Uск2, Uск3 and the reset pulse UкСБ.



When the power supply is turned on and there are no voltage pulses, discharge occurs only at the standby electrodes, creating a zone of initial ionization that also covers the reset cathode of the KsB nearby. Then the control circuit with three stable states applies a pulse UkSB to the reset cathode, where a discharge arises, ionizing the zone adjacent to the nearest cathode of group 1. After the reset pulse passes, its discharge stops, but a pulse is immediately applied to the scanning cathodes of group 1 and the discharge moves to the adjacent cathode K1-1. After this pulse ends, a pulse is applied to the cathodes of group 2 Uk2. The discharge moves to the neighboring K2-1, and so on.



Thus, under the action of the pulses, the discharge sequentially moves in a fixed direction along the anode, i.e., a scan of the discharge occurs. After the discharge reaches the last electrode of the row, a reset pulse is applied, and the scanning cycle repeats.

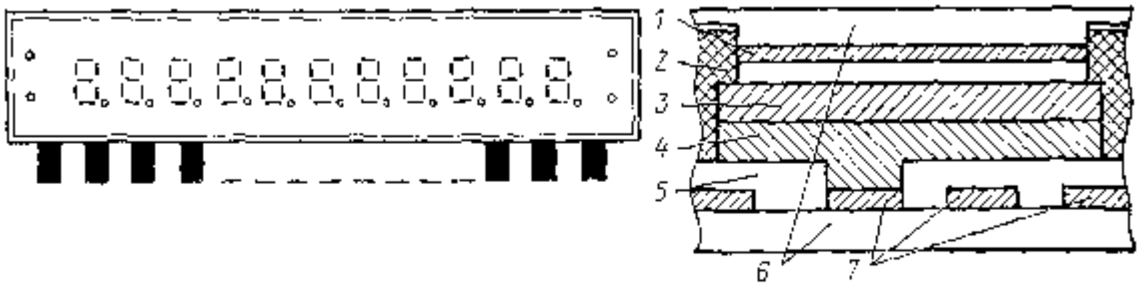
The scanning discharge is auxiliary and intended for preliminary ionization of the main gap between the indication cathodes and anodes. The glow of the scanning discharge is practically invisible from the front glass, as the holes in the cathodes are very small.

To create a visible image, it is necessary to ignite the discharge in the main

To create a visible image, it is necessary to ignite the discharge in the main gap. At certain moments, voltage pulses are applied to the indication anode, and the discharge occurs in the cell where the scanning discharge currently exists. The indication anodes are parallel to the scanning anodes; to avoid arbitrary movement of the discharge along the indication anode, a resistor Ra is included in the anode circuit. When a discharge occurs and the current in the indication anode circuit increases, the voltage drop across this resistor increases and the anode voltage becomes lower than the voltage required to initiate discharge in other gaps. In addition, to reliably ignite only the required cell, sufficient ionization of exactly this discharge gap must be ensured with the help of the scanning discharge. The diffusion time of the ions of the scanning discharge into the indication cell is relatively long, therefore the pulses to the indication anode are applied with a delay of several microseconds relative to the pulses to the corresponding scanning cathode. The duration of the pulses is chosen so that their fall times coincide. Since the resistors are in the circuit of each indication and scanning anode, in each row of the indicator there can exist independent scanning and indicator discharges, so information can be entered in parallel across the entire indicator field. When voltages are removed from the indication anodes, the discharge glow stops, therefore external memory devices are required for panels of this type.

Self-scanning DC gas-discharge indicators are used to display only character information.

In indicator equipment, single-digit and multi-digit (for example, GIP-11) digital indicators are also used. Since the former are part of the latter, let’s consider the structural design of a multi-digit digital indicator.



1 - transparent anode; 2 - black dielectric mask; 3 - protective coating of the cathodes; 4 - cathode segments; 5 - dielectric film; 6 - glass plates; 7 - cathode leads

Structurally, the cathode segments are arranged as a standard seven-segment “eight,” forming a character position, above which a single anode is placed. Since the supply of multi-digit digital indicators is pulsed, the leads are connected as follows: each of the seven cathode segments is connected to the corresponding one of all digits; the cathodes of identical segments are combined by one lead; each anode has its own individual lead.

The control principle for such a device is as follows. Suppose signals about the digit of the first position have been applied to the decoder. The source voltage is applied to the cathode segments selected according to the decoder code. At the same time, the anode of the first position is connected to the +Ua source, while the other anodes (of all other positions) are at zero potential during this time. Between the anode and the selected cathodes of the first position, a potential difference is established that ensures the occurrence of a glow discharge. Thus, the digit of the first position is illuminated. Similarly, the required digit of the second and any other position is displayed.

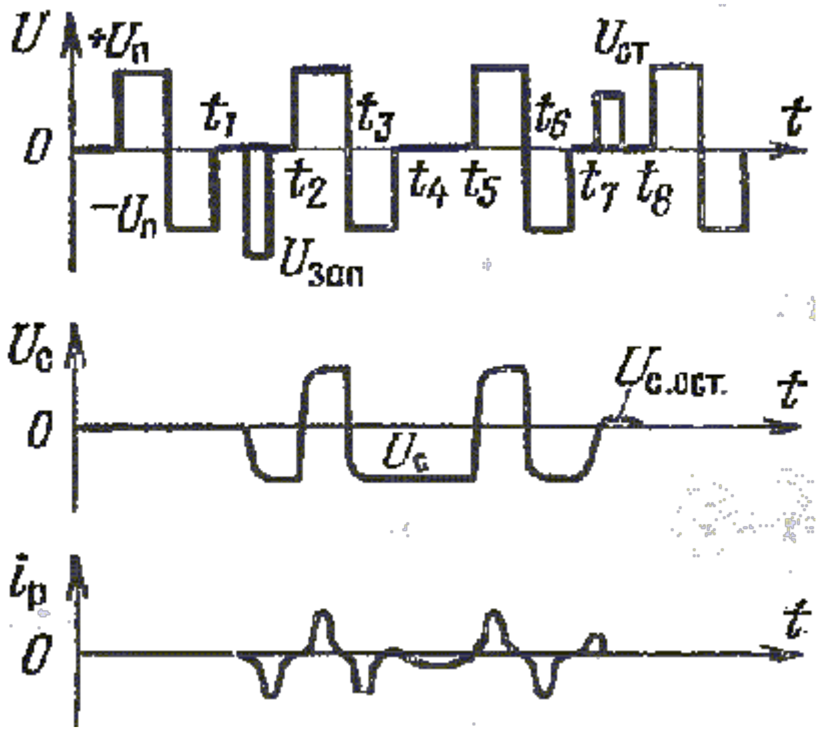
Because the pulse repetition frequency of the supply voltage is 100—700 Hz, there is no flicker in the images. They are perceived as shining almost continuously.

Control of the segment panels is carried out using external devices.

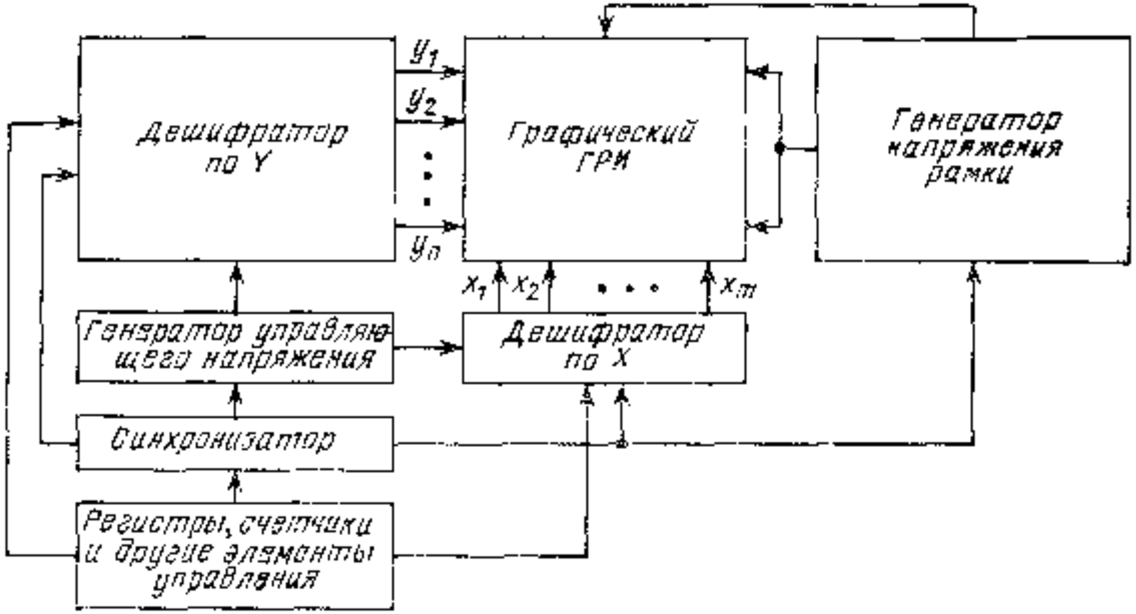
Due to the property of maintaining a glowing discharge, AC indicators are the simplest in the control principle.

An impulse maintenance voltage is applied to all indicator cells, the amplitude of which is not sufficient to ignite any cell, but sufficient to maintain in an ignited state a previously occurred discharge. The discharge in the selected cell occurs due to applying a write pulse to it and is then stored in the cell until a erase pulse arrives. After the cell is erased, the discharge will not occur again until a new write pulse is applied.

It has been established that signals of rectangular shape with front durations around 1 μs best satisfy the discharge maintenance requirements. For writing (erasing) the corresponding cells, half-amplitude pulses are used, applied at the appropriate times to the selected cell in synchronization with the maintenance discharge voltage.



Structural diagram for selecting the required cells.



Through decoders, a maintaining voltage of discharge of opposite polarity with a clock frequency defined by the sync generator is applied to the indicator. For the matrix elements chosen according to the code, a write or erase voltage of reverse polarity is applied. Relative to a cell, these voltages are summed by their absolute value, resulting in the full maintaining voltage of discharge Uпр and the corresponding write or erase voltage.

The greatest application in indicator technology (mainly in displays and various kinds of terminals) was found for matrix indicators. DC matrix indicators are used in dot-matrix screens and public scoreboards, while multi-digit digital indicators are used in control and measurement equipment.

Gas-discharge indicators have been created in both monochrome and multicolor, emitting in the following colors: orange, reddish-orange, green, red, blue, yellow. The main colors are achieved by introducing a phosphor into the design that is excited by UV radiation from the gas discharge.

An alternating-current matrix indicator operating at a single frequency and fixed amplitude of the sustaining voltage has only two brightness levels. Using a more complex shape of the sustaining voltage can yield a greater number of brightness levels. For example, by varying the signal duration, a scale of up to 64 brightness levels is obtained, while the range of drive voltages is practically preserved.

Early designations of gas-discharge indicators were not systematized, and the designation of each instrument was deciphered according to its own rules.
For example:
IMG-1 - (I)ndicator (M)odule (G)as-discharge, 1st development
GIP-10000 - (G)as-discharge (I)ndicator (P)anel, total capacity 10000 cells
IGPP-100/100 - (I)ndicator (G)as-discharge (P)anel (P)ermanent current, 100 columns * 100 rows
GIPS-32 - (G)as-discharge (I)ndicator (P)anel with (S)amoscanning, 32 symbols
IGPS1-222/7 - (I)ndicator (G)as-discharge (P)anel with (S)amoscanning, 1st modification, 222 columns * 7 rows

In 1982 a unified system of conditional designations for indicators of all types was adopted. According to it:

- the first element - the letter I - denotes the instrument's belonging to indicators
- the second element - the letter indicating the type of indicator; for gas-discharge, this is G
- the third element - the letter indicating the type of displayed information (D - unit; C - digital; V - alphanumeric; T - scale; M - mnemonic; G - graphical)
- the fourth element - development sequential number (without built-in control circuit 1...69, with built-in control 70...99)
- the fifth element - a letter indicating parameter breakdown for indicators of the same type; unused for gas-discharge indicators
- sixth element (for multi-digit indicators) - numbers indicating the quantitative characteristic of the information field. For sign-synthesizing indicators - a fraction, numerator is the number of digits, denominator is the number of segments. For matrix sign-synthesizing indicators - a fraction, numerator is the number of digits, denominator is the product of the number of elements in a row and the number of elements in a column. For matrix graphical indicators - the product of the number of elements in a row and the number of elements in a column. For mnemonic and scale indicators - the number of elements.
- seventh element - the letter indicating the emission color: K - red; L - green; C - blue; J - yellow; R - orange; G - blue; M - multicolor; U - ultraviolet emission. In gas-discharge indicators this element is generally used only for single-digit indicators.
- eighth element - a digit indicating the type of construction for bare instruments. Not used for gas-discharge indicators.

Example of a device labeled according to this system - IGV70-16/5x7.

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