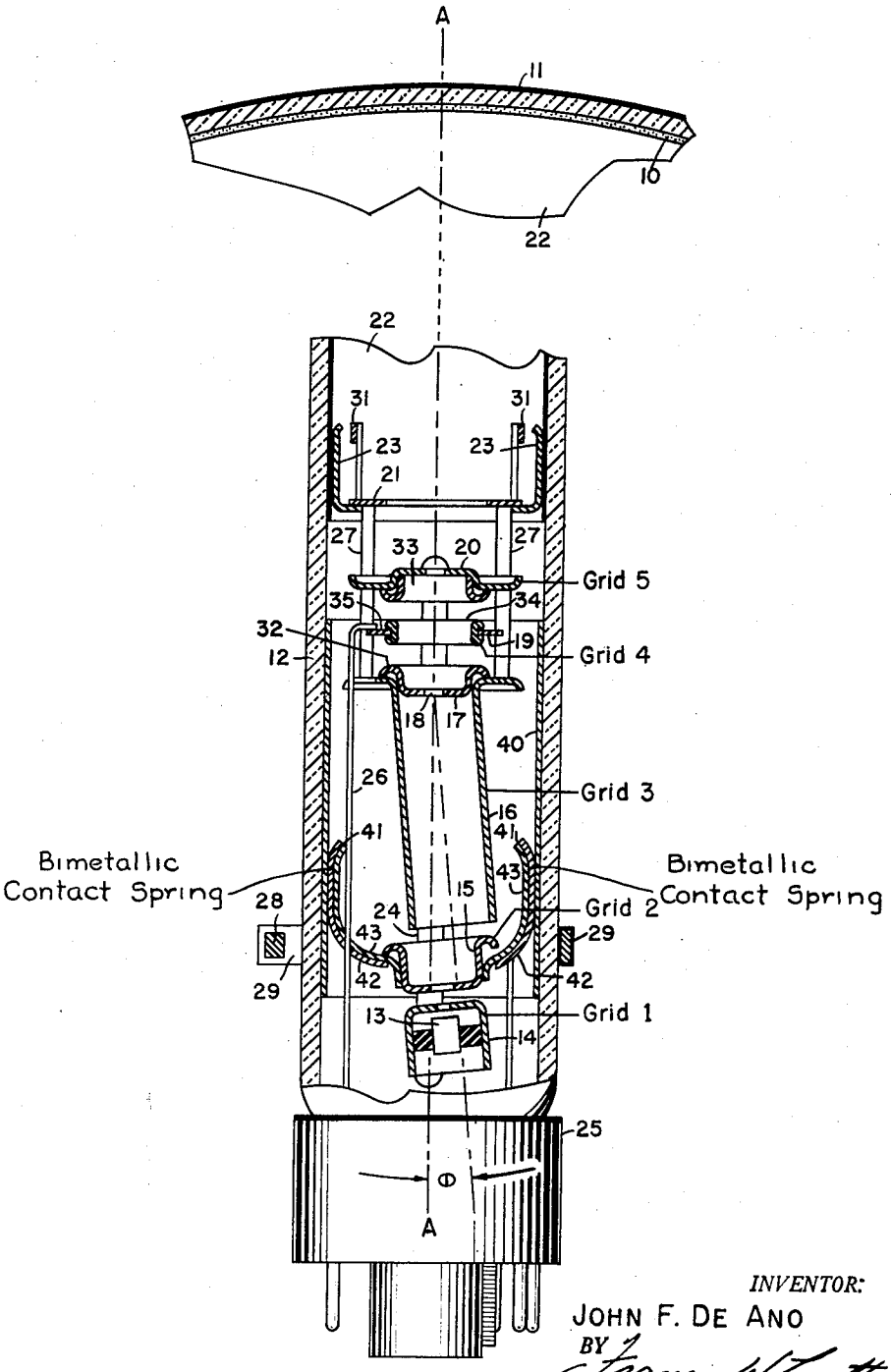
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IMAGE-REPRODUCING DEVICE

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IMAGE-REPRODUCING DEVICE

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2 Claims. (Cl. 313—82)

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This invention relates to image-reproducing devices and more particularly to cathode-ray tubes for use as picture-reproducing devices in television receivers and the like.

One of the problems often encountered in the production of television receivers stems from the susceptibility of commonly employed cathode-ray tube constructions to exhibit extraneous cold emission and spark discharge in the electrode system. Whenever two closely spaced electrodes are maintained at large potential differences, these undesirable phenomena are apt to be encountered. For example, most electron guns comprise a cathode, a control grid, a so-called second grid which is maintained at a low constant positive potential with respect to the cathode, and a tubular anode closely spaced from the second grid and maintained at a much higher positive potential. Due to the large potential difference and the close spacing between the tubular anode and the second grid, cold emission and spark discharge may lead to a condition commonly referred to as "popover" which is manifested by a momentary loss of brightness or a "tearing out" of minor portions of the reproduced image. The problem is further aggravated in the case of electrostatically focused cathode-ray tubes employing unipotential focusing lens systems, particularly in the case of such systems wherein the focusing electrode is maintained at or near cathode potential, due to the extremely high voltage gradients between the focusing electrode and the other two elements of the focusing lens.

In the copending application of Russel S. Peterman, Serial No. 257,692, filed November 23, 1951, for "Image-Reproducing Device" and assigned to the present assignee, there is disclosed and claimed an image-reproducing device in which the problem of cold emission and spark discharge in the electrode system is effectively overcome by providing a conductive coating, separate from the final anode coating, on the inner wall of the neck portion of the envelope at least partially encompassing the electron gun. To inhibit cold emission and spark discharge, this auxiliary conductive coating is preferably maintained at a low positive operating potential with respect to the cathode, as by direct connection to the first accelerating electrode known as the second grid. To minimize the number of external connections to be brought through the tube base, it is preferred that this connection be made internally of the envelope by means of contact springs fixed to the second grid and adapted to

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bear outwardly against the auxiliary conductive coating. In practice, considerable difficulty has been encountered in a construction of this type, for the reason that during the sealing-in process when the gun assembly is fused to the neck portion of the envelope, the metal contact springs are heated appreciably above ambient or room temperature while the glass envelope, being a much better insulator, remains at a much lower temperature. This has been found to result in a troublesome tendency toward breakage of the envelope in the region where the contact springs bear on the auxiliary coating.

Difficulties of a practical nature have also been encountered during the outgassing operation when the gun is subjected to a radio-frequency induction heating field as the envelope is being evacuated. Localized stresses are also produced during this operation, with a further tendency toward breakage of the envelope. Moreover, it has been found that with a construction of the type described in the above-identified Peterman application, successful outgassing of the gun electrodes has been exceedingly difficult to accomplish when more than one contact spring is employed to establish the electrical connection between the second grid and the auxiliary coating. While a single contact spring is adequate to establish the desired electrical connection, the use of plural springs is desirable for reasons which are well known in the art.

It is an important object of the present invention to provide a new and improved image-reproducing device of the type disclosed and claimed in the above-identified Peterman application in which breakage of the envelopes during the sealing-in process is effectively avoided.

Another object of the invention is to provide a new and improved image-reproducing device, comprising an auxiliary conductive coating on the inner wall of the neck as disclosed and claimed in the above-identified Peterman application, in which plural contact springs may be employed to establish the desired electrical connection with the auxiliary coating while at the same time permitting successful outgassing of the gun electrodes with conventional radio-frequency induction heating methods.

It is a further object of the invention to provide a new and improved device for establishing and maintaining electrical contact between an electrode of a cathode-ray tube and a conductive coating on the inner wall of the tube envelope.

In accordance with the present invention, a new and improved electron-discharge device such

as a cathode-ray tube or the like comprises an evacuated envelope, an electrode within the envelope, and a conductive coating on the inner wall of the envelope. An electrically conductive bimetallic contact member is fixed to the electrode and adapted to make electrical contact with the conductive coating under predetermined ambient temperature conditions such as those encountered in normal operation of the device. With an arrangement of this type, a predetermined change in the ambient temperature conditions, such as that which may be effected during the sealing-in process, results in a withdrawal of the contact member from mechanical and electrical contact with the conductive coating, so that breakage of the envelope is effectively avoided.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may best be understood, however, by reference to the following description taken in connection with the accompanying drawing, in which the single figure is a fragmentary side elevation, partly in cross-section and partly cut away, of an image-reproducing device constructed in accordance with the present invention.

The image-reproducing device of the figure comprises a fluorescent screen 10 affixed to the glass target portion 11 of a cathode-ray tube envelope which also comprises a glass neck portion 12 enclosing an electron gun and an electrostatic focusing system. The electron gun comprises a cathode 13, a control electrode 14, and first and second tubular accelerating electrodes 15 and 16 respectively. A diaphragm 17 having a central aperture 18 is disposed across the outlet end of second accelerating electrode 16, and aperture 18 is symmetrically centered with respect to the tube axis A—A perpendicular to the center of the fluorescent screen 10. Second accelerating electrode 16 is laterally offset from first accelerating electrode 15 to provide a steady transverse electrostatic-deflection field component in the region between these two electrodes, and the entire electron gun structure is tilted with respect to the tube axis A—A by the angle θ.

An electrostatic focusing system of the unipotential lens type is disposed between the electron gun and the fluorescent screen. The focusing system comprises the outlet end of second accelerating electrode 16 including diaphragm 17, a lens electrode 19, and an additional electrode 20 which are all coaxially mounted with respect to the tube axis A—A. A centrally apertured conductive disc 21 is disposed in the neck portion of the envelope between the focusing system and target portion 11. A conductive coating 22, of colloidal graphite such as aquadag or the like extends from the direction of target portion 11 into the neck portion of the envelope, and conductive disc 21 is maintained at a common potential with conductive coating 22 by means of metal contact springs 23.

For convenience, electrodes 14, 15, 16, 19 and 20 may be termed "grids" and may be designated by number starting with control electrode 14 as the first grid and progressing in the direction of beam travel to additional electrode 20 which is the fifth grid. All five grids are supported in predetermined mutually spaced relation by means of a pair of glass pillars 24, of which only one is shown, in a manner which will be apparent to

those skilled in the art. Separate leads for grids 1, 2 and 4 extend through the base 25 of the tube, as do the supply leads for the cathode 13 and its associated heater element (not shown). Lead 26 from grid 4 through the base of the tube may be provided with an insulating glass bead (not shown) to inhibit spark discharge to electrode 16. Conductive disc 21 is mechanically supported from and electrically connected to grids 3 and 5 by means of metal connecting strips 27. Operating potential for the conductive coating 22, and therefore for the third and fifth grids, may be supplied by means of a conventional contact button if the envelope is of the all glass type, or directly to the metal cone member if the tube is of the glass-metal variety.

An external permanent magnet 28, supported in a spring clamp 29 which fits snugly around the neck of the tube and is movable both axially and rotationally, is provided to develop a magnetic field within the tube to provide separation of the negative ions from the electron beam.

The tube is evacuated, sealed and based in accordance with well known procedures which require no further explanation, and suitable getters 31 are supported from the surface of conductive disc 21 facing fluorescent screen 10 to absorb residual gases after evacuation.

In operation, a mixed beam of electrons and negative ions originating at cathode 13 is projected through the aperture in second grid 15. When the mixed beam emerges from grid 2, it encounters an electrostatic field having a transverse component due to the lateral offset of grid 3 with respect to grid 2. Consequently, electrons and ions are both deflected to the left in the view of the figure. The magnetic field imposed by beam-bender magnet 28 serves to deflect the electrons to the right as viewed in the figure without substantially affecting the path taken by the negative ions. Thus, when beam-bender magnet 28 is accurately adjusted, the beam of electrons is projected centrally through aperture 18 of diaphragm 17 in a direction along the tube axis A—A, while the negative ions are intercepted by the metallic portions of grid 3 and diaphragm 17. The ion-trap mechanism is disclosed and claimed in the copending application of Willis E. Phillips et al., Serial No. 156,746, filed April 19, 1950, now Patent No. 2,596,508, issued May 13, 1952, for "Electron Gun for Cathode-Ray Tubes," and assigned to the present assignee.

The axially directed electron beam is subjected to the focusing action of the electrostatic fields produced by diaphragm 17, lens electrode 19 and the fifth grid 20 which together constitute a unipotential electrostatic focusing lens system. The general construction and operation of lenses of this type are well understood by those skilled in the art as indicated by an article entitled "Measured properties of strong 'unipotential' electron lenses" by G. Liebmann, Proceedings of the Physical Society, Section B, volume 62, Part 4, pages 213–228 (April 1, 1949).

The required operating potential difference between the lens electrode (grid 4) and the other electrodes of the focusing system (grids 3 and 5) is determined by the dimensions of and the spacing between the electrodes constituting the unipotential lens. Although the relationships are not necessarily linear, the required focusing potential difference varies directly with the length and inversely with the diameter of grid 4, and inversely with the separation between grid 4 and grids 3 and 5. Certain limitations on these

parameters are imposed by practical considerations; if the diameter of grid 4 is made too small, excessive spherical aberration is encountered, and if the separation between grids 3 and 4 is made too great, the deflecting influence exerted by the asymmetrical electrostatic field established between lead wire 26 and grid 3 becomes objectionable. The focusing system is preferably constructed and arranged to obtain focusing with grid 4 operated at or near cathode potential, in order to avoid the necessity of providing a source of operating potential intermediate the B-supply voltage and the final anode voltage.

In order to obtain satisfactory focusing with grid 4 operated at a potential between cathode potential and the B-supply voltage, it is necessary to maintain rather stringent manufacturing tolerances with respect to the dimensions and spacings of the several electrodes constituting the focusing system. In addition, when grid 4 is operated at a potential substantially equal to that of the cathode, extremely high voltage gradients are produced between grid 4 and grids 3 and 5. In order to suppress undesirable corona effects and field emission, grids 3 and 5 are each provided with corona rings 32 and 33 in the form of rolled flanges of stainless steel or the like which are welded or otherwise secured to the respective electrodes, and grid 4 is constructed by rolling the two ends of a metal cylinder 34 over the edge of a large aperture in a metal disc 35.

Corona rings 32 and 33 also perform an additional function in facilitating the maintenance of the required close manufacturing tolerances by mechanically reinforcing the circular flanges to which they are attached against warping or bending during the assembly of the electrode system. The electrodes are assembled by means of accurately constructed jigs and are all rigidly supported by means of opposed common glass pillars 24, the gun assembly being properly oriented in the tube neck by means of other jigs in the usual manner. It has been found that these precautions suffice to insure satisfactory operation of the completed structure, any small deviations in dimensions and spacings being readily compensated by adjustment of the ion-trap magnet 28.

For best results, it has been found that the apertures in grids 1, 2, 3 and 5 should be in marginally overlapping alignment in a direction parallel to the tube axis A—A. In other words, all of these apertures should intercept an imaginary straight line parallel to reference axis A—A, and the apertures in grids 1 and 2 should intercept that line asymmetrically. Fulfillment of this condition is dependent upon the angle θ by which the entire electron gun is tilted with respect to the tube axis, and also upon the length of the electron gun from the cathode to aperture 18 in diaphragm 17. If the angle θ and/or the length of the gun is increased to such an extent that the apertures in grids 1, 2, 3 and 5 are no longer in marginally overlapping alignment in a direction parallel to the tube axis, increased multiplicity of focus is encountered, and the performance of the focusing system is inferior. On the other hand, if the angle θ is decreased so that the apertures are in complete coaxial alignment, ion trapping may no longer be conveniently accomplished.

By employing a separate conductive disc 21 for establishing electrical contact to conductive coating 22, and by terminating conductive coating 22 at substantially the plane of the conductive

disc 21, high potential gradients and undesirable spark discharge between the low-potential lens electrode 19 and the high-potential conductive coating 22 are substantially avoided. Moreover, even though this construction results in a space between grid 5 and conductive disc 21 in which the boundary potentials are not definitely established, no observable distortion or defocusing of the beam is encountered. The size of the aperture in conductive disc 21 is not critical but should be large with respect to the apertures in grids 3 and 5.

Moreover, conductive disc 21 serves as an effective getter shield to avoid conductive deposits on glass support pillars 24 when the getter 31 is flashed during the processing of the tube. In this manner, excessively high potential gradients along the insulating pillars and possible insulator breakdown are substantially avoided.

Due to the close spacings and the high potential differences between grids 2 and 3 and between grid 4 and grids 3 and 5, undesirable cold emission and spark discharge between these electrodes may be encountered. This undesirable situation may be avoided by observing every precaution to insure that the glass envelope and all of the electrodes are kept clean and free from grease or other organic matter, and by avoiding sharp edges on the closely spaced opposing portions of the several electrodes. Moreover, it has been found in practice, particularly in the production of electrostatically focused picture tubes embodying unipotential focusing lens systems, that the requisite degree of cleanliness cannot be effectively maintained by the use of commercially feasible production methods.

As disclosed and claimed in the above-identified Peterman application, undesirable cold emission and spark discharge in the electrode system are effectively inhibited by providing a second conductive coating 40, separate from the conductive coating 22 which is connected to grids 3 and 5 and maintained at high potential, within the glass neck portion of the envelope in a position at least partially encompassing the tubular electrodes 15 and 16 of the electron gun. Conductive coating 40 is maintained at a constant low positive potential with respect to cathode 13, preferably by means of contact springs 41 connected to the second grid 15. It has been found that a cathode-ray tube constructed in this manner may be operated with final anode voltages considerably in excess of those required in actual use of the tube in a television receiver or the like without encountering spark discharge or "popover" in the electrode system.

The technical reasons underlying the success of the illustrated construction are not fully understood. One theory which seems in agreement with numerous observations is predicated on the hypothesis that cold emission and spark discharge are only encountered, at normal operating voltages, in the presence of extraneous gas molecules. In a conventional image-reproducing device not provided with the conductive coating 40 of the present invention, primary or secondary electron bombardment of the glass neck portion of the envelope is thought to result in the liberation of occluded gases from grease, dirt, or other extraneous organic matter which may be present. These gas molecules then become ionized and are caused to bombard the gun electrodes, leading to cold emission which ultimately results in spark discharge. This theory is supported by the observation that troublesome spark discharge generally

takes place along the glass wall of the envelope in the first instance and only later across the shorter intervening space between the gun electrodes. By providing internal conductive coating 40, and by maintaining that coating at a low constant positive potential by means of contact springs 41 connected to second grid 15, gas liberation is avoided for two reasons. In the first place, coating 40 acts as a physical barrier between the offending primary and/or secondary electrons and the glass wall of the envelope, thus rendering extraneous grease or dirt on the glass wall inaccessible. In the second place, such stray electrons as reach the wall of the tube are collected by coating 40 and conducted off through the external circuit associated with the second grid.

Coating 40 may be formed of silver paint or any other conductive material which is amenable to application in the form of an internal coating. The length of coating 40 is not critical, although it is essential that the tubular gun electrodes be at least partially encompassed by the coating, and that coating 40 be maintained physically and electrically separate from the final anode coating 22.

In practice, considerable difficulty has been encountered during the process of sealing the electron gun into the neck portion of the envelope, due to stresses caused by unequal heating of the glass neck and the metal contact members 41. In accordance with the present invention, this difficulty is effectively avoided by constructing contact members 41 of bimetallic strip material. To this end, contact springs 41 are of bilaminar construction each comprising an outer strip 42 of material having a predetermined temperature coefficient of expansion and an inner strip 43 of different material having a predetermined, lower, temperature coefficient of expansion. With this construction, during the sealing-in process when the gun assembly is fused to the neck portion of the envelope, contact springs 41 are heated considerably above normal room temperature. Both the inner and outer strips 42 and 43 are thereby caused to expand, but the inner strips 43, having a lower temperature coefficient of expansion than the outer strips 42, expand to a lesser extent. As a result, contact springs 41 are retracted inwardly toward the gun assembly and are withdrawn from contact with conductive coating 40. On cooling, after the sealing-in process has been completed, and in subsequent operation, contact springs 41 resume their original shape and are caused by virtue of their natural resiliency to bear against conductive coating 40 to maintain the desired electrical contact.

In order to achieve this type of operation, the outer strips 42 may be constructed of an alloy of 22% nickel, 3% chromium, and the balance iron, or an alloy of 72% manganese, 18% copper, and 10% nickel, while the inner strips 43 may be constructed of an alloy of 36% nickel and 64% iron. These alloys are specified merely by way of example, as other bimetallic strip materials suitable for use in high vacuum are known in the art.

The use of bimetallic contact springs 41 is also advantageous with respect to the outgassing operation during exhaust of the envelope when the gun electrodes are subjected to a radio-frequency induction heating field. In the first place, contact springs 41 are automatically withdrawn from contact with the auxiliary coating 40 during this operation, thus avoiding breakage of the envelope as explained in connection with the sealing-in process. Moreover, when a plurality of contact springs are employed, the contact members and the conductive coating form one or more closed conductive loops or short-circuited turns which have the effect of suppressing the induction heating field. On withdrawal of the bimetallic contact members from contact with the auxiliary coating, which is accomplished automatically during the induction heating process, these closed loops are interrupted or opened, and the entire applied induction heating field is utilized in the subsequent outgassing of the gun electrodes. Consequently, any number of bimetallic contact springs may be employed, as dictated by considerations of a practical nature.

Thus the present invention provides a new and improved arrangement for establishing electrical contact between an electrode and a conductive coating on the inner wall of a glass envelope while avoiding glass breakage caused by unequal stresses induced during sealing-in or other processes involving the application of localized heat during the manufacture of an electron-discharge device. The arrangement is simple and inexpensive, and the desired purpose is achieved automatically without the attention of the processer. While the invention has been described in connection with a particular type of conductive coating employed in an electron-discharge devices of the cathode-ray type, it is apparent that the invention may be employed to advantage in other types of electron-discharge device where analogous problems may be presented.

Certain features of the construction illustrated and described in the present application are disclosed and claimed in the copending applications of Constantin S. Szegho, Serial No. 229,013, filed May 31, 1951, for "Image-Reproducing Device," Jerome J. O'Callaghan, Serial No. 235,045, filed July 3, 1951, for "Image-Reproducing Device," now U. S. Patent No. 2,627,043, issued January 27, 1953, and Robert W. Shawfrank, Serial No. 234,920, filed July 3, 1951, for "Cathode-Ray Tube Electrode," now U. S. Patent No. 2,627,049, issued January 27, 1953, all of which are assigned to the present assignees.

While a particular embodiment of the present invention has been shown and described, it is apparent that various changes and modifications may be made, and it is therefore contemplated in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

1. A cathode-ray tube comprising: an evacuated envelope; a fluorescent screen supported within said envelope; an electrode system within said envelope including a cathode, a plurality of tubular electrodes, and a conductive coating on the inner wall of said envelope between said tubular electrodes and said fluorescent screen; means for electrically connecting said conductive coating to one of said tubular electrodes; another conductive coating on the inner wall of said envelope, separate from said first mentioned coating and at least partially encompassing said tubular electrodes, for inhibiting cold emission and spark discharge in said electrode system; and at least one bimetallic contact spring fixed to another of said tubular electrodes and adapted to make electrical contact with said other conductive coating under normal ambient temperature conditions, whereby said contact spring is withdrawn from contact with said other conductive coating in re-

sponse to a predetermined change in said ambient temperature conditions.

2. A cathode-ray tube comprising: an evacuated envelope; a fluorescent screen supported within said envelope; an electrode system within said envelope including a cathode, first and second grids, a tubular electrode, and a conductive coating on the inner wall of said envelope between said tubular electrode and said fluorescent screen; means including a plurality of contact springs for electrically connecting said conductive coating to said tubular electrode; another conductive coating on the inner wall of said envelope, separate from said first-mentioned coating and at least partially encompassing said second grid and said tubular electrode, for inhibiting cold emission and spark discharge in said electrode system; and a plurality of bimetallic contact springs

fixed to said second grid and adapted to make electrical contact with said other conductive coating under normal ambient temperature conditions, whereby said contact spring is withdrawn from contact with said other conductive coating in response to a predetermined change in said ambient temperature conditions.

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