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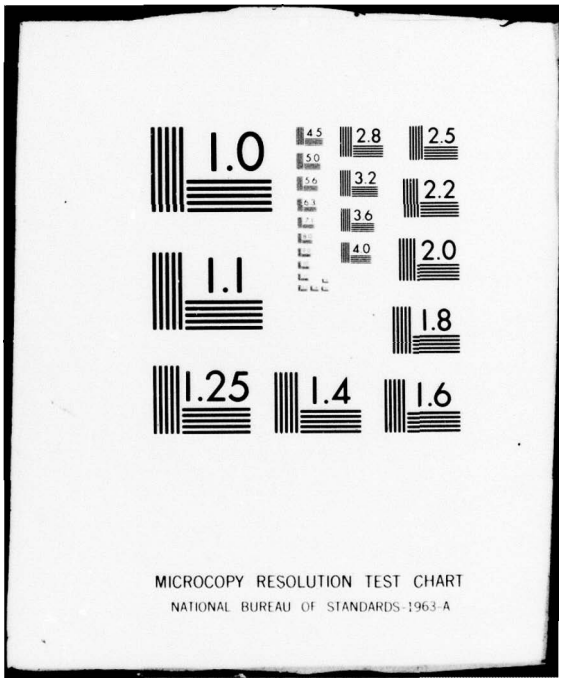
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# FOREIGN TECHNOLOGY DIVISION

THERMOELECTRONIC CATHODES
(SELECTED PAGES)

By

G. A. Kudintseva, A. I. Mel'nikov, et al



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# EDITED TRANSLATION

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THERMOELECTRONIC CATHODES (SELECTED PAGES)

By: G.A. Kudintseva, A. I. Mel'nikov, et al

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## U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

| Block | Italic | Transliteration | Block | Italic | Transliteration |
|---|---|---|---|---|---|
| А а | *А а* | A, a | Р р | *Р р* | R, r |
| Б б | *Б б* | B, b | С с | *С с* | S, s |
| В в | *В в* | V, v | Т т | *Т т* | T, t |
| Г г | *Г г* | G, g | У у | *У у* | U, u |
| Д д | *Д д* | D, d | Ф ф | *Ф ф* | F, f |
| Е е | *Е е* | Ye, ye; E, e* | Х х | *Х х* | Kh, kh |
| Ж ж | *Ж ж* | Zh, zh | Ц ц | *Ц ц* | Ts, ts |
| З з | *З з* | Z, z | Ч ч | *Ч ч* | Ch, ch |
| И и | *И и* | I, i | Ш ш | *Ш ш* | Sh, sh |
| Й й | *Й й* | Y, y | Щ щ | *Щ щ* | Shch, shch |
| К к | *К к* | K, k | Ъ ъ | *Ъ ъ* | " |
| Л л | *Л л* | L, l | Ы ы | *Ы ы* | Y, y |
| М м | *М м* | M, m | Ь ь | *Ь ь* | ' |
| Н н | *Н н* | N, n | Э э | *Э э* | E, e |
| О о | *О о* | O, o | Ю ю | *Ю ю* | Yu, yu |
| П п | *П п* | P, p | Я я | *Я я* | Ya, ya |

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ë in Russian, transliterate as yë or ë.

## RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

| Russian | English | Russian | English | Russian | English |
|---|---|---|---|---|---|
| sin | sin | sh | sinh | arc sh | $\sinh^{-1}$ |
| cos | cos | ch | cosh | arc ch | $\cosh^{-1}$ |
| tg | tan | th | tanh | arc th | $\tanh^{-1}$ |
| ctg | cot | cth | coth | arc cth | $\coth^{-1}$ |
| sec | sec | sch | sech | arc sch | $\operatorname{sech}^{-1}$ |
| cosec | csc | csch | csch | arc csch | $\operatorname{csch}^{-1}$ |

| Russian | English |
|---|---|
| rot | curl |
| lg | log |

EXCERPT FROM "THERMOELECTRONIC CATHODES"

N. D. Devyatkova, Corresponding Member of the AS USSR

Operating Conditions of Cathodes in Instruments

In experimental diodes with cooled copper anodes, pressed and impregnated cathodes in static conditions permit taking current up to 10 $A/cm^2$, and in pulsed conditions - up to dozens of amperes with 1 $cm^2$. With the use of cathodes in instruments, as in the case of oxide cathodes, this current density must be decreased by 2-2.5 times. This is due to more complex operating conditions in the instrument (the large number of parts in lamps, impossibility of sufficiently efficient degasification and cooling of electrodes, etc.)

In instruments, as with the experimental diodes, with an increase in the emitting surface of the cathode, the maximum possible current density taken from it in static conditions decreases. This phenomenon can be explained by the fact that with an increase in power dispersable on the anode, separation of gases sent to the cathode increases. Even with comparatively little heating of the electrodes, gas pressure in the instrument sharply increases and emission of the cathode falls.

On the other hand, a decrease in the area of the emitting surface of the cathode permits increasing the density of the taken current only up to the determined limit; in the case where the surface of the emitter is too small, it is easily contaminated by the remaining gases.

Pressed and impregnated cathodes can be used in instruments

with taken current in static conditions from 0.5 to 6 A/cm$^2$ [36]. Here, their service life, depending on the current density, fluctuates from several thousand to several hundred hours. These impregnated cathodes with a small area of emitting surface, which permit taking current with density significantly greater than 6 A/cm$^2$ in conditions near impregnation are also known.

The use of these cathodes in static conditions is of special interest when they are used in some instruments in the SHF range. However, the use of cathodes in impregnation conditions, or close to it, will encounter extremely serious difficulties as a result of the insufficient stability of their emission. Therefore, the use of these cathodes in series production of instruments is possible only with the satisfaction of the following conditions: an extremely high vacuum in the instrument, absolute stability of temperature, and a high level of technology in the production of electrovacuum instruments and cathodes.

Pressed and impregnated cathodes are rather widely used in backward-wave tubes, traveling wave tubes, and klystrons, mainly in static conditions with the taken current density at 1-3 A/cm$^2$, in which regard the conditions of spatial charge are characterized by the fact that the change in filament voltage of the heater by $\pm$5% from its nominal value (with the cathode's temperature at 1150° C) should not cause oscillation in the cathode's current more than 5-7% from its value with nominal filament voltage and direct anode current.

Impregnated cathodes are also used in magnetrons. A comparison of the behavior of impregnated and oxide cathodes in magnet-

rons [20] shows that an oxide cathode, which possesses a higher derived emission coefficient, operates with short duration of pulses, which is no worse and sometimes better than an impregnated [cathode]. However, with an increase in duration of pulses, the magnetron with impregnated aluminate cathode operates more stably than an oxide [cathode] (the number of sparkings is less and the anode current is more stable.) With intensive sparking and arc-forming, which leads to a separation of gases, the surface of impregnated cathodes, as opposed to oxide, barely breaks down. The density of current taken from impregnated cathodes can reach several dozens of amperes per 1 $cm^2$ with a service life of from several hundred to several thousand hours. The service life is determined mainly by the temperature of the cathode and the reserve of active matter in the sponge. Overheating of the cathode due to electronic bombardment leads to a sharp cut in its service life. Usually, the temperature of impregnated cathodes in magnetrons fluctuates from 850 to 1000°C. With the goal of decreasing sparking and increasing service life, careful systematic control of the cathode's temperature is necessary. For decreasing spraying of barium on the anode, it is expedient to conduct vacuum treatment of the cathode before its assembly in the instrument.

Despite literary data on the use of impregnated cathodes in some types of magnetrons, the expediency of this use is necessary to carefully study each individual case.

A serious influence on the operation of instruments (as in the case of using L-cathodes) is rendered by evaporation of barium, which is condensed on the electrodes of the instrument and with

their subsequent heat-up evaporates, causing a so-called spontaneous growth in current, hampering the operation of the instrument (see ch. 5-5). With a significant amount of barium and rapid heat-up of electrodes the spontaneous growth in current changes to "surging"; here, in the space between the cathode and the electrode, there sometimes arises green glow due to ionization of the vaporous barium. Spontaneous growth in current occurs mainly as a result of compensation of spatial charge of electrons by barium ions. In the case when, together with the emitting surface of the cathode, there is some kind of metal surface heated to a high temperature (molybdenum housing of the cathode, cylinder, located very close to the cathode, a holder, etc.), barium, evaporating from the heated electrodes (from the network, anode, etc.), falls to this surface and activates it; here we also observe an undesirable growth in current which hinders the operating conditions of the instrument (parasitic emission.)

The probability of occurrence of spontaneous current grows with an increase in temperature of the cathode and an increase in anode voltage. The spontaneous growth in current is not observed in the case where electrodes of the instrument have a temperature less than 200 or more than 1000°C.

Sometimes, "spontaneous" current can be taken as "normal" current for the cathode. A simple method which permits establishing a difference between these currents is cooling the network or the anode by removing voltage from them. With a rapid feed of voltage to these cooled electrodes "normal" current of emission is immediately fixed by the needle of the ampmeter and remains un-

changeable. With the presence of "spontaneous" current the needle of the ampmeter, according to the heat-up of the electrode, shows a gradual rise in current for several seconds, and sometimes also a change of this rise to a "surge" in current.

With the goal of eliminating parasitic emission from parts of the cathode which should not emit, and from electrodes on which barium condenses, they can be covered with special antiemission substances. Especially necessary is protection against condensation of barium in those cases where in the instrument there is a network positioned at a very close distance from the cathode; for example, at a distance of dozens of microns (SHF triodes.) The rather well-known antiemission substance - gold - can not be used for application on those parts of metal-porous cathodes which should not emit as a result of its comparatively low melting temperature. Molybdenum carbide [30] is used abroad as an antiemmision substance; it is formed by applying carbon on the molybdenum surface with subsequent heating in well-cleaned hydrogen at 1700-1800°C, and also platinum in conjunction with carbides ("C-coverings".) Presently, for suppressing emission, we study carbides of tungsten, titanium, tantalum, zirconium, molybdenum silicides, boron compounds, and also metals - zirconium, platinum, etc. For decreasing parasitic emission it is also expedient to use metal-porous cathodes with reduced speed of evaporation.

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