

**Zeitschrift:** Helvetica Physica Acta  
**Band:** 32 (1959)  
**Heft:** VI-VII  
  
**Artikel:** A CdS analog triode  
**Autor:** Ruppel, W.  
**DOI:** <https://doi.org/10.5169/seals-113019>

### **Nutzungsbedingungen**

Die ETH-Bibliothek ist die Anbieterin der digitalisierten Zeitschriften auf E-Periodica. Sie besitzt keine Urheberrechte an den Zeitschriften und ist nicht verantwortlich für deren Inhalte. Die Rechte liegen in der Regel bei den Herausgebern beziehungsweise den externen Rechteinhabern. Das Veröffentlichen von Bildern in Print- und Online-Publikationen sowie auf Social Media-Kanälen oder Webseiten ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. [Mehr erfahren](#)

### **Conditions d'utilisation**

L'ETH Library est le fournisseur des revues numérisées. Elle ne détient aucun droit d'auteur sur les revues et n'est pas responsable de leur contenu. En règle générale, les droits sont détenus par les éditeurs ou les détenteurs de droits externes. La reproduction d'images dans des publications imprimées ou en ligne ainsi que sur des canaux de médias sociaux ou des sites web n'est autorisée qu'avec l'accord préalable des détenteurs des droits. [En savoir plus](#)

### **Terms of use**

The ETH Library is the provider of the digitised journals. It does not own any copyrights to the journals and is not responsible for their content. The rights usually lie with the publishers or the external rights holders. Publishing images in print and online publications, as well as on social media channels or websites, is only permitted with the prior consent of the rights holders. [Find out more](#)

**Download PDF:** 08.08.2025

**ETH-Bibliothek Zürich, E-Periodica, <https://www.e-periodica.ch>**

## A CdS Analog Triode

by **W. Ruppel**

Laboratories RCA Ltd., Zurich, Switzerland

(21. XII. 1959)

---

Attempts to design a solid state triode that operates in close analogy to the vacuum triode date well back in the history of solid state physics<sup>1)</sup>. The closest approach have been the unipolar transistor and the proposed analog transistor. The analog transistor in the originally proposed form<sup>2)</sup> has not, to the writer's knowledge, ever been realized. It is the purpose of this letter to describe an analog triode which makes use of the modulation of a space-charge-limited current through an insulator precisely analogous to the modulation of a space-charge-limited current in a vacuum triode.

SMITH and ROSE<sup>3)</sup> have demonstrated space-charge-limited current flow in CdS analogous to that in a vacuum tube when an indium or gallium electrode was used as electron emitting cathode. To obtain an analog triode an electron retaining (blocking) control grid electrode is necessary by which the electron space charge and with it the space-charge-limited current is modulated. Tellurium was found to be a suitable material to form a blocking control grid.

The CdS analog triode is shown in Fig. 1. An indium cathode and a tellurium grid and anode are evaporated onto a 10 micron thick CdS single crystal. The choice of the anode material is not critical and tellurium was used for convenience of application. The contact area of each of these electrodes is about 1 mm<sup>2</sup>. The contact geometry is not optimized since only a demonstration of the operation of the device was aimed.

The dark resistivity of the CdS crystal when measured at very low voltages where the current flow is due to carriers thermally generated in the volume of the crystal exceeds 10<sup>12</sup> ohm.cms. At larger voltage when biased as indicated in Fig. 1 a large electron current due to excess electrons injected from the indium cathode is drawn between cathode and anode as observed by SMITH and ROSE<sup>3)</sup>. The current is limited only by

the injected negative space charge built up in the crystal. When a negative bias is applied to the grid the negative space charge barrier is enhanced and the anode current flow is accordingly reduced.

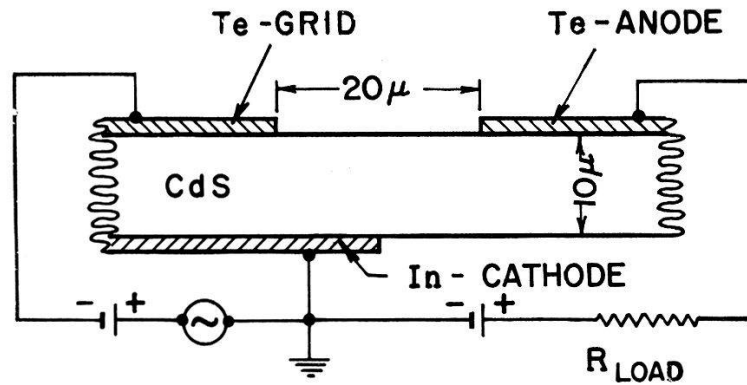


Fig. 1

Cross section through CdS analog triode with basic circuit connections

In Fig. 2 the dc – output characteristics are given. The input dc – grid resistance is larger than  $10^{11}$  ohms; the input capacitance is about  $10\mu\mu\text{f}$ . While the voltage amplification is about unity, current and power amplification are in the order of  $10^4$  to  $10^5$ .

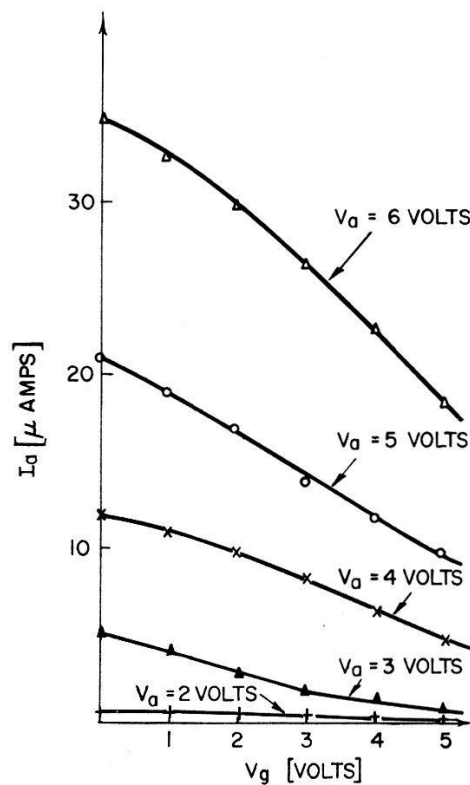


Fig. 2

Anode current  $I_a$  as a function of grid voltage  $V_g$  for several anode voltages  $V_a$

The ac – performance is shown in Fig. 3. The upper frequency limitation is probably due to trapping of the modulated space charge but the precise mechanism is not clear. The enhanced response at 1000 c/s is

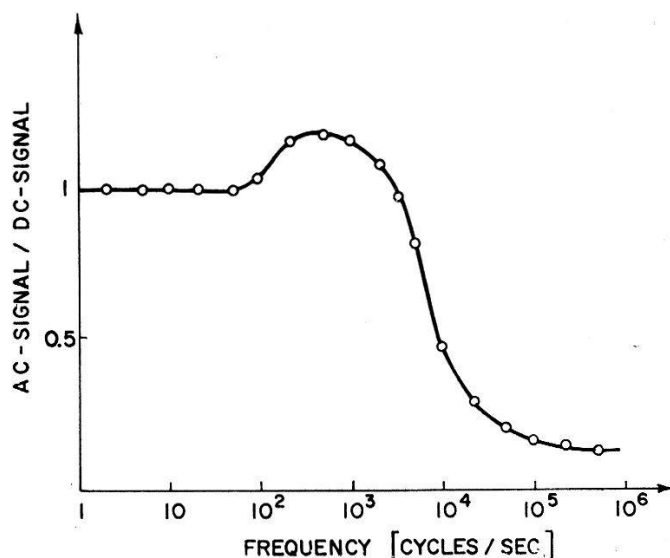


Fig. 3

Ratio of *ac* to *dc* – output signal as a function of frequency at  $V_a = 6$  volts,  
 $V_g = 3$  volts,  $\Delta V_g = \pm 1$  volt

accounted for by a transient overshoot of about a millisec in the change of the anode current when a negative step voltage is applied to the grid.

In a vacuum tube the movement of positive ions adds only little to the space-charge-limited current. In an insulator by simultaneous injection of electrons from the cathode and holes from the anode a two-carrier space-charge-limited current far in excess to the one-carrier current can be drawn<sup>4)</sup> thus leading to a great enhancement of the anode current and probably resulting in a major improvement of the performance of the device.

A detailed paper is in press in the RCA Review.

#### References

- <sup>1)</sup> E. g. O. HEIL, British Patent 439,457 (1935); R. HILSCH and R. W. POHL, Z. Phys. 111, 399 (1938).
- <sup>2)</sup> W. SHOCKLEY, Proc. IRE 40, 1365 (1952).
- <sup>3)</sup> R. W. SMITH and A. ROSE, Phys. Rev. 97, 1531 (1955).
- <sup>4)</sup> R. H. PARMENTER and W. RUPPEL, J. Appl. Phys. 30, 1548 (1959).