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MULTI-ANODE ELECTRON TUBES AND WORKING CIRCUITS THEREFOR

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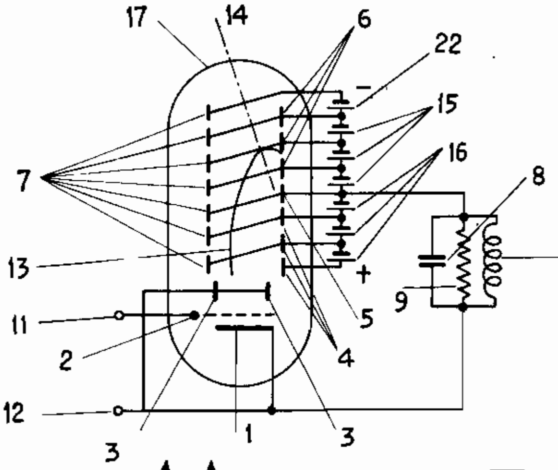

Fig. 1

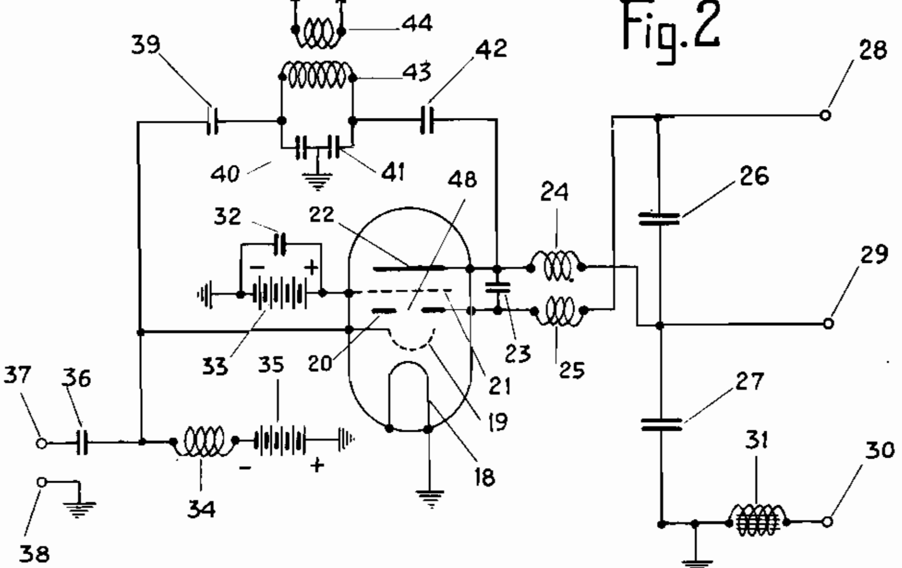

Fig. 2

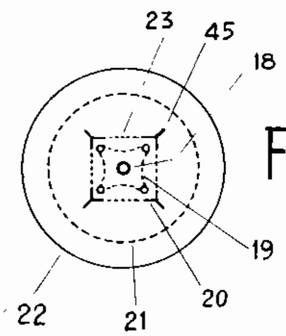

Fig. 3

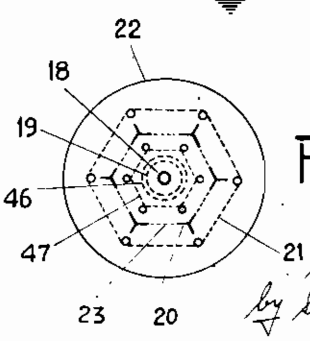

Fig. 4

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MULTI-ANODE ELECTRON TUBES AND WORKING CIRCUITS THEREFOR

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This invention relates to multi-anode electron tubes in connection with suitable working circuits.

The basic principle of this invention is to replace the usual anode of the usual electronic tubes (triodes, tetrodes, pentodes, etc.) by another more complex system of electrodes, which will be referred to hereinafter as "recovering anode" capable of recovering the kinetic energy developed by the impact of the electrons, which in usual tubes has no useful effect on the working circuit and is lost as heat, especially when the tube is working in class A or B.

The recovering anode consists of a series of electrodes, the direct current potentials of which range from a given maximum positive value down to a lower value, which may be positive, nil or even negative. Said electrodes are connected together by means of condensers so that the alternating current component of the anode potentials is strictly the same for all electrodes. Things are to be so arranged that superposing in the system the said ranging direct current potential and the alternating current component of the anode tension (which last is the same as for a usual anode) there is always an electrode having an instantaneous potential very slightly positive with respect to the cathode, at least when space current is flowing. While the most positive of all electrodes has always the task of causing space current to flow and with just the same intensity as in a usual tube, electron trajectories are to be so arranged that electrons always impinge on the electrode which in that moment is only slightly positive with respect to the cathode. Thus, while alternating current anode potential amplitude is limited by the direct current potential of the most positive electrode, which potential behaves as the direct current potential of a usual anode, anode dissipation is almost suppressed, because impact potential is reduced almost to zero.

Fig. 1 shows diagrammatically a multi-anode valve and electric circuit embodying the principle of the invention. **1** is the cathode; **2** the control grid; **3—3'** are a pair of electrodes so arranged as to produce an electron beam, according to the electron optics **4** are positive plates; **5** a plate maintained at zero direct current potential; **6** are plates maintained at negative d. c. potential; **7** are other plates arranged opposite the said negative ones, but not at level therewith and connected in parallel to said plates **6**; **8** is the tank condenser of the resonant anode circuit; **9** stands for the load; **10** is the inductance of the resonant circuit; **11** and **12** are the terminals for the input signal; **13** is one of the electron trajectories; **14** is the symmetry axis thereof; **15** and **16** are feed batteries and **17** is the tube bulb.

The electron beam emerging from **3—3'** and accelerated by the most positive ones of the electrode **4** (the most positive one may consist of a wire net portion fitted at right angles to the electron path so as to electrostatically act as a usual anode) follows a substantially parabolical path the form of which depends on the electron velocity, i. e. on the instantaneous value of the alternating current anode potential component. By properly adjusting the distance between the two electrode sets and the inclination of the equipotential planes connecting each electrode pair **6—7** it is possible to obtain that at any moment the instantaneous trajectory ends on the proper electrode of the set. It is sufficient to arrange things so that the time taken by the electron to be longitudinally stopped (to reach the top of the parabole) to be the same taken thereby to be transversally brought on to the set of capturing plates by the transversal component of the electric field set up between the two plate sets. The electron should be captured when near the top of its parabole. Secondary emission is avoided by the said transversal component present even on the surfaces of the capturing plates **4**, **5**, **6**.

In case of operation in class A the batteries **16** simply recover power, because they are charged by the electrons reaching plates **6**, passing through said batteries and returning to the cathode through load circuit **8**, **9**, **10**. In case of class B operation, the plates **6** become useless, because they have the right potential for catching electrons only when there is no space current. In case of operation in class C even plate **5** and some of the plates **4** together with the corresponding battery portions might be missing.

With other words, it may be said that the described tube works as a usual one, as far as the electrone reach the mesh connected with the most positive electrode. In a usual tube they would be simply captured; in the new tube they emerge in a decelerating field where they are stopped, then caught; then they are conveyed again, through the remaining part of the battery, to the same path (load-cathode) as with a usual tube, but by avoiding to discharge that part of the battery which would give the anode, in correspondence of the instantaneous value of the alternating current potential across the loads a surplus potential, which is quite useless for the economy of the circuit and which, once spent, should be somehow lost again.

The finer is the disposition of the anode potential along the anode sets, the better is the effect obtained. But even with tubes having only two anode electrodes the reduction of dissipation may be considerable.

Fig. 2 shows by way of example a tube with two electrodes inserted in a circuit for high frequency amplification, particularly adapted for use for modulated high frequency class B amplification.

18 is the cathode, **19** the control grid, **20** the most positive of the two anode electrodes having a window **49** which may be closed by a wire net; **21** is an antisecondary grid, **22** a less positive anode electrode, **23** a condenser shunting the two anode electrodes as to high frequency; **24**, **25** and **34** are high frequency chokes; **26** and **27** smoothing condensers; **28**, **29** and **30** terminals for feeding direct-current tensions; **31** is a smoothing inductance; **32** a by-pass for the slightly positive bias battery **33** of the antisecondary grid **21**; **35** is the usual bias battery for grid **19**; **36** a coupling condenser for the input signal; **37** and **38** the terminals for the input signal; **39** the neutralizing condenser; **40**, **41** tank condensers; **42** a blocking condenser; **43** the inductance for the resonant circuit, **44** the coupling for the load.

The electron beam, controlled by the grid **19**, shaped so as to be slightly convergent, and accelerated by anode electrode **20**, passes through window **45**, then is decelerated and reaches anode electrode **22** if this one is positive; if not, it is reflected on anode electrode **20**; it can be seen that in case of two electrodes anode the selection of the right electrode is obtained in simpler way.

In case of class B amplification of modulated high frequency, it is convenient to give electrode **22** half the direct current potential of electrode **20**. Thus, when there is the carrier only, electrode **22** is always positive and is always the capturing electrode; this electrode, as an anode, works with full anode swing and has a practical efficiency of 66% instead of 33%, as would be; should the electrons reach directly either electrode **20** or also a usual anode. When modulation intervenes, electrode **22** becomes negative for a part of the cycle and then electrode **20** is the capturing one; modulation can be increased up to a swing utilizing the whole direct current tension of electrode **20**. Thus the output is just the same as with a triode having the anode direct current potential of electrode **20**, but when only the carrier is present, its efficiency is twice as much (the direct current anode current is delivered at half tension between the terminals **29**, **30**). When there is modulation, the efficiency is always higher than in a usual tube, because electrode **22** is always working at least for one half of the modulation cycle.

Antisecondary grid **21** may be given a slightly positive bias, because otherwise electrons might be unduly reflected even when electrode **22** is positive, due to the roughness of the equipotential surfaces near grid **21**.

It is to be remarked that the potential of electrode **22** has no effect on the value of the total anode current, because electrode **22** is screened towards the cathode by grid **21** and anode **20**.

In case of class A low frequency amplification, the most convenient direct current potential of electrode **22** may be very low, especially if no-signal periods are foreseen; in this condition, although the quiescent anode current is maintained at its value, it implies low power losses.

Fig. 3 shows a quasi-constructional arrangement of the electrodes of a tube having a two electrodes anode. The same reference numerals indicate like parts as in Fig. 2. **45** are fins of electrode **20**. The field between grid **19** and electrode **20** is convergent, so as to make the electron flow into beams; fins **45** serve for dissipating purposes and for rendering the field external to electrode **20** divergent, in order to avoid that the electron beam, once reflected, enters again window **23**, which fact would cause troubles in space charge and in the linearity of the characteristic curves.

Fig. 4 shows a penthode with two anode electrodes. The parts existing in the tube shown in Fig. 3 are referred to by the same numerals: **46** is the screen grid and **47** the ordinary antisecondary grid of the pentode, which in this case is that having convergent properties, obtained by proper shape of said grid.

In the circuits in which the direct current anode current is fed through the resonant circuit inductance, it is possible to do without any high frequency choke even if a multiple anode tube of the above described types is used. In such case it is sufficient that the various direct current tensions be brought to the various electrodes by leads contained in the main tubular lead of the inductance, from a zero high frequency point of said inductance up to an end of it. Known laws teach that the insulation among the various leads is loaded only by direct current potentials.

In the cases according to Figures 3 and 4, the outer electrode **22** may be part of the tube envelope so as to render it possible to cool same by means of a fluid like in ordinary cooled-anode tubes. The heat of the inner anode **20** is generally dissipated by radiation, unless cooling by means of separate devices is adopted.

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