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ELECTRON DISCHARGE DEVICE

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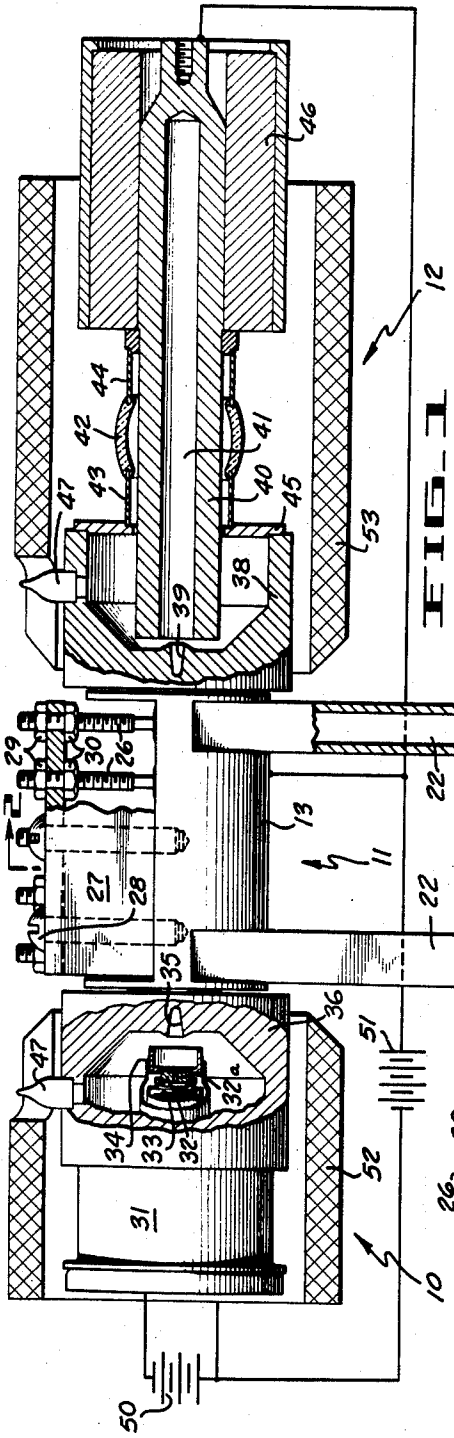


FIG. 1

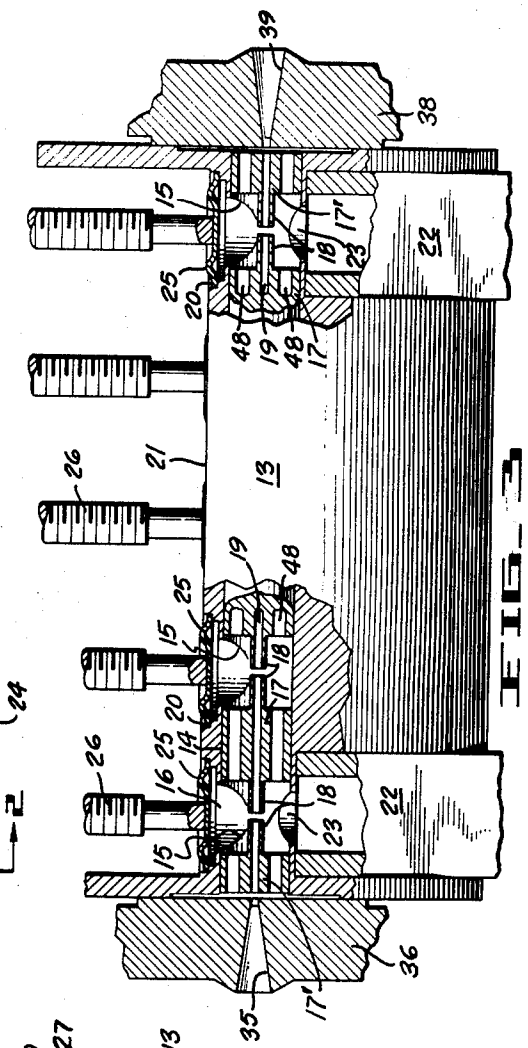


FIG. 2

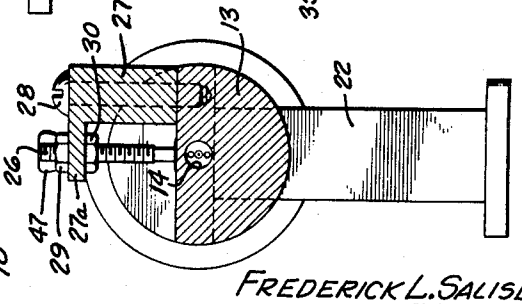


FIG. 3

FREDERICK L. SALISBURY
INVENTOR.

BY Paul B. Hunter
ATTORNEY

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# ELECTRON DISCHARGE DEVICE

Frederick L. Salisbury, Los Altos, Calif., assignor to Varian Associates, San Carlos, Calif., a corporation of California

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2 Claims. (Cl. 315—5.39)

This invention relates to electron discharge devices and, more particularly, to an electron discharge device of the velocity modulation type arranged to operate at microwave frequencies as an amplifier.

As the operating frequency of electron discharge devices or tubes has increased, a corresponding increase has been noted with respect to the critical nature of the alignment of the elements thereof, the geometric shape and tolerances of such elements, and the losses of energy resulting from any deviation in these tube design factors. While the design problems presented have been severe with tubes such as reflex klystrons and two-cavity klystron amplifiers, they have been further accentuated, for obvious reasons, with multi-cavity klystrons, particularly when frequencies of the order of 20–30 kmc. are approached. In such cases, since a wavelength is in the neighborhood of 1 centimeter, even such minor structural aberrations as produced by brazing can affect the losses and the tunability of the amplifier.

Accordingly, a feature of the present invention involves the provision of a multi-cavity microwave amplifier of relatively simple construction and having optimum gain characteristics.

A further feature is the provision of a microwave amplifier of the multi-cavity type having a structural arrangement which facilitates assembly and efficient operation thereof.

Yet another feature of the invention is the provision of a microwave amplifier structurally arranged to insure proper alignment of the parts and the maintenance of design tolerances.

These and other features will become more apparent from the following description of a preferred embodiment of the present invention as shown in the accompanying drawings wherein:

Fig. 1 is an elevational view of a multi-cavity microwave amplifier, parts being cut away to illustrate features of construction,

Fig. 2 is a section taken along line 2—2 of Fig. 1, and

Fig. 3 is an enlarged view partially in section illustrating interior construction of the resonator cavities of the amplifier.

The microwave amplifier generally includes a beam-producing section **10** followed by a central section **11** wherein the interaction between the beam and the applied radio frequency wave takes place to provide the amplification and a collector section **12** where the electrons of the spent beam are collected.

In accordance with the invention, the amplification section **11** of the tube preferably has a body formed from a substantially semi-cylindrical block **13** of copper, as best illustrated in Fig. 2. A cylindrical bore **14** which extends longitudinally through the semi-cylindrical block **13** is intersected by a number of spaced transverse bores **15** extending from the flattened side **21** of the block **13** and is adapted to receive a plurality of drift-tube members **17**. Each member **17** comprises a copper cylinder which is provided with small cylindrical extensions **18** at its ends and has a central bore extending therethrough and through such extensions to provide a drift space **19** for the electron beam. When the members **17** are inserted in the bore **14** in properly spaced relation, as determined by the spacing of the transverse bores **15**, resonator cavities **16** of the desired frequency are formed between adjacent members. Prior to insertion of the copper drift-tube members **17** into the bore **14**, the latter is provided by a flash-plating technique with a thin layer of silver. The exterior dimension of the drift tube members **17** is slightly greater than the diameter of the plated bore **14** through the described semi-cylindrical block **13** so that upon insertion a pressed-fit is obtained. After the insertion of the drift tube members **17**, a single heating operation will cause the copper and silver to alloy and the members to be fused within the bore. It should be noted that the same fusing technique and resulting assembly can be employed with drift tube members **17** which are not of solid copper construction; for example, copper-clad molybdenum drift tube members can be utilized in the fabrication. This technique obviously avoids the mentioned difficulty of conventional brazing methods and a clean juncture is formed between the drift tube members **17** and the bore **14** which provide, in effect, the walls of the resonator cavities **16**.

An inner drift tube member **17** which is machined to provide the theoretically desired geometry to as close tolerances as possible is first inserted and, in turn, each of the adjacent drift tube members **17** is inserted to an extent slightly less than that required to provide the spacing productive of the desired resonant frequency of the cavities **16**. Subsequently, radio frequency energy is supplied to each cavity **16** between adjacent drift tube members through the respective one of the transverse bores **15** extending from the flattened-side **21** of the semi-cylindrical block **13**. While radio frequency energy of the desired frequency is inserted through the transverse bore **15** a slight axial movement is imparted to the drift tube member **17** until the resonance condition is achieved, this then being the final disposition of the member. The above described technique has been found not only desirable but actually indispensable to produce the desired cavity dimensions when operating at frequencies between 20 and 30 kmc. because at such frequencies normal machining operations have insufficient accuracy to effect the desired structural tolerances.

As is shown clearly in Fig. 3, the first and last cavities **16** of the illustrated five-cavity amplifier are completed by members **17'** which in effect constitute one-half of the complete drift tube members **17** previously described, in the intermediate portions of the bore **14**.

To provide coupling of radio frequency energy into and out of the amplifier, the described semi-cylindrical block **13** is cut away in its lower portion for the reception of conventional waveguide sections **22** which communicate with the first and last resonator cavities **16** through bored iris openings **23**. A mica window **24** is suitably secured at the end of each of the waveguide sections **22** to maintain the vacuum within the cavities **16** and the remainder of the tube.

The previously mentioned bores **15** are enlarged adjacent the flattened side **21** of the semi-cylindrical block **13** as indicated at **20** to receive in vacuum-tight relation a tuning diaphragm **25** secured at the end of a tuning screw **26** which is adjustably suspended from the lateral arm **27a** of a bracket **27** secured to the flattened side **21** of the block **13** by suitable screws **28**. The diaphragms **25** are maintained in adjusted position by pairs of lock nuts **29, 30** on the tuning screws **26** which nuts engage

respectively the upper and lower surfaces of the lateral bracket arm 27*a*.

The beam-producing section 10 includes a substantially cylindrical hollow body 31 having a cathode button 32 and associated heater element 33 and focusing ring 34 mounted centrally therein and axially aligned with a tapered bore 35 formed in the base of an attached pole piece 36 of magnetic material and adapted to register with the aligned drift spaces 19 in the drift-tube members 17, 17′ within the amplification section 11 of the tube. To assure that such alignment is achieved, the cathode button 32 is provided with a small central aperture 32*a* which enables the cathode 32 and the drift tube members 17, 17′ of the tube to be aligned optically; that is, a light may be positioned at the end of the beam-producing section 10 and the same laterally shifted until such light passes through the small central aperture 32*a* in the cathode button 32, the registering bore 35 in the pole piece 36 and the drift tube members 17, 17′ so as to be visible to a viewer whose eye is adjacent the drift space 19 at the output end of the amplification section 11. While so aligned the beam-producing section 10 or more particularly the attached pole piece 36 is annularly brazed or otherwise secured to the amplification section 11 of the tube so that the alignment will be maintained.

The collector section 12 of the electron discharge device is preferably mounted on the second cup-shaped pole piece 38 having a tapered bore 39 extending centrally through its base and adapted to register with the aligned drift spaces 19 when said cup-shaped element is brazed in position at the output end of the amplification section 11 of the tube so as to accommodate the electron beam. Such alignment is again attained by the optical technique described above. The collector section 12 includes an elongated member 40 having a deep cylindrical recess 41 machined therein and arranged so that its open end is adjacent and axial with the tapered bore 39 in the pole piece 38. The two elements are secured in such relation through a glass-to-metal seal 42 formed between tubular stubs 43, 44 extending in opposite directions from an annular cap 45 on the cup-shaped pole piece 38 and a thick sleeve 46 telescoped onto the outer end of the elongated collector member 40. This construction and insulated mounting of the collector enables current readings to be taken when desired.

Tubulations 47 in the side of the two pole pieces 36, 38 enable evacuation of the tube after completion of the assembly, and are then pinched-off as shown in Fig. 1. To facilitate evacuation, eccentric axially-extending passages 48 are formed in the drift tube members since the actual diameter of the drift spaces 19 will be somewhat less than .02″ at the mentioned operating frequencies. Because these passages 48 are relatively well below cutoff at the operating frequency, no radio frequency energy can be transmitted therethrough.

The tube is electrically connected quite conventionally, a battery 50 being arranged, as shown in Fig. 1 to provide heater current, and a second battery 51 to provide positive D.C. voltage for the central and collector sections 11, 12 of the tube. Conventional coils indicated at 52, 53 are disposed adjacent the pole pieces 36, 38 to provide for proper focusing of the beam during its traverse through the tube. In operation, the beam of electrons emitted from the cathode button 32 is accelerated through the bore 35 and into the small cylindrical bores through the drift tube members 17. The radio frequency signal to be amplified is fed into the first or buncher cavity resonator through the input waveguide 22. The radio frequency electric field produced across the resonator gap in this first cavity resonator velocity modulates the electrons, that is, the electrons are slowed down or speeded up depending on the phase of the radio



frequency field across the gap at the time of transit of the electron. In the field-free drift space defined by the first drift tube member 17 and extensions 18, the velocity modulation forms the beam into groups or bunches of electrons which, at their point of sharpest bunching, pass through the resonator gap in the second cavity resonator. All of the cavity resonators are so proportioned as to size and gap spacing as to be sharply resonant at the desired operating frequency of this cascade amplifier. The cavity resonators are initially tuned during assembly by the proper positioning and brazing of the drift tube members 17 to establish correct resonator gap spacing, the cavities thereafter being fine-tuned by means of the diaphragms 25. All of the cavity resonators between the first or input resonator and the last or output resonator serve to improve the bunching of the electron beam initiated in the first cavity resonator so that optimum bunching is produced before the beam passes through the resonator gap in last or output resonator. The amplified radio frequency energy is passed out from this cascade amplifier through the output waveguide 22. An actual tube which has been constructed and operated with 1500 volts on the sections 11, 12 has produced a gain of as high as 74 decibels, as a result of the minimization of losses through the described arrangement in accordance with the invention. What losses do occur, of course, appear as heat in the amplification and collector sections 11, 12 of the tube and are easily dissipated because of the large volume of the semi-cylindrical block 13 and the thick sleeve 46 on the collector member 40, no cooling fins being required.

Since many modifications and variations in the described arrangement can obviously be made without departing from the scope of the invention, it is intended that all matter in the foregoing description or shown in the drawing shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. An electron discharge device comprising an electron beam-producing section, an electron collecting section, a microwave amplification section disposed between said first and second named sections comprising a metallic body with a longitudinal bore extending therethrough, a thin layer of high electrically-conducting soldering material coated on the surface of the bore, and a plurality of drift tube members disposed within said bore in spaced relation whereby a plurality of resonator cavities are formed therein the drift tube members being secured within the bore fused to said layer of electrically-conducting soldering material, said drift tube members having axial bores therein through which said beam passes and having eccentrically disposed passages therein parallel to said axial bores and of dimensions such that the transmission of energy of the resonant frequency of said discharge device through said passages is precluded.

2. An electron discharge device according to claim 1 wherein said drift tube members are of copper and the coat on the surface of a said bore is a thin layer of silver.


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