

July 2, 1946.

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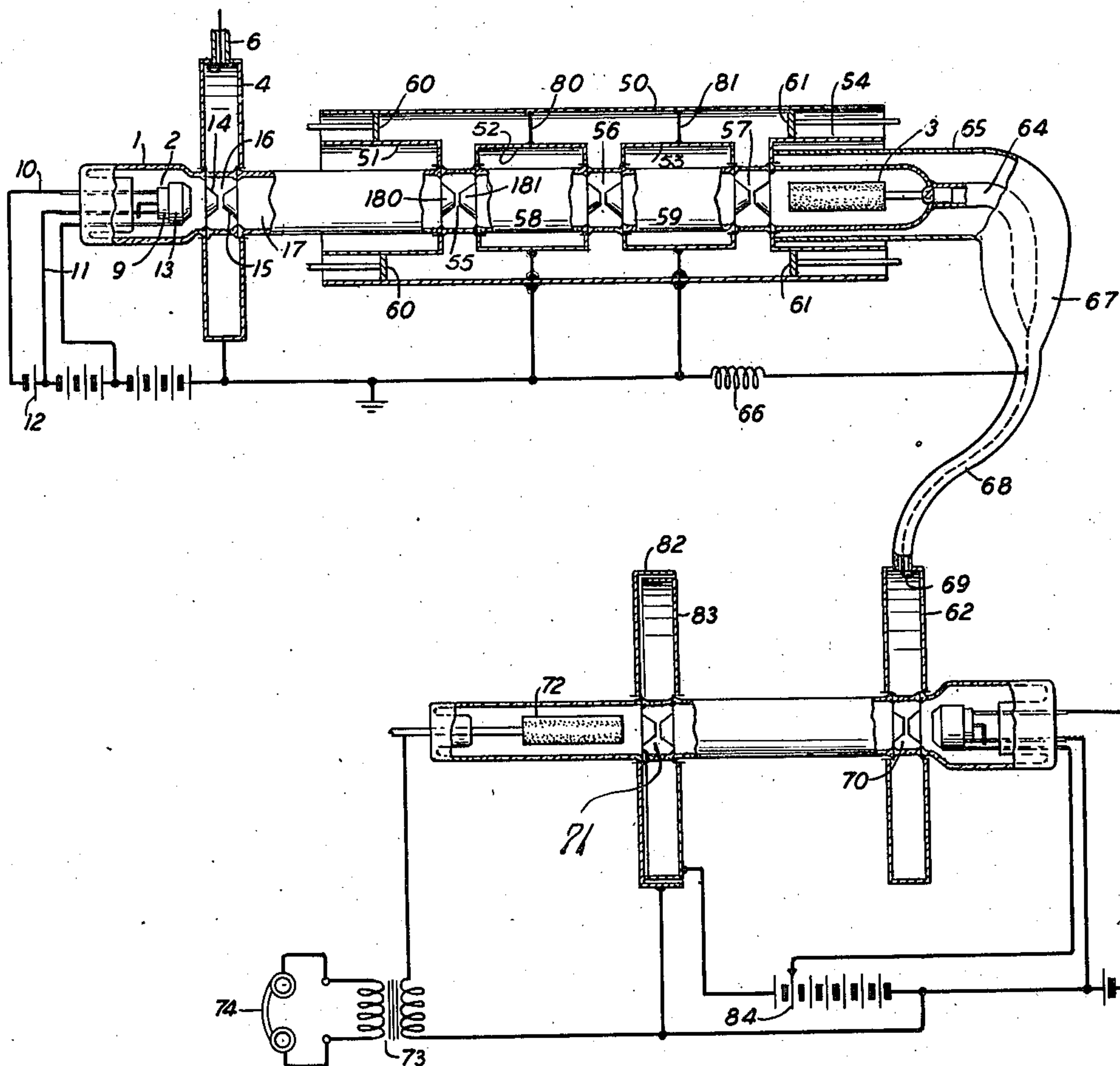
2,403,025

ELECTRON BEAM DEVICE

Filed Sept. 24, 1941

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FIG. 1



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FIG. 5

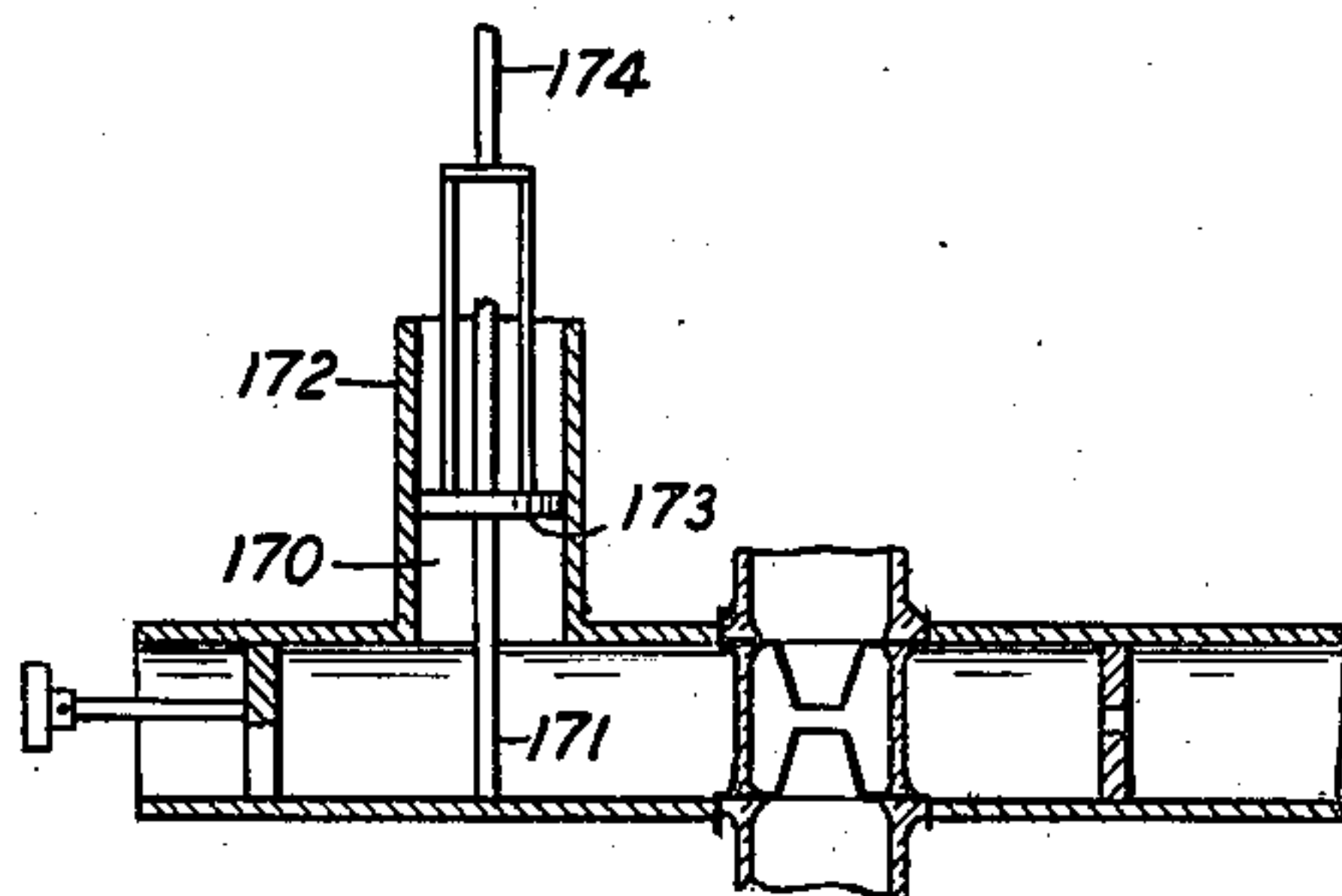
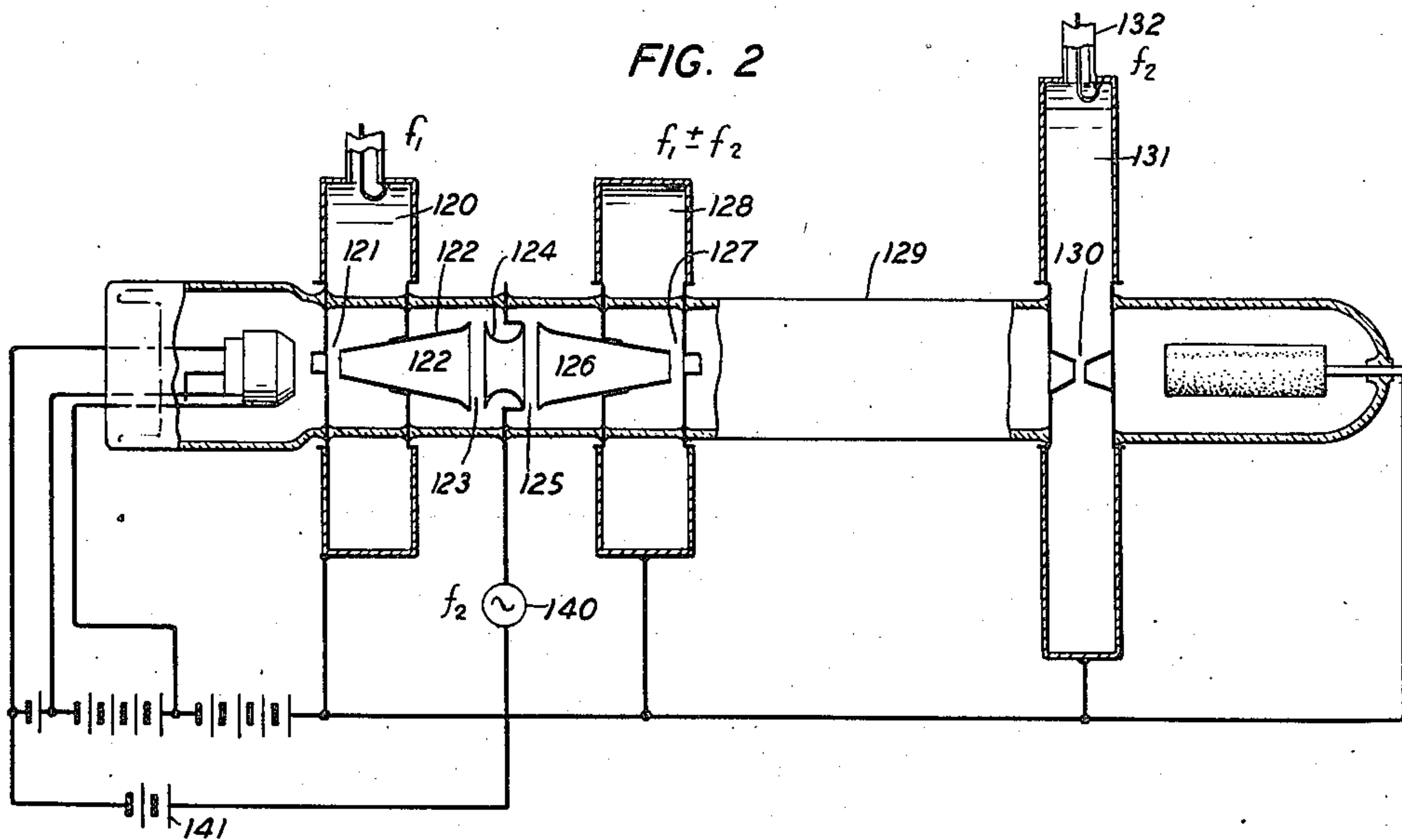


FIG. 2



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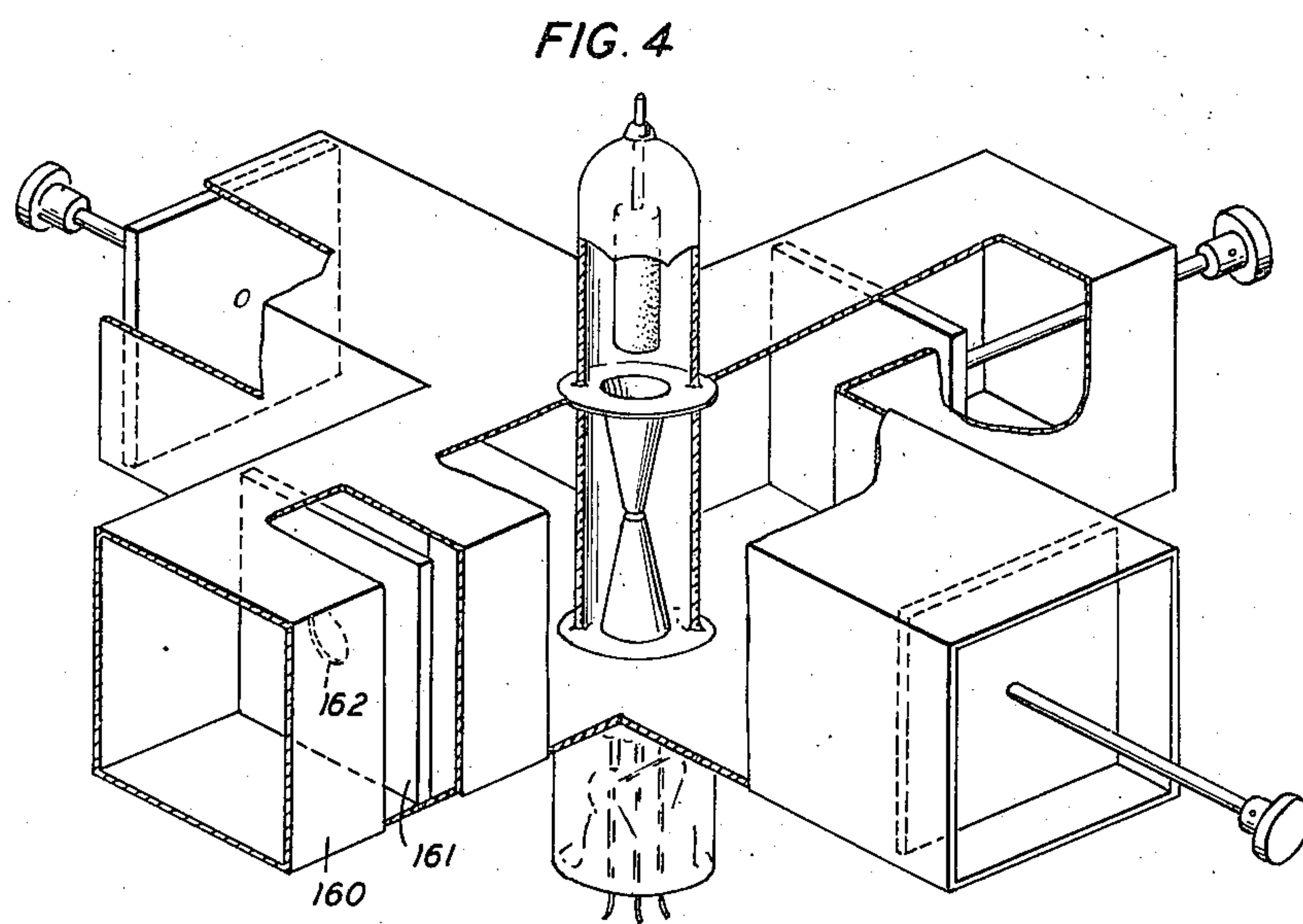
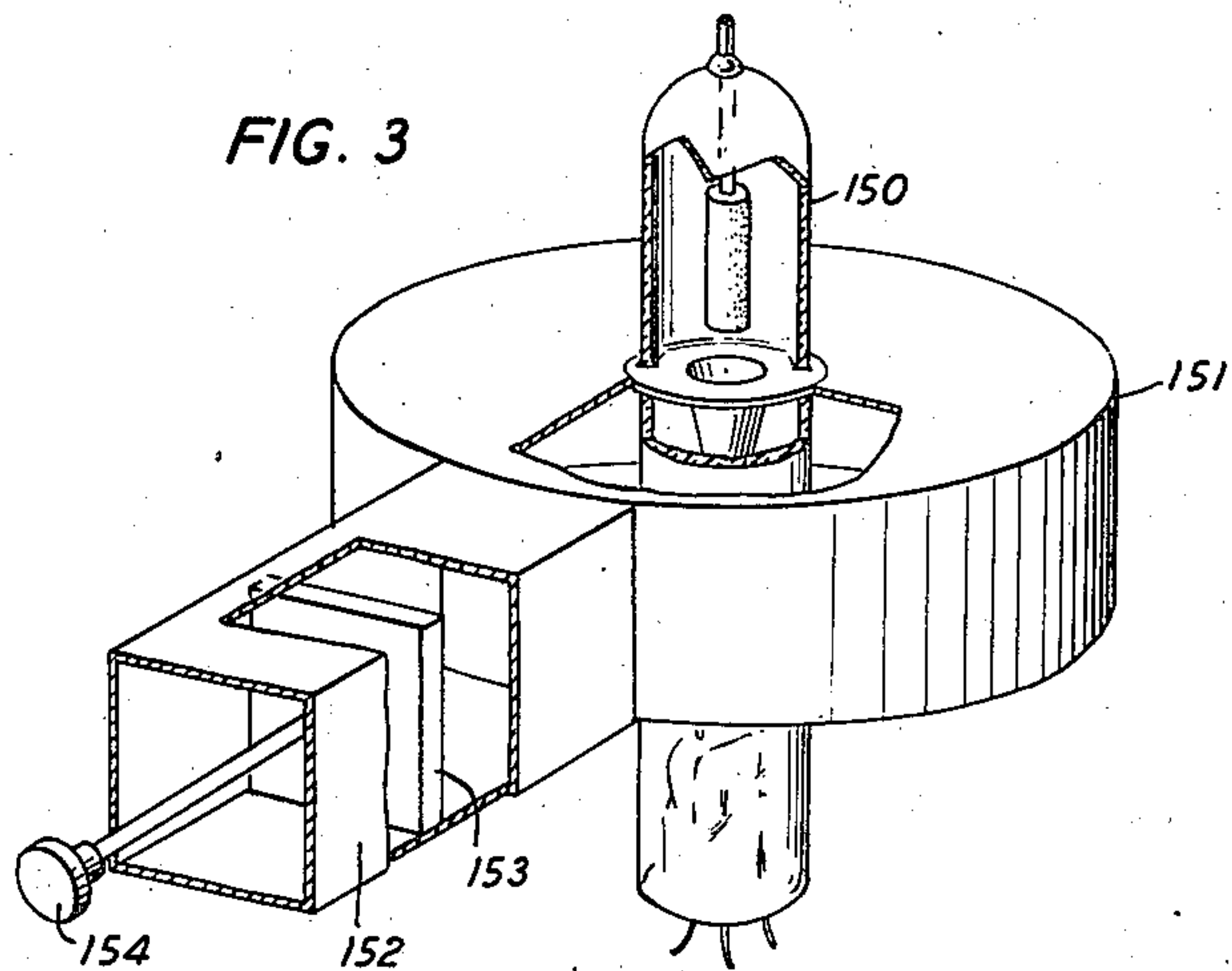
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3 Sheets-Sheet 3



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2,403,025

ELECTRON BEAM DEVICE

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Application September 24, 1941, Serial No. 412,067

3 Claims. (Cl. 250—27)

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This invention relates to electron beam devices, particularly for operation at ultra-high frequencies.

An object of the invention is to intermodulate wave energies by virtue of non-linear actions in electron beams associated with a plurality of electrodes, particularly in frequency shifting arrangements for radio repeaters, first and second detectors in superheterodyne receiving systems, and the like.

Another object of the invention is to facilitate the operation and tuning of amplifiers and oscillators especially those employing resonating chambers or cavity resonators.

A feature of the invention is a system of frequency conversion employing an electron stream and one or more resonating chambers, in which the output is obtained at the frequency of a local energy source.

Another feature of the invention is a split resonator the parts of which are insulated to permit the use of a direct current field within the resonator.

Other features include fine adjustment and broad band tuning arrangements for a resonating chamber.

Further objects and features of the invention will be apparent from the following detailed description and the accompanying drawings, while the scope of the invention is defined in the appended claims.

Claims to a frequency conversion system disclosed herein are made in my copending application Serial No. 441,937, filed May 6, 1942. Claims to an amplifier energized by a velocity varied electron stream which has been sorted with respect to velocity by a retarding field are presented in my copending application Serial No. 448,591, filed June 26, 1942. A tuning arrangement to effect a fine adjustment as disclosed herein is claimed in my copending application Serial No. 462,537, filed October 19, 1942. All of these applications are assigned to the same assignee as the present application.

In the drawings,

Fig. 1 shows a superheterodyne receiving system employing features of the invention;

Fig. 2 shows a system in which amplitude modulations in a received wave may be translated into amplitude variations at the frequency of a local oscillator;

Fig. 3 shows an arrangement for the fine adjustment of the tuning of a resonating chamber; and

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Figs. 4 and 5 show multiple tuning arrangements for producing broad band tuning effects.

More particularly, Fig. 1 shows a superheterodyne receiving system employing two electron beam devices in a tandem arrangement. In the first tube, shown at the top of the figure, an evacuated, insulating envelope 1 is represented as enclosing a plurality of elements including an electron gun shown generally at 2 and an electron intercepting electrode or collector 3. An input resonating chamber 4 is associated with certain electrodes within the envelope 1 and is provided with any suitable means 6 for the introduction thereof of an incoming electromagnetic wave. The electron gun 2 is provided with an electron emitting cathode 9 which is associated with any suitable heating means energized, for example, through leads 10 and 11 by a source 12 of electromotive force. Associated with the cathode 9 is an electrode 13 for use in regulating and varying the current of the electron beam and commonly known as an accelerating electrode. It may be adjacent to and coaxial with the cathode. A pair of suitably shaped electrodes 14 and 15, which may be fused into the walls of the envelope 1, define an input gap 16 and serve to close the resonator 4 except for suitable apertures provided in the electrodes for the passage of an electron beam or stream from the gun 2.

Any other suitable arrangement for maintaining an electron beam may be substituted for the electron gun 2.

The incoming wave is impressed upon the resonator 4 by means of the coupling 6 to produce a velocity variation in the electron beam at the gap 16. Conversion of the velocity variations into current density variations is provided for in a drift space 17, the length of which is determined by the spacing between the electrode 15 and an electrode 180. The local oscillations are generated in a resonant chamber of concentric structure having an outer wall 50, and inner walls 51, 52, 53 and 54, of which 52 and 53 may be conductively connected with the outer wall by wires 80 and 81, respectively. The wires are preferably of sufficiently small dimensions not to interfere materially with the transmission or oscillation of electro-magnetic waves within the enclosure. The wires preferably extend radially or substantially perpendicular to the electrical lines of force normally existing therein. Three gaps 55, 56 and 57 are provided along the course of the electron beam separated by additional drift spaces 58 and 59. The electrode 180 together with an electrode 181 defines the gap 55 and the gaps 56 and 57.

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are defined by similar pairs of electrodes. The ends of the resonating chamber are closed by means of annular pistons 60 and 61 which are slidable for purposes of tuning the resonant chamber. The collector 3 is conductively connected to the inner conductor 64 of a concentric transmission line of which a tube 65 of conductive material connected conductively with the walls of the resonating chamber is the outer conductor. The conductor 64 is connected to the tuning chamber and to ground through a high frequency choke coil 66. The concentric line 64, 65 is connected to another concentric line 68 of smaller diameter through a tapering section 67.

A second electron beam tube serving as an amplifier and second detector is shown in the lower portion of the figure and has an input resonator 62 coupled to the transmission line 68 by means of a coupling loop 69 inside the resonator. The wave impressed upon the resonator 62 produces a velocity variation of the electron beam at an input gap 70. Velocity sorting is effected on the output gap 71 due to the steady difference of potential maintained between insulated portions 82 and 83 of an output resonator by the electromotive force of a biasing source 84. The slower electrons of the beam are turned back and only the faster electrons continue, finally striking a collector 72. A coupling transformer 73 is provided for repeating the alternating portion of the pulsating current in the collector lead and a translating device such as a telephone receiver 74 is connected to the secondary of the transformer 73.

In the operation of the system of Fig. 1 the incoming oscillations from the coupling means 6 and local oscillations produced in resonating chamber having walls 50—54 are combined nonlinearly in the first or upper tube to produce a wave of somewhat lower frequency corresponding to the usual "intermediate frequency" wave. The wave so produced is amplified by the second or lower tube and the signals are detected by the velocity sorting process above described. Input resonator 62 and output resonator 82—83 may both be tuned to the frequency of the wave to be amplified. The local oscillator comprising the resonating chamber having walls 50—54 and gaps 55—57 is substantially a two-stage amplifier with coupling between the output and input. The relative voltages impressed upon the input gap 55 and the output gap 57 may be adjusted by proper setting of the tuning pistons 60 and 61, a movement of both pistons in the same direction an equal amount having substantially no effect on the resonant frequency.

In the arrangement of Fig. 2 an input resonator 120 is associated with an input gap 121. One side of the gap 121 is formed by the small end of a flaring tube 122, the large end of which forms a gap 123 in conjunction with one side of a ring-shaped electrode 124. The other side of electrode 124 forms a gap 125 in conjunction with the large end of a second flaring tube 126. Another gap 127 is formed between the small end of the tube 126 and an electrode associated with a resonator 128. The portion of the arrangement so far described is similar to one disclosed and claimed in my copending application, Serial No. 388,031 filed April 11, 1941; and assigned to the assignee of the present application.

Separated from the gap 127 by a drift space 129 is a gap 130 which is associated with a resonator 131 and an output coupling 132. A source 140 of alternating potentials is connected with

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the electrode 124, the direct current potential of electrode 124 being maintained at a relatively low potential with respect to the cathode by a source 141, whereas the resonators 120, 128 and 131 are maintained in suitable manner at a relatively high positive potential with respect to the cathode.

In the operation of the system of Fig. 2 the input wave of frequency which will be designated f_1 and which may bear signals in the form of amplitude modulations, is resonated in the chamber 120 and produces a velocity variation in the electron beam in the associated gap 121. The frequency of the local source 140 will be designated f_2 . Electron velocity sorting takes place within the tube 122 due to the influence of the relatively low potential upon the electrode 124. The degree of velocity sorting produced is under the control of the local source 140 by virtue of the variable potential superimposed upon the direct current biasing potential of the electrode 124 which causes the resultant bias to fluctuate. The faster electrons pass through the space within the electrodes 124 and 126 whereas the slower electrons are deflected and intercepted by the electrodes 122, 124 and 126. A density varied wave is produced at the gap 127 and excites electromagnetic oscillations in the resonator 128 which is preferably tuned to frequency $(f_1 \pm f_2)$ differing from that of resonator 120 by an amount equal to the value of the frequency of the source 140. Oscillations thus produced in resonator 128 impress a corresponding velocity variation upon the electron beam. This velocity variation will contain a component of the local frequency of source 140 bearing the amplitude modulations of the received wave. The velocity variation is converted by means of the drift space 129 into density variations at the gap 130. The resonator 131 may be tuned to the frequency f_2 of the source 140 and will be excited into forced oscillations by means of the density variations at the gap 130. The output may be taken off through the device 132 and led to an intermediate frequency amplifier or other utilization means.

Fig. 3 shows a precise or fine tuning adjustment which may be employed with any of the resonators in the systems heretofore described or which may be used as a tuning device in any other system employing a resonant chamber. An electron beam tube 150 is shown associated with a resonant chamber 151, the chamber having a side cavity 152 of relatively small dimensions in which is slidably mounted a piston 153 which may be moved by means of a suitable connecting rod terminating in a knob 154. The branch cavity is made preferably of such dimensions that the operating frequency desired is close to or somewhat below the range of free transmission so that the branch will not fully support the desired wave, in which case a relatively large motion of the piston 153 will produce only a relatively small change in the resonant frequency of the combination. The currents flowing in the side branch cavity will be less than in the main cavity with the result that any losses associated with the sliding contacts between the piston 153 and the walls of the cavity 152 will be minimized.

Fig. 4 shows a resonant cavity with multiple tuning arrangements for the purpose of producing a relatively wide frequency band. The side cavities may be independently adjusted to resonate at the same frequency or at slightly different frequencies, producing in either case a broad frequency band or relatively flat transmission

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characteristic in well-known manner. One of the side branches, for example, 160 may be connected with a suitable wave guide for transmission of waves into or out of the resonant chamber, the guide being separated from the resonant chamber by a conductive partition 161. Coupling between the guide and the resonant chamber may be effected by means of an aperture 162 in the partition 161.

Fig. 5 shows an alternative arrangement somewhat similar to the system of Fig. 4. One of the tuning branches 170 comprises a section of coaxial transmission line with inner conductor 171 and outer conductor 172, the latter being conductively joined with the main wall of the resonating cavity. The coaxial line may be adjusted by means of a slidable conductive disc 173 fitted over the inner conductor 171 and manipulated by means of a suitable mechanical arrangement shown as having a handle 174.

What is claimed is:

1. In an electron beam device, means for coupling an electron collecting element of said electron beam device to a concentric transmission line, in which the collecting element is directly and conductively connected to the inner conductor of said concentric line, and the outer conductor of said line surrounds said collector and is conductively connected to an electrode of said electron beam device adjacent to said collector.

2. A velocity sorting device for use with an electron beam comprising a resonating chamber

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substantially closed against the escape of electromagnetic radiations at the resonant frequency, said resonator comprising two conductive portions insulated from each other, said resonator being coupled with the electron beam and means for impressing a potential difference between the insulated portions of said resonator to produce an electron retarding field between the said insulated portions.

3. In a device for regulating the ratio of alternating potentials impressed at successive points along the path of an electron beam by a standing electromagnetic wave in a resonating chamber, the combination of a resonating chamber comprising a coaxial pair of cylindrical conductive surfaces closed at either end by reflecting annular pistons adjustable in the axial direction, and means to maintain an electron beam within the inner of said cylindrical surfaces and substantially parallel to the axis, said inner cylindrical surface being modified with inwardly directed radial extensions apertured to define a plurality of gaps in the path of the said electron beam to couple the beam with the electromagnetic field in said resonating chamber, translation of said pistons with fixed separation therebetween resulting in variation of the potential ratio at said gaps with substantially no effect on the resonant frequency of said resonating chamber.

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Disclaimer

2,403,025.—*Arthur L. Samuel*, Summit, N. J. ELECTRON BEAM DEVICE. Patent dated July 2, 1946. Disclaimer filed Sept. 24, 1948, by the assignee, *Bell Telephone Laboratories, Incorporated*.

Hereby enters this disclaimer to claim 2 of said patent.

[*Official Gazette October 26, 1948.*]