

[54] **PHASE ARRAY TARGET AMPLIFIERS**

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[58] Field of Search..... **315/3, 5.24, 5.27; 313/366; 330/43**

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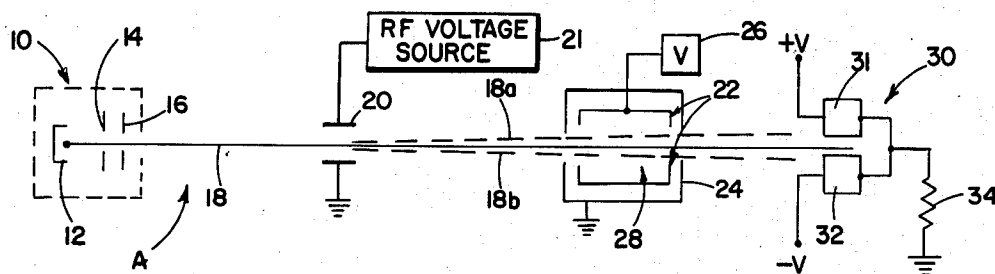
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[57] **ABSTRACT**

A phase array target amplifier for generating multiple

channels of high frequency electromagnetic power. The amplifier comprises a plurality of spaced apart amplifier channels, each of which contains similar channel components. Thus, the amplifier includes a plurality of electron generating guns which generate a plurality of electron beams, and where each of the beams exists in a separate beam channel. Deflector plates to modulate the beams are located along the beam path for optionally and individually or simultaneously deflecting various of the electron beams. In addition, an electron drift region is established downstream from the deflector plates by means of a pair of opposed phase shift electrodes. The velocity of the various beams are modulated in these drift regions through the potential on the phase shift electrodes so that each of the beams are phase shifted in a time controlled manner with respect to each of the other beams. A semiconductor target device is also provided in each amplifier channel so that each target device is associated with an individual electron beam. These target devices are modulated responsive to the fraction of the beams current deflected on the active region of the target devices, to generate an array of amplified output signals with controlled phase relationship. In this way, it is possible to drive multiple power radiating arrays (e. g. phase array antennas).

9 Claims, 4 Drawing Figures



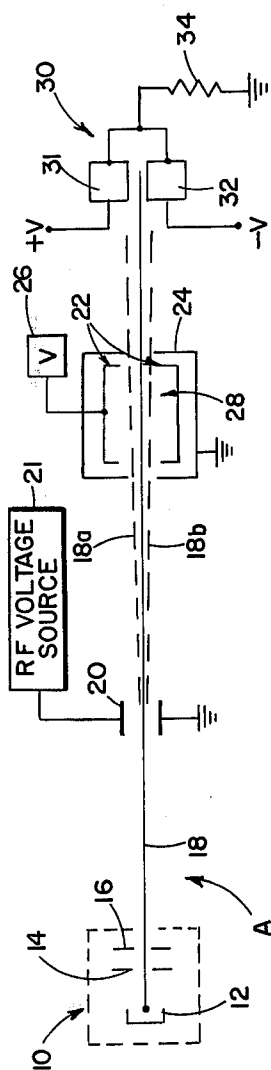


FIG. 1

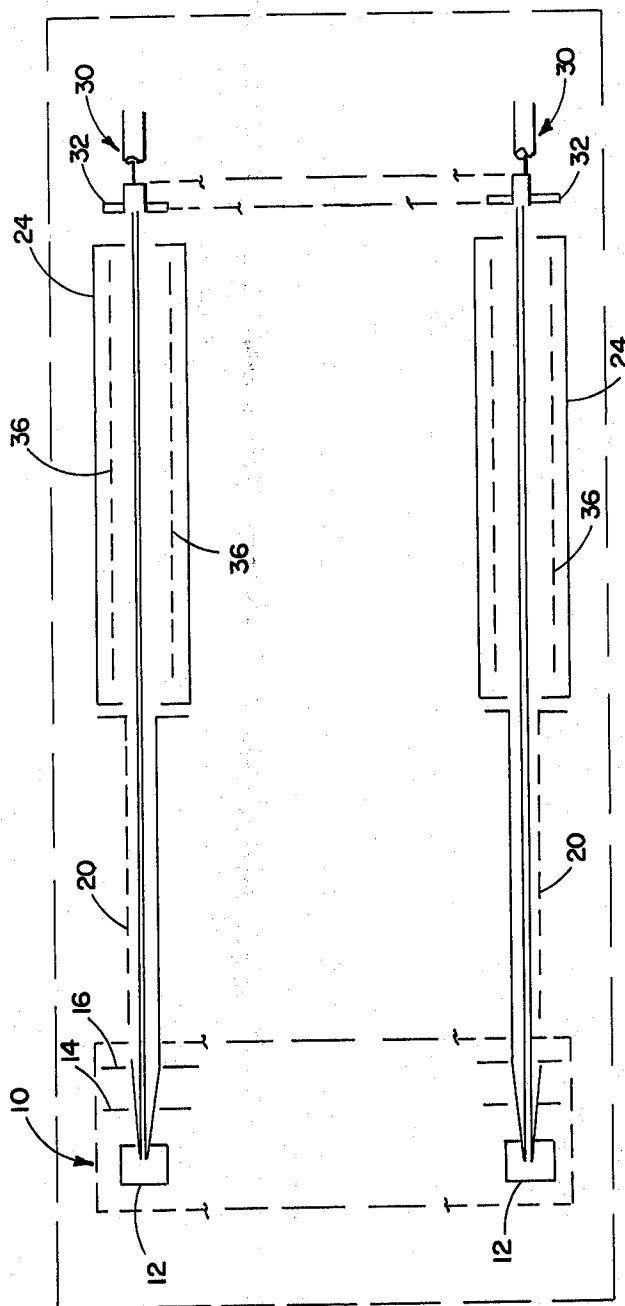
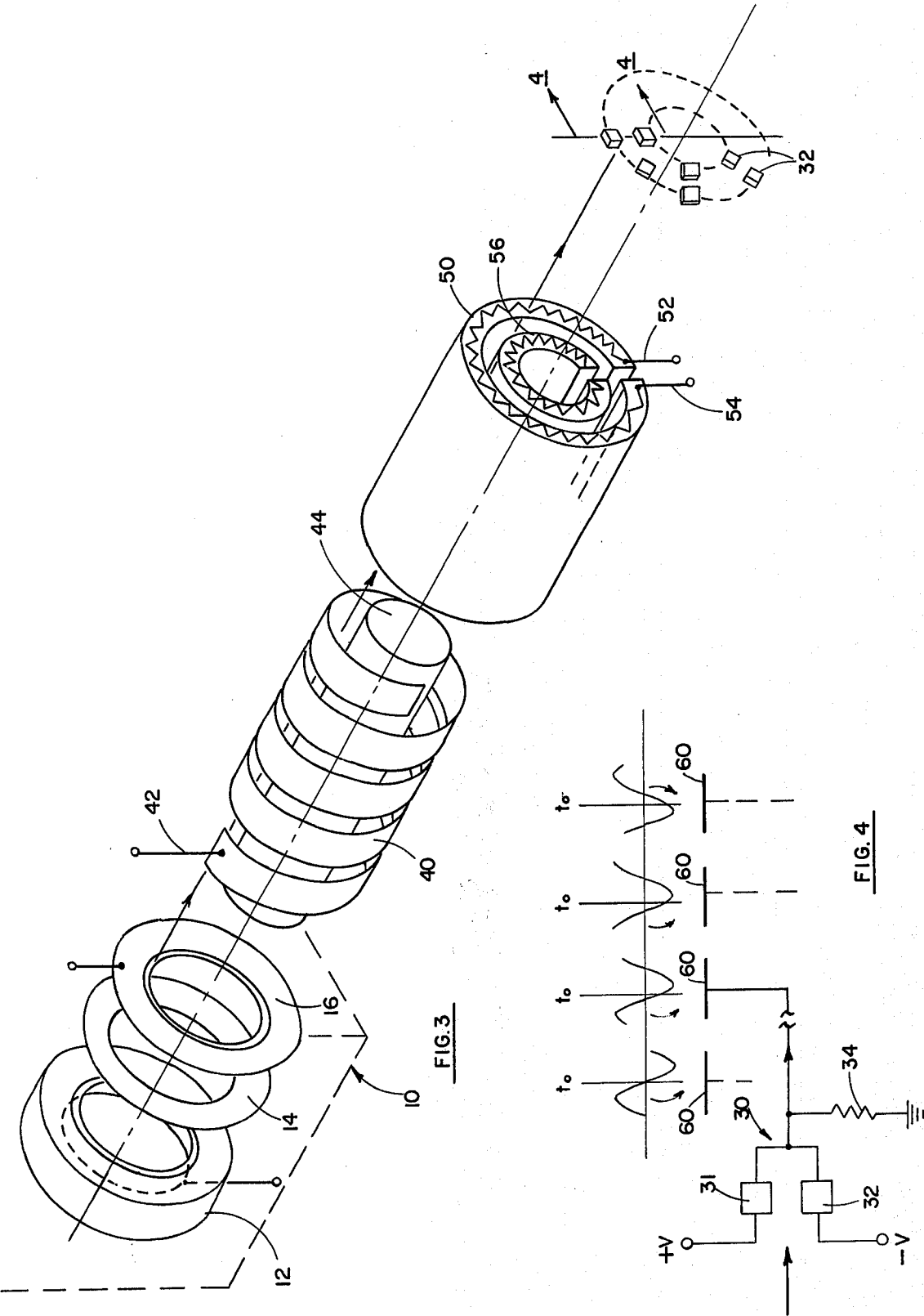


FIG. 2



PHASE ARRAY TARGET AMPLIFIERS

BACKGROUND OF THE INVENTION

This invention relates in general to certain new and useful improvements in target amplifiers, and more particularly, to phase array target amplifiers which are capable of generating channels of high frequency electromagnetic power.

For many years, antenna systems for transmitting and receiving signals to and from remote sources have been widely used in both civilian and military applications. Furthermore, these antenna systems have been used in a wide variety of environments. It is very common to use ground based antennas for tracking airborne equipment, such as missiles, airplanes or other forms of aircraft, and the like. In addition, antenna systems of this type are also used on sea going vessels. In like manner, the airborne equipment may also be provided with antenna systems, which are used in connection with ground based or other remote radar equipment, tracking systems or the like.

Many of these antenna systems include a dipole which is operated by a power amplifier for generating the electromagnetic wave. These antenna systems also additionally include a reflector, such as a parabolic reflector, for transmitting the electromagnetic wave. Fairly substantial prime movers and complex control systems are generally required to rotate the reflector for purposes of scanning with the electromagnetic waves. In addition, this form of antenna system requires a substantial amount of energy for operation, which may often necessitate the use of power stations. Consequently, this form of antenna system is oftentimes quite heavy and bulky and not readily transportable thereby hindering the versatility of the system. Moreover, it has been found that the resolution obtained with this type of antenna system is not very sharp.

In view of the above described shortcomings with the known antenna systems, there have been recent developments in the field which relies upon the use of arrays of dipoles operated with phase shifters. Thus, a plurality of dipoles, located in a one or two dimensional array, operates to generate individual sources of electromagnetic waves and by phase shifting the energy to the dipole, it is possible to alter the direction of the resultant electromagnetic wave. In this arrangement, each dipole is provided with a separate phase shifter, and furthermore, all of the phase shifters are operated from an individual power amplifier or oscillator.

While this latter form of system does provide a much greater resolution, it nevertheless suffers from the deficiency of high cost. The phase shifters, which carry the full power to the dipoles, presently cost approximately \$100 each and in a large array, the phase shifters alone would be exceedingly costly. As a result thereof, this form of combination of amplifier, multiple phase shifters and dipole arrays has only found limited use on aircraft and in other applications where the use would be desirable but not economically feasible.

There have been several attempts to use low cost low power phase shifters to drive an individual traveling wave tube for each dipole element. However, again the required large number of traveling wave tubes are very expensive and consequently, there is little if any overall reduction in cost of the entire system.

These antenna systems of the type mentioned above normally use electron tubes, such as vacuum tube

power amplifiers or traveling wave tubes due to the need for high frequency generation. solid state circuitry is generally not applicable because the present solid state circuitry is not capable of generating the power levels required in these antenna systems.

One of the other problems associated with the use of electron tube amplifiers is that, while these amplifiers can operate at relatively high power levels to generate high frequencies, they also operate in a resonant structure. Consequently, power tube amplifiers generally have very narrow bandwidths and therefore cannot handle the broad frequency spectrums required for many applications.

The present invention obviates these and other problems in the provision of a phase array target amplifier which generates a plurality of properly phased channels of high power electromagnetic energy in a single vacuum envelope by means of phase shift-drift regions in conjunction with the use of electron beam semiconductor elements. The amplifier of the present invention employs deflector plates to deflection modulate the beam along its beam path. The phase shift drift regions electronically control the velocity of the beams after modulation, and hence the various beams may be phase shifted relative to each other. The individually phase shifted deflection modulated electron beams generate amplified output power in an array of semiconductor target devices.

It is therefore the primary object of the present invention to provide a phase array target amplifier which is capable of generating multiple channels of properly phased high frequency electromagnetic power with solid state circuitry.

It is another object of the present invention to provide a phase array target amplifier of the type stated which can be built at a relatively low cost, but which is nevertheless highly efficient in operation.

It is a further object of the present invention to provide a phase array target amplifier of the type stated which is relatively simple in its construction, and requires little if any maintenance.

It is an additional object of the present invention to provide a phase array target amplifier of the type stated which is capable of operating over a broad frequency spectrum and which is also capable of generating high frequencies.

It is another salient object of the present invention to provide a method of generating high frequency electromagnetic power with a phase array target amplifier of the type stated and which method operates on the principle of optionally deflecting certain of the electron beams and controlling the velocity of the electron beams in order to provide effective phase shifts among the beams.

With the above and other objects in view, my invention resides in the novel features of form, construction, arrangement, and combination of parts presently described and pointed out in the claims.

GENERAL DESCRIPTION

In general terms, the present invention relates to an amplifier operating with a plurality of electron beams and having a plurality of similar circuit configurations or so-called "amplifier channels." Each of these circuit configurations or amplifier channels comprises at least an electron gun to generate an electron beam, a pair of deflection plates to deflect or modulate the beam with

a low power input signal, an electron beam drift region to phase shift the beam, and a semiconductor target amplifier.

One of these amplifier channels can be described as a phase array target amplifier apparatus for generating high frequency electromagnetic power. This amplifier apparatus comprises electron generating means for generating an electron beam. Electrically energizable deflector means are located downstream with respect to the path of the electron beam for deflecting or modulating the electron beam. Phase shift electrodes are also located downstream from the deflector means with respect to the path of the electron beam. These phase shift electrodes are located on opposite sides of the electron beam to establish an electron beam drift region therebetween by virtue of the potential applied to these electrodes. In this way it is possible to control the velocity of the beam through the drift region. A semiconductor target device is located to receive the electron beam and to be modulated responsive to the deflection of the electron beam by the deflector means and to be shifted in phase by variation of the drift time in the drift region.

The phase array target amplifier apparatus of the present invention can be characterized in further detail in that the semiconductor target device is an amplifier which amplifies a signal represented by the modulated electron beam. In a preferred aspect of the present invention, the semiconductor members modulated by the electron beam deflected alternately on these semiconductor members. One of these members generates an amplified positive current actuated by the deflected electron beam current incident upon it, and the other of these members generates an amplified negative current actuated by the deflected electron beam current incident upon it to provide an amplified AC power output.

The amplifier apparatus can also be further characterized in that the electron generating means comprises a cathode operable electron gun. In addition, the deflector means comprises a pair of deflector plates, each of which is located on opposite sides of the electron beam to deflection modulate the electron beam.

In a preferred embodiment of the present invention, the apparatus comprises a plurality of individual electron generating means. A plurality of individual electrically energizable deflector means is also provided. Each one of these deflector means is associated with an individual electron generating means. A plurality of pairs of phase shift electrodes are also included in the apparatus. Each individual pair of phase shift electrodes is associated with an individual deflector means and an individual electron generating means. Finally, the apparatus includes a plurality of individual target devices. Again, each one of the target devices is associated with an individual one of the electron generating means, an individual one of the deflector means and a pair of the phase shift electrodes.

In a further preferred embodiment of the present invention, the phase array target amplifier apparatus is capable of generating multiple channels of high frequency electromagnetic power. This amplifier apparatus also comprises a plurality of spaced apart electron generating elements for generating a plurality of electron beams. Individual spaced apart electrically energizable deflector means are associated with each of the electron generating elements. These deflector means

are also located downstream with respect to the path of the electron beams for optionally and individually deflecting the electron beams.

Individual phase shift electrode means are associated with each one of the electron generating elements and associated ones of the deflector means. Again, these electrode means are located downstream from the deflector means with respect to the path of the electron beams. Each of these phase shift electrode means have electrodes located on opposite sides of the associated electron beam for establishing an electron beam drift region therebetween. In this way, it is possible to control the velocity of each of the beams therethrough to thereby create time delays in some of the electron beams by adjusting the potential of the electrode means, thereby varying the electron energy and therefore the velocity of one of the beams with respect to the other of the beams. A plurality of individual spaced apart semiconductor target devices are also included in the apparatus. Each one of these target devices is associated with an electron beam and is located to receive the electron beam so as to be modulated responsive to the deflection of the beam by the deflector means and the phase by varying the potential of drift plates in the drift region.

The phase array target amplifier apparatus in this preferred embodiment can be further characterized in that each of the semiconductor target device is an amplifier which amplifies a signal represented by the associated electron beam. Each semiconductor target device comprises a pair of electron beam modulated semiconductor members. One of these semiconductor members is positively actuated by the electron beam and the other of these semiconductor members is negatively actuated by the electron beam to provide AC modulation. In addition, each of the electron generating elements comprises a cathode operable electron gun.

In the most preferred form of construction of the phase array target amplifier, all of the deflector means comprised of a helically wound spiral electrode member with a central electrode member extending therethrough. In this way, it is possible to form a stripline spiral electrode and thereby efficiently generate a high frequency deflecting field for all the electron beams by a single low power high frequency voltage generator. In addition, all of the phase shift electrode means for each channel comprise a first tubular resistive member and a second resistive tubular member concentrically located within and spaced from the first tubular resistive member. The first and second tubular resistive members are connected in such a manner that a voltage drop is created about their annulus to create a variable retarding potential as a function of annulus position to control the velocity and thereby the phase of the electron beams as a function of annulus position.

The present invention can also be described in general terms as a method for generating high frequency electromagnetic power with a phase array target amplifier. This method comprises the generating of an electron beam. Thereafter, the electron beam is deflected or modulated as desired with electrically energizable deflector plates located downstream with respect to the path of the electron beam. An electron beam drift region is established between a pair of phase shift electrodes on opposite sides of the electron beam. The velocity of the beam is controlled through this electron

beam drift region by the potentials on the phase shift electrodes. The direction modulated electron beam current creates an amplified output current in the semiconductor target devices.

The method for generating high frequency electromagnetic power can be characterized in further detail in that the method comprises the positively actuating of one of a pair of electron modulated semiconductor members, and the negatively actuating of the other of the pair of semiconductor members by the modulated electron beams to provide AC modulation.

The method for generating high frequency electromagnetic power can also be further characterized in that the method comprises the generating of a plurality of electron beams from a plurality of individual electron generating means. Certain of the electron beams are deflected by each of a plurality of individual electrically energizable deflector means. Furthermore, each one of these deflector means is associated with an individual electron generating means. In addition, certain of the electron beams are phase shifted by a plurality of pairs of phase shift electrodes. Each of the electron beams are finally modulated on a plurality of individual target devices responsive to the current of the respective electron beams incident on the active regions of the individual target devices.

In a preferred embodiment of the method for generating multiple channels of high frequency electromagnetic power with a phase array target amplifier, the method comprises the generating of a plurality of spaced apart electron beams, where each beam lies in a separate electron beam channel. The electron beams are individually and optionally deflected with individual spaced apart electrically energizable deflector means which are located downstream with respect to the path of the electron beams. An electron beam drift region is established between phase shift electrodes located on opposite sides of the associated electron beam for each electron beam channel. The velocity of each of the beams is controlled through the drift regions to create time delays in some of the electron beams with respect to the other of the beams. The electron beams modulate the electron beam current incident on a plurality of individual spaced apart semiconductor target devices creating a modulated amplified output current flow through the semiconductor devices.

The preferred embodiment of the method of generating multiple channels of high frequency electromagnetic power can be characterized in further detail in that the method comprises the positively actuating of one of a pair of electron modulated semiconductor members, and negatively actuating the other of the semiconductor members in the pair by the electron beam to provide AC modulation.

BRIEF DESCRIPTION OF THE DRAWINGS

Having thus described the invention in general terms, reference will now be made to the accompanying drawings in which:

FIG. 1 is a schematic side elevational view of one amplifier channel of a phase array target amplifier constructed in accordance with and embodying the present invention;

FIG. 2 is a schematic side elevational view of a phase array target amplifier constructed in accordance with and embodying the present invention and which illus-

trates a plurality of spaced apart amplifier channels thereof in an array;

FIG. 3 is an exploded perspective view of the preferred construction of one embodiment of the phase array target amplifier of the present invention; and

FIG. 4 is a diagrammatic view of some of the components of the phase array target amplifier of the present invention and the wave forms generated therein.

DETAILED DESCRIPTION

Referring now in more detail and by reference characters to the drawings which illustrate practical embodiments of the present invention, A designates one amplifier channel of a phase array target amplifier. Thus, a combination of a plurality of like amplifier channels A normally located in an array thereof, in the manner as illustrated in FIG. 2 of the drawings, would constitute a phase array target amplifier.

The amplifier channel A generally comprises an electron gun 10 which includes a hot wire cathode 12 and a pair of slit focusing electrodes 14 and 16. Generally, the cathode 12 would be maintained at a negative voltage with respect to the grounded focusing electrode 16. The electron gun would generate an electron beam schematically designated as 18 in FIG. 1, and which would lie in a electron beam channel.

Located in forwardly spaced relationship to the electron gun 10 in the direction of movement of the electron beam 18 are a pair of deflector plates 20, one of which is grounded and the other of which is connected to RF voltage source 21. This voltage source 21 represents the radio frequency input signal that is to be amplified. In this way, by properly biasing the deflector plates, it is possible to change the direction of the beam as illustrated by the dotted lines 18a and 18b FIG. 1. Thus, it can be observed that by merely placing an electrical bias on the plates 20, it is possible to change the path of the beam 18.

Also located in downstream relationship to the deflector plates 20 are a pair of opposed phase shift electrodes 22, which are located on opposite sides of the beam channel. These phase shift electrodes 22 are preferably included within a grounded housing 24. The electrodes 22 when energized by a positive voltage source 26, will accelerate the electrons in the electron beam and thereby increase their velocity while transversing the drift region 28 established between the phase shift electrodes 22. Due to this increased velocity for a positive voltage the traversal time through the drift region 28 will be shorter than the time for zero voltage applied to the phase shift electrodes 22. Conversely, a negative voltage applied to the phase shift electrodes 22 will increase the drift time in region 28.

By varying the duration time of the electrons in the drift chamber, and hence the time for an electron beam to pass through the drift chamber 28, it is possible to introduce phase shifts between input signals implanted on the electron beams by the deflector plates 20 in different electron beam channels. It can be observed that due to the delay in time of passage of the various electron beams in their respective beam channels, that some of the beams would be selectively phase shifted with respect to others of the electron beams.

Located at the output of the electron beam drift region 28 is a semiconductor target device 30 which comprises a pair of semiconductor elements 31 and 32 connected in common and grounded through a load resis-

tor 34. Each of these target elements 31 and 32 may adopt a form of a P-N junction target diode, such as that described on Page 78 of Physics of Semiconductor Devices by S. M. Sze, Wylee Interscience, New York (1969). Typically, a silicon-diffused P-N diode may be utilized as one of the target elements with the junction diode being located in a position at a depth below the surface of about $\frac{1}{2}$ micron. With a beam having an energy of about 10 kilovolts, the junction depth of the target diode should be less than 1 micron for proper operation. It is desirable to provide junction passivation at the junction of this diode so that the junction is not subject to damage by the electron beam. This can generally be achieved, for example, by growing an oxide or a dielectric layer over the junction. The energetic electron beam penetrates to the diode junction and creates electron-hole pairs thereby generating a conduction current in the output proportional to the instantaneous electron beam current incident on the particular diode.

In essence, the pair of target elements 31 and 32 operate as a form of push-pull amplifier. For example, one of the semiconductor elements 31 would be biased to generate a positive current flow when activated by the electron beam current incident on its surface and penetrating to the intrinsic regions to generate electron-hole pairs. The other of the semiconductor elements 32 would be biased to generate a negative current flow in order to provide alternating current modulation by the alternating deflected electron beam to the semiconductor devices. If the deflector plates 20 were biased so that the electron beam in a particular electron channel was deflected upwardly, to follow the beam path 18a, a positive current flow would be achieved. In like manner, if the deflector plates 20 were biased in such manner that the electron beam in such beam channel was deflected downwardly and followed the beam path 18b, a negative current flow would be achieved. In this respect, the amplifier device 30 acts somewhat as a so-called "push-pull" amplifier. In addition, it can be observed that this form of target device 30 will provide a high current gain with modulation at essentially any frequency initially applied to the deflecting electrode 20 by an input voltage from the source 21. In this manner an amplified RF signal in accordance with the RF applied to electrode 20 is generated across resistor 34.

As indicated previously, a plurality of these amplifier channels A located in an array would form the phase array target amplifier of the present invention. This array of amplifier channels A may be formed so that the channels A all lie in coplanar relationship, or otherwise in any other form, such as a cylindrical pattern.

When the amplifier channels A are mounted in the form of a cylindrical array, then the drift regions 28 also include pairs of controllable (e.g. linear) resistive accelerating electrodes 36 having controllable voltage drops (e.g. linear) between the phase shift electrode pairs 36 of the plurality of channels A. These accelerating electrodes 36 provide a controllable (e.g. linear) variation in the acceleration potential across the plurality of target elements in the target array. In the case of a driver for an array of dipoles, the required input power to the phase shift resistive electrode array will depend upon the desired sweep rate of the radiated electromagnetic wave. However, for a 1 MHz sweep rate of the directed radiate EM wave, the input power would be approximately 10 watts. For a cross antenna array, the resistive array of accelerating electrodes 36

can be divided into two independently controllable sets of channel arrays.

In a preferred aspect of the present invention, the phase array target amplifier of the present invention would include about one hundred or more phased outputs which is capable of operating over many octaves of frequency and requires a single low power tunable oscillator to modulate the deflection plates 20. The geometry of the various amplifier channels can have the right circular cylindrical symmetry, as indicated above, and in this form, would be less than five centimeters in diameter and fifteen centimeters long.

In a flattened geometry, the typical dimensions would be in the order of 2 centimeters by eight centimeters by 15 centimeters. The target amplifier, in this case, would modulate a low current relatively high voltage electron sheath beam. Furthermore, the array of amplifier channels A would be packages in a single vacuum envelope (not shown). The target structure would probably require some form of conventional heat removal mechanism.

A preferred embodiment of the phase array target amplifier of the present invention is more fully illustrated in FIG. 3 of the drawings. In this case, the electron gun 10 for the array of amplifier channels A would comprise the hot cathode electrode 12 along with the slit focusing electrodes 14 and 16. For the array of amplifier channels A, the deflector plates 20 would adopt the form of a helically wound conductive electrode 40 having a connecting terminal 42 for connection to a suitable input R.F. voltage supply (not shown). In addition, this form of deflector mechanism would include a coaxially located central conductive ground electrode 44, in the manner as illustrated in FIG. 3 of the drawings to form with the conductive electrode 40, a helically wound stripline designed to match the impedance of R.F. supply, and efficiently deflection modulate the concentric array of electron beams from the electron guns 10.

This form of deflector mechanism as described above is typically referred to as a "strip-line deflector" mechanism. It can be observed that this deflector mechanism is capable of replacing all of the deflector plates in the array of amplifier channels A in that the various beams could be properly deflected by energizing the electrode 40 over its axial length with respect to the electrode 44. In this way, it would be possible to deflect simultaneously all of the electron beams either inwardly or outwardly. In essence, this form of deflector mechanism would operate with a sheath electron beam and would essentially cause the beam to expand or contract pursuant to the biasing levels applied to the electrode 40.

The drift region 28 along with the phase shift electrodes 22, would be replaced by phase shift resistor electrodes 50 and 56 which are cylindrical in shape and slit along the axial length to provide a pair of opposed terminal ends 52 and 54, in the manner as illustrated in FIG. 3 of the drawings. The terminal end 54, for example, is connected to a variable voltage source (not shown) to generate the required phase shift potentials while the terminal end 52 is grounded. Not shown in the figure are concentric ground shields internal to electrode 56 and external to electrode 50.

In this case, it can be observed that the pair of resistive electrodes 50 and 56 suitably replace each of the phase shift electrodes 22 and the drift region 28 estab-

lished therebetween. A voltage drop will be created along each of the electrodes 50 and 56 over their circumferential lengths. Thus, one end 52 of the electrodes 50 and 56 will have the extreme phase shift voltage level, and the other of the opposed ends at the slit will have a zero phase shift voltage level. In like manner, a potential drop will exist circumferentially between the two electrodes 50 and 56.

Referring now to FIG. 4, it can be observed that each of the semiconductor devices 31 and 32 are respectively biased by positive and negative voltage sources respectively. Further, it can be observed that the wave form produced at each of the antenna elements 60 is more fully illustrated as an output from the array of the target electrodes 30 shifted in phase at a particular time t_0 as determined by the specific phase shift potential applied to electrode 52.

Thus, there has been illustrated and described novel phase array target amplifiers and method of using same which fulfill all of the objects and advantages sought therefore. Many changes, modifications, variations and other uses and applications of the target amplifiers and the method of using the same, will become apparent to those skilled in the art after considering this specification and the accompanying drawings. Therefore, all such changes, modifications, variations, and other uses and applications which do not depart from the spirit and scope of the invention are deemed to be covered by the invention which is limited only by the following claims.

Having thus described my invention, what I desire to claim and secure by Letters Patent is:

1. A phase array target amplifier apparatus for generating multiple channels of high frequency electromagnetic power from a single high frequency electromagnetic power signal, the signals in said channels having predetermined phase shifts relative to each other, said amplifier apparatus comprising:

- a. a plurality of spaced apart electron generating elements for generating a plurality of electron beams,
- b. individual spaced apart electrically energizable deflector means associated with each of said electron generating elements and located downstream with respect to the path of the electron beams for individually deflecting each of the electron beams in response to said single high frequency power signal,
- c. individual phase shift electrode means associated with each one of said electron generating elements and associated ones of said deflector means and being located downstream from said deflector means with respect to the path of the electron beams,
- d. each of said phase shift electrode means having electrodes located on opposite sides of the associated electron beam for controlling the velocity of each of the beams therethrough to thereby create said predetermined relative phase shifts in the signals in each of said channels, and
- e. a plurality of individual spaced apart semiconductor target devices, each one of which is associated with an electron beam and is located to receive said electron beam and to be modulated responsive to the deflection of said electron beam.

2. The phase array target amplifier apparatus of claim 1 further characterized in that each said semicon-

ductor target device is an amplifier which amplifies a signal represented by the associated electron beam.

3. The phase array target amplifier apparatus of claim 1 further characterized in that each said electron generating element comprises a cathode operable electron gun.

4. The phase array target amplifier apparatus of claim 1 further characterized in that each said semiconductor target device comprises a pair of electron modulated semiconductor members, one of which is positively activated by the electron beam and the other of which is negatively actuated by the electron beam to provide AC modulation.

5. The phase array target amplifier apparatus of claim 1 further characterized in that all of said deflector means comprises a helically wound tubular electrode member with a center electrode member extending therethrough.

6. The phase array target amplifier apparatus of claim 1 further characterized in that all of said phase shift electrode means comprises a first tubular resistive member and a second resistive tubular member concentrically located within and spaced from said first tubular resistive member.

7. The phase array target amplifier apparatus of claim 1 further characterized in that all of said phase shift electrode means comprises a first tubular resistive member and a second resistive tubular member concentrically located within and spaced from said first tubular resistive member, said first and second tubular resistive members being connected so that a voltage drop is created about their annulus thereby creating a change in the velocity of the electron beams as a function of the annular position of these beams.

8. A method for generating multiple channels of high frequency electromagnetic power with a phase array target amplifier, said method comprising:

- a. generating a plurality of spaced apart electron beams where each beam lies in a separate electron beam channel,
- b. individually and optionally deflection modulating the electron beams with a high frequency electromagnetic power signal by means of individual spaced apart electrically energizable deflector means located downstream with respect to the path of the electron beams,
- c. establishing an electron beam drift region between phase shift electrodes located on opposite sides of the associated electron beam for each electron beam channel,
- d. controlling the velocity of each of the beams through said drift regions,
- e. creating time delays in some of the electron beams with respect to the other of the beams,
- f. modulating said electron beams responsive to the initial deflection and drift time of said electron beams,
- g. amplifying the modulated electron beams by a plurality of individual spaced apart semiconductor target devices.

9. The method of generating multiple channels of high frequency electromagnetic power of claim 8 further characterized in that said method comprises positively actuating one of a pair of electron modulated semiconductor members, and negatively actuating the other of the semiconductor members in the pair by the electron beam to provide AC modulation.

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