

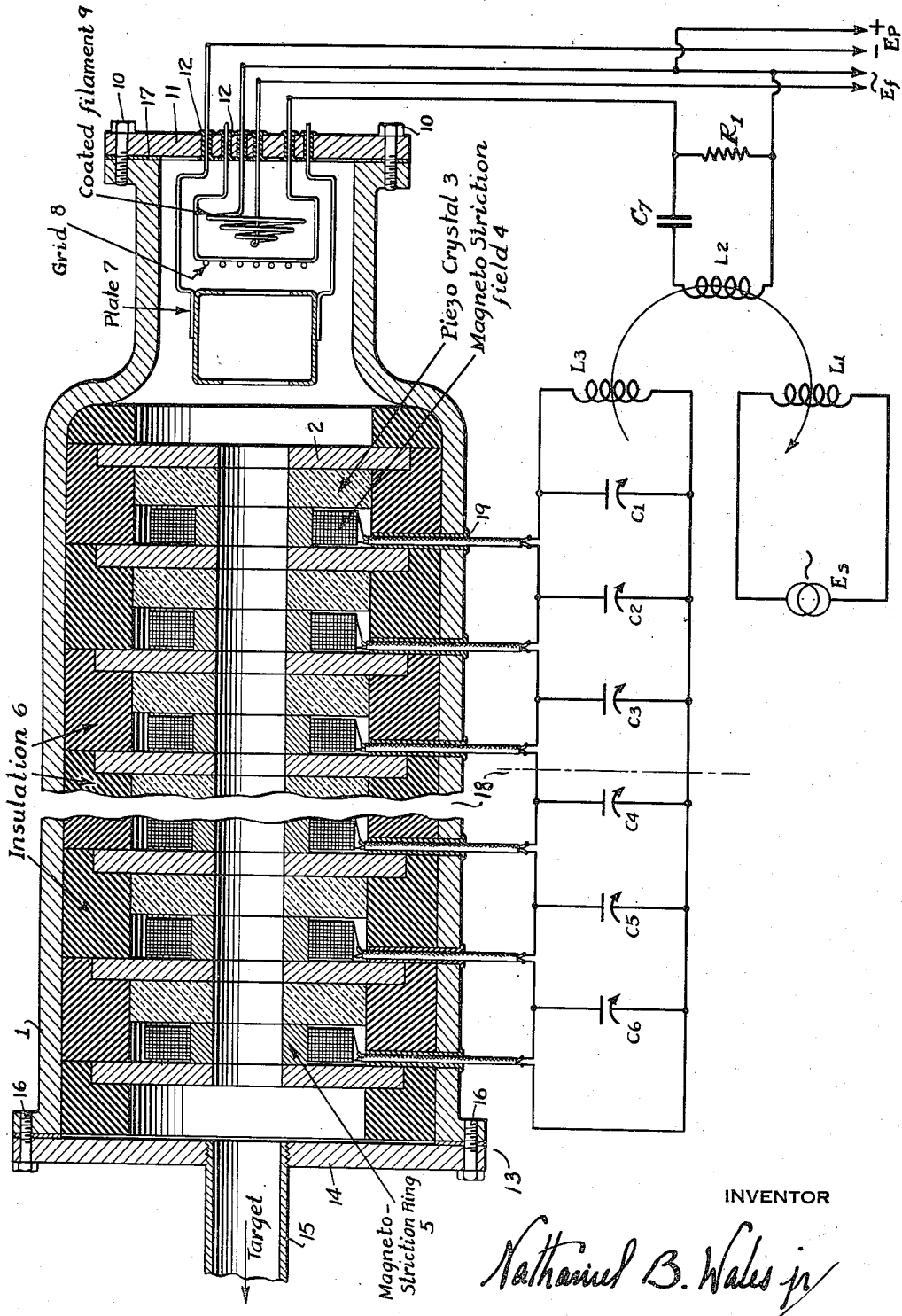
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PHASE WAVE ION GUN

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# UNITED STATES PATENT OFFICE

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## PHASE WAVE ION GUN

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6 Claims. (Cl. 250—27)

This invention relates to the acceleration of charged particles by electrostatic impulses. In particular, I disclose a method of utilizing the piezo-electric differences of potential appearing periodically on the faces of a series of piezo crystals under oscillatory pressure in such a way as to successively accelerate through said differences of potential groups of ions passing along this series. Specifically, my method attains its objects by allowing for the decreasing time intervals subtended by successive equidistant points along the path of an accelerating particle through the use of phase differences of the oscillating electrostatic generators, whether they be piezo-electric or otherwise, so adjusted that the field of any given generator will attain a maximum potential difference at a time corresponding to the arrival of the accelerating charged particle within the locus of said field. Among the several objects in this invention is that it is desirable to attain ions or charged particles of high kinetic energy for purposes of transmutation, and for the induction of radioactivity. My invention allows a potential drop on the order of 10,000 volts such as that appearing on piezo crystals under relatively small displacements to be successively applied to the accelerating ion or charged particle until it has attained an energy equivalent corresponding to as many times a multiple of this incremental piezo drop as there are composite sections in the apparatus.

It is also desirable that the apparatus satisfying the former object be compact and of light weight. This invention is unique in size and weight as compared to other electrostatic accelerators.

A further object is to obviate the necessity of using excessive input potentials to the accelerating apparatus.

In the following specification, I shall disclose a clear and complete exposition of the construction and operation of my invention. It is understood that the method, as well as the specific structure involved in this invention, comprises its novelty. Considering now the drawing as illustrative of one exemplification of my invention where in like numerals in the specification and drawing refer to corresponding parts.

The figure shows a broken section in side elevation of the assembly of the cylindrical chamber of the "gun" which illustrates my invention and with the external parts of the associated electrical system shown in schematic diagram.

Referring to the figure, the cylindrical alumi-

num casing 1 is sealed at the one end by an insulating disk 11 and gasket 17 secured thereto by cap screws 10 and at the other end by the plate 14, gasket 13 and cap screws 16, altogether forming with exhaust tube 15 a chamber capable of supporting a high vacuum when the source of ions used so permits. In this exemplification of my principle a coated filament 9 has been chosen for simplicity as a source of ions. This filament has its leads brought through the insulating support 11 within gromets 12 forming with them a soldered and crimped seal. The annular plate 7 and control grid 8 are similarly supported, and together with the filament 9 form a source of low velocity ions axially collimated down the casing 1 and capable of modulation by potentials impressed on control grid 8. Within the casing 1 are enclosed a series of rigid insulating annuli 6 which centralize and axially space a series of rigid steel annuli 2, thus forming a series of insulated annular partitions incapable of longitudinal displacement of any moment. The multiple nature of these partitions is illustrated by the broken casing and circuit at 18. Within each partition, there is arranged a piezo crystal 3 of Rochelle salt, for instance, in annular form, and subject to the axial pressure which may result from a magneto strictive longitudinal extension of the nickel alloy ring 5, positioned to bear upon said crystal 3.

Concentrically surrounding each ring, 5, is an energizing field winding, 4, capable of inducing and maintaining magneto-strictive oscillation in these rings, especially at the natural mechanical resonant frequency. The electrical leads for each field winding pass through conduits 19 to enter into the series transmission circuit comprising the coupling inductance  $L_3$ , parallel condensers  $C_1, C_2, C_3, C_4, \dots, C_5$  and  $C_6$ , spanning one side of the line and the series field elements 4. Evidently any wave form of electric displacement induced in  $L_3$  will travel down the line to supply oscillatory energy to the inductances 4 in turn, and if sustained in periodic succession each magneto-striction ring 5 will respond at the frequency induced in  $L_3$ . However, the phase of this response relative to the preceding one in any given field coil 4 will be a function of its position in the artificial transmission line and of the capacitance of the parallel condenser preceding it. In that the characteristics of this line are adjustable, the phase of each section may be made to lag behind or to advance ahead any fraction of its period beyond its preceding section in the series. The oscillator  $E_2$  is coupled

to  $L_3$  and  $L_2$  by the inductance  $L_1$ . The inductance  $L_2$  is made to impress the oscillations of  $L_1$ , on a control grid circuit comprising bias resistor  $R$  and grid condenser  $C_7$ .  $E_r$  and  $E_p$  supply the filament and plate with potentials suitable to maintain their ionic beam.

The operation of my invention is as follows: A quantum of ions leaves the plate 7 and is projected into the axial space between the faces of the first piezo crystal. The antinodal maximum which released said quantum from the space cloud of ions near the filament is arranged by the relative phasing effected by  $C_1$  to bring pressure on said crystal only at a time calculated to allow for the arrival of said quantum within the electrodes of the first of said electrostatic generators. Consequently, although there has been no appreciable retarding of the approaching charged group of particles, this quantum suddenly finds itself in a region of high potential gradient through which it proceeds to fall with an attendant gain in kinetic energy. At the region of departure from this electrostatic locus, the ordinary retarding force which would obtain with the recession of a charged particle from an oppositely charged plane is absent due to the disappearance of the piezo field with the recession of the compressive antinode, and only a negligible image field remains to retard the increased velocity of this accelerated group of particles. This cycle of operations is continued with a phase difference for successive sections calculated to correspond to the decreasing periods of transit attendant upon the passage of equidistant points by an accelerating point. The theoretical limit to the velocities so attained is determined by the frequency at which the period is equal to the period of transit for the first of the series of piezo fields. Practically the limit is determined by the natural period associated with magnetostriction elements of structural convenience.

It is desired to emphasize that the novel principle involved, together with the novel means used to incorporate it, is in brief the use of discrete electrostatic generators of oscillatory potential so phased as to cause a gradient of potential to obtain at points so disposed and at such times as to coincide with the path of an accelerating particle. The particular structure here disclosed may also be paralleled in its satisfaction of the principle by an annular column of electrets controlled in phase by an oscillatory neutralization of their fields under scansion of their associated electrodes by a cathode beam. Or similarly, the principle of discrete generators may be satisfied by the photoelectric charges oscillatorily deposited on an annular column of electrodes scanned as above by a phasing cathode or ultra violet beam.

What I claim and desire to secure by United States Letters Patent is:

1. A device to electrostatically accelerate charged particles, comprising a source of charged particles, a plurality of electrostatic generators

sequentially aligned to form a path of acceleration for said particles, said generators having relative phase of potential means to form an accelerating region of maximum potential gradient to accelerate said charged particles along said path.

2. A device to electrostatically accelerate charged particles, comprising a source of charged particles, a plurality of piezo electric generators, sequentially aligned to form a path for said particles, said generators having relative phase of compression means to form corresponding electrostatic charges in said generators, and means thereby to maintain an accelerating maximum gradient of potential along said path to accelerate said charged particles.

3. A device to electrostatically accelerate charged particles, comprising a source of charged particles, a plurality of electrostatic generators, a plurality of aligned electrodes connected therewith to form a path for said particles, means to electrically impress said generators on said aligned electrodes, and relative phase means to produce a region of a maximum potential gradient to move along said path and to accelerate said charged particles.

4. A device to electrostatically accelerate charged particles, comprising a source of charged particles, a plurality of piezo electric crystal generators, an alignment of electrodes, means to electrically impress said generators thereon, said alignment forming a path for said particles, and relative phase means of compression on said crystals to produce an accelerating region of maximum potential gradient on said path to accelerate said particles therealong.

5. The combination in a system to produce electrostatic acceleration of charged particles, comprising a source of charged particles, a plurality of oscillatory electrostatic generators, electrodes for said generators aligned to form a path for said particles, means to impress the oscillatory potentials of said generators sequentially on said electrodes to produce a maximum of potential gradient to move along said path and effective to accelerate the motion of said particles thereon.

6. A device to electrostatically accelerate charged particles, comprising a source of said charged particles, a plate for collimating said charged particles, a grid for controlling the flow of said charged particles, an alignment of electrodes to form a path for said particles, a plurality of piezo electric generators, means for impressing the potentials of said generators on said electrodes, a magnetostriction element for exciting each piezo electric generator, electromagnetic means for exciting said magnetostriction elements, and means for adjusting the relative phases of said electromagnetic means to produce a maximum of potential gradient to move along said path to accelerate said particles.

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