Linear electron accelerators

P. Bakker

During 1980 the first test results were obtained from IKO's new electron accelerator, the Medium-Energy Accelerator (MEA) (fig. 1). It is planned to bring this accelerator into service in 1981 or 1982. The MEA has been designed to supply electrons at energies up to 500 MeV, with a maximum peak current of 20 mA, a peak width of 50 µs and a maximum repetition frequency of 2 kHz. The relatively large duty cycle (maximum 10%) is particularly suitable for coincidence experiments, in which observations are made of the scattered electron and a nucleon released from the atomic nucleus after an electron has collided with an atomic nucleus. The equipment constructed for this purpose (fig. 2) has already provided excellent test results.

The primary electron beam will also produce secondary beams of pions and muons and these in turn can be used for investigating atomic nuclei.

The construction of the MEA and the nuclear instrumentation and equipment to go with it became a practical possibility when the Minister of Education and Science gave his approval to the plan in 1972 and made the necessary funds available — about ten million dollars at 1971 values. The Minister also decided that IKO should combine with the Dutch High-Energy Physicists to form a National Institute to be known as NIKHEF (National Institute for Nuclear and High-Energy Physics) and that IKO's two existing accelerators — the synchrocyclotron and the EVA electron accelerator — should be shut down; the accelerators were shut down in 1976 and 1977.

The story behind the MEA is quite a long one and one in which Philips also played an important part. In about 1957 Prof. P. C. Gugelot, who was then the Director of IKO, had the idea of building a linear accelerator for electrons with an energy of 3000 MeV, to complement the synchrocyclotron. However, the plan did not seem to be practicable, because of insufficiencies in money and manpower, and so it was decided, in consultation with Philips Research Laboratories, to build a much smaller machine (60 MeV). At Philips the main interest in building such an accelerator was the chance of acquiring greater experience in the specialized technologies of high vacuum, microwave techniques (klystrons), high-voltage work and precision engineering. The Philips activity would supplement the experience already gained at Mullard Research Laboratories at Redhill, England in the construction of low-energy accelerators (about 20 MeV) for medical use.

In 1961 a team of Philips employees led by Ir R. A. Koolhof started the development of the injector, modulator, waveguides, vacuum and cooling system, and the first experiments with the accelerator were made in 1964 for the radiochemical department of IKO. The accelerator was in use until 1967; it was then succeeded by EVA (Elektronen Versneller Amsterdam), a linear accelerator for electrons of energies up to 85 MeV.

Fig. 1. The MEA, the Medium-Energy Accelerator, IKO's new two-hundred-metre long accelerator for electrons up to 500 MeV.

Principle of a linear electron accelerator

In a linear electron accelerator an electromagnetic wave travels along a waveguide. The field has an electric component in the direction of propagation of the wave. The electromagnetic power is obtained from a klystron driven by a pulsed high-voltage modulator, so that the power enters the waveguide in pulses. Electrons are injected simultaneously with the wave pulse. The electrons are accelerated by the electric component of the field. The phase velocity of the travelling electromagnetic wave is made equal to the velocity of the electrons (almost equal to the velocity of light). The acceleration process is maintained in this way over the entire length of the waveguide. The correct phase velocity is obtained by placing diaphragms in the waveguide.

In the construction of the accelerator the finish of the interior surfaces of the waveguide structure must be of the highest quality and the dimensional accuracy must be exceptionally good. The injection of the electrons also requires the greatest care, particularly if the spread in energy of the accelerated electrons is required to be small.

The Philips accelerator

Something has already been said about the earlier history of the Philips accelerator. The design was for an accelerator for 60 MeV with an energy spread of 1%, a mean beam current of 200 μA, a repetition frequency of 200 Hz and a duty cycle of 0.1%. Most of the components (fig. 3) were developed by Philips. The manufacture of the waveguides, for example, was in general terms as follows.

Copper discs and aluminium rings were machined on a precision lathe with hydrostatic bearings \(^{14}\). The discs and rings were then stacked alternatively to form a 'pipe' about a metre long and were then clamped...
together (fig. 4). A copper layer about 1 cm thick was electroplated on to the outside of this pipe. The aluminium was next removed by selective etching. After a brief finishing treatment the waveguide was ready.

**Further development**

In the early sixties the use of electron accelerators began to increase rapidly on an international scale and in about 1965 the requirements for the quality (energy spread, duty cycle) of the beam began to become more exacting, especially if it was to be used for nuclear-physics research. Further developments in this direction, however, no longer came within the purview of Philips Research Laboratories. IKO were fortunate in that they were able to obtain two accelerator sections on loan from the Stanford Linear Accelerator Center (SLAC) in California. These were manufactured for a two-mile long electron accelerator that had been constructed at SLAC, containing about a thousand sections each three metres long. A modulator to drive these accelerator sections was built at IKO. Substantial help was given here by the Philips people who had worked on the construction of Philips' own accelerator. In 1967 EVA was used for the first nuclear-physics experiments. The research carried out with this accelerator generated some twenty doctoral theses, ten dissertations and twenty-five publications.

In the second half of the sixties international interest in research with electrons moved more towards precision and coincidence measurements at higher energies. These developments and the experience that IKO had gained with electron accelerators eventually led to the construction of the MEA.

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*Fig. 3. The injector developed by Philips for the Philips accelerator, which was in use until 1967 at IKO, mainly for radiochemical experiments.*

*Fig. 4. Sketch of the corrugated waveguide of the Philips accelerator. Accurately machined copper discs (1) and aluminium rings (2) were stacked alternately to form a pipe and then clamped together. A copper coating (3) was electroplated on to the outside. The aluminium rings were then removed by selective etching.*

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Recent aerial photograph of the Scientific Centre at Watergraafsmeer in the Netherlands; as well as the National Institute for Nuclear and High-Energy Physics the site also contains the FOM Institute for Atomic and Molecular Physics, the Amsterdam Academic Computer Centre, the 'Anna's Hoeve' Biological Centre of the University of Amsterdam and the Mathematics Centre.
Recent United States Patents

Abstracts from patents that describe inventions from the following research laboratories that form part of or cooperate with the Philips group of companies:

- Philips Research Laboratories, Eindhoven, The Netherlands
- Philips Research Laboratories, Redhill, Surrey RH1 5HA, England
- Laboratoires d'Electronique et de Physique Appliquée, 3 avenue Descartes, 94450 Limeil-Brévannes, France
- Philips GmbH Forschungslaboratorium Aachen, Weißhausstraße, 51 Aachen, Germany
- Philips GmbH Forschungslaboratorium Hamburg, Vogt-Kölln-Straße 30, 2000 Hamburg 54, Germany
- Philips Research Laboratory Brussels, 2 avenue Van Becelaere, 1170 Brussels (Boitsfort), Belgium
- Philips Laboratories, N.A.P.C., 345 Scarborough Road, Briarcliff Manor, N.Y. 10510, USA

4253 880
Device for the conversion of solar energy into electrical energy
J. Bellugue

A device is described for the conversion of solar energy into electrical energy with the aid of a photo-voltaic cell. A central lens forms a round radiation spot on the radiation-sensitive area of the cell, while a toric mirror arranged round the lens forms an annular radiation spot. Thus, it is ensured that the entire area of the cell remains illuminated, independent of the movement of the sun relative to the cell. Owing to the selected intensity distribution in the radiation spots a satisfactory efficiency of the cell can be maintained even at a high concentration of the solar energy.

4254 427
Semiconductor device having a compact read-only memory
J. Lohstroh

A read-only memory in which each memory cell is formed by two back-to-back diodes across which a connection can be formed by means of punch-through. Since cross-talk between adjacent cells is impossible, the packing density may be very large. Additionally, the cycle time of the memory is low due to the very short reverse recovery time of the invented structure.

4254 820
Heat transport device
G. A. A. Asselman
J. Schröder
F. Mahdjuri

There is provided heat transport apparatus comprising a closed tube having an evaporator and a condenser with the condenser being positioned above the evaporator during operation. The closed tube includes a heat transport medium which, during operation, is vaporized in the evaporator and condensed in the condenser, the resulting condensate being returned to the evaporator. A valve is positioned in the closed tube in the condenser region for controlling the condensate return. A pressure-expansion chamber is arranged within the closed tube and is connected to the valve for closing the same when the vapor pressure in the condenser exceeds a given value. A pressure-equalization duct forms part of the valve and provides communication between the evaporator and the condenser.

4254 442
Circuit for the protection of telephone lines
E. C. Dijkmans
F. A. C. M. Schoofs

Arrangement for protecting telephone lines and electronic circuits connected thereto from overvoltages. A first pair of diodes clamp the voltage of each wire versus the supply voltages in cooperation with a current limiting impedance. A second pair of (Zener-)diodes, separated from the first diode pair by means of a current limiting impedance, clamp the forward "transient" produced across the first diode pair versus the same or slightly different supply voltages.

4255 677
Charge pump substrate bias generator
L. Boonstra
C. W. Lambrechise
R. H. W. Salters
R. M. G. Wijnhoven

A semiconductor device having an integrated circuit of which a region of one conductivity type is charged by supplying charge carriers from a zone of the opposite conductivity type to an inversion layer formed in the said region below a field electrode at which a voltage is set up. When the voltage is switched off, a part of the charge carriers recombine in the said region. According to the invention, the charge carriers are supplied from a supply conductor and an electronic switch is present between said conductor and the inversion layer, which switch prevents the flow back of charge carriers to the supply conductor when the inversion layer disappears.

4257 854
Method of producing objects with a supersmooth aluminum surface
T. E. G. Daenen
J. M. Oomen
J. F. M. van de Berg

Method of producing objects having an aluminum surface of a supersmooth quality by applying an aluminum layer which is at least 10 micron thick onto the surface of the object from an electropolishing bath and by therefrom subjecting the object to a mechanical machining precision operation. The aluminum layer is preferably electropolished by means of an anhydrous bath with an aprotic solvent.
4 258 114
Electrophotographic recording material and method of manufacturing same
R. Clasen
H. G. Junginger

An electrophotographic recording material having a porous layer of photoconductor-binder, particularly with crystalline tetragonal lead monoxide as the photoconductor, is provided between an electrically conductive layer and a dielectric foil, said pores of the layer of photoconductor-binder, prior to providing the foil, being filled with a high-ohmic dielectric liquid to wet both the layer of photoconductor-binder and the foil. Preferably, the pores of the layer are filled with tetramethyl tin as the photoconductor-binder. As a result of this, the use of an adhesive between the foil and the layer of photoconductor-binder may be omitted. A large porosity and hence a great sensitivity of the layer of photoconductor-binder are maintained.

4 258 256
Device for examining a body by means of penetrating radiation
G. Harding

A body is irradiated by a primary radiation beam; the scattered radiation produced thereby is incident on a detector device consisting of a plurality of detectors and is a measure for the density distribution of materials in the primary beam. However, this gives rise to multiple scattered radiation which disturbs the measurement. The present invention provides a device in which disturbance by multiple scattered radiation is greatly reduced, without any significant effect on the scattered radiation originating from the primary beam. A device in accordance with the invention is provided with flat laminations which are arranged between the primary beam and the detector device and which are aligned with the primary beam in a fan of flat planes.

4 258 282
Device for the generation of a control voltage across a piezoelectric positioning element
A. M. A. Rijkcaert

A device for the generation of a control voltage across a piezoelectric positioning element. In order to enable a high voltage to be generated across the piezoelectric element without using a comparatively high supply voltage, use is made of the capacitance of such an element as an integrating element. The device comprises a current source and switches for transferring current pulses to and from the piezoelectric element on command of control pulses.

4 258 554
Refrigerator
G. A. A. Asselman
A. J. van Mensvoort

A refrigerator comprising a freezing compartment and a refrigerating compartment which refrigerator is provided with a primary refrigerating system containing a refrigerant with a primary evaporator disposed in the freezing compartment, and a secondary refrigerating system which also contains a refrigerant with a secondary evaporator disposed in the refrigerating compartment, and a secondary condenser which is in heat-exchanging contact with the primary evaporator, which condenser has a condensation wall on whose surface the refrigerant condenses during operation, means being provided for varying the available condensation wall area, so as to control the temperature of the secondary evaporator. Preferably, the secondary condenser is provided with a reservoir containing a control gas, which during operation constitutes an interface with the refrigerant vapor at the location of the condensation wall with the aid of a reversible control gas getter, which can be heated and which is located in the reservoir, which getter enables the amount of light control gas to be varied. The reversible control gas getter can be heated by means of an electric heating element which is included in an electrical control circuit.

4 259 435
Additive method of manufacturing metal patterns on synthetic resin substrates
D. J. Broer
A. J. M. van den Broek

Additive method of manufacturing metal patterns on synthetic resin substrates, printed circuits in particular. A nuclear image of a desired pattern is obtained by means of a salt of a metal which may occur in more than one valency and a noble metal salt by inactivating the substrate area outside the desired pattern by photooxidation by means of exposure to light in the presence of oxygen. The ultimate metal pattern is deposited by electroless metal deposition on the nuclear image.

4 259 678
Semiconductor device and method of manufacturing same, as well as a pick-up device and a display device having such a semiconductor device
G. G. P. van Gorkom
A. M. E. Hoeberechts

The invention relates to a semiconductor cathode based on a tunnel breakdown in the p-n junction. The released electrons obtain extra accelerating energy by means of an electrode provided on the device. The achieved efficiency increase makes the manufacture of such cathodes in planar silicon technology feasible. Such cathodes are applied, for example, in cathode ray tubes, flat displays, pick-up tubes and electron lithography.

4 260 663
Method of producing a dielectric having a perovskite structure
H. J. Hagemann
S. Hunten

Only those dielectrics which have a correspondingly low sintering temperature are suitable for the production of ceramic multi-layer capacitors having intermediate electrodes consisting of non-noble metals, such as nickel and cobalt. Suitable are ceramic masses comprising alkaline earth zirconates, wherein up to 10 mole% of the zirconium may have been replaced by titanium; iron or nickel of manganese being added as doping agents to the stoichiometrical perovskite basic compound having a composition of alkaline earth metal (Zn(1-x)Ti)3O3 where 0 < x ≤ 0.07 and the whole assembly being sintered in a reducing atmosphere.

4 260 887
Electroradiographic recording device
H. Dannert
H.-J. Hirsch

An electroradiographic display with a high picture quality at low radiation intensities is obtained with a device consisting of a source of X-rays, an electrode passing X-rays, an intermediate recording space for an object to be displayed, an electrode on the side remote from the recording space on which a layer of dielectric material is disposed, and a second electrode with a photoconductive layer. The layers are separated by a gas gap which is bounded by one or more side walls. A direct voltage source is in electrical contact with the electrodes. The photoconductive layer comprises a granular photoconductive material in a binder. The gas gap between the dielectric layer and the photoconductive layer is from 50 to 500 μm wide and the electrode passing X-rays has a surface resistance between 10⁴ to 10⁶ Ohms.
Device for directing electrically charged particles towards a target

P. Bakker
R. S. Kuit
J. Politiek

A device for directing electrically charged particles towards a target present on a connection place of a support comprises an electrostatic deflection system having deflection plates for controlling a beam of charged particles in two mutually perpendicular directions towards the target with the deflection plates being brought at a desired voltage by means of an electronic control system, and two juxtaposed rods of electrically conductive material being provided on oppositely located sides of the target with the rods being each connected by a resistor to a fixed potential and being furthermore connected to a control device which reacts to a voltage which arises across the resistors if the beam of electrically charged particles impinges on a rod and which, if the beam, during each stroke across the target, impinges on a combination of rods other than the two innermost rods, produces a correction voltage for the control of the deflection plates.

Method of and device for implanting ions in a target

P. Bakker
R. S. Kuit
J. Politiek

In a method of implanting ions in a target, an ion beam is directed onto the target by means of an electrostatic deflection system where the beam describes a pattern over the target dependent on voltage variations on two mutually perpendicular sets of deflection plates. One of the sets of deflection plates is subjected to a varying voltage difference and the other set of deflection plates is subjected to a constant voltage difference so that the ion beam describes a straight line on the target, while at the end of the beam stroke a fixed voltage difference is superimposed on the plates having a constant voltage difference and the variation in the voltage difference is reversed in the plates having a varying voltage difference in such manner that lines described consecutively by the ion beam are always parallel and are situated at a fixed distance from each other.

Low-pressure mercury vapor discharge lamp with luminescent coatings on envelope walls

G. A. Wesselink
H. Roelofs
C. H. M. van Bommel

Low-pressure mercury vapor discharge lamps of the fluorescent type are known which comprise two nesting glass members so grooved as to provide between their nesting surfaces a circuitous ("folded") discharge path between two electrodes, the length of the discharge path being considerably greater than the physical distance between the electrodes. The whole surface of each glass member is coated with luminescent material with the result that, when the lamp is in use, the portions of the members not surrounding the discharge appear dark due to their poor light transmissibility. According to the invention, these portions of the two members are not coated with luminescent material and thus act as windows for light generated in the luminescent layers facing the lamp axis. Preferably, a fluted reflector is provided inside the lamp.

Method of and device for determining internal body structure

M. Tasto
H. Schombrek

Determining the internal structure of a body, for example, a human body, by means of an electric field which extends between individual electrodes of an electrode array which at least partly surrounds the body. Each time the value of the currents flowing through the individual electrodes is measured. From the currents electrical resistance values in individual tubes of flux generated between the electrodes are measured. By exposure of the body successively to electric fields which each have a different direction and by measurement of the resistance values then occurring, the specific resistance in individual elements of a matrix which is imagined to be stationary with respect to the body can be determined. From the given distribution of the specific resistance in the elements of the matrix, resistance values are calculated in all tubes of flux successively at least once for each field direction. For determination of a correction for the specific resistance in the elements of the matrix, the calculated resistance values are compared with the measured resistance values. The magnitude of the difference determines the magnitude of the correction.

Capstan drive for a tape

H. Althuber
H. Dimigen
H. Hübsch

The driving arrangement for a magnetic tape is comprised of a drive shaft having a smooth surface and a pressure roller having a high surface friction coefficient. The circumference of the drive shaft is provided with a thin layer of the borides, nitrides or carbides of a hard metal, which increases the friction resistance of the shaft. This measure reduces the slip, without affecting the proper uniform travel of the tape.

Liquid crystal display device

M. de Zwart
T. W. Lathouwers

In a liquid crystal matrix display device in which the bistability effect of a cholesteric liquid crystal is used, the number of lines to be driven is increased by providing the electrodes on grooves provided in the supporting plates. The electrodes partly overlap the part of a supporting plate present between two grooves. The electrode surface and the remaining surface of the supporting plates are covered by a dielectric layer. The grooves have a depth which is equal to half the desired thickness of the liquid crystal layer. Herewith a uniform thickness of the liquid crystal layer is also obtained.

Microwave device provided with a half lambda resonator

F. C. de Ronde

A microwave device is disclosed comprising a microstrip line pattern including an open ring forming a \( \lambda/2 \) resonator having a narrow gap in which the electromagnetic field is closely tied to the ring.

Receiver for frequency modulated signals having two quadrature channels

J. O. Voorman

A receiver for frequency modulated signals comprises two phase quadrature channels with synchronous demodulation and low-pass filtering. The object aimed at is to provide a tunable receiver without input filter. The absence of an input filter excludes the use of a limiter and the receiver will then be sensitive to amplitude variations. This problem has been solved by dividing the signals in the receiver in one or two stages by an amplitude factor which is derived from the output signals of the low-pass filters.
A. J. A. Nicia
C. J. T. Potters

A detachable connector, for coupling the ends of optical fibers, comprising two connector portions, each connector portion having fixing means, for detachably connecting the connector portions to each other, and at least one rotationally symmetrical housing having a bore which is coaxial to a central axis. The housing has a reference face at one end and adjusting means secured in the bore at an opposite end. The adjusting means enables an optical axis, at an end of an optical fiber to be secured in a tube, and to be adjusted parallel to the central axis of the housing. When the two interconnected connector portions contact each other by way of the reference faces, the optical axes of the fibers in each connector portion are parallel to one another.

A. H. M. van Roermond

Charge transfer devices having switchable blocking electrodes

A charge transfer device having one or more control electrodes connected to switching means so that the electrode can perform two functions. Normally the electrode is used for charge transfer but it may be switched to act as a blocking electrode for blocking the charge present underneath it for one or more clock phases. This permits the device to be formed as a filter, an analog-to-digital converter or digital-to-analog converter in a simple and inexpensive manner. The charge transfer channel may be split into sections using isolation diffusions.

F. A. C. M. Schoofs

Arrangement for applying a signal to a transmission line

An electronic circuit for applying a signal to a telephone line is disclosed wherein the signal to be transferred is superimposed on a direct current and applied to the reference voltage circuit of a bidirectional current source. The current source in turn applies, from high internal resistances, oppositely directed currents which are equal to each other and proportional to the signal onto the two wires of the telephone line.

J. H. T. van Roosmalen

Cathode-ray tube

A cathode-ray tube having an electron gun to generate an electron beam and a focusing lens to focus the electron beam on a target. The anode of the electron gun forms part of the focusing lens and has a very small aperture to limit the electron beam. In order to prevent positive ions formed in the tube from poisoning the cathode the potential of the anode is at most 75 volts relative to the cathode potential and the distance from the center of the focusing lens to the aperture in the anode is at least equal to 1.5 times the largest dimension of the anode taken in a cross-section at right angles to the axis.

A. Molenaar

Bath for electroless depositing tin on substrates

Method of currentless deposition of tin on a catalytic surface by means of a highly alkaline solution which contains stannous ions in a quantity of at least 0.20 mol/l and is used at temperatures of 60 to 90°C. The solution operates on the basis of the mechanism of disproportioning of stannous ions. The tin deposition is, however, accelerated by means of a strong reducing agent such as a hypophosphite.

A. H. Boonstra
C. A. H. A. Mutsaers
F. N. G. R. van der Kruis

Resistance material consisting of a mixture of metal oxide compounds, metal oxides, a permanent and a temporary binder, the resistance-determining component consisting of thallium rhodate TlRh2O4. This component has a linear positive temperature coefficient of the resistance TCR which enables the composition of a resistor having a very low TCR by combining it with a material having a negative TCR. The resistor is produced on the basis of this resistance material provided on a substrate.

W. G. Opheij
P. F. Greve

An apparatus as described for reading an optical radiation-reflecting information carrier for controlling focus

L. J. M. Bollen
J. Goorissen

A method of manufacturing a semiconductor device utilizing a mono-polycrystalline deposition on a pre-deposited amorphous layer

M. J. J. Dona

A reduction drive having a drivable first structural member which presses a number of bodies of revolution against at least one thin intermediate plate. The intermediate plate is connected to the output of the drive and is supported by a second structural member. The material of the intermediate plate has a modulus of elasticity at least equal to that of the second structural member, and the bodies of revolution are pressed with sufficient force to locally but elastically deform the plate and second member.

U. K. P. Bierman

Absorption heat pump work medium consisting of a solution of a fluorochloroalkane in a substituted amino phosphorus oxide

A work medium for use in an absorption heat pump consists of a solution of a chlorofluorocarbon in a substituted amino phosphorus oxide. With such a work medium it is possible for an absorption heat pump to absorb heat at −20°C and to give up heat at 70°C.