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SCHOOL ON PHYSIC IN INDUSTRY

27 January - 14 February 1986

" TRAINING OF PHYSICISTS "

presented by

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SHORT SUMMARY

"TRAINING OF PHYSICISTS"

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12 FEB 1986

SCHOOL ON PHYSICS IN INDUSTRY

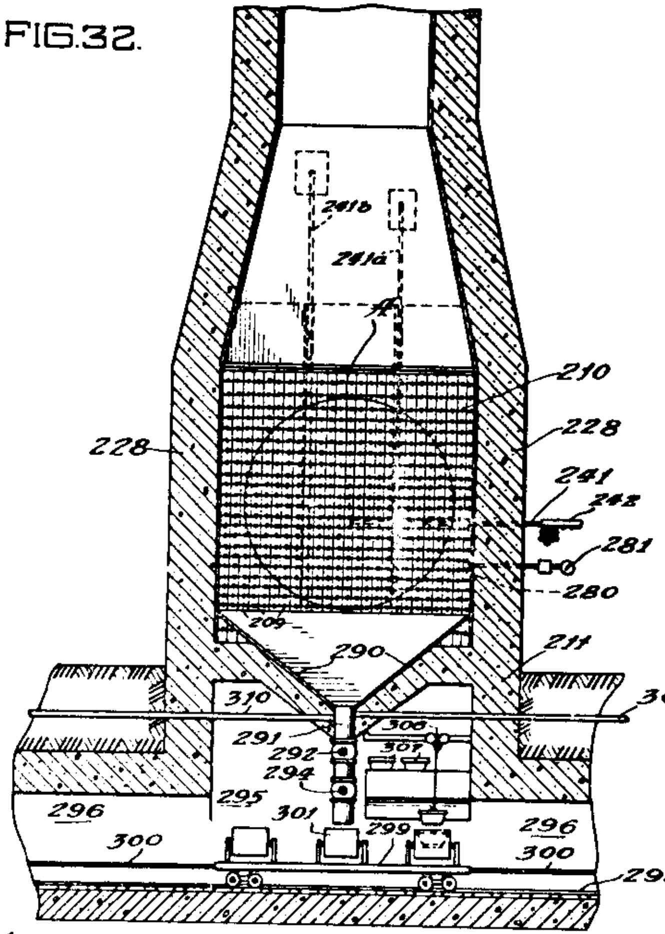
ICTP

May 17, 1955 E. FERMI ET AL 2,708,656

NEUTRONIC REACTOR

Filed Dec. 19, 1944 27 Sheets-Sheet 21

FIG.32.



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United States Patent Office 2,708,656
Patented May 17, 1955

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2,708,656

NEUTRONIC REACTOR

assignors to the United States of America as represented by the United States Atomic Energy Commission

Application December 19, 1944, Serial No. 568,904
8 Claims. (Cl. 204—193)

The present invention relates to the general subject of nuclear fission and particularly to the establishment of self-sustaining neutron chain fission reactions in systems embodying uranium having a natural isotopic content.

Experiments by Hahn and Strassman, the results of which were published in January 1939, Naturwissenschaften, vol. 27, page 11, led to the conclusion that nuclear bombardment of natural uranium by slow neutrons causes explosion or fission of the nucleus, which splits into particles of smaller charge and mass with energy being released in the process. Later it was found that neutrons were emitted during the process and that the fission was principally confined to the uranium isotope U^{235} present as 1/139 part of the natural uranium.

When it became known that the isotope U^{235} in natural uranium could be split or fissioned by bombardment with thermal neutrons, i. e., neutrons at or near thermal equilibrium with the surrounding medium, many predictions were made as to the possibility of obtaining a self-sustaining chain reacting system operating at high neutron densities. In such a system, the fission neutrons produced give rise to new fission neutrons in sufficiently large numbers to overcome the neutron losses in the system. Since the result of the fission of the uranium nucleus is the production of two lighter elements with great kinetic energy, plus approximately 2 fast neutrons on the average for each fission along with beta and gamma radiation, a large amount of power could be made available if a self-sustaining system could be built.

In order to attain such a self-sustaining chain reaction in a system of practical size, the ratio of the number of neutrons produced in one generation by the fissions, to the original number of neutrons initiating the fissions, must be known to be greater than unity after all neutron losses are deducted, and this ratio is, of course, dependent upon the values of the pertinent constants.

In the co-pending application of Enrico Fermi, Serial No. 534,129, filed May 4, 1944, and entitled "Nuclear Chain Reacting Systems," there is described and claimed a means and method of determining the neutron reproduction ratio for any type of uranium-containing structure, directly as a result of a simple measurement which can be performed with precision. Accurate values for all of the pertinent nuclear constants need not be known.

We have discovered certain essential principles required for the successful construction and operation of self-sustaining neutron chain reacting systems (known as neutronic reactors) with the production of power in the form of heat. These principles have been confirmed with the aid of measurements made in accordance with the means and method set forth in the above-identified application, and neutronic reactors have been constructed and operated at various power outputs, in accordance with these principles, as will be more fully brought out hereinafter.

In a self-sustaining chain reaction of natural uranium with slow neutrons, as presently understood, reactions occur involving the isotopes U^{238} and U^{235}. Thus, 92^{238}

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is converted by neutron capture to the isotope 92^{239}. The latter is converted by beta decay to 93^{239} and this 93^{239} in turn is converted by beta decay to 94^{239}. Other isotopes of 93 and 94 may be formed in small quantities. By slow or thermal neutron capture, 92^{235}, on the other hand, can undergo nuclear fission to release energy appearing as heat and gamma and beta radiation, together with the formation of fission fragments appearing as radioactive isotopes of elements of lower mass numbers, and with the release of secondary neutrons.

The secondary neutrons thus produced by the fissioning of the 92^{235} nuclei have a high average energy, and must be slowed down to thermal energies in order to be in condition to cause slow neutron fission in other 92^{235} nuclei. This slowing down, or moderation of the neutron energy, is accomplished by passing the neutrons through a material where the neutrons are slowed by collision. Such a material is known as a moderator. While some of the secondary neutrons are absorbed by the uranium isotope 92^{238} leading to the production of element 94, and by other materials such as the moderator, enough neutrons can remain to sustain the chain reaction, when proper conditions are maintained.

Under these proper conditions, the chain reaction will supply not only the neutrons necessary for maintaining the neutronic reaction, but also will supply the neutrons for capture by the isotope 92^{238} leading to the production of 94, and excess neutrons for use as desired.

As 94 is a transuranic element, it can be separated from the unconverted uranium by chemical methods, and as it is fissionable by slow neutrons in a manner similar to the isotope 92^{235}, it is valuable, for example, for enriching natural uranium for use in other chain reacting systems of smaller overall size. The fission fragments are also valuable as sources of radioactivity.

The ratio of the fast neutrons produced in one generation by the fissions to the original number of fast neutrons in a theoretical system of infinite size where there can be no external loss of neutrons is called the reproduction of multiplication factor or constant of the system, and is denoted by the symbol K. For any finite system, some neutrons will escape from the periphery of the system. Consequently a system of finite size may be said to have a K constant, even though the value thereof would only exist if the system as built were extended to infinity without change of geometry or materials. Thus when K is referred to herein as a constant of a system of practical size, it always refers to what would exist in the same type of system of infinite size. If K can be made sufficiently greater than unity to indicate a net gain in neutrons in the theoretical system of infinite size, and then an actual system is built to be sufficiently large so that this gain is not entirely lost by leakage from the exterior surface of the system, then a self-sustaining chain reacting system of finite and practical size can be built to produce power and related by-products by nuclear fission of natural uranium. The neutron reproduction ratio in a system of finite size therefore differs from K by the external leakage factor, and by a factor due to the neutron absorption by localized neutron absorber, and the reproduction ratio must still be sufficiently greater than unity to permit the neutron density to rise exponentially with time in the system as built.

Progressive empirical enlargement of any proposed system for which the factor K is not accurately known, in an attempt to attain the overall size of a structure of finite size above which the rate of loss of neutrons by diffusion through the periphery of the structure is less than the rate of production of neutrons in the system, leads only to an expensive gamble with no assurance of success. The fact that K is greater than unity and the fact that the critical size is within practical limits must

United States Patent Office 3,041,166
Patented June 26, 1962

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3,041,166

XEROGRAPHIC PLATE AND METHOD

John Bardeen, Champaign, Ill., assignor to Xerox Corporation, a corporation of New York

Filed Feb. 12, 1958, Ser. No. 714,929
38 Claims. (Cl. 96—1)

This invention relates in general to photosensitive members and in particular to improved and more highly responsive photosensitive members such as are particularly useful in xerography.

It is the usual practice in the xerographic arts to form an electrostatic image by first evenly distributing electrical charge on the surface of a photoconductive member and then exposing the surface to a pattern of activating radiation corresponding to the desired image. More specifically, in the electrostatic photographic process that is xerography, a radiation sensitive element or plate is customarily used that is basically composed of a photoconductive layer on a conductive base. In the absence of any activating radiation, a uniform electrostatic charge is placed on the free surface of the photoconductive layer which surface is subsequently exposed to a radiation image, the conductivity through the layer in exposed areas thereby being considerably increased over that in unexposed areas. As a result, a differential is produced between the exposed and unexposed regions in the rate of charge flow from the free surface to the base which, in turn, results in a differential between these regions in the amount of charge remaining on the free surface of the photoconductive layer. It is thus seen that an electrostatic image remains on the surface that corresponds to the incident radiation image.

Although the xerographic processes and devices produce highly satisfactory results, it should be recognized that the methods employed are handicapped by the fact that the photoconductive layers usually used are far from ideal. An ideal radiation sensitive material, for example, possesses an infinite resistivity in the absence of radiation and thereby has the ability to retain the charge on its surface for long periods of time without diminution. In actual practice, there is usually a degree of charge leakage which causes an undesired loss in quality of the final image. Also, the resistivity of an ideal photoconductive layer is sharply reduced when exposed to radiation, thereby permitting the rapid passage of surface charge through the photoconductive layer to the base. In other words, an ideal photoconductive material is highly sensitive to radiation. Such sensitivity is important because it makes possible the production of highly satisfactory images in less time than previously required and also with less intense radiation which means an increase in light sensitivity. In actual practice it has not yet been possible to produce directly a photosensitive material having the above characteristics to the desired degree.

An object of the invention is to provide a new photosensitive member particularly for xerography having an increased response to activating radiation, that is, an increased photographic speed.

It is a further object of the present invention to provide a new xerographic photosensitive member that can retain electric charge on its surface without loss for relatively long periods of time.

According to the invention there is provided a photosensitive plate adapted to give a photon efficiency substantially in excess of 1 when charged to a predetermined polarity, comprising an insulating layer possessing long range charge carriers, a barrier semiconductor layer one of whose surfaces is in intimate surface contact with said insulating layer, the electric current carriers in said barrier semiconductor being predominantly of the same

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polarity as the polarity of charging, and a solid supporting body having a high density of electric current carriers of polarity opposite to the polarity of charging, the solid body being in intimate surface contact with the opposite surface of the barrier semiconductor layer to support the insulating layer and the semiconductor layer. Thus, if the semiconductor layer has a p-type conductivity the insulating layer must be charged positively and if the semiconductor layer has n-type conductivity, the insulating layer must be charged negatively if, in each, the desired results are to be obtained.

The semiconductor may include a second layer adjacent the supporting solid body having a conductivity type opposite to that of the other semiconductor layer.

The insulating layer is preferably selenium, although other known materials having long range charge carriers such as sulphur, cadmium sulfide, cadmium selenide, etc. may be used, and the semiconductor layer is preferably selenium with a p- or n-type impurity. When the semiconductor layer is p-type, the solid supporting body is a low work function metal, and when the semiconductor layer is n-type, the supporting body is a high work function metal. When the plate is to be exposed through the front, the insulating layer must either be transparent to the incident radiation or a photoconductive insulating material. When the plate is to be exposed through the supporting body, the supporting body must be transparent to the incident radiation and the insulating layer need only have a long range for charge carriers, i.e., need not be photoconductive, as will be more fully disclosed hereinbelow.

In order that the invention may be clearly understood, reference will now be made to the accompanying drawings in which two embodiments of the invention are illustrated by way of example, and in which:

FIG. 1 is a diagrammatic cross section of a photosensitive member according to a first embodiment of the invention;

FIG. 2 is an electron-energy diagram of the photosensitive member of FIG. 1 in the absence of any potential gradient thereacross;

FIG. 3 is an electron energy diagram of the member illustrated in FIG. 1 with a high potential gradient of positive polarity applied to the member;

FIG. 4 is an electron-energy diagram of a photosensitive member of the type illustrated in FIG. 1 with a high potential gradient of negative polarity applied thereacross;

FIG. 5 is a diagrammatic cross section of a photosensitive member according to another embodiment of the invention;

FIG. 6 is an electron-energy diagram of the member of FIG. 5 with a high potential gradient of positive polarity applied thereacross;

FIG. 7 is an electron-energy diagram of a photosensitive member of the type shown in FIG. 5 with a high potential gradient of negative polarity applied thereacross; and

FIG. 8 is an electron-energy diagram similar to that of FIG. 6 and is representative of a photosensitive member of the type shown in FIG. 5 wherein the conductive backing member is a low work function conductor.

FIGS. 9(a), 9(b) and 9(c) are diagrammatic cross-sectional views of the xerographic plate of FIG. 5 illustrating its use in xerography.

Referring now to the drawings, there is diagrammatically shown in FIG. 1 a photosensitive member according to the present invention, the member being generally designated 10 and comprising an insulating layer 11 overlying a conductive backing member 13 with an intermediate semiconductor barrier layer 12 therebetween. This composite member is suitably a xerographic plate,

Choyke 1-86

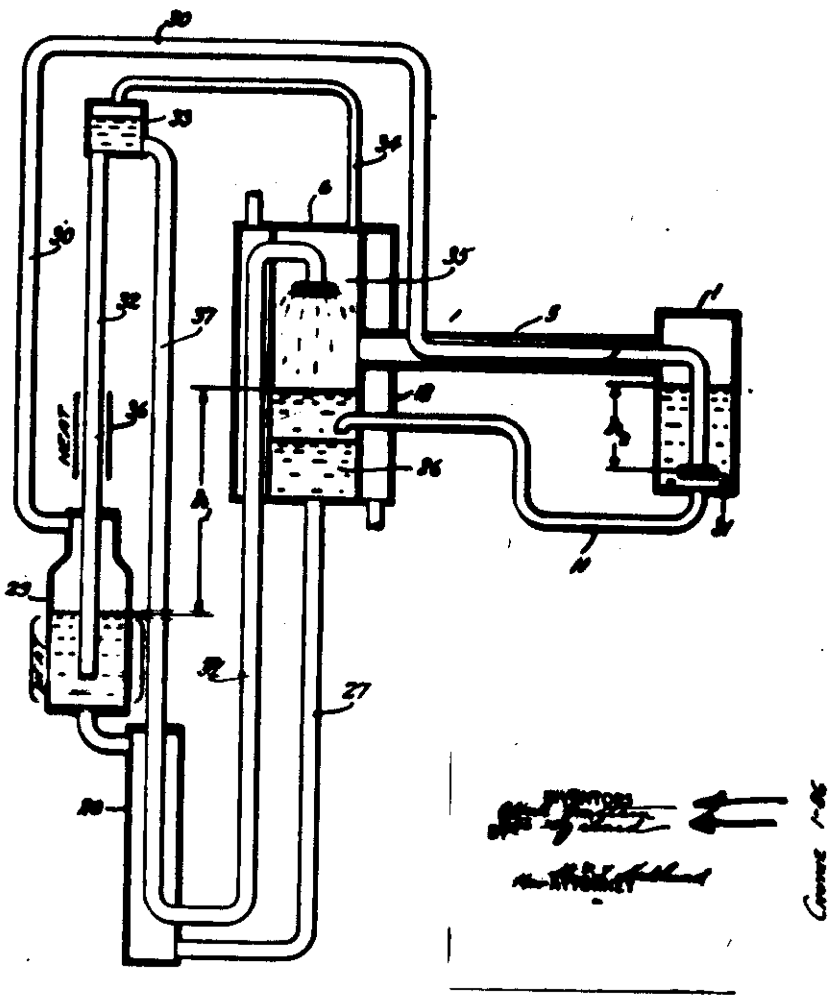
Nov. 11, 1930.

A. EINSTEIN ET AL

REFRIGERATION

Filed Dec. 16, 1927

1,781,541



Patented Nov. 11, 1930

1,781,541

UNITED STATES PATENT OFFICE

ALBERT EINSTEIN, OF BERLIN, AND LEO SZILARD, OF BERLIN-WILMERSDORF, GERMANY, ASSIGNORS TO ELECTROLUX SERVEL CORPORATION, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE

REFRIGERATION

Application filed December 16, 1927. Serial No. 240,366, and in Germany December 16, 1926.

Our invention relates to the art of refrigeration and particularly to an apparatus and method for producing refrigeration wherein the refrigerant evaporates in the presence of an inert gas and more particularly to the type disclosed in Patent No. 1,685,764 granted September 25th, 1928, to Von Platen and Munters and our British Patent No. 282,428.

The objects and advantages of our invention will be apparent from the following description considered in connection with the accompanying drawing which shows, more or less diagrammatically, a preferred embodiment of our invention.

Referring to the drawing, reference character 1 designates an evaporator, which is ordinarily placed within a chamber to be cooled. A conduit 5 connects the upper part of evaporator 1 with the more intermediate portion of the condenser 6. A conduit 11 communicates with the bottom of evaporator 1 and extends within condenser 6 at a level below the point of communication of conduit 5 with the condenser. A cooling water jacket 12 surrounds the condenser and is adapted for the passage therethrough of water for the purpose of cooling the condenser.

A conduit 27 communicates with the bottom of condenser 6 and with the lower part of a heat exchanger jacket 28. The upper part of jacket 28 is connected to the lower part of generator 29. Generator 29 is heated in any suitable manner. A conduit 30 communicates with the upper part of generator 29 and extends within evaporator 1 to a point near the bottom thereof where it terminates in a distributor head 31. Conduit 30 extends within conduit 5 in order that the fluids passing through the respective conduits may be brought into heat exchange relationship with each other.

A conduit 32 extends upwardly from within the lower part of generator 29 and communicates with a container 33 placed at a level above that of condenser 6. A source of heat 36 is provided for heating conduit 32 at a point above generator 29. A conduit 37 extends downwardly from container 33 and passes within heat exchanger jacket 28 and thence upwardly to within the upper part of condenser 6 where it terminates in a distributor head 35. Conduit 37 passes within cooling water jacket 12 in order that fluid passing through this conduit may be cooled. A vent conduit 34 connects the upper part of container 33 with the upper part of condenser 6.

The operation of the above described apparatus is as follows:

A suitable refrigerant, for instance butane, in liquid form is contained within evaporator 1. An inert gas, for instance ammonia, is introduced into evaporator 1 through conduit 30 and distributor head 31. The refrigerant evaporates in the evaporator in the presence of the inert gas due to the fact that the partial pressure of the refrigerant is reduced thereby and the resulting gaseous mixture passes through conduit 5 to within condenser 6. Here the mixture comes in intimate contact with an absorption liquid, for example water, which is introduced into the condenser through conduit 37 and distributor head 35. Inasmuch as the ammonia gas is very soluble in water, while the butane is quite insoluble, the ammonia gas is absorbed by the water, thus freeing the butane from the gaseous mixture. Thus the butane assumes substantially the entire pressure within the condenser, which pressure is sufficient to cause its liquefaction at the temperature maintained therein by the cooling water.

The specific gravity of liquid butane is less than that of the solution of ammonia in water and hence stratification of the two liquids occurs, the liquid butane floating upon the ammonia solution. The latter solution is indicated by reference character 26. The liquid butane passes from condenser 6 through conduit 11 and returns to evaporator 1, where it is again evaporated and the cycle repeated.

The ammonia solution flows by gravity from condenser 6 through conduit 27 and heat exchanger jacket 28 to within generator 29. Here the application of heat causes the ammonia to be expelled as a gas from the solution and this ammonia gas passes through conduit 30 and distributor head 31 to within evaporator 1, where it reduces the partial pressure of the butane, wherefore the latter evaporates as previously described,

Zu der Patentschrift 590783
Kl. 21a² Gr. 1_{04}

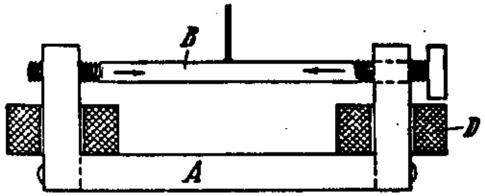


Abb. 1

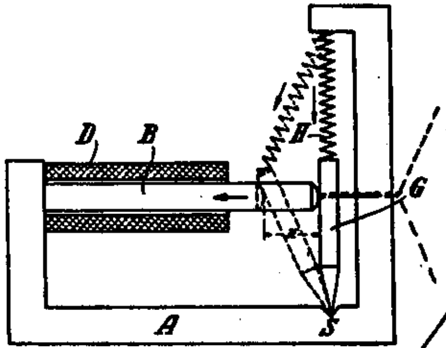


Abb. 2

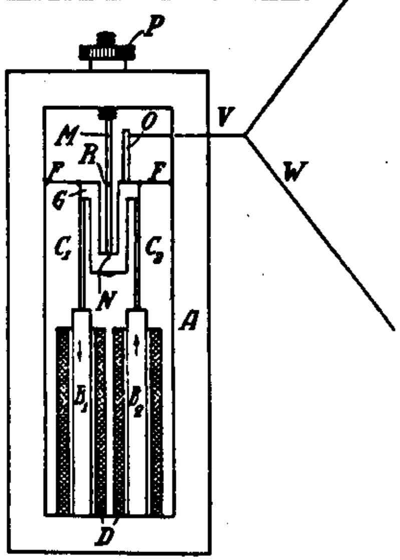


Abb. 3

DEUTSCHES REICH

AUSGEGEBEN AM 10. JANUAR 1934

REICHSPATENTAMT

PATENTSCHRIFT

№ 590783

KLASSE 21a² GRUPPE 1_{04}

G 76240 VIII a/21 a²

Tag der Bekanntmachung über die Erteilung des Patents: 21. Dezember 1933

Dr. Albert Einstein früher in Berlin, jetziger Wohnsitz unbekannt, und Dr.-Ing. Rudolf Goldschmidt in Berlin-Charlottenburg

Vorrichtung, insbesondere für Schallwiedergabegeräte, bei der elektrische Stromänderungen durch Magnetostriktion Bewegungen eines Magnetkörpers hervorrufen

Patentiert im Deutschen Reiche vom 25. April 1929 ab

Wenn man den Magnetismus eines Eisenstabes, etwa durch eine stromdurchflossene Spule, ändert, so wird dadurch nicht nur eine magnetische Wirkung nach außen hervorgerufen, sondern es entstehen auch Kräfte in seinem Innern, die ihn zu verkürzen suchen: die Kräfte der Magnetostriktion. Diesen Kräften widersteht die Steifheit des Stahles selbst, die es nur zu einer verhältnismäßig kleinen Arbeitsleistung kommen läßt.

Gegenstand dieser Erfindung ist eine Vorrichtung, die Steifheit des magnetisierten Stabes künstlich zu brechen, ihn zu labilisieren und dadurch einen Magneten ohne eigentlichen Anker arbeitsfähig zu machen.

Die Erfindung betrifft somit eine Vorrichtung, insbesondere für Schallwiedergabegeräte, bei der elektrische Stromänderungen durch Magnetostriktion Bewegungen eines Magnetkörpers hervorrufen und bei der erfindungsgemäß die diesen Bewegungen entgegenwirkende Kraft des Magnetkörpers durch äußere Kräfte vermindert wird, die entweder durch Vorspannung eines besonderen mit dem Magnetkörper mechanisch gekuppelten Gebildes geschaffen werden und bei Längenänderungen (Zusammenziehung oder Ausdehnung) zur Geltung kommen oder die durch axiale Vorspannung des Magnetkörpers selbst erzeugt werden.

Abb. 1 zeigt ein erstes Beispiel. In die Schenkel eines U-förmigen steifen eisernen Joches *A* ist ein Eisenstab *B* mit Links- und Rechtsgewinde so eingeschraubt, daß er in seiner Längsachse zusammengepreßt werden kann. Erreicht die Längskraft eine Größe, die in der Nähe des sog. Knickwertes (Eulersche Formel) liegt, so genügt eine kleine weitere Kraft, um große Bewegungen hervorzurufen. Der Stab ist labilisiert, mit anderen Worten: die Biegungskräfte kompensieren die Steifheit gegen Längskontraktion, so daß eine schwache Erregung der Spulen *D* eine erhebliche Bewegung zur Folge hat.

Abb. 2 gibt ein Ausführungsbeispiel wieder, das den Erfindungsgedanken deswegen besonders deutlich hervorhebt, weil hier die kompensierenden Kräfte nicht bei der Knickung des zu labilisierenden Stabes *B* in seinem Innern hervorgerufen werden, sondern von dem Stabe losgelöst durch eine besondere Vorrichtung erzeugt werden. Eine vorgespannte Feder *H* mit praktisch konstanter Spannkraft preßt über den bei *S* drehbaren Hebel *G* auf die Stirnfläche des Stabes *B*. Der Hebel *G* bildet mit der Stabachse einen Winkel von nicht ganz 90°. Drückt man nun den Stab um den Betrag x zusammen (in der Abbildung stark übertrieben), so vergrößert sich der Hebelarm, an dem der

A

Grad. Stud. Problems

- Stress formation during growth & processing
- Formation of point & line defects during processing
- Fund. deviations from stochiometry

↑

Materials & Growth Methods

- (CZ, FZ) boule growth of Si
- △ (CZ) boule growth of GaAs
- ⊡ Boule growth of CdTe

↑

IR&D

- Ultrapure (large diam) boules of Si for (VLSI) & high voltage devices
- △ Fast devices (Radar etc.)
- ⊡ Substrates for IR det. & Mag Semic.

B

Grad. Stud. Problems

↑

Materials & Growth Methods

↑

IR&D

- Nature of Twin Plane/Planes Formation and Associated Dislocation Density
- Web Si
- High Efficiency Solar Cells

C.

GRAD. STUD. PROBLEMS

- QUANTUM WELL INTERFACES (STATES / STRESS)
- QW. BAND OFFSETS
- MODELLING OF QWELLS FOR NEW APPLICATIONS
- LINE DEFECTS / IMPURITIES AS A FUNCTION OF GROWTH PARAMETERS
- NATURE & ORIGIN OF THE DEFECT CENTERS

↑

MATERIALS & GROWTH METHODS

- MBE
  - GaAs / AlGaAs
  - CdTe / InSb
  - HgCdTe

↑

IR&D

- QW. DEVICES
- IR DETECTORS

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GRAD. STUD. PROBLEMS

↑

MATERIALS &

GROWTH METHODS

↑

IR&D

- QUALITY AND UNIFORMITY OF EPI
  FLUORIDE CRYSTAL GROWTH
- LATTICE MISMATCH & DEFECT FORM.

- EPI (VAPOR DEP)
  - CaF_2 / GaAs (111) (100)
  - LaF_3 / Si (111)
  - CeF_3 / Si (111)
  - NdF_3 / Si (111)

- S-I-S DEVICES
- INSULATORS FOR GaAs (FAST DEVICES / PREVENT LATCH-UP)

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E.

GRAD. STUD. PROBLEMS

- COMP. OF STRUCTURAL AND ELECTR. PROP. OF MBE & MOCVD PREPARED QW.
- QM. MODELING OF NOVEL DETECTORS BASED ON MBE/MOCVD GROWTH TECHNIQUES

↑

MATERIALS & GROWTH METHODS

- MOCVD GaAs/AlGaAs STRUCTURES

↑

IR&D

- COST RED. OF 1 OR 2 DIMENSIONAL DEVICES

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1.

Grad. Stud. Problems

↑

Materials & Growth Methods

↑

IR&D

- Study simplified Surf. Mol. Int. under highly controlled conditions so as to help model/understand processes which are used in practice and appear to show promise for applications.

- Plasma Deposition of Thin Films
  - $Si:C:H$
  - $Si_xC_{1-x}:H$
  - Si_3N_4

- Protective Optical Coatings
- Special Refl. Coatings

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G.

GRAD. STUD. PROBLEMS

- THE NATURE OF DEFECTS & IMPURITIES INCORPORATED DURING CVD GROWTH
- THE ROLE OF H/H_2 IN CVD GROWTH
- DISLOCATION FORMATION / NUCLEATION AT SUBSTRATE-INTERFACE DURING CVD GROWTH

↑

MATERIALS & GROWTH METHODS

- EPI-CVD 3C SiC

↑

IR&D

- HIGH TEMP. (>200°C) SEMIC. DEV. USING PLANAR TECHNOLOGY
- HIGH SPEED DEVICES IN UNFRIENDLY AMBIENTS

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17.

Grad. Stud. Problems

↑

Materials & Growth Methods

↑

IR&D

- Surface Modification of Metals & Ceramics by Ion Implantation
  Studied by
  (• RBS/Channeling, XTEM
  • Optical Techniques, Hardness Meas.)

- SiC
  - Single Crystal (Ion Implt)
  - Hot Pressed
  - Reaction Bonded
  - Sintered
  - Thread, Whiskers

- Composite Materials for Super Strength and Hostile Environments

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ISSUES

1. FIND OUT WHAT TECHNICAL PROBLEMS <u>LOCAL</u> INDUSTRIES ARE FACING.

2. PROMOTE (<u>OPEN</u> + <u>FREE</u>) UNIV.-INDUSTRY INTERACTION:

   (a) DON'T ASK FOR MONEY!

   (b) ASK FOR:

      (i) TECHNICAL COOPERATION (EXCHANGE IDEAS/BOOKS)

      (ii) OLD BUT <u>USEFUL</u> EQUIPMENT

      (iii) THE USE OF THEIR MODERN (EXPENSIVE) DIAGNOSTIC FACILITIES etc.

   (c) AVOID - - - - - COMPANY CONFIDENTIAL PROBLEMS!

3. THINK OF <u>INTELLECTUALLY</u> <u>CHALLENGING</u> PROBLEMS SUITABLE FOR TRAINING STUDENTS AT <u>ALL</u> LEVELS IN HARMONY WITH THE TECHNICAL PROBLEMS OF INDUSTRY.

A/Pr CHOYNE