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**BULLETIN**  
**OF THE**  
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**HOKKAIDO UNIVERSITY**  
**NOTICE**  
**No. 135      May 1987**

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## **The Effect of Anisotropic Consolidation on the Stress-Strain-Strength Characteristics of Saturated Sand**

Liu CHAO-GANG, Shosuke TOKI and Seiichi MIURA  
(Received December 27, 1986)

### **Abstract**

The effect of stress or strain history on the stress-strain-strength characteristics of sand was studied experimentally. The stress or strain history was induced by two series of anisotropic consolidation procedures using triaxial compression apparatus. One is the conventional stress controlled consolidation test which keeps the principal stress ratio constant, and the other is the strain controlled consolidation procedure which keeps the principal strain ratio constant. Both of the tests were carried out with various overconsolidation ratio values.

Experimental results showed that the relationships between principal stress ratio and principal strain ratio in both of the tests were almost identical within the normally consolidated region. Hence it seems reasonable to perform relatively simpler stress controlled tests to evaluate the behavior of sand, such as the coefficient of earth pressure at rest, in normally consolidated region, but the results obtained from stress controlled tests can not be used to represent those obtained from strain controlled tests in the overconsolidated region. The history of anisotropic consolidation affected the deformation behavior within the small shear strain range only where the volume contraction of specimen occurs. It was also clarified that the ultimate shear strength under drained condition was not affected by the stress or strain history.

## **Visual Images for Dual Alternative Theorems**

Kazuyuki HOTTA  
(Received December 27, 1986)

### **Abstract**

There exists a style of theory composing in the nonlinear programming where frequent resorts are made to the so-called dual alternative theorems as to the existence of the solution to a pair of linear vectorial equality and inequality. Many such theorems are available but the algebraic and/or analytic proofs for them are often very complicated. Once a geometrical interpretation is introduced, it becomes easier to get a clearer insight into the implication of the theorems.

It has been a common practice to give such an interpretation, which is persuasive

only in the applications of the theorems to low dimensional cases. Here in this report, an effort is made to extend the practice to the higher dimensional cases. The main feature of the new trial of interpretation is to classify the whole polyhedral convex cones into four distinct sets.

The correspondence between a real matrix and a convex polyhedral cone and the mutual exclusiveness of the forementioned classification enable us to establish the validity of some of the dual alternative theorems.

Since no new theorem is derived by this approach, the contribution, if any, of this report is rather in engineering education than in engineering itself.

## **Formation of (MnO + MnS) Two-Phase Inclusion in Steel**

Yoichi ITOH, Akira KINOSHITA and Kaichi MATSUBARA  
(Received December 27, 1986)

### **Abstract**

The formation process of (MnO + MnS) two-phase inclusions was investigated in very low carbon and silicon steels, quenched at various temperatures during and after the solidification. Through a monotectic reaction ( $L_1 \rightarrow L_2 + Fe$ ), manganese and oxygen were concentrated in a second liquid phase ( $L_2$ ), while sulfur remained in the first one ( $L_1$ ). As the temperature decreased, the liquid droplets  $L_2$ , trapped in the growing steel dendrites, increased in manganese and sulfur by reacting with MnS over the solubility of the steel. Following the further cooling, MnO began to crystallize in the liquid droplets  $L_2$  and the remaining melt became steeply rich in sulfur. Finally, the (MnO + MnS) two-phase inclusion was produced by the solidification of sulfur-rich melt around the primary crystal MnO.

## **Substantiation of Self-Carburizing Phenomenon by Sintered Iron**

Makoto SOHMA, Kazuya ÔUCHI

(Received December 27, 1986)

### **Abstract**

One of the authors proposed a growth theory by self-carburizing phenomenon for the growth theory in oxidizing atmosphere where a large growth occurred and the prospect of explaining many complicated growth phenomena consistently by this theory was obtained. In this paper, a model experiment was achieved to substantiate the theory directly.

A sintered iron with carbon displaced in its cavities in vacuo was heated in the oxygen reduced air and then quenched. The hardness showed a remarkable increase near the surface with a martensitic structure. This hardening was considered to be attributable only to the self-carburizing phenomenon, because there was no carbonaceous gas in the atmosphere surrounding the specimen. Therefore the growth theory by self-carburizing phenomenon was substantiated clearly. Furthermore this phenomenon was considered to be a new method of surface hardening for sintered irons and steels.

## **Freezing Heat-Transfer Characteristics in a Return Bend with a Rectangular Cross Section**

Makoto TAGO and Shoichiro FUKUSAKO

(Received December 27, 1986)

### **Abstract**

This report deals with an experimental study of freezing heat-transfer characteristics in a return bend with a rectangular cross section having a comparatively large aspect ratio. The experiments were mainly focused on the freezing heat-transfer behavior on a concave wall of the return bend, and was carried out with three kinds of duct height and curvature-radius under the condition that the concave wall of the return bend was cooled at uniform temperature maintained at less than freezing temperature, while the convex wall was insulated.

It was found from this experiment that the average freezing heat-transfer on the concave wall of the return bend increased both with increasing duct height and decreasing radius of the curvature.

## A New Residue Decoding Technique Using Chinese Remainder Theorem

Kimio MISEKI, Hideo KITAJIMA, Tetsuo SHIMONO,  
Yoshihiko OGAWA

(Received December 27, 1986)

### Abstract

A new technique for converting the RNS (residue number system) to binary is proposed. Although the basic algorithm is a form of the CRT (Chinese remainder theorem), the technique is unique in that it can be used in finding the value of the integer function  $P$  without a base extension operation. In this paper, we restrict the moduli used as  $m_i \leq 32$  for high-speed computation of ROM table look-up method. Sign detection is readily achieved in 2's complement by adopting the symmetric residue representation and using mod  $2^k$  adder in place of mod  $M$  adder. In spite of the CRT algorithm, this method can be applied to a large number of small moduli RNS ( $n \leq 10$ ). Therefore we can expand the dynamic range in the RNS even when high-speed processing is required. Applied to a scaler in RNS recursive filtering, its throughput is insensitive to the increase of the number of the moduli. With our method, RNS table look-up recursive digital filter with a high-speed and high-precision performance will be realized.

## Modified Block Transform Coding of Images

Zhi-xiong WU, Tetsuo SHIMONO,  
Hideo KITAJIMA and Yoshihiko OGAWA

(Received December 27, 1986)

### Abstract

The block transform coding techniques are considered to be efficient in irreversible compression of images. In block transform coding the image is segmented into blocks, and transform coding is applied to each block separately and independently. It achieves the reduction in computing complexity. On the other hand, significant autocorrelations will remain because of the segmentation of the image into small blocks, and an aggravating side effect called a block effect may be observed as a result of independent coding of each block. To remove these side effects, we propose

in this paper a modified block transform coding technique in which we make use of inter-block of the autocorrelations by transforming the transform coefficients to achieve a high compression rate or a high SNR. A simulation shows satisfactory improved performance of the proposed method over the traditional block transform coding techniques.

## The Structure of the Uranyl Chloro-Complex Determined with the Stability Constants

Hiroshi OHASHI and Takashi MOROZUMI  
(Received December 27, 1986)

### Abstract

The theory of ion pair formation, the outer-sphere complexation theory, for a dumbbell configuration of the uranyl ion was used to explain the ionic strength dependence of the stability constant of uranyl chloro-complex. In this model, it was assumed that the chloride ion interacted electrostatically with each of the uranium and oxide ions, and the distance was evaluated to be 0.3 nm between the uranium and chloride ions. This distance suggests that one of the water molecules coordinating with the uranium ion is replaced by a chloride ion and that a complex of the type  $\text{UO}_2(\text{H}_2\text{O})_3\text{Cl}^+$  is formed. One chloride ion and three water molecules coordinate around the uranium ion in the same plane, perpendicular to the long axis of the uranyl ion dumbbell. A semiempirical equation,  $K_{os} = 0.0681 \exp \{1815 / \{1 + 17.05 (I/T)^{1/2}\} T\}$ , was determined for the stability constant of the uranyl chloro-complex as a function of the ionic strength,  $I$ , and temperature,  $T$ .

## Effect of aging treatment on void swelling behavior in modified 316 stainless steel

Hiroshi KINOSHITA, Heishichiro TAKAHASHI, Somei OHNUKI,  
Ryukichi NAGASAKI

(Received December 27, 1986)

### Abstract

The effect of aging treatment on void swelling behavior in Ti modified 316 stainless steels was investigated by electron irradiations in HVEM. After the specimens were solution-treated at 1448K-1323K for 1 hour, part of the specimens were cold worked by 10% and/or aged at 1073K or 923K for 10-1531 hours. And then electron irradiations and in-situ observations were performed at 773K or 723K up to 80 dpa. When the irradiation doses were over 3-5 dpa, void formation was recognized in all specimens. The mean size of voids became larger with the irradiation dose. Void swelling of no-aged specimens were much lower than aged ones. When the solution treatment temperature was high and the irradiation temperature was low, the void swelling became lower. Thus, it can be said that the behavior of swelling depended on the temperature of the solution treatment. Furthermore, radiation-enhanced precipitation with corresponded to MC carbides was also observed, and then with the occurrence of these precipitates, voids were newly formed in such a way that the swelling increased. It is, therefore, assumed that the amount of additional element in the solution in the matrix was more effective in void swelling suppression.

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## Stratification of a Sand bed

Naoyuki FUNAMIZU and Tetsuo TAKAKUWA  
(Received March 31, 1987)

### Abstract

Sedimentation tests were carried out by the use of single and multi-species suspensions of sand particles. In these tests settling velocities of sand particles and particle diameter distributions in settled beds were measured.

Settling velocity data showed that the formulation<sup>1)</sup> of a hindered settling velocity presented by the authors is applicable to non-spherical sand particles.

Diameter distributions of settled beds were computed by the model describing a differential settling process and a stratification pattern of a settled bed. Computed results were compared with those of experimentals obtained both in the laboratory and a practical water treatment plant and the validity of this model was confirmed.

## Density Changes during Solidification of Hypoeutectic Al-Si Alloys

Farooq SIDDIQUI\* Tadayoshi TAKAHASHI\*  
Masayuki KUDOH\* and Kenichi OHSASA\*  
(Received March 31, 1987)

### Abstract

It is necessary to know the density changes during the liquid-solid transformation in order to prevent macrosegregation and to secure the soundness in conventional castings. In this study the density changes of hypoeutectic Al-Si alloys were measured in liquid and solid states. By using the obtained values, the following relationships, between density and liquidus temperatures, and between the density and solidus temperatures, are established:

$$\rho_L = 1.862 + 2.46 \times 10^{-3} \times T_L - 2.59 \times 10^{-6} \times T_L^2 \quad (2)$$

$$\rho_S = 3.383 - 0.227 \times 10^{-2} \times T_S + 0.155 \times 10^{-5} \times T_S^2 \quad (6)$$

where  $\rho_L$  and  $\rho_S$  are liquid density at the liquidus temperature  $T_L$  and solid density at

the solidus temperature  $T_s$ , respectively.

Furthermore a method is formulated to calculate the changes in density during liquid-solid transformation of a binary alloy by using the fraction solid, fraction liquid and the corresponding densities of the liquid and solid phases.

## Feeding Behavior during Solidification of Binary Alloy Ingots

Farooq SIDDIQUI\* Tadayoshi TAKAHASHI\*

Masayuki KUDOH\* and Kenichi OHSASA\*

(Received March 31, 1987)

### Abstract

In the solidification process, with the fall in temperature, liquid volume gradually decreases with the increase in solid volume. This results in volumetric shrinkage and necessitates compensation by liquid metal, which is called feeding. Feeding during solidification has been considered to have its limit, because the liquid metal is trapped by the solid at a certain fraction solid due to the growing dendritic network. In this study, Al-3 wt%Si alloy was selected as a representative binary alloy and its feeding behavior during solidification was measured by using an experimental method devised by the authors. The experimental results show that the rate of feeding decreases rapidly and attains a very small value after the fraction solid at the neck of the ingot reaches 0.67. Therefore the limiting fraction solid to feed is determined as 0.67 and the value is in agreement with that of the limit to flow of the interdendritic liquid. Furthermore the density of the ingot is directly related to the limiting fraction solid and the rate of feed.

## Theoretical Analysis of Feeding Behavior during Solidification of Binary Alloy Ingots

Farooq SIDDIQUI\* Tadayoshi TAKAHASHI\*  
Masayuki KUDOH\* and Kenichi OHSASA\*  
(Received March 31, 1987)

### Abstract

The feeding of an alloy ingot consists of a compensation of metal due to volume contraction in liquid and solid states before and after solidification, and is due to the volume contraction during solidification. The measured feeding represents the total amount of feed from the pouring temperature in liquid state to room temperature in solid state, and poses a problem of separation of solidification contraction and thermal contraction. Partitioning became possible by the theoretical analysis of the feeding behavior that utilized the numerical method established by the authors. The analyses were carried out for unidirectionally and cylindrically solidified ingots. In both cases, the comparison of measured and calculated results shows that, the total calculated feed and the actual measured feed shows a good agreement if 0.67 fraction solid is used as the limit to direct feeding during solidification.

## Formation of Equiaxed Zone and Fluidity of Liquid in the Zone for Al-Si Alloy

Masayuki KUDOH and Tadayoshi TAKAHASHI  
(Received March 31, 1987)

### Abstract

In order to investigate the sedimentation and accumulation phenomena of free crystals and to estimate the fluidity of the liquid coexisting with accumulated crystals, two experiments by methods established by authors were carried out.

The first is a stirring method of the upper part of the liquid filled crucible. The granular crystals formed by stirring settles down and are accumulated at the bottom of the crucible. Then the fraction solid in the accumulated zone becomes more excessive than the equilibrium fraction solid because of the closed packing of the granular crystals. Furthermore, liquid

pores are observed in the accumulated zone and is considered to contribute to the formation of semimacro-segregation.

The second is seepage method. It allows the liquid in the accumulated zone composed of granular crystals to flow into a hole formed in that zone. The fluidity of the liquid is estimated as the effective permeability. Obtained values agreed with those in the case of a slowly solidifying ingot which is composed of dendrites. The liquid in the accumulated zone may flow in the range of approximately 0.49 to 0.69 of the fraction solid.

## On the Formation of Type III Sulfides in Cast Steel

Yoichi ITOH, Toshimi KOBAYASHI and Kaichi MATSUBARA

(Received March 31, 1987)

### Abstract

Angular-shaped MnS inclusions (type III sulfide according to Sims' classification) observed in fully deoxygenized steel are highly deformable at elevated temperatures and therefore are harmful to the short-transverse ductility of hot-rolled plates.

We have already reported the formation process of type III sulfides in low carbon steel. These are fine structured and are precipitated from solid steel. However, coarse type III sulfides in the cast steel with high carbon, silicon and/or aluminium contents seem to be formed by different processes. The condition for the formation of this type of sulfides was examined quantitatively in steels with 0.2-2 wt%C, 0-4 wt%Si and 0-1 wt%Al. Carbon among these elements was most favorable for the formation of coarse type III sulfides but the increase in cooling rate was found to be unfavorable. The formation process of the sulfides was also investigated in steels quenched at various temperatures. Microscopic observation of these steels showed that the sulfides were crystallized from residual melt among the primary iron dendrites.

It might be concluded from the above results that coarse type III sulfides were formed by a divorced eutectic reaction.

## **Analysis for Main Descriptions and Performances of Reciprocating Internal Combustion Engines Made in Japan**

Noboru MIYAMOTO, Hideyuki OGAWA,  
Nobuyuki YAMAZAKI and Kenji YAMAZAKI  
(Received March 31, 1987)

### **Abstract**

This report classifies and analyzes the main characteristics and performance of internal combustion engines produced in Japan.

In the analysis, data for all types of internal combustion engines were compared using a microcomputer and schematic correlation diagrams for the performances. Descriptions were made to analyze the mutual relationships.

As a result, the mutual relationship between the main performance and design factors, ie. engine types, engine speeds, and compression ratios, and also advantageous features for design and research of internal combustion engines were obtained.

## **Characterization of Semi-Insulating InP Substrates by Photo-Conductance Measurement**

Hitoshi YANO Hideo OHNO  
Hideki HASEGAWA Takayuki SAWADA  
(Received March 31, 1987)

### **Abstract**

Theoretical and experimental investigations of photo-conductance (PC) of semi-insulating (SI) InP substrates for the characterization of electrical non-uniformity of the substrates is presented. Surface recombination is appropriately incorporated in the theoretical model by the use of a newly proposed model based on unified disorder induced state model. Theoretical analysis shows that the deep trap density can be measured by measuring the magnitude of PC provided that the surface state density remains the same. PC of SI InP wafer is shown to have a four fold symmetry which is known to be a bulk character indicating that PC reflects the bulk properties of the substrate.

## Metal-Organic Vapor Phase Epitaxy Growth of InGaAs

Nobuaki TOMESAKAI, Atushi OHUCHI, Shunsuke OHTSUKA  
Eiji IKEDA, Hideo OHNO, Hideki HASEGAWA  
(Received March 31, 1987)

### Abstract

InGaAs layers are grown on InP substrates by metal-organic vapor phase epitaxy. From X-ray diffraction spectrum, Hall effect measurement, and surface morphology, it was shown that the intermittent bubbling of trimethylgallium, the source material of Ga, results in non-uniform composition of the growth direction of InGaAs.

To overcome this unwanted phenomena, a mixing cylinder is inserted in the supply line of group III material. It was shown that the surface morphology and electron mobility are dramatically improved by inserting the cylinder. The highest mobility so far obtained is 34,000 cm<sup>2</sup>/V. sec with an electron concentration  $n=3.0 \times 10^{15} \text{cm}^{-3}$  at 77K.

## THE INFLUENCE OF PREPARATION CONDITIONS OF POWDER MIXTURES ON THE REACTION OF V<sub>2</sub>O<sub>5</sub>-Fe<sub>2</sub>O<sub>3</sub> SYSTEM

Akira SHIMIZU, Ryusaburo FURUICHI and Tadao ISHII  
(Received March 31, 1987)

### Abstract

In order to investigate the influence of preparation conditions of powder mixtures on the rate of FeVO<sub>4</sub> formation, five mixtures (**M1-M5**) were prepared by using three V<sub>2</sub>O<sub>5</sub> (**V1**, **V2** and **V3**) and two Fe<sub>2</sub>O<sub>3</sub> (**F1** and **F2**) powders. **V1** was prepared by thermal decomposition of NH<sub>4</sub>VO<sub>3</sub> at 450°C and **V2**, **V3** were prepared from **V1** by manual grinding in a mortar (**V2**) and by jet mill grinding (**V3**), respectively. **F1** and **F2** were prepared from commercial α-Fe<sub>2</sub>O<sub>3</sub> by sieving under 325 mesh (**F1**) and by manual grinding in a mortar (**F2**), respectively. Equimolar mixtures of these V<sub>2</sub>O<sub>5</sub> and Fe<sub>2</sub>O<sub>3</sub> were obtained by mixing in an agate mortar for 1 hr with a weak force (**w**) and strong force (**s**) respectively. The preparation conditions of the mixtures are as follows: **M1** (**V1**, **F2**, **w**), **M2** (**V2**, **F2**, **w**),

M3 (V3, F2, w), M4 (V2, F1, w) and M5 (V2, F2, s). The rate was evaluated by using Jander's equation ( $[1 - (1 - \alpha)^{1/3}]^2 = k_j t$ ). The order of the rate was  $k_{jM5} \approx k_{jM3} > k_{jM2} > k_{jM4} > k_{jM1}$ . Particle sizes ( $d$ ) of  $V_2O_5$  and  $Fe_2O_3$  in the mixtures were  $d_{V1} > d_{F1} > d_{V2} = d_{V3} = d_{F2}$ . Lattice strain ( $\eta_a$ ) of  $V_2O_5$  was estimated by Hall's plot of (200), (400) and (600) planes. The order of  $\eta_a$ -value of  $V_2O_5$  in the mixtures was found to be  $\eta_{aM3} > \eta_{aM5} > \eta_{aM2} = \eta_{aM4} > \eta_{aM1}$ . The increase in  $k_j$ -value was explained by the increase in  $\eta_a$  of  $V_2O_5$  and in the contact point between reacting particles.

## Theory of the Intermediate Size Distribution in Random Cutting

Alexander Vilenkin<sup>†</sup>, Shigeji FUJITA\* and Junkichi SOHMA

(Received March 31, 1987)

### ABSTRACT

A homogeneous thread of length  $L$  is cut at random subject to the restriction that no thread of a size less than a predetermined length  $b$  should be produced. It is shown that the original length  $L$  is considerably large as compared with the average size  $l_0$  of the threads generated and the size distribution is characterized by  $\rho(x) = (l_0 - b)^{-1} \exp [(x - b)/(l_0 - b)]$ ,  $x > b$ , with  $\langle x \rangle = \int_b^\infty dx x \rho(x) = l_0$ . In particular, for  $b = 0$  (no minimum length), the size distribution is of an exponential decay type:  $\rho = l_0^{-1} \exp(-x/l_0)$ . A few applications of the theory, including the effect of the radiation damage on polymers and the molecular weight reduction by high speed stirring in polymer solutions, are discussed.

## Liquid Argon : Molecular Dynamics Calculations for the Van Hove Self-correlation Function

Yukio TANAKA,\*\* Yoshiaki AOKI\* and Hatsuo YAMAZAKI\*

(Received March 31, 1987)

### Abstract

Molecular dynamics calculations for liquid argon were made using the Lennard-Jones potential and the Barker-Fisher-Watts pair potential with the Axilrod-Teller three-body interactions, which is known to be a more realistic potential for argon. Van Hove self-correlation function  $G_s(r, t)$  was obtained at the intermediate time region, 0.32~4.6 ps. The present  $G_s(r, t)$  curves for both potential functions are in essential agreement with each other. It was revealed that the differences between the potential functions have hardly any effect on the present  $G_s(r, t)$ .

## Behaviour of Hydrogen under Irradiation in Ferritic/Martensitic Steel

Fa-rong WAN, Ryukichi NAGASAKI,  
Heishichiro TAKAHASHI and Somei OHNUKI

(Received March 31, 1987)

### Abstract

To investigate the interaction between hydrogen and defects in steel, hydrogen was implanted into ferritic/martensitic stainless steel (JFMS), Fe-10Cr, Fe-1Ni and pure Fe with an ion accelerator or chemical cathodic charge, followed by electron irradiation in HVEM. Special streaks in electron diffraction patterns were observed clearly during irradiation. For the formation of the streak patterns, (1) the specimens should contain Ni or Cr atoms, (2) the specimens should also contain hydrogen, (3) and the temperature of irradiation should be 623-723 K. Streak patterns would disappear if annealed at 823 K. From the results it can be concluded that the streak pattern is due to the formation of the clusters of Cr or Ni atoms and hydrogen along  $\langle 100 \rangle$ .

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## Studies of the Mechanical Characteristics of Tertiary Sedimentary Rocks (Part I)

—Fracture Criteria of Tertiary Sedimentary Rocks—

Akira NAKAMURA and Yoji ISHIJIMA

(Received June 30, 1987)

### Abstract

This paper presents the results of investigations on the mechanical characteristics of Tertiary sedimentary rocks at room temperature under various confining pressures up to 1705 kgf/cm<sup>2</sup>. Fracture strength, residual strength, post-failure behaviors and effects of intermediate principal stress are discussed in the corresponding Parts of this paper respectively.

In Part I, bilinear fracture criteria for the rocks are suggested. The criteria are simply expressed in terms of overburden pressure ( $\gamma h$ ) of the rocks as follows;

$$0 \leq \sigma_3 \leq \gamma h \quad \sigma_1 = A_1 \sigma_3 + C_0$$

$$\gamma h \leq \sigma_3 \quad \sigma_1 = A_2 \sigma_3 + (A_1 - A_2) \gamma h + C_0$$

where  $\sigma_3$  is the confining pressure,  $\sigma_1$  is the fracture strength,  $C_0$  is the uniaxial compressive strength and  $A_1$ ,  $A_2$  are constants.

## On the displacement and stress in the coal seam around a shot point and their effect against the parameters of coal and gas outbursts

Masuyuki UJIHIRA and Tsutomu WATANABE

(Received June 30, 1987)

### Abstract

To evaluate the effect of blasting shock against the occurrence of coal and gas outbursts, it is necessary to prepare data regarding the dynamic behaviour of the coal seam around a shot point. We previously conducted strain and particle velocity measurement in the underground of Sorachi Coal Mine. From the measurements, it was found that the value of displacement decreases according to a power function of the distance  $r$  from a shot point and the decreasing index is  $-1.559$ .

Then it was determined that when dynamic vibration is added to the coal seam, cohesion or the coefficient of internal friction would suddenly decrease.

## The Effect of Phytic Acid on the Anodic Dissolution of Copper and Copper-Zinc Alloys

Takenori NOTOYA

(Received June 30, 1987)

### Abstract

The effects of phytic acid ( $C_6H_{18}O_{24}P_6$ ) and calcium phytate ( $Ca_6C_6H_6O_{24}P_6$ ) on anodic dissolution of copper and four different copper-zinc alloys are studied in a sodium borate-boric acid buffer solution at 60°C.

Anodic polarization was made potentiostatically from a corrosion potential up to 0.90 V vs S. C. E. for copper and 0.50 V for brasses in the unstirred solutions containing phytic acid or calcium phytate. In the presence of phytic acid both inhibition and acceleration of anodic dissolution depending on its concentration and pH of the solution were observed, i. e., copper dissolution was inhibited by phytic acid to an extent less than  $10^{-3}$  M of pH 9.2 solution while it was accelerated in the solutions at lower pHs.

Copper-zinc alloys dissolution was accelerated at more than  $10^{-2}$  M phytic acid for 90/10 brass,  $10^{-3}$  M for 80/20 brass, and  $10^{-4}$  M for 70/30 and 60/40 brasses in the pH 9.2 solution. These opposite effects are probably due to the formation of insoluble and soluble chelates of copper-or zinc-phytate on the metal surfaces depending on phytic acid concentration and copper/zinc ratio in the alloys.

The solution saturated with calcium phytate (about  $4 \times 10^{-4}$  M) inhibited the anodic dissolution of both copper and copper-zinc alloys.

## Harmonic Components of Cylinder Pressure Variation and Their Characteristics for Combustion Noise in Internal Combustion Engines

Sung-Ro LEE\*, Noboru MIYAMOTO\*\* and Tadashi MURAYAMA\*\*

(Received June 30, 1987)

### Abstract

Combustion noise is a considerable detrimental problem in internal combustion engines.

This investigation attempts to clarify the general characteristics of harmonic components in cylinder pressure variations which are the main exciting force of combustion noise.

noise.

Cylinder pressure variation for different combustion behaviors and their harmonic components were calculated and an attempt was made to relate the various components.

The results indicate that the harmonic components can be approximately described by a linear function with four variables, namely four characteristic values of cylinder pressure variation. The coefficients of the four variables depend solely on the order number of engine revolution, and are independent of the combustion behavior and engine operating conditions.

### **Effect of the Metals in Combustion Chamber Wall on Methanol Ignition in Diesel Engines**

Zhixin HOU, Akira HARADA, Hideyuki OGAWA,  
Takemi CHIKAHISA, Noboru MIYAMOTO and Tadashi MURAYAMA

(Received June 30, 1987)

#### **Abstract**

This research was conducted to investigate methanol ignition and combustion on different metals of the combustion chamber wall, and to determine means to improve ignitability.

The results indicate that among the metals tested, Fe is the most effective in improving methanol ignition. The in-chamber concentration of HCHO, an intermediate product of methanol combustion, appears to be an important determinant in methanol ignition. To achieve smooth ignition without misfiring, a certain HCHO concentration is necessary immediately prior to methanol injection in the combustion chamber.

In addition, it was found that ignition in IDI engines is more strongly affected than in DI engines, as in the case of combustion systems where unburnt methanol tends to remain more and longer.

## Numerical Simulation for Upset Forging of Cylinders

Shigeru TADANO and Hiromasa ISHIKAWA

(Received June 30, 1987)

### Abstract

The authors have investigated a simple method of numerical simulation by a personal computer in order to analyse how materials show their deformation behavior during plastic working; extruding, rolling, forging, etc.. A simplified rigid-plastic finite element method employing the penalty method was reported previously.

In this paper, numerical simulation using this method for the upset forging of pure aluminium cylinders between perfectly rough and rigid parallel platens is presented. The model for calculation is concerned with the Levy-Mises material considering strain-hardening, and has the initial height-to-diameter ratio of 0.5 to 1.5. In the finite element method, it is difficult to deal with deformation near a singular point, where the velocity boundary condition changes sharply. However, this deformation could be represented well by a new element with 4 nodal points.

As a result, the numerical analysis agrees well with the experimental results of bulging and folding behavior up to 50 % reductions in height.

## Investigation of Breakdown Mechanism of Semi-Insulating GaAs

Yali LIU, Hideki HASEGAWA and Hideo OHNO

(Received June 30, 1987)

### Abstract

The breakdown of semi-insulating (S. I.) GaAs is investigated both experimentally and theoretically.

All these experimental results cannot be explained by the Space-Charge-Limited Current theory (SCLC). A new model based on the avalanche theory is proposed which can explain all of the experiment results.

Using carefully designed sample structures with guard rings, current-voltage (I-V), dependence of the characteristics breakdown voltage  $V_{BD}$  on the thickness of the substrate and the temperature dependence of the breakdown voltage are measured.

Light emission associated with breakdown is observed for the first time. It showed a broad spectrum covering 400 nm~900 nm.

## Generation of Random Telegraph Signal using Exponential Random Numbers based on Walker's Method

Toshio OHYANAGI, Yoshihiro NAKAGAWA and Ikuo KAJI

(Received June 30, 1987)

### Abstract

In this paper a method of generating random telegraph signals of good statistical quality is described. For this purpose a method of generating exponential random numbers based on Walker's method is proposed and its adequacy was first verified. Then a method of generating random telegraph signal in such a way that its lead-time can be almost ignored is explained using a petri-net model and its validity was verified by computer simulation.

And a block diagram of random telegraph signal generator based on this concept is given.

## Vibrational Spectra of Percolation Clusters —Alexander-Orbach Conjecture—

Kousuke YAKUBO, Kouichi TAKASUGI, Satoshi TANAKA  
and Tsuneyoshi NAKAYAMA

(Received June 30, 1987)

### Abstract

We study numerically the dynamical properties of percolation clusters with fractal dimensions as the simplest model for amorphous solids or porous media. It is found, using a novel numerical technique suitable for the present problem, that the fracton density of states  $g(\omega)$  is proportional to  $\omega^{1/3}$  as conjectured by Alexander and Orbach. The mode patterns of fractons are obtained for the first time, and it is shown that fracton excitations are localized in some "peninsulas" in the percolation cluster.

## High Temperature Reaction of SiC with Ni and Ni-Base Alloys

Kazuya KUROKAWA, Syougo KON-YA and Ryukichi NAGASAKI

(Received June 30, 1987)

### Abstract

Reaction couples consisting of Ni/SiC, Ni-10 Cr/SiC, Ni-10 Mo/SiC, and Hastelloy C/SiC were studied to clarify the structure and growth kinetics of the reaction layer, and behaviors of constituents of alloy and SiC. The reactions were carried out under a pressure of  $5 \times 10^{-4}$  Pa at temperatures ranging from 1173 K to 1373 K.

In all systems, the reaction was mainly dominated by the diffusion of Ni into SiC. The resulting products were  $\delta$ -Ni<sub>2</sub>Si and graphite which formed a banded structure consisting of alternating layers of  $\delta$  and ( $\delta$ +graphite). The growth of the reaction layer was suppressed when Cr was present in alloy. The Cr carbides formed as a result of preferential reaction of Cr with SiC prevented the penetration of Ni into SiC. Mo was concentrated in alloy with Ni and Cr diffusing to the SiC side to form a silicide or carbide. It was suggested that the maximum application temperature of Ni-base alloy/SiC composite material for a hot machinery was about 1200 K.

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## The phenomenological calculation of a Cu-Au phase diagram with a Lennard-Jones type potential on a uniformly deformable lattice

Tetsuo MOHRI, Junsei TSUTSUMI and Katsuya WATANABE

(Received September 30, 1987)

### Abstract

By using the Lennard-Jones type potential, the phenomenological calculation of the Cu-Au phase diagram was attempted. The phase boundaries of order-disorder transition showed a considerable shift toward higher temperatures over the entire concentration range. The discrepancy is explained in terms of local lattice relaxation.

The phenomenological calculation of thermodynamic properties of alloy phases by using experimental data is one of the powerful approaches to alloy thermodynamics. Sanchez et al. [1] obtained the  $\gamma/\gamma'$  phase boundaries of Ni-Al system by combining the Cluster Variation Method (hereinafter abbreviated as CVM) with the phenomenological Lennard-Jones type potentials which are extracted from experimental data of heats of formation and lattice parameters of both pure constituents and an ordered compound. We also performed the calculations of the concentration dependency of heat of formation and lattice parameter of disorder phase for the Cu-Au system at 720K [2] based on the same method devised by Sanchez et al. Both calculations were quite satisfactory to achieve an overall agreement with experimental data. The calculations were, however, confined to a limited portion of the entire phase diagram and thermodynamic quantities of a single phase. In order to examine the method more critically, a calculation for an entire phase diagram of the Cu-Au system is attempted.

The Cu-Au system has been attracting wide attention by theorists because of the peculiar topological features of the phase diagram characterized by three ordered compounds. The initial stage of the phase diagram calculations was devoted within a framework of the Ising model with an antiferromagnetic interaction. The Bragg-Williams model [3] and the quasichemical approximation [4] were clearly unsatisfactory for reproducing both topological features of phase boundaries and transition temperatures. The first successful calculation may be attributed to van Baal [5] who applied the tetrahedron approximation of Kikuchi's Cluster Variation Method [6]. According to the ground state analysis of Cahn et al. [7, 8] and Kanamori et al. [9, 10], both the  $L1_0$  and  $L1_2$  ordered structures are stabilized by the positive first nearest neighbor and the negative second nearest neighbor pair interac-

## Measurement of Polynuclear Aromatic Hydrocarbon in Particulates and Gaseous Unburnt Hydrocarbon from Diesel Engines

Koji YAMANE\*, Takemi CHIKAHISA\*, Noboru MIYAMOTO\*\* and Tadashi MURAYAMA\*

(Received September 30, 1987)

### Abstract

This paper provides information on measurement techniques for the soluble organic fraction in the particulate and gaseous unburnt hydrocarbon in diesel exhaust. A dilution mini-tunnel and teflon coated glass fiber filter were used to collect the particulates. The soluble organic fraction (SOF) is extracted from particulates by soaking filters in dichloromethane, which was isolated by column-chromatography. Its PAH fraction was determined by high performance liquid chromatography (HPLC). Column-chromatography with a silica-gel column and HPLC with an octadecylsilan-bonded column kept at high temperatures improved the analytical efficiency. The gaseous hydrocarbon in raw exhaust was analysed by a gaschromatography (GC) with FID. The temperature of the sample glass syringe affected the measurements of the high boiling point hydrocarbon constituents.

## Cluster Analysis for Scientific Articles by Optimal Relationship Model

Tatsuki SAITO

(Received September 30, 1987)

### Abstract

A methodology for modeling and clustering of large scale complex information space is discussed in order to analyze the structure of relation among scientific articles. An object to be modeled in data base system "ANGEL" is expressed by a point, and a binary relation between objects is expressed by points and lines in relational graph. A similarity matrix is derived through operation of an initial relational graph matrix. And various similarity matrices are produced from various relations in the information space to be dealt with. A method which optimizes the consistency is proposed when these real number matrices are combined. And another method is proposed for modeling and clustering by application of characteristics of the relational graph. The performance of the proposal method was superior to the interpretive structural model which applies a 1-0 reachability matrix for cluster analysis of some scientific articles.

## **Graph-theoretic Cluster Analysis Algorithms Based on the Concept of Weak Connected Components of a Digraph.**

Azuma OHUCHI\*, and Ikuo KAJI\* and Khoichi KURIHARA\*\*

(Received September 30, 1987)

### **Abstract**

A sequence of digraphs can be associated with a given matrix by converting it into binary matrices. Any such binary square matrices can be interpreted as an adjacent matrix of a digraph in which there is a directed edge from vertex  $i$  to vertex  $j$ , iff the  $(i, j)$  entry of the binary matrix is 1. The vertices of any digraph can be partitioned into weak components. By taking the thresholds in the ascending order, and determining the weak components of each of the associated digraphs, vertices can be hierarchically clustered. Ten algorithms for the clustering are implemented and their efficiency is compared.

## **Consideration on Windows in Computed Tomographic Image Reconstruction**

Guo-qing WU and Yoshihiko OGAWA

(Received September 30, 1987)

### **Abstract**

The generalized Hamming window function is frequently used in computed tomographic (CT) image reconstruction. But the blur and SN ratio are very sensitive to the value of parameter,  $\alpha$ , used in the window. Generally, when the improvement of the SN ratio is aimed, at the reconstructed picture is more blurred. Thus, it is required to select the value of  $\alpha$  for the sake of moderately satisfying both characteristics, namely the blur and the SN ratio.

The above-mentioned problem is discussed in this paper. And it is concluded that the appropriate value of  $\alpha$  is 0.5 or a somewhat more than 0.5. It is possibly preferable to select 0.54 of  $\alpha$  corresponding to the normal Hamming window function.

## A Method for Machine Translation Using Conjunctive Relation of Words

Yasuhiro SUZUKI, Yosikazu MIYANAGA, Koji TOCHINAI

(Received September 30, 1987)

### Abstract

This paper proposes a new method for machine translation. This method uses the conjunctive relation of words, instead of the syntactic and semantic analysis employed in the conventional machine translation system. An experimental translation system was constructed, and experiments were performed using 116 titles extracted from the transactions of IPSJ. As a result of the experiments in English-Japanese translation, the rate of exactly translated titles was 75%, and in Japanese-English translations, the rate was 66%.

## Effect of mixing procedure, mixing ratio and compaction pressure of reactant oxides on $\text{CuO}-\eta\text{-Al}_2\text{O}_3$ powder reaction

Takeshi TSUCHIDA, Kunihito MATSUI and Tadao ISHII

(Received September 30, 1987)

### Abstract

The rate of reaction between the compacted powders of  $\text{CuO}$  and  $\eta\text{-Al}_2\text{O}_3$  was measured in air at 800–900°C and the effect of mixing procedure (dry and wet mixing), mixing ratio ( $\text{CuO}$  30, 50, 60, 70mol%) and compaction pressure (0, 0.9, 2.1, 4.1, 6.3,  $8.3 \times 10^8$ Pa) of reactant oxides on the fraction of reaction completed ( $\alpha$ ) was investigated. In an equimolar mixture of  $\text{CuO}$  50mol%, the  $\alpha$ -values obtained in the wet mixing system were higher than those in dry one and were not influenced by the compaction pressure. On the other hand, the  $\alpha$ -values obtained in the dry mixing system varied with the compaction pressure and had its maximum value at  $2.1 \times 10^8$ Pa. The effect of the mixing procedure and compaction pressure on the  $\alpha$ -values was explained on the basis of the aggregate size of  $\text{CuO}$  dispersed in the matrix of fine  $\eta\text{-Al}_2\text{O}_3$  powder which was observed by a scanning electron microscopy (SEM).

## Joining of Magnesia with Iron or with Cobalt

Koji ATARASHIYA and Ryukichi NAGASAKI

(Received September 30, 1987)

### Abstract

The joining of magnesia to iron metal at 1473 K in vacuum was accomplished with the use of a preoxidized iron specimen. The joining of magnesia to cobalt metal at 1273 to 1573 K in air was also accomplished. These joinings were examined by a low pressure process that does not require heterogeneous fillers.

The fracture strength measurements by three-point-bending tests and the microstructure observations of joining parts and fracture surfaces were examined.

In order to elucidate the joining mechanism, the diffusion phenomena in related quasi-binary oxide systems were discussed.

The advantage of these methods is that the joining can be accomplished under nul pressure without the use of fillers.

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## **Probe Measurement of Afterglow Plasma by the Sampling Method Using a Boxcar Integrator**

Fumiyuki FUJITA, Mitsugu TAKAHASHI and Hatsuo YAMAZAKI  
(Received September 30, 1987)

### **Abstract**

Since the electron density of an afterglow plasma rapidly varies with time, it is difficult to apply the conventional probe methods to this plasma. Thus, we developed a new probe measurement system in which a boxcar integrator was used for data sampling. In order to guard the probe measurement system against the rush current from the plasmas at discharge, we constructed a protection circuit using a surge absorber. A microwave measurement was also performed to confirm the validity of the new probe method. Both results agreed well.

## **Application of Etched Track Method to Fusion Neutronics**

Fumiyuki FUJITA, Kazunari OGUCHI, Michio YOSHIKAWA,  
Masakuni NARITA, Tomo-o NAKAMURA, Hiroshi MAEKAWA  
(Received September 30, 1987)

### **Abstract**

A fission track detector (FTD) is a kind of solid state nuclear track detectors using the etched track method. It is a neutron detector which has an excellent spatial resolution. We examined the absolute sensitivity of this detector in detail. It was found that irradiation, chemical processing and calibration of FTD should be handled with appropriate and adequate care. For application to the fusion neutronics, we measured the fission rate distributions in a graphite assembly installed in front of a 14 MeV neutron source. The FTD allows for the useful measurement of the local fission rate as a spectrum index in the fusion blanket neutronics experiments.

## **Suboptimal Control of a Pressurized Water Reactor Power Plant Using an Approximate Model-Following Method**

Masashi TSUJI\* and Yuichi OGAWA\*

(Received September 30, 1987)

### **Abstract**

An attempt to design an effective control system for maneuvering the nuclear steam supply system of a pressurized water reactor power plant in an operational mode requiring relatively small variations of power is presented. For this design, a procedure consisting of two design steps using the optimal control theory based on the linear state-feedback control and an approximate model-following method is proposed. Utilizing the respective merits of these two methods, the proposed method becomes practically applicable to the control problems of large-scale complex dynamical engineering systems, because it can readily provide a simply, yet practiced, suboptimal controller. Digital simulation and frequency analysis demonstrates the effectiveness of the suboptimal control, and the applicability of the proposed design method as well.

## **Theoretical Analysis of Time-Dependent Neutron Spectra in Bulk Assemblies**

Tadashi AKIMOTO, Orihiko TOGAWA and Yuichi OGAWA

(Received September 30, 1987)

### **Abstract**

Time-dependent neutron spectra in an iron assembly and in a graphite assembly are obtained with the one-dimensional  $S_N$  calculation, in order an attempt to investigate the availability of these spectra to the benchmark test by the LINAC-TOF method for evaluation of nuclear data and numerical methods. The group constants are taken from the JAERI FAST SET Version 1, 2 and the ABBN SET. It was demonstrated by a sensitivity test that the time-dependent neutron spectra are sensitive to changes in the inelastic scattering cross section data in the iron assembly and to changes in the elastic scattering cross section data in the graphite assembly. Moreover, it is shown that the time-dependent spectra in the graphite assembly are sensitive to the group structure. Because some information about the

neutron transport phenomena which has not been obtained in the stationary spectra is observed in the time-dependent spectra, the availability of the benchmark test based on the time-dependent spectra is indicated from the theoretical analysis.

## **Physicochemical Study of Crud Characterization Effect of Preparation Conditions on Magnetite Properties**

Hiroshi OHASHI, Tamotsu KOZAKI, Naohumi KOZAI,  
Naohiro MIYAZAWA and Takashi MOROZUMI  
(Received September 30, 1987)

### **Abstract**

About thirty specimens of magnetite were prepared by five methods under various conditions, and characterized by X-ray diffraction, BET surface area measurement, Mössbauer spectroscopy, and SEM observation. The dissolution rate was also determined in three kinds of decontamination reagents: oxalic acid, EDTA, and EDTA-N<sub>2</sub>H<sub>4</sub> solutions.

The morphologies of the products were divided into four groups: sphere, cube, octahedron, and fine particles. Although all of the specimens showed Mössbauer absorption spectrum composed of nine peaks which is typical to magnetite, the intensity ratio of the peak 2 to peak 1,  $I_2/I_1$ , varied with the preparation methods and conditions. The values of the  $I_2/I_1$  ratio were distributed between 0.5 and 1.9, increasing with the decreasing BET surface area. The BET surface area was estimated to be  $4\text{m}^2\text{g}^{-1}$  when extrapolated to the limiting  $I_2/I_1$  ratio, 2. The dissolution rate depends upon both the BET surface area and  $I_2/I_1$  ratio. These findings suggest that the valence state of iron as well as the surface area plays important role in the dissolution of magnetite in the decontamination reagents.

## Corrosion of SUS304 stainless steel in oxalic acid solution

Takashi MOROZUMI, Makoto MORIYA, Kazumi OGURA  
and Yoshiaki TAKEMOTO  
(Received September 30, 1987)

### Abstract

The corrosion rate of oxidized and unoxidized SUS304 stainless steel was measured in 0.1M oxalic acid at 80°C under the potentiostatically polarized conditions.

The dissolved amounts of Fe, Cr and Ni were determined by atomic absorption analysis after 166 min of polarization as a function of the potential. The corrosion potential and the sweep potentiostatic polarization curve were also measured in the same solution.

The unoxidized specimen was severely attacked at the cathodic potential between  $-200$  and  $-700$  mV vs Ag-AgCl. Similar cathodic corrosion was also found, but with a decreased dissolution rate, for oxidized specimens. Since the corrosion potential of the alloy situated nearly at the boundary of active passive transition, both specimens frequently suffered localized attack due to insufficient passivation during spontaneous immersion.

The dissolution rate of the surface oxide was slightly effected by the electrode potential within the active and the passive regions. Therefore, weakly anodic polarization is desirable for the dual purposes of the effective dissolution of surface oxide and the protection of substrate alloy surface.

## Low Energy Excitation in Amorphous Polymers

Kazuhiko INOUE  
(Received September 30, 1987)

### Abstract

The measurements of low energy neutron scattering spectra from various amorphous polymers are reported. The scattering spectra show a characteristic behaviour which is not observed in the measurements of crystalline solids; the spectra show inelastic peaks near 2 meV at low temperature irrespective of the structural differences between the polymers, and on raising the temperature the inelastic peaks undergo change to the quasielastic peaks. The Q dependence of scattering intensities seems to support that the spectral features are due to the low energy excitation and thermal fluctuation in two-site system.

## Optimum Proton Energy for a Spallation Neutron Source

Yoshiaki KIYANAGI, \*Masatoshi ARAI and \*Noboru WATANABE

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### Abstract

Neutron yield obtained by the spallation reaction and thermal neutron intensity emitted from the moderators were calculated as a function of incident proton energy to find the optimum proton energy for a spallation neutron source. The neutron intensity obtained by the spallation reaction does not level off even at a proton energy of 3 GeV. The axial neutron distribution becomes wider with the increasing the proton energy. The intensity of the thermal neutrons emitted from the moderators is almost saturated at proton energy of about 2 GeV due to this widening. Therefore, the optimum proton energy to obtain the highest thermal neutron intensity is about 2 GeV.

## On the Kolmogorov's Spectrum for Turbulence

— A Review of the Statistical Mechanical Theory of Turbulence —

Norio OHTOMO\*) Tadashi SEIDOU\*\*) Yukio TANAKA\*\*\*)

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### Abstract

Several contributions to the recent development of a statistical mechanical theory of turbulence are briefly reviewed. The first group of these is represented by Wyld's theory, which adopts a perturbation method for solving the Navier-Stokes equation, analogous to the perturbation theory using Feynman's diagrams of quantum field theory. The Kolmogorov " $-5/3$ " spectrum is derived by Shut'ko on the basis of Wyld's theory. The next is Hopf's theory based on the functional formulation, in which the so-called Hopf equation is derived. The Hopf equation is formally identical with the Tomonaga-Schwinger equation of quantum field theory. The Kolmogorov " $-5/3$ " spectrum is derived by Edwards and McComb using the maximum-entropy (ME) principle.

## Principal Characteristics of SFC-Type MHD Generator

Naoyuki KAYUKAWA, Shun-ichi OIKAWA, Yoshiaki AOKI,  
Tadashi SEIDOU and Noriyuki OKINAKA

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### Abstract

This paper describes the experimental and analytical results obtained for an MHD channel with a two dimensionally shaped magnetic field configuration called "the SFC-type". The power generating performance was examined under various load conditions and B-field intensities with a 2 MWt shock tunnel MHD facility. It is demonstrated that the power output performance and the enthalpy extraction scaling law of the conventional uniform B-field MHD generator(UFC-type) were significantly improved by the SFC-design of the spatial distribution of the magnetic field.

The arcing processes were also examined by a high speed camera and the post-test observation of arc spot traces on electrodes. Further, the characteristic frequencies of each of the so-called micro and constricted arcs were clarified by spectral analyses. The critical current densities, which define the transient conditions of each from the diffuse-to micro arc, and from the micro-to constricted arc modes could be clearly obtained by the present spectral analysis method.

We also investigated the three-dimensional behavior under strong magnetic field based on the coupled electrical and hydrodynamical equations for both of the middle scale SFC- and UFC-type generators. Finally, it is concluded from the above mentioned various aspects that the shaped 2-D magnetic field design will offer a most useful means for the realization of a compact, high efficiency and a long duration open-cycle MHD generator.

## High-Speed Measurement of Time-Dependent Temperature Variation of MHD Plasma and Elucidating the MHD turbulent flow

Yosiaki AOKI, Hiroki KITAGAWA, Shunichi OIKAWA,  
Naoyuki KAYUKAWA, Hatsuo YAMAZAKI, Yuichi OGAWA,  
Tatsuo KASAHARA and Yasutomo OZAWA  
(Received September 30, 1987)

### Abstract

The space-dependent plasma temperature profile in the boundary layer within the channel of a combustion MHD generator with an externally applied magnetic field was measured by means of a newly devised method using a light-polarization line-reversal technique. The measurements were performed at four hundred positions across the boundary layer during a period of 0.4 ms. The spatial distribution of temperature thus obtained indicated the 1/7-th or 1/8-th power of the temperature.

The maximum entropy method (MEM) was applied to time-Series data. A deviation of  $k$ -dependent power spectral densities from Kolmogoroff's  $k^{-5/3}$ -law was found in the inertial subrange ( $k$ : wave number) due to the effect of the strong magnetic field on the plasma turbulent flow.

## STUDY ON PLASMA SURFACE INTERACTIONS FOR NUCLEAR FUSION

Toshiro YAMASHINA and Tomoaki HINO  
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### Abstract

Recent studies in Surface and Vacuum Science Laboratory, Hokkaido University are summarized. Experimental devices of our laboratory are also briefly introduced. Our main subjects are preparations and characterizations for coating films, surface modifications by plasmas and heat treatment, developments of low  $Z$  ceramics, ion irradiation effects on fusion first wall materials and plasma wall interactions in fusion confinement devices. For these items, surface analysis techniques and ultrahigh vacuum techniques are effectively utilized. Our devices typically used are AES, XPS, TDS, RS, SRF, EBE, SEM,

magnetron and RF sputterings, a cylindrical plasma device and ECR ion source. For the plasma surface interaction study, our research work is aimed at the task in which both simulation and actual confinement plasma experiments are performed. Our current activities on plasma surface interactions are briefly described.

## **Characterizations of Graphite as a Fusion First Wall Material**

TOMOAKI HINO, YUKO HIROHATA, SHIN FUKUDA, MASAO HASHIBA  
and TOSHIRO YAMASHINA  
(Received September 30, 1987)

### **Abstract**

For the isotropic graphite currently used in large fusion devices, vacuum engineering, thermal-mechanical properties and the interactions with hydrogen ion were investigated. For this purpose, eighteen graphite samples were gathered from seven major graphite companies in Japan. It was predicted that the vacuum and the thermal-mechanical properties were superior for high and low density graphites, respectively. However, we could not find this relation. The vacuum property was superior in low density graphite if the production method and the final treatment were same. The thermal-mechanical property depended on the production method. By the experiment of hydrogen ion irradiation, the change of surface state and the hydrogen trapping were studied. The required conditions for the graphite were discussed based on the obtained results.

## **A Study of Wall Deposition from Multicomponent-Solution Flow**

Ryoji ISHIGURO, Hiroto SAKASHITA, and Ken-ichiro SUGIYAMA

(Received September 30, 1987)

### **Abstract**

An experimental study was carried out to clarify the deposition mechanism in multicomponent solution on a solid wall. Deposition of  $\text{CaCO}_3$  from carbonate aqueous solution was chosen as a typical example for the problem. While precise experiments were difficult in the past studies, it became possible by developing a new method which maintains the supersaturated condition at a fixed state during the whole duration of the experimental period. A series of measurement were performed under conditions of turbulent flow in a tube heated uniformly. The results indicated that the deposition process consists of two parts. One is the "induction period" of a few hours, and the other is "period of constant deposition rate" following the induction period. The behavior occurring for both periods was significantly affected by Reynolds number, measuring location and the degree of supersaturation. Optical measurements were attempted to observe the microscopic process of deposition.

## **A Basic Study on Heat Transfer Characteristics of Liquid Na in a Decay-Heat Removal System of LMFBR**

Ken-ichiro SUGIYAMA, Ying MA and Ryoji ISHIGURO

(Received September 30, 1987)

### **Abstract**

A numerical analysis is performed to clarify the heat transfer characteristics of combined convection around the tubes which form a single row perpendicularly arranged to a forced flow in the direction of gravity. A boundary-fitted coordinate transformation technique is adopted to solve the governing equations numerically. It is found in the case of liquid sodium that gravity-induced flow gives no substantial effect to heat transfer augmentation in a low Reynolds number region while it can be sufficiently expected in the ordinary fluids in the same Reynolds number region. This means that such heat transfer augmentation as expected in ordinary fluids can not be realized when crossflow-type heat exchangers installed for decay-heat removal operates in a low Reynolds number region.

## Identification of crystallographic polarity in CdTe and determination of specific lattice locations of Zn doped in CdTe by means of ion-channeling methods

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Akikazu Tanaka<sup>†</sup>, and Yutaka ABE\*  
(Received September 30, 1987)

### Abstract

Crystallographic polarity in CdTe and the specific lattice locations of Zn atoms doped in CdTe were investigated by ion-channeling methods combined with particle induced x-ray emission. Observing the asymmetry of the channeling dips around the  $\langle 110 \rangle$  axis, crystallographic polarity in CdTe is determined without contradiction and discrepancy. Furthermore, observing the asymmetry and analysing the asymmetry factors for host atoms and doped Zn atoms, it is revealed that almost all Zn atoms occupy the Cd sublattice sites and Zn doped CdTe crystals appear to be almost completely free from the segregation of doped Zn atoms.

## Multi-Stable States in Nonlinear Conduction in a Semiconductor at low Temperatures

Yutaka ABE  
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### Abstract

A model for recombination instability of a semiconductor in the freezeout regime is investigated. It is shown that the nonlinear redistribution of trapped electrons among the ground state, the excited state and the conduction band under impact ionization lead the bistable states in the density of the conduction electron. The distinct relation between the macroscopic instability and the microscopic ionization and recombination processes are also investigated.

## Stroboscopic Picosecond Pulse Radiolysis Studies of the Short Lived Cation Produced in Butylhalides

Takashi SUMIYOSHI, Tatsuya YAMADA, Akira OHTAKA,  
Kazunori TSUGARU, and Meiseki KATAYAMA  
(Received September 30, 1987)

### Abstract

Transient species produced in neat butylchloride, butylbromide and butyliodide were observed by means of picosecond pulse radiolysis using 11 ns pulses of 45 MeV electrons.

The visible band which was produced during electron pulse and then decayed with a half lifetime of 2 ns was assigned to a vibrationally excited cation.

## Development of a Ultra High Speed Framing Camera without a Deflecting Electrode — High Speed Shuttering Characteristics of Proximity Focused Image Intensifier —

Takeaki ENOTO Masanori KIMURA Kazuo HARUYAMA  
(Received September 30, 1987)

### Abstract

This paper shows the transient behavior of a Ultra High Speed Framing Camera using the proximity focused image intensifier with an additional external transparent electrode. The experiment of fast speed gating of proximity focused image intensifier by supplying electrical pulse voltage to photocathode or to the additional external transparent electrode is accomplished. By utilizing an external transparent electrode, gating time of subnanosecond is available.

Experimental results can be analysed sufficiently and accurately, by using RLC transmission line equations. The fundamental experiment of pulse operation of image intensifier by using divided electrodes is accomplished, and MTF characteristic is obtained. This result can be explained well by the resolution function of proximity focused image intensifier.

## **A Study of Beam Position Monitors of Linear Electron Accelerator By using Slot Antennas**

Takeaki ENOTO Takahiko YOSHIDA Akira ENDO  
(Received September 30, 1987)

### **Abstract**

It became clear that microwave band slot antennas can be used as beam position monitors of linear electron accelerator. This monitor can be made easily and cheaply and is characterized by its' small size. Experimental results show that this monitor can be used for the electron beam with a duration from 10 nsec to 3  $\mu$ sec. Changing the slot length and the shape of beam transit hole, cutting upon a conductive plate, the relation between output voltage of the slot antennas and beam position was improved. The electric field distribution obtained experimentally is well explained theoretically, by using Lorents transform. Then, the beam position could be calculated accurately using the output voltage of both right and left slot antenna. It seems that the slot antenna is excited not only by the electromagnetic field but also electro static induction on conductive plate by electron beams.

## **High Temperature Plasma Confinement by Field Reversed Configuration**

Shigeo YATSU, Tatsuo KASAHARA  
Yuichi OGAWA, Yasutomo OZAWA  
(Received September 30, 1987)

### **Abstract**

The formation process of field reversed configuration was studied experimentally. Plasma diamagnetism, cross sectional figure, integrated electron density, and electron temperature were measured. From the results of measurements some experimental facts which characterized the formation process were extracted as follows. After the radial implosion, elliptical deformation in the central cross section and radial shift of plasma axis were observed. In the axial contraction phase, the oscillatory variation of diamagnetism and radially integrated electron density was found. The sudden decay of trapped poloidal flux was observed after the field reversal.

The analysis of the temporal change of axially integrated electron density distribution

measured from end-on holographic interferometry shows that plasma is plowed to the coil center region from the coil end area by the strong axial contraction after the reconnection of magnetic lines of force. Another estimation implies that axial motion of plasma and magnetic field may play an important role in the oscillatory phenomena. It is also shown that loss mechanism of poloidal flux may be closely related with radial implosion and axial contraction processes.

### **Development of MCS Interface and Application to The Low Energy Neutron TOF Method**

Ikuo MURAI, Yoshiaki KIYANAGI and Ryoji ISHIGURO  
(Received September 30, 1987)

#### **Abstract**

A multi-channel scaler (MCS) built in a personal computer (PC9801) was developed and applied to the low energy neutron time-of-flight (TOF) measurement. In this system two counters working alternately are adopted to achieve the desired dwell time by using simple circuits. The entire circuits are assembled on a single board. The achieved minimum dwell time is 16  $\mu$ sec; jitter, 125 nsec and dead time, 20 nsec. By measuring the neutron TOF spectra, the performance was proved to be satisfactory for low energy neutron TOF measurement.

The MCS costs were much lower and is much easier to operate than the units on the market because it is for a single purpose, ie, the neutron TOF measurement. It has another advantage in that it can be used at any laboratory having a personal computer (PC-9801 series).