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Appendix

Abstracts & Titles, No. 82~83

BULLETIN
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No. 82

December 1976

NOTICE

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Internal Laminar Heat Transfer of a Radiating Gas with Gas-Property Variation

Nobuhiro SEKI* Shoichiro FUKUSAKO*
Masahiro SUGAWARA*

(Received June 30, 1976)

Abstract

The results of a numerical investigation of internal heat transfer to an absorbing and emitting gas with temperature-dependent properties under the condition of uniform wall temperature are reported.

The solution is based on the coupled partial differential equations of continuity, momentum, energy and integral continuity describing the two-dimensional flow of perfect gas between horizontal heated black parallel plates. Numerical examples for CO_2 gas are worked out including (1) simultaneous convection and radiation with constant properties; (2) simutaneous convection and radiation with gas-property variation; and superimposed natural convection with gas-property variation.

Studies on Electrochemical Machining Electrolytes

— A Criterion for Evaluating the Qualities of Electrolytes —

Eiji MAKINO Noboru KOMINE Toshikazu SATO

(Received June 30, 1976)

Abstract

An evaluation method of electrochemical machining electrolytes was developed for the purpose of obtaining good dimensional control.

A criterion for evaluating the qualities of electrolytes was derived theoretically from a concept of throwing power which is in use in the field of electro-plating. This criterion consists of the factors concerned with the current distribution and the current efficiency.

In the experiments, solutions of NaCl, KNO_3, $NaNO_3$ and $NaClO_3$ were evaluated for machining carbon steel (S 45C) and 18–8 stainless steel (SUS 304) by use of the criterion derived theoretically. Moreover, these electrolytes were applied to the actual electrochemical machining.

The experimental results show that the derived criterion is useful for evaluating the qualities of electrolytes.

Program Code and Table of Toroidal Functions

Masaharu SEKI*, Masafumi KITO***, Ikuo KAJI*
and Toshihisa HONMA**

(Received June 28, 1976)

Abstract

Toroidal functions, $P^m_{n-\frac{1}{2}}(z)$, $Q^m_{n-\frac{1}{2}}(z)$ are useful for the analysis of toroidal plasma. The authors programmed a numerical calculating FORTRAN code for the toroidal functions, using a representation by series in powers of z and a recurrent formula. The toroidal functions were numerically calculated by this code and tabulated.

Theory of Carrier Waves Along Semiconductor-Insulator Boundaries

Hideki HASEGAWA*

(Received June 30, 1976)

Abstract

A new theory of carrier waves in semiconductors, formulated in the form of transverse resonance of transmission-line analogs, is presented. It enables one to discuss the wave propagation along a mixed system with semiconductor-insulator boundaries in a general manner. The bourdary conditions associated with carrier diffusion are discussed in detail. Bulk and surface waves in the collision-dominant semicondnctors are analyzed with a brief mention of possible convective instabilities and their mechanisms.

On the Complex Refractive Index of Silicon

— Wavelength from an Millimeter to a Few Micronmeters —

Yoshihiko OGAWA

(Received June 24, 1976)

Abstract

Complex refractive indices of silicons are calculated by using the Lorentz classical

theory in a wavelength range of 1 millimeter to five micronmeters. Reflectivities normal to a silicon surface are also calculated. The main conclusions from the results of calculations are as follows: (a) For any wavelength (λ), there exists the carrier density (n_{min}) to which the reflectivity becomes minimum, and the relation of λ and n_{min} are $\lambda \propto n_{min}^{-b}$ ($b=0.48\sim0.49$), (b) In a temperature range of 200~400°K, complex refractive indices of P-type silicon are almost independent of the temperature, while those of N-type are slightly dependent and those of the case of high injection are dependent to some extent (especially in a range of long wavelengths).

Voice Analyzer by Microcomputer

Tsuyoshi YAMAMOTO Yoshinao AOKI

(Received June 30, 1976)

Abstract

A voice analyzer was built by using a microcomputer system. This system is applicable not only as a voice analyzer but also as a low-frequency waveform analyzer, where the following operations can be performed, namely, sampling of analog data, calculation of power spectrum and auto-correlation function, generation of soundspectrogram and display of the processed data. The advantage of such a system with a microcomputer was discussed and the experimental results showed that this system is superior to the conventional voice analyzer with analog devices in such points as low cost and high flexibility in expanding the system.

Purification of Sulfate Pulp with Oxygen in Caustic Soda Medium

Jisuke HAYASHI Kunio TOSAKA Sadayoshi WATANABE

(Received June 30, 1976)

Abstract

Unbleached sulfate pulp was purified by treatment with oxygen gas or air in an alkaline medium. A porous mass of the wet pulp with caustic soda aqueous solution was subjected to the action of oxygen gas or air in an autoclave.

This treatment resulted in remarkarble brightening and removal of lignin from pulp.

For example, spruce sulfate pulp was oxidized with 1% caustic soda (based on pulp weight) under 10 kg/cm^2 oxygen gas pressure at 80°C for 4 hrs. The chlorine absorptions of the oxidized pulps were found to decrease from 5.8% to 2.1%, while the brightness was found to increase from 27 to 44 points. Strength properties of the pulp were equal or superior to the original except for folding strength.

However, when the pulp was bleached by ordinary processing, its strength properties decreased in comparison with those of the unoxidized pulp treated with the same bleaching process.

Purification of Sulfate Pulp with Oxygen in Sulfate Cooking Liquor or Its Waste Liquor

Jisuke HAYASHI Kunio TOSAKA Sadayoshi WATANABE

(Received June 30, 1976)

Abstract

Unbleached sulfate pulp was purified with oxygen by employing sulfate cooking liquor as an alkaline medium, because a special effect of Na_2S in the liquor on the purification reaction was expected. This treatment yielded remarkarble brightening and removal of lignin from pulps. For example, spruce sulfate pulp was immersed in a cooking liquor containing 4.17% of effective alkali and Na_2S corresponding to 31.2% of the sulfidity, and then the pulp with an excess of the solution was pressed to three times of the weight of the pulp. The pulp was then oxidized at 80°C under 5 kg/cm^2 oxygen gas pressure. The lignin content of the oxidized pulp was found to decrease from 9.20 to 1.92%, while the brightness was found to increase from 24.2 to 51.8 points. However, the result was equal to that in an equivalent manner employing caustic soda medium an no special effect of Na_2S was found.

The oxidation employing waste sulfate liquor as an alkaline medium resulted in equal purification and superior strength for the pulp as when equivalent caustic soda was employeel.

A Study of Crystal Structure of Cellulose Triacetate I

Mitsuo TAKAI, Hideaki WATANABE, Jisuke HAYASHI
and Sadayoshi WATANABE

(Received June 30, 1976)

Abstract

The crystal structure of cellulose triacetate (TAC) I was studied by x-ray analysis by reference to the result of the crystal structures of cellulose and tetra-0-acetyl glucopyranosyl bromide and of polarized infrared spectra of TAC I. The reliability index of the obtained structure was 0.116. In the structure, methyl groups came in contact with adjacent carbonyl groups on neighbouring chain molecules at the van der Waals radii. The molecules formed a sheet like structure in (101) plane as in cellulose by the van der Waals atractive forces. The figure of TAC I was similar to that of cellulose II, however, an arrengement of chains in the sheet structure for TAC I was rather similar to that for cellulose I. The similar arrangement for TAC I and cellulose I might be related to the close relationship in transfer reactions between them. And weak bonds between the sheet explained experimental results in which recrystalization and decrystalization of TAC I was easily obtained.

A Study of Crystal Structure of Cellulose Triacetate II

Mitsuo TAKAI Hideaki WATANABE Jisuke HAYASHI
and Sadayoshi WATANABE

(Received June 30, 1976)

Abstract

The crystal structure of cellulose triacetate (TAC) II was studied by x-ray analysis with a chain conformation of "Bent and Twisted" type.

A super lattice having dimensions of a=21.76 Å, b=10.45 Å (fiber axis), c=21.58 Å, $\alpha=\gamma=90°$, $\beta=76.55°$ and a sub-cell having dimensions of a=10.88 Å, b=10.45 Å, c=10.79 Å, $\alpha=\gamma=90°$, $\beta=76.55°$ were employed to harmonize a plane lattice structure and experimental data of TAC II. All equatorial diffractions of TAC II were explained by the sub-cell.

In the obtained structures, methyl groups came in contact with the adjacent carbonyl groups on neighbouring chain at van der Waals radii in the sheet structure, while the contacts in TAC I were on the surface of the sheet structure.

Molecular chains of TAC II protruded from the surface of the sheet structure, and were in gear with them in the next sheets. This structure appears to explain that the recrystalization of TAC II was difficult and after the recrystalization the decrysralization there of was also difficult.

Hindered Rotation of Tetrahedral Molecule in the Potential with Cubic Symmetry

Kazuhiko INOUE Yukio SAKAMOTO

(Received June 30, 1976)

Abstract

The eigenvalues and eigenfunctions on the hindered rotations of tetrahedral molecules in the molecular crystals with cubic symmetries are necessary to analyse the neutron inelastic scattering data. In the case of fourth order potential the eigenvalues and eigenfunctions have were calculated for a wide range of potential barrier height.

Correlation Coefficient for Three Variables and the Quantification of Categorical Data Thereby

Masaru SHIMBO Yoshiharu SATO
Takahiro YAMANOI Michiaki KAWAGUCHI

(Received June 30, 1976)

Abstract

A three dimensional correlation coefficient was newly defined in this paper to represent the degree of the linearity in the distribution of three dimensional data. It is different from that of the moment of third order defined elsewhere, which may represent the degree of their inclination. It follows an extension of the quantification theory III, in multivariate analysis proposed by C. Hayashi, which is originally restricted to two dimensional categorical data, to three dimensional ones with an example, where the correlation coefficient plays an important role.

Adjunct Grammars and their generative powers

Yoshio MOMOUCHI

(Received June 30, 1976)

Abstract

Adjunct Grammars are based on Local String Adjunct Grammars. The adjunct rules in an Adjunct Grammar have a character different from the local adjunct rules in a String Adjunct Grammar. Several modified Adjunct Grammars are studied. They are Unilateral Adjunct Grammars, Outside Adjunct Grammars, Bilateral Adjunct Grammars and Parallel Adjunct Grammars. An infinite hierarchy of the subclasses of Parallel Adjunct Grammars and the closure properties of Parallel Adjunct Languages are considered.

Such a study of Adjunct Grammars is of interest because a string adjunction is suited for characterizing certain aspects of the Japanese language structure.

BULLETIN

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No. 83

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NOTICE

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A Study on the Relation Between Traffic Accidents, Social and Economic Factors

— A Consideration by Multivariate Analysis —

Terutoshi KAKU, Shinzo TSUJI and Keiichi AOKI

(Received September 30, 1976)

Abstract

Traffic accidents have decreased in Hokkaido since it reached a peak in 1970, although it was expected that traffic accidents may well have increased with the increment of registered vehicle numbers and the development of social and economic life. The aim of this study using multivariate analysis is to determine the relationship between contributing factors including social and economic factors which may exert an influence on the traffic accidents.

For the above purpose, considerable data accumulated from 1965 to 1974 were gathered from extensive fields related with traffic accidents and these were analyzed to determine or otherwise clarify the main factors involved in traffic accidents. Finally, using the analyzed results, the future trend of traffic accidents were caluculated by multicorrelated equations.

A Biography of Max Hinder, Architect

Yukihiro KADO and Takeshi KOSHINO

(Received September 30, 1976)

Abstract

Max Hinder (1887–1963) is remembered as the Swiss architect who designed two missionary schools, the Fuji (1924) and the Hokusei (1929), and the St. Franciscan monastery (1925) in Sapporo. But we have known nothing about his career beyond that.

In this paper, the authors try to throw light on the biography of Max Hinder.

He was born in Zürich on January 20th, 1887. In 1924, after pursuing his career as an architect in Switzerland, Germany, Austria etc, he arrived in Japan.

He resided in Sapporo for three years till 1927, where he worked on numerous dwellings including his own, two mountain huts, a cathedral in Niigata (1927) and others buildings besides those mentioned above.

He moved to Yokohama in 1927 and continued his work as an architect untill 1940, when he returned to Germany.

During these thirteen years, he designed the Jochi University, Tokyo (1931), the Saint Mary Hospital, Tokyo (1931) and others. He closed his earthly pilgrimage in Regen, Germany in 1963.

An Experimental Study on the Structures of Buoyant Circulation and Turbulent Air Flow in Enclosed Heated Spaces

Masamichi ENAI, Noboru ARATANI and Takashi SASAKI

(Received September 29, 1976)

Abstract

By measuring the buoyant circulation in enclosed spaces of some small models and a medium-sized room, the authors obtained the following results of circulation and turbulent flow.

These were used for numerical analyses.

1) As for the approximate law of similarity, the ralationship of the reduced scale n of turbulent kinematic viscosity K_T and the size of room H is $n_{KT}=n_H$. Therefore K_T is proportional to H.

2) A visual observation with the aid of pappi of dandelion for tracing the air flow (especially slow ones) can be obtained and the mean velocity of turbulent space may be calculated.

3) Variations of velocity u_p are inferred from temperature variations T at a certain point and temperature difference to the adjoining point $(\partial T/\partial \xi)_p$ by next equation.

$$u_p=(dT/dt)/(\partial T/\partial \xi)_p$$

4) Kolmogoroff's theory is clearly substantiated at the internal zone of a room.

5) By using the scale of vorticity Λ, and the distance from the wall to a certain point L_n and its mean velocity U, K_T can be expressed by the following equation.

$$\Lambda \propto L_n, \qquad K_T \propto U\Lambda$$

A Technological Study on Moisture Permeation Resistivity of Clothing

Tohru MOCHIDA* and Shintaro YOKOYAMA*

(Received September 28, 1976)

Abstract

Garments not only work as thermal resistivity in the presence of radiation and convection heat release from the body, but also play a role of moisture permeation resistance against perspiration heat release. Whereas clo values may be generally used

as a unit for thermal resistivity, a practical unit for moisture permeation resistivity has not been established as yet.

The authors, using a technological approach, derived an index for the quantitative evaluation of moisture permeation of garments based on heat transfer and mass transfer theory. In addition using a dry and a wet cylinder, model experiments were carried out to verify its effectiveness. Further, several moisture permeation units set forth previously by other workers were mentioned and a comparison between the present unit and its relatonship were discussed in the present paper.

On the Mechanical Behaviour of Rocks under Impulsive Loading

Shigenori KINOSHITA, Kazuhiko SATO, Minoru KAWAKITA

(Received September 30, 1976)

Abstract

A compression test with Split Hopkinson Bar Method was carried out to investigate the mechanical behaviour of rocks under impulsive loading. Rocks selected for the experiment were limestone with fine grain size and coarse ones and tuff and sandstone occurring in two collieries. The experimental work comfirmed that the response of rocks to the impact varies with the intensity of the stress pulse, in other words, the mechanical behaviour of rocks is sensitive to the strain rate in high rate compression. Taking these results, into account in this paper, a constitutive equation is formulated as follows:

$\varepsilon = \sigma / E_0$, for pre-failure deformation,

$\dot{\varepsilon} = \frac{\dot{\sigma}}{E} + \frac{1}{\tau}\left(\frac{\sigma - S}{S}\right)^n$, for post-failure deformation,

where E_0: Young's modulus in static pre-failure deformation,

E, S: secant modulus and residual strength in static post-failure deformation.

After determining power n and constant τ regarding each rock, stress-strain curves in various strain rates were drawn employing the above constitutive relations.

Analysis of Impact Vibration of Cantilever Beams by the Finite Element Method

Toshihiro IRIE, Gen YAMADA and Masaharu ASANO

(Received September 21, 1976)

Abstract

In the past, the impact vibration arising when a uniform beam colliding with another dody at a point has been studied theoretically in detail, but in general it is difficult to analyze the impact vibration caused in beams with variable thicknesses and more complicated systems.

In this paper, the finite element method is used to analyze the impact vibration caused in a cantilever beam with variable thicknesses and a concentrated mass at the free end. The dynamic property of the colliding point is represented by two models. One of them is a mathematical model consisting of two springs and a damper, and the other is a typical collision model assuming the proportionality relation between the colliding velocity and the bounding velocity in each collision. From the present study, the following conclusions were obtained. The dynamic response of beams can be simulated on a digital computer with sufficient accuracy by dividing the beam into several elements at an appropriate ratio. The vibrational components of high order appear in beams in which internal friction and the attached mass are small, but the increase of internal friction and statical force pressed against the other body, and the appropriate selection of the attached mass, the beam shape and the location of colliding point reduce these components and the displacements and colliding velocities.

Radiation Effect on Developing Free Convection from Two-Dimensional Isothermal Vertical Parallel Plates

Nobuhiro SEKI* Shoichiro FUKUSAKO* and Masahiro SUGAWARA*

(Received September 29, 1976)

Abstract

Steady laminar convection of a radiating gray gas between vertical parallel plates of isothermal temperature is theoretically investigated. A formulation of the interaction of radiation and free convection in an absorbing and emitting medium was made by a non-linear integro-differential equation. The basic governing continuity, momentum and energy equations, including the temperature dependable transport properties, are expressed in each finite-difference form and solved numerically with a digital computer. Parameter

surveys pertaining to the effects of radiation on variations of pressure and temperature profiles throughout a flow field are made. Effects of thermal radiation on heat transfer characteristics of the channel are also discussed in detail.

Identification of Multi-Input/Multi-Output Systems

Koji TAJIMA*, Shoichi KOYAMA** and Ryoichi MIURA**

(Received September 30, 1976)

Abstract

A new method is presented for identifying the controllable and observable part of multi-input/multi-output systems from measurements of the input-output signals contaminated with noises. The pulse transfer function matrix is estimated by using a vector input/output equation of an autoregressive/moving-average type. The minimal realization of the system is given by the Ho-Kalman's algorithm. The Markov parameters are used to determine the degree of the minimal polynomial of the system matrix and the minimal order of the system.

Studies on the Energy System of Hokkaido; Part I

--First Attempt; Model-I—

Jun HASEGAWA, Ken-ichi NISHIYA, Kuniaki MURAI and Yoshinori SATOH

(Received September 27, 1976)

Abstract

Recently, the importance of the energy problem had been recognized from all directions, and a variety of discussions have been carried out from international, national and regional viewpoints. The energy problem has a multitude of factors, which requires a systems approach.

The authors have been conducting work on the energy system of Hokkaido, and in this paper, their first modeling effort was discussed.

The present system model developed by the authors, Model-I, was constructed for analyses of the present situation and of the optimum structure of the energy system of Hokkaido.

Model-I is a static, linear programming model which ignores dynamic behaviour in the energy system. This linear programming model has 192 variables, 46 equality constraints and 28 inequality constraints with a density of about 6 percent.

The effects of energy systems of other regions, the economic systems, the environmental systems and the social systems, to the energy system of Hokkaido, are dealt with exogenously in Model-I.

This paper is part of a series of studies followed by Part II (Various data and their basis) and Part III (Simulations by Model-I).

Studies on the Energy System of Hokkaido; Part II

—Various data and their basis—

Jun HASEGAWA, Ken-ichi NISHIYA, Kuniaki MURAI and Yoshinori SATOH

(Received September 27, 1976)

Abstract

The authors have been carrying out studies on the energy system of Hokkaido, and have developed an energy system model (Model-I) of Hokkaido.

In this paper, the various data which are required for analyzing the energy system of Hokkaido by using Model-I, and their basis, are discussed.

All data were gathered, as a rule, during 1974 (calendar year). The supplies and demands of each energy source and use, the efficiencies in converting one energy source type to another type, and the proportions of products in the coking processes and in the petroleum refineries are determined or estimated. Thus, the energy requirements in end-use are determined and the efficiencies in consuming energy at the end-use were determined or were assumed.

The costs and the emissions of SO_x, NO_x, and dust following energy conversion, transmission, distribution and utilization were determined or assumed.

This paper is part of a series including Part I (First Attempt; Model-I) and Part III (Simulations by Model-I).

Studies on the Energy System of Hokkaido; Part III

—Simulations by Model-I—

Jun HASEGAWA, Ken-ichi NISHIYA, Kuniaki MURAI and Yoshinori SATOH

(Received September 29, 1976)

Abstract

The authors have been carrying out studies on the energy system of Hokkaido. And in a series of including Part I and Part II, an energy system model developed by the authors (Model-I) and various data required for simulations using Model-I were discussed.

In this paper, various results obtained by the simulations are mentioned. And 9 important conclusions are also included. Although detailed numerical values in the results or conclusions may not always coincide with the present situation of Hokkaido, the tendencies of the results are valid, and the contents and implications of the conclusions are also valid.

In order to conduct a more detailed analysis of the present situation of the energy system of Hokkaido and the future thereof, the energy model must be improved and more reliable and detailed data basis on the energy systems must be constructed.

Growth and Properties of Iron-Doped LPE GaAs Layers

Hideki HASEGAWA*, Kiyoaki KOJIMA*, Takamasa SAKAI*, ** and Hiroaki TAGASHIRA*

(Received September 30, 1976)

Abstract

Iron-doped GaAs layers were grown from gallium-melts by the liquid-phase-epitaxy (LPE) technique in order to study the electrical behaviors of iron atoms in LPE materials. A new horizontal LPE growth system with a 'gold furnace' was developed for the purpose. Grown layers showed n-type and p-type conduction, depending on the amount of iron added to the Ga-melt. This indicates the presence of a compensation effect by iron atoms acting as acceptors, and it does not agree with the findnigs of previous works. It was found that iron-doped LPE layers with Schottky contacts, grown on n^+ substrates, exhibit a new current-controlled negative resistance phenomena under certain conditions. In a simple circuit configuration consisting of a series resistor and d.c. power supply, such a diode shows switching and oscillation behaviors. High frequency quasi-sinusoidal oscillations up to several ten megaherz and low-frequency relaxation oscillations with sharp voltage drops are observed, depending on the circuit conditions.

Fourier Imaging of Rectangular Grating in Partially Coherent Light

Hirofumi FUJIWARA*

(Received September 29, 1977)

Abstract

Fourier imaging of a rectangularly transparent grating under partially coherent illumination was investigated by putting stress on comparison with the sinusoidally transparent grating. It is apparent that the decrease of spatial coherence leads to a distinguishable deformation of Fourier images and also a suppression of modulation depth of the axial intensity in other words, lower spatial frequency components contribute to Fourier imaging under illumination of poor spatial coherence.

Changes in Surface Composition of Clean Copper-Nickel Alloys with Ion Bombardment and Annealing

Kuniaki WATANABE*, Masao HASHIBA*, Yasuo FUKUDA**
and Toshiro YAMASHINA*

(Received September 28, 1976)

Abstract

Changes in the surface composition of clean Cu-Ni alloys with ion bombardment and annealing were investigated by Auger spectroscopy. The surface compositions were compared systematically for 8 Cu-Ni alloys by Auger spectra in the lower energies around 100 eV or thereabouts with the higher energies at 700~1000 eV.

It was found that the surface layers were considerably enriched with Cu atoms by annealing, but the Auger peak of Ni in a lower energy region did not disappear by high temperature annealing even at 600°C for all Cu-Ni alloys.

The configuration of component distribution in several atomic layers at the surface of Cu-Ni alloys was proposed by utilizing the difference in escape length of the Auger electrons from different transitions.

Corrosion and Passivation of Iron-Chromium Alloys

M. I. ISMAIL* and N. SATO**

(Reccived September 13, 1976)

Abstract

The corrosion and passivation of Fe-Cr alloys, heat-treated with different cycles, then subjected to different environmental conditions, were studied using metallographic, electrochemical and chemical techniques. On exposure of the thermally formed oxide films to air, for 8 months, the films formed on rapidly cooled specimens (Water Quenched, WQ) proved to be more protective than those formed on slowly cooled specimens (Furnace Cooled, FC). Potentiostatic polarization in sulfuric acid indicated that the rate of corrosion (current density) decreases with increase of Cr content, with a minimum value for the alloy 10 Cr. The grains varied in their susceptibility to attack. Some specimens were characterized by corrosion-resistant bands on the surface. The rate of passivation (current decay ratio) increased with increase of the temperature of heat-treatment and with an increase of Cr content for air cooled specimens (Air Cooled, AC). Thermal cycling lead to a decrease in the anodic current decay ratios. WQ specimens had lower current densities than FC or AC ones.

Spectrophometric analysis of the electrolyte after electrolysis indicated that Cr dissolved from FC specimens with higher rates than from WQ for the 5 Cr alloy, but for 20 Cr alloy, the reverse was true. The dissolved Cr increased with increase of Cr content for WQ while for AC specimens, no influence was seen. The dissolved metal ratio (Fe/Cr) had a maximum value at the alloy 10 Cr for WQ specimens, but for FC specimens this ratio decreased with Cr content of the alloy. However, if the heat-treatment cycle was repeated in FC type then the Fe/Cr ratio increased with increase of Cr content.

On a Proving System, PROVER, for the Verifivation Conditions

Shigeru YANAGI, Michinori URASAKI, Yoshiharu SATO and Michiaki KAWAGUCHI

(Reccived September 30, 1976)

Abstract

The problem of proving a program correctness was reduced to prove a set of formulae which are called verification conditions.

The purpose of this paper is to construct a system named PROVER which is designed for proving the verification conditions of program correctness, and is intended to produce a program verifying system.

In order to represent the verification conditions, we must introduce new functions. But there is no formal way to prove the formulae with the functions. And to prove these formulae, we have set forth the properties of new functions by certain adequate formulae which are interpreted as tautologies. Then these formulae are added to the deductive system of the PROVER as axioms.

By adopting this method, the PROVER increases its capacity for proviog formulae. And thus it is possible to construct a system which verifies the program correctness.