ASME TURBO EXPO '96, Birmingham, UK, June 10-13, 1996

## Free Vibration of a Rotating Disk-Blade Coupled System with Shrouds

Y. KOBAYASHI*, T. TOMIOKA** and G. YAMADA*
*Department of Mechanical Engineering II, Hokkaido University, Sapporo, 060 Japan
**Railway Technical Research Institute, Kokubunji, 185 Japan

The free vibration of rotating disk-blade coupled system is investigated by the Ritz method. Centrifugal effects due to rotation are taken into account for both of the disk and blades. Artificial springs are introduced at the joints between the disk and blades. In addition to them, the shroud is expressed as translational springs with respect to the out-of-plane and in-plane motion of the blades, respectively. The orthogonal polynomials generated by using the Gram-Schmidt process are employed as admissible functions for both of the disk and blades. The frequency equation is derived by substituting the Lagrange functional into the conditions for stationary values of the functional. By this approach, the mass matrix derived from the kinetic energies becomes diagonal and this makes the numerical manipulation easy and stable. Natural frequencies and mode shapes are calculated numerically, and effects of rotating speed, position and mass of shrouds are investigated.

The fifth International Symposium on Plasticity and Its Current Application July 17-21, 1995, Osaka, Japan

## An Unified Constitutive Model for Plasticity, Creep and Ratchetting

Hiromasa ISHIKAWA, Katsuhiko SASAKI
Department of Mechanical Engineering II,
Hokkaido University, Sapporo,
060 Japan

For demand of the larger level of accuracy involved in the implementation of computer codes, the development of a unified constitutive equation to describe the material behavior such as cyclic plasticity, creep, ratchetting and their interaction is required. In this paper, to predict accurately cyclic plastic strain, creep strain, mechanical ratchetting strain and the interaction between them, a unified constitutive equation for polycrystalline metals was developed. The constitutive equation employed one surface, i. e. the yield surface where both isotropic flow stress and kinematic back stress with the memorization of nonproportional preloading and the plastic deformation induced anisotropy were incorporated. Moreover, the modified Ram-

berg-Osgood stress-strain relation was also incorporated with the constitutive equation to describe the nonlinearity or the roundness of the stress-strain curve. In order to verify the applicability of the constitutive equation to cyclic plasticity, creep, ratchetting and their interaction, a series of experiments were conducted using stainless steel, copper and solder alloys. As a result, it was clear that the material properties used in the constitutive equation are determined by a few kinds of the simple material tests and that the computer simulation based on the constitutive equation is verified to be adequate to describe the essential features of the materials.

The fifth International Symposium on Plasticity and Its Current Application July 17-21, 1995, Osaka, Japan

## Fatigue Failure of 60Sn-40Pb Solder Alloys and Its Prediction Using Constitutive Model for Cyclic Plasticity

Ken-ichi OHGUCHI, Hiromasa ISHIKAWA and Katsuhiko SASAKI
Department of Mechanical Engineering II,
Hokkaido University,
Sapporo, 060 Japan

Solder joints provide both electrical interconnection and mechanical support. Therefore, the structural integrity of solder joint is very important reliability concern. Especially, the fatigue resistance of near eutectic Pb-Sn solders is a major concern in the development of surface mount technology. In this paper, the authors proposed the constitutive equation for cyclic viscoplasticity in which a viscoplastic potential function, the modified Prager-Ziegler kinematic hardening rule, and the modified Ramberg-Osgood law are incorporated. In order to verify the applicability of the proposed constitutive equation to the deformation of Pb-Sn solder alloys, a series of basic experiments, such as pure tensile tests, creep tests and cyclic tension-compression tests with constant strain amplitudes under constant strain rates were performed using 60Sn-40Pb solder alloys at several temperature. Moreover, the proposed constitutive equation applied to predict fatigue failure of the solder alloy using the relation between the plastic strain energy density and the number of cycle to fatigue failure, which was obtained from some basic fatigue tests. As a result, it was clear that the proposed constitutive equation was applicable to explain the viscous deformation of the solder alloy, and that fatigue failure of the solder alloy could be predicted using the plastic strain energy density calculated by the simulation based on the proposed constitutive equation.

International Conference on Computational Engineering Science July 30-August 3, 1995, Hawaii, USA

## Inelastic Behavior of CFRP Subjected to Cyclic Loading

H. ISHIKAWA and K. SASAKI
Department of Mechanical Engineering II,
Hokkaido University, Sapporo, Japan

The authors have already proposed the constitutive model for cyclic plasticity of metal alloys, and verified the applicability of the constitutive equation to the cyclic proportional loading and nonproportional loading using Type 304 stainless steel. In this paper, the authors proposed the constitutive equation for inelastic behavior of CFRP subjected to cyclic loading considering damage effect, which was based on the constitutive equation for cyclic plasticity proposed by the authors previously. Namely, a damaged loading function in plasticity that was similar to the loading function, the Ziegler type assumption to represent the movement of the center of the damaged loading surface, and the Ramberg-Osgood type of stress-strain relation were incorporated into the constitutive equation. To verify the applicability of the constitutive equation, a series of experiments such as cyclic tension-compression loading with several strain amplitudes were conducted using laminated graphite/epoxy specimens that had an angle of 45 degree of fibers measured from the axial direction of the specimens.

International Conference on Computational Engineering Science July 30-August 3, 1995, Hawaii, USA

## Constitutive Model for Viscoplasticity and Creep

H. ISHIKAWA, K. SASAKI and K. OHGUCHI
Department of Mechanical Engineering II,
Hokkaido University, Sapporo, Japan

To predict accurately short-term plastic strain, long term creep strains, and the interaction between them, a viscoplastic model for polycrystalline metals is developed in this paper, where both isotropic flow stress and kinematic back stress with the memorization of nonproportional preloading and the plastic deformation induced anisotropy are incorporated. A primary objective in the development of this model is that it analytically reduces to the theory for steady creep and that for viscoplasticity. This model employs one surface, i. e. the yield surface, and the modified Ramberg-Osgood stress-strain relation to describe the nonlinearity or the roundness of the stress-strain curve in viscoplasticity. Material properties are determined

by a few kinds of the simple material tests. The computer simulation based on the model is verified to be adequate to describe the essential features of viscoplasticity and creep. Finally, examples of the correlative and predictive capabilities of the model for 60Sn-40Pb solder alloy are represented.

1995 International Mechanical Engineering Congress & Exposition November 12-17, 1995, San Francisco, USA

## Unified Approach to Interaction of Plasticity and Creep

H. ISHIKAWA, K. SASAKI
Department of Mechanical Engineering II,
Hokkaido University,
N13, W8, Kita-ku, Sapporo,
060 Japan

To predict accurately short-term plastic strain, long-term creep strains, and the interaction between them, a viscoplastic model for polycrystalline metals is developed in this paper, where both isotropic flow stress and kinematic back stress with the memorization of nonproportional preloading and the plastic deformation induced anisotropy are incorporated. In addition, in this study, a series of tests that supports to construct a unified constitutive model for cyclic plasticity, creep and ratchetting was carried out. Namely, cyclic proportional loading, creep and uniaxial ratchetting tests were conducted at room temperature and at 550°C using Type 304 stainless steel to study the viscoplastic behavior of the material in detail. Moreover, tests of creep combined with uniaxial ratchetting were also conducted to study the interaction between them. Finally, examples of the correlative and predictive capabilities of the model for Type 304 stainless steel are represented. As a result, the computer simulation based on the model is verified to be adequate to describe the essential features of viscoplasticity, creep and ratchettig.

14th International Symposium on Nonlinear Acoustics, Nanjing, China, June 17-21, 1996

## WEAKLY NONLINEAR PROPAGATION OF PLANE WAVES IN A NON-UNIFORM GAS

Y. INOUE, N. KUBO and M. YOSHIMOTO
Department of Engineering Science,
Faculty of Engineering,
Hokkaido University, Sapporo 060, Japan

The weakly nonlinear progressive waves are studied, which propagate in a perfect gas with the spatial distribution of the density and constant thermoviscosity. As a far-field approximation, a generalized Burgers equation is first derived by making use of the method of multiple scales. A typical boundary value problem is here taken up, in which the source begins to execute the unceasing sinusoidal motion at the time $t=0$ and so radiates a harmonic wave train. When the acoustic Reynolds number is extremely high, the exact solution of the generalized Burgers equation is easily obtained with the aid of the method of characteristics and the equal-areas rule: In marked contrast to the wave behaviour in homogeneous media, no shock may emerge in some cases, and in the other cases the leading wave in a half-cycle may evolve into a triangular wave and the subsequent wave train into a sawtooth-like wave, or may not completely evolve, or the wave may even diverge. The amplitude saturation does not necessarily take place in the sawtooth-like wave. It is shown by the numerical calculation that the effect of a finite acoustic Reynolds number consists in depressing the rapid increase of the wave amplitude due to the non-uniformity.

14th International Symposium on Nonlinear Acoustics, Nanjing China, June 17-21, 1996

## STRONGLY NONLINEAR WAVES OF NONPLANAR MODE IN A TWO-DIMENSIONAL WAVEGUIDE

T. YANO and Y. INOUE
Department of Engineering Science,
Faculty of Engineering,
Hokkaido University, Sapporo 060, Japan

Propagation of strongly nonlinear acoustic waves and shock waves of the lowest nonplanar mode in a two-dimensional waveguide is numerically studied for the case that the acoustic

Mach number $M=O(1)$ and the acoustic Reynolds number $Re \gg 1$. The wave is excited at one end of the semi-infinite waveguide by a sinusoidal source, whose frequency is comparable with but larger than the linear cutoff frequency. Owing to the strongly nonlinear effect, the waveform is rapidly distorted and this leads to the formation of shock with curved front in the near field. With increase in nonlinearity, the curvature of shock front becomes large and the intersection of shocks arises near the walls. At the shock intersection points, the vorticity is strongly produced and accumulated there. As a result, a vortex-pair-like streaming (mean mass flow) is induced in the near field. By the streaming motion, the density of the gas is gradually decreased in the high-vorticity regions as time goes by.

SAE International Congress & Exposition, February 26-29. 1996 Detroit, Michigan

## Time-Resolved Nature of Exhaust Gas Emissions and Piston Wall Temperature Under Transient Operation in a Small Diesel Engine

Iman K. REKSOWARDOJO, Hideyuki OGAWA, and Noboru MIYAMOTO
Hokkaido Univ. Yoshiteru ENOMOTO
Musashi Institute of Technology
Toru KITAMURA
Toyota Motor Co.

Diesel combustion and exhaust gas emissions under transient operation (when fuel amounts abruptly increased) were investigated under a wide range of operating conditions with a newly developed gas sampling system. The relation between gas emissions and piston wall temperatures was also investigated.

The results indicated that after the start of acceleration NOx, THC and smoke showed transient behaviors before reaching the steady state condition. Of the three gases, THC was most affected by piston wall temperature; its concentration decreased as the wall temperature increased throughout the acceleration except immediately after the start of acceleration. The number of cycles, at which gas concentrations reach the steady-state value after the start of acceleration, were about 1.2 times the cycle constant of the piston wall temperature for THC, and 2.3 times for smoke.

SAE International Congress & Exposition, February 26 -29. 1996 Detroit, Michigan

## Analysis of Ambient Gas Entrainment Processes in Intermittent Gas Jets by LIFA Technique

Akihiro KIDO, Masaki UENO, Hideyuki OGAWA, and Noboru MIYAMOTO
Hokkaido Univesity

Time-resolved and local ambient gas entrainment processes in intermittent gas jets with a range of injection conditions were evaluated by a LIFA (laser-induced fluorescence of ambient gas) technique. Local mixture strength inside gas jets was quantified by the fluorescence of iodine in the ambient gas excited by the sheet light of a Nd: YAG laser. Experimental results showed that the influence of injection conditions on the ambient gas entrainment processes correlates with the influence both of specific gravity ratio between injection and ambient gases and eddy kinematic viscosity which was calculated from the discharge turbulence intensity of jets. With increased discharge turbulence intensity and decreased the specific gravity ratio, the jet mass concentration decreased. The discharge turbulence intensity increased with an increase in discharge velocity and with decreases in specific gravity of jet, the nozzle hole length to diameter, and nozzle hole diameter.

SAE International Spring Fuels & Lubricants, Meeting May 6-8, 1996, Dearborn, Michigan, U. S. A.

## Simultaneous Reductions in Diesel NOx and Smoke Emissions with Aqueous Metal-Salt Solutions Directly Injected into the Combustion Chamber

Noboru MIYAMOTO and Hideyuki OGAWA
Hokkaido University
Jianxin WANG
Tsinghua University, Beijing, China
Kenji YAMAZAKI
Hokkaido University

The effect of several aqueous metal-salt solutions on NOx and smoke lowering in an IDI diesel engine were examined. The solutions were directly injected into a divided chamber independent of the fuel injection. The results showed that significant lowering in NOx and smoke over a wide operation range could be achieved simultaneously with alkali metal solutions which were injected just prior to the fuel injection. With sodium-salt solutions, for

instance, NOx decreased by more than 60 % and smoke decreased 50 % below conventional operation. The sodium-salt solution reduced dry soot significantly, while total particulate matter increased with increases in the water soluble fractions.

5th International Conference on Atmospheric Sciences and Applications to Air Quality, 18-20 Jun. 1996, Seattle, USA

## Behavior of $C_2$-$C_5$ Hydrocarbons in the Central Osaka Metropolitan Area

Tazuko MORIKAWA*, Shinji WAKAMATSU**, Masanobu TANAKA***, Itsushi UNO**, Toshikazu KAMIURA***, Tsuneaki MAEDA****
*Department of Mechanical Engineering, Hokkaido University, Sapporo, 060 Japan
**National Institute for Environmental Studies, Tsukuba, 305, Japan
***Osaka City Institute of Public Health and Environmental Science, Osaka, 543 Japan
****D. K. K. Corporation, Musashino, 180 Japan

Hourly measurements of nine $C_2$-$C_5$ species were made for period of more than a year, in the center of Osaka city, Japan. The measurements were done by an automated system consisted of a combination of a sample preconcentrator and gas chromatograph. The number of samples obtained was 8007, that corresponding 81.2% from all potential measurements. The meteorological effect and/or chemical reactions which affect hydrocarbon (HC) concentration in the urban atmosphere were also examined. The influence of reaction is appeared clearly on the $C_3H_6$ concentration which is the most reactive component among the nine HCs. Even for $C_2H_4$, which is the second reactive species among the nine HCs, the reaction effect was small. It can be explained as follows; since the monitoring point was located in the central urban area, the influence of emission on HCs concentration was larger than influence of reaction. The ratio of $C_4$-$C_5$ HCs to the nine measured HCs was rising with increase in ambient temperature, indicating stronger emission of higher molecular hydrocarbons in summer.

20th International Symposium on Space Technology and Science. 20-24 May, 1996, Gifu.

## Use of Microgravity Environment to Investigate the Effect of Magnetic Field on Flame Shape.

Osamu FUJITA*, Kenichi ITO*, Yukio KURODA*, and Nobuko I. WAKAYAMA**
*Department of Mechanical Engineering, Hokkaido University, Sapporo 060, Japan
**National Institute of Materials and Chemical Research, Tsukuba, 305, Japan

The effect of magnetic field on diffusion flame has been investigated under microgravity to make a clearer discussion without the disturbance caused by buoyancy. Three types of magnetic fields were examined on a butane diffusion flame: (1) within a decreasing magnetic field strength, (2) within a increasing field strength and (3) at the center of the magnetic field. Within the decreasing field, (1), the flame shape under microgravity was similar to that of a flame under normal gravity. Within the increasing field, (2), the flame was deflected downward. The flame was round at the tip of the burner. At the center of the field, (3), the flame was extended both upwards and downwards, forming a flat flame with a wide surface area and suggesting that combustion reactions can be promoted through the control of surface area of flames.

The 11th International Conference on Alcohol Fuels, 14-17 Apr. 1996, Sun City, South Africa

## Formation of Methyl Nitrite in the Garage and Tunnel from Methanol Vehicle's Exhaust Gases.

Tazuko MORIKAWA and Kenichi ITO
Department of Mechanical Engineering, Hokkaido university, Sapporo 060, Japan

By using experimental results from the measurement of pollutants from MFV, computer simulations have been done to evaluate the MN level under three different conditions; 1. in a garage, 2. in a tunnel, and 3. in an urban atmosphere. For the numerical model of garage experiment, the MN level was high above 100 (ppm) inside the closed garage at 0 (°C), as a result of both high emission and secondary formation. The amount of secondary MN formation inside the model garage was larger than the MN emitted from the MFV at a temperature

of 20 (°C) during the first 180 (s) from when the engine started. Both inside the tunnel and for the urban atmosphere, the MN concentration would be low enough to make some effect on environments.

3rd Asia-Pacific International Symposium on combustion and energy Utilization, 11-15 December, 1995, Hong Kong.

## Observations on Flame Propagation of Coal Dust Clouds in Microgravity — The effect of Pressure and Oxygen Concentration —

Osamu FUJITA, Kenichi ITO, and Akihiro SAKAMOTO,
Department of Mechanical Engineering, Hokkaido university,
Sapporo 060, Japan

Microgravity combustion experiments have been conducted using a 500m drop shaft to determine flame propagation speeds of coal dust clouds. The quiescent coal dust mixture was provided under microgravity and was ignited by a Nichrome wire. Its flame propagation phenomena were recorded by a high speed camera. The experimental parameters considered were pressure and oxygen concentration. The coal used was bituminous coal. The coal dust size was under 100 mesh sieve.

The experimental results showed that the flame propagated spherically outward from the ignition source. The flame propagation speed dramatically increased with increase in oxygen concentration and decreased with increased pressure. Although the number of experimental runs are limited, analysis of the dependency on oxygen and pressure indicated that speed of flame propagation relates to about 1.5-2.0 times the order of oxygen concentration and about 0.7-0.8 times the order of pressure.

31th National Heat Transfer Conference, Portland, USA, August 6-8, 1995

# ANALYSIS ON RADIATIVE ENERGY TRANSFER THROUGH FIBROUS LAYER CONSIDERING FIBROUS ORIENTATION

Kazuhiko KUDO, BingXi LI and Akiyoshi KURODA,
Department of Mechanical Engineering
Hokkaido University
Sapporo, Japan

By using the Monte Carlo method, radiative energy transfer through fibrous layer is analyzed. For the material of the layer, glass and nickel fibers are assumed. Mie scattering is assumed for the scattering mechanism by the fibers. The validity of these method is shown by comparing the results with the experiment obtained by Tong et al.. The heat fluxes through the layer for various temperature differences over the layer and for different thicknesses are predicted well by the method.

In the present study, the directional profiles of the scattered radiative energy are obtained to study the effect of multiple-scattering. Two types of fiber orientations are considered: a three-dimensionally randomly oriented layer, and a layer which is oriented randomly in two-dimension and is parallel to the bounding surface. From the analysis, following results are obtained. (1) The heat flux through the layer with three-dimensionally randomly oriented fibrous layer is about 1.3 times larger than that with two-dimensionally randomly oriented layer. (2) The directional profile of scattered energy within the layer changes when the number of scattering is increased. (3) The average extinction efficiency for the radiative energy which has the above mentioned directional profile is almost the same for the layers with the two types of orientations. (4) The difference in the directional profile of scattered energy is the main cause to give the difference in the heat flux passes through the layer with different fiber orientations.

International Symposium on Radiative Heat Transfer, Kusadasi, Turkey, August 14-18, 1995

## SOLUTION OF THE INVERSE RADIATIVE LOAD PROBLEMS BY THE SINGULAR VALUE DECOMPOSITION

Kazuhiko KUDO*, Akiyoshi KURODA*, Amr EID*
Takahiko SAITO* and Masahito OGUMA**
*Department of Mechanical Engineering, Faculty of Engineering
Hokkaido University, Sapporo, JAPAN
**Advanced Technology Department 2, Research Institute
Isikawajima-Harima Heavy Industries Co., Ltd., Yokohama, JAPAN

A method is developed to solve inverse radiative load problems within multi-dimensional systems with arbitrary shapes. The energy equations for each gas and wall element are expressed in a matrix form, and the inverse matrix is obtained by the singular value decomposition technique to estimate the temperature and heat load distributions within the gas region from the profiles of the heat flux and the temperature of the wall elements. From these analyses, the method is shown to give stable results for the radiative inverse load problems when the condition number of the matrix is reduced to an appropriate lower value by setting some singular values to 0.

1995 ASME Winter Annual Meeting, San Francisco, USA, November 12-17, 1995

## HEAT TRANSFER AND FLOW CHARACTERISTICS OF OFFSET FINS IN LOW-REYNOLDS-NUMBER REGION

Masayuki MIZUNO, Mikio MORIOKA and Masayosi HORI
Research Institute
Isikawajima-Harima Heavy Industries Co., Ltd.
Yokohama, Japan
Kazuhiko KUDO
Department of Mechanical Engineering, Faculty of Engineering
Hokkaido University
Sapporo, Japan

The characteristics of heat exchangers with offset-type plate fins for space stations are studied in a Reynolds-number region less than 300 based on the hydraulic diameter. To study the effects of the development of the thermal boundary layer along the bottom plate on the

heat-transfer characteristics of the fins standing on the plate, three-dimensional analysis is carried out. The parameters used in the study are the Reynolds number, the Prandtl number of fluid and the thermal properties of the fluid and the fins. Also, an experiment is carried out to show the validity of the present analyses. It is found that the Nusselt number on the fin surfaces is characterized by the ratio of the thermal-conductivity of the fluid to that of the fin material. This is caused by the fact that the thermal boundary layer which developed on the bottom plate relaxes the temperature gradient in the fluid perpendicular to the fin surface.

International Symposium on Advanced Energy Conversion System and Related Technologies, Nagoya, Japan, December 4-6, 1995

## Transient Heat Transfer Analysis in Vacuum Furnaces by Radiant Tube Burners

A. MOCHIDA and K. KUDO
Dep. of Mech. Engng., Hokkaido Univ., Sapporo, Japan
Y. MIZUTANI, M. HATTORI and Y. NAKAMURA
Toho Gas Co., Nagoya, Japan

To develop the method to analyze transient characteristics of the combined radiative-convective and conductive heat transfer in the industrial furnaces, heat transfer in vacuum furnaces is numerically analyzed. The vacuum furnace is heated by several radiant tube burners and enclosed with thermal insulation walls. Object materials to be heated are placed at the central region of the furnace.

A three dimensional computer program for general purpose is developed to solve radiative heat transfer within enclosure including the transient conductive heat transfer within the insulation walls surrounding the system. The Monte Carlo Method is used for the radiative heat exchange calculation. The results of the numerical simulation are compared with the results of experiment. The simulated results fit very well with the experimental ones, which shows the validity of the present simulation method.

6th International Symposium on Transport Phenomena and Dynamics of Rotating Machinary, Hawaii, USA, February 4-7, 1996

## Transient Heat Transfer Analysis in Vacuum Furnace by Radiant Tube Burners

A. MOCHIDA and K. KUDO
Dep. of Mech. Engng., Hokkaido Univ., Sapporo, Japan
Y. MIZUTANI, M. HATTORI and Y. NAKAMURA
Toho Gas Co., Nagoya, Japan

The exhaust gas of gas turbines is recently used to generate steam by using waste-heat boilers. The transient heat transfer characteristics are very important for the design and operation. To develop the method to analyze transient radiative-convective and conductive heat transfer, the characteristics of vacuum furnaces are analyzed. These vacuum furnaces are heated by several radiant tube burners and enclosed with thermal insulation wall. And object materials to be heated are placed at the center of the furnace.

Three dimensional general purpose computer program is developed to solve radiative transfer analysis within enclosure and to treat transient heat transfer analysis containing transient heat conduction within the insulation walls surrounding the system. The Monte Carlo Method issued for the radiative transfer analysis. The results of the numerical simulation are compared with the results of experiment. They fit very well, which shows the validity of the present method.

2nd International Conference on Inverse Problems in Engineering, Theory and Practice Le Croisic, France, June 9-14, 1996

## ANALYSIS ON INVERSE RADIATIVE LOAD PROBLEM

Kazuhiko KUDO, Akiyoshi KURODA and Tatsuhiko SAITO
Department of Mechanical Engineering, Hokkaido University
Kita-13, Nishi-8, Kita-ku, Sapporo 060 JAPAN
Masahito OGUMA
Research Laboratory, Ishikawajima Harima Heavy Industry
Shin'nakahara 1, Isogo-ku, Yokohama 235, JAPAN

A method to solve inverse radiative load problems are developed and the validity of the method has been demonstrated. In the present study, a two-dimensional rectangular furnace is

treated in which a rectangular heating object is set within the furnace and is heated by several heater elements set along the furnace walls. The distributions of the heat flux and the temperature of the heater elements required to realize specified heat flux along the surface of the heating object are properly estimated by using the singular value decomposition method (SVD), when the condition number of the singular values is chosen properly.