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33rd National Heat Transfer Symposium of Japan. Proceedings of the symposium, Niigata, May 1996, Volume 2

Japan Heat Transfer Society, (Japan Heat Transfer Society), *33rd National Heat Transfer Symposium of Japan. Proceedings of the symposium, Niigata, May 196, Volume 2,* 1996, (203 p.). In English.

This volume contains 102 papers presented at the National Heat Transfer Symposium of Japan. They are divided into numerous sections, the titles of which include: enhancement of convective heat transfer; radiation heat transfer; modelling and numerical analysis of two-phase flow; visualization and measurement of two-phase flow; film boiling; heat exchangers; heat transfer in combustion; heat pumps and refrigeration.

33rd National Heat Transfer Symposium of Japan. Proceedings of the symposium, Niigata, May 1996. Volume 3

Japan Heat Transfer Society, (Japan Heat Transfer Society), *33rd National Heat Transfer Symposium of Japan. Proceedings of the symposium, Niigata, May 1996, Volume 3,* 1996, (287 p.). In English.

This volume contains 144 papers presented at the National Heat Transfer Symposium of Japan. They are divided into numerous sections, the titles of which include: heat transfer in rotating fields; heat transfer in separated flow; impinging jets and film cooling; evaporation heat transfer; condensation heat transfer; heat transfer in porous media; fluid flow and heat/mass transfer under microgravity; hydrodynamics and heat transfer in two-phase flow and natural convection around bodies.

Advances in sensors for fluid flow measurement. Proceedings of a colloquium, London, April 1996

ed Beeston J.W., (Institution of Electrical Engineers; Digest No. 96/092), *Advances in sensors for fluid flow measurement. Proceedings of a colloquium, London, April 1996,* 1996. In English.

The colloquium which is presented in this volume was organized by three professional groups of the IEE: instrumentation systems and components; hardware and systems engineering; measurements and instruments. There are fifteen papers and their titles include: multiphase flow measurement, current and future developments; an electromagnetic flowmeter for measuring rheological parameters and reconstructing the flow profile; a novel ultrasonic mass flowmeter for liquids; three phase pipe flow imaging using a capacitance tomography system and measurement of multiple velocities in multiphase flow.

Hydrodynamic characteristics of a three-phase inverse fluidized-bed column

Ibrahim Y.A.A., Briens C.L., Margaritis A. & Bergongnou M.A., *AIChE Journal,* 1996, 42/7 (1889-1900). In English.

Gas-liquid-solid inverse fluidized beds were studied, in which the gas and the continuous liquid phase flow countercurrently fluidizing particles that are lighter than the liquid. Conductivity and static pressure measurements were combined to provide the vertical profiles of the gas, liquid and solid holdup, in beds of 4- or 6-mm polypropylene particles with a density of about 870 kg/m^3. Various bed heights were obtained with different measurement methods. The minimum fluidization velocity was estimated using the bed static pressure gradient. A new transition velocity, called the uniform fluidization velocity, was identified using conductivity measurements. This is the superficial liquid velocity at which the fluidization quality becomes the same throughout the bed.

Extraction of spray particles with supercritical fluids in a two-phase flow

Wagner H. & Eggers R., *AIChE Journal,* 1996, 42/7 (1901-1910). In English.

A new process for extractive separation with supercritical fluids is described. It is characterized by mixing a liquid feed with a dense gas in a special mixing device and the formation of spray particles when this mixture is injected into an extraction zone where the fluid phase is loaded with the extracts. By dividing the extraction into two process steps, mixing and loading, it is possible to adjust the devices and the apparatuses for different media. Two different materials were tested in an apparatus on a semiindustrial scale with different mixing devices and extraction zones. By measuring fluid loading in the extraction zone, the mass-transfer parameter of a mathematical extraction model could be adapted. The model considers particle formation in the mixing zone, the fluid dynamic in the loading zone, and the mass transfer between spray particles and fluid phase. Calculated concentration profiles make it possible to determine the residence time and the size of the extraction zone for given geometries and fluid dynamics.

Estimation of three-phase flow functions in porous media

Mejia G.M., Watson A.T. & Nordtvedt J.E., *AIChE Journal,* 1996, 42/7 (1957-1967). In English.

Several important processes involve the flow of three immiscible fluids through porous media, such as the flow of oil, water and gas in petroleum reservoirs, or water, non-aqueous phase liquid and air in underground

aquifers. Multiphase flow functions are important to simulate the flow in such systems. Unfortunately, there are few, is any, reliable estimates of these flow properties from laboratory experiments. A method is presented for simultaneous estimation of three-phase relative permeability and capillary pressure functions from laboratory experiments. The method is not limited by restrictions in the experimental design or assumptions regarding the saturation dependence of shape of the functions to be estimated. The method is demonstrated with simulated experiments. It is shown that with a suitable experimental design, regions of the functions represented by the measured data can be determined accurately.

Analysis of thin film thickness determination in two-phase flow using a multifiber optical sensor
Yu. S.C.M., Tso C.P. & Liew R., *Applied Mathematical Modelling*, 1996, 20/7 (540-548). In English.
Simulation studies has been conducted utilizing the principle of virtual image and vector analysis to demonstrate the possibility of using a multifiber optic sensor to determine the thickness and orientation of a clear liquid film in a gas-liquid two-phase flow situation. The sensor system consists of a central light emitting fiber which is surrounded symmetrically by six light receiving fibers. By analyzing the different patterns of light intensity reflected back at the gas-liquid interface and collected by the six receiving fibers, the thin film thickness and its orientation with respect to the measuring point can be determined.

A thermally stratified wind tunnel for environmental flow studies
Ohya Y., Tatsuno M., Nakamura Y. & Ueda H., *Atmospheric Environment*, 1996, 30/16 (2881-2887). In English.
A wind tunnel was constructed to study the effects of thermal stratification on flow and diffusion in the atmospheric boundary layer. The wind tunnel is of a suction type and has a 1.5 m wide, 1.2 m high, 13.5 m long, rectangular test section. Designed to produce thermally stratified flows, the tunnel is equipped with two independent temperature systems, an air-flow heating unit (AHU) and a floor temperature controlling unit (FTCU).

Simulation of airlift pumps for deep water wells
Nenes A., Assimacopoulos D., Markatos N. & Mitsoulis E., *Canadian Journal of Chemical Engineering*, 1996, 74/4 (448-456). In English.
A mathematical model for the simulation of water airlift pumps is developed, based on the 'interspersed continua' approximation for two-phase flow systems, together with an algorithm that selects the appropriate friction correlation for specific flow regimes. The model presented can either predict the water or air flow rate for a given airlift system. Predictions obtained by the model were compared with a series of experiments performed by the Greek Institute of Geological and Mineral Exploration and were found to be in good agreement. The present predictions are far superior to those obtained by an existing simple model currently in general use.

Liquid phase residence time distribution for two phase flow in coiled tubes
Saxena A.K., Nigam K.D.P., Schumpe A. & Deckwer W.D., *Canadian Journal of Chemical Engineering*, 1996, 74/6 (861-866). In English.
The residence time distribution (RTD) of the liquid phase in air-water flow through helical coils has been studied. Upward and downward cocurrent flows have been investigated in three coils with curvature ratios ranging from 11 to 60.7. The ranges of the Reynolds numbers for the gas and the liquid varied from 1500 to 3000 and 620 to 3200, respectively. A model has been proposed that describes the liquid phase RTD as combination of two different residence time distributions applicable for turbulent and laminar liquid flows.

Horizontal cross flow filtration and rinsing of ice from saline slurries
Dickey L.C., Dallmer M.F., Radewonuk E.R. & McAloon A., *Canadian Journal of Chemical Engineering*, 1996, 74/6 (905-910). In English.
Continuous filtration of ice slurries to generate potable water was investigated. In the filtration process the ice is driven through a stationary channel with liquid draining through narrow slots in the base. Most of the liquid drained from the slurry at ambient pressure and the residual liquid trapped in the pores of the consolidated ice bed was displaced to a vacuum after downstream rinsing with sprayed or melt water. The cost of this approach may be competitive with reverse osmosis if an automated unit is developed.

Effects of pressure and temperature on flow regimes in gas-solid fluidization systems
Bi H.T. & Grace J.R., *Canadian Journal of Chemical Engineering*, 1996, 74/6 (1025-1027). In English.
The effects of operating temperature and pressure on the flow regimes of gas-solids fluidization are predicted based on the recently published flow regime diagram of Bi and Grace (1995b). The predictions are consistent with the evidence available in the literature. At constant superficial gas velocity, increasing system pressure and decreasing system temperature shift the behaviour toward higher velocity flow regimes. The opposite trends are realized if, instead, the gas mass flowrate is held constant.

Special traits of the cavitation technology of stirring highly viscous liquids
Yakhno O.M., Yaske N.N. & Koval A.D., *Chemical and Petroleum Engineering*, 1996, 32/3 (218-221). In English.
When a cavity forms in any region of a flow of a viscous liquid, gas bubbles are liberated. The growth and collapse of bubbles are discussed. The effects of cumulative cavitation on the rheological properties of the raw material during stirring were investigated. Cavitation stirring led to a reduction in the viscosity of the raw material. The dependency of viscosity on temperature could be changed and the stability of disperse petroleum systems against lamination could be enhanced.

A method to investigate filtration by the use of a pressure test filter
Palica M., *Chemical Engineering and Processing*, 1996, 35/5 (333-342). In English.
The article describes filtration investigations on a laboratory scale by the use of a pressure test filter. It enables the estimation of filtration constants, compressibility coefficient of the final product and dewatering in a cake compression zone. A method of experimental treatment of data was proposed for particular slurries based on constants K or modified constants K' of the characteristic filtration equation. The use of a pressure test filter makes it possible to reduce the investigation time, reduce the costs and approximate the results for other process conditions.

On the modelling of particle-body interactions in Stokes flows involving a sphere and circular disc or a torus and circular cylinder using point singularities
O'Neill M.E., *Chemical Engineering Communications*, 1996, 148-150/- (161-182). In English.
Exact solutions for the three-dimensional Stokeslet and rotlet placed axisymmetrically along the axis of a circular disc are found and combined with Brenner's first order interaction formulae to determine the effect of the presence of the disc on the force and torque acting on a particle whose dimensions are small compared with its distance from the disc. The results are compared with those of a full numerical integration of the Stokes equations for a sphere translating towards a disc. Brenner's first order wall correction theory is applied to the motion of a particle in a circular cylinder using the exact solutions for a torus translating or rotating in isolation. The theoretical predictions for the drag on a torus settling symmetrically in a circular cylinder are compared with those determined experimentally.

Rapid characterization of flow regimes in multiphase reactors through box-counting dimensions with an embedding dimension of two
Briens C.L., Hudson C. & Briens L.A., *Chemical Engineering Journal*, 1996, 64/1 (169-178). In English.
The performance of multiphase reactors is greatly affected by their flow regime. The box-counting dimension of a probe signal characterizes its intrinsic, dimensionless structure and is not significantly affected by moderate changes in probe calibration constants. This study uses an approximate box-counting dimension which is so rapidly calculated that it could be used for on-line control. The box-counting dimension of the raw signal from a bubble probe allows the accurate detection of gas maldistribution in bubble columns and of liquid maldistribution in bubble columns and gas-liquid-solid fluidized beds. The fluidization regime of liquid-solid and gas-liquid-solid beds can be accurately identified from the box-counting dimension of the signal recorded with either local probes or cross-sectional probes.

Numerical modelling of the mixing of viscoplastic slurries in a twin-blade planetary mixer
Tanguy P.A., Bertrand F., Labrie R. & Brito-De La Fuente E., *Chemical Engineering Research and Design*, 1996, 74/A4 (499-504). In English.
Slurries are known to exhibit stiff non-Newtonian properties, in particular yield stress and, from an engineering standpoint, their rheology can be well described by the Bingham model. In industry, the design of the slurry make-down process is a difficult and costly task. The flow of such materials in a twin-blade vertical planetary mixer is studied using 3D computer simulation. The flow structures and the power consumption are investigated for various values of the Bingham number.

Hydrodynamic characteristics of two-phase flow through fixed beds: air Newtonian and non-Newtonian liquids
Iliuta. I., Thyrion F.C. & Muntean O., *Chemical Engineering Science*, 1996, 51/22 (4987-4995). In English.
An experimental investigation was carried out to determine the effects of gas and liquid flow rates and flow consistency index on the liquid-phase axial dispersion coefficient, pressure drop and the liquid holdup for two-phase downflow and upflow in a fixed bed. Water and non-Newtonian liquids were employed as liquid phase. The liquid-phase flow in a fixed bed was examined using the piston-diffusion-exchange (PDE) model. The time-domain analysis of tracer response data was used for the flow model parameter estimation.

Size, structure and dynamics of 'large' bubbles in a two-dimensional slurry bubble column
De Swart J.W.A., Van Vliet R.E. & Krishna R., *Chemical Engineering Science*, 1996, 51/20 (4619-4629). In English.
This paper reports preliminary results of a study on the hydrodynamics of a two-dimensional slurry bubble column. Experiments have been carried out with air/paraffin oil slurries with solids concentrations of 0, 28.3 and 38.6 vol% of porous silica particles (mean diameter of 38 μm). Bubble sizes, bubble coalescence and bubble break-up rates were determined by video image analysis. A population model for mass transfer has been set up and used to establish that frequent bubble-bubble interactions could lead to an order of magnitude increase in the mass transfer rates for the large bubble class.

Hydrodynamic and kinetic modelling of circulating fluidized bed reactors applied to a modified Claus plant
Puchyr D.M.J., Mehrotra K., Behie L.A. & Kalogerakis N., *Chemical Engineering Science*, 1996, 51/24 (5251-5262). In English.
Simulations of circulating fluidized-bed (CFB) reactors applied to the modified Claus process were performed to assess their potential for eliminating the costly tail gas clean-up unit (TGCU) from a Claus plant. The TGCU could be eliminated by achieving very high H_2S conversions in the catalytic reactors. Both the CFB regimes of pneumatic transport and fast fluidization were examined. Moreover, a newly developed CFB model accounting for the downflow of both the gas and solids in the annulus was applied to the fast fluidization regime. Recently published intrinsic reaction kinetics were employed for the hydrolysis of the problematic COS and CS_2 compounds on the Kaiser 201 alumina catalyst.

Fluidization at vacuum conditions. A generalized equation for the prediction of minimum fluidization velocity
Llop M.F., Madrid F., Arnaldos J. & Casal J., *Chemical Engineering Science*, 1996, 51/23 (5149-5157). In English.
The hydrodynamical behaviour of fluidized beds at reduced pressures is studied. The minimum fluidization velocity is strongly influenced by pressure, decreasing as pressure increases. The well-known equation of Wen and Yu and two equations proposed for the calculation of u_{mf} at reduced pressures are tested; the comparison with experimental data shows that they can be applied only over restricted pressure ranges. The relationship between flow rate, pressure and pressure drop at conditions ranging from high vacuum to high pressure is analysed for the different flow regimes (molecular, slip, laminar, transition and turbulent). A generalized equation is found which predicts fairly well the value of u_{mf} at vacuum conditions, atmospheric pressure and high pressures.

Modify sealless pumps
Jaskiewicz S.A., *Chemical Engineering World*, 1996, 31/5 (63-65). In English.
There is a general misconception that canned motor pumps can only be used on clean fluids. Such pumps can be used for solids-laden fluids and slurries. Design modifications and equipment alternatives for handling solids are presented. Hard bearings and journals allow solids to pass through the motor section without causing damage. Canned motor pumps that are designed for external circulation can be modified to have filters installed on the recirculations line. Backflushing with a lip seal is recommended. There are canned motor pumps in service that are specifically designed to pump slurries.

Numerical simulation of two-phase flow and solute transport with interphase exchange in porous media
Xiaoyong Zhan, *Communications in Numerical Methods in Engineering*, 1996, 12/7 (433-444). In English.
The development of a numerical method for modelling two-phase flows and solute transport, particularly with interphase exchange in porous media, is presented. The governing equations are derived to describe two immiscible and compressible fluids flows such as water-air and two-phase solute transport with interphase exchange. Application examples are shown to confirm the applicability of the numerical method.

A comparison of numerical models for evaporative two-phase flow in a self-heated porous medium
Kim S.H., *Computers and Fluids*, 1996, 25/8 (699-718). In English.
Two different numerical models using the finite difference method (FDM) for one-component time-dependent two-phase flows in a porous medium are investigated: the iterative four-variable model (I4VM) and the direct three-variable model (D3VM). The former includes the pressure gradient and uses the iterative method to solve a system of flow equations, whereas for the latter, the formulation without the pressure gradient is simultaneously solved using the algorithm for tri-tridiagonal equations of three dependent variables. The steady-state solution as well as the unsteady results obtained by two models are compared only for the low heat generation rate below the dryout limit.

Evaporation of water from agitated freezing slurries at low pressure
Dickey L.C., *Desalination*, 1996, 104/3 (155-163). In English.
In an absorptive vacuum freezing process, water evaporates from the freezing solution and condenses on a cold salt solution. Given sufficient condensing capacity, the evaporation rate will be controlled by the freezing solution vapor pressure. The size of the condensing equipment which matches a given evaporation system can be estimated using rate measurements made with low vapor pressure freezing solutions.

Enhanced reliability for dredge pump cavitation testing
Teijema J., *Dredging and Port Construction*, 1996, 23/6 (9-10). In English.
Problems caused by cavitation in dredge pumps are discussed. Factors influencing pump cavitation testing are outlined. Cavitation curves are measured in a closed loop or in the actual condition. The reliability of measured cavitation curves is affected by the way of adjustment in the suction head and the properties of the test water. Approaches for ensuring the accuracy of pump cavitation testing are described.

(La cavitazione nelle turbine Pelton. (Parte II)) (Cavitation pitting of Pelton turbines. (Part II))
Brivio R. & Zappi O., *Energia Elettrica*, 1996, 73/4 (266-270). In Italian.
The hydraulic laboratory experimental research, performed in cooperation with other European partners and financed by the BRITE project, is described. This research had the purpose to define the parameters and the model/prototype correlations in order to be able to determine the cavitation pitting of Pelton turbines, both from the quality and from the quantity points of view.

Integrated tests for removal of nitric oxide with iron thiochelate in wet flue gas desulfurization systems
Yao Shi, Littlejohn D. & Shih-Ger Chang, *Environmental Science and Technology*, 1996, 30/11 (3371-3376). In English.
Wet flue gas desulfurization scrubbers can be retrofitted for combining removal of SO_2 and NO_x from flue gas by adding a newly developed iron(II) thiochelate to limestone slurries. This additive enhances the solubility of NO in limestone slurries by binding NO to form iron nitrosyl thiochelates. The bound NO is then converted to an ammonium ion by iron metal, regenerating the active iron(II) catalyst for continued NO capture. The conditions of the chemical regeneration of iron(II) thiochelate have been studied. This chemical reduction method is efficient, simple, and cost-effective. Integrated tests of this new iron additive on a bench-scale system have been conducted. The bench-scale test results were used to develop a prediction of the performance of a full-scale spray absorber.

A nonintrusive auto-transformer technique for the measurement of void fraction
Kendoush A.A. & Sarkis Z.A., *Experimental Thermal and Fluid Science*, 1996, 13/2 (92-97). In English.
Winding low resistance wires around the tube of the test section in a method analogous to the auto-transformer winding was proved experimentally successful for the measurement of void fraction in the two-phase medium inside the tube. This novel technique is based upon the fact that the two-phase mixture becomes the region for a magnetic field where any change in the void fraction produces a change in the permeability of the two-phase mixture. The present technique is suitable for two-phase flows, which are contained in nonmetallic tubes.

Two-phase flow behind a shock wave with phase transitions and chemical reactions
Smirnov N.N., Zverev N.I. & Tyurnikov M.V., *Experimental Thermal and Fluid Science*, 1996, 13/1 (11-20). In English.
A theoretical and experimental study was undertaken of the shock wave propagation in heterogeneous media containing an oxidant in the gaseous phase and a fuel in the condensed phase. A system of governing equations with boundary conditions is composed that makes it possible to simulate numerically the initiation of detonation and the acceleration and slowing down of an unsteady wave to a self-sustaining regime. Experiments were carried out in a shock tube for pure gas, for inert dispersed droplets, and for combustible dispersed droplets. The comparison of the results shows good agreement of theoretical and experimental data.

Development of local two-phase flow parameters for vertical bubbly flow in a pipe with sudden expansion
Rinne A. & Loth R., *Experimental Thermal and Fluid Science*, 1996, 13/2 (152-166). In English.
Experimental data are presented for vertical air-water bubbly flow obtained by fiber-optic sensors in a pipe with sudden expansion (40 mm to 90 mm). The local void fraction, local bubble velocity, local bubble frequency, bubble chord length, bubble size, and local interfacial area concentration were determined. Main emphasis is put on the local interfacial area concentration. The calculation of the surface area was based on different bubble shapes. The calculated distribution of bubble sizes depends on the chord length resulting from the product of measured bubble velocity and bubble residence time at the sensor tip. The values for the interfacial area concentration for flows with low void fractions ($\alpha \leq 0.04$) agree well with those measured by assuming only spherical bubbles. The existing deviations for flows with void fractions above $\alpha = 0.04$ seem reasonable according to the differently assumed bubble shapes in the determination methods. This leads to an increase in the values for the interfacial area concentration.

Electrokinetically enhanced vacuum dewatering of mineral slurries
Gopalakrishnan S., Mujumdar A.S., Weber M.E. & Pirkonen P.M., *Filtration and Separation*, 1996, 33/10 (929-932). In English.
Vacuum dewatering of titanium oxohydrate and pyrite slurries was enhanced electrokinetically through application of a constant DC voltage across the bed. The power was applied either continuously or in an interrupted mode, with the electrodes short-circuited during the periods of power interruption. The interrupted mode removed more water than continuous power, with a lower consumption of energy. Additional water could be removed in the interrupted mode by adding base at the anode to neutralise the acidity produced by the reaction at the anode when the power was on.

Error analysis based development of a bubble velocity measurement chain
Rossi G.L., *Flow Measurement and Instrumentation*, 1996, 7/1 (39-47). In English.
In this paper a measurement chain for bubble velocity measurements has been designed, developed and tested. The sensing element used for testing is a double fiber optic probe. Error sources associated with the measurement techniques are illustrated by theoretical models. The conclusions are also valid for other sensing elements used to detect bubbles in two-phase flow. A special purpose data acquisition and processing system has been implemented to obtain velocity data from the sensor signals.

Nuclear magnetic resonance (NMR) two-phase mass flow measurements
Kruger G.J., Birke A. & Weiss R., *Flow Measurement and Instrumentation*, 1996, 7/1 (25-37). In English.
An NMR measurement method for highly-turbulent liquid-gas two-phase flow has been developed in this laboratory. It allows measurement of the liquid velocity and of the fraction, both averaged over the inner volume of the NMR RF coil and over the measuring time. By signal-averaging, it is possible to extend the averaging time to mins, or even hrs or days. This time-averaging improves the signal relative to background noise as well as to fluctuations caused by the flow and hence improves the accuracy of the measurements. The influence of insufficient mixing of the spins during the polarization period is discussed.

Effect of homogeneous condensation on the dynamics of a hot vapor bubble in a cold liquid jet
Ocheretyanyi S.A. & Prokof'ev V.V., *Fluid Dynamics*, 1996, 31/6 (842-847). In English.
The problem of initiating cavitation bubbles in a cold liquid jet by injecting hot steam into high-pressure zone especially organized at the nozzle outlet is considered. Previously a plane flowfield in which vapor bubbles were formed at the cusp of the cavity (high-pressure zone) and propagated together with the liquid along the axis of symmetry was considered. In certain cases, in the bubble expansion process the vapor temperature drops below the saturation temperature. Vapor condensation in the bubble volume (homogeneous condensation) is also taken into account.

Calculation of axisymmetric cavities downstream of a disk in subsonic compressible fluid flow
Vasin A.D., *Fluid Dynamics*, 1996, 31/2 (240-248). In English.
Cavitation subsonic water flow past a disk is calculated in accordance with the Riabouchinsky scheme by a finite-difference method at Mach numbers $M \leq 0.95$ and cavitation number $\alpha \tilde{} 0.02$. The calculated results are compared with the data of slender body theory and the results obtained from some approximate formulas.

Some solutions of the problem of plane steady flow of a gas condensate mixture through a porous medium
Dinariev O.Yu., *Fluid Dynamics*, 1996, 31/2 (268-273). In English.
The plane problem of steady two-phase flow of a multicomponent mixture through a porous medium with phase transitions is considered. It is shown that the system of equations for the two-phase multicomponent flow process, together with the equations of phase equilibrium, can be solved in quadratures if the solution of two auxiliary problems is known. These are the problem of conformal mapping of the neighborhood of a well onto a rectangle and the purely physicochemical problem of the description of the mechanical and thermodynamic properties of a mixture. The solutions for a vertical well with a barrier and for a horizontal well in a finite pproductive stratum are found under certain assumptions concerning the properties of the mixture.

Subsonic gas-liquid cavitation flow past a disk
Zigangareeva L.M. & Kiselev O.M., *Fluid Dynamics*, 1996, 31/2 (334-338). In English.
The problem of axisymmetric subsonic gas-liquid cavitation flow past a disk in accordance with the Riabouchinsky scheme is solved. Formulas relating the main flow parameters with the cavitation number, the Mach number on the free boundary and the gas/liquid volume ratio under stagnation conditions are presented.

Stokes waves on a cavity surface in a rotating fluid
Amromin E.L., *Fluid Dynamics*, 1996, 31/6 (886-890). In English.
The axisymmetric flow of an inviscid incompressible fluid rotating about a cavity with constant presure is considered. Due to the centrifugal force, on the cavity surface waves may exist, in particular, waves with a break in the wave base where the cavity meridional sections form the angle $2\pi/3$, ie Stokes waves. A method of finding these waves from the boundary-value problem for the fluid velocity potential is described. For an infinite cavity, the dependence of the wave parameters on the cavitation number, calculated using the pressure in the cavity, is given.

(Ultraschalleinsatz in der Trinkwasseraufbereitung, Inaktivierung von Plankton - Entwicklung und Bau einer technischen Anlage) (Ultrasound and the treatment of drinking water: inactivation of plankton - development and construction of a technical system)
Mues A., *GWF Wasser-Abwasser*, 1996, 137/14 Spec. Iss. (S167-S172). In German.
Experiments in the field of zooplankton elimination during the drinking water purification cycle have shown that plankton can effectively be eliminated by applying a combination process of inactivation, flocculation, and filtration. Because of its purely physical inactivation with few side effects, ultrasound was demonstrated to be an excellent choice of technology. To transmit the technology to an actual field project, it was necessary to develop and construct a system capable of continuously treating water quantities of up to 4000 m^3/h with acoustic cavitation. The development led to a cavitation module for the inactivation of plankton with a capacity of 400 m^3/h, that was successfully tested at the Wahnbachtalsperrenverband near Koln.

(Une approche lagrangienne pour la simulation d'interactions particule/particule en ecoulement) (Lagrangian approach for the simulation of particle interactions in two phase flows)
Berlemont A., Chang Z. & Gouesbet G., *Houille Blanche*, 1996, 51/1-2 (57-63). In French.
Hydrodynamic interactions between particle pairs are studied following sedimentation theory. For two spheres, interactions are directly obtained through the resistance matrix which links interaction forces to particle relative velocities. For more than two spheres, the mobility matrix is estimated with a four order approximation on the particle distance, and then it is inversed to get the resistance matrix. A set of motion equations is then solved to describe the particle behaviours.

Recommendation of small hydraulic turbine types
Hydro Power and Equipment, 1996, 4/- (66-69). In English.
Specifications and applications of small types of hydraulic turbines are summarized. The following turbines are described: S-type, Kaplan, Francis, Banki, Pelton and Turgo. Turbine efficiencies, cavitation and applications are discussed.

Experimental investigations of the conditions of the onset of air entrainment by plunging liquid jets
Fetisov Yu.M., *Hydrotechnical Construction*, 1996, 30/2 (87-91). In English.
Intense air entrainment occurs at the place of contact of a plunging jet with the surface of a stationary liquid. The entrained air reduces the eroding capacity of a deflected or free-falling nappe when joining pools of hydraulic structures and decreases cavitation erosion of structural members. Jet aeration is finding wide use for saturating water with oxygen of air to improve its quality and for intensifying biological wastewater treatment processes. It was established that air entrainment can occur under conditions when the average jet velocity at the point of incidence reaches a certain value. The value of this velocity is called the minimum or critical air-entrainment velocity. An analysis of works pertaining to the subject of investigation indicates the complexity of interaction of the plunging jet with the liquid surface, the contradictoriness of theoretical approaches, and limitedness of experimental data. This article gives the results of experimental investigations of the conditions of onset of air entrainment by vertical jets issuing from smooth, long nozzles.

Hydropower requirement of the Zagorsk pumped-storage station: design features and operating experience
Kuleshov A.P., Magruk V.I., Mart'yanov S.I., Rodionov V.G., Khutoryanskii S.A. & Cherepanov M.M., *Hydrotechnical Construction*, 1996, 30/4 (184-191). In English.
This hydroelectric power station features vertical mixed-flow pump-turbines of the RONT-115/812-V-630 type from the Leningrad Metals Plant. The two-machine layout operates in the reversible mode. This article discusses in detail the design and operation of the pump-turbine including the runner, turbine shaft and seal,

gate apparatus, servo motor, thrust and guide bearings. Cavitation resistance depends on the correct selection of runner blade geometry, accuracy of manufacture and machining quality. Cavitation erosion and associated vibration problems are detailed. A number of protective coatings were tested and results are reported. It is concluded overall that the design is correct and the pump-turbine has operated reliably, however, some design improvements to the end seals are suggested.

Information-analytical support of reliable operation of power facilities: computer program for hydraulic calculation of structures for controlling aeration of the flow on spillways
Semenkov V.M. & Saranchev V.O., *Hydrotechnical Construction*, 1996, 30/5 (234-242). In English.
A computer program is presented for calculating the hydraulic performance of structures and controlling aeration of spillway flow. Cavitation occurrence, cavitation erosion of the spillway surface and aeration of the flow are important in improving the design of a high-head spillway. The program can be used to optimize the design parameters of a system for anticavitation protection of a high-head spillway which consists of a sequence of aerators.

Predicting the reliability of runner pits of diagonal-flow and adjustable-blade turbines
Dzyubanov E.M., Dmitriev N.Yu., Klimovich V.I., Levin S.M. & Shtil'man V.B., *Hydrotechnical Construction*, 1996, 30/2 (59-68). In English.
An analysis of documents and on-site inspections at several hydrostations has revealed many causes of hydropower equipment failure, especially related to runner pit damages. The principal causes of damage are discussed: fatigue cracking with cavitation erosion, cavitation-erosion damage resulting in cracking, and fatigue failure due to defects in metal, manufacturing and assembly. Factors influencing this damage and the reliability of the runner pit are examined.

Titanium - first choice for desalination plant heat exchangers
McCue D.M. & Peacock D.K., *Industrial Water Treatment*, 1996, 28/4 (44-52). In English.
The advantages of titanium for desalination plant heat exchangers are discussed. Problems of corrosion and erosion in heat exchanger tubes are considered. The replacement of heat exchanger internals with prefabricated all titanium modules is described. The corrosion resistance of titanium is discussed particularly to microbiologically influenced corrosion, pitting, erosion and cavitation, stress corrosion cracking, fatigue, fouling, crevice corrosion, galvanic corrosion and corrosion fatigue. The economics of corrosion prevention in different plant layouts are considered.

Flow characteristics of sage and peppermint leaves
Martinov M., Babic M. & Adamovic D., *International Agrophysics*, 1996, 10/4 (289-293). In English.
The separation of the desirable parts of a medicinal plant in air flow is a widely applied procedure. Therefore there has been established the goal to measure flow characteristics of sage (Salvia officinalis L.) and peppermint (Mentha piperita L.) leaves. Leaves were picked from stem and classified according to dimensions in four (sage) and three (peppermint) fractions. The flow characteristics defined by the air velocity of fluidization of a material layer show the possibility of separating sage leaves and stems, due to a significant difference in velocity values, 1.75 m s^{-1} maximum for leaves and 3.35 m s^{-1} for stems. Due the difference in flow characteristics the separation of different peppermint leaves fractions is also possible.

An experimental investigation of critical flow rates of subcooled water through short pipes with small diameters
Moon-Hyun Chun, Choon-Hyung Park & Jee-Won Park, *International Communications in Heat and Mass Transfer*, 1996, 23/8 (1053-1064). In English.
Critical two-phase flow rates of subcooled water through short pipes ($L < 400$ mm) with small diameters ($D < 7.15$ mm) have been experimentally investigated for wide ranges of subcooling (0-199°C) and pressure (0.5-2.0 MPa). Experimental results that show effects of various parameters on subcooled critical two-phase flow rates are presented in the form of graphs such as the dimensionless mass flux versus the dimensionless subcooling curve. An empirical correlation expressed in terms of a dimensionless subcooling is also obtained for subcooled two-phase flow rates through present test sections. Comparisons between the mass fluxes calculated by present correlation and a total of 679 selected experimental data points of 9 different investigators show that the agreement is fairly good except for very subcooling data obtained from small L/D (less than 10) orifices.

Heat transfer from a horizontal tube in a magnetofluidized bed
Saxena S.C. & Dewan S.S., *International Communications in Heat and Mass Transfer*, 1996, 23/5 (655-664). In English.
Heat transfer coefficient values are reported for a horizontal Nylon 24.1 mm diameter heated probe immersed in an iron shot bed of 1511 μm average diameter and exposed to an external uniform magnetic field collinear with the fluidizing air velocity. Total and local heat transfer coefficients are measured at different axial and angular positions over a range of air velocity and magnetic-field intensity values. The bed is also characterized by its hydrodynamic properties, viz., minimum fluidization and bubbling velocities and mean bed voidage.

Analysis of influence of physical parameters on vapor-liquid flow behavior up to dryout in a heat-generating porous medium
Kim S., *International Communications in Heat and Mass Transfer*, 1996, 23/8 (1097-1107). In English.
In the present work the influence of various physical characteristics on the two-phase flow behavior in a self-heated porous medium has been studied using a numerical model, that is, the effects of heat generation, rate of porosity, of particle size, and of system pressure on the dryout process. To analyze the effect of these characteristics, the variation of both liquid volumetric fraction and liquid axial velocity is evaluated at the steady state or

at the onset of a first boiled-out region. The analysis of computational results indicate that a qualitative tendency exists between the characteristics such as heat generation rate, porosity, effective particle diameter and the temporal development of the liquid volumetric fraction field up to dryout.

Two phase thermalhydraulic code used for fast transient calculations
Prah M., Feretic D. & Grgic D., *International Journal for Engineering Modelling*, 1996, 9/1-4 (21-26). In English.
The thermalhydraulic model was developd as a base for a fast running computer code for the purpose of a nuclear power plant primary system simulation. The model is based on the drift flux theory and integrated momentum equation. It is a nonhomogeneous four-equation model of a two-phase flow. On the basis of the developed theoretical model, the computer code in FORTRAN 77 for PC 386/486 compatible computers was prepared. The results of simulation are quite good and the accuracy of the program for selected test cases is comparable to the accuracy of RELAP5/mod2 computer code with CPU time reduction.

The analysis of nonlinear internal wave induced by arbitrary pressure distribution in a stratified flow
Chin-Hwa Kong & Chieh-Yao Chang, *International Journal for Engineering Modelling*, 1996, 9/1-4 (11-20). In English.
Nonlinear internal waves induced by arbitrary pressure loads in a stratified flow are treated, and the analytical solutions are given. The analytical solutions are supplied by applying Rayleigh and Lamb methods to linear waves on the free surface with infinite depth. It is shown that for a stratified-flow category, a number of differences are influenced by interfacial Froude numbers between the two methods. These variances derived from the Froude numbers are interpreted physically. The purpose of this study is to analyze the effects of the nonlinearity, to compare the different results derived from different pressure distribution functions by the above two analytical methods and to develop the appropriate model which is capable of solving the similar problem under any other conditions.

Numerical prediction of two-phase flow in bubble columns
Boisson N. & Malin M.R., *International Journal for Numerical Methods in Fluids*, 1996, 23/12 (1289-1310). In English.
A numerical model is described for the prediction of turbulent continuum equations for two-phase gas-liquid flows in bubble columns. The mathematical formulation is based on the solution of each phase. The two-phase model incorporates interfacial models of momentum transfer to account for the effects of virtual mass, lift, drag and pressure discontinuities at the gas-liquid interface. Turbulence is represented by means of a two-equation k-ϵ model modified to account for bubble-induced turbulence production.

A multiphase mixture model for multiphase, multicomponent transport in capillary porous media - I. Model development
Wang C.Y. & Cheng P., *International Journal of Heat and Mass Transfer*, 1996, 39/17 (3607-3618). In English.
A new model for multiphase, multicomponent transport in capillary porous media is developed, in which the multiple phases are considered as constituents of a multiphase mixture. This multiphase mixture model consists only of the conservation equations for the multiphase mixture and is derived from the classic multiphase flow formulation without making any approximations. In addition, algebraic relations are found which can be used to back out the individual phase flow fields from the mixture velocity in a post-processing fashion.

New low-Reynolds-number k-ϵ model including damping effect due to buoyancy in a stratified flow field
Murakami S., Kato S., Chikamoto T., Laurence D. & Blay D., *International Journal of Heat and Mass Transfer*, 1996, 39/16 (3483-3496). In English.
A new k-ϵ model which includes damping effect on vertical turbulent transport due to thermal stratification is proposed. The proposed model was tested by application to two kinds of two-dimensional thermally stratified flow fields. One is a high-Reynolds-number open channel flow, and the other is a low-Reynolds-number flow-field within an enclosure. The new model also includes low-Reynolds-number treatment which is effective not only in the vicinity of the wall, but also apart from the wall.

A model for slurry rheology
Shi F.N. & Napier-Munn T.J., *International Journal of Mineral Processing*, 1996, 47/1-2 (103-123). In English.
A semi-empirical model has been developed to predict slurry rheology from easily-measured slurry properties. The model demonstrates the complex influence of these properties on rheology, and also permits rheological information to be predicted in cases where it cannot be measured. It is intended for use with slurries commonly encountered in mineral processing. The model has been applied to 127 sets of Debex viscometer measurements of a variety of slurries totalling more than 1200 data points, with good agreement between the predicted and the measured data. The separate effects of solids volume fraction and particle size on slurry rheological nature, simulated using the model and turbulence-corrected by the TC curve procedure, are demonstrated graphically. The influence of various factors of slurry rheology is discussed, and it is shown that a single slurry can exhibit many different rheological natures, depending only on the concentration and size distribution of the solids.

Measuring the rheology of slurries using an on-line viscometer
Shi F.N. & Napier-Munn T.J., *International Journal of Mineral Processing*, 1996, 47/3-4 (153-176). In English.
This paper presents a new procedure for obtaining a full shear rate-shear stress flow curve for unstable slurries using the single bobbin Debex on-line viscometer. It is based on the use of a calibration algorithm which incorporates a correction for turbulent flow in the measurement vessel. It is shown that torqueoc efficient data from a variety of Newtonian fluids and non-Newtonian slurries fall on a single curve, and it is suggested that this calibration curve (the 'TC curve') is characteristic for a particular instrument configuration. In principle, it can

be easily determined using Newtonian fluids alone. It is shown that the Debex on-line viscometer gives flow curves very similar to a conventional laboratory viscometer when this procedure is applied.

Rheological characterization of mineral suspensions using a vibrating sphere and a rotational viscometer
Kawatra S.K., Bakshi A.K. & Miller T.E. Jr, *International Journal of Mineral Processing*, 1996, 44-45/- (155-165). In English.
A new technique has been developed for the characterization of the rheology of mineral slurries into Newtonian and non-Newtonian flows. It utilizes a rotating type viscometer to measure apparent viscosity at a low shear rate, and a vibrating sphere type viscometer to measure the apparent viscosity at a high shear rate. Special precautions were taken to allow measurements of apparent viscosity of rapidly setting mineral suspensions. Both the viscometers are able to measure apparent viscosity as low as one mPa.s (millipascal-seconds) (1 mPa.s = 1 centipoise), which is the approximate room temperature viscosity of water.

Swirl flow characteristics and froth phase features in air-sparged hydrocyclone flotation as revealed by X-ray CT analysis
Das A. & Miller J.D., *International Journal of Mineral Processing*, 1996, 47/3-4 (251-274). In English.
The time-averaged multiphase flow characteristics of air-sparged hydrocyclone flotation have been studied using X-ray computed tomography. Criteria of froth stability and the relationship between froth phase features and flotation response have been established. Quantification of the spatial extent of the different flow regimes has been done in order to characterize the flow behavior during steady-state operation of a nominal 2-inch diameter air-sparged hydrocylone (ASH-2C). The influence of different operating and design variables on multiphase flow characteristics has also been established.

On-line measurement of viscosity and determination of flow types for mineral suspensions
Kawatra S.K. & Bakshi A.K., *International Journal of Mineral Processing*, 1996, 47/3-4 (275-283). In English.
A viscometry system involving a vibrating sphere viscometer and a rotational viscometer has been developed for on-line measurement of viscosity, and for rheological characterization of mineral slurries into either Newtonian or non-Newtonian flows. Both the viscometers were able to measure viscosity as low as one centipoise, which is the approximate room temperature viscosity of water. Ground silica of 80% passing 65 μm size was suspended in water, and was used to prepare slurries at different percent solids. Viscosity of each slurry sample was measured simultaneously by both the viscometers, and the results were compared to determine the rheological characters of the slurries. With this technique, it was found that all the silica slurry samples (up to 70 wt% solids) at the given size distribution were in the Newtonian flow regime.

Some characteristics of air-water two-phase flow in small diameter vertical tubes
Mishima K. & Hibiki T., *International Journal of Multiphase Flow*, 1996, 22/4 (703-712). In English.
Flow regime, void fraction, rise velocity of slug bubbles and frictional pressure loss were measured for air-water flows in capillary tubes with inner diameters in the range from 1 to 4 mm. Although some flow regimes peculiar to capillary tubes were observed in addition to commonly observed ones, overall trends of the boundaries between flow regimes were predicted well by Mishima-Ishii's model. The void fraction was correlated well by the drift flux model with a new equation for the distribution parameter as a function of inner diameter.

A computer based hot-film technique used for flow measurements in a vertical kerosene-water pipe flow
Farrar B. & Bruun H.H., *International Journal of Multiphase Flow*, 1996, 22/4 (733-751). In English.
This paper presents the application of a hot-film anemometer based two-phase flow measurement technique to the investigation of the structure of a vertical pipe flow of a water-kerosene mixture. Experiments were carried out within the bubbly flow, spherical cap bubble and churn flow regimes. The results obtained show that the radial profile of the local volume fraction is uniform at low volumetric quality, β, but becomes wall peaked as β increases. The average oil drop size is uniform across the pipe and independent of β for values of β below 15%, but at higher values the drop size increases in the central region of the pipe.

Design of a flow metering process for two-phase dispersed flows
Boyer C. & Lemonnier H., *International Journal of Multiphase Flow*, 1996, 22/4 (713-732). In English.
This paper describes the methodology used to conceive and size a flowmeter for two-phase dispersed flows. The Venturi having been chosen as the velocity measurement device, focuses on its measurement sensitivity to the velocity slip between the phases at the throat. Among the different two-phase flow models reviewed, an original one has been selected and adapted to predict; velocity and pressure distributions along a Venturi tube with air/water and oil/water flows. Bubble and liquid velocity calculations performed by this model are compared with experimental data to show a good agreement between predicted and measured velocities at the throat.

Experimental study of a two-phase bubbly flow in a flat duct symmetric sudden expansion - part II: liquid and bubble velocities, bubble sizes
Aloui F. & Souhar M., *International Journal of Multiphase Flow*, 1996, 22/5 (849-861). In English.
Experimental results obtained in a gas-liquid bubbly flow in a flat horizontal sudden expansion are presented in this study and constitute useful data for the numerical code. The use of hot film anemometry in the continuous phase (liquid) of a bubbly flow allows a determination of the average and fluctuating velocity. For the dispersed phase, the use of a double optical probe allows the determination of the average and fluctuating axial velocity and the granulometry of the bubbles. A comparison of these quantities with the results obtained by a fast video camera shows very good agreement.

Relation of slug stability to shedding rate
Woods B.D. & Hanratty T.J., *International Journal of Multiphase Flow*, 1996, 22/5 (809-828). In English.

Measurements are presented for the shedding rate of liquid from slugs created by the flow of air and water in a horizontal 0.0953 m pipe at atmospheric conditions. These are used to predict a critical liquid carpet height below which slugs will decay. Of particular interest is the finding that the initiation of the slug flow regime at high gas flows is related to the stability of slugs, rather than the stability of a stratified flow.

Characterization of two-phase flows using fractal analysis of local temperature fluctuations
Kozma R., Kok H., Sakuma M., Djainal D.D. & Kitamura M., *International Journal of Multiphase Flow*, 1996, 22/5 (953-968). In English.

This works deals with the characteristics of two-phase flows based on fractal techniques in order to develop objective flow regime indicators. The fractal dimension of measured time series have been evaluated by Higuchi's method. It is shown that the error of the linear fit of the fractal dimension is a sensitive indicator of the changes in the flow regime, while the fractal dimension value itself is less suitable for flow regime identification. The developed method has been applied to the evaluation of two-phase flow experiments at the SIDAS boiling loop.

Experimental study of a two-phase bubbly flow in a flat duct symmetric sudden expansion - part 1. visualization, pressure and void fraction
Aloui F. & Souhar M., *International Journal of Multiphase Flow*, 1996, 22/4 (651-665). In English.

The present work involves an experimental study of bubble flow in a flat horizontal sudden expansion. This study consists of two parts which are interdependent and complementary. Here in the first part, the qualitative study by visualization shows that the bubble flow changes from a dissymmetric configuration to a symmetric configuration beyond a certain volumetric quality.

A first order relaxation model for the prediction of the local interfacial area density in two-phase flows
Millies M., Drew D.A. & Lahey R.T. Jr, *International Journal of Multiphase Flow*, 1996, 22/6 (1073-1104). In English.

It is the purpose of this paper to present a first order relaxation model which is derived from the Boltzmann transport equation, and which accurately describes the evolution of interfacial area density for bubbly flows. In particular, the local, instantaneous interfacial area densities and volume fractions are predicted for vertical flow of a vapor/liquid bubbly flow involving both bubble clusters and individual bubbles.

An interfacial friction correlation for shell-side vertical two-phase cross-flow past horizontal in-line and staggered tube bundles
Rahman F.H., Gebbie J.G. & Jensen M.K., *International Journal of Multiphase Flow*, 1996, 22/4 (753-766). In English.

A correlation is presented for the interfacial friction factor between the gaseous and liquid phases in vertical two-phase flows past horizontal in-line and staggered tube bundles. The interfacial friction data were determined from pressure drop, void fraction, and mass flux data taken by Dowlati et al. (1990, 1992b) and Schrage et al. (1988). These data were correlated using two non-dimensional quantities: a Reynolds number based on the mixture density and relative velocity between the two phases, and the porosity of the tube bundle.

Two-phase stratified flow splitting at a T-junction with an inclined branch arm
Penmatcha V.R., Ashton P.J. & Shoham O., *International Journal of Multiphase Flow*, 1996, 22/6 (1105-1122). In English.

The objective of this study is to investigate, experimentally and theoretically, two-phase splitting under stratified wavy flow conditions at a regular horizontal T-junction with an inclined branch arm. Experimental data reveals that gravity forces have a significant effect on the flow splitting. For downward inclination of the side arm more liquid is diverted into the branch arm, as compared to the case in which the side arm was horizontal. A mechanistic model has been developed for the prediction of the splitting phenomenon for both the horizontal and the downward orientations of the side arm. The model is based on the momentum equations applied for the separation streamlines of the gas phase and the liquid phase. Very good agreement is observed between the prediction of the model and the data acquired for all the cases.

Large eddy simulation of particle deposition in a vertical turbulent channel flow
Wang Q. & Squires K.D., *International Journal of Multiphase Flow*, 1996, 22/4 (667-683). In English.

The deposition of particles in fully-developed turbulent channel flow has been calculated using large eddy simulation of the incompressible Navier-Stokes equations. Calculations were performed for Reynolds numbers of 11 160 and 79 400 (based on bulk velocity and hydraulic diameter); subgrid-scale stresses were parameterized using the dynamic eddy viscosity model. Particle motion was governed by both drag and lift. The effect of particle-particle interactions as well as modification of the turbulent carrier flow by the particles was neglected.

Bottom bed regimes in a circulating fluidized bed boiler
Svensson A., Johnsson F. & Leckner B., *International Journal of Multiphase Flow*, 1996, 22/6 (1187-1204). In English.

This paper extends previous work on the fluidization regimes of the bottom bed of circulating fluidized bed (CFB) boilers. Pressure measurements were performed to obtain the time-averaged bottom bed voidage and to study the bed pressure fluctuations. Two bubbling regimes were identified: a 'single bubble regime' with large single bubbles present at low fluidization velocities, and, at high fluidization velocities, an 'exploding bubble regime' with bubbles often stretching all the way from the air distributor to the surface of the bottom bed. The exploding bubble regime results in a high through-flow of gas, indirectly seen from the low average voidage of the bottom bed, which is similar to that of a stationary fluidized bed boiler, despite the higher gas velocities in the

CFB boiler. Methods to determine the fluidization velocity at the transition from the single to the exploding bubble regime are proposed and discussed. The transition velocity increases with an increase in particle size and bed height.

An experimental study on developing air-water two-phase flow along a large vertical pipe: effect of air injection method
Ohnuki A. & Akimoto H., *International Journal of Multiphase Flow*, 1996, 22/6 (1143-1154). In English.
The flow structure in a developing air-water two-phase flow was investigated experimentally along a large vertical pipe. Two air injection methods (porous sinter injection and nozzle injection) were adopted to realize an extremely different flow structure in the developing region. No air slugs occupying the flow path were recognized in this experiment regardless of the air injection methods even under the condition where slug flow is realized in the small-scale pipe. In the lower half of the test section, the axial distribution of sectional differential pressure and the radial distribution of local void fraction showed peculiar distributions depending on the air injection methods. However, in the upper half of the test section, the effects of the air injection methods are small in respect of the shapes of the differential pressure distribution and the phase distribution.

Measurements of fluid/particle correlated motion in the far field of an axisymmetric jet
Prevost F., Boree J., Nuglisch H.J. & Charnay G., *International Journal of Multiphase Flow*, 1996, 22/4 (685-701). In English.
Typical features of fluid-particle interaction in the far field of an axisymmetric polydispersed particle laden tube jet were measured and analysed in the present study. Measurements up to 45 jet diameters were obtained by using a phase doppler anemometer. The statistical properties of four particle size classes were obtained in order to cover a wide range of particle relaxation times. The downstream evolution of the mean longitudinal particle velocity field and of the particle radial and longitudinal turbulent components is first displayed. A method is proposed and validated to determine the statistics of the velocity of the fluid seen by the particles.

Determination of the interface curvature in stratified two-phase systems by energy considerations
Brauner N., Rovinsky J. & Moalem Maron D., *International Journal of Multiphase Flow*, 1996, 22/6 (1167-1185). In English.
A configuration of a plane interface between two stratified layers is appropriate for two-phase systems which are dominated by gravity, as is the case for large scale air-water systems under earth gravitation. However, for a general two-fluid system, the basic in situ configuration is stratified layers with a curved interface. Energy considerations are employed to predict the interface configuration. The effect of the fluid physical properties, in situ hold up, tube dimension, wall adhesion and gravitation on the characteristic interface curvature are explored. The prediction of interface curvature provides the closure relation required for a complete solution of stratified flows with curved interfaces for a variety of two-fluid systems.

The application of split-coefficient matrix method to transient two phase flows
Lu D.M., Simpson H.C. & Gilchrist A., *International Journal of Numerical Methods for Heat and Fluid Flow*, 1996, 6/3 (63-76). In English.
An easy-to-use numerical model for transient two-phase pipe flow analyses was developed by applying the split-coefficient matrix method (SCMM) to a homogeneous equilibrium two-phase flow model. Te basic idea of the SCMM is to split the Jacobian coefficient matrix into two sub-vectors, each associated with eigenvalues of the same sign. Hence, one-sided finite difference schemes can accordingly be applied to the sub-vectors. The present model was validated against experiments. It is numerically stable provided that a criterion is met due to the use of a time explicit format.

End of the rope for vortex pressure pulsations
Amini F., *International Water Power and Dam Construction*, 1996, 48/11 (26+28). In English.
The effects of cavitation on the performance and efficiency of hydraulic turbines are examined. Mathematical models are presented for predicting vortex pressure pulsations. The first is a spiral cone cavity model and the other is a partially rolled up vortex model. The effectiveness of the recovery rotating ring, fabricated in a simple manufacturing process, for controlling unwanted pulsations and swirls in draft tubes in Francis turbines is discussed.

A boundary current induced by diffusion near a motionless horizontal cylinder in a continuously stratified fluid
Baidulov V.G. & Chashechkin Yu.D., *Izvestiya - Atmospheric and Oceanic Physics*, 1996, 32/6 (751-756). In English.
The Cauchy problem of the formation of a diffusion-induced boundary layer near a motionless horizontal cylinder in a continuously stratified fluid at rest is solved in the Boussinesq approximation. Asymptotics of the tangential and radial velocities and of the salinity perturbation for short periods are obtained using the Laplace transformation, and conditions of their applicability are determined. The boundary current under formation splits into two sublayers of considerably different thicknesses. Expressions for the circulation and the dynamic vorticity are also obtained.

Hydrodynamic behavior of a binary solids fluidized bed
Bai D., Madusa Y., Nakagawa N. & Kato K., *Journal of Chemical Engineering of Japan*, 1996, 29/2 (211-216). In English.
This paper presents a study on the hydrodynamic behavior of a fluidized bed containing mixtures of solids of different sizes and densities. The transition velocity from bubbling to turbulent fluidization and solids holdup of the dense bed in different fluidization regimes were experimentally determined. The onset velocity to turbulent fluidization was found to increase with increasing fraction of coarse solids. Solids holdups changed dif-

ferently with gas velocity and fraction of coarse particles in bubbling and turbulent fluidization regimes. As a quantitative measure for describing the complexity or the self-affine property of the time series signals, a fractal analysis was introduced and related to the hydrodynamics of the fluidized beds. A correlation to predict the transition velocity of a binary solids fluidized bed was also developed in this paper.

Effect of packed bed on mass transfer in external-loop airlift bubble column
Okada K., Nagata Y. & Akagi Y., *Journal of Chemical Engineering of Japan*, 1996, 29/4 (582-587). In English.
The influence of packed bed set in the riser section on the liquid-side volumetric mass transfer coefficient (K_La_R) in an external-loop airlift bubble column was examined with water, 20 wt% glycerol, 10 wt% ethanol and 0.3 wt% CMC aqueous solutions. Bubble size, bubble rise velocity and gas holdup in the riser were measured to examine the effect of the packed bed using an optical fiber two-phase flow system. The presence of the packed bed in the riser increased the K_La_R values for the liquids used. This was associated with the increase in the specific gas-liquid interfacial area due to bubble breakage by the packed bed. A correlation equation for K_La_R was proposed for both types of airlift bubble columns with and without the packed bed.

Predictions of gas hold-up and liquid velocity in airlift reactors using two-phase flow friction coefficients
Garcia-Calvo E. & Leton P., *Journal of Chemical Technology and Biotechnology*, 1996, 67/4 (388-396). In English.
The overall friction coefficient of airlift reactors was estimated using equivalent lengths and friction factors. The friction factor was calculated taking into account the riser liquid velocity profile corresponding to the two-phase flow and using classical one-phase equations. A previously described model was used to obtain simultaneously both gas hold-up and liquid circulation velocity. The model simulates experimental data obtained in a wide range of configurations of internal and external airlift reactors with Newtonian and non-Newtonian systems.

Computational methods for multiphase flow and reactive transport problems arising in subsurface contaminant remediation
Arbogast T., Bryant S., Dawson C., Saaf F., Chong Wang & Wheeler M., *Journal of Computational and Applied Mathematics*, 1996, 74/1-2 (19-32). In English.
A mathematical formulation and some numerical approximation techniques are described for a system of coupled partial differential and algebraic equations describing multiphase flow, transport and interactions of chemical species in the subsurface. A parallel simulator PARSIM has been developed based on these approximation techniques and is being used to study contaminant remediation strategies. Numerical results for a highly complex geochemistry problem involving strontium disposal in a pit at Oak Ridge National Laboratory are presented.

Influence of particle size, fluidization velocity and relative humidity on fluidized bed electrostatics
Guardiola J., Rojo V. & Ramos G., *Journal of Electrostatics*, 1996, 37/1-2 (1-20). In English.
The influence of particle size, fluidization velocity, and relative humidity on the degree of electrification reached by a fluidized bed of glass beads has been studied. The static electrification of the bed was measured by means of the potential difference observed between an electric probe and the metallic distributor. The effect of relative humidity appears to be complex and is connected with the quality of fluidization existing in the bed. A characteristic curve for electrification vs. humidity has been proposed that consists of five zones. When the value of the relative humidity is lower than a critical value (RH_c), the static electrification of the bed cannot be measured accurately because the adhesion of particles to the probe leads to irreproducible voltage values. The degree of electrification increases with particle size and air velocity. The relationship between the average solid circulation veocity and electrification is studied.

Interaction of single travelling bubbles with the boundary layer and attached cavitation
Chih-Yang Li & Ceccio S.L., *Journal of Fluid Mechanics*, 1996, 322/- (329-353). In English.
Individual travelling cavitation bubbles were examined as they interacted with the flow over a two-dimensional hydrofoil. Each bubble was produced from a single nucleus created upstream of the hydrofoil, and the flow near the hydrofoil was visualized using particle imaging velocimetry (PIV). Travelling bubbles were observed to generate a local region of turbulence as they passed close to an unstable laminar boundary layer. By producing a locally turbulent region, the bubbles could temporarily sweep away a portion of attached cavitation at the foil midchord. Also, the bubbles were observed to strongly interact with a turbulent boundary layer, producing local regions of patch cavitation.

On general transformations and variational principles for the magnetohydrodynamics of ideal fluids. Part 2. Stability criteria for two-dimensional flows
Vladimirov V.A., Moffatt H.K. & Ilin K.I., *Journal of Fluid Mechanics*, 1996, 329/- (187-205). In English.
The techniques developed in Part 1 of the present series are here applied to two-dimensional solutions of the equations governing the magnetohydrodynamics of ideal incompressible fluids. We first demonstrate an isomorphism between such flows and the flow of a stratified fluid subjected to a field of force that we describe as pseudo-gravitational. We then construct a general Casimir as an integral of an arbitrary function of two conserved fields, namely the vector potential of the magnetic field, and the analogous potential of the modified vorticity field.

Concentration waves and the instability of bubbly flows
Lammers J.H. & Biesheuvel A., *Journal of Fluid Mechanics*, 1996, 328/- (67-93). In English.
This paper examines whether G.K. Batchelor's (1988) theory of the propagation of planar concentration disturbances and the occurrence of instabilities in uniform fluidized beds can be applied to bubbly flows. Experi-

ments on the propagation of weak concentration shock waves and small, but finite, amplitude periodic waves are presented; good agreement is found with classic solutions of Burger's equation. Batchelor's instability conditions are given for bubbly flows, and his model for the bulk modulus of elasticity of the dispersed phase is used to obtain estimates of the critical volume concentration at which a uniform bubbly flow becomes unstable to planar disturbances. Observations of the onset of instabilities of bubbly flow in a pipe are described, and compared with what would be expected from Batchelor's theory.

On the motion of laminar wing wakes in a stratified fluid
Spalart P.R., *Journal of Fluid Mechanics*, 1996, 327/- (139-160). In English.
We present numerical solutions for two-dimensional laminar symmetric vortex systems descending in a stable stratified fluid, within the Boussinesq approximation. Three types of flows are considered: I) tight vortices; II) those deriving from an elliptical wing lift distribution; III) those deriving from a 'high-lift' distribution, with a part-span flap on the wing. The descent velocity increases exponentially with time, as the distance between vortices decreases and the circulation of the vortices proper is conserved. With moderate stratification, wakes with sufficient energy also attain the accelerating regime, until the vortex cores make contact. However, they first experience a rebound, which is both of practical importance and out of reach of simple formulas. Type III wakes produce two durable vortex pairs which tumble, and mitigate the buoyancy effect by exchanging fluid with the surroundings.

High-frequency acoustic noise emission excited by laser-driven cavitation
Likhterov L., *Journal of Fluid Mechanics*, 1996, 318/- (77-84). In English.
A high-frequency part of the acoustic noise spectrum excited by laser-driven cavitation in liquid is investigated theoretically. It is assumed that the liquid is inviscid and compressible and the surface tension may be neglected. The specific heat ratio is taken to be 5/3. It is shown that, in the first approximation, the spectral density of the acoustic energy emitted by a cavity explosion varies as the -4/7 power of the frequency and asymptotically decreases by ~ 3.4 dB/octave.

Stability of stratified flow of large depth over finite-amplitude topography
Prasad D., Ramirez J. & Akylas T.R., *Journal of Fluid Mechanics*, 1996, 320/- (369-394). In English.
The flow of a Boussinesq density-stratified fluid of large depth past the algebraic mountain ('Witch of Agnesi') is studied in the hydrostatic limit using the asymptotic theory of Kantzios and Akylas (1993). The upstream conditions are those of constant velocity and Brunt-Vaisala frequency. On the further assumptions that the flow is steady and there is no permanent alteration of the upstream flow conditions (no upstream influence), Long's model (1953) predicts a critical amplitude of the mountain above which local density inversions occur, leading to convective overturning.

The stability of two-phase flow over a swept wing
Coward A.V. & Hall P., *Journal of Fluid Mechanics*, 1996, 329/- (247-273). In English.
We use numerical and asymptotic techniques to study the stability of a two-phase air/water flow above a flat porous plate. This flow is a model of the boundary layer which forms on a yawed cylinder and can be used as a useful approximation to the air flow over swept wings. We also investigate the instability of inviscid stationary modes. We calculate the effective wavenumber and orientation of the stationary disturbance when the fluids have identical physical properties. Using pertubation methods we obtain corrections due to a small stratification in viscosity, thus quantifying the interfacial effects. Our analytical results are in agreement with the numerical solution which we obtain for arbitrary fluid properties.

Experiments on density-gradient anisotropies and scalar dissipation of turbulence in a stably stratified fluid
Thoroddsen S.T. & Van Atta C.W., *Journal of Fluid Mechanics*, 1996, 322/- (383-409). In English.
The anisotropic behaviour of density-gradient fluctuations in stably stratified grid turbulence and the consequences for simplified (isotropic) estimates of scalar dissipation rates χ were experimentally studied in a thermally stratified wind tunnel at moderate Reynolds numbers (Re_λ 20). The correlation method was used to estimate the mean-square cross-stream and streamwise density gradients. Cross-stream gradients were measured using two cold wires. Gradient spectral relations show that this buoyancy-induced anisotropy persists at all length scales. Better closure of the scalar variance balance was attained than in previously reported measurements by other researchers. This is attributed to our use of cold-wire temperature sensors having larger length-to-diameter ratio then used in the previous measurements.

Fluid-structure interaction and cavitation in a single-elbow pipe system
Tijsseling A.S., Vardy A.E. & Fan D., *Journal of Fluids and Structures*, 1996, 10/4 (395-420). In English.
The simultaneous occurrence of fluid-structure interaction (FSI) and vaporous cavitation in the transient vibration of freely suspended horizontal pipe systems is investigated by numerical simulation and physical experiment. Extended waterhammer and beam equations, including the relevant FSI mechanisms, are solved by the method of characteristics. Column separation and cavitation are accounted for by a lumped parameter model.

Localized convection in rotating stratified fluid
Whitehead J.A., Marshall J. & Hufford G.E., *Journal of Geophysical Research*, 1996, 101/C11 (25705-25721). In English.
The convective overturning of a rotating stratified fluid is studied in the laboratory. The experiments are motivated by physical scaling arguments which attempt to predict the length and velocity scales of the convective chimney as it adjusts under gravity and rotation and breaks up through baroclinic instability. In this idealized problem the depth of penetration is found to depend only on the size and strength of the forcing and the

ambient stratification encountered by the convection event; it does not depend explicitly on rotation. The implications of the work to deep water formation in the Labrador Sea and elsewhere are discussed.

Geyser periodicity and the response of geysers to deformation
Ingebritsen S.E. & Rojstaczer S.A., *Journal of Geophysical Research*, 1996, 101 B/10 (21891-21905). In English.
Numerical simulations of multiphase fluid and heat transport through a porous medium define combinations of rock properties and boundary conditions which lead to geyser-like periodic discharge. Within the rather narrow range of conditions that allow geyser-like behavior, eruption frequency and discharge are highly sensitive to the intrinsic permeabilities of the geyser conduit and the surrounding rock matrix, to the relative permeability functions assumed, and to pressure gradients in the matrix. In theory, heat pipes (concomitant upward flow of steam and downward flow of liquid) can exist under similar conditions, but the simulations suggest that the periodic solution is more stable.

Generation of intermediate water vortices in a rotating stratified fluid: laboratory model
Afanasyev Y.D. & Filippov I.A., *Journal of Geophysical Research*, 1996, 101/C8 (18167-18174). In English..
It is hypothesized that a formation mechanism of anticyclonic eddies (lenses) is the outflow of intermediate waters down the canyons of the continental shelf. The horizontal injection of fluid into the rotating stratified surroundings at the equilibrium density level was reproduced in the laboratory. The experiments demonstrate that such an injection forms an anticyclonic eddy. The periphery of the eddy is formed by the jet flow. The main features of the laboratory flow are consistent with those of the 'young' eddy observed recently in the Gulf of Cadiz.

Principles and practice of hydraulic modelling of braided gravel-bed rivers
Young W.J. & Warburton J., *Journal of Hydrology (New Zealand)*, 1996, 35/2 (175-198). In English.
This paper outlines the principles of the hydraulic modelling of braided gravel-bed rivers, describes the practical limitations of this approach and compares model and prototype characteristics. Modelling procedures are based on the principles of hydraulic (dynamic) similarity. Models of braided river systems involve mobile bed modelling of complex two-phase flow. However, restrictions imposed by scaling ratios for gravitational acceleration, fluid viscosity and fluid density make it impossible to achieve full dynamic similarity, except with a length scale of unity. Therefore model experiments use approximate dynamic similarity, which is to be satisfied only requires similarity of relative depth between the model and prototype.

Are pore size distributions in microfiltration membranes measurable by two-phase flow porosimetry?
Zeman L., *Journal of Membrane Science*, 1996, 120/2 (169-185). In English.
The issue of evaluating equivalent pore diameter distributions in membrane microfilters from gas-liquid (g-l) porosimetry data has been critically examined. Experiments performed with one isotropic and one composite anisotropic membrane in both possible orientations revealed conspicuous dependence of the obtained (g-l) porosimetry peaks on imposed pressure ramp rates, ρ. For two experiments, the observed effects of ρ could be reconciled with predictions of the Schlesinger-Bechhold theory. The data obtained with the thin top layer of the composite membrane facing intruding air directly did deviate somewhat from the theory. Pores characterized by (g-l) porosimetry are likely of the 'throat type', and their size distribution is considerably more narrow than that obtained for the 'node-type' pores by SEM-image analysis. A single bivariate distribution function was constructed for these two distinct pore populations.

Gas sparging to enhance permeate flux in ultrafiltration using hollow fibre membranes
Bellara S.R., Cui Z.F. & Pepper D.S., *Journal of Membrane Science*, 1996, 121/2 (175-184). In English.
This study focuses on the use of gas-liquid two-phase crossflow to overcome concentration polarisation in the ultrafiltration of macromolecular solutions as applied to hollow fibre membrane systems. The experimental work was conducted on a purpose built pilot-plant scale rig with albumin and dextran as the test media. The effect of gas injection on the permeate flux and membrane sieving coefficient was examined at different transmembrane pressures, feed concentrations and gas to liquid flow ratios. The results were encouraging, with flux enhancements of 20-50% obtained for dextran and 10-60% for albumin, when air was injected into the system over the range of process variables examined. The sieving coefficient of albumin was considerably reduced when gas-liquid two-phase cross-flow was used.

Prediction of slurry convection in hydraulic fractures
Clark P.E., *Journal of Petroleum Science and Engineering*, 1996, 15/2-4 (389-391). In English.
The possibility of convective transport during hydraulic fracturing is discussed. Earlier experiments led to a complete analysis of the system which resulted in the development of two dimensionless groups that are useful for predicting the importance of convection in slot flow. This paper describes the dimensionless groups for Newtonian and non-Newtonian fluids, and presents evidence that they can be used to describe slurry flow in a slot. Horizontal versus vertical transport of fracturing fluid slurries is dictated by the forces available to drive the flow in each direction (horizontal, F_H and vertical F_V).

Liquid holdup in horizontal two-phase gas-liquid flow
Abdul-Majeed G.H., *Journal of Petroleum Science and Engineering*, 1996, 15/2-4 (271-280). In English.
The purpose of this study was to simplify and improve the mechanistic model developed by Taitel and Dukler (1976) for estimating the liquid holdup in horizontal two-phase flow. An experimental study was first conducted to develop a data bank used for evaluation and improvement. The holdup data were obtained using an air-kerosene mixture flowed through a test section consisting of a horizontal pipe 2-in (50.8 mm) in diameter and 118 ft (36 m) long. The flow patterns observed were stratified, slug and annular. Based on the measured data, it was found that Taitel-Dukler model tends to overestimate liquid holdup for stratified wavy, slug and annular

flow patterns, whereas it tends to underestimate the liquid holdup for stratified smooth flow. An empirical modification, therefore, is proposed which results in a significant improvement in predictions compared to experimental data.

The linear stability and structure of convection in a circular mean shear
Kanak K.M. & Lilly D.K., *Journal of the Atmospheric Sciences*, 1996, 53/18 (2578-2593). In English.
An investigation is made of the linear stability and structure of convection embedded in a mean shear flow with a circular hodograph. This can be considered an extension of Asai's work, but with emphasis on the rotational and helicity features of the disturbances. It also examines the relevance of the Beltrami flow solutions presented previously by Lilly and Davies-Jones, which could not be directly extended to consider the effects of buoyancy. The Boussinesq equations are applied to neutrally and unstably stratified fluids, with emphasis placed on the inviscid solutions. Upper and lower boundary conditions are free slip and rigid. Lateral conditions are periodic, which allows casting the disturbance equations into a horizontally periodic normal-mode structure. The growth rates and disturbance forms are generally fairly similar to the results presented by Asai, except that the most unstable modes are nearly always oriented transverse to the shear component at the channel center. The most rapidly growing modes at small Richardson number are found to be highly helical, with the helicity obtained from the Beltrami mean state. The helicity transfer efficiency and disturbance relative helicity decrease rapidly, however, for negative Richardson numbers greater than about 1.

Numerical simulation of unsteady flow in air-lift pump
Kajishima T. & Saito T., *JSME International Journal, Series B: Fluids and Thermal Engineering*, 1996, 39/3 (525-532). In English.
A numerical method for simulation of unsteady flow in a large-scale air-lift pump, which is the main element of a deep-sea mining system, has been developed. We have proposed an iterative scheme for implicit time marching of density and pressure, and numerically simulated an air-water two-phase flow using a drift-flux model. We describe improvements in the numerical scheme, especially for the convection term. Numerical results for both unsteady and steady-state features show reasonable agreement with the experimental data obtained using an air-lift system of a depth of 200 m.

Experiments on air-water two-phase flow pump impeller with rotating-stationary circular cascades and recirculating flow holes
Furukawa A., Shirasu S. & Sato S., *JSME International Journal, Series B: Fluids and Thermal Engineering*, 1996, 39/3 (575-582). In English.
Gas accumulation and its extension in a centrifugal impeller of a two-phase flow pump cause head degradation. To decrease the head degradation, a special type of impeller has been designed based on the following concepts. The open impeller consists of two stages of rotating and stationary circular cascades with an appropriate number of thin blades for creating a dispersive effect of each cascade inlet for gas-phase flow. The outer rotating cascade has a large blade outlet angle to keep the pump recirculating liquid flows may blow off the gas accumulation region, are equipped in each flow passage. Results are discussed in the present paper with help of visual observation of gas behavior in the impeller flow passage.

Direct numerical simulation for three-dimensional gas-solid two-phase jet using two-way method and experimental verification
Yuu S., Umekage T. & Tabuchi M., *JSME International Journal, Series B: Fluids and Thermal Engineering*, 1996, 39/2 (230-238). In English.
In this study, three-dimensional Eulerian air velocities and Lagrangian particle trajectories are simultaneously calculated to describe the interaction between particles and air using a two-way method. Although the mesh size is roughly seven times the Kolmogorov microscale, the calculated turbulent characteristic of air and particles (mean velocity distributions and turbulent intensity distributions) are in fairly good agreement with experimental data obtained using laser Doppler anemometry. This means that the simulation well describes the motion of large-scale eddies which play an important role in the formation of turbulent gas-solid two-phase flow.

Air-water two-phase flow performance of centrifugal pump impellers with various blade angles
Sato S., Furukawa A. & Takamatsu Y., *JSME International Journal, Series B: Fluids and Thermal Engineering*, 1996, 39/2 (223-229). In English.
Air/water two-phase flow performance of a centrifugal pump was investigated for five kinds of closed impellers, each of which has a different outlet or inlet blade angle. The results showed that sudden pump head degradation due to gas accumulation in the impeller occurs at a lower air flow rate with increasing inlet or outlet blade angle of the impeller and the pump head remains high even under the condition of gas accumulation when the impeller has large blade outlet angle. These results are qualitatively discussed including numerical calculations of one-dimensional two-phase flow.

Dynamics of laser-induced bubble in pressurized liquid nitrogen
Tsubota M., Tomita Y., Shima A. & Kano I., *JSME International Journal, Series B: Fluids and Thermal Engineering*, 1996, 39/2 (257-263). In English.
The dynamics of a laser-induced bubble in liquid nitrogen is studied experimentally. The motion of an almost spherical bubble, formed under appropriate control of optical conditions, is visualized by high-speed photography. Low subcooled liquid nitrogen at 78.0K is used; the resulting high vapor pressure inside a bubble causes motion different from that in water at normal temperatures. Estimation of the cavitation parameter in experi-

ments of liquid nitrogen and water enables us to understand the transition from the motion being heat transfer dominant to that being liquid inertia dominant.

Oxidation of iron powder in a fluidized bed reactor
Bodas M.G., Dash D.R. & Sivaramakrishnan C.S., *Materials and Design*, 1996, 17/3 (167-172). In English.
The potential and technological viability of oxidation of iron powder for the production of higher purity ferric oxide for soft ferrites have been discussed. Results of cold model studies have been incorporated. It has been shown that the conversion of iron powder to ferric oxide is a function of particle size, time and temperature of fluidization.

Non-uniform hydrogen attack cavitation and the role of interaction with creep
Van der Burg M.W.D. & Van der Giessen E., *Materials Science and Engineering A*, 1996, A220/1-2 (200-214). In English.
Hydrogen attack (HA) is the development of grain-boundary porosity by cavities filled with high-pressure methane that originates from the reaction of carbides with hydrogen at high temperatures. The cavities grow by grain-boundary diffusion and by creep of the adjacent grain material till they coalesce with neighbouring cavities to form a microcrack. Here, non-uniform cavitation properties on the grain-size scale are assumed in a polycrystalline aggregate, and unit cell analyses are performed to investigate the influence of the adjacent grains on the development of the grain-boundary HA. The numerical results are explained in terms of two simplified models which highlight the key parameters governing the grain deformation-grain boundary cavitation interaction process.

Microstructure, permeability and mechanical behaviour of ceramic foams
Lopes R.A. & Segadaes A.M., *Materials Science and Engineering A*, 1996, A209/1-2 (149-155). In English.
This work is part of a model study aimed at upgrading the technique of creating porosity via the incorporation of organic particles used in traditional ceramics, exploring at the same time colloidal processing from coagulated slurries. The method described in another work, based on the manipulation of short-range repulsive (lubricating) hydration force and long-range attractive van der Waals force, was used to pack to a high density a bimodal mixture of submicron ceramic particles (matrix) and much larger organic particles (inclusions) during consolidation by pressure filtration of dispersed suspensions coagulated by added electrolyte. Investigations carried out to produce strong porous ceramic bodies, with a tailored pore structure, are described.

Notched behaviour of a silicon carbide particulate reinforced aluminium alloy matrix composite
Ze Weng Huang, McColl I.R. & Harris S.J., *Materials Science and Engineering A*, 1996, A215/1-2 (67-72). In English.
The notched fatigue behaviour of a fine particulate reinforced Al-Cu-Mg (2124) matrix composite is compared with that of an equivalent monolithic alloy (2024), both in the T4 condition. The difference in response of the materials for tensile and fatigue loading is pronounced. Under tensile loading the composite exhibits 'notch weakening' and an almost brittle fracture, while the monolithic alloy shows a degree of 'notch strengthening'. In contrast, under fatigue loading the composite exhibits a much smaller notch sensitivity than that of the monolithic alloy. The notched tensile behaviour of the composite is interpreted in terms of its reduced ductility and susceptibility to cavitation. Conventional notch theory is able to account for the notch sensitivity of the monolithic alloy in fatigue, but not the composite.

Void fraction measurements in gas-liquid flows using capacitance sensors
Elkow K.J. & Rezkallah K.S., *Measurement Science and Technology*, 1996, 7/8 (1153-1163). In English.
Void fraction measurements for vertical flow in a small diameter tube (9.53 mm) were taken using two non-intrusive capacitive void fraction sensors. The sensors were needed to measure the void fraction of water-air two-phase flow under normal gravity and microgravity conditions. Void fraction data were collected with: 1) a sensor having helical wound electrodes that was used to collect data under normal gravity and microgravity conditions, 2) a sensor having concave plate electrodes, used to collect data at normal gravity. This paper covers the calibration results for both sensors and some of the problems associated with the helical wound design. Nonlinearity in the helical sensor is addressed, with improvements shown in the concave plate sensor. Comparisons are made between the capacitive sensors, quick-closing valves and a gamma densitometer.

Particle image velocimetry: simultaneous two-phase flow measurements
Jakobsen M.L., Easson W.J., Greated C.A. & Glass D.H., *Measurement Science and Technology*, 1996, 7/9 (1270-1280). In English.
A method using particle image velocimetry to study pneumatic conveyance of a solid phase is presented. The technology enables simultaneous velocity measurements of both phases by isolating the measurements of each phase. The image processing which implements the phase separation is simple, but has limitations. The method is restricted to low solid densities to avoid a quality drop in the measurements, and cross-talk between measurements of the two phases.

Study optimizes gas lift in Gulf of Suez field
Abdel-Waly A.A., Darwish T.A., Salama A.O. & El-Naggar M., *Oil and Gas Journal*, 1996, 94/26 (38,40-44). In English.
Studies of pressure-volume-temperature (PVT) data combined with fluid and multiphase flow correlations were used to optimise gas lift in oil wells on the Ramadan Field. This article describes this study, production optimisation, and results in detail. PVT data was used to determine the best fluid properties and multiphase flow correlations for calculating pressure losses. This was applied to calculate production tubing pressure losses in each well. Expected production rates were then determined for injected gas rates at various points of injection

(POI). Each well's POI was determined from actual pressure and temperature surveys, and a gas lift performance curve was constructed for each well. The optimal gas lift was determined by comparing actual and optimum operating conditions.

By-pass pig passes test for two-phase pipelines
Wu H.L., Van Spronson G., Klaus E.H. & Stewart D.M., *Oil and Gas Journal,* 1996, 94/42 (73-74,76-77). In English.
A simulation model is presented for the dynamics of a by-pass pig and related two-phase flow behaviour. Results of field trial as of the pig in a dry gas pipeline have shown significant gains in the use of the by-pass pig in modifying gas and liquid production rates. The design and performance of the by-pass pig are described. Field trials carried out in the interfield gas and condensate pipeline in the Maui fields offshore New Zealand are discussed. The field results are compared with predicted data.

Well control model analyzes unsteady state, two-phase flow
Jonggeun Choe & Juvkam-Wold H.C., *Oil and Gas Journal,* 1996, 94/49 (68-72). In English.
This dynamic two-phase well control model accurately analyses fluid kicks based on a realistic assumption of the unsteady state of the two-phase mixture. Changing flow geometry is accounted for by new finite difference equations. The model is applicable to both onshore and offshore wells with water-based muds. This article details the model assumptions, equations in the two-phase and single-phase regions, mathematical models, solution procedures, and numerical problems. The two-phase well control model has been compared with field data, a full-scale rig simulator, and a single-phase model. Results of these comparisons are presented and discussed.

Multiple-correlations improve well pressure-loss calculations
Mawla A.M.A., Darwich T., Sayyouh M.H. & Abdel-Fattah K., *Oil and Gas Journal,* 1996, 94/37 (62-68). In English.
Multiple correlations have been derived for the transition region from bubble to slug regimes in multiphase pipeline flow. The correlations were developed from actual field multiphase flow data points and tested against various pressure-volume-temperature equations. The error analysis of different multiphase flow correlations has been related to the in situ flowing correlations. The applicable ranges of the most widely used correlations have been defined on two-dimensional superficial velocity maps. Programming correlations are discussed. Development of an expert system and master code incorporating the multiphase flow correlations is described. Presure loss calculations have been improved.

(Dianostica acustica della cavitazione nelle pompe centrifughe) (Acoustic diagnosis of cavitation in centrifugal pumps)
Boccazzi A., *Oleodinamica-Penumatica,* 1996, 37/9 (92-95). In Italian.
Cavitation is one of the most common erosive agents and can drastically reduce the life span of machine tools, valves and pumps. The air bubbles which form during cavitation explode and produce noise. This can be used for an acoustic detection of cavitation. Recent results show that the acoustic method allows researches to detect the beginning of cavitation at a much earlier stage than visual methods.

(Vibroakustische und optische Untersuchung der Kavitation bei Axialkolbenmaschinen) (Vibroacoustical and optical investigation of the cavitation in axial piston units)
Kunze T. & Brunner H., *Olhydraulik und Pneumatik,* 1996, 8/- (542-546). In German.
Hydrostatic systems find a wide range of applications in the field of drive technology. Hydraulic systems do however stand in competition with mechanical, electrical and pneumatic drives. Also increasing demands are being made with respect to user comfort, work quality, energy efficiency, ease of maintenance and environmental compatability. For this reason it is crucial to mitigate the drawbacks of hydraulic systems such as noise emission, flow losses, fluid leakages, oscillations in torque and rotary speed and not least cavitation by the use of innovative approaches. With this in mind the present article is concerned in the first place with the problem of cavitation., diskette

Phoenics 2.2
ed CHAM, (Concentration, Heat and Momentum Ltd, London SW19 5AU), *Phoenics 2.2,* 1996. In English.
The Phoenics system is a suite of CFD programs which run on PC 486 and Pentium computers. CFD problems it solves are: steady-state and transient phenomena; zero, 1, 2 or 3 space dimensions; single or two-phase flows; interphase transfer processes and properties; porosities; parabolic or elliptic formulation. You can also look at: laminar and turbulent flows; interacting chemical species; combustion modelling; compressible and incompressible flows; sub, trans and supersonic flows. There is also a post-processor for graphical output of results., index

Photomechanics, contact mechanics and tribology. Proceedings of a conference, Montpellier, July 1996. Volume 4
ed Lagarde A. & Raous M., (American Society of Mechanical Engineers; Petroleum Division, 76), ISBN 0791814998, *Photomechanics, contact mechanics and tribology. Proceedings of a conference, Montpellier, July 1996. Volume 4,* 1996, (217 p.). In English.
The twenty-nine papers included in this volume were presented at the Third Biennial Joint Conference on Engineering Systems Design and Analysis and was organised by the ASME Petroleum Division. Titles of the papers include: contact and thermal analysis of sliding real surfaces; thermal effects and misaligned and starved hydrodynamic thrust bearing; the role of mechanics and physical chemistry in tribological contact life; cavitation in journal bearing using multigrid techniques.

Particle dispersion and deposition in direct numerical and large eddy simulations of vertical pipe flows
Uijttewall W.S.J. & Oliemans R.V.A., *Physics of Fluids*, 1996, 8/10 (2590-2604). In English.
The importance of particle dispersion and deposition in two-phase flows has been well recognized in numerous different fields of research and industry. In this paper the motion of dense particles in a turbulent gas flow is studied by means of numerical simulations. The single-phase turbulent pipe flow was modelled using direct numerical simulation and large eddy simulation. At tube Reynolds numbers of 5300, 18 300 and 42 000 particles with dimensionless relaxation times ranging from 5 to 10^4 were released. Assuming the system to be dilute, the characteristics of particle dispersion, deposition and concentration distribution were studied under various conditions of gravity and lift.

Baroclinic generation of vorticity by an axisymmetric vortex in a linearly stratified fluid; in the passive limit
Thoroddsen S.T. & Van Atta C.W., *Physics of Fluids*, 1996, 8/10 (2774-2776). In English.
The interaction of vorticity and buoyancy forces is of major importance in the study of geophysical flows, since large parts of the ocean and atmosphere are stably density stratified. In this paper we consider analytically the baroclinically generated vorticity that is produced by a stationary axisymmetric vortex that overturns a fluid having an initial linear mean density profile. The instantaneous net production of vorticity due to a point vortex is shown to be proportional to the buoyancy time. These results are valid only for the nondiffusive, passive limit, where the baroclinically produced vorticity is negligible and does not alter the velocity field.

Numerical simulation of particle interactions with wall turbulence
Pan Y. & Banerjee S., *Physics of Fluids*, 1996, 8/10 (2733-2755). In English.
The interaction between particles and turbulent flows provides a research topic of both fundamental importance and practical interest. As aspect in which we are particularly interested relates to effects on heat and mass transfer arising from interactions of particles with wall turbulence. This paper considers the results of a numerical investigation of the effects of near-neutral density solid particles on turbulent liquid flow in a channel. Interactions of particles, in a size range about the dissipative length scale, with wall turbulence have been simulated at low volume fractions. Fluid motion is calculated by directly solving the Navier-Stokes equations by a pseudo-spectral method and resolving all scales of motion.

A round turbulent jet produced by an oscillating diaphragm
James R.D., Jacobs J.W. & Glezer A., *Physics of Fluids*, 1996, 8/9 (2484-2495). In English.
Fluid motion induced by an oscillating boundary or by the transmission of sound (often referred to as acoustic streaming) has been subject of a number of analytical and experimental investigations. In this paper a round turbulent water jet produced normal to, and at the center of a submerged, resonantly driven diaphragm is investigated experimentally. The jet which is formed without mass injection and is comprised entirely of radially entrained fluid, is present only when the excitation amplitude exceeds a given threshold. Above this excitation level, a small cluster of cavitation bubbles appears near the center of the diaphragm. The bubbles grow, apparently collapse, and then disappear during each oscillation cycle.

Role of particle cavitation in rubber-toughened epoxies: 1. Microvoid toughening
Bagheri R. & Pearson R.A., *Polymer*, 1996, 37/20 (4529-4538). In English.
The research described here was undertaken to further elucidate the role of particle cavitation in toughening through comparative examination of epoxies modifed by conventional rubber modifiers and hollow plastic particles. The results of this study illustrate that rubber particles with different cavitation resistance and pre-existing microvoids toughen the present epoxy matrix in the same manner. Therefore, we conclude that the cavitation resistance of the rubbery phase does not directly contribute to toughness, but instead simply allows the matrix to deform by shear.

Multiphase flow: summary paper
Roco M.C., *Powder Technology*, 1996, 88/3 (275-284). In English.
An overview of the contributions made at the Particle Technology Forum in the general context of multiphase flow research is presented. Recent developments in the measuring and computational simulation techniques have made significant inroads in the field. The numerical simulations are more sophisticated and closer to industrial design and applications. Rapidly changing technologies provide support for the non-intrusive instrumentation and on-line technology for two-phase flow. Several open research issues have been identified.

Measurements of solids concentration and axial solids velocity in gas-solid two-phase flows
Nieuwland J.J., Meijer R., Kuipers J.A.M. & Van Swaaij W.P.M., *Powder Technology*, 1996, 87/2 (127-139). In English.
Several techniques reported in the literature for measuring solids concentrations and solids velocity in (dense) gas-solid two-phase flow have been briefly reviewed. An optical measuring system, based on detection of light reflected by the suspended particles, has been developed to measure local solids concentration and local axial solids velocity in dense gas-solid two phase flows. This system has been applied to study hydrodynamics of a cold-flow circulating fluidized bed unit operated in the dense flow regime. With increasing solids mass flux, at constant superficial gas velocity, lateral solids segregation became more pronounced while the radial profiles of axial solids velocity hardly changed. A decrease in superficial gas velocity, at constant solids mass flux, also augmented the lateral solids segregation. The axial solids velocity decreased over the entire tube radius, although the shape of the profiles showed no strong dependence with respect to the superficial gas velocity. Average solids mass fluxes calculated from the measured local values of solids concentration and solids velocity extended the imposed solids mass flux, a finding which could be explained by the downflow observed visually of solid particle close to the tube wall.

Summary paper on fluidization and transport phenomena
Fan L.-S., *Powder Technology*, 1996, 88/3 (245-253). In English.
The papers presented in the sessions on fluidization and transport phenomena cover a wide range of subjects pertaining to fluid-particle systems. Examples of these subjects include bubble coalescence mechanisms, entrainment, pressure effects and chaos in bubbling and turbulent fluidized beds, wave phenomena and cluster structure in circulating fluidized beds, and spectral and fractal characteristics in gas-liquid-solid fluidized beds. In this summary paper, an overview based on these papers is given and salient results are highlighted.

A predictive hydrodynamic model for circulating fluidized bed risers
Pugsley T.S. & Berruti F., *Powder Technology*, 1996, 89/1 (57-69). In English.
A predictive mathematical model, able to characterize and quantify all facets of the time-averaged gas and solids flow structure and properties within circulating fluidized bed (CFB) risers, is proposed. The model can be used as a tool to assess a-priori the operation of a riser and can be easily coupled to kinetic models for process simulation. The model postulates the existence of a core-annulus type of flow structure and is based on both fundamental principles and empirical relationships. The model is successfully vertified against experimental data from CFB units of various sizes and operating under different regimes of fluidization. The model outputs, consisting of axial pressure drop profiles, axial and radial voidage profiles, radial solids velocity and mass flux profiles, average gas velocity and core radius, are compared to existing data and are assessed critically.

Characterization of gas fluidization regimes using pressure fluctuations
Bai D., Shibuya E., Nakagawa N. & Kato K., *Powder Technology*, 1996, 87/2 (105-111). In English.
Flow regimes varying from bubbling fluidization to pneumatic transport were characterized by analyzing the differential pressure fluctuations. Two kinds of particles, typifying those from group A and group B, were employed in the experiments. It is found, under all the operating conditions and at various axial positions, the standard deviation of the differential pressure fluctuations almost coincides, if the solids holdup is the same. For the two particles employed, the dimensionless standard deviations normalized by the maximum standard deviation at U_c showed a unique relationship with the solids holdup, giving a favorable characteristics that allows the determination of the boundaries between the flow regimes of gas-solids fluidization. Based on the experimental results, we find approximate values of: $\epsilon_{sb} > \epsilon_s > 0.35$, for bubbling fluidization; $0.15 < \epsilon_s < 0.35$, for turbulent fluidization; $0.05 < \epsilon_s < 0.15$ for fast fluidization; and $\epsilon_s < 0.05$ for pneumatic transport.

Bed expansion and average bubble rise velocity in a gas-solid fluidized bed
Al-Zahrani A.A. & Daous M.A., *Powder Technology*, 1996, 87/3 (255-257). In English.
A model for bed expansion of a gas-solid fluidized bed is proposed. Bed expansion is found to depend on excess fluidization velocity, and the geometry and physical properties of the bed and the particles. An expression for predicting the average velocity of an isolated bubble in a gas-solid fluidized bed, which is based on the bed expansion model, is also presented. The predictions of the proposed models agree well with experimental measurement.

Novel gas fluidized bed stirred media mill: design and performance of a prototype
Sadler L.Y., Odom J.M. & Hood E., *Powder Technology*, 1996, 89/1 (37-43). In English.
The performance of a prototype novel gas fluidized bed stirred media mill was compared with that of conventional stirred media mills. The gas fluidized bed stirred media mill concept is thought to offer the advantages of reduced viscous dissipation of energy into the suspending fluid, continuous removal of product fines, and comminution in a dry environment. The test results confirm reduced power consumption relative to the liquid suspension stirred media mill. The energy efficiency of the prototype was found to be less than that of the liquid suspension mill, but it was greater than when the mill was operated without liquid suspension or air fluidization. Resources did not permit optimization of the mechanical design or operating conditions of the mill.

Particle granular temperature in gas fluidized beds
Cody G.D., Goldfarb D.J., Storch G.V. Jr & Norris A.N., *Powder Technology*, 1996, 87/3 (211-232). In English.
This paper introduces and validates a novel non-intrusive probe of the average kinetic energy, or granular temperature, of the particles at the wall of a gas fluidized bed. Data is presented on the granular temperature of monodispersed glass spheres which span region B, and extend into region A, of the Geldart powder classification. The underlying physics of the measurement is the acoustic shot noise excitation of the surface of the fluid bed vessel by random particle impact. The concept and calibration of this acoustic shot noise probe is validated in the frequency range 10-20 kHz, through a comprehensive series of laboratory measurements with gasses and cylinders of significantly different acoustic properties. Data is presented on the dependence of the granular temperature on gas flow and particle diameter and on the change in the character of the fluidization transition from first order (hysteretic and discontinuous) to second order (reversible and continuous) for Geldart B glass spheres as the A/B boundary is approached. A striking difference in the dependence of the granular temperature on gas flow between Geldart B and A glass spheres is noted. The vibrational probe was used to study the time dependence of the granular temperature under bed collapse conditions when fluidizing gas is withdrawn rapidly from the system.

Pipeline friction losses of coarse sand slurries. Comparison with a design model
Sundqvist A., Sellgren A. & Addie G., *Powder Technology*, 1996, 89/1 (9-18). In English.
Friction losses in 0.2-0.3 m i.d. pipelines were investigated for three coarse sands with mass median particle sizes of 0.6-0.7 mm and size distributions of 1.4, 5.4 and 27.3, respectively, when expressed in terms of the ratio of particle diameters 85 to 15% by mass finer. The partially-stratified friction loss model proposed by K.C.

Wilson, G.R. Addie and R. Clift, Slurry Transport Using Centrifugal Pumps, Elsevier, Oxford, 1992 predicted the observed friction losses reasonably well at volumetric concentrations of 12-15% for velocities of practical interest. Good agreement was found for concentrations of up to 31% for sand with the intermediate distribution. Friction losses for the broadest sand were overestimated markedly at concentrations of 28-39%. With these two sands, observed losses did not increase linearly with concentration, in disagreement with model assumptions. The different mechanisms involved are discussed in light of results demonstrating how particle size distribution content of particles 0.1-0.5 mm in size, and concentration affect friction losses.

Effect of particle size on the flow properties of a South Australian coal-water slurry
Logos C. & Nguyen Q.D., *Powder Technology*, 1996, 88/1 (55-58). In English.
The rheological behaviour of a low-rank coal-water slurry from Lochiel, South Australia, has been studied as a function of solids concentration, particle size and size distribution. Coal slurries consisting of particles finer than 45 μm suspended in water were found to exhibit a wide spectrum of flow behaviour ranging from Newtonian at low solids concentrations to shear-thinning and viscoplastic with a yield stress at higher concentrations. By adding a narrow-sized coarse coal fraction (208-279 μm) to the fine coal slurry, the flow characteristics of the slurry, at a fixed total solids concentration, could be changed significantly with a substantial reduction in the slurry viscosity. The significant improvement in the rheological behaviour with changing the particle size distribution may be explained in terms of spatial rearrangement of the particles, and an apparent dilution effect. The results obtained in this study indicate that, with a careful control of the particle size distribution, it is possible to prepare an optimum coal-water slurry which has a low viscosity but with high solids loadings.

A pseudo-Stokes representation of the effective drag coefficient for large particles entrained in a turbulent airstream
Littman H., Morgan M.H. III & Paccione J.D., *Powder Technology*, 1996, 87/2 (169-173). In English.
Recently published data by Littman et al., Powder Technol., 77 (1993) 267 and Powder Technol., 84 (1995) 49, for the effective drag coefficient in the vertical pneumatic transport of 1 and 2 mm glass and 190 mm rapeseed particles are represented by the psuedo-Stokes equation, $C_d = 24/Re_{pc}$. The effects of freestream turbulence are represented using Lee's (Int. J. Multiphase Flow, 13 (1987) 247) correlation for the apparent turbulent kinetic viscosity of the fluid felt by the particles in a suspension flow. These results not only confirm that importance of freestream turbulence in lowering the drag coefficient for those particles significantly below that on the standard drag curve but suggest that the turbulence intensities are high enough to largely or completely eliminate the particle wake. These low drag coefficients increase corresponding slip velocities above terminal suggesting that solids residence times in the pipe are much higher than predicted by use of the standard drag curve.

Attrition and changes in particle size distribution of lime sorbents in a circulating fluidized bed absorber
Cook J.L., Soon-Jai Khang, Sang-Kwun Lee & Keener T.C., *Powder Technology*, 1996, 89/1 (1-8). In English.
The attrition data of calcium oxide pellets in a circulating fluidized bed absorber (CFBA) are presented with a modified second-order attrition model incorporating an asymptotic minimum bed weight and an excess gas velocity from the minimum fluidization. Two sizes (903 and 1764 μm) of calcium oxide pellets are fluidized with several superficial gas velocities. The experimental attrition rate constants obtained from the attrition model are used to fit a modified Arrhenius equation, with a pseudo activation energy term potential to the excess fluidizing energy. The model with the measured rate constants for single-particle size is used to predict the changes in size distribution in a bed with a mixture of various particle sizes.

Particle-particle interactions in concentrated dispersions as probed by the capillary force balance with application to batch sedimentation
Nikolov A.D. & Wasan D.T., *Powder Technology*, 1996, 88/3 (299-304). In English.
A novel capillary force balance technique in conjunction with differential interferometry was used to measure quantitatively the dynamic stability of micro- and macrostructures due to the interaction between coarse and fine particles in concentrated dispersions. Using this technique, the values of threshold capillary pressures or yield stress for both fine and coarse particles are reported for the first time. The measured values of the threshold capillary pressures were then used to predict the batch sedimentation rates of particles in a concentrated suspension.

What is turbulent fluidization?
Rhodes M., *Powder Technology*, 1996, 88/1 (3-14). In English.
Recent literature relating to turbulent fluidization is reviewed and earlier literature reassessed in the light of present knowledge in an attempt to resolve the confusion and controversy surrounding the subject. There is mounting evidence and support for the view that the velocity U_k at which the amplitude of bed pressure fluctuations levels off heralds the onset of dilute transport, as suggested by Rhodes and Geldart, rather than the onset of the turbulent fluidization regime as proposed by Yerushalmi and co-workers. There is also now considerable agreement that the velocity U_c, at which the amplitude of bed pressure fluctuations is maximum, marks the beginning of a regime of transition from bubbling or slugging to transport. This transition regime is now widely referred to as the turbulent fludization regime.

Effect of inclination on liquid-solid fluidized beds
Hudson C., Briens C.L. & Prakash A., *Powder Technology*, 1996, 89/2 (101-113). In English.
Conductivity and salt tracer measurements provided both the local holdup and the circulation pattern of the liquid and solid phases in vertical and inclined liquid-solid fluidized beds. The local liquid velocity was obtained from the local liquid holdup and the local particle-liquid heat transfer coefficients. The box counting fractal dimension of the conductivity signal provided accurate detection of local and overall fluidization of the liquid-

solid bed. Segregation of a lower density tracer particle could be avoided at low liquid velocity by inclining the bed, thus, limiting power consumption of the pump and particle attrition. A simple model was developed to obtain the solid circulation pattern.

Fluidization regimes
Mooson Kwauk & Jinghai Li, *Powder Technology*, 1996, 87/3 (193-202). In English.
In recent years much has been discussed regarding fluidization regimes, but most of the deliberations have been concerned with gas/solid (G/S) systems. Furthermore, designations of terminologies, such as phases, regions and regimes are far from being standardized. The present paper proposes a generalized scheme for regimizing fluidized systems, be they gas/solid (G/S) or liquid/solid (L/S), inclusive of the influences of the operating variables, and the physical properties of the particles and the fluid. The proposed scheme will be presented in conceptual terms and more or less in the chronological sequence of our growing understanding of fluidization.

Calculation of optic fibres calibration curves for the measurement of solids volume fractions in multiphase flows
Amos G., Rhodes M.J. & Benkreira H., *Powder Technology*, 1996, 88/2 (107-121). In English.
A model that calculates calibration curves (probe response functions) of reflection type optical probes for the measurement of solids volume fractions is presented. The reflection from a single surface is calculated from a relaxed inverse square law to allow the introduction of the effects of multiple reflections that occur in the cavities of rough surfaces, represented as an assembly of spherical particles. The probe response function is then calculated as the summation of the reflections of several successive surfaces with corrections for obscuration. The probe response function obtained agrees reasonably well with experiments using aqueous suspensions of aluminium hydroxide particles, with a surface volume mean diameters of 75 and 20 μm.

Effects of bed particle size on heat transfer in circulating fluidized bed boilers
Andersson B.-A., *Powder Technology*, 1996, 87/3 (239-248). In English.
Local values of heat transfer to membrane walls of a circulating fluidized bed (CFB) boiler were measured for three sizes of the same silica sand, with mean diameters of 0.22, 0.34 and 0.44 mm. A change from 0.44 to 0.22 mm sand at constant fluidization velocity led to a considerable increase in particle concentration and, hence, heat transfer. However, at a given cross-sectional average bulk density, the average heat transfer coefficient across the membrane wall was insensitive to the changes of bed particle size. Also, the lateral distribution of heat flow, to the crest and side of the tube and to the fin, was independent of particle size when the bulk densities were similar. This was achieved by keeping constant the ratio of fluidization velocity to terminal velocity of a single average size particle. It was possible to estimate the vertical distribution of the heat transfer coefficient of the CFB furnace with an accuracy of $\pm 20\%$ by a simple semi-empirical method.

Latest pump advances embody new drives, bearings, alloys
O'Keefe W., *Power*, 1996, 140/6 (71-77). In English.
New developments in boiler-feed pumps are described. These are: (i) an advanced Russian hydraulic-turbine-drive circulating pump; (2) a new magnetic bearing for powerplant pumps developed by BW/IP International Inc.; (3) a remedy for the long-term cavitation problems of high-energy first-stage impellers using a new corrosion-resistant alloy, X-Cavalloy from Ingersoll-Dresser Pump Co.

Pressure surges and fluid transients in pipelines and open channels. Proceedings of an international conference, Harrogate, April 1996
ed Boldy A., (Mechanical Engineering Publications Ltd), ISBN 0852989911, *Pressure surges and fluid transients in pipelines and open channels. Proceedings of an international conference, Harrogate, April 1996*, 1996, (638 p.). In English.
These proceedings deal with all aspects of fluid transients and pressure surges in a variety of industries. Analytically, the topic is a somewhat specialized field, but is one whose concepts are widely applied in petroleum, environmental, chemical, civil, mechanical, and many other areas of engineering. Subjects covered include: petrochemicals; multiphase flows; pipeline systems; fluid structure interaction; hydraulic machinery; free surface flows., index

Proceedings of the ASME heat transfer division. Proceedings of a conference, Atlanta, November 1996. Volume 3
Cheung F.B., Yang B.W., Riznic J.R., Seyed-Yagoobi J., Hassan Y.A., Kim J.H., Paolucci S., Kihm K.D. & Oosthuizen P.H., (American Society of Mechanical Engineers; HTD, 334), ISBN 0791815218, *Proceedings of the ASME heat transfer division. Proceedings of a conference, Atlanta, Novermber 1996. Volume 3*, 1996, (428 p.). In English.
The fifty papers contained in this volume were presented at the 1996 International Mechanical Engineering Congress and Exposition. They are divided into four sections which are entitled as follows: experimental studies in multiphase flow; multiphase flow in porous media; experimental multiphase flows and numerical simulation of two-phase flows; fundamental aspects of experimental methods. Each section is begun with an introduction to the subject area.

Profit through synergy. Proceedings of a conference, Calgary, November 1996
SPE, (Society of Petroleum Engineers), *Profit through synergy. Proceedings of a conference, Calgary, November 1996*, 1996, (972 p.). In English.
This volume includes ninety papers which were presented at the 2nd International Three-Day Conference and Trade Show on Horizontal Well Technology. Titles include: performance of longitudinally fractured horizontal wells in high-permeability anisotropic formations; well plugging operations in West of Shetland; hor-

izontal wells using coiled tubing techniques; calculation and design of flow parameters for two-phase flow in aerated drilling; challenges with jointed pipe underbalanced operations; a multiply-fractured horizontal well in a rectangular drainage region and characterization and prevention of formation damage during horizontal drilling.

Modelling the turbulent flow of non-Newtonian slurries
Slatter P.T., *R-and-D Journal*, 1996, 12/2 (68-80). In English.
The only reliable approach open to designers of pipeline systems conveying non-Newtonian slurries in the turbulent flow regime has been large scale pipe tests. This paper addresses this design problem, with particular emphasis on the theoretical modelling of the turbulent flow behaviour of these slurries in pipes. The literature and theory pertinent to the flow of slurries in pipes is examined. A new model for the prediction of the turbulent energy gradient is developed from widely accepted fundamentals. A particle roughness effect has been observed and turbulent flow is modelled using a new roughness Reynolds number to correlate the roughness function. Turbulent flow predictions using the new turbulent model are accurate and better than previous models, particularly in the rough wall region.

A new model for the dispersion of droplets and particles in turbulent two-phase flows
Elsden M. & Hutchinson P., *Revue - Institut Francais du Petrole*, 1996, 51/2 (291-300). In English.
Two-phase flows are important in many industrial situations from combustion applications to the pharmaceutical trade. These flows are generally very complex consisting of two, or more, distinct phases interacting with each other in many different ways. Many types of model have been developed in order to attempt to predict the behaviour of these flows while remaining trackable computationally. The following work falls into two distinct sections; namely the Lagrangian calculation of droplet diffusion coefficients and the solution of the Eulerian equations for both phases.

Study on some kinematic characteristics of sediment laden flow
Chen Deming & Chen Jiayang, *Shuili Xuebao/Journal of Hydraulic Engineering*, 1996, 12/- (49-55). In Chinese.
In this paper the sediment-laden flow is regarded as a stratified flow in atmosphere due to the temperature gradient. Based on the shear stress balance equation the expression of velocity distribution in the vicinity of the wall is deduced. By using this expression the mixing length, momentum exchange coefficient and turbulence intensity along the depth can be obtained.

Study on cavitation and energy properties of developed cascades near Francis runner band
Wang Zhengwei, Qu Lunfu & Tan Yuecan, *Shuili Xuebao/Journal of Hydraulic Engineering*, 1996, 10/- (39-45,50). In Chinese.
This paper studies the remedial measures for Francis runner (HL220-LJ-410) installed in Zhexi Water Power Station. The energy property and cavitation characteristic of the cascade are studied in water tunnel and 2-d boundary element method based calculation. The energy and cavitation properties of the HL220 turbine are improved. The detailed experiment and calculation results of three sets of cascades are presented in this paper.

Numerical modelling of solid-liquid two-phase turbulent flow and wear
Liu Xiaobing & Cheng Liangjun, *Shuili Xuebao/Journal of Hydraulic Engineering*, 1996, 11/- (20-27). In Chinese.
A two-equation K-ϵ turbulent model has been developed for predicting solid-liquid two-phase flows based on the two-fluid model. The continuity, the momentum, K and ϵ equations are modeled. In this model, the solid-liquid slip velocity, the interactions of particle-particle and particle-fluid are considered. By using this turbulence model and the wear model, the solid-liquid turbulent flows and the wear rate of the wall caused by solid particles suspended in a turbulent flow can be predicted. As an example the wear rate of a hydraulic turbine gate vane has been numerically predicted. The result shows that good agreement is attained.

A optimum design method for hydraulic turbine runners
Luo Xingqi, Liang Wuke, Chen Naixiang, Peng Guoyi & Lin Ruchang, *Shuili Xuebao/Journal of Hydraulic Engineering*, 1996, 10/- (32-38). In Chinese.
By taking the hydraulic losses of the runner and the cavitation factor of the blade as the objective function, an optimum method for multivariable is developed in this paper. The optimization results show that the hydraulic performances of the runner can be improved.

Computer simulation predicts unfavorable mud rate and optimum air injection rate for aerated mud drilling
Boyun Guo, Hareland G. & Rajtar J., *SPE Drilling and Completion*, 1996, 11/2 (61-66). In English.
The importance of maintaining adequate air and mud flow rates is generally recognized in aerated drilling operations. However, it remains unclear to drilling operators as to what constitutes an 'adequate flow rate'. On the basis of computer simulation, this paper discusses carrying capacity of an aerated mud and the optimum air-injection rate that ensures a maximum penetration rate. It is found that the carrying capacity of an aerated mud is very different from that of both the conventional mud and pure air. There is an unfavorable range of mud flow rate that provides lower carrying capacity of the aerated fluid for a given air injection rate. As a unique characteristic of multiphase flow, there exists an air injection rate that gives the lowest flowing annulus presssure for a given well geometry and a mud rate. By considering both the carrying capacity and flowing annulus pressure, an optimum combination of mud and air rates an be determined.

A review of hydraulics in fluidized-bed biological filters
Summerfelt S.T. & Cleasby J.L., *Transactions - American Society of Agricultural Engineers*, 1996, 39/3 (1161-1173). In English.

Fluidized sand-beds are efficient and cost-effective methods for biological treatment within recirculating aquaculture systems. This article summarizes and applies techniques developed in other disciplines for calculating fluidization hydraulics, based solely upon characteristics of the granular medium, for the purpose of designing biological fluidized-bed units for use in recycle aquaculture. Solutions to fluidization calculations are presented as simplified curves useful for sensitivity analysis for optimizing unit design. This article also discusses the characteristics which make a medium suitable for use in nitrifying fluidized beds in aquaculture, design criteria for proper distribution of water at the bottom of the fluidized bed, and special issues involving fluidization hydraulics and the application of fluidized beds to aquaculture.

Two-phase air/oil flow in aero engine bearing chambers: characterization of oil film flows
Glahn A. & Wittig S., *Transactions - ASME: Journal of Engineering for Gas Turbines and Power*, 1996, 118/3 (578-583). In English.

For the design of secondary air and lubrication oil systems, a sufficient knowledge of two-phase flow and heat transfer phenomena under bearing chamber flow conditions is required. The characterization of oil film flows at the bearing chamber walls is one of the major tasks for a better understanding of these processes and, therefore, a necessity for improvements of the efficiency of aero engines. Utilizing a fiber-optic LDV setup, measurements of oil film velocity profiles have been performed in our high-speed bearing chamber rig simulating real engine conditions. All data have been compared with different theoretical approaches, which have been derived from a force balance at a liquid film element, including geometric conditions and temperature dependent fluid properties, and by approaches for the eddy viscosity available in the literature.

Mechanism and effects of predominant parameters regarding limitation of falling water in vertical countercurrent two-phase flow
Sudo Y., *Transactions - ASME: Journal of Heat Transfer*, 1996, 118/3 (715-724). In English.

In this study, an investigation was carried out to clarify the mechanism of countercurrent flow limitation (CCFL) or flooding, that is, limitations in the falling water mass flux in countercurrent two-phase flow in vertical channels, and to identify the effects or predominant parameters regarding CCFL, adopting the criterion that the CCFL condition be given by an envelope of momentum equation applied for the entire length of the channel with respect to any void fraction. As a result, it was found that the analytical model proposed could adequately predict all existing experimental results investigated in this study.

In search of two-phase flow
Hewitt G.F., *Transactions - ASME: Journal of Heat Transfer*, 1996, 118/3 (518-527). In English.

The objective of this paper is to take an overview of progress in the search for knowledge in two-phase flow over the past three and half decades, and to try to draw conclusions about future directions from this historical perspective. Rather than to try to cover the whole range of possible topics, two have been selected for examination, namely flooding and disturbance waves in annular flow.

A Fickian diffusion model for the spreading of liquid plumes infiltrating in heterogeneous media
Pruess K., *Transport in Porous Media*, 1996, 24/1 (1-33). In English.

Infiltration of water and non-aqueous phase liquids (NAPLs) in the vadose zone gives rise to complex two- and three-phase immiscible displacement processes. Physical and numerical experiments have shown that ever-present small-scale heterogeneities will cause a lateral broadening of the descending liquid plumes. This behavior of liquid plumes infiltrating in the vadose zone may be similar to the familiar transversal dispersion of solute plumes in single-phase flow. Noting this analogy we introduce a mathematical model for phase dispersion in multiphase flow as a Fickian diffusion process.

Determination of permeability tensors for two-phase flow in homogeneous porous media: theory
Lasseux D., Quintard M. & Whitaker S., *Transport in Porous Media*, 1996, 24/2 (107-137). In English.

This paper continues previous studies of the closure problem for two-phase flow in homogeneous porous media, and shows how the closure problem can be transformed to a pair of Stokes-like boundary-value problems in terms of pressures that have units of length and velocities that have units of length squares. To determine the geometry associated with the closure problem, one needs to solve the physical problem; however, the closure problem can be solved using the same algorithm used to solve the physical problem, thus the entire procedure can be accomplished with a single numerical code.

Experimental determination of the flow transport coefficients in the coupled equations of two-phase flow in porous media
Dullien F.A.L. & Dong M., *Transport in Porous Media*, 1996, 25/1 (97-120). In English.

The transport coefficients in the coupled equations of two-phase flow are defined if the pressure gradient in one of the two flowing fluids is equal to zero. This definition has been used in experiments with oil and water in a sandpack and the four transport coefficients have been measured over wide water saturation ranges. The values of the cross coefficients were found to be significant as they ranged from 10 to 35% of the value of the effective permeability to water and from 5 to 15% of the effective permeability to oil, respectively.

Pore-scale network model for drainage-dominated three-phase flow in porous media
Pereira G.G., Pinczewski W.V., Chan D.Y.C., Paterson L. & Oren P.E., *Transport in Porous Media*, 1996, 24/2 (167-201). In English.

Drainage displacements in three-phase flow under strongly wetting conditions are completely described by a simple generalisation of well understood two-phase drainage mechanisms. As in two-phase flow, the sequence of throat invasions in three-phase flow is determined by fluid connectivity and threshold capillary pressure for the invading interface. A three phase, two-dimensional network model based on the pore-scale fluid distribu-

tions and displacement mechanisms reported by Oren et al. and which accounts for flow through both wetting and intermediate fluid films is shown to correctly predict all the important characteristics of three-phase flow observed in glass micromodel experiments.

Porosity variations in saline media caused by temperature gradients coupled to multiphase flow and dissolution/precipitation
Olivella S., Carrera J., Gens A. & Alonso E.E., *Transport in Porous Media*, 1996, 25/1 (1-25). In English.
This paper presents a theoretical-numerical investigation of porosity variations induced by temperature gradients in unsaturated saline media. It is known that temperature variations cause humidity variations which lead to liquid flow towards and vapour flow away from the hot source. When this phenomenon occurs in saline media, the liquid is salt saturated brine, so that evaporation causes salt precipitation and an ensuing porosity reduction. This process may be important in the case of heat generating waste because it suggests that selfsealing may take place near the waste.

Abrasion resistance of carbon cathode materials at room temperature
Xianan Liao & Oye H.A., *Tribologia: Finnish Journal of Tribology*, 1996, 15/3 (3-34). In English.
A test equipment similar to a slurry erosion pot tester was designed to study the abrasion of carbon cathode materials by alumina slurries at room temperature. The alumina was suspended in a heavy liquid-sodium polytungstate aqueous solution (SPT). Effects of test time, specimen velocity and solid concentration of the slurry were studied. The wear is mainly caused by sliding contact. This mechanism is different from that in an erosion test. The lower velocity range and higher concentration range employed in the present study are attributed to the difference. Various carbon cathode materials were ranked against CS graphite which was used as the standard.

Effect of lubricant supply starvation on the thermohydrodynamic performance of a journal bearing
Vijayaraghavan D., Keith T.G. Jr & Brewe D.E., *Tribology Transactions*, 1996, 39/3 (645-653). In English.
With judicious selection of supply groove location for journal bearings, the lubricant supply rate and power loss can be considerably reduced without sacrificing the load-carrying capacity. In addition, the lubricant supply rate can further be reduced, either accidentally or deliberately, and the applied load may still be maintained. In this parametric study, the effects of reduced lubricant supply rate compared to the flooded inlet is studied for an axial-grooved journal bearing. Cavitation effects in the fluid film are taken into account and a full THD model, including heat conduction to the metal surfaces, is included in the analysis. Performance parameters at various load values due to reduced supply rate and typical temperature distributions are presented. It is found that, it may be possible to operate the bearing with as much as 70% reduction in lubricant supply rate.

Surface roughness effects in journal bearings with non-Newtonian lubricants
Wang-Long Li, Cheng-I Weng & Jang-I Lue, *Tribology Transactions*, 1996, 39/4 (819-826). In English.
The static performance of finite journal bearings lubricated with non-Newtonian power law fluids is analyzed by using a control volume method with an Elrod algorithm to solve the average Reynolds equation and determine the cavitation region accurately. The results show that the flow behavior index of power law fluids has an insignificant effect on the load ratios, side flow ratios and cavitation regions, while it significantly affects load capacities and side flow rates. Furthermore, the effects of film thickness ratios, pressure flow factors, shear flow factors, slenderness ratios, eccentricities and inlet pressures on the variations of cavitation regions are also discussed.

Two-dimensional piston ring lubrication - part II: elastic ring consideration
Qingmin Yang & Keith T.G. Jr, *Tribology Transactions*, 1996, 39/4 (870-880). In English.
A two-dimensional analysis for piston ring lubrication is presented by considering elastic deflection, EHL and cavitation effects. A numerical procedure is developed for solving hydrodynamic pressure and oil film thickness shape due to ring deflection and elastic deformation. An elliptic cylinder liner and elastic ring are considered to investigate the circumferential flow effect which has been ignored in previous studied. Results for a typical automotive engine demonstrates that the elastic deflection and deformation of the piston ring have a tendency to reduce the gap caused by the noncircular cylinder. The two-dimensional analysis presented also reveals a reduction of piston ring oil film thickness due to the circumferential flow compared to one-dimensional analysis.

Two-dimensional piston ring lubrication - part I. rigid ring and liner solution
Qingmin Yang & Keith T.G. Jr, *Tribology Transactions*, 1996, 39/4 (757-768). In English.
A two-dimensional elastohydrodynamic cavitation algorithm is developed for piston ring lubrication. The nonlinear governing equation derived from the Reynolds equation to include cavitation and elastohydrodynamics is linearized for numerical efficiency. An elliptic cylinder liner and rigid ring are considered to investigate circumferencial flow effects which have been ignored in previous studies. The hydrodynamic pressure distribution and film thickness at various crank angles are determined. Results for a typical automotive engine show that the elliptic liner causes a dramatic drop in the hydrodynamic pressure and reduces the film thickness. It is found that the pressure reformation effect cannot be neglected when the piston ring moves away from the top dead center.

The turbulent flow of non-Newtonian slurries in pipes
Slatter P.T., *Vodohospodarsky Casopis/Journal of Hydrology and Hydromechanics*, 1996, 44/1 (24-38). In English.
Large quantities of solid material are transported hydraulically as non-Newtonian slurries in many industries. The theoretical models of Torrance and Wilson and Thomas for predicting the turbulent flow behaviour from

the rheology of the slurry are used as a comparison. A data base of pipe line test results over extensive ranges of both the laminar and turbulent regimes was compiled for the evaluation of turbulent flow models. A new model for the prediction of turbulent flow behaviour is developed from widely accepted fundamentals. A particle roughness effect has been discovered and the turbulent flow is modelled using a new roughness Reynolds number to correlate the particle roughness effect. The new model is evaluated and validated using the test data base and is shown to be better in describing the behaviour of these slurries.

Some aspects of steam-water flow critical stage in the development of geothermal fields
Shulyupin A.N., *Volcanology and Seismology*, 1996, 18/2 (187-194). In English.
The critical stage of steam-water flow is considered as a condition for the theorem of momentum being independent of pressure gradient. A mechanism is proposed for the effect of a local critical stage influencing the flow structure. Several models are tested to obtain analytical relations for the flow velocity. Critical stages can arise in local flows that move at velocities common for two-phase flows in geothermal fields. Local supercritical flows can exist at the vents of steam-water discharge. This affects the behavior of the upward flow; the actual velocities averaged over the cross-section may exceed the calculated values.

Filtration characteristics of hollow fiber microfiltration membranes used in membrane bioreactor for domestic wastewater treatment
Shimizu Y., Okuno Y., Uryu K., Ohtsubo S. & Watanabe A., *Water Research*, 1996, 30/10 (2385-2392). In English.
Cross-flow microfiltration using submerged membrane with air bubbling can provide a continuous solid-liquid separation system by simple equipment, such as a low-rate suction pump, an air blower and a vessel. In this system, the size of the separation module could be reduced by using hollow fiber membranes packed in high density. In order to apply this beneficial process to a wastewater treatment bioreactor, we constructed filtration models to design the membrane system. Higher transmembrane pressure and lower fluidity of feed operations (eg transmembrane pressure of over 40 kPa and air-liquid two phase flow velocity, u*, of under 0.5 $m.s^{-1}$) caused the rapid crowding of hollow-fiber membrane elements and reduced the effective membrane surface area. We defined the conditions that the hollow fiber membrane module packed in high density could be applied for solid-liquid separation.

A functional relationship between capillary pressure, saturation, and interfacial area as revealed by a pore-scale network model
Reeves P.C. & Celia M.A., *Water Resources Research*, 1996, 32/8 (2345-2358). In English.
The constitutive relationships required for the parameterization of multiphase flow and transport problems are of critical importance to hydrologic modeling. Recently, a hypothesis has been developed that predicts a functional relationship between capillary pressure, saturation, and interfacial area. A network model was developed to test this hypothesis. Microscale physical processes were simulated and volume averaging was used to derive the macroscopic measures of saturation and fluid-fluid interfacial area per volume of porous media. Results indicate that a smooth, though complex, functional relationship exists at the continuum scale.

The influence of mass transfer characteristics and porous media heterogeneity on nonaqueous phase dissolution
Mayer A.S. & Miller C.T., *Water Resources Research*, 1996, 32/6 (1551-1567). In English.
A two-dimensional multiphase flow and species transport model was developed and applied to the case of nonaqueous phase liquid (NAPL) emplacement and dissolution in both homogeneous and heterogeneous porous media systems. Simulations were performed to observe dissolution rate variations and the degree of NAPL-aqueous phase nonequilibrium as a function of two aqueous phase velocities and five forms of the NAPL-aqeuous phase mass transfer formulation. An integrated form of the Damkohler number was introduced to analyze the degree of NAPL-aqueous phase nonequilibrium. Results illustrate the importance of the statistical characteristics of heterogeneous porous media on NAPL distribution and dissolution processes.

Abrasive wear of aluminium composites - a review
Deuis R.L., Subramanian C. & Yellup J.M., *Wear*, 1996, 201/1-2 (132-144). In English.
Aluminium-silicon alloys and aluminium-based metal-matrix composites (MMCs) containing hard particles offer superior operating performance and resistance to wear. In industrial processes where abrasive slurries are transported by rotating paddles or impellers, elements fabricated from MMC materials provide higher abrasive resistance and therefore a longer service life compared to those made from iron or nickel-based alloys. Composites characterized by a hardness greater than the abrasive particles and a reinforement phase of high fractures toughness and low mean free path, compared to the abrasive grit dimension, exhibit high abrasive wear resistance. Studies related to abrasive wear of Al-Si alloys and aluminium-based MMCs that contain discontinuous reinforcement phases are reviewed.

Fiber-optic pressure sensors detect cavitation and flow instabilities in centrifugal pumps
Perez R.X., Akins R.A., Lee C.E. & Taylor H.F., *World Pumps*, 1996, 359/- (28-33). In English.
A vibration monitoring program is a common means of protecting mechanical equipment from catastrophic failures. For critical pumps, handling highly flammable or toxic fluids, prudent operation also requires users to monitor pressure pulsations as a means of ensuring proper hydraulic operation and preventing flow related mechanical failures.

The Sweepax pumping system
World Pumps, 1996, 363/- (28-31). In English.
The 1851 patent for the centrifugal pump, registered by John Gwynne, contains all the main elements of a

modern single stage or multistage barrel pump so there is not much new in centrifugal pumping. The Sweepax approach tackles a very specific problem in a very specific market with an original solution. It consists of three stages in series: a centripetal stage, an axial inducer and a centrifugal stage. This is to pump slurries and waste products with such high concentrations of solids in suspension that they do not flow naturally into the pump.

Multiplex process diaphragm pump meets industry demands for flexibility
World Pumps, 1996, 362/- (30-32). In English.
Traditionally, demanding and hazardous processing operations have involved the use of fixed stroke positive displacement reciprocating pumps, such as the triplex type as well as multi-stage and high speed centrifugal pumps. However, these contain inherent limitations particularly in respect of sealing and high operation costs. Leak-free and energy efficient high volume pumping of aggressive and dangerous liquids, slurries and suspensions can now be achieved by using a new concept of process pump, the 'Novaplex' developed by Bran + Luebbe.

Waves and nonlinear processes in hydrodynamics
Grue J., Gjevik B. & Weber J.E., (Kluwer; Fluid Mechanics and its Applications, 34), ISBN (HARDBACK) 0 7923 40, 1996. In English.
Waves and Nonlinear Processes in Hydrodynamics contains thirty-one papers by international experts in hydrodynamics based on talks at a symposium held in honour of Professor Enok Palm on his 70th birthday. The volume begins with two review papers on the history of hydrodynamic research at the University of Oslo and on engineering applications of hydrodynamics in the offshore industry. It continues with recent developments in marine hydrodynamics, nonlinear wave-diffraction, wave drift damping, nonlinear wave theory, breaking of waves, effect of surface tension on wave motion, nonlinear stability, thermal convection, turbulence stratified flows, particle drift and dispersion, self-organization, damping of waves in kelp forests and ocean modelling. (Publisher)

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Heat transfer. Transactions of a conference, UK, September 1995
ANON, (Mechanical Engineering Publications Ltd, for Institution of Mechanical Engineers; IMechE Conference Transactions 1995 - 2), ISBN (HARDBACK) 0 85298 9, 1996. In English.
The selection of refereed papers included in this book are primarily concerned with ongoing work and the latest advances in heat transfer. These transactions address the key areas of: radiation and combustion; convection; conduction; two-phase flow and condensation; boiling; numerical techniques and modelling; heat exchangers and heat transfer augmentation; and applied heat transfer and measurement. (from Publisher)

Annual review of fluid mechanics. Volume 28
Lumley J.L., Van Dyke M. & Reed H.L., (Annual Reviews Inc, Palo Alto), ISBN (HARDBACK) 0 8243 07, 1996. In English.
This volume begins with a review of the Vth Volta Congress and continues by including thirteen papers entitled as follows: numerical models for two-phase turbulent flows; new trends in large-eddy simulations of turbulence; vorticity, free surface, and surfactants; fully elastic instabilities of multiphase flow in porous media; modelling of the oceanic general circulation; computations of nonlinear free-surface flows; the role of surface-wave breaking in air-sea interaction; fluid phenomena in scramjet combustion systems; the fluid dynamics of parachute inflation; linear instability theory applied to boundary layers; atmospheric lee waves; vortex dynamics in the cylinder wake. (A.Slowey)

Axisymmetric thermophoresis of multiple aerosol spheres
Shih Chen H. & Huan Keh J., *Aerosol Science & Technology*, 1996, 24/1 (21-35). In English.
A semianalytical study of the thermophoretic motion of a finite chain of aerosol spheres along the line through their centers is presented. The spheres may differ in radius, thermally conductivity, and in surface properties, and they are allowed to be unequally spaced. Also, the spheres can be either freely suspended in the gaseous medium or connected by infinitesimally thin rods. The Knudsen numbers are assumed to be small so that the fluid flow is described by a continuum model with a thermal creep and a hydrodynamic slip at the particle surfaces. Through the use of a boundary-collocation method, a set of energy and momentum equations governing this problem is solved in the quasisteady limit and the interaction effects are computed for various cases. For the thermophoretic motion of two-sphere systems, the numerical results for the particle velocities agree very well with the exact calculations using spherical bipolar coordinates. For the cases of two or three spheres touching one another, the numerical solutions for the particle interaction parameters compare quite favorably with the formulas derived analytically. (from Authors)

Particle reentrainment from a fine powder layer in a turbulent air flow
Matsusaka S. & Masuda H., *Aerosol Science & Technology*, 1996, 24/2 (69-84). In English.
Particle reentrainment from a fine powder layer was investigated both in a steady-state flow and in an unsteady-state (accelerated) flow. Experiments were conducted in a rectangular channel, where a powder layer of fly ash was placed. Microscopic observation showed that small aggregates were reentrained randomly from the surface of the powder layer, and then the reentrainment gradually progressed through the depth of the powder layer. Through these processes, surface renewal of the powder occurred. The experimental results also showed that the distribution of adhesive strength (wall shear stress) was approximated by a log-normal distribution. Further, the time-delay of the reentrainment was found to be represented by two simple exponential functions with different time constant. A new reentrainment model is presented to explain the time-dependence of the reentrainment flux, which is based on the adhesive strength distribution, surface renewal of the powder layer, and the time-delay of the reentrainment. (from Authors)

Simulations of particle dynamics in a confined shear flow
Chang E.J. & Kailasanath K., *AIAA Journal*, 1996, 34/6 (1160-1166). In English.
The dynamic behavior of particles injected into the high-speed shear flow in the confined geometry of an axisymmetric dump combustor is studied computationally using the flux-corrected transport algorithm and a Lagrangian approach to track particles in the flow. Dispersion of the particles is found to be optimal at Stokes numbers on the order of unity when particles that have been deposited on the combustor walls are neglected. Further analysis shows that it is the shedding frequency that governs the dispersion, even at downstream locations where the first merging frequency governs the fluid flow. This property is observed for all particle sizes studied except for cases at very low Stokes numbers, where the merging frequency, as well as the frequency obtained by combining the merging and shedding frequencies, is observed. A correlation between particle size and flow vorticity is also obtained and shows that high concentrations of particles can be associated with high vorticity for small particles, whereas the opposite is true for intermediate to large sized particles. (from Authors)

Dusty shock flow with unstructured adaptive finite elements and parcels
Sivier S., Loth E., Baum J. & Lohner R., *AIAA Journal*, 1996, 34/5 (1078-1080). In English.
When solving the compressible two-phase equations, the gas as a continuum is best represented by an Eulerian description. The particles (or droplets), however, may be modeled by either an Eulerian description, or a Lagrangian description. Herein, the former will be referred to as an Eulerian-Eulerian (E-E) treatment, whereas the latter will be defined as an Eulerian-Lagrangian (E-L) treatment. This research seeks a comparative study between these two approaches when coupled with a dynamically adaptive unstructured finite element method with a novel parcel adaptive technique. The objective of the present study was to formulate and develop an E-L method with an adaptive grid FEM-FCT flow solver that is computationally efficient. This method was used to predict a particle laden shock wave attenuation as a test case and to compare performance characteristics (computation speed, memory, and accuracy) with an E-E implementation that also includes adaptive unstructured grids. (from Authors)

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Network simulation of steady-state two-phase flow in consolidated porous media
Constantinides G.N. & Payatakes A.C., *AIChE Journal*, 1996, 42/2 (369-382). In English.
A computer-aided simulator of steady-state two-phase flow in consolidated porous media is developed. The porous medium is modeled as a 3-D pore network of suitably shaped and randomly sized unit cells of the constricted-tube type. The problem of two-phase flow is solved using the network approach. The mean ganglion size and fraction of the nonwetting phase in the form of stranded ganglia are studied as functions of the main dimensionless parameters. Fractional flows and relative permeabilities are determined and correlated with flow phenomena at pore level. Effects of the wetting phase saturation, the viscosity ratio, the capillary number, and the coalescence factor on relative permeabilities are examined. (from Authors)

Fluidization characteristics of biobone particles used for biocatalysts
Ellis N., Margaritis A., Briens C.L. & Bergougnou M.A., *AIChE Journal*, 1996, 42/1 (87-95). In English.
Liquid-solid fluidization characteristics of irregularly shaped Biobone particles were studied in a fluidized bioreactor column. The Biobone is a natural cheap material composed of collogen embedded with microcrystals of hydroxyapatite and calcium phosphate, and it is an excellent matrix of commercial importance used for the immobilization of enzymes, whole cells and other biocatalysts. Fluidization characteristics of Biobone particles, which include measurements of pressure drops, holdups, minimum fluidization velocities, particle entrainment, and residence time distributions at different water superficial velocities, are reported. (from Authors)

Gas-solid mass transfer in a jetloop reactor
Moller K.P. & O'Connor C.T., *AIChE Journal*, 1996, 42/4 (1187-1190). In English.
This article presents results of a study of the mass-transfer rates in a new internal recycle rector, the jetloop reactor (JLR) as proposed by Luft. The residence time studies in this reactor have shown that it behaves as a well-mixed reactor, with recycle ratios easily exceeding the minimum value of 20 required for CSTR behavior. In this system, however, the influence of mass-transfer rate on the reaction rate cannot be determined by varying the impeller speed, as the recycle ratio is dependent on the flow rate and must therefore be measured independently. The objective of this work was to symmetrically investigate the effect of particle size and flow rate on the mass-transfer rates to catalyst particles with a view to using this reactor for kinetic studies. (from Authors)

Gas-solid and gas-liquid mass-transfer coefficients
Dudukovic A., Milosevic V. & Pjanovic R., *AICHe Journal*, 1996, 42/1 (269-270). In English.
In 1934 Gilliland and Sherwood presented the data on the rates of vaporization of nine liquids into air in a wetted-wall column, in order to test the analogy of Colburn (1930). The results obtained were interpreted as gas-solid transport and correlated by: $Sh = 0.023\,Re^{0.83}\,Sc^{0.44}$. However, some of the texts also offer an alternative relation: $Sh = 0.023Re^{0.83}\,Sc^{0.33}$ as a general equation for turbulent mass transfer in pipes for both gases and liquids. (from Authors)

Wavy-to-slug flow transition in slightly inclined gas-liquid pipe flow
Grolman E., Commandeur N.C.J., De Baat E.C. & Fortuin J.M.H., *AIChE Journal*, 1996, 42/4 (901-909). In English.
A process-engineering model is presented for the stratified-wavy-to-intermittent (SW-I) flow-pattern transition in slightly inclined gas-liquid pipe flow. The main parameter for predicting (in)stability of wavy flow in inclined pipes is the average liquid holdup, which was found to reach a maximum, critical value at flow-pattern transition. Observed values of the critical liquid holdup vary between 0.07 and 0.42, depending on pipe diameter, angle of inclination and transport properties of the gas-liquid system. Flow-pattern maps are presented for selected angles of inclination, showing excellent agreement between predicted and observed flow-pattern boundaries. (from Authors)

Fickian diffusion in binary mixtures that form two liquid phases
Pertler M., Blass E. & Stevens G.W., *AIChE Journal*, 1996, 42/4 (910-920). In English.
New data on the variation of the diffusion coefficient with concentration in binary nonideal liquid mixtures are presented. The diffusion coefficients were measured with laser holography with an improved analysis procedure and are primarily in systems that form two liquid phases. The results show that for such systems the diffusion coefficient is constant if a chemical-potential driving force is used. If, however, the miscibility gap is wide, the Schreiner equations (Schreiner, 1922) is shown to be more accurate than relations that consider the variation of viscosity. Cluster theories developed for diffusion behavior near critical points were found to explain the data only in water-organic systems on the water-rich side. (Authors)

Permeability of gigaporous particles
Pfeiffer J.F., Chen J.C. & Hsu J.T., *AIChE Journal*, 1996, 42/4 (932-939). In English.
The volumetric flow rate of liquid and gas through small gigaporous particles was measured by a new method that isolates single particles in a test apparatus. High-performance liquid chromatography particles from 30 to 50 mum in diameter, previously reported to exhibit convection-enhanced intraparticle mass transfer, were studied. Using a CFD model of the test system, the permeability of individual particles was determined from the pressure-drop-flow-rate relationship. The results of this study might imply that the intraparticle structure does not behave like a bed of uniformly packed microspheres, but rather as an inhomogeneous assemblage of microparticles. The measured permeability values offer the possibility of developing better models of the intraparticle flow field under normal operating conditions. (from Authors)

Modelling two-phase flows using CFD
Lun I., Calay R.K. & Holdo A.E., *Applied Energy*, 1996, 53/3 (299-314). In English.
Two-phase flows are encountered in a wide range of industrial and natural situations. Due to their complexity such flows have been investigated only analytically and experimentally. New computing facilities provide the flexibility to construct computational models that are easily adapted to a wide variety of physical conditions without constructing a large-scale prototype or expensive test rigs. But there is an inherent uncertainty in the numerical predictions due to stability, convergence and accuracy. The importance of a well-placed mesh is highlighted in the modelling of two-phase flows in horizontal pipelines. (Authors)

Airflow through beds of cereal grains
De Ville A. & Smith E.A., *Applied Mathematical Modelling*, 1996, 20/4 (283-289). In English.
The equations used to model the flow of air through beds of cereal grains become nonlinear when the resistance to flow is a function of the velocity of the air. An analytical solution to this problem is obtained for the case where the flow is predominantly in one direction. The problem is defined in terms of a parameter epsilon which for typical cereal grains has values in the range of 0.02-1.0. A perturbation expansion in terms of epsilon is used to obtain a weakly nonlinear solution to flow problem. The solution is valid for small epsilon and this corresponds to small grains and low air velocity. The solution is used to study the effect of the nonlinearity on the flow pattern. A numerical method is used to extend the solution to larger values of epsilon, and this confirms the general effect of the nonlinear term on the airflow pattern which was determined by the analytical solution. (Authors)

Numerical computation of free boundary problems in elastohydrodynamic lubrication
Durany J., Garcia G. & Vazquez C., *Applied Mathematical Modelling*, 1996, 20/2 (104-113). In English.
An alternative algorithm has been developed for computing the behavior of thin fluid films in two elastohydrodynamic lubrication problems. The presence of elasticity, lubrication, and cavitation leads to a nonlinear coupled system of partial differential equations. A numerical method decoupling the hydrodynamic part of the problem and the elastic one is presented. This method also involves an upwind scheme to discretize the lubrication model and finite element approximations. (from Authors)

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Thermal effects on flow and dispersion over urban areas: capabilities for prediction by physical modeling
Cermak J.E., *Atmospheric Environment*, 1996, 30/3 (393-401). In English.
Criteria for physical modeling of urban area heating and thermally stratified, boundary-layer flows approaching the area are summarized. Flow modeling facilities, boundary-layer tunnels and a natural convection chamber, developed at Colorado State University that can satisfy the essential criteria are described. Three categories of studies are summarized to illustrate the range of capabilities for physical modeling of flow and dispersion over urban areas: (1) idealized heat island, (2) heat island for a particular urban complex, and (3) mountain-valley drainage flow onto a town. Model data are compared with available field measurements and observations. (Author)

Transition to turbulent fluidization in a binary solids fluidized bed
Bai D., Masuda Y., Nakagawa N. & Kato K., *Canadian Journal of Chemical Engineering*, 1996, 74/1 (58-62). In English.
This paper presents a study on the transition velocity from bubbling to turbulent fluidization in a binary solids fluidized bed. Experiments were carried out with two kinds of binary solids mixtures with FCC as fine particles and silica sands as coarse particles. The onset velocity to turbulent fluidization, U_c, determined by the measurement of pressure fluctuations, was found to increase with increasing the fraction of coarse/heavy solids. (from Authors)

Analyzing the effectiveness of an intake compensator for a piston mud pump
Itkis Ya. M. & Sotnikov O.A., *Chemical & Petroleum Engineering*, 1995/96, 31/5-6 (243-247; translated from: Khimicheskoe i Neftyanoe Mashinostroenie, 5, 1995, pp 2-5). In English.
A mathematical procedure is given for calculating the effectiveness of an intake compensator for a piston mud pump. The intake compensator of a piston pump increases the suction head and decreases the possibility of cavitation caused by decreased inertial losses in the inlet pipe. The procedure can be applied to both cylindrical and conical compensators. (P.M.Taylor)

Vent & flare systems - the problem
Selwa R. & Reid A., *Chemical Engineer*, 1996, 607/- (24-26). In English.
Reviews papers presented at a recent workshop in Aberdeen on offshore vent and flare systems. Nine papers were presented, each providing examples of key issues in the design and operation of relief and blowdown systems. They covered the following topics: operating experience of onshore gas plant and offshore platform flare systems; risk based decision; reducing atmospheric emissions; two-phase flow conditions via depressurisation systems design; high-pressure relief and process flaring incident on a pressure relief sizing; gas flaring radiation and noise effects; and minimising relief loads via dynamic simulation during design. (J.M.McLaughlin)

Particles as prizes
Cleaver J. & Taylor T., *Chemical Engineer*, 1996, 609/- (28-30). In English.
Advances in research in particle technology and their contributions to process engineering are discussed. The nature of single particle interactions is vital knowledge for the discrete element modelling approach. Positron emission particle tracking and positron emission tomography are being used in particle flow visualization. The positron emission particle tracking technique is described. It is being applied to a range of particle technology operations including mixing, gravity-driven flows, and agglomeration. (A.Peters)

A review of some parameters involved in fluidized bed bioreactors
Wright P.C. & Raper J.A., *Chemical Engineering & Technology*, 1996, 19/1 (50-64). In English.
Three-phase fluidized bed bioreactors have advantages over conventional chemical reaction systems. There is a lack of agreement over most major operational conditions, and a wide range of design variables are open to question. A large body of recent work in the field has been reviewed, with a degree of historical comparison and discussion. It has been found that aspects of fluidized bed biofilm reactors of vital importance include: choice of solid media, gas and liquid loadings, bacterial type and reactor mechanical design. A large proportion of the

work in the field of three-phase fluidization is non-biologically specific, or not tested on a bacterially inoculated system. (from Authors)

Experimental study of turbulent bubbly shear flows: group multiphase flows and group interfaces
Lance M., 7 others & et al., *Chemical Engineering Communications*, 1996, 141-142/- (51-70). In English.
This paper summarizes a set of experiments on bubbly shear flows. Homogeneous shear flows, plane mixing layer, boundary layer on a flat plate and sudden area expansion have been investigated, for low and moderate void fraction. Measurements of mean liquid velocity show that the main features of the corresponding single phase flow are conserved, in particular self-similarity of the mean velocity profiles. However, the turbulent field is strongly modified. The transverse interfacial momentum transfer has been evaluated, and proves to be dominated by instantaneous local forces, which are not usually taken into account in eulerian models. (Authors)

Bubble and slug flow at microgravity conditions: state of knowledge and open questions
Colin C., Fabre J. & McQuillen J., *Chemical Engineering Communications*, 1996, 141-142/- (155-173). In English.
Based on the experiments carried out over the past decade at microgravity conditions, an overview of current knowledge of bubbly and slug flows is presented. The transition from bubble to slug flow, the void fraction and the pressure drop are discussed from the data collected in the literature. The transition from bubble to slug flow may be predicted by introducing a critical void fraction that depends on the fluid properties and the pipe diameter: however, the role of coalescence which controls this transition is not clearly understood. The void fraction may be accurately calculated using a drift-flux model: it is shown from local measurements that the drift of the gas with respect to the mixture is due to the non uniform radial distribution of void fraction. The pressure drop happens to be controlled by the liquid flow for bubbly flow whereas for slug flow the experimental results show that pressure drops is larger than expected. The guidelines for future research in microgravity are given. (Authors)

Two-phase flow pressure change across sudden expansions in duct areas
Schmidt J. & Friedel L., *Chemical Engineering Communications*, 1996, 141-142/- (175-190). In English.
A new model to calculate the two-phase flow pressure change across a expansion in a duct area was developed and checked against data measured with mixtures of air and water, aqueous glycerol, watery calcium nitrate and with refrigerant R12. In the model all relevant physical parameters are included and, in contrast to equations in the literature, the entrainment of liquid in the gas stream is considered. The predictions are validated for a wide range of conditions, pipe diameters and physical properties typically encountered in industrial pipe line systems. Calculations based on this new approach are sufficiently accurate for engineering purposes. (Authors)

Dryout of water film on a heated tube surface caused by an obstruction in a boiling two-phase vertical upward flow
Fukano T., Goto A., Tsurusaki Y. & Morooka S., *Chemical Engineering Communications*, 1996, 141-142/- (191-206). In English.
One of the restriction in the thermal design of the safe and economic nuclear reactor, especially in BWR is pointed out to be the heat removal from the fuel rods supporting spacer. The purpose of the present paper is to investigate the mechanism of the water film breakdown which results in the burnout of heating tube near the spacer under various flow pattern. The experimental results show that the film breakdown occurs near the leading edge, ie., just below the spacer, as well as the inside of the down part of the gap between the heating tube and the spacer. (Authors)

Dynamic slug tracking simulations for gas-liquid flow in pipelines
Nydal O.J. & Banerjee S., *Chemical Engineering Communications*, 1996, 141-142/- (13-39). In English.
A Lagrangian slug tracking model for dynamic gas-liquid slug flow in pipelines of varying inclinations has been formulated and implemented in C + + using an object-oriented approach. The flow parameters are determined from dynamic integral mass and momentum balances on each slug and bubble. Slugs and bubbles are initiated at the pipe inlet, or at low points along a pipeline, and the propagation of individual slugs are tracked dynamically, and without numerical diffusion. Some sample cases demonstrate how the structure of the flow can be followed as it evolves from terrain effects, expansion and wake effects. These are effects that may in some instances cause slugs to disappear and merging of bubbles during simulations. Terrain slugging computatations compare well with some experimental data. (from Authors)

Disperse phase stress in two-phase flow
Prosperetti A. & Zhang D.Z., *Chemical Engineering Communications*, 1996, 141-142/- (387-398). In English.
The usual two-fluid models for disperse two-phase flows feature an average disperse-phase stress in the disperse-phase momentum equation. It is shown that it is possible to derive an expression for this quantity without considering the detailed nature of the constitutive relation to the disperse phase. The result, which is more general than other relations of the same nature, is illustrated with a number of examples. It is also shown that a new formation of the averaged equations recently proposed by the authors is equivalent to the more usual one. (Authors)

Stratified three phase flow in pipes - stability and transition
Barnea D. & Taitel Y., *Chemical Engineering Communications*, 1996, 141-142/- (443-460). In English.
The stability of stratified three phase flow (water-oil-gas) was analyzed using two approaches. A straight forward Kelvin-Helmholtz stability analysis on the two interfaces termed here the 'exact' approach and a simplified approach. In the 'exact' approach the two interfaces (water-oil and oil-gas) are perturbed, while

in the simplified approach the perturbed interface is only the upper oil-gas interface. Both approaches include the viscous Kelvin-Helmholtz analysis in which the shear stresses are taken into account and the inviscid KH analysis where the shear stresses are neglected. Comparison with some experimental results suggests that the simplified method is a better predictor of the transition from stratified flow than the 'exact' approach, suggesting, perhaps, that the stability analysis on the upper interface alone is preferred. (Authors)

Interfacial interactions and secondary flows in stratified two-phase flow
Line A., Masbernat L. & Soualmia A., *Chemical Engineering Communications*, 1996, 141-142/- (303-329). In English.

In this paper are analyzed the interactions between a surface wave field and the kinematic structures above and below the waves, in gas-liquid stratified flow in a rectangular cross sectional channel. The analysis is based on experimental data both on the local structure of the flows and on the deformation of the gas-liquid surface. The basic phenomena that have been observed are: on the one hand, the wave that propagates over the liquid surface can exhibit a crosswise distribution of amplitude; on the other hand, secondary flows can be generated both in the gas and in the liquid. A theoretical attempt is developed to explain the distribution to wave amplitude; in fact, the waves propagate over a non uniform liquid current. The physical mechanisms which are based on the analysis of experimental results are also validated with numerical simulations. (from Authors)

A proposal for treatment of turbulent mixing in a two-phase subchannel flow
Sato Y., Kawahara A. & Sadatomi M., *Chemical Engineering Communications*, 1996, 141-142/- (399-413). In English.

A practical method for the treatment of turbulent mixing rate in a two-phase subchannel flow in a hydrodynamic non-equilibrium state is proposed. Based on the assumption that the fundamental modes of the inter-subchannel fluid transfer in such a state are turbulent mixing, void drift, and diversion cross flow, the turbulent mixing rate is considered to be equal to that in the hydrodynamic equilibrium state that the flow will attain. The applicability of the method is examined by experiments concerning the axial variation in tracer concentration in a non-equilibrium flow without diversion cross flow. A good agreement is seen between the calculations and the measurements. (Authors)

Turbulent flow in a pipe with intermittent rough patches: an analogue of annular two-phase flow
Jayanti S., Kandlbinder T. & Hewitt G.F., *Chemical Engineering Communications*, 1996, 141-142/- (237-259). In English.

The response of turbulent pipe flow to sudden changes in wall roughness and flow cross-sectional area has been studied experimentally and numerically. Changes typical of those encountered by the gas phase in annular gas-liquid flow have been considered. The results show that the flow field and the pressure field can be significantly distorted at these transitions. Good agreement has been obtained between the measured results and those calculated using the Harwell-FLOW3D computational fluid dynamics (CFD) code. (Authors)

On the different forms of momentum equations and on the intra-and interphase interaction in the hydromechanics of a monodispersed mixture
Nigmatulin R.I., Lahey Jr R.T. & Drew D.A., *Chemical Engineering Communications*, 1996, 141-142/- (287-302). In English.

Many different forms of the phasic conservation equations of two-phase flows have been presented in the literature. Unfortunately, there is still a lot of controversy as to 'best' form for two-fluid modeling. In addition, while there have been many attempts to constitute the intraphase and interfacial closure laws to achieve closure, ill-posed models are still the rule rather than the exception. The purpose of the paper is to show how various popular forms of the two-fluid model are related, and to summarize the current state-of-the-art in the modeling of interfacial and intraphase closure laws. Moreover, new closure laws are proposed which attempt to account for the effect of dispersed phase (ie., inter-particle) interactions. It is hoped that this paper will help stimulate multiphase flow researchers to redouble this effort to achieve accurate, properly closed, two-fluid models which can used for the mechanistic predictions of multidimensional two-phase flows. (Authors)

Shear and interfacial instabilities of oil-water flow in an inclined channel
Tilley B.S., Bankoff S.G. & Davis S.H., *Chemical Engineering Communications*, 1996, 141-142/- (41-49). In English.

A study of the linear stability of a laminar flow of an oil-water system in an inclined channel is presented. A novel shear-mode of instability, which is necessarily decaying in plane Poiseuille flow, is found to be the primary instability in certain situations. When the channel is sufficiently inclined, the long-wave mode can become unstable, regardless of the total volumetric flow rate of the fluids. The consequences to oil transport are discussed. (Authors)

Experimental study of turbulent bubbly shear flows: group multiphase flows and group interfaces
Lance M., 7 others & et al., *Chemical Engineering Communications*, 1996, 141-142/- (51-70). In English.

This paper summarizes a set of experiments on bubbly shear flows. Homogeneous shear flows, plane mixing layer, boundary layer on a flat plate and sudden area expansion have been investigated, for low and moderate void fraction. Measurements of mean liquid velocity show that the main features of the corresponding single phase flow are conserved, in particular self-similarity of the mean velocity profiles. However, the turbulent field is strongly modified. The transverse interfacial momentum transfer has been evaluated, and proves to be dominated by instantaneous local forces, which are not usually taken into account in eulerian models. (Authors)

Shear and interfacial instabilities of oil-water flow in an inclined channel
Tilley B.S., Bankoff S.G. & Davis S.H., *Chemical Engineering Communications*, 1996, 141-142/- (41-49). In English.
A study of the linear stability of a laminar flow of an oil-water system in an inclined channel is presented. A novel shear-mode of instability, which is necessarily decaying in plane Poiseuille flow, is found to be the primary instability in certain situations. When the channel is sufficiently inclined, the long-wave mode can become unstable, regardless of the total volumetric flow rate of the fluids. The consequences to oil transport are discussed. (Authors)

Analytical solution for laminar-laminar two-phase stratified flow in circular conduits
Brauner N., Rovinsky J. & Maron D.M., *Chemical Engineering Communications*, 1996, 141-142/- (103-143). In English.
Many attempts made in modelling stratified two-phase flow for predicting the operational flow characteristics (pressure drop, holdup etc) assume mostly plane interface between the phases. Obviously, the interaction between the stratified layers and the resulting flow characteristics may be significantly affected by the configuration of the interface. Moreover, complete analytical solutions for stratified flows in circular conduits are not yet available even for laminar flows with plane interface and most of the previous studies resort to average two-fluid modelling. The present study presents analytical solutions for laminar stratified two-phase flows in pipes with plane and curved interfaces. (Authors)

Liquid-solid mass transfer in packed beds of Raschig rings with upward two-phase (gas-liquid) flow
Sedahmed G.H., El-Kayar A.M., Farag H.A. & Noseir S.A., *Chemical Engineering Journal*, 1996, 62/1 (61-65). In English.
The effect of upward two-phase bubbly gas-liquid flow on the rate of liquid-solid mass transfer in fixed beds of Raschig rings were studied by measuring the rate of diffusion-controlled dissolution of a bed of copper Raschig rings in acidified chromate solution. Variables studied were gas flow rate, liquid flow rate, physical properties of the solution and Raschig ring diameter. (from Authors)

Added mass effects in two-phase solid/liquid media
Mahgerefteh H. & Khodaverdian A., *Chemical Engineering Research & Design*, 1996, 74/A2 (272-280). In English.
The results of a series of studies are reported in which the added mass experienced by a 25 mm sphere oscillating in two-phase systems consisting of bonded spheres in various liquid media is measured in a variety of configurations using a remote drive vibrating reed technique. The arrangements considered investigate the effects of surface roughness and bed voidage together with variations in fluid density and viscosity expressed in terms of the Stokes number in the range of 4.5-110. The results are then correlated in terms of simple mathematical expressions for the subsequent prediction of added mass as a function of the above parameters. (Authors)

Effects of non-Newtonian fluid and porous medium parameters on two-phase flow in porous media
Chiu T.W., Wakeman R.J., Harris P.R. & Meuric O.F.J., *Chemical Engineering Research & Design*, 1996, 74/A2 (220-238). In English.
This paper describes a three-dimensional finite element method for modelling two-phase non-Newtonian flows using the power law to describe the non-Newtonian behaviour of the non-wetting and/or the wetting fluid. The fluids can be either dilatant or a pseudoplastic. The porous medium may be anisotropic and the permeability may be a function of distance in any of the three orthogonal directions. The porosity of the medium may also be defined as a function of the spacial coordinate system. The first application illustrated is the one-dimensional displacement of a non-wetting fluid by a wetting fluid in a isotropic porous medium. (from Authors)

The design and operation of oil-gas production separator desanding systems
Priestman G.H., Tippetts J.R. & Dick D.R., *Chemical Engineering Research & Design*, 1996, 74/A2 (166-176). In English.
Details are given of extensive tests done to study the design and operation of desanding systems for oil-gas production separators. Sand and water are used in vessels of diameter between 0.9 m and 2.7 m. The use of non-dimensional groups, representing solids volume, wash time and wash jet momentum, permits generic scaling of the data. The fluidization factor, F, is defined which is found, for a given solid, to have a critical optimum value, higher values implying unnecessarily excessive washing and lower values less than optimum solids removal. The increase in critical F found between sand and Proppant appeared to be mainly due to increased particle size. Specific recommendations are made regarding wash jet design and deployment, and spacing and design of drain points and the use of discrete baffled wash zones. (from Authors)

Heat transfer to walls of a circulating fluidized-bed furnace
Basu P. & Nag P.K., *Chemical Engineering Science*, 1996, 51/1 (1-26). In English.
A critical review of information on heat transfer between the furnace and enclosing walls of a circulating fluidized-bed boiler is presented. A good understanding of the heat transfer process was impeded for some time by a lack of detailed information about the hydrodynamics of fast fluidization. With improvement in the understanding of the furnace hydrodynamics a clear picture of the heat transfer process is also emerging. Several mechanistic models for the heat transfer process exist and the surface renewal model explains the observed phenomenon most faithfully. (from Authors)

Monitoring the fluidization characteristics of polyolefin resin using X-ray computer assisted tomography scanning
Kantzas A. & Kalogerakis N., *Chemical Engineering Science*, 1996, 51/10 (1979-1990). In English.

Flow visualization of chemical reactor phenomena was given a new direction with the implementation of process tomography techniques. In this study, the fluidization characteristics of a series of commercially available LLDPE, HDPE and IPP resins were investigated. The experiments were run in a small column of 10 cm in diameter and variable bed heights. The fluidization velocities were varied between one and three times the minimum fluidization velocity of each sample. The particle size distribution varied from very narrow mesh sizes to full particle sphericity. This paper describes the various categories of voidage distributions observed and provides some first correlations between voidage and operating parameters. A discussion of the implications of such phenomena to the performance of a gas phase polymerization reactor is also presented. (from Authors)

Effects of temperature and pressure on gas-solid fluidization
Yates J.G., *Chemical Engineering Science*, 1996, 51/2 (167-205). In English.
The objective of this paper is to review experimental and theoretical studies of gas-solid fluidization at elevated temperatures and pressures. The survey begins with the low velocity end of operations in the region between minimum fluidization velocity and minimum bubbling velocity and shows how correlations established at ambient temperature and pressure for these two quantities may be used to calculate their values at superambient conditions. The application of purely hydrodynamic fluid-bed stability criteria to account for the transition from the non-bubbling to the bubbling state is described and compared with the expected effect of interparticle forces on this transition. Circulating fluidized beds (CFBs) operated at high velocity are then considered and it is shown that many of the observed effects in these systems at superambient conditions can be accounted for in terms of changes in the value of the terminal fall velocity of the bed particles. (from Author)

Gas absorption in reactive slurries: particle dissolution near gas-liquid interface
Mehra A., *Chemical Engineering Science*, 1996, 51/3 (461-477). In English.
The rates of gas absorption into reactive slurries constituted by 'fine' particles of sparingly soluble reactant are known to be enhanced when the particle size is smaller than the characteristic diffusional lengths of the reactive species. This study examines the process of particle dissolution and the consequent change in particle size(s) near the gas-liquid interface, in the presence of diffusional gradients, using Higbie's extended theory of mass transfer with chemical (instantaneous) reaction. The effect of changing particle size on the mechanism and extent of enhancement in the specific rate of absorption has been assessed using a population balance approach to track the interaction of the dissolution process with the evolving particle size distributions. (from Author)

Solid effects on gas-liquid mass transfer in three-phase slurry catalytic hydrogenation of adiponitrile over Raney nickel
Joly-Vuillemin C., De Bellefon C. & Delmas H., *Chemical Engineering Science*, 1996, 51/10 (2149-2158). In English.
Many three-phase catalyst reactions are limited by gas-liquid mass transfer. Previous works have found the transfer rate to be increased by the presence of fine catalyst particles. Most of the studies concerned active carbon particles in aqueous media. This paper intends to point out and to explain this effect in the case of catalytic hydrogenation of adiponitrile over Raney nickel particles. The experiments based on pressure variation due to the hydrogen absorption in a stirred batch reactor point out clearly an increase of $k_l a$ at an optimum catalyst loading. (from Authors)

Distinct element simulation of interstitial air effects in axially symmetric granular flows in hoppers
Langston P.A., Tuzun U. & Heyes D.M., *Chemical Engineering Science*, 1996, 51/6 (873-891). In English.
Two-phase flow of interstitial air in a moving packed bed of granular solids is modelled using a distinct element (DE) technique which considers the Newtonian dynamics of particle motion passing through a radial flow field of air in a mass flow hopper. The particle-particle and particle-hopper wall interactions are modelled using a Hertzian interaction law and a contact friction algorithm of the Mindlin analytic form (Langston et al. 1995, Chem. Engng Sci. 50, 967). Predictions of discharge rates in both air-retarded and air-assisted flows are compared with the continuum mechanics calculations based on the steady-state flow assumption. The DE simulation results indicate certain transient and oscillatory features of the flow fields which have not hitherto been demonstrated by the continuum theories. Furthermore, it is shown that air-assisted flow leads to increased wall stresses which reduce the bulk solids discharge rate for discharge through small orifices. (from Authors)

Coherent structures and axial dispersion in bubble column reactors
Groen J.S., Oldeman R.G.C., Mudde R.F. & Van Den Akker H.E.A., *Chemical Engineering Science*, 1996, 51/10 (2511-2520). In English.
In this paper results of measurements of the local and time-dependent behaviour of the two-phase flow in a bubble column are presented. Measurements with Laser Doppler Anemometry (LDA) and with glass fibre probes were performed in two homogeneously aerated air/water bubble columns, of 16 and of 23 cm dia. These measurements show that considering the flow field as stationary considerably underestimates the velocities present. Although the time averaged liquid velocity profiles resemble textbook data, these averaged values are a result of the passage of coherent structures. (from Authors)

Radial nonuniformity of flow structure in a liquid-solid circulating fluidized bed
Liang W.-G., Zhu J.-X., Jin Y., Yu Z.-Q., Wang Z.-W. & Zhou J., *Chemical Engineering Science*, 1996, 51/10 (2001-2010). In English.
Electrical conductivity probes were used to measure the radial distributions of solids holdup and liquid velocity in a liquid-solid circulating fluidized bed. These distributions are found to be non-uniform, unlike those in a non-circulating bed. The effects of superficial liquid velocity and particle circulation rate on the radial distributions of bed voidage and liquid velocity are studied. Based on the experimental results, a qualitative expla-

nation is given for the difference between the dispersed fluidization and the circulating fludization. (from Authors)

Radial pressure differences and their fluctuations in dense fluidized beds
Bi H.T. & Grace J.R., *Chemical Engineering Science*, 1996, 51/4 (663-665). In English.

Pressure fluctuations have been widely used in the diagnosis of the flow behaviour of gas-solids fluidized beds. In this work, the local instantaneous pressures in both the wall and the core regions have been measured using pressure transducers in a fluidized bed operated in the bubbling and turbulent fluidization regimes. The local time-mean pressures and the standard deviations of pressure fluctuations were then calculated and used to evaluate the radial variation of local pressures. (from Authors)

Gas-solid fluidization: a typical dissipative structure
Jinghai Li, Guihua Qian & Lixiong Wen, *Chemical Engineering Science*, 1996, 51/4 (667-669). In English.

In accordance with the controlling role of the particles and/or the fluid, Li et al. (1992) characterized the three major regimes in particle-fluid two-phase flow as: particle dominating (PD) for the fixed bed, particle-fluid compromising (PFC) for fluidization and fluid dominating (FD) for dilute transport. According to the theorem of minimum entropy production (Prigogine, 1967), steady states of linear nonequilibrium systems prevail only when the entropy production rate is minimized. There is however no single and general variation theorem for nonlinear steady-state dissipative systems (Gage et al., 1966; Nicolis, 1994). This paper purports to examine the extremum behavior of fluidized systems in the light of nonequilibrium thermodynamics in order to explore valid approaches to elucidate the bifurcation phenomenon and dissipative structure for such complicated systems. (from Authors)

Modeling of dilute sulfur dioxide absorption into calcium sulfite slurries
Gerard P., Segantini G. & Vanderschuren J., *Chemical Engineering Science*, 1996, 51/12 (3349-3358). In English.

The absorption rate of SO_2 into calcium sulfite slurries is predicted by means of a model, based on the film theory, which considers absorption in a liquid film located at the gas-liquid interface and simultaneous dissolution of calcium sulfite in a liquid film surrounding the particles. The involved reactions are supposed to be reversible and instantaneous. Diffusive transport of ionic and molecular species in both films accounts for the effect of equilibrium and, due to unequal diffusivities of ions, for the effect of the electric potential gradient. (from Authors)

Inviscid, slender, annular and liquid jets
Ramos J.I., *Chemical Engineering Science*, 1996, 51/6 (981-994). In English.

Regular pertubation expansions are used to analyse unsteady, inviscid, slender, incompressible (constant density), axisymmetric, annular liquid jets when the gases enclosed by and surrounding the jet are dynamically passive. Both inertia-and capillary-dominated annular jets are considered. It is shown that, for inertia-dominated jets, closure of the leading order equations is achieved at second order in the perturbation parameter which is the slenderness ratio, whereas closure is achieved at first order for capillary-dominated jets. The leading order equations are used to determine the fluid dynamics of steady annular jets. (Author)

Fluidization of potato starch in a stirred vibrating fluidized bed
Kuipers N.J.M., Stamhuis E.J. & Beenackers A.A.C.M., *Chemical Engineering Science*, 1996, 51/11 (2727-2732). In English.

A novel gas-solid reactor for cohesive C-powders such as potato starch is introduced, designed and characterized, the so-called stirred vibrating fluidized bed. The effects of a sinusoidal vibration of the gas distributor and/or stirring of the bed are investigated. The fluidization index, bed expansion, torque and visual behaviour of the bed are determined as a function of air velocity, bed height and moisture content of the starch, stirred type and speed and vibration frequency and amplitude. By simultaneously applying both vibration and stirring of the aerated bed, it is possible to eliminate both channelling and starch agglomeration. Even homogeneous fluidization is possible. Optimal combinations of stirring and vibration parameters are reported for various bed heights and moisture contents. (from Authors)

LDA measurements and CFD modelling of gas-liquid flow in a stirred vessel
Morud K.E. & Hjertager B.H., *Chemical Engineering Science*, 1996, 51/2 (233-249). In English.

Turbulent two-phase flow in a stirred vessel has been investigated experimentally and numerically. Mean and turbulent gas velocities are measured using a laser/phase Doppler anemometer (LDA/PDA). The effects of varying gas flow rates and impeller rotational speeds on axial, radial and tangential mean and turbulent velocities at three levels of the vessel are investigated. Furthermore, total gas fractions are measured by observing the level of the liquid surface. A two-dimensional computational fluid dynamics (CFD) two-fluid model, with a standard k-epsilon turbulent model, is used to predict the gas-liquid flow. (from Authors)

Local solids concentration measurement in a slurry mixing tank
Nasr-El-Din H.A., MacTaggart R.S. & Masliyah J.H., *Chemical Engineering Science*, 1996, 51/8 (1209-1220). In English.

The local solids concentration in a mixing tank was measured using both sample withdrawal and a new conductivity probe. The conductivity probe was used to assess the errors associated with various sample withdrawal techniques and to measure solids concentration profiles in the mixing tank. The effects of sampling tube design (tip shape, face angle and inside diameter), sampling position, bulk solids concentration and particle size on the sampling errors were examined in detail. Solids concentration profiles were also measured as a function of particle size, bulk solids concentration and mixer rotational speed. A strong variation in solids concentration

with the axial position was observed at the impeller plane for the sand particles examined in the present study. This variation increased with the particle mean size and the mixer rotational speed. (from Authors)

Phase distributions in semibatch slurry bubble columns with guar gum solutions
Alarcon Z., Parra E., Gomez M.G., Siquier S. & Saez A.E., *Chemical Engineering Science*, 1996, 51/12 (3367-3371). In English.

In this work we perform an experimental study of the hydrodynamics of slurry bubble columns in which the liquid phase is a solution of guar gum. The main emphasis is to analyze how the presence of intermolecular cross links affects hydrodynamic parameters such as gas holdup and solids distribution in the bubble column. (from Authors)

Alcohol synthesis with Zn/Cr catalysts in a slurry reactor
McCutchen M.S., Marquez M.A. & Roberts G.W., *Chemical Engineering Science*, 1996, 51/11 (2959-2964). In English.

A laboratory stirred autoclave reactor has been developed to operate at temperatures up to 375 degrees C and pressures of at least 170 atma. The performance of a commercial 'high-pressure' methanol synthesis catalyst, the so-called 'zinc chromite' catalyst, has been characterized over a range of temperatures from 300 to 375 degrees C, pressures from 68 to 174 atma. H_2/CO ratios from 0.5 to 2.0 and space velocities from 1500 to 10 000 sL/kg(catalyst)-hr. Towards the lower end of the temperature range, methanol was the only significant product. At the highest temperature, the methanol synthesis reaction was close to equilibrium. (from Authors)

Coalescence of two gas slugs rising in a vertical column of liquid
Pinto A.M.F.R. & Campos J.B.L.M., *Chemical Engineering Science*, 1996, 51/1 (45-54). In English.

This work describes an experimental investigation about the coalescence of pairs of gas slugs rising in vertical columns of liquid covering a wide range of liquid viscosities. The experiments were performed in columns with 19, 32 and 52 mm of internal diameter and slug coalescence was followed by means of a new experimental technique, based on the signals of differential pressure transducers. (from Authors)

Local solids concentration measurement in a slurry mixing tank
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The local solids concentration in a mixing tank was measured using both sample withdrawal and a new conductivity probe. The conductivity probe was used to assess the errors associated with various sample withdrawal techniques and to measure solids concentration profiles in the mixing tank. The effects of sampling tube design (tip shape, face angle and inside diameter), sampling position, bulk solids concentration and particle size on the sampling errors were examined in detail. Solids concentration profiles were also measured as a function of particle size, bulk solids concentration and mixer rotational speed. A strong variation in solids concentration with the axial position was observed at the impeller plane for the sand particles examined in the present study. This variation increased with the particle mean size and the mixer rotational speed. (from Authors)

Bubble characteristics in three-phase systems used for pulp and paper processing
Reese J., Jiang P. & Fan L.-S., *Chemical Engineering Science*, 1996, 51/10 (2501-2510). In English.

Experiments are conducted to study the hydrodynamic behavior of three-phase pulp slurry systems at consistencies ranging from 0.1 to 1.0% (weight percent pulp). The pulp phase is a low-density fibrous material which swells to several times its original volume in water. The overall hydrodynamic behavior, including the regime transitions, of a multi-bubble, three-phase pulp slurry is studied by measuring the overall gas holdup and by using a light transmittance probe to determine the bubble characteristics. (from Authors)

The influence of coalescence on droplet transfer in vertical annular flow
Soldati A. & Andreussi P., *Chemical Engineering Science*, 1996, 51/3 (353-363). In English.

In vertical annular flow, the motion of droplets in the gas core is determined either by a diffusion mechanism, when the droplet size is small, or by inertial effects when droplets are large. These two mechanisms have to be considered when predicting deposition rates. Furthermore, since droplet-droplet interactions influence droplet motion, a deposition model should also account for collisions and coalescence among droplets. After reviewing the available deposition models, the effects of coalescence on droplet motion is theoretically analyzed. The results demonstrate that coalescence extends droplets residence time in the gas core thus decreasing the deposition coefficient. On the basis of these results, a new deposition model which accounts for the two deposition mechanisms and includes the effects of coalescence is proposed and compared against existing experimental data. (Authors)

On the relative motion of a particle in a swarm of different particles
Van der Wielen L.A.M., Van Dam M.H.H. & Luyben K.C.A.M., *Chemical Engineering Science*, 1996, 51/6 (995-1008). In English.

The classification of dissimilar particles in a liquid suspension is exploited in many industrial unit operations. A possible formulation of the effective driving force and friction in multicomponent mixtures is discussed in this paper. A new expression is derived, which is based on a steady-state force balance for the classifying particle. The new expression is compared with some existing classification models with respect to their predictive value for a wide range of classification data. The new expression proved to be accurate over the entire range of known experimental data and can be extended easily to multicomponent fluidized suspensions. The particle-particle interaction force is proportional to the product of the hold-up of the fluidized particles and the slip velocity of dense and fluidized particles. The particle-particle interaction coefficient was correlated with a modified Stokes-Einstein equation. (from Authors)

Condensing heat transfer in an advanced two-phase closed thermosyphon
Li Xiulun, Wen Jianping, Shan Yankun & Huang Hongding, *Chinese Journal of Chemical Engineering*, 1996, 4/1 (85-89). In English.

A new type of two-phased closed thermosyphon was designed by inserting respectively two inner tubes into the thermosyphon, one in the boiling section and the other in the condensing section. The two-phase flow boiling heat transfer coefficient was calculated successfully on the basis of Chen's dual-mechanism. A boiling heat transfer model for the two-phase closed thermosyphon with an inner tube in the boiling section was proposed by Huang. The main purpose of this paper is to investigate the heat transfer performances of the closed thermosyphon and to develop a mathematical model for condensing heat transfer in a narrow annulus based on Saliman condensing heat transfer model. (from Authors)

Interpretation of flow nonuniformity and hysteresis with a capillary array model
Mao Zaisha, Wang Yuefa, Wang Rong & Chen Jiayong, *Chinese Journal of Chemical Engineering*, 1996, 4/1 (28-38). In English.

A novel capillary array model is proposed to shed light on the development of the maldistribution of cocurrent downward gas-liquid flow and the hysteretic performance behavior in a packed column. The model is based on the principle of nonequilibrium thermodynamics and in combination with lateral random walk of elemental liquid rivulets. The liquid distribution over a one-dimensional array of capillaries is simulated and the basic features of gas-liquid flow in packed beds are demonstrated. With proper correspondence of hysteresis branches with nonuniformity of flow distribution assumed, the experimentally observed hysteresis in pressure drop, liquid holdup and mass transfer rate can be qualitatively simulated. Strenuous effects are still required for further developing this model into a predictive tool for the evaluation of performance of packed-bed type devices. (Authors)

An experimental and modeling study of fires in ventilated ducts. Part II: PMMA and stratification
Comitis S.C., Glasser D. & Young B.D., *Combustion & Flame*, 1996, 104/1-2 (138-156). In English.

A theoretical and experimental treatment of fire processes in horizontal, ventilated passages, containing an axial distribution of fuel, is presented. Experiments for radially well-mixed flows are performed where gas temperature histories and fire-shaped solid fuel mass axial distributions are acquired from polymethyl methacrylate (PMMA)-fueled fires. The theory developed in part I is able to quantitatively model all the experimental results for PMMA fires. In particular, the solid fuel profiles (axial distributions) are modeled from gas-phase information alone. To assess the concept of an ignition temperature as a controlling mechanism for growth a brief fire growth analysis is also performed. A simple approach to study fires in stratified flow conditions is also presented. A general model requires a knowledge of the degree of stratification and mixing, in advance of experimentation. A new correlation for stratification using fuel/duct properties and air velocity is proposed as a means of predicting flow regimes. (from Authors)

Homogenized model with capillary nonequilibrium for two-phase flow through highly heterogeneous porous media
Panfilov M., *Comptes Rendus - Academie des Sciences, Serie II: Mecanique, Physique, Chimie, Astronomie*, 1996, 322/3 (195-202). In English.

The two-phase flow through a dual-porosity medium whose component parts differ by the order of global permeability and capillary forces is investigated. The classification of elementary flows at the one-cell level and the diagram of their predominance is proposed. The homogenized model is constructed for one class of systems. (from Author)

The numerical determination of the Kelvin impulse of a bubble close to a submerged rigid structure
Harris P.J., *Computer Methods in Applied Mechanics & Engineering*, 1996, 130/3-4 (195-202). In English.

This paper describes a numerical method which can be used to compute the Kelvin impulse of a bubble close to a submerged rigid structure. This is achieved by using a point-source representation of the fluid velocity potential due to the bubble and the boundary integral method to model the velocity potential due to the rigid structure. The whole system is integrated through time using a fourth-order Runge-Kutta method. Results are presented for some typical structures. (Author)

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Presentation of a family of turbulence closure models for stratified shallow water flows and preliminary application to the Rhine outflow region
Luyten P.J., Deleersnijder E., Ozer J. & Ruddick K.G., *Continental Shelf Research*, 1996, 16/1 (101-130). In English.

Three turbulence closure schemes, designed for stratified shallow water flows, are presented. They are based upon k-epsilon theory and use respectively two, one or zero transport equations for turbulent variables. The models are first tested on the evolution of a wind-driven turbulent layer in a stratified fluid. The results are at least qualitatively in agreement with observational and experimental data. A discussion is given about the existence of self-similar solutions. The models are compared next with the observational data of the Rhine

outflow area. The periodic variation in the density structure, forced by wind and tides and which is clearly visible in the data, is predicted by the model. A physical interpretation of the model results is given in the absence of wind forcing. The effects of estuarine circulation, tidal straining and mixing on the development or breakdown of stratification are well presented by the model calculations. (Authors)

Debirs flow modeling: a review
Hutter K., Svendsen B. & Rickenmann D., *Continuum Mechanics & Thermodynamics*, 1996, 8/1 (1-35). In English.
This review begins with a survey of the literature on the physical-mathematical modeling of debris flows. We discuss the basic aspects of their phenomenology, such as dilatancy, internal friction, fluidization, and particle segregation. The basic characterization of a debris flow as a mixture motivates the application of the continuum thermodynamical theory of mixtures to formulate a model for a debris flow as a viscous fluid-granular solid mixture. A major advantage of such a formation, is that it can be used to expose and better understand the assumptions underlying existing models, as well as to derive new, more sophisticated models. Finally, we delve into the issue of how such models have been or can be implemented numerically, as well as general boundary conditions for debris flows. (from Authors)

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The long-time evolution of the initially turbulent wake of a sphere in a stable stratification
Spedding G.R., Browand F.K. & Fincham A.M., *Dynamics of Atmospheres & Oceans*, 1996, 23/1-4 (171-182). In English.
Experiments on late wakes ($Nt < 20$) of towed spheres in a stably stratified fluid reveal some startling similarities and differences when compared with unstratified, 3D wakes. Predicted decay rates stemming from 3D, turbulent wake studies are unexpectedly successful in accounting for the decay in fluctuating horizontal velocity components and their spatial gradients, even at late times when the vertical velocity component is almost or exactly zero. On the other hand, the mean wake defect velocity is almost one order of magnitude higher than in the unstratified case. This is due to the increased coherence and organisation of the patches of vertical vorticity, which are stable, and persist for very long times. A correct accounting for this type of wake structure will be essential in modelling efforts for certain practical ocean applications. (Authors)

Internal waves generated by a translating and oscillating sphere
Dupont P. & Voisin B., *Dynamics of Atmospheres & Oceans*, 1996, 23/1-4 (289-298). In English.
At high Reynolds and Froude numbers, lee waves owing to the horizontal motion of a body in a stratified fluid are suspended by random waves generated by its wake. The origin of these waves lies in the buoyant collapse of the large-scale coherent structures of the wake, and can be modelled as a source moving at the velocity of the body and of strength oscillating at the frequency of vortex shedding. In the presnt paper two parallel studies of the associated wavefield are described. The first of these is theoretical and considers localized and extended models of the source, while the second is experimental and involves a vertically oscillating and horizontally translating sphere. (from Authors)

Some aspects of turbulence and mixing in stably stratified layers
Fernando H.J.S. & Hunt J.C.R., *Dynamics of Atmospheres & Oceans*, 1996, 23/1-4 (35-62). In English.
This paper presents a brief overview of recent work on turbulence and mixing in stably stratified flows. It is concluded (1) that the usual generalizations and 'scaling laws' of these flows need careful qualification, and (2) that the usual feature of unstratified turbulence of having a single length scale for all large-scale processes may not be present, especially when mean shear and buoyancy forcing have different length scales and when there is significant wave motion (ie. the Ozmidov length scale is not the relevant macroscale). The second part of the paper reviews the modeling of motions and mixing in stable density interfaces interacting with contiguous layers of turbulence. Although the rates of mass and momentum transfer across stratified interfaces are much weaker than in unstratified turbulence, they play a crucial role in the heat and mass balances in the atmosphere and oceans. (from Authors)

Efficiency of mixing by a turbulent jet in a stably stratified fluid
Larson M. & Jonsson L., *Dynamics of Atmospheres & Oceans*, 1996, 24/1-4 (63-74). In English.
Mixing in a two-layer stably stratified fluid by a turbulent jet was studied by a laboratory experiment. A non-swirling jet was discharged vertically downwards in a confined fluid system consisting initially of a top layer of fresh water and a bottom layer of salt water. A three-layer density structure developed in all cases with an intermediate layer that grew in size with time elapsed as fresh and salt water were mixed. The mixing efficiency, defined as the percentage of the supplied kinetic jet energy that is used for increasing the potential energy of the fluid system, was related to a densimetric Froude number based on the intermediate layer depth. Overall, the

calculated jet mixing efficiency displayed higher values than comparable efficiencies for destratification with air-bubble plumes. (from Authors)

The structure of the turbulent wake and the random internal wave field generated by a moving sphere in a stratified fluid

Bonneton P., Chomaz J.M., Hopfinger E. & Perrier M., *Dynamics of Atmospheres & Oceans*, 1996, 23/1-4 (299-308). In English.

Presents experimental results on the structure of the turbulent wake of a sphere and on the frequencies associated with the vortex shedding in a stratified fluid. The strong correlation between the random internal wave field emitted by the wake and the coherent structures of the turbulent wake is demonstrated. (Authors)

Internal waves and related initial-value problems

Lighthill J., *Dynamics of Atmospheres & Oceans*, 1996, 23/1-4 (3-17). In English.

This paper gives a detailed account of how small disturbances to uniformly stratified fluid develop when the initial disturbances are confined to a limited region. Special stress is laid on properties of vorticity in stratified fluid, with horizontal (yet not vertical) components of vorticity being propagated away, alongside density variations, in any internal wave - an important difference from corresponding properties in homogeneous fluid. The paper includes a comprehensive analysis of the waves which emanate from the initial disturbances, as well as of those residual motions that are left behind after all waves have been propagated away (those in each horizontal plane being determined from the initial distribution over that plane of the vorticity's vertical component). Some mathematical details are included in an appendix, which outlines too an additional benefit from these studies by showing how the wave motion generated by any transient local forcing effect can always be identified as the solution of a well-defined initial-value problem. (Author)

A numerical study of wave-breaking in stratified flow over obstacles

Paisley M.F. & Castro I.P., *Dynamics of Atmospheres & Oceans*, 1996, 23/1-4 (309-319). In English.

This paper describes results of numerical computations of stratified flow of finite depth D over a variety of obstacles using the time-dependent Navier Stokes equations with stability-dependent eddy viscosity turbulence models. Most computations were performed with the Froude number F_h in the range of 0.5 = or F_h = or 2 and the parameter $K = D/(piF_h)$ in the range of 1 = or K = or 10. Here $F_h = U/Nh$, where U is the free stream velocity, N is the buoyancy frequency and h is the height of the body. The domain and boundary conditions correspond to those of a towing tank experiment and the initial conditions were 'impulsive start'. Critical Froude numbers for wave-breaking over two-dimensional obstacles are compared with theoretical predictions and experimental results. Preliminary results with mixing length and one-equation turbulence models suggest that differences in the representation of flows with breaking waves with such models are small. The occurrence of 'merged flow', in which the breaking region joins with the secondary separation zone, and which has been seen in experiments, is found in the computations in three dimensions, but not those in two. (Authors)

An exact, stratified model of a meddy

Maas L.R.M. & Zahariev K., *Dynamics of Atmospheres & Oceans*, 1996, 24/1-4 (215-225). In English.

An exact model to describe submesoscale, coherent vortices in a uniformly stratified fluid is presented. The model allows for stratification of the eddy interior, so as to agree with observations. The closed set of equations governing the evolution of the eddy on the f-plane is derived. In the case that the interior isopycnal surfaces remain horizontal the stratified analogue of the 'rodon', a special solution of the 'lens equations' that govern the evolution of uniform-density, warm-core surface eddies, is obtained. (Authors)

Stably stratified flows in meteorology

Hunt J.C.R., Shutts G.J. & Derbyshire S.H., *Dynamics of Atmospheres & Oceans*, 1996, 23/1-4 (63-79). In English.

It is generally believed by researchers in the fundamental aspects of geophysical fluid dynamics and meteorology that their results contribute to the improvements to numerical weather prediction and in practical weather forecasting. However, the techniques whereby the appropriate research results are selected and incorporated into the numerical models are not widely known, particularly sub-grid scale phenomena. Atmospheric motions on these scales are not like molecular motions in an ideal gas, but shows considerable structure, approximating to combinations of various idealized states. This paper, focuses on a restricted range of phenomena associated with stably stratified flows, notably mountain waves, convection and clouds, and boundary layer phenomena. This category provides many examples of structures which need to be considered in detail to reconstruct the large-scale picture accurately, as well as in local forecasting. (from Authors)

Some similarity states of stably stratified homogeneous turbulence

Chasnov J.R., *Dynamics of Atmospheres & Oceans*, 1996, 23/1-4 (183-192). In English.

The decay of statistically homogeneous velocity and density fluctuations in a stably stratified fluid is considered. Over decay times long compared with the turbulence time scale but short compared with the period of internal gravity waves. Three distinct high Reynolds number similarity states may develop. These similarity states are a consequence of the invariance of the low wavenumber coefficients of the three-dimensional kinetic or potential energy spectrum, and their preferential development depends on the relative magnitudes of the initial kinetic and potential energy per unit mass of the fluid. When the turbulence has decayed over a time comparable with the period of the gravity waves, the three similarity states mentioned above are disrupted. Evidence will be presented of a new similarity state which then develops asymptotically. In this similarity state, the time decay exponent of the total energy per unit mass of the turbulence is reduced by a factor of two from its value for decaying isotropic turbulence, and the associated vertical integral scale approaches a constant independent of time. (Author)

Streamwise vortices near a density interface
Baba N., *Dynamics of Atmospheres & Oceans*, 1996, 24/1-4 (95-105). In English.
The interaction of streamwise vortices with a density interface is investigated by experiments and by computations of the stratified cavity flow. The flow pattern of the primary circulation is different from that of homogeneous fluid. The results show that the deepening of a mixed layer into a region of constant density gradient proceeds with three-dimensional deformation of the interface and that pairs of counter-rotating streamwise vortices appear in the strong shear layer near the interface. The comparison between the three-dimensional and two-dimensional computations indicates that this streamwise vortical structure contributes to mixing across the interface. (Author)

Nonlinear effects in the unsteady, critical withdrawal of a stratified fluid
Clarke S.R. & Imberger J., *Dynamics of Atmospheres & Oceans*, 1996, 24/1-4 (163-171). In English.
The evolution of the withdrawal through a line sink of an initially quiescent, stratified fluid in a semi-infinite, horizontal duct is investigated in the inviscid, nondiffusive limit. A weakly nonlinear, long-wave formulation of the problem of critical withdrawal is presented, which is then used to study the critical withdrawal of a two-layer' fluid from a sink at the base of the duct. Solutions for the evolution of the interfacial shear front are presented and related to the steady solutions for the critical withdrawal of a two-layer fluid. (Authors)

On the three-dimensional internal waves excited in the flow of a linearly stratified Boussinesq fluid
Hanazaki H., *Dynamics of Atmospheres & Oceans*, 1996, 23/1-4 (279-288). In English.
Three-dimensional flow of a linearly stratified Boussinesq fluid is studied numerically. The flow is assumed to be confined in a rectangular channel and internal waves are excited by bottom topography. Near resonance of the first vertical internal wave mode, it was found that the reflection of the internal wave at the sidewall is 'abnormal' in the sense that the reflection angle is larger than the incident angle and a third wave perpendicular to the sidewall is generated. The waves become straight crested (two-dimensional) as this third wave becomes longer. The whole mechanisms is similar to the 'Mach reflection' observed in the general stratified fluid in which the usual solitary waves are generated. In the case of the linearly stratified Boussinesq fluid, the abnormal reflection occurs even though the wave near the sidewall has a sinusoidal profile and not a $sech^2$ profile. This suggests that the abnormal reflections similar to Mach reflection always occur when the wave amplitude is large enough, irrespective of the wave profile. (Author)

Stratified flow over three-dimensional topography
Kadri Y., Bonneton P., Chomaz J.M. & Perrier M., *Dynamics of Atmospheres & Oceans*, 1996, 23/1-4 (321-334). In English.
In order to investigate flows over topography in an atmospheric context, the authors have studied experimentally the wake structure of axi-symmetric Gaussian obstacles towed through a linearly stratified fluid. Three dimensionless parameters govern the flow dynamics; F, the Froude number based on the topography height h; Re, the Reynolds number and the aspect ratio r = h/L, where L is the topography horizontal scale. Two-dimensional (2-D), saturated lee wave (SLW) and three-dimensional (3-D) regimes, as defined in Chomaz et al. (1993), are found to be functions of F and r only as soon as Re is larger than Re_c approx 2000. (from Authors)

Heat and mass transfer in a stable thermally stratified flow
Komori S., Nagata K. & Murakami Y., *Dynamics of Atmospheres & Oceans*, 1996, 23/1-4 (235-245). In English.
Heat and mass transfer mechanism in strong stable thermal-stratification is experimentally investigated in unsheared water flows downstream of turbulence-generation grids, where both active scalar (heat) with a Prandtl number of about six and passive scalar (mass) with a Schmidt number of about 600 are diffused. Instantaneous velocity, temperature and concentration are simulataneously measured using a laser-Doppler velocimeter, a resistance thermometer and a laser-induced fluorescence technique, and the turbulence quantities such as turbulent scalar fluxes, joint probability density functions and cospectra are calculated. The results show that the difference of turbulent diffusion between heat (active scalar) and mass (passive scalar) with different molecular diffusitivites in thermally stratified water flows appears in the high-frequency region, and it results in a slighly larger turbulent mass flux than heat flux in strong stratification. The contributions of small-and large-scale motions in the present thermally stratified water flows are in contrast to the measurements in previously investigated thermally stratified air flows, where the counter-gradient heat transfer is generated mainly by large-scale motions. (from Authors)

Turbulent mechanisms in stratified fluids
Redondo J.M., Sanchez M.A. & Cantalapiedra I.R., *Dynamics of Atmospheres & Oceans*, 1996, 24/1-4 (107-115). In English.
Probability distribution of basic instabilities appearing in stratified flows and point density fluctuations have been studied. Various parameters of the mixing process have been changed in the experiments, to investigate mixing. Detailed flow visualization as well as density measurements have been used in zero-mean-flow laboratory experiments involving grid-stirred turbulent mixing across a density interface and bubble-induced mixing. The overall mixing efficiency of the processes depends on the local Richardson number as well as on the local vorticity. Parameter distributions of low and high mixedness corresponding to different instabilities are presented, showing that dipolar vortices penetrating the interface are the most efficient mixing instabilities. (Authors)

Irreversible processes in a binary two-phase counter flow
Kouremenos D.A., Rogdakis E.D. & Houzouris G.E., *Energy (Oxford)*, 1996, 21/4 (263-272). In English.
A thermodynamic method is proposed for the description of irreversible, binary, two-phase, counter-current

flow processes. Irreversibilities in these processes are related to temperature and mole-fraction deviations from equilibrium which result from internal-exchange delays. The method is applied to a heat-rejecting, two-phase, counter flow of an NH_3 /H_2 O binary mixture with liquid matter in excess. A parametric study with different values of the three delay ratios involved has been performed and yields, among others, entropy production, temperature deviations, and heat exchange with the ambient. (Authors)

Fluidized-bed combustion for energy production from olive cake
Abu-Qudais M., *Energy (Oxford)*, 1996, 21/3 (173-178). In English.

An experimental combustion study is presented of olive-oil mill waste (olive cake, OC) in a fluidized bed combustor. Tests were performed in a 13.2-cm i.d. reactor. Cold-flow tests included investigations of the effects of particle-size distribution, fluidization velocity, and bed height. Combustion was carried out by feeding the OC in a bed of sand particles. The temperature distribution was found to become fairly uniform 12 cm above the distributor plate. The combustion intensity was about 812 kg/m^2 -h and increased with bed height between 0.1 and 0.15 m. The combustion efficiency ranged from 86 to 95% and increased with air-flow rate. (Author)

Development of two biomass control strategies for extended, stable operation of highly efficient biofilters with high toluene loadings
Smith F.L., Sorial G.A., Suidan M.T., Breen A.W., Biswas P. & Brenner R.C., *Environmental Science & Technology*, 1996, 30/5 (1744-1751). In English.

For stable long-term continuous operation of highly loaded trickle bed air biofilters, the prevention of plugging due to accumulating biomass is essential for avoiding biofilter failure. Two biomass control strategies were evaluated to maintain high VOC removal efficiencies at high toluene loadings over 200 days. A sustained toluene removal efficiency of over 99% was achieved. Backwashing with medium fluidization was found to be very effective in preventing accumulation of excess biomass. The use of nitrate (NO_3-N) instead of ammonia (NH_3-N) as the sole source of nutrient-nitrogen (N) was very effective in reducing the observed biomass yield. (from Authors)

Decomposition of hydroxybenzoic and humic acids in water by ultrasonic irradiation
Nagata Y., Hirai K., Bandow H. & Maeda Y., *Environmental Science & Technology*, 1996, 30/4 (1133-1138). In English.

Sonochemical decomposition of a series of hydroxy-benzoic acids such as monohydroxy-, 3,4-dihydroxy-, 3,4,5-trihydroxybenzoic acids, tannic acid, and reagent and prepared humic acids in water under argon or air atmosphere was investigated. It is suggested that, in sonolysis under argon, the main sonochemical decomposition of the substances employed in this study proceeds via reactions with OH radicals in the bulk solution and that the contribution of thermal decomposition in cavitation bubbles or the interfacial region (between the bubbles and bulk solution) is small. In the sonolysis under air atmosphere, the role of oxygen was small in monohydroxybenzoic acids but increased with increasing numbers of OH groups substituted on the aromatic ring, suggesting the occurrence of decomposition of polyhydroxybenzoic acids induced by oxygen molecules at the interface. The chloroform formation potentials of 3-hydroxybenzoic acid and humic acids decreased due to the sonication, but the reduction in the potential was less than the corresponding amounts of decomposition of the starting substances. (from Authors)

Melting characteristics along a bundle of horizontal heated cylinders immersed in a liquid ice layer
Yamada M., Fukusako S., Morizane H., Myoung-Hwan Kim & Schneider W., *Experimental Thermal & Fluid Science*, 1996, 12/3 (305-312). In English.

Experiments were performed to investigate the melting of liquid ice along a bundle of horizontal heated cylinders. A mixture of fine ice particles and ethylene glycol aqueous solution was adopted as the liquid ice for the test. In one set of experiments, the liquid ice was a quiescent layer, whereas in a second set of experiments the liquid ice was a fluidized bed layer. Measurements were carried out for a range of initial concentration of aqueous binary solution, heat flux, and airflow rate for fluidization. The heat transfer coefficient for the fluidized liquid ice bed was more than 25 times as large as that for the quiescent liquid ice bed. (from Authors)

Interactions of particles and microbubbles with turbulence
Maxey M.R., Chang E.J. & Wang L.-P., *Experimental Thermal & Fluid Science*, 1996, 12/4 (417-425). In English.

Dilute, dispersed two-phase flows arise in many contexts ranging from solid particles or droplets in gas flows to bubbles in liquids. Many of the flows of interest are turbulent, which presents a complex problem to analyze or to determine the dominant physical processes contributing to the observed phenomena. Advances in experimental techniques have made it possible to measure directly turbulent and particle velocity fluctuations in dilute systems. This has provided a counterpart to advances in computational and analytical models and a basis on which to test these models. Three specific areas are considered: the fluctuating forces on an individual particle in an unsteady flow, the response of a solid particle to a turbulent air flow, and the corresponding response of a small bubble in turbulent liquid flows. (from Authors)

Free jet expansion and gas entrainment characteristics of a plunging liquid jet
Evans G.M., Jameson G.J. & Rielly C.D., *Experimental Thermal & Fluid Science*, 1996, 12/2 (142-149). In English.

The change in effective jet diameter is measured as a function of free jet length for vertical liquid jets passing through air. The data are incorporated into a model to predict the rate of gas entrainment for a liquid jet plunging into a confined column of liquid. In the model it was assumed that the total gas entrainment rate included gas contained within the effective diameter of the free jet at the plunge point and an annular film adjacent to the surface of the jet, where the outer boundary of the film was defined to be the separating stream-

line between the entrained and unentrained components of the moving gas boundary layer. It was further assumed that the radial location of the separating streamline was independent of both liquid and gas flow rates and system geometry. Excellent agreement between model predictions and gas entrainment measurements were obtained once a number of experimental parameters were determined. (Authors)

Quantitative limits of thermal and fluid phenomena measurements using the neutron attenuation characteristics of materials

Mishima K. & Hibiki T., *Experimental Thermal & Fluid Science*, 1996, 12/4 (461-472). In English.

Temporal and spatial resolution of the neutron radiographic technique were investigated to apply this technique to the visualization and measurement of thermal and fluid phenomena. The temporal resolution of three imaging methods of temporally resolved neutron radiography - static neutron radiography with a pulsed neutron beam and high frame rate neutron radiography with either a pulsed or steady neutron beam - was studied. An image processing method was proposed to measure flow characteristics such as void fraction. The void fraction measuring method was experimentally confirmed by comparing the void fraction values in a rectangular duct with a 2.4 mm gap obtained by neutron radiography with those obtained by optical and conductance probe methods. It was shown quantitatively that the measurement error decreased when consecutive frames were temporally integrated. (from Authors)

High-speed observation of ultrahigh-speed submerged water jets

Soyama H., Yanauchi Y., Sato K., Ikohagi T., Oba R. & Oshima R., *Experimental Thermal & Fluid Science*, 1996, 12/4 (411-416). In English.

Some peculiar phenomena occur around ultrahigh-speed submerged water jets accompanied by very severe cavitation erosion. Using the flow visualization technique with a xenon flash, the water jets were carefully observed, and the spatial distributions of highly erosive impulsive pressures around the jets were measured by means of a pressure-sensitive film technique. The effects of the injection pressure and the nozzle configuration are systematically clarified. Thus, the characteristics and structures of ultrahigh-speed submerged water jets are clearly shown. (Authors)

Non-Newtonian flow over the trailing edge of an airfoil

Sheridan J., Wu J. & Pullum L., *Experimental Thermal & Fluid Science*, 1996, 12/2 (244-249). In English.

Results are presented from an experimental study of flow over a C4 airfoil in a shear-thinning non-Newtonian flow. A digital particle image velocimeter (DPIV) was used to measure the instantaneous velocity field in the trailing edge region of the airfoil placed at an angle of attack of 35 degrees . This flow field is relevant to that occurring around hydrofoils of agitators used for mixing slurries. It is shown that the Kutta condition was not satisfied at the trailing edge region. This implies a low lift force coefficient for the airfoil. Features including velocity distributions and strain rate are presented based on measurement using the DPIV technique. (Authors)

Free jet expansion and gas entrainment characteristics of a plunging liquid jet

Evans G.M., Jameson G.J. & Rielly C.D., *Experimental Thermal & Fluid Science*, 1996, 12/2 (142-149). In English.

The change in effective jet diameter is measured as a function of free jet length for vertical liquid jets passing through air. The data are incorporated into a model to predict the rate of gas entrainment for a liquid jet plunging into a confined column of liquid. In the model it was assumed that the total gas entrainment rate included gas contained within the effective diameter of the free jet at the plunge point and an annular film adjacent to the surface of the jet, where the outer boundary of the film was defined to be the separating streamline between the entrained and unentrained components of the moving gas boundary layer. It was further assumed that the radial location of the separating streamline was independent of both liquid and gas flow rates and system geometry. Excellent agreement between model predictions and gas entrainment measurements were obtained once a number of experimental parameters were determined. (Authors)

Recovery of glaze in sanitaryware manufacture

Jones H., *Filtration & Separation*, 1996, 33/2 (123,125). In English.

A new filtration system using ceramic membranes and Mono pumps is helping ceramics, minerals and paper companies to save money and reduce their effluents by recovery glaze and other coating materials. The technology is now being applied to similar applications where dewatering of dilute or high-density slurries is required. Designed and produced by Xtract Process Systems Ltd, the system is reducing effluent levels, and is said to be making substantial savings in operation costs. Mono Pumps Ltd has worked with Xtract Process Systems for two years on the development of an effective crossflow filtration system capable of handling extremely viscous and abrasive materials. (from Author)

General characteristics of two-phase flow distribution in a multipass tube

Watanabe M., Katsuta M., Nagata K. & Sakuma K., *Heat Transfer - Japanese Research*, 1996, 24/1 (32-44; translated from: Transactions - JSME, 60B(580), 1994, pp 4145-4150). In English.

An experimental study has been performed using two different types of multipass tubes, one with four vertical upward passes attached to a horizontal main pipe and the other with five horizontal passes placed to a vertically oriented main pipe. Multipass tubes simulated evaporators for air-conditioning systems, and refrigerant R11 was used as the working fluid. Vapor and liquid flow rates at each pass were measured under various conditions of two-phase mixture at the main pipe inlet, that is, inlet flow rate and quality. Results suggested that measured values of flow distribution ratio presented a marked distinction between the vertical and horizontal types. (from Journal summary)

(Sondes optiques: innovations sur un capteur classique) (Optical probes: innovations upon a conventional sensor)
Cartellier A., Poupot C., Chamberod E. & Barrau E., *Houille Blanche*, 1996, 51/1-2 (120-128). In French.
Optical probes are an essential component of the two-phase flow instrumentation, but their performances are still not well known, mainly due to a bad control of their sensitive tip, and to defects in signal processing. The DER-EDF, the LEGI and the GICEP have grouped together in order to improve the mastership of such probes. New sensitive tips geometries have allowed simultaneous measurement of the gas phase characteristic function and its velocity with a single probe. The measuring ensemble has been checked in various air-water flows. The discrepancy with reference measurement lies between 0 and -13% for the void fraction as well as for the velocity, provided that the gas fraction is higher than 5%. The real time processing has been extended to double-probes, but, in that case, a criteria remains which must be set by the user. Calibrations of bi-probes exhibit an error on velocity as high as 30%. (from English summary)

(Approche lagrangienne des ecoulements diphasiques multidimensionnels) (Lagrangian approach to multi-dimensional two-phase flows)
Hulin A. & Znaty E., *Houille Blanche*, 1996, 51/1-2 (71-76). In French.
Mathematical modelling of two phase flows gained profits from progress made in computational fluid dynamics and from increased needs in availability of simulation tools for processes involving multiphase mixing. Two approaches, called Eulerian and Lagrangian, have been proposed for two phase flow modelling. Lagrangian approach is described with a focus on physical models for mass, momentum, internal energy, turbulent kinetic energy exchanges. Coupling between dispersed phase and continuous phase is described. Specific ranges of application of each method are presented. Some results showing evaporation and two way coupling between dispersed phase and continuous phase turbulence are briefly described. Possible evolution of two phase flow modelling are sketched. (from English summary)

(Techniques tomographiques en ecoulement diphasique) (Tomographic techniques in two-phase flows)
Lemonnier H. & Peytraud J.-F., *Houille Blanche*, 1996, 51/1-2 (86-97). In French.
Impedance tomography consists in reconstructing the conductivity distribution from electrical data which characterise the electrical response of a medium to arbitrary excitations. Impedance tomography is an ill-conditioned problem and designing a tomograph therefore requires the quantitative knowledge of the sensitivity of the reconstruction to the measurements noise. The numerical conditioning of an original and accurate algorithm has been studied. The algorithm does not suffer from the shortcomings already identified in the literature. It is shown that for media encompassing inclusions which is a typical situation in two-phase flows, the necessary accuracy for the measurements is far beyond any technological reach. Moreover, within these high requirements for accuracy, some side effects must be carefully controlled or compensated for and relevant procedures are provided. It is concluded that impedance tomography has a low potential as an accurate phase fraction distribution measuring technique in any arbitrary two-phase flows. (from English summary)

(Recentes applications des techniques electrodiffusionnelles en ecoulement diphasique) (Recent applications of electrodiffusion techniques to two-phase flow)
Benabes B., Cognet G., Pascal G., Martemianov S. & Sobolik V., *Houille Blanche*, 1996, 51/1-2 (129-133). In French.
This article concerns non-conventional uses of the electrochemical method applied to the study of two-phase flows. One deals with the analysis of transport phenomena at liquid-liquid interface in a set-up where the active electrode is made of gallium, which is a metal changing from solid to liquid state almost at room temperature (29.8 degrees C). With the same hydrodynamic conditions an appreciable reduction of mass transfer is observed when passing through the melting point to the liquid state. The other application uses a three-segmented probe which is convenient for 3-D analysis of flow. The stability of solid-liquid flow (ie fiber suspension) is studied in a Taylor-Couette device. The influence of the fibers on the secondary flow is pointed out. (English summary)

(Anemometrie Phase Doppler en milieux multiphasiques: vers de nouvelles possibilites) (Doppler phase anemometer in the multiphase medium: towards new possibilities)
Grehan G., Onofri F. & Gouesbet G., *Houille Blanche*, 1996, 51/1-2 (98-104). In French.
To master two or multi-phase flows it is necessary to have a close dialogue between theory, numerical simulation and experiments. Optical techniques are often used because they give the possibility of local, in situ and on line measurements. For example a phase Doppler anemometer measures the size and the velocity of individual particles in flows. Nevertheless, classical phase Doppler geometries are limited by the finite size of the optimal probe created by two focused laser beams, leading to so-called 'Gaussian beam effects'. New geometries, free of Gaussian beam effects, are introduced. With these geometries the quality of flux measurements is improved and the phase Doppler technique can be extended to the measurement of the refractive index of the particles. (English summary)

(Application de la resonance magnetique nucleaire aux ecoulements diphasiques) (Application of nuclear magnetic resonance to two-phase flows)
Javelot S., Leblond J. & Baradel C., *Houille Blanche*, 1996, 51/1-2 (113-119). In French.
The results presented in this paper demonstrate the good performance of the PFGSE-NMR to obtain a complete characterization of two-phase flows. This method has been applied to air-water flows and also to water-Freon 113 flows where the two liquids are discernible by NMR and can be characterized independently. (English summary)

Comparison of upflow and downflow two-phase flow packed-bed reactors with and without fines: experimental observations
Wu Y., Khadilkar M.R., Al-Dahhan M.H. & Dudukovic M.P., *Industrial & Engineering Chemistry Research*, 1996, 35/2 (397-405). In English.

This study compares the performance of laboratory trickle-bed and upflow reactors over a range of operating conditions, using the hydrogenation of alpha-methylstyrene to cumene in hexane solvent over 25% Pd on alumina extrudate catalyst as a test reaction. It is shown that the trickle bed performs better than the upflow reactor at low pressures when the reaction is gas limited, due to ready access of the gas to the incompletely externally wetted catalyst, while the upflow reactor performs better at high pressures when the liquid reactant limitation controls the rate, due to the completely wetted catalyst. Comparison of the two reactors at different pressures, liquid reactant feed concentrations, and gas flow rates is presented, and differences in performance are explained based on the observed shift from gas limitation to liquid limitation. (from Authors)

The stability of free convection in a particle-fluid mixture with a free surface
Rhazi M., Mir A., Zrikem Z. & Gouesbet G., *International Communications in Heat & Mass Transfer*, 1996, 23/3 (345-353). In English.

The onset of thermal instability for simultaneous surface tension and buoyancy driven mechanisms in a horizontal fluid layer with suspended particles is theoretically investigated by means of a small disturbance analysis. The critical Marangoni, Rayleigh and wave numbers are computed and compared with those known for a pure fluid. The effect of the particles enters through three parameters: gamma, phi and GAMMA. The first describes how much particles are present, the second is determined by the particle-fluid thermal energy change ratio and the third characterizes the size of the individual particles. (from Authors)

On the influence of temperature and viscosity fluctuations on interfacial instability
Pinarbasi A. & Liakopoulos A., *International Communications in Heat & Mass Transfer*, 1996, 23/4 (485-493). In English.

Recently, Pinarbasi and Liakopoulos [1] investigated the effect of variable viscosity on the interfacial stability of two-layer, plane, Poiseuille flow. Temperature and viscosity fluctuations were neglected based on the observation that their effect on the stability of single-layer, Poiseuille flow is very small [2,3]. It is shown in the present work that temperature and viscosity fluctuations, under some conditions, have a significant effect on the interfacial mode of instability, especially for large Prandtl numbers. (Authors)

Onset of slugging criterion based on characteristics and stability analyses of transient one-dimensional two-phase flow equations of two-fluid model
Moon-Hyun Chun & Chang-Kyung Sung, *International Communications in Heat & Mass Transfer*, 1996, 23/4 (473-484). In English.

A two-step approach has been used to obtain a new criterion for the onset of slug formation: in the first step, a more general expression than the existing models for the onset of slug flow criterion has been derived from the analysis of singular points and neutral stability conditions of the transient one-dimensional two-phase flow equations of two-fluid model. In the second step, introducing simplifications and incorporating a parameter into the general expression obtained in the first step to satisfy a number of physical conditions a priori specified, a new simple criterion for the onset of slug flow has been derived. (from Authors)

Theoretical and experimental investigation of the onset of slugging in horizontal stratified air-water countercurrent flow
Moon-Hyan Chun, Byung-Ryung Lee & Ho-Yun Nam, *International Communications in Heat & Mass Transfer*, 1996, 23/1 (11-22). In English.

An experimental and theoretical study has been carried out to derive the wave height and transition criterion from wavy to sludge flow in horizontal air-water countercurrent stratified flow conditions. A theoretical formula for the wave height in a stratified wavy flow regime has been developed using the concept of total energy balance over a wave crest to consider the shear stress acting on the interface of two fluids. From the limiting condition of the formula for the wave height, a criterion for transition from a stratified wavy flow to a slug flow has been derived. A series of experiments have also been conducted changing the non-dimensional water depth and the flow rates of air in a horizontal pipe and a duct. Comparisons between the measured data and the predictions of the present theory show that the agreement is within +/-10%. (Authors)

On the influence of temperature and viscosity fluctuations on interfacial instability
Pinarbasi A. & Liakopoulos A., *International Communications in Heat & Mass Transfer*, 1996, 23/4 (485-493). In English.

Recently, Pinarbasi and Liakopoulos [1] investigated the effect of variable viscosity on the interfacial stability of two-layer, plane, Poiseuille flow. Temperature and viscosity fluctuations were neglected based on the observation that their effect on the stability of single-layer, Poiseuille flow is very small [2,3]. It is shown in the present work that temperature and viscosity fluctuations, under some conditions, have a significant effect on the interfacial mode of instability, especially for large Prandtl numbers. (Authors)

Numerical modelling of conduction-driven bulk evaporation and condensation processes with constant volume
Zhongtao Ding & Anghaie S., *International Journal for Numerical Methods in Engineering*, 1996, 39/2 (219-233). In English.

This work is to develop a control volume finite-difference method to model the bulk evaporation and condensation processes involved in liquid-vapour phase changes. An internal energy formulation, for these phase change processes that occur under the constraint of constant volume, is proposed. All calculations are carried

out on a fixed grid using the cylindrical co-ordinate system. The well-established enthalpy formulation and the proposed internal energy formulation are compared. Both formulations yield identical results with similar computational efficiencies, while the internal energy formulation has a more concise and compact form. Two iterative methods for the update of the vapour-phase fraction, the E-based and T-based methods, are investigated. The evolution of the phase change processes is investigated. (from Authors)

Application of flux-vector-splitting scheme to a dilute gas-particle JPL nozzle flow
Hsiao Tzu Chang, Lih Wu Hourng & Lai Chen Chien, *International Journal for Numerical Methods in Fluids*, 1996, 22/10 (921-935). In English.

A time-dependent numerical algorithm is developed for the two-fluid model Euler of TLNS (thin layer Navier-Stokes) equations. The analysis is based on a MUSCL (monotone upstream central scheme for conservation laws)-type flux-vector-splitting scheme with the multi-level technique. This algorithm is applied to investigate JPL (Jet Propulsion Laboratory) nozzle flow. Calculated results for both one-and two-phase flows are given to show the accuracy, the computational efficiency and the particle influence on the flow field. (Authors)

Computation of dilute particulate laminar flow over a backward-facing step
Barton I.E., *International Journal for Numerical Methods in Fluids*, 1996, 22/3 (211-221). In English.

Particle-laden flows are calculated for a classical laminar backward-facing step problem. The particle tracks are calculated using a recently developed exponential Lagrangian tracking scheme. The behaviour of the particle-laden flow is considered for various inlet for Reynolds number, Stokes numbers and void fractions. Doping the flow with low-Stokes-number particles has the effect of increasing the inlet inertia of the flow and this increases the strength of the recirculation behind the step. High-Stokes-number particles are dominated by gravitational effects which affect the flow accordingly. Differences between the single-phase flow and the particle-laden flows are therefore dependent on the Stokes number and increase linearly with void fraction. (Author)

Simulation of wave motion using a lattice gas model
Buick J., Easson W. & Greated C., *International Journal for Numerical Methods in Fluids*, 1996, 22/4 (313-321). In English.

The lattice gas model for simulating two-phase flow, proposed by Appert and Zaleski, has been modified by the introduction of gravitational interactions and the new model has been used to simulate standing wave patterns on the free surface of a fluid. The results compare well with linear theory. (Authors)

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Flow and transport in a multilayered fluid system - I. influence of 1-or mu-g environment
Fontaine J.-P. & Sani R.L., *International Journal of Heat & Mass Transfer*, 1996, 39/13 (2751-2770). In English.

The combined effects of thermocapillary and buoyancy forces in an open cavity heated from one side have been modeled numerically. The configuration is that of two shallow, immiscible superposed liquid layers. High Pradtl number fluids are considered under both 1-and mu-g environments. The interfaces are considered deformable. it is shown that encapsulation strongly reduces the flow in the lower layer, and that a mu-g environment significantly reduces the flow in the lower layer. (from Authors)

Turbulent buoyant thermal in a density-stratified atmosphere
Makhviladze G.M., Roberts J.P. & Yakush S.E., *International Journal of Heat & Mass Transfer*, 1996, 39/7 (1453-1462). In English.

A model of a turbulent axisymmetric thermal rising in an atmosphere with altitude-dependent density is proposed. A numerical study of the thermal is performed for an isothermal atmosphere with exponentially decreasing density. An analytical solution is found for a wide class of the density variation functions and studied in detail for an inverse-square law of density diminution with height. It is shown that as the thermal penetrates the low-density atmospheric layers, its top edge becomes less sharp and the width of the thermal increases. (from Authors)

Thermophoretic deposition including an application to the outside vapor deposition process
Wu C.K. & Greif R., *International Journal of Heat & Mass Transfer*, 1996, 39/7 (1429-1438). In English.

A study has been made of the flow, heat and mass transfer with chemical reactions and thermophoretic deposition with application to the outside vapor deposition (OVD) process. The system includes a flow that is emerging from a burner containing methane, oxygen, nitrogen and silicon tetrachloride and impinges on a cylind-

rical target. The governing equations which include the effects of buoyancy, variable properties, chemical reactions and thermophoretic transport have been solved numerically for a slot burner and a long cylinder in a two-dimensional configuration. The effects of the seperation distance between the burner and the target, the diameter and the rotational speed of the target and the eccentricity of the burner have been studied. The particle deposition flux and the deposition efficiency are investigated over a range of values of the parameters. (from Authors)

Interfacial wave stability of concurrent two-phase flow in a horizontal channel
Wu Q. & Ishii M., *International Journal of Heat & Mass Transfer*, 1996, 39/10 (2067-2075). In English.
The interfacial wave stability is analyzed by applying a wave front perturbation method to a one-dimensional two-phase flow in a horizontal duct. The governing equations are thus reduced to a first-order ordinary differential equation (ODE). The linear solution of this ODE agrees with the conclusion from the small amplitude wave perturbation approach. The non-linear theory suggests that the linear stability result is sufficient for predicting instability in wavy flow, and may over-predict the critical gas velocity for large disturbances. (after Authors)

Effect of valve lift and disk surface on two-phase critical flow at hot water relief valve
Osakabe M. & Isono M., *International Journal of Heat & Mass Transfer*, 1996, 39/8 (1617-1624). In English.
Critical flows through disk-type relief valves with different disk surfaces and lifts were investigated experimentally. The disk surfaces used were fouling brass with calcium scale, mirror-finished brass and clean Teflon. The critical flow rate obtained from the experiment was sufficiently higher than that calculated by the empirical correlation which is often used for calculation of valve capacity. From the comparison with data and a nonequilibrium homogeneous model, nonequilibrium effect was smallest in a valve using a disk of fouling brass and highest in a valve using a disk of mirror-finished brass. The nonequilibrium state was affected with flashing characteristics of valve disks and effects of lift were relatively small. (Authors)

Friction pressure drop of R-12 in small hydraulic diameter extruded aluminum tubes with and without microfins
Yang C.-Y. & Webb R.L., *International Journal of Heat & Mass Transfer*, 1996, 39/4 (801-809). In English.
Adiabatic, single-phase liquid and two-phase flow pressure drop were measured for R-12 flowing in both rectangular plain and micro-fin tubes with hydraulic diameters 2.64 and 1.56 mm, respectively. This work shows that the pressure drop is dominated by vapor shear in both the plain and micro-fin tubes. Vapor shear effects in micro-fin tube do not cause significant disturbances in the two-phase flow. This observation provides additional evidence to support the conclusion in other work by Yang and Webb that the distinctly steep condensation heat transfer curves at low mass velocity and high vapor quality are caused by surface tension drainage force. (from Authors)

Heat transfer bibliography - Japanese works 1994
Tanasawa I., Nishio S. & Suzuki K., *International Journal of Heat & Mass Transfer*, 1996, 39/15 (3089-3100). In English.
Papers on heat transfer published in Japan during 1994 are listed. Those that are in English are identified. The papers are classified under the following titles: conduction, natural convection, forced convection, boiling and evaporation, condensation, multiphase flow, melting and solidification, porous media (including fluidized and packed beds), mass transfer, thermal radiation, molecular and microscale heat transfer, measurement, thermophysical properties, heat exchanger, heat pipe and thermosyphon, thermal storage, various applications, and miscellaneous. (A.Peters)

The effect of fluid properties on two-phase (vapor-liquid) flow patterns in the presence of helical wire ribs
Weisman J., Lan J. & Disimile P., *International Journal of Multiphase Flow*, 1996, 22/3 (613-619). In English.
Since helical ribbing is one of the widely used methods for enhancing boiling heat transfer and increasing the critical heat flux inside tubes, it is desirable to understand the flow patterns produced during vapor-liquid flow. The present study examines flow-pattern behavior in horizontal lines with the refrigerant 113 vapor-liquid system using two of the helical coil arrangements tested in the air-water experiments. (from Authors)

Lagrangian coordinates for a drift-flux model of a gas-liquid mixture
Gavrilyuk S.L. & Fabre J., *International Journal of Multiphase Flow*, 1996, 22/3 (453-460). In English.
The mass Lagrangian coordinate associated with the velocity field of the gas for a nonstationary drift-flux model of a gas-liquid mixture is introduced here. If the mass transfer is neglected, this results in a quite simple structure of the governing equations and permits to integrate one of the equations independently on the others. The simplified model, describing the horizontal two-phase flow for high Froude number is considered and some explicit solutions to this model in the mass Lagrangian coordinates are obtained. (Authors)

The multiphase particle-in-cell (MP-PIC) method for dense particulate flows
Andrews M.J. & O'Rourke P.J., *International Journal of Multiphase Flow*, 1996, 22/2 (379-402). In English.
A multiphase particle-in-cell (MP-PIC) method has been developed. This numerical technique draws upon the best of Eulerian/Eulerian continuum models and Eulerian/Lagrangian discrete models. The MP-PIC method uses an accurate mapping from Lagrangian particles to and from a computational grid. The result of this procedure is a computational technique for multiphase flows that can handle particulate loading ranging from dense to dilute, a distribution of particle sizes and a range of particle materials. (from Authors)

An experimental and numerical study of flow patterns in a circulating fluidized bed reactor
Samuelsberg A. & Hjertager B.H., *International Journal of Multiphase Flow*, 1996, 22/3 (575-591). In English.

This paper presents an experimental and a numerical study on radial profiles of axial particle velocity component in a cold flow laboratory scale circulating fluidized bed reactor. Laser Doppler anemometry (LDA) has been used to measure mean and root mean square (RMS) particle velocities for three different superficial gas velocities. A two dimensional two phase flow model with a turbulent kinetic energy equation based on kinetic theory of granular flow is verified against the experimental data. (from Authors)

Droplet flux distributions and entrainment in horizontal gas-liquid flows
Williams L.R., Dykhno L.A. & Hanratty T.J., *International Journal of Multiphase Flow*, 1996, 22/1 (1-18). In English.

Measurements of entrainment and of droplet distributions are presented for air and water flowing in a horizontal 0.095 m pipe. A stratification of drops is observed because of the influence of gravity. Entrainment does not depend on pipe diameter and it increases strongly with increasing gas velocity. At small gas velocities, it is lower in horizontal pipes than in vertical pipes because gravitational settling enhances deposition. (Authors)

Flooding in a horizontal pipe with bend
Wongwises S., *International Journal of Multiphase Flow*, 1996, 22/1 (195-201). In English.

Flooding or countercurrent flow limitation (CCFL) have been studied both experimentally and analytically, mostly in vertical pipes. Relatively little information is currently available on countercurrent flow limitation, or flooding phenomena in horizontal pipes with a bend. In the present study, the main concern is to obtain the experimental results of CCFL of air and water in a bend between a horizontal pipe and a pipe inclined to the horizontal. (from Author)

Numerical simulation of the dynamics of an electrostatically levitated drop
Feng Z.C. & Leal L.G., *International Journal of Multiphase Flow*, 1996, 22/1 (93-120). In English.

The boundary integral method was used to simulate the dynamics of a liquid drop levitated by electrostatic force. The numerical code reproduces the Rayleigh limit, the Taylor limit and the stable equilibrium shape of a levitated drop obtained by previous authors. It also reveals the mechanism by which a levitated drop might breakup. Using this code, the natural frequencies of the drop were obtained under various levitation conditions. The effect of the electrostatic field on the resonant interactions between the modes was examined. The presence of the electric field enhances the modal interactions; modes which otherwise would not interact become coupled to each other. Calculations of the dynamics of a levitated drop under a time-periodic electric field indicate that the main resonance occurs when the frequency of the electric field is near the free oscillation frequency of the fundamental mode. (from Authors)

Tribochemically assisted wear of silicon nitride ball
Jisheng E., Stolarski T.A. & Gawne D.T., *Journal - European Ceramic Society*, 1996, 16/1 (25-34). In English.

The response of silicon nitride balls to different chemical additives contained in a diamond slurry was studied in a high speed four-ball machine. It was found that there are two effective inorganic chemical additives: acid additive (A) and alkaline additive (B). Use of A or B in the diamond slurry resulted in a high material removal rate and a rough surface. With an increase in the size of the diamond particles contained in the slurry, the material removal rate and the roughness of the surface also increased. Addition of sulfur-containing additives into the diamond slurries produced a decrease in the material removal rate but a smoother surface. The presence of water in the oil-based diamond slurry gave an increase in the material removal rate and a relatively smooth surface. In the ester-containing slurry, there was an increase in the material removal rate and the roughness of the surface. (Authors)

Cavitation induced by high-temperature plastic deformation in aluminium nitride ceramics
Choux S., Masson I., Feiereisen J.P., George A. & Michel J.P., *Journal - European Ceramic Society*, 1996, 16/5 (515-519). In English.

Intergranular cavitation has been investigated in samples deformed plastically up to a few per cent in four-point bending and uniaxial compression above 1500 degrees C. Even for strains of 0.5%, cavities with a size of several tenths of a micrometre were observed, generally nucleated at small sintering additive particules. Cavities are preferentially formed in grain boundaries perpendicular to the stress axis in areas deformed in tension but are rather isotropically distributed in samples deformed in compression. The volume fraction of cavities was found to be near the total strain. (Authors)

Drying of microparticle slurry and salt-water solution by a powder-particle spouted bed
Qimin Guo, Hikida S., Takahashi Y., Nakagawa N. & Kato K., *Journal of Chemical Engineering of Japan*, 1996, 29/1 (152-158). In English.

The powder-particle spouted bed (P-PSB) was developed as a new type of dryer for continuous drying of microparticles under several microns in diameter. The powder-particle spouted bed dryer is a cone-bottomed fluidized bed without a gas distributor. Coarse particles were located into the dryer and the hot gas was fed to it from the cone-bottom so that coarse particles were fluidized violently, and a microparticle slurry and a salt-water solution were continuously fed to it. Continuous drying of a microparticle slurry and a salt-water solution were carried out by using the powder-particle spouted bed, and the drying characteristics were investigated. The moisture content of the microparticles dried by this process from the submicroparticle slurry and the salt-water solution were nearly equal to their equilibrium moisture content over the range of the experiment. When the drying efficiency was above 60%, agglomerates were observed in the bed. (from Authors)

Gas holdup and volumetric liquid-phase mass transfer coefficient in a spout-fluid bed
Anabtawi M.Z. & Ibrahim G.A., *Journal of Chemical Engineering of Japan*, 1996, 29/1 (20-24). In English.

The effects of gas velocity, liquid velocity and nozzle diameter on the gas holdup and the volumetric liquid phase

mass transfer coefficient, $k_L a$, were studied a experimentally in a spout-fluid bed by absorption of oxygen in air into tap water. Gas holdup was found to increase with increasing gas velocity and to decrease with increasing liquid velocity and not to depend on nozzle diameter. $k_L a$ was found to increase with increasing gas velocity and liquid velocity and to decrease with increasing nozzle diameter. $k_L a$ was found to be strongly dependent on the liquid velocity. Two correlations for gas holdup and $k_L a$ in spout-fluid bed were presented with maximum deviation of 8% and 7% respectively. (Authors)

Dynamic analysis on constant pressure filtration of power law slurry
Kuo-Jen Hwang & Wei-Ming Lu, *Journal of Chemical Engineering of Japan*, 1996, 29/1 (65-74). In English.
The mechanism of cake formation in constant pressure filtration of power law slurry is studied. By analyzing the forces exerted on the deposition particles, the critical friction angles, $theta_c$ are estimated under various conditions. The lowest value of $theta_c$ is found when the frictional drag and the interparticle force are of the same order of magnitude. The packing structure of particles on the cake surface has been simulated, and the results indicate that a more compact cake will be obtained if a power law slurry with smaller n is filtered. A numerical program based upon the continuity equation and the Rabinowitsch-Mooney equation is also designed to estimate the variations of local cake properties during a course of constant pressure filtration. The calculated results of cake porosity and specific filtration resistance agree very well with the experimental data. (Authors)

Finite-amplitude effects on steady lee-wave patterns in subcritical stratified flow over topography
Yang T.-S. & Akylas T.R., *Journal of Fluid Mechanics*, 1996, 308/- (147-170). In English.
The flow of a continuously stratified fluid over a smooth bottom bump in a channel of finite depth is considered. Comparison with numerical results indicates that the asymptotic theory often remains reasonably accurate even for moderately small values of mu and epsilon, in which case the (formally exponentially small) lee-wave amplitude is greatly enhanced by nonlinearity and can be quite substantial. Moreover, these findings reveal that the range of validity of the classical linear lee-wave theory (A 1) is rather limited. (from Authors)

Elastohydrodynamic collisions of solid spheres
Lian G., Adams M.J. & Thornton C., *Journal of Fluid Mechanics*, 1996, 311/- (141-152). In English.
Recent developments in solving the problem of the elastohydrodynamic collision between two solid elastic bodies involved elaborate numerical procedures in order to simultaneously account for the elastic deformation of the solid surfaces and viscous fluid pressure. This paper describes a simple analytical approximation based upon a Hertzian-like profile for the elastic deformation of the two solid elastic spheres. By introducing a scaling coefficient, a closed-form solution has been developed which is capable of predicting the evolution of the relative velocity, force and restitution coefficient to an accuracy that is comparable with the exact numerical solutions. (Authors)

Entrainment into two-dimensional and axisymmetric turbulent gravity currents
Hallworth M.A., Huppert H.E., Phillips J.C. & Sparks R.S.J., *Journal of Fluid Mechanics*, 1996, 308/- (289-311). In English.
Entrainment of ambient fluid into both two-dimensional and axisymmetric gravity currents is investigated experimentally using a novel neutralization technique. The technique involves the titrative neutralization of an alkaline gravity current which intrudes into and entrains an acidic ambient, and is visualized using a pH indicator solution. Using this technique, we can determine quantitative results for the amount of dilution in the head of the current. We also obtain experimental results for constant-volume gravity currents moving over horizontal surfaces of varying roughness. A range of similar results is determined, both theoretically and experimentally, for the instantaneous release of a fixed volume of (heavy) fluid in an axisymmetric geometry. By constrast, the results of our experiments with gravity currents fed by a constant flux exhibit markedly different entrainment dynamics due to the continual replenishment of the fluid in the head by the constant input of undiluted fluid from the tail. (from Authors)

Internal waves, turbulence and mixing in stratified flows: a report on Euromech Colloquium 339
Staquet C. & Sommeria J., *Journal of Fluid Mechanics*, 1996, 314/- (349-371). In English.
Euromech colloquium 339 was organized by C. Staquet in Lyon (France) from September 6 to 9, 1995. It involved seventy-six participants from fourteen countries. Papers were presented on various aspects of stably stratified flows; internal waves, their generation mechanisms, propagation and reflection properties, their instabilities leading to breaking; vortex structures in stably stratified fluids, which can be slow layerwise structures, or small intense vortices, appearing for instance in shear flow instabilities; statistical properties of random wave fields or stratified turbulence. (from Authors)

Non-continuum lubrication flows between particles colliding in a gas
Sundararajakumar R.R. & Koch D.L., *Journal of Fluid Mechanics*, 1996, 313/- (283-308). In English.
Solid-body collisions between smooth particles in a gas would not occur if the lubrication force for a continuum imcompressible fluid were to hold at all particle separations. When the gap between the particles is of the order of the mean free path $lambda_0$ of the gas, the discrete molecular nature of the gas becomes important. For particles of radii a smaller than about 50 mum colliding in air at a relative velocity comparable to their terminal velocity, the effects of compressibility of the gas in the gap are not important. To find the lubrication force in the transition regime (aepsilon approx $0(lambda_0)$), we use the results of Cercignani & Daneri (1963) for the flux as a function of the pressure gradient in a Poiseuille channel flow. The non-continuum lubrication force is shown to have a weak, log-log divergence as the particle separation goes to zero. As a result, the energy dissipated in the collision is finite. When $lambda_0$ per mille $aepsilon^{1/2}$, we have a free molecular flow in the gap. In this case, owing to the curvature of the particles, the flux versus pressure gradient relation is non-local. We analyse the free molecular flow between two cylinders and obtain scalings for the lubrication force. (from Authors)

Weakly nonlinear wave motions in a thermally stratified boundary layer
Denier J.P. & Mureithi E.W., *Journal of Fluid Mechanics*, 1996, 315/- (293-316). In English.
We consider weakly nonlinear wave motions in a thermally stratified boundary layer. Attention is focused on the upper branch of the neutral stability curve, corresponding to small wavelengths and large Reynolds number. In this limit the motion is governed by a first harmonic/mean flow interaction theory in which the wave-induced mean flow is of the same order of magnitude as the wave component of the flow. We show that the flow is governed by a system of three coupled partial differential equations which admit finite-amplitude periodic solutions bifurcating from the linear, neutral points. (Authors)

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An inverse energy cascade in two-dimensional low Reynolds number bubbly flows
Esmaeeli A. & Tryggvason G., *Journal of Fluid Mechanics*, 1996, 314/- (315-330). In English.
Two direct numerical simulations of several buoyant bubbles in a two-dimensional periodic domain are presented. Simulations of the motion of both 144 and 324 bubbles show the formation of flow structures much larger than the bubble size, and a continuous increase in the energy of the low-wavenumber velocity modes. Plots of the energy spectrum show a range of wavenumbers with an approximately -5/3 slope. This suggests that a part of the work done by buoyant bubbles is not dissipated, but instead increases the energy of flow structures much larger than the bubbles. This phenomenon prevents the appearance of a statistically steady-state motion that is independent of the size of the computational domain. (from Authors)

Turbulence, similarity scaling and vortex geometry in the wake of a towed sphere in a stably stratified fluid
Spedding G.R., Browand F.K. & Fincham A.M., *Journal of Fluid Mechanics*, 1996, 314/- (53-103). In English.
Late wakes of towed spheres in a stably stratified fluid were analysed in a plane using a reliable, customized DPIV technique that provides sufficient spatial and temporal resolution to cover all important scales of motion in this freely decaying geophysical flow. Individual vortex cross-sections appear to be well approximated by Gaussian distributions of all Re, F and Nt studied here. The scaling behaviour of individual vortices mimics that of the statistical, wake-averaged quantities, and differs measurably from a simple two-dimensional viscous diffusion model. The importance of formulating a realistic three-dimensional model is discussed, and some limited steps in this direction point to future useful experiments and modelling efforts. (from Authors)

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Two-dimensional vortex dynamics in a stratified barotropic fluid
Arendt S.C., *Journal of Fluid Mechanics*, 1996, 314/- (139-161). In English.
We show that two-dimensional 'point' vortex dynamics in both a polytropic fluid of gamma = 3/2 and an isothermal fluid stratified by a constant gravitational field can be written in Hamiltonian form. We find that the formulation admits only one constant of the motion in addition to the Hamiltonian, so that two vortices are the most for which the motion is generally integrable. Closed trajectories analogous to the circular orbits of the uniform-fluid two-vortex problem, open trajectories for which the self-propelled vortices scatter off each other, and both unstable and stable steadily translating pairs of vortices are found. Comparison is made to the case of two vortices in a uniform density fluid bounded by a wall. (from Author)

Non-continuum lubrication flows between particles colliding in a gas
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Solid-body collisions between smooth particles in a gas would not occur if the lubrication force for a continuum imcompressible fluid were to hold at all particle separations. When the gap between the particles is of the order of the mean free path $lambda_0$ of the gas, the discrete molecular nature of the gas becomes important. For particles of radii a smaller than about 50 mum colliding in air at a relative velocity comparable to their terminal velocity, the effects of compressibility of the gas in the gap are not important. To find the lubrication force in the transition regime (aepsilon approx $0(lambda_0)$), we use the results of Cercignani & Daneri (1963) for the flux as a function of the pressure gradient in a Poiseuille channel flow. The non-continuum lubrication force is shown to have a weak, log-log divergence as the particle separation goes to zero. As a result, the energy dissipated in the collision is finite. When $lambda_0$ per mille $aepsilon^{1/2}$, we have a free molecular flow in the gap. In this case, owing to the curvature of the particles, the flux versus pressure gradient relation is non-local. We analyse the free molecular flow between two cylinders and obtain scalings for the lubrication force. (from Authors)

Axisymmetric pressure-driven flow of rigid pellets through a cylindrical tube lined with a deformable porous wall layer
Damiano E.R., Duling B.R., Ley K. & Skalak T.C., *Journal of Fluid Mechanics*, 1996, 314/- (163-189). In English.
A closed-form analytic solution for the motion of axisymmetric rigid pellets suspended in a Newtonian fluid and driven under a pressure gradient through a rigid impermeable cylindrical tube lined with a porous deformable biphasic wall layer is derived using mixture and lubrication theories. The analysis details the velocity distributions in the lubrication and wall layers as well as the solid-phase displacement field in the wall layer. Expressions for the shear stress and pressure gradient are obtained throughout the lubrication and wall layers. Results are presented in terms of resistance, volume flow, and driving pressure relative to smooth-walled tubes for cases both with and without rigid spheres flowing in the free lumen. (from Authors)

Turbulence, similarity scaling and vortex geometry in the wake of a towed sphere in a stably stratified fluid
Spedding G.R., Browand F.K. & Fincham A.M., *Journal of Fluid Mechanics*, 1996, 314/- (53-103). In English.
Late wakes of towed spheres in a stably stratified fluid were analysed in a plane using a reliable, customized DPIV technique that provides sufficient spatial and temporal resolution to cover all important scales of motion in this freely decaying geophysical flow. Individual vortex cross-sections appear to be well approximated by Gaussian distributions of all Re, F and Nt studied here. The scaling behaviour of individual vortices mimics that of the statistical, wake-averaged quantities, and differs measurably from a simple two-dimensional viscous diffusion model. The importance of formulating a realistic three-dimensional model is discussed, and some limited steps in this direction point to future useful experiments and modelling efforts. (from Authors)

Linear dynamics of wind waves in coupled turbulent air-water flow. Part 2. Numerical model
Harris J.A., Belcher S.E. & Street R.L., *Journal of Fluid Mechanics*, 1996, 308/- (219-254). In English.
We develop a numerical model of the interaction between wind and a small-amplitude water wave. The model first calculates the turbulent flows in both the air and water that would be obtained with a flat interface, and then calculates linear perturbations to this base flow caused by a travelling surface wave. The damped eddy viscosity model has a free constant that is calibrated by comparing with results from a second-order closure model. The new model is then used to calculate the variation of form drag on a stationary rigid wave with Reynolds number, R. Results from the numerical model show reasonable agreement with profiles measured over travelling water waves by Hsu & Hsu (1983), particularly for slower moving waves. The model suggests that the wave-induced flow in the water is irrotational except in an extremely thin interface layer, where viscous stresses are as likely to be important as turbulent stresses. (from Authors)

Stability of two-layer stratified flow in inclined channels: applications to air entrainment in coating systems
Severtson Y.C. & Aidun C.K., *Journal of Fluid Mechanics*, 1996, 312/- (173-200). In English.
To understand the physics of air entrainment in thin-film liquid coating and other applications, the stability characteristics of general stratified two-layer Poiseuille-Couette flow are examined in inclined channels. The generalized eigenvalue problem, formed by spectral decomposition and solution of the general two-layer Orr-Sommerfeld equation, is solved to obtain all of the critical modes. Analysis of the air/liquid interface corresponding to experiments reveals that because of the large density variation between the two layers, the interfacial mode is the only mode of instability in air entrainment. (from Authors)

Finite-amplitude effects on steady lee-wave patterns in subcritical stratified flow over topography
Yang T.-S. & Akylas T.R., *Journal of Fluid Mechanics*, 1996, 308/- (147-170). In English.
The flow of a continuously stratified fluid over a smooth bottom bump in a channel of finite depth is considered. Comparison with numerical results indicates that the asymptotic theory often remains reasonably accurate even for moderately small values of mu and epsilon, in which case the (formally exponentially small) lee-wave amplitude is greatly enhanced by nonlinearity and can be quite substantial. Moreover, these findings reveal that the range of validity of the classical linear lee-wave theory (A 1) is rather limited. (from Authors)

Surfactant dynamics and rectified diffusion of microbubbles
Fyrillas M.M. & Szeri A.J., *Journal of Fluid Mechanics*, 1996, 311/- (361-378). In English.
Surfactant transport dynamics and the consequences for rectified diffusion of microbubbles are treated for bubbles undergoing arbitrarily large-amplitude periodic radial oscillations. A perturbation technique is used to reveal averaged equations for the slow convection-enhanced diffusive transport of surfactant molecules. Bubble oscillations are shown to drive an increased number of surfactant molecules to the interface, if it is lightly populated, but to reduce the maximum possible population of surfactants on the interface. These effects have important consequences for rectified diffusion, in which the interfacial resistance to gas transfer of a surfactant monolayer is a strong function of the surface excess population. (from Authors)

The effect of centreline particle concentration in a wave tube
Vainshtein P., Fichman M., Shuster K. & Gutfinger C., *Journal of Fluid Mechanics*, 1996, 306/- (31-42). In English.
The interaction of sound waves with an aqueous suspension of solid particles was analysed experimentally and theoretically. A heretofore unreported effect of particle concentration in the vicinity of a wave-tube centreline was observed. The phenomenon is related to the combined effect of Rayleigh-type acoustic streaming, jet-like streaming (quartz wind) and drift forces occurring in the presence of a sonic wave in the suspension-filled tube. (Authors)

Stability of two-layer stratified flow in inclined channels: applications to air entrainment in coating systems
Severtson Y.C. & Aidun C.K., *Journal of Fluid Mechanics*, 1996, 312/- (173-200). In English.

To understand the physics of air entrainment in thin-film liquid coating and other applications, the stability characteristics of general stratified two-layer Poiseuille-Couette flow are examined in inclined channels. The generalized eigenvalue problem, formed by spectral decomposition and solution of the general two-layer Orr-Sommerfeld equation, is solved to obtain all of the critical modes. Analysis of the air/liquid interface corresponding to experiments reveals that because of the large density variation between the two layers, the interfacial mode is the only mode of instability in air entrainment. (from Authors)

Numerical simulations of uniformly stratified fluid flow over topography
Rottman J.W., Broutman D. & Grimshaw R., *Journal of Fluid Mechanics*, 1996, 306/- (1-30). In English.
We use a high-resolution spectral numerical scheme to solve the two-dimensional equations of motion for the flow of a uniformly stratified Boussinesq fluid over isolated bottom topography in a channel of finite depth. The focus is on topography of small to moderate amplitude and slope and for conditions such that the flow is near linear resonance of either of the first two internal wave modes. The results are compared with existing inviscid theories: the steady hydrostatic analysis of Long (1955), time-dependent linear long-wave theory, and the fully nonlinear, weakly dispersive resonant theory of Grimshaw & Yi (1991). Also, we present some new results on the modal similarity of the solutions of Long and Grimshaw & Yi. (from Authors)

Simple shear flows of dense gas-solid suspensions at finite Stokes numbers
Sangani A.S., Guobiao Mo, Heng-Kwong Tsao & Koch D.L., *Journal of Fluid Mechanics*, 1996, 313/- (309-341). In English.
We examine the problem of determining the particle-phase velocity variance and rheology of sheared gas-solid suspensions at small Reynolds numbers and finite Stokes numbers. The simulation results are compared to the predictions of two theories. The two theories agree with each other at higher values of volume fraction phi of particles over a surprisingly large range of values of St. For smaller phi, however, the two theories deviate significantly except at sufficiently large St. A detailed comparison shows that the predictions of the approximate theory based on Grad's method are in excellent agreement with the results of numerical simulations. (from Authors)

Stable and unstable monopolar vortices in a stratified fluid
Flor J.B. & Van Heijst G.J.F., *Journal of Fluid Mechanics*, 1996, 311/- (257-287). In English.
This paper presents experiments on planar monopolar vortex structures generated in a non-rotating, stratified fluid. Characteristics such as cross-sectional profiles (angular velocity and vorticity) and vorticity-stream function scatter plots have been measured experimentally by using digital image processing techniques. The characteristics of the monopolar vortices are compared with analytical vortex models known from literature. Simple models, based on vertical diffusion of vorticity, are proposed to describe the monopolar vortex decay; they show reasonable agreement with the experimental results. From the multipolar structures, the tripolar vortex and a specific case of a triangular vortex, neither having been observed before in a stratified fluid, are studied in detail. A comparison with point-vortex models yields good agreement. (from Authors)

The behaviour of a gas cavity impacted by a weak or strong shock wave
Zhong Ding & Gracewski S.M., *Journal of Fluid Mechanics*, 1996, 309/- (183-209). In English.
Two-dimensional simulations of gas cavity responses to both weak shocks (p = or 30 MPa) and strong shocks (p ranging from 500 to 2000 MPa) are performed using a finite volume method. An artificial viscosity to capture the shock and a simple, stable, and adaptive mesh generation technique have been developed for the computations. The details of the shock propagation, rarefaction, transmission and bubble wall motions are obtained from the numerical computations. The bubble collapse and re-expansion time predicted by this model agree with spherically symmetric computations. When impacted by strong shock waves, the bubble will collapse and a liqud jet is formed that propagates through the bubble to the opposite bubble wall. (from Authors)

The initial response of a stratified lake to the surface shear stress
Stevens C. & Imberger J., *Journal of Fluid Mechanics*, 1996, 312/- (39-66). In English.
Laboratory experiments are used to study the initial response of a stratified fluid to the action of a wind stress. The experiments are described in the context of a parameterization scheme that quantified the strength of the applied stress relative to the bulk stability of the fluid an also the duration of the wind stress relative to the periods of the waves generated by the stress. This study concentrates on the first fundamental internal wave period in experiments where the fluid is considered to have upwelled, i.e. the stratified region of the fluid reaches the surface at the upwind endwall. A linear model using normal modes proved successful prior to the commencement of upwelling and this enabled an estimate to be made of the time at which upwelling occurred. (from Authors)

Axisymmetric pressure-driven flow of rigid pellets through a cylindrical tube lined with a deformable porous wall layer
Damiano E.R., Duling B.R., Ley K. & Skalak T.C., *Journal of Fluid Mechanics*, 1996, 314/- (163-189). In English.
A closed-form analytic solution for the motion of axisymmetric rigid pellets suspended in a Newtonian fluid and driven under a pressure gradient through a rigid impermeable cylindrical tube lined with a porous deformable biphasic wall layer is derived using mixture and lubrication theories. The analysis details the velocity distributions in the lubrication and wall layers as well as the solid-phase displacement field in the wall layer. Expressions for the shear stress and pressure gradient are obtained throughout the lubrication and wall layers. Results are presented in terms of resistance, volume flow, and driving pressure relative to smooth-walled tubes for cases both with and without rigid spheres flowing in the free lumen. (from Authors)

Simple shear flows of dense gas-solid suspensions at finite Stokes numbers
Sangani A.S., Guobiao Mo, Heng-Kwong Tsao & Koch D.L., *Journal of Fluid Mechanics*, 1996, 313/- (309-341). In English.

We examine the problem of determining the particle-phase velocity variance and rheology of sheared gas-solid suspensions at small Reynolds numbers and finite Stokes numbers. The simulation results are compared to the predictions of two theories. The two theories agree with each other at higher values of volume fraction phi of particles over a surprisingly large range of values of St. For smaller phi, however, the two theories deviate significantly except at sufficiently large St. A detailed comparison shows that the predictions of the approximate theory based on Grad's method are in excellent agreement with the results of numerical simulations. (from Authors)

Time-dependent viscous deformation of a drop in a rapidly rotating denser fluid
Lister J.R. & Stone H.A., *Journal of Fluid Mechanics*, 1996, 317/- (275-299). In English.

Viscous stretching of a cigar-shaped drop due to the centrifugal pressure field in a surrounding rapidly rotating denser fluid is analysed. Scaling arguments are used to examine the various contributions to the viscous stresses resisting deformation, and a number of asymptotic regimes are identified which are delineated by the relative magnitudes of the aspect ratio, the viscosity ratio and unity. Detailed analysis based upon a slenderness assumption combined with an integral of the drop as a function of time in the different regimes. The analytical results are in good agreement with numerical simulations based upon a boundary-integral solution to the full viscous flow equations. (from Authors)

Two-dimensional vortex dynamics in a stratified barotropic fluid
Arendt S.C., *Journal of Fluid Mechanics*, 1996, 314/- (139-161). In English.

We show that two-dimensional 'point' vortex dynamics in both a polytropic fluid of gamma = 3/2 and an isothermal fluid stratified by a constant gravitational field can be written in Hamiltonian form. We find that the formulation admits only one constant of the motion in addition to the Hamiltonian, so that two vortices are the most for which the motion is generally integrable. Closed trajectories analogous to the circular orbits of the uniform-fluid two-vortex problem, open trajectories for which the self-propelled vortices scatter off each other, and both unstable and stable steadily translating pairs of vortices are found. Comparison is made to the case of two vortices in a uniform density fluid bounded by a wall. (from Author)

The initial response of a stratified lake to the surface shear stress
Stevens C. & Imberger J., *Journal of Fluid Mechanics*, 1996, 312/- (39-66). In English.

Laboratory experiments are used to study the initial response of a stratified fluid to the action of a wind stress. The experiments are described in the context of a parameterization scheme that quantified the strength of the applied stress relative to the bulk stability of the fluid an also the duration of the wind stress relative to the periods of the waves generated by the stress. This study concentrates on the first fundamental internal wave period in experiments where the fluid is considered to have upwelled, i.e. the stratified region of the fluid reaches the surface at the upwind endwall. A linear model using normal modes proved successful prior to the commencement of upwelling and this enabled an estimate to be made of the time at which upwelling occurred. (from Authors)

Entrainment into two-dimensional and axisymmetric turbulent gravity currents
Hallworth M.A., Huppert H.E., Phillips J.C. & Sparks R.S.J., *Journal of Fluid Mechanics*, 1996, 308/- (289-311). In English.

Entrainment of ambient fluid into both two-dimensional and axisymmetric gravity currents is investigated experimentally using a novel neutralization technique. The technique involves the titrative neutralization of an alkaline gravity current which intrudes into and entrains an acidic ambient, and is visualized using a pH indicator solution. Using this technique, we can determine quantitative results for the amount of dilution in the head of the current. We also obtain experimental results for constant-volume gravity currents moving over horizontal surfaces of varying roughness. A range of similar results is determined, both theoretically and experimentally, for the instantaneous release of a fixed volume of (heavy) fluid in an axisymmetric geometry. By constrast, the results of our experiments with gravity currents fed by a constant flux exhibit markedly different entrainment dynamics due to the continual replenishment of the fluid in the head by the constant input of undiluted fluid from the tail. (from Authors)

Elastohydrodynamic collisions of solid spheres
Lian G., Adams M.J. & Thornton C., *Journal of Fluid Mechanics*, 1996, 311/- (141-152). In English.

Recent developments in solving the problem of the elastohydrodynamic collision between two solid elastic bodies involved elaborate numerical procedures in order to simultaneously account for the elastic deformation of the solid surfaces and viscous fluid pressure. This paper describes a simple analytical approximation based upon a Hertzian-like profile for the elastic deformation of the two solid elastic spheres. By introducing a scaling coefficient, a closed-form solution has been developed which is capable of predicting the evolution of the relative velocity, force and restitution coefficient to an accuracy that is comparable with the exact numerical solutions. (Authors)

High-Reynolds-number weakly stratified flow past an obstacle
Chernyshenko S.I. & Castro I.P., *Journal of Fluid Mechanics*, 1996, 317/- (155-178). In English.

Stably stratified steady flow past a bluff body in a channel is considered for cases in which the stratification is not sufficiently strong to given solutions containing wave motions. The physical mechanisms by which stratification influences the flow are revealed. The drag reduction under weak stratification, observed in experiments, is

explained. This is achieved by constructing an asymptotic laminar solution for high Reynolds number (Re) and large channel width, which explicitly gives the mechanisms, and using comparisons with numerical results for medium Re and experiments for turbulent flows to argue that these mechanisms are expected to be common in all cases. (from Authors)

Linear dynamics of wind waves in coupled turbulent air-water flow. Part 2. Numerical model
Harris J.A., Belcher S.E. & Street R.L., *Journal of Fluid Mechanics*, 1996, 308/- (219-254). In English.
We develop a numerical model of the interaction between wind and a small-amplitude water wave. The model first calculates the turbulent flows in both the air and water that would be obtained with a flat interface, and then calculates linear perturbations to this base flow caused by a travelling surface wave. The damped eddy viscosity model has a free constant that is calibrated by comparing with results from a second-order closure model. The new model is then used to calculate the variation of form drag on a stationary rigid wave with Reynolds number, R. Results from the numerical model show reasonable agreement with profiles measured over travelling water waves by Hsu & Hsu (1983), particularly for slower moving waves. The model suggests that the wave-induced flow in the water is irrotational except in an extremely thin interface layer, where viscous stresses are as likely to be important as turbulent stresses. (from Authors)

Surfactant dynamics and rectified diffusion of microbubbles
Fyrillas M.M. & Szeri A.J., *Journal of Fluid Mechanics*, 1996, 311/- (361-378). In English.
Surfactant transport dynamics and the consequences for rectified diffusion of microbubbles are treated for bubbles undergoing arbitrarily large-amplitude periodic radial oscillations. A perturbation technique is used to reveal averaged equations for the slow convection-enhanced diffusive transport of surfactant molecules. Bubble oscillations are shown to drive an increased number of surfactant molecules to the interface, if it is lightly populated, but to reduce the maximum possible population of surfactants on the interface. These effects have important consequences for rectified diffusion, in which the interfacial resistance to gas transfer of a surfactant monolayer is a strong function of the surface excess population. (from Authors)

Stable and unstable monopolar vortices in a stratified fluid
Flor J.B. & Van Heijst G.J.F., *Journal of Fluid Mechanics*, 1996, 311/- (257-287). In English.
This paper presents experiments on planar monopolar vortex structures generated in a non-rotating, stratified fluid. Characteristics such as cross-sectional profiles (angular velocity and vorticity) and vorticity-stream function scatter plots have been measured experimentally by using digital image processing techniques. The characteristics of the monopolar vortices are compared with analytical vortex models known from literature. Simple models, based on vertical diffusion of vorticity, are proposed to describe the monopolar vortex decay; they show reasonable agreement with the experimental results. From the multipolar structures, the tripolar vortex and a specific case of a triangular vortex, neither having been observed before in a stratified fluid, are studied in detail. A comparison with point-vortex models yields good agreement. (from Authors)

Weakly nonlinear internal waves in a two-fluid system
Wooyoung Choi & Camassa R., *Journal of Fluid Mechanics*, 1996, 313/- (83-103). In English.
We derive general evolution equations for two-dimensional weakly nonlinear waves at the free surface in a system of two fluids of different densities. We consider the case of a free upper boundary for its relevance in applications to ocean dynamic problems and the case of a non-uniform rigid upper boundary for applications to atmospheric problems. Some numerical solutions of the model for one-dimensional waves in deep water are presented and compared with the known solutions of the uni-directional model. The effects of finite-amplitude slowly varying bottom topography are included in a model appropriate to the situation when the dependence on one of the horizontal coordinates is weak. (from Authors)

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Weakly nonlinear wave motions in a thermally stratified boundary layer
Denier J.P. & Mureithi E.W., *Journal of Fluid Mechanics*, 1996, 315/- (293-316). In English.
We consider weakly nonlinear wave motions in a thermally stratified boundary layer. Attention is focused on the upper branch of the neutral stability curve, corresponding to small wavelengths and large Reynolds number. In this limit the motion is governed by a first harmonic/mean flow interaction theory in which the wave-induced mean flow is of the same order of magnitude as the wave component of the flow. We show that the flow is governed by a system of three coupled partial differential equations which admit finite-amplitude periodic solutions bifurcating from the linear, neutral points. (Authors)

The behaviour of a gas cavity impacted by a weak or strong shock wave
Zhong Ding & Gracewski S.M., *Journal of Fluid Mechanics*, 1996, 309/- (183-209). In English.
Two-dimensional simulations of gas cavity responses to both weak shocks (p = or 30 MPa) and strong shocks (p ranging from 500 to 2000 MPa) are performed using a finite volume method. An artificial viscosity to capture the shock and a simple, stable, and adaptive mesh generation technique have been developed for the computa-

tions. The details of the shock propagation, rarefaction, transmission and bubble wall motions are obtained from the numerical computations. The bubble collapse and re-expansion time predicted by this model agree with spherically symmetric computations. When impacted by strong shock waves, the bubble will collapse and a liqud jet is formed that propagates through the bubble to the opposite bubble wall. (from Authors)

Gravity granular flows of slightly frictional particles down an inclined bumpy chute
Cao J., Ahmadi G. & Massoudi M., *Journal of Fluid Mechanics*, 1996, 316/- (197-221). In English.
Gravity-driven granular flow of slightly frictional particles down an inclined, bumpy chute is studied. A modified kinetic model which includes the frictional energy loss effects is used, and the boundary conditions for a bumpy wall with small friction are derived ensuring the balance of momentum and energy. The mean velocity, the fluctuation kinetic energy and the solid volume fraction profiles are evaluated. It is shown that steady granular gravity flow down a bumpy frictional chute could be achieved at arbitrary inclination angles. The computational results also show that the slip velocity may vary considerably depending on the granular layer height, the surface boundary roughness, the friction coefficient and the inclination angles. The model predictions are compared with the existing experimental and simulation data, and good agreement is observed. (from Authors)

Fluid-structure interaction in liquid-filled pipe systems: a review
Tijsseling A.S., *Journal of Fluids & Structures*, 1996, 10/2 (109-146). In English.
This paper looks at the literature on transient phenomena in liquid-filled pipe systems. Results show that they experience severe dynamic forces during a waterhammer event. When these forces make the system move, significant fluid structure interaction may occur, so that liquid and pipe systems cannot be treated separately in a theoretical analysis: interaction mechanisms have to be taken into account. In the majority of the analyses reviewed, the pipes are slender, thin-walled, straight, prismatic and of circular cross-section. The liquid and the pipe-wall material are assumed linearly elastic and cavitation is assumed not to occur. The theories developed are valid for long wavelength, acoustical phenomena. (after Author)

Uncertainty and sensitivity analysis for gas and brine migration at the Waste Isolation Pilot Plant: permeable shaft with panel seals
Helton J.C., 6 others & et al., *Journal of Hazardous Materials*, 1996, 45/2-3 (107-139). In English.
Uncertainty and sensitivity analysis techniques based on Latin hypercube sampling, partial correlation analysis, stepwise regression analysis and examination of scatter plots are used in conjunction with the BRAGFLO model to examine two-phase flow at the Waste Isolation Pilot Plant, which is being developed by the US Department of Energy as a disposal facility for transuranic waste. The following topics are investigated to develop insights on factors that are potentially important in establishing compliance with applicable regulations of the US Environmental Protection Agency: (1) gas production due to corrosion of steel; (2) gas production due to microbial degradation of cellulosics; and (3) gas migration through a sealed shaft to the Culebra Dolomite. Important variables identified in the analysis include initial brine saturation of the waste, stoichiometric terms for corrosion of steel and microbial degradation of cellulosics, and seal permeabilities. (from Authors)

Numerical calculations of unsteady heavy gas dispersion
Pereira J.C.F. & Chen X.-Q., *Journal of Hazardous Materials*, 1996, 46/2-3 (253-272). In English.
This paper concerns both near-field and far-field numerical predictions of liquefied gas releases in atmospheric environment. The near-field prediction was related to sudden depressurization of liquefied propane into atmospheric environment. Three phases of propane vapor, propane droplets, and entrained air were considered. Simplification was made that air and vapor have the same velocity and temperature but different volume fractions so that an air-vapor mixture phase could be assumed, and was treated using an Eulerian formulation. The droplet phase was handled using a Lagrangian formulation by which droplet trajectories were computed. A thin-skin evaporation model was used to account for droplet evaporation for the near-field prediction. Present numerical results for the near-field modelling were compared with those obtained with a twin-fluid Eulerian-Eulerian model. Numerical results were presented for the Burro 8 LNG field test. Results for the far field simulation were also compared with those obtained with the commercial code DEGADIS. (from Authors)

CLOUD: a vapour-aerosol dispersion model accounting for plume 3D motion and heat and mass transfer betwen phases
Banerjee S., Martini R. & Pattison M.J., *Journal of Hazardous Materials*, 1996, 46/2-3 (231-240). In English.
The CLOUD (concentration levels of unconfined dispersion) code has been developed, the nucleus of which is an innovative two-phase fluid dispersion model characterized by conservation equations for mass, momentum, energy and species, averaged over a volume slice transverse to the direction of plume motion. The initial and boundary conditions for the above equations are determined either by using auxiliary models or by direct input of the space distribution, and respectively of the time evolution, of the relevant variables. The boundary conditions for semi-continuous, jet releases have been used on literature models for critical two-phase flow at the rupture. The code has been validated with data from three large scale release test series: the Desert Tortoise series (ammonia), the Goldfish series (HF), and the Thorney Island series (heavy gas). (from Authors)

Experimental and theoretical analysis of flashing water flow through a safety valve
Bolle L., Downar-Zapolski P., Franco J. & Seynhaeve J.M., *Journal of Hazardous Materials*, 1996, 46/2-3 (105-116). In English.
A set of experiments has been carried out on the model of the CROSBY safety valve for flashing and nonflashing water flow. The pressure distribution inside the valve, the inlet and outlet temperature and the mass-flow rate

have been measured. The characteristics of the valve giving the mass-flow rate as a function of the square root of the pressure drop are given. The experimental results were compared with equilibrium and relaxation two-phase flow models. The nonequilibrium character of fast evaporation and its substantial influence on the two-phase flow behaviour has been emphasized. This could constitute a comprehensive base for a better understanding of two-phase flow through safety valves. (Authors)

CLOUD: a vapour-aerosol dispersion model accounting for plume 3D motion and heat and mass transfer betwen phases

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Measurement of particle/membrane interactions by a hydrodynamic method

Elzo D., Schmitz P., Houi D. & Joscelyne S., *Journal of Membrane Science*, 1996, 109/1 (43-53). In English.

A fundamental study of particle detachment of micron-sized glass particles from a model membrane surface is made. The model membrane surface consisted of a cellulose diacetate film which is the polymeric constituent of the hollow fibre membranes used in industrial water treatment. This experimental study aims to analyse the factors leading to the retention of particles on these membranes. A hydrodynamic method was used in which the release of deposited particles was measured under the action of fluid flow. The hydrodynamic force is calculated under well defined hydrodynamic conditions and related to the total adhesive force acting on the particle. In the absence of organic solutes adsorbed on the particles, the magnitude of the particle-membrane interaction depended on the pH and the salinity of the aqueous medium. When adsorbed polymer layers are coated on the surface of the particles, the adhesive force between the particles and the surface was found to be significantly greater than that for bare particles. This contrasted to the decrease in adhesion force observed for particle coated with non-ionic surfactant. (from Authors)

Damping of internal gravity waves by small-scale turbulence

Ostrovsky L.A. & Zaborskikh D.V., *Journal of Physical Oceanography*, 1996, 26/3 (388-397). In English.

The interaction between turbulence and internal waves in a stratified fluid with a shear flow is considered on the basis of perturbation theory permitting a description of internal wave damping by turbulence. The results show that the behavior of the damping rate for internal waves is rather anomalous for the long-wave range: it remains finite for such waves but may decrease to very small quantities in a restricted range of wavenumbers, depending on the mode structure. Detailed computations are made for the first three modes of the internal waves. The effects of anisotropy of the turbulent fluxes are also considered. For the case of constant buoyancy frequency an exact solution is obtained for the linearized semiempirical equations valid even for a strong wave damping. Estimates show that the damping by the upper turbulent layer may be an effective energy sink for long internal waves in the ocean. (Authors)

Flow regimes and transient dynamics of two-dimensional stratified flow over an isolated mountain ridge

Yuh-Lang Lin & Ting-An Wang, *Journal of the Atmospheric Sciences*, 1996, 53/1 (139-158). In English.

Four regimes are identified for two-dimensional, unstructured, nonrotating, continuously stratified, hydrostatic uniform Boussinesq flow over an isolated mountain ridge: (I) flow with neither wave breaking aloft nor upstream blocking (F = or 1.12, where F = U/Nh; U and N are upstream basic flow speed and Brunt-Vaisala frequency, respectively; and h is the mountain height), (II) flow with wave breaking aloft in the absence of upstream blocking (0.9 F = or 1.12), (III) flow with both wave breaking and upstream blocking, but where wave breaking occurs first (0.6 F = or 0.9), and (IV) flow with both wave breaking and upstream blocking, but where blocking occurs first (0.3 = or F = or 0.6). These regimes are detailed. (from Authors)

Application of three-layer model analysis to single-component two-phase critical flow through a converging nozzle: comparison of the experimental results for steam-water mixture and carbon dioxide with the calculated results

Ochi J., Ayukawa K. & Kawahara G., *JSME International Journal, Series B: Fluids & Thermal Engineering*, 1996, 39/1 (80-85). In English.

A two-phase critical flow with phase change through a converging nozzle is investigated and discussed in terms of the applications of three-layer model analysis which has already been reported for a case of two-component two-phase flow by Ochi and Ayukawa. In the theoretical analysis of a single-component two-phase flow during rapid phase change, there are some difficulties arising from the modeling of a complicated flow pattern at the interface. The calculated results using our proposed model are in good agreement with experimental data of the flow rate and the pressure of carbon dioxide or steam-water mixture flows. The flow properties of each layer through the channel are discussed in comparison with the completely separated flow or the homogeneous flow model. It is found that the three-layer model is a useful method for single-component two-phase flow undergoing rapid change of state in variable-area channels. (Authors)

Wind tunnel experiment on flow and tracer gas diffusion in convective planetary boundary layer

Sada K., *JSME International Journal, Series B: Fluids & Thermal Engineering*, 1996, 39/1 (19-27). In English.

The temperature of a flat tunnel floor was increased almost uniformly to 80 degrees C to simulate an unstable atmospheric boundary layer. The velocity, temperature and surface temperature heat flux on the wind tunnel floor were measured using a laser Doppler anemometer, a resistance thermometer and a thin-film-type heat flowmeter. The tracer gas was released from continuous point sources located in the simulated unstable boundary layer, and its spatial concentration was measured by flame ionization detectors. The measured turbulent flow and tracer gas concentration characteristics such as turbulence intensities and plume spreads showed good agreement with those obtained from field experiments and water tank experiments when normalized by the convective velocity. It appeared that the convective velocity and convective temperature could be applied as the similarity parameter for the flow and tracer gas diffusion when considering the corresponding equivalent atmospheric conditions. (from Author)

The development of cavitation in superplastic aluminum composites reinforced with $Si_3 N_4$
Iwasaki H., Mabuchi M., Higashi K. & Langdon T.G., *Materials Science & Engineering A*, 1996, (116-121). In English.

Two metal matrix composites, an Al-Cu-Mg (2124) alloy and an Al-Mg-Si (6061) alloy reinforced with $Si_3 N_4$ particulates, exhibit superplastic elongations at a true stress of 8 MPa at high strain rates at 783 K and 833 K respectively. Internal cavities are formed in these composites at the interfaces between the particulates and the matrix even at strains of only 0.2. However, the rate of cavity growth after nucleation is very low because diffusion growth is of negligible importance at these high strain rates. (from Authors)

Numerical study of gasdynamics influence on three-dimensional transport phenomena in vertical zinc selenide LPCVD reactor
Garibin E.A., Mironov I.A., Khoruzhnikov S.E. & Vorob'ev A.N., *Materials Science & Engineering B*, 1996, (8-14). In English.

The chemical vapour deposition of polycrystalline zinc selenide in a vertical rectangular reactor is numerically simulated on the basis of the three-dimensional transport equations for low Mach number flows. The results obtained suggest two different regimes of mass transfer. The influence of carrier gas flow rate on the process efficiency and the uniformity of deposited layers is analysed. (Authors)

Applications of nuclear magnetic resonance imaging on process engineering
Gladden L.F. & Alexander P., *Measurement Science & Technology*, 1996, 7/3 (423-435). In English.

During the past decade, the application of nuclear magnetic resonance (NMR) imaging techniques to problems of relevance to the process industries has been identified. The particular strengths of NMR techniques are their ability to distinguish between different chemical species and to yield information simultaneously on the structure, concentration distribution and flow processes occurring within a given process unit. In this paper, examples of specific applications in the areas of materials and food processing, transport in reactors and two-phase flow are discussed. One specific study, that of the internal structure of a packed column, is considered in detail. This example is reported to illustrate the extent of new, quantitative information of generic importance of many processing operations that can be obtained using NMR imaging in combination with image analysis. (Authors)

Process tomography applied to multi-phase flow measurement
Dyakowski T., *Measurement Science & Technology*, 1996, 7/3 (343-353). In English.

This paper presents the state of the art in measuring multi-phase flows by using tomographic techniques. The results presented show a wide range of industrial applications of process tomography from the nuclear and chemical to the food industry. This is illustrated by examples of the application of various tomographic sensors to the measurement of geometric or kinematic parameters of multi-phase flows. An application of process tomography for the validation of computational fluid dynamic models and the possibility of constructing a flowmeter for multi-phase flow are addressed. (Author)

Modelling of multiphase flow in packed beds by computer-assisted X-ray tomography
Toye D., Marchot P., Crine M. & L'Homme G., *Measurement Science & Technology*, 1996, 7/3 (436-443). In English.

The high resolution which can be obtained by computer-assisted X-ray tomography is used to investigate various scale heterogeneities of the flow texture characterizing multiphase flow in packed beds. The direct counting of 'irrigated' pixels allows the determination of the number of individual liquid rivulets as well as their size. The evolution of the liquid flow texture versus the liquid velocity agrees well with the predictions of a percolation-based model. This agreement is further confirmed by the comparison of the experimental hold-up values averaged over the column cross-section with the theoretical model. (Authors)

Further development of a tomographic imaging system using optical fibres for pneumatic conveyors
Abdul Rahim R., Green R.G., Horbury N., Dickin F.J., Naylor B.D. & Pridmore T.P., *Measurement Science & Technology*, 1996, 7/3 (419-422). In English.

This paper describes the further development of optical sensor hardware for a process tomography system in which emitters and detectors are used to exploit the optical characteristics of multiphase flow regimes. The optical arrangement is described and the importance of fibre beam position discussed. The proportion of the measurement volume interrogated by the beams is derived. The response of a single fibre is shown followed by a reconstructed concentration profile. (Authors)

Analysis of chaos in fluidization using electrical capacitance tomography
Kuhn F.T., Schouten J.C., Mudde R.F., Van den Bleek C.M. & Scarlett B., *Measurement Science & Technology*, 1996, 7/3 (361-368). In English.

Fluidized beds display a degree of structure which it is vital to understand in any design and scale-up of equip-

ment. This paper is on the employment of chaos theory to describe this structure. The measuring technique of electrical capacitance tomography is used to determine the local porosity of a gas-solids fluidized bed and to monitor its fluctuation with time. These raw data are translated into invariants characteristic of the structure mentioned, such as the Kolmogorov entropy. Initial measurements have shown a strong variation in these chaotic invariants with bed position and operational parameters. First results are compared with earlier data from pressure measurements. (Authors)

Development of an ultrasonic tomography system for application in pneumatic conveying
Brown G.J., Reilly D. & Mills D., *Measurement Science & Technology*, 1996, 7/3 (396-405). In English.
This paper details the development of a tomographic technique for imaging gas-solid flow distributions in pneumatic conveying pipelines. The technique utilizes ultrasonic transmission-mode measurements constrained to the megahertz region. Image reconstruction is performed by an efficient backprojection method implemented with standard graphics algorithms. Simulated reconstructions of dense and dilute distributions are presented. These results demonstrate the capabilities and limitations of the technique. Aspects of transducers array design are also addressed. An optimal arrangement for imaging dense phase flow distributions is derived and the characteristics of air-loaded and water-loaded, matched and unmatched peizoceramic transducers are evaluated. The validity of the technique is demonstrated using a low-frequency (72 kHz) system constructed with prototype fan-shaped-beam electrostatic transducers. (from Authors)

Simulator predicts transient flow for Malaysian subsea pipeline
Inayat-Hussain A.A., Ayob M.S. & Zain A.B.M., *Oil & Gas Journal*, 1996, 94/16 (62-64,67). In English.
ABASs is dedicated software developed for two-phase flow simulation of slow gas condensate transient flow during pigging operations in the Duyong pipeline network offshore Malaysia. It predicts steady state pressure drop against flow rate, condensate volume, and pigging dynamics. Predictions have been verified against field data. This article describes software development, verification and application. Field data and results of simulation studies are included. (J.M.McLaughlin)

Fluid properties determine flow line blockage potential
Hunt A., *Oil & Gas Journal*, 1996, 94/29 (62-66). In English.
Thermal and chemical methods are described for overcoming fluid behaviour problems caused by hydrate and other fluid constituents in subsea multiphase flow. Types of problems and their causes are discussed. The differences between nucleation, growth and deposition in the pipelines are considered. Process simulation packages for predicting hydrate formation conditions within the pipeline are described. The use of thermodynamic and kinetic inhibitors for preventing hydrate formation is discussed. (P.M.Taylor)

Multiphase-flow choke correlation limits analyzed
Lannom D.A. & Hatzignatiou D.G., *Oil & Gas Journal*, 1996, 94/15 (37-41). In English.
Correlations for determining the flow rate of multiphase fluids through restrictions are examined. The seven correlations are evaluated using production data from 181 well tests. Parameters influencing the performance and selection of each correlation are discussed. Although no one correlation performed best in all ranges of flow parameters, the Gilbert, Ros, and Poetmann and Beck correlations tended to predict flow rates more accurately over the widest range of flow conditions. (P.M.Taylor)

Fluid properties determine flow line blockage potential
Hunt A., *Oil & Gas Journal*, 1996, 94/29 (62-66). In English.
Thermal and chemical methods are described for overcoming fluid behaviour problems caused by hydrate and other fluid constituents in subsea multiphase flow. Types of problems and their causes are discussed. The differences between nucleation, growth and deposition in the pipelines are considered. Process simulation packages for predicting hydrate formation conditions within the pipeline are described. The use of thermodynamic and kinetic inhibitors for preventing hydrate formation is discussed. (P.M.Taylor)

Shock waves in a liquid containing small gas bubbles
Kameda M. & Matsumoto Y., *Physics of Fluids*, 1996, 8/2 (322-335). In English.
Numerical and experimental studies of the transient shock wave phenomena in a liquid containing non-condensable gas bubbles are presented. In the numerical analysis, individual bubbles are tracked to estimate the effect of volume oscillations on the wave phenomena. Thermal processes inside each bubble, which have significant influence on the volume oscillation, are calculated directly using full equations for mass, momentum and energy conservation, and those results are combined with the averaged conservation equations of the bubbly mixture to simulate the propagation of the shock wave. A silicon oil/nitrogen bubble mixture, in which the initial bubble radius is about 0.6 mm and the gas volume fraction is 0.15%-0.4%, is used in the shock tube experiments. The numerical predictions where such a distribution is taken into account agree well with those experimental data. Wave phenomena in bubbly mixture, which has close connection with the performance of chemical reactors, safety of nuclear power plants, performance of oceanic devices. Heat transfer between the bubbles and the surrounding liquid, rather than relative motion, is the main factor affecting the relaxation process. The heat transfer is governed by the thermal behavior of the bubble interior. (after Authors)

Observations of a cavitation bubble interacting with a solid boundary as seen from below
Jin Y.H., Shaw S.J. & Emmony D.C., *Physics of Fluids*, 1996, 8/7 (1699-1701). In English.
This paper looks at cavitation which is the process by which vapour cavities or bubbles, when they come close to a solid boundary, cause damage to that surface. We present a schlieren photographic sequence of a laser generated cavity in water interacting with a solid boundary as seen from the boundary's perspective looking through the bubble. (after Authors)

Experimental study of incompressible Richtmyer-Meshkov instability
Jacobs J.W. & Sheeley J.M., *Physics of Fluids*, 1996, 8/2 (404-415). In English.
The Richtmyer-Meskhov instability of a two-liquid system is investigated experimentally. The instability is generated by vertically accelerating a tank containing two stratified liquids by bouncing it off of a fixed coil spring. A controlled two-dimensional sinusoidal initial shape is given to the interface by oscillating the container in the horizontal direction to produce standing waves. The motion of the interface is recorded during the experiments using standard video photography. Instability growth rates are measured and compared with existing linear theory. Disagreement between measured growth rates and the theory are accredited to the finite bounce length. When the linear stability theory is modified to account for an acceleration pulse of finite duration, much better agreement is attained. (from Authors)

Internal capillary-gravity waves of a two-layer fluid with free surface over an obstruction - forced extended KdV equation
Choi J.W., Sun S.M. & Shen M.C., *Physics of Fluids*, 1996, 8/2 (397-404). In English.
We study steady capillary-gravity waves in a two-layer fluid bounded above by a free surface and below by a horizontal rigid boundary with a small obstruction. Two critical speeds for the waves are obtained. Near the smaller critical speed, the derivation of the usual forced KdV equation (FKdV) fails when the coefficient of the nonlinear term in the FKdV vanishes. To overcome this difficulty, a new equation, called a forced extended KdV equation (FEKdV) governing interfacial wave forms, is obtained by a refined asymptotic method. Various solutions and numerical results of this equation are presented. In general, we can find three types of solutions. The first-type solution consists of symmetric solitary-wave-like solutions. The second-type solution is one that is a part of a free solitary wave behind the bump and a periodic wave solution ahead of the bump. By a third-type solution we mean a solution that is constant behind the bump and periodic ahead of the bump. (from Authors)

Internal gravity wave radiation into weakly stratified fluid
Sutherland B.R., *Physics of Fluids*, 1996, 8/2 (430-441). In English.
It is shown nonlinear numerical simulations of flow restricted to two dimensions that a compact wavepacket of large-amplitude internal gravity waves incident upon a weakly stratified region in which the buoyancy frequency is less than the frequency of the wavepacket may partially transmit energy into this region through the generation of a wavepacket of lower frequency. For a range of simulations initialized with wavepackets of different amplitude and vertical extent, the characteristics of the reflected and transmitted waves are analyzed and reflection coefficients are calculated. It is demonstrated in theory and by fully nonlinear numerical simulations restricted to two dimensions that a compact IGW wavepacket incident upon an evanescent level may be transmitted across this presumed barrier in the form of a propagating wavepacket of smaller amplitude. (from Author)

Droplet size control in liquid jet breakup
Hilbing J.H. & Heister S.D., *Physics of Fluids*, 1996, 8/6 (1574-1581). In English.
This paper considers the breakup of a low speed liquid jet which is one of the fundamental problems in two-phase flow. The resultant drop sizes formed from the breakup process are of interest to a variety of industrial processes, such as the manufacture of metal powders via solidification of a stream of molten material. The size of the droplets is affected by changes in the perturbation wavelength, perturbation magnitude and Weber number. Satellite droplet velocities are less than main droplet velocities due to the sequential shedding of droplets from the orifice. (after Authors)

Vapour cavitation in very confined spaces for Newtonian and non Newtonian fluids
Ouibrahim A., Fruman D.H. & Gaudemer R., *Physics of Fluids*, 1996, 8/7 (1964-1971). In English.
An experimental program aimed at investigating the inception and extent of vapour cavitation in very confined spaces is shown here with Newtonian fluid and non Newtonian viscoelastic fluids. The conditions for cavitation occurrence as well as the morphology of the developed cavities were determined. In the case of water, onset of cavitation is in the form of isolated spots randomly distributed along a cylinder generatrix. As compared to the solvent, the polymer solution delays cavitation inception, decreases the length of developed cavities, and eliminates the interstitial film between successive cavities. (after Authors)

Experimental study of incompressible Richtmyer-Meshkov instability
Jacobs J.W. & Sheeley J.M., *Physics of Fluids*, 1996, 8/2 (404-415). In English.
The Richtmyer-Meskhov instability of a two-liquid system is investigated experimentally. The instability is generated by vertically accelerating a tank containing two stratified liquids by bouncing it off of a fixed coil spring. A controlled two-dimensional sinusoidal initial shape is given to the interface by oscillating the container in the horizontal direction to produce standing waves. The motion of the interface is recorded during the experiments using standard video photography. Instability growth rates are measured and compared with existing linear theory. Disagreement between measured growth rates and the theory are accredited to the finite bounce length. When the linear stability theory is modified to account for an acceleration pulse of finite duration, much better agreement is attained. (from Authors)

A two-phase flow model of the Rayleigh-Taylor mixing zone
Yupin Chen, Glimm J., Sharp D.H. & Qiang Zhang, *Physics of Fluids*, 1996, 8/3 (816-825). In English.
The Rayleigh-Taylor instability of an interface separating fluids of distinct density is driven by an acceleration across the interface. The hydrodynamics of the mixing zone are characterized by low order statistical moments of fluctuating fluid quantities. A new model is proposed for the momentum coupling between the two phases.

This model is validated against computational data for compressible flows, including flows near the incompressible limit. (after Authors)

The effect of surfactant on the rise of a spherical bubble at high Reynolds and Peclet numbers
Bel Fdhila R. & Duineveld P.C., *Physics of Fluids*, 1996, 8/2 (310-321). In English.
Experiments and numerical simulations of rising spherical bubbles in quiescent surfactant solutions are presented. The rise velocities versus the concentration in the bulk are measured using three surfactants, Triton X_{100}, $Brij_{30}$ and SDS for different bubble sizes, between 0.4 and 1 mm equivalent radius. We also present a brief description of the finite-difference numerical method developed to solve the full Navier-Stokes equations around the contaminated bubble for Reynolds numbers ranging from 50 to 200. The distributions of the tangential velocity, the vorticity, the pressure and the surfactant concentration on the bubble surface are calculated. The numerical technique described here is similar to the one used by Ryskin and Leal for a clean surface but does not take into account the deformation. However, we consider the influence of a gradient of surface tension due to the presence of a surfactant. Coupled with the surfactant transport equations this procedure provides all the flow quantities at the interface. The bubble rise velocity versus the bulk concentration is calculated by incorporating this numerical procedure in an iterative process accounting for the changes in the bulk concentration. The computed results are compared with our measurements. (after Authors)

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Sutherland B.R., *Physics of Fluids*, 1996, 8/2 (430-441). In English.
It is shown nonlinear numerical simulations of flow restricted to two dimensions that a compact wavepacket of large-amplitude internal gravity waves incident upon a weakly stratified region in which the buoyancy frequency is less than the frequency of the wavepacket may partially transmit energy into this region through the generation of a wavepacket of lower frequency. For a range of simulations initialized with wavepackets of different amplitude and vertical extent, the characteristics of the reflected and transmitted waves are analyzed and reflection coefficients are calculated. It is demonstrated in theory and by fully nonlinear numerical simulations restricted to two dimensions that a compact IGW wavepacket incident upon an evanescent level may be transmitted across this presumed barrier in the form of a propagating wavepacket of smaller amplitude. (from Author)

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Stilbene-containing liquid crystalline side chain homo-and copolysiloxanes: microphase separation and chemical modification to electroconducting materials
Castelvetro V., Ciardelli F., Fischer H. & Karasz F.E., *Polymer International*, 1996, 39/1 (37-46). In English.
The phase behaviour of two classes of side chain polysiloxanes, containing respectively 4-cyano-and 4-alkoxy-4 minutes -stilbene-ether mesogens, was studied over a wide temperature range by differential scanning calorimetry and wide angle X-ray diffraction, with special attention devoted to the characterisation of the microdomain phase morphology. Room temperature X-ray diffraction studies suggest for certain polymers with cyanostilbene mesogens the occurrence of microphase separation; this effect becomes significant as the amount of polysiloxane backbone versus the side chains increases. The onset of electrical conductivity was followed upon exposure of the polymeric films to various doping agents. (from Authors)

Study on magnetic fluidization of group C powders
Qingshan Zhu & Hongzhong Li, *Powder Technology*, 1996, 86/2 (179-185). In English.
The fluidization behavior of Geldart's group C powders has been studied and the experiments demonstrate that channels and bubbles can be eliminated effectively. Theoretical analysis shows that the fluidization quality is improved due to the formation of a chain structure. Two optical fiber probes are used to measure the size of the bubble in the bed and it shows that the bubble size decreases with increasing magnetic field intensity and magnetic powder fraction. The length of the chain, obtained by using a CA5300 board and modular system, has been found to be strongly influenced by the magnetic field intensity. A mathematical model has been derived through theoretical analysis and the calculated results are in agreement with experimental data. A dimensionless number M_h is developed to forecast the magnetically condensed state. (Authors)

Measurement of voidage in a fluidized bed using a capacitive sensor
Delmon G., Faure R., De Gasquet B., Giraud G. & Clerc J.P., *Powder Technology*, 1996, 86/2 (149-153). In English.
A theoretical study of particule concentration in two-phase flow is presented. The flow is contained in a cylindrical column fitted with an electric sensor on the external surface. We have calculated the capacitance variation as particules of the flow across the space between the electrodes. Taking into account the dielectric constant of the system, the particule concentration is then calculated applying the effective medium theory. These analytical results are compared with experimental results. A good agreement is found and size effects predicted without applying any phenomenological coefficient. (Authors)

Fluidization of ferromagnetic particles in a magnetic field part 1: the effect of field line orientation on bed stability
Hristov J.Y., *Powder Technology*, 1996, 87/1 (59-66). In English.
An investigation of the effect of the field line orientation on the behaviour of gas fluidized beds has been carried out, using different, non-cohesive ferromagnetic powders in the absence of a magnetic field. The field line orientation was varied from parallel to transverse with respect to the fluidizing flow. The results obtained show that stabilized beds can be created under different orientation of homogeneous magnetic fields. (Author)

Prediction of transition velocities and hydrodynamical regimes in fluidized beds
Arnaldos J. & Casal J., *Powder Technology*, 1996, 86/3 (285-298). In English.
Amongst the diverse fluid velocities establishing the existence of the different fluidization regimes, only minimum fluidization velocity has been extensively studied. Although an increasing number of communications have been devoted in the last decade to circulating fluidized beds, the prediction of the velocities over which bubbling, turbulent and fast fluidization exist is still difficult. Even the existence of the different fluidization regimes is not perfectly established. The diverse correlations available for the circulation of u_c, u_k and u_u are analysed and compared to experimental data. Conclusions are derived about their adequacy, and a simple map is proposed for the operating conditions over which each fluidization regime exists. (Authors)

Fluidization regimes in non-slugging fluidized beds: the influence of pressure drop across the air distributor
Svensson A., Johnsson F. & Leckner B., *Powder Technology*, 1996, 86/3 (299-312). In English.
The purpose of the present work is to study the influence of the pressure drop across the air distributor on the bubbling conditions of the bottom bed of circulating fluidized beds (CFB). The bottom bed is the dense bubbling zone just above the distributor. The experimental work was carried out in a 12 MW_{th} CFB boiler and in a cold CFB. Three different distributions of the bubble flow in time and space, termed fluidization regimes, were identified in the cold CFB. These bubbling conditions were observed during variations in the gas velocity and the distributor pressure drop. A comparison with the 2 m^2 cross-section CFB boiler showed that the boiler always operates in the single or in the exploding bubble regime, which indicates a bubble flow that is not continuous and not well distributed over the cross-section of the bed. The conditions in the boiler are influenced by the relatively large area of gas passage and the low pressure drop of the boiler air distributor. (from Authors)

Molecular dynamics modelling of granular chute flow: density and velocity profiles
Zheng X.M. & Hill J.M., *Powder Technology*, 1996, 86/2 (219-227). In English.
A molecular dynamics simulation technique is applied to the modelling of a granular chute flow, and the density and velocity profiles of the chute flows are examined by considering different inclination angles, rough and smooth boundary conditions, accelerating and fully developed flows. In general, the chute velocity profiles are non-linear, concave in shape and there is a slip velocity at the chute base. However, a linear velocity profile with no boundary slip can be obtained at small inclination angles and therefore a slow flow regime. For fully developed flows, the density profiles show no low density zone near the chute base, but a density profile with a low density zone near the base surface can be obtained at an accelerating stage for a rough base. A rough boundary can produce both resistance and anti-rotational effects on the flow. (Authors)

A classification and design method for moving bed flow in pipes
Ould-Dris A., Molodtsof Y. & Large J.F., *Powder Technology*, 1996, 87/1 (49-57). In English.
The detailed flow structure and characteristics of moving bed flow in pipes in the presence of an either co-or counter-currently flowing interstitial gas are studied both experimentally and theoretically. Experiments are performed with 0.2 mm diameter sand particles in an L-valve installation operated in the moving bed flow regime both in the vertical and horizontal pipe. Accurately characterized bed porosity and specific area variations revealed behaviour different from that suggested in the Kojabashian classification. A simple design and prediction method is presented and tested for the calculation of moving bed lines. (Authors)

Development of slurry mixing models using resistance tomography
Williams R.A., Jia X. & McKee S.L., *Powder Technology*, 1996, 87/1 (21-27). In English.
This contribution describes the application of electrical resistance tomography (ERT) for three-dimensional imaging of the concentration of solids in a slurry mixer as a function of key process variables (particle size, impeller type, agitation speed). This principle is illustrated using descriptions of mixer behaviour based on an empirical approach, although the measurement methodology described is equally suited to development of computational fluid dynamics models, cellular models or design approaches based on artifical intelligence. It is demonstrated that ERT can be used for routine acquisition of experimental information thereby accelerating the development of empirical correlations for design and scale-up. The experimental data can be built into a visualization databank, which acts as a 'process toolkit' by allowing a library of process responses to be catalogued. (from Authors)

Implementation of an algoritm to model the starved lubrication of a piston ring in distorted bores: prediction of oil flow and onset of gas blow-by
Ma M.-T. & Smith E.H., *Proceedings - IMechE: J, Journal of Engineering Tribology*, 1996, 210/J1 (29-44). In English.
Experimental evidence suggests that piston rings in internal combustion engines normally experience 'starved' lubrication at some points along their stoke. To take account of lubricant starvation (and hence move towards a full ring pock analysis), a 'flow continuity algorithm' has been incorporated into a non-axisymmetric lubrication model of a single ring. The algorithm allows both inlet and cavitation boundaries of the full film to be located, making it possible to predict the occurrence of gas blow-by through the ring face, particularly for

distorted bores. In addition, oil availability has been determined by applying the principle of mass conservation while considering lubricant accumulation. (from Authors)

An analytical solution for the Wilson point in homogeneously nucleating flows
Lixi Huang & Young J.B., *Proceedings - Royal Society of London, A*, 1996, 452/1949 (1459-1473). In English.
The calculation of conditions at the Wilson point is the key to both theoretical and numerical studies of the condensation of pure vapours by homogeneous nucleation. Nucleation and droplet growth occurs in a very short period of time, during which the changes of many vapour properties due to the normal thermofluid dynamic processes are negligible compared with the change of the heat release rate. This feature is exploited in an analysis leading to an approximate solution for the maximum subcooling and other properties at the Wilson point. Crucial approximations are justified over a wide range of steam pressures and the analytical results reveal the dependency of steam properties at the Wilson point on controlling parameters such as the rate of pressure decrease. (from Authors)

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The impact and penetration of a water surface by a liquid jet
Bourne N.K., Obara T. & Field J.E., *Proceedings - Royal Society of London, A*, 1996, 452/1949 (1497-1502). In English.
A series of experiments were thus conducted in which liquid jets of varying velocity were fired at semi-infinite water targets. The penetration was monitored using high-speed streak and framing photography. An unexpected feature of the penetration was found to be the appearance of an axial cavitation cloud ahead of the jet. This cloud was subsequently collapsed by what is believed to be an entrapped air bubble collapsing at the jet-target interface. The subsequent motion of this interface showed periodic acceleration and deceleration. The results have interest to a range of practical solutions involving cavities and their collapse. (from Authors)

On cavitation in thin liquid layers
Me-Bar Y., *Proceedings - Royal Society of London, A*, 1996, 452/1947 (741-755). In English.
A new apparatus is described, which allows events occurring within a thin liquid layer while being dynamically loaded in tension to be viewed. Experiments were carried out with water layers of initial thickness of ca. 100 mum and ca. 10 mum. A model is proposed for the mechanism of cavity inception and growth which is based on comparison between the rate of gas ejection into the cavities and the rate of total volume increase. Using the experimental results, this model enables calculation of the 'evaporation constant'. (from Author)

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On the collapse of vapour cavities in a thin liquid layer under high pressure transient
Me-Bar Y., *Proceedings - Royal Society of London, A*, 1996, 452/1947 (757-768). In English.
An apparatus was built in conjunction with the transparent anvils drop weight machine to view the events occurring during the formation, growth, and collapse of vapour cavities in thin liquid layers. During the collapse phase, several mechanisms operate, namely: proportional shrinkage, volume jetting, surface jetting and secondary cavitation, which can be attributed to features of the liquid flow under compression. A simple model which considers the liquids as perfectly plastic material and assumes a very rapid rate of vapour condensation fits the experimental results throughout most of the collapse process. (from Author)

Potential vorticity inversion and balanced equations of motion for rotating and stratified flows
Vallis G.K., *Quarterly Journal - Royal Meteorological Society*, 1996, 122/529 (291-322). In English.
Balanced equations of motion based on potential vorticity evolution and inversion for the shallow water and stratified primitive equations are derived and, in some shallow-water cases, numerically tested. The schemes are based on asymptotic expansions in Rossby or Froude number, or rational scaling-based truncations of the equations of motion, assuming that the dynamics are determined by the advection of potential vorticity. Thus, regimes of validity are rapidly rotating and/or highly stratified flow. A model is also proposed that is valid at both planetary and synoptic scales, combining the familiar planetary geostrophic and quasi-geostrophic equations. The balanced model valid for both planetary and synoptic scales shows a significant qualitative and

quantitative improvement over both planetary geostrophy and quasi-geostrophy for large-scale flows, and its evolution is in good agreement with a primitive equation model. (from Author)

Momentum rate probe for use with two-phase flows
Bush S.G., Bennett J.B., Sojka P.E., Panchagnula M.V. & Plesniak M.W., *Review of Scientific Instruments*, 1996, 67/5 (1878-1885). In English.

This paper concentrates on an instrument for measuring the momentum rate of two-phase flows. The design and construction details are provided. The device utilizes a conelike body to turn the flow from the axial to the radial direction. The force resulting from the change in momentum rate of the turning flow is measured using a strain-gage-instrumented cantilevered beam. The instrument is applicable to a wide range of flows. (after Authors)

Phase splitting of wet steam in annular flow through a horizontal branching tee
Sze-Foo Chien, *SPE Production & Facilities*, 1996, 11/2 (83-88). In English.

A phase-splitting equation for flow of a two-phase fluid through a tee junction was derived. It shows that the fluid quality at an outlet of the tee is determined by the relationship between the liquid and vapor extraction ratios of the fluid through that outlet. This equation applies to any tee junction regardless of its geometry, orientation, and inclination. This paper presents its application to the flow of wet steam through a horizontal branching tee. Experimental data were for wet steam flowing through a standard branching tee, were analyzed focusing on the effect of the vapor-extraction ratio of the run stream on the liquid-extraction ratio of the same stream. A correlation between these two extraction ratios has been established with steam quality, superficial vapor velocity, and critical velocity at the inlet to the tee as controlling parameters. Using this correlation and the phase-split equation, it was possible to predict steam qualities existing from horizontal branching tees to within +/-15% of the experimental values, which is more accurate than other phase-splitting models. (from Author)

Vertical multiphase flow correlations for high production rates and large tubulars
Aggour M.A., Al-Yousef H.Y. & Al-Muraikhi A.J., *SPE Production & Facilities*, 1996, 11/1 (41-48). In English.

This paper presents a comprehensive evaluation of existing correlations and modifications of some correlations to determine and recommend the best correlation or correlations for various field conditions. More than 400 field data sets covering tubing sizes from 2 3/8 to 7 in., oil rates up to 23 200 B/D, water cuts up to 95%, and gas/oil ratio (GOR) up to 927 scf/STB were used in this study. Considering all data combined, the Beggs and Brill correlation provided the best pressure predictions. However, the Hagedorn and Brown correlation was better for water cuts above 80%, while the Hasan and Kabir model was better for total liquid rates above 20 000 B/D. The Aziz correlation was significantly improved when the Orkiszewski flow-pattern transition criteria were used. (from Authors)

A water-vapor permeable drying surface for thin films
Bowser T.J. & Wilhelm L.R., *Transactions - American Society of Agricultural Engineers*, 1996, 39/2 (617-623). In English.

A new drying technique for thin films of colloidal slurries and solutions has been proposed and evaluated. A bench-top representation of the proposed drying system was constructed to test feasibility and performance. Preliminary tests showed that a water-vapor permeable drying surface may be an attractive alternative to traditional thin-film drying methods. Four experiments, using modified corn, potato, and rice starch films, were conducted. (from Authors)

Analytical study of critical heat flux in two-phase thermosyphon: relationship between maximum falling liquid rate and critical heat flux
Monde M., *Transactions - ASME: Journal of Heat Transfer*, 1996, 118/2 (422-428). In English.

An analytical study has been done on the critical heat flux of a two-phase thermosyphon, in which a liquid film and a vapor film exist in a countercurrent annual flow. The CHF point on the thermosyphon is proved to correspond to a maximum falling liquid rate fed to the thermosyphon, which can be determined from three equations of momentum, its partial derivative with void fraction, and mass balance in the thermosyphon. This maximum point, furthermore, becomes identical to the point at which an envelope line generated from the momentum equation and its partial derivative intersects the mass balance line. The CHF calculated from the maximum liquid rate is found to be in fairly good agreement with the existing CHF data. (Author)

Heat transfer of air/water two-phase flow in helicoidal pipes
Xin R.C., Awwad A., Dong Z.F. & Ebadian M.A., *Transactions - ASME: Journal of Heat Transfer*, 1996, 118/2 (442-448). In English.

Heat transfer of air/water two-phase flow in helicoidal pipes is experimentally investigated in this study. Three test sections were tested in axially horizontal, vertical, and inclined orientations. It has been found that the ratio of the average heat transfer coefficient to that of the water flow is affected by the water flow rate along with the Lockhart-Martinelli parameter. For a fixed water flow rate, there is a maximum heat transfer coefficient as the air flow rate increases. The results indicate that tube diameter has a significant effect on the average heat transfer coefficient ratio. For large-tube-diameter coils, average heat transfer results vary from different orientations. For small-tube-diameter coils, orientation has an insignificant effect on the average heat transfer coefficient. Based on the experimental data, a set of correlations is proposed for the average heat transfer coefficient ratio versus the liquid superficial Reynolds number and Lockhart-Martinelli parameter. (Authors)

Elastohydrodynamic lubrication by powder slurries
Hua D.Y. & Khonsari M.M., *Transactions - ASME: Journal of Tribology*, 1996, 118/1 (67-73). In English.

Thermoelastohydrodynamic analysis of a powder slurry containing a mixture of MoS_2 particles and a carrier fluid is presented for a line-contact configuration. The constitutive equation of the slurry is a non-Newtonian formulation based on experimental data. The model includes provisions for elastic/plastic deformation of particles in the slurry. Through this deformation, particles are shown to contribute to the load-carrying capacity. (from Authors)

Elastohydrodynamic model of the rotary lip seal
Salant R.F., *Transactions - ASME: Journal of Tribology*, 1996, 118/2 (292-296). In English.
A model of the non-leaking equilibrium behavior of the lip seal has been developed. It consists of an elastohydrodynamic model of the lubricating film and a simplified model of the meniscus on the air-side of the seal. The model predicts the location of the meniscus, the film thickness and pressure distributions, and the locations of cavitation regions. It also predicts the maximum pressure that can be sealed with zero leakage, and the maximum speed, above which the meniscus is ingested into the sealing zone. (Author)

On the dynamic thermal state in a hydrodynamic bearing with a whirling journal using CFD techniques
Tucker P.G. & Keogh P.S., *Transactions - ASME: Journal of Tribology*, 1996, 118/2 (356-363). In English.
A thermohydrodynamic analysis, based on computational fluid dynamics (CFD) techniques, that accounts for conduction in the rotating and orbating shaft of a hydrodynamic bearing is presented. Dynamic cavitation effects are also introduced, such that pressures in the cavitation region are predicted rather than set. The model predictions are validated against analytical and published experimental results. For the case of a centrally located synchronous forward circular whirl orbit, it is demonstrated that the journal does not behave as a circumferentially isothermal element and that significant steady temperature differentials across the journal may occur. (from Authors)

Dimensional analysis of pore scale and field scale immiscible displacement
Hilfer R. & Oren P.E., *Transport in Porous Media*, 1996, 22/1 (53-72). In English.
A basic re-examination of the traditional dimensional analysis of microscopic and macroscopic multiphase flow equations in porous media is presented. We introduce a 'macroscopic capillary number' Ca which differs from the usual microscopic capillary number Ca in that it depends on length scale, type of porous medium and saturation history. Illustrative sample calculations are presented which show that the breakpoint in capillary desaturation curves for different porous media appears to occur at Ca approx 1. The length scale related difference between the macroscopic capillary number Ca for core floods and reservoir floods provides a possible explanation for the systematic difference between residual oil saturations measured in field floods as compared to laboratory experiment. (from Authors)

On the nonequilibrium segregation state of a two-phase mixture in a porous column
Shapiro A.A. & Stenby E.H., *Transport in Porous Media*, 1996, 23/1 (83-106). In English.
The problem of segregation of a two-phase multicomponent mixture under the action of thermal gradient, gravity and capillary forces is studied with respect to component distribution in a thick oil-gas condensate reservoir. Governing equations are derived on the basis of nonequilibrium thermodynamics. A steady state of the two-phase mixture with nonzero diffusion fluxes and exchange between phases is described. In the case of binary mixtures analytical formulae for saturation, component distribution and flow in the two-phase zone are obtained. (Authors)

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Simulation of immiscible multiphase flow in porous media: a focus on the capillary fringe of oil-contaminated aquifers
Hadad A., Bensabat J. & Rubin H., *Transport in Porous Media*, 1996, 22/3 (245-269). In English.
This paper deals with the analysis of some aspects of the vertical and lateral migration of oil spills in the unsaturated and the capillary zone of a phreatic aquifer. Motivation stems from the fact that such contamination represents a severe danger for groundwater resources all over the world and from the present acute problem of jet-fuel contamination in some locations of Israel. The study focuses on the analysis of the upper layers of the aquifer which are subjected to the most significant oil contamination. Neglecting coupled processes and

adopting Richard's assumption, a three-phase flow model is introduced with capillary heads of the water and the oil as variables. The resulting model which is coupled and strongly non-linear is solved using a vertical two-dimensional finite-element procedure together with a quasi-Newton optimization algorithm. Various scenarios of oil migration in the unsaturated and the capillary zone were simulated. In particular, the dynamics of the water and oil phases during the migration process is discussed. (from Authors)

(Schaden beim Einsatz keramischer Werkstoffe im Tribosystem mit Wasser) (Cavitation caused damage of ceramic materials in tribological contact with water lubrication)
Franke H.-J., Fritsch J. & Lachmayer R., *Tribologie und Schmierungstechnik*, 1996, 43/1 (40-42). In German.
The importance of environment safety leads to an increasing number of water lubricated machine parts. In this context bearings and seals made of ceramic materials are often an innovative solution with good performance. But experimental observation and theory show, that as soon as the boiling point of the lubricant is reached and two phase phenomena arise, completely different behaviour of a device may occur. Two cases are discussed, dealing with the performance of mating rings for mechanical seals and Si_3N_4 roller bearings mounted in magnetic couplings. (from English summary)

Modelling the Bagnold stress effects in vertical slurry flow
Bartosik A.S., *Vodohospodarsky Casopis/Journal of Hydrology & Hydromechanics*, 1996, 44/1 (49-58). In English.
The Bagnold hypothesis has been used to construct a mathematical model for fully developed turbulent slurry flow in a vertical pipe. In the mathematical model the total shear stress is modelled as the sum of liquid-wall and particle-wall stresses. The particle-wall stress is described by a modified Bagnold function. Predictions of frictional headloss for slurries are compared with experimental data obtained for two different pipe diameters. The slurries contains water and coarse particles and the smallest and highest median particle diameter was 1.5 and 3.4 mm respectively. Comparison between predicted and measured data are made for solids concentration up to 45% by volume and for solid/liquid density ratio between 1.04 and 2.65. (from Author)

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Multiphase approach to the numerical solution of a sharp interface saltwater intrusion problem
Huyakorn P.S., Yu Y.S. & Park N.S., *Water Resources Research*, 1996, 32/1 (93-102). In English.
A sharp interface numerical model is developed to simulate saltwater intrusion in multilayered coastal aquifer systems. The model takes into account the flow dynamics of salt water and fresh water assuming a sharp interface between the two liquids. In contrast to previous two-fluid flow models which were formulated using the hydraulic heads of fresh water and salt water as the dependent variables, the present model employs a mixed formulation having one fluid potential and a pseudosaturation as the dual dependent variables. Conversion of the usual sharp interface flow equations for each aquifer to an equivalent set of two-phase flow equations leads to the definitions of pseudosaturation, capillary pressure, and constitutive relations. The desired governing equations are then obtained by connecting neighboring aquifers via vertical leakage. The proposed formulation is based on a Galerkin finite element discretization. The numerical solution incorporates upstream weighting and nonlinear algorithms with several enhanced features, including rigorous treatment of aquitard leakage and well conditions, and a robust Newton-Raphson procedure with automatic time stepping. (from Authors)

A finite volume Eulerian-Lagrangian localized adjoint method for solution of the contaminant transport equations in two-dimensional multiphase flow systems
Binning P. & Celia M.A., *Water Resources Research*, 1996, 32/1 (103-114). In English.
An Eulerian-Lagrangian localized adjoint method (ELLAM) numerical solution is described for the multiphase contaminant transport equations in two dimensions. The ELLAM uses finite volume test functions in the space-time domain defined by the characteristics of the hyperbolic part of the governing equation. Combination of the finite volume test functions with the conservative form of the governing equation results in a local conservation of mass property. A combined conservative/nonconservative ELLAM is developed with an ELLAM formulation based on the nonconservative form of the governing equation being applied to subdomains intersecting first-type boundaries and a conservative ELLAM being used for all other subdomains. The combined conservative/nonconservative ELLAM is compared to a Galerkin finite element scheme and is found to have greatly superior performance, requiring far fewer time steps to obtain a solution of equivalent accuracy. (from Authors)

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Assessment of resistance of non-metallic coatings to silt abrasion and cavitation erosion in a rotating disk test rig

Zhang J., Richardson M.O.W., Wilcox G.D., Min J. & Wang X., *Wear*, 1996, 194/1-2 (149-155). In English.

Hydraulic damage tests have been carried out on five types of non-metallic coating materials in slurry water. A rotating disk test rig was used to simulate silt abrasion and cavitation erosion. The resistances of the various coatings to silt abrasion, and the combination of abrasion and cavitation, have been measured and compared under specified hydraulic conditions. The tests show that among the five selected materials, epoxy resin reinforced by synthetic corundum particles and castable polyether-based polyurethane rubber were the most resistant coatings to abrasion and the combined abrasion-cavitation damage, respectively. High elasticity polyurethane had the greatest resistance to cavitation, whilst a brittle material, epoxy resin, had the least in high-silt-content water. The erosion rates of the coatings examined were generally proportional to the peripheral speed of the disk raised to the power of 3.1-4.5 under the given conditions. The synergistic effect of cavitation and abrasion on different coating materials has been discussed. (from Authors)

Research on reducing erosion by adding ribs on the wall in particulate two-phase flows

Song X.Q., Lin J.Z., Zhao J.F. & Shen T.Y., *Wear*, 1996, 193/1 (1-7). In English.

In the particulate two-phase flow with smooth wall and rib-welding wall, improved k-epsilon turbulence model and one-way coupling method are employed to compute partical velocities and trajectories, and wall wastage caused by particle impacts. In order to verify the computational results, an apparatus is designed and corresponding experiment is made. Both computational and experimental results show that adding ribs on the wall can reduce wall erosion caused by particle impacts in the particulate two-phase flow. The wall wastage does not vary linearly as rib height. Under a definite rib height, it is most beneficial to reduce erosion when rib width is equal to gap between ribs. For a definite flow, in the region with relative small particle size, the variety of wastage rate changes steeply, whereas particle size exceeds a criterion, the wastage rate changes smoothly. The initial angle of motion direction between particles and gas affects the wall wastage. (Authors)

Hydrodynamic lubrication of journal bearings including micropolar lubricants and three-dimensional irregularities

Lin T.-R., *Wear*, 1996, 192/1-2 (21-28). In English.

The effects of lubricant rheology and three-dimensional irregularities in hydrodynamic journal bearings are presented in this paper. This equation is incorporated into the Elrod cavitation algorithm. This numerical procedure, which conserves mass throughout the bearing, implicity incorporates the JFO boundary conditions at rupture and reformation boundaries. (from Author)

An investigation of the corrosive wear of stainless steels in aqueous slurries

Fan Aiming, Long Jinming & Tao Ziyun, *Wear*, 1996, 193/1 (73-77). In English.

Pumping installations made of stainless steels have been widely used for transporting slurries in chemical process industry. However, knowledge of the attack of stainless steels due to corrosive wear in two-phase liquid-particle flow is still incomplete. This paper studies the behaviours and mechanisms of corrosive wear for two austenitic stainless steels, 24Cr-25Ni-4Mo and 18Cr-12Ni-2Mo, using a rotating disc apparatus made by the authors. The two components, wear by slurry abrasion and corrosion, within the corrosive wear process, are first examined individually. Then the synergistic effect between wear and corrosion is investigated. An analytical model is developed which would help to reveal the mechanisms of the corrosive wear processes. (from Authors)

Cavitation in dynamically loaded journal bearings using mobility method

Vincent B., Maspeyrot P. & Frene J., *Wear*, 1996, 193/2 (155-162). In English.

The effect of cavitation and the determination of the cavitation boundaries are important to get a realistic model of a journal bearing. A numerical investigation of cavitation in dynamically loaded journal bearings using mobility method is presented. The numerical procedure incorporates an algorithm of cavitation based on the work of Elrod. Film rupture and reformation are predicted considering mass flow conservation through the entire bearing. In order to improve the computing efficiency, the mobility method of Booker is applied. (from Authors)

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