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INDUSTRY PROGRAM OF THE COLLEGE OF ENGINEERING

INDUSTRY PROGRAM ABSTRACTS

Ninth Compilation

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INDUSTRY PROGRAM OF THE COLLEGE OF ENGINEERING

ABSTRACT OF THESIS

THE STUDY OF NUCLEAR DECAY SCHEMES BY THE SINGLE CRYSTAL GAMMA-SUMMING-METHOD AND A 30-CHANNEL PULSE HEIGHT ANALYZER

Fang-Cher Chang

IP-337 Dated November, 1958

The problem of this thesis was the measurements of the gamma spectra of some nuclei and the study of their energy levels. A single-crystal NaI(Tl) spectrometer was used to observe gamma-gamma coincidences. A hole was drilled along the axis of the cylindrical crystal from one of the surfaces to the center. With the source placed inside the crystal, cascade gamma rays from a single disintegration will give a pulse corresponding to the sum of the gamma energies involved. It was found that this device is effective and simple in obtaining decay schemes provided all the lines could be resolved (NaI(Tl) crystal has a resolution of 6-9%). A 30-channel pulse analyzer employing the Philips EIT tubes was built and used for spectrum analysis. The analyzer has a resolving time of about 4 microseconds. The decade tube facilitates the construction of the analyzer and the number of counts can be readily read off the tube. However "skipping" has been the main drawback of the tube and frequent checking is therefore necessary to ensure reliable operation.

The conclusion is drawn that the chief obstacle to the wide use of single crystal coincidence device is the low resolution of NaI(Tl) crystal. If a crystal were found with all the good features of NaI(Tl) and yet a resolution of only a few per cent, a great deal more information on nuclear energy levels could be easily obtained.

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ABSTRACT OF REPORT

INTRODUCTION TO LINEAR SHIFT-REGISTER GENERATED SEQUENCES

T.G. Birdsall
M.P. Ristenbatt

IP-338 Dated November, 1958

This report deals with both maximal and non-maximal sequences of linear, shift-register generators. The mathematical formulations necessary to deal with these sequences are treated. In general, matrix theory is used to prove necessary theorems while the theory of algebraic polynomials and their factors is used to determine the properties of sequences from a given generator. For a given number of stages, the number of available maximal generators is considered. Also, two methods for finding the proper connections of these maximal generators are described. The second method allows one to determine all the proper connections if one is known. For non-maximal generators, the determination of the number of sequences and the lengths of these sequences from a given generator is treated. In addition the shift-and-add properties of both maximal and non-maximal sequences are discussed. The main body of the report is concerned with describing the pertinent material and giving examples, while the more complex mathematical proofs are contained in the Appendix.

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ABSTRACT OF REPORT

RADIOCHEMICAL SEPARATIONS AND ACTIVATION ANALYSIS

W. W. Meinke

IP-339 Dated November, 1958

This paper is the seventh of a series of progress reports and covers work which has been completed from November 1957 to October 1958.

The Ford Nuclear Reactor of the University of Michigan has finally gone into routine operation. The pneumatic tube system of the reactor and the 100-channel pulse analyzer with dual memories are described and problems of their operation are discussed.

Some of the discussions presented are on: 1) radiochemical separations of cadmium using a dithizone extraction and an anion exchange method, 2) separations by vacuum distillation to determine if distillation could be used to separate many radioactive nuclides of the elements (with or without carriers), and 3) extraction of Zn and Ag from chloride solutions using dioctylamine salts.

Discussions on the investigation of the utilization of short-half-lived radioisotopes in activation analysis in: 1) determining the rhodium, silver, and indium content of chondritic meteorites; 2) vanadium in petroleum process streams; 3) activation analysis for selenium and tellurium in stony meteorites; 4) arsenic in marine organisms, and 5) vanadium in marine organisms are also included.

Separation procedures are given for vanadium, arsenic, rhodium, silver, cadmium and indium.

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INDUSTRY PROGRAM OF THE COLLEGE OF ENGINEERING

ABSTRACT OF PAPER

NATURAL CONVECTION FLOW IN LIQUID-METAL MOBILE-FUEL NUCLEAR REACTORS

Frederick G. Hammitt
Elayne M. Brower

IP-340 Dated December, 1958

The general nature of natural convection flow expected in single, small-bore, vertical ligaments as presently conceived in the design of liquid-metal cooled reactors is shown. This can be predicted directly from analytical and experimental results using a boundary layer type solution for aqueous fluids and considering the limiting case when fully developed flow has been achieved. Fully developed flow would indicate the condition when the boundary layer completely fills the tube and hence is no longer a function of axial position.

The boundary layer type solution applies to a maximum of the top 6% of the tube and becoming less as the non-dimensional heat generation term is decreased. The remainder of the tube length then is completely filled with the boundary layer in the axial direction.

These influences are shown to be of importance in the wall heat flux, mass transport, and disposition of fission gas created within the coolant.

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INDUSTRY PROGRAM OF THE COLLEGE OF ENGINEERING

ABSTRACT OF PAPER

A STUDY OF NONLINEAR SYSTEMS WITH RANDOM INPUTS

Kuei Chuang
Louis F. Kazda

IP-341 Dated December, 1958

It is the purpose of this paper to investigate the probability distribution of the response of a nonlinear system subjected to a Gaussian random input.

The mathematical theory of Markoff random process was used, the associated Fokker-Planck equation for a generalized continuous nonlinear system was given. The justification for assuming the error response of a nonlinear control system as being a Markoff process was discussed.

The theoretical result of this investigation for the stationary case was obtained in a closed form. It was verified by an experimental method which consisted of an electronic automatic counting device. This device records the percentage of total time of observation that a random signal exceeds a certain preset voltage level. The agreement between the theoretical calculations and the experimental measurements is within the limits of experimental measurement.

From the results of this investigation a general conclusion can be drawn. If the nonlinear element in a control system is approximately linear over a certain part of its operating region then the probability distribution of its error response is approximately Gaussian distributed. Under this condition Booton's linearization technique, which is based on the assumption that the error response of a nonlinear control system is Gaussian distributed if the input is Gaussian distributed, can be applied.

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INDUSTRY PROGRAM OF THE COLLEGE OF ENGINEERING

ABSTRACT OF THESIS

THE CONSTANT VOLUME HEAT CAPACITIES OF GASEOUS PERFLUOROCYCLOBUTANE AND PROPYLENE

Noel H. de Nevers

IP-342 Dated December, 1958

The purpose of this research was to determine constant volume heat capacity of perfluorocyclobutane and propylene over as wide a range of temperatures and densities as possible in one calorimeter, and to compare the experimental values of C_v with those calculated from equations of state and the values of the zero-pressure constant volume heat capacity, C_v^*.

The C_v of perfluorocyclobutane was found to vary from 0.2164 to 0.2594 cal/gm°C in the temperature range 101 to 147°C and the density range 0.1569 to 0.5366 gm/cc. The C_v of propylene was found to vary from 0.3903 to 0.4991 cal/gm°C in the temperature range from 67 to 146°C and the density range from 0.04814 to 0.1609 gm/cc. For temperatures close to the critical density, C_v increases very rapidly with decreasing temperature.

The experimental results have been compared with the predictions of the Martin-Hou, Beattie-Bridgeman, and Benedict-Webb-Rubin equations of state. In general, the agreement between the measured C_v and that calculated from C_v^* and the above equations is satisfactory; the maximum difference is 6.7% of the experimental value. However, the comparison does reveal certain systematic differences.

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INDUSTRY PROGRAM OF THE COLLEGE OF ENGINEERING

ABSTRACT OF PAPER

ELECTROSPHERICS AND MAGNETOSPHERICS

A. D. Moore

IP-343 Dated December, 1958

Quite a number of new and striking effects are presented, and the simple techniques and equipment by which they are accomplished are fully described.

Electrospheric phenomena occur when small spheres (usually metallic) are shaken or rolled over the bottom of a plastic bowl, thus becoming electrified. Statically, spheres mutually repel and space themselves apart. Dynamically, when the bowl is tilted, flow of the little balls due to gravity is sharply and interestingly modified by repulsion between them, and their attraction for the surface. Fronding and chaining also occurs under certain conditions. Electrospherics carry over into a number of magnetospheric effects.

Magnetospheric phenomena occur when magnetic spheres on the bottom of a bowl are influenced by a vertical alternating magnetic field. If selected hard cast iron shot, copperplated and burnished to make them smooth, are used, they will, if previously magnetized, spin about their axes at synchronous speed, and put on the "ball ballet" - dancing in and out and among each other.

The vertical field causes magnetic repulsion between balls. If unmagnetized balls are used, this repulsion will make them spread out at random over the surface. This has been developed to give other dramatic effects. One is the "ball crystal", another is the floating formation.

The above, and other effects, constitute a series of new and most fascinating family of phenomena, interesting in their own right, highly instructive as to principles involved, and perhaps promising as furnishing various useful analogs.

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ABSTRACT OF THESIS

THE RELIABILITY PROBLEM IN DIGITAL COMPUTER NETS

William L. Kilmer

IP-344 Dated December, 1958

The purpose of this study was to evolve and specify some logical design procedures for inserting redundancy into digital computer nets to make them more reliable. The study is based on the familiar "and", "or", and "not" components. These components operate in discrete time, and with one or zero units time delay. An upper bound is assumed on their probabilities of failure which is compatible with failure rates that have been recorded in current practice.

A "2k + 1" form of binary output net is defined which has the property that its outputs are entirely unaffected by any set of k or fewer component failures which occur within the net. The 2k - 1 method is used to derive k-correcting memory nets which are probably the most economical ones capable of regenerating their own storage states.

This study is also concerned with the specification of two economical forms of over-all k-correcting computer nets. Both these forms are based on a common computer representation which is composed of a pure memory subnet and a combinational subnet. The first form is made up entirely of 2k + 1 type nets, and so has all its redundancy in the equipment domain. The second form has as much of its redundancy shifted to the time domain as possible.

The use of the merger technique to derive some results on k-degree failure detecting nets which have m wires, $m > 2$, in each of their binary output channels is given. An outline of a procedure for most economically constructing such nets is given, and it is shown that by using the merger technique, k-correcting nets can also be made q-degree failure detecting, for arbitrarily high q.

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ABSTRACT OF THESIS

ASPECTS OF HEXOSAMINE METABOLISM

Joseph Murray Merrick

IP-345 Dated December, 1958

The purpose of this study is to investigate the metabolism of D-galactosamine and D-glucosaminic acid. D-galactosamine is a constituent of many complex substances found in nature. D-glucosaminic acid is not known to occur in nature, but is of interest, since it is an amino acid which is structurally related to the hexosamines. Little is known about the intermediary metabolism of either D-galactosamine or D-glucosaminic acid. This study also describes the preparation of N-carbobenzyloxy-D-glactosamine.

As an aid in studying the intermediary metabolism of D-galactosamine, certain related compounds were prepared for enzyme studies. Since the phosphate esters are known to be the principle intermediary metabolites of D-glucosamine, D-galactosamine 6-phosphoric acid was prepared. This compound was obtained in crystalline form and was characterized by elementary analysis and by periodate oxidation studies.

The metabolism of D-glucosaminic acid was also studied with a bacterium which utilized this sugar as the sole carbon source. Respiration studies indicated that resting cell suspensions of the organism oxidized D-glucosaminic acid and D-gluconic acid but did not consume oxygen in the presence of various other sugars. Cell-free extracts of the organism converted D-glucosaminic acid to equimolar quantities of an α-keto acid and ammonia. The α-keto acid was enzymatically prepared, crystallized as the calcium salt, and identified as 2-keto-3-deoxy-D-gluconic acid by various procedures.

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ABSTRACT OF THESIS

THE USE OF NUCLEAR REACTOR RADIATION TO PROMOTE CHEMICAL REACTIONS

George H. Miley

IP-346 Dated December, 1958

A pilot unit for high temperature and pressure flow irradiation experiments was designed and operated in the beam-port of a 1-megawatt swimming pool type nuclear reactor. Special attention was given to safety and hazards. Radiation flux calibrations were made using gold foil and cobalt wire in conjunction with benzene-water, flow system, chemical dosimetry techniques.

The effect of nuclear radiation on the thermal cracking of n-heptane was investigated for the following conditions: 500-750°F, 250 psi, 0-5 moles H_2 per mole C_7 in the feed, and residence times of 2 to 15 minutes corresponding to doses of about 3 to 30 kilorep (average thermal flux of 10^9 n/cm sec plus associated fast neutrons and gamma radiation). For this incipient thermal cracking region, yields were low (< 3% n-heptane decomposed), and a significant increase due to radiation was observed.

The cracked product distribution obtained from radiation runs is similar to that obtained from ordinary thermal cracking. Exploratory work with other systems are also performed.

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ABSTRACT OF PAPER

THE NUTRITIONAL VALUE OF IRRADIATED WHEAT

C. H. Burns and L. E. Brownell

IP-347 Dated January 1959

The treatment of wheat and other grains to low doses of ionizing radiation offers a feasible method of insect control. To determine whether the nutritional properties of wheat are altered by irradiation, it was exposed to 10,000 rep of gamma radiation and subjected to a feeding experiment with rats. The grain was supplemented only with those nutrients not supplied by the untreated grain which are required by the rat. Over a two-year period, using 250 animals, no effect of the irradiation treatment could be consistently detected by growth rate, reproductive performance, and pathology of animals lost while on the experiment.

Wheat is a rich source of Vitamin E, which is an excellent index of radiation damage since it is one of the most radiosensitive of the vitamins. Since these experiments revealed no reduction in reproductive performance, where Vitamin E plays its most critical role, it can be concluded that a deinfectation dose of irradiation does not effect this vitamin, nor does it impair other nutritious values. It was also apparent from this two-year rat feeding experiment that no toxic effects were produced in the wheat by irradiation.

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ABSTRACT OF THESIS

THE THERMAL TRANSIENT RESPONSE OF A STEP PRESSURIZED BOILING LIQUID NITROGEN SYSTEM

Saul Fenster

IP-348 Dated January, 1959

A study was made of liquid nitrogen, boiling at constant wall heat flux varying from approximately 1200 to 4200 BTU/Hr.Ft^2 in a cylindrical container which was rapidly pressurized with ambient nitrogen gas. Two levels of pressurization were used, 20 and 35 psig.

It was found that upon pressurizing the boiling liquid, boiling ceased, and thereupon followed in sequence a single-phase convection process, two-phase convection, and finally re-established boiling at the new pressure. Assuming that the step-pressurization causes a step decrease in the heat transfer coefficient, a theoretical analysis was made to predict wall and average liquid temperature transients. Actually, the heat transfer coefficient does not decrease step-wise upon pressurization.

It was deduced that no bubbles had formed up to the time of the minimum heat transfer coefficient. During the period between the pressurization and the time the minimum in coefficient was reached only two effects were presumed to influence the transients. These were:

1. The viscous deceleration of the high liquid turbulence due to boiling before pressurization. This tends to decrease the heat transfer coefficient.

2. The increasing contribution of free convection, since during the time interval under discussion the difference in temperature between the wall and the liquid, at a given location from the cylinder bottom, was increasing.

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ABSTRACT OF THESIS

ELASTIC SCATTERING OF 1.1 BEV POSITIVE PIONS BY PROTONS AND THE ELASTIC SCATTERING OF 582 MEV PROTONS BY PROTONS

Leonard O. Roellig

IP-349 Dated January, 1959

Measurements of pion-nucleon and nucleon-nucleon scattering cross sections have been of great importance to the understanding of meson physics and in the investigation of nuclear forces. In this experiment, the elastic scattering cross section and the angular distribution of high energy positive pion-proton and proton-proton scattering has been measured. The high energy positive pion-proton beam was obtained from the cosmotron at the Brookhaven National Laboratory. The detecting device used was a 5" x 5" x 12" propane bubble chamber.

A total of 1.726×10^6 cm of pion track was scanned for elastic scatterings. On the basis of 661 identified π^+-p elastic scatterings the total elastic cross section and the angular distribution of the differential cross section were measured. The angular distribution of the differential cross section was found to exhibit a peaking for small angle scattering and a rather isotropic distribution for large angle scattering. The optical model was then applied to the experimental data, and a proton interaction radius was found to fit the data by two independent methods of calculation.

A total of 2,442 elastic p-p scatterings was observed from the scanning of the proton tracks. The angular distribution of the p-p elastic differential cross section was found to agree with that previously reported by counter experiments in this energy region.

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ABSTRACT OF THESIS

HOST-CELL METABOLISM DURING VIRAL SYNTHESIS

Philip C. S. Loh

IP-350 Dated January, 1959

In this paper an investigation was made of certain biochemical and biological aspects of viral development in cell cultures of human origin (strain HeLa) infected with Type I poliovirus. This study was largely centered on the relationships of nucleic acid protein synthesis to viral replication.

Part I of the study deals with the response of cells, labeled with radioactive phosphorus (P^{32}), to infection with poliovirus. After a period of several hours there occurs a marked transfer of labeled materials from the infected cells into the extracellular fluid. The initiation of this transudation coincides with the first release of virus and with retraction of the cytoplasm. The enhanced release of radioactivity is related to the size of the viral inoculum and is not seen when virus, pre-neutralized with antiviral serum, is used.

In Part II, data are presented from a chemical and isotopic analysis of sub-cellular fractions of HeLa cells at various times during a single sequence of infection. Within one hour after the initiation of infection, there is a detectable accumulation in the cytoplasm of newly synthesized protein and RNA (ribonucleic acid). From the amounts of nucleic acid and protein produced, their distribution relative to virus among various sub-cellular fractions, and from the nucleotide composition of the RNA, it was concluded that the major portion of the newly formed materials was not virus and at least in the case of the RNA was not destined to be virus. From consideration of these observations, a hypothesis is presented, which suggests that "unbalanced growth" is responsible for cytopathology.

The multitude of questions which may be asked about the action of viruses within animal cells can be formulated under three general categories: 1) the attachment to and entry of the virus into the cell; 2) the intracellular synthesis of new virus; and 3) the release of virus from the cell. Least is known concerning the second category. An understanding of the various mechanisms involved in the cell's production of virus would effectively contribute towards a rational approach to the chemotherapy of viral infections. Since a virus is composed primarily of nucleic acid and protein, information regarding its synthesis would contribute towards an understanding of the cell's biosynthetic activities in the synthesis of macromolecules.

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ABSTRACT OF PAPER

EXPLORING THE DEPTH OF SURFACE LAYERS OF THE MOON AND PLANETS FROM A RADAR SPACE OBSERVATORY

W. E. Fensler, T. B. A. Senior, and K. M. Siegel

IP-351 Dated February, 1959

A method is suggested for finding the depth of the surface layers of the moon and planets. In essence, the method involves the determination of the power reflection coefficient at different wavelengths and this coefficient as a function of the number and depth of any layers present, and of the electromagnetic constants associated with these layers. Using the mathematical formula for the reflection coefficient of a layered structure, the above quantities can be calculated from measured values of the power return at different wavelengths.

It is suggested that this experiment be carried out by placing a radar-equipped satellite in orbit around the moon. The data on the power reflection coefficient could be telemetered back to earth for analysis. The feasibility of the whole system is discussed.

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ABSTRACT OF THESIS

EFFECT OF NUCLEAR RADIATIONS ON BENZENE-WATER SYSTEMS

Terry R. Johnson

IP-352 Dated February, 1959

The purpose of this investigation was to study the effect of gamma photons and neutrons on benzene-water systems. Water solutions saturated with benzene were irradiated in the cobalt-60 source and the Ford Nuclear Reactor which are located in the Phoenix Memorial Laboratory on the North Campus of the University of Michigan. Cadmium sulfate, boric acid, and lithium metaborate were added to the benzene-water solution in order to increase the energy absorbed in the solution due to the thermal neutrons. Phenol was the principal product in all cases. The radiation yield of phenol in each solution in cobalt-60 radiation was compared to the yield in the mixed radiation from the nuclear reactor. A photometric analysis for phenol was adapted to each of the experimental systems, and the thermal neutron flux was calculated from an empirical correlation of gamma and neutron fluxes.

The yield of phenol in irradiated pure aerated water saturated with benzene was found to be 2.06 micromols per liter per kilorep. The phenol yield was equal to the reported yield of hydroxyl radicals in irradiated water indicating that benzene was a specific scavenger for hydroxyl radicals. No effect of the neutrons present in the reactor radiation was detected. Cadmium sulfate and boric acid had a small, explainable effect on the phenol yield from gamma radiation. Lithium metaborate had a large, but unexplained effect.

The benzene-pure water system proved to be an excellent dosimeter for gamma energy. It has several important advantages over the ferrous dosimeter. Benzene-water is as accurate as the Fricke dosimeter but is more reliable and adaptable.

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ABSTRACT OF THESIS

KINETICS OF THE LIQUID-PHASE ADDITION REACTIONS INITIATED BY PROPYLENE OXIDE AND METHANOL AND CATALYZED BY SODIUM HYDROXIDE

Manchiu D. S. Lay

IP-353 Dated February, 1959

The purpose of this investigation was to study the kinetics of the series of consecutive, competitive and irreversible chemical reactions initiated by the reaction of methanol with propylene oxide. The reaction of propylene oxide with dipropylene glycol methyl ether and with tripropylene glycol ether was studied in detail in a batch reactor.

The effects of temperature and catalyst concentration on the rates of the reaction of propylene oxide with methanol; propylene oxide with dipropylene glycol methyl ether; and propylene oxide with tripropylene glycol methyl ether were determined over a temperature range of 35°C to 100°C and in the sodium hydroxide catalyst range of 0.556 - 0.3495 moles/liter. The effect of the concentration of methanol on the rates of reaction of the succeeding reactions was investigated. Product distribution data were obtained to test the applicability of the correlation for the rate constants.

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ABSTRACT OF THESIS

NON-IDEAL STAGE MULTICOMPONENT ABSORBER CALCULATIONS BY AUTOMATIC DIGITAL COMPUTER

Arthur E. Ravicz

IP-354 Dated February, 1959

The purpose of the investigation was fourfold: (1) to formulate a mathematical model of an actual or non-ideal vapor-liquid contact device, and to make this model suitable for use with an automatic computer; (2) to develop a computer procedure for predicting the mass transfer relations involved in the non-ideal stage; (3) to investigate the use of enthalpy, equilibrium, and physical property correlations more rigorous and accurate than those currently in use, and (4) to demonstrate the soundness and applicability of the non-ideal stage approach by writing a computer program for its use and comparing predicted performance of actual equipment with test data.

The equipment selected for investigation was the multicomponent petroleum gas absorber. Computation was done on the IBM 704 electronic data processing machine.

Mass transfer relationships for the non-ideal stage were developed. These equations made use of the Murphree vapor plate efficiency concept in a manner slightly different from the original definition. A heat transfer expression, similar in form to the mass transfer equations, was used for computing vapor temperatures. The Colburn mass transfer-heat transfer analogy was employed to estimate heat transfer efficiencies based on the Murphree plate efficiencies. A digital computer program was written for predicting the performance of petroleum gas absorbers.

It appears that the non-ideal stage calculation is a very useful tool for those seeking better ways of understanding, analyzing, and predicting the operating conditions of vapor-liquid stage contacting devices. The mass transfer and heat transfer relationships employed by the computer program are suitable, but the methods of estimating the efficiencies involved require improvement.

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ABSTRACT OF PAPER

MODERN HIGH CARBON FERROUS METALS FOR RESISTANCE TO SURFACE DAMAGE

F. B. Rote

IP-355 Dated February, 1959

This paper presents a review of modern metals in the high carbon ferrous family, their structure and properties, and post-production processes which can be utilized to develop uniquely desirable characteristics for specific applications. Particular reference is made to applications where resistance to surface damage and inherent mechanical strength are important.

The graphite-bearing materials discussed are divided into three types on the basis of the shape and distribution of the graphitic particles. These are: 1) gray cast iron-flake graphite, 2) malleable and pearlitic iron-temper carbon graphite, and 3) modular iron-nodular or spherulitic graphite.

Photomicrographs of typical graphite structures, and tables showing the chemical composition ranges for high carbon ferrous casting alloys and the specification properties for graphite iron castings of importance to the design engineer, are included.

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INDUSTRY PROGRAM OF THE COLLEGE OF ENGINEERING

ABSTRACT OF THESIS

EFFECT OF CHEMICAL ENVIRONMENT ON THE LETHALITY OF GAMMA RADIATION FOR ANAEROBIC BACTERIAL SPORES

Nancy Jane Williams-Walls

IP-356 Dated March, 1959

The purpose of this investigation was to determine the possible protective effects of the chemical constituents of an aqueous environment on survival of anaerobic bacterial spores during irradiation with gamma rays from cobalt-60. Three organisms of importance in food preservation, Clostridium botulinum, strains 62A and 213B, and Clostridium sp., putrefactive anaerobe, P.A. 3679, were used as the test organisms. The technique employed for determining the number of viable spores present in solutions before and after irradiation was the conventional 10-fold serial dilution method followed by plate counts in anaerobic medium.

Of 21 chemicals tested, nine were able to protect the anaerobic bacterial spores from the lethal effects of irradiation. In order to afford protection, these chemicals had to be present during irradiation in the solution in which the spores were suspended. It was concluded that the death of the bacterial spores, which occurred even when protective chemicals were present in the suspending solution, was produced by the ionizing radiations and not by the toxicity of by-products of the irradiated chemicals. The importance of the sulfhydryl group in the total protective effect obtainable with reduced glutathione was also studied.

The results of experiments performed using sodium hydrosulfite seemed to indicate that the protective mechanism of this chemical involved more than a simple removal of oxygen from the medium. The degree of protection obtained with p-chloromercuribenzoate was found to be a function of the concentration of the chemical present in the solution. The high degree of protection obtained when catalase was present in the suspending solution seemed to indicate a significant role of hydrogen peroxide in the lethal effects produced by cobalt-60 gamma radiations on anaerobic bacterial spores.

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ABSTRACT OF THESIS

HYDRATION OF N-BUTENE WITH A CATION EXCHANGE RESIN

W. J. M. Douglas

IP-357 Dated March, 1959

The purpose of this investigation was to study the hydration of liquid n-butene to secondary butyl alcohol using a cation exchange resin as the catalyst. Liquid n-butene and water, and sometimes also secondary butyl alcohol, were passed over a bed of Dowex 50 x 8 (monosulfonated polystyrene resin, cross-linked with 8% divinylbenzene) at temperatures from 115° to 145°C. All measurements were made under steady-state conditions. The reactor product was collected at atmospheric temperature and pressure as two phases in equilibrium -- an aqueous alcohol liquid and a butene-rich gas. The alcohol content of the liquid product was determined by measurement of density.

Hydration reaction rates and chemical equilibrium were determined. Using 100-200 mesh resin, integral reaction rates were measured as a function of temperature and space velocity. Rates at high space velocities were extrapolated to determine initial reaction rates, which were correlated with temperature. At moderate flow rates the liquid phase mass transfer resistances were large, probably due to the presence of two almost completely immiscible liquid phases.

Two related operations with the cation exchange resin were explored. For catalytic hydration of propylene, the reaction rates and equilibrium conversions are more favorable than those for n-butene. Also, the cation exchange resin can replace the sulfuric acid in the two-step esterification-hydrolysis process for secondary butyl alcohol. The hydration rates for the two-step process using the resin appeared to be much lower than those for the continuous catalytic process.

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INDUSTRY PROGRAM OF THE COLLEGE OF ENGINEERING

ABSTRACT OF PAPER

A METHOD FOR THE ANALYSIS OF MULTICOMPONENT EXPONENTIAL DECAY CURVES

Donald G. Gardner
Jeanne C. Gardner
George Laush
W. Wayne Meinke

IP-358 Dated March, 1959

A frequently encountered problem in many branches of science involves the resolution of experimental data into a sum of independent exponential curves of the form $f(t) = \sum_{i=1}^{n} N_i e^{-\lambda_i t}$, in order to estimate the physically significant parameters N_i and λ_i. Such problems arise, for example, in the analysis of multicomponent radioactive decay curves, and in the study of the dielectric properties of certain compounds.

This paper is concerned with the numerical evaluation of a mathematical approach to the problem. The approach is based on the inversion of the Laplace integral equation by a method of Fourier transforms. The results of the analysis appear in the form of a frequency spectrum. Each true peak in the spectrum indicates a component, the abscissa value at the center of the peak is the decay constant λ_i, while the height of the peak is directly proportional to N_i/λ_i. Results obtained on an IBM 650 computer indicate that the method may possess certain advantages over previous methods of analysis.

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INDUSTRY PROGRAM OF THE COLLEGE OF ENGINEERING

ABSTRACT OF PAPER

SLIDING CHARACTERISTICS OF METALS AT HIGH TEMPERATURE

M. B. Peterson
J. J. Florek

IP-359 Dated March, 1959

This paper presents a study of friction and wear processes at elevated temperatures for several types of materials; particularly where operating conditions exclude fluid film or rolling contact bearings, where design specifications require a sliding contact bearing system, and where the load is fully supported by the bearing material.

Specimens were tested in an apparatus consisting essentially of a hemisphere sliding against a flat palte. Friction-temperature cycle tests were run on pure metals; namely, iron, copper, cobalt, nickel, chromium, molybdenum, aluminum, and zirconium, sliding against themselves. Next, friction data for these pure metals were compared with values of friction obtained with several types of alloys which contain these pure metals.

It is concluded that the presence or lack of oxide formation and the hardness or softness of the oxide plus temperature and clearance requirements are important factors in the selection of a suitable bearing material. In addition, a compromise needs to be made with other material requirements such as strength, oxidation resistance, corrosion resistance, thermal expansion, and ease of fabrication.

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ABSTRACT OF THESIS

PLATE EFFICIENCIES AND MASS TRANSFER FOR VALVE TRAYS AND TRAYS WITH LARGE PERFORATIONS

Robert H. Miller

IP-360 Dated March, 1959

The use of bubble cap plate towers have been standard in petroleum and chemical industries for several years. Recently, rising costs has encouraged manufacturers to investigate other types of vapor-liquid contacting devices, some of which are claimed to be superior to bubble cap plates. This paper investigates two types of plate design, valve and perforated, and compares their performance with bubble cap plates.

Two types of experimental systems were used: 1) humidification of air and 2) the absorption of ammonia from air by water. In the first system all the resistance to mass transfer is in the vapor phase. In the second, the majority of resistance is in the vapor phase, but some liquid phase resistance is also present.

Data for the humidification of air with water covered an operating range in which the weir height was 1-1/2 and 3-1/2 inches, liquid rate from 8 to 24 gallons per minute, and gas velocity varied from 1 to 5 feet per second. For data on absorption of ammonia from air by water the weir height was 2 and 3-1/2 inches, liquid rate from 8 to 32 gallons per minute, gas velocity varied from 1 to 5 feet per second.

It was found that the Murphree vapor efficiency for both systems investigated increased with either an increase of weir height or an increase of liquid rate. The weeping limit was found to be a function of the vapor velocity through the holes in the tray. Liquid mixing with the perforated tray was found to be greater than with the valve tray, but for either tray is not as large as produced by bubble cap trays.

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ABSTRACT OF PAPER

INTERACTION EXPERIMENTS OF LATERAL JETS WITH SUPERSONIC STREAMS

James L. Amick
Gerard F. Carvalho
Hans P. Liepman

IP-361 Dated March, 1959

This paper is concerned with theoretical and experimental studies of missile control, stabilization, and sustenation by means of jets exhausting laterally from a typical missile.

The experimental program, carried out in the 8 by 13 inch atmosphere-to-vacuum supersonic wind tunnel at the University of Michigan, studied the effects of two or more radial jets at right angles to the surface of the missile, inclined jets, the effect of forward jet locations, and other pertinent factors. Photographs of the details of the model used in the study, and representative schlieren pictures of the jet effects on the boundary layer, are included.

The performance of single aft jets, both inclined and normal, was found to be superior to both multiple and nose jets. Future studies will include the effectiveness of aft-inclined jets, nose jets and studies of the flow field.

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INDUSTRY PROGRAM OF THE COLLEGE OF ENGINEERING

ABSTRACT OF PAPER

THE DESIGN OF POSITION AND VELOCITY SERVOS FOR MULTIPLYING AND FUNCTION GENERATION

Edward O. Gilbert

IP-362 Dated March, 1959

In this paper the design of position and velocity servos used in analog computation and simulation for multiplying and function generation is considered. The important characteristics of potentiometers, gear train, motor, amplifier, and tachometer are defined and discussed. Nonlinear performance requirements such as velocity and acceleration limits, overshoot for large step inputs, and static resolution are defined in terms of component parameters. A minimum gear reduction ratio is determined on the basis of acceleration, frictional torque ratio, overshoot for large step inputs, or static resolution. Linear system analysis is made and related to system components and nonlinear performance; in particular, it is shown that static resolution is limited by servo amplifier bandwidth for given motor, potentiometers, and gear train. The selection of damping methods and the reduction of steady-state errors are described.

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INDUSTRY PROGRAM OF THE COLLEGE OF ENGINEERING

ABSTRACT OF PAPER

DRESDEN NUCLEAR POWER STATION

Wayne Lowell Townsend

IP-363 Dated March, 1959

This paper is concerned with the nearly completed Dresden Nuclear Power Station being built as a part of the "Independent Industrial Program" of the Atomic Energy Commission. This station, located near Chicago and scheduled for operation in 1960, will be the largest privately financed all-nuclear power plant in the United States.

The capacity of the plant has been estimated at 180,000 kw with a potential of 245,000 kw. It has also been estimated that Dresden will produce electricity for approximately 3/4 cents per kwhr. The fuel used in this boiling-water reactor will consist of uranium dioxide, slightly enriched.

Included in the paper is a detailed discussion of the power cycle, the reactor design and operation, the radiation problem, and the safety devices of the plant.

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ABSTRACT OF PAPER

DYNAMIC ANALYSIS OF ELASTO-PLASTIC STRUCTURES

Glen V. Berg

Donald A. DaDeppo

IP-364 Dated April, 1959

This paper presents two numerical methods for solving the differential equations of motion for nonlinear systems. The differential equations of motion are formulated for a lumped mass multi-story elasto-plastic framework subjected to dynamic lateral forces, taking into account elasto-plastic deformation and viscous damping which may be linear or nonlinear.

The method consists of numerical integration combined with a matrix solution for the elasto-plastic constraints. A numerical example illustrates the process.

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ABSTRACT OF PAPER

THE FISSION GAS PROBLEM FOR MOBILE FUEL FAST REACTORS

Frederick G. Hammitt
Evan C. Kovacic
Fred J. Leitz, Jr.

IP-365 Dated April, 1959

In this paper, the problems that might result from the release of fission gases in mobile fuel fast reactors are considered for two types of mobile fuel systems: 1) a molten alloy fuel system of the type to be used in the Los Alamos Molten Plutonium Reactor Experiment, and 2) a paste fuel system of the type being developed by the Atomic Power Development Associates, Inc. Fission gases generated in fast reactors operating at high power density can supersaturate such fuel systems in minutes or less.

An examination of the physical conditions generated in the reactor core and an evaluation of the phenomena responsible for bubble formation indicate that neither fuel system will sustain significant supersaturation, and that bubble formation will likely occur at a solid-liquid interface rather than in the bulk of the liquid. The effects of bubble formation in each system are considered.

Preliminary experiments, using supersaturated solutions of carbon-dioxide in water and in water-glass bead beds are reported, verifying some of the analyses made regarding the location of bubble formation and the growth of bubbles. The flow characteristics of pastes in tubes and the behavior of gas bubbles in such flow systems are discussed in the light of experiments which were conducted using a simulant system of air/glass beads/water.

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INDUSTRY PROGRAM OF THE COLLEGE OF ENGINEERING

ABSTRACT OF THESIS

THERMAL EFFECTS IN JOURNAL BEARINGS

Elsayed Morsi Aly Afify

IP-366 Dated April, 1959

The purpose of this paper was to explore some of the aspects not discussed by most of the previous investigators in the field of lubrication. Both the heat conducted through the bearing and that convected by the oil flow were considered in the study of the effect of speed, load, and external heating on the average oil film temperature, oil flow, and correspondingly the heat balance of journal bearings.

For this investigation, a simple journal bearing was constructed with oil fed at a constant pressure of one psig through a single hole placed at the unloaded side of the bearing. Thermocouples were placed flush with the inner surface of the bearing to measure the temperature along the axial as well as the circumferential direction. Measurement was also made of the journal surface temperature at four different positions, of the oil flow rate, and of the inlet and outlet oil temperatures.

Three series of tests were conducted from which the heat convected by the oil flow and the heat dissipated through the bearing and housing were determined for different combinations of speed and load.

It was concluded that: 1) the bearing will run cooler at light loads than at no-load, 2) the average oil film temperature was affected more by variations in speed than by variations in load, and 3) the oil flow rate was influenced more by changes in load than by changes in speed.

A mathematical treatment of the unloaded bearing was derived, while experimental correlations from the test results were obtained to calculate the heat convected, the heat dissipated, and the oil flow rate. A method, for estimating the average temperature of the bearing was also presented.

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ABSTRACT OF THESIS

PREDICTION OF GAS STORAGE RESERVOIR BEHAVIOR

Keith Hal Coats

IP-367 Dated April, 1959

The purpose of this research has been the development of fundamental theory relating to the performance of gas storage reservoir-aquifer systems and evaluation of this theory by application to actual gas field studies. The specific objectives of the research were, 1) development and application of a general digital computer method of predicting the pressure and volume behavior of a storage reservoir subjected to an arbitrary time-variant gas injection-production schedule, 2) development and application of a method of determining the "effective" values of reservoir physical constants, i.e., those values which result in best agreement between the calculated and actual field performances, 3) an investigation of the effect of reservoir geometry on the field performance, 4) development and application of methods to treat the special problems of interference between gas fields, non-uniformity of the aquifer initial pressure distribution, and growth of the gas bubble radius with time in "aquifer storage" operations. Data were obtained from three Michigan gas fields and two aquifer storage reservoirs in order to evaluate the predictive accuracy and field applicability of the methods developed in the research.

The agreement obtained between calculated and observed reservoir performances indicates that both the accuracy and applicability of the developed methods are more than adequate for present engineering needs. The methods developed in the research appear to be useful tools for those seeking better ways of understanding, analysing, and predicting gas storage reservoir performance.

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ABSTRACT OF THESIS

EXPERIMENTAL DETERMINATION OF THE THERMODYNAMIC PROPERTIES OF GASES AT LOW TEMPERATURES AND HIGH PRESSURES

Richard C. Faulkner, Jr.

IP-368 Dated May, 1959

The purpose of this work was to (1) design and construct equipment suitable for determining experimentally the enthalpy of light hydrocarbon mixtures over the temperature range from 70°F to -280°F, over the pressure range from atmospheric to 2500 psia, (2) mechanically test and calibrate the equipment, and (3) obtain sufficient data on a gaseous substance to evaluate the performance of the system.

In order to deliver fluid to a flow calorimeter or expansion device at a specified temperature and pressure, a compressor for circulation, equipment for continuous purification, means for stabilization and control of pressure and flow rate, and a cooling system employing dry ice and liquid nitrogen, were incorporated in a closed flow cycle. A high pressure flow calorimeter was constructed to measure isobaric specific heats of liquids, gases, or single phase systems above their critical pressures, and to measure isobaric integral latent heats of vaporization of mixtures. An expansion device employing radial porous plugs, often described as a Joule-Thomson throttle, was constructed to measure isenthalpic throttling.

The majority of the experimentally measured values of the isobaric specific heat of nitrogen agreed with literature values within 2%. An evaluation of the individual measurement errors indicated a maximum uncertainty of 0.7% in mass flow rate, energy addition 0.1%, temperature rise of the fluid 0.3%. Based on experience gained during operation of the equipment, it was concluded that modifications should be undertaken by the next investigator to reduce the length of time required to obtain data and to eliminate sources of inaccuracy which became apparent.

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ABSTRACT OF THESIS

TWO-PHASE COCURRENT FLOW IN PACKED BEDS

Robert Pruett Larkins

IP-369 Dated May, 1959

In this paper two-phase cocurrent flow of gas and liquid through packed beds was investigated experimentally to determine a correlation suitable for the prediction of the pressure drop accompanying two-phase downward flow. The fraction of the void volume occupied by liquid, termed the liquid saturation, was also investigated since the density of the flowing mixture represents a contribution to the total frictional energy loss in vertical flow. An important application of the correlations for liquid saturation and pressure drop is in the design of trickle bed reactors of the type used to react hydrogen gas and lube oil at high temperature and pressure during cocurrent downward flow over a catalyst bed.

Experiments were carried out with air and several liquids on several packing materials contained in a 4-inch column. The liquid viscosity was varied with water, water solutions of methylcellulose, and ethylene glycol, and the packing properties were varied with 3/8-inch Raschig rings, 3/8-inch spheres, and 1/8-inch cylinders. Measurements of pressure drop and liquid saturation were obtained over the entire range from 100 per cent liquid to 100 per cent air. A wide range of flow rates were investigated and pressure drops as high as 14 psi per foot were obtained at the maximum rates.

Data taken on foaming systems were found to have pressure drops as much as six times those for the corresponding non-foaming conditions. The effect decreases with increased rates or packing diameters. A considerable number of unpublished data on hydrocarbon systems supported the correlation for non-foaming systems and confirmed the deviations observed for foaming systems. Agreement with correlations for two-phase flow in pipes supports the wide extrapolation of porosities.

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ABSTRACT OF THESIS

ORDERING AND CREEP PROPERTIES OF NI-CR-AL-ALLOYS

Charles Milles Hammond

IP-370 Dated May, 1959

Many important heat and corrosion resistant alloys are based upon the nickel-chromium-aluminum system. Because of the complexity of these industrial alloys the essential features of the simple nickel-chromium-aluminum system have been obscure, and investigators have indicated that two structural transformations may be of importance:

1. Ordering of the $Ni_3Cr(\gamma)$ phase - (controversial)
2. Controlled precipitation of the $Ni_3Al(\gamma')$ phase.

This paper investigates the controlversial order-disorder transformation as well as γ' precipitation in the Ni-Cr-Al system and correlates creep properties with the structural transformations disclosed. The alloy compositions selected for this research extended from the Ni_3Cr to Ni_3Al. The existence of ordering was studied by elevated and ambient temperature X-ray diffraction. Optical and electron microscopy were used to ascertain the phases present during X-ray diffraction and creep testing.

The data of this investigation indicate that no long range ordering exists in the γ solid solution of Ni-Cr-Al alloys. The superlattice indications from ambient temperature X-ray patterns of solid specimens, quenched from the single phase γ field to room temperature, results from γ' precipitation during quenching.

Precipitation of γ' results in marked strengthening of simple Ni-Cr-Al alloys at 750°C. The results agree with recent theoretical predictions of the effect of dispersion hardening upon creep properties.

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ABSTRACT OF THESIS

CONTRIBUTIONS TO ESTIMATION IN A CLASS OF DISCRETE DISTRIBUTIONS

Ganapati P. Patil

IP-371 Dated June, 1959

This paper first shows that the binomial, Poisson, negative binomial and logarithmic series distributions can be regarded as special cases of a general class of discrete distributions referred to as "generalized power series distribution" (gpsd). It is therefore possible to examine the work on estimation in the case of the above discrete distributions from a general point of view. The purpose of this paper is to derive results for this general class of distributions and then apply them to the special cases of binomial, Poisson, etc.

To begin with, a few results which bring out some interesting properties of a gpsd are presented. An explicit functional relationship between the variance and mean of a gpsd is discovered and based on this fundamental relation some characterization theorems are presented. To mention one, it is established that the equality of variance and mean is necessary and sufficient for a gpsd to be Poisson.

Next, certain estimation problems connected with a gpsd are investigated. It is shown that the maximum likelihood method and the method of moments give the same estimate when the gpsd involves a single parameter. A computational method for evaluating the maximum likelihood estimate is developed which requires only a table of values of the mean of the gpsd for various values of the parameter at sufficiently close intervals. It is also shown how the standard error of the estimate can be approximately evaluated by using this table.

Results obtained by general approach are applied to specific distributions - namely, the binomial, Poisson, negative binomial and logarithmic series. Illustrative examples have been worked out in detail to illustrate the methods suggested.

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ABSTRACT OF THESIS

STABILITY OF CELLULAR COFFERDAMS

Kamal Tawfiq Al-Chalabi

IP-372 Dated June, 1959

This paper presents a general solution for the stability analysis and design of cellular cofferdams with reference to 1) the granular property of the soil and its stability according to the theory of arching, 2) the cohesive property of soil, and 3) soil stability due to cohesion resulting from the molecular attraction of the clay particles. In addition, special emphasis has been placed on the mass stability of the cofferdam, a problem not dealt with previously in regard to cofferdams, as a major concept in designing and analyzing cellular cofferdams. Particularly when the cofferdam is to carry a great lateral thrust as in the case in shore cofferdams as used for ore yards.

A brief historical review of cofferdams and a discussion of the previous solutions and their basic theories are also presented, and a resumé of soil mechanics as developed and adopted at the University of Michigan is given. Based on these concepts of soil mechanics formulas are derived for designing and analyzing cellular cofferdams filled with various types of fill and built on various types of foundations.

An existing cellular cofferdam is analysized. It is found to be critical with respect to mass movement. To test this cofferdam a lateral thrust is applied against it by loading an area behind the cofferdam. From the analysis it is concluded that an area of 48.5 feet by 48.5 feet must be loaded. The load capacity of the cofferdam is calculated for various overload ratios, (ratios of the stress imposed on the clay soil divided by the yield value as measured by laboratory test).

Three general conclusions are drawn. 1) The formulas derived for analyzing and designing cellular cofferdams, which were applied in the analysis of this cofferdam, are reliable, 2) the mass stability is a critical factor in cofferdam design, and, 3) the introduction of the overload ratio allows the designer to design the cofferdam for various ratio of settlements, whether the cofferdam is designed as a temporary structure or as a permanent structure.

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ABSTRACT OF THESIS

AN EXPERIMENTAL STUDY OF THE STRESSES IN RING STIFFENERS IN LONG THIN-WALLED CYLINDERS SUBJECTED TO BENDING

Wadi Saliba Rumman

IP-373 Dated June, 1959

This paper presents and illustrates methods for computing the stresses in ring stiffeners in long thin-walled cylinders subjected to bending. Both the pure bending of the cylinder and the bending caused by transverse local loading are considered.

The study also includes both an analytical and an experimental investigation. The analytical investigation, which is based on solutions of analogous problems, is primarily used to establish the major parameters upon which the forces in the ring stiffeners depend. The constants that are introduced in the equations of the analytical investigation are evaluated from the experimental results. The forces in the stiffeners are classified under three types of action, namely: (1) flattening of the cylinder, (2) bulging of the cylinder, and (3) separate effect of the local loading.

The flattening of the cylinder is due to the inward vertical forces caused by the longitudinal elastic curvature. The bulging of the cylinder is caused by the increase of the radii in the compression half, and a decrease in the tension half, of the cylinder due to Poisson's ratio. The distortions in the cross sections of the cylinder, due to the bulging effect, produce primarily normal forces in the ring stiffeners. Both the flattening and the bulging effects are studied from the pure bending moment tests on the cylinder. The separate effect of the local loading is investigated by eliminating the effects of flattening and bulging which are known from the pure bending moment tests on the cylinder.

In conclusion, it can be stated that this dissertation presents equations that can be used satisfactorily to establish the character and magnitude of the forces acting on the ring stiffener in long thin-walled cylinders subjected to bending. The results obtained by applying these equations to the ring stiffeners in steel stacks are reasonable and fall within current engineering practice.

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ABSTRACT OF THESIS

THE ONSET OF LAMINAR NATURAL CONVECTION IN A FLUID WITH HOMOGENEOUSLY DISTRIBUTED HEAT SOURCES

Walter Ralph Debler

IP-374 Dated June, 1959

In this paper the thermal instability of a horizontal layer of fluid that has homogeneously distributed heat sources is examined. It is shown that the onset of laminar natural convection is determined by a critical Rayleigh number, and graphs relating the Rayleigh number and the cell number are presented for three cases; (a) both bounding surfaces rigid and isothermal, (b) a rigid adiabatic lower boundary and a rigid isothermal upper boundary, and (c) a rigid adiabatic lower boundary and a free isothermal upper surface.

It is also shown that the degree of stability of a fluid layer is dependent on the manner in which the velocity at the horizontal boundary is prescribed. A layer with a free surface was found to be less stable than if the boundary were rigid. The influence of the mean temperature distribution is also discussed. An experiment was conducted to verify the analysis for case (a), above.

The governing equations, boundary conditions and some computational coefficients are presented for other problems which are related to those treated. The results for the problems studied should have application to the design of atomic reactors which employ radioactive fluids.

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