ABSTRACTS

DEPARTMENT OF GENERAL CHEMISTRY

1. SPREADING PROPERTIES OF RUBBER. PART I. Surface Films of Purified Rubber. N. H. Sivaramakrishnan and M. R. A. Rao, *Trans. Inst. Rubber Ind.*, 1956, **32**, 19.

The spreading properties of solutions of natural rubber, purified by four different methods, have been studied at the air-water interface. With benzene or chloroform as solvent, moderately stable films are formed. In the case of benzene solutions, maximum limiting areas can be obtained, by spreading from sufficiently dilute solutions, whose values depend on the treatment of the rubber during purification. It is shown that the spreading properties of the rubber are not due to protein impurities or to oxygenated rubber compounds. The minimum thickness of the rubber films varies from about 270 Å to 700 Å, which is nearly 100 times greater than that found for most polar high polymers. This high value is attributed to the relatively weak hydrophilic nature of the double bond in rubber and to the large lateral cohesive forces between the rubber chains, which prevent more extensive spreading of the molecules.

2. SPREADING PROPERTIES OF RUBBER. PART II. Effect of Oxidising Agents on Spread Films of Rubber. N. H. Sivaramakrishnan and M. R. A. Rao, *Trans. Inst. Rubber Ind.*, 1956, **32**, 69.

The effect of potassium permanganate and hydrogen peroxide on the oxidation of rubber films has been investigated employing various concentrations of oxidising agents and at different pH values. In general, oxidation brings about an increase in the area of the film, but prolonged oxidation diminishes the film area, due to dissolution of hydroxy rubber compounds. Increase in the concentration of the oxidising agent enhances the oxidation. An increase in the pH of the potassium permanganate solutions decreases the rate of oxidation of rubber, while the opposite effect is noticed with hydrogen peroxide. This has been attributed to the variation of redox potentials of the oxidising systems. Rubber films are also slowly oxidised by atmospheric oxygen in the presence of water. When aqueous chlorine and bromine are employed as oxidising agents, the oxidised films are far more stable than those exposed to potassium permanganate or hydrogen peroxide solutions. This is due to the insolubility of the halogenated films produced. In the case of iodination of the film, the area of the oxidised film is very small. The effect is attributed to the highly hydrophobic nature of iodinated rubber.

3. SPREADING PROPERTIES OF CHLORINATED RUBBER. N. H. Sivaramakrishnan, *Trans. Inst. Rubber Ind.*, 1956, **32**, 168.

The spreading properties of chlorinated rubber prepared either by chlorination of latex or chlorination of crepe in carbon tetrachloride solution, have been

studied. It has been found that the thickness of the spread film is affected only slightly by the viscosity and method of preparation of the chlorinated rubber. Films of thickness varying from 40 Å to 62 Å were obtained, these values being nearly the same as those obtained by spreading purified rubber on aqueous solutions of chlorine or bromine.

4. THE RATE OF HYDROLYSIS OF CHLOROACETAMIDE IN AQUEOUS ACID. Sundaresa Soundararajan and Marjorie J. Vold, *Proc. Ind. Acad. Sci.*, 1957, **46 A**, 303.

In 0·3 N acid the hydrolysis of chloroacetamide follows a bimolecular law with the activation energy and activation entropy both greater than the corresponding quantities for acetamide in accord with prediction based on the charge distribution. However, at even slightly lower acidity the free energy of activation is a continuous function of the hydrogen-ion concentration becoming more positive with decreasing acidity in the range studied.

5. THE DIPOLE MOMENTS AND MOLECULAR STRUCTURE OF SUBSTITUTED ACETAMIDES. Sundaresa Soundararajan, *Trans Faraday Soc.*, 1957, **53**, 159.

Thioacetamide has a dipole moment substantially higher than the vector sum of the normal characteristic moments of its constituent bonds. However, the effect can reasonably be accounted for on the scheme of alterations in charge distribution and hence of bond moments proposed by Smith, Ree, Magee and Eyring. The same is probably true for chloroacetamide even though the problem of rotation about the C–C single bond renders the conclusion less certain. For cyanoacetamide the observed moment cannot be accounted for satisfactorily on this basis.

6. POLAROGRAPHIC BEHAVIOUR OF METALS IN ETHANOLAMINES. PART V. Copper. R. S. Subrahmanya, *Proc. Ind. Acad. Sci.*, 1957, **46 A**, 377.

The polarographic behaviour of copper-ethanolamine complexes has been studied at various pH values and also employing the following alkaline reagents, namely, sodium hydroxide, sodium carbonate and ammonium chloride-ammonium hydroxide. It has been noticed that the reduction process is essentially reversible in presence of mono- and diethanolamines and irreversible with triethanolamine. The phenomenon of split wave has been noticed only in solutions containing triethanolamine and non-ammoniacal alkaline reagents. In ammoniacal solutions the split waves are noticed with all the three amines. These observations have been suitably accounted for. The formation of the following complexes is deduced from the polarographic data:

$Cu_2(Moen)_4(OH)_3^+$	$Cu(Moen)_2^{++}$	$Cu(Moen)_3^{++}$
$Cu(Dien)_1(OH)_2$	$Cu(Dien)_2(OH)_2$	$Cu(Dien)_2^{++}$

Moen and Dien represent monoethanolamine and diethanolamine respectively. Thermodynamic constants have been calculated from polarographic data in systems

giving rise to reversible reduction processes. It has been concluded that ethanolamine complexes of copper can be employed for analytical estimation of copper.

7. POLAROGRAPHIC BEHAVIOUR OF METALS IN ETHANOLAMINES. PART VI. Lead. R. S. Subrahmanya, *Proc. Ind. Acad. Sci.*, 1957, **46 A**, 433.

The polarographic behaviour of lead has been studied at different pH values in presence of sodium hydroxide, sodium carbonate and ammonium chloride-ammonium hydroxide employing the ethanolamines as the complexing agents. The results indicate that the process is substantially reversible in the case of mono- and diethanolamines. In the case of triethanolamine the reduction process shows varying degrees of irreversibility depending upon the concentration of triethanolamine. The formation of the following complexes is indicated by the polarographic data:

$Pb\,(Moen)_1\,(OH)_2$	$Pb\,(Moen)_3\,(NH_3)_a^{++}$	$Pb\,(Moen)_4\,(NH_3)_x^{++}$
$Pb\,(Dien)_2\,(OH)_2$	$Pb\,(Dien)_1\,(NH_3)_y^{++}$	$Pb\,(Trien)_1\,(OH)_2$
$Pb\,(Trien)_1\,(NH_3)_z^{++}$	$Pb\,(Trien)_2^{++}$	

Moen, Dien and Trien represent monoethanolamine, diethanolamine and triethanolamine respectively. Thermodynamic constants have been calculated from polarographic data in reversible systems. The suitability of employing the reduction waves of lead in ethanolamines for analytical purposes has been discussed.

8. POLAROGRAPHIC BEHAVIOUR OF METALS IN ETHANOLAMINES. PART VII. Zinc. R. S. Subrahmanya, *Proc. Ind. Acad. Sci.*, 1957, **46 A**, 443.

The polarographic behaviour of the ethanolamine complexes of zinc has been studied at various pH values and in the presence of sodium hydroxide, sodium carbonate and ammonium chloride-ammonium hydroxide. The reduction process is essentially irreversible, the degree of irreversibility increasing with the number of ethanol groups in the amine. It has not been possible to elucidate from polarographic data the number of ethanolamine groups that enter the complex in solutions containing sodium hydroxide or ammonium chloride-ammonium hydroxide due to the closeness in the stability of the various complexes. The following complexes have been indicated from the polarographic data:

$Zn\,(Moen)_2\,(CO_3)_1$ $Zn\,(Dien)_2\,(CO_3)_x^{2-2x}$ $Zn\,(Trien)_2\,(CO_3)_y^{2-2y}$

Moen, Dien and Trien represent monoethanolamine, diethanolamine and triethanolamine respectively. The reduction waves of zinc-ethanolamine complexes can be used for the estimation of zinc in sodium carbonate solutions. Thermodynamic constants are calculated from polarographic data in the case of the reversible system. Some important types of polarographic wave forms obtained in the study of metallic complexes have been given. The limitations regarding the use of irreversible wave equations to derive the formulæ of metallic complexes have been pointed out.

DEPARTMENT OF ORGANIC CHEMISTRY

1. INVESTIGATION ON THE BY-PRODUCT OBTAINED IN THE COPE-KNOEVENAGEL CONDENSATION OF ETHYL α-ACETOGLUTARATE WITH ETHYL CYANOACETATE. Dilip K. Banerjee, Pasupati Sengupta and Sunil K. Das Gupta, *J. Org. Chem.*, 1954, **19**, 1516.

The solid by-product, m.p. 155·5°, obtained in the Cope-Knoevenagel condensation of ethyl α-acetoglutarate with ethyl cyanoacetate has been identified as ethyl 1, 4, 5, 6-tetrahydro-2-methyl-6-oxonicotinate (V). This has been formed by the reaction of ammonia, produced by the dissociation of ammonium acetate, with ethyl α-acetoglutarate followed by the elimination of a molecule of ethyl alcohol.

2. A SIMPLE VALVE TO PREVENT BACK SUCTION IN A VACUUM SYSTEM. M. C. Chaco, *J. Chem. Education*, 1954, **31**, 547.

A simple, compact device has been worked out to prevent back suction of water from a water pump.

3. SEED FAT OF *Anamirta cocculus*. T. R. Kasturi and B. H. Iyer, *J. Indian Chem. Soc.*, 1954, **31**, 8, 623.

Fatty acids of the seed fat of *Anamirta cocculus* consist of palmitic (6·1%), stearic (47·5%), oleic (43·3%) and linoleic (3·12%). The glyceride composition of the fat as determined by the acetone permanganate oxidation method is: trisaturated (GS_3), 9·77%; disaturated mono-unsaturated (GS_2U), 41·55%; monosaturated di-unsaturated (GSU_2), 48·78% and tri-unsaturated (GU_3), nil. The unsaponifiable matter from the fat contains sitosterol.

4. REFINING OF NAHOR SEED OIL. T. R. Kasturi, N. L. Narayana Murthy and B. H. Iyer, *J. Sci. and Ind. Res.*, 1954, **13 B**, 6, 453.

A colourless, odourless and tasteless oil of *Mesua ferrea* Linn. (N.O.: *Guttiferæ*; Hindi: *Nagkesar*) has been obtained in 75–80 per cent yield, by chromatographing the crude oil over a column of alumina using carbon tetrachloride as eluent.

5. CHEMICAL EXAMINATION OF THE OIL FROM THE SEEDS OF *Cucurbita pepo*. N. L. Narayanamurthy, B. H. Iyer, P. R. J. Gangadharam and M. Sirsi, *Indian Jour. Pharm.*, 1954, **16**, 7, 148.

Fatty acids of the oil from the Bangalore variety of the seeds of *Cucurbita pepo* consist of palmitic (9·51%), stearic (7·93%), oleic (38, 99%) and linoleic (43·49%). The glyceride composition of the oil as determined by the permanganate oxidation method is: trisaturated (GS_3) 4·1%, disaturated mono-unsaturated (GS_2U) 12·81%, monosaturated di-unsaturated (GSU_2) 14·4% and tri-unsaturated (GU_3) 68·69%.

6. SYNTHESIS OF 1-METHYL-*Trans*-2-DECALONE AND 2, 3, 4, 4 *a*, 4 *b*, 5, 6, 7, 8, 8 *a*, 9, 10-DODECAHYDRO-2-PHENANTHRONE. D. K. Banerjee, S. Chatterjee and S. P. Bhattacharya, *J. Am. Chem. Soc.*, 1955, **77**, 408.

1-Methyl-*trans*-2-decalone and *trans*-2-decalone have been prepared by the metal-amine reduction of 1-methyl-$\Delta^{1,8}$-2-octalone, and $\Delta^{1,9}$-2-octalone, respectively. 2, 3, 4, 4*a*, 4 *b*, 5, 6, 7, 8, 8 *a*, 9, 10-Dodecahydro-2-phenanthrone has been prepared from *trans*-2-decalone.

7. SYNTHETIC INVESTIGATIONS IN DITERPENOIDS. K. Raman and P. N. Rao, *Experientia*, 1956, XII/**12**, 472.

The synthesis of 1, 1-dimethyl-4 *a*-methyl-6-methoxy-1, 2, 3, 4, 4 *a*, 9, 10, 10 *a*-octahydrophenanthrene (DL-6-methoxypodocarpane) from 1-methyl-7-methoxy-tetralone-2 has been described.

8. CHEMISTRY AND ANTIBACTERIAL ACTIVITY OF NUT GRASS. Senich Radonit, Sukh Dev and M. Sirsi, *Curr. Sci.*, 1956, **25**, 118.

The medicinal properties of the essential oil obtained from the tubers of *C. rotundus* have been subjected to a pharmacological study. A short note on the chemistry and antibacterial activity of the essential oil and its fractions is presented.

9. SYNTHESIS OF *Ortho*-, *Meta*-, AND *Para*-METHYL *Cyclo*-HEXYLIDENE ACETALDEHYDES. M. C. Chacko and B. H. Iyer, *Chem. and Ind.*, 1956, 155.

A synthesis of *ortho*-, *meta*-, and *para*-methyl cyclohexylidene acetaldehydes has been described.

10. STUDIES IN SESQUITERPENES. PART XIII. SYNTHESIS OF 4 : 5- AND 4 : 8-DIMETHYLEUDALENES. G. S. Krishna Rao and Sukh Dev. *J. Indian Chem. Soc.*, 1956, **33**, 8, 561.

To serve as reference compounds, 4 : 5- and 4 : 8-dimethyleudalenes have been synthesised and suitably characterised. Incidentally, a simpler preparation of 4-methyleudalene has been achieved.

11. STEREOSPECIFIC SYNTHESES OF *Trans*-1 β-HYDROXY-8-METHYL-4, 5-(4′-METHOXYBENZO)-HYDRINDANE, *Trans*-1 β-HYDROXY-8-METHYL-4, 5-(3′-METHYL-4′-METHOXYBENZO)-HYDRINDANE AND *d*, *l*-EQUILENIN METHYL ETHER. D. K. Banerjee, S. Chatterjee, C. N. Pillai and M. V. Bhatt, *J. Am. Chem. Soc.*, 1956, **78**, 3769.

By modification of Johnson, Peterson and Gutsche's synthesis of equilenin it has been possible to realize stereospecific syntheses of *trans*-1 β-hydroxy-8-methyl-4, 5-(4′-methoxybenzo)-hydrindane, *trans*-, 1 β-hydroxy-8-methyl-4, 5-(3′-methyl-4′-methoxybenzo)-hydrindane and *d*, *l*-equilenin methyl ether.

12. ZERUMBONE: A MONOCYCLIC SESQUITERPENE KETONE. Sukh Dev, *Chem. and Ind.*, 1956, 1051.

As a result of this investigation it has been shown that the structure assigned by Parihar and Dutt for zerumbone is untenable, and an eleven-membered ring structure has been proposed for it.

13. THE SCHMIDT AND CURTIUS REACTIONS WITH *o*-BENZOYLBENZOIC ACIDS. M. V. Bhatt, *Chem. and Ind.*, 1956, 1390.

A mechanism for the Schmidt and Curtius reactions with *o*-benzoylbenzoic acids has been proposed.

14. ABNORMAL BECKMANN REARRANGEMENTS: A MECHANISM OF THE SEMMLER REACTION. M. V. Bhatt, *Experientia*, 1957, XIII/2, 70.

A mechanism for the Semmler (Wolff Aromatisation) reaction has been proposed.

15. A PARADOXICAL CASE OF DIECKMANN CYCLISATION. D. K. Banerjee, J. Dutta and G. Bagavant, *Proc. Ind. Acad. Sci.*, 1957, **46**, 80.

The isomerisation of ethyl 1-ethoxycarbonyl-2-oxo*cyclo*pentylacetate to ethyl 3-ethoxycarbonyl-2-oxo*cyclo*pentylacetate has been shown to proceed *via* diethyl β-ethoxycarbonylpimelate. The mechanism proposed by Chakravarti is untenable. A mechanism based on the equilibrium nature of the reaction has been formulated to explain the formation of ethyl 3-oxo*cyclo*hexane-1:2-dicarboxylate or ethyl 3-ethoxycarbonyl-2-oxo*cyclo*pentyl acetate, as the major product, from diethyl β-ethoxycarbonylpimelate under different experimental conditions of Dieckmann cyclisation. Other mechanisms have also been discussed.

16. HYDROLYSIS of ETHYL 4-(1-CARBETHOXY-2-OXO*cyclo*PENTYL)-2-PENTENOATE AND ETHYL 4-(1-CARBETHOXY-2-OXO*cyclo*PENTYL)-VALERATE. D. K. Banerjee and T. R. Kasturi, *J. Am. Chem. Soc.*, 1957, **79**, 926.

Hydrolysis of ethyl 4-(1-carbethoxy-2-oxo*cyclo*pentyl)-2-pentenoate (I *a*) and ethyl 4-(1-carbethoxy-2-oxo*cyclo*pentyl)-valerate (I *b*) with 10% sulfuric acid yielded the normal hydrolysis products. Treatment of I *a* with hydrochloric acid yielded a mixture of a rearrangement product, and the normal product.

DEPARTMENT OF BIOCHEMISTRY

ANTIBIOTICS

ANTIBIOTIC PRINCIPLES FROM *Moringa pterygosperma*—PART IX. INHIBITION OF TRANSAMINASE BY ISOTHIOCYANATES. B. R. Das and P. L. Narasimha Rao. *Indian Jour. Med. Res.*, 1958, **46** (1), 75–77.

Purified pterygospermin inhibits glutamic acid $\rightleftharpoons$ alanine transaminase system [*vide Indian J. Med. Res.*, **42** (1), 115, 1954; *Ibid.*, **45** (2), 191, 1957]. It was suggested that this inhibition might be due to *in situ* formation of benzylisothiocyanate (B.I.T.) and the antimicrobial activity could be accounted for on this basis. Further evidence for this view is now provided by a demonstration of inhibition of the transaminase system by B.I.T., isobutyl (I.I.T.) and allylisothiocyanates (A.I.T.) also occurring in nature. The degree of inhibition depends on the concentration of isothiocyanates and falls off with time. The observed degree of inhibition of the enzyme system qualitatively corresponds with the antistaphylococcal activity of the three isothiocyanates.

VITAMINS

THE EFFECT OF THYROID ACTIVITY ON THE CONVERSION OF CAROTENE AND RETINENE TO VITAMIN A AND ON SERUM PROTEINS. H. R. Cama, N. C. Pillai, P. R. Sundaresan and C. Venkateshan, *J. Nutrition*, 1957, **63**, 571.

Iodinated casein decreased whereas thiourea enhanced liver reserves of vitamin A when retinene was administered orally to rats but thiouracil did not show any significant effect. On the other hand, on administration of carotene, hyperthyroid rats stored larger amounts of vitamin A in the livers and hypothyroid rats accumulated much less vitamin A. Thyroid activity does not have any direct effect on the conversion of intravenously administered retinene to vitamin A as observed by identical vitamin A values in the liver. The changes in the different components of serum proteins, in vitamin A-deficient, hyper- and hypothyroid rats have been shown. In vitamin A-deficiency, a very low albumin and an increase in α_2, β_2 and γ-globulin levels are observed. In hyperthyroidism there is a decrease in the albumin and an increase in α_2- and β_2-globulins. In hypothyroidism, a remarkable increase in α_1-globulin is noted.

SANITATION BIOCHEMISTRY

1. THE PRESENT STATE OF KNOWLEDGE REGARDING SEWAGE PURIFICATION. S. C. Pillai and C. Anandeswara Sastry, *Surgical and Med. News*, 1957, **3**, 7–23.

The developments in the field of sewage purification during the last 100 years, the different views regarding the mechanism of sewage purification, and the work

at Bangalore on the vital role of certain forms of protozoa in the purification process are discussed.

2. OXYGEN TRANSACTIONS IN SEWAGE AND OTHER POLLUTED WATERS. S. C. Pillai and C. Anandeswara Sastry, *J. Indian Med. Profession*, 1957, **4**, 1703-05 and 1708.

The available evidence on the deoxygenation and reoxygenation processes in sewage and other polluted waters is examined and fresh information is given particularly on the oxygenation of sewage during the activated sludge process and during natural purification of flowing sewage. The protozoa, especially Vorticellids, which develop during the purification process, are reported to have a very considerable influence on the oxygenation of the media.

3. TREATMENT AND DISPOSAL OF LIQUID RADIOACTIVE WASTES. C. Anandeswara Sastry and S. C. Pillai, *J. Ind. Eng.*, 1957, **1**, 76–81.

An account of the sources and nature of liquid radioactive wastes, their pollutional effects and of the various methods which are being tried for their safe disposal is given.

4. TREATMENT AND UTILISATION OF SEWAGE EFFLUENTS. P. V. R. Subrahmanyam, C. Anandeswara Sastry and S. C. Pillai, *J. Ind. Eng.*, 1958, **2** (3), 8–13.

The paper contains experimental results showing that the purified effluents from the activated sludge process and from the natural purification of flowing sewage at Bangalore could be softened by treatment with ion-exchange carbon prepared from tea waste. The possibility of using the softened effluents, after chlorination, for industrial purposes, is indicated.

DEPARTMENT OF METALLURGY

LATTICE PARAMETERS AND CRYSTALLOGRAPHIC ANGLES OF HEXAGONAL COBALT. T. R. Anantharaman, *Curr. Sci.*, 1958, **27**, 51–53.

The lattice parameters of close-packed hexagonal cobalt, which are difficult to determine accurately owing to its normal admixture with face-centred cubic cobalt and also the presence of stacking faults in its basal planes, were determined by the author from Debye-Scherrer photographs of pure cobalt filings taken from a large-grained block melted and cooled slowly *in vacuo*, and later annealed for a few weeks at 375° C., a temperature slightly below the phase transformation temperature. The annealed filings contained only traces of the cubic phase and were practically free from stacking faults in the hexagonal phase. The lattice parameters were: $a = 2{\cdot}5071$ Å; $C = 4{\cdot}0686$ Å; $c/a = 1{\cdot}6228$. The crystallographic angles for hexagonal cobalt, calculated for $c/a = 1{\cdot}6228$, are also given.

PHARMACOLOGY LABORATORY

1. STUDIES ON INDIAN MEDICINAL PLANTS *Curcuma longa*, LINN.—*In vitro* ANTIBACTERIAL ACTIVITY OF CURCUMIN AND THE ESSENTIAL OIL. C. Ramaprasad and M. Sirsi, *J. Sci. Industr. Res.*, 1956, **15 C**, 262.

The sodium salt of Curcumin (Sodium curcuminate) specifically inhibits *Micrococcus pyogenes* var. *aureus* in 1/million dilution. The essential oil and its fractionates exhibit a similar type of activity but only in very high concentration.

2. *Curcuma longa*, LINN.—EFFECT OF CURCUMIN AND THE ESSENTIAL OILS OF *C. longa* ON BILE SECRETION. C. Ramaprasad and M. Sirsi, *J. Sci. Industr. Res.*, 1956, **15 C**, 262.

Sodium curcuminate isolated from *Curcuma longa* is an active choleretic, inducing nearly one hundred per cent. increase of bile production in anæsthetized dogs, in doses non-toxic to the animal. The essential oil and some of its fractional distillates also induce choleresis but to a less extent than the pigment.

3. ESTROGENIC SUBSTANCES IN PLANTS. (Miss) M. Indira and M. Sirsi, *Souvenir, 25th Ann. Conference of Mysore Med. Asso.*, 1956, 65.

A catalogue of Indian medicinal plants whose physiological action resembles those due to estrogen hormone is listed. Experimental evidence for the occurrence of estrogen substances in the leaves of *Moringa pteriogsperma* and in *Cyperus rotundus* is presented.

4. EFFECT OF RAUVOLFIA ALKALOIDS ON BILIARY SECRETION IN DOGS. C. Ramaprasad and M. Sirsi, *J. Ind. Med. Asso.*, 1957, **28**, 307.

The crude total alkaloids of *Rauvolfia serpentina* (Benth.) when given intravenously reduces the bile output in anæsthetized dogs. A relationship exists between the systemic hypotension and biliary reduction. The possible mechanism of action has been discussed.

5. OBSERVATION ON THE PHARMACOLOGY OF RAUVOLFIA ALKALOIDS—EFFECTS OF RAUVOLFIA ALKALOIDS ON SOME ENDOCRINE FUNCTIONS. M. Sirsi, R. Rama Rao and (Miss) M. Indira, *Indian Med. Record*, 1956, **74**, 228.

The curde total alkaloids of *Rauvolfia serpentina* caused functional derangement and reduction in the weight of the ovaries in rats. The mild degree of adrenal hypertrophy and thymic atrophy appears to be a non-specific reaction. Pituitary hypofunction resulting in diminished gonadotrophic hormone secretion has been shown to be the primary causative factor for the dysfunction.

DEPARTMENT OF APPLIED MATHEMATICS

1. NON-ADIABATIC PULSATIONS OF A STELLAR MODEL. P. L. Bhatnagar and Pyare Lal, *Zeitschrift fur Astrophysik*, Bd. **41**, S. 21–34, 1956.

Eddington, Schwarzchild, Woltjer and others have discussed the non-adiabatic pulsations of a Star in connection with the problem of phase lag and maintenance and destruction of pulsations in the case of cepheid variable stars, but so far no general method for the solution of the non-adiabatic equation has been given. Rosseland, in connection with the problem of secular stability of variable stars, has suggested a systematic method for the solution of the non-adiabatic equation. We have applied this method and obtained the solution of the non-adiabatic pulsation equation in terms of a series of characteristic functions of the corresponding adiabatic equation. We have worked up to higher approximation than the previous workers. In the second part of the paper we have applied the solution obtained to the study of a homogeneous star, and have made a numerical estimation of the period of pulsation in the fundamental mode and the time of relaxation in case of the cepheid variable having mass equal to 5·02 solar masses and radius equal to 16·382 solar radii. These numerical estimates suggest that the departure from the adiabatic conditions must be taken into account more precisely than what has been done in the present paper.

2. ON SUPERPOSABLE FLOWS. P. L. Bhatnagar and P. D. Verma. *Proc. Ind. Acad. Sci.*, 1957, **45** (5), 281–92.

In the first section of the present paper we obtain the condition of superposability working through vectors and in particular give explicitly the condition of superposability of axi-symmetrical flows. This enables us to make some general remarks on the possibility of superposition of two axi-symmetrical flows. The rest of the paper is devoted to the consideration of the possibility of superposition of general rotational flow on the flows due to a vortex, spiral-vortex and vortex-doublet and of irrotational flow on a radial flow in two-dimensions.

In case of the flow due to a vortex, we find that a family of rotational flows for which the isocurls are concentric circles is superposable on it. In the case of the remaining three flows we find that the contemplated types of flows do not exist.

3. ADDITION OF AXIALLY SYMMETRIC MOTIONS OF VISCOUS LIQUIDS. S. K. Lakshmana Rao, *Proc. Ind. Acad. Sci.*, 1957, **45** (6), 418–23.

Conditions are noted for the addition of two axially symmetric motions of viscous liquids in which the velocities have toroidal as well as poloidal components and characterization relations are obtained for the class of self-additive axially symmetric motions.

4. PROBLEMS ON THE MOTION OF NON-NEWTONIAN VISCOUS LIQUIDS—GENERAL CONSIDERATIONS. P. L. Bhatnagar and S. K. Lakshmana Rao, *Proc. Ind. Acad. Sci.*, 1957, **45** No. (3), 160–71.

The study of Non-Newtonian fluid motions has been initiated by Rivlin (*Nature*, 1947, **160,** 611–13). The Non-Newtonial fluid which is highly viscous, is distinguished from the classical viscous fluid by the addition in the stress tensor of second order terms in the components of the rate of deformation tensor. Reiner (*Q.J.M.A.M.*, 1952) puts the stress tensor in the form

$$t_j^i = -p\delta_j^i + F_1 d_j^i + F_2 d_\alpha^i d_j^\alpha$$

where p is the mean pressure and

$$d_j^i = \tfrac{1}{2}(v^i{}_{,j} + v^j{}_{,i})$$

The constants

$$\tfrac{1}{2}F_1 = \mu,\ \tfrac{1}{2}F_2 = \mu_e$$

are the viscosity and cross-viscosity coefficients.

In the present paper we discuss some of the general aspects of Non-Newtonian flows like the energy equation, circulation variation and the change of vorticity.

(i) We notice that besides the usual expression

$$2\mu\,[(d_1^1)^2 + (d_2^2)^2 + (d_3^3)^2 + 2(d_2^1)^2 + 2(d_3^2)^2 + 2(d_1^3)^2]$$

the dissipation function contains an additional term which is a numerical multiple of

$$\mu_e \begin{vmatrix} d_1^1 & d_2^1 & d_3^1 \\ d_1^2 & d_2^2 & d_3^2 \\ d_1^3 & d_2^3 & d_3^3 \end{vmatrix}$$

(ii) The cross-viscosity μ_e has no effect on the change of vorticity in plane flows, while this is not true in general for spatial flows.

(iii) We find that the circulation can be conserved in a plane flow if and only if, the vorticity is harmonic.

(iv) The two plane flows (u_1, v_1, p_1, ν_1) and (u_2, v_2, p_2, ν_2) are superposable if and only if, the adjusted pressure π is given by

$$d\left(\frac{\pi}{\rho}\right) = \nu_e d\left[2\left(\frac{\delta u_1}{\delta x}\frac{\delta u_2}{\delta x} + \frac{\delta v_1}{\delta y}\frac{\delta u_1}{\delta y}\right) + \left(\frac{\delta v_1}{\delta x} + \frac{\delta u_1}{\delta y}\right)\left(\frac{\delta v_2}{\delta x} + \frac{\delta u_2}{\delta y}\right)\right]$$
$$- d(u_1u_2 + v_1v_2) + (v_1\zeta_2 + v_2\zeta_1)\,dx - (u_1\zeta_2 + u_2\zeta_1)\,dy.$$

In order that the resultant motion is uniquely determined from the component motions, it is necessary and sufficient that

$$\frac{\delta}{\delta x}(u_1\zeta_2 + u_2\zeta_1) + \frac{\delta}{\delta y}(v_1\zeta_2 + v_2\zeta_1) = 0.$$

This is the same as the criterion for the superposability of the classical viscous flows.

5. CHARACTERISTIC RELATIONS FOR THE ULTRASPHERICAL POLYNOMIALS. S. K. Lakshmana Rao, *Proc. Ind. Acad. Sci.*, 1957, **45** (3), 172–76.

If $f_0(x), f_1(x), f_2(x), \ldots$ is a sequence of functions defined over a finite or infinite interval, the expression

$$\Delta_n(x) = f_n(x)^2 - f_{n+1}(x) f_{n-1}(x) \qquad (n = 1, 2 \ldots)$$

may be called the Turan expression for the functions $f_n(x)$. In recent years it has been noticed that many special functions like the Legendre and the more general ultraspherical polynomials, Laguerre and Hermite polynomials, and some other functions like the ordinary and modified Bessel functions, satisfy Turan's inequality which asserts the (positive or negative) definiteness of $\Delta_n(x)$ over different ranges in x. In the course of proving this property for ultraspherical polynomials, some authors have employed relations like

$$\frac{d^2}{dx^2}\{[\mathrm{P}_n(x)]^2 - \mathrm{P}_{n+1}(x)\,\mathrm{P}_{n-1}(x)\}$$

$$= \frac{-2}{n(n+1)}\left[\frac{d}{dx}\mathrm{P}_n(x)\right]^2 \qquad (n \geqslant 1), \quad (1)$$

$$(1-x^2)\left\{\left[\frac{d}{dx}\mathrm{P}_n^{(\lambda)}(x)\right]^2 - \frac{d}{dx}\mathrm{P}_{n+1}^{(\lambda)}(x)\,\frac{d}{dx}\mathrm{P}_{n-1}^{(\lambda)}(x)\right\}$$

$$= n(n+2\lambda)\,[\mathrm{P}_n^{(\lambda)}(1)]^2\left\{\left(\frac{\mathrm{P}_n^{(\lambda)}(x)}{\mathrm{P}_n^{(\lambda)}(1)}\right)^2 - \left(\frac{\mathrm{P}_{n+1}^{(\lambda)}(x)}{\mathrm{P}_{n+1}^{(\lambda)}(1)}\right)\left(\frac{\mathrm{P}_{n-1}^{(\lambda)}(x)}{\mathrm{P}_{n-1}^{(\lambda)}(1)}\right)\right\}. \quad (2)$$

In the present note it is shown that all such (auxiliary) relations are characteristic for ultraspherical polynomials by proving several theorems of which the following is a specimen.

THEOREM: *If*

$$f_0^{(\lambda)}(x) = 1, f_1^{(\lambda)}(x) = 2\lambda x, f_2^{(\lambda)}(x), f_3^{(\lambda)}(x), \ldots.$$

is a sequence of polynomials such that

(*a*) $f_n^{(\lambda)}(x)$ is of degree n,

(*b*) *the relation* (2) *above is satisfied,*

then

$$f_n^{(\lambda)}(x) \equiv P_n^{(\lambda)}(x).$$

All the theorems in the note are proved by the method of induction.

6. SHOCK RELATIONS IN A FERMI-DIRAC GAS. Pyare Lal and P. L. Bhatnagar, *Proc. Nat. Inst. Sci.*, 1957, **23 A** (1), 9–15.

The study of shock waves is becoming more and more prominent in the astrophysical context. When an element of mass crosses a shock wave, discontinuous changes are produced in its physical and dynamical variables. Rankine and Hugoniot relations determine the jumps in these variables for a perfect gas. The matter of which stars are composed ranges from perfect gas to degenerate gas. Hence the relations corresponding to Rankine-Hugoniot relations for a perfect gas have been obtained to determine the jumps in the physical and dynamical variables for a Fermi-Dirac gas. The perfect gas and the degenerate gas form the two limiting cases of a Fermi-Dirac gas. For these two limiting cases these jumps have been obtained in an explicit form as functions of Mach number of the incoming flow while for the intermediate range a numerical method is indicated for determining them.

7. OSCILLATIONS OF AN INFINITE GRAVITATING CYLINDER OF COMPRESSIBLE FLUID IMMERSED IN MAGNETIC FIELD WITH FINITE ELECTRICAL CONDUCTIVITY. P. L. Bhatnagar and S. R. Nagpaul, *Zeit. fur. Astrophysik*, 1957, **43**, 273–89.

In Part I we discuss the radial pulsations of an infinite cylinder immersed in a magnetic field H given by

$$H^2 = H_s^2 + (H_0^2 - H_s^2)\left\{1 - \left(\frac{r}{R}\right)^2\right\},$$

where H_0 and H_s are the magnetic field on the axis and on the surface of the cylinder respectively and r and R are the distance from the axis and the radius of the cylinder. The particular case of a uniform magnetic field is obtained by taking $H_s = H_0$, while the particular case considered by LYTTKENS corresponds to $H_s = 0$. In LYTTKENS case, the magnetic field is proportional to the square root of the pressure at each point.

In Part II we discuss the effect of finite conductivity on the radial pulsations of an infinite cylinder immersed in uniform magnetic field. We evaluate the change in the phase of the displacement function and the amplitude of the magnetic field for $0 \leqq r \leqq R$ and the damping time of the first three modes for various magnitudes of the initial magnetic field.