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Journal of Scientific & Industrial Research

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A-

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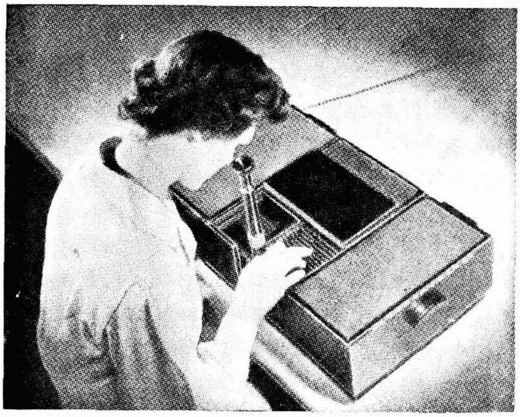

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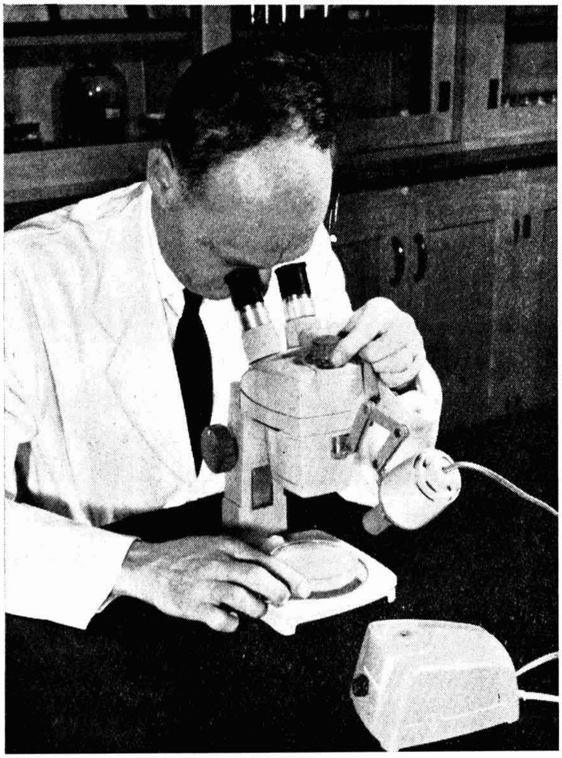

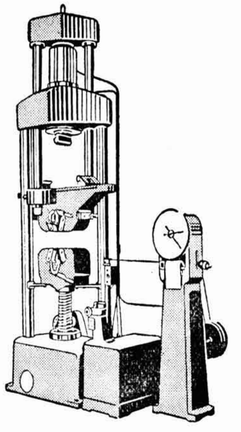

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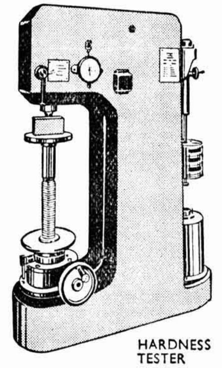

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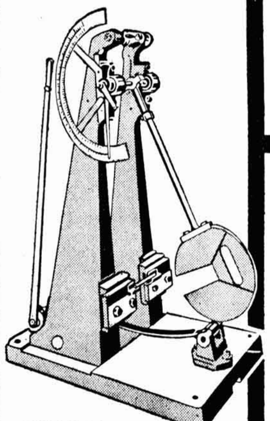

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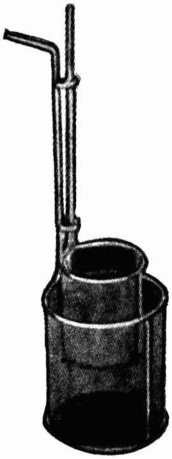

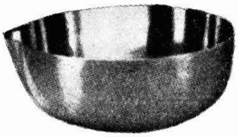

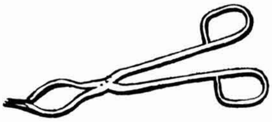

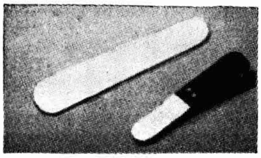

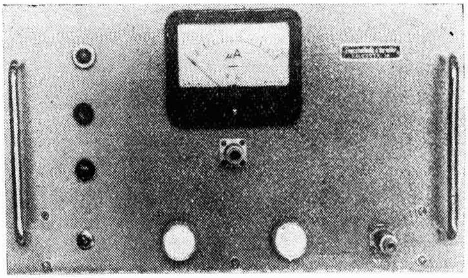

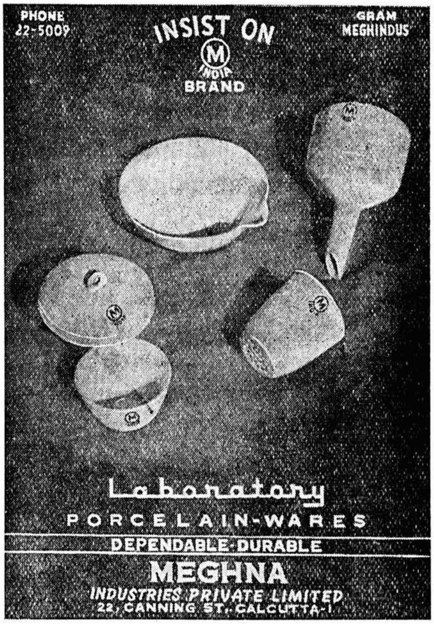

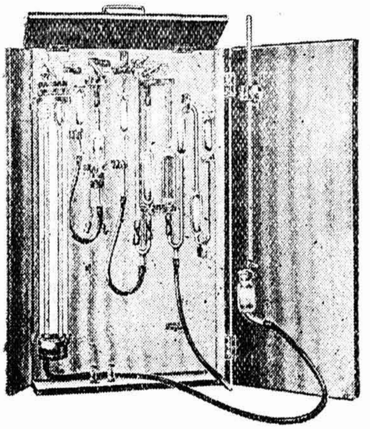

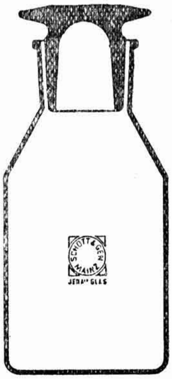

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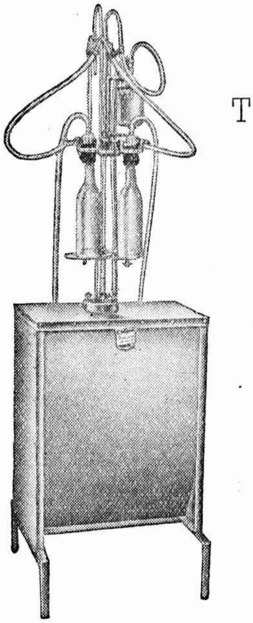

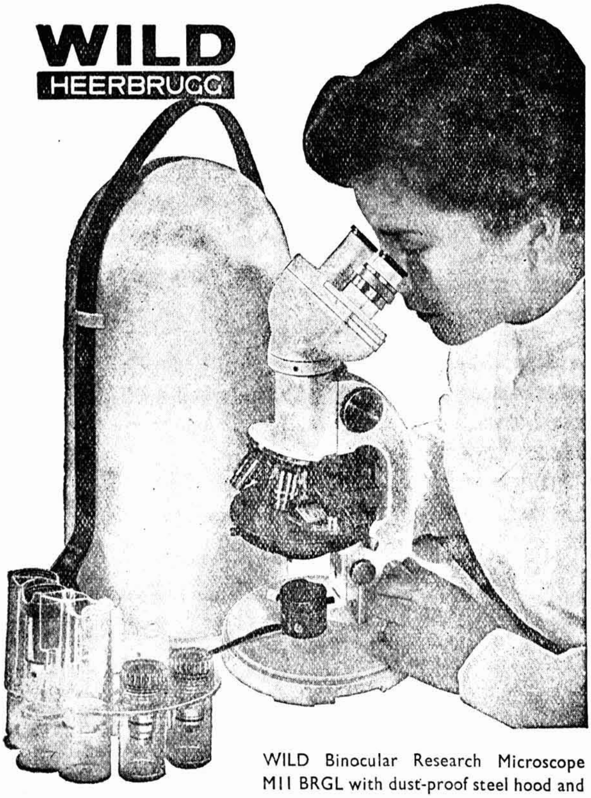
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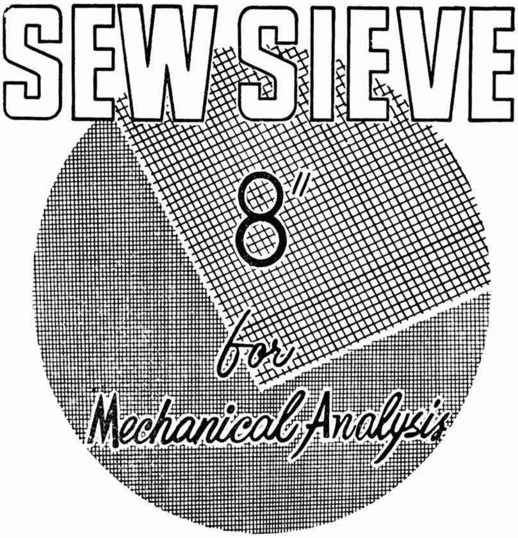
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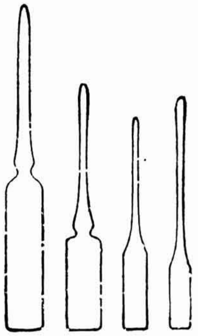

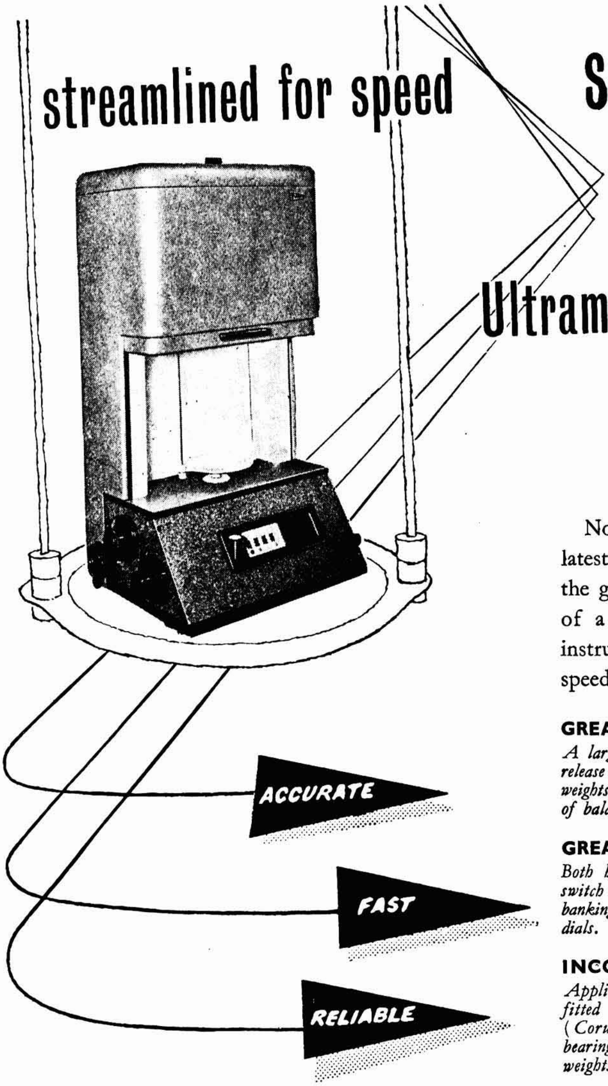
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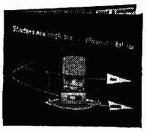

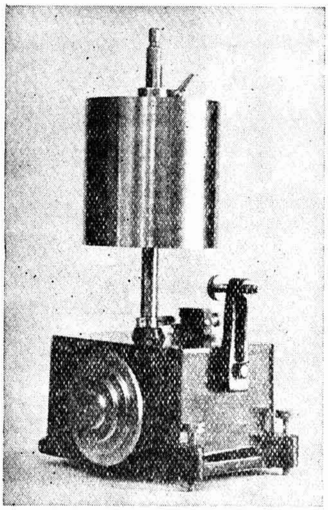

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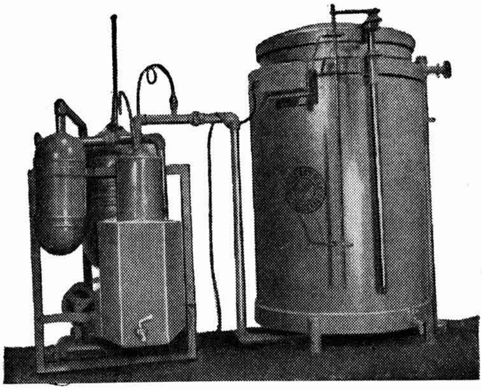

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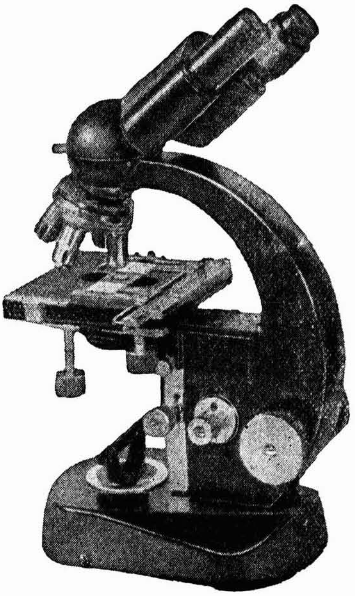

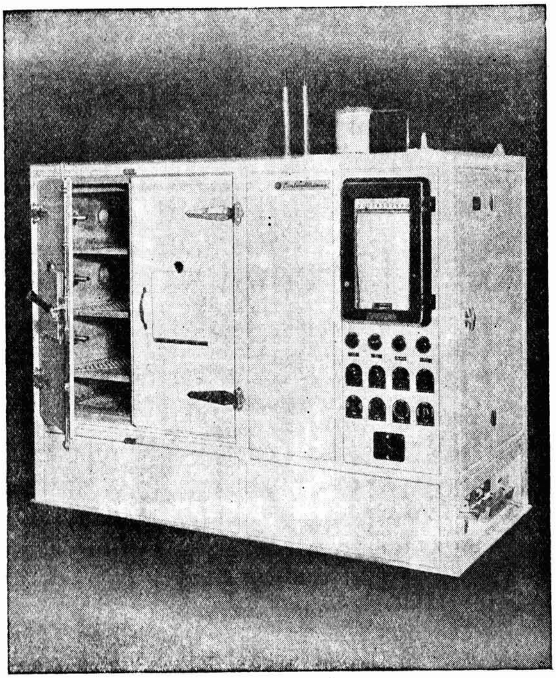

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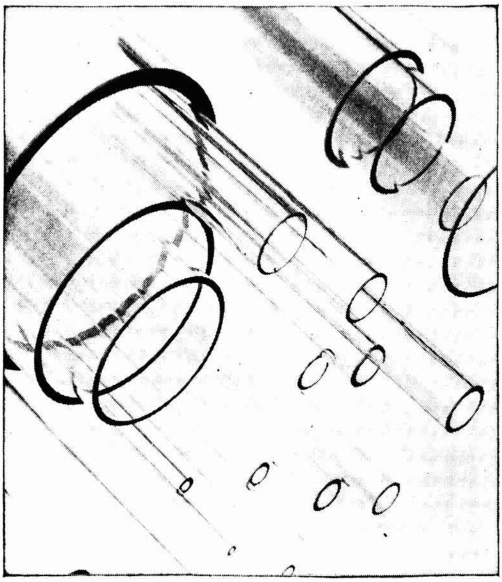

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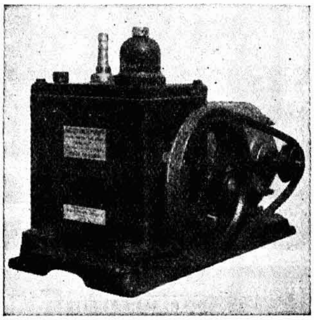

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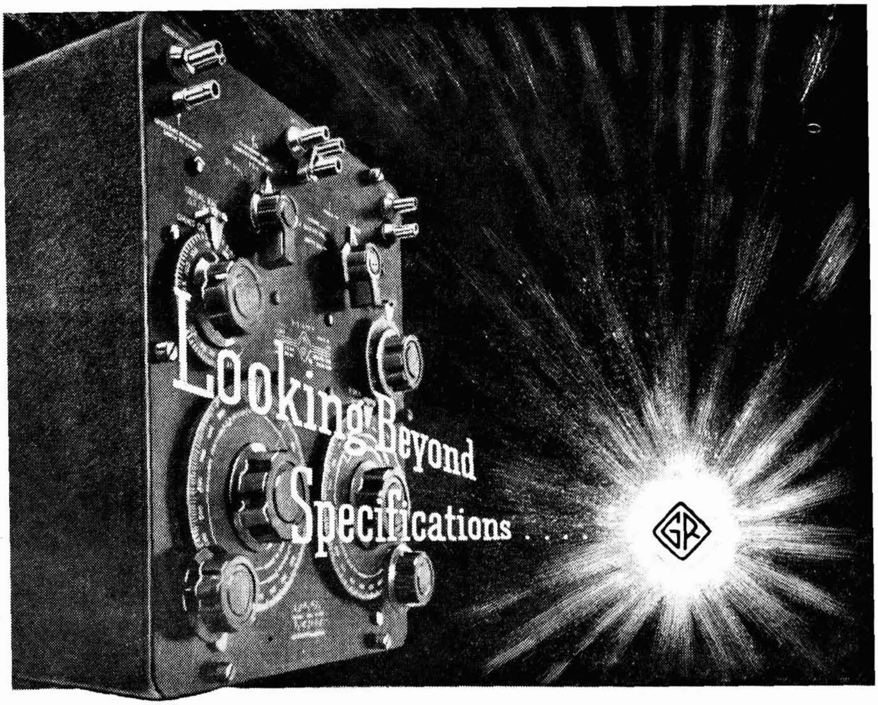
Looking Beyond Specifications . . . . .
GR

Current Topics

CENTRAL SCIENTIFIC INSTRUMENTS ORGANIZATION

THE DECISION TAKEN RECENTLY BY THE COUNCIL OF Scientific & Industrial Research to set up a Central Scientific Instruments Organization is a measure of considerable significance.

Under the stimulus of the First and the Second Five-Year Plans the number of institutions for teaching and research in science and technology has increased several-fold and there has been a growing demand for instruments required for teaching and research. There has also been a demand for a large variety of drawing and survey instruments as well as for industrial and control instruments. This increasing demand coupled with restrictions on imports created a serious situation and it was realized that the indigenous industry stands in need of immediate development and expansion. The matter was taken up by the Planning Commission and a committee was set up in April 1957 to examine the question in detail and recommend steps for promoting the production of scientific instruments in the country. The committee recommended the setting up of a central organization charged with the responsibility of taking steps to further the development and production of all categories of scientific instruments in the country.

Reliable information is not available on the number and types of instruments which are being imported at present. The present value of imports is estimated at ten crores of rupees while the value of indigenous production amounts hardly to one crore of rupees. It will be one of the responsibilities of the organization to bridge this gap as expeditiously as possible. An estimate made by the Planning Commission reveals that on an average 2 per cent of the capital value of new plant and machinery is accounted for by control or measuring equipment. In the Third Plan there is likely to be considerable increase in the import of capital plant and as such the value of scientific instruments imported is likely to increase to twenty or thirty crores of rupees by the end of the Third Plan.

The organization will take effective steps to stimulate production by not only removing bottlenecks where they exist but also by providing suitable machinery and technical know-how when needed. It may be possible to arrange for these facilities by obtaining foreign collaboration but by and large it would be desirable to put up design and development cells at some of the larger manufacturing centres to undertake the solution of specific problems.

In any contemplated large-scale expansion programme the availability of trained technical personnel will be a vital factor. At present, only one or two institutions in the country are providing advanced courses in instrument technology. It is apparent that active steps will have to be taken to increase the output of both instrument engineers and technicians.

While increased production is necessary it will be equally desirable that quality and reliability of the instruments are not sacrificed and necessary provision should be made for quality control. The industry will gain in strength only through insistence on workmanship and standards of quality and performance. In achieving this objective the Indian Standards Institution can contribute greatly by laying down norms for quality and performance of various types of instruments.

REFRESHER COURSE ON HIGH VACUUM TECHNIQUES

UNDER THE JOINT AUSPICES OF THE UNESCO AND THE National Physical Laboratory (N.P.L.), a regional training course will be held in the N.P.L. buildings from 18 January to 12 February 1960. Trainees for the course will be chosen from Afghanistan, Burma, Ceylon, India, Nepal and Pakistan. The course will be directed by Prof. A. Reimann, Research Professor of Physics, University of Queensland (Australia).

The rapid progress in high vacuum technology and even more rapid strides of its applications in industry, especially after the Second World War, have evidently induced the organizers to select this subject for the course. Such progress has been made possible by the applications of the fundamental laws of basic sciences; in turn, the development of the subject is making valuable contributions both to the promotion of studies in basic sciences as well as extensive technological developments in industry.

Contributions towards the development of better types of vacuum pumps include: gas ballasting in rotary pumps, commissioning of blowers used at atmospheric pressure as booster pumps for low pressure work, better understanding of fractionation process in oil-vapour pumps leading to the introduction of a self-purifying stage for purging volatile components in pumping fluids, reduction of back streaming in vapour pumps and pumping by new mechanisms such as ' ion-pumping ' and ' getter-pumping '.

Significant improvements are reported regarding pressure measurements in vacuum systems. Conventional gauges are now made more robust to suit industrial needs, and improved to cover wider ranges or even modified for use in ranges other than the ones in which they have been normally used. New types like the magnetron gauge are available for very low pressure measurements.

Leak detection is no longer a hit-and-try method; it is now a systematic procedure based on scientific principles. A variety of techniques ranging from the simple ' backing space technique ' using a Pirani gauge to costly mass spectrometric methods involving the use of helium as a probe gas are now available for spotting leaks of various magnitudes. Side by side compact mass spectrometers based on different methods of focussing ions are available for the measurement of the relative partial pressures of gases and vapours in evacuated systems. Vacuum technologists are ever conscious of ' vacuum cleanliness '. Synthetic elastomers are replacing the use of wax and grease, making way for the introduction of metal gaskets in vacuum seals. Use of alloys containing metals of low volatility together with the advent of argon arc-welding of stainless steel have facilitated the fabrication of vacuum chambers that can stand high temperature baking for degassing.

Societies for the promotion of vacuum technology have been started in industrially advanced countries and these have recently formed themselves into an international union for exchange of ideas. Methods of imparting education in vacuum technology are receiving serious consideration in many universities and we are already witnessing the birth of a new branch of engineering — Vacuum Engineering. Scaling up in size and capacity of laboratory designs and the large outlay involved in setting up industrial vacuum plants have led to standardization of equipment. The National Standards Committees of U.S.A., England, France, Germany and Japan exchange information on standards for nomenclature, units, pumping equipment and measuring techniques with a view to reaching agreement as far as possible.

The outcome of this tremendous progress is the consciousness on the part of the scientist and the technologist of the scope for future work. The fifty years old vapour pump is still designed by trial and error methods though backed by enlightened experience rather than by any complete theory. Unsolved problems in connection with the newer methods of pumping are many. Although several pitfalls in the procedures adopted for the measurement of speeds of evacuation of pumps have come to light recently, there is still want of agreement on fundamentally correct concepts in adopting a unified procedure for rating the performance characteristics of vacuum pumps. Accuracies obtainable in pressure measurements in vacuum systems still defy the effort of several standardizing laboratories.

In this refresher course the younger generation will have an opportunity to learn about new developments in the subject from experts conducting the course; the more advanced workers can discuss various unsolved problems in the subject and critically assess the contributions; and research workers who use vacuum techniques as a tool for furthering advances in the various disciplines of science can have an accelerated course in the subject and thus save the effort of having to weed through literature that is widely scattered.

C.B.

Symposium on Microorganisms, Enzymes & Vitamins

THE Indian Institute of Science Golden Jubilee Symposia on (1) The Biology and Biochemistry of Microorganisms, (2) Enzymes and (3) Vitamins, which were inaugurated by Dr S. Bhagavantam, continued for three days (28-30 August 1959) and were attended by over 200 scientists including 50 delegates representing most of the centres of biochemical research in the country.

The first day of the session was presided over by Major General S. L. Bhatia who gave an illuminating address on the " Progress of Physiology and Biochemistry in India ". Presiding over the proceedings of the second day, Dr P. S. Sarma gave a lucid account of the varied contributions of the late Prof. K. V. Giri in the field of enzymes. Dr V. N. Patwardhan, who guided the deliberations of the third and final day of the symposium, reviewed the mode of action of vitamin D. Dr V. Subrahmanyan gave an interesting account of the work carried out by the Department of Biochemistry during his professorship. Prof. M. Sreenivasaya described the elegant physico-chemical and ultramicro methods developed by him for the study of enzyme systems, and referred to his work on the nutrition of invertebrates including those of the lac insect, the rice moth and the silkworm.

In addition to the 69 papers presented before the session, there were four thought-provoking evening lectures: (1) Pentose Phosphate Metabolism by Dr D. P. Burma of the Bose Institute (B.I.), Calcutta; (2) Purification of Enzymes by Dr B. K. Bachhawat of the Christian Medical College (C.M.C.), Vellore; (3) Protein Synthesis by Dr P. M. Bhargava of the Regional Research Laboratory (R.R.L.), Hyderabad; and (4) Coenzyme Q by Dr T. Ramasarma of the Indian Institute of Science (I.I.Sc.), Bangalore.

Twenty-one papers were presented during the first session under three sections: General Microbiology, Agricultural and Industrial Microbiology and Metabolism of Microorganisms. Investigations on thermal destruction of pathogenic bacteria at the Dairy Research Institute (D.R.I.), Bangalore, have shown that *Mycobacterium tuberculosis* H_{37}Rv, *Eberthella typhosa* and *Shigella sonnei* inoculated into milk do not survive when subjected to Holder and H.T.S.T. methods of processing and that the fat in the cream inhibits the growth of the tubercle bacillus. Studies undertaken at I.I.Sc. on the nutrition and metabolism of *Pseudomonas convexa* var. *hippuricum*, isolated from soil, have led to the discovery of a new pathway of benzoate breakdown by the bacteria, involving salicylate, a mechanism different from the classical scheme of the metabolism of the aromatic ring. Investigations on the growth of *Pseudomonas fluorescens* at R.R.L. have revealed that the rate of increase of bacterial mass during logarithmic phase continuously decreases, and hence the metabolic activity of individual bacterium also decreases. Important findings have emerged from studies carried out at I.I.Sc. on the cytology of yeast. The presence of a nucleus and a vacuole has been demonstrated as well as the occurrence of nuclear and vacuolar membranes which show the general similarity of the structure of yeast and plant nuclei. Three papers on sewage treatment from I.I.Sc. dealt with bacteria in sewage. It was shown that bacteria in sewage, singly or collectively, were inefficient in clarifying and oxidizing sewage. Activated sludge process was reported to remove 90 per cent of phosphorus from the sludge and yield an effluent free from fatty matter.

A process developed on a pilot plant scale at the National Chemical Laboratory (N.C.L.), Poona, was reported to yield a product comparable with imported desizing agents. The production of bacterial protease, a substitute for pancreatin and papain in pharmaceutical products, was described in a paper from the Indian Institute of Biochemistry and Experimental Medicine, Calcutta. A similar protease from microorganisms which can serve as a substitute for rennin for cheese production has been developed at D.R.I. Antagonism between microorganisms in soil was discussed in three papers from the Annamalai University, and it was reported that a strain of *Streptomyces levendulae* produced maximum antibiotic (mycothricin) in a soya peptone-cerelose medium.

In a paper entitled " Microbial Synthesis of Protein in Relation to Biogenesis of Nucleic Acids " from B.I. and reporting the results of studies carried out using P^{32} and S^{35}, it was revealed that in the resting cells of *Azotobacter vinelandii*, the conditions under which nucleic acid synthesis is inhibited lead to a decrease in protein synthesis, but, on the contrary, the incorporation of P^{32} into nucleic acid continues uninterrupted even when protein synthesis is inhibited. The purification of hydrogenase from *D. desulfuricans* by ion exchange and cellulose chromatography was described in a paper from N.C.L., and it was shown that iron and

FMN were necessary for hydrogenase activity when methylene blue was employed as the hydrogen acceptor. The effect of metal chelating agents like α,α'-dipyridyl, E.D.T.A. and 8-hydroxyquinoline on the nicotinamide deamidating enzyme systems present in cell-free extracts of *L. arabinosus*, *A. niger*, *Neurospora crassa*, *S. cereviseae*, pigeon liver and chick kidney has been investigated at the University Biochemical Laboratories (U.B.L.), Madras. It has been observed that the enzyme systems are inhibited by the chelating agents. The inhibition by α,α'-dipyridyl is reversed by Fe^{++} in the case of enzyme systems of *Corcyra cephalonica*, pigeon liver and chick kidney, while those of *A. niger* and *N. crassa* are reversed by Mg^{++} and Mn^{++} respectively.

Seventeen papers were presented at the session on enzymes. Evidence was presented, in a paper from C.M.C., to show that enzyme systems are involved in the transport of fatty acids into cells. The uptake of C^{14}-stearate, which is stimulated by the addition of phosphate and glucose, has been found to be inhibited by fluoride, iodoacetate or cyanide, suggesting that both oxidative and glycolytic pathways are important. The detection and purification of a stereospecific dihydrolipoic acid dehydrogenase were reported, for the first time, in a paper from B.I.; a 60 to 70-fold enhancement in the activity of the enzyme has been achieved by purifying it. The enzyme is DPN-linked and specific for dihydrolipoic acid and its amide; the reaction is irreversible when lipoic acid is employed as the substrate. Studies on the specificity of (i) pectin methyl esterase, (ii) pentosonase and (iii) transglycosidase present in tea leaves, discussed in a paper from the Tocklai Experimental Station, Cinnamara, have shown that the enzyme reacts with maltose with the formation of maltotriose, maltotetrose and glucose. The formation of a disaccharide containing glucose and arabinose has been observed by employing arabinose as the acceptor of glycosyl residues and maltose as the donor.

The purification and properties of glutamic-oxalacetic transaminase from human and ox brain were described in a paper from C.M.C., and the results of a comparative study of the enzyme from the two sources with regard to their susceptibility towards sulphydryl reagents, *p*H optima and affinity towards pyridoxal phosphate were presented. Purified ox brain transaminase has shown complete dependence on pyridoxal phosphate for its activity even without using a pyridoxal phosphate binding reagent to dissociate it from the holo-enzyme. A new type of enzymatic transamination reaction in which glyoxylate transaminates with a number of amino acids to produce glycine, was reported in a paper from I.I.Sc. Isonicotinic acid hydrazide and L-penicillamine, at low concentrations, have been found to inhibit the enzyme but the inhibition can be reversed by pyridoxal phosphate. Unequivocal evidence has been adduced to show that the enzyme is a metallo-enzyme. Studies on the incorporation of P^{32} into phosphate fractions of *Neurospora crassa*, strain E_m 5297A, and the results of analysis of the various fractions were presented in a paper from U.B.L. These studies have revealed that after the removal of lipid, extractions by water at *p*H 8·2 solubilized further a fraction containing some non-dialysable phosphorus compounds which are only partially split to orthophosphate even on prolonged hydrolysis with *N* hydrochloric acid. The method of purification of a naturally occurring inhibitor of glutamine synthesis present in the galls of *Pongamia glabra* and the characteristics of the partially purified inhibitor were described in a paper from I.I.Sc.; the possible significance of the inhibitor in the nitrogen metabolism of plants was also discussed. The inhibitor is thermolabile and non-dialysable, suggesting thereby that it is a high molecular weight protein.

Seventeen papers were presented at the last session of the symposium on vitamins. The application of the maleic anhydride reaction to the study of *cis-trans* isomers of vitamin A_2 and the preparation of visual pigments were described in a paper from I.I.Sc. Vitamin A_2 has been found to occur mainly in all-*trans* form in fish liver oils. The isolation of crystalline retinene$_2$ and retinene$_2$-oxime was also reported. Another paper from I.I.Sc. reported the results of recent investigations on the occurrence of flavin nucleotides in plants. Very little free riboflavin has been found in plant materials. However, the radicles of germinating seedlings are reported to contain almost all the FAD and the major portion of the total flavin, while the cotyledons and the plumules contain FMN as the major flavin.

A paper from the Indian Cancer Research Centre, Bombay, discussed the possible role of nicotinamide analogues in carcinogenesis. To explain the uncontrolled growth in tumours, the possibility of the malignant cells developing a capacity for obtaining their energy requirements through hexose monophosphate pathway was suggested. The resistant strains of mice were discussed in the light of this hypothesis. Some interesting examples of species specificity in the mechanism of pyridine nucleotide synthesis by erythrocytes were reported in a paper from the Nutrition Research Laboratories, Hyderabad. Of the seven species investigated, only human and guinea-pig erythrocytes have been observed to be capable of synthesizing DPN from nicotinamide and glucose. Human and monkey erythrocytes also synthesize appreciable amounts of DPN from nicotinic acid and glucose in the presence of glutamine, whereas this metabolic pathway does not seem to operate in the guinea-pig. Red blood cells of the monkey are able to synthesize DPN from nicotinamide only in the presence of glutamine, suggesting that nicotinamide is converted into nicotinic acid prior to incorporation into DPN.

Theory of Thin Elastic Shells — A Symposium

A SYMPOSIUM on the 'Theory of Thin Elastic Shells', sponsored by the International Union of Theoretical and Applied Mechanics (IUTAM), was held at Delft, Holland, under the Chairmanship of Prof. W. T. Koiter from 24 to 28 August 1959. Twenty-five invited research papers were read at the symposium.

On 25 August, the session started with a welcome address by Dr C. H. Van der Leeuw, President of the Board of Governors of the Technological University of Delft, followed by introductory remarks by Prof. F. K. G. Odqvist, President of IUTAM, who explained how the symposium on selected topics like 'Theory of Thin Shells' fulfilled the objectives laid down by IUTAM.

Dr C. B. Biezeno, Honorary Chairman of the symposium, gave an excellent résumé of the work done in shell theory and pointed out avenues which still remain to be explored.

The symposium mostly dealt with non-linear and axially asymmetric problems. W. T. Koiter (Netherlands) showed that the assumptions of a plane stress permitted a scientific classification of all linear theories. He pointed out that Love's first approximation for the strain energy as the sum of stretching energy and bending energy has a consistent first approximation, both in the linear and the non-linear theories. His assumption of a plane stress was questioned by Eric Reissner (U.S.A.) and others.

W. Zerna (Germany) gave results of his analysis taking into account a non-linear stress-strain relation of the form proposed by Kauderer, while B. R. Seth (India) showed that, by using finite components of strain and the strained state as a reference framework, a thin cylindrical shell could be deformed into a conical one by applying normal surface loads. W. A. Nash (U.S.A.) showed that Berger's method of neglecting the second invariant of the strain energy gave good results for finite amplitude oscillations of rectangular plates and deflections of spherical shells. P. M. Naghdi (U.S.A.) showed that the problem of shallow shells reduced to a system of coupled non-linear partial differential equations involving the axial displacement and a stress function. With some approximation they reduced to the systems obtained by Grigolyuk (U.S.S.R.) and Reissner. Buckling of shallow spherical and conical shells was extensively discussed by B. Budiansky, P. Seide, N. J. Hoff (U.S.A.) and J. Singer. There did not seem to be any agreement between the results obtained by them. Budiansky took into account the 'waviness' of the shell deformation and the boundary layer of localized deformation.

J. W. Cohen (Netherlands) and Reissner dealt with helicoidal shells. Cohen showed that the classical stress-strain relations were insufficient and that the consequent inconsistency in the stress calculations could be removed by slightly altering the equation of equilibrium. Reissner took into account the effects of transverse stress and normal stress deformation and found that the state of stress in such a shell could be split into two parts — one of inextensional bending and the other of membrane or moment free state.

The symposium left open the question of what would constitute a comprehensive theory of thin shells. Most of the approximations made in existing literature were shown to be inconsistent with the order of approximation permitted in the problem. This explains the wide divergence in design calculations. A direct attack on the problem through the fundamental equations of elasticity can be expected to give better results.

A New Glass Spectrograph

HEINRICH SCHELLER
VEB Carl Zeiss, Jena

THE new glass spectrograph, designed by VEB Carl Zeiss, Jena, is a versatile instrument which can be employed with equal facility in research and industrial laboratories as well as in organic and inorganic analysis. The optical principle of this new instrument is mainly based on that of Zeiss's former ' spectrograph for physicists ', operating with the Foersterling three-prism set. The instrument has many desirable qualities which make it eminently suited to rough conditions of handling in an industrial laboratory: it is of robust build, manipulation is easy and simple, and rearrangement of its components can be effected rapidly.

The design of the instrument is based on the principle of the three-prism spectrograph, with two cameras of different focal length and of large relative aperture for the spectrographical recording of the Raman emission of organic substances or of other low light intensity phenomena, e.g. luminescence, flame and converter spectra. The three-prism spectrograph is a high-dispersion glass instrument, which, in conjunction with an autocollimation camera, of 130 cm. focal length, is suitable for the detection and quantitative determination of rare earths, analysis of tungsten-based high-alloy steels and hard metals, titania or zirconia-based ceramic products.

Basic optical construction

The prism set, in accordance with the well-known Foersterling principle, consists of two 63° prisms, between which is located an Abbe prism with a constant deviation of 90°. The collimator objective, a double lens achromatic system of *c.* 30 cm. focal length, is exactly adjusted for infinity for a mean wavelength range. The high-speed camera lens systems are three-component systems of 12 or 27 cm. focal length. In conjunction with the collimator, they yield an excellent definition of lines in addition to a plane image of the spectral region under study.

Mechanical design

Particular attention has been paid in this instrument to the mechanical rigidity and the manipulation arrangements, so as to ensure the quick and accurate setting of prisms, extension of objective, turning of the plate holder and its run, etc. No adjustment is necessary when the cameras are interchanged.

To fulfil the demand for rigidity, the prism set has been provided with a very firm base and an enclosed casing. Pivot bearings have been reduced from three to two without impairing the optical function of the prism set. The prism set is rotated on the outside by a large, easily readable scale drum. The entire adjusting range is subdivided into 3000 intervals ensuring a setting accuracy for the prism of 15 arc-seconds per interval.

A rail guide is provided for attaching the 130 cm. long, cantilever autocollimation camera to the casing of the prism. Its relatively long carrier base

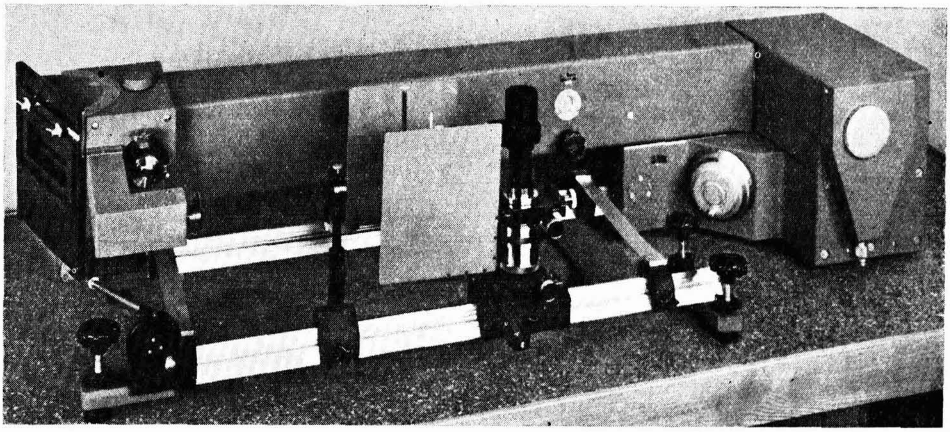

FIG. 1 — THREE-PRISM SPECTROGRAPH WITH AUTOCOLLIMATION CAMERA AND SECOND OPTICAL BENCH WITH ILLUMINATING SYSTEM AND SPARK STAND

ensures that the camera is correctly focussed on the prism set. The autocollimation mirror (Fig. 1) is securely attached on the other side of the prism casing, viz. a cylinder rod on the mirror support is inserted in a V-bearing on the wall of the casing; a screw bolt from below holding both parts firmly together. The mirror adjustment, once set, needs no further attention.

The collimator and the autocollimation camera have symmetrical precision slits. The range of the slit width is 0·3 mm. with a setting accuracy of 0·001 mm. The density of the spectral lines does not, however, depend on the reproducibility of the slit setting but rather the density of the continuous background which, for the quantitative Raman analysis, should be kept as constant as possible.

The lens systems of the collimator and the camera are set and adjusted by a rack and pinion assembly. The setting can be read off on a mm.-scale with a vernier reading up to 0·1 mm. The 12 cm.-focal length camera is adjusted by means of a micrometer screw with a 1/100 mm. division (Fig. 2). The plate holders are rotatable (correct to 1/10 arc-degrees) about vertical axes to permit precise adjustment of photo plates in the focal plane of the spectrum. The plate-holder guide, which serves for exposing several spectra on one plate, is fed by a threaded spindle of 1 mm. pitch (Fig. 2). The accuracy of the plate-holder guide and a stop device on the spindle wheel ensure that spectra are placed at regular distances exactly beneath one another as required for accurate comparison of spectra. By means of a remote control, it is possible to operate and read all settings for each of the three combinations from the operating position, i.e. from the light source (spark stand or Raman lamp). The plate holders of the camera ensure reproducible positions for the photographic plate, which is remarkable in view of the low depth of field of the high-speed cameras.

Illuminating devices

The optical bench method of mounting has been maintained for setting up the illuminating devices and, if required, it can be easily exchanged for other methods of mounting. Provision has been made for a three-lens condenser system with intermediate image formation of the light source, especially suitable when using small-size light sources and a one-lens system for large light source, such as flames, Raman cells, fluorescent plane emitters, jet flames, etc. A second bench (Fig. 1), parallel to the first and separated by spaces, carries the light source, usually a spark stand and the first illuminating condenser. The second illuminating condenser is connected to a unit with the requisite mirror as an illuminating fixture.

Optical data and performance

The optical data for the instrument are given in Table 1. Due to the limitations of the prism an effective aperture corresponding to a diameter of 50 mm. is realized. From this the values of the effective aperture ratios (Table 1) can be calculated.

The comprehensive spectral region commences with the transmittance of the glass at *c.* 3600 A. and extends up to the limit of infrared sensitized photographic emulsion at *c.* 10,000 A. The camera (f = 12 cm.) with a medium setting of the prism covers the entire visible region from 4000 to 8000 A. in one spectrogram 30 mm. in length. The autocollimation

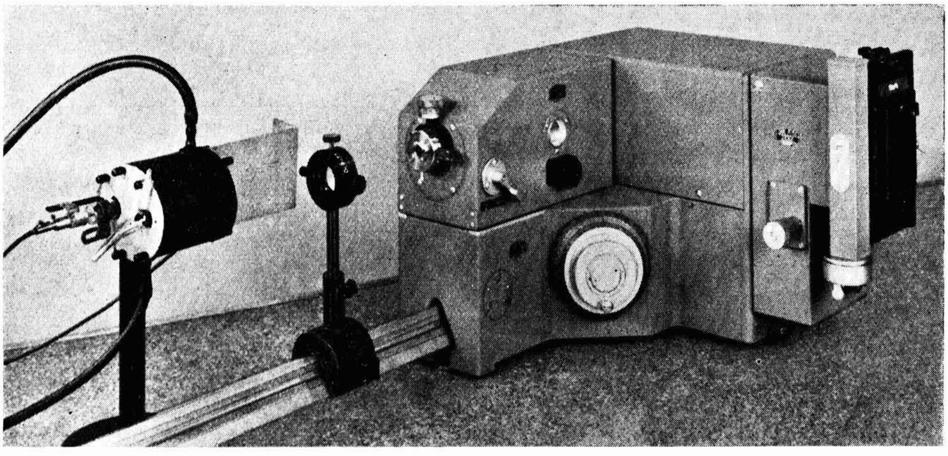

FIG. 2 — THREE-PRISM SPECTROGRAPH WITH CAMERA FOCAL LENGTH EQUAL TO 12 CM. (RAMAN ILLUMINANT IS IN FRONT OF THE COLLIMATOR)

TABLE 1 — OPTICAL DATA

FOCAL LENGTH OF CAMERA *cm.*	RELATIVE APERTURE	EFFECTIVE APERTURE	LENGTH OF THE SPECTRUM FROM 4000 TO 8000 A. *mm.*	DISPERSION (*A./mm.*) IN THE REGION OF		
				4000 A.	5000 A.	8000 A.
12	1:2·0	1:2·4	30	42	105	441
27	1:4·5	1:5·4	67	19	47	196
130	1:22	1:26	640	2	5	20

TABLE 2 — RESOLVING POWER OF THE CAMERAS AT 5200 A.

FOCAL LENGTH OF CAMERA *cm.*	TYPE OF PLATE	RESOLVING POWER		$R = \frac{\lambda}{\Delta\lambda}$
		(Δλ) *A.*	Δ*a** μ	
12	Mikrat	1·10	8	4700
27	do	0·50	10	10000
130	Photo-technical	0·16	34	32000

*Δ*a* is the dispersion in μ on the plate corresponding to the resolving power of the instrument.

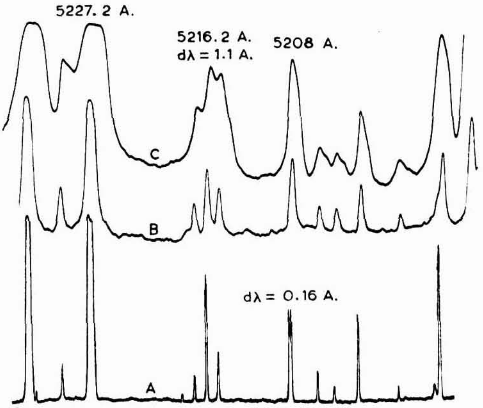

FIG. 3 — RECORDED CURVES OF THE IRON SPECTRUM AT 5200 A. WITH A CAMERA FOCAL LENGTH OF (A), 130 CM.; (B) 27 CM.; AND (C) 12 CM.

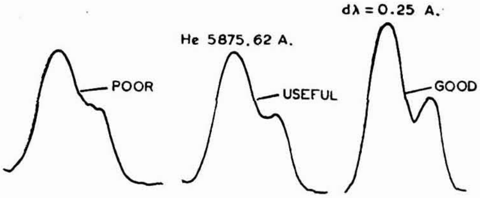

FIG. 4 — TYPICAL CURVES OF THE He-DOUBLET AT 5875 A. RECORDED WITH THE AUTOCOLLIMATION CAMERA (× 500)

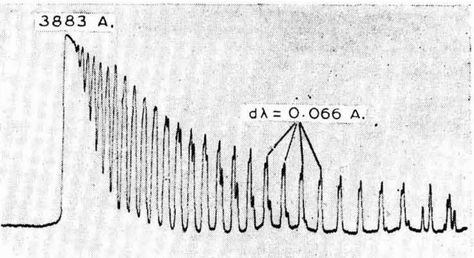

FIG. 5 — TYPICAL CURVE OF THE CYANOGEN BANDS AT 3883 A. RECORDED WITH THE AUTOCOLLIMATION CAMERA (× 20)

camera requires *c.* 6 consecutive exposures to represent the requisite spectral region of *c.* 640 mm. length. This does not imply any restriction for using the long-focus camera, since the emission spectra analyses to be solved by this maximum-dispersion instrument do not as a rule call for the entire spectrum, but for one or two selected regions only.

The resolving power (Δλ) of the instrument and the dispersion (Δ*a*) on the photographic plate, corresponding to the resolving power, with different camera focal lengths and photographic plates, are given in Table 2.

The three recorded curves (Fig. 3) give an idea of the resolving power of the three types of cameras. The same portion of the iron spectrum at 5200 A. was taken with each camera and the spectra were recorded in such a manner that the curves have almost the same length. The resolution of 0·16 A. is seen in curve A for the autocollimation camera on lines Fe = 5208·60 A. and Cr = 5208·44 A. Curve B for the f = 27 cm. camera shows that the Fe lines at 5215·2, 5216·3 and 5217·4 A., each having a wavelength difference of 1·1 A., are so clearly separated that it is possible to achieve a separation of 0·5 A. The curve C obtained with the f = 12 cm. camera shows the separation of the same three Fe lines.

A further example of the efficient resolving power of the 130 cm. camera is provided by the recorded curve of the He-doublet (Fig. 4) at 5875·62 and 5875·87 A. with a 0·25 A. wavelength separation, showing three different qualities of the optical system. It is possible, by visual evaluation of the resolution of this pair of lines, to clearly discern useful prism sets (right) from faulty ones, perhaps with striations or strains (centre and left). The curve in Fig. 5 gives an idea about the resolution of the cyanogen band at 3883 A. The double-peaks are attributable to carbon isotopes. They correspond to wavelength differences of 0·066 A. and thus to a resolving capacity $R = \lambda/\Delta\lambda = 59{,}000$.

Ionospheric Absorption & Electron Collisional Frequency in the F Region

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The total absorption of radio waves proceeding vertically upwards through the E layer and suffering reflection from the F layer has been determined over a range of frequencies from nearly 3 to 7 Mc/s. by measuring the most probable values of the signal amplitudes of the first and second orders of ionospheric reflection. In some measurements, continuous photographic records of the signal amplitudes of the first and second orders of ionospheric reflection have been simultaneously taken and the method has proved useful for the quick and accurate study of the variation of the ionospheric absorption with frequency.

The electron collisional frequency (ν) in the F region has been calculated by applying Appleton's modified formula (connecting the electron collisional frequency with reflection coefficient and group path) near the critical penetration frequency. The mean value of ν in the F region has been found to be 4 kc/s. which agrees well with the values obtained by other workers.

IN the present communication some experimental results on the total absorption of the radio waves in an ionospheric region over a range of frequencies using pulsed transmission at vertical incidence have been reported. Also, a description is given as to how the effective electron collisional frequency in the F region of the ionosphere over Varanasi is obtained, following the method of Appleton[1] and based on his formula relating the apparent reflection coefficient of an ionospheric region with the difference between the group and the optical paths within the region.

Measurement of absorption

In the experimental study of ionospheric absorption with vertically directed radio pulses of short duration, the total absorption is obtained from the apparent reflection coefficient of the ionospheric region determined directly from the observed signal amplitudes of the first and second orders of ionospheric reflection. As there is often appreciable fading of the radio signal, the usual procedure[2] is to take the arithmetic mean of a large number of varying signal amplitudes observed at regular short intervals over a certain length of time. In the present experiments carried out between 0500 and 0600 and between 2130 and 2300 hrs IST, the most probable values of the signal amplitudes were taken instead of the arithmetical mean values and the apparent reflection coefficient (ρ) of the ionospheric region was obtained from

$$\rho = \frac{2\bar{E}_2}{\bar{E}_1} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

where $\bar{E}_1$ and $\bar{E}_2$ were the most probable values of the signal amplitudes for the first and second orders of ionospheric reflection. The total absorption of the waves as expressed in db. was then obtained from

$$k = -20 \log_{10} \rho \quad \ldots\ldots\ldots\ldots (2)$$

over a range of frequencies from 3 to 7 Mc/s.

In a few sets of observations, simultaneous fading records of the first and second orders of reflection were taken continuously on the same photographic film and the amplitude distribution curves were drawn from the fading records to find the most probable values of the signal amplitudes. It is evident that this method of taking simultaneous and continuous photographic records of the first and second orders of the ionospheric reflections for a number of frequencies over a range is much quicker than the method of taking isolated observations at regular short intervals for the different frequencies within the range and is suitable for studying absorption during periods where the ionospheric ionization changes rapidly.

The frequencies employed in this investigation are greater than the critical penetration frequency of the E layer at the time of the experiments, so that the

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observed reflections are from the F region. As the ordinary magneto-ionic component is much stronger than the extraordinary component for these frequencies, the weak extraordinary echo is well covered by the strong ordinary echo, so that the height of the unresolved F echo could be taken as the amplitude of the ordinary component. Thus, the total absorption suffered by the ordinary component in the ionospheric region is obtained from the determination of the apparent reflection coefficient of the F region, for the range of frequencies under investigation.

Results

The signal amplitudes of the first and second order echoes at regular intervals of 10 sec. were noted for about 2 min. The apparent reflection coefficient of the ionospheric region as obtained from equation (1) was used in finding the total absorption of the waves. The results of three different sets of observations are shown in Fig. 1. Two typical records of simultaneous reading of the first and second order echoes on a frequency of 3·8 Mc/s. are depicted in Figs. 2A and 2B. The most probable values of the signal amplitudes of the first and second order echoes in Fig. 2A as obtained from the amplitude distribution curves drawn for the purpose, gave the values of the apparent reflection coefficient of the F region and the total absorption as 0·8 and 1·9 db. respectively. The corresponding values obtained from Fig. 2B are 0·343 and 9·3 db. The maxima and minima in Fig. 2B are evidently due to the steady drift of the F region irregularities.

Discussion

Explanation of the absorption curves — To explain the variation of the observed ionospheric absorption during early morning hours (before sunrise) and early night hours with the frequency of the exploring radio waves, it is to be noted that the overall ionospheric absorption is due to (i) collisional loss in both the non-deviating and the deviating regions of the ionosphere, (ii) loss due to partial reflection, and (iii) losses due

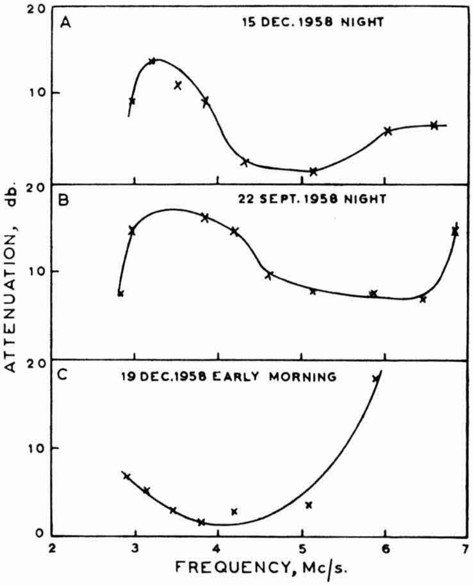

FIG. 1 — IONOSPHERIC ABSORPTION VERSUS FREQUENCY

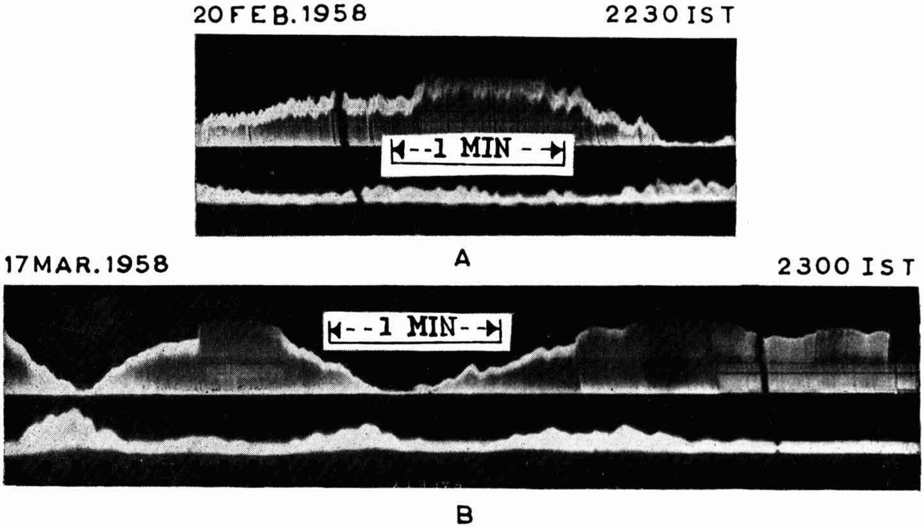

FIG. 2 — SIMULTANEOUS FADING RECORDS OF THE FIRST AND SECOND ORDER F ECHOES

to scattering from ionospheric irregularities, of which the contribution due to the collisional loss is the most important. Considering the collisional loss alone, it is expected that for frequencies slightly higher than the critical penetration frequency of the E layer, the decrease of the non-deviative absorption with frequency would be more than the increase in the deviative absorption in the F region, so that the combined absorption would decrease with frequency and that at frequencies midway between the critical penetration frequencies of the E and F regions, the decrease of the non-deviative absorption would be almost balanced by the increase of deviative absorption, so that the combined absorption would be more or less constant over the middle region. As the critical penetration frequency of the F region is approached, the increase of deviative absorption would preponderate over the decrease of non-deviative absorption with frequency and the observed absorption curve would show a distinct rise tending towards a large value at the critical penetration frequency of the F region. In the absorption curves shown in Figs. 1A and 1B, the initial increase in the observed absorption is to be attributed to the presence of the sporadic E region, where partial reflection is expected at frequencies in the neighbourhood of the critical penetration frequency of the sporadic E region, giving rise to an increase in absorption[3]. The presence of the sporadic E echo was confirmed, on frequencies between 3 and 4 Mc/s., at the time of the absorption measurements.

Estimation of the electron collisional frequency — Our measurements of the electron collisional frequencies in the F region were based on the formula of Appleton[1]:

$$\log \rho = -\frac{\nu}{2c}(P'-P) \qquad \text{. . . . . (3)}$$

where P' and P are the group and optical paths, ρ the apparent reflection coefficient, c the velocity of light and ν the electron collisional frequency, which is very much less than the frequency f of the exploring wave. This relation was also expressed in the differential form:

$$\nu = \frac{2c}{f} \cdot \frac{\delta(f.\log_e \rho)}{\delta P'} \qquad \text{. . . . . (4)}$$

Thus by determining the apparent reflection coefficient for two different frequencies near the critical penetration frequency of the F region from the most probable values of the amplitudes of the first and second order echoes and finding the change in the group path corresponding to the frequency difference, the electron collisional frequency was found with the help of equation (4). According to our measurements, the mean value of the electron collisional frequency in the F region was found to be 4 kc/s. agreeing well with the values obtained by other workers[4-9].

Acknowledgement

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References

1. Appleton, E. V., *Nature, Lond.*, **135** (1935), 618.
2. Chatterjee, B., *Indian J. Phys.*, **26** (1952), 585.
3. Appleton, E. V., Beynon, W. J. G. & Piggott, W. R., *Nature, Lond.*, **161** (1948), 967.
4. Datta, S., *Indian J. Phys.*, **29** (1955), 279.
5. Eckersley, T. L., *Nature, Lond.*, **135** (1935), 435.
6. Farmer, F. T. & Ratcliffe, J. A., *Nature, Lond.*, **135** (1935), 585; *Proc. roy. Soc.*, **151A** (1935), 370.
7. Ginsburg, V. L. & Alpert, I. L., *Bull. Acad. Sci. U.R.S.S.* (*Physics Series*), **8** (1944), 42.
8. Vilbig, H. F., *Lehrbuch der Hochfrequenztechnic, I* (Akad Verlagsgesellschaft, Leipzig), 1944, 338.
9. White, F. W. & Brown, L. W., *Proc. roy. Soc.*, **153** (1936), 639.

Molecular & Allied Devices for Generation & Amplification of Microwaves

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Recent developments in molecular and allied devices for the generation and amplification of microwaves are briefly reviewed. Simple expositions of the principle of operation and representative experimental arrangements of the Maser and the Mavar type of devices are given. The possibilities of developing devices using plasma interaction and Cerenkov radiation are also briefly outlined. The relative advantages and disadvantages of the various classes of devices and their present states of development are critically discussed.

CONVENTIONAL active elements like magnetrons, travelling wave tube amplifiers or backward wave oscillators for the microwave band are composed mainly of two parts, viz. (a) a delay line and (b) an electron beam. The delay line supports a slowly moving electromagnetic field, and d.c. energy from the electron beam is transferred to the a.c. field through suitable coupling provided between the two. The constructional features, however, have two disadvantages. Firstly, with the increase of the operating frequency the elements of the delay line become extremely small making their fabrication difficult. Secondly, the electron beam, which is derived from a hot cathode, introduces appreciable amount of noise, and this limits the sensitivity of the device. In recent years investigations have been made to develop active elements which are not subject to the above two limitations. Several different methods of generation and amplification of microwaves have already evolved out of these investigations. These methods almost invariably involve transference of energy to the desired field through energy stored in a molecular system. The purpose of this article is to report in brief the results achieved so far with these methods. To save space the discussions will be made only in general terms and description given of a few typical experimental arrangements suggested so far.

Classification of the molecular devices

Of the various methods suggested for the construction of active microwave elements free from the limitations of conventional microwave tubes, the most promising are the following two: (a) microwave amplification by stimulated emission of radiation (Maser) and (b) modulated amplifier by variable reactance (Mavar) or the parametric amplifier.

Apart from the Maser and the Mavar, devices involving the use of plasma oscillations and the Cerenkov radiation have also been suggested. Investigations on these two methods have, however, to the knowledge of the authors, been so far largely theoretical. Further, their performance as regards noise is still somewhat obscure. These can, therefore, be considered very briefly at this stage.

Microwave amplification by stimulated emission of radiation

Basic physical principles — Consider a molecular system with a series of discrete energy levels E_1, E_2, E_3,........., E_s—E_1 being the ground state and E_2, E_3,........., E_s the outer states in the order of increasing energy content. The number of molecules N_1, N_2, N_3,.........N_s in these various states, under condition of equilibrium would follow a Boltzmann distribution law so that

$$N_1 > N_2 > \ldots . > N_s$$

Under this condition, there would be a net absorption of an incident radiation flux of frequency f_{1s} given by

$$f_{1s} = \frac{E_1 - E_s}{h}$$

The situation is, however, different if the molecular system is exposed to a stimulus that disturbs the condition of thermal equilibrium leading, for example, to a new distribution with

$$N_2' > N_1'$$

the primes denoting the population densities in the disturbed state. A radiation flux of frequency f_{12} will now cause more molecules to make transition from the higher to the lower energy state than in the reverse direction. There will then be a net release of energy which will add to the incident radiation field and result in amplification. This, in brief, is the basic theory of action of a Maser.

Depending upon the method of upsetting the condition of thermal equilibrium, a Maser may be of several types. The more important ones of these are: (a) two-level Masers and (b) three-level Masers.

Two-level Masers — The first two-level Maser using ammonia was built at Michigan in 1930 employing the phenomenon of ammonia inversion. Townes[1] and his co-workers, in 1955, used the same phenomenon to construct the first useful Maser. (Incidentally, the term Maser is also due to these authors.) It is known that the ammonia molecule is of pyramidal form with the three hydrogen atoms at the corners of the base and the nitrogen atom at the apex. The nitrogen atom may be either at a point on one side of the base or at its mirror image due to the base. These two positions represent two different energy states*. Emission or absorption associated with the so-called inversion phenomenon takes place when the N-atom changes place from one of these positions to its image on the other side of the base. Normally, in an assemblage of ammonia gas, the N-atoms mostly occupy the position corresponding to the lower of these two states. It is, however, possible to sort out the molecules in the higher energy state by taking advantage of the fact that the two types of molecules are polarized oppositely with respect to an external electric field. This was done by Townes and his co-workers by using the molecular beam technique in the manner shown in Fig. 1. The lens gives a non-uniform electric field in which the two types of molecules drift in opposite directions — the excited ones moving towards and the normal ones away from the axis. The axial part of the beam with the excited molecules is separated and allowed to interact with a cavity. A weak source of signal of frequency equal to that of ammonia inversion sets up a field in this cavity and this stimulates a transition of the excited molecules to the ground state in a coherent manner before they can relax to that state in the normal way. The radiation amplified occupies a narrow band of frequencies around 23,870 Mc/s.

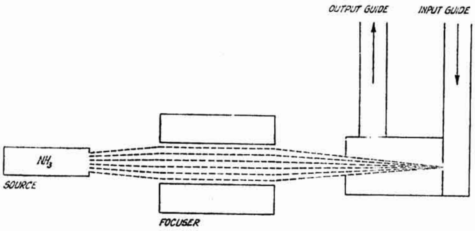

FIG. 1 — SIMPLIFIED DIAGRAM OF THE AMMONIA-BEAM MASER

Masers of the type described above have inherently low noise figure[2-8] (the lowest noise figure reported is as low as 1 db.), have a narrow bandwidth and give extremely low power — a few millimicrowatts at the most. As oscillators[1,9-14], Masers possess a very good frequency stability — 1 in 10^9 — which makes them suitable for use as standards of frequency.

Three-level Masers — Basov and Prokhorov[15] proposed a 'three-level' Maser in 1955. Their study was, however, confined to the gas type Maser. The more practical form of this — the solid state Maser — was first proposed by Bloembergen[16] and operated successfully by Scovil *et al.*[17]. To understand its working we consider a solid that gives a system of discrete energy levels E_1, E_2 and E_3 with N_1, N_2 and N_3 particles in the equilibrium state[18] (Fig. 2). Obviously,

$$N_1 > N_2 > N_3$$

An increase in the density created in the upper state E_3 by some disturbing agency would normally decay to the equilibrium value after some time which is determined by the so-called 'time of relaxation'. With a sustained disturbing agency, the density at the higher state would be governed by the strength of this agency on the one hand and time of relaxation on the other. In a three-level solid state Maser, a strong disturbing field from a source — called the 'pump' — at a frequency f_{13} is applied so that transitions from state 1 to 3 occur at a rapid rate. The relaxation time is simultaneously increased to a fraction of a millisecond by cooling the sample. This helps to create a condition such that

$$N_3' > N_2'$$

Stimulated emission may now be obtained at the frequency

$$f_{23} = \frac{E_3 - E_2}{h}$$

by applying a weak field at the same frequency. Amplification of this latter field, therefore, results.

One can also introduce in the solid a suitable impurity that causes most of the particles excited to

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*For simplicity, the various possible vibrational states have been disregarded.

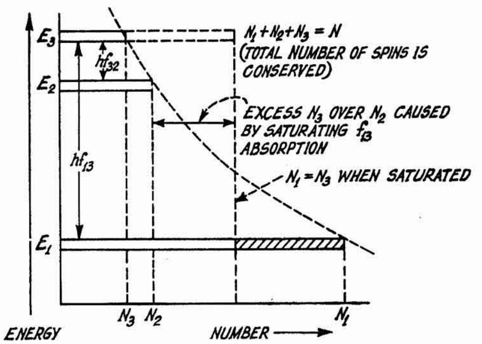

FIG. 2 — SPIN DISTRIBUTION OVER THREE ENERGY LEVELS

state 3 to make an immediate transition to state 2 so that

$$N_2' > N_1'$$

Amplification of a signal at the frequency f_{12} can, therefore, be obtained. It is to be noted that the process of amplification consists essentially in pumping into the signal a portion of the power delivered by a source working at a different frequency.

It is clear that the solid used must provide discrete and non-equispaced energy levels. The solids found suitable for this purpose belong to the class of paramagnetic salts. The required energy states are provided by the alignment of the spins of the unpaired electrons in these solids with respect to an externally applied magnetic field. One of the extensively used[17] solids is lanthanum ethyl sulphate with 0·5 per cent of non-magnetic La ion replaced by paramagnetic gadolinium ions [$La(Gd)(C_2H_5SO_4)_3$, $9H_2O$]. Cerium impurity to the extent of 1 in 500 has been found to be useful for Maser action. Another material used[19-22] is the crystal of cobalt potassium cyanide [$K_3Co(CN)_6$] with 0·5 per cent Cr. Under the normal condition of operation the power of the so-called 'pump' is maintained at a sufficiently high value so as to attain the condition $N_1' = N_3'$ — the 'condition of saturation' as it is called. This ensures the optimum of output and a minimum of noise contributed by spontaneous fluctuations of population in the various levels.

The basic experimental arrangement[23] for a three-level Maser is shown in Fig. 3. The disturbing 'pump' field, which is of higher frequency, is fed through a section of waveguide and the signal through a piece of strip line. The guide is of silver-plated stainless steel to reduce both the r.f. and the heat losses. The circulator device for isolation between the input and the output cavity is shown separately. In a typical operation[17] with H = 2850 oersted inclined at 17° to the crystal axis, f_{13} was 17,500 Mc/s. and f_{12} was 9000 Mc/s.

The outstanding advantage of a three-level Maser over a two-level one is that while the latter is essentially a fixed frequency device, the former is tunable over a fairly good frequency range — its frequency of operation being a function of the magnetic field (about 2·8 Mc/s. per oersted for the arrangement shown in Fig. 3). Bandwidth is, therefore, much larger here — limited in practice by the Q of the resonant system. A bandwidth of 10 Mc/s. with 10 db. gain has been reported[24] while a value of several 100 Mc/s. has been achieved with lower gain. Typical output is 10^{-4}-10^{-3} W. Noise temperature of a few °K. is usual[25,26] — in sharp contrast with the value of the order 10^2°K. for conventional tubes. Noise can be reduced indefinitely by increasing the pumping power and by reducing the temperature. Unfortunately, the full benefit of the extremely low noise figure, thus obtained, cannot be utilized as the associated circuit elements, e.g. the feeder lines, contribute more noise than the Maser itself[27,28]. As such, from the point of view of noise alone it is not necessary to operate the Maser at extremely low temperature. However, low temperature helps to improve the gain-bandwidth product which varies inversely as the temperature.

The system described above can be made to oscillate by increasing the pumping power level to a high value. In the above example, 15 microwatts of

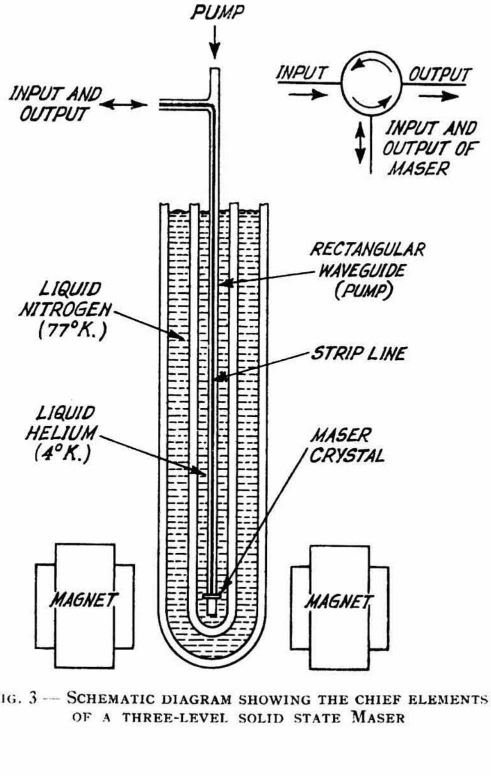

FIG. 3 — SCHEMATIC DIAGRAM SHOWING THE CHIEF ELEMENTS OF A THREE-LEVEL SOLID STATE MASER

power at 9000 Mc/s. was obtained with 0·2 W. of pumping power.

Parametric amplifier or the Mavar

Basic physical principles — In the Mavar, a resonant circuit is coupled to a non-linear energy storage element whose value is made to vary by a source working at a different frequency. Energy is extracted from this latter source and transferred to the resonant circuit. The mechanism of transfer is provided by the bound electrons contained in the material. Nevertheless, amplification may be explained in classical terms involving constants of the bulk material or, in other words, in terms of the concept of equivalent circuit parameters and hence the name ‘ parametric ’. A more recent and descriptive term is the acronym Mavar (modulated amplifier by variable reactance, suggested by Weiss).

The principle of operation of a Mavar using a mechanical system had been given as early as 1883 by Lord Rayleigh[29]. A later study using an electromechanical system is due to Hartley[30] who gave a set of general relations between the power and the frequencies of oscillations. The study had been extended and put on an elegant theoretical foundation by Manley and Peterson[31] and by Manley and Rowe[32]. These studies showed that when oscillations of two different frequencies f_p and f_s ($f_p > f_s$) are simultaneously coupled to a non-linear reactance a series of frequencies $m^f{}_p \pm nf_s$ (m and n positive integers) are generated. Considering a simple system in which only $f_p + f_s = f_+$ and $f_p - f_s = f_-$ may be sustained, Manley and Rowe gave the following power relations:

$$\frac{P_p}{f_p} = -\frac{P_+}{f_+} - \frac{P_-}{f_-} \quad \ldots\ldots\ldots\ldots (1)$$

and
$$\frac{P_s}{f_s} = -\frac{P_+}{f_+} + \frac{P_-}{f_-} \quad \ldots\ldots\ldots\ldots (2)$$

positive P denoting power leaving the reactor and negative P the power absorbed by it. Since P_+ and P_- are always positive it is apparent from (1) that power is always absorbed at the frequency f_p. For oscillations at the lower frequency f_s the position is more interesting. If only the sum frequency f_+ is sustained and the difference frequency f_- is completely suppressed, then P_s is negative and power at f_s is absorbed. Under such a condition

$$P_+ = -P_s \frac{f_+}{f_s} \quad \ldots\ldots\ldots\ldots (3)$$

showing that power generated at the sum frequency is f_+/f_s times the power absorbed at the signal frequency. This provides the basis of the so-called up-converter mode of operation[33] of the Mavar. If, however, oscillations at f_- are sustained and those at f_+ completely suppressed, we find that P_s is positive showing that the reactor supplies power at the frequency f_s. Bearing equation (1) in mind, one can say that the reactor in the presence of a circuit sustaining the difference frequency f_- absorbs power from the source at f_p and delivers a part of it to build up oscillations at the frequency f_s. In terms of the language of circuitry, the non-linear reactor controlled by the source at the higher frequency effectively couples a ‘ negative resistance ’ to the circuit supporting the lower frequency f_s. This provides the basis of the so-called ‘ negative resistance ’ mode of operation of the Mavar. The same result is obtainable by sustaining any of the other difference frequency components $mf_p - nf_s$. In principle the ‘ pump ’ can have any frequency greater than f_s. But best results are always obtained with a degenerate frequency relationship, i.e. $f_p = 2f_s$.

For the negative resistance type of Mavar, an auxiliary circuit sustaining the difference frequency is needed. This is called the ‘ idler circuit ’. The source at frequency f_p which is the ultimate source of power is called the ‘ pump ’ and plays the role of the h.t. supply of the conventional vacuum tube amplifier. Figs. 4(A) and 4(B) show the equivalent circuit of a Mavar amplifier without and with the idler circuit respectively.

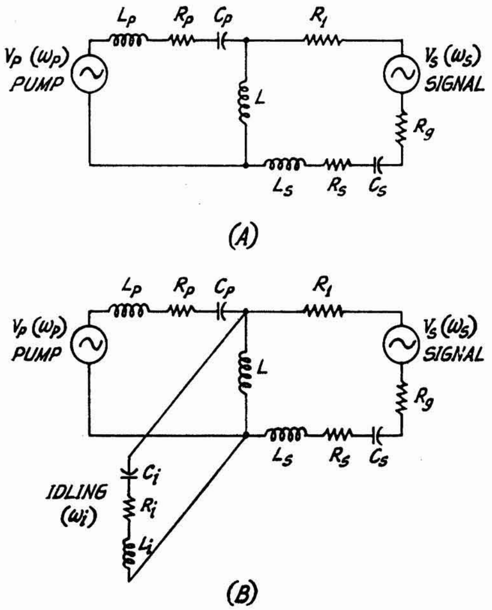

FIG. 4 — EQUIVALENT CIRCUIT OF A MAVAR AMPLIFIER (A) WITHOUT AND (B) WITH THE IDLER CIRCUIT ADDED

Since the ohmic resistance in the signal circuit is neutralized, the only noise that is significant is that contributed by the demodulator in the case of an up-converter Mavar and by the idler circuit in the case of a negative resistance Mavar.

Experimental Mavars with promising performances have been reported[34-44] by several investigators. These involve the use of (a) ferrites providing a non-linear inductor, (b) reverse biased semiconductor diodes ' giving a non-linear capacitor ' and (c) a modulated electron beam providing a non-linear inductor or a capacitor.

Ferromagnetic Mavar — A negative resistance ferromagnetic Mavar usually employs a ferrite as the non-linear inductor[45-48]. Three different modes of operation are possible with such an element. These are the magnetostatic, the semi-static and the electromagnetic modes.

In the magnetostatic mode[49] of operation, the signal, the pump and the idler frequencies are chosen to equal three of the so-called magnetostatic resonance modes of the ferrite sample in an appropriate d.c. magnetic field. The pump frequency is selected to equal the uniform precession frequency defined by $\omega_p = \Upsilon H_{d.c.}$ where Υ is the gyromagnetic ratio. The remaining frequencies f_s and f_- are also sustained by the ferrite sample satisfying the condition of parametric amplification. The magnetostatic modes are, however, varied and many and a large number of pairs whose frequencies add up to ω_p are possible. This involves the possibility of pick up and wastage of power in the modes having undesired frequencies.

In the semi-static mode, the ferrite sample is placed in a cavity which is resonant to either f_s or f_-, oscillations at the other frequency being sustained by the ferrite — one magnetostatic mode of which has an identical frequency. The value of the applied d.c. magnetic field is adjusted to excite a uniform precession frequency equal to the pump frequency f_p — the latter being so chosen that no two magnetostatic modes can add up to the pump frequency.

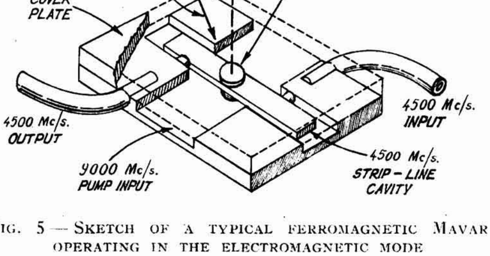

FIG. 5 — SKETCH OF A TYPICAL FERROMAGNETIC MAVAR OPERATING IN THE ELECTROMAGNETIC MODE

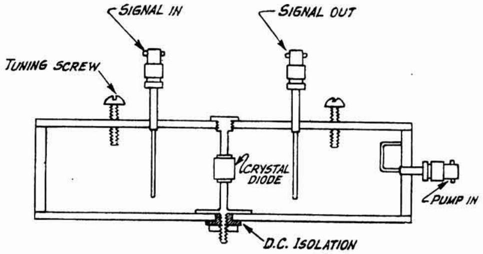

FIG. 6 — ARRANGEMENT OF A NEGATIVE RESISTANCE TYPE PARAMETRIC AMPLIFIER USING A REVERSE BIASED DIODE

In the electromagnetic mode a cavity is used that is simultaneously resonant to f_s and f_-. The only magnetostatic mode used is the one having the uniform precession frequency ω_p.

For practical manipulation, an electromagnetic mode of operation is the best, although, for the same output, the magnetostatic mode requires much less pump power. Fig. 5 shows a typical ferromagnetic Mavar[34] operating in the electromagnetic mode with a ' pump ' frequency of 9000 Mc/s. and signal frequency of 4500 Mc/s. Signal power is coupled to a shielded strip line cavity, half wavelength long, by means of a coaxial probe and pump power is fed into the device through a waveguide orthogonal to the strip line. Manganese ferrite discs at the top and bottom of the strip line near its centre support the pump frequency when a magnetic field is applied at an angle of 45° to the strip line as shown in Fig. 5. Gain of the order of 8 db. is realizable and, with high values of pump power, oscillations at 4500 Mc/s. have been observed.

Variable capacitance Mavar — Heffner and Kotzebue[35] have described a negative resistance Mavar using the non-linear junction capacitance of a reverse biased diode. The device shown schematically in Fig. 6 consists essentially of a rectangular cavity in which the diode (zero bias capacity = 1 $\mu\mu$F. and spreading resistance = 5Ω) is placed between central posts. With the help of tuning screws, the cavity can be made simultaneously resonant at 3500, 2300 and 1200 Mc/s. The pump frequency, 2500 Mc/s., is coupled to the cavity by means of a loop, and two probes are provided to serve as signal-in and signal-out terminals at either the 1200 Mc/s. or the 2300 Mc/s. resonance, the coupling for the former being made stronger. With pump power up to 100 milliwatts, amplification is obtainable; beyond this, the device oscillates at both the frequencies. Net gain up to 40 db. has been obtained. The bandwidth at 19 db. gain is 1·0 Mc/s. The saturated power output is 1·5 milliwatts and noise figure less than 4·8 db.

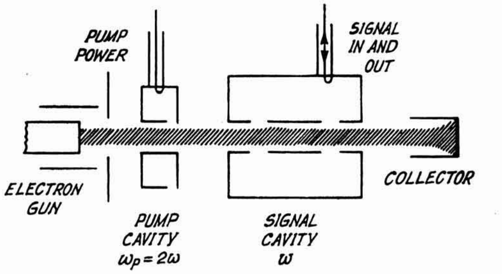

FIG. 7 — SKETCH OF A PARAMETRIC AMPLIFIER USING AN ELECTRON BEAM

Recently Brand *et al.*[36] have constructed a negative resistance amplifier using two diodes in a balanced hybrid system. A noise figure of 2·7 db. has been achieved.

In a typical up-converter arrangement due to Herrmann *et al.*[38] the signal is introduced at 460 Mc/s. and the ' pump ' at 8915 Mc/s. The output at the sum frequency, viz. 9375 Mc/s., was detected by a superheterodyne receiver using balanced point contact crystals. Gain obtained was 9 db. and the noise figure was 2·0 ± 0·5 db. Broad band amplification as predicted by theory has not, however, been achieved.

Uhlir[41] and others have developed special types of diffused junction diodes with the high and right degree of non-linearity of the junction capacitance and it is with such diodes that one can achieve good Mavar action.

Electron beam Mavar — Bridges[42] has utilized an electron beam to produce Mavar action. It is well known that if an electron beam is made to pass through a cavity containing two equal gaps separated by a drift space L, an effective impedance is produced by the beam across the cavity which is a function of the drift angle α. For values of $\alpha = n\pi$ radians, where n is any integer, the beam presents a pure reactance which can be varied by modulating the electron beam. In Bridges' arrangement, shown in Fig. 7, this is done by passing the beam through a cavity resonant to the pump frequency which, for simplicity and better gain, is made equal to twice the signal frequency. The noise figure of the device is improved by making $\alpha = (2n + 1)\pi$ radians, so that induced noise current components at the signal frequency at the two gaps are equal in amplitude but opposite in phase and, therefore, cancel out. An experimental tube built on this principle with a pump frequency of 8300 Mc/s. and signal frequency of 4150 Mc/s. produced a gain of 20 db. at a power level of 140 milliwatts.

Another type of Mavar, similar to the above but employing space charge waves imposed on a modulated electron beam, has been suggested by Adler[43] and others[50-52]. When an electron beam is modulated by an r.f. signal, a pair of travelling space charge waves, one called the slow and the other the fast wave, are produced. In conventional travelling wave tubes, the former is utilized to produce gain. This, however, sets a minimum limit for the noise present in such devices. While the fast wave component does not set such a limitation, it cannot provide gain through conventional travelling wave interaction. A device has, therefore, been suggested which employs the fast wave interaction only in its input and output sections, the amplitude of the wave in between being increased by parametric amplification. This can be accomplished by modulating the beam with the help of a pump oscillator as a result of which the fast wave grows exponentially with distance along the beam at the expense of the pump power. Practical Mavars based on this principle have been constructed by Adler[43] and Adler *et al.*[44].

It may be noted that electron beam type of Mavars are not actually of molecular type although these work on the same principle.

Travelling wave devices

As has been stated already, present-day Masers possess comparatively limited bandwidth, of the order of 1 to 10 Mc/s. This is a consequence of the sharp resonance of electron spin systems. A straightforward way to increase the bandwidth would, therefore, be to place the material in a non-uniform magnetic field so that the resonant frequencies are distributed. A suggested[53] approach to the problem is to make use of the non-uniform d.c. field of a few hundred gauss around a straight wire carrying a current of a few amp. The wire has a helix wound around it, supporting a travelling r.f. field as in a travelling wave tube and both the wire and the helix are embedded in a paramagnetic salt at 4°K. (Fig. 8). Pulsed changes of current direction in the centre wire will now periodically activate the amplifier by the same technique as discussed previously.

Increased bandwidth through travelling wave interaction has also been achieved with a variable capacitance Mavar. Thus, Engelbrecht[54] of the Bell

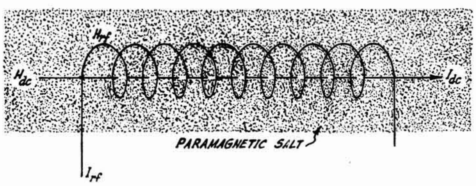

FIG. 8 — SCHEMATIC DIAGRAM OF A TRAVELLING WAVE MASER USING A PARAMAGNETIC SALT

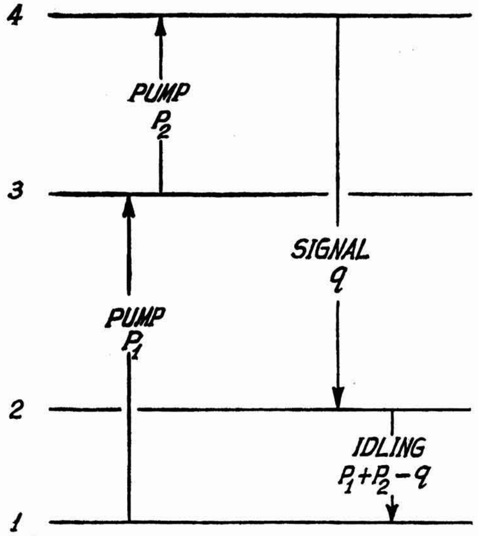

FIG. 9 — ENERGY LEVEL CONFIGURATION OF A TWO-PUMP PARAMETRIC AMPLIFIER

Telephone Laboratories has described an experimental travelling wave amplifier using four stages of diodes arranged in tandem and in such a phase relationship that a growing wave is generated as the signal travels down the line of successive stages. This arrangement was found to give a bandwidth of 20 Mc/s. at a signal frequency of 400 Mc/s. Gain achieved was 10 db. with a noise figure of 3·5 db. only.

Cullen[55] and others[56] have proposed various forms of travelling wave Mavars using non-linear inductance. These devices are, however, still in a very early stage of development.

Amplifier with low frequency pumping

The use of a high power pump source at a higher frequency puts a limitation on the operation of the Maser or the Mavar higher up in the frequency spectrum. This drawback may be removed by using two or more pump sources at frequencies lower than f_s. In order to achieve this with a Mavar, use has to be made of a reactance having a higher than quadratic order of non-linearity. The frequency relationship in this case, according to Bloom and Chang[57], would be as shown in Fig. 9. Chang[58] and Chang and Bloom[59] have successfully tested the practicability of such an arrangement in the u.h.f. range. Chang used both a Ni-Mn ferrite as a non-linear inductor and a reverse biased diode as a non-linear capacitor. With the diode and with $f_s = 380$ Mc/s., f_{p_1} and $f_{p_2} = 300$ Mc/s., and $f_d = 220$ Mc/s., a stable gain of 20 db. was obtained with 30 milliwatts of pump power. Sustained oscillations were obtained when the gain exceeded 40 db., the output power being 1 milliwatt. The noise figure was nearly 10 db. and the bandwidth 0·3 per cent.

Devices based on plasma interaction

As mentioned already, most of the work[60,61] relating to plasma oscillations as source of microwaves are theoretical and are extensions of the discussions of the original work of Bohm and Gross[60]. These discussions have established the possibility of growth of the so-called electrostatic type of plasma waves and of generating sustained oscillations in a plasma through interaction with an electron beam shot into the same. It has also been shown that regenerative feedback required for oscillation may be achieved by using a plasma of such a length that standing waves are produced, the reflected component of waves supplying the feedback. Some experimental evidence[62] in support of these deductions has also been reported.

The most serious difficulty in the way of constructing a practical plasma oscillator in the millimetre waveband is the high input power required to maintain the requisite plasma density in a gaseous discharge. This difficulty is not so serious with a plasma in solid, but unfortunately, attenuation and collisional damping of waves in solids constitute a major disadvantage of a device using solid state discharge.

A somewhat different approach to the use of a plasma for generating microwaves consists of utilizing shock-excited plasma of short duration in a reverse biased p-n junction[63]. From the characteristic of such a junction (Fig. 10) it is noted that the portion marked AB is the region where a breakdown occurs. One of the ways in which a breakdown can occur is through the so-called avalanche effect[64,65]. In this, an intense localized field in the depletion layer of the

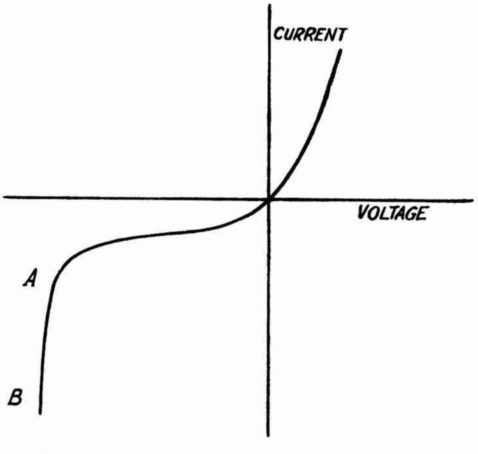

FIG. 10 — CHARACTERISTIC OF A REVERSE BIASED P-N JUNCTION

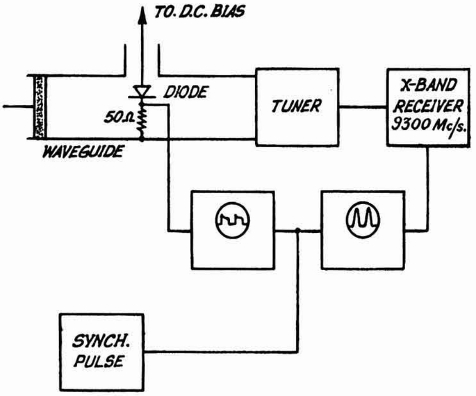

FIG. 11 — BLOCK DIAGRAM OF THE CIRCUIT USED BY MOLL *et al.* FOR DETECTING MICROWAVE TRANSIENTS OBTAINED BY AVALANCHING SILICON DIODES

junction causes a nearby electron to gather energy sufficient for initiating a chain process of formation of electron-hole pairs. Unfortunately, in ordinary junctions, all impurity centres are not identical and are also scattered at various places of the junction and the breakdowns at these various centres are not coherent. In recent years, specially designed junctions have been described[66] for which the breakdown occurs as a whole through a single micro-plasme giving rise to a narrow current pulse and it is possible to generate microwave signals by utilizing a harmonic of such pulses. Moll, Uhlir (Jr) and Senitzsky[63], using the arrangement shown in Fig. 11, successfully produced an avalanche effect in a specially designed silicon diode and obtained a signal at 3000 Mc/s., the microwave pulses being generated at the onset of the breakdown current. The duration of the pulses was *c.* $\frac{1}{2}$ microsec. and the power was 32 db. above the noise power. Simple calculation showed that this was also the theoretically expected value.

Devices based on Cerenkov effect

It was Ginsburg[67] who had first suggested in 1947 that the Cerenkov effect could, in principle, be used to produce microwaves. One of the main difficulties was that such a source would give a continuous spectrum whereas in most radio applications, oscillators running on a single frequency are desired. Again, the radiation emitted would be incoherent leading to very little useful output. A way out of the first difficulty is to use circuit or resonator systems having definite modes so that the energy of the Cerenkov radiation will be concentrated into these modes, resulting in a line rather than a continuous spectrum. Using conventional transmission line and circuit theory, Pierce[68] has considered the effects of the interaction of charges moving close to distributed circuits and has shown that the Cerenkov radiation is an example of a transfer of energy from a moving charge to a dispersive circuit when the velocity of the former is equal to the wave velocity of the circuit. Regarding coherence, proposals have been made of using a highly bunched electron beam.

The first experimental investigations for the generation of microwaves utilizing the Cerenkov effect were carried out by Danos *et al.*[69] in 1953. In their arrangement, a flat electron beam, bunched at a frequency of 24,000 Mc/s., was allowed to pass as closely as possible to the surface of a dielectric material (polycrystalline TiO_2). Radiation from the dielectric was picked up by a microwave horn and detected with a crystal diode. Approximately 10^{-7} watt of Cerenkov radiation at a wavelength of 1·25 cm. was obtained.

Recently, a slightly different type of a microwave generator utilizing the Cerenkov effect has been constructed by Minakova and Volkova at the University of Moscow. In the arrangement used by them, electrons move freely through a narrow hole drilled in a suitable material, the radius of the hole being small compared to the wavelength of the Cerenkov radiation. The first experimental model generated waves in the 2-10 cm. band and had an output of only a few milliwatts. Generators of shorter waves are stated[70] to be under development.

Conclusion

The developments of the Maser and the Mavar for generation and amplification of microwaves have opened up one of the most promising avenues of investigation in the field. Their outstanding advantages are the extremely low noise figure and the possibilities of application in the domain of sub-millimetre waves. The former enables one to detect very weak signals — as for example those from extra terrestrial bodies. The latter holds out promise for bridging the gap between the infrared and the conventional microwaves.

From the standpoint of noise alone Masers appear to give the most suitable method. Nevertheless, their constructional complexities, e.g. use of d.c. magnetic field and cooling arrangement, as also their extremely low power output, are great disadvantages from the practical point of view. Further, a tunable Maser, like the three-level one, makes use of paramagnetic resonance, and a good amount of research on paramagnetic materials is required before Masers can be adapted for use over an appreciable range of frequencies. Frequency stability of Maser oscillators is, however, good and these will certainly find use as standards of frequency although other types of standards with much better frequency stability have been successfully constructed.

Mavars give quite good power output. In respect of noise, however, the ' negative resistance ' type is worse than Masers. This drawback arises mainly out of the noise generated in the idler circuit and it has been suggested[71] that cooling of this circuit might be a remedy for this trouble. But that would again make the whole arrangement a little awkward from the practical point of view. Further, the ' negative resistance ' Mavars are also inherently unstable devices; as such, the bandwidth of the system is restricted. The up-converter mode of operation is free from these troubles, but this requires the use of a demodulator. Also, it is not possible to see how this mode of operation can give a gain which is equal to that obtainable with the ' negative resistance ' mode. One disadvantage of the Mavar is the use of circulator for isolating the input from the output. The circulator is a costly device and would make the system expensive. A directional coupler is better in this respect but it entails a higher insertion loss and restricts the available power output. It may be noted that the problem of isolation does not arise in case of a Maser using a transmission type of cavity[72,73]. Recently, a Maser amplifier system without requiring any non-reciprocal element has also been proposed[74].

Travelling wave operation would overcome to a great extent the bandwidth limitation of ' negative resistance ' Mavars. Further, their noise figure, although a little higher than that obtainable with Masers, is still very low — lower at least than that of the associated external circuit elements. With a little progress towards achieving stability, it is likely that Mavars with this mode of operation will surpass the others in practical applications.

With regard to materials, the reverse biased junction diode appears to be the most promising one. These are simple, compact, rugged, inexpensive and non-selective with respect to frequency. These also give a higher degree of non-linearity which makes them more suitable than anything else for four-level operation using a lower pump frequency. Since a pump frequency lower than the signal frequency is convenient from the practical point of view, the importance of this last advantage is significant. However, the temperature sensitivity of these diodes is still a practical difficulty. This remains to be overcome. Other alternatives, e.g. ferrites, are comparatively free from this handicap. But an electron beam type of Mavar is the best from this point of view; it is also better suited to the existing tube making techniques — a consideration which will also influence considerably the course of future investigations on Mavars.

Plasma oscillations and Cerenkov radiation also hold out promise of interesting developments, particularly in the sub-millimetre range. But many practical difficulties have to be overcome before these can yield results which can place them on the same footing as Maser and Mavar in the field of microwave electronics.

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References

1. Gordon, J. P., Zeiger, H. J. & Townes, C. H., *Phys. Rev.*, **99** (1955), 1264.
2. Shimoda, K., Takahasi, H. & Townes, C. H., *J. phys. Soc., Japan*, **12** (1957), 686.
3. Muller, M. W., *Phys. Rev.*, **106** (1957), 8.
4. Wittke, J. P., *Proc. Inst. Radio Engrs, N.Y.*, **45** (1957), 291.
5. Strandberg, M. W. P., *Phys. Rev.*, **106** (1957), 617.
6. Helmer, J. C., *Phys. Rev.*, **107** (1957), 902.
7. Alsop, L. E., Giordmaine, J. A., Townes, C. H. & Wang, T. C., *Phys. Rev.*, **107** (1957), 1450.
8. Gordon, J. P. & White, L. D., *Phys. Rev.*, **107** (1957), 1728.
9. Ramsey, N. F., *Phys. Rev.*, **78** (1950), 695.
10. Shimoda, K., Wang, T. C. & Townes, C. H., *Phys. Rev.*, **102** (1956), 1308.
11. Townes, C. H., *J. appl. Phys.*, **28** (1957), 920.
12. Bonanomi, J., Herrmann, J., Prins, J. De & Kartaschoff, P., *Rev. Sci. Instrum.*, **28** (1957), 879.
13. Javan, A. & Wang, T. C., *Bull. Amer. phys. Soc.*, **2** (1957), 209.
14. Wells, W. H., *J. appl. Phys.*, **29** (1958), 714.
15. Basov, N. G. & Prokhorov, A. M., *J. exp. theor. Phys., U.S.S.R.*, **28** (1955), 249 [Translation: Soviet Phys., *J. exp. theor. Phys.*, **1** (1955), 184].
16. Bloembergen, N., *Phys. Rev.*, **104** (1956), 324.
17. Scovil, H. E. D., Feher, G. & Seidel, H., *Phys. Rev.*, **105** (1957), 762.
18. Javan, A., *Phys. Rev.*, **107** (1957), 1579.
19. McWhorter, A. L. & Meyer, J. W., *Phys. Rev.*, **109** (1958), 312.
20. Kingston, R. H., *Proc. Inst. Radio Engrs, N.Y.*, **46** (1958), 916.
21. Meyer, J. W., *Electronics* (Engng ed.), **31** (1958), 66.
22. Artman, J. O., Bloembergen, N. & Shapiro, S., *Phys. Rev.*, **109** (1958), 1392.
23. Scovil, H. E. D., *Bell Lab. Rec.*, **36** (1958), 243.
24. Morris, R. J., Kyhl, R. L. & Strandberg, M. W. P., *Proc. Inst. Radio Engrs, N.Y.*, **47** (1959), 80.
25. Weber, J., *Phys. Rev.*, **108** (1957), 537.
26. McWhorter, A. L., Meyer, J. W. & Strum, P. D., *Phys. Rev.*, **108** (1957), 1642.
27. Arams, F. R. & Krayer, G., *Proc. Inst. Radio Engrs, N.Y.*, **46** (1958), 912.
28. McWhorter, A. L. & Arams, F. R., *Proc. Inst. Radio Engrs, N.Y.*, **46** (1958), 913.
29. Rayleigh, John William Strutt, *Phil. Mag., Ser.* 5 (April 1883); *The Theory of Sound*, Vol. I (Dover Publications, New York), 1945, 81.
30. Hartley, R. V. L., *Bell Syst. tech. J.*, **15** (1936), 424.
31. Manley, J. M. & Peterson, E., *Trans. [mon.] Amer. Inst. elect. Engrs*, **65** (1946), 870.
32. Manley, J. M. & Rowe, H. E., *Proc. Inst. Radio Engrs, N.Y.*, **44** (1956), 904.
33. Uhlir, A. (Jr), *Proc. Inst. Radio Engrs, N.Y.*, **44** (1956), 1183.
34. Weiss, M. T., *Phys. Rev.*, **107** (1957), 317.
35. Heffner, H. & Kotzebue, K., *Proc. Inst. Radio Engrs, N.Y.*, **46** (1958), 1301.
36. Brand, F. A., Matthei, W. G. & Saad, T., *Proc. Inst. Radio Engrs, N.Y.*, **47** (1959), 42.

37. Oguchi, B., Kita, S., Inage, N. & Okajima, T., *Proc. Inst. Radio Engrs, N.Y.*, **47** (1959), 77.
38. Herrmann, G. F., Uenohara, M. & Uhlir, A. (Jr), *Proc. Inst. Radio Engrs, N.Y.*, **46** (1958), 1301.
39. Leenov, D., *Bell Syst. tech. J.*, **37** (1958), 989.
40. Salzberg, B. & Sard, E. W., *Proc. Inst. Radio Engrs, N.Y.*, **46** (1958), 1303.
41. Uhlir, A. (Jr), *Proc. Inst. Radio Engrs, N.Y.*, **46** (1958), 1099.
42. Bridges, T. J., *Proc. Inst. Radio Engrs, N.Y.*, **46** (1958), 494.
43. Adler, R., *Proc. Inst. Radio Engrs, N.Y.*, **46** (1958), 1300.
44. Adler, R., Hrbek, G. & Wade, G., *Proc. Inst. Radio Engrs, N.Y.*, **46** (1958), 1756.
45. Landon, V. D., *R.C.A. Rev.*, **10** (1949), 387.
46. Suhl, H., *Proc. Inst. Radio Engrs, N.Y.*, **44** (1956), 1270.
47. Suhl, H., *Phys. Rev.*, **106** (1957), 384.
48. Suhl, H., *J. appl. Phys.*, **28** (1957), 1225.
49. Walker, L. R., *Phys. Rev.*, **105** (1957), 390.
50. Louisell, W. H. & Quate, C. F., *Proc. Inst. Radio Engrs, N.Y.*, **46** (1958), 707.
51. Ashkin, A., *J. appl. Phys.*, **29** (1958), 1646.
52. Wade, G. & Adler, R., *Proc. Inst. Radio Engrs, N.Y.*, **47** (1959), 79.
53. Smith, W. V., *I.B.M.J.*, **1** (1957), 232.
54. Engelbrecht, R. S., *AIEE-IRE Solid State Device Research Conference, Ohio State University, Ohio*, 1958; *Proc. Inst. Radio Engrs, N.Y.*, **46** (1958), 1655.
55. Cullen, A. L., *Nature, Lond.*, **181** (1958), 332.
56. Tien, P. K. & Suhl, H., *Proc. Inst. Radio Engrs, N.Y.*, **46** (1958), 700.
57. Bloom, S. & Chang, K. K. N., *J. appl. Phys.*, **29** (1958), 594.
58. Chang, K. K. N., *Proc. Inst. Radio Engrs, N.Y.*, **47** (1959), 81.
59. Chang, K. K. N. & Bloom, S., *Proc. Inst. Radio Engrs, N.Y.*, **46** (1958), 1383.
60. Bohm, D. & Gross, E. P., *Phys. Rev.*, **75** (1949), 1851, 1864; **79** (1950), 992.
61. Lampert, M. A., *J. appl. Phys.*, **27** (1956), 5.
62. Boyd, G. D., Field, L. M. & Gould, R. W., *Phys. Rev.*, **109** (1958), 1393.
63. Moll, J. L., Uhlir, A. (Jr) & Senitzsky, B., *Proc. Inst. Radio Engrs, N.Y.*, **46** (1958), 1307.
64. McKay, K. G., *Phys. Rev.*, **94** (1954), 877.
65. Wolff, P., *Phys. Rev.*, **95** (1954), 1415.
66. Read, W. T. (Jr), *Bell Syst. tech. J.*, **37** (1958), 401.
67. Ginsburg, V. L., *C.R. Acad. Sci., U.R.S.S.*, **56** (1947), 253. Translated by Defence Science Information Service, Defence Research Board, Canada, T 103 R, 1954.
68. Pierce, J. R., *J. appl. Phys.*, **26** (1955), 627.
69. Danos, M., Geschwind, S., Lashinsky, H. & van Trier, A., *Phys. Rev.*, **92** (1953), 828.
70. Tamm, I. E., *Times Sci. Rev.*, Winter 1958, 12.
71. Heffner, H. & Wade, G., *J. appl. Phys.*, **29** (1958), 1321.
72. Stitch, M. L., *J. appl. Phys.*, **29** (1958), 782.
73. Siegman, A. E., *Proc. Inst. Radio Engrs, N.Y.*, **45** (1957), 1737.
74. Autler, S. H., *Proc. Inst. Radio Engrs, N.Y.*, **46** (1958), 1880.

Variations in the Distribution of Susceptibilities of a Population

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An attempt has been made to explain the nature of the variations, which occur from day to day and in the same laboratory, of the distribution of the susceptibilities of an insect or animal population to a drug or poison. A theory has been proposed according to which there is a maximal dose at which every individual of a population succumbs. That the theory is plausible has been shown by an analysis of the data obtained by the author in an earlier investigation [Seasonal variations in the mortality of *Culex fatigans* Weid exposed to DDT, *Proc. Indian Sci. Congr.* (*Forty-sixth Session*), Pt III (1959), 22], in which it has been shown that the variations are seasonal, even after making corrections for the changes in temperature and humidity, and that the mean and the slope of the dose-response relationship increase or decrease together.

IT is well known that the distribution of susceptibilities of an animal or insect population to a drug or poison changes from day to day even in the same laboratory. It is for this reason that in any biological assay for estimating the potency of an unknown preparation, a parallel experiment has to be carried out with the reference standard. It is not permissible to make an assay with the standard preparation, determine the dose-response relationship, and use this relationship for assaying an unknown preparation at any subsequent time. The reason for this is that the same relationship may not hold good at any subsequent period. The dose-response relationship can only change when there is a change in the distribution of the susceptibilities of the test animal or insect population.

Sollmann[1] has referred to experiments by various workers on the change in the susceptibility of both cold-blooded and hot-blooded animals to poisons as a result of changes in temperature. Jeppson *et al.*[2] and Munson *et al.*[3] have studied the effect of changes in temperature on the susceptibility of insects to poisons. Bordas and Navarro[4], Burnett[5] and Barlow and Hadaway[6] have studied the effect of changes in humidity on the susceptibility of insect pests to insecticides. Ranganathan and Koshi[7] have studied the effects of temperature and humidity on the mortality of mosquitoes by DDT. The effect of change in the season on the mortality of the mosquito *Culex fatigans* Weid exposed to DDT has been studied by the author [Chakravarti, N. K., *Proc. Indian Sci. Congr.* (*Forty-sixth Session*), Pt III (1959), 22].

Direct measurement of the susceptibility of an animal or insect to a poison is generally not possible. It is the effect of the administration of a drug or poison that is observable. In quantal response assays, where the effect is generally death, the observation is the percentage response to a given dose of the poison. The hypothesis of log-normal distribution of susceptibilities has provided satisfactory explanations of the observed results. Even though other transformations are available, and some may have more theoretical justification, yet the assay techniques developed and generally used are based on the assumption of the susceptibilities being log-normally distributed. This assumption is made in this study also. Since a normal distribution is completely specified by specifying its mean and standard deviation, when the susceptibility changes, both the means and standard deviations may vary.

In this paper a relationship is established between the mean and standard deviation of the susceptibility distribution. The importance of this relationship to pest control measures arises from the fact that the maximal effective dose of a poison is constant, no matter what the season, temperature or humidity is, provided the same insect population is considered. However, if different populations are considered, or if the insects develop resistance to the poison, the population should be considered as different, and the same maximal effective dose does not apply.

Theory

Let x be the logarithm of the susceptibility of an individual of a population to a poison. Then x is distributed normally. Let the mean be m and standard deviation σ. If p be the proportion of response to a dose C, then:

$$p=\frac{1}{\sqrt{2\pi}\sigma}\int_{\log C}^{\infty}\text{exp.}\,\{-(x-m)^2/2\sigma^2\}dx$$

$$=\frac{1}{\sqrt{2\pi}}\int_{(\log C-m)/\sigma}^{\infty}\text{exp.}\,(-z^2/2)dz$$

where $z=\dfrac{x-m}{\sigma}$

If Y is the normal equivalent deviate corresponding to p, we have

$$Y=\frac{\log C-m}{\sigma}=\frac{1}{\sigma}\,.\,\log C-\frac{m}{\sigma}$$

Hence the regression coefficient of Y on $\log C$ is $1/\sigma$. If the dose-response relationship is

$$Y=a+b\log C$$

we have $b=1/\sigma$, or $\sigma=1/b$.

Let the maximal dose be e^K, at which all the individuals succumb. If the dose is larger than e^K, every individual will succumb. However, since the theoretical susceptibility distribution is assumed to be log-normal, whose tail extends to infinity, it may be considered that there is a fixed large chance p_o for response when this dose is administered. That is

$$p_o=\frac{1}{\sqrt{2\pi}}\int_{(K-m)/\sigma}^{\infty}\text{exp.}\,(-z^2/2)dz$$

If Y_o is the normal equivalent deviate corresponding to p_o, we have $Y_o=(K-m)/\sigma$.

The hypothesis now put forward is that K remains the same, whatever may be m or σ. Since p_o is fixed, Y_o is fixed and can be considered as a constant. Thus

$$Y_o=\frac{K-m}{\sigma}\ \text{or}\ Y_o\sigma=K-m\ \text{or}\ m=K-\sigma Y_o$$

Thus m and σ are linearly related. From any particular assay, $\bar{x}$ and the regression coefficient $b=1/S$ (where S is the estimate of σ) are determined. Hence, substituting these values

$$\bar{x}=K-\frac{1}{b}\cdot Y_o$$

or, that $\bar{x}$ and $1/b$ are linearly related.

Verification of the theory

From studies on the distribution of susceptibilities of insect or animal population to a drug or poison, Chakravarti (loc. cit.) obtained a series of dose-response relationships. The seasonal indices of b and LD-50 showed a marked similarity of movement. For each of these relationships, the $\bar{x}$, i.e. the mean log dose values[8] were also determined. A regression was fitted between s and $\bar{x}$ and the following equation was obtained:

$$\bar{x}=2{\cdot}209-0{\cdot}563S$$

The significance of the regression coefficient (Y_o) was tested (Table 1) and was found to be highly significant.

TABLE 1 — ANALYSIS OF VARIANCE

SOURCE OF VARIATION	d.f.	S.S.	M.S.	F
Regression	1	0·078	0·078	31·2*
Dev. from regression	127	0·437	0·0025	—
Total	128	0·515	—	—

*Highly significant.

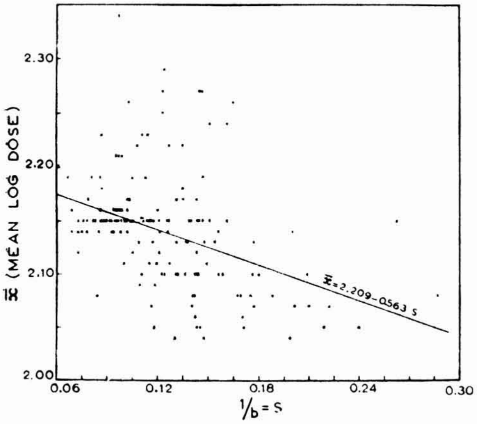

FIG. 1 — GRAPH SHOWING THE DATA ($S = 1/b$ VERSUS $\bar{x}$) AND THE FITTED LINE

The data with the fitted line are shown in Fig. 1. It is clear that there is no apparent curvature, so that no further subdivision of the sum of squares due to non-linear components is necessary. This verifies the theory.

Discussion

Since $b = 1/\sigma$, when the slope is large, σ is small; and when the slope is small, σ is large. However, when σ changes, m changes in such a manner that the least susceptibility of the population remains the same. Hence, if the minimum dose of a poison to obtain 100 per cent kill is worked out, it remains fixed, even if the distribution of susceptibilities shows a marked change, due to normal causes, namely the changes in temperature, humidity, season, etc. This presupposes that the insect population has not undergone any fundamental change. Hence, if other factors are the same, the dose of insecticides to be used in pest control operations is the same. But other factors generally do not remain the same. For example, Barlow and Hadaway[6] have found that the availability of DDT on mud surfaces changes with humidity. If it could be so arranged that the availability of an insecticide at the surface, which establishes contact with the insect pests, does not change, a maximal dose which could be used in all seasons, can be determined.

References

1. SOLLMANN, T., *A Manual of Pharmacology and Its Application to Therapeutics and Toxicology* (W. B. Saunders Co., London), 1949, 41.
2. JEPPSON, L. R., JESSEN, M. J. & COMPLIN, J. O., *J. econ. Ent.*, **47** (1954), 520.
3. MUNSON, S. C., PADILLA, G. M. & WEISMANN, M. L., *J. econ. Ent.*, **47** (1954), 578.
4. BORDAS, E. & NAVARRO, L., *Insecticides*/38 (World Health Organization, Geneva), 1955.
5. BURNETT, G. F., *Nature, Lond.*, **177** (1956), 633.
6. BARLOW, F. & HADAWAY, A. B., *Nature, Lond.*, **178** (1956), 1299.
7. RANGANATHAN, S. K. & KOSHI, T., *Nature, Lond.*, **181** (1958), 199.
8. *British Pharmacopoeia*, 1953.

Performance of a Pulsed Heat Exchanger

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Data are reported on the effect of pulsations on heat transfer efficiency. Employing three heat exchangers the values for the overall heat transfer coefficient have been obtained over a wide range of Reynolds numbers and at frequencies of 40, 81 and 160 cycles/min., the pulses being damped to various degrees at each of the frequencies. The results, which show that pulsations can be used to improve heat transfer coefficients, are discussed in the light of the conflicting data reported in the literature.

THE object of employing any type of agitation in a heat transfer equipment is to reduce the film thickness of the fluid or, in an extreme case, to break the film, thus decreasing the thermal resistance across it. One of the methods for imparting agitation is the use of pulsations or vibrations. A notable patent on the subject is that of Andreas[1] who employed a mechanically vibrated heat exchanger. There have also been other patents[2-6] but they provide little information.

The earliest reported data on the use of pulsations to enhance heat transfer efficiency are perhaps those of Martinelli and co-workers[7,8]. They showed that steady-unidirectional flow data can be used for predicting heat transfer performance under conditions of periodic flow and observed that pulsations have no effect in the region of turbulent flow for water. Marchant[9] determined the overall heat transfer coefficient (U) for water heated by steam over a wide range of Reynolds numbers using a constant pulse amplitude and three different frequencies, 10, 25 and 60 cycles/min. He found a slight improvement in U in the viscous region but observed no effect in the turbulent region.

On the contrary, Morris[10] and Webb[11] observed no difference in heat transfer between steady and pulsating flows in the viscous region while West and Taylor[12], who extended this investigation to the turbulent region, found a considerable improvement in the water side heat transfer coefficient (h). These investigators worked at a fixed frequency of 100 cycles/min. and varied the pulse amplitude which they expressed in terms of a pulsation ratio.

It has also been reported that pulsations enhance heat transfer efficiency both in the viscous and turbulent regions, the difference being only in the extent of improvement. Using oil in his experiments, Linke[13] observed a four-fold increase in the viscous region as against a rise of only 35 per cent in the turbulent region. Use of vibrations has been observed[14] to improve convective heat transfer.

Results on the effect of vibrations and pulsations on the heating of a compressible fluid like air have also been reported. No increase in heat transfer was found in the turbulent region[15] while an improvement of about 50 per cent was observed in the viscous region[16]. Havemann *et al.*[17] report improvements only at certain Reynolds numbers and within a limited range of frequencies.

It is thus clear that the data reported in the literature are fragmentary and, for liquids in particular, conflicting. The present study was undertaken with the object of investigating the effect of pulsations on the heating of water over a wide range of Reynolds numbers in the turbulent region at different values of pulse frequency and amplitude.

Experimental procedure

Equipment — A flow diagram of the experimental assembly is shown in Fig. 1. Briefly, water from a reciprocating pump entered a modified air chamber where the pulses were damped to the required extent, passed through 10 ft of calming section where they were regulated, and finally entered the heat exchanger.

The reciprocating pump served not only to pump the liquid into the system but also to impart pulses to the liquid stream through the modified air chamber. The air chamber that is usually fixed on the discharge port of a reciprocating pump was replaced by a larger chamber (4 in. diam. × 25·5 in. height) provided with an air connection at the top to enable

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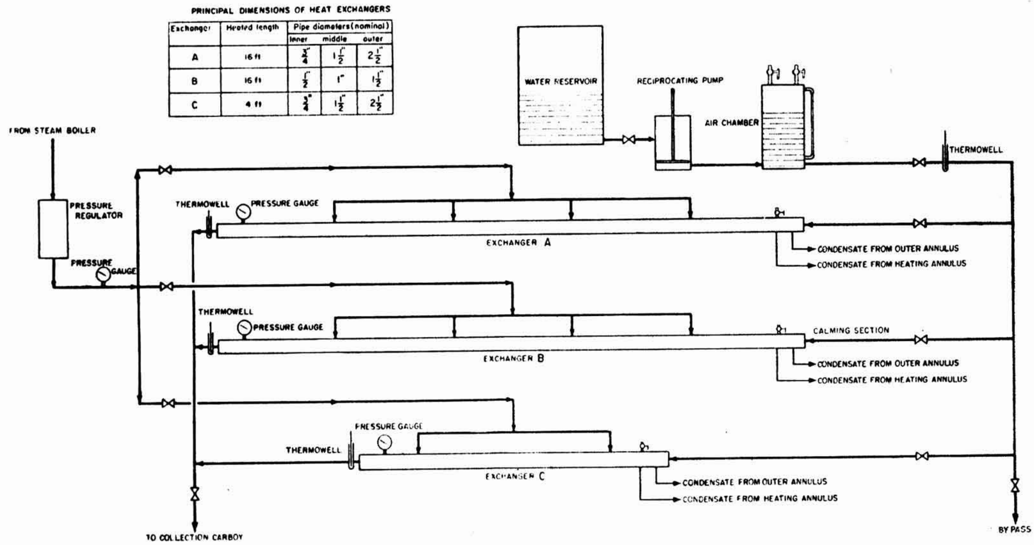

PRINCIPAL DIMENSIONS OF HEAT EXCHANGERS

Exchanger	Heated length	Pipe diameters (nominal)		
		Inner	middle	outer
A	16 ft	$\frac{3}{4}''$	$1\frac{1}{2}''$	$2\frac{1}{2}''$
B	16 ft	$\frac{1}{2}''$	$1''$	$1\frac{1}{2}''$
C	4 ft	$\frac{3}{4}''$	$1\frac{1}{2}''$	$2\frac{1}{2}''$

FIG. 1 — FLOW DIAGRAM OF HEAT TRANSFER ASSEMBLY

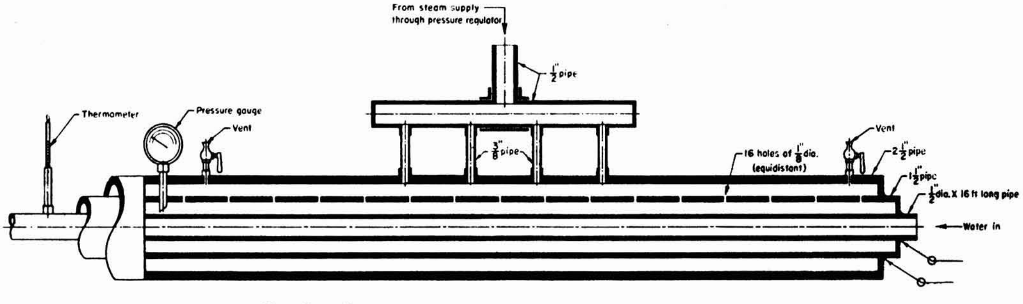

FIG. 2 — CONSTRUCTIONAL DETAILS OF HEAT EXCHANGER B

adjustment of air volume (or liquid level) in it. The air vessel operates by expelling the liquid at the end of the delivery stroke due to the pressure developed inside it during the commencement of the stroke, thus evening out the flow in the delivery line. It was thus possible to obtain flows with various degrees of pulsation by controlling the liquid level in the chamber as indicated by a gauge glass.

The pulse amplitude was expressed by a 'pulsation ratio' after West and Taylor[12]. This expresses the ratio of the maximum air volume to the minimum volume enclosed in the air chamber, filled with the liquid to the required level, during one complete stroke of the piston. Change in frequency was accomplished through a system of pulleys specially prepared for the purpose.

Three heat exchangers of different sizes were assembled in parallel and used one at a time. A sketch of exchanger B is shown in Fig. 2. The liquid (flowing through the innermost pipe) was heated by steam passed through the annular space between this pipe and the next. Radiation losses were minimized by first introducing the steam into the outer annulus through four holes on the outermost pipe and then letting it into the inner annulus through 15 equidistant holes on the second pipe. The total heated length of the pipe was 16 ft. Exchanger C was only 4 ft in length. The outermost pipe had two holes for steam inlet while the middle one was provided with five holes. For each of the exchangers, both the annuli were provided with condensate outlets. The exchangers were given a slight tilt in order to avoid accumulation of condensate and to ensure its free flow.

Procedure — In carrying out a run, the pump was started and the liquid height in the air chamber adjusted to the required value by manipulation of the air valve on the chamber. Steam was introduced and its pressure regulated so that the gauge installed on the exchanger showed a steady value. It usually took about half an hour for the system to reach steady state. The liquid and condensate rates were then measured at regular intervals; the run was stopped only after two consecutive readings showed a constant value. During a run, care was taken to maintain the liquid level in the air chamber at a constant height, and the maximum and minimum air heights were recorded at regular intervals to obtain a representative average pulsation ratio for the entire run. For obtaining data at different Reynolds numbers, the flow rates were varied by means of a bypass introduced before the calming section.

Results and discussion

The three heat exchangers shown in Fig. 1 were necessary in order to cover a wide range of Reynolds numbers. Preliminary runs were made with these exchangers using water at various flow rates and the data were plotted as U versus N_{Re}. All the points were found to lie on a smooth curve, thus establishing that the results obtained from these exchangers could be collectively used to analyse the effect of pulsations at different Reynolds numbers.

The effect of pulsations would be to increase the value of the water side heat transfer coefficient which would be reflected in an increase in the magnitude of U. The data obtained in this investigation have, therefore, been presented in terms of U.

In calculating U from the experimental data, the measurement of the steam side temperature is of considerable importance. West and Taylor used in their calculations the temperature corresponding to the pressure before the steam entered the system. This choice of pressure assumes negligible pressure

TABLE 1 — HEAT TRANSFER DATA

RUN No.	WATER FLOW RATE *lb./hr*	CIRCULATING WATER TEMP. °*F.* In	CIRCULATING WATER TEMP. °*F.* Out	REYNOLDS NUMBER	OVERALL HEAT TRANSFER COEFFICIENT (U) *B.t.u./hr/sq. ft/°F.*
		Steady-unidirectional flow			
148	612	77·6	181·0	8650	174
143	691	77·9	176·4	9430	205
90	492	84·2	199·4	10300	233
89	541	83·7	198·5	11250	252
88	768	83·3	193·1	15700	305
87	987	82·8	187·7	19550	371
86	1315	82·8	180·1	25300	428
117	1500	81·5	175·6	37800	448
113	1840	79·8	169·2	44900	500
116	2050	83·8	167·2	49900	518
115	2420	83·8	160·2	57000	532
112	2540	80·6	158·0	59000	551
114	3610	82·8	147·6	80300	626
		f = 81; P.R. = 1·035			
147	626	77·6	178·7	8730	197
85	474	84·0	199·4	9940	—
84	640	84·0	196·0	13300	226
83	690	84·0	194·2	14200	282
82	832	83·2	190·8	16800	293
81	930	82·8	187·9	18550	331
80	1065	82·6	184·6	20800	354
79	1300	82·4	180·5	24900	427
		f = 81; P.R. = 1·095			
146	457	78·5	187·7	6690	164
144	511	77·2	183·2	7570	172
78	547	82·4	197·6	11250	251
77	728	82·8	192·8	14600	303
76	852	82·4	189·5	17100	332
75	1065	82·8	184·1	20800	363
74	1290	84·2	178·4	24800	402
		f = 81 ; P.R. = 1·18			
106	517	82·4	199·4	10850	247
105	660	82·4	194·4	13450	285
104	840	82·4	190·8	16850	336
103	978	83·3	186·8	19400	358
102	1370	84·2	179·2	26300	417
		f = 81; P.R. = 1·29			
145	439	77·4	186·4	6350	153
101	557	84·2	202·0	11700	282
100	824	84·2	191·8	17000	334
99	1035	84·2	186·4	20600	375
98	1260	84·2	181·6	24400	415
97	1460	83·4	178·7	28100	453
97b	1470	84·2	177·8	28200	463
		f = 81 ; P.R. = 2·0			
96	633	84·2	197·2	13200	285
95	794	84·2	192·4	16500	311
94	1070	84·2	185·0	21100	378
93	1615	84·2	173·5	30200	455
92	1790	83·3	170·0	32800	476
91	2080	83·3	165·6	37500	506
109	2420	80·6	158·9	56500	535
107b	3300	80·6	148·1	73500	556
		f = 160 ; P.R. = 1·18			
150	201	77·0	184·0	2840	231
151	305	77·8	170·6	4100	271
152	365	77·8	165·2	4800	297
153	925	77·8	129·2	10200	358
154	1050	77·0	129·2	11600	413
155	1520	77·8	120·2	15600	458
		f = 160 ; P.R. = 2·00			
157	403	77·0	159·8	5130	297
158	665	77·8	140·0	7780	335
159	728	77·0	136·4	8350	340
160	1280	76·2	123·0	13500	438
161	1350	77·0	122·5	14100	448
162	1615	—	—	30200	—

f, frequency in cycles/min.; **P.R.**, pulsation ratio.

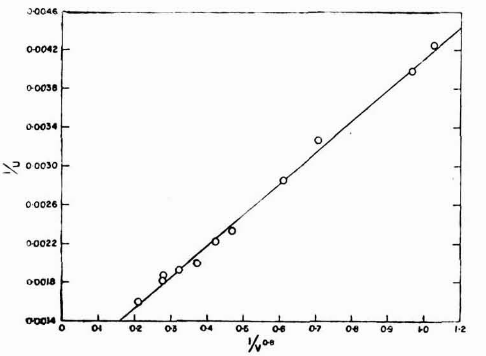

FIG. 3 — PLOT OF $1/U$ VERSUS $1/V^{0 \cdot 8}$

drop across the many small holes through which the steam passes before entering the heating jacket. As this assumption is evidently incorrect, the temperature of steam in the heating annulus was determined by a pressure gauge attached to this annulus.

In Table 1 are recorded the data obtained for steady flow and at a frequency of 81 cycles/min. for five different pulsation ratios. The calculated values of U are tabulated for different Reynolds moduli. Only those runs have been included for which the energy balance error was less than 6 per cent. The Reynolds number for both pulsed and unpulsed runs was calculated from the *average* velocity obtained by dividing the total volumetric flow per unit time by the cross-sectional area of the pipe. The values of U for steady flow were determined by making runs at a pulsation ratio of unity, i.e. with the air chamber kept empty of liquid. The steady flow values obtained in this investigation are generally slightly higher than those calculated from known equations for the steam and water sides at corresponding Reynolds numbers. On the other hand, the steady flow data of other investigators tend to be lower, presumably due to scale formation. In order to compare pulsed and unpulsed operations, therefore, it is advisable to obtain these data on the same equipment.

The values of U for steady flow are plotted as $1/U$ versus $1/V^{0 \cdot 8}$ in Fig. 3. It can be seen that a straight line is obtained, thus showing that the trend of U values obtained is correct and dependable.

Curve 1 in Fig. 4 is a plot of N_{Re} versus U at $f = 81$ cycles/min. It is evident that pulsation at this frequency has no effect on U in the entire range of N_{Re} investigated. This is contrary to the observations of West and Taylor who, at a higher value of f (100 cycles/min.) and at $N_{Re} = 37{,}000$, observed an improvement to the extent of 70 per cent. Our data confirm the results of Marchant that low frequency pulsation has no effect in the turbulent region. Further confirmation of these results was provided by runs made at $f = 40$ cycles/min. and at two different pulsation ratios. Since these data almost coincided with the steady flow results of Table 1, they have not been reproduced here.

Runs were also made at $f = 160$ cycles/min. using two different pulsation ratios; the results which are recorded in Table I and plotted in curve 2, Fig. 4, clearly show that use of higher frequencies enhances heat transfer efficiency. At lower values of Reynolds number the improvement is more marked than at higher values, indicating that there is a decreasing response of U to the imposition of pulsation as the flow becomes increasingly turbulent. The conclusions of Linke[13] are somewhat similar, although he only reports a broad comparison between the effects in the viscous and turbulent regions. From Fig. 4 we see that at $N_{Re} = 5000$, there is an improvement of about 130 per cent as against about 30 per cent at $N_{Re} = 20{,}000$. As the values of N_{Re} employed by Linke are not known, a direct comparison with his results cannot be made.

The effect of pulsations in the turbulent region at any given average Reynolds number is the resultant of two opposing influences: (a) increase in h due to an increase in the instantaneous value of N_{Re} during the upsurge of the pulse and (b) decrease in h due to a decrease in the instantaneous value of N_{Re} during the downsurge of the pulse. The average value of h is, therefore, a complex function of the severity and nature of the pulse. The data obtained for water in this investigation suggest that unless the pulsations are of sufficient severity, the average value of h does not increase.

In the laminar region, where the entire body of the liquid is in viscous flow, the effect of pulsations is not

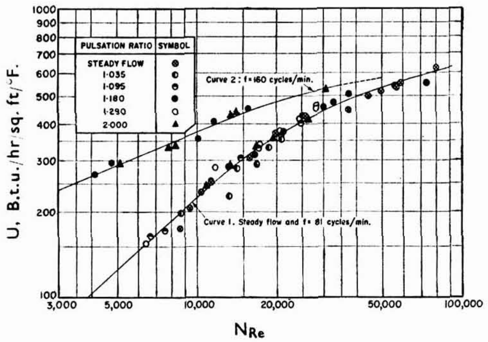

FIG. 4 — PLOT OF U VERSUS N_{Re}

likely to be significant due to the absence of a distinct film. The data of Webb and Morris support this view. On the other hand, it has been suggested from theoretical considerations[18] that when pulsations are imposed on a fluid in viscous flow, some kind of a turbulence is created in the entire body of the liquid which should greatly improve heat transfer rate. Experimental evidence for this is also reported[13,16]. Obviously, the nature of the pulse is of great importance in the viscous region.

Summary

The effect of pulsations on the heating of water (in the turbulent region) by steam in a tube-and-shell type heat exchanger has been investigated. For the type of pulsations resulting from the use of a reciprocating pump, the broad observations are: (1) unless the pulse frequency exceeds a certain value, the effect is not perceptible; (2) the improvement in *U* due to pulsation decreases as the Reynolds number is increased; beyond a certain Reynolds number the effect is almost negligible; and (3) the extent of pulse dampening (i.e. amplitude) at any frequency has no effect on heat transfer rate.

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References

1. ANDREAS, A., *Germ. Pat.* 717,766 (1942).
2. Maschinenfabrik Oerliken, *Brit. Pat.* 532,144 (1941).
3. ORMELL, E. A. I., *Germ. Pat.* 736,883 (1943).
4. ROBINSON, R. S., *U.S. Pat.* 2,514,797 (1950).
5. SCHREY, A., *Fr. Pat.* 806,030 (1936),
6. WORN, G. A. & RUBIN, F. L., *U.S. Pat.* 2,664,274 (1953).
7. MARTINELLI, R. C., BOELTER, L. M. K., WEIRBERG, E. B. & YAKAHI, S., *Trans. Amer. Soc. mech. Engrs*, **65** (1943), 789.
8. MARTINELLI, R. C. & BOETLER, L. M. K., *Proc. Fifth Internat. Congr. appl. Mech.*, 1938, 578.
9. MARCHANT, J. H., cf. MARTINELLI, R. C., BOETLER, L. M. K., WIERBERG, E. B. & YAKAHI, S., *Trans. Amer. Soc. mech. Engrs*, **65** (1943), 789.
10. MORRIS, R. R., *M.S. Thesis, Univ. of Washington*, 1950.
11. WEBB, R. P., *M.S. Thesis, Univ. of Washington*, 1949.
12. WEST, F. B. & TAYLOR, A. T., *Chem. Engng Progr.*, **48** (1952), 39.
13. LINKE, W., *Z. Ver. dtsch. Ing.*, **95** (1953), 1179.
14. LENLICH, R., *Industr. Engng Chem.*, **47** (1955), 1175.
15. STANTON, T. E., MARSHALL, D. & GRIFFITHS, E., *Advisory Committee for Aeronautics, R. and M. No.* 520, 1917, 16.
16. KUBANSKU, P. N., *J. tech. Phys., Moscow*, **22** (1952), 585, 598.
17. HAVEMANN, H. A., NARAYANA RAO, N. N., JAYACHANDRA, P. & GARG, G. C., *J. Indian Inst. Sci.*, **38B** (1956), 172.

Development of Catalysts for Methanol Synthesis

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The performance of a number of catalysts, which are ternary mixtures of metals and metal oxides with thoria and ceria as promoters, has been compared with that of the standard catalyst, ZnO : Cr_2O_3, at 100 atm. pressure and 300°C., and attempts have been made to replace Cr_2O_3 with other inexpensive metal oxides. It has been observed that a higher yield of methanol is obtained with a catalyst of the composition Cu : Zn : TiO_2 : ThO_2 : Ce_2O_3 (50·15 : 36·00 : 12·03 : 1·55 : 0·25) than with the standard catalyst. A conversion of 59 per cent of synthesis gas is achieved with this catalyst under the above conditions, and the product contains 90 per cent methanol and 10 per cent water.

INFORMATION on the catalysts employed in the synthesis of methanol is mostly covered by patents and a survey of the literature shows that efficient catalysts for use in the synthesis of methanol from hydrogen and carbon monoxide mixtures consist of zinc oxide, chromium oxide or copper oxide, or binary mixtures of difficultly reducible oxides of zinc, chromium or copper, chromium and the oxides of zinc and other metals such as silver, uranium and cadmium. Fenske and Frolich[1], Dolgov[2] and Plotnikov and Ivanov[3] found that a catalyst consisting of the oxides of copper, zinc and chromium had considerably higher activity for both the decomposition and synthesis of methanol than any of the binary systems copper-zinc or zinc-chromium[4-6].

In the present investigation, some catalysts which are ternary mixtures, with thoria and ceria as promoters, have been prepared, and attempts have been made to replace the costly chromium in the Cu-Zn-Cr catalyst by a suitable cheap metal, so that the cost of the catalyst may be lowered. A number of catalysts have been prepared and their performance at 100 atm. pressure has been studied. The results of these studies are recorded in this paper.

The main factors governing the catalytic synthesis of methanol are pressure, temperature, and CO: H_2 ratio in the synthesis gas mixture. Since the formation of methanol is accompanied by a large decrease in volume, the application of the high pressure and low temperature favour the synthesis reaction. Even with the best catalyst it is not possible to reduce the temperature of reaction below 300°C., and though with a pressure of 1000 lb./sq. in. practically 100 per cent methanol may be obtained at 300°C., it is desirable to work at higher pressures to prevent the formation of methane.

Experimental arrangement

The set-up used is shown in Fig. 1. The entire plant, including the compressor, was fabricated in the workshop of the Indian Institute of Science, Bangalore. Since the compressor (A) could develop a maximum pressure of 120-30 atm. only, all the studies were carried out at 100 atm. pressure. In a run, *c*. 200-50·litres of purified water gas were taken in a drum and compressed. The gas, enriched with hydrogen whenever necessary, was compressed and fed to the heated reactor (R), containing 30-40 ml. of the catalyst; the feeding of gas was done through the check valve (B) to prevent back suction, and then to a high pressure vessel (D), provided with a safety valve (C), and containing active charcoal and Cu-CuO catalyst to remove traces of iron carbonyl, oxygen and oil vapour, if any, coming from the compressor. The gas was passed to the heated reactor through the bleeder valve (N_2), and compressed after closing the needle valves (N_3 and N_4) till the pressure of 100 atm. was indicated in the pressure gauge (G_2).

The reactor was made of chrome steel containing 14 per cent chromium, and lined with copper. It was

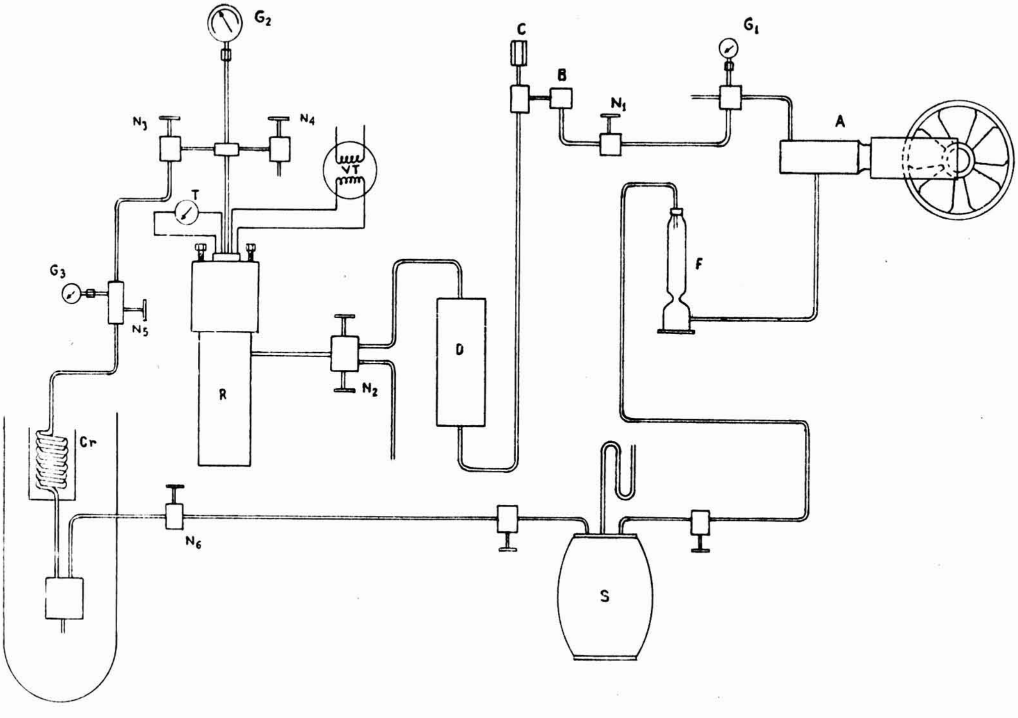

FIG. 1 — EXPERIMENTAL SET-UP (DIAGRAMMATIC) FOR THE SYNTHESIS OF METHANOL FROM SYNTHESIS GAS [A, compressor; B, check valve; C, safety valve; Cr, condenser; D, high pressure vessel; F, calcium chloride tower; G_1-G_3, pressure gauges; N_1-N_6, needle valves; R, reactor; S, steel drum; T, millivoltmeter; and VT, voltage transformer]

heated electrically, the heating being regulated by means of voltage transformer (VT). The temperature of the reactor was indicated by a thermocouple, put inside a well and connected to a sensitive millivoltmeter (T).

As soon as the desired temperature of *c*. 300°C. and pressure of *c*. 100 atm. were attained in the reactor, the needle valves (N_3, N_5 and N_6) were slowly opened till the required space velocity was obtained, precautions being taken to see that the temperature and pressure of the reactor were not disturbed. The pressure inside the reactor was maintained constant by releasing the reacted gas through the needle valve (N_6), placed at the end of the copper condenser (Cr), which trapped methyl alcohol and the uncondensed gases passed on to the mild steel drum (S) from which they were returned to the suction of the compressor after passing through calcium chloride tower (F) to remove moisture. This operation of recycling the gas was maintained for 4-5 hr.

In designing the apparatus, contact of hot gases (mixture of CO and H_2) with iron was eliminated as far as possible by using copper in the reactor and a condenser. The gas from the catalyst chamber was allowed to pass through a reducing valve (N_5) to a copper condenser where methyl alcohol condensed at 25 atm. pressure.

The whole system was calibrated once under the same conditions at room temperature to note the volume of gas passing through the catalyst chamber at 100 atm. pressure in 1 hr; this enabled the space velocity to be calculated. Decrease in the volume of gas at atmospheric pressure in 1 hr and also after 4-5 hr of reaction was noted.

A material balance calculation showed that about 90 per cent of synthesis gas can be accounted for in the product. There will be, however, loss of some gas, mainly due to (i) the collection of synthesis gas over water, (ii) difficulty of removal of all the methyl alcohol from the condenser and (iii) removal of a small quantity of gas along with the lubricating oil when it is tapped out from the condenser every 15 min.

Preparation of the catalysts — The compositions of the catalysts used in this investigation are given below:

Catalyst No.	Composition %
1	Cu, 50·15; Zn, 36·0; Cr, 12·03; ThO_2, 1·55; Ce_2O_3, 0·25
2	Cu, 50·15; Zn, 36·0; TiO_2, 12·03; ThO_2, 1·55; Ce_2O_3, 0·25
3	Cu, 50·15; Zn, 36·0; V_2O_5, 12·03; ThO_2, 1·55; Ce_2O_3, 0·25
4	ZnO, 75; Cr_2O_3, 25

Catalyst No. 1 — Requisite amounts of the dilute solution (30 per cent) of nitrates of zinc, copper, chromium, thorium and cerium were heated up to 60°C. and the carbonates of the metals precipitated by the addition of 30 per cent solution of sodium carbonate at 60°C. The precipitates were washed free from alkali with distilled water, filtered in a Buchner funnel and dried at 110°C. The cake was broken into granules (−5 to 10 mesh B.S. size). The granules were reduced at 350°C. in a current of hydrogen for 3-4 hr at a space velocity of 100. The reduced catalyst was removed under a current of hydrogen and quickly charged into the reaction chamber and again reduced at 350°C. with hydrogen for 4 hr. The catalyst was then ready for use.

Catalysts No. 2 *and No.* 3 — In case of these catalysts requisite amounts of titanium dioxide and vanadium pentoxide were kept in suspension in a solution of zinc, copper, thorium and cerium nitrates. While precipitating the carbonates of the metals by the addition of sodium carbonate solution, the same procedure was followed as in the case of catalyst No. 1. Vanadium petoxide was prepared by heating ammonium vanadate in air at 400°C.

Catalyst No. 4 was prepared from solutions of zinc and chromium nitrates to which sodium carbonate solution was added at 60°C. to precipitate the carbonates. The procedure followed for washing, drying and reducing the catalyst was the same as that employed for catalyst No. 1.

Results and discussion

The performance of different catalysts is recorded in Table 1. The results show that catalysts No. 1 (Cu : Zn : Cr) and No. 2 (Cu : Zn : TiO_2) show minimum side reactions at 300°C. and 100 atm. pressure and also give methanol of 90 per cent purity (rest being mainly water). The amount of methyl alcohol obtained per hour per litre of catalyst was *c*. 240 g. with catalyst No. 1 and 254 g. with catalyst No. 2 using synthesis gas containing CO and H_2 in the ratio of 1 : 2. Higher temperatures increased the formation of carbon dioxide and methane and lowered the methyl alcohol content of the crude product from 90 to 55-58 per cent.

The crude product obtained with catalysts No. 1 and No. 2 at 300°C. was distilled and the fraction distilling between 64° and 65°C. was collected; this formed 90 per cent of the crude product. The sp. gr. at 25°C. of the crude product was 0·8201-0·8109 and acid value 1·0-1·7. Sulphuric acid test was negative indicating the absence of olefines. Iodoform test was also negative showing the absence of aldehydes and ketones. Water content of crude product, determined by pyridine-acetyl chloride method, was 9-10 per cent. Higher alcohols, if any, in

TABLE 1 — PERFORMANCE CHARACTERISTICS OF DIFFERENT CATALYSTS

(Space velocity in all the experiments was 4·06 litres/hr/ml. of catalyst and reaction pressure, 100 atm.)

EXPT No.	ANALYSIS (%) OF INITIAL GAS					REACTION TEMP. °C.	REACTION PERIOD hr	ANALYSIS (%) OF FINAL GAS					CONVERSION OF SYNTHESIS GAS FROM NITROGEN BALANCE %	SPACE-TIME-YIELD g. methanol/hr/litre of catalyst
	CO_2	H_2	CO	CH_4	N_2			CO_2	H_2	CO	CH_4	N_2		
Catalyst No. 1 (*Vol. of catalyst, 30 ml.; wt of catalyst, 6·4 g.; synthesis gas enriched with hydrogen*)														
1	6·7	55·0	28·8	2·6	6·9	300	5	9·4	44·5	24·0	5·6	16·5	58·1	242
2	8·6	56·0	26·5	3·7	5·2	300	4	10·1	47·4	22·6	8·5	22·4	54·1	232
3	5·0	58·4	26·9	2·7	7·0	350	4	11·4	43·6	15·5	11·1	18·4	61·9	190
4	4·3	58·3	27·8	2·8	6·8	350	4	12·2	42·9	16·2	11·9	16·8	59·5	178
Catalyst No. 2 (*Vol. of catalyst, 30 ml.; wt of catalyst, 8·1 g.*)														
5	6·2	29·3	59·1	1·9	6·5	300	4	9·6	20·6	46·1	7·8	15·9	59·1	254*
6	2·3	28·6	57·9	2·2	7·0	350	4	20·0	11·8	33·0	17·9	17·3	60·8	165*
Catalyst No. 3 (*Vol. of catalyst, 30 ml.; wt of catalyst, 10·9 g.; synthesis gas enriched with hydrogen*)														
7	2·7	28·4	58·1	1·8	9·0	300	4	2·9	27·4	55·3	2·1	12·6	28·3	150
8	2·5	27·7	59·4	1·9	8·5	300	4	3·0	26·5	56·0	2·4	12·1	29·0	141
9	1·6	29·6	58·6	1·2	9·0	350	4	8·3	19·5	39·5	16·2	16·5	47·1	112
Catalyst No. 4 (*Vol. of catalyst, 30 ml.; wt of catalyst, 7·8 g.*)														
10	7·2	51·5	26·7	2·2	12·4	300	5	5·8	42·4	25·9	4·8	21·1	41·2	168*
11	7·0	53·1	26·2	2·2	11·5	350	5	9·8	41·7	22·4	7·1	19·8	41·7	142*

*A number of experiments were carried out under a particular set of conditions, but only data for one experiment are given here.

TABLE 2 — COMPARISON OF THE ACTIVITIES OF DIFFERENT CATALYSTS

[Composition of synthesis gas, 1CO : 2H₂ (approx.); reaction pressure, 100 atm.; reaction temp., 300°C.; and space velocity, 4·06 litres/hr/ml. of catalyst]

CATALYST No.	VOL. CONTRACTION FROM NITROGEN CONC. %	SPACE-TIME-YIELD g. methanol/hr/litre of catalyst
1	58·0	240
2	59·0	254
3	29·0	150
4	41·2	168

the product could not be identified by the phthalic anhydride method.

By incorporating V_2O_5 in place of chromium in the Cu-Zn-Cr catalyst (No. 3) the activity of the catalyst diminished considerably (Table 1), and the contraction in volume was only 27-31 per cent and about 150 g. of methyl alcohol per hour per litre of catalyst were obtained at 300°C. and 100 atm. pressure. V_2O_5 seems to have a deleterious effect on the catalyst.

The standard catalyst No. 4, containing ZnO and Cr_2O_3 in the ratio of 3 : 1, gave only 41 pér cent contraction in volume and about 168 g. of methyl alcohol per hour per litre of catalyst. Under the same conditions of temperature and pressure, the contraction in volume employing catalysts No. 1 and No. 2 was 51·9 and 57·8 per cent respectively. At higher temperature (350°C.), the standard catalyst yielded large quantity of methane and carbon dioxide as in the case of Zn-Cu catalyst containing Cr and TiO_2. But the yield of methyl alcohol was only 40 per cent — probably some undesirable side reactions taking place with this catalyst resulting in the decomposition of methanol into methyl ether and water.

It is evident from these studies that catalysts No. 1 and No. 2 are more effective for methanol synthesis at 100 atm. pressure than the catalyst No. 4.

A comparison of the performance of the various catalysts with the standard catalyst No. 4 (Table 2) shows that catalysts No. 1 and No. 2 containing Cu-Zn-Cr and Cu-Zn-TiO_2 and promoted by thoria and ceria, give much higher yields of methyl alcohol. By incorporating vanadium in catalyst No. 3 in place of chromium or titanium, the yield of methanol is very much lowered. The results given in Table 2 also indicate that the optimum temperature for these catalysts is 300°C.; higher temperatures decrease the yield of methanol in all cases although the volume contraction may be more.

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References

1. FENSKE, M. R. & FROLICH, P. K., *Industr. Engng Chem.*, **21** (1929), 1052-3.
2. DOLGOV, B. N., *Khim. Tverdogo Topliva*, **3** (1932), 185-204.
3. PLOTNIKOV, V. A. & IVANOV, K. N., *J. Industr. Chim., Moscou*, **7** (1930), 1136-45; *J. gen. Chem., Moscow*, **1** (1931), 826-44.
4. FROLICH, P. K., *J. Soc. chem. Ind., Lond.*, **47** (1928), 173-9T.
5. FROLICH, P. K., FENSKE, M. R., TAYLOR, P. S. & SOUTHWICK, C. A., *Industr. Engng Chem.*, **20** (1928), 1927-30.
6. CRYDER, D. S. & FROLICH, P. K., *Industr. Engng Chem.*, **21** (1929), 867-71.

Investigation of Less-known Oils in Hydrogenation Industries: Use of Tobacco Seed Oil

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Hydrogenation of tobacco seed oil has been investigated with a view to finding out its suitability as a new source material for vanaspati industry. For refining of the raw oil, before subjecting it to hydrogenation, treatment of the oil with 16°Bé alkali in 0·25 per cent excess and 2 per cent Fulmont earth plus 0·5 per cent activated carbon gives the best results.

It has been observed that on hydrogenation, besides saturated fatty acids, iso-oleic acid also contributes to the melting characteristics of the fat. Iso-oleic acids are undesirable constituents and do not offer any improvement in the stability of the product and restrict the formation of the saturated fatty acids. The variation in the characteristics and chemical composition of the hydrogenated products obtained under different conditions of hydrogenation has also been investigated.

TOBACCO seeds contain up to 46 per cent of a pale brown oil. In recent years the seed oil has found increasing use in the paint and varnish industry. During the Second World War, due to short supply of edible oils, tobacco seed oil was used in a number of countries as an edible oil without any adverse effects. Tobacco seed oil is readily available in the country at a comparatively low cost and the characteristics of the oil are well known[1].

The present communication records the results of hydrogenation experiments, carried out on the tobacco seed oil, with a view to finding out its suitability as a new source material for vanaspati industry. In particular, the selectivity of hydrogenation reaction and the formation of iso-oleic acids, which is very important for this partially hydrogenated edible fat, has been studied in detail. In order to achieve some selectivity in the hydrogenation reaction, the following factors were taken into consideration: (1) the type of catalyst used and its concentration; (2) pressure of the hydrogen gas; (3) temperature of the reaction; and (4) the degree of dispersion of hydrogen gas. In this investigation a few trial runs with different catalysts, supplied by Messrs Hindustan Levers and Messrs Swaika Vanaspati Products, and the nickel catalyst made by wet-reduction process in this laboratory and Rufert catalyst, were tried. Among these, Rufert catalyst has been found to be the best as regards its uniformity

TABLE 1 HYDROGENATION OF TOBACCO SEED OIL AND THE FATTY ACID COMPOSITION OF HYDROGENATED PRODUCTS

SAMPLE No.	DURATION OF HYDROGENATION *hr*	IOD. VAL. OF OIL (WIJ'S ½ HR)	REF. INDEX AT 40°C.	SLIP POINT °*C.*	WILLEY M.P. °*C.*	FATTY ACID COMPOSITION				
						Linolenic acid %	Linoleic acid %	Oleic acid (total) %	Iso-oleic acid %	Saturated acids (by difference) %
			Expt I [*Charge*, 100 *g.*; *catalyst*, 0·5% (*active nickel*); *temp.*, 150-80°*C.*]							
0	0	139·60	1·4690	—	—	1·6	71·50	12·20	1·10	14·70
1	1	128·00	1·4690	24·0	—	—	60·00	23·50	11·90	16·50
2	2	97·90	1·4665	32·0	—	—	25·20	57·50	23·84	17·30
3	3½	56·40	1·4615	48·0	53·0	—	0·60	64·10	37·24	35·30
4	4½	34·08	1·4595	56·5	62·5	—	0·30	38·70	21·04	61·00
5	5½	16·90	1·4571	63·0	68·5	—	0·20	18·60	8·25	81·20
6	6½	7·75	1·4550	66·0	71·5	—	0·10	6·50	3·20	93·40
			Expt II [*Charge*, 1500 *g.*; *catalyst*, 0·5% (*active nickel*); *temp.*, 160-5°*C.*]							
0	0	139·60	1·4690	—	—	1·6	71·50	12·20	1·10	14·70
1	2	118·70	1·4690	—	—	—	49·64	33·31	11·43	17·05
2	3	105·40	1·4680	—	—	—	34·33	47·99	19·20	17·68
3	4	97·75	1·4670	—	—	—	27·11	54·42	8·20	18·47
4	5½	83·33	1·4654	—	—	—	12·60	67·39	10·47	20·01
5	7½	71·60	1·4640	35·0	—	—	2·30	75·46	36·58	22·24
6	8½	69·39	1·4638	36·0	—	—	0·32	76·54	40·09	23·14
7	9½	63·28	1·4638	39·0	—	—	0·16	70·08	40·79	29·76
8	10½	57·68	1·4625	42·0	—	—	0·10	63·98	32·89	35·92
9	11½	55·18	1·4620	45·5	—	—	0·90	61·20	30·07	38·71

of behaviour and selectivity. Accordingly, Rufert catalyst was used in all subsequent investigations.

Experimental procedure

Refining of tobacco seed oil — Tobacco seed oil (iod. val., 139·6; free fatty acid content, 1·47 per cent) was highly coloured as shown by its colour index, determined with the help of a Lovibond tintometer. As it was considered inadvisable to use this highly coloured oil directly for hydrogenation, and due to insufficient data on the refining of the oil, the coloured oil was subjected to the following refining procedure. The oil was treated with alkali solution of different strengths and in varying proportions. Fullers' earth (B.D.H.), bentonite, activated charcoal and Fulmont earth 511C (I.C.I.) were employed in different concentrations in a series of experiments to bleach the oil. The extent of colour removal in each experiment was studied with the help of a Lovibond tintometer. From the point of view of per cent colour removal and per cent loss in refining, treatment with 16°Bé alkali in 0·25 per cent excess and 2 per cent Fulmont earth plus 0·5 per cent activated carbon gave the best results. These refining conditions were followed while the oil was processed through a De Laval oil refining unit. Total loss through alkali refining and vacuum bleaching (22 in. Hg) for 1 hr was 18·5 per cent. This high loss could be easily reduced by employing a large charge. The degree of colour removal was quite satisfactory (red, 75 per cent and yellow, 71·4 per cent).

Hydrogenation of the oil — Hydrogenation experiments were carried out on a laboratory scale to determine the optimum conditions which could be adopted on pilot plant scale in a dead-end circulating type of hydrogenator. Experiments were repeated employing the same experimental conditions but with a charge of 1500 g.

Refined oil contained in a three-necked flask fitted with a magnetic stirrer was hydrogenated at temperatures ranging from 150° to 180°C. and at atmospheric pressure. In order to gain a better understanding of the hydrogenation reaction, the oil was hydrogenated to the maximum extent, i.e. when there was no more absorption of hydrogen by the oil. A series of samples at regular intervals were drawn and analysed. In Table 1 are recorded the analytical data for the different samples collected from an experiment conducted with 100 and 500 g. of oil.

Cis-linoleic acid was estimated by the ultraviolet spectrophotometric method employed by Hilditch *et al.*[2] and iso-oleic acids by the method of Cocks *et al.*[3].

Discussion

From the results of expt I (Fig. 1) it is seen that reaction rate is higher at higher temperatures as compared to the reaction temperature of 150-5°. In

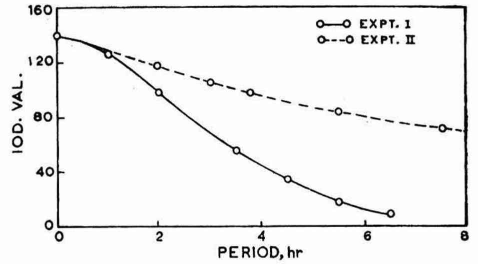

FIG. 1 — PROGRESS OF HYDROGENATION AT DIFFERENT TEMPERATURES [Temperature during the first hour of reaction 150-5°C., second hour 170-5°C. and thereafter 180-5°C.]

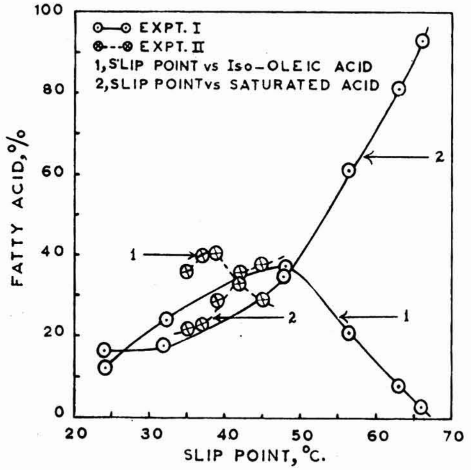

FIG. 2 — INFLUENCE OF SATURATED AND ISO-OLEIC ACIDS ON THE MELTING CHARACTERISTICS OF HYDROGENATED PRODUCT

expt II (Fig. 1) the curve is somewhat flattened, indicating the lengthening of the period of reaction. This is understandable in view of the large amount of charge used in expt II.

It is observed from Fig. 2 that along with saturated fatty acids, iso-oleic acids definitely contribute to the melting characteristics of fats.

Conversion of linoleic acid to oleic acid is much higher as compared with oleic to saturated acids (Fig. 3). With the gradual decrease in the concentration of linoleic acid, concentration of oleic and iso-oleic acids increases. When linoleic acid concentration attains a low value, hydrogenation of iso-oleic and oleic acids starts. It is thus clear that the hydrogenation takes the following course:

$$\text{Linoleic} \left[\begin{array}{l}\rightarrow \text{oleic}\\ \rightarrow \text{iso-oleic}\end{array}\right]\rightarrow \text{saturated acid}$$

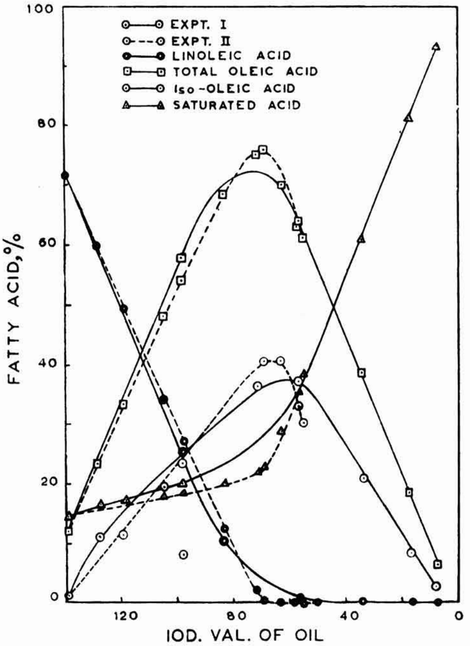

FIG. 3 — CHANGES IN FATTY ACID COMPOSITION OF HYDROGENATED PRODUCT WITH PROGRESS OF HYDROGENATION

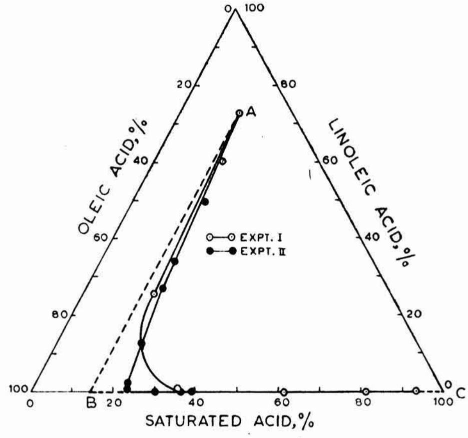

FIG. 4 — COMPARISON OF THE SELECTIVITY OF THE HYDROGENATION REACTION WITH THEORETICAL SELECTIVITY

Fig. 4 shows the selectivity of the hydrogenation reaction in which ABC represents theoretical selectivity whereas the curved line is the actual selectivity of the reaction. It appears from the graph that the run is fairly selective.

It is seen from the analytical data for expts I and II that broadly comparable values are obtained. Selectivity of hydrogenation reaction in expt II is better than that in expt I, as the hydrogenation in expt II is accompanied by the formation of small amount of iso-acids at comparable iodine values of the hydrogenated oils.

Conclusion

The use of partially hydrogenated fat in hydrogenation reaction requires that it should have an extended plastic range, it should be soft and plastic at room temperature, and should possess some body at temperature close to body temperature. Stability of the hydrogenated oils is important since they are exposed to a high temperature in baking and frying and are not usually kept in cold places. Selective hydrogenation conditions are necessary in order to convert all linolenic and linoleic acids to stearic and oleic acids and thus achieve maximum stability. However, such selective hydrogenation also favours the formation of iso-acids, which are undesirable constituents, because they have a higher melting point than normal oleic acid. Also, iso-acids do not effect improvement in the stability of the product. Since the iso-acids are high melting, they restrict the formation of saturated acids that could otherwise be formed with greater benefit to the stability of the product. Saturated acids also serve to extend the plastic range and provide body required at high temperature. It may be pointed out that samples No. 5 and 6, expt II, falls closely within the range of vanaspati insofar as their fatty acid composition, melting points and consistency are concerned. Further work regarding the nutritional aspects of these hydrogenated fats is in progress.

Production of hydrogenated tobacco seed oil has many attractive features. There is a large saving in the cost of raw tobacco seed oil, which is at present available in commercial quantities and is cheaper than groundnut oil. However, tobacco seed oil requires a large amount of hydrogen during hydrogenation reaction to produce a product which has a consistency like that of vanaspati. It can safely be remarked that advantages gained in raw oil cost will by far outweigh the disadvantages incurred from the increasing cost of hydrogen gas and finally the cost of production will be lowered.

Acknowledgement

The authors' thanks are due to the Council of Scientific & Industrial Research, New Delhi, for awarding a research assistantship to one of them (M.K.C.) and also to Prof. B. C. Guha, Head of the Department of Applied Chemistry, Calcutta University, for providing facilities.

References

1. CHAKRABARTY, S. R. & CHAKRABARTY, M. M., *J. Indian chem. Soc., Industr. & News Ed.*, **20** (1957), 17.
2. HILDITCH, T. P., MORTON, R. A. & RILEY, J. C., *Analyst*, **70** (1945), 68.
3. COCKS, L. V., CHRISTIAN, B. C. & HARDING, G., *Analyst*, **56** (1931), 368.

Symposium on Algology

UNDER THE JOINT SPONSORSHIP OF THE INDIAN Council of Agricultural Research and the Unesco South Asia Science Co-operation Office, a Symposium on Algology will be held in New Delhi from 7 to 12 December 1959. Delegates from Afghanistan, Australia, Burma, India, Nepal and Pakistan will be participating in the symposium; F.A.O. has been invited to send an expert. Prof. Horishi Tamiya, Tokugawa Institute for Biological Research, Tokyo, Dr G. E. Fogg, Department of Botany, University College, London, Prof. H. V. Witsch, Director, Botanisches Institut, Freising-Weihenstephen (Federal Republic of Germany), and Prof. G. E. Papenfuss, Department of Botany, University of California, are expected to take part in the symposium.

The symposium will confine itself to problems concerning edible and nitrogen fixing algae. About 30 papers will be presented at the symposium of which 22 will be by the Indian delegates. The papers will be discussed at the following six technical sessions: Morphology, Phylogeny and Systematics; Physiology and Biochemistry; Ecology; Limnology and Economic Uses; and Cytology. In addition, three popular lectures by Prof. M. O. P. Iyengar (Present Status of Algology in India), Prof. H. Tamiya (Role of Algae as Food) and Dr G. E. Fogg have been arranged.

REVIEWS

INDUSTRIAL HYGIENE AND TOXICOLOGY: Vol. 1 — GENERAL PRINCIPLES by Frank A. Patty (Interscience Publishers Inc., New York), Second Edition (Revised), 1958. Pp. xxviii + 830. Price $ 17.50

Dr Patty is well known for his work in the field of industrial hygiene, and since 1948, when the first edition was published, his book, *Industrial Hygiene and Toxicology*, has been a standard reference work.

The science of industrial hygiene has emerged as a homogeneous discipline in recent years and more so during and after the Second World War. Many an underdeveloped country was developing health programmes on scientific lines as a result of the establishment of new industries, and even in industrially advanced countries many a new problem had arisen. The need was urgent for making available all scientific information in diverse branches of science leading ultimately to the promotion and maintenance of the health of the man behind the machine. The excellent compendium brought out by Dr Patty in 1948 met the needs of the day admirably. The constant changes in the concepts of industrial health and community health services necessitated the bringing out of a new revised edition of the book. Industrial environmental analysis occupied a single chapter in the first edition; the subject has now grown in status and is proposed to be treated in a full volume (III). Special mention may also be made here of the useful chapter on industrial sanitation in the second edition. It brings out the importance of the role of the sanitary engineer in the field of industrial health.

If the object of the author is to see that the book continues to serve as a reference volume, the following suggestions may be considered while revising this edition. Information on the following subjects would be welcomed by workers and administrators in the field, either as separate chapters or as parts of the existing ones.

Industrial health administration — Many an underdeveloped country has to go a long way to learn from the more advanced countries on the administrative bottlenecks in general and especially in a specialized subject like industrial hygiene. Similarly, industrial hygiene administration inside a factory or work place is not well recognized in underdeveloped countries, as industry itself is not developed on sound lines.

Industrial medical services — In spite of its obvious difficulties the situation often arises that due to lack of trained personnel, the effective practice of industrial hygiene is relegated to the background and not too often the only scientific person implementing industrial hygiene in the factory is the medical officer. It would be useful if, in this reference volume, the organization of industrial medical services in factories and other work places is treated in an adequate manner.

Industrial health in the tropics — Not a few international conferences have been convened to study problems of industrial health peculiar to the tropics. It would, therefore, be advantageous if a special chapter is devoted to this subject.

In conclusion, the reviewer would like to make another suggestion: it would be better if the few pages dealing with equivalents, conversion factors and tables for gases and vapours at the beginning of the book are taken over to the end of the volume.

The book is a must for every laboratory and library directly or indirectly connected with occupational health.

M. N. RAO

MODERN TRANSISTOR CIRCUITS by John M. Carrol (McGraw-Hill Book Co. Inc., New York, Toronto, London), 1959. Pp. xii + 268. Price $ 8.50

This volume contains over 100 articles that appeared in the magazine *Electronics* during the years 1956 to 1958. The book is divided into 17 chapters and contains over 200 circuit diagrams with design information and component values.

The first chapter, entitled circuit design data, contains articles giving information on the operation of transistors under the influence of atomic radiation, design nomographs for stable operation of junction transistors at high temperatures, design nomographs for transistors at audio frequencies, design formulae for using h-matrix parameters, and conversion formulae for hybrid parameters.

The next four chapters (Chapters 2-5) are devoted to transistor circuits of generic types such as amplifiers, oscillators, power supplies, and pulse circuits. Chapter 2 on amplifiers contains articles dealing with temperature compensation of audio amplifiers and 1-Mc/s. i.f. amplifiers using thermistors, design information on audio amplifiers with high input impedance, and high frequency amplifiers using melt-back tetrodes. Chapter 3 is on oscillators and has valuable information on Colpitt, crystal-controlled, and feedback oscillators design. It also contains an interesting article on oscillators employing silicon crystals for obtaining high temperature stability. Design of voltage regulated power supplies, using balancing bridges, series and shunt regulators, and multivibrators forms the contents of articles in Chapter 4. The next chapter on pulse circuits contains articles on variable width pulse generators, sweep generators, flip-flop circuits and techniques for increasing their switching speed.

The remaining chapters of the book are devoted to specialized circuit applications. Chapter 6 on home-entertainment circuits has articles ranging from simple pre-amplifiers for ceramic and magnetic pickups to reflex-type radio receivers with two and four transistors, and automobile radio receivers with eleven transistors. The next chapter is a collection of articles on radio and television broadcast equipment and contains circuits on video pre-amplifiers for studio monitors, portable television cameras, two-channel mixers for tape recording, etc. Chapters 8 and 9 are devoted to r.f. and audio communication circuits. The r.f. circuits include a 52-Mc/s. transceiver, a 40-metre transmitter, a rural carrier system with selective calling; the audio circuits cover public address systems operating under aircraft noise, and instantaneous speech compressors. Chapter 10 contains circuits of test equipment for transistor production, measurement of junction transistor parameters, and other laboratory equipment such as oscilloscope pre-amplifiers, null-detectors. The next three chapters (11, 12 and 13) are devoted to industrial control, and measurement and detection circuits. The control circuits include operation of air-borne searchlight, nuclear reactors, navigation trainer ship models, and servo systems; measuring instruments include those for indication of jet aircraft exhaust, monitoring of gamma rays using Geiger tubes, and a transistor clock; detection circuits include those used for detection of metal ducts, pipes, buried cables, and crevasse in glacial trails. Chapter 14 is devoted to transistor circuits in aircraft, missiles and satellites. Scientific and medical instruments such as pill telemeters for use in digestive tract, pen-recorder amplifiers for use in medical diagnosis, and telemeters for determining ocean temperatures form the subject matter of Chapter 15. The last two chapters (16 and 17) deal with circuits and auxiliary equipment for computers. These comprise counters, basic logic circuits, and digital to analogue converter circuits.

In these days, when the transistors are finding increasing and varied applications ranging from home-entertainment to conquest of outer space, *Modern Transistor Circuits* provides an excellent collection of articles for the electronic engineer.

D. L. SUBRAHMANYAM

SOVIET PHARMACEUTICAL RESEARCH: Vol. I — PHARMACEUTICAL CHEMISTRY (Consultants Bureau Inc., New York), 1958. Pp. 447. Price $ 95.00

The translation of some of the more important Soviet research papers into English and their publication in a volume is highly commendable. Since Soviet scientific literature in any specialized discipline is bound to be voluminous, it is inevitable that the choice of papers for translation must be rather limited, and the scientific interests of the translating body must also lead to selective translations, and in this process some important papers may be left out.

The first of the three volumes published under the title " Soviet Pharmaceutical Research " is a collection of selected papers on physical chemistry, some of which deal with physical aspects of pharmaceutical chemistry. One has a feeling that the title ' Pharmaceutical Chemistry ' for such a volume is rather misleading because many of the papers in it would be of interest to chemists occupied in professions other than pharmaceutical chemistry. The 73 papers in this volume are divided into four specific sections dealing with (i) Solubility, (ii) Stability, (iii) Ion exchange and (iv) Emulsions, suspensions and gels, and there is a fifth section subtitled ' Miscellaneous '.

The section on solubility carries a translation of 17 papers in which the laws of solubility, solubility variation, the mechanism of solubilization and a study of precipitates and their solubility in the presence of common ions are discussed. All these papers are fairly representative of the trends of Soviet research in this field. There is a good paper on the solubility of alginates, but for a volume on pharmaceutical chemistry one would expect a translation of a paper, if there is any, on the solubility factors of alginates in the production of plasma substitutes.

The section on stability (6 papers) carries an interesting paper on the effect of activated charcoal on the oxidation of papaverine by atmospheric oxygen, and one on the thermal stability of collagen in the dry state. In the former, the authors have shown that the colour reaction of papaverine with sulphuric acid is due to the interaction of sulphuric acid with papaverinol which is an oxidation product of the parent base. The latter paper is of particular interest to leather chemists. The authors have suggested a mechanism involved in the thermal shrinkage of dry collagen both in the untanned and the tanned states.

The section on ion exchange carries 8 interesting papers on different aspects of this important subject. There are interesting contributions on heterogeneous ion-exchange reactions, determination of the absorptive capacity of ion-exchange materials and ion exchange on starch, and the possibility of preparing starch samples containing a definite ion. Perhaps translations of some more papers in this section would have been worth while.

The section on emulsions, suspensions and gels (13 papers) carries a variety of papers on subjects like the mechanism of emulsification, effects of selective wetting on emulsion formation, emulsion stabilizers, structure of gels and the effect of surface active substances on the properties of agar gels.

The last section, carrying a miscellaneous group of papers (30), is truly pharmaceutical in character. It includes papers on such subjects as the optimum conditions for preparing crystalline glucose, a colorimetric method for the quantitative determination of penicillin, the decomposition voltage of alkaloidal salts, the adsorption method of separating caffeine, polarographic investigation of sulphanilamides, methods of determining powder dispersion and causes of the granulation of powders, a study of a process for sorbing essential oil vapours on porous adsorbents, chemical nature of alginic acids, application of infrared absorption spectra in the investigation of the intermediates in carotene synthesis, and a study of pharmacologically active substances by physicochemical methods. All these papers are of considerable importance to a pharmaceutical chemist.

The papers cover the period 1947-55 and most of these were published after 1950. It would be of considerable advantage to the scientific world if the Consultants Bureau Inc. carry forward these efforts and provide translations of the important papers as and when they appear.

There are a few language errors in translation, but otherwise the volume is got up nicely. The price, however, is far too high, and even some of the libraries, not too well endowed, may find it difficult to acquire it. Perhaps the Consultants Bureau may eventually be able to reduce the price to a level where more libraries can afford to buy these excellent publications.

M. L. DHAR

SOVIET PHARMACEUTICAL RESEARCH: Vol. II — PHARMACOGNOSY (Consultants Bureau Inc., New York), 1958. Pp. 401. Price $ 90.00

This volume is a collection of translations of 82 papers on phytochemistry. The title ' Pharmacognosy ' is rather misleading. The term pharmacognosy, as generally accepted, implies the study of the characteristics of crude drugs and their powders, while the papers in this volume deal with the isolation of the chemical constituents of plants and the investigation of their structure and chemical behaviour. Perhaps a more appropriate title would be ' Medicinal Phytochemistry ' or just ' Phytochemistry '.

The bulk of this volume (61 papers) is devoted to alkaloids. There are three papers on cardiac glycosides, seven on essential and fatty oils and the remaining eleven papers deal with saponins, resin acids and colouring matters, etc. Perhaps the articles on Butlerov's doctoral dissertation on essential oils and the review of Pigulevsky's book on terpenes could have been omitted and the space devoted more profitably to a few more papers on glycosides.

The interest of the Soviet scientists in plant chemistry is clearly reflected in these papers which represent the work of several important research centres in the Soviet Union. A large number of papers are from the S. Ordzhonikidze Research Institute of Pharmaceutical Chemistry, Moscow, and the Alkaloid Chemistry Laboratory of Uzbek Academy of Sciences, Tashkent. They represent some of the important contributions of Menshikov, Kuzovkov, Massagetov, Proskurina and Yunusov to the study of the structure of alkaloids isolated from a variety of plants. Other centres such as the Lomonosov Institute of Fine Chemicals Technology, Moscow, where Preobrazhensky is working on the synthesis of colchicine analogues and of magnoline bases, and the Kharkov Research Institute of Pharmaceutical Chemistry are also represented.

The papers on alkaloids are mainly of a fundamental nature. There are 14 papers dealing with the structure and interrelationship of the Aconite and the Delphinium alkaloids, three each on the Thalictrum and the Anabasis bases and four on the alkaloids of the Senecio species. The interest of the Soviet chemists in the exploitation of natural products for the production of drugs for clinical purposes is reflected in the papers on the separation and purification of anabasine, cytisine and cinchona alkaloids.

One of the papers on glycosides describes a commercial process for the isolation of cymarin from Indian hemp, as a substitute for strophanthin, and a polarographic method for the quantitative estimation of some cardiac glycosides is discussed in another paper. The essential oil from the wild carrot, *Daucus carota*, has been claimed to be a new source for geraniol and the Artemisia essential oils have been shown to be varyingly rich in cineole and camphor.

There are a number of typographic and translation errors, though the volume is otherwise well printed. The price of this volume is high and it is to be hoped that the publishers will consider reducing it so that it may be available to groups of interested workers in most laboratories.

M. L. DHAR

ELECTRICAL ENGINEERING PRACTICE: Vol. I — A PRACTICAL TREATISE FOR ELECTRICAL, CIVIL AND MECHANICAL ENGINEERS, by J. W. Meares & R. E. Neale (Chapman & Hall Ltd, London), Revised Sixth Edition, 1958. Pp. xiii + 716. Price 60*s*. net

This is a completely revised edition. The book has a long-established reputation as a practical treatise for electrical, mechanical and civil engineers. For revising the various portions of the text, the publishers obtained the services of the following experts and specialists in different fields: C. C. Barnes for Cables; E. H. W. Banner for Instruments and Measurements; D. J. Bolton for Electrical Costs and Tariffs; T. H. Carr for Power Stations, etc.; and Prof. E. Bradshaw for M.K.S. System and Units. The general plan of the book remains as it was in the previous edition.

The revised edition has taken into account recent advances in equipment and materials, specially insulating materials. The chapter on materials has been completely revised. Among others, the new M.K.S. system units, new methods of measurement of magnetic flux, nuclear energy in power generation, latest developments in insulated wires and cables and in protection of circuit and apparatus have been discussed. New standards for instrument transformers and factors regulating breaking capacity of oil circuit breakers are incorporated.

The radical changes in the supply of electrical energy resulting from the operation of the Central Electricity Board in Great Britain and corresponding developments in other countries have been given due notice in the revised edition. Latest British Standard Specifications have been referred to in revising different data. The table of conventional signs for electrical diagrams has been completely revised and includes conventional signs for thermionic tubes.

Bibliography at the end of each chapter has been completely revised and brought up to date. All the photoplates in the earlier editions are, however, missing in this edition.

The publishers have been successful in maintaining the high standard and technical accuracy for which the book is reputed. The revised edition will continue to be useful to all engineers.

C. S. GHOSH

PRINCIPLES OF ELECTRONICS — Cleaver-Hume Electrical Series No. 9, by H. Buckingham & E. M. Price (Cleaver-Hume Press Ltd, London), Second Edition, 1958. Pp. 419. Price 17*s*. 6*d*. net

This book is the ninth in the Cleaver-Hume Electrical Series and is intended for those following a general electrical engineering course. In particular, the book satisfies the needs of heavy current electrical engineers and others who require a knowledge of basic electronic methods and their applications.

The subject matter of the book falls broadly into three parts. The first five chapters deal with basic facts and fundamental concepts underlying electronic phenomena and the next six chapters (VI-XI) are devoted to a description of common electronic devices such as high vacuum diode and triode, multielectrode valves, gas-filled diodes, thyratrons, mercury arc rectifiers, cathode tubes, etc., and their principles of operation and construction, and characteristics. The portion of the chapter on vacuum diode, dealing with interstage coupling, power amplifier and oscillator circuits, is rather cursory in treatment. Since these subjects are basic to all electronic applications, it would be desirable to treat them more exhaustively. Chapter VIII on multielectrode valves suffers from a similar drawback, falling short in adequate description and explanation. The next nine chapters (XII-XX) deal with various kinds of electronic devices and methods of application to engineering and industrial problems. These include high frequency triode tubes, magnetrons, klystrons, emitrons, orthicons, particle accelerators, electron microscope, measuring instruments, etc. There is also a brief description of the Dekatron, which gives an output pulse for every tenth input pulse. Measurement of opacity and turbidity, photoelectric controls, high temperature indicators, induction and dielectric heating, and measuring instruments such as valve voltmeters, counters, etc., are also discussed in these chapters. The last two chapters (XIX and XX) deal with the principles of operation and applications of magnetic amplifiers and junction transistors. Lastly, the book contains over 120 questions which include a good number of numerical problems.

The book under review should prove useful for non-electronic engineers interested in electronics.

D. L. SUBRAHMANYAM

REFRIGERATION AND AIR-CONDITIONING — McGraw-Hill Series in Mechanical Engineering — by W. F. Stoecker (McGraw-Hill Book Co. Inc., New York), 1959. Pp. vii + 397. Price $ 8.00

The author, who has had considerable experience in teaching and research on the subject, has, in bringing out this book, made a useful contribution to the existing literature on Refrigeration and Air-conditioning. The emphasis in the book is on the basic concepts of thermodynamics and fluid mechanics, in so far as they apply to heat and mass transfer problems. The principles are lucidly explained with the minimum of mathematics and with the help of appropriate diagrams, charts and tables.

The vapour compression system is more exhaustively dealt with and the performances of compressors, condensers, expansion devices and evaporators are described separately bringing out clearly the factors contributing to their efficient performances, individually and in combination. The other systems like absorption refrigeration, air-cycle and steam-jet refrigeration are also adequately covered. A discussion of heat pumps and their working principles is included.

Useful tables give the comparative properties of the different refrigerants in common use, more especially ammonia, and halocarbon refrigerants. Their volume flow and power requirements per ton of refrigeration and their coefficients of performance are critically discussed and their relative economies and special applications indicated. Psychrometry and enthalpy potentials are adequately explained with applications to the design of cooling towers, dehumidifying and spray equipment. Calculations of air-conditioning loads, due to all contributing sources, are briefly but clearly explained to the necessary extent. Calculations of the pressure drops inside connecting pipes and their effect on the general efficiency of the system are also not overlooked. In fact no important subject connected with the refrigeration and air-conditioning technology is omitted. The treatment throughout is clear, concrete and specific. A chapter on liquefaction of gases including hydrogen and helium, and methods of approximating to the absolute zero of temperature, may appear perhaps to be outside the strict scope of the book. One would wish that descriptions of actual items of associated equipment and auxiliary gadgets and their workings are also described in greater detail.

The book should prove a valuable reference work to refrigeration and air-conditioning engineers. Exhaustive tables and charts to aid correct design are included both in the body of the book and at the end. Charts on pressure-enthalpy relations of refrigerants and psychrometric charts for low and normal temperature ranges are printed in separate sheets and included in a pocket on the back cover. The book can also be used with advantage as a textbook in technological institutions. A large number of worked out examples in the body of the text, besides fairly comprehensive bibliographies and illustrative test problems included at the end of each chapter, increase the utility of the book for the student.

The emphasis laid, throughout the book, on basic principles influencing performance and design is a refreshing feature of this book. It can be recommended to both engineers and physicists.

T. N. SESHADRI

CHEMICAL CONSTITUTION — AN INTRODUCTION TO THE THEORY OF THE CHEMICAL BOND by J. A. A. Ketelaar (Elsevier Publishing Co., Amsterdam, New York, London; *Sole Distributors for the Commonwealth excluding Canada*: Van Nostrand Co. Ltd, London), Second Revised Edition, 1959. Pp. viii + 448. Price 47*s*. 6*d*.

The enormous progress made by theoretical chemistry in the last 25 years has been to a large extent due to the advent of wave mechanics and the fresh insight provided by this theory into problems of atomic and molecular structure. Dr Ketelaar's objective in writing this volume was to bridge the gap between the classical organic chemist and the theoretician, and in showing the systematization brought into organic chemistry by the development of the quantum theory and the new ideas that have spread under its influence. The volume is described as ' an introduction to the theory of the chemical bond ' and is intended for the general reader with limited mathematical attainments.

The second edition incorporates several improvements on the original edition which appeared in 1953. Many of the figures and tables have been revised and several new topics have been included. Prominent among them are those on stereochemistry, crystal field theory and cyclopentadienyl-metal complexes. A few sections, notably that on the hydrogen bond, have been completely rewritten making the subject matter up to date. The large number of references to recent literature and review articles that have been given, form a useful addition.

An introductory chapter on the periodic table, the basic concepts of wave mechanics and the four types of chemical bonding (ionic, atomic, metallic and Van der Waals) comprise the first of the five sections that make up this volume. The section on ionic compounds which follows next is devoted to a discussion of the subject mostly from a classical point of view, special attention being paid to ionic radii, crystal structures, ion-ion complexes, ion-dipole complexes, acid and base strength, volatility hardness, colour and solubility. The author begins the next section on the atomic bond with the quantum mechanical treatment of covalency and the structures of the hydrogen molecule ion and the hydrogen molecule, and then proceeds to a discussion of the more complex molecules in terms of resonance, bond energy, hyperconjugation and colour. A serious attempt has been made to use both of the two main competing theories, commonly known as the molecular orbital and valence bond methods. A short section is devoted to a discussion of the metallic bond and the last part of the book deals with Van der Waals interaction and the nature of the hydrogen bond.

The first edition of Pauling's volume on Nature of the Chemical Bond appeared two decades ago. Though a number of treatises on modern physical organic chemistry have appeared since then, Dr Ketelaar's book is unique in so far as an attempt is made by the author to treat the nature of chemical bond and chemical constitution as one single problem approached from a number of facets. The book is well produced and is free from linguistic errors and misprints. The book is highly recommended to all chemists interested in theoretical organic chemistry. Those approaching the subject for the first time will find it an excellent introduction to the field; those already acquainted with the subject matter will find delight in the systematization brought into organic chemistry by Dr Ketelaar's approach.

H. SREEPATHI RAO

SUCCESSFUL PROCESS PLANT PRACTICES — OPERATION, MAINTENANCE AND SAFETY by Robert L. Davidson (McGraw-Hill Book Co. Inc., New York), 1959. Pp. xxii + 302. Price $ 10.00

The author of the book, who is at present the Associate Editor of *Petroleum Processing*, has had wide professional experience of many process industries, and, therefore, the book has the authority of an expert behind it. The book, which is stated to be based on 500 articles published in *Petroleum Processing*, presents a wealth of practical information arranged in a handy manner to facilitate quick reference. It covers such subjects as operation, maintenance, repair, safety, etc., in process industries, particularly the chemical industries, with which the author was associated and had to deal with problems like corrosion, leakage, etc. The author should be commended in bringing together useful data and information from a large number of sources under one cover, which only a man of his long experience in the field can attempt.

A feature of this book is the large number (270) of excellent illustrative diagrams and photographs of plant, equipment, etc., which amplify, step by step, the instructions regarding various intricate maintenance and operational procedures met with in process industries. Details of work procedure are adequately covered.

In five parts, under the heads Managing the Job; Maintaining the Equipment; Handling Processes and Products; Protecting Equipment; and General Equipment, the book is largely devoted to subjects which will interest those in chemical plants, particularly those connected with maintenance. Equipment common to all process industries such as pumps, towers, reactors, piping, valves, motors, control instruments, exchangers, condensers, etc., are fully treated. Practical plant working data such as capacities, operating conditions and schedules, materials of construction, tools to be used and how to use them, are presented. The applications of automatic controls in chemical industry are presented in non-mathematical language, which permits easy understanding of the subject by the process engineer.

The book is essentially a practical manual, and should serve as a valuable reference work for the chemical and plant engineers.

T. N. RAO

POLAROGRAPHY IN MEDICINE, BIOCHEMISTRY AND PHARMACY by M. Brezina & P. Zuman, translated from Czech into English by S. Wawzonek (Interscience Publishers Inc., New York), Revised English Edition, 1958. Pp. xviii + 862. Price $ 19.50

Since the publication of the second edition of the two monumental volumes on Polarography by Kolthoff and Lingane in 1952, literature on polarography has accumulated enormously; this is particularly true of the application of polarography in the estimation of inorganic and organic constituents of biological and pharmacological systems. It is gratifying to note that the volume under review is designed to meet the requirements of the analytical chemist for the polarographic estimation of various constituents in a variety of biological systems like blood, urine, muscle tissue, proteins, etc. To cite an example, the polarographic estimation of lead is given for the following systems: blood, cerebrospinal fluid, urine, stools, liver, bones, gallstone, cadavers, teeth, foods, plants, phenol, soil, water and other organic and biological systems. When the authors had to deal with such a large number of systems, it is quite understandable that they could not give the experimental details for every one of the estimations; but the authors have spared no efforts in giving suitable references for such information.

The book is divided into eight parts. The first part forms the introduction; the second part deals with the determination of most of the common inorganic radicals (anions and cations) of the biological systems; and the third part deals with the estimation of organic compounds like quinones, halogen derivatives, aldehydes, ketones, sugars, nitrogen compounds including alkaloids, vitamins, hormones, sterols, etc. Parts four and five are devoted to the polarographic studies on proteins and enzymes respectively. Applications of polarographic maxima in the analysis of body fluids and other systems are given in part six while buffers and half-wave potentials are discussed in the next part. The last part is devoted to bibliography, index of materials and subject index.

The presentation of the subject matter is excellent and even a beginner in polarography could easily follow the methods described. The book will be of immense value both to the research worker and also to the chemist who employs the polarograph as an analytical tool.

M. R. A. RAO

THE ATOM AND ITS ENERGY by Amalendu Das Gupta (Asia Publishing House, Bombay), 1959. Pp. vii + 140. Price Rs 9.50

This book is meant to familiarize the layman with the basic principles, practical applications and potentialities of nuclear energy. The author, a teacher turned science writer, is now on the staff of the International Atomic Energy Agency, Vienna, and has brought to bear his rich experience and skill in exposition, in writing this book in popular language. The book is eminently readable and occasionally gripping, as for example the chapters tracing the history of making the world's first atomic bomb and subsequently the hydrogen bomb.

Starting from the definitions of fundamental terms like matter and energy, and concepts like atomic models, chemical and nuclear energy, radioactive decay, etc., the sixteen chapters of the book take the reader through various aspects of nuclear energy — the nature, potentialities (both for peaceful and destructive purposes), harnessing and control, as well as the radiation hazards involved in its destructive exploitation. The processes of fission, fusion, chain reaction, and the principles of reactors, etc., have been explained lucidly. Though certain amount of repetition is evident in the book, it serves to fix, in the layman's mind, the concepts and ideas involved. The chapter entitled 'Atomic Energy in India', which deals with the possibilities and plans to exploit the country's huge thorium deposits for harnessing power for industry and agriculture, will be of particular interest to Indian readers.

A table of elements with their atomic numbers for ready reference and a reading list of books for further reading, both up to date, and an index have been appended.

The book will interest both the layman and the graduate student of Indian universities.

D. S. SASTRY

PUBLICATIONS RECEIVED

READING GERMAN FOR SCIENTISTS by Hans Eichner & Hans Hein (Chapman & Hall Ltd, London; *Distributors in India*: Asia Publishing House, Bombay), 1959. Pp. xi + 207. Price 30*s*. net

THE LIVING BODY — A TEXT IN HUMAN PHYSIOLOGY by Charles Herbert Best & Norman Burke Taylor (Chapman & Hall Ltd, London; *Distributors in India*: Asia Publishing House, Bombay), Fourth Edition, 1959. Pp. xi + 756. Price 45*s*. net

AN INTRODUCTION TO THERMONUCLEAR RESEARCH — International Series of Monographs on Nuclear Energy — Division XIV, Vol. I, by Albert Simon (Pergamon Press Ltd, London), 1959. Pp. ix + 182. Price 35*s*. net

A NEW METHOD IN THE THEORY OF SUPERCONDUCTIVITY (translated from Russian) by N. N. Bogoliubov, V. V. Tolmachev & D. V. Shirkov (Chapman & Hall Ltd, London; *Distributors in India*: Asia Publishing House, Bombay), 1959. Pp. iii + 121. Price 50*s*.

A SUPPLEMENT TO 'HELIUM' (translated from Russian) by E. M. Lifshits & E. L. Andronikashvili (Consultants Bureau Inc., New York; *Distributors in India*: Asia Publishing House, Bombay), 1959. Pp. v + 167. Price 60*s*.

THE CATHODE RAY TUBE AND ITS APPLICATIONS by G. Parr & O. H. Daire (Chapman & Hall Ltd, London), 1959. Pp. xii + 433. Price 50*s*. net

ANTIBIOTICS, THEIR CHEMISTRY AND NON-MEDICAL USES, edited by Herbert S. Goldberg (D. Van Nostrand Co. Inc., Princeton, New Jersey), 1959. Pp. x + 608. Price $ 15.00

ADVANCES IN CHEMICAL PHYSICS : Vol. II, edited by I. Prigogine (Interscience Publishers Inc., New York), 1959. Pp. x + 412. Price $ 11.50

PROGRESS IN VACUUM SCIENCE AND TECHNOLOGY, edited by A. S. D. Barrett (Pergamon Press Ltd, London), 1959. Pp. 160. Price 70*s*. net

PERFUMES, COSMETICS AND SOAPS: Vol. I, by W. A. Poucher (Chapman & Hall Ltd, London), 1959. Pp. xvi + 463. Price 75*s*.

THE GEOCHEMISTRY OF RARE AND DISPERSED CHEMICAL ELEMENTS IN SOILS by A. P. Vinogradov (Consultants Bureau Inc., New York), Revised & Enlarged Second Edition, 1959. Pp. 209. Price $ 9.50

PHYSICO-CHEMICAL BASIS OF THE ANALYSIS OF THE PARAGENESIS OF MINERALS (translated from Russian) by D. S. Korzhinskü (Consultants Bureau Inc., New York), 1959. Pp. 142. Price $ 7.50

PRINCIPLES AND APPLICATIONS OF RANDOM NOISE THEORY by Julius S. Bendat (John Wiley & Sons Inc., New York; *Distributors in India*: Asia Publishing House, Bombay), 1958. Pp. xxi + 431. Price Rs 11.00

NOTES & NEWS

Huygens' principle and the diffraction of light

DR C. V. RAMAN, IN A PAPER published in the *Proceedings of the Indian Academy of Sciences* [**50A** (1959), 83], has pointed out a basic misunderstanding in the classical Kirchoff's treatment of diffraction problems based on the original ideas of Huygens regarding the propagation of light, as approached by Kirchoff. He has also presented a new analysis of the phenomenon of diffraction (still based on some of the conclusions from Huygens' original concepts) which has been experimentally verified.

The present analysis rests on the hypothesis that, since the diffraction of light is a consequence of the presence of obstacles in the path of the light waves, the optical character of the obstacles and their configuration space are the very essence of the problem. Thus, whereas the diffracting body plays the leading role in the present theory, it was not considered at all in Kirchoff's formulation. The latter is based on the idea that the primary radiation from a source situated in free space can be expressed as a summation of secondary radiations from a set of sources distributed over a closed surface in free space enclosing the point of observation. However, even with radically different approach to the problem, Raman has shown that it is possible to base a theory on Huygens' concept of partial waves and his explanation of the reflection and refraction of light at the boundary between media with different optical properties. Such a theory leads to the result that the amplitude of the secondary waves vanishes along the plane of the surface at which they originate and increases progressively as we move away from that plane towards the direction of its normal. According to Kirchoff's analysis, the secondary waves should have a maximum amplitude in the forward direction of light rays from the original source and zero amplitude in the backward direction. The difference between the consequences of the two theories is striking enough to permit experimental verification with a simple set-up.

Experiments have been carried out using diffracting apertures of various sizes ranging from several cm. to fractions of a mm. and angles of incidence from 0° to 90°, and under different circumstances in which diffraction manifests itself, e.g. reflection at a plane surface of a dielectric or metal, the emergence of light after refraction through a transparent medium at various angles, internal reflection within a transparent medium at various incidences, and transmission through apertures in thin opaque screens — simple and multiple apertures and plane reflection and transmission diffraction gratings prepared by various techniques, have also been used in these experiments. In all cases, the consequences of the present theoretical approach are completely vindicated by the facts of observation.

Harnessing thermonuclear fusion energy — the DCX

A NEW TYPE OF MACHINE, CALLED the DCX (direct current experiment), has been designed and developed at the Oak Ridge National Laboratory, Tennessee, for producing a controlled thermonuclear fusion (of deuterium) reaction. In contrast with other types of machines used for similar purposes, it works in the steady state. The unique feature of the DCX is the novel method by which energetic deuterium ions are trapped and contained inside a ' magnetic mirror '. The energy of the trapped beam is such that no further heating is required.

The machine is a vacuum tank containing a magnetic field into which a beam of deuterium ions (D_2^+) is injected, and then dissociated by a new type of carbon-arc discharge. The (D_2^+) ions dissociate either into two deuterons and an electron or into a deuteron (D^+) and a neutral deuterium atom. The resulting deuterons are trapped in the magnetic field. By this method a large density of energetic deuterons can be obtained. As these impart energy to and ionize the neutral gas particles, a randomized plasma will be formed. If the average temperature becomes sufficiently high, thermonuclear reactions will take place in large numbers. The thermonuclear plasma is being produced in a magnetic mirror machine, a linear (or axial-field) device which achieves containment by a bunching of its magnetic flux lines at the ends. If the point of dissociation is properly located, the path of the trapped particles will be a circle about the magnetic axis of the machine. The deuteron density which can be obtained in the circulating ring of ions is a function of the trapped input-ion current and the rate of escape by various loss mechanisms. Each D^+ ion will undergo *c.* 20 ionizing collisions before it becomes lost by charge exchange.

At a certain value of the trapped-ion current, the rate of ionization by the incoming beam will equal or exceed the influx of neutrals into the plasma region, and the neutrals will soon disappear. This condition is called ' burn-out '. Theoretically, once the condition of burn-out has been reached, the circulating-ion density will build up quite rapidly to a point where thermonuclear reactions will take place.

An increase in beam current by a factor of 15, or a corresponding improvement in vacuum, will put DCX at the burn-out critical point. The present accelerator assembly has demonstrated the ability to inject more than the needed ion current, but with the larger beam currents, better vacuum systems, not available now, should be developed [*Mech. Engng*, **81** (8) (1959), 55].

Three-level maser for detection of ultramicrowaves

A METHOD TO DETECT ULTRAMICROWAVES which is more sensitive than those using the conventional electronic detectors (in the millimetre and sub-millimetre range), has been proposed. The method involves the observation of the direct transition between *l*-type doublet of OCS molecule either as emission or absorption using the three-level maser action. The pumping radiation is supplied by a klystron 2K33 at the frequency corresponding to $J=2 \leftarrow 1$ and the l-type doubling transition at 12·78 Mc/s. for $J=1$ has been observed by a modified Pound-Knight circuit.

The principle of the method will be clear from the following: Consider a system of molecules having three energy levels E_1, E_2 and E_3 such that a transition between levels E_2 and E_3 corresponds to the conventional microwave frequency ν_o. When the other transition between the levels E_1 and either E_2 or E_3 is allowed the system can be used to detect high frequency waves at frequencies ν_p or $\nu_{p'}$. Absorption at ultramicrowaves at the frequency ν_p or $\nu_{p'}$ changes the population of levels and results in the increase or decrease of microwave absorption at the frequency ν_o. The ultramicrowaves at the frequency ν_p will be appreciably absorbed by a small amount of gas. It can be easily shown that the absorbed ultramicrowave power (ΔP) can be expressed as

$$\Delta P = \frac{3h^2c}{4\pi} \cdot \frac{\nu_p}{\nu_o} \frac{\Delta\nu_o.\Delta\nu_p}{\nu_o|\mu_o|^2} \cdot V.\Delta\alpha_o$$

where h is Planck's constant; c, velocity of light; $\Delta\nu_o$ and $\Delta\nu_p$, the half-widths of the lines; μ_o, the dipole matrix element; V, volume of the gas and $\Delta\alpha_o$ is the change in the gas absorption coefficient at the frequency ν_o. It is significant that the above equation does not include n_2 or n_3. Thus, it is desirable to have large value of $|\mu_o|$ and high absorption coefficient at frequency ν_p. Assuming typical practical values for $\Delta\nu_o = \Delta\nu_p = 100$ kc/s. and $|\mu_o|^2 = 3D^2$, the above equation reduces to $\Delta P = V.\frac{\nu_p}{\nu_o} \cdot \Delta\alpha_o.10^{-4}$ watts. As a typical microwave spectrometer can detect changes in absorption of the order of 10^{-8} cm.$^{-1}$ the minimum detectable power at $\lambda_p = c/\nu_p = 0{\cdot}4$ mm. is $\Delta P/V = 3 \times 10^{-11}$ W./cu. cm. Due to high absorption of ultramicrowaves a long waveguide cell should not be used and a compromise will be the use of a cavity cell tuned to the frequency ν_o in which the ultramicrowave is radiated. With a cell volume of 10 cu. cm., a power of 3×10^{-10} watts is detectable. Crystal detectors are estimated to just detect a power of 10^{-6} watt at the same wavelength [*J. phys. Soc., Japan*, **14** (1959), 966].

Tunnel diode

A TINY ELECTRONIC DEVICE, THE 'tunnel diode', developed by physicists of the General Electric Co., Schenectady, U.S.A., in which tiny electrical charges at extreme speeds tunnel through silicon, germanium and compounds of gallium and indium, may ultimately replace the transistor in many of its applications. The tunnel diode is so tiny that a radio transmitter of the size of a 50-cent piece was built with it, including battery. The radio successfully transmitted to a nearby F.M. receiver. One special advantage of the tunnel diode is its resistance to nuclear radiation, outranking the transistor 1000 to 1 in this respect. It is also little affected by the environmental conditions. It can withstand much higher temperatures (up to 650°F.) than the conventional silicon diodes which fail at *c.* 400°F.

The tunnel diode is an improvement of the device first reported by a Japanese scientist in 1958 and only limited quantities are now being made available to industry for experimentation. In contrast to other devices which involve switching and amplification, the tunnel diode works at the speed of light, which enables the attainment of frequencies higher than 10,000 Mc/s. At frequencies higher than 2000 Mc/s. the device has already given a performance matching the best transistor available. Possible application of the tunnel diode is in miniature radios, fast computers and controls for nuclear reactors. The tunnel diode requires only a millionth of a watt of power to work, compared to the one thousandth of a watt for the transistor and one-tenth of a watt for a conventional triode valve. But the tunnel diode has a peculiar property that, as the voltage applied across it increases, the transmitted current decreases [*Sci. Newslett., Wash.*, **76** (1959), 68].

Electrolytic jet machining

A NOVEL TECHNIQUE TO OBTAIN thin foils of steel and other hard ferrous alloys for direct examination by transmission electron microscopy, without destroying or modifying the structure of the metal, is reported. The technique involves an electrolytic jet machining operation on the specimen blank in a specially designed apparatus, followed by controlled electropolishing. As the deformation caused by surface grinding is not likely to extend to more than 50-100 μ below the surface, the electrolytic machining operation is made to remove considerably more material than this thickness on either side of the cut blank.

In the electrolytic jet machining apparatus, built mainly of Perspex and Tufnol, the electrolyte (a mixture of concentrated hydrochloric acid and concentrated solution of cupric chloride in the ratio of 3: 1) is made to flow through a copper tube-cathode which is connected to a glass nozzle, *c.* 1 mm. in diameter. The specimen holder is mounted perpendicular to the jet assembly with the specimen *c.* 2 mm. from the end of the glass nozzle. The jet traverses backwards and forwards across the specimen at a constant velocity 30 times a minute, while the specimen is also moved slowly (1 cycle in 6 min.) up and down, at constant speed, at the appropriate speeds, by a geared constant speed motor. A potential of 40-50 V. and a current of 2 amp. are used, giving a rate of metal removal of about 10 μ/min. over the 1-in. square window cut in the specimen. Since the rate of metal removal is fairly constant at 300 μ/amp. hr even for different steels, the thickness of the specimen at any time during the thinning operation can be estimated from the initial thickness, the machining time, and the current. The error in the present apparatus in determining the thickness of the metal removed is less than 2 per cent of the amount dissolved.

The thinned specimen is removed from the apparatus at a thickness of 50-100 μ, washed and then electropolished in 10: 1 acetic-perchloric acids to reduce the thickness to 20 μ. The final reduction is done in this way, as the degree of control of the thinning is better using ordinary electropolishing. The 'figure of eight method' developed by Brandon and Nutting for producing thin foils of iron is used in the final thinning of the specimen. Thin foils (20 μ thick) of 0·14 and 0·98 per cent carbon steels, in various conditions of heat treatment, have been successfully prepared from bulk specimens using this method [*J. Iron St. Inst.*, **192** (Pt 3) (1959), 246].

Measurement of small variations in potential gradient

AN ACCURATE AND RELIABLE ELECTRONIC instrument by which the changes in potential difference between any two points in a conducting liquid can be measured is described. The instrument finds application in the study of cataphoretic velocity of colloidal particles.

A potential divider applies a highly stabilized voltage across the electrodes of a U-tube and a resistance R (one hundredth of the resistance of the liquid in the U-tube) in series. The potential at that end (Q) of the resistance R, which is connected to one of the limbs of the U-tube, is initially balanced by connecting a vacuum tube voltmeter (V.T.V.M.) between Q and a suitable point on the potential divider. Any subsequent minute changes in the current (from 0·02 to 0·002 ma.) of the liquid circuit can be detected and measured by the V.T.V.M. reading; a sensitive galvanometer may also be used in the place of the V.T.V.M.

The changes in the potential between any two points on the limb of the U-tube containing the conducting liquid can also be determined by fusing platinum terminals at the required points and supplying the connections previously corresponding to the ends of the U-tube at these points. Due to the small magnitude of the potential, the change in potential is amplified by a valve circuit before feeding to a V.T.V.M. [*Agra Univ. J. Res.* (*Sci.*), **8** (Pt 1) (1959), 89].

Magnetometric titration

A NEW METHOD OF QUANTITATIVE chemical analysis called 'magnetometric titration' requires only small amounts of the solute for the estimation of an ion. The method consists in the addition of a complexing agent to the solution of a paramagnetic ion in solution. However, the method is applicable only in cases where the formation takes place of a new complex ion of different μN and of high stability in solution (μN is a parameter expressing the effectiveness of a particular solute in this phenomenon, also called the 'effective' paramagnetic moment of the solute). Concentration (C) of the ions is then determined from the equation

$$(T_1^{-1}-T_0^{-1})=\alpha\mu N^2C$$

where T_1 and T_0 are spin-lattice relaxation times in the presence and absence of added solute respectively and α is a proportionality constant. μN can be determined by the use of a low-resolution nuclear magnetic-resonance spectrometer. In practice the values of $T_1^{-1}-T_0^{-1}$, corrected for the dilution effect which accompanies the addition of the titrating agent, are plotted against the amount of complexing agent added to a solution of the ion to be estimated. The dilution of the reaction mixture during the experiment can be kept low by using a concentrated solution of titrating agent but it is easily allowed for by multiplying the values of $T_1^{-1}-T_0^{-1}$ by V/V_0, where V_0 is the initial volume of the solution and V the volume after addition of the titrating agent [*Nature, Lond.*, **183** (1959), 1804].

Molecular sieves

MOLECULAR SIEVES ARE FOUND TO have potential uses in organic chemistry for drying and purification of substances, for the separation of compounds of similar chemical and physical behaviour, and as reagent carriers for halogens, simple olefins, alcohols, aldehydes and amines.

Linde molecular sieves employed as selective adsorption agents are dehydrated synthetic zeolites characterized by their ability to retain certain substances by forming macromolecular inclusion compounds. This ability is due to the existence of cavities interconnected by channel-like restrictions in the aluminosilicate framework. Originally, these spaces are occupied by water, but dehydration leaves empty cavities and pores, without any damage to the crystalline structure. At present, there are two major types available: Type 4A, a sodium aluminosilicate, presenting, in the hydrated state, the unit cell formula

$$Na_{12}[(AlO_2)_{12}(SiO_2)_{12}],\ 27H_2O$$

where the apparent diameter of the pores is about 4·5 A., and Type 5A, where sodium has been exchanged by calcium, with a unit cell composition $Ca_6[(AlO_2)_{12}(SiO_2)_{12}]$, $30H_2O$, which has an apparent pore diameter of about 5·5 A. These two types can adsorb molecules of critical dimensions up to 4·7 A. and 5·6 A. respectively; the critical dimension of a molecule is the diameter of the circumscribed circle of its cross-section of minimum area.

Many applications of molecular sieves are reported. For example, molecular sieves are satisfactory dehydrating agents for rapid drying of substances and mixtures and may be employed in the purification of certain organic substances. They cannot be used as catalysts in the cold in condensation reactions where water is eliminated, instead of heating or using chemical agents such as concentrated sulphuric acid, because they cannot provide the necessary activation energy for starting the reaction. An important potential use lies in the separation of compounds of very similar chemical and physical behaviour, but with different critical dimensions, as in the case of straight chain alkanes and their branched-chain isomers. Thus, it is possible to separate and estimate some individual representatives of normal alkanes from a complex mixture of paraffinic hydrocarbons. This is done by shaking the mixture with the zeolite followed by washing with benzene. The hydrocarbons retained on the sieve are liberated by treatment with water. Similar results may be obtained in other series, e.g. the separation of *n*-pentyl alcohol from a mixture of pentyl alcohols. The most promising application seems to be the utilization of molecular sieves as reagent carriers for halogens, simple olefins, alcohols, aldehydes and amines, to effect reactions in heterogeneous media. Gradual introduction into the reacting mixture of a reagent previously adsorbed on the synthetic zeolite can be performed by displacement by means of a compound with greater affinity to the molecular sieve, such as water, methyl alcohol, etc., which may be liberated from the reaction itself [*J. appl. Chem.*, **9** (1959), 417].

Assessment of nutrients in agar

A METHOD REPORTED FOR THE assessment of nutrients in agar consists in exposing a small number of cells to a comparatively large volume of substratum in a manner that allows convenient determination of the amount of growth produced by each cell of the inoculum.

A millipore membrane filter of type TV 20 μ thick with pore size 50 μμ, is cut into pieces, 5×10 mm., sterilized by autoclaving in distilled water and placed on the surface of sterilized filter paper in a petri dish. Each piece is seeded with a platinum loop of washed cell suspension. If the petri dish contains two 9-cm. Whatman No. 3 filter papers with one 7-cm. No. 1 filter paper on top, the whole being moistened with 5 ml. sterilized water or buffer, the suspension liquid is drawn through the membrane into the filter papers by surface tension forces within a few seconds, leaving the cells on the surface. This operation makes a filtration funnel unnecessary for membrane seeding, with resulting economy in area of membrane needed per experiment. The pieces of membrane can then be conveniently transferred with a small stainless steel spatula to any desired environment. At the end of the growth period, the membrane pieces are transferred to small drops of erythrosin-saturated lactophenol on a slide. The lactophenol partially clears the membrane and the cells are made more easily visible by the dye. The mounts thus prepared are semi-permanent and growth on each substratum is estimated by inspection with the high dry objective of 50 randomly selected colonies [*Canad. J. Microbiol.*, **5** (1959), 421].

Reconstitution of tobacco mosaic virus

EVIDENCE FROM CHEMICAL, PHYSICO-chemical, electron-microscopical and X-ray studies has resulted in a definite concept of the structure of tobacco mosaic virus (TMV) particle. It has been suggested that about 2800 protein subunits of a molecular weight of approximately 18,000 are arranged in a helical shape to form a rod with hollow core in which the nucleic acid occurs as strands. When the two are separated, the protein is non-infectious whereas the nucleic acid alone can initiate the disease, although only at several hundred-fold higher concentration than the intact TMV. On the addition of native virus protein to infective nucleic acid, a co-aggregation occurs to some extent, leading to the formation of particles which are very similar, if not identical, with the original virus. A consequence of this reaction is an enhancement of the infectivity of nucleic acid.

H. Fraenkel-Conrat and colleagues [*Biochim. biophys. Acta*, **33** (1959), 359] have now clearly demonstrated that reconstitution of protein and nucleic acid components of several strains of TMV takes place to form active preparations possessing 30-80 per cent of the infectivity of undergraded virus in pyrophosphate or substituted pyrophosphate (e.g. nucleoside diphosphate) media between *p*H 7·0 and 7·7 at 30-35°C.

The chemical nature of the progeny and infectivity character of active virus have been shown to be characteristic of the strain supplying the nucleic acid whereas serological characteristics are determined by the protein donated by the virus. That about 5 per cent of RNA is incorporated into stable sedimentable nucleoprotein has been shown by the aid of P^{32}-labelled RNA.

This finding of a viral activity showing properties characteristic of each parent strain appears to rule out any interpretation of the mode of virus reconstitution other than the *in vitro* production of active principles from the two components.

Candida albicans infection

INDISCRIMINATE ADMINISTRATION of antibiotics is now known to lead to an increased incidence of Candida infections. *Candida albicans* is a pathogenic yeast-like fungus often found in the skin, gastro-intestinal tract, etc. Although individuals differ in their sensitivity to this organism, diabetics and those who generally use detergents and work under humid conditions seem to be particularly susceptible to it. The widespread use of diverse antibiotics may be considered to be a major factor in that the normal microbial flora of the human body is thereby altered, apparently in favour of *C. albicans*.

However, the frequent association of *C. albicans* with *Mycobacterium tuberculosis* noticed in the sputum of pulmonary tuberculosis patients is a point of serious consideration, since a polysaccharide synthesized by *C. albicans* has now been demonstrated to be a growth-promoting factor for the tubercle bacillus — including those strains isolated from patients administered with streptomycin and isonicotinic acid hydrazide (INH). The polysaccharide contains glucose and mannose. It is considered that a possible structural relationship between streptose moiety of streptomycin and the polysaccharides of *M. tuberculosis* and *C. albicans*, may explain the mode of action of streptomycin in inhibiting the biosynthesis of the *Mycobacterium polysaccharide* [*Canad. J. Microbiol.*, **1** (1954), 85; **5** (1959), 261].

These observations are of considerable importance in the treatment of tuberculosis and indicate the necessity of an effective control of *C. albicans* infection with supplementary administration of antifungal antibiotics. This point may require serious consideration by the clinicians in future.

Atomic energy developments in Austria

AUSTRIA'S DOMESTIC POWER RESOURCES are inadequate to meet the growing demands of industry. The country's power requirements for the expanding industries and public utilities have increased four-fold in the past decade: power consumption in 1946 was 3 billion kWh. as compared to 13·5 billion kWh. in 1958. In order to meet the continuously increasing demand for power, Austria is at present engaged in developmental plans designed to provide a large part of the country's power requirements through atomic energy.

As a member of the European Nuclear Energy Agency, Austria established in 1956 the Austrian Society for the Study of Atomic Energy which has been allocated 105 million Austrian Shillings for the period 1956-60. Of this, 49·52 per cent come from industrial enterprises interested in atomic energy research and 50·48 per cent from the Austrian Federal Government, a part of which has been contributed by the U.S. Atomic Energy Commission under the 1956

Agreement and by the funds allocated under the Marshall Plan. One of the main tasks of the Society is to construct and operate a 5 MW. swimming-pool type research reactor, ASTRA, which will be built by the American Machine and Foundry Co., New York. The concrete cupola of the reactor has already been completed and the assembly of the atomic pile is under way.

The Society works in close collaboration with the International Atomic Energy Agency at Vienna, which has set up its laboratories on the campus of the atomic reactor centre at Seibersdorf. The reactor centre provides opportunities for the training of scientists and technicians from Austrian universities and technical colleges in the fields of nuclear physics, reactor technology and related fields. The reactor will also carry out experimental work for industry and also in agriculture. Its immediate task, however, is to provide practical knowledge in the planning and construction of atomic power stations in Austria.

Central Laboratories, C.S.I.R., Pakistan

THE FOUNDATION-STONE OF THE Central Laboratories of the Pakistan Council of Scientific & Industrial Research to be built in Karachi was laid by the President of Pakistan on 6 April 1959. The construction of the Laboratories buildings, furnishing and equipment are estimated to cost Rs 10,900,000. The Laboratories will consist of seven divisions for research in Physics & Testing; Building Materials; Plastics, Paints & Varnishes; Fuels; Chemistry; Drugs & Pharmaceuticals; and Biology.

ICSU Review

THE ELSEVIER PUBLISHING CO. HAS started, since the beginning of 1959, this new quarterly publication for the International Council of Scientific Unions (ICSU). In addition to articles embracing different branches of the natural sciences, *ICSU Review* will contain information about the activities of the ICSU and its member unions, reports on the symposia organized by the unions, forthcoming meetings, as well as reviews of the publications of the unions. It will also provide a forum for discussion of problems of interest to all members of the Unions of the ICSU and to scientists in general.

The International Journal of Mechanical Sciences

THE PERGAMON PRESS LTD, London, has commenced, since the summer of 1959, the publication, in English, of *The International Journal of Mechanical Sciences*. The journal will publish original research work in mechanical and civil engineering sciences. The journal will cover many topics of engineering research which, because they fit under no well-defined headings, are not treated in the established specialized journals. Reviews and critical appraisals of published material, translations of outstanding papers hitherto not available in English and selected letters to the editor will also be published from time to time, in addition to preliminary announcements of original work of importance warranting immediate publication.

The subscription for the journal is £ 6 ($ 17.00) per volume for libraries and £ 3 10*s*. ($ 10.00) for certified individual subscribers.

Journal of Electroanalytical Chemistry

THE ELSEVIER PUBLISHING CO., Amsterdam, has started the publication of a new international journal entitled the *Journal of Electroanalytical Chemistry* with effect from 1959. The subjects covered by the journal will include: potentiometric, amperometric and coulometric determinations; recent developments in polarography: chronopotentiometry, oscillographic polarography, square wave polarography, anodic stripping; conductimetry; and high-frequency methods. The journal will also contain papers on fundamental problems of electrochemistry. The annual subscription is £ 6 5*s*.

Comparative Biochemistry and Physiology

AN INTERNATIONAL JOURNAL OF interest to workers in the fields of physiology, biochemistry and zoology is the *Comparative Biochemistry and Physiology*, being published by the Pergamon Press Ltd, London, since the summer of 1959. It publishes papers containing the results of original research on the biochemistry and physiology of animals (vertebrate and invertebrate). Particular attention will be paid to those papers that compare the biochemistry and physiology of various animals. Papers dealing with clinical or applied aspects of the subject will not be considered.

The new publication, issued quarterly, will contain review articles, reports of conferences, book reviews in the fields of biochemistry, physiology and zoology, and letters to the editor. The preferred language for papers and other communications is English, but papers in French or German may also be accepted if they are provided with an English abstract.

Translations of Soviet research publications

THE CONSULTANTS BUREAU HAS recently published the following English translations of Russian publications reviewing the research work done in the U.S.S.R. in a number of scientific disciplines:

Soviet Research in Crystallography, 1956 ($ 10.00), is a collection of reports which appeared in the 1956 issues of some Soviet chemical journals. Another publication, the *Soviet Research in Fluorine Chemistry*, 1949-56, is divided into three volumes. Part I ($ 15.00) is devoted to organic fluorides and fluorocarbon olefins, Part II ($ 20.00) to inorganic fluorides and analysis and Part III ($ 20.00) to hydrogen fluoride, boron trifluoride and its etherates, and fluoborates. The complete collection is priced at $ 45.00.

New Instruments and Methods of Engineering Geology ($ 3.25) reviews the present methods and equipment utilized by the Soviet engineering geologists and hydrologists emphasizing, in particular, the methods based on the radioactive properties of elements.

Syntheses of Heterocyclic Compounds, Vols. I and II ($ 6.00), is a guide to the laboratory preparation of heterocyclic compounds. It is a translation of the series of collections of methods of syntheses, originally published by the Armenian Academy of Sciences.

Corrosion of Chemical Apparatus ($ 7.50) is a monograph on intercrystalline corrosion and stress corrosion of various metals and alloys used in chemical machine construction. In this book are discussed the fundamental causes of these types of corrosion, specific cases of destruction of industrial equipment, and methods of protection of metals against corrosion cracking.

With a view to making quickly available, to the Western metal scientists and technologists, the abstracts of technical articles appearing in the journals of the U.S.S.R., the East European and Slavonic countries, and the Peoples' Republic of China which either do not appear or appear belatedly in the Western abstracting journals, the Pergamon Press has started publication of a new monthly, *The Abstracts Journal of Metallurgy, Part B*, a translation of the *Russian Referationyi Zhurnal*, which abstracts scientific and technical information throughout the world. However, in these abstracts, the readily available Western source material will be omitted. *Part B* will complement *Part A* (in which are published mainly abstracts of a highly scientific nature) and will contain abstracts on a comprehensive range of technological subjects. The annual subscription of the new journal will be £ 17 or $ 50.00 for industrial subscribers and libraries and £ 8 10*s*. or $ 25.00 for individual members of the various approved mining and metallurgical associations and other institutions.

Translation of Chinese scientific literature

THE NATIONAL SCIENCE FOUNDATION, U.S.A., will begin next year to translate many of the scientific and technical journals that are published in the Peoples' Republic of China. According to a survey by the Foundation, about 450 scientific journals are published in China.

Second U.N. Conference on Peaceful Uses of Atomic Energy

The Official Editions of the Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy fill the need for a comprehensive reference library and cover the entire field of the peaceful uses of atomic energy.

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To enable an economy to be made by making proper selections to serve particular needs of individual libraries, purchase of individual titles of Official Proceedings Editions, separately or in groups, e.g. Physics, Chemistry, Reactors, etc., is allowed.

Orders may be sent directly to: United Nations, Sales Section-PUAE, New York, N.Y.

Symposium on Prestressed Concrete as Applied to Buildings

The Proceedings of the Symposium on Prestressed Concrete as Applied to Buildings, held at Roorkee in February 1958, has been published by the Central Building Research Institute, Roorkee. It includes twenty-three papers contributed by experts in the field from U.S.S.R., U.K., U.S.A. and India. The broad subjects covered in the papers are: (1) Materials and Methods, (2) Prestressed Roofs for Buildings, (3) Research, and (4) Economics of Prestressed Concrete as Applied to Buildings. The publication is priced at Rs 5.00 and can be obtained from the Director, Central Building Research Institute, Roorkee (U.P.), India.

Announcements

- *The Twenty-fifth Annual Meeting of the Indian Academy of Sciences* will be held at Annamalainagar from 26 to 28 December 1959 under the auspices of the Annamalai University.

- *The Twelfth Annual Scientific Meeting of the Palaeobotanical Society* will be held at the premises of the Birbal Sahni Institute of Palaeobotany, Lucknow, on 22 and 23 January 1960. The programme includes lectures, reading of papers and discussions. Palaeobotanists from all over India will be participating in the discussions.

ERRATUM

Article entitled " Expression of Humidity in Centigrade-Gram-Metre System ", **18B** (1959), 348, caption for Fig. 1, *for*: " The C.G.M. psychrometric chart (barometric pressure = 100 mb. or 750 mm. of mercury) [V_A, water vapour concentration, g./cu. m. of dry air; V_d, water vapour concentration]" *read*: " The C.G.M. psychrometric chart [Barometric pressure = 1000 mb. or 750 mm. of mercury; water vapour concentration in the atmosphere in g./cu. m. is obtained by multiplying the vapour concentration in g./cu. m. of dry air by the factor $(1-0{\cdot}001 \times$ vapour pressure in mb.)] ".

Progress Reports

INDIAN ASSOCIATION FOR THE CULTIVATION OF SCIENCE: 1958-59

THE NEW DEPARTMENT OF APPLIED HIGH POLYMERS started functioning from the beginning of the year under review. The Council of Scientific & Industrial Research, New Delhi, sanctioned eight research schemes tenable in the laboratories of the Association for the year 1958-59. Eighteen senior scholarships were made available by the Government of India under its scheme of training research scholars. Two special monographs published during the year covered the following subjects: The Modern Theory of Turbulence by Prof. N. R. Sen, being the text of his Ripon Professorship Lectures and Molecular Physics and Intermolecular Forces by Prof. J. O. Hirschfelder, being his Coochbehar Professorship Lectures.

A new method for determining unlike interactions on the Lennard-Jones (12 : 6) model by combining interdiffusion and viscosity data on gas mixtures has been suggested and applied to cases where accurate interdiffusion data are available at only one or two temperatures. An apparatus for measuring interdiffusion of gases over a wider range of temperature and employing tracer technique has been designed and is being fabricated.

Studies on the effect of chemical and other treatments on the conductivity of graphite along the principal axis have shown that the loose type of binding that exists in crystals of graphite in the direction parallel to the principal axis is affected by such treatments which are usually undertaken to purify the naturally occurring crystals. Such treatments cause a definite derangement in structure along particular directions perpendicular to the basal plane. It is, therefore, obvious that such purified crystals may not show the peculiarities in electrical conductivity along the principal axis, namely the semiconduction along the basal plane.

A new self-recording grating spectrophotometer for studying many problems of Raman effect has been constructed; the resolving power of the grating used is about 150,000.

A résumé of the work done in the Physics and Chemistry Departments of the Association is given below.

Physics — Measurements of single crystal rotation and Weissenberg photographs of *o*-tolidine have been obtained, and its cell dimensions have also been accurately determined. These studies have shown that the crystal belongs to the ortho-rhombic system and its space-group is $P2_12_12_1$. Appearance of a Renninger reflection has been reported. The crystal class, unit cell dimensions and space-group of chinizarin have been determined and the results show that the crystal belongs to the monoclinic prismatic class, the space-group being $P^2_{1/n}-C^5_{2/1}$. The unit cell contains four molecules.

The intensity distribution in the ' wing ' of the Rayleigh line due to pyridine, α-picoline, *o*-cresol, *o*-chlorophenol and *p*-xylene at temperatures just above the freezing points of the liquids and also at room temperature has been determined quantitatively and it has been concluded that at lower temperatures small groups of molecules are formed and intermolecular vibrations in these groups produce very broad bands of distances beyond 45 cm.$^{-1}$ from the Rayleigh line in some cases. With solidification these bands become sharp.

Luminescence spectra exhibited by chloro- and bromo-toluenes have been found to be excited strongly when the monochromatic exciting radiation from a carbon arc has a mean wavelength of about 3650 A., and very weakly when the wavelength is increased to 3750 A. The luminescence, however, disappears when the wavelength of the exciting radiation is increased to 3800 A. These studies suggest that luminescence is produced by direct excitation to the triplet state and emission thereafter, and that the selection rule regarding singlet-triplet transition is violated.

The relative intensities of the central component and Brillouin components in the light scattered by water and acetone have been studied using a technique in which it has been possible to eliminate stray light almost completely. It has been concluded that the higher intensities of the central component in the light scattered by these liquids are due to the presence of stray light and that the correct values observed are in agreement with Landau and Placzek's theory.

The problem of the analysis of nucleon-nucleus scattering at high energies has been extended by taking the spin-orbit coupling term along with Woods-Saxon type of nucleon-nuclear potential. For small angles the scattering cross-section is not affected by the spin-orbit coupling term which predominates as the scattering angle increases. At 30° angle of scattering the contribution of the spin-orbit coupling term to the scattering cross-section is ten times greater than that of the central potential. The experimental values agree with those calculated on the basis of Born approximation for 300 MeV. protons.

An anisotropic solution of the Einstein gravitational equations has been obtained. The solution is cosmologic in the sense that it extends over all space and the world lines of matter form a coherent pencil of geodesics. The distribution of the matter is uniform as $t \rightarrow \infty$; the solution asymptotically tends towards isotropy.

Chemistry — A detailed investigation of the polymerization of methyl methacrylate using various laurate soaps and in particular ferric laurate has shown that the rate of polymerization behaves abnormally with respect to catalyst concentration and also the degree of polymerization goes on increasing with time in the same run even for low yields, a fact which is difficult to be reconciled with the type of polymerization mechanism. Polymers containing built-in dye units have been prepared and their properties are being investigated. Physico-chemical studies on synthetic polymeric ampholytes have shown that these polymers exhibit precipitation phenomena analogous to 'denaturation' of proteins. The kinetics of precipitation have been studied and a mechanism has been proposed; the energy of activation has also been worked out. Hemmet's acidity function for perchloric acid and hydrochloric acid in pure ethylene glycol and glycol-water mixtures has been determined employing *p*-nitroaniline, 1-nitroaniline and 4-chloro-2-nitroaniline as indicators. Kinetics of the two reactions, inversion of sucrose and iodination of acetone, in the same media have been studied and useful correlations between acidity function and reaction rates have been obtained.

DEPARTMENT OF ATOMIC ENERGY : ANNUAL REPORT, 1958-59

THE NEW ATOMIC ENERGY COMMISSION, CONSTITUTED by a resolution of the Government of India on 1 March 1958, commenced functioning from June 1958. The Commission is responsible for (1) formulating the policy of the Department of Atomic Energy for the consideration and approval of the Prime Minister, (2) preparing the budget of the Department of Atomic Energy for each financial year and getting it approved by the Government, and (3) implementing Government's policy in all matters concerning atomic energy. An Architecture and Civil Engineering Division has been established which is responsible for civil engineering work of the Commission.

A major project completed during the year was the design and construction of a plant for the manufacture of atomically pure uranium metal; the first ingot of uranium weighing 40 kg. was produced in January 1959. Another important development concerns a process worked out for the production of atomically pure graphite from petroleum coke and tar.

Physics — The physics group have made a preliminary study of a power natural uranium reactor moderated by an organic compound in which the hydrogen atoms are replaced by heavy hydrogen atoms. Organic moderators offer a number of advantages, such as high boiling point and good heat transfer properties and thus do not require the use of vessels capable of withstanding extremely high pressures; they also do not present any serious corrosion problem.

Investigations on the behaviour of neutrons in materials such as water, graphite and beryllium oxide, used as moderators in reactors, have been carried out in the Nuclear Physics Division. Transmission of fast neutrons has been studied in graphite, water and water plus lead media. These studies are important for the design of reactor shields and in the verification of theoretical calculations. The slowing down age of neutrons from various neutron sources has also been studied in water-aluminium mixture as this parameter is necessary in the evaluation of the critical size of a water-moderated reactor.

A number of specialized electronic instruments have been designed and fabricated such as a 21-channel analyser for measuring the time of flight frequency. A xenon poison computer, which will permit more efficient operation of the reactor Apsara, at high power, has been designed and constructed. A miniature fission counter for flux distribution measurements has also been constructed. A special spectrometer useful for locating brain tumours and for liver and gall-bladder function studies (by external counting) was constructed and supplied to the Mental Health Institute, Bangalore. Equipment has been built and is being used to determine minute quantities of radioactivity in foods, such as vegetables and milk. It is proposed to extend the analyses to measurements of radioactivity in the human body. Radiation meters (165) for prospecting for atomic minerals and laboratory instruments (169) were manufactured during the year, thereby saving approximately Rs 5 lakhs of foreign exchange.

Chemistry — The most important work being done in this Division is in connection with the tracer study made in collaboration with the Bombay Port Trust and the Hydraulic Research Station, U.K., to investigate silt movements in the Bombay harbour. The information gained from this study will be used in planning a large-scale dredging operation, which is shortly to be undertaken.

Engineering — The feasibility of different reactor systems for power generation has been investigated in detail, including an organic moderated and cooled reactor.

Studies have been carried out on heat transport, corrosion and compatibility problems met with in reactors. Two out of pile experiments were started. The first is a wind tunnel type experiment designed to provide heat transfer data on fuel element cans for gas-cooled reactors. The second is an experiment in which the conditions prevailing in one of the channels of a gas-cooled power reactor are simulated. A third experiment started later and being continued employs a liquid metal loop, and will provide necessary experience in the handling of liquid sodium and also develop satisfactory designs of sodium-water heat exchanges. A fourth experiment concerns with the design of a high pressure gas loop to be inserted in the Canada-India reactor for compatibility and fuel element development studies.

A new method of separating hafnium from zirconium was developed and nuclear grade zirconium salts prepared on a laboratory scale.

Biology and medicine — In the Biology Division, emphasis has been on investigations concerned with the effects of neutron ionizing radiations of various types and chemicals on biochemical systems. By using special radioactive chemicals like tritium-labelled thymidine, it has been possible to obtain an insight into the structure and mode of duplication of genes. Studies on the effect of millet (*Setaria italica*) and *Isafghol* (*Plantago ovata*) by thermal neutrons have shown that at low dose levels, the plants grow more vigorously and faster than the controls. Synthesis of specific chemical substances as potential chemotherapeutic agents against tumours in experimental animals has been a new development of the Division. Work has also been initiated on problems of food sterilization and pasteurization using ionizing radiations.

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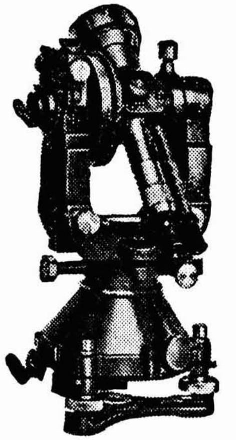

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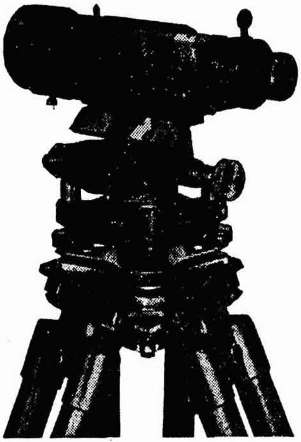

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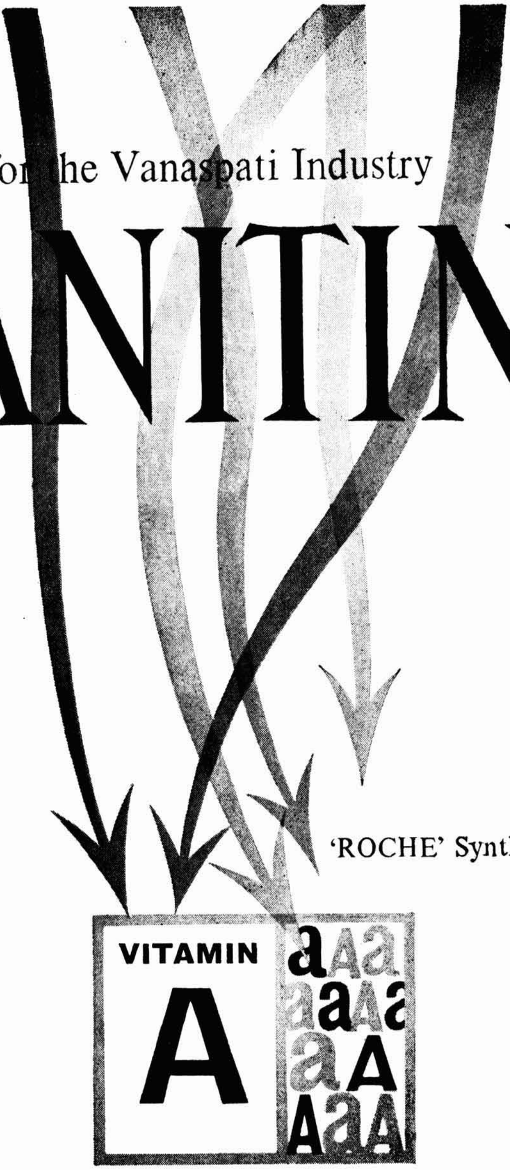

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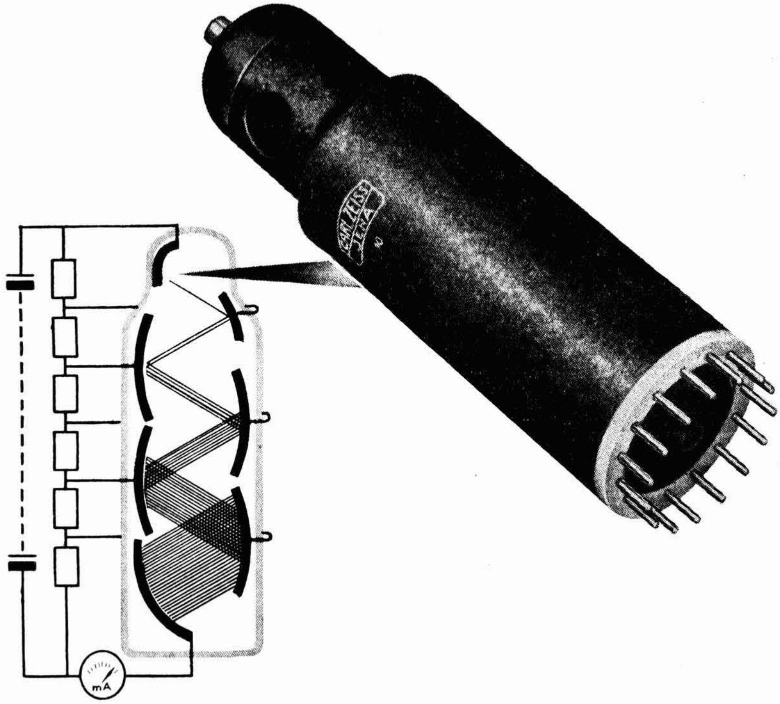
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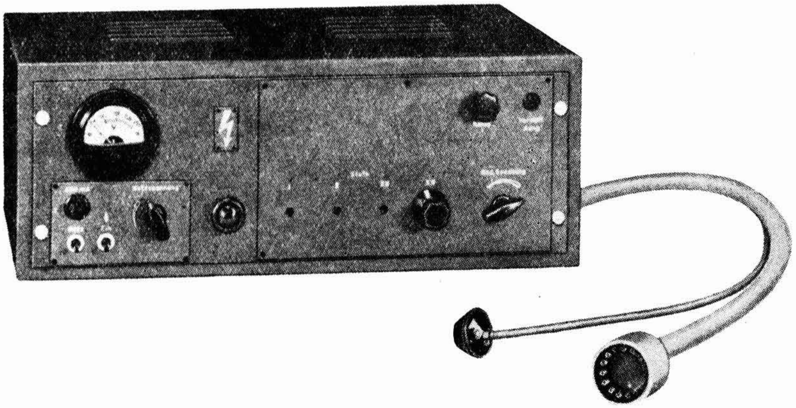

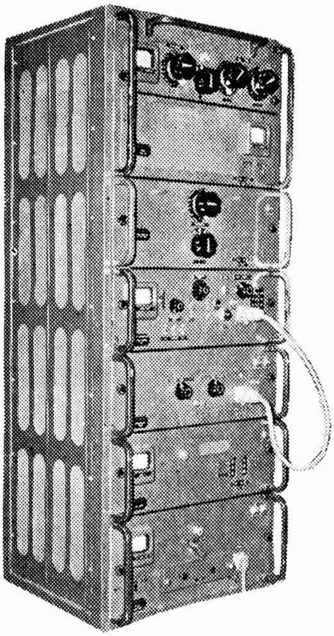

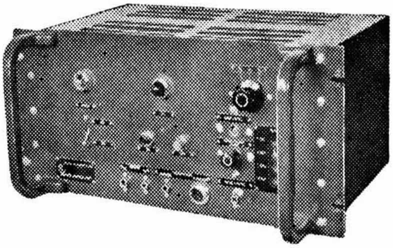

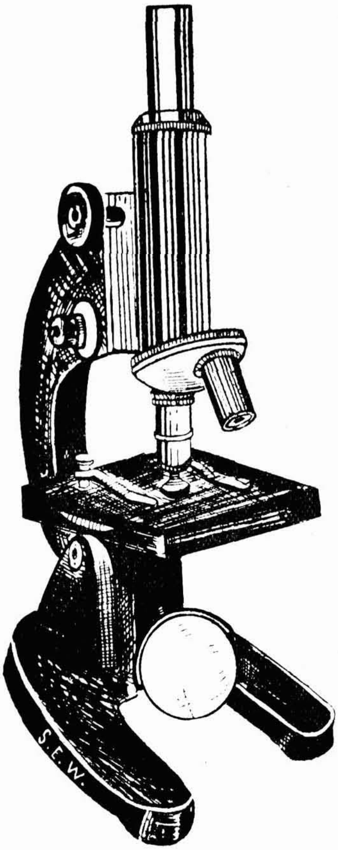
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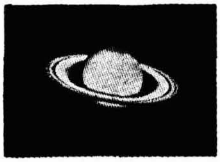

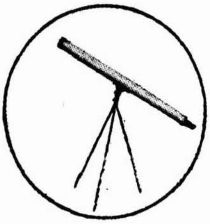

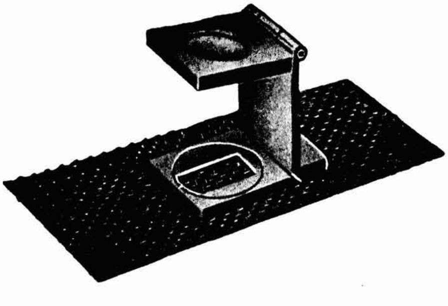

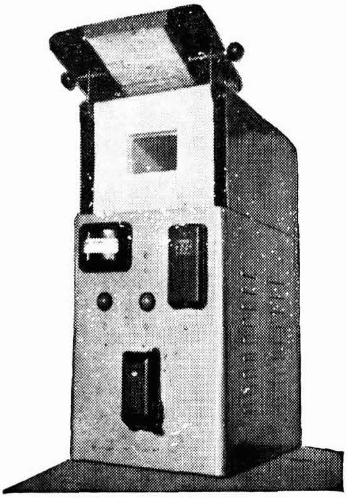

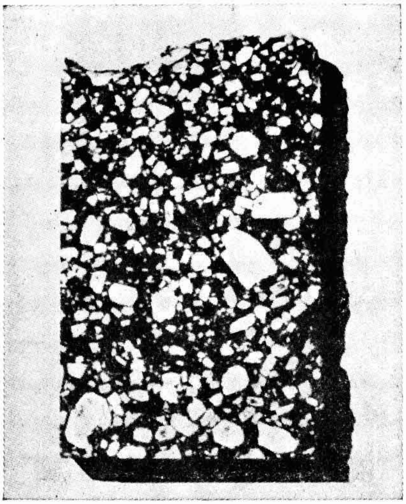

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