material requirements of yeast enter the cell largely as a result of active transport during fermentation, a process requiring energy derived from other systems and effected by means of carriers, the general cationic carrier being a redox carrier of the cytochrome type. The affinity of the carrier for potassium ions is much greater than that for sodium or magnesium ions.

Aspects of yeast genetics were dealt with in two papers which followed the showing of the film, the "Life Cycle of the Yeast Cell", made for the Anheuser-Busch Co., with a commentary by C. C. Lindegren. Mr. R. B. Gilliland introduced the film and followed with a paper on "Yeast Genetics in Industry". He said that, as yet, the application of the technique of breeding yeasts for the purposes of brewing beer is disappointing, partly because of difficulties inherent in a yeast-breeding programme and partly because the assessment of desirable qualities is so difficult. The situation with respect to other yeast industries appears to be more hopeful, and the possibilities of polyploid yeasts have yet to be examined. On the more positive side, the study of yeast genetics has accumulated valuable data on the inheritance of the ability to flocculate and to ferment maltotriose, dextrin and starch. In more academic fields, the genetic analysis of yeast hybrids may find use in the separation of yeast enzymes.

In a paper on "Some Genetical Aspects of Panary Fermentation", Mr. R. R. Fowell (Distillers Co., Ltd.) presented the results of fermentometer tests on standard doughs fermented by yeasts obtained by breeding in a scheme which permitted subsequent genetical analysis. The results for the 1 hr. volume tests can be explained in terms of four major genes operating for dominance, but those for the 1-3 hr. test are complicated by action of genes operating negatively. He concluded that detailed genetical analysis of the haploid parents is necessary before the panary performance of individual hybrids could be predicted.

"The Utilization of Flour Sugars during Panary Fermentation" was discussed by Dr. R. R. McKenzie (Distillers Co., Ltd.). The subject had been studied by the application of quantitative paper chromatography to that fraction of flour extracted by aqueous ethanol. The observed changes in concentration of glucose, sucrose, glucodifrutose and laevosine during fermentation were presented and their significance discussed.

The final paper, by Dr. J. White (Fardon's Vinegar Co., Ltd., Birmingham), on "Influence of Environmental Factors upon Yeast Behaviour", urged a greater appraisal of environmental effects as a step towards the production of yeasts of high fermentative capacity and good keeping qualities. The importance of such effects was illustrated by reference to the phenomenon of 'osmosensitivity', the conditions for which are developed by growth of yeasts in direct culture, but not by growth under conditions of incremental feeding. Dr. White also discussed the change in enzyme content of yeasts in relation to the capacity to ferment glucose and maltose and to secrete invertase. The enzyme content is often influenced both by the stage of harvesting of the yeast and by the nature of the sugar present in the medium.

The final summing up of the symposium was made for the brewing industry by Dr. A. H. Cook (Brewing Industry Research Foundation) and for the baking industry by Dr. J. B. M. Coppock (British Baking Industries Research Association). Dr. Cook pointed

to the recent upsurge of yeast research, but also indicated the gulf which still separates pure research from the reality of technological practice. Dr. Coppock directed attention to the new questions posed as a result of every scientific advance. Both speakers brought out the value of work ostensibly carried out in one field to work in another field: in particular, the 'cross-linking' between brewing and baking had manifested itself in this symposium.

Perhaps it was surprising that no paper devoted to questions of the fundamental nutrition of yeast was presented. Such questions, of course, arose incidentally; but it is to be hoped that this deficiency does not reflect a neglected aspect of yeast research. For all that, the symposium was undoubtedly most successful: the amount and vigour of the discussion succeeding each paper testified to the interest aroused at this most informative and stimulating meeting. It is also necessary to add that splendid organization and generous hospitality, for the major part of which the symposium was deeply indebted to the firm and staff of Arthur Guinness, Son and Co. (Dublin), Ltd., contributed substantially to its success.

C. RAINBOW

FREE RADICALS

SYMPOSIUM OF THE CHEMICAL INSTITUTE OF CANADA

A SYMPOSIUM on recent progress in the production, isolation and identification of free radicals was held during September 10-11 in the Chemistry Department of Laval University, Quebec. The meeting was sponsored by the Physical Chemistry Division of the Chemical Institute of Canada, and the arrangements were made by Dr. J. A. Morrison (National Research Council) and Prof. P. A. Giguère (Laval University).

The first group of papers dealt with spectroscopic studies of radicals produced by flash photolysis or shock waves. The paper by Drs. G. Herzberg and J. Shoosmith (National Research Council, Ottawa) discussed the CH_3 and CD_3 radicals. Although their spectra are predissociated, the structure of the CD_3 band at 2140 Å. indicates that one state, probably the upper, is planar with $r_0(\text{CD}) = 1.072$ Å. and that the other state is slightly bent. Further work is in progress with the view of finding a predicted 'forbidden' transition in the visible which would not be predissociated.

Prof. G. Porter (University of Sheffield) presented a paper showing that simple aromatic radicals such as benzyl can be observed in vapour phase and in solution using flash photolysis, as well as in rigid media at low temperatures. He cited recent work by Bridge and Porter on the photochemistry of quinones in solution, where triplet states, semi-quinone radicals and radical ions have been observed and their reactions studied.

Two papers from the National Research Council (Ottawa) dealt with triatomic radicals. In the first of these, Dr. D. A. Ramsay discussed the spectra of HCO , NH_2 and PH_2 , all of which show long progressions of the bending vibration ν_2 due to a large difference in bond angle between the upper and lower states. The NH_2 radical has a 2B_1 ground state with $r(\text{NH}) = 1.025$ Å. and a bond angle of 103° . Its upper state is linear, probably $^2\pi_u$, and

provides the first example of the interaction of the electronic angular momentum and the vibrational angular momentum of the bending mode of a linear molecule which was predicted by Renner. For PH_2 and PD_2 the bending vibrational interval in the upper state is found to pass through a minimum with increasing vibrational quantum number (v'_2). This is thought to be due to steric repulsion of the hydrogen (or deuterium) atoms at large vibrational amplitudes. The second of these papers was presented by Dr. F. W. Dalby, who showed that bands near 7500 Å. tentatively assigned to DCO by Herzberg and Ramsay are due to DNO. Bands due to HNO in this region of the spectrum and lasting up to 1/10 sec. have been obtained in the flash photolysis of nitroethane, amyl nitrite and ammonia plus nitric oxide.

The only paper describing shock-wave techniques was given by Dr. N. Davidson (California Institute of Technology), who has studied the decomposition of nitrogen pentoxide in an excess of argon. In this system he was able to photograph the absorption spectrum of the NO_3 radical and to measure the rate constants of the following reactions:

The discussion of these papers brought out both the relative advantages and limitations of these techniques and of work in rigid media, the conclusion being that they were complementary to each other.

The second group of papers dealt with the mass-spectrometric detection of free radicals and atoms produced in a variety of ways. Drs. W. A. Bryce, D. J. Fabian and K. U. Ingold (University of British Columbia) used the pyrolysis of mercury dimethyl to produce methyl radicals which reacted with oxygen in a quartz vessel designed to eliminate the need of a carrier gas. CH_3 , CH_2 , CH_3O , CH_3O_2 , OH and HO_2 were among the radicals detected. In his paper, Dr. F. P. Lossing (National Research Council) described the detection of free radicals in the mercury photosensitized decomposition of acetaldehyde, acetone, ethylene, etc., using a flow system; by varying the length of the irradiated zone it was possible to distinguish between primary processes and secondary reactions. Dr. Lossing also showed that recent calculations of free-radical ionization potentials by Dr. J. A. Pople were in good agreement with the experimental values.

The electric discharge was the source favoured by Drs. S. N. Foner and R. L. Hudson (Johns Hopkins University) and by Drs. J. Herron and H. I. Schiff (McGill University, Montreal). The former have studied the formation of the HO_2 radical in a variety of systems and have found that an important homogeneous reaction is

The latter have studied the reaction of oxygen atoms with various species and find a rate constant of 3×10^{10} ml. mole⁻¹ sec.⁻¹ for bimolecular reaction with nitric oxide.

The papers by Drs. P. LeGoff and L. P. Blanchard (University of Nancy) and Dr. A. J. B. Robertson (King's College, London) discussed processes occurring on hot metal surfaces in the presence of gases at low pressures. The former authors observed such species

as CCl_2 from CCl_4 and CS from CS_2 . Dr. Robertson discussed the adsorption of ethane and oxygen on platinum surfaces, and showed that the decomposition of the former was not in accordance with the transition-state theory. This point was further brought out in discussion, as was a general agreement over the mechanism of the formation and removal of the HO_2 radical which is still eluding the spectroscopists. Dr. C. K. Jen (Johns Hopkins University) reported unsuccessful searches over a wide range of the microwave region, and, in a later paper, Prof. P. A. Giguère and Dr. K. B. Harvey (Laval University) reported their failure to date to obtain the infra-red spectrum of HO_2 at low temperatures by condensing the products of a discharge through water vapour.

The next two papers described work at the National Bureau of Standards (Washington, D.C.) on the products from a microwave discharge through nitrogen collected on a surface at liquid-helium temperature. Dr. A. M. Bass discussed the experimental side of the work, the most striking feature of which is a green glow from the condensed solid with a half-life of about 15 sec. after the discharge has been switched off. Dr. C. M. Herzfeld showed that this spectrum arises from the $^2D \rightarrow ^4S$ atomic transition of nitrogen, the position of which is shifted by the presence of molecules within one or two angstroms. Also present are bands attributed to a $^5\Sigma_g^+ \rightarrow ^4\Sigma_u$ transition of N_2 , the $^5\Sigma$ state arising from normal atoms and having a very shallow minimum. Dr. G. C. Pimentel (University of California, Berkeley) described infra-red studies of radicals trapped during the photolysis of hydrazoic acid in an inert matrix at 30° K. There is strong evidence for NH_2 and N_3 radicals in this system. This produced a lively discussion, and Pimentel's work agrees with that of Dr. B. A. Thrush (Cambridge), who has found the ultra-violet absorption spectra of N_3 , NH and NH_2 in flash photolysis of hydrazoic acid. N_3 was probably absent in the work at the Bureau of Standards, as its ultra-violet spectrum was not observed. It is surprising that N_3 is not formed from a metastable N atom and an N_2 molecule in this system; but Herzfeld has estimated the binding energy of the atom to be only a few hundred wave-numbers.

Dr. P. Smith (Purdue University, Indiana) presented evidence from various sources for the existence of the HO_3 radical and H_2O_4 . No one present had any direct experimental evidence of these species.

The last three papers dealt with paramagnetic resonance. Dr. R. Livingston and H. Zeldes (Oak Ridge, Tennessee) pointed out the importance of using single crystals if trapped radicals were to be positively identified in irradiation experiments at low temperatures. They had, however, good evidence for OH radicals in the glass obtained by condensing the products of a discharge through water vapour. Drs. C. K. Jen, S. N. Foner, E. L. Cochran and V. A. Bowers (Johns Hopkins University) studied the products condensed from a discharge through hydrogen at liquid-helium temperatures. They found two triplets and a quartet near the free-electron resonance, and suggested that these might be due to H_3 or triplet H_2 .

Dr. J. E. Wertz (University of Minnesota) discussed the hyperfine structure of the resonance spectra of semiquinone radicals; this is determined by the number and distinguishability of the protons present in the radical and greatly facilitates identification of the steps in quinone reactions. The dis-

cussion showed that this technique had great sensitivity and could well be applied to short-lived species.

The credit for the success of the meeting must be shared between the organizers and the authors of the nineteen papers presented, which dealt with very recent advances in fields that were, almost without exception, completely unknown ten years ago.

B. A. THERUSH

INSPECTION OF INDUSTRIAL POLLUTION IN BRITAIN

REPORT FOR 1955

THE ninety-second report on alkali, etc., works in England and Wales and in Scotland by the chief inspectors, covering 1955*, records 921 works in England and Wales registered under the Act at the end of the year, operating 1,794 processes, which is a decrease of six in the number of works and an increase of ten in the number of processes. The 3,894 visits and inspections made during the year included 165 special visits by the chief and deputy chief inspectors; of the total, 521 visits were to or in connexion with works not registered under the Act, and a further 60 visits were to or in connexion with colliery spoil-banks. During the inspections, 2,057 quantitative analyses were made of gases evolved from processes in operation, and 827 special samples were submitted for detailed examination to the Government Chemist. Complaints and requests for technical advice and assistance involved a hundred registered and ninety-four non-registered works, the corresponding figures for 1954 being seventy and ninety, respectively; the increase is attributed not to deteriorated conditions but to a greater public awareness of the desirability of cleaner air. During the past few years there has been an increase in what are conveniently termed "area complaints", the complaint being directed against emissions from a highly industrial area or one of intensive production, such as Trafford Park, Manchester, and the Thames-side cement area, rather than against that from individual works.

On twenty-one occasions the total acidity of gases escaping to the atmosphere exceeded the statutory limits, and a further twenty-seven infractions related to failure to use "best practicable means". Since on formal notification of infraction suitable action ensued, there was no occasion to institute proceedings. Visits were paid both to the oil-fired Bankside and the coal-fired Battersea electricity generating stations, both of which are in London, to assess the efficiency of the installations for washing flue gas. While the position at Bankside was most satisfactory, the problem at Battersea is more difficult and has to contend with a doubling of the ash content of the coal since before 1939.

The high demand for cement has continued, and all kilns have operated at full output even when their associated dust-arrestment plants are undergoing repair, so that it was not surprising, especially in view of the fine summer, that there were

complaints from most cement-making areas. The inspectorate continued its general policy of ensuring that all de-dusting plant is kept in as efficient a state as possible, that shut-downs are kept to the absolute minimum and that standards of supervision and "housekeeping" are as high as possible. The operation and maintenance of electrical precipitators still give real difficulty at many works. The production of sulphuric acid as monohydrate reached a record in Britain of 1,899,000 tons, an increase of 61,000 tons over 1954, and there was a spectacular increase in the usage of anhydrite for the dual production of sulphuric acid and cement clinker—from 177,000 tons in 1954 to 382,000 tons—and this process involves a serious problem of mist in the final escapes to air.

The Chief Inspector for Scotland reports no change in the number of works (82) registered under the Acts; but the number of processes operated increased by three to 119. On the 195 visits made to registered works, 92 chemical tests of flue emission were made involving the analysis of 116 samples, 14 by the Government Chemist; a further 166 visits were made which were not directly related to the provisions of the Acts. The Chief Inspector remarks that recent research has thrown more light on the dispersal of gases and dust from chimneys, and it seems desirable that the results of this work should be applied more generally, if only to test their validity; he cites an instance in which recently published work on dispersal of dust from high chimneys was particularly useful in connexion with dust emission from a power station in the west of Scotland which is fired with pulverized fuel.

BIRD SEMANTICS

MOST birds have a rudimentary language. A crow, for example, gathers its flock by uttering a distinctive 'assembly call' and disperses it by squawking an 'alarm call'. The flock will respond to tape recordings of these calls just as it does to the cries of a live bird.

Two research groups, one in the United States, the other in France, recently exchanged tapes on which they had recorded the calls of their native crows. Their object was to learn whether French 'crows' (rooks, jackdaws and carrion crows) would understand the language of the American eastern crow, and vice versa (*Sci. Amer.*, August 1956). Roosting French 'crows' consistently ignored the alarm call of American crows; but more than half the French birds were aroused by the broadcast of an American 'gathering' call. American crows were wholly unmoved by the plaintive cries of nestling rooks or the strident assembly call of adult jackdaws—commands which all three species of French crow invariably obey.

In a further experiment, the French investigators broadcast the food-finding and alarm calls of the American herring gull, a bird that also dwells on French coasts. The French gulls paid no heed to the American calls. From these experiments the investigators concluded that birds learn the language of their kind from older birds of their own group. The investigators included R.-G. Busnel, J. Giban and Ph. Gramet, of the French National Institute for Agricultural Research; the Americans were Hubert and Mabel Frings and J. Jumber, of Pennsylvania State University and the Mount Desert Island Biological Laboratory.

* Ministry of Housing and Local Government: Department of Health for Scotland. Alkali, etc., Works Regulation Act, 1906, and Alkali, etc., Works Orders 1928-1950. Alkali, etc., Works Regulations (Scotland) Acts, 1906 and 1951. Ninety-second Annual Report on Alkali, etc., Works by the Chief Inspectors, 1955. Pp. 51. (London: H.M.S.O., 1956.) 2s. net.