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THE HORTICULTURAL CHEMIST

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INTRODUCTION

Horticulture is man's oldest industry. You will remember that Adam had a garden; it had fruit in it, good fruit, too, that was too great a temptation for his wife and later for himself; we are not told whether he had any insect or fungal pests or any weeds in that garden to worry him. But his idyllic state was not maintained and he had to move into an area where weeds grew so that he had to work hard to keep it in order, and to obtain his food. Probably he had some pests there also. Since that time man has had a continuous struggle against weeds and pests. By hard experience he has been able to establish systems of agriculture which by development of resistant or more prolific strains of crops allowed him to keep ahead of the depredations of his natural enemies, increase his numbers, and migrate to other regions of the earth.

With increase in population, and the concentration into cities, there arose a demand for quality in the produce from the land. Doubtless preferences for goods of one or more particular origin arose from their superior appearance or flavour; quality was judged by eye or nose, assisted by the organs of taste. Those early people even had some theoretical ideas about the constitution of the atoms of which different substances were made. Thus Lucretius, in the first century B.C., has this to say, "Substances of a pleasant taste, as honey and milk, have smooth round atoms, while bitter substances, as wormwood, have jagged atoms which lacerate the tongue. Other substances of a spicy flavour, as tartar of wine and elecampane, have atoms with slender projections that simply tickle the tongue." On the practical side there were chemical tests that could be used to judge the quality, if in that term we include freedom from adulteration; even test papers were used. Thus strips of papyrus steeped in an infusion of nut galls was used in a test with sulphate of iron, when the paper was turned black.

EARLY CHEMICAL INVESTIGATORS

Possibly the earliest chemist that we would be prepared to regard as having ideas that would be reasonably acceptable at the present day was Bernard Palissy (1510-1589), a self-taught Frenchman, mainly interested in ceramics but who nevertheless investigated agricultural matters. And he lived at a time when chemistry had not yet become a science. During Palissy's working life van Helmont, the first great chemical experimentalist with plants, was born (1577-1644). It has been stated that van Helmont's experiment with the willow tree, with which we are all familiar, is a research "of which an agricultural experiment station of today need not be ashamed." Then during van Helmont's lifetime Robert Boyle was born (1627) and he lived through most of the 17th century, dying in 1691. Boyle is remembered by chemists for his physical chemistry and his theoretical work, but he also carried out and reported a large number of observations of agricultural interest. Typically he records, "Thus many, by my recommendation, have continued fruits, as quinces, for instance, good, almost, all the year round . . . but cherries I have preserved fresh and juicy for more than a year . . ." Further he says, "I must here observe that the more comprehensive any trade is, the more improvements it will admit of from philosophy; because, depending upon many natural productions and operations, there must arise many particulars to be ameliorated, or reformed, either in the manufacture, or profession." Some years before Boyle's death Stephen Hales, afterwards to become one of the most famous investigators in plant physiology, and a member of the Royal Society, was born (1677). His "Vegetable Staticks, or an account of some statical experiments on the sap of Vegetables; being an Essay towards a Natural History of Vegetation," is a classic. Hales experimented with many horticultural crops: among vegetables were cabbages, radishes, pumpkins, peas, cucumbers; among fruits, grapes, currants, apples, pears, quinces, plums, peaches, lemons. He was particularly interested in the amounts of water required for transpiration and in the movement of the sap. It has been said of him:

"No one previous to Hales had conducted so large a number of experiments upon the growth of various crops and his investigations in this field have for two centuries been a source of inspiration to agricultural chemists in all parts of the world." Hales died in 1761.

Overlapping the life of Hales we have the relatively short life of Antoine Laurent Lavoisier (1743-94), of whom Liebig said, "He discovered no new body, no new natural phenomenon; all the facts established by him were the necessary consequences

of researches that had preceded his own. His immortal services consisted in endowing the body of the science with a new spirit; but all the members of that body were already present and correctly united." Of him also it has been written, ". . . he brought into chemistry a new doctrine, a new nomenclature, a new outlook, and a new spirit. His reforms in the various branches of inorganic, organic, physiological, and agricultural chemistry mark the commencement of the modern era."

Seven years before Lavoisier's death at the guillotine a German boy, Carl Sprengel (1787-1859) was born. He became a remarkable investigator in agricultural chemistry, and yet is relatively little known, being overshadowed by his compatriot, Justus von Liebig (1803-1873). Indeed Sprengel was really the originator of many ideas for which credit is usually given to Liebig. For example Sprengel clearly expressed "the law of the minimum," according to which even if only one essential element should not be present in sufficient amounts, then the plant will not grow normally. Suggestions that the "law of the minimum" should become the "law of the optimum" follow out Sprengel's ideas. Sprengel also taught that any nutrient could be present in too large an amount; he was for "not too much" and "not too little." He was also probably the first to recognise the importance of what we now call the trace elements. You will see that in the space of the lives of only six men we have encompassed a span of 350 years, passing from the alchemical to the chemical period. It is only 95 years since Sprengel died so that we are brought to a relatively modern period of time, and if we add to this list Thomas Hill Easterfield (1866-1949), whose memory we hope to commemorate at our Conference this year by the first award of the Easterfield Memorial Medal, we bring our lists of chemists who had a great influence on the application of chemistry to agriculture and horticulture, right up to our own times.

THE AGRICULTURAL CHEMIST

In the earlier part of last century the term agricultural chemist became current, not without some protests. Indeed some universities closed down their direct agricultural courses and redistributed the necessary lectures through the physics, chemistry, etc. departments. Yet such a term for a branch of chemistry is clearly necessary. Is it not just as clearly necessary to have the term horticultural chemist? To imitate a definition that has been given of an agricultural chemist, he will study the "chemical composition and mutual relationships of soils and plants," and we find it necessary to add, the chemistry of those substances necessary for the control of growth of plants and fruits, and for attack on the fungus and

insect pests of those plants and fruits. The fully qualified horticultural chemist must therefore have a training in soil chemistry, plant physiology, inorganic, organic and physical chemistry; and in addition he should be a competent analyst. He should have some knowledge of botany and zoology. A good all-rounder!

SOILS

Let us take up some of these branches in turn. From very early times it has been recognised that certain soils suited particular crops better than others. Some, such as peanuts, require a sandy soil, others such as grapes and olives do well on clay soils. Yet there is something deeper than this to be inquired into. How does the proportion of sand, silt and clay regulate the supply of nutrients to the growing plant? We believe that the mineral nutrients are held mainly by the clay particles as part of the crystal structure of those particles. They have certain properties of ionisation, and metal ions can be exchanged, mostly by hydrogen ions supplied by the plant, when the metal ion is taken up by the plant. But the story is not so simple as this. It is found that uptake of positive ions is related to the amount of organic acid in the plant; with intake of, say, potassium or calcium the amount of organic acid increases. Again, why are some plants able to absorb nutrients more successfully than others? Take, for example, phosphorus. Lupins will grow quite well and build up relatively large amounts into their structures, when grown on a soil which by chemical tests is a very poor supplier of that element. Swedes and turnips would not grow well on such a soil, so a fertilizer supplying available phosphorus must be provided. A good crop is then obtained—but the plants absorb only relatively small amounts of phosphate. Apparently the absorbing mechanism in the turnip requires a high threshold concentration of phosphate before absorption takes place in amount sufficient to produce a satisfactory crop. Equivalent examples could be given for other nutrients.

Consider now the trace element situation. We know that climatic conditions exert a very considerable influence on the appearance, or not, of symptoms due to lack, so far as the plant is concerned, of elements such as boron, zinc or magnesium. Conditions in the soil are governed by climatic effects. But there is more to it than this. Why, for example, is the Sturmer apple so sensitive to the level of the supply of boron, while the Delicious apparently hardly ever shows any symptoms? Again it is quite well known that there are varieties of red beet and celery which may be sensitive or insensitive to low supplies of boron. Is their behaviour a result of the chemical reactions in their roots or in their leaves? I doubt if anyone knows. We may note at this point

that boron still remains an element whose precise function in the plant is unknown. Other trace elements can be related to some enzyme system in the plant but so far as is known boron has no connection with any such system. It has, however, been suggested recently that boron-carbohydrate complexes have the property of passing through the cell walls more readily than carbohydrate molecules. It might be added that the attempted fractionation of boron compounds in the plant, especially in relation to the cell walls, could be very informative.

Another soil matter on which information is badly required is concerned with waterlogging. Why is it that plants, such as tobacco, cannot withstand waterlogging of the soil? We can grow them in liquid culture solutions quite satisfactorily. The supply of oxygen is presumably concerned, but it does not seem to be the only factor concerned. At the opposite end consider the rice plant: it requires a waterlogged soil for satisfactory growth; it uses ammonium ions apparently—nitrate is not beneficial. What biochemical differences are there in the roots of the tobacco and the rice plant? It may have been worked out by someone, but I have not come across it. Such knowledge should be very useful for a number of plants.

QUALITY

The question of quality in crops cannot at present be fully explained by chemical analysis. We know that it is desirable that cured tobacco leaf to be used in cigarette manufacture should have a relatively high content of sugars and relatively low total and protein-nitrogen contents. But what compounds are responsible, and in what quantity, for the most desirable texture and aroma cannot be stated. Again the amount of inorganic material, especially of potassium or chlorine, may have a determining effect on its quality.

To return to apples: Why have Cox's Orange such a desirable aroma and flavour? We know that there are certain relationships between acids and sugars to give a clean sharp taste as against a sweet or flat taste, and that a number of organic compounds (esters, alcohols) can be distilled from apples. How do the compounds and their quantities vary from variety to variety and what regulates their formation? Work in U.S.A. is proceeding on these lines, but a great deal more still needs to be known.

At rock bottom we are faced with the questions, why and how: why does the flavour and aroma vary from variety to variety? Why do soil and climatic conditions affect quality from season to season? How do the living processes operate to produce these

differences? We can graft a Cox's Orange scion on to a Wyken Pippin stock; then the graft produces Cox's Orange fruits. Suppose we cross Cox's Orange with Wyken Pippin? Then we get a new apple with some outward appearance of a Cox's Orange but with little flavour, and with a white flesh, although both parents are yellow-fleshed and aromatic. You will say that the genes should have carried the characteristics of the two varieties to the new variety, but they have not in any obvious way. How do the genes influence the chemical reactions which are necessary for the production of those compounds which give the characteristic appearance of the skin or the flavour and aroma?

STORAGE OF FRUIT

Let us now go in another direction, that of fruit storage. Empirical trials have to some extent determined the conditions under which the different varieties of fruit can be held to lengthen their period of sale to the consumer. Each variety has its own requirements of temperature and composition of the atmosphere in the store. Now why should this be so? Storage life of an apple seems to be determined by the proportion of nitrogen, soluble—and protein—in relation to the sugars, particularly sucrose, in the fruit; in more precise terms to the concentration of these in the cells. Now it has been found that the rate of respiration of an apple (and of other plant material) is approximately proportional to the protein content, and a high rate of respiration goes with poor storage quality, therefore storage quality is related to protein content. There is a further matter. The number of cells in an apple, after a very early stage of its growth, remains constant throughout its life. The number is slightly variable from variety to variety. Seeing that the number of cells per fruit is constant the size of the cells increases as the fruit grows, and the amounts of the several constituents, protein, soluble nitrogenous compounds, sugars and organic acids will generally increase, although the amount of some of them on the fresh or dry basis may decrease. The result is that the amount of metabolizable material per cell will increase. After removal from the tree, whether the fruit is held at ordinary temperatures or in cool storage, the organic acid, Vitamin C, sugar and starch contents fall, but by what system of reactions is not completely known. Again at a certain stage in the life of the fruit the so-called climacteric is reached with a corresponding rapid increase in rate of respiration. Ethylene appears and protein formation increases. How this compound arises is not known, but it has very marked effects on the fruits (not only apples, but bananas, oranges, etc., respond, too). Rate of ripening is increased markedly. How this is accomplished is again not known.

We are still left with a complicating matter, each fruit is an individual and therefore all fruits on a tree are not at the same stage of development, and indeed there may be appreciable differences in chemical composition between one fruit and another. How great is the opportunity therefore for variation in composition between fruits from different trees in an orchard? And therefore what appreciable variations in storage quality may we expect to find in the contents of a case of fruit!

NITROGEN COMPOUNDS IN FRUIT

There is a further matter to which attention may be directed. During respiration of leafy material removed from a plant, but held so that the living processes may continue, decomposition of protein with formation of simpler nitrogenous substances occurs. But in the apple (whether in other fruits, too, I do not know) we find that protein synthesis occurs specially at the climacteric. Now why is that? We do not know.

To change the direction again of our discussion: fruit from trees treated liberally with nitrogenous fertilizers, and from young trees, is of poor storage quality. How far is the non-protein nitrogenous fraction concerned in this? In England it has been suggested that this fraction may provide nutriment for micro-organisms which are thus enabled to develop better on high nitrogen than on low nitrogen fruit.

The presence of large amounts of these simpler compounds might also make the fruit more susceptible to physiological disorders. A plea was made for more data on the soluble and protein nitrogen fractions and for storage data on the same samples of fruit; by correlating these it might be possible to get more positive information on the relationship of nitrogenous fertilizing to fruit quality. The same plea may be made for New Zealand fruit.

HORMONES, ETC.

I would like to pass now to a consideration of hormones, fungicides and insecticides, those compounds whose numbers have increased so rapidly since the end of the last world war, to the bewilderment not only of the chemist, but also of the horticulturist to whom these are offered for use.

The hormones or growth regulators act in two capacities, either to increase or to reduce growth; some of them will do both according to the species of plant and the concentrations at which they are employed. Now, one of the problems that concerns the fruit grower is the drop of young fruits that occurs early in their growth and again as the fruit approaches maturity. To take the

first condition first. Estimation of the quantity produced and its locus of production in an apple has shown that the auxin responsible for growth is produced in the body of the pips, not in the embryo. Although the young fruits grow rapidly during the first 3-4 weeks after setting, no auxin is detectable in the seeds over that period. Production of auxin begins as the seeds develop still further, but, owing to the drain on the supply of auxin due to rapid growth, the amount present in the seeds falls as the embryo enlarges, to increase later, and then again to fall as the fruit grows. These periods of low auxin content correspond to the periods when the fruit falls from the tree. It may be noted that the fallen fruit contains few seeds and less auxin per seed than fruit still on the tree. By spraying the trees at the appropriate time with a dilute solution of naphthalene-acetic acid losses of nearly mature fruits can be greatly reduced. As pre-harvest sprays this idea has been commercialised so that one finds advertised various proprietary products with accompanying names descriptive of their purpose. It is unfortunate, however, that a given hormone is not equally effective on all varieties of fruit, for each variety seems to exhibit its own specific behaviour. Field trials have therefore been necessary to sort out these differences. It would be very interesting to know how and why these differences occur between varieties in a given species of fruit, e.g., the apple.

Although use of a hormone spray will reduce the amount of windfalls in fruit as it approaches maturity one finds the surprising fact that when naphthalene-acetic acid (NAA) was applied in attempts to prevent fall of young fruitlets 5-6 weeks after blossoming an increased drop of fruit occurred. This suggested that hormones might be used as chemical thinning agents, which would be much less drastic on the trees than the strongly caustic dinitro compounds which had already been employed. Results with NAA have, however, been very irregular when applied at varying intervals after petal fall: 7 days after petal fall has been suggested by Long Ashton workers as the best compromise period. Compromise is necessary because one must balance the effect of the hormone in reducing the crop too much with danger of toxic action on young foliage. A concentration of 20 ppm. of NAA is suggested as being suitable. Because of the irregularity of the results in different countries obviously more work is required especially in the direction of relationship of the state of nutrition of the tree to the effects obtained.

ACCELERATION OF RIPENING

Another very interesting development has been the use of hormones in particular 2,4,5, trichlorophenoxy-propionic acid

(2,4,5,T.P.), to increase the rate of ripening. The attraction of such a property in a chemical compound is that fruit, especially of early varieties, could be put on the market earlier, and in a large orchard part could be sprayed to induce earlier maturity in later varieties and thus spread the length of the harvesting period. With 2,4,5,TP at 100 ppm. or 50 ppm. on Worcester Pearmain in England colouration of the fruit occurred, but the fruit was flavourless and of poor quality. At 20 ppm. very little acceleration of ripening occurred. At 30 ppm. ripening was uneven; it was suggested that a certain concentration of the hormone is required to "trigger" the reactions in the fruit which lead to production of colouring matter and thus produce the outward signs of ripeness. As an interim recommendation a concentration of 40 ppm., applied 6 or 7 weeks before the usual harvest date, has been made. This compound also acts as a preventative of pre-harvest drop.

DANGERS FROM USE OF HORMONES

During the work with 2,4,5,TP, definite indications of loss of storage quality of the fruit were obtained. At the higher concentrations rot around the calyx area developed. Care is apparently required even with hormones of the NAA type, because I have heard growers in the Nelson district say that even at picking time such treated fruit is of poor quality. One would need to check up on the maturity of the fruit to see that the increased stick-on effect had not trapped the grower into leaving his fruit on the tree beyond the normal time of picking for the variety concerned. But the main point is that by the use of these hormones we have upset the normal life of the organism. We may have encouraged it to ripen prematurely, we may have prevented its normal development (by use of maleic hydrazide), we may have actually poisoned it when using the hormone as a weedicide. Provided, of course, that we do not use the produce as food we affect nothing except the plant. But do we know enough to say that these compounds, or their conversion products in the plants and fruit, are really harmless to man and animals? I am driven to ask this because somewhere recently I noticed a report that certain hormones had been found to produce cellular changes leading to mutants similar to those induced by X-rays and radioactive materials. It seems that we are interfering with nature in a dangerous way, with results that may not be for our eventual benefit.

CHEMICAL CONSTITUTION AND ACTIVITY

We will glance for a short time at the influence of chemical constitution on the activity of some compounds related to 2-4D. It must be stated that in the literature there will be contradictions

in the reported activity of many compounds due to different methods of measurement of activity being adopted by different experimenters. Questions of chemical stability and ability to enter the plant tissues, whether the compound exerts its activity through cell division, cell elongation, etc., will determine its apparent activity. Some investigators, for example Wain of Wye College, consider it safest to put any series of compounds through a variety of tests before deciding on its potential activity. If any compound fails to elicit responses in all of these tests there is not much chance of its being an active growth substance.

The compounds related to 2-4D (2-4 Dichlorophenoxyacetic acid) have been well examined. Some such compounds are reported upon in Table 1, where their activity is compared with the activity of indole-acetic acid in the "split pea stem curvature" test which is taken as 100.

TABLE 1

Activity of phenoxyacetic acid derivatives.

Phenoxyacetic acid	0
2-Chlorophenoxyacetic acid	4
4-Chlorophenoxyacetic acid	200
2-4-dichlorophenoxyacetic acid	1000
2-4-5-trichlorophenoxyacetic acid	500
2-4-6-trichlorophenoxyacetic acid	0
2-3-4-6-tetrachlorophenoxyacetic acid	1
Pentachlorophenoxyacetic acid	5

The effect of substitution is very clearly seen, substitution in the 4 (or para) position being very great, until at least the trichloro compound. However, other constitutional effects (steric hindrance) enter, because the 2-4-6-trichloro compound is stated to be inactive. One suggestion that has been made is that progressive substitution by chlorine leads to greater solubility in fatty compounds—a suggestion that we will find later also in discussing the activity of certain insecticides. Excessive fat-solubility may reduce solubility in water and thus in the tetra and penta compounds the growth-activity effect is reduced. This theory has not, however, been completely accepted by some workers.

For further consideration, the data of Table 2, due to Wain, are given.

TABLE 2

Activity of aryloxy-acetic, -propionic and -iso-butyric acids in the tomato leaf epinasty test.

Aryloxy grouping	-acetic acid	-propionic acid	-isobutyric acid
Phenoxy-	inactive	+ +	inactive
2-chlorophenoxy-	+	+ +	"
4-chlorophenoxy-	+ +	+ +	"
2-methyl-4-chloro- phenoxy-	+ + + +	+ + +	"
2-4-Dichlorophenoxy-	+ + + +	+ + +	"
2-4-5-trichlorophenoxy-	+ + + +	+ + +	"

Wain has suggested as a result of his work that the main requirement for activity is an unsubstituted hydrogen atom on the carbon atom alpha to the carboxyl carbon atom. You will notice that the iso-butyric acids in which this requirement is not met, are all inactive.

SYSTEMIC FUNGICIDES

In the past, fungicides have been applied on the external surfaces of the plant that we wished to protect. Recent work has shown that a number of hormone-type compounds when allowed entry into the plant are capable of giving appreciable protection against certain fungous diseases. What is really interesting though, is that compounds which appear in the above tables as being inactive in regulation of plant growth, are effective fungicides. They are called systemic because they act within the tissues of the plant and travel in the sap stream of the plants. It may happen that in some cases the compounds do not act as such, but that products of their transformation within the plant are the active agents. The possibility that such compounds induce biochemical changes within the plant which in turn confer resistance to infection must not be overlooked. A vastly important field of research is opened up here.

ANTIBIOTICS AS FUNGICIDES

Another most important field has been opened up by the discovery that a number of antibiotics are effective fungicides, and are effective in the control of bacterial, and even some virus, diseases. Streptomycin and Terramycin have given good results,

even with such a troublesome disease to control as fire-blight of apples and pears. Of the antibiotics and other chemical compounds so far examined, Griseofulvin has been claimed "to be the most effective systematic fungicide yet discovered." It has been claimed also for some systemic fungicides that lasting protection or even immunity is conferred on the plant. If the promising results already obtained with various wilts of tomatoes and other plants are extended and confirmed, we shall have most valuable means for the control of these troublesome diseases.

INSECTICIDES

Insecticides cover many types of chemical compound so that we shall not be able to discuss them at any length. However, it is interesting and important to note that certain compounds, in particular the organic phosphorus ones such as parathion and the inorganic selenium compounds, act as systemic insecticides, being absorbed into the sap stream from sprays and conferring protection from sucking insects by reason of the fact that the insects are poisoned and killed by the insecticide in the sap that they ingest. Nor must we overlook the undesirable effects on flavour of various crops from compounds present as impurities in benzene hexachloride and D-D; but the former in the pure gamma form, gammexane, is practically free from tainting.

A chemical study that we can make concerns the activity of DDT and its relatives on insects. At one time it was thought that their toxicity lay in their solubility in fats. This does not give a completely satisfactory grading between the compounds. When combined with the idea of relative ease of hydrolysis with production of HCl much better, although not perfect, correlation of constitution and activity is obtained. It is of interest to note that in the DDT series the effect of halogen substitution leads to the order $F > Cl > Br > I$. In any case there must be a chemically reactive group somewhere in the molecule which will react with living cell contents if the compound is to be a killing agent. Removal of HCl is apparently related to toxicity because in the higher animals the symptoms of DDT toxicity are accompanied by the excretion of bis-(*p*-chlorophenyl) acetic acid. It is difficult of course to obtain a chemical test method that will simulate even approximately the conditions which the insecticide will meet in the cells of a living organism. Also there are great differences in toxicity of a given substance to the different species of insects. We are also faced with the ability of the living cell to be educated to the presence of an originally noxious substance, an ability that probably leads to the development of races of the insect resistant to the compound in question.

Another most important line of advance is the discovery of insecticides uniquely toxic to a given species. Thus the proprietary material Chlorocide (*p*-chlorobenzyl-*p*-chlorophenyl sulphide) has been issued for control of red spider without doing any injury to the insects predatory to this mite. Discovery of compounds having such selective action on other insects would be extremely valuable, and would assist in preventing that upset of the natural balance of the useful insects which many entomologists fear may arise, indeed some say that it already has arisen, from the widespread use of non-selective insecticides.

CONCLUSION

We have covered a wide range of matters in our discussion but there are as many more not mentioned that also warrant examination. I think that you will see that the horticultural chemist has a very wide field to cover. He has learnt much about the growth of his crops and their reaction to their surroundings, still we must admit that he cannot yet give a full answer to that question in the children's rhyme,

"Do you, or I, or anyone know,
How oats, peas, beans, or barley grow?"

EASTERFIELD AWARD

At the Combined Institutes of Chemistry Conference held in Nelson, Mr. John Rogers, M.Sc., Senior Lecturer in Mineral Engineering at the School of Mines, Otago, received the first award of the Easterfield Medal.

The Medal, which is provided by the Royal Institute of Chemistry, is an award in honour of the late Sir Thomas Easterfield, first chairman of the N.Z. Section of the R.I.C., and second president of our own Institute.

The award is open to all chemists in New Zealand under the age of 35 and is given to recognise the outstanding quality and originality of their research work.

Dr. J. K. Dixon, Chairman of the N.Z. Section of the R.I.C., in presenting the medal to Mr. Rogers, apologised for the unavoidable absence of Sir Henry Jephcoate, President of the R.I.C.

In his Memorial lecture which was delivered immediately following the presentation Mr. Rogers gave an account of his researches on the flotation process in mineral dressing which earned him the award.

CHEMICAL DEVELOPMENTS IN THE MINERAL INDUSTRY

J. Rogers, School of Mines, Otago University
Chairman's address to Otago Branch

In preparing this address I was concerned with illustrating several themes. The first of these is the importance of industry in this country making progress by the application of scientific discovery in its processes. Sir Henry Tizard discussed this with special reference to the problems of Great Britain in his Messel Lecture to the Society of Chemical Industry in 1952. He quotes a very pertinent remark of Sir Ewart Smith's that "any basic knowledge which is evolved is, broadly and relatively, quickly available to all and it is therefore upon technological skill in application that the progress of industry and, consequently, the economic position of the nation will mainly depend." Sir Ewart's words are well illustrated by the work of New Zealand chemists and technologists in developing the cyanide and dredging processes of the gold industry at the end of the last century. The mineral industry, largely through these developments of the cyanide process in Thames and dredging in Otago, was the source of much of the capital for the railways, roads, etc., which have been such important factors in the growth of our agriculture.

The second point I propose to discuss is the time, capital and team work required for the application of a laboratory discovery in an industry.

Thirdly, it is our duty as scientists to help the public, and especially our industrialists, to understand our way of thinking. You will recall how the Duke of Edinburgh stressed this point in his address to scientists in Wellington. Similar to the problem of contact between the man in the street and the scientist is that of communication of developments and trends between workers in the various branches of chemistry or more broadly science generally. Our meetings are one of the channels of communication between chemist and chemist and it seemed fitting that I should take this opportunity of outlining to you some recent advances in the mineral industry in illustrating my first two points.

The Forward Process for Recovery of Nickel, Cobalt and Copper

Accordingly I propose to discuss the research and development programme which led to the discovery and application of an ammonia pressure leaching process for producing nickel, copper and cobalt from the nickel concentrate prepared from ore mined at Lynn Lake by Sherritt Gordon Mines Limited of Canada. Some of you who listened to the Empire greetings broadcast before the Queen's message last Christmas Day may remember hearing

the mine manager speaking from Lynn Lake. This project has involved: Building 144 miles of railway from Sheridan to Lynn Lake; the moving of a town, 2000 ton mill and mining equipment this distance; preparing to mine 2000 tons of ore per day at Lynn Lake; and building a 75 ton per day ammonia plant and a nickel leaching and recovery plant at Fort Saskatchewan, Alberta, where cheap natural gas was available.

In October, 1949, I met at the University of British Columbia, Professor Frank Forward, who discovered the process. He was recently returned from a summer working with the first pilot plant which I saw later in Ottawa. In 1949 he had little to say but last year he was in Australia for the Fifth Empire Mining and Metallurgical Congress and this was his story.

The Lynn Lake mine in Manitoba had been developed by Sherritt Gordon Mines Limited since 1946 and over 14 million tons of ore containing 1.2% nickel, 0.6% copper and some cobalt proved. The company's copper-zinc-gold mine at Sheridan was approaching exhaustion and it was proposed to use the mining and milling equipment to treat the new ore body. Preliminary tests showed that the ore could be concentrated by flotation to give a copper concentrate and nickel concentrate containing 10-14% nickel, 0.3-0.4% cobalt and less than 2% copper. The copper concentrate could be economically smelted and refined in the usual way. As the nickel concentrate contained almost no precious metals and as it contained more nickel than comparable sulphide ore concentrates the choice of treatment process and location of a plant required careful study.

First consideration was given to methods of recovering nickel from sulphide ores in common use. These normally include either reverberatory or electric smelting and converting to make a nickel-copper matte which is then treated by one of the several methods such as the carbonyl process or the Orford or Inco processes which include electrolytic refining to separate and recover the nickel and copper. These processes all have the advantage that the operating factors are known and any precious metals in the ore are recovered during electrolytic refining. However, it appeared that operating costs for treating the Lynn Lake nickel concentrate might be high because of the location of the mine, the cost and availability of fuel, fluxes and power and the high labour requirement usually associated with smelting and refining processes. Another disadvantage was that most of the cobalt is usually lost in smelting.

Leaching processes have the advantage that materials handling techniques are simpler, gas and dust handling problems are eliminated and as automatic controls can often be used, the labour requirement is low. If a leaching process could be developed which gave high extraction of the metals and allowed their separation

and recovery from the leach solutions it appeared to offer some advantages over the standard smelting methods if the cost, recovery or regeneration of reagents was reasonable. Time was another factor as although the period between discovery and commercial operation of a new process is usually ten years, the need to start production at Lynn Lake as soon as possible after the Sheridan mine was shut down meant only about five years was available. With this background research work began at the University of British Columbia in 1947 and the commercial plant was to begin operations in April, 1954.

The Research and Development Programme

At the University of British Columbia in 1947 experiments showed that the metals could be recovered by roasting the concentrate, reducing the calcine with hydrogen and leaching with aqueous ammonia and ammonium carbonate. During this work certain conditions of temperature, pressure, ammonia and oxygen concentration were discovered under which the nickel-copper-cobalt-sulphide minerals dissolved without roasting and reduction leaving the iron as insoluble hydrated oxide and converting the sulphur to a soluble form. The ammonium carbonate could be replaced by sulphate and simple inexpensive methods of separating and recovering the metals and ammonium salts were developed. By the end of 1948 these systems had been exhaustively studied at the University and in the Sherritt Gordon laboratories and a conference was arranged with the technical staff of Chemical Construction Corporation to discuss problems of engineering and design of a pilot plant. By coincidence the Chemico research staff in studying the pressure leaching of sulphide ores in acid solutions had found that nickel could be readily precipitated from ammonical solutions by hydrogen under pressure and plans were made to use this discovery in the ammonia leach process.

In 1949 the Chemical Construction Corporation designed the first pilot plant with a capacity of 600 lb. of concentrate per day to test continuous leaching operations as only batch units were used in the laboratory. This pilot plant was used intermittently for fourteen months and the discovery made that copper could be precipitated and removed as the sulphide by controlling the concentrations of trithionate and thiosulphate ions in the leach and then boiling. From the copper free solution pure nickel metal could be precipitated without adding sulphuric acid and precipitating as nickel ammonium sulphate.

By mid-1950 the process offered promise of being feasible, physically and economically, but many details of chemistry and engineering required study before a full size unit could be designed with confidence. Another pilot plant was built which allowed the precipitation of nickel in high pressure batch auto-claves, and

used semi-continuously for about three months when the need for tests on a bigger scale became evident. To provide data for scaling up design calculations, units of semi-commercial size were operated for six months.

Towards the end of 1951 a third pilot plant was built to treat 3000 lb. of concentrate a day. This was equipped for continuous two stage counter-current leaching with requisite thickeners, continuous filters, two tailing washing stages, ammonia absorption units, continuous distillation for ammonia recovery, copper removal units, solution treatment and classification and large scale nickel precipitation autoclaves, the latter for intermittent operation. It was operated continuously for about five weeks and some 60,000 readings and samples were taken and over 14,000 determinations made in the chemical laboratory. The information from this and previous work was the basis for designing a commercial plant to treat 235 tons per day of nickel concentrate.

At this stage, early in 1952, the plant design was "frozen" but another pilot plant was built to gain operating information on all the operations planned for the commercial plant and to train staff. This fourth pilot plant began operation in March, 1952 treating 3000 lb. of nickel concentrate per day for about 4 months. The nickel-copper-cobalt-sulphide concentrate is first partly leached with recycle liquor from the second stage; the leached pulp is filtered to produce a pregnant liquor, and the partly leached solids charged with wash water and ammonia to the second stage, where the valuable metals and most of the sulphur are dissolved. The iron is filtered off as a hydrated oxide together with silica and other insolubles and is washed and discarded. The weak leach liquor from this stage is used to leach fresh concentrate in the first stage.

The pregnant liquor contains nickel, cobalt and copper as amines; free ammonia, ammonium sulphate, ammonium sulphamate, ammonium thiosulphate and ammonium trithionate. This solution is boiled to produce aqua ammonia, to decompose trithionate and to precipitate copper sulphide. The aqua ammonia is returned to the leaching circuit leaving nickel and cobalt amines, ammonium sulphate, and ammonium sulphamate with small amounts of free ammonia and ammonium thiosulphate in a substantially copper-free solution.

The copper-free solution is hydrolysed, oxidised and clarified and then treated with hydrogen in an autoclave at a high temperature and pressure to precipitate nickel as a metal powder which is washed and dried. The solution from nickel precipitation is treated with H_2S to precipitate the cobalt and some residual nickel and is then evaporated to obtain ammonium sulphate. The nickel-

cobalt sulphide precipitate is leached with ammonia and air and the cobalt separated from the nickel by a simple method discovered and developed in the pilot plant. The nickel is returned as a soluble salt to the nickel precipitation circuit and the cobalt precipitated by hydrogen under pressure.

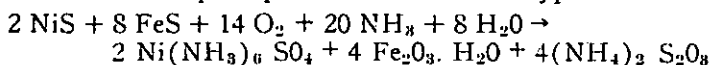
Operating Conditions and Materials

From the wide study of the variables of composition, temperature, pressure, etc., for optimum operation in the various pilot plants leaching is done between 150-220 degrees F. at a pressure of 125 lb. per sq. inch, the copper sulphide is precipitated by boiling in a continuous still at atmospheric pressure and the hydrolysis and hydrogen reduction of nickel are done between 200 and 400 degrees F. and at pressures up to 900 lb. per sq. inch. As the solution of the sulphides liberates about 1500 B.T.U.'s per lb. of concentrate which is more than required to heat the solutions to the leaching temperature the autoclave design required the provision of cooling water. In the hydrogen precipitation units conditions can be controlled to make spheroidal particles of nickel between 50 and 80 microns in diameter. The cobalt powder particles are smaller.

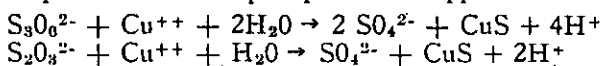
The leaching time is less than 24 hours and the other operations require from 30 minutes to two hours. The equipment is not greatly different from that used in the chemical industry and to reduce maintenance and prevent corrosion all wetted surfaces are stainless steel. Little difficulty has been met with corrosion, erosion, scaling or precipitation of insoluble salts.

Chemistry of the Process.

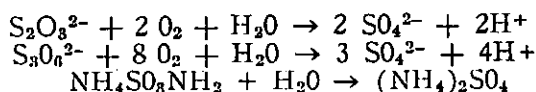
The mechanism of the leaching reaction is not fully established as a number of reactions occur in sequence. It is presumed that one of the principal reactions is of the type



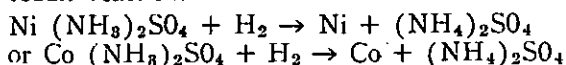
In the precipitation of copper sulphide free ammonia is removed from the system by boiling in a continuous still with rectifying units and recovered as high strength aqua. As the ammonia concentration falls the thiosulphate and trithionate decompose to give sulphide ions which precipitate the copper but not the nickel.



The copper-free solution from this boiling step contains small amounts of thionate and thiosulphate and a considerable amount of sulphamate which must be removed to reduce the sulphur content of the nickel metal. Heating under pressure with oxygen or air oxidizes and hydrolyses these compounds.



The chemistry of the hydrogen precipitation of nickel and cobalt is straightforward and it is fortunate that the reaction with nickel goes under more moderate conditions and faster than the cobalt reaction.



As there is some overlap in the nickel-cobalt precipitation curves about 1 gram per litre of nickel is left unprecipitated to ensure a minimum of cobalt in the nickel powder.

Research and Development Costs

The costs of this project to date have been tabulated by Professor Forward as follows:

Expenditures on Research and Development

	Capital	Operating	Total	No. of men employed:		
				Tech.	Oper.	Total
1947-8	—	\$17,000	\$17,000	6	—	6
1949	\$ 16,000	164,000	180,000	14	9	23
1950	77,000	257,000	334,000	15	22	37
1951	290,000	310,000	600,000	34	56	90
1952	114,000	607,000	721,000	49	78	127
1953	200,000	456,000	656,000	54	89	143
Total:	\$697,000	\$1,811,000	\$2,508,000			

The figures in this table include operation of the pilot concentration plant at Lynn Lake as well as the Ottawa pilot plants, engineering, and other expenses such as rentals and fees. Forward stresses the fact that the obtaining of the required technical knowledge in such a short time resulted, in no small measure, from the large percentage of technical personnel on the staff. Of the current technical staff about ten are on fundamental and background research with the others in analytical laboratory, pilot plant operation or executive positions.

For this investment of \$2,508,000 the Sherritt Gordon Company has a process under its control which is expected to produce nickel from nickel concentrate at rather less than half the cost of conventional smelting and refining processes. Additional income will be obtained from the sulphur in the concentrate, recovered as ammonium sulphate. The cost of the leaching plant to treat 80,000 tons of concentrate each year will be less than a smelting and elec-

trolytic refining plant of equal capacity. The net advantage of using the ammonia leaching process should be some \$2,500,000 per annum so that the expense of research and development should be recovered in one year.

A Problem in Surface Chemistry

My second example of technological skill in application of basic knowledge is the recently published solution to a difficulty in the separation of potassium and sodium chlorides. There are large deposits of these salts in New Mexico. The ore is principally interlocked crystals of potassium chloride, about 40 per cent., and sodium chloride. There is also as much as 1.5 per cent of a montmorillonite clay slime which complicates the separation of the chlorides by flotation prior to crystallization.

Montmorillonite is a clay built from sheets of unit cells superimposed one upon the other and held together by relatively weak forces. This clay absorbs water and some organic compounds binding them with relatively weak forces. Usually, there are two or more inter-sheet layers of water molecules loosely held in a more or less regular pattern. These molecules are fluid in two dimensions and offer little or no interference to the movement of inter-sheet exchange cations.

As the ease of replacement order for the inter sheet cations is, large organic cations $> H^+ > Ca^{++} > Mg^{++} > K^+ > Na^+$ the appetite of the clay for the organic cations used to float the potassium chloride is obvious. The clay particles absorb the organic cations between the sheets of unit cells, often in multilayers and it was found that, in spite of physical removal from the flotation feed by desliming, the ratio of active clay surface to potassium chloride surface was greater than 2000 to 1. The problem was to prevent the competition, between the clay and potassium chloride surface, for the cationic collector. This was achieved by "blinding" the structural interstices of the montmorillonite before adding the cationic reagent.

In choosing the type of "blinding" compound there were many factors to consider. First the reagent must contain hydroxyl groups to adsorb on the montmorillonite, secondly it should not be anionic because of electrostatic interference, thirdly configuration of the molecule must allow easy access between the clay sheets, fourthly the molecule should be large so that it would have many bonding points and by protruding shield the clay particle against penetration by the cationic collector. These specifications were satisfied by the polysaccharide mannogalactan found in the endosperm of several pod-bearing legumes and marketed as "guar." The molecular weight is estimated variously to 500,000 which

would give a molecule about 1 micron in length or larger than the average montmorillonite crystal.

Recovery of Wool Wax*

In conclusion I will briefly outline how the technique of the flotation process usually applied to the separation of minerals is about to be used for the recovery of wool wax from the scouring plant of a Dunedin woollen mill.

In the scouring of wool to clean and remove the wax from the fibres before spinning, liquors are obtained which contain from 0.5 to 5 per cent. of wax as an emulsion, 0.15 to 0.4 per cent. soap and several per cent. of dirt. These liquors are a problem as an offensive trade waste and recently important new uses for wool wax have provided stimulus for the recovery of wax. New Zealand wool wax is recovered in special centrifugal separators as a concentrated emulsion. The fraction of the total wool wax recovered by the centrifuge is very variable and at the request of a local firm my department at the School of Mines and Metallurgy has investigated a process developed by the Australian C.S.I.R.O. which is reported to give better and more constant recoveries in commercial operation. A plant has been designed and built to treat the scour liquor in a Dunedin woollen mill.

The process is an adaption of the metallurgical process of flotation to recover the wool wax as a froth containing 20 per cent. of wax. This froth on heating separates into layers of wax and water which are separated by decantation. The wax layer contains 50 per cent. wax which is centrifuged to remove the water.

The three projects I have outlined show some of the ways the mineral industry is using chemical discoveries and also how one of its techniques has found an application in an apparently unrelated industry. Overall the mineral industry overseas is progressing in a manner reminiscent of the chemical industry following the adoption of pressure processes, fractional distillation, catalytic cracking, solvent extraction and exchange resins. In fact most of these techniques are now either in use or under active development in the mineral processing industries. In New Zealand our lack of major industries based on metallic ore deposits restricts the field of work but in industry, P.A.C.R.A., the D.S.I.R. and this University interesting discoveries have been made and are being made.

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Attwood, G. E. and Bourne, D. J. (1953) *A.I.M.E. Trans.*, 196, 1099.
Forward, F. A. (1953), *Can. Min. Met. Bull.* 46, 677.
Tizard, H. (1952), *J.S.C.I.* 788.

CHANGE OF EDITOR AND JOURNAL COMMITTEE

With this issue a further stage in the fortunes of the Journal comes to an end. After seven years' sojourn in Auckland the management of the Journal is to be transferred to the Manawatu Branch where Dr. McGillivray and a Journal Committee from that Branch and an Advertising Manager from the Wellington Branch will be responsible for its future production.

In future please address all Journal correspondence to:—

Dr. W. A. McGillivray,

Editor,

Journal of the N.Z. Institute of Chemistry,

Massey Agricultural College,

Palmerston North.

As retiring Editor I wish to record my grateful appreciation of the assistance and excellent co-operation Stan Brooker, my predecessor, and I have received from members of the Journal Committee, Dr. Harry Bloom, Alan Freiberg, Gordon Stace, Doug. Whillans, George Calnan, and the late Gordon D'Ath. We have had difficulties in producing the Journal but it would have been impossible without the co-operation we have received from the authors we have approached for articles, the branch editors who came to light regularly with their local scandal and very useful suggestions for articles, and finally our friends the printers, particularly Eric Salmon, who has always taken a personal interest in the Journal.

The Moving Finger writes; and having writ,
Moves on: nor all your Piety nor Wit
Shall lure it back to cancel half a Line,
Nor all your Tears wash out a Word of it.

BALANCES FOR SALE

The School of Mines and Metallurgy, University of Otago has for sale several balances. There are:

- 1 x Sartorius Balance: sensitivity 0.1 mg
- 1 x Oertling Balance: sensitivity 0.1 mg
- 1 x Bechner Balance: sensitivity 0.2 mg
- 2 x Assay Balances

The balances are in working order and further particulars may be obtained from the Dean.

RESUME OF A MEETING OF COUNCIL HELD AT NELSON ON 24th AND 25th AUGUST, 1954

Present—Dr. H. O. Askew, President, in the chair; K. M. Griffin, Vice-president; J. Ricketts (Auckland); Dr. W. G. Whittlestone (Waikato proxy); Dr. L. G. Neubauer (Wellington); F. H. G. Johnstone (Canterbury); J. Rogers (Otago); W. G. Hughson, Hon. Gen. Sec.; B. G. Stanley, Asst. Sec.; B. Jackson (Auckland proxy, present by invitation).

Apologies—Were received from F. E. Mason, Waikato and C. V. Fife, Manawatu.

Future Conferences—The location of future conferences were confirmed (A335). The question of co-ordination with other scientific bodies such as the Royal Society and the A.N.Z.A.A.S. was discussed and it was decided that maximum co-operation should be extended while maintaining the continuity of our own annual conferences.

Examinations—On the recommendation of the Examinations Committee Clause 1.5 of the Regulations for the Associateship Examination requiring Pure Mathematics I, as a pre-requisite was deleted. Provision was made for advisory panels to be set up by Branch Committees to report on the acceptability of the work being carried out by a candidate for the L.A.C. who was not working under a member of the Institute. Six new candidates for the L.A.C. have been enrolled.

Insurance on Examination Candidates—The Hon. Gen. Sec. was instructed to take out an insurance policy covering L.A.C. examination candidates to the extent of £5000 against any injuries sustained in their examination.

Journal—Dr. McGillivray will accept nomination as Editor. Widening the interest of the Journal was discussed and possible methods will be considered at the November Council meeting. Branches are asked to submit practical ideas. Wellington Branch intimated that they anticipated being able to provide the Business Manager for the new Journal committee, as requested.

Salaries—Approval of Dr. Bottomley's recent article in the Journal was received. The president was thanked for his excellent covering letter which accompanied the reprints of the article now being distributed to Members of Parliament, Universities, Industries and other interested parties.

Accounts—Amounting to £245 were passed for payment. The Hon. Gen. Sec. stressed the need for members to pay their subscriptions promptly and for branches to remit funds without delay to ensure the smooth functioning of the Institute's finances.

Rules—Proofs of the amended rules and regulations were tabled. The new rule book will be distributed shortly.

P.C.I.L.S.—A letter was received from the Secretary R.I.C., London, regarding the interchange of Journals of the Commonwealth Institutes of Chemistry. It was decided that in view of the distances separating Branches of the N.Z.I.C. it was desirable that each branch should continue to receive one copy of the various Journals. Branches are requested to house these Journals in a suitable place ensuring permanent safe keeping and ready access by members.

New Associates: The following were elected to the Associateship of the Institute:—

RICHARDS, Nolan Earle, M.Sc. (1st Class Honours), Auckland University College, continuing research for his Ph.D. degree.

BATT, Richard Dean; Ph.D., M.A. (Oxon.), D.Phil. (Oxon), Senior Lecturer in Biochemistry. Otago Medical School.

STOTT, James Boothroyd; Ph.D. (Leeds), Friel Research Chemist, Otago School of Mines, Dunedin.

ELLIS, Albert James; M.Sc. (1st Class Honours), Chemist, Geothermal Chemistry Section, Dominion Laboratory, Wellington.

SUTTON, Harry Callender; Ph.D. (Dunedin), Shirtcliffe Scholar, Senior Research Officer, Cancer Research Dept., Medical School, Dunedin.

ANNUAL GENERAL MEETING

A General Meeting of members was held in Nelson during the Conference on the afternoon of Thursday, August 26th, 1954. Apologies were received from a large number of well-wishing members. A special mention was made of Greetings to the Conference from our first president, Dr. W. P. Evans.

In his Presidential remarks, Dr. H. O. Askew referred to a wide range of subjects which were of vital interest to the Institute. He announced the election of five new members as Associates (see Council Minutes), and in conclusion presented the I.C.I. Prize to Dr. W. S. Metcalf, and the Morcom Green and Edwards Prize to C. F. Denmead.

Reports by the various committees of the Institute were then read. (See A332-335.)

The extent of liaison and inter-relation with other Commonwealth Chemical Institutes was discussed. This is mainly by interchange of Journals and elsewhere in this issue is reproduced an offer by the R.I.C., London, with regard to their Monographs and Reports.

The question was raised as to the need for a Benevolent or Emergency Aid Fund for our members.

In a discussion on the Co-ordination of Scientific Societies members were urged to consider Dr. Briggs' article in the last Journal, and to forward any helpful suggestions for discussion at Branch meetings.

The problems associated with the ways and means of giving secondary school children an insight into science and scientific method were discussed.

The need or not for the Institute to charge an Entrance Fee was also discussed.

pH METER FOR SALE

Model B pH Meter made by N. L. Jones of Melbourne. This instrument which cost £93 has had very little use and is in new condition. The price asked £50.

For further particulars apply to the Liquidator, Newdick Bros. Ltd. (In Voluntary Liquidation), P.O. Box 313, Auckland.

CONFERENCE 1954

The combined conference of the New Zealand Institute of Chemistry and Royal Institute of Chemistry in Nelson, presented a few unusual features. Its committee showed some symptoms of split personality. The programme, transport, etc., were arranged in Wellington, but the all-important matters such as accommodation, catering and social events, were attended to by the members of the small chemical staff of the Cawthron Institute, headed by the President, whilst Miss Currie, Chemistry Mistress at the Nelson Girls' College, where meetings were held, provided an efficient and attractive link between the Conference and its abode. Sir Theodore Rigg's chairmanship contributed much to the official standing of the Conference. It is only fair to state that this heterogeneous composition of the committee did not seem to affect the smooth running of Conference.

Another new feature was the increased time allotted to the reading of papers, i.e., 45 minutes instead of the customary 30 minutes. This proved very popular with the lecturers, chairmen and audience and on no occasion was there need to use the ominous alarm clock. It is true that the number of papers was this time smaller than usual, but nevertheless, the arrangement proved so satisfactory as to warrant the attention of future conference committees. The papers offered refreshing variety, pure chemistry holding its own against applied chemistry, but it seems that the thunder was stolen by two papers on medical topics. There was some evidence that Dr. Hamilton's remarks regarding the delivery of papers during the recent N.Z. Science Congress did not remain unheeded.

The award of the Easterfield Medal, Dr. Nixon's moving tribute to the late Sir Thomas and Mr. Rogers' brilliant memorial lecture contributed to the unique nature of the conference. But perhaps the most outstanding feature of the conference was its close contact with the Nelson community. The wide publicity given to the Conference by the local press and the broadcasting station, the interest aroused by Dr. Askew's masterly Presidential address which became the talk of the town, the friendly co-operation and hospitality shown by all and sundry, supplied ample proof in this respect. While this is undoubtedly due to the sterling services rendered by the Cawthron Institute to the Nelson Province, it was nevertheless most gratifying to every member at the Conference. It is, therefore, only natural that during the winding up ceremony, Dr. L. G. Neubauer, instead of a long peroration, moved simply a sincere vote of thanks—to Nelson.

L. H.

PUBLICATIONS OFFER TO MEMBERS

Very cordial relations continue to exist between the Royal Institute of Chemistry and our New Zealand Institute. We are now indebted to the Royal Institute for the following offer of a concession on publications. Dr. A. J. T. Ellingham of the R.I.C., London, has written to our Council offering to supply the Monographs and Reports of the R.I.C. to members of the N.Z.I.C. at the reduced figure of 12s 6d. per annum (actual value varies but would possibly be not less than 21s). Members wishing to avail themselves of this offer for the coming year (1955) are asked to send their name and postal address to The Hon. General Secretary, P.O. Box 250, Wellington, together with the required 12s. 6d. before November 1st.

Members of our Institute who are also members of the R.I.C. already get these publications as part of their subscription.

INSTITUTE PRIZES

On August 24th Council awarded the I.C.I. Prize to Dr. W. S. Metcalf, Mus.B., M.Sc., D.Phil. (Oxon.), Senior Lecturer in Chemistry at Victoria University College, and the Morcom Green and Edwards Prize to Mr. C. F. Denmead, B.Sc., of the Dominion Laboratory, Wellington. The official announcement was made at the Annual General Meeting on August 26th when the president presented the recipients with cheques for 25 guineas and £25 respectively. The I.C.I. Medal is to be suitably inscribed and will be presented to Dr. Metcalf at a Wellington Branch meeting.

I.C.I. PRIZE

This prize is awarded to the member of the Institute who, in the opinion of Council, has contributed most to some branch of chemical science, the contribution being judged by research work published or accepted for publication during the five years immediately preceding the date fixed for the closing of nominations.

Dr. Metcalf submitted papers, already published, dealing with the optical properties of peroline, an alkaloid of rye grass, and on the reactions of chlorine with ammonia in water. This latter work was done at the suggestion of Professor F. G. Soper, of Otago, and published jointly with him and Dr. R. E. Corbet in *J. Chem.Soc.* 1953. A study of the fluorescence of anthracene gas and its quenching by oxygen, suggested by Dr. E. J. Bowen, F.R.S., of Oxford, was extended by a further study in viscous solutions and was published in the *Proc.Roy.Soc.* 1951. A study (with H. W. Mellnish) of the quenching of fluorescence in solution appeared in *J.Chem.Soc.* 1954 and a further study of gaseous quenchers has been accepted by the same Journal. The final paper, on the reactions of nitrous acid with phenol, was presented by Dr. Metcalf and Mr. T. A. Turney at this Conference.

MORCOM GREEN AND EDWARDS PRIZE

This prize is offered for the encouragement of original work in pure and applied chemistry. Mr. Denmead dealt with investigations carried out on the tank curing of Cumberland bacon with the object of providing a fuller understanding of the processes involved and an appreciation of what factors are important in conferring good keeping quality upon the bacon. Particular attention was directed towards the elucidation of the mechanism of curing.

CHEMIST

A graduate in Chemistry is required for the laboratories of an established organisation carrying out scientific investigations in the fellmongering, tanning and footwear industries. The commencing salary will be according to qualifications and experience. The appointee will be eligible for superannuation scheme. Headquarters are in Lower Hutt but activities extend throughout the country.

Apply to—

THE DIRECTOR, N.Z. LEATHER AND SHOE
RESEARCH ASSOCIATION (Inc.)
Private Bag, Lower Hutt.

BOOK REVIEWS

Lehrbuch der Organischen Chemie. Vol. I., second half. By Friedrich Klages. Pages 533-985. 1954. Berlin: Walter de Gruyter & Co. DM62. The first part of this book was noted in our issue for February last and this part confirms our good impressions. By leaving theoretical aspects to Vol. II. and natural products, dyes, plastics and biochemistry to Vol. III., a vast amount of systematic organic chemistry has been packed into Vol. I. The completed series should give an excellent coverage of the subject. The work is well presented with numerous cross references, but the reduction of literature references to the year of publication only is hardly good enough for a work of this quality. Generally the work is up-to-date and the printing and binding are excellent.

Vols. III. and IV. of the *Kurses Handbuch der Chemie*, by Wlademar Koglin, previously referred to in our issues for February and August of last year, have now come to hand, and cover the remainder of the properties of chemical substances alphabetically listed. A total of 33,457 entries includes exhaustive references to alloys and plastics. Many of the values given differ from those given in English and American works of reference, and are probably those accepted in Germany. The comparison can be stimulating. A final volume of tables will complete the series, which is priced at 280 DM (£24/10/-).

Chemistry of the Defect Solid State, by A. L. G. Rees, Chemical Physics Section, C.S.I.R.O., Melbourne. 136 pages. Methuen and Co. (London). Price 8/6. This excellent little book is a member of "Methuen's Monographs on Chemical Subjects." It gives a clear and concise introduction to the theory of lattice defects in crystals, including a discussion of experimental methods of investigating lattice defects; tarnishing and decomposition reactions and heterogeneous catalysis as influenced by lattice defects. One minor criticism which may be levelled is that the book deals mainly with non-stoichiometric crystals—the discussion of defect stoichiometric crystals being treated very briefly. The treatment is theoretical and will appeal strongly to post-graduate students of Theoretical Chemistry.

H.B.

Qualitative Inorganic Analysis. G. Charlot. Methuen and Co. Ltd., London, 1954. 42/-. This is a translation of the fourth French edition also published this year. The treatment of the theory of qualitative analysis is excellent the material being presented in note form so that there is no sorting of fact and filling involved. The application of physico-chemical principles to explain many of the phenomena of qualitative analysis is a new and stimulating approach to the subject. The practical part of the book gives an excellent description and presentation of methods of chemical characterisation of the ions as well as a very adequate list of physical properties useful in their separation. In a treatise that has attempted to give such complete information it is unfortunate that Professor Charlot did not avail himself of the opportunity, with this revision, of incorporating much more information on the use of organic reagents in characterization e.g. diethyldithiocarbamates for copper and the dithizone complexes. Despite this deficiency the book, which is extremely well printed, presents a new and more logical approach to qualitative analysis and will be of value to students and teachers in both physical and inorganic chemistry but its usefulness should not be restricted to the academic field.

G.M.W.

Organic Coating Technology, Vol. I., H. F. Payne. John Wiley and Sons Inc., New York, 1954. 674 pages; 10 dollars. In this volume Payne discusses the oils, resins, varnishes and polymers, plasticisers and driers

used for clear coatings, or as the vehicle for pigmented coatings. In its presentation there is a build-up from the more or less fundamental facts so that the derivation and method of action of the various components used in "paints" follow logically on a sound chemical basis. Formulations illustrating the methods of application of the various materials discussed are typical of the practical approach of the book. Besides giving an adequate explanation of the chemical nature of these materials and the reactions in which they become subsequently involved there is considerable information on their physical properties. The book is American consequently, as is common with all such books listing commercial formulae, there are included materials listed only by their commercial names and which are not readily available to us in New Zealand. This is, however, but a slight disability in what should prove a very useful addition to the libraries of the paint industry and those of consultants and public analysts.

The Biochemistry of Brewing, I. A. Preece. Oliver and Boyd, Edinburgh, 1954. 393 pages, 30s. Professor Preece, who is a very able research worker in the field of brewing, has written a most comprehensive work on his subject. Nearly every aspect of brewing including raw materials, brewing processes, beer characteristics and process control are dealt with from a biochemical point of view. The difficulties of writing on so extensive a subject must be appreciated when reading this work, as brewing is allied to no one science but to many. In attempting to cover such a wide field the author appears to have attempted too much as the discussion of the various points raised is in most cases inadequate, while some important aspects of beer production are omitted. The chapters on "Beer Character and Stability" and "Process Control," are sketchy with inadequate references while there is no adequate discussion of the bottling and kegging processes which are essential preliminaries to the stability of beer.

It would appear that the last two chapters have been added to round off the work without much consideration to their continuing the standard of the previous chapters.

The book probably will not appeal to brewers as there is no practical application of the concepts discussed while, to chemists the main value will lie in the references it contains.

R.C.S.

Dr. G. W. Vivian, of the New Zealand Leather and Shoe Research Association (Inc.), was in 1951 awarded the Proctor Memorial Fellowship for study in England, and he went to the Leather Industries Department of Leeds University. He studied under Professor Donald Burton and specialized in research on chrome re-tan (vegetable tannage of chrome tanned leather). Last month Dr. Vivian was awarded the Ph.D. for this work and he is now returning to New Zealand to continue his research with the research association.

G. W. Vivian, M.Sc., Ph.D., was educated at Christchurch Boys' High School and afterwards graduated at Canterbury College, where he gained his M.Sc. In 1947 he joined the Department of Scientific and Industrial Research, and was appointed to the section engaged on leather and shoe research. When this section in 1949 became incorporated under the title of the New Zealand Leather and Shoe Research Association (Inc.) Dr. Vivian transferred to this organization.

The N.Z. Association of Scientists has awarded its Research Medal for 1954 to Dr. W. G. Whittlestone, Physical Chemist at the Ruakura Animal Research Station. The Medal is awarded each year for outstanding research work in the various fields of science by a person less than 40 years of age.

The Mellor Memorial Lecture was delivered on June 2nd by Dr. F. G. Soper, Vice-Chancellor of the University of Otago, his theme being, "Chlorination and some of its Mechanisms." At the same meeting the Institute of Chemistry prize, donated annually by the Wellington Branch, for the best student in chemistry at Victoria College the previous year was presented to Mr. R. A. Bell.

At its June meeting the Canterbury Branch was privileged to hear an address by Dr. H. McIlwain, reader in biochemistry in the University of London, who for the last four months has been a visiting lecturer at the Medical School in Dunedin. Dr. McIlwain's lecture on "The Speed of Chemical Change in the Brain" included a discussion of the techniques used to measure the absorption of oxygen from blood supplied to the brain and to determine the glycogen content of brain tissue.

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