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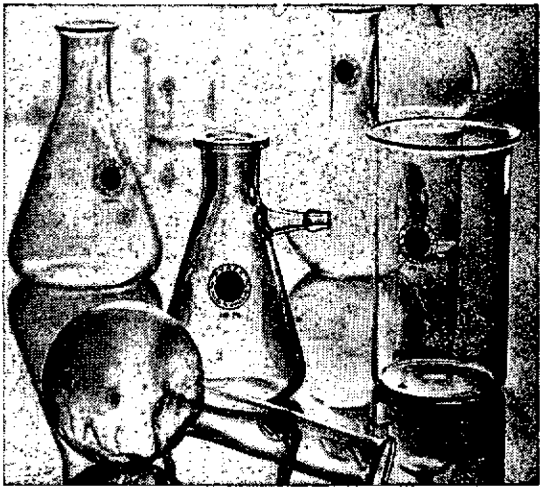

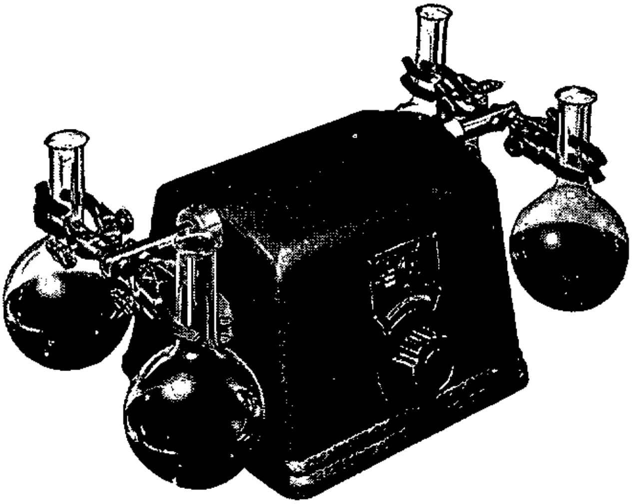

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INSTITUTE OF CHEMISTRY

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WHAT DO OUR MEMBERS DO?

From time to time in discussion of Institute affairs there has been a need for information on the distribution of our members among various forms of employment. When this question arose again in considering selection of papers for the *Journal,* the Editor, C.B. with a cold, solicited the aid of his likewise rheumy sons in analysis of the 1960 *List of Members.* The 1947 *List* was also examined to see whether there had been any great change in distribution over the intervening years, during which membership has increased by 70 per cent.

If all members of the New Zealand Section of the R.I.C. are included, the 1960 *List* contains 556 entries with an indication of the nature of employment—for 12 other entries either there is no such indication or the employment does not involve the practice of chemistry. The 1947 *List* contains 329 entries. These entries were classified under the broad headings of Industry (including research associations); Government service; University teaching and research; Medical service and research; Secondary teaching; Retired; Employed overseas. Allotment to these categories was not always clearcut—how, for example, does one classify an Associate listed as Minister of Departments of Education and Scientific and Industrial Research? It is considered, however, that the figures obtained give a reasonably accurate picture of the employment distribution of our membership, which itself comprises a very high proportion of the chemists of New Zealand.

The following table contains the main results of this analysis.

Employment Group	*% of Total*		*% of "Active Group"*	
	1947	*1960*	*1947*	*1960*
Industry	40	44	48	55
Government	30	22	36	27
University	12	12	14	15
Medical	1	3	2	3
Secondary teaching	9	8	—	—
Employed overseas	4	7	—	—
Retired	4	4	—	—

The three groups, Secondary teachers, Retired, and Employed overseas, make up a surprisingly high proportion of the present membership (19%). Removal of this group leaves 449 members actively employed within New Zealand in some aspect of the profession of chemistry apart from school teaching. The distribution within this "active group" is shown in the last two columns. Teachers were eliminated from this "active group" partly because they are not primarily engaged in the application of chemistry but also because those within the Institute make up only a small part of their employment group.

It is not wise to generalize too much from these figures because of the way in which they were derived, which is on the basis of place of employment rather than on work performed by the individual. They indicate, however, that over half of the members working as chemists are engaged in industry, and that there has been a marked increase in this group since 1947. At the same time, the proportion employed directly by the Government has fallen from over one-third to about one-quarter. To some extent this may be accounted for by an increase in the number of research associations, nurtured within the D.S.I.R. and deriving some of their initial staff from there. Over this period of 13 years the proportion of chemists on university staffs has increased very little.

An increase in the percentage of members employed overseas (from four to seven per cent.) is to be expected with the migration of scientists from this country. This figure, of course, gives no measure of the proportion of New Zealand trained chemists who have left New Zealand, since many expatriates have resigned from the Institute or left soon after graduating, without qualifying for Associateship.

In taking out these figures an attempt was made to distinguish between chemists associated with agricultural production and those in other pursuits; but here subdivision became increasingly arbitrary and uncertain. The figures obtained suggest that over one-quarter of the "active group" is associated with agriculture—one-quarter of the Industrial, nearly half of the Government, and one-tenth of the University chemists. Between 1947 and 1960 the proportion has decreased slightly, mainly in the University group. However, in including these estimates we emphasize that, even if information were available for a more exact assessment, to do it properly would involve fractionating many individual chemists; and at that verbal paradox we draw the line.

"CHEMISTRY IN ACTION"

(Based on a third series of lectures arranged by the Canterbury Branch of the N.Z. Institute of Chemistry for sixth-form pupils from Christchurch post-primary schools.)

PHLOGISTON AND FIRE-AIR

J. VAUGHAN

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In this age of specialization, chemistry seems at times to be a hopelessly complicated subject. Looking at lists of vacant positions, one sees advertisements for spectroscopists, thermodynamicists and radiochemists, food chemists, dye chemists, polymer chemists and many others. It is a situation we have come to accept and there is no doubt that it can be an exciting and challenging situation, especially for a student, because he can see so many possible fields from which he can choose according to his talent and inclination. But the increasing complexity can still be exasperating to many chemists because the increasing output of new research material restricts our reading very much, if we are to keep abreast of developments within our own speciality.

There seems to be another feature of today's scientific scene which is worthy of mention. There are many phenomena for which we do not yet have satisfying explanations, and we are continually seeing exciting fresh chemical country ready for exploration. But in this scene we seem to have become unconsciously confident that our general theoretical concepts are securely based. We may have to modify ideas or extend them, or develop new ones to add to the old, but we still have little doubt that the road we are building to lead us to the understanding of natural phenomena is pointed, as surely as it can be, in the right direction. Chemistry may be complex but it is not disorganized. Yet there have been other times when scientists have been sure of themselves and their ideas. It is all too easy for us to be amused at disproved theories, without perhaps fully realizing that many of these ideas were held by highly intelligent men whose theoretical concepts were based on far, far fewer scientific data than we possess today. Let us look briefly at one of these ideas.

For a period lasting little longer than a man's lifetime, people interested in chemical phenomena generally believed that they had the key to understanding in what we call the theory of phlogiston. The phlogiston theory was dominant in the eighteenth century and it was that century which also saw its downfall. It was a century which became progressively more exciting in many fields. It was a century which could claim writers such as Swift and Voltaire, composers like Bach and Mozart, actors like Garrick, and painters like Gainsborough. It saw Wesley starting the Methodist movement; it saw that literary part-time chemist, Samuel Johnson, exercising his superb gift for conversation in the London coffee-houses and taverns; it saw Cook sailing the *Endeavour* round the world; it saw unsuccessful rebellions by the Scots and a successful revolution by the American colonists—and it saw the revolution in France which brought about, as one of its consequences, the premature death of the man who was responsible both for the demolition of the phlogiston theory and for the birth of modern chemistry.

If you had been experimenting in chemistry in the eighteenth century, it is unlikely that you would have been a professional chemist at all. The apparatus at your disposal would have been crude and clumsy by present-day standards and your experiments would have taken longer to perform. In preparing a gas, you might have collected it in an ox-bladder tied to the outlet of a retort. Perhaps you would have used a pneumatic trough and collected the gas, over water, in a jar or in a bottle suspended by cords, but it would have been well past the middle of the century before you would have used a beehive shelf and before you would have collected water-soluble gases over mercury. You would have recognized a few alkalis and acids but you would have had few pure compounds with which to work. Your source of heat might have been a fire, furnace or large burning-glass and you, like most other chemists of that time, would probably have been extremely interested in the respiration of plants and animals and in the action of heat on materials. It was in this field that the phlogiston theory was apparently most successful, but it was also work in this field which led to its overthrow. The very name phlogiston is derived from the Greek verb *phlego* = I burn, and the substantive *phlox, phlogos* = a flame; the bright-coloured garden flowers called phlox presumably derive their name from the same source.

The principles of the theory were laid down by a German chemist Becher and were publicized, in a modified form, by his fellow-countryman Stahl. Becher, like others before him, accepted air, water and earth as elementary principles, and Becher (like van Helmont) believed that air did not actually enter into chemical reaction. Earth originally just meant solid matter and Becher recognized three kinds of earth. A particular earth in a body gave to that body some characteristic properties of the earth. One earth was called fusible earth, or vitreous earth; it gave solidity, permanence of shape, and structure to the substance containing it. Another was a fluid or mercurial earth; this gave a substance weight, some metallic properties and allowed it to melt readily. The third was the fatty earth—*terra pinguis*—or, as Stahl later called it, phlogiston. This was the earth which made a substance inflammable; it was the principle of combustibility. Chemists at this time had a crude idea of atoms and, in Stahl's view, the atoms of various earths were attracted to each other. This produced something more than a mere "mixture", as we would recognize the term; it produced an intimate, strongly-bound conglomerate amounting rather to our "compound." Furthermore, it was assumed early in the development of the theory, that in general you could not isolate an element like phlogiston. It would not leave one material without having a second substance to enter. Thus the way in which you could detect the presence or absence of an element was by seeing whether you could recognize its properties in the substance under study. Phlogiston, which was to be the key to the success of the theory, was clearly present in high proportion in materials like oil and sulphur and many organic substances because they burned readily. Charcoal in particular was considered to be extremely rich in phlogiston and, as will be seen, was used as a ready source of phlogiston.

When a substance burned, the vibrant flame seemed to indicate pretty clearly that something was escaping. The something was phlogiston. Air was recognized as being essential for combustion because, although in general it did not take part in chemical reaction, air was needed to absorb the phlogiston. The phlogiston had to have something to escape into, and air had an attraction for phlogiston. But obviously the air could not be expected to absorb an unlimited amount of phlogiston. Sooner or later it became saturated and then it would not support further combustion. So if one tried burning a material in a limited supply of air, in a bell-jar, for example, the burning would stop when the air became saturated with the escaping phlogiston. Thus far, on what chemists knew, all this seemed quite logical. But there was much more, and it all added up to a theory which was convincing because it appeared to link together so many otherwise unrelated pieces of chemical information. This is what scientists continuously seek— a general theory which embraces a large number of phenomena. In particular, the phlogiston theory offered a simple explanation for a common, useful process, the extraction of a metal from an (oxide) ore by heating with charcoal. When a metal is heated strongly, it burns or glows and thereby loses phlogiston to the air. What is left is the dephlogisticated metal—the so-called calx. If one wishes to put the phlogiston back into the calx and reform the metal, all that should be necessary is to heat the calx with some material rich in phlogiston. Charcoal is an obvious choice and, on heating the calx with charcoal, the phlogiston should be transferred from charcoal to calx, and the product should be the metal—which it is, of course! J. R. Partington describes a "proof" of Stahl's that sulphur is a combination of phlogiston and what we know as sulphuric acid. When sulphur burns, phlogiston escapes and sulphuric acid is formed. Putting the phlogiston back into the sulphuric acid is a tricky business, more difficult than getting a metal back from its calx. It is first of all necessary to prevent losses which would accompany the heating of sulphuric acid itself with charcoal. The acid is therefore "fixed" with potash, to give a non-volatile salt. And now this salt may confidently be heated with something rich in phlogiston and, using charcoal as the source of phlogiston, sulphur is indeed formed. It all seemed so reasonable on the information available to early eighteenth-century chemists.

It must not be assumed that all chemists accepted Stahl's views, but the majority of important chemists did so and the tragedy of the phlogiston theory is that, in tying themselves to these misleading premises, chemists very naturally could not help having, to a certain extent, preconceived notions as to what was important and what was unimportant. To this extent, then, the development of chemistry was retarded and, in John Read's words, "the most striking feature of the phlogiston era was its air of chemical stagnation." But the chemists of that day laboured under some severe handicaps. One of the most important was their difficulties in the handling of gases. In the early years of the eighteenth century different gases were unrecognized; a gaseous fluid was air, modified or contaminated depending upon the conditions under which it was produced, but still air. It was only near the end of the phlogiston period that chemists broke through this particular barrier of ignorance. And let us note here that the fact that a metal increased in weight on heating to form its oxide, even though it lost phlogiston in the process, is not a clear case of deliberately ignoring an unpalatable fact. The importance escaped the early phlogistonists and, in the circumstances, they surely should not be subjected to any harsh censure.

But, especially in the second half of the century, important and exciting discoveries were made by men who were professed phlogistonists, and one of these men has an extraordinary number of scientific discoveries to his credit. This man was Carl Wilhelm Scheele, a Swedish apothecary who was born near the end of 1742 and who died, at the early age of 43, in 1786. Carl was apprenticed, at the age of fourteen, to a pharmacist and he remained loyal and devoted to his profession. His chemical investigations were carried out as his pharmaceutical duties permitted, a fact which, added to his short span of life, made his long record of chemical discoveries all the more remarkable. There are many instances which show the affection and respect which this modest chemist engendered in people. In 1774 he was made the manager of a small pharmacy in the little town of Köping, a position he took with delight because it gave him, as he put it, no more worry about his room and board. But shortly after he had taken this post, the owner of the pharmacy decided to sell out to a wealthy apothecary who intended to run the place himself. Such was Scheele's reputation that the good citizens of Köping announced publicly that they did not want any apothecary other than Scheele. In the face of this opposition and possible boycott, the deal fell through and Scheele remained at Köping for the rest of his life.

Many of Scheele's investigations were undoubtedly prompted by his pharmaceutical work, but his range of interests was remarkably wide. You will know of his celebrated discovery of oxygen and of chlorine. He was also an independent discoverer of ammonia, hydrogen chloride gas and hydrofluoric acid. His study of the chemistry of manganese and barium was major work, and his discovery of molybdic and tungstic acids allowed the later isolation of the two metals. He discovered prussic acid—and recorded its taste! He isolated glycerine; he discovered tartaric acid and a whole range of organic acids. He was a pioneer in the use of the blowpipe for qualitative analysis and he made many important contributions to analytical chemistry. You can see, from this partial list of his achievements, that at that time the field of chemistry was wide open, ready for profitable exploitation provided that there were men of Scheele's calibre around.

Scheele was a phlogistonist but the stagnating influence of the theory was probably minimized in his case by his boundless curiosity and his love for pure experiment. He was one of the great experimenters of that or any age; but he accepted the main tenets of the phlogiston theory, although his famous contemporary, Joseph Black, considered Scheele to have been the first to express any dissatisfaction with the theory as outlined by Stahl. Therefore we can fairly say that Scheele extended our knowledge, but did not contribute any major theoretical idea; we cannot place him on a par with great thinkers, like Lavoisier, who have virtually changed the face of a science. .

But the phlogiston theory, although false, was self-consistent in many ways, and it appears that Scheele used it profitably in his famous discovery of oxygen, which is thought to have been made in 1771 or 1772. Let us look at the story, taken from his *Treatise on Air and Fire,* published a few years later. We shall simplify the story, but if you can get hold of a translation of his book, I think you will find that the full account of his experiments and arguments makes fascinating reading.

Let us first recall that, in Stahl's view, when substances rich in phlogiston were heated, they gave off phlogiston which was absorbed in the surrounding air. When the air became saturated with phlogiston, burning could no longer take place. Some of Scheele's first experiments on combustion were those in which he put phlogiston-rich materials in a confined air space. In some cases he did not heat his materials—with substances like ferrous hydroxide, moist iron filings or oil of turpentine, the experiment took up to two weeks to reach completion. In each case he put the material into an empty bottle of known volume, closed the bottle with a cork and inverted the bottle in a trough containing water. At the end of the experiment the cork was withdrawn under water and Scheele measured the amount of water which entered the bottle. In the case of phosphorus, Scheele put it in a thin flask, which was then closed "most securely", and he applied heat until the phosphorus melted and took fire. When the flask was cold again, it was opened under water. In all these cases, Scheele found that after the experiment the volume of air in the flask or bottle had been reduced by 25 to 30 per cent. The air before the experiment supported combustion; the air after the experiment did not. If phlogiston had entered the air and the volume even then became smaller, instead of greater, then the residual air must be denser than ordinary air, because Scheele believed phlogiston to be a material substance, with weight. "But how perplexed was I", he said, "when I saw that a very thin flask which was filled with this air and most accurately weighed, not only did not counterpoise an equal bulk of ordinary air, but was even somewhat lighter."

Scheele was thus led to the important conclusion that ordinary air was composed of two gaseous fluids. One of these gases, the gas which remained after his combustion experiments and which made up 70 to 75 per cent. of ordinary air, had no attraction for phlogiston. This he called vitiated air, and it approximates, of course, to our nitrogen. The other gas, making up roughly a third to a quarter of ordinary air by Scheele's measurements, was particularly attracted to phlogiston and combined with it during the experiment. This was the gas he was to call *fire-air*. But where had it gone during combustion? Scheele came close to the truth when he considered the possibility that his "lost air" had become "fixed" in the residue after combustion. He rejected the possibility, apparently because he could not get his lost air back from the combustion residue by any of the methods he tried.

An experiment which must have influenced Scheele's subsequent reasoning is one in which he burned "inflammable air" (hydrogen) in a flask of air inverted in a trough of hot water. When the flame went out, the water had risen to fill a fifth of the flask. The remaining air appeared to be just "vitiated air" and there seemed to be no visible products of combustion. He had missed the formation of water, which Priestley was later to bring to the notice of Cavendish, and which Lavoisier was to explain correctly. Where then, had the fire-air gone? There was no visible, material product of the combustion—or was there? Now in the reaction heat had been given off and Scheele was forced to conclude that the hydrogen had combined with the fire-air to produce—heat! Here we must remember two things. First, heat, fire and light were then regarded as material things and even Lavoisier, who destroyed the phlogiston theory, stuck to the idea of heat as a kind of element. Second, phlogistonists like Priestley and Cavendish considered hydrogen to be virtually pure phlogiston. Although Scheele was not quite in agreement, the difference in beliefs is not particularly relevant here. Hence, when hydrogen burns in air, it is simply a case of phlogiston (the hydrogen) combining with the fire-air (the oxygen) to produce heat.

Well, then, if this were so, how could one get the fire-air back? It has a great affinity for phlogiston but if there are substances with an even greater affinity for phlogiston, then these should extract the phlogiston from heat and leave the fire-air, which could then be collected and tested. Scheele thought he had good grounds for considering that nitric acid was such a substance and, to simplify matters, we can miss out some dramatically successful experiments of his to reach a very straightforward one. He used nitric acid, "fixed" as potassium nitrate. The nitre was put in a retort and heat was fed to it by a sand-bath placed over a furnace. At the mouth of the retort was an ox-bladder "moistened and emptied of air." As soon as the nitre became red-hot and began to boil, the bladder began to fill with a gas. It was Scheele's fire-air. Perhaps it would be as well for us to remember that it was not the only time that a false hypothesis has led to the right result. Within the limits of his beliefs, Scheele's thinking was of a high order, and he obtained oxygen as an expected result of experiments based on theory.

To this we may add that among the phlogistonists Scheele was perhaps the most brilliant experimenter. In 1774 he wrote a letter to his colleague Johann Gahn. Scheele had just been appointed to the Köping pharmacy and had told Gahn in the letter how happy he was to take up the position. Then he added, ". . . to explain new phenomena, that will be what I have to worry about, and how glad is the experimenter if he finds what he was so eagerly searching for—a pleasure which makes his heart leap with joy." Chemistry is still an experimental science and every chemist will know exactly how Scheele felt.

Scheele discovered oxygen at the beginning of a decade in which the phlogiston theory was to be damaged beyond repair, and the man responsible for the damage was the French chemist, Antoine Lavoisier. Lavoisier has been called the father of modern chemistry, and you are likely to know much more about this great chemist than about Scheele. You will almost certainly have been told of his tragic execution in 1794 after the French revolution. The execution followed a trial which has been described as a mockery of justice, and a trivial, trumped-up charge resulted in the world of science losing its foremost thinker. But Lavoisier had triumphed before he died. His first significant experiments leading to his new theory were published in 1772 and it took approximately six years for Lavoisier to get his ideas about oxygen quite clear. At the end of that time the phlogiston theory had suffered a defeat from which it was never to recover.

As the eighteenth century had progressed, chemists had become more conscious of quantitative data and the big difficulty for the later phlogistonists was to explain why a metal increased in weight when it was converted to its calx (oxide). When Lavoisier met this trouble he kept looking for the answer with a single-minded determination. He had burned phosphorus in air and had found that the white product (oxide) weighed about twice as much as the phosphorus with which he had started. It is likely that Lavoisier's biggest problem then was similar to Scheele's. If he assumed that the burning material was absorbing something from the air, then surely there must be a case in which it was possible to demonstrate this by recovering this "something" from the residue. When Lavoisier was probably still worrying over this problem, Scheele had already, without publication, prepared oxygen and, unknown to Lavoisier, was examining its properties. But the answer to Lavoisier's difficulties was not to be delayed for long. In 1774, Priestley obtained oxygen independently and he obtained it from mercury oxide, an oxide with very convenient properties. When mercury is heated in air it forms an oxide which will yield its oxygen on further heating without the aid of charcoal.

$$2Hg \xrightarrow[O_2]{\text{heat}} 2HgO \xrightarrow{\text{further heat}} 2Hg + O_2$$

Using a large burning glass, Priestley was able to supply enough heat from the sun's rays to decompose the oxide and obtained oxygen, but at first he did not realize that he had obtained a new gas. Lavoisier repeated the experiment and for a suspenseful moment in history he also was misled. Priestley recovered himself, he realized the nature of his new gas but missed the significance. Lavoisier also recovered from his mistake, but he realized also that in oxygen he had the key to all simple combustion phenomena. In burning, phlogiston was not given to the air; oxygen was absorbed. The corner-stone of Lavoisier's new chemistry was laid.

But there was one further step of major importance to be taken before Lavoisier's theories could be generally accepted. When a metal like zinc reacts with an aqueous acid, a salt is formed and hydrogen is evolved. We would write:

$$Zn + H_2SO_4 = ZnSO_4 + H_2$$

The salt may be obtained by evaporation. If zinc oxide is dissolved in the acid, no hydrogen is given off, but the very same salt is formed:

$$\underset{\text{Zinc calx}}{ZnO} + H_2SO_4 = ZnSO_4 \ (+ H_2O)$$

We know that water is formed in this reaction, but until the 1780's this production of water was unsuspected, and the composition of water was generally unknown. Therefore it was quite a reasonable question to ask whether Lavoisier could explain where the hydrogen had come from in the first experiment. If it came from the acid, why was it not produced in the second reaction? The reactions were quite straightforward to the phlogistonists because zinc was "calx plus phlogiston (*i.e.*, hydrogen)" and this gave up its hydrogen (phlogiston) in forming the salt. The calx, of course, did not contain hydrogen so that it could not be expected to give any up.

But for the followers of Lavoisier, reactions like these proved a real headache. In 1784, Cavendish reported the experiments which best indicated that water was a compound of hydrogen and oxygen. There was quite a controversy about who should get the credit for what—thus showing how very human chemists are—but the upshot of it all was that Lavoisier's theory could be completed as a general chemical theory. He could now, for example, provide a material product for the burning of hydrogen in air and he could now explain the action of acids on metals and their oxides. From that time the rise of the "new chemistry" was unchecked, and the phlogiston theory, as an effective force, was spent before the eighteenth century had ended.

SHEEP, COWS AND CHEMISTS

W. A. McGILLIVRAY

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In this series of lectures it is the aim of the Institute of Chemistry to tell you something of the work of chemists in New Zealand today and to show you that this work can be just as exciting, just as interesting, as that in any other scientific field. It is my job in particular to tell you something about chemistry as applied to agriculture.

I use the term "chemistry as applied to agriculture" rather than the more common "agricultural chemistry" for a real reason. Those of us who are working in agricultural fields are using normal chemical techniques for the solution of our problems. We are not using some special sort of chemistry which we can call agricultural chemistry just as we can label one branch of chemistry as organic and another as theoretical. This point is rather important in connection with this article.

When chemical work first started to play a part in agricultural research, it was thought that all that was needed was a chemist who would sit in his laboratory and churn out results of assays on soils, pastures and animal tissues. He need know little about the origin of the samples or how his results fitted into the general picture of things—that was not his field of work. The sort of assay required from him was fairly limited—moisture, ash, fat, protein, a few minerals, that was about all—so he needed little in the way of specialized apparatus or laboratory space and he got little credit for the work that he did. I do not want to belittle the work that these people did—they often did excellent jobs with very limited facilities. But with that sort of approach to chemical work agriculture was not getting the full value of its chemists, and agricultural work was not considered very attractive to chemists.

And then quite suddenly the situation changed. Thanks to the personality of some of the people concerned, the chemist was let out of his laboratory, was allowed to take a part in planning and organizing experimental work with soils, pastures and animals. This was the start of what I think represents a "new look" in agricultural research. During the past ten to fifteen years the chemist or the biochemist has replaced the agriculturalist as the key scientist in agricultural research in the country. Many of our major research organizations are now directed by chemists and are staffed largely by chemists whose research takes them into many spheres of activity besides their traditional laboratory work. Their facilities are of the very best—some of the more elaborate pieces of chemical equipment in New Zealand were set up first in laboratories devoted to agricultural research. I think of electronic devices of all sorts, of equipment for radioactive isotopes, of major units like the ultra-centrifuge and the electrophoresis apparatus used in protein chemistry; and of chromatography of all types, requiring less elaborate apparatus, but elegant tools for separating compounds quickly and easily.

The work of the early chemist may have been so limited in its scope that we could give it the name of agricultural chemistry; what we have today is something quite different. It is the application of chemistry in its widest sense to agricultural problems.

I can assure any of you who may be interested in chemistry as a career that you will find agricultural research no longer the Cinderella of the profession. It is as well that you should realize this because I have been having a look at some figures which indicate that the odds are better than 1 in 4 that if you take up chemistry as a career, you will find yourself working in an agricultural environment. Of course, that is the way it should be in a primary-producing country such as New Zealand.

I am now going to give you some examples of the types of problems which are being tackled by chemists engaged in agricultural research in this country. These examples are all concerned with diseases of sheep and cattle—diseases which are very different in their physical manifestations but which have in common the fact that they all stem from abnormalities in the composition of the pasture which the animals are consuming. Diseases of this type may result from toxins present in the pasture or from excesses or deficiencies or imbalances of normal nutrients. Their effect is usually apparent in the digestive tract, the liver, the kidneys, etc., but secondary symptoms often influence more remote tissues such as muscles, bones, skin, and so on. Thus such widely different conditions as facial eczema, bloat, hogget ill-thrift, grass staggers, to mention a few common names for complicated diseases, certain more clearly defined vitamin deficiency diseases, and even the problem of the excessive wear in sheep's teeth are all diseases of this type and all result from changes in the composition of the pasture associated with changes in the conditions under which it is growing.

These are all serious diseases in New Zealand—they cost us many thousands of pounds annually in loss of butter, cheese, wool, meat. To see just why they have become so serious, we must remember that as an agricultural country New Zealand has always been in a very favoured position with a naturally fertile soil and favourable climate. Pasture grows fast and readily and animals can be fed on pasture out-of-doors throughout the year with no stall-feeding problems and little need to worry about expensive supplementary feeding. The classical approach to agricultural research in this country was therefore very different from overseas. Farming was a relatively simple matter and the main problems were thought to be those of increasing the stock-carrying capacity of the land through the introduction of higher-producing strains of grasses and clovers and through investigations of the fertilizer requirements of the soil and management of the pastures to produce the greatest possible yield throughout the year.

In other words, the emphasis was on quantity and greatest credit went to those whose contribution, to borrow a well-known phrase, was the making of two blades of grass grow where only one grew before. Some outstanding and valuable work was done in this field both by the plant breeders who developed the very high producing strains of clovers and ryegrass which are the basis of most of our modern pasture, and by soil chemists who provided the information about the fertilizer requirements, and particularly about the trace element requirements, of the different areas in New Zealand.

But in all this there was really little thought of the animal that was to eat the pasture. It was assumed that, as long as you could produce more and more high quality pasture, more animals could be fed and more meat, wool and milk produced without any trouble. However, it was not long before the practical farmer found that increased soil fertility and the replacement of native pastures with improved strains was not all profit and that there was also a marked increase in the incidence of disorders of the type I have just mentioned. At first it was thought that the solution to these problems lay in the management of the new pastures and that there was nothing wrong with the environment in which they were being grown. And so productivity of the pasture has been pushed almost as an end in itself with, in some cases, the naive assumption that if we can breed the grass so too we can surely breed the animals that eat it. Thus we have in general use throughout the country high-producing pastures which are, or at least become at certain times of the year, very dangerous feeds indeed.

This is where the chemist comes into the picture so strongly. It is for him to find out what is wrong with the soil, the pasture, or the animal—why do we get these diseases on pastures that appear to be perfectly safe and healthy?

My first example is the disease known as facial eczema. This disease was first reported 50 years ago. There are outbreaks of it somewhere in New Zealand in most years, but there was a very serious epidemic in 1938 and scientific investigation of the disease really starts from that epidemic. It is a disease that occurs in the autumn. It is most severe on high producing pastures—heavily manured soils sown with new improved strains of grass. The outbreaks since 1938 have been less severe mainly because, as we came to know more about the disease, reasonable warnings could be given and control measures applied. But there are still outbreaks almost every autumn and the control measures are costly and inconvenient and disrupt normal farm routine.

When animals suffer from facial eczema the first thing the farmer notices is that his sheep (or cows) crowd together in shady places. They feel an irritation in the areas of skin that are exposed to light—round their eyes and mouth—anywhere the wool cover is thin. Oedema, that is a swelling of the tissue through accumulation of fluid, follows, and the ears, for example, droop through the weight of this fluid. The fluid seeps through the skin producing a necrotic or eczema-like condition.

This sort of reaction to light is called photosensitivity and it was soon found that an organic compound, phylloerythin, was responsible. This photosensitizing compound is a normal breakdown product of the green chlorophyll of plants. It is formed in the rumen or first stomach. It is absorbed into the blood but is normally got rid of by being taken up by the liver and secreted along with the bile. If, however, something goes wrong with this excretion mechanism phylloerythin builds up in the blood and tissues and the animal then becomes sensitive to light and shows all the symptoms I have described.

This substance, phylloerythin, is a perfectly normal product of digestion. Why should the sheep suddenly fail to get rid of it? This is where the facial eczema toxin comes in. It was soon found that the photosensitivity was only the outward sign of a much more serious change which had taken place in the liver. This organ takes on a blotched appearance, the surface becomes mottled and the bile ducts stand out very clearly with white, thickened walls. The lumen of the bile ducts, that is the opening through them, is

Sheep with facial eczema. Note swollen lips and nose, drooping ears, and abrasion around eyes.

often clogged with cellular debris and the whole liver is grossly distorted.

As you can imagine a severely diseased liver cannot function very well and the animal is likely to succumb very quickly. One thing that happens is that the liver loses its ability to excrete phylloerythin—it builds up in the blood and tissues and gives the photosensitivity that I mentioned earlier.

The recovery of the animals depends on their ability to regenerate damaged liver tissue and it is amazing how well animals can sometimes repair what appears to be hopeless damage to a delicate organ like the liver.

Photosensitivity associated with liver damage had previously been reported in South Africa. It was associated with a toxin in a plant and therefore the chemists first looked at the composition of the pasture eaten.

But how were they going to collect the grass? Grass was apparently toxic for only a few days at a time and by the time sheep showed photosensitivity the grass was usually perfectly normal again. After a time it became clear that in addition to high soil fertility and improved pastures a warm summer followed by warm autumn rain was needed. Under these conditions you could almost see the grass growing and the toxin was thought to be associated with this onset of growth after rain.

Consider the task facing those chemists confronted with this problem of examining the grass.

They had no idea what sort of toxic compound they were looking for. They had only a rough guide from climatic conditions and the appearance of the grass when toxicity might be expected. They had no idea how stable the toxin was or how to preserve the grass without destroying the toxin. Their only test for toxicity was to feed the grass to lambs—each test required 100 to 120 lb of grass for each animal and at this dosage level they had to wait 6 weeks for the results. They had only a few days each autumn in which to collect, preserve and store enough grass for chemical work throughout the year.

Do you want any tougher assignment than that to test your initiative, your resourcefulness, your sheer scientific ability?

These difficulties were overcome. Toxic grass was collected and preserved. Guinea pigs were found to be susceptible to the toxin. These needed less grass but the test still took 4 to 5 weeks and even then negative results were not very reliable.

No obvious differences could be found between normal and toxic grass. Over years of careful work the toxin was gradually concentrated to the stage where it was clear that the chemists were dealing with a very toxic compound indeed. The concentration of the substance was clearly less than a few parts per million in the dried toxic grass.

Even the most concentrated toxic extract obtained still showed no physical or chemical differences from a similar fraction extracted from non-toxic grass. And of course these chemists had the advantage of all the modern techniques which we use for identifying microgram quantities of organic compounds—chromatography for separating individual components from a mixture, infra-red spectroscropy for identifying groups present in organic compounds or mixtures, and so on. The toxin just refused to reveal itself.

This was all rather disappointing but one very important thing did come out of this work. One worker noticed that during the extraction of toxic grasses a white precipitate always appeared at an early stage. This was absent from non-toxic grasses. From this he developed a very simple test—the "beaker-test"—in which the white precipitate that he had noticed earlier was extracted and caused to form as a white film on the sides of a beaker. The amount of this film is roughly proportional to the toxicity of the sample. The film is not the toxin but it always accompanies it. The test was very useful for sorting out grasses that might be toxic. It took only a few hours to perform and saved the collection of tons of useless non-toxic grass.

About this time a lot of things happened that contributed to the final solution of the problem. I cannot discuss all these but the important point was that microbiologists had suspected that a micro-organism might be involved in the problem. They started examining soil and pasture samples from one area which had consistently provided toxic grass every autumn for many years—actually Claudelands Racecourse near Hamilton. Obviously any micro-organism that showed a significant increase in numbers at the time when the pasture became toxic would be suspect. In all, some 6,000 organisms were followed. Any suspicious organisms were cultured and extracts of the cultures subjected to the beaker test and a few were grown on a really big scale to give enough material for tests with guinea pigs.

The next step is a small incident in itself but it is worth mentioning because of two important points which it illustrates. A scientist who went out to check the collection of toxic grass noticed that the mower was black with a fine dust. The men using the mowers told him that they sometimes saw a cloud of the dust over the mowers on this toxic area. He collected some of this dust and it was found to give the highest "beaker test" yet found in the laboratory. This dust was largely spores of a fungus, *Sporidesmium bakeri,* which the microbiologists had already found in the pasture, but which had not proved toxic previously. The microbiologists tried again and found that by different culture methods, which made this fungus produce spores, they could produce large amounts of toxic material.

Now this incident of the mower shows two things.

First, how important it is for the scientist to get out of his laboratory—out into the field so that he can supervise every stage of his experiment. Secondly, how important it is for the scientist to be observant. It would have been so easy for this scientist to have ignored this black dust, and have carried on with his investigations without giving it another thought. You know, I think it is this power of observation that makes a scientist. He needs training, of course, but it is this power of observation that distinguishes the real scientist from the skilled routine worker. If you remember nothing more of this, will you carry away that one point? If you want to be a chemist, or a scientist of any sort, you must cultivate the ability to *break off your current line of thought and assess the value of any new observation that confronts you.*

Well, now it is clearly established that this fungus is responsible for facial eczema. The conditions which stimulate rapid growth of pasture also favour the fungus. From the chemical point of view, culture of the fungus gave the chemists large quantities of the toxin in a much more concentrated state than they had in the dried grass. Dr R. L. M. Synge, a world-famous chemist, a Nobel prize winner, was brought out from Scotland and with the local chemists was able to purify the toxin. They are now determining its chemical composition. Once they have done that they may be able to introduce better and more certain control measures. They may be able to immunize sheep against the disease because many fungi are known to promote antibody formation. The chemists will work with the plant breeders in trying to breed a natural protection into the plant against the fungus. Some pasture plants like sweet vernal and red clover contain in their cuticle waxes phenolic compounds that inhibit the growth of the fungus so there is already a promising lead here.

I have devoted a good bit of time to the problem of facial eczema but I think it is interesting to see how the chemist comes into a problem of this type. I could tell the same sort of story about other diseases to which sheep are prone, "hogget ill-thrift," for example—a wasting disease which can probably arise from several distinct nutritional causes. Recently it has been shown that in many areas the disease can be prevented by dosing the sheep with small amounts of selenium. In other areas, however, rapidly growing autumn grass leads to weight losses in hoggets which cannot be corrected by selenium dosing. Here chemists have found that the grass has a high content of nitrate and other nitrogenous compounds and a relatively low carbohydrate content. So it would seem that perhaps in these cases we have an imbalance problem and a very strong team of chemists is investigating the nitrogen metabolism of plants in order to get a line on the compounds involved in this disease.

Then there is the problem of the excessive wear in sheep's teeth on improved pastures. The teeth lasted well on native pastures but on the modern highly fertilized pastures they wear out very quickly and the sheep lose condition because they simply have nothing left to bite with. This problem took chemists into very fundamental studies on calcification and the structure of sheep's teeth which are very different from human and rat teeth which have been the ones traditionally studied in connection with dental caries. A most interesting field, and a problem again peculiar to New Zealand.

And so we could go on talking about other diseases of sheep that are attracting the attention of chemists today. But I did include the term cattle in the title of this talk so let us have a look at a typical disorder of cattle—bloat.

Bloat is just what the name suggests—a blowing up of the animal. Ruminants like cows have four stomachs. The first of these, the rumen, is a large fermentation vat in which microorganisms, particularly bacteria and protozoa, break down the food before it undergoes the normal digestive processes. Fermentation of this sort gives off gas—carbon dioxide, methane, hydrogen —and the volume formed is very large as you can well imagine it would be from a vessel the size of the rumen of a cow (40 to 50 gallons capacity).

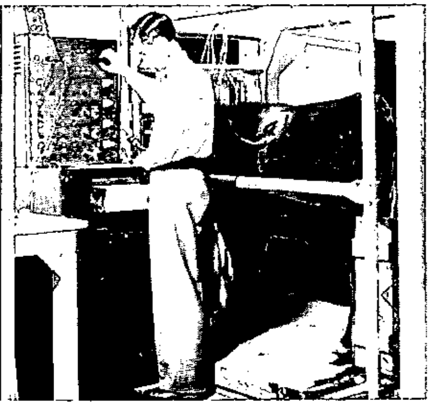
The process of rumination and rumen digestion is, of course, a very interetsing study in itself and teams of chemists and other scientists all over the world are working on various aspects of what happens in the rumen. But as far as bloat is concerned we are only interested in the gas which is formed. This is normally got rid of by the simple process of belching. If, as the Chinese claim, belching is a tribute to the enjoyment of a meal, then no one enjoys a meal more than a cow.

When an animal suffers from bloat it is because it cannot get rid of the fermentation gases by belching. The chemists involved in this problem had to turn physiologists and study just how the cow belched before they could make much progress with the problem of bloat. This work has been greatly aided by the use of rumen fistulas. These are openings through the flank of the animals into the rumen. A surgical technique has been worked out which enables a permanent opening to be made, sealed by a rubber bung when not in use and giving direct entry into the rumen. The animals suffer no ill effects and experiments such as withdrawing rumen contents for analysis or introducing new materials into the rumen to study their breakdown can be performed quite readily through the fistula.

In studying the formation of gas and the belching mechanism, recording instruments were also introduced through the fistula to follow pressure changes, muscular movements, etc., at different points in the rumen. It was found that the belch mechanism could only handle gas. The inlet to the rumen must open to release the gas and quite a chain of events is involved. The inlet is below the level of liquid in the rumen. Muscular contraction throws the liquid back, brings gas alongside the inlet, opens the inlet and forces gas up the gullet. The reflex controlling the opening of the inlet to the rumen can distinguish between gas, for which it will open, and other material for which it remains shut.

The essential thing is that the gas should come away from the fermenting mass and form a distinct layer above it. This normally happens and the animal can belch quite freely. But if the cows are on certain types of feed, and here lush, fast-growing red and white clovers are the main culprits, the gas does not break cleanly from the liquid in the rumen. Instead of the rumen being filled mainly with liquid and a gas space above the liquid, we find the gas space filled with a foam which entraps the gas. The animal tries to belch; the liquid is thrown back to bring gas around the inlet of the rumen but instead of gas there is only foam. The reflex distinguishes between foam and gas and will not open for the foam. There is no release of pressure and so the pressure continues to build up in the rumen as more and more gas is formed. In mild cases this reduces the animal's appetite through giving it a full feeling and there is a consequent reduction in milk production. But as the pressure builds up further, the animal's respiration is interfered with and death follows when pressure reaches above 45 mm mercury. It is estimated that one cow in every 200 dies every year from bloat. Add to this the loss of production due to mild bloat and the loss of sleep and interference with normal farm routine experienced by the dairy farmer at times when bloat is prevalent and you have an idea of the seriousness of the problem.

The chemistry of foams is a most interesting study in itself but I cannot discuss this here. The important point is that the foam that forms in the rumen is a very stable one and takes a long time to break. Study on it showed that it could be broken quickly only by adding something that displaced the foam-producing compound, whatever it might be, from the surface of the gas bubbles. A foam which is very viscous and stable is replaced by one which has a low viscosity and is unstable. It breaks easily



Above: *Multichannel recorder recording pressure changes in rumen of fistulated cow.*

Left: *Close-up view of fistula with instruments being inserted.*

to yield free gas which the animal can get rid of in the normal way by belching.

This is the basis of bloat control. Oils are used to replace the natural foam-forming compounds from the surface of the foam to give the desirable unstable foams which break rapidly. The oils are sprayed on the pasture or the animals can be drenched individually. These successful control measures developed directly from fundamental studies on the chemistry of the foams. Their use has, however, raised many very interesting problems for other chemists since oils used for bloat control may have a marked effect on the composition of the milk fat. But that is another story altogether.

The question remains, why does the foam form when animals eat certain types of pasture and not when they eat other types? There are two possible answers. Bloat-producing pastures may lack certain oils, etc., which could act as natural foam-breakers just as does the oil with which a bloating animal is drenched. Or they may possess abnormally large amounts of certain foam-producing substances such as proteins or saponins. A lot of work is being done on the composition of the pastures but the answer to this complex problem is not yet forthcoming.

That is briefly the story so far of research on facial eczema and bloat—two diseases which illustrate how highly improved pastures, new strains of clovers and grasses growing under conditions of high soil fertility produce at different times of the year substances which can interfere with the normal physiological functions of grazing animals and can result in a wide range of different symptoms.

As I have indicated there are strong chemical groups working on these and other diseases. But their work is going beyond these diseases themselves out into the much wider fields of pasture composition in general. Traditionally we divide plant tissues into certain chemical groups—carbohydrate, fat, minerals, protein, and nitrogen fractions. Each one of these becomes suspect in some disease. Because we depend so much on pasture in New Zealand, there seems grounds for a very thorough fundamental investigation of each one of these traditional fractions—how they vary from one pasture species to another, how they alter throughout the year and under different growth conditions, and so on. This is starting to happen in New Zealand today. We tend to find now chemists investigating not so much a particular disease with all its varied ramifications, but rather the detailed composition of a particular plant fraction. One group may be looking at plant proteins, another at plant nitrogen compounds, elsewhere pasture fats may be under investigation. This makes for greater specialization with the formation of very strong teams, for, I think, more interesting work, and for the greater chance of the sum total of fundamental knowledge leading to the solution of some of our major agricultural problems. Much work has already been done in this direction but it has really only scratched the surface and some of you may in future years find interesting posts for yourselves as members of these teams and will make major contributions in some of these important fields.

In conclusion, I should stress that I have confined myself to certain specific diseases. But of course the application of chemistry to agriculture does not end here. There is all the mineral work connected with soils, plants and animals; the work of the various research institutes—dairy, wheat, wool, meat, etc.—on fundamental and applied problems connected with our primary products, and so on. I have not tried to be exhaustive but I hope I have indicated the variety of work going on and established that agricultural chemistry, if we must use that horrible term, is no longer an isolated backwater but that those who are applying chemistry to agricultural problems are in the very forefront of chemical research and development today.

CHEMISTRY AND THE MAGIC OF WOOD

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Have you ever carefully examined the structure of a piece of wood, or given any real thought to the way in which a tree grows? For instance, there is the old question: "If a nail is hammered into a tree at a height of 3 ft and the tree grows at the rate of 1 ft per year, how high above the ground will the nail be in 30 years' time?" The answer is that it will still be at a height of 3 ft. A tree grows by the process of laying down a cone-shaped sheath of timber over the whole of the exterior of the trunk and the nature of the wood which is produced varies from season to season within the year and from year to year with the life of the tree, so that we have quite a complicated picture of development.

The components which make up the wood are commonly referred to as fibres, which are in essence hollow, tapering tubes linked together by a cementing material called lignin. In other sections of the wood called vessels food material is stored during the period of growth of the tree.

To extend the picture a little further, it is necessary to have a reasonable working knowledge of the chemical components of the wood and have an understanding of where they exist within the wood structure. Reference to Fig. 1 shows that the main components are cellulose, hemicelluloses, and lignin, together with an assortment of so-called extraneous materials which we need not bother about at this stage. The cellulose and hemicelluloses

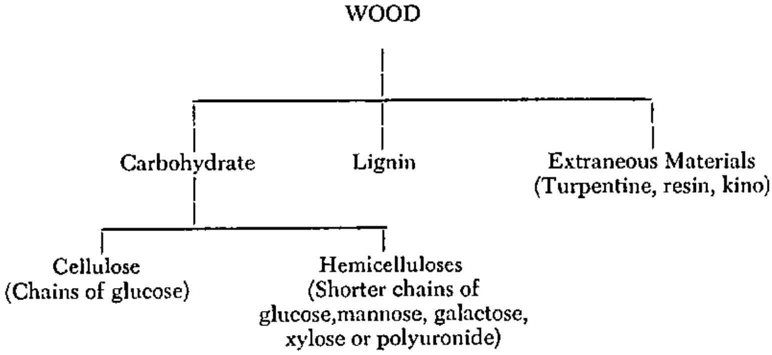

Fig. 1: Chemical Composition.

consist essentially of sugar units linked together in long chains. They can be broken down by a process of hydrolysis to give the component sugars. They are quite complex in their nature and vary a great deal in their resistance to chemical attack. Most of you have had experience of cloth being damaged by the spilling of acids and this is an illustration of the way the cellulose and hemicellulose may be broken down. Incidentally, this is a reason why it is common practice in plants manufacturing acids to supply the workers with woollen clothing which is very much more resistant to acid attack. Cellulose and hemicellulose make up the bulk of the fibre and it is this section of the wood which is most important when we reach the point of converting to various grades of pulp. The lignin which I have previously mentioned as being a cementing material to hold the fibres together is an extraordinarily complex chemical which has resisted attempts at utilization as a separate chemical entity. It is a very difficult material to isolate in an unchanged form and in most processes one is more concerned with getting it out of the way than in making good use of it. In some processes it is burned as a fuel and in a few cases it may be isolated and used in making certain grades of plastics or in compounding rubber. Generally speaking, however, it has resisted attempts to use it on any considerable scale as a chemical raw material.

With this background knowledge of the growth and anatomy of wood and of its chemical composition, I want to take you through an examination of the methods of conversion of trees into usable products and give you some idea of the part which the chemist plays in these processes. It might appear that timber production is a simple operation. It is, in fact, highly skilled and the chemist or wood technologist has a very important part to play in this field. The timber must be graded to ensure that it is used to the very best advantage. Timber with major defects is cut into boxes. Timber free of defects is used for the highest classes of joinery or building construction. After cutting, the timber must be dried, and where this is carried out under accelerated conditions in kilns, very precise attention must be given to humidity and temperature and strict control must be kept by following the change in weight of sample pieces. For certain purposes the timber must be treated to ensure protection against attack by borers, fungi, and marine organisms, or even to make it resistant to fire. A wide range of chemicals is used for this purpose and the treatment of timber by pressure or diffusion processes is the field of highly trained specialists. Linked with timber production are all the problems in finishing, such as the application of stains, varnishes, and paints, difficulties that arise with the adhesion of paint to knots, and questions that may be asked over the yellowing of timber. It is necessary, for the understanding of these problems, to have the knowledge of the expert who is generally a trained chemist with many years' experience in this field.

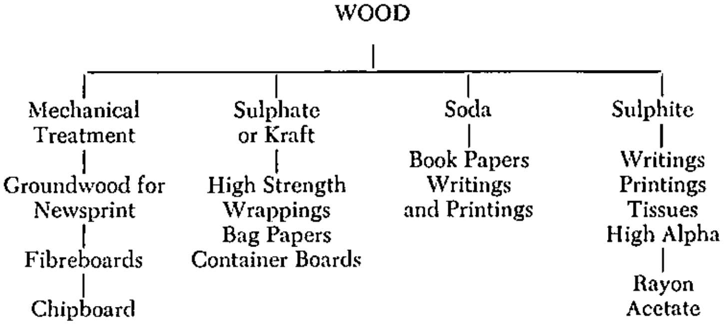

Fig. 2: Pulping Processes.

The simplest of the pulping methods (Fig. 2) involves breaking down of the wood to fibres by a purely mechanical action. The wood is submitted to abrasion by rubbing against a revolving stone or by breaking it up between a pair of revolving discs in the presence of water. In essence, the timber is broken down into a crude sort of fibre by an action which endeavours to break the fibres apart at the lignin bond. In actual fact, a good deal of damage is done to the fibres and the quality of pulp produced is not very high. However, the production cost is low and the yield is very nearly 100 per cent. of the dry weight of the wood. Pulp of this kind has a number of uses. First of all, it constitutes 80 per cent. of ordinary *newsprint*. Newsprint is a material which is used in tremendous tonnages but is required to have only a very short life. It must therefore be low in cost, but nevertheless it must have special properties to enable it to run over very high speed printing presses, involving application of ink at enormously high rates. To improve its strength properties, it contains 20 per cent. of chemical pulp which is a material we shall be discussing later. It must have certain properties of opacity so that it can be printed on both sides without shadows showing through. For the sake of low cost of production it must be produced on high speed machines, some of which are now running at about 30 miles per hour making a sheet nearly 27 ft wide.

Ground wood of this kind is also used in making *chipboard.* This is used in cheaper grades of containers where strength is not important but good appearance may be required.

A further method of utilization is in the manufacture of wallboards where the wood is ground into a pulp and felted into a thick mat. This is subsequently dried to form insulation board or dried and pressed to form *hardboard.* Thus through the simple process of a mechanical breakdown of wood into its component fibres we may, with the admixture of other fibres, or of certain chemicals, but using predominantly ground wood, make newsprint, chipboard, or a wide variety of structural building boards.

Let us now consider the chemical methods of making *pulp.* These are the processes in which the wood is reduced to chips and then subjected to treatment with chemicals under elevated conditions of temperature and pressure so that the bonding material between the fibres is dissolved and free fibres are obtained in an undamaged condition. There are many methods of doing this and the one which is most important to us in New Zealand is the sulphate or kraft process. The term "sulphate" arises because of the chemical which is used for make-up purposes in the operation and the alternative name "kraft" originates from the German or Swedish word meaning "strength". The essential feature of the process is that the digestion is carried out using a mixture of caustic soda and sodium sulphide, and the pulp, which is a brown colour, is used primarily for making those papers or boards which have special strength requirements such as multiwall bag papers, wrapping papers, bag papers, and linerboards. There are two big plants in New Zealand operating this process and it should be realized that installations of this kind are extremely costly, the capital involved running into millions of pounds. Because the chemicals used are expensive, it is essential to have a chemical recovery plant so that a full-scale sulphate mill consists of digesters, with blow tanks for receiving the pulp after digestion, washers, screens, and pulp drying equipment, together with plant for evaporating the liquor, burning it, and treating it so that the alkaline constituents are regenerated.

The chemistry of the process is quite simple and as an exercise in straightforward inorganic chemistry it is worth noting the relevant equations:

$$\text{Wood substance} + \text{alkali} \longrightarrow \text{Fibres} + \text{Sodium salts of organic substance}$$

$$\text{Sodium salts of organic substances} \xrightarrow{\text{Burn}} Na_2CO_3$$

$$Na_2SO_4 + 2C \longrightarrow Na_2S + 2CO_2$$

$$Na_2CO_3 + Ca(OH)_2 \longrightarrow CaCO_3 + 2NaOH$$

$$CaCO_3 \longrightarrow CaO + CO_2$$

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

You will see from these equations that the sodium salts used in the digestion combine with the organic constituents of the wood which are dissolved out and after concentration in evaporators are burned and appear as sodium carbonate. Since there is inevitably some loss of chemicals even in the best plants, a proportion of sodium sulphate is added and during the burning of the concentrated liquor this forms sodium sulphide. The material coming from the recovery furnaces, therefore, is a smelt consisting primarily of sodium carbonate and sodium sulphide. This smelt is dissolved in water, treated with slaked lime and settled to remove the precipitated calcium carbonate. The further step in the cycle is recovery of the slaked lime which is carried out in an oil-fired rotary kiln.

Mention has already been made of the colour of this pulp which is quite well known to you, being that of ordinary brown paper. It is less well known, however, that it can be bleached to white pulps having a very high brightness and retaining a great deal of the outstanding strength properties of the original dark-coloured fibre. This bleaching process is quite complicated and expensive and involves as many as six different stages including chlorination, extraction with alkali, treatment with sodium or calcium hypochlorite, then possibly a repetition of this series or further treatment with sodium peroxide or chlorine dioxide. A complete kraft pulp mill, including a bleach plant, will have added to it a plant for the production of chlorine and chlorine dioxide, and may, for the sake of improved economics, produce hydrochloric acid, caustic soda, or liquefied chlorine for sale. These are very big undertakings and represent a wide diversity of chemical interests.

Certain chemicals are required in paper-making to give water resistance and usually wood rosin precipitated by alum is used for this purpose. Also, for certain specific grades, dyestuffs or coating chemicals may be applied to the paper. Most important, however, is the control of the strength properties of the finished sheet. For this purpose the fibre received from the pulp mill is subjected to a process of beating, which involves a fraying of the fibre, increasing its surface area and permitting increased fibre-to-fibre contact and thereby greater strength development. The chemist has had to devise means of determining the extent to which this beating process has been carried out and to assess the results which are reflected in the strength properties of the paper. The strength may be examined in various ways. In certain classes of paper one may be interested only in bursting strength; in others, both tensile strength and tearing strength may require attention. For other purposes, porosity, smoothness, or even the surface softness, may need to be measured, and attention must always be given to the weight and thickness of the sheet.

Returning to the pulping process we should now make a brief survey of the other more important chemical pulping methods. The sulphate process is strongly alkaline and the ratio of caustic soda to sodium sulphide may be varied. In the extreme, sodium sulphide may be eliminated altogether and the resulting pulp is called *soda pulp*. This is free of the dark brown colour of sulphate pulp and is much easier to bleach, tending to make a very thick, bulky sheet which is commonly used for book papers. The paper made from soda pulp is, however, quite weak because the direct attack by caustic soda on the chips causes some breakdown of the cellulose in the fibre. This process is not operated in New Zealand.

A completely different approach to the pulping process involves digestion under acid conditions. For this purpose the most common combination of chemicals involves the use of calcium or sodium bisulphite containing free sulphur dioxide. If the process is based on calcium it is customary to obtain the chemicals by burning sulphur and passing the resulting sulphur dioxide solution through a tower packed with limestone, regulating the conditions to ensure a residue of free sulphur dioxide. When this cooking liquor is used for digestion of chips the resulting pulp has a light colour and is readily bleached. It tends to be considerably weaker than sulphate pulp because the acid has a hydrolysing effect on the cellulose of the fibre. Its main advantages are that it is easily bleached and the resulting bleached pulp has properties of softness which are most desirable for products such as tissues and certain types of writing or printing papers. It is the raw material used for conversion to a very wide range of materials in the making of which the cellulose is dissolved and regenerated. Sulphite pulp which is subjected to the necessary purification to make it suitable for these purposes is called *dissolving pulp* or *high alpha pulp*. The latter term indicates that it has a high content of alpha-cellulose which is the more resistant portion of the cellulose present in the wood. The sulphite process is not operated in New Zealand but there is no reason why it should not be and future developments could see further substantial capital outlay in this field.

In considering these chemical pulps it must be realized that the digestion process dissolves 50 per cent. or a little more of the wood substance so that the yield is commonly 40 to 50 per cent. of the dry wood substance applied to the digester. In order to improve the economics of the processes, a great amount of work has been carried out in the production of pulps at higher yields and for obvious reasons these processes are called "semi-chemical" pulping methods. It is possible to operate almost any of the standard processes to produce a semi-chemical pulp. For this purpose the severity of the cooking is reduced either by reducing the amount of cooking liquor or reducing temperature and pressure. The dissolving of the cementing material is incomplete and the softened chips are taken from the digester and broken down by some form of grinder. Semi-chemical kraft pulp can be obtained in yields between 60 and 85 per cent. and used for making the thick boards which are used for packaging purposes. Another variant is the neutral sulphite semi-chemical process in which the chemical pulping medium is a mixture of sodium sulphite and sodium carbonate. This process is operated in New Zealand and is producing a very good quality material for manufacture of linerboard.

The multiplicity of pulping processes may seem very involved but it must be realized that an endeavour is made to produce fibres tailor-made for specific purposes. Going beyond this I would like to draw attention to the very wide range of chemical products which can be made and perhaps give more justification for my use of the term "magic" in the title of this article.

First of all, let us come back to the carbohydrate content which I have described as consisting of sugar units linked together. These can be broken down to the individual sugars which may be fermented by yeasts to make a variety of products, the most important of which is ordinary *ethyl alcohol*. In the Scandinavian countries the residue from the sulphite pulping process is used as a source of sugars which are fermented to make alcohol and when purified and blended according to appropriate formulae this constitutes the basis of Swedish schnapps. So when you come to visit the Scandinavian countries and are entertained by those very hospitable people, you will undoubtedly consume quantities of wood by-products. Also the wood can be partially broken down but still left in a fibrous form so that it is suitable for animal fodder. It requires, of course, the addition of certain other chemical constituents but it was used for this purpose during the last war by the Scandinavian people. Alcohol can also be made as a primary product in plants developed to carry out the so-called saccharification process, which is simply an acid hydrolysis carried to completion giving sugars and lignin. Several plants for this purpose were built during the last war and operated successfully. Unfortunately, they are on the borderline of satisfactory economics and have not been continued in post-war years because of the intense competition with alcohol from petroleum sources. If an outlet could be obtained for the lignin from this process the economics would be very different and such plants would be very profitable. Ethyl alcohol is of great importance as a raw material in the organic chemical manufacturing processes. Synthetic methods lead to a very wide range of most important and complex organic chemicals so that wood can be regarded as a raw material for the production of almost any of the products within the field of organic chemistry.

We return now to the use of dissolving pulps which, as indicated previously, are derived from sulphite pulp by a process of purification involving alkaline extraction and bleaching. These pulps may be dissolved in a mixture of caustic soda and carbon disulphide to form a complex alkali cellulose combination and then regenerated by extruding into acid solution in the form of either a sheet or a thread. This product is the material commonly known in its sheet form as *cellophane* or in the spun thread form as *viscose*. For other purposes, advantage is taken of the fact that cellulose consists of a long chain of polyhydroxy alcohols and the hydroxyl groups can be treated with various chemicals to form esters or ethers. Probably the oldest derivative of this kind is *cellulose nitrate* which forms the basis of gun cotton and is also encountered under the name of collodion for coating materials and rendering them air-tight, for the manufacture of certain types of artificial silk, and in photography. This material is mixed with camphor to form the product known as *celluloid*. Another derivative of a similar kind is *cellulose acetate*, which is obtained by the action of acetic anhydride on high-alpha pulp, giving a product which is used for manufacture of moulding powders. Articles moulded from cellulose acetate have high mechanical strength, good shock resistance, toughness and good electrical properties, and are easy to fabricate. Also it is possible to make mixed esters such as *cellulose-acetate-butyrate*. This is used primarily for the insulation of wire in cable but also for decorative purposes for belts, handbags, millinery, and so on. More recently cellulose ethers such as *methyl* and *ethyl cellulose* have become available. The former is soluble in water and finds its main outlet in the pharmaceutical industry, in creams and lotions and as a granulating agent. The latter is used as a protective barrier against corrosion of metal parts during storage and shipment. Finally, *carboxy methyl cellulose* is a new commercial product frequently used in the pharmaceutical, food, paper, and textile industries. As a thickening agent, it is very often used in ice cream.

We now give brief consideration to those materials which are grouped as the extraneous constituents of wood. These are extremely varied in their composition and the uses to which they may be put are very wide. *Tannins* are materials extracted from either wood substance or bark and are used in the tanning of leather, manufacture of adhesives, and for unusual applications such as controlling the viscosity of the muds which are required in drilling for petroleum products. *Turpentine* and *rosin* are obtained from certain classes of pines by a process of wounding the tree and collecting the material which exudes from the wound. The turpentine is the volatile fraction and consists mainly of *pinene*. The non-volatile fraction of this exudate is rosin and it is this product which is used most commonly for waterproofing paper and fibreboards. In the chemical digestion of pines by the kraft process the turpentine is obtained with the gases from the digester during relief of pressure and can be condensed, isolated, and purified. There is a potential supply in New Zealand from the kraft pulping processes at present operating of about 150,000 gallons of turpentine per year. Also in this process the rosin is obtained as a by-product appearing with the residual cooking liquor in the form of sodium salts. It can be separated from the cooking liquor and recovered by acidification, the product then being known as tall oil. This provides a relatively cheap soap or emulsifying agent and can also be used as a basic raw material for conversion to highly purified rosin and fatty acids by vacuum distillation.

I want to refer very briefly to the process of breaking down wood by carbonization. If wood is burned with a restricted supply of air, combustion is incomplete and various volatile products appear in the form of a tar. This tar may contain materials such as *methyl alcohol, acetic acid, acetone,* and a residual creosote-like substance which has some value as a wood preservative. The residue of wood coke may be applied in the production of iron or as a fuel for driving gas producers of the type used during petrol shortages in the last war. The process of carbonization of wood is not satisfactory for application to softwoods because of the low lignin content of the wood.

Finally, let us turn to the light-hearted treatment of a serious suggestion. This deals with the possibility of producing yeast protein concentrates as a meat substitute by growing certain organisms on hydrolysed wood. So we have the following offering taken from *The Observer* some years ago:

FRIED CHIPS

I dream of evolutions
In gastronomic lore,
And wooden constitutions,
We never had before.
Of eaters gladly toying
With ti-tree fillets, but
The epicures enjoying
A Kauri undercut.

With Saturday tomorrer
And running short of stock,
A butcher, to his horror,
Would simply do his block.
At times it might be trying—
I take a case in point,
Of hungry diners spying
Some borer in the joint!

The scheme will gain in bigness
In restaurants, they say,
With "sausages insignis"
The order of the day.

BRANCH NEWS AND NOTES

AUCKLAND BRANCH

Dr C. A. Nicholls, Forest Products, Ltd., Penrose, presented a technical paper entitled "Laboratory Studies on Bleaching New Zealand *Pinus radiata* Kraft Pulp" at the Pulp Bleaching Conference sponsored by the Pulp Purification Committee of the Technical Association of the Pulp and Paper Industry (TAPPI), held in Chicago during June.

WELLINGTON BRANCH

Mr W. R. B. Martin, recently on iron and steel investigations at Victoria University, Wellington, has accepted an appointment as Processing Unit Manager with Kodak New Zealand Limited in Wellington.

Dr A. J. Ellis returned to the Dominion Laboratory at the end of June after a three-month tour of U.S.A., Iceland, Great Britain, Italy and Australia observing recent advances in inorganic chemistry and developments in geothermal work.

Dr J. K. Dixon, Assistant Director, Soil Bureau, left on July 9, on a two months' visit to Canada and the United States. He will visit soil research institutions and attend the 7th Congress of the International Society of Soil Science being held at Madison, Wisconsin, and join pre- and post-congress tours across the continent.

CANTERBURY BRANCH

Mr G. Smith, South Island Manager for H. H. York Pty. Ltd., has been transferred to the firm's Sydney office.

OTAGO BRANCH

The Branch extends congratulations to Dr R. E. Corbett, Reader in Chemistry at the University of Otago, on his election to Fellowship in the Institute.

OVERSEAS MEMBERS

Mr W. J. Wilson, formerly of the Forest Research Institute, Rotorua, is now Chemist to Fraser Companies Ltd. Research Laboratories, Atholville, N.B., Canada.

Dr H. F. Wilson, who left New Zealand two years ago on a post-doctoral fellowship of the University of Florida, is now in the Research Department, Canadian Chemical Co., Edmonton, Alberta, Canada.

Dr R. M. L. Paterson is now with the Research Division, Canadian Chemical Co., Prince Rupert, Canada.

Dr R. A. Robinson, formerly of the University of Singapore, is now Reader in Chemistry at the University of New England, Armidale, N.S.W.

Miss E. M. Sampey, who left the Hamilton Girls' High School last year on an extended visit to Australia, is at present working in the Hospital Laboratory at Toowoomba.

Mr J. E. Brundell, who had been working in the Gilbert and Ellice Islands Colony, Central Pacific, has returned to New Zealand and is now a master at the Auckland Grammar School.

THE REGISTRY

Fellows

(Elected May 11, 1960)

BLOOM, Harry, M.Sc.(Melb.), Ph.D.(Lond.), D.I.C., University of Auckland (Associate Professor).

CORBETT, Robert Edward, M.Sc., Ph.D.(Cantab.), Otago University (Reader).

Associates

(elected May 11, 1960)

BISHOP, Charmian Jocelyn, M.Sc., Chemistry Department, University of Auckland (Lecturer).

FERGUSON, Jack Eric, M.Sc., Ph.D.(Lond.), Chemistry Department, University of Canterbury (Lecturer).

HOARE, John Leonard, M.Sc., Chemistry Department, University of Auckland (Research Student).

LEONARD, John Henry, M.Sc., N.Z. Forest Products Ltd., Auckland (Research Chemist).

MOORE, Francis Hugh, M.Sc., Chemistry Dept., University of Auckland (Temporary Junior Lecturer).

PETERSEN, George Bouett, M.Sc., Plant Chemistry Division, Palmerston North (Scientific Officer).

THORP, John Martin, B.Sc.(Hons.), Ph.D., Auckland University (Lecturer in Physical Chemistry).

Laboratory Assistant Certificates

(awarded May 11, 1960)

BEALING, Gerald Stanley; BROWN, Janice Anne; DEWEY, Charles James George; FAULDS, William; HEDGES, Neville Southern; MURRAY, Brian Russell; OWERS, William Ronald; PICKARD, Robert Frederick.

OBITUARY

Egon Francis Joseph Schwarz, Ing.Chem.(Prague). Egon Schwarz came to New Zealand in 1939 from Czechoslovakia as a refugee from Nazi Germany and worked for a number of Christchurch firms as an industrial chemist. He established a very high reputation in Christchurch for his ability in this field and became Director of the Guild Rubber Co. He was elected Associate in 1945.

Frederick Egmont Mason, B.A., B.Sc. Aged 66 years. A graduate of Auckland University College, Mr Mason was science master at the Hamilton High School for 34 years. On retiring four years ago he went to England and taught there for over a year, and then joined the staff of the Hamilton Technical College, until illness caused him to relinquish work last March. In a lifetime devoted primarily to education, "Freddie" Mason developed many other interests. He organized school bands, choirs and orchestras, took a leading part in Automobile Association affairs, and was an Air Training Corps Instructor with the rank of Flight-Lieutenant. He served as Chairman of the Waikato Scientific Association and of the Waikato Branch of the Institute, and was a life member of the New Zealand Science Teachers' Association. He was an Associate of the Institute from its inception and always referred with pride to the fact that he was asked to organize the first Combined Conference in Hamilton in 1935.

COUNCIL MINUTES

ABRIDGED MINUTES OF A MEETING OF THE COUNCIL OF THE NEW ZEALAND INSTITUTE OF CHEMISTRY (INC.) HELD AT VICTORIA UNIVERSITY, ON WEDNESDAY, MAY 11, 1960, AT 4 p.m.

PRESENT:

E. W. Hullett (President, in the Chair), R. W. Olliff (Auckland proxy), N. T. Clare (Editor and Waikato proxy), Dr G. M. Butler (Manawatu), J. R. Beck (Wellington), D. J. Hogan (Registrar, Canterbury), Dr A. D. Campbell (Otago), A. P. Oliver (Acting Hon. Gen. Secretary). Apologies for absence were received from Prof. H. N. Parton (Vice-President), Prof. H. Bloom (Auckland) and Dr E. P. White (Waikato).

PROFESSIONAL STATUS COMMITTEE

A letter was received from the Professional Status Committee, and a separate report from Dr R. B. Miller, a member of the Committee, reporting on the submissions to Government made by the Association of Agricultural Science and the N.Z. Association of Scientists.

Resolved (Wellington/Auckland): That the action of the Professional Status Committee in withdrawing the support of the N.Z.I.C. from the committee drawing up submissions entitled "The Crisis in N.Z. Science" be confirmed.

Resolved (Canterbury/Manawatu): That the Professional Status Committee be requested to prepare a case on salaries of chemists for submission to Cabinet, and to report progress at the August meeting of Council.

Resolved (Manawatu/Hon. Gen. Sec.): That Dr Miller's letter re the Submissions be received.

Resolved: That a letter from W. B. Healey, Chairman of the Combined Subcommittee re the presentation of the Submissions to Hon. Mr Skinner and Hon. Mr Holloway be received. This letter stated that Cabinet was advised that the report would not be widely circulated until the Government had announced its salary recommendations.

EXAMINATIONS

The Examinations Committee requested a decision on the following matter: A Colombo Plan student from Indonesia had returned home having passed Stage I Chemistry. The Dept. of External Affairs enquired whether it could be possible to grant him the L.A.C. Certificate. The view of the Committee was that the student was not eligible.

Resolved (Otago/Wellington): That the view of the Examinations Committee be approved.

Resolved: That in the matter of an examiner for the A.N.Z.I.C. candidate Russell, Dr E. B. Davies having withdrawn, Prof. H. Bloom be appointed, and that the Examinations Committee be granted power to appoint another examiner if Prof. Bloom is unable to accept.

A letter was received from P. R. Parr referring to the Chemical Society *Proceedings* for February, 1960. On p.87 it is announced that the R.I.C. have instituted a research diploma of a standard approximating the Ph.D. which is open to members of the R.I.C.

Resolved (Canterbury/Wellington): That Branches and the Examinations Committee be asked for their opinion on the desirability of inaugurating a similar scheme in the N.Z.I.C.

MEMBERSHIP

Resolved (Waikato/Manawatu): That the resignations of R. H. Brickell, A. R. Caverhill, R. A. W. Green and Mrs A. C. Morton be accepted, and that any arrears of subscriptions due be written off. It was decided that overseas members resigning be advised that they can subscribe to the *Journal* through Editorial Services or overseas publishing houses.

Resolved (Wellington/Otago): That the Registrar be congratulated on the work he has put into the revision of membership lists and the collection of overdue subscriptions, which now stand at £140 instead of £650 last year.

SALARY SURVEY

Resolved (Wellington/Manawatu): That the Professional Status Committee be requested to carry out a Salary Survey as soon as possible, and that they be empowered to co-operate with other scientific and professional bodies towards this end.

EMPLOYMENT

The opinion of Council and the Employment Officer (Mr Mandeno) was that the present situation with regard to employment did not warrant setting up a different employment service.

LIST OF MEMBERS

The List will be distributed shortly at a cost of some £50.

Resolved (Canterbury/Wellington): That the List of Members be published annually as the sixth or December issue of the *Journal*, the Canterbury Branch to set up a revision committee.

RULES

Resolved (Canterbury/Wellington): That admendments to Rules since 1954 be printed on a loose leaflet for distribution to members.

PRIZES

Resolved (Canterbury/Otago): That the President and Editor, with power to consult, be appointed examiners *ex officio* for the Chemical Essay Prize (three entries).

Morcom Green, Edwards Prize: The President and Vice-President are examiners *ex officio* (three entries).

Resolved: That Prof. S. N. Slater and Prof. J. Packer be appointed examiners for the I.C.I. Prize, with power to consult (four entries).

R.I.C. CHEMICAL FILMS AND MONOGRAPHS

Resolved (Canterbury/Otago): That the Institute purchase 100 copies of each of the R.I.C. Monographs *Principles of Electrolysis, Principles of Oxidation and Reduction* and *Principles of the Extraction of Metals* for resale to Secondary Schools, and twelve Indexes of Chemistry Films and Film Strips.'

EDUCATIONAL FUND

Donations totalling £75 were received from four companies. It was decided to make a further approach to companies through both the manager and chemist in each case. The production of a brochure is to be considered.

LIBRARY

A letter was received from Dr G. Archey, Auckland Museum, thanking the N.Z.I.C. for the annual subscription to the Journal *Science*.

TECHNICIAN TRAINING CONTROLLING AUTHORITY

It is understood that the Authority is, at present, being appointed.

A. P. Oliver,
Acting Hon. Gen. Secretary.

GENERAL MEETING MINUTES

ABRIDGED MINUTES OF A GENERAL MEETING OF MEMBERS HELD IN THE CHEMISTRY LECTURE THEATRE, VICTORIA UNIVERSITY OF WELLINGTON, ON MONDAY, MAY 16, 1960, AT 11.15 a.m.

PRESENT

Professor H. N. Parton (Vice-President, in the Chair) and 52 members. Apologies were received from Mr E. W. Hullett (President), Dr D. J. Brasch, Mr N. T. Clare, Dr A. D. Campbell, Dr F. N. Fastier, Mr K. M. Griffin, Mr R. Hicks, Mr D. J. Hogan, Professor F. Llewellyn, Mr G. F. Martin, Dr E. P. White.

INCOME AND EXPENDITURE

Details to April 30, 1960, were presented. Reference was made to the valuable efforts of the Registrar, Mr D. J. Hogan, resulting in a reduction of overdue subscriptions from £650 to £140.

ADDRESSOGRAPH PLATES

Prof L. H. Briggs and Mr G. M. Wallace moved: "That the N.Z.I.C. will not allow the use of the addressograph plates by commercial organizations for any purpose, and that these organizations be encouraged to advertise in the *Journal*."

Mr J. L. Mandeno pointed out that the *Journal* appeared too infrequently to be useful in advertising positions vacant and that, owing to the high cost of advertising in the Press, a good income could be derived from hire of the plates. This could be applied to the *Journal*, which would probably lose some advertising. The scheme would provide a service to chemists. Mr H. R. Penhale considered the Institute should not shut the door too firmly, but should charge a reasonable fee, and stipulate plain envelopes and no postcards. Messrs P. R. Parr and W. G. Hughson agreed that Council should have control over the form of advertising.

S. G. Brooker and W. G. Hughson moved by way of amendment: "That the matter be left to Council for consideration of each case on its merits."

The amendment was lost, and so was the original motion. It was finally resolved, on a motion by Prof L. H. Briggs and Mr E. F. Hubbard: "That the addressograph plates be hired to advertisers at a rate to be determined by Council, which must approve the material for which it is proposed the plates be used in each case."

LIST OF MEMBERS

It was announced that the list would be published annually as a sixth or December issue of the *Journal*, together with a list of Institute officers, committees, and similar data.

EDUCATIONAL FUND

The purpose of the Fund was explained. The poor response from the first circular letter, posted by the secretaries of 26 organizations, was commented on by Mr M. Rands, who suggested that the letters should have gone to the chemists, who could then explain the Fund further to their managers.

INTERNATIONAL SYMPOSIUM ON CHEMISTRY OF NATURAL PRODUCTS

A letter was received from the Chairman of the Symposium organising committee who asked for the appointment of an Institute representative at the Symposium.

Resolved (Prof. S. N. Slater/Mr S. G. Brooker): That Prof. L. H. Briggs be appointed to represent the N.Z.I.C.

Reference was made to the valuable work carried out by Prof. Briggs in building up good relationships with the chemists of Australia.

PROFESSIONAL STATUS COMMITTEE

It was announced that the Committee had been requested to conduct a Salary Survey in 1960 and draw up submissions for Cabinet on the subject of salaries.

Resolved (Dr J. K. Dixon/Dr F. B. Shorland): That the Professional Status Committee be asked to prepare the submissions with all possible speed, owing to the rapidly changing position of salaries.

DEATH OF Dr DENZ

The Vice-President announced the death, in Dunedin, on May 15 of Professor F. Denz.

Resolved (Vice-President/Dr J. K. Dixon): That a letter of condolence be sent to Mrs Denz.

A. P. Oliver,
Acting Hon. Gen. Secretary.

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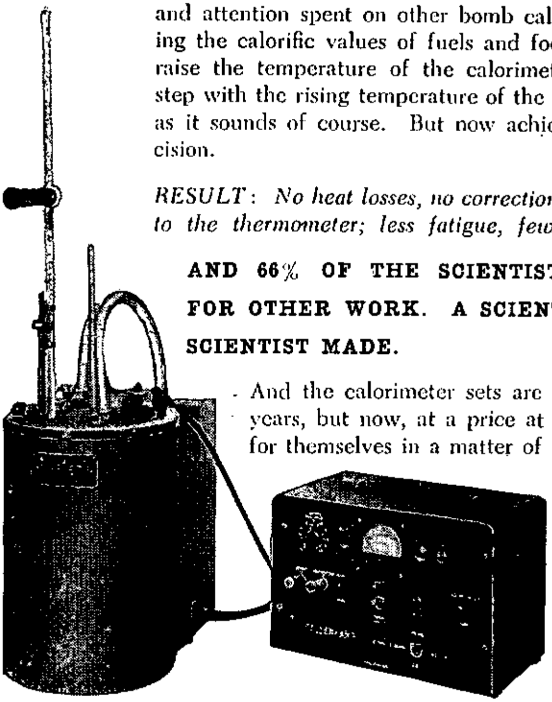

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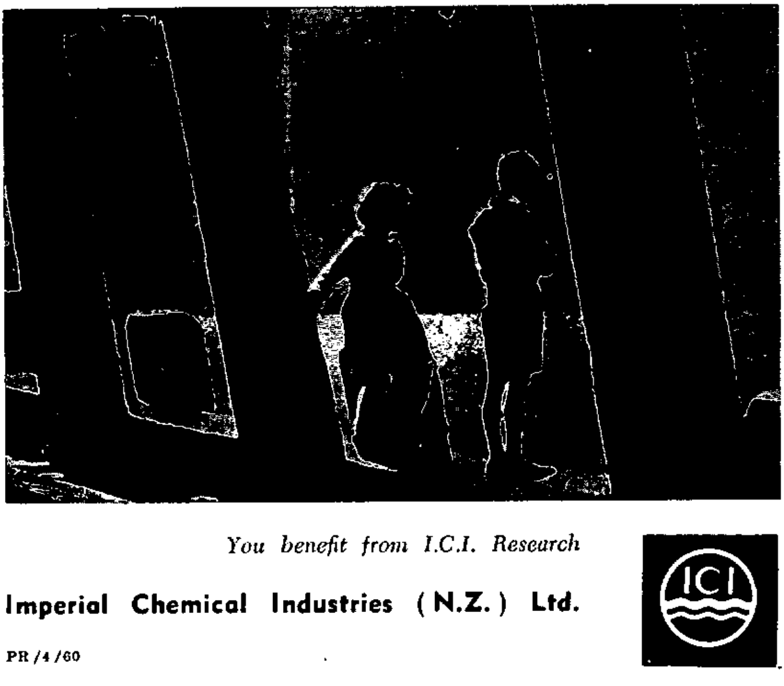

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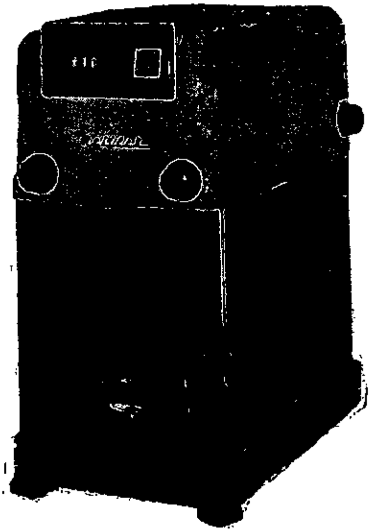

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