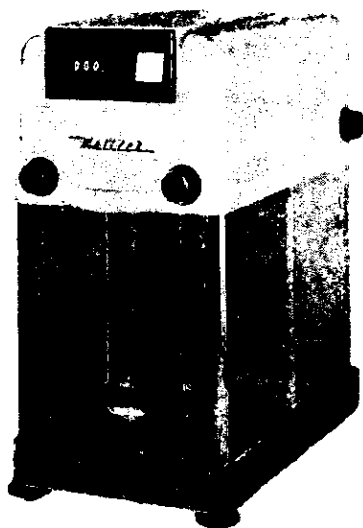


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INSTITUTE OF CHEMISTRY

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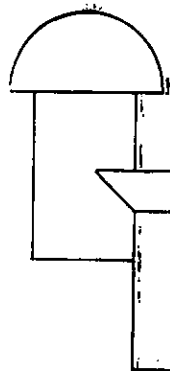
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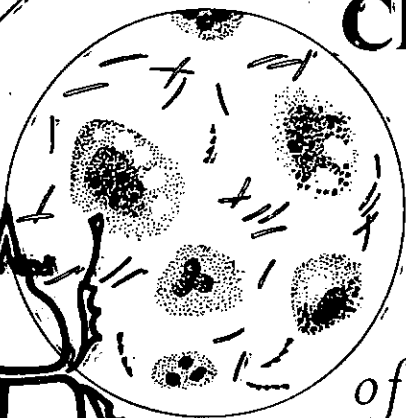
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JOURNAL OF THE NEW ZEALAND INSTITUTE OF CHEMISTRY

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EDITORIAL

Five and a half years ago the Manawatu Branch took over from Auckland responsibility for the production of the *Institute Journal*. Now twenty-seven issues and some thousand-odd pages of copy later, this Branch hands over to the Waikato Branch and to a new *Journal* Committee under the leadership of N. T. Clare as Editor. All members of the Institute will join in wishing the Waikato Branch well in their new venture and those of us who have been closely associated with the *Journal* hope that future Editors and *Journal* Committees will derive as much pleasure from their work as we have done.

As is the case with the work of all Institute committees, the production of the *Journal* has not always been easy. There have been difficulties in obtaining copy, in making ends meet financially, in meeting printing deadlines, and so on; but always our task has been lightened by the willing co-operation and forbearance of all Institute members.

As retiring Editor I should like to thank those who have served on the various *Journal* committees and who have helped with the special publications which have been produced over the past five years. How often they must have cursed when their planned evenings or weekends have been disrupted by the arrival of "another set of *Journal* proofs" for urgent checking. And yet members like Drs Barnicoat and Dolby and Messrs Fife, Robertson and Wallace were always willing to serve another year and continued to do so until transfer from the district or overseas travel necessitated their replacement. My thanks are due, too, to all officers of the Institute with whom I have worked—the various Presidents, the Hon. General Secretaries, the Registrar, Council Members—to the printers, to the Branch Editors, and finally to the authors themselves for the help they have given me in so many ways. Editing the *Journal* has certainly been an interesting experience and one which I would not like to have missed. Both my wife, who has taken a large share in the editorial work, and I myself have enjoyed our association with the *Journal* tremendously.

And now, as this final issue from the Manawatu Branch is "put to bed", it remains only to say, "Good luck, Waikato", and to remind members that all future correspondence should be addressed to:

N. T. CLARE,
Ruakura Animal Research Station,
Private Bag, Hamilton.

AIR POLLUTION AND THE CHEMIST

L. WILKINSON

Dominion Laboratory, D.S.I.R., Christchurch.

*(Based on chairman's address delivered to Canterbury Branch,
March, 1959.)*

A comparison of aerial photographs of Christchurch during a winter fog and Los Angeles during a period of smog shows a striking similarity. Los Angeles (Magill, 1956) is a smog-ridden city where nearly £200,000 is spent annually on air pollution control measures, where industry has supplied £7,000,000 for the installation of pollution control equipment and devices in five years up to 1949, and where continuing research work on the smog problem costs another £300,000 annually. The similarity of Christchurch to the American city might well raise in our minds the question, "Can it happen here?" This is a very vital question because on the average each of us requires in a day 30 to 40 lb of air yet we consume only 3 to 4 lb of water and only about 1.5 lb dry matter as food. We can, if necessity arises, refrain for several days from drinking polluted water or from eating poisonous food and still survive. None of us would exist five minutes without air.

Drinker (1958) has recently stated that air pollution is a problem of population growth and describes the growth rate since 1700 as explosive. He cites the world population in the year 1200 A.D. as 300 million, in 1700 as 500 million and in 1958 as over 2,000 million. On the other hand, Parker (1956) has noted that, even in the thirteenth century, serious complaints were being made about the pollution from the burning of coal in London. Seven hundred years ago when annual coal consumption in Great Britain was one million tons compared with 200 million tons today, a proclamation was issued prohibiting the use of coal in London while Parliament was in session. In 1648, Londoners asked Parliament to prohibit entirely the import and use of coal in their city. Air pollution, therefore, has been with us a long time.

It is interesting, however, to compare growth rates of population and coal consumption in England since 1700 (Fig. 1). The growth of coal consumption during the last 250 years greatly exceeds the growth of population. Unfortunately, very little information exists to enable an estimate of the growth rate of air pollution during the same period. There does seem to be some evidence to show an association of air pollution and population.

During the period 1937-1939, a very intensive survey (D.S.I.R. (U.K.), 1945) of air pollution was made in the City of Leicester and in the report on this survey an empirical rule was adduced that

$$\frac{\text{winter mean smoke (mg/m}^3\text{)} \times 10^4}{\sqrt{\text{population}}} = 7 \pm 1$$

This rule appears to be applicable in Christchurch. If the rule is valid over a long period of time, it would suggest that the growth rate of air pollution in England has been less than the growth rate of population. It is certain, however, that, during the last 250 years, other factors besides growth of population have determined the growth rate of smoke pollution. Unfortunately, the decimation of population by cholera, smallpox, typhoid, etc., persisted well into the nineteenth century and this would obscure any effects on health of increasing air pollution. It was not until the last quarter of the nineteenth century that medical statistics (Ministry of Health, 1954) showed that severe fogs occurring in London between 1873 and 1892 were accompanied by definite rises in mortality. In each the death roll from bronchitis was large. In the twentieth century the effect of air pollution on health has been tragically demonstrated on several occasions. In December, 1930, a fog persisted for five days in the Meuse Valley in Belgium

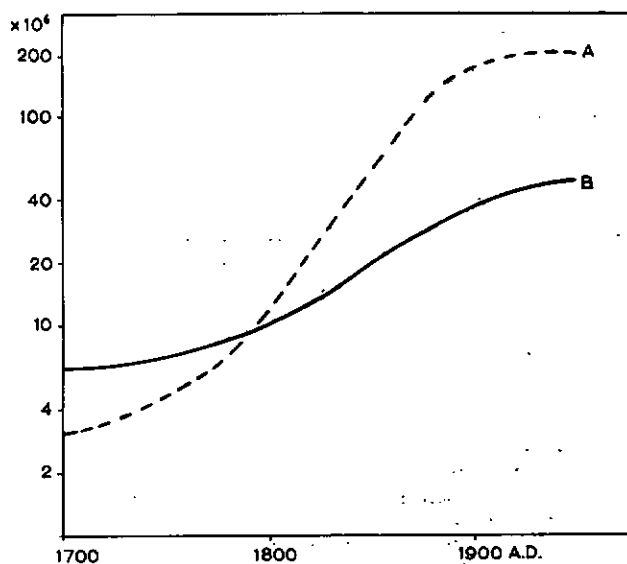


Fig. 1: Growth of coal consumption (tons) and population in Great Britain. A: Coal. B: Population. (After Parker, 1956).

and during this period 63 people died, their deaths being attributed to respiratory disorders associated with the fog. In October of 1948 approximately 14,000 people in the environs of the town of Donora in Pennsylvania were exposed to a fog which persisted for four days and during this period 18 people died as a result of harmful constituents in the fog. In the tragic London fog of December, 1952, the deaths of 4,000 people suffering from chronic respiratory and cardiovascular diseases are believed to be directly attributed to harmful constituents in the four-day fog. Again in 1956 the deaths of 1,000 people in London were associated with persistent fog laden with harmful constituents.

In some areas air pollution originates from natural emissions such as pollen which affects four million North Americans with varying degrees of hay-fever discomfort each year (Magill, 1956). In other areas natural emissions, such as hydrogen sulphide from estuarine mudflats, may be aggravated by the uncontrolled deposition of human and putrifying industrial wastes. The recent fume attack in the southern areas of Auckland adjacent to the Mangere Inlet is an example of this type of problem, as is, on a much smaller scale, the localized stench from the Christchurch estuary.

It is now considered that air pollution generally results from the burning of coal and petroleum products.

A comparison of the relative amounts of natural and man-made contaminants for the United States is shown in Table 1.

The arresting feature of this table is the comparison of carbon dioxide and pollen. Despite the emission of 3,000 million tons of carbon dioxide there is no known general air pollution hazard from this gas, but, as already stated, one million tons of pollen cause discomfort to about four million Americans. This com-

TABLE 1: MAJOR AIR CONTAMINANTS IN THE UNITED STATES.
(After Magill, 1956)

<i>Material</i>	<i>Annual Emission (million tons)</i>
NATURAL	
Fog —25ft high	15
Pollen	1
Dust	30
MAN-MADE	
Carbon dioxide	3,000
Carbon monoxide	60
Organic vapours	42
Sulphur dioxide and trioxide	19
Dust and grit	7
Smoke	5

parison is even more remarkable when the sources of the two emissions are taken into account. Carbon dioxide, emitted by combustion processes, originates from a relatively small area in comparison to the pollen which comes largely from the open spaces. It is clear, therefore, that harmful agents in polluted air are not necessarily the most abundant emissions. Another feature of this table is the low proportion of industrial dust and grit compared with natural dust. Some comparative particle size and free silica determinations of the dusts from various sources might prove very interesting. The amount of organic vapours emitted in the United States far exceeds that of smoke and sulphur dioxide and more will be said about this later.

An indication of the potential severity of air pollution for any given area can be obtained from the comparison of the amount of fuels burnt in that area with the amount burnt in known polluted areas.

In Christchurch and London the domestic consumption of coal is one-fifth of the total consumption of coal; but unlike the industrial users, domestic coal is burnt largely in winter. No coal is burnt in Los Angeles. The proportion of petroleum products burnt in London is small compared with that of domestic coal but in Christchurch both oil and petrol are burnt in amounts comparable to that of domestic coal. In Los Angeles more natural gas and fuel oil are burnt than petrol and huge quantities of garbage are also burnt. The *per capita* consumption of fuels in London and Los Angeles is roughly the same and Christchurch about one-half of the other two. On an area basis Christchurch burns one-fifth the fuel burnt in London and about one-half that burnt in Los Angeles.

Table 2 shows estimated emissions according to user for London and Los Angeles.

TABLE 2: ESTIMATED EMISSIONS ACCORDING TO USER.
(Tons per day)

Nature of Emission	London ^o		Los Angeles [†]	
	General Public	Other	General Public	Other
Smoke	400	500	45	45
Grit and dust	40	300		
Sulphur oxides	400	2,000	45	120
Hydrocarbons	n.a.	n.a.	600	30
Nitrogen oxides	n.a.	n.a.	100	80
Aldehydes	n.a.	n.a.	25	10

n.a.—not available.

^oCommittee on Air Pollution (1953, 1954)

[†]Stanford Research Institute (1954).

In both cities the domestic consumer contributes almost as much soot as do all other users put together and in Los Angeles the general public contribute the greater part of hydrocarbons, nitrogen oxides and aldehydes. The other users exceed the domestic consumer only in the emission of sulphur oxides, grit and dust.

Before leaving this aspect of air pollution, mention must be made of discharges from motor transport. Most people are familiar with these low-level discharges and the nuisance they cause in streets carrying dense traffic. The effect of the automobile is most noted in Los Angeles which, with one million cars, has the highest concentration of motor vehicles in the world. This city is unfortunate in its topography and climate. The phenomenon known as temperature inversion occurs on the average about 250 days in the year. During temperature inversions the colder sea breezes lie below the warmer westerly air stream and this results in little vertical movement of air. Although the Los Angeles "smog" is considered not now likely to be a menace to human existence, it does cause marked eye irritation, a reduction in visibility, and damage to vegetation. The estimated emissions from the million-odd cars in Los Angeles City, population over two million, form the major bulk of the general emissions given in Table 2. No similar sets of estimates are available for London but Fitton (1956) has obtained figures which he regards as typical of petrol and diesel engine exhausts. These figures and the range in composition with different conditions of engine operation are given in Table 3.

The significant features of this table are the large amounts of carbon monoxide and hydrocarbons in the exhaust gases emitted

TABLE 3: COMPOSITION OF PETROL AND DIESEL EXHAUST
(After Fitton)

Constituent	Petrol		Diesel	
	Range	Typical	Range	Typical
	%	%	%	%
Carbon dioxide	2.7-15	9	0.70-14	9
Carbon monoxide	0-14	4	0-7.6	0.1
Oxygen	0-17	4	0.50-20	9
Hydrogen	0-6	2	0-2.6	0.03
Hydrocarbons	0-4	0.5	0-0.5	0.02
Aldehydes	0-0.03	0.004	0-0.004	0.002
Oxides of nitrogen	0-0.2	0.06	0-0.15	0.04
Sulphur dioxide	0-0.008	0.006	0.01-0.03	0.02

by the petrol engine compared with those emitted by the diesel engine and the substantial quantities of oxides of nitrogen emitted by both types of engine. The diesel engine may emit from three to four times the volume of exhaust gases as does a petrol engine of the same power.

It is obvious that all large cities emit tremendous quantities of potentially dangerous substances to the atmosphere and that a substantial amount of these materials comes from the domestic use of fuel and from the individually-owned motor car. The next important question which arises is how much of these polluting substances stay at a low level over towns. Both England and America are spending large sums of money in making measurements of air pollution. Mention has been made of the cost of air pollution measurements to the people of Los Angeles. Similar information is not readily available for the British effort, but it is considered that an estimate of the order of several hundred thousand pounds per annum would not be greatly in error.

A recent issue of *Chemistry & Industry* carries an announcement of the change in functions of the Fuel Research Station. In future air pollution research will form a very major part of its activities. Since about 1915 the Fuel Research Station (Parker, 1956) has sponsored the growth of the co-operative scheme of measurement of air pollution. Under this scheme nearly three thousand instruments are in use throughout Great Britain at present. They are serviced largely by local authorities on whom rests the initiative for installing the instruments. The results from these instruments are forwarded to the Fuel Research Station for statistical treatment and several hundred thousand results are now processed each year. The Fuel Research Station provides the central services, advises on location of instruments, and issues a monthly bulletin summarizing results and a yearly report. The numbers of the four different types of instruments in use in 1957 are as follows: Deposit gauge (dust, ash, grit, etc.), 1,077; smoke filter (soot), 244; lead peroxide for sulphur dioxide, 1,180; volumetric sulphur dioxide, 186; total, 2,687.

About 250 of these instruments, in roughly equal numbers, are installed in Metropolitan London giving a coverage of two instruments to every square mile. English experience over the years since 1915 has shown that large numbers of sampling sites are necessary owing to the wide variations in local and meteorological conditions. The smoke filter and volumetric sulphur dioxide instrument are often combined in the one unit and require

daily attention. The other two instruments are serviced monthly and the deposit gauge provides samples from which several results are obtained. The Fuel Research Station develops and standardizes instruments and methods of analyses. The cost of installing and servicing the instruments is borne usually by the local authority and the analyses are made by the local public analyst.

Table 4 lists the most important substances found in polluted air over cities, the maximum value observed, usually under very foggy conditions in winter, and where available the threshold value. The threshold value or maximum allowable concentration is the average maximum concentration to which a worker can be exposed for eight hours daily over an indefinite period without incurring injury or occupational disease. The limits are based on the best available information and are reviewed annually by the Conference of American Governmental Industrial Hygienists.

TABLE 4: MAXIMUM OBSERVED VALUES AND THRESHOLD VALUES OF SUBSTANCES FOUND IN POLLUTED ATMOSPHERES.

<i>Pollutant</i>	<i>Place</i>	<i>Maximum Observed Value</i>	<i>Threshold Value</i>
Carbon dioxide, ppm	U.K. & U.S.A.	600	5,000
Carbon monoxide, ppm	Los Angeles	160	100
Smoke, mg/m ³	London	4.46	2-15
Hydrocarbons, ppm	Los Angeles	3	500
Sulphur dioxide, ppm	London	1.3	5
Nitrogen oxides, ppm	Windsor	3.5	5
Sulphuric acid mist, mg/m ³	Los Angeles	0.24	1
Formaldehyde, ppm	Los Angeles	0.3	5
Acrolein, ppm	Los Angeles	Present	0.5
Ozone, ppm	Los Angeles	0.8	0.1
3:4 Benzpyrene, µg/m ³	London	0.15	
Fluoride, ppm	Baltimore	0.08	3
Lead, µg/m ³	Los Angeles	42	200
Silicon, µg/m ³	Los Angeles	28	
Beryllium, µg/m ³	Windsor	0.07	

The maximum values noted in this table are by no means usual and are generally several times greater than the average value for winter conditions in England and most of the United States, or smog conditions in Los Angeles.

No estimate of carbon dioxide emission appears to be available for Great Britain but it would be of the order of 500 to 1,000 million tons yearly. However, the concentration in polluted air never seems to reach a value which would indicate a potential hazard to health. In spite of the lesser but nevertheless tremen-

dous quantities of carbon monoxide emitted in England and the United States, maximum values of this substance in the busiest streets seldom exceed 100 ppm although in road tunnels values of 590 ppm can be obtained. Average values are generally very considerably less than 100 ppm. During the 1956 London fog, the highest value for carbon monoxide (50 ppm) was recorded on the first day of the fog, but the average of 29 measurements made that day was only 14 ppm. Movement of traffic during such fogs of zero visibility would, of course, be at a minimum. The question of smoke will be discussed in more detail later. Dust and grit would not, on account of their particle size, appear to be a health hazard although undoubtedly they are a nuisance to human comfort and convenience.

Sulphur dioxide is a rather ubiquitous gas. It is commonly present in the air of workshops attached to foundries, etc., and workers appear to become acclimatized and even may have superior health on the average. On the other hand, the superiority in health may only be apparent, the weaker having found more congenial work elsewhere. It is significant, however, to note that in 1957 the threshold value for this gas was lowered from 10 to 5 ppm. There is presumptive evidence that the fatal fogs in England, in the Meuse Valley, and in Donora, were associated with high concentrations of this gas although the maximum amount present in each case was less than the new threshold value. In general, the winter average value for a polluted city is about one-fifth of that recorded in Table 4.

During recent years increasing importance has been attached to the significance of nitrogen oxides in the atmosphere. Apart from Los Angeles and a few other American cities, little is known about these oxides. Substantial quantities are emitted from petrol and diesel engines and although there seem to be no, or only a few, analyses of chimney or stack gases, it is almost certain that these sources would also emit substantial quantities of these oxides. The toxicity of the various forms of nitrogen oxides also seems to be in considerable doubt. It was formerly held that nitrogen dioxide was more toxic than nitric oxide but there is some evidence that the reverse holds, namely, nitric oxide might be four times as toxic as nitrogen dioxide. The very high maximum value recorded for Windsor is not typical of the maxima for other towns in the United States or for London, and is considerably greater than the mean 0.9 ppm recorded for Windsor. As with sulphur dioxide the threshold value for nitrogen oxides has been lowered

in recent years. In 1954 it was reduced from 25 ppm to 5 ppm. It is also interesting to note that, in four of five towns investigated in the United States, the mean value for nitrogen oxides exceeds that for sulphur dioxide. The nitrogen oxides will be discussed more fully later.

Of the other constituents in the table little can be said about all but two owing to insufficient information about the emission of these substances. Most of these measurements have been made in America. The two exceptions are 3:4-benzpyrene and ozone. Much has been said recently on the association of lung cancer with tobacco smoking habits and of a probable association of lung cancer with air pollution. 3:4-benzpyrene is a known potent carcinogen, producing skin tumours, but so far has not been proved to produce lung cancer. It is present in soot derived from the burning of coal and petroleum products.

Both atmospheric and diesel soot contain comparable quantities of other similar polycyclic hydrocarbons. Unfortunately, no detailed work appears to have been carried out on petrol engine exhausts which are known to emit 120 μg 3:4-benzpyrene per minute compared with 0.01 μg for diesel engine exhausts. Of the other polycyclic hydrocarbons, only two, 1:2-benzpyrene and 1:12-benzperylene, are known as possibly carcinogenic and then only weakly so, if at all. However, it has been estimated that man would retain sufficient smoke in his lungs during life-time to give a retention of about 250 μg 3:4-benzpyrene. The minimum amount of this substance which will produce sarcoma in a mouse is 0.5 to 1.0 μg . Before leaving this subject of lung cancer, mention must be made of the work being carried-out by the Fuel Research Station on behalf of the British Empire Cancer Campaign on trace elements found in smoke stains from North Wales and Liverpool. The conventional and special smoke stains from these areas are examined spectrographically for twelve minor elements and results so far for two years show little yearly variation. Lead and zinc, the more abundant elements, are present in the smoke of North Wales and Liverpool in considerably less amounts than found in several American cities such as Cincinnati and Donora.

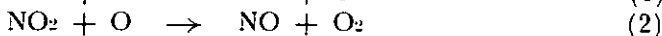
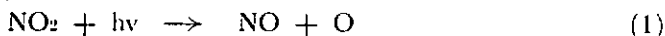
It will be noted that in Table 4 none of the constituents, with the exception of smoke, oxides of nitrogen, and ozone, exceeds the threshold value even under the worst conditions examined. During the last thirty years air pollution has been associated with the loss of life and serious illness on four occasions. In the Meuse Valley incident (December, 1930) fog covered the valley and

caused the death of 63 persons and severely affected several thousands. Ten post-mortem examinations were made and chemical tests for poisoning by carbon monoxide, sulphur dioxide, fluorine, arsenic and zinc were negative. An extensive list of possible chemicals was reviewed by a subsequent Commission and all but sulphur dioxide exonerated. Roholm, reviewing the incident in the light of later knowledge of fluorine poisoning considers, however, that circumstantial evidence indicted fluorine. In the Donora episode (October, 1948) fog caused the death of 18 people and affected 6,000 others, either mildly or severely, with bronchial illnesses. Again a subsequent enquiry could not indict any specific constituent of the fog as the causative agent of death. Sulphur dioxide and particulate matter were, however, considered to be significant contaminants. The last two episodes are the 1952 and 1956 London fogs. The former of these was very thoroughly investigated by a Committee appointed by the Minister of Health (Ministry of Health, 1954) and again no specific substance was found responsible for the deaths but smoke and sulphur dioxide were implicated. A statistical analysis made by the Fuel Research Station following the 1956 fog gave tentative evidence that there was a correlation between the increases in mortality in six London boroughs and average smoke concentrations but no definite correlation with average concentrations of sulphur dioxide.

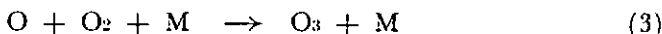
While dealing with Table 4 discussion on the ozone found in Los Angeles atmosphere was purposely omitted. As far as is known this substance is not emitted to the atmosphere but frequently occurs in Los Angeles and the daily pattern is quite regular. Ozone is normally present at low levels at about 6 parts per hundred million. It has been measured in Alaska, Europe, England and at several places in the United States. In all but Los Angeles and Alaska, values are always low. In Alaska there is a seasonal variation, high values reaching 45 pphm but the average for the year is about 5.9 pphm. In Los Angeles the ozone concentration commences to rise from about 5 or less pphm at about 8.00 a.m. and attains a maximum at about midday. The midday maximum is greatest on sunny, calm days when smog is likely, and low on windy or heavily overcast days. An investigation revealed no sources likely to emit ozone in the quantities found and the possibility of transportation of ozone from high altitudes was excluded. The ozone in Los Angeles atmosphere therefore appears to be formed *in situ* as a result of photochemical processes occurring in polluted air. This raises immediately the question—"What

chemical reactions occur in polluted air?" Unfortunately, there is very little evidence but much speculation on possible reaction mechanisms. No work of this nature seems to have been carried out in England and we are dependent on the Los Angeles investigations for information on this aspect of air pollution (Stanford Research Institute, 1954).

The substances which can react chemically in the atmosphere fall into two main groups: major natural constituents which are present in high concentration, such as oxygen, and contaminants which are usually present in low concentrations. The large difference in concentrations calls for careful interpretation of the kinetic and photochemical data in the literature. For example, when nitrogen dioxide is irradiated by near-ultra-violet radiation, molecular oxygen and nitric oxide are formed by the following reactions:



However, in an atmosphere containing much less than 1 ppm of nitrogen dioxide and about 21 per cent. oxygen, the following reaction (where M is any molecule) will be faster than reaction (2).

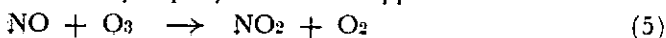


It is well known that nitric oxide reacts with oxygen to form nitrogen dioxide—*e.g.*,

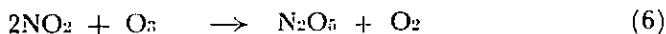


It is not so well known that concentration greatly affects the reaction rate. When the concentration of nitric oxide is 1 per cent., the half-life is 36 sec but if the concentration is 1.0 ppm the half-life is 100 hours and if 0.1 ppm the half-life is 1,000 hours. Photochemically active radiation in sunlight near the earth's surface varies in wavelength from about 2,900 to 7,000 Å. Substances which absorb in this region can act as primary photochemical reactants or photosensitizers, which function by transferring the absorbed energy to potentially reactant molecules. When a substance is present in small concentration it must have a high specific absorption of the solar radiations if it is to initiate important photochemical reactions. When present in high concentration the substance need absorb only weakly and still initiate reactions.

If nitric oxide and ozone are both present in an atmosphere they will react very rapidly even at 0.1 ppm as follows:



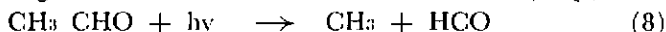
When nitric oxide is in excess, ozone will be virtually absent. If, however, ozone is in excess, as in Los Angeles, another reaction can take place



Analyses of Los Angeles air indicate that about two-thirds of the "oxides of nitrogen" are present as nitric acid vapour. While ozone could be formed in the atmosphere by reactions (1) and (3) it would rapidly react with the nitric oxide also formed in equation (1).

Sulphur dioxide absorbs solar radiation with a maximum occurring between 2,900 and 3,000 μ . It reacts very slowly, however, with oxygen in sunlight to form sulphur trioxide and the rate of reaction is not affected by nitrogen dioxide, sodium chloride nuclei, or water vapour. The reaction rate amounts to 0.1 to 0.2 per cent. per hour in strong sunlight. If, however, chlorine should be present in the atmosphere, oxidation of sulphur dioxide could proceed very rapidly but there seems to be no evidence that chlorine is, or could be, formed in appreciable quantities by any reaction process in the atmosphere. Fairly rapid reaction takes place between ozone and various olefines at concentrations likely to occur in contaminated atmospheres. The first stage of the reaction appears to be a bimolecular addition reaction which forms an unstable complex. The complex then forms unknown fragments which combine with more olefine. Free radicles may be an important part of the subsequent reaction chains.

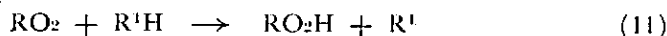
Aldehydes, ketones and di-olefines absorb solar radiation. The most important primary reaction with aldehydes and ketones is the breaking of the molecule into two free radicles, *e.g.*,



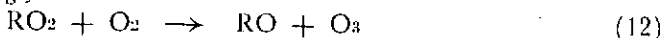
Some of these radicles are remarkably stable. A few of the earlier reactions described produce atoms which would attack organic molecules to produce organic free radicles. It is quite possible, therefore, for organic free radicles to form in a polluted atmosphere and if such were the case they would then react rapidly with oxygen to form peroxy free radicles, *e.g.*,



These in turn would react with other organic molecules to form organic peroxides and new free radicles



or react with olefines to form polymerization products. There is speculation but no proof that peroxy free radicles may produce ozone, *e.g.*,



If this reaction should take place, then atmospheric conditions with large amounts of oxygen and relatively small concentrations of competing molecules (equation 10) would be favourable.

Little is known of the effect particulate matter present in the atmosphere would have on many of the reactions described. It may promote heterogeneous gas-phase reactions, it may absorb reactant gases and catalyse reactions, and it may change the absorption spectrum of a gas adsorbed on its surface.

Altogether some 57 reactions have been studied and speculated upon by the Los Angeles investigators in the hope of finding some clue of the mechanism of ozone formation but with little success. On the experimental side a little more, but so far mainly negative, information has been obtained, leaving the mechanism still obscure. Artificial irradiation of polluted air using mercury vapour lamps resulted in the formation of ozone and it was found that, when such outside polluted air was fed continuously through the irradiated flask, ozone concentrations reached their maximum at about 8.00 a.m., remained constant at that level for about 12 hours and then fell to the minimum about 4 a.m. the following day. If meteorological conditions outside were not stable but turbulent, constant irradiation gave two maxima, one at about 8.00 a.m. and the other at about 8.00 p.m. The formation of ozone in artificially irradiated air was not affected by removal of nitrogen dioxide, particulate matter, aldehydes, ketones or peroxides. The precursors for ozone formation were not removed by cooling to -80°C but were removed by cooling to -180°C or by passing the air through a combustion tube containing copper oxide at 760°C .

In the absence of definite knowledge of any one or more specific contaminants being present in air in amounts dangerous to health, abatement measures must necessarily aim at reducing all emissions to as low a level as economically possible. For quite a long time we have known how to deal with the reduction of specific contaminations from various factory processes although the small size of the industry concerned might in some cases have made the installation of equipment for a major reduction in emission either uneconomic or impracticable. Today, however, industry is no longer indicted as the major contributor to air

pollution and the institution of abatement measures to reduce emissions from the individual activities of the general public is a complex problem involving not only technical considerations but also major economic and social changes. First of all let us look at the economic cost of air pollution which in Great Britain is estimated to be £250 million a year. Using this figure as a basis, Scorer has derived a very controversial table of costs of damage per ton of coal burnt by different users. His findings are summarized in Table 5. In apportioning the cost, Scorer gave each type of coal use a factor which was a multiple of other weighting factors given for:

1. Height and temperature of emission and bulk of source.
2. Radiative effects—*i.e.*, the number of sources of emission.
3. Closeness to site of damage.
4. Concentration into adverse weather.
5. Chemical nature of pollutants.

TABLE 5: DAMAGE BY AIR POLLUTION—Gt. BRITAIN
(After Scorer, 1957)

<i>User</i>	<i>Cost/Ton Coal</i> (£)
Domestic	6
Road traffic	1.6
Railways	0.7
Collieries	0.23
Industry	0.16
Electricity	0.03

Scorer presented his paper at a meeting of the Institute of Fuel in November, 1956, and provoked a very vigorous discussion. None of his audience was inclined to accept his estimate of the relative cost of damage for the different users but there was general agreement that the order in which he placed the users was substantially correct. It was certain, however, that despite the various challenges as to the veracity of his estimates—and no one was able to produce any alternative figures—Scorer has done much to crystallize present thinking on the problem of air pollution. His table shows quite clearly that the cost of the damage done by a ton of coal burnt in the domestic grate is roughly the same as the cost of the fuel itself and therefore a considerable sum of money could be spent on improvement of coal quality and coal burning appliances without affecting total costs if the improvements succeeded in reducing air pollution. In the case of other users, the cost of damage is far less than the cost of the fuel and an increase in costs by using higher quality fuels and improved fuel-burning equipment is likely to be a disadvantage on economic grounds although

it might be highly desirable in order to preserve the health of the community.

Let us now look at the position we are faced with in New Zealand. We are justly proud of the fact that we use electricity more abundantly than many other countries and this is confirmed somewhat by our low *per capita* fuel consumption compared with London and Los Angeles. We also have huge water resources in the South Island which are largely unexploited. In reality, however, electrical energy accounted for only 10 per cent. of our total energy consumption in 1955, coal and imported fuel oils supplying 45 per cent. each. These figures assume, of course, 100 per cent. efficiency of conversion. Nicholson (1958) concludes that, as coal and fuel oils are burned at 35 per cent. efficiency and electricity at about 75 per cent. efficiency, coal accounted for 39 per cent., and electricity 20.5 per cent. of the total energy effectively used in 1955.

It would seem that we would need to increase our production of electricity to three times the present amount before electricity could replace coal completely. The costs of such a tremendous expansion in the supply of hydro-electricity and of replacement of existing coal-burning equipment are enormous and it is quite obvious that our economy will depend for a long time on coal as a principal source of energy. The major problem in air pollution abatement in New Zealand is therefore how to use the principal energy supplies in the most rewarding manner. Nicholson believes that much the greater use of coal should be for water- and space-heating. The relative costs of different fuels used for water and space heating are summarized in Table 6. Two rates are estimated for costs of electricity based on the basic rates of $\frac{3}{4}$ d and 1d per kWh. The ranges in rates for coal and coke used for space-heating are due to the differing efficiencies of grates. The old-fashioned open fireplace has an efficiency of 15 per cent. or less whereas the low-rate stove has an efficiency of 65 per cent. These efficiencies are for coal and are about 10 per cent. higher for coke.

TABLE 6: COMPARATIVE COSTS OF FUELS USED FOR HEATING.
Pence per therm of effective heat
(After Nicholson, 1958)

Method of Heating	Water	Space
Electricity	31-41	22-29
Gas	41.5	33
Coal	25	10-47
Coke	16	10-23
Oil	—	15-19

In New Zealand already one-third of our electricity supply is used for water-heating and one-third for other domestic purposes. Nicholson quotes a figure of £100 per added kilowatt as the cost of capital expenditure on new power stations and reticulation and considers that such new power should, because of its very high cost, be used only for essential lighting and for industrial motors.

If expansion of our hydro-electric resources to take over the energy supplied by coal for water and space-heating is impracticable, and if it is unwise, as it certainly is, to expand our imports of fuel oils which also pollute the air, we must therefore burn our coal in such a way as to keep emission of harmful substances to a minimum. The efficiency of burning coal in the domestic grate can be increased at least four times by the installation of improved appliances and, apart from the reduced emission from these new grates, the consumption of domestic coal used for space heating would be reduced to about one-quarter of its present value. This would be a significant reduction in a major emission as domestic coal is largely burned in the three winter months.

In addition, the use of smokeless fuels such as coke could replace the present custom of burning in domestic grates the highly-bituminous West Coast coal which is far better used for gas-making. Gas burned in domestic appliances is certainly more expensive than other forms of energy derived from coal and oil but no doubt improvements could be effected so that the cost is reduced. The burning of gas produces no smoke and little sulphur dioxide. Expansion of coke supplies would follow an expansion in the gas industry and coke can be burned in domestic grates almost smokelessly and with less sulphur dioxide emission than coal. The production of other forms of smokeless fuels could also be developed or expanded.

The removal of harmful gaseous constituents from industrial sources of fuel burning appears uneconomic but abatement of air pollution can be effected by increasing heights of stacks, by improvements in fuel quality and by increasing the efficiency of usage. Sufficient knowledge is available to ensure that emissions of smoke, grit and dust are kept to a minimum. New power stations built in Great Britain and burning 2,000 tons of coal a day have been shown to make no material increase in the amount of soot, sulphur dioxide, grit and dust in the air of residential areas surrounding the stations.

Further relief from the evils of air pollution in built-up areas can be given also by the provision of an adequate area of open

space such as parkland. This is a matter of town planning but English surveys of air pollution show that such areas are desirable.

The remaining major contributor of air pollution is road transport and technical aspects of abatement of pollution from this source lie in better engine design and careful engine maintenance. Various devices to ensure complete combustion of the exhaust fumes are being investigated overseas. Further abatement could perhaps be achieved by legislation controlling traffic density in busy streets.

The chemist has made an important contribution to our existing knowledge on air pollution but many of the questions posed are still unanswered. At the beginning of this paper reference was made to the explosive growth rate of population. There is no sign that the growth rate is lessening. Abatement plans for the future must take into account not only the emissions of today but also the likely emissions of the future as population increases. There is not the slightest doubt that the chemist owes a social responsibility to the community to continue to look for the answers to the air pollution problems which at present defy solution.

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PRINCIPLES OF SEWAGE PURIFICATION

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*(Based on lecture delivered to N.Z. Dairy Science Association,
August, 1959.)*

The problem of sewage disposal is one of the many problems of how to deal with wastes of a community.

"Ill fares the land, to hast'ning ills a prey, where
wastes accumulate and men decay"
(apologies to Oliver Goldsmith).

In former times where man lived alone or with his mate, he "lost" all his "unwants" by merely "moving on" when he wished. His wastes were few—no cans, no bottles, no cellophane wrappings, no papers, no tea leaves, no potato peelings, no rags, no sanitary towels, no contraceptives, in fact, precious little at all. Even "no soap" as our American friends would say! But there must have been a little ammoniacal liquor and solid "goo" which doubtless was deposited in odd spots round the district. Possibly the house-proud female may have nagged her mate into going out from the cave even on colder nights but the staunch club-wielder is more likely to have insisted upon his rights and made use of the odd niche, nook and cranny at the bottom of the cave for his sanitary convenience. River pollution was probably not very serious but it could have been started by Adam himself. It is reasonable to assume that, in the excited state he found himself, when tasting the luscious sweetness of Eve's apple, Adam flung the core over his left shoulder into the river Eden.

All of man's discoveries and inventions have gradually led him through tortuous paths of creating more and more wastes and particularly of concentrating more and more wastes in the narrow confines of his living community. The discovery of fire gave him the opportunity to "distil" a lot of his wastes into the air he had to breathe, whilst the invention of plumbing gave him the opportunity of carrying away a lot of his waste through piping systems to rivers and streams. The re-use of the polluted waters led to wholesale epidemics of water-borne diseases and the sanitary engineer came into his own in recognizing the causative agents and their mode of transmission as well as methods of avoiding such troubles, "sewage treatment" being one of the methods. It is to be hoped that sanitary engineers may one of these days help in determining principles safeguarding the use of polluted air!

In considering the principles guiding the disposal of the "sewage wastes" of a community, the origin and nature of the wastes has to be considered first. With single houses or a group of houses, the water-borne wastes will be derived from kitchens, bathrooms and toilets, with only an occasional drowned kitten or scrubbing brush in the "larger lump" class, whereas from very large groups of houses with larger sewers and manholes available, for some reason as yet unknown, bricks, bottles, and even motor-car cushions frequently appear. When industry settles in the community, then the industrial wastes may have a great effect upon the general wastes, and large proportions of inert solids or organic solids, of colloidal and of dissolved matters, of toxic and of noxious substances may appear. According to the nature of the sewerage system, too, considerable variation in community water-borne wastes may appear. A combined system, leading off rainwater, etc., in high volume, may carry large amounts of road grit and sand and would produce high dilutions following heavy rains yet excessive strengths temporarily in light rains, following scouring of a system.

Methods for the disposal of "sewage wastes" may be classified arbitrarily under the following heads:

- (a) "Losing" the stuff.
- (b) "Hiding" the stuff.
- (c) "Treating" the stuff.

Before discussing the details of these methods, it may prove worth while to devote a little thought to what we are seeking to do in our plans for disposing of these water-borne wastes. First, it can be taken as axiomatic that nothing of monetary value can be expected to be recovered from sewage. It is true that the occasional ring or watch may fall down the toilet and be flushed into the bubbling stream or that investigational junior may drop the objects to be found in mother's purse, one by one, down the outside drain, but as one swallow does not make a summer, neither do occasional mishaps invest sewage with recoverable treasure-trove. We want to get rid of our wastes because they *look* bad, they *smell* bad, and they contain bad little bugs which can, if let loose, make us *feel* real bad. And we do not want to spend any more money than we have to, in getting rid of these wastes. So really we want to "lose" the stuff as cheaply as possible. However, we do appreciate that any method to be employed should "lose" the stuff successfully and not merely temporarily, since if it turned up later it may not be in much better shape. So really method (a) is the

basic method we employ; sometimes we may be able to employ method (b) as a forerunner to method (a) since we can advise in some circumstances, methods of "hiding" the stuff which result in the stuff being "lost" well enough, so as not to bother us any more. Unfortunately for us, however, we cannot generally find places good enough (or should we say cheap enough) to hide all our sewage wastes in, so we are forced to "treat" them to such a degree that a hiding place or losing place can be found near enough or cheap enough to cope with the residual. Thus the degree of treatment necessary to be given to any wastes will be governed by what is in the wastes, where they can be led to be hidden, and what is then needed to enable them to be well enough lost.

With individual homes, where piped waste systems are not economic, obviously special conditions exist. But where a group of houses in a small or large community are united by the common bond of a sewerage system, the first step in losing much of their wastes is to flush them down the drain. It is true to say that a large number of citizens feel that a drain is provided to take anything and everything that they wish to get rid of—hence the catholic nature of the assorted "goods" that appear at the terminus of the main drain. The individual householder who is, shall we say, "unconnected" has the opportunity of segregating his wastes but the responsible public official when deciding what shall be done with a community's water-borne wastes must accept that the main sewer may deliver anything and everything.

Considering the "unconnected citizen" first. His toilet wastes may be kept separate and housed in a so-called sanitary container, called for periodically by the "night-cart" man with his "four wheels and fly's" vehicle. Or the problem of disposal may be left to the citizen himself, in which case ground conditions round the citizen's home may influence his choice of disposal methods. In general he employs a "septic tank" with irrigation system—more will be said later about this—or with really unsuitable ground he may employ the post-hole borer and dig holes, shallow or deep, into which he may transfer his unwanted. Of one matter he may be sure; should he want to recover any of his buried treasure, it will be waiting for him, practically unchanged in character, for quite a few years thereafter, and he has really only "hidden" the stuff; not lost it!

Method (a), "losing the stuff," cannot often be successfully employed directly. Although chucking the stuff over one's left

shoulder is a method used by the citizen outside of his home for getting rid of his cigarette ash and butts, his cellophane and paper wrappings and the like, water-borne wastes, even with the wind, would make a sorry mess if handled in similar fashion. Extending the terminal of the main sewer to a stream, river, estuary, or harbour is a method extensively employed in New Zealand for "losing" community wastes but only in very few cases can the method be claimed to be satisfactory. If the old Yorkshire adage, "where there's muck, there's brass" is true, successive downstream communities may be "in the money" (or should it be in the metal trade?) as a result of the gratuities of their upstream neighbour. Thus Cambridge may donate to Hamilton, the pair donate to Ngaruawahia, the trio donate to Huntly and so on, during the meanderings of the Waikato River. Again, some communities centred on harbours or sea coasts may be unlucky enough to be greeted with "many happy returns" when unfavourable wind and tide deposit the stuff back again, maybe adding nutrient to its bathing beaches, as is the case occasionally at Auckland from its Orakei discharge. Whilst it is true that in a few cases evidence can show that a community's waste can be carried far out to sea continuously and be "lost" well enough by a combination of dispersal, dilution and self-purification processes, the number of cases is very limited. Even though preliminary screening-out or mincing-up of gross solids may hide the very obvious; sleek streams, fat globules, and high bacterial concentrations may mitigate against really satisfactory results. It is, of course, possible in these modern days to prove that there is a lot of spare space outside our planet, but even if the stuff could be shot into orbit by "placer guns" or the like, we would have to anticipate that complaints would arise from space travellers in the future, and expect them to bump into stuff that had not been lost, but merely gone before! All in all, method (a) of losing the stuff is only practicable in combination with methods (b) and (c).

"Hiding" and "treating" the stuff as forerunners to "losing it," are methods extensively practised. The extent and degree of such practice is dependent upon many factors determined, amongst others, by:

- Nature, extent and habits of the population involved.
- Their ability to finance any scheme.
- Climate, topographical and allied terrain features.
- Conditions available at disposal points.
- Use of receiving waters, if any.

Methods available for use can be classified as follows:

- Land treatment, including percolation.
- Lagooning and pond treatment.
- Septic tank treatment.
- Imhoff tank treatment.
- Settling tank treatment, coupled with sludge treatment.
- Chemical precipitation tank, coupled with sludge treatment.
- Contact bed filtration.
- Percolating filter treatment.
- Activated sludge processes; and so on.

In the case of the "unconnected" the general method of handling of sewage wastes is by septic tanks. The toilet wastes may be segregated and passed through the tank, the effluent then being led into irrigation pipes laid in suitable soil which permits of the liquid percolating below surface continuously. In such cases the kitchen and bath wastes have to be dispersed by other subsoil irrigation pipes or allowed to flow over suitably-prepared grass-sown patches of ground. Since such wastes, even though separated from toilet flushings, can be unsightly and possess or produce bad smells, it is generally recommended that they all be passed through the septic tank (which would need to be suitably sized) and the mixed effluent irrigated by subsoil methods. Provided that the septic tank is suitably sized and shaped, it can alter the character of sewage wastes admitted and do a deal of good in helping the process of disposal without nuisance. But it does little really to "purify" the wastes. The tank can become the habitat of groups of bacterial and allied population capable of bringing about chemical changes by a process mainly of hydrolysis. Operating best at low (negative) potential, these agents solubilize a lot of the organic matter contained in the wastes and convert carbon, hydrogen, nitrogen, and sulphur-containing groups into gaseous products. "Large lumps" either settle in the tank to mix with the sludge or rise to mix with the scum. The scum in a septic tank may consist of a layer having a high grease content, associated with organic solids not being continuously wetted by the liquor or contacted on its upper face by the actively fermenting sludge. This scum layer will ferment under "acidic" conditions producing little or no methane, much carbon dioxide, and some hydrogen sulphide. Butyrates, lactates and pyruvic acid derivatives will give the typical odour of bad cheese and sweaty feet so that such scum must not be open to atmosphere nor discharge with the

liquid. The sludge in the tank will be evolving methane and carbon dioxide but sulphides will not be evolved in gaseous state since the pH value will be above 7.4 and dissociation will not be significant. However, some sludge particles will frequently be gas-borne and hence be carried out of the tank with the associated liquor. Such solids, if not excessive in proportion, will not, however, seriously affect the subsoil irrigation system since they are granular enough to meld with the soil. The liquid in proper condition is reasonably free from colloids but it will smell most unpleasantly and will be very high in bacterial population, some of which will undoubtedly be potentially pathogenic. Thus the receiving subsoil irrigation system must not drain to any well or source of potable water. Where the local water-table is high, so that soil absorption by subsoil irrigation is not operable, it must be expected that foul and contaminated liquors will appear at soil level and present problems. Deodorants applied to the garden in such case may hide the smell but they do not overcome the danger inevitably associated with sewage effluents and it is obvious that septic tanks should not be installed under such conditions. It must be realized also, that septic tanks, if operated properly, inevitably increase their solids content. Although the bacteria are said to "eat up" the solids, they do have their own methods of excretion and although excretory organs as such may not exist as specialized entities, their excretory equivalents are very, very many, since there are many, many millions of bacteria! If the surplus solid content of the septic tank is not held down by sludge removal at intervals, as required by sludge increase rates, it is obvious that a deal of solid matter will be carried over into the irrigation channels. A lot of sludge solid can be relied upon to seal effectively even the best of irrigation trenches, and costly opening up of such trenches is not good business as compared with the comparatively small cost of having some of the sludge taken out of the tank.

Where groups of houses are reticulated to a common point it is seldom practicable to irrigate the wastes into ground without some form of pretreatment to remove solids. With small communities ranging from populations of say 20 to 20,000 people, septic tanks have been employed very frequently for handling the solids. Unfortunately septic tank operation on a large scale has been deplorably bad in New Zealand and many large tanks have never been desludged other than to the waters they were designed to protect. Because of risk of explosion, these large tanks are often without top cover and their presence is most obvious from the smell nuisance they create, and from the presence of hordes

of blowflies to which they act as host. Septic tanks can be operated without serious nuisance but very few large ones in New Zealand are so handled. With small communities it is often possible to locate a septic tank on a large low-lying section and to handle the whole community waste by irrigating in the one area, the vacant section being later utilized when the sewerage system can be extended. Such an installation is not frequently practicable, however, so that even small communities have to depend upon streams, rivers, etc., to carry away their wastes. Where the available dilution is large, so that high oxygen demand can be satisfied without interfering with the stream's oxygen resources, and where recreational use or potable use of the receiving waters is not upset by the bacterial content of the effluent, septic tanks often afford enough protection and enable the wastes to be "lost" without trouble. But the excess sludge from such a septic tank must be regularly removed and handled by some acceptable method. It should not be deposited down the outfall pipe!

Simple settling tanks (coupled with screens or mincers) can, of course, be employed in place of septic tanks where removal of colloids is not essential. But the solids removed by such tanks, in the form of crude sludge, have to be processed by some form of digestion treatment or equivalent, in order to remove the secondary nuisance caused by acid-putrefying slurries. The effluents from simple settling tanks do not smell as badly as do septic tank effluents but they still contain colloidal and finely divided matters, they have a fairly high oxygen demand, and they must be expected to hold a high bacterial content, including potential pathogens. Where high available dilution can be relied upon and where recreational and potable use of the receiving waters has little significance, simple settling is often enough relied on to "hide the stuff" in disposal by dilution and dispersal. The separate sludge treatment facilities involved can, however, be quite costly.

In an effort to combine the advantages of fresh-smelling effluents with partial sludge digestion in one plant, Imhoff tanks have been employed extensively all over the world. They consist of "two decker" tanks, the upper deck or compartment being a settling tank through which liquid passes continuously, remaining fresh. The settled solids fall through slots in the floor of the tank into the lower deck where they ferment as in a normal sludge digestion tank, at low negative potential, to yield a sludge black in colour, flocculent in character and tarry in odour, which can be handled without separate digestion in the same manner as sludge

from a separate digester or septic tank. Although the effluent from an Imhoff tank may be superior in quality and particularly in smell, to that from a septic tank, it is no safer bacteriologically and the Imhoff tank does require more regular attention. Some sludge should be removed at the most at weekly intervals and preferably at two-day intervals to keep the slots well open and the sludge active enough. Ground irrigation of Imhoff tank effluent is not practicable because of high colloid content.

In recent years, and particularly in the mid- and north-west States of North America, ponds or lagoons have been employed as pretreatment plants for water-borne wastes. According to loadings, temperatures and sunlight available, simple ponds handling even crude sewage have been able to hide all evidence of sewage matters and "lose" effluents without any risk or nuisance. Such ponds are now known as "sewage stabilization ponds" and consist of suitably fairly flat bottomed areas contained within earth-banked walls, where the wastes can be retained for long periods (20 to 120 days) and allowed to "self-purify". Such ponds usually hold the liquid to a depth of three feet. This is deep enough to prevent the spread of weed growth from the bottom of the pond, yet shallow enough to allow sunlight penetration to stimulate photosynthetic activity in the upper layers. In practice, two separate mechanisms operate in the holding pond. At the surface, by air absorption due to the large area of wind-disturbed water layer and by photosynthesis influenced by sunlight, a highly oxidative system exists with oxidation-reduction potential well in the positive region. Under good conditions of sunlight algae may become prolific and oxygen concentrations in excess of 30 parts per million by weight can often be found. At the same time the bottom of the pond may hold vigorously fermenting solids, the system operating at low (negative) potential and producing methane, carbon dioxide and a little hydrogen sulphide. The methane merely acts as a stirring agent but at such little depth does not cause any significant sludge rising. The carbon dioxide is dissolved in the water and helps to stimulate photosynthesis. The little hydrogen sulphide is immediately oxidized before it can leave the pond. Under suitable conditions there is little doubt that even crude sewage ponds can and do operate successfully. The usual factors mitigating against their use are:

- (a) Difficulty of finding large areas of flat land at low cost.
- (b) High sewerage costs in conveying wastes for long distances.

- (c) High cost of protecting banks against scour and wave action.
- (d) The large area maintenance required to eliminate weeds and overhanging vegetation from banks, essential in control of midge and mosquito.

The area of pond necessary for wastes treatment can be reduced by employing septic tanks, Imhoff tanks or the like prior to admittance of the wastes to the ponds. Very many of such ponds are employed in Texas and they do produce well oxidized and nuisance-free effluents. Under conditions of very bright sunlight, however, algae growth can be phenomenally high and the effluents discharged are often very deep green in colour. In drought areas, where no dilution, or only very little dilution, is available in the receiving waters, high evaporation rate can deposit masses of the algae along the bed of the creek or stream. If moist algae is slowly heated it gives off evil smelling odours which can be troublesome over large areas and close care is needed in examining local factors before choice of disposal method is finalized. Either crude sewage ponds or ponds following solids-removing pretreatment plants can be designed to afford well oxidized effluents but it must always be recognized that, since pathogenic bacteria are always likely to be present in the raw sewage, there is always a risk of their being present in the pond and hence in the pond effluent. The environment existing in lagoons, self-stabilization ponds, and oxidation ponds is, however, not favourable to sewage-borne pathogens and the longer the retention period, and the less heavy the loading, the greater the bacterial kill as measured by coliform, etc., count. Where it is necessary to reduce coliform count severely, as is the case where effluents are discharged into recreational waters, lightly loaded ponds of long retention period (say twenty days or more) can be relied upon to reduce pathogens to almost negligible risk. In such cases the pretreatment provided is usually to a higher degree than mere solids-removal.

It has long been known that, when sewage effluents are allowed to percolate through soil, etc., they do "self-purify" and the polluting organic matter is absorbed into the soil texture. Provided a long time exists before the liquid emerges, either to stream or well, etc., little risk need be associated with its bacterial content. But any short-circuiting through fissures or cracks, permitting the liquid to emerge in a time of, say, but a few days, results in bacterial contamination and, in the case of potable supplies, to a dangerous situation. But, with the exception of bacterial con-

tamination, the liquids emerging are fully stable and do not create nuisance. It is not surprising, therefore, that land treatment on "sewage farms" was practised extensively for many years. With the increased concentration of population and the rapid rise in values of land adjacent to centres of population, the method became uneconomic and more intensive treatment methods, capable of being used in very small areas, had to be developed. Recognizing that the method of self-purification in soils was due to biological agencies, the contact-bed was first developed. This consisted of a large tank, usually rectangular in shape, which was filled to a depth of between four and six feet with material graded in size between, say, one and four inches. The material used varied considerably, being either rock, river stones, coke, coal, or slag, etc. Settled sewage was admitted into the tank and allowed to remain in contact with the "media" for a number of hours. The bed was then emptied, allowed to "aerate" by being left empty for say a couple of hours and then the sequence repeated. In the course of time it was evident that a slimy mass, chocolate in colour when in good condition, became attached to the surface of the media. This slimy mass was an active film biologically, containing many bacteria and protozoa existing in symbiosis. By contact with the film the colloids and suspensoids in the sewage were adsorbed and absorbed and some of the solubles were chemically altered. The emerging liquid was higher in settleable solids than was the liquid being treated, owing to colloid flocculation, and secondary settling tanks, known as "humus tanks", were necessary to prevent these (highly polluting) solids from escaping with the effluent. These flocculated solids were known as "humus" because they were found to behave in pattern close to composted matters in forming humic acid derivatives and adding "tilth" to soils, etc. The clarified liquor from well-operated contact beds was found to be without objectionable odour, clear and sparkling in appearance, colourless to light amber in colour, and with no evidence of its sewage origin. From bacteriological aspects it was, of course, still highly polluted, but it could be "lost" without worry into most streams, rivers or estuaries.

Contact beds did not last for long as a method of sewage treatment, because it was shown that the percolating or trickling filter bed was more economic in use. The same basic principles of biological treatment apply, but the bed is not left "empty" to re-aerate. The settled sewage is added continuously, or at planned intervals according to flow rates, over the surface of the "filter" by means of a moving distributor, the falling liquid carrying air with

its particles into the media. By suitable upward ventilation, air currents are also induced to rise through the filter bed and assist in the oxidation process. In a few cases the filter beds are totally enclosed and air is drawn or forced through the media by ventilating fans suitably arranged. Because of the conditions pertaining to such a process the surfaces of lightly loaded filter beds form an excellent environment for higher forms of life and insects such as pycoda breed very well. Completely closed filters overcome the nuisance associated with this unwanted biological population or the insects may be drowned by applying the liquid at very high rate so that the whole of the surface area is continuously washed down.

With the demonstration of the ability of biological films to effect sewage purification, it was evident that further intensification could lead to more compact plants. The activated sludge process was developed in which the biological slime is cultivated away from any holding medium and circulated in a well-aerated liquid through the sewage to be treated. Such activated sludge processes are closely allied to bacterial filtration systems but vary according to the mechanisms employed for ensuring film contact with the sewage and maintaining dissolved oxygen content. Surface aeration systems, such as Simplex, Haworth, Kessener, or Pasveer, rely mainly upon surface absorption from atmospheric air whilst diffused air sparger and coarse-bubble aeration systems are kept aerated and mixed by compressed air introduced into the plant. Activated sludge plants are free from pycoda nuisance but the separation of sludge from liquor requires specialized secondary settling tanks and surplus activated sludge involves sludge handling plant. Effluents obtainable from these systems may be completely nuisance free—apart from bacteriological aspects—and completely without characteristics suggesting sewage origin.

In more recent years attempts have been made to step up the efficiencies of all processes involved in sewage treatment and indeed great success has followed the use of "high-rate" plants. Each process has, of course, its limitations, and local situation, effluent quality necessary, and cost involved are the most important criteria in planning methods of ultimate waste disposal. The ever-increasing knowledge of *modus operandi* of biological systems is assisting greatly in developing handling methods and an extension of methods involving "anaerobic activated sludge" is on the immediate horizon. It is predicted that, in the near future, air

flocculation and mixing will improve operating techniques and reduce costs in sludge digestion systems whether applied to liquid treatment (as in stabilization ponds or Pasveer plants) or to open solids digestion plants.

Although no specific reference has been made to the disposal of water-borne industrial wastes it should be understood that, apart from occasional interference by toxic matters present in such wastes, the same methods of treatment can normally be applied, provided loadings are at equivalent rates. Indeed in some cases, even toxic matters need not provide insuperable difficulties. Cyanides and phenols can be handled in quite high concentration, provided the biological media are slowly and gradually accustomed to the toxic matter. Certainly industrial wastes can present special problems but modern methods are available for coping with difficulties. In general "conditioning for cheap losing" of the wastes of industry can be effectively carried out within the industrial premises themselves by "good housekeeping" methods. It is much cheaper to keep fleshings out of a drain in meat works, to prevent milk powder being wasted in a dairy factory, to retain peach fruit on a screen in a packing station and so on, than to remove them biochemically in a sewage treatment plant. Like charity, waste removal should begin at home, and the difficult job of successfully "losing" a community's wastes should commence with the community. Householders, shopkeepers, hotelkeepers and factory personnel alike, should all recognize that drains do lead to somewhere and that what goes down comes up again! A little discrimination originally can save a deal of sorting out later and sewage treatment processes can then be operated more successfully in really treating sewage. Although divers ways and means, tricks and dodges, subterfuges and devices can be employed nowadays in "losing unwanted" nature has a canny way of pointing the finger of scorn at the cheapjack who tries to act parsimoniously, and of "letting the grave yield up its dead" where burial is not practised with sufficient care or reverence. Methods for the safe disposal of water-borne wastes are available but need to be chosen with care and knowledge if we are to avoid the wrath of nature and avoid the situation where we can have:

*Water, water, everywhere
And all the boards did shrink.
Water, water, everywhere
Nor any drop to drink!*

(S. T. Coleridge)

THE INSTITUTE'S LIBRARY

S. G. BROOKER

Honorary Librarian

In November last the Council appointed an Honorary Librarian, thus giving official recognition to the Institute's growing and valuable holding of chemical journals.

This library had its genesis in 1949 when a proposal was made by Dr H. J. T. Ellingham, then Secretary and Registrar of the Royal Institute of Chemistry, London, that the Chemical Institutes of Great Britain, Canada, Australia, South Africa and New Zealand should exchange their official Journals. This modest beginning was followed up by requests for exchanges, some initiated from here and some from abroad, until we now receive 30 Journals from 21 different countries as shown in the list at the end of this article.

A remarkably large number of these publications are not, to our knowledge, received elsewhere in New Zealand, and included in this category are such Journals as *Chimie Analytique*, the only French journal devoted to analytical chemistry, the Russian *Chemical Review*, and the *Collection of Czechoslovak Chemical Communications* which contains a translation into one of the major languages of all papers on chemistry originally published in Czechoslovakia. To buy all these publications would cost the Institute at least £200 per annum.

The library was initially looked after by the writer in his laboratory at Abels Limited, Auckland, but its rapid growth soon made other arrangements necessary. Through the courtesy of Dr G. E. Archey, Director of the Auckland Institute and Museum, and the very willing co-operation of the Librarian, Miss E. Evans, the Institute was fortunately able to house its Journals in the Museum library, now established in the very much enlarged quarters in the extensions to the Museum which were officially opened last month. We are now assured that the Journals are in good hands and properly catalogued; they are entered in the serial list of publications held in New Zealand libraries and they are available on interloan and to members of the N.Z.I.C. on application to the Librarian, Auckland Institute and Museum, Box 9027, Auckland, S.E.1. The only restriction is that the Museum library is unwilling to house duplicates of Journals they already hold.

The Institute's Journals are kept separately on the Museum shelves and any members wishing to inspect them are very wel-

come to do so. (The new library is well worth a visit on its own account.) There is every reason to expect this happy arrangement to continue for many years—perhaps until the N.Z. Institute of Chemistry has its own quarters where its library can be housed. As a mark of our appreciation the Institute has taken out a subscription to the American publication *Science* which will be useful to a number of members of the Museum staff.

The holding of Journals is remarkably good in view of the Institute's policy of not publishing any original papers in our own *Journal*. The Canadian and South African Institutes do not subscribe to this policy, while the Australian Institute publishes a very valuable *Reviews of Pure and Applied Chemistry*. It is worth noticing here that some scientific bodies publish original work partly so that they have an attractive medium of exchange. In this way the Royal Society of New Zealand, for instance, has built up an exceedingly valuable collection. There is no really satisfactory medium at present available in the Dominion for publishing original work in chemistry which is usually sent abroad, but it is inevitable that a *New Zealand Journal of Chemistry* will sooner or later be issued. When that time will come is problematical and controversial, but it is important that such a publication be sponsored by the Institute as being the body best fitted to do so. We should then be able to build up a very fine library using the *Journal* as a medium of exchange.

The library is at present confined to journals as books are not available on exchange and in any case they soon become outdated with the present rate of scientific progress.

In closing, an invitation is extended to any members of the Institute who have Journals they no longer require to offer them to the library. Such offers should be addressed to the writer at Box 9012, Newmarket, Auckland, S.E.1.

Acta Chemica Scandinavica.
Copenhagen.

**Acta Chimica Sinica*. Peking,
China.

Asociacion quimica Argentina,
Anales. Buenos Aires.

**Canadian Journal of Chemical
Engineering*. Ottawa.

Chalmers Tekniska Hogskolas,
Handlingar. Goteborg, Sweden.

**Chemistry in Canada*. (Chemical
Institute of Canada). Ottawa.

**Chemie Analytique*. Paris.

**Polska Akademia Nauk. Roczniki
Chemii* (Annales Societatis
Chimicae Polonorum). War-
saw.

*Reviews of Pure and Applied
Chemistry*. (Royal Australian
Chemical Institute, Mel-
bourne).

**Revista Portuguesa de Farmacia*.
Lisbon.

*Royal Australian Chemical Insti-
tute, Proceedings*.

- Croatica Chemica Acta. (Hrvatski Prirodoslovno Društvo) Zagreb, Yugoslavia.
- ° Collections of Czechoslovak Chemical Communications. Czechoslovak Academy of Science, Prague.
- ° Deutsche Akademie der Wissenschaften zu Berlin. Various publications in chemistry, geology and biology.
- ° Deutsche Akademie der Wissenschaften, Monatshefte. Berlin.
- ° Industria y Química; revista de la Asociación Química Argentina. Buenos Aires.
- ° Irish Chemical Association, Journal. Dublin.
- ° Kemija u Industriji : Casopis Kemičara i Tehnoloza Jugoslavije. Zagreb.
Kyoto University, Institute for Chemical Research, Bulletin. Japan.
- ° Polish Technical Abstracts. Warsaw.
- ° Indicates a journal not known to be available elsewhere in New Zealand.
- Royal Institute of Chemistry, Journal. London.
- Royal Institute of Chemistry, Lectures, Monographs and Reports.
- South African Chemical Institute, Journal. Johannesburg.
- South African Industrial Chemist. Johannesburg.
- ° Studii si cercetari de Chimi. (Academia Republicii Populare Romine) Cluj, Rumania.
- ° Svensk Kemisk Tidskrift. Stockholm.
- ° Tidsskrift for Kjemi, Bergvesen og Metallurgi. Oslo.
- Uppsala. Kungl. Lantbrukshogskolans Annaler, Sweden.
- ° Uspekhi Khimii. (Chemical Reviews). (Akademiia Nauk). Moscow.
- Zhurnal Prikladnoy Khimii. (Journal of Applied Chemistry). (Akademiia Nauk). Moscow.

NEW JOURNALS

THE RUSSIAN JOURNAL OF INORGANIC CHEMISTRY

One of the major chemical journals of the world, the *Journal of Inorganic Chemistry*, published by the Academy of Sciences of the U.S.S.R., is now available in a cover-to-cover English translation. This is supervised by an editorial board with Professor P. L. Robinson as Executive Editor, and is published in London by the Chemical Society with the support of the D.S.I.R. Translation is by Infosearch Ltd., and world distribution is in the hands of Cleaver-Hume Press Ltd., London. Publication commenced with the January, 1959, issue and the subscription is £30 per annum (£22s 10s. 0d. universities). A free summary of the 1958 contents of the *Journal* may be obtained from the publishers.

TETRAHEDRON LETTERS

The first volume of *Tetrahedron Letters*, a new journal designed for the rapid publication of communications in organic chemistry in preliminary form, appeared in March, 1959. The journal will appear every two to four weeks and the aim is to publish articles within four weeks of acceptance. The subscription is £7 per annum but private subscribers to *Tetrahedron* may, on application, receive *Tetrahedron Letters* at no extra cost.

POLYMER

Butterworths announce the publication of this new journal devoted to the chemistry, physics and applications of polymer science. The journal will provide for short preliminary communications as well as complete papers. *Polymer* will appear quarterly commencing in October, 1959; about 500 pages per volume, and price £5 per volume, from Butterworths Scientific Publications, London.

BRANCH NEWS AND NOTES

AUCKLAND BRANCH

K. E. Seal, Chief Technical Officer, Amalgamated Brick and Pipe Co., Ltd., Auckland, has been appointed a member of the Council of the D.S.I.R.

MANAWATU BRANCH

The staffs of The Dairy Research Institute and Massey College collaborated recently in helping to organize an "Open Day" when the laboratories and other facilities of the two institutions were open to the general public. Extensive displays in the chemical laboratories aroused considerable interest and the opportunities which such occasions provide for bringing the work of chemists and scientists in general to the notice of the public would seem to fully justify the effort involved in providing an interesting and striking display. Over 5,000 visitors passed through the laboratories during the course of the afternoon.

Good progress is being made with the set of slides and the tape-recorded commentary which is being prepared by the Manawatu Branch to show something of the work of chemists in local laboratories. Entitled "Chemists in Action", the programme will be made available to post-primary schools, parent-teacher associations, etc., as part of the Branch's effort to interest children in scientific careers.

J. J. Molloy, formerly Chief Chemist of the H.B. Farmers Meat Co. Ltd., Hastings, has taken a new post as Chief Chemist and Production Superintendent, East Coast Farmers Fertiliser Co. Ltd., Napier.

The Branch takes pleasure in congratulating Dr A. T. Johns, Director, Plant Chemistry Division, D.S.I.R., on his recent election to the Fellowship of the Institute.

WELLINGTON BRANCH

F. J. T. Grigg, Dominion Analyst and Director, Dominion Laboratory, was farewelled, on the occasion of his retirement, at a social function last month. Mr Grigg joined the Department in 1918 in Wellington; from 1925 to 1947 he was Government Analyst in Christchurch; in 1947 he was appointed Assistant Government Analyst and the following year became Dominion Analyst and Director, positions he has held since that time.

Last December J. A. D. Nash attended a Conference in Java on the organization of science. This conference was convened jointly by the Unesco Science Co-operation Office for South-east Asia in Jakarta and the Indonesian Council for Science.

T. A. Rafter, Director of the Division of Nuclear Science, is to attend a conference this month at Lucas Heights, Sydney, arranged by the Institute of Nuclear Science and Engineering to consider what programme of radioactive dating work should be undertaken in Australia.

Staff changes at the Victoria University of Wellington include the following:

Dr W. E. Harvey is on leave of absence for a year, working at Harvard University. W. E. Dasent has returned after spending a year in Cambridge on a Nuffield Fellowship. Michael Briggs has arrived from Cornell University to take up a Lectureship in Biochemistry. Dr A. T. Wilson, previously of the staff of the Nuclear Research Institute, has taken up the newly-created position of Senior Lecturer in Applied Chemistry.

Dr W. Segal has arrived from the London School of Hygiene and Tropical Medicine to take up a Lectureship.

On February 10 the graduates in chemistry from the Victoria University of Wellington, in association with the staff of the Chemistry Department and the members of the Wellington Branch, entertained Professor and Mrs A. D. Monro to a 5 o'clock buffet party to mark the occasion of Professor Monro's retirement from the University, which he joined in 1921. Speeches were delivered by G. A. Lawrence, W. A. Joiner and Professor S. N. Slater, and on behalf of the graduates, Mr Lawrence presented Professor and Mrs. Monro with three pieces of furniture and (in view of their forthcoming overseas trip) a pair of binoculars. Professor Monro, in accepting these gifts, made special reference to the great pleasure he had received over the years in his association with the students he had taught.

Dr L. D. Swindale, Soil Bureau, D.S.I.R., has been appointed Director of the N.Z. Pottery and Ceramics Research Association in succession to I. C. McDowall who is taking up a Research Fellowship on clay products and ceramics at Melbourne University.

It is with regret that we record the death of one of our oldest members, George Bagley of Lower Hutt.

CANTERBURY BRANCH

Professor J. Packer has returned from a six months' visit to the United Kingdom and the United States where he has been particularly observing trends in university chemistry departments.

J. R. McGimpsey has transferred from N.Z. Dairy Products Ltd., Edendale, to Davis Gelatine Ltd., Christchurch, where he is Assistant Production Manager.

C. G. Martin, Consulting Chemical Engineer, has transferred from the Wellington Branch.

J. L. Grigg has returned from Australia and is working at the Department of Agriculture Irrigation Research Station, Winchmere, Ashburton.

OTAGO BRANCH

It is with regret that we record the retirement of "Harry" G. Gilbert, Senior Technical Officer of the Otago University Chemistry Department, after 45 years of valuable service. Harry was a Branch member of the Institute for many years and helped to make our meetings successful by cheerful catering and preparation of the Lecture Theatre. Harry has been the unofficial projectionist for the Otago Branch and has made many life-long friendships with Institute members. The Otago Branch honoured Harry's long service to chemistry with a dinner and presentation last month.

INSTITUTE PRIZES

Members are reminded that the closing date for all Institute Prizes is April 30. Prizes offered this year are: The I.C.I. Prize; the Morcom Green, Edwards Prize; the Chemical Essay Prize. The revised regulations covering these prizes were published in this *Journal* last year (*J.N.Z.I.C.*, 23, 47).

COUNCIL MINUTES

ABRIDGED MINUTES OF A MEETING OF THE COUNCIL
OF THE NEW ZEALAND INSTITUTE OF CHEMISTRY (INC.)
HELD IN THE CONFERENCE ROOM, D.S.I.R., WELLING-
TON, ON FRIDAY, FEBRUARY 12, 1960.

PRESENT

E. W. Hullett (President, in the Chair), Professor H. N. Parton (Vice-President), Professor H. Bloom (Auckland), Dr E. P. White (Waikato), Dr G. Butler (Manawatu), H. Penhale (Wellington Proxy), D. J. Hogan (Registrar, Canterbury), Dr A. D. Campbell (Otago), A. P. Oliver (Hon. Gen. Sec.). Apologies for absence were received from J. R. Beck (Wellington) and Dr W. A. McGillivray (Editor).

PROFESSIONAL STATUS COMMITTEE

Resolved (Auckland/Waikato): That the appointment of the following members by the Executive Committee be confirmed: J. K. Johannesson, C. L. Stonyer, Dr R. B. Miller.

Resolved (Vice-President/Manawatu): That the N.Z.I.C. support the N.Z. Association of Scientists and N.Z. Institute of Agricultural Science in presenting a case to the Government for improved status and salaries for scientists.

Resolved (Hon. Gen. Sec./Wellington): That the Professional Status Committee and Executive Committee be empowered to collaborate in the preparation of a case to Government re status and salaries for scientists, and that the Professional Status Committee be empowered to join the subcommittee initiated by the N.Z. Association of Scientists and the N.Z. Institute of Agricultural Science.

Two reports were received from J. K. Johannesson on behalf of the Professional Status Committee who have been acting as observers on the joint committee.

A copy of the draft submissions by the Committee was received.

SCIENCE CONGRESS 1960

A report was received from J. R. Beck, convener of the Chemical Section. Extracts:

- Symposia
1. Utilization of *Pinus radiata*.
 2. Water Supplies and Pollution.
 3. Modern Food Processing.

In addition there will be two 3-hour sessions in general and pure chemistry, for which further papers are invited.

Resolved: That the convener of the Chemical Section approach the Royal Society to find more detail on the allocation of costs and profits.

EXAMINATIONS

Resolved (Otago/Auckland): That the results of the 1959 Laboratory Assistant Examination be confirmed.

Dr Campbell has resigned from the Examinations Committee.

JOURNAL

A report was received from the Editor, Dr W. A. McGillivray. Extracts: N. T. Clare and the Waikato Committee will take the *Journal* over as from the June issue. Editorial Services are to prepare a contract for the 1960 issues of the *Journal*. The style of lay-out is to return to that obtaining before 1959. The Editor suggested that an annual list of members could be regarded as a sixth issue of the *Journal*, including also

list of officers, balance sheet, annual report, biographical notes on Branch chairmen, etc.

Resolved (Hon. Gen. Sec./Auckland): That the Editor's report be received, and that the Editor and his staff be thanked for their valuable services.

MEMBERSHIP

Election of Fellows:

Resolved (Waikato/Manawatu): That J. K. Johannesson, and A. T. Johns be elected Fellows of the Institute:

Election of Associates:

Resolved (Wellington/Auckland): That the following be elected Associates of the Institute:

ARMSTRONG, Alan George, B.Sc., Dominion X-Ray & Radium Laboratory, Box 1456, Christchurch (Analytical Chemist).

BARNES, James Francis, B.Sc., James Wren & Co. Ltd., Dunedin (Factory Manager).

MEREDITH, Peter, M.Sc., Ph.D., Wheat Research Institute, Box 1497, Christchurch (Scientific Officer).

MOORE, John Brian, B.Agr.Sc., Canterbury Frozen Meat Co. Ltd., P.O. Box 2, Belfast (Chemist).

THOMSON, Cullen William, B.Sc., Fletcher Industries Ltd., Box 67, Dunedin (Works Chemist).

FREITAG, Walter, M.Sc., B.P. (N.Z.) Ltd., Wellington (Chemist).

CARTER, Denver Milton, B.Sc., Rangitoto College, Mairangi Bay, Auckland (Assistant Master).

SKELTON, Charles Derek, M.Sc., M. A. Walker Ltd., Auckland (Industrial Chemist).

Resignations:

Resolved (Auckland/Otago): That the resignation of J. E. Reeves be accepted, and the arrears written off as being unrecoverable.

Resolved (Auckland/Manawatu): That the resignations of the following members be accepted:

Mrs. M. C. Claridge, R. Holden, A. J. Curtis, H. C. Clark, B. R. Johns, Mrs. M. C. Lusty.

Deaths:

The deaths of the following members were recorded with regret:

G. Bagley, R. A. J. McIntyre.

Honorary Membership:

Resolved (Pres./Vice-Pres.): That G. A. Lawrence be admitted to Honorary Life Membership.

Subscription Defaulters and Missing Members:

Resolved (Pres./Manawatu): That the following names be removed from the list of members:

R. M. Milburn, D. Y. Smith, L. H. Fitzgerald, T. R. Watson.

INSTITUTE LIBRARY

Resolved (Vice-Pres./Auckland): That the approval given by the Hon. General Secretary to the Hon. Librarian to subscribe to *Science* be endorsed.

EMPLOYMENT

Report received from Mr Gallagher, convener of the Employment Subcommittee of the Auckland Branch. Extracts: As authorized by Council in November, 300 copies of an employment survey of the Auckland-Waikato district were cyclostyled at a cost of £5. Fifty copies were sent to the Registrar, 60 copies to the Waikato Branch, and 180 copies to the Auckland Vocational Guidance Officer for distribution to schools. An early offer by the Vocational Guidance Office to cover the cost of printing and distribu-

tion has been withdrawn, but the subcommittee is still trying to cover their expenses.

It is proposed to undertake a Dominion-wide survey, and Branches are asked to advise the Auckland Branch of their requirements of the questionnaire to Industry.

ADDRESSOGRAPH PLATES:

It was decided to discuss at the annual general meeting the terms under which the Institute will allow use of the plates by advertisers.

UNIONS

A letter was received from the Secretary-Treasurer of the Auckland Provincial Dairy Chemists Association promising co-operation in the event of the formation of a Union.

TECHNICIANS' TRAINING

The Institute has already nominated Dr A. L. Odell. A second nomination was invited by the Hon. Minister of Education.

Resolved (Otago/Auckland): That Dr R. Gardner be nominated.

OVERSEAS VISITORS

Report received from the committee organizing the visits. The committee consists of W. A. Joiner representing D.S.I.R.; A. P. Oliver, representing N.Z.I.C.; Professor S. N. Slater, acting organizing Professor of Chemistry. Suggestions were made for the centres to be visited by each visitor. Branches made certain requests which will be considered by the committee. It has to be remembered that the universities and government are helping to finance the scheme, therefore it may not be possible to comply with all Branch requests. Adequate finance is already available.

Resolved (Auckland/Otago): That the above Wellington committee handle finance and arrangements.

LIST OF MEMBERS

Report received from the Canterbury Branch, which has almost completed the list. In the 15 months that have elapsed since the last list was printed there have been 53 deletions, 58 additions and 206 corrections to existing entries.

Resolved (Vice-Pres./Canterbury): That Council approves the principle of the annual publication of a list of members, and asks the opinion of the Editor and Publishers on the possibility of making it a sixth issue of the *Journal*.

COMMISSION ON EDUCATION FOR SECONDARY SCHOOLS

The Manawatu Branch asked whether Council should make submissions. It was decided that no action would be taken.

CHEMICAL FILMS

Resolved (Manawatu/Canterbury): That the N.Z.I.C. spend up to £25 for the purchase of chemical films from the R.I.C. for presentation to the National Film Library.

EDUCATIONAL FUND

Resolved (Auckland/Otago): That a fund known as the Educational Fund be established and recorded separately in the accounts.

A letter has been sent to the main employers of chemists in New Zealand asking them to contribute to a fund to sponsor visits by overseas chemists.

Donations will be suitably acknowledged in the *Journal* at a later date.

NEW YEAR HONOURS

Letters have been sent to Dr H. O. Askew and Dr F. H. McDowall congratulating them on the receipt of the O.B.E.

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

CONFERENCE, 1960

As already noted, the Institute of Chemistry is not holding its normal Conference in August, 1960, but is participating instead in the Ninth New Zealand Science Congress to be held in Wellington next May. The Organizing Committee of the Congress has supplied the following information:

NINTH NEW ZEALAND SCIENCE CONGRESS

ENROLMENT: It will greatly assist the Organizing Committee if those intending to take part in the Congress will send in their enrolments as soon as possible. Forms may be obtained from the Hon. General Secretary, R. E. R. Grimmett, c/o Soil Bureau, Wellington, or from Mrs R. M. Allen (Tel. 69-514), P.O. Box 3085, Wellington.

Intending participants are reminded that the Congress fee of £2.0s.0d. (students £1.0s.0d.) is reducible by 10s. (students 5s.) *only if paid by 30th April*. After that date the full amount must be paid.

ACCOMMODATION: Those who wish to have hotel accommodation reserved are advised that the block bookings now held are filling up, and the hotels are reluctant to hold any unallocated part of these bookings later than 31st March. A deposit of £1 per person is required when making application for a hotel booking.

ANZAAS CONFERENCE, BRISBANE, 1961

Section B

The next ANZAAS Conference will be held in Brisbane between May 29 and June 2, 1961, and the Committee for Section B is seeking guidance on the arrangement of the programme. The following topics have been suggested for inclusion, and the committee would appreciate an indication of those subjects upon which it may expect to receive papers.

1. Chemistry of carbohydrates.
2. Metal-catalysed enzyme reactions.
3. Chemistry of mineral treatment.
4. Radiochemical techniques and radiation chemistry.
5. Kinetics of inorganic substitution reactions.
6. Stereochemistry of inorganic complexes.
7. Natural products.
8. Organic chemistry—aliphatic, aromatic & heterocyclic.
9. Reaction mechanisms (organic).
10. Solid state chemistry.
11. Reaction kinetics.
12. Analytical chemistry.
13. Spectroscopy.

The Committee asks that those who expect, at this stage, to be able to present papers to Section B at the meeting notify the Secretary, I. R. Wilson, Dept. of Chemistry, University of Queensland, Brisbane, giving some indication of the subject to be discussed.

Comments on the above topics, suggestions of others, and general criticism would also be welcomed.

Further information on the meeting will be available shortly.

BOOK REVIEWS

CONTINUOUS ANALYSIS OF CHEMICAL PROCESS SYSTEMS, by S. Siggia. Published by John Wiley & Sons, Inc., New York, 1959. 381 pp. Price, 8.50 dollars.

THIS is the book for which many industrial chemists have been waiting—an up-to-date, authoritative account of the various continuous analytical devices available, with examples of the use of each instrument in specific applications. This is a field which is expanding rapidly but its literature tends to be concentrated in forms which are scientifically non-conventional and therefore hard to locate—technical bulletins of instrument manufacturers, etc. The present text brings this literature together in a compact, convenient form whose accuracy and completeness have been assured by the submission of relevant sections of the manuscript to the manufacturers concerned.

The book is an extension of the standard texts on instrumental analysis and assumes only a basic knowledge of instrumental analysis and the standard laboratory instruments. It then deals with continuous aspects of the subject, covering such analyses as refractive index, density and specific gravity, viscosity, infrared, ultraviolet and visible absorption, pH, electrical capacitance, electrical conductivity, coulometry, X-ray fluorescence, vapour chromatography, mass spectrometry, thermometric analysers, thermal conductivity, gas analysis using sonic velocity, determination of water, oxygen, carbon dioxide and combustibles, water analysis, etc., etc.

The book is of the usual Wiley quality. It is very fully illustrated and well referenced. In addition to its immediate factual value, no chemist can help but be intrigued by the devices described—the simplicity of some, the ingenuity of others, and above all the increasing versatility of the “robot” analyst.

—W.A.McG.

FUNDAMENTALS OF PHYSICAL CHEMISTRY, by H. D. Crockford and S. B. Knight. Published by John Wiley & Sons, Inc., New York, 1959. 463 pp. Price, 6.95 dollars.

THIS text is a revised and extended version of the author's *Fundamentals of Physical Chemistry for Premedical Students* and is intended for students who wish to extend their knowledge of physical chemistry but who do not have the mathematical preparation for the usual University courses.

In writing such a text an author is faced with two alternatives or a compromise between them. On the one hand, he may treat very thoroughly a very limited number of topics; on the other, he may treat many topics but compress each severely. The authors of the present text have managed to strike a sensible balance.

The choice of topics is completely conventional and presents an honest, if somewhat elementary, view of physical chemistry. The book jacket states bluntly that only a limited background in mathematics is required and, perhaps for this reason, the chapters on thermodynamics are the least satisfactory. The sections on the modern theory of strong electrolytes and electromotive force are, however, particularly well covered.

At the end of each chapter are brief references to some half dozen standard textbooks, and an over generous number of questions and problems—one chapter, for instance, is followed by seven pages of problems!

A large number of relevant examples are worked out in the body of the book.

The printing, paper and lay-out of the book are of the usual high standard one has come to expect from John Wiley. —R.C.L.

AN INTRODUCTION TO BACTERIAL PHYSIOLOGY (Second Edition), by Evelyn L. Oginsky and Wayne W. Umbreit. Published by W. H. Freeman & Co., Inc., San Francisco, 1959. 443 pp. Price, 7.50 dollars.

THE very rapid advances in bacterial physiology over the past five years have necessitated a fairly extensive revision of a number of chapters in this second edition of what has come to be recognized as one of the standard texts in this field, and a great deal of new material has been incorporated but this has been done without altering the general concept of the first edition. Many readers will question the authors' acceptance of bacterial physiology as the foundation of other fields of bacteriology; rather would we place bacterial biochemistry in this key position and indeed much of the material covered in this text is biochemical rather than physiological—its title gives only a limited indication of its scope.

The text is divided into six sections. The first deals briefly with the nature of bacterial physiology; the second with bacterial anatomy—cytology and cytochemistry; a third section on populations deals with growth, nutrition, chemical and physical environment, and genetics; the purely biochemical topic of bacterial metabolism is covered in the fourth section making up over a third of the text; the fifth section briefly deals with, on the one hand, organisms which have increased their self-reliance, and, on the other hand, with those which are dependent—e.g., the bacteriophages; a final section on the capacity of the cell covers adaption, mechanisms of survival, virulence, etc.

The book is well produced, fully and very clearly illustrated and contains many references, in general to review articles. —W.A.McG.

THERMODYNAMICS AND STATISTICAL THERMODYNAMICS, by J. Aston and J. J. Fritz. Published by John Wiley & Sons, Inc., New York, 1959. 462 pp. plus 78 pp. of appendixes. Price, 8.25 dollars.

THE first six chapters present a complete and clear account of the fundamental concepts of thermodynamics. More detail is included in these opening chapters than is usual in a book of this standard but unfortunately this is not continued throughout the book. Functions such as entropy are defined with no qualitative explanation of the need for them. An indispensable part of any thermodynamics course should be a molecular interpretation in words of as much thermodynamic data and as many equations as possible, and this in general the authors have not done.

For the mathematically inclined, however, this will not be too serious an objection. The six introductory chapters are followed by the usual classical applications to phase equilibria, imperfect gases and fugacity, osmotic properties of solutions of non-electrolytes, solutions of electrolytes and activity, and the electromotive forces of cells. Chapter 16 contains a rather complete account of energy levels of atoms and molecules which is very useful in later calculations. Chapter 17 is an introduction to statistical mechanics and the next four chapters deal with their practical application in the measurement of the thermodynamics properties of gases and crystals.

This is not an elementary text and assumes a considerable background in advanced calculus and statistical mechanics. It will therefore be

used more as a reference book by the lecturer rather than as a general text for the student.

The book is well printed and clearly written, includes over 250 numerical problems (with answers) and an excellent appendix containing outlines of mathematical method, tables of functions and of data to supplement the material in the text.

—R.C.L.

THE STRUCTURE OF ELECTROLYTIC SOLUTIONS, edited by Walter J. Hamer. Published by John Wiley and Sons, Inc., New York, 1959.

Based on a symposium held in Washington, D.C., in May, 1957, sponsored by the Electrochemical Society, Inc., New York, and The National Science Foundation, Washington, D.C.

The measurement of the physical properties of electrolytic solutions and attempts at their theoretical interpretation has long been an important part of that branch of the subject of chemistry which has the label "physical chemistry". A good historical account has already appeared in this journal (H. N. Parton (1954), *J. N.Z.I.C.*, 18, 76).

The present book is a series of twenty-seven papers grouped around the subject of the structure of electrolytes. To quote from the preface. "The chapters cover subjects extending from dilute solutions through concentrated and fused electrolytes to the pure ionic solid state. Thermodynamics and statistical mechanics are used in describing the state of ions in simple and complex media. New experimental methods for investigating the equilibria and kinetics of electrolytic solutions are to be found in several chapters. Activity and osmotic coefficients are considered from different points of view. Recent concepts on ion solvation and ion transfer and new information on ion diffusion are presented. The structure and properties of complex ions, ion pairs, polyelectrolytes, fused salts, ionic crystals and the rare earths are discussed from a modern point of view."

None of the articles in this volume is without interest and a nice balance between experiment and theory is evident. Because of the wealth of material, your reviewer confines himself to a few papers only. First, there is an interesting account of some thermodynamic properties of solutions of salts of bivalent metals by J. M. Austin, R. A. Matheson and H. N. Parton. Perhaps the interest is local as all the authors are staff members of New Zealand Universities. Nevertheless, the paper seems equal to any in the symposium. The paper deals with the experimental determination of the extent of ion pairing together with a discussion of the changes in entropy found.

Four papers on diffusion indicate the extent of current interest in this type of measurement. Finally there is a very interesting paper on the Raman spectra of strong electrolytes by T. F. Young, L. F. Maranville and H. M. Smith. The Raman spectrum is a measure of the modes of vibration in a molecule. The modes of vibration of the nitrate ion and the nitric acid molecule are different so that the proportion of the two species can be found at any concentration. This has been done at all concentrations for aqueous nitric acid and the results confirmed by nuclear magnetic resonance measurements. Similarly the species present in aqueous sulphuric acid at all concentrations have been found. The method is a very promising one for determining the species present in concentrated solutions and also in molten salt systems. With regard to the latter, valuable preliminary information has been provided by another New Zealand worker, Dr. H. Bloom.

The book will prove welcome reading to those who have an interest in electrolytic solutions.

—T.A.T.

PROCESS EQUIPMENT DESIGN—VESSEL DESIGN, by Lloyd E. Brownell and Edwin H. Young. Published by John Wiley & Sons, Inc., New York, 1959. 408 pages.

There has for long been a need for a book containing collected information on the design of vessels and tanks for chemical process work. Most of the information on the subject has consisted of working rules, data from various pressure vessel codes, or has been on specific topics well-hidden in the literature. This book sets out to provide a theoretical background for the usual design criteria and also presents detailed information on topics not covered by code data. Such a coverage of the subject makes the book useful to both the student and the practising design engineer. Chapters are included to deal with matters such as design of special flanges, supports for vertical and horizontal vessels, large storage tanks and ultra high pressure vessels, as well as the more routine aspects of vessel design.

Since this book is written primarily for engineering students and graduates, it will not have much appeal for the average chemist, but it does fill a definite gap in chemical engineering literature. The layout and illustrations are first class, as one expects in books from this publisher.

—D.W.K.

LEHRBUCH DER ORGANISCHEN CHEMIE (13th Edition), by Paul Karrer. Published by Georg. Thieme Verlag, Stuttgart, 1959. 1,057 pages. Price DM. 80.

Professor Karrer celebrated his 70th birthday in 1959 but his textbook shows no sign of old age. The 13th edition has evidence of vigorous revision so that it is a decided advance on the 12th edition of 1954. Notable additions are chapters on conformation analysis, pesticides and herbicides, macromolecular chemistry, cyanine dyes and on polyacetylenes while numerous other chapters have been rewritten and extended. An author index is also included for the first time. This has meant an expansion of 108 pages but by using a different (though very adequate) paper the new edition is thinner than the old. This textbook can be recommended.

—S.G.B.

LEHRBUCH DER ORGANISCHEN CHEMIE (2nd Edition), Vol. 1, second half by W. Klages. Published by Walter de Gruyter and Co., 1959. 521 pages. Price DM .66.

The first edition was reviewed in 1954 and the reviewer is glad to note that several suggestions he made then have been incorporated. In particular there are more literature references (though still not enough for a work of this type) and an author index has been included. About 10% of new material and an index to the complete work have been added.

—S.G.B.

METHODEN DER ORGANISCHEN CHEMIE (4th Edition), edited by Eugen Muller. Vol. 1, General Laboratory Practice, Part 2. Published by Georg Thieme Verlag, 1952. 1,017 pages. Price DM. 196 (about £17).

This part covers grinding, sifting, mixing, emulsifying, foambreaking, pumping of liquids, handling gases, working in oxygen and moisture-free atmospheres, handling explosives, micromethods, high pressure and vacuum work, heating, cooling and temperature measurement, solvents, drying agents, dangerous and cancerous substances. No higher tribute can be paid than to say that the standards of production, printing and illustration

equal those we have seen in other parts of this fourth edition. This book is not cheap but could save much money in reducing the need for other books, e.g., the chapters on solvents (100 pages) and on poisonous and cancerous substances (56 pages) contain what all but the specialist will generally need to know, and the reviewer will use his copy as a first reference on this subject. One slight but natural drawback is that practically all the apparatus offered is of German origin.

—S.G.B.

THE CHEMISTRY OF INDUSTRIAL TOXICOLOGY (2nd edition), by H. B. Elkins. Published by John Wiley and Sons, Inc., New York, 1959. 452 pages.

Since the date of publication of the first edition of this book (1950), many new processes have been introduced into industry, and many old ones have been abandoned. With the passage of time, many products which exhibited no short-term toxicity have been found to give delayed effects, sometimes not recognized until twenty or more years after exposure; this applies in particular to cancerogenic substances, and to certain industrial dusts. For these reasons the publication of a second edition of Elkins' book must be welcomed, and the carry-over of many of the shortcomings of the first to the second edition might be excused because of the urgent need for its publication.

The book is well printed and set up. The first 25 pages are devoted to introductory and general considerations, followed by a detailed treatment of potentially hazardous substances used in industry, including elements, inorganic and organic compounds, natural and industrial products, and radioactive isotopes. This is followed by chapters on preventive measures, industrial operations, and maximum allowable concentrations. Finally, the more important air sampling devices are described, and a large number of analytical procedures are given. The book concludes with a bibliography.

The value of the book would be greatly enhanced if, in addition to the chemical names of the compounds (which in some cases lack precision), the trivial and trade names were listed; these are often the only ones known to those concerned in manufacturing or handling chemical products.

A major deficiency is the absence of any information on selective herbicides. Nor is there any mention of fluoroacetate, in spite of its extensive use as a pesticide, and there is only a single, uninformative reference to Warfarin.

A sample survey of the analytical procedures section disclosed one error. The concentration of *p*-nitrophenol standard prepared according to the directions given on p. 383 is 2.5 $\mu\text{g}/\text{ml}$, not 10 $\mu\text{g}/\text{ml}$ as stated in the text.

Some of the information given seems somewhat dated. For example, the statement is made on p. 60 that "phosphorus poisoning arises from long exposure to such vapors [yellow phosphorus], notably in match manufacture . . ."; it must be more than half a century since the manufacture of phosphorus matches was abandoned!

The statement made on p. 193 that "some beauty shops have used *p*-phenylenediamine as a hair dye, apparently without serious results", is highly misleading. Substantial damages have been awarded in British courts to victims of the use of such hair dyes.

—R.T.

LIPIDE CHEMISTRY, by D. J. Hanahan, with contributed chapters by F. R. N. Gurd and I. Zabin. Published by John Wiley & Sons, Inc., New York, 1960. 330 pages. Price 10.00 dollars.

This text is a further valuable addition to the rapidly expanding literature on this topic. The chemistry and biochemistry of lipids has long proved a profitable field of research; it has of recent years acquired a considerable degree of urgency with the possible relationship between lipids and the incidence of atherosclerosis and related diseases. This text is therefore a timely survey of the whole field with particular reference to the rapid development of knowledge over the last ten or so years.

After a brief introduction, chapters deal with: The isolation and purification of the lipids; Phosphoglycerides; Phosphoinositides; Sphingolipids (by I. Zabin); Minor Phospholipids; Simple Lipids; Association of lipids with proteins; and Some naturally occurring lipoprotein systems (these two latter by F. R. N. Gurd). The text is of the usual high standard we associate with John Wiley & Sons. It is well and clearly illustrated and each chapter includes references to recent literature sufficiently complete as a guide to further reading.

The two concluding chapters (making up about one third of the book) merit special mention. Much of the material presented breaks new ground as far as textbook presentation is concerned and will be of very considerable interest to both chemists and biochemists.

—W.A.McG.

BOOKS RECEIVED

TRANSLATION FROM GERMAN FOR CHEMISTS, by H. H. Neville and W. E. Yuill. Published by Blackie & Sons, Ltd., London, 1959. 139 pp. Price, 15s.

This text assumes no previous knowledge of German. All irrelevant grammatical material is omitted and only those features of the language are presented which are necessary for the "Englishing", with the intelligent use of a dictionary, of German chemical literature. A valuable book at a very modest price.

MEDICINAL CHEMISTRY, VOLUME 4. Edited by F. F. Blicke and R. H. Cox. Published by John Wiley & Sons, Inc., New York, 1959. 334 pp. Price, 12 dollars.

This fourth volume in an already well known series is devoted entirely to the barbituric acid hypnotics. It deals in 39 pages with the chemistry and pharmacology of the barbituric acids and the remainder of the volume is taken up mainly with tabular classification of the acids and some of their physical properties. There are over 1,200 references and very extensive formula and subject index. A most valuable integration of a scattered literature.

SYNTHESIS AND ORGANISATION IN THE BACTERIAL CELL, by E. F. Gale. Published by John Wiley & Sons, Inc., New York, 1959. 110 pages. Price 3.50 dollars.

A further text in the CIBA Lecture series, this volume covers the three 1959 lectures presented at the Institute of Microbiology, Rutgers University. With a central theme of biosynthesis, the lectures deal with Structure and Organisation in the Bacterial Cell; Amino Acid Incorporation; and Nucleic Acid and Protein Synthesis.

EQUIPMENT PAGE

(Contributed by Dr J. R. L. Walker, The Dairy Research Institute, Palmerston North.)

In many fields of research, especially biochemical, it is necessary to routinely measure out small aliquots of liquid (0.01 to 0.5 ml). Much loss of time and temper can be avoided by the use of auto-zero pipettes now available from several American and British firms. The reproducibility of these pipettes is greater than that available with the conventional 1 ml pipette graduated in 0.01 ml divisions. In this laboratory they find great use in Warburg respirometer experiments and for the applications of measured quantities of liquid on to chromatographic papers.

Another useful automatic volume measuring device is the "Aupipette" which is, essentially, a self-filling 10, 5, or 1 ml hypodermic syringe that can be accurately set to deliver any desired quantity at each stroke of the plunger.

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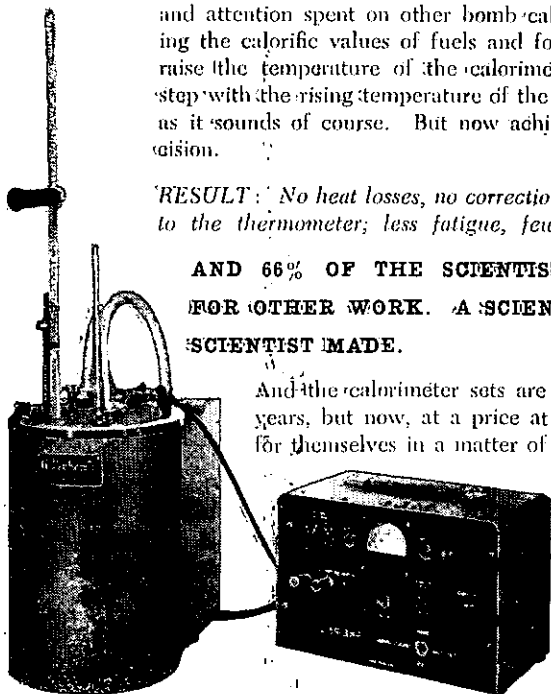
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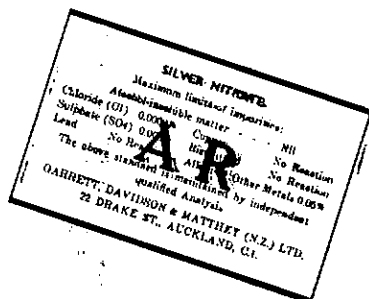
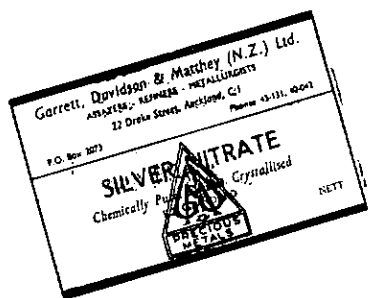
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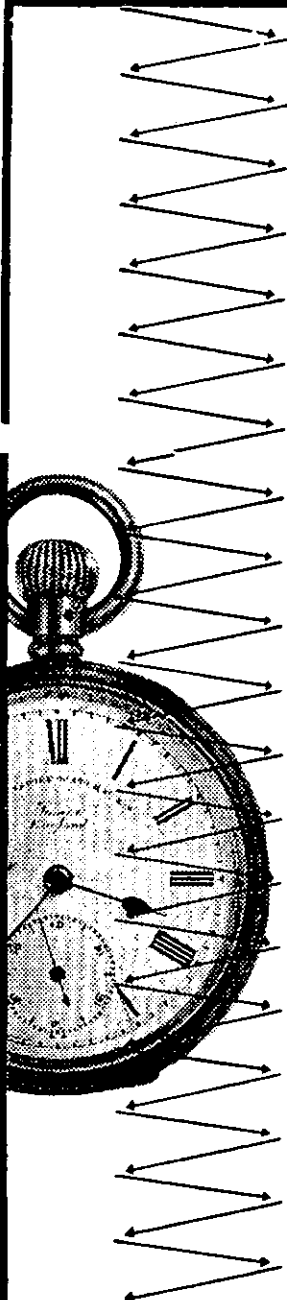
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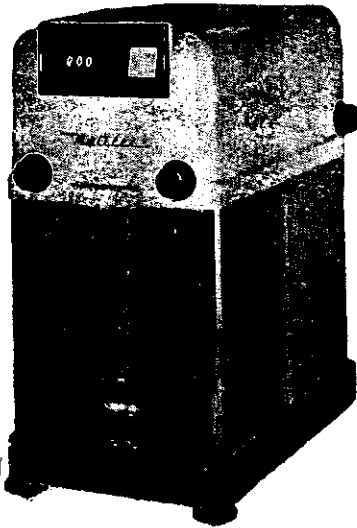
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