suitable staffs had to be trained by the chemist in charge. Machinery, processes, technique and specifications have constantly changed, necessitating much resource on the part of the chemical staffs.

The present day cement works laboratory is composed of three distinct departments:

1. Physical testing, for checking up on the performance of all cements made each day.
2. Chemical control—manufacturing.
3. Analytical and research.

Research includes new products, new production methods, and an immense amount of concrete research covering the exceptional variety of uses to which modern civilisation applies these versatile materials.

The following table will show the progress made in tensile and compressive strengths of portland cements during the past 46 years in New Zealand. With chemical control this has been made possible, and continuous production of the finished article with predetermined characteristics is now of uninterrupted regularity.

| | | Tensile Strength (lbs. per sq. inch) Sand Mortar | | | | | Compressive Strength (lbs. per sq. inch) Sand Mortar | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Proportions / Age | 1 day | 2 days | 3 days | 7 days | 28 days | 1 day | 2 days | 3 days | 7 days | 28 days |
| 1892 | 1 Part Sand 1 Part Cement | Nil | Nil | Nil | 60 | 80 | Nil | Nil | Nil | 600* | 800* |
| 1894 | 2 Parts Sand 1 Part Cement | Nil | Nil | Nil | Nil | 53 | Nil | Nil | Nil | ‡ | 535* |
| 1909 | 3 Parts Sand 1 Part Cement | Nil | Nil | Nil | 95 | 170 | Nil | Nil | Nil | 950* | 1700* |
| 1919 | 3 Parts Sand 1 Part Cement | ‡ | ‡ | ‡ | 202 | 305 | ‡ | ‡ | ‡ | 2190 | 3210 |
| 1929 | 3 Parts Sand 1 Part Cement | 234 | ‡ | 357 | 421 | 532 | ‡ | ‡ | ‡ | 4500 | 5670 |
| 1934 | 3 Parts Sand 1 Part Cement | 280 | ‡ | 420 | 485 | 590 | ‡ | ‡ | ‡ | 5280 | 6380 |
| 1938 | 3 Parts Sand 1 Part Cement | 307 | ‡ | 435 | 494 | 600 | ‡ | ‡ | 4000 | 5503 | 7000 |
| **RAPID HARDENING CEMENT** | | | | | | | | | | | |
| 1933 | 3 Parts Sand 1 Part Cement | 417 | 485 | 539 | 601 | 645 | 3390 | 5527 | 6819 | 8185 | 9497 |
| 1938 | 3 Parts Sand 1 Part Cement | 485 | 569 | 601 | 632 | 665 | 4843 | 6543 | 7607 | 8600 | 9960 |

* Compressive tests not done up to 1909—figures mentioned are close estimates as factor of 10 to 1 compression to tension was about correct until later years.

‡ Not Done.



# CHEMISTRY AND THE BREWING INDUSTRY

R. GARDNER

Brewing affords an interesting example of an essentially chemical industry that is nevertheless much older than the science of chemistry. Such operations as mashing and fermenting depend on chemical changes, that is, of transformation of one substance into another, and therefore fall within the province of chemical science. As in other such processes known from very early times—examples are soap-making and many metallurgical processes—the methods were probably discovered accidentally in the first place and have been carried on for century after century on an empirical basis. The workers knew from experience and tradition that if they did the job in a certain manner certain results would be obtained. They did not know why or how these things happened and nobody could forecast with certainty what would be the result of a slight alteration of method. In these circumstances improvement of methods was necessarily slow and uncertain, adaptation to altered circumstances often impossible and process troubles at times inevitable. There are recorded instances, and there must have been many of which we have no record, of a brewery experiencing in an acute form the type of trouble that we now have learned to associate with "wild" yeasts and bacterial infections. In spite of all the care that could possibly be taken with the knowledge then available the quality of the product would fall and fall until the brewery had no alternative but to close down. As even the cause of these occurrences was unknown, nothing effective could be done. In a modern scientifically controlled brewery it is likely that the presence of wild yeasts would be detected before any serious damage resulted. At any rate, as soon as any trouble of this type is experienced it can be effectively dealt with.

Brewing operations attracted the attention of some of the very earliest scientific workers but as the substances and operations occurring are complex there is still plenty of scope for research. Attention may be drawn here to the very far-reaching effect of some of the scientific studies of brewing methods. The outstanding example is the work of Louis Pasteur. It is probably not generally realised that the process known now as pasteurisation, now generally associated with milk, was invented for use on beer and wine. Pasteur's studies on the "diseases" of beer and wine led him to the idea of microbial origin of human diseases and the methods of controlling such diseases. Whatever one's ideas may be as to the ethics of the use of alcohol there can be no question of the benefit to mankind of Pasteur's work. Other examples of the same kind could be quoted from later work, for instance the now well-known pH notation which, by facilitating the use of the hydrogen ion concentration, has had important effects in agriculture and in medicine and was introduced by a brewer's chemist.

Brewing must have been one of the very early manufacturing industries of New Zealand and there would be ample material for a very interesting essay on its history. A study of it from the economical angle would be worth while in itself and there are many interesting connections with the general history of New Zealand. To mention only one example, the story of the once famous brewery of Simpson & Hart, at Lawrence, and its rise and fall with the Otago gold-rush would be full of interest. Some of the buildings of this brewery, the name of which was once almost as much of a household word in New Zealand as "Speight's" is today, are still in existence and are used in connection with a very different industry—the growing of daffodils.

There are no particular landmarks in the history of the application of chemistry to brewing in New Zealand. Here, as elsewhere, the process has been gradual. On the one hand there has been growing up gradually a body of scientific knowledge capable of application to the industry and on the other the industry itself has gradually come to realise that it can make good use of this knowledge, at first mostly through occasional consultations with University professors, and later principally by the constant use of the services of consulting chemists. From the brewing side this has come about, as it has in other industries, partly through the foresight of some progressive men in the industry and partly from sheer force of necessity. At the present time most of the major breweries of New Zealand make some use, and in nearly all cases an increasing use, of analytical control methods. In this connection it may be pointed out that the average beer brewed today is of much lower alcohol content than that of thirty years ago. Public taste today demands a lighter beer. It is much more difficult to brew, and especially to impart satisfactory keeping qualities to, a light beer than was the case with the heavier beers of years ago. This greatly increases the necessity for exact control and has been a considerable factor in the application of scientific methods to the industry.

It is well known that a suitable water supply is one of the first essentials for successful brewing and the location of



many of the best known breweries depends on the fact that their water supplies had been found by trial to be suitable. It is now possible to decide in advance from the analysis of a water whether it is suitable for brewing purposes and even in some cases to treat an originally unsuitable water so as to make it suitable. Many breweries now keep an analytical check on the purity and suitability of their water supplies. The chemist also examines hops and barley—the latter both in the original form and more especially, after malting. The data obtained enables the brewer to blend malts to advantage as well as being a check on malting methods. The operation of mashing is checked by frequent examination of wort, and the chemist also examines the yeast for signs of loss of fermenting power or the presence of the much-feared wild yeasts and detrimental bacteria. The finished beer is frequently examined for strength and purity and a vigilant watch is kept for traces of arsenic or other poisonous metals which in beer, as in other foodstuffs, have been known to creep in by unsuspected routes such as the use of arsenic-bearing coal. In these and many other respects the chemist can help the brewer and his help is being increasingly used.

This article has reference principally to the brewing of beer, which is the chief brewed beverage in New Zealand, and it is possible to make only brief reference to the brewing of cider and wine, both of which are carried out commercially in New Zealand. In the case of the wine industry there is a Government experimental station at Te Kauwhata, in the Auckland district and the station does much to ensure that the work of science is utilised by the industry.

It is perhaps worth emphasising that in brewing, as in other connections, there is, so far as the chemist is concerned, no opposition of interests between the manufacturer and the public. The aim of the manufacturer is generally to turn out an article of high and consistent quality in as economical a manner as possible. Hence in such a body as the New Zealand Institute of Chemistry the Government chemist who watches the product on behalf of the consuming public is found side by side with the chemist employed by the manufacturer, and professional knowledge is freely shared for the benefit of all parties.

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## PETROLEUM.

M. L. STEWART

In considering the history of Petroleum in New Zealand, the layman's first question is invariably "does oil exist in this country?" Whilst oil and gas seepages do occur over a scattered area, the presence of oil in quantity has not yet been established.

It is not generally known that since 1866, some 40 odd wells, ranging from under 200 feet to over 4,000 feet in depth have been drilled in New Zealand. Even a brief history of these wells would require a volume in itself and no useful purpose would be served since the majority were abandoned either without any sign of oil having been obtained or with but small shows of gas and oil; in a few cases only has a small flow been obtained.

Since the introduction of the Petroleum Act, 1937, interest has been re-awakened and prospecting over wide areas, using modern geological and geophysical methods is in hand. An immense amount of field work is being done, whilst the Department of Scientific and Industrial Research, together with the Department of Geological Research, are carrying out work over large areas. During this period of search, the Dominion's requirements for Petroleum have been well supplied from overseas and it is possible to obtain motor spirits, kerosenes, and other products in every habitable part of both islands.

The development of the petroleum industry is one of the marvels of our age and petroleum in its many and varied forms has contributed greatly towards the standard of living which we now accept as our right. In this "Age of Petroleum" as it has been called, the chemist has played an important role and in the research laboratories of the major oil companies new products are being added to an already amazing list of substances produced from the magic crude.

The petroleum chemist in New Zealand has had little scope for research but at least two of the major oil companies have their own laboratories fully equipped to control the quality of their products.

To the layman, petroleum means oil and motor spirit, but to the technician and chemist, it is the raw material from which an ever increasing field of chemicals is being derived. The paint, varnish and lacquer industries are supplied with petroleum solvents and synthetic chemicals, such as alcohols, ketones and esters which are now produced from petroleum in a much higher state of purity and at lower cost than when produced by fermentation or destructive distillation. Naphthenic acids for the preparation of dryers for use in paint manufacture, wetting and scouring agents, emulsifiers and many chemicals hitherto regarded as laboratory curios, are being produced on a commercial scale. In America, liquid ammonia is being produced from petroleum gas and supplied direct to the farmers where it is incorporated in their irrigation waters, a novel way of supplying a nitrogenous fertiliser—a novel source of supply.



Whether petroleum will be found in payable quantities in this country is yet to be answered; certain it is that if oil is obtained in quantities sufficient for the country's requirements, the assistance of chemists and technical men familiar with the many refining processes, will be required. For its supply of petroleum, New Zealand depends on oils, spirit, etc., imported from other countries. A considerable quantity of the refined lubricating oils are however, blended within the country and three blending plants, one of which has been operating for 15 years, produce the various grades required. These oils must conform to rigid specification and in order to maintain a uniform product, fully equipped laboratories under the control of qualified chemists are attached to these plants.

Besides the mineral lubricants produced for a variety of uses, such as the lubrication of aeroplane engines, motor and diesel engines, turbines and industrial purposes, a large range of industrial greases, tanners and textile oils, spraying oils and insecticides, cutting oils, etc., are manufactured. The blending of these numerous products requires specialised knowledge and without the services of the chemist it would be impossible to maintain the high standard and uniform quality. Much of the chemist's work must of a necessity be of a routine nature, but apart from the control exercised over both the raw materials and the finished products, there are numerous special problems which require his attention. Many oils for special purposes are blended with one or other of a series of blown oils. A plant for the production of these blown oils is in operation in New Zealand and in addition, special blown oils for several industrial processes are produced under chemical control.

Several plants for the production of bituminous emulsions and road oils, have been established and the majority of these employ qualified chemists to control the quality of their various products.

Motor spirits and particularly aviation spirits, require constant chemical control and in most of the laboratories, the estimation of metallic salts, e.g. lead, is carried out as a routine determination. Whilst much of the work of the chemist in this country in the control of petroleum products, is far from spectacular, the control exercised results in a uniform product of high quality being supplied to the purchasing public.

# THE CHEMISTRY OF HIGHWAY MATERIALS

J. B. HYATT

The gradual development of Highways Chemistry throughout the world has been the logical result of the demands of the Highways Engineer for constructional materials that shall be capable of withstanding the stresses imposed by the rise of rapid motor transport. For this reason it is essentially the offspring of the present century, struggling from small beginnings in the first two decades (when the only universally recognised property of a binder was that it should be black and sticky) to full lustiness during the past fifteen years or so.

Technical developments in New Zealand, in so far as bituminous construction is concerned, have been mainly of a control character, and in this branch of endeavour have followed closely the practice of other countries—notably Great Britain, in the sphere of tars, and the United States in that of asphaltic materials. It follows, therefore, that the benefits conferred upon the local industry by the chemist's activities have rested four-square upon his ability to interpret improved specifications and standard methods. The consequent close control of the materials offered to the engineer has fostered a similarly close association between the latter and the laboratory.

When, in 1926, the Main Highways Board of New Zealand, in cooperation with the newly-formed Department of Scientific and Industrial Research, took the first step towards securing laboratory control of bituminous roadway materials, specifications and methods of analysis were emerging from the primitive stage. In those days the materials covered by specifications were confined to two or three grades of road tar, a few of petroleum bitumen, and a rather heterogeneous assortment of straight-distilled road oils for "hot" or "cold" application. Today, with a fuller appreciation of the demands of varying service conditions and their relation to the physical and chemical properties of the appropriate binder, products controlled by specification are not only far wider in range, but are also much more definitely identified with the respective purposes for which they are intended.

To quote an outstanding example of such development the rise to prominence of bituminous emulsions deserves particular attention, and the contribution of the control chemist in intelligently applying the constantly improving methods of examination of these materials has done much to render them effective tools in the hands of the engineer. Their development, besides being something of a laboratory achievement, affords a noteworthy example of economic cause and technical effect. Thus, in and around the year 1926, the almost universal method of permanent construction was that of the "hot-mix" bituminous concrete, using a semi-solid petroleum bitumen of 80/100 penetration pre-mixed with graded aggregate. While this is still recognised as affording the most durable pavement, it is unfortunately expensive and not of the greatest convenience. It was gradually found to be better policy economically to employ a lighter form of construction, especially in the case of the less densely trafficked highways, and to rely on more frequent maintenance to keep the surface in good order. As a natural consequence many methods of "cold application" —chiefly *in situ*—were explored, and these soon resolved themselves into two main categories. The first of these is the "cutback," in which a cementitious binder is diluted with volatile distillate to render it sufficiently liquid for application in the cold. The second is the bitumen emulsion, in which the same object is achieved by dispersion of the binder in water instead of its "solution" in added oil.



These materials, than which probably no other constituent of the modern roadway has suffered so many analytical vicissitudes, have opened up a quite new horizon both to the engineer and to the chemist, particularly in the attempted measurement of their "breaking" characteristics after contact with the surfaces which it is their function to seal. Even today, controversy centres round the merits of the various widely divergent methods sponsored by different standardised authorities. Nevertheless, satisfactory road emulsions are nowadays regularly manufactured in New Zealand, and credit for their uniformity of quality goes largely to the control chemist who, in this instance, must exercise a wide discretion in his choice of method and considerable initiative in his interpretation of results.

Nor has the chemist been idle in the province of gasworks coal-tar—the earliest form of road binder to be used in large-scale operations. In this country, moreover, it is likely that under war conditions he will be shortly still more actively engaged in this direction. The earliest specifications for road tars issued by the British Road Board provided for three grades —one designed for the manufacture of pre-mixed tar macadam, and two others for surface sealing purposes. Today, in addition to these three grades which have survived in modified form, there exists a wide range of specifications for "tar primers," many of which have been adopted by the Main Highways Board, after careful selection and occasional modification to suit local conditions. Here again the gasworks laboratories of New Zealand, together with the Dominion Laboratory organisation, have been instrumental in greatly improving and maintaining the quality of output. This is, of course, particularly obvious in the case of the smaller and less well equipped works, to which, through the Main Highways

Board, the Dominion Laboratory has frequently acted in an advisory capacity.

It has often been contended, and with considerable truth, that in industry the gap between the laboratory and the field is a major barrier to progress. In so far as the highways industry is concerned, however, New Zealand has been fortunate in experiencing close and cordial cooperation between chemist and engineer. One of the outstanding examples of this collaboration is afforded by the frequent laboratory experimentation which has been performed in order to formulate for the local preparation of products to fill standard specifications. Such activities have been of frequent occurrence when stocks of the imported material have fallen low, but in many instances the initiative in formulating for special conditions has arisen from the engineer, and the chemist has performed the necessary analytical work in connection with the innovation.

A review of this nature would be incomplete without reference to the British Road Research Board, from whose annual reports much of the latest investigational material becomes available in this country. Such problems as that of viscosity standardisation, the principles of weathering, the design of accelerative tests, the proportioning of aggregate, and a wealth of similar matter not yet incorporated in standard specifications, are fully discussed, and enable the highways chemist to keep abreast of the times and in close contact with "headquarters."

In this connection it has been indicated at the commencement of this article that the chemist's services to the industry in New Zealand have been mainly of a control character. This is naturally not intended to imply that the profession has failed specifically to throw any fresh light upon the many complex problems involved in bitumen chemistry. With industrial chemists of the calibre to be encountered in the laboratories of our oil and gas companies it would be remarkable if locally important problems involving fundamental principles had not been successfully faced. Much of this, however, is doubtless of a confidential nature, and little has been published. It seems likely that with the paramount need for fostering the development of our own resources at the present time, more and more applied investigational work will have to be performed. The further improvement of tar products has already been prophesied, and it is not difficult to envisage other avenues of development, all of which will doubtless demand the attention of the research worker, and some of which may in the long run result in those worthwhile contributions to the welfare of society that manage somehow to emerge from the lamentable business of warfare.



## PHARMACEUTICALS AND COSMETICS IN NEW ZEALAND.

H. F. HARVEY

*Pharmaceuticals.*—The man in the street immediately associates them with the pharmacy, or as it is wrongly called, the chemist's shop. At one time the pharmacist prepared his drugs and cosmetics from the raw materials, but now, due to the demand made upon his time, and the large quantity that is required of some hundreds of different preparations, the manufacture of these has been left to the manufacturing chemist who is able to prepare these goods on a large scale, and therefore at a much reduced cost.

*Cosmetics.*—Everybody understands and recognises this term and knows the thousands of products on the market. These, too, are prepared by the manufacturing chemist.

But this is a comparatively modern industry in New Zealand. Up to the present time, the New Zealand manufacturing chemists have been unable to compete with overseas goods, mainly because they have not been able to get fully trained men locally and to import them would burden their overhead to such an extent not warranted by their output. The public have further held back the growth of this industry for it is the general belief that New Zealand cannot possibly manufacture goods to the standard of overseas lines. Now, however, skilled technicians are being brought from overseas, and New Zealand made pharmaceuticals and cosmetics are able to compete quite favourably with imported lines.

Now let us look through this modern industry and find out what part the chemist plays and what he is doing for the public health.

Through the steam and fumes we see coppers, pans and retorts boiling and bubbling, hear the roar of machinery, and we smell odours and perfumes. On a miniature stairway there is a bank of extractors in which, from roots, leaves and barks, various drugs are extracted by a continuous stream of boiling water; in others various solvents are used, such as alcohol, benzine and acids, for from experiments and research, it has been found that different drugs require different solvents in order to extract the necessary active principals.

Next we see mixers, churns and large storage vats containing syrups, creams, soaps, etc., each with its odorous vapour compelling one to take notice. Now we hear a queer sound like waves beating on the shore and we find pills being prepared at the rate of 500,000 per day, tablets dropping from a chute at the rate of 500 per minute, rotating pans holding some half a million pills or tablets, coating them with a solution of sugar or chocolate, in order to preserve, as well as to make them pleasant to the eye.

Biological preparations have been made possible by the work of the eminent chemist Pasteur, some 40 odd years ago, and these preparations are becoming more necessary every day. Various glands are used, which are first selected and sorted by girls, specially trained for the purpose. After being trimmed, the glands are cut up fine with a meat chopper, dried in special vacuum driers, defatted in extractors and redried, ground, and in many cases, extracted with various solvents, similar to the vegetable drugs. These extracts are purified and finally filled into small vials, sealed hermetically and finally pasteurised. This consists of heating the sealed vials to a temperature from 60 to 80 deg. Centigrade for at least thirty minutes, in order to kill any bacterial spores or fungoidal growth, thus making the solution sterile and fit to be used for hypodermic injection. These are just a few examples of the many hundreds of preparations manufactured by a manufacturing chemist.

Throughout manufacture the materials are subjected to various analytical tests, and on completion, each preparation is assayed to determine the exact percentage of each ingredient and, if necessary, the products are adjusted to the necessary standards of various authorities.

The plant used is usually of special design, which is found from experiment and is usually designed by the chemist for each particular preparation. The raw materials mostly have to be imported on account of the climatic conditions under which they must be grown, although for the cosmetic industry, many of the ingredients are purchased locally.

Thus, to sum up the chemist's place in this industry, we may say that he has to train men, design plant, invent formulae and test all raw materials as well as the finished product.

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