

DEVELOPMENT AND MANUFACTURE OF FERTILIZERS IN QUEENSLAND, FIELD MEETING JULY 29, 1967

DEVELOPMENT OF THE FERTILIZER INDUSTRY IN QUEENSLAND

by

J. S. PULSFORD, A.C.F. AND SHIRLEYS FERTILIZERS LIMITED,
BRISBANE, QUEENSLAND.

The application of animal manures, chalk, wood ashes and other substances for increasing the productivity of soil was practised by the early Chinese, Romans and Greeks, apparently before recorded history. Any understanding of the fundamental principles of plant nutrition did not occur until the mid 18th and 19th centuries, when the foundations of chemistry were laid by such chemists as Priestly, de Saussure, Sir Humphrey Davy, Boussingault, von Liebig and Lawes. These people recognised the role of the gases — oxygen, carbon dioxide and nitrogen — and the mineral elements in the ash of plants — phosphorus, potassium, calcium etc. — for the growth of plants.

The fertilizer industry grew out of the research for cheaper or more readily available sources of plant nutrients. The first chemical factory, using "chemical" as distinct from "organic" (plant and animal matter), was put into operation about 125 years ago in England.

The most important materials in the fertilizer industry are nitrogen, phosphorus and potassium. The growth in world consumption (in '000 tons of nutrient) during this century has been as follows:

<i>Year</i>	<i>N</i>	<i>P</i>	<i>K</i>
1900	292	435	194
1909	568	680	654
1919–20	757	752	892
1929–30	1797	1535	1983
1938–39	2670	1580	2420
1949–50	3639	2550	3328
1959–60	9220	4144	6983
1965–66	17500	6090	10000

NITROGEN FERTILIZERS

The essential nature of nitrogen for plant growth resulted from work by Gilbert and Lawes at Rothamsted in the 1850's. Some years earlier de Saussure had recognised nitrogen as a plant constituent, which he believed to have been derived from ammonia present in the air or from the organic matter in the soil. The role of the root nodule bacteria of legumes in fixing gaseous nitrogen was not recognised until about 1886, although the practice of inoculation of lucerne fields with soil containing the bacteria had been practised in Europe for centuries.

Of the 250,000 chemical compounds containing nitrogen, less than 20 are of much use as fertilizers, and only a dozen or so forms are used in any quantity. The atmosphere contains about 80% nitrogen, but plants cannot use it unless it is combined with oxygen or hydrogen in some relatively simple chemical compound.

The sources of nitrogen freely available to farmers — the small amounts brought down as nitrates in rainfall, similarly small amounts fixed by free-living soil bacteria and algae, nitrogen fixed by the legume root-nodule bacteria, animal

manures, and plant and animal residues — were probably sufficient to meet the needs of crops used for human consumption until about 1800. The world was then thinly populated — 900 million people, 200 million of whom lived in Europe and North America.

As the world population explosion began in these two continents (they had 545 million of the 1600 million in 1900), the natural resources of nitrogen were exceeded. The immediate situation was saved by the discovery and use of large deposits of guano and sodium and potassium nitrate on the eastern coast of South America, and the longer term situation by ammonia synthesis.

Organic Nitrogen Fertilizers

Due to ammonia synthesis, the nitrogen fertilizer industry has developed into a vast chemical industry, although it was once regarded as a scavenger industry gathering waste plant and animal material such as seed meals, sea weed, fish meals, slaughterhouse tankage, bones, feathers, hooves and horns, dried blood, meat meal, waste leather, wool and hair, soot etc.

In the early days of Queensland, sheep manure and abattoir wastes were marketed. Bones were collected and milled and, though acting also as a source of phosphorus, they did contribute to nitrogen supply. Some use is still being made of them. Pre-bounty nitrogen prices for organic materials such as blood and bone, were nearly four times those of ammonia, urea etc.

Guano

The island deposits of guano (mainly the excrement of sea birds) off the coast of Peru were analysed in Germany in 1804 and found to contain about 5% N as well as phosphorus. Guano had been used for agricultural purposes from the 12th century, and by the Incas before the Spanish Conquest of Peru in the 16th century. The Peruvian Government let contracts for the exploitation of the guano deposits after 1840, and by 1875 over 10 million tons had been removed, largely to England and U.S.A. Most of the easily accessible deposits had been exhausted by 1880.

Sodium Nitrate

The Chilean deposits (previously Peruvian territory) of sodium and potassium nitrates were discovered about 1809, and though mined by Spaniards in 1813, they were not exploited until after 1830. In that year, British interests exported 800 tons to America and by 1840, shipments of 10,000 tons a year were going to England, Europe and America. Output was 1,660,000 tons in 1907 and in 1910 sodium nitrate accounted for 65% of the agricultural nitrogen market. Reserves were estimated at 250 million tons in 1926, but more recent estimates are in excess of 6,000 million tons.

Synthetic sodium nitrate became available in the U.S.A. in 1928, being produced by absorbing nitrogen oxides (from oxidation of ammonia) in sodium carbonate which was obtained by the Solvay process from salt. World usage is now about 1 million tons a year, its share of the nitrogen market having dropped to 25% in 1929, 10% in 1939 and now to 2%. In Australia, about 5,000 tons are used annually, accounting for about 1% of the total nitrogen usage. In Queensland, sodium and potassium nitrate have been used for producing tobacco mixtures in which the ammonium form of nitrogen is considered to be deleterious for the production of flue-cured leaf. Larger amounts were used in the horticultural and sugar industries during the war, when ammonium sulphate was not obtainable in sufficient quantity.

Ammonium Sulphate

When coal is burnt in the absence of air to produce gas or coke, some of the nitrogen in the coal is released as ammonia. In England, this gas and other impurities are sometimes collected in water to produce gas works or ammonia liquor, containing relatively low amounts of nitrogen. Close to the site of manufacture, since 1843, ammonia liquor has been used as a fertilizer.

At some works, the ammonia is set free from the liquor with lime and led into tanks of sulphuric acid, to form ammonium sulphate. More generally, the coke-oven gases are led directly into tanks of sulphuric acid. This by-product ammonium sulphate is crystallised by removing excess water, followed by centrifuging to drive off the last traces of acid and liquid. Ammonium sulphate was first used experimentally by Lawes in 1843 at Rothamsted. It was first produced commercially in England in 1850 and in U.S.A. in 1893. In 1923, synthetic ammonium sulphate came on to the world market in large quantities. This was produced by the gypsum process, in which ammonia water is introduced into a tank containing pulverised gypsum through which carbon dioxide is bubbled.

Ammonium sulphate was first produced in Australia by town gas supply companies towards the end of the last century. B.H.P. commenced manufacture over 40 years ago to make use of by-product ammonia from coking operations. Electrolytic Zinc commenced manufacture at Risdon in Tasmania in 1956, using sulphuric acid produced from by-product sulphur dioxide from zinc smelting. Total Australian production of ammonium sulphate was 24,000 tons in 1939, 22,000 tons in 1946 and 120,000 tons in 1958. Current production is over 110,000 tons per year, less than half from the gas-coke-steel industry and the remainder in Tasmania.

As from April 1962, the Commonwealth Government provided a bounty of \$4 per ton on ammonium sulphate produced and sold for fertilizer use in Australia. This was increased to \$8 in May 1964, and extended in 1966 until the end of 1969. Usage of ammonium sulphate in Australia was about 175,000 tons in 1966-7. Queensland has been a major user of ammonium sulphate, in mixtures for horticultural crops and sugar cane, and also as a nitrogen dressing to sugar cane. Usage increased from 2,000 tons in 1924 to 20,000 tons in 1926, 30,000 tons in 1950 and 80,000 tons in 1960.

Ammonia

Up till about 1910, the Chilean nitrate industry held a monopoly of the nitrogen market and was able to fix prices at a high level. Together with a high Government export tax (estimated to have brought in \$U.S.900 million to Chile between 1870 and 1920), this resulted in a strenuous effort in Europe to become independent of Chilean nitrates.

Haber, a German chemist, developed a process between 1905 and 1908 for synthesising ammonia from nitrogen and hydrogen. The credit for the large scale development of the Haber process belongs mostly to the engineer Bosch, who overcame the technical difficulties. Large scale development from 1910 onwards rendered Germany independent of Chilean sodium nitrate denied it by the blockade of World War I.

From 7,000 tons N in 1913, plant capable of extracting 600,000 tons N had been erected by 1918, and this had been increased to 1 million tons by 1923. Soon after the end of the 1914-18 war, more than half of the world's total nitrogen requirements were able to be supplied by Germany. Other countries, particularly Japan, U.S.A. and in Europe soon followed, but in 1934 Germany

was still producing 35% of the world's synthetic nitrogen. At this time, the total N production consisted of about 65% synthetic N, and 12% each of cyanamide N, by-product N and sodium nitrate.

Most of the early production of ammonia was converted into nitric acid and ammonium nitrate for explosives and later ammonium phosphate. The direct agricultural use of ammonia through irrigation water was developed by Shell in California and Oregon about 1933. Work in the Mississippi delta in 1939 led to soil injection of ammonia in cotton crops in 1946.

Aqua ammonia was introduced experimentally into Queensland in 1959 and imports from Japan were marketed throughout the agricultural areas, particularly sugar cane districts from 1962 onwards. Anhydrous ammonia was introduced to the Darling Downs in 1965. Queensland's first ammonia plant at Pinkenba was opened in August 1965.

Ammonium Nitrate

Following the 1914-18 war, large stocks of ammonium nitrate manufactured for explosives, were disposed of as a fertilizer in Europe. This was generally mixed with gypsum and later with ammonium sulphate or potash salts. Still later, mixtures with lime appeared under various names such as Nitrochalk, Calnitro, C.A.N. etc. Fertilizer grade ammonium nitrate production commenced about 1943. Limited quantities of ammonium nitrate and ammonium nitrate-lime materials have been imported into Australia. Imports have been heavier in recent years, being marketed in advance of large scale manufacture of ammonium nitrate near Newcastle, N.S.W.

Ammonium Phosphates

Mono- and di-ammonium phosphates can be made by ammoniating phosphoric acid. They were available in U.S.A. by 1930 and are now being produced in Australia, together with intermediate grades, containing a proportion of ammonium sulphate. At Pinkenba, the Nissan spray tower process is used.

Urea

This is made from carbon dioxide and ammonia and was first marketed pre-war in U.S.A. as Uramon. The growth of the plastics industry, where urea-formaldehyde resins are used, gave impetus to urea manufacture, so that increased amounts became available for fertilizer use at competitive prices from about 1950, when world production was about 180,000 tons. Production increased to nearly 2 million tons by 1959, 5 million tons in 1963, 9 million tons in 1966 and is expected to increase to 20-30 million tons by 1970. There were 147 plants producing urea in 1966. The largest plants produce about 1,000 tons per day. Two are in operation in England and Korea, others are being built in Alaska, India, Italy and Rumania. Medium sized units produce from 400-700 tons per day, while smaller units produce 230-330 tons per day.

Australian use of urea started about 1958 and has grown considerably over the last 5 years. Imports were about 30,000 tons in 1964-65 and 56,000 tons in 1966-67, about half of the latter going to Western Australia and 20% to Queensland. Urea is produced at Botany, N.S.W. Queensland use was 7,000 tons in 1960 increasing to 13,000 tons in 1964. Price competition from anhydrous and aqua ammonia has held urea use fairly static over recent years in Queensland.

The total market for nitrogen in Australia is currently about 100,000 tons per year, only slightly more than existing production capacity. Plants which will lift capacity to five times current use will be in operation in Australia by the end of 1969.

In 1966, the Commonwealth Government introduced legislation to provide for the payment of a subsidy to the producer or importer of nitrogen fertilizers at the rate of \$80 per ton of contained nitrogen in naturally occurring sodium nitrate or in products manufactured from inorganic nitrogen. The Act came into operation on 17th August, 1966 and is due to expire on 31st October, 1969. Payments in 1966-67 were nearly \$7 million.

PHOSPHORUS FERTILIZERS

The element phosphorus was discovered in urine by the Hamberg merchant and alchemist, Brandt in 1669. A hundred years later, a Swedish chemist, Gohn, produced phosphoric acid from bones and a little later a practical process for recovering phosphorus from bones was discovered by Scheele.

The main sources of phosphorus for plants have been bones, phosphatic guano, the mineral phosphates and more soluble fertilizers manufactured from these.

Bones

The use of bones as a fertilizer is such an ancient practice that it is now impossible to establish definitely when or where it had its origin. The first recorded use of bones was in England in 1653, their value being generally recognised there earlier than on the Continent of Europe.

The manurial value of bones had been attributed to their phosphorus content by the end of the 18th century, and crude machines for grinding bones were in use in England as early as 1778. By 1815 the English supply of bones was so inadequate that they were imported from the Continent, reaching 30,000 tons per year. The British became known as the "grave-robbers" of Europe, collecting bones from the battle fields of Waterloo and the Crimea and the Catacombs of Sicily. Large quantities of buffalo bones were collected from the plains of America. With the discovery of phosphorus in apatite, a mineral phosphate, by Vanquelin and Klaproth, the use of bones became less, but in 1907 England still imported 46,000 tons of bones.

The idea of making a phosphate more soluble than bones occurred independently to several people about the same time, but Escher of Germany is credited with the first proposal to treat bones with sulphuric acid in 1835. Justus von Liebig demonstrated the improved fertilizer value of bones following acid treatment, in 1840.

Phosphatic Guanos

The guanos formed in the higher rainfall areas lose much of their nitrogen. The Holbourne Island Phosphate Company Limited mined phosphatic guanos on Holbourne Island, 20 miles east of Bowen in Central Queensland in the early part of the century. A new company, Holbourne Fertilizers Limited (in which Australian Co-operative Fertilizers Limited had a one-third interest), was formed in 1918. The company continued to operate the guano deposits for a few years, in conjunction with a bone milling plant at Townsville.

Rock Phosphate

The mineral phosphates (chiefly fluorapatites) are the main source of phosphorus for fertilizer production. Rock phosphate is relatively unavailable to plants, only 5-25% of its P being citrate soluble. Given adequate time, soil acids will make the phosphorus more soluble by breaking the apatite structure—the

reaction rate is increased by fine grinding, by moderate soil acidity and by large amounts of decomposing organic matter. Treating the rock with strong acids — sulphuric, phosphoric or nitric — is the most common method of making rock phosphate more soluble.

While rock phosphate deposits had been discovered in South Carolina (U.S.A.) in 1837, the first mining company was not formed there until 1867, 4 years after mining had commenced in Canada. The Florida deposits were discovered in 1882. World rock phosphate production was 1 million tons in 1888 and 13 million tons in 1938. 75 million tons were produced last year, 80% of this in U.S.A., Morocco and Russia. Production took place in 28 countries, but only 11 of these produced more than 1 million tons. 85% of this rock was used for fertilizer manufacture. 65% of the world's trade in rock phosphate is taken by Europe.

All the rock phosphate used in Australia for the manufacture of phosphoric acid and superphosphate is imported. Most has come from Nauru and Ocean Island, but in recent years, though there has been a marked increase in output from these islands, increasing quantities of rock phosphate have come from Christmas Island, Florida and Africa. The Nauruan and Ocean Island deposits have been worked since 1906. Imports of rock phosphate into Australia were about 1 million tons in 1950, 2 million tons in 1964 and over 3 million tons in 1966.

Superphosphate

Bones, guano and other natural sources of phosphorus are relatively insoluble in water and only slightly soluble in dilute acids. In 1842 and later, John Lawes, co-founder of Rothamsted Experiment Station in 1843, took out patents for making superphosphate (a term then in use in France for water-soluble calcium phosphate) from bone products and from mineral phosphates. He built his first factory at Deptford in 1843. The discovery of mineral phosphates (coprolites) in England in 1845 enabled large quantities of superphosphate to be produced, and by 1857 Lawes had built a second factory.

Superphosphate was first produced in U.S.A. in 1852 from bones. It was often called acid superphosphate, other names being given depending on the source of phosphate, e.g. bone black superphosphate, Florida Rock superphosphate etc.

The earliest Australian manufacture was at Yarraville in Victoria by Cuming Smith & Company in 1878, using refinery bone char as the source of phosphorus. The Colonial Sugar Refining Company commenced manufacture in Sydney in 1886. Bone char was produced for use in clarifying sugar and the spent material was treated with sulphuric acid to make superphosphate for export chiefly to Madagascar. At this time, and until 1924, Australia was a sugar importer.

South Australia first produced superphosphate in 1883, Western Australia in 1910 and Tasmania in 1924. Superphosphate was not used in any quantity in Australia until the turn of the century, when farmers began using it on wheat in South Australia. 3,000 tons were used there in 1887, 24,600 tons in 1900 and 44,500 tons in 1903.

Use on pastures followed the 1914–18 war, but usage on crops was greater than on pastures until 1951. The area of pastures fertilized was 7 million acres in 1938, 14 million acres in 1950, 21 million acres in 1955, 28 million acres in 1961 and over 35 million acres in 1964.

Sales of superphosphate in the various states for 1962-63 and 1966-67 were as follows:

	1962-63	1966-67
	('000 tons)	
New South Wales	490	738
Victoria	971	1454
South Australia	443	663
Western Australia	727	1184
Tasmania	120	153
Queensland	85	135
Australia	2836	4327

Production reached 4.6 million tons in 1966-67. 97% of the total fertilizer used in Australia is superphosphate. 97% of the superphosphate produced in Australia in 1966 was used south of latitude 30° S. While P deficiency is as severe and as widespread in northern Australian as in the south, superphosphate was not manufactured north of Newcastle until 1946.

Building of the 25,000 tons per year Pinkenba plant had commenced in 1939, on the old Queensland Meat Export Company site. It was almost completed in February 1940, but the Federal Government recommended that the superphosphate and associated sulphuric acid plant not be commissioned until after the war, due to the uncertainty of rock phosphate (the Japanese had occupied Nauru in 1942) and sulphur supplies. A plant was opened in Cairns in 1955. The capacity of both plants has been increased since.

The reasons for this 70 to 80 year lag behind the southern states in superphosphate manufacture are fairly simple. The main agricultural crops were grown on the fertile alluvial soil of the coastal rivers and the Darling Downs. Pasture research was neglected until 20 years ago, hence there were (and still are) only small areas of productive pasture legumes. Up till 1950, less than 100 tons of super were used annually on pastures in Queensland. Over 1,000 tons were used in 1955 and 10,000 tons in 1965.

Phosphoric Acid

Superphosphate is made by reacting finely ground rock phosphate with about half its own weight of sulphuric acid. In the first chemical reaction which takes place, gypsum and phosphoric acid are formed. The acid reacts with more rock phosphate to form the water soluble monocalcium phosphate. If the proportion of rock phosphate and acid is controlled, the gypsum can be filtered off, leaving ortho phosphoric acid (24% P). This acid is termed "wet process" phosphoric acid, as distinct from "electric furnace" acid which is produced from elemental phosphorus. *Superphosphoric Acid* is made by dehydrating "wet process" acid using a submerged combustion technique, to produce 31-34% P material. This contains about 44% orthophosphoric acid and 56% of other phosphoric acids, and is now in use in U.S.A. for the production of high analysis fertilizers, particularly liquid formulations.

Double and Triple Superphosphate

These are made by reacting phosphoric acid and rock phosphate. Triple superphosphate (containing about three times as much P as single super) was first produced in U.S.A. in 1890. Double superphosphate is a term used to describe superphosphates with P contents in between 10 and 20% — they are made either from mixtures of sulphuric acid and phosphoric acid, or from wet process phosphoric acid (which usually contains some sulphuric acid). The sul-

phur content in triple superphosphate may be up to 2%, and about 6% in double superphosphate, compared with 10–12% in superphosphate.

The Phosphate Fertilizers Bounty Act came into force in August 1963 and is current until October 1969. It provides for a \$6 per ton bounty on superphosphate produced and sold for fertilizer use in Australia, with pro rata payments for other P fertilizers and mixtures, depending on their "available" P content. Bounty paid in 1966–67 was \$26 million.

POTASSIUM FERTILIZERS

The element potassium was recognised as a constituent of plants by the end of the 18th century, and shown to be an essential element in 1857. Woodashes (containing 2–10% K) constituted one of the most ancient sources of K for both industrial and fertilizer uses. One of the incentives of Great Britain to establish colonies along the American Atlantic coast was the acquisition of a source of potash supply from woodashes to meet the growing industrial needs of England. Production commenced in Virginia in 1608 and exports continued for two centuries, supposedly retarding the agricultural development of eastern U.S.A.

A British patent for making potash was granted in 1662. The value of potassium nitrate was known as early as 1669, and prior to the discovery of potassium salts in Germany in 1850, it was a major source of fertilizer K. The German deposits at Stassfurt were discovered in 1843, while drilling for brine. Other sources were found in Holland (1862), Alsace (1904), U.S.A. (1911), Spain (1916), Russia and New Mexico (1925), Palestine (1930) and Canada (1946). Up to 1914, Germany contributed 90% of world requirements and then took over the bulk of the remainder—the Alsatian deposits, which were first exploited in 1908. It took the 1914–18 war, when prices reached \$500 per ton, to force other countries to develop their potash resources. Nevertheless, just before the outbreak of World War II, the world production of 2.4 million tons K equivalent was distributed as follows—Germany 55%, France 17%, U.S.A. 10%, Russia 8%, with Poland, Spain and Palestine producing the bulk of the remainder.

Current world production is about 14 million tons of potassium per year. Australian usage is over 50,000 tons, made up of about 100,000 tons of potassium chloride (muriate of potash) and 10,000 tons potassium sulphate. Use has increased 11-fold since 1950 and doubled since 1957. Queensland's first potash shipment (worth £4,500) arrived from Alsace in 1920. Current use is nearly 40,000 tons of potash fertilizer each year, used mainly for sugar cane and horticultural crops. Some potassium sulphate is used for tobacco and pineapples.

All potassium fertilizers used in Australia are imported except for some flue dust from cement works in Victoria used as a liming material but which contains a small amount of potassium. Treatment of deposits of alunite in Western Australia for the production of potassium sulphate commenced during the last war, but processing was abandoned due to high costs in 1950. Texado Mines Pty. Ltd., a local subsidiary of I.M.C. announced in July 1967 a \$13 million project to extract potassium chloride at Lake McLeod 20 miles north of Carnarvon in Western Australia.

N P K MIXTURES

The earliest Queensland-made fertilizer mixtures were formulated from ammonium sulphate, superphosphate and potassium chloride, with some meat works (blood and bone). Small amounts of sodium nitrate, potassium sulphate and bone char were also used. There appeared to be some competition from New South Wales-produced "all chemical" mixtures produced by George Shirley Pty. Ltd. (later Shirleys Fertilizers Ltd.), Paton Burns and Sulphide Fertilizers,

for early annual reports of A.C.F. made special mention, e.g. in 1923: *A.C.F. compound fertilizers have given better results unit for unit because of the organic basis of our fertilizers than where entirely chemical compounds were used, and numerous tests confirmed this statement.* (It is interesting to note that when meatworks became scarce, considerable effort was put into convincing farmers that inorganic mixtures were just as effective).

In the first 50 years of fertilizer use in Queensland, meatworks by-products were an important constituent of fertilizer mixtures. Being ground relatively coarsely, they imparted some texture to otherwise powdery materials, assisting in preventing caking and helping in spreading.

Granulation of fertilizers was introduced at Pinkenba in 1959 and later at Mackay and Cairns. Granulation improved works handling, on-farm spreadability and reduced caking and setting of mixtures. A major problem (rotting of bags) occurred particularly in mixtures containing high amounts of potassium chloride, where as a result of reaction with acids in superphosphate, hydrochloric acid was formed. This was overcome to some extent by using polythene liners in the jute bags, but the problem was not properly solved until ammoniation of mixtures took place in 1962. This involved the addition of ammonia to the granulator (3 lb ammonia per 100 lb super) so that any free acid in the super was converted to ammonium phosphate. The 3% level of ammoniation prevented bag rot without unduly reducing the solubility of the phosphorus in the mixture.

Fertilizer packaging has changed through 187 lb bags to 160 lb and more recently to 112 lb packs. Paper bags were used for super but have now been replaced by heat-sealed polythene packs. Bulk handling of mixtures and superphosphate for aerial spreading has been introduced since aerial application of fertilizers commenced in 1963.

The most recent major advance has been in increasing the N P K contents of mixed fertilizers by using ammonium phosphates instead of sulphate of ammonia plus superphosphate. This has reduced the sulphur content of most mixtures, moreso where concentration has been greatest.

QUEENSLAND FERTILIZER USE STATISTICS

In March each year, Australian primary producers provide agricultural, pastoral and dairying statistics to the Bureau of Census and Statistics. On these statistical returns, they are required to insert information on fertilizer use on a range of crops and pastures, together with the types of fertilizers used. This information is available for Queensland from 1945-46, tabulated on the basis of both acreage and tonnage used by crops and by districts. Since 1964-65, the fertilizer information includes tonnages of straight nitrogen fertilizers, superphosphate and other or mixed fertilizers.

Queensland farmers understate their actual usage, and confusion arises from the use of "superphosphate" and "Other" in that the latter may contain 30-80% superphosphate. The following figures of fertilizer tonnages for various types of crops and for pastures indicate some of the trends in fertilizer use over the last 15 years.

	1951-52	1955-56	1960-61	1965-66
	'000 tons	'000 tons	'000 tons	'000 tons
Sugar Cane	55.5	75.8	75.8	149.0
Fruit & Vegetables	13.4	17.0	20.0	26.7
Other Crops	3.4	4.7	10.3	25.5
Pastures	0.3	1.5	2.1	13.3
	<hr/> 72.6	<hr/> 99.0	<hr/> 108.2	<hr/> 214.3

Acreages fertilized were:

	1951-52	1955-56	1960-61	1965-66
	'000 acres	'000 acres	'000 acres	'000 acres
Sugar Cane	250	339	343	520
Fruit & Vegetables	36	44	56	71
Other Crops	38	65	123	293
Pastures	3	18	21	131
	<u>327</u>	<u>467</u>	<u>543</u>	<u>1014</u>

The average rate of fertilizer application per acre fertilized has not changed over the 1951-66 period. In 1965-66, 92% of the fruit acreage planted was fertilized, 85% of the sugar cane, 64% of the vegetables, 9% of the other crops (cereals, cotton, tobacco, fodder crops etc.) and less than 4% of the pastures.

AMMONIA PRODUCTION IN QUEENSLAND

by

H. G. RODWELL, MANAGER, AMMONIA COMPANY OF QUEENSLAND PTY. LTD.,
BRISBANE.

Prior to 1938 the only ammonia produced in Australia was as a by-product from the towns' gas industry or steelworks. Most of this ammonia was converted to ammonium sulphate for use as fertilizer. Some anhydrous ammonia was produced in Victoria and New South Wales by distillation from gas works liquor and this supplied the refrigeration requirements of Australia, New Zealand, and certain of the nearer islands in the Pacific.

In 1938 ICIANZ installed a small ammonia plant at Deer Park, a suburb of Melbourne. This unit had a capacity of about 5,000 tons per annum and the ammonia was used to produce nitric acid, ammonium nitrate and nitroglycerine for use in commercial explosives of the gelignite type. This plant operated from 1939 until the end of 1967.

During World War II ICIANZ constructed for the Commonwealth Government four similar plants, strategically located at explosives factories throughout Australia. These were at Albion, Victoria; Ballarat, Victoria; Villawood, New South Wales; and Mulwala on the Murray River. You will note that all of these were located south of Sydney. At the end of the war these four factories were almost complete but had not operated. As there was a world shortage of nitrogen fertilizers the Commonwealth Government decided to utilize them to produce ammonium sulphate in sufficient quantity to satisfy a large percentage of the Australian demand. Two of the plants were later purchased from the Commonwealth Government by ICIANZ and operated until the early 1960's. The other two were retained by the Commonwealth but have been shut down.

ICIANZ Ltd. had been investigating the possibility of economically justifying a large ammonia plant since the late 1940's and had one such proposed installation on the brown coalfields at Gelliondale in Victoria. This project was subsequently abandoned.

Electrolytic Zinc Company installed an ammonia plant of 1600 tons per annum capacity in Tasmania in 1956. Sulphuric acid was available by treatment of sulphur dioxide resulting from ore roasting, and it was therefore economical and desirable to install a plant to produce ammonia and ammonium sulphate.

In 1962 ICIANZ decided to install an ammonia plant at Botany, New South Wales with a capacity of 33,000 tons per annum of ammonia and 11,500 tons per annum of methyl alcohol. The outlets for this ammonia were nitric acid for use in ammonium nitrate manufacture and to supply the local market with nitric acid and urea to be used as a high nitrogen fertilizer. The urea plant installed was of Stamicarbon design with a capacity of 33,000 tons per annum of urea. Ammonium nitrate output was largely for use in explosives and because of the change in type during the late 1950's and early 1960's a plant was installed capable of producing a high quality low density prilled product.

The Botany plant commenced operations in early 1964. Later in 1964 ICIANZ Ltd. and A.C.F. & Shirleys Fertilizers Ltd. decided to install an ammonia plant of 50,000 tons per annum capacity, adjacent to the fertilizer works of A.C.F. & Shirleys Fertilizers Ltd., at Pinkenba, Brisbane. The capital value of this plant is approximately \$6m and the plant was sized to meet the Queensland requirements for some years. Both the Botany and Pinkenba plants utilised the naphtha reforming process developed by I.C.I.

The Botany plant was, therefore, the first of the modern ammonia plants to operate in Australia and although there is only two year's difference in design between it and the Pinkenba plant of the Ammonia Company of Queensland Proprietary Limited the latter plant incorporates many new features, and, in fact, is of the most modern design. The major change in the process on modern plants is in the gas production section where the use of coke as a raw material has been replaced by steam reforming of naphtha. The steaming naphtha reforming process has revolutionised gas production and is currently in use in almost all countries in the world for the production of towns' gas and synthesis gas where natural gas is not available.

The ammonia synthesis itself has little changed in the last 30-40 years. The basic steps in the process as operated at the Ammonia Company of Queensland (commissioned late in 1966) are as follows:—

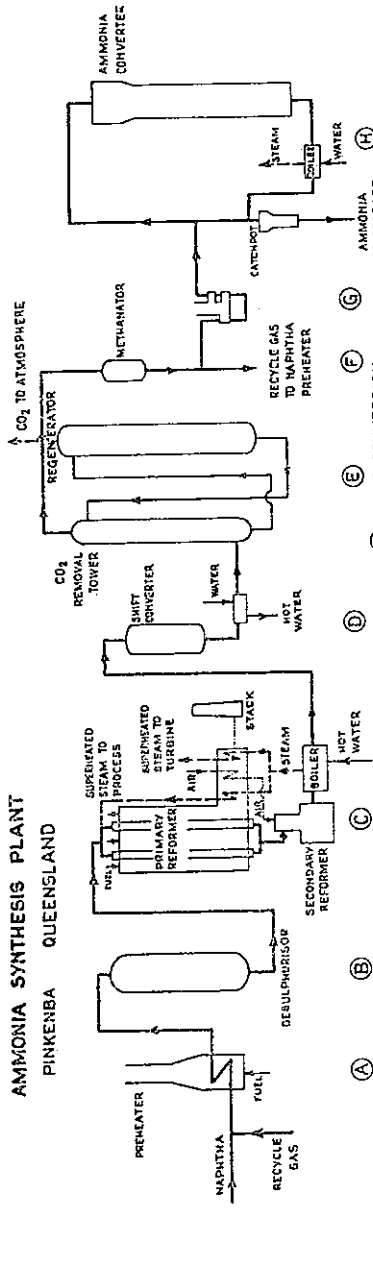
- (A) Preheating
- (B) Desulphurising
- (C) Reforming
- (D) Shift Conversion (See Figure 1)
- (E) CO₂ Removal
- (F) Methanation
- (G) Compression
- (H) Synthesis

The total synthetic ammonia capacity of Australia is now approximately 100,000 tons per annum and half of this is installed in Queensland.

In 1966 a consortium of ICIANZ Ltd., C.R.A., King Ranch and Mitsui decided to install a large ammonia complex at Walsh Point, Kooragang Island, Newcastle, New South Wales. This plant has a design capacity of 180,000 tons per annum of ammonia and will produce nitric acid and fertilizer grade ammonium nitrate. The raw material will be naphtha.

The Kwinana Nitrogen Company, owned by C.S.B.P. is currently constructing a 100,000 ton per annum plant at Kwinana, Western Australia to supply the growing demand for nitrogen fertilizers in that State. This plant will produce nitric acid and ammonium nitrate solution, which will be utilized by C.S.B.P., who are located on an adjacent site. The raw material is expected to be refinery gas from the B.P. Refinery, with whom they are associated.

AMMONIA COMPANY OF QUEENSLAND PTY. LIMITED
 AMMONIA SYNTHESIS PLANT
 PINKENBA QUEENSLAND



(A) **PREHEATING**
 NAPHTHA IS VAPORIZED AND PREHEATED IN A REFINERY GAS OR NAPHTHA FIRED HEATER. A PRESSURE OF 470 P.S.I.G. IS GENERATED.

(B) **DESULPHURISING**
 THE NAPHTHA VAPOUR, TOGETHER WITH SOME RECYCLED HYDROGEN, IS PASSED OVER ZINC OXIDE AND COBALT MOLYBDATE BEDS TO REMOVE SULPHUR COMPOUNDS

(C) **REFORMING**
 SUPERHEATED STEAM IS ADDED TO THE VAPOUR STREAM AS IT ENTERS THE PRIMARY REFORMER CATALYST FILLED TUBES. THE TUBES ARE HEATED BY BURNERS WHICH USE NAPHTHA OR REFINERY GAS AS A FUEL. THE MIXED VAPOUR PASSING OVER THE CATALYST REFORMS INTO CARBON DIOXIDE (CO₂), CARBON MONOXIDE (CO), HYDROGEN (H₂) AND METHANE (CH₄).
 $2C_7H_{16} + 14H_2O \longrightarrow 14CO + 29H_2$



IN THE SECONDARY REFORMER AIR IS ADDED TO SUPPLY NITROGEN (N₂). THE AIR BURNS. FURTHER HEATING THE GAS AND ON PASSING OVER MORE CATALYST METHANE IS CONVERTED TO CARBON MONOXIDE.



STEAM FOR THE REFORMER AND TURBO ALTERNATOR IS RAISED WITH WASTE HEAT FROM THIS SECTION

(D) **SHIFT CONVERSION**
 THE REFORMED GAS PASSES INTO THE CO CONVERTER WHERE CARBON MONOXIDE AND STEAM ARE CONVERTED INTO CARBON DIOXIDE AND HYDROGEN
 $CO + H_2O \longrightarrow CO_2 + H_2$

(E) **CO₂ REMOVAL**
 THE GAS IS SCRUBBED IN A TOWER WITH VETROCKE SOLUTION WHICH ABSORBS MOST OF THE CARBON DIOXIDE. THE VETROCKE SOLUTION IS HEATED IN A REGENERATION TOWER TO LIBERATE THE CARBON DIOXIDE, WHICH IS VENTED TO ATMOSPHERE.

(F) **METHANATION**
 REMAINING CARBON DIOXIDES REACT WITH HYDROGEN IN THE METHANATOR TO FORM METHANE
 $CO + 3H_2 \longrightarrow CH_4 + H_2O$
 $CO_2 + 4H_2 \longrightarrow CH_4 + 2H_2O$

(G) **COMPRESSION**
 THE GAS IS COMPRESSED IN THREE STAGES TO 350 ATMOSPHERES AND IS PASSED INTO THE AMMONIA SYNTHESIS CIRCUIT.

(H) **SYNTHESIS**
 GAS PASSES THROUGH THE AMMONIA CONVERTER. A CATALYST AND HEAT CONVERT HYDROGEN AND NITROGEN TO AMMONIA.
 $3H_2 + N_2 \longrightarrow 2NH_3$

THE WASTE HEAT IS USED TO RAISE STEAM. ON COOLING THE AMMONIA CONDENSES AND IS SEPARATED FROM UNCONVERTED GAS IN A CATCHPOT. THE AMMONIA LIQUID IS LET DOWN INTO THE STORAGE SPHERE.

M/1743 A

FIGURE 1.

In 1967, Austral Pacific Fertilizers Limited announced that they would be installing a 185,000 tons per annum ammonia plant and 200,000 tons per annum urea plant at Gibson Island on the south side of the Brisbane River. Both the Eastern Nitrogen Limited plant and Austral Pacific Fertilizers Limited expect to be in operation by early 1969. When all these plants are commissioned, the installed capacity will, therefore, rise from approximately 300 tons per day in 1968 to 1,800 tons per day in 1969. This dramatic change in output is going to place great demands on the promoters and users.