

187

ORDNANCE FACTORIES

Maribyrnong, Bendigo, Echuca, Northam, Stueell.

When the Government in 1918 decided to abandon the proposal for establishing at Tuggeranong (A.C.T.) a series of factories comprising a Central Arsenal for the production at the one location of munitions of war of all kinds, the section of the Department of Defence which had been engaged in the detailed planning for the Arsenal became the Munitions Supply Board -- i.e. the central administrative authority for managing munitions production throughout Australia in times of peace or of war.

One of the Factories included in the Arsenal concept which the new Board inherited was intended for the production of ordnance and shell, the need for which from local sources was becoming increasingly pressing. Production by Australian industry of large quantities of 18-pdr. shell during 1915-16 on behalf of the British Government had shown that the problems involved could be overcome readily.

It was contemplated that capacity for this purpose should be created once the higher priority needs in war-time planning had been covered. First in line was the establishment of facilities for production of "... articles that are expendable or are subject to relatively rapid deterioration under storage conditions ... explosives and such equipment as cartridges, fuzes and so on".

It was contemplated further that the initial action regarding the capacity to be provided for the production of "...articles which are used as weapons and in general the engines of War ... (which) ... do not deteriorate in store ..." should be "... to establish factories equipped to maintain stocks in good order and to repair the casualties of war".

Possibilities of making guns in Australia had, of course, been given some thought from time to time much earlier. There was, for instance, the enquiry addressed to the British authorities in September 1914 as to the possibility of obtaining from England the technical information and the expert technical assistance needed for the successful production locally of 18-pdr. guns and ammunition. The response was sufficiently discouraging regarding gun manufacture to deter any thought of immediate action apart from the inclusion of gun production in Arsenal planning which began in 1915.

If required for use by Field Artillery, the gun as then visualised had to be provided with an appropriate gun-carriage, together with an accompanying

mounted on wheels and fitted with a "pole" to which two or four horses would be harnessed.

This combination of gun/gun-carriage/ammunition limber comprised the 18-pdr. Q.F. Equipment proposed for local production. Some other guns, with appropriate mountings, were also needed for installation in the fortresses which guarded the approaches to the capital cities in those days.

The manufacture of limbers for 18-pdr. Q.F. Guns and of the supporting "Ammunition Wagons" -- which were designed to maintain supplies of ammunition to the guns when in service -- had been established locally for many years prior to the outbreak of World War I. Robinson Bros. & Co. of Melbourne supplied 251 ammunition wagons and 16 gun-carriage limbers between 1910 and 1913. G.H. Olding & Co. of Sydney delivered 98 ammunition wagons and 34 gun-carriage limbers between May 1913 and March 1916, to be followed by an order for 48 ammunition wagons for delivery in 1918.

Cockatoo Dockyard in Sydney was also given a contract, in 1911, for the construction of five mountings and pedestals for 6-inch B.L. Fortress Guns, the last of which was not delivered until after War started in 1914.

On February 28, 1922, the Munitions Supply Board submitted to the Minister for Defense a programme for the extension of munitions production capacity estimated to cost £900,000 over a six-year period (plus £355,000 which had already been spent for plant and other facilities which would be absorbed) and including £240,000 of the new money for "Ordnance & Shell Production", comprising :-

.. Buildings & Works	£115,000
.. Plant	95,000
.. Gauges and Tools	30,000

Expenditure already incurred for this project totalled £174,500, mainly for plant items purchased during the disposal of surplus munitions plant from British war-time factories. They included many excellent heavy machines including a 1500-ton press for forging heavy gun parts, such as gun jackets and liners.

The proposed new Factory was to be erected on land at Waribyrnong, adjacent to the area already occupied by the Explosives (Cordite) Factory.

Planning and design were entrusted to F.C. Spiller, Engineer-in-Charge, assisted by F.S. Daley and M.M. O'Loughlin, Assistant Engineers. The production contemplated was 18-pdr. and 4.5" Q.F. field artillery components, together with ammunition to serve these guns.

Simultaneously, while the planning of the proposed new Factory was proceeding

training depot which adjoined the site of the Explosives Factory at Haribymong. This depot comprised large barracks, stores, stables, gun parks, amenities blocks and even eight attractive residences, all built in brick and spread over 103 acres of land. Some buildings were extensive in floor-space and could be immediately and usefully occupied for manufacturing purposes, even though not ideal.

Transfer of this property from the control of Army to that of the Munitions Supply Board was approved by the Minister for Defence on September 25, 1922, on reimbursement to Army of the amount expended on the site -- approximately £48,000.

This enabled the plans for the Ordnance Factory to be advanced by several years and provided reserve space that was to be of immeasurable value for the extensions needed after the outbreak of World War II. Two brick buildings -- formerly large stables -- were adapted for a shell-production unit and a toolroom with stores and tradesmen's shops ^{were} accommodated in other existing buildings.

The first unit of the Factory to be ready for production was, consequently, the experimental shell shop in which some 40 reconditioned British machines were installed in 1924, together with hydraulic copper-banding press and sand-blast units. Machines selected from those used by Australian engineering concerns who had undertaken during World War I to make high-explosive shell-bodies for the British Government were also installed.

Twenty-five 18-pdr. high-explosive shell bodies were produced in 1926 in a pilot run to prove the tooling and to test the planned sequence of operations. Although there was at the time no Army demand for this ammunition, a first production run of 1,000 shell was then authorised, the completed shell to be held in store awaiting Army orders.

Included in the products contemplated under this expansion programme to be made at the new Ordnance Factory were guns and gun-carriages up to 4.5 inch calibre to a total of 38 a year on the basis of a single-shift of 48-hours weekly and 50,000 shell annually. Initial production was proposed of 18-pdr. equipments, then the 4.5 inch howitzer and later the 60-pdr. B.L. gun. The project was approved by the Government on May 22, 1922.

How to make the 18-pdr. gun had been studied by engineers Daley and O'Loughlin at Woolwich Arsenal in England during 1919-20 and the planning for the Ordnance Factory included capacity for making that gun. Despite the efforts which went into the production of the tooling and gauges for making the gun and the

wide depression of the early 1930's and the increasing obsolescence of the 18-pdr. gun - which had been a standard weapon of the British Army since 1904 - brought about the abandonment of the project in favor of a more modern gun.

It was recognized that, while the gun-manufacturing plant would be balanced for an out-put of 38 gun-equipments annually, a considerable proportion of the plant would have machining capacity for a much greater output per machine and that many of the machines could handle larger types of guns if necessary.

This reserve capacity enabled the Factory in later years to undertake production of the much larger anti-aircraft guns without the need to purchase and house complete new plants. For each new type of gun, however, some additional machines were needed.

The first of the new buildings to be erected was the large workshop planned specially for production of guns and gun-carriages -- a steel structure in two bays, each 50-ft. wide and 350-ft. long and each served by a 10-ton travelling crane.

Factory planning provided next for the setting-up of the Smithy and the Forge, for which suitable mechanical hammer and forging presses -- a 3-ton steam hammer, a 1500-ton hydraulic forging press and several shell-forging presses -- had been procured in England under the arrangements for disposal of war-time surpluses.

Funds to a total of £31,000 for the erection of the Forge Shop -- a building 200-ft. long by 120-ft. wide -- were approved during October 1924. Another 100-ft. was added to the length of the building later.

During 1925, Spiller resigned and Brodribb carried on with the establishing of the Factory as Acting Manager with Daley as Assistant Manager responsible for the Carriage Factory, Toolroom and Woodworking Plant and O'Loughlin as Assistant Manager in charge of the Gun Factory, Shell Factory and Forge.

During 1926-27, installation of plant was completed in the Gun-machining Shop and the Carriage Shop was approaching the same stage. Construction commenced that year of the General Woodworking Shop to cost £21,000, to which it was intended to transfer the activities undertaken in the existing woodworking plants at the Ammunition and Explosives Factories, as well as responsibility for production of artillery vehicles and any other timber products needed by the Services in time of war.

In the Forge Shop the 1500-ton hydraulic forging press was erected during

the construction of the hammer and shrinking furnaces and pits, hydraulic

By June 1929, when the work-force totalled 162, manufacture of tools, jigs and gauges for the recoil mechanism of the 18-pdr. gun-carriage was still in full swing and facilities were being provided also for the quantity production of high-explosive and shrapnel types of shell for 18-pdr. guns and for the 20-cwt. anti-aircraft 3" gun.

The Ordnance Factory capacity at that stage included a large forging shop equipped with the largest hydraulic forging press in Australia, together with appropriate supporting furnaces. It was, consequently, possible to forge large gun-bodies. There were also carriage and gun-machining shops, a steel-plate fabricating shop and the wood-working shop. Gun manufacture, however, did not commence until 1934, when an order was received for supplies of 3" 20 Cwt.A.A. guns for the Army. The first of these guns passed proof tests at Port Wakefield (S.A.) on June 22, 1937.

In common with the other Factories, the Ordnance Factory was conducted under "nucleus production" conditions after the Great Depression 1930 restricted Defence activities. By mid-1930, however, production of 18-pdr. and 4.5" How. shell had commenced and the completed cartridges passed all tests. Shell for the Navy had been ordered and commercial demands for such items as forgings and metal and wooden components of motor-cars and marine engines were in hand. In 1931, 8" Naval projectiles and 250-lb. G.P. Aircraft bombs were made for the first time.

The following figures indicate the volume of work undertaken at the Ordnance Factory during the worst of this Depression period and the source of the orders in hand :-

Year	Source and value of orders				Total
	Defence Dept.	Other C ^o wealth Dents.	State Gov't Semi-Govt.	Commercial	
	£	£	£	£	£
1929-30	10,413	9,143	-	215	19,776
1930-31	37,550	6,487	98	2,212	46,347
1931-32 (anticipated)	20,000	1,000	250	12,470	33,720

Service orders in hand at this time included the conversion of 6-inch shell, manufacture of 60-pdr. cast-iron shot, reconditioning of 18-pdr. shell, lapping and milling of 6-inch B.L. guns and the modification of breech mechanisms and percussion locks.

A large volume of grinding and repair work was carried out on aero and

192.
piece of apparatus -- a Colestat -- was in production for the Mount Stromlo Observatory at Canberra.

Replacement by Australian-made products of the motor-car and truck axles which were being imported by the motor industry from America was discussed with the Factory management during 1930, at the time when the Factory's forging equipment had been installed and proved but was likely to be lightly loaded with service orders because of the Great Depression.

After a trial batch of car axles to be sold as replacement parts had been forged to the complete satisfaction of General Motors (Aust.) Pty.Ltd., it was agreed, despite protests from the Victorian Chamber of Manufactures, that orders would be accepted from that Company for car parts previously imported and that orders would not be accepted from any other party for motor-car components which were obviously intended for fitment to General Motors cars. Motor-car shock absorbers and universal joints were also made, together with adjustable wrenches -- but a "threatened" order for tin-openers was not accepted!

This work, however, tapered off by the end of 1931, when the General Motors group commenced production within its own factories. Daley, Assistant Manager of the Ordnance Factory, resigned and joined the Company in this venture but was not replaced at the Ordnance Factory, the only change in the duties of the management team being that the Chief Draftsman (A. Healand) was given responsibility for the oversight of the Toolroom as well as of the Central Drawing Office.

Increasing demands by the Services compensated for the loss of this commercial work, including shell and other components of artillery ammunition in various calibres. A substantial order for 8" practice shell of a type formerly imported from England brought into use on a production order for the first time the 1500-ton hydraulic press and associated furnaces. By the end of 1930, 20 different varieties of projectiles were being made, as well as anti-submarine depth-charges and smoke-floats to be filled at Explosives Factory, Warrilyrnong.

In the Woodworking Shop, the growing importance of the R.A.A.F. was reflected in the orders handled for the reconditioning of a Seagull flying-boat hull and of Wapiti sea-plane floats. Other aircraft work successfully handled during the next few years included the production of six De.Havilland Moth fuselages together with thousands of metal components for Moth, Bulldog, Wapiti and other types of aircraft being assembled and maintained in R.A.A.F. workshops as well as

ranges and a large assortment of details of camp equipment added to the variety.

Australian timbers had largely replaced imported timbers in this work, more than 200,000 feet of mountain ash and pinus radiata having been expended, together with lesser quantities of King Billy pine, yellow-wood, blue gum, spotted gum and jarrah.

Pressure on the Factory for the production of projectiles for the Army and the Navy -- 15 types of shells and bombs were on order in early 1933 -- emphasised the inadequacy of the converted stable then being used as a Shell Factory but which had been equipped merely as a pilot plant for systematic study of manufacturing techniques.

Consequently there was included in the 1933-34 Estimates the amount of £35,000 for a Projectile Shop of about one-acre of floor space to cost £30,000, plus £5,000 for plant and tools. This was approved in September 1933 and the new building was available in December 1934.

In February of that year, O'Loughlin -- at this time Works Manager of the Factory -- left for England for 12 months to study the machining and forging of heavier types of projectiles and the manufacture of light armored-cars and of aero engines, as well as the production of the mobile 3-inch 20-cwt. anti-aircraft gun then favored for strengthening the nation's anti-aircraft defence.

An order for 24 of these guns in 1934 launched the Factory into gun production. The first guns, completed in 1936, introduced the system of "Auto-fretage" for making gun tubes and liners. Under the system, worn liners could be replaced by new ones in half an hour as compared with the earlier method of using heat and shrinkage to build the new liner into the outer gun-jacket, involving a period of months.

During O'Loughlin's absence, planning of the necessary additional factory buildings proceeded actively, provision having been made in the 1933 Programme to the amount of £25,000 for this purpose, as well as £13,700 for a new Toolroom to replace the converted stable still being used for housing the precision machinery for tool and gauge manufacture as well as taking care of the work on the anti-aircraft gun.

To cope with the increasing requirements of forging work for gun and shell manufacture and the heat-treatment of various steels, approval was given in 1936 for the Forge Building to be increased in area by 50 per cent. at a cost of

increasing volume of fabricated steel work, including the mountings and parts of the travelling platform of the 3-inch anti-aircraft gun and armoured-car bodies.

With the retirement of Leighton from the position of Controller-General of Munitions Supply, he was succeeded, on November 2, 1937, by Brodribb whose place as Manager of the Ordnance Factory was taken by O'Loughlin. The other Assistant Manager (Statton) was promoted to the position of Sub-Manager until 1939 when he became Manager of the Ammunition Factory. R.H. Doyle transferred from the Small-Arms Factory to become Sub-Manager of the Ordnance Factory.

Experience during the first 12 years of operations at the Ordnance Factory had clearly demonstrated that the quality and variety of the plant installed there and the training and experience of the work-force were such that there appeared to be no requirement of an engineering nature likely to be demanded by the Australian Services which technically could not be handled successfully.

It was, however, another matter when volume of production became important, as it did when effect had to be given to the conclusions of the Imperial Conference of 1937, as reflected in the augmented Four-Year Programme - to be spread over the period 1936-37 to 1939-40 -- with provision for extensions at the Ordnance Factory at an estimated cost of £330,000, as follows :-

.. Extensions to the Gun & Carriage Workshops	£65,000
.. Additions to the Toolroom	20,000
.. Additions to the Projectile Shop	30,000
.. Roads, Drainage, Sewerage, etc.	<u>4,000</u>
	£119,000
.. Plant and Tools	<u>£211,000</u>

By the end of 1937, both gun and shell manufacture were proceeding satisfactorily.

Also included in the new Programme was £300,000 to establish new capacity for the manufacture of the heavier 3.7 inch anti-aircraft gun on fixed mounting. A saw-tooth building, 525 feet long by 162 feet wide, was built for this purpose, to house machine tools and other plant selected as the best available throughout the world. In the programme funds were provided also for substantial additions to the plant for tool and gauge production, for a new Shell Shop and for another new building for the manufacture of machine-gun links, pyrotechnic stores and sheet-metal components.

The new Shell project included the installation of a second complete shell-forging plant which, incidentally, was ordered from Germany as being the most modern of its kind in both speed of output and economy of operation. This

10 months after the drawings of the guns were received in Australia. By 1943, these guns were being produced at the rate of four per week.

In October 1938 a further revision of the programme ^{had been} ~~was~~ prepared which, so far as the Ordnance Factory was concerned, included :-

- .. increased production of anti-aircraft guns;
- .. provision for heavy plate work for armored cars;
- .. repair and reconditioning of guns and equipment; and
- .. plant for producing 9.2-inch projectiles and 250-lb. bombs.

While these expansion projects were being developed, production activities were proceeding on a modest scale. For 1936-37, the Factory output was valued at £72,630 and at £95,847 the following year, by which time the work-force had increased to 845, many of whom were engaged in developing new projects. Production for 1938-39 had jumped to £338,120 in value.

By June 30, 1939, the Factory assets were valued at £1,452,193, including:-

.. Land and buildings	£447,009
.. Machinery and plant	757,331
.. Stocks in hand and work in progress	248,124

and the 1,325 employees included 51 females. This was a dramatic increase in the work-force from 657 in 1936, 695 in 1937 and 845 in 1938. By April 1941, the total was 3,639 of whom 172 were females.

Still further extensions at the Ordnance Factory were provided for in the Expansion Programme proposed in June 1939 which included £300,000 as the estimated cost of a factory to make 25-pdr. Q.F. gun-howitzers.

In a statement submitted for War Cabinet consideration on September 6, 1939, which included proposed expenditures of £855,000 (of a total of £2,755,000) "... to provide extensions to the Gun, Gun Ammunition and Explosives Factories for manufacture of 25-pdr. field-gun equipments and ammunition", it was noted that:-

"The present gun and ammunition Factories cannot undertake the 25-pdr. gun equipments and ammunition while they are employed upon other war requirements. The present Gun Factory is already prepared to undertake to make the large number of 2-pdr. Q.F. Anti-Tank Gun with its existing resources.

"The 18-pdr. and 4.5-inch Q.F. guns and carriages are obsolete although quite effective for local defence. The 25-pdr. equipments, however, would be required for an overseas Expeditionary Force.

that overseas orders can be expected. The plant to be purchased would be suitable for more anti-aircraft guns if required."

The War Cabinet Decision, dated September 29, 1939 was as follows:-

"Above approved, with exception of £855,000 provision for 25-pdr. gun and its ammunition. The Anti-Tank Gun manufacture is to be proceeded with."

On other papers, a direction was given to proceed also with the 3-inch mortar at the Ordnance Factory.

The case for establishing plant for the production of the 25-pdr. guns and ammunition was strengthened by the request received from the British authorities on October 19, 1939 for proposals regarding the supply of that gun, together with a forecast of likely deliveries. Further consideration by War Cabinet was, however, indecisive until it was pointed out that, irrespective of the desirability of assisting with supplies of these guns for Britain, additional gun-making plant was essential to meet the war-wastage of the obsolete 18-pdr. and 4.5-inch guns with which the Australian Army had been equipped during World War I and earlier and that any surplus capacity could be absorbed on production of 25-pdr. guns if still required.

On January 17, 1940, capital funds totalling £400,000 were approved for the production of 25-pdr. gun equipments but production of ammunition for those guns was still not authorised. Later, with further extension of the 25-pdr. gun project, the gun carriages and trailers were entrusted to industry and instead of two gun equipments per week, the Factory built up its output to 16 guns and breech mechanisms a week.

By "good" planning, a building already being erected at the Ordnance Factory as a charge against funds provided for another smaller project approved earlier and which had floor-space of 3½-acres with provision for extension to 5½-acres -- the latter being coincidentally (?) the same space as was needed for the 25-pdr. gun plant -- was able to be "diverted" for the new project. Jensen claimed that his confidence that the 25-pdr. project would eventually be approved had inspired him to anticipate approval and to plan the building for that project.

Four months later -- May 21, 1940 -- approval was given for an expenditure of £30,000 for further shell-forging plant and furnaces for the Factory to provide for production of 400,000 shell annually and to safeguard the Factory against any breakdown in the German plant then operating. Statistics prepared at that time show

... and four anti-aircraft guns were being

On June 18, 1940, approval was given for the expenditure of £1,980,000 as the first section of a further programme estimated to cost £14,000,000 for increased manufacturing facilities to meet the expected war-time needs of the Army. This initial stage included the proposed installation at the Ordnance Factory of three units of shell-forging plant from the U.S.A. at an estimated cost of £110,000.

Two months later, the Treasury obtained Parliamentary approval for a Loan Bill of £10,200,000 which included £1,000,000 for gun-production, £700,000 for Aircraft bombs and £4,000,000 for the Government Factories section of increased gun-ammunition production.

On September 18, 1940, £400,000 (increased to £500,000 three months later) was provided for the production of bombs for the R.A.A.F. The outstanding item in this project was the 250-lb. semi-armour piercing bomb to be made at the Ordnance Factory. Additional buildings and plant for gun manufacture at the Factory were authorised on April 3, 1941, at an estimated cost of £290,000 and £156,802 was provided on June 30, 1941 for further shell and bomb manufacturing capacity.

The original Factory -- No. 1 Gun Shop and No. 1 Projectile Shop -- provided for the annual production of 38 guns and 50,000 shell under 1926 planning conditions. These shops had been supplemented by additions which had been built, equipped with plant and brought into service before the War-time production peak had been attained, in 1943, comprising:-

- .. Projectile Factory -- for production of 750,000 shell of some 30 types annually, and including limited quantities of shot also.
- .. Woodworking Shop -- for production of ammunition boxes and other timber items as needed.
- .. Sheet-metal & Pressed-parts Factory -- for the manufacture of charger clips and machine-gun links for .303" ammunition at the rate of 20,000,000 annually.
- .. Shell & Bomb Forging Unit -- for the weekly production of :-

250-lb. S.A.P. Bombs	500
500-lb. S.A.P. Bombs	100
25-pdr. shell forgings	30,000
6" shell forgings	3,000

together with other miscellaneous forgings, including those for 9.2" H.E. shell.

.. No. 2 Machine Shop -- for an output of :-

Predictors (which control the fire of anti-aircraft guns)	5 per month
25 pdr. guns (ordnance)	16 per week
Bofors A.A. guns	5 per week

with provision for an increase to 10 per week of certain Bofors components

.. Plate Shop -- to cater for the production of mountings for 3.7" and Bofors guns.

.. No. 1 Machine Shop Extension -- for machining 3.7" A.A. guns at the rate of 4 per week as well as 4" Naval Ordnance (guns only), the relining of barrels of 4" Mark V naval guns and general purpose machining involved in the reconditioning of machine-tools.

.. No. 2 Projectile Machine Shop -- for the production of 250-lb. S.A.P. bombs, of 8" Naval practice shot and of other heavy projectiles.

.. No. 1 Gun Forge Shop Extension -- including the installation of several horizontal "Bogie" heat-treatment furnaces and of large vertical electrical furnaces complete with subsidiary quenching tanks for the heat-treatment of guns up to 6".

As at June 30, 1943, capacity had been provided also for the production of 500-lb. S.A.P. bombs, 9.2" shell, 40-mm and 3" 20-cwt. AA guns with mobile mountings, and 3" 17-pdr. AA guns (ordnance only) with which it was planned to replace the 25-pdr. guns.

Pressure on the capacity available at the Maribyrnong Factory had made it necessary not only to place orders with commercial industry through the Ordnance Production Directorate (see page 237), but also to plan to provide relief on a decentralised basis by the establishment of suitable Government Factory capacity in country locations in Victoria which could be supervised by the parent Factory. O'Loughlin had by this time been appointed also as Divisional Manager for the Ordnance Group with responsibility for the activities at the Maribyrnong Factory and also of those being set up at country centres in the western half of Victoria.

ORDNANCE FACTORY, BENDIGO.

Of these subsidiary Factories, the most important was that located at Bendigo, where plant was installed to handle the heavier types of ordnance production, including 4" Naval guns and the machining and grinding of air-vessels for

It is pertinent to point out that the relining of a large Naval gun -- such as the 8" type -- is a major task. In fact, in 1941, no facilities existed anywhere in the world-wide British Commonwealth for carrying out work of this kind outside the United Kingdom.

The decision to equip the Bendigo Factory was, consequently, made against the background that the only alternative so far as the Royal Australian Navy was concerned would be to continue to send the "used" guns -- across thousands of miles of sea routes menaced by German submarines -- to the British Naval repair yards.

The 8" gun barrel was 35-ft. long and weighed 17-tons. The largest gun previously handled by the Australian Ordnance Factory was the 4" with a 16-ft. barrel and a weight of only two tons. To handle the 8" gun-barrel, an unusually large gun-boring lathe -- more than 120-ft. in length -- was installed at Bendigo, together with other plant items on a similar grand scale.

Success in the handling of this task was due largely to the generous assistance of the Canadian authorities in making available hard-to-come-by heavy gun boring and engine lathes and to the welcome given to O'Loughlin at the U.S. Naval Establishments where such tasks were undertaken, including the opportunity to study in detail and to adopt for Australian purposes the American practices and the tooling developed specially for the task.

By June 30, 1945, the Factory activities included the modification of 4.7" guns, the production of three and six cylinder Diesel engines, of clips for Browning weapons, of pontoons and of spare components for 2-pdr. and 6-pdr. guns.

Employment at the Ordnance Factory at Bendigo, which had averaged around 800 in mid-1945, had dropped to around 400 twelve months later. By that time, the programme of relining of 6" guns for the Army and of 8" guns for the Navy had been completed. Manufacture of 3-cylinder Diesel engines for the Army and of forged rings and balls for the Ball-Bearing Factory established at Echuca continued. The Factory was also well advanced in the planning and tooling-up for a major new programme -- the production of twin-mountings for the Navy's 4.5" guns for installation in the six "Battle" class destroyers, ^{two} of which were already being built as part of the Defence programme.

Approval had been given also for the erection of a new building to house the specialised plant needed for the cutting of turbine gears for these Naval vessels, a task which was to put to the test the skill of the Factory's most

CENTRAL DRAWING OFFICE.

Original functions entrusted to the Central Drawing Office when it was established as a section of the Arsenal organisation during the closing stages of World War I were as follows :-

- .. Organisation of drawing and recording office activities and systems;
- .. Preparation of drawings in connection with the construction programme of the Department;
- .. Survey of sites and preparation of plans for Factories and works;
- .. Design of factories, plant, services and equipment and the inspection of plant under construction in association with and under the direction of technical officers; and
- .. Drafting of specifications for buildings, services, plant, machinery and equipment and the preparation of estimates.

Providing a service to all Factories, C.D.O. reached a peak of employment in 1942 with a War-time branch in Adelaide and with staff totalling 258. Output for that year comprised 11,542 drawings plus no fewer than 2,115,331 "reproductions" in the form of contact prints from tracings of drawings, photographic prints, etc. For 1943, the corresponding numbers were 10,758 and 2,299,808 respectively, representing more than 2,000,000 square feet of printed surface for the year.

In addition to these "reproductions", of prints and photographs, C.D.O. was responsible for the duplication of records, technical data, photography, cinematography and film projection, as well as the recording and storage of the master copies of Factory Board and "foreign" drawings, records of manufacture, technical data, etc.

Before the War ended in 1945, C.D.O. had stored and indexed in its strong rooms approximately 150,000 drawings and 650 process specifications. Duplicate copies on 35 mm microfilm were made of all original drawings during the War years as a precaution against destruction of the originals and, together with selected documentary information, were transferred to a remote area for safe-keeping.

Among the unusual demands successfully handled by C.D.O. was the reproduction of the maps which were required for the preliminary discussions on military operations in the South-West Pacific Area. Those 20-ft. by 16-ft. maps involved the printing and developing of sheets of sensitised paper measuring 16-ft. by 3-ft. 6-ins. each.

variety of stationery, forms, brochures, reports, booklets and books including illustrations in colour in some instances. The standard of the work compared very favorably with that produced by the leading commercial printers.

Planning for the BALL-BEARING FACTORY at Echuca began in 1942 when the problems of providing supplies of ball and roller bearings needed for the War effort were becoming increasingly acute. It was, nevertheless, only after lengthy negotiations with the Lend-Lease authorities that authority was obtained for the procurement in U.S.A. of the special-purpose machines needed for this task. The approval given was for American supply of about 50 per cent. only of the plant needed -- the more specialised items. The more general-purpose machines would have to be provided locally.

American assistance included the opportunity for two engineers of the Ordnance Factory, Maribyrnong -- J.S. Brown and A.D. McRae -- to study the technique of making complete bearings as practised at the works of the New Departure Manufacturing Company, a division of the General Motors Corporation.

It should be realised that the Echuca Factory had been planned as an emergency plant only -- i.e. to meet approximately 10 per cent. only of the total Australian requirements -- but with capacity for producing all types of bearings from 1½" to 6" outside diameter on a production basis and other sizes by tool-room methods. Steel balls and steel rollers in sizes from about ½" to 1¼" diameter would also be made.

Planning was for a daily output, on an emergency basis, of --

½-ton of steel balls

500 ball or roller bearings

together with a quantity of steel rollers. It is of interest to note the planners' claim that ½-ton of steel balls represented more than 7,500,000 balls of ½" diameter and approximately 121,000 of ¼" diameter and that, if a long run of any particular size of bearing were maintained, the forecast daily output could be increased.

Production commenced in June 1944. By June 30, 1945, 26,000 bearings had been delivered and an output of 8,000 complete bearings monthly had been achieved. Twelve months later, an increase of 100 per cent. on the 1945 production was claimed, together with a substantial reduction in the direct-labour costs as the result of increasing skill and experience of the work-force, combined with improved

machine tools, etc. but included also those needed for -

Gray marine diesel engines -- 1715 set s
(as made by General Motors-Holdens)

Cheetah aircraft engines -- 40,000 steel balls

Gravity conveyor rollers -- 6,000,000 steel balls

Mechanical coal-winning equipment -- 29 sets of large thrust-bearings.

Post-War activities at the Ball-Bearing Factory saw the installation of additional plant and the improvement of manufacturing technique. Despite intense competition for orders from the major bearing manufacturers overseas, General Motors-Holdens^{Pty} Ltd. placed sufficient orders with the Factory for the supply of certain bearings as original equipment for its Australian motor-car project, to supplement orders for general industrial bearings and thereby to maintain the Factory in existence but only on a limited basis, employing around 200 people.

The Department of Defence Production, satisfied that effective local Factory capacity had been provided and that the ability of the Australian tradesman to make bearings had been established, accepted the fact that further development of the Factory was tied with the supply of bearings commercially and that a Government Factory in this field should not attempt to compete for commercial business with private enterprise.

Tenders were accordingly invited in 1959 for the purchase of the Factory as a "going concern" and with a guarantee of continued operation required from the successful tenderers. A combination of three overseas manufacturers - Ransome & Marles Bearing Co. Ltd., England; SKF Ball-Bearing Co., Sweden; and Skefko Ball-Bearing Co., England -- submitted the tender considered to be most favorable to the Commonwealth and the Factory is still operating successfully.

COUNTRY FEEDER FACTORIES.

At the time of maximum demand in 1942-43, it was planned that the Ordnance Factory, Maribyrnong should also have the assistance of "feeder" factories at Hamilton, Horsham, Stawell and Swan Hill. At each of the first three locations it was decided to establish shell-machining units with an output of some 315,000 25-pdr. shell bodies annually, commencing late 1943 to early 1944. The Horsham Factory was in production from September 1943 until 1945 and the Stawell Factory until December 1944. Production at Hamilton was limited to machining of 3" mortar bombs. Because of the programme revisions in 1943, however, the Swan

POST-WAR ACTIVITIES

During this expansion period, production at Ordnance Factory, Maribyrnong had been varied in September 1943 by the introduction of work against an order for 12 ocean-going small-craft, each 85 ft. 9" long. The first was delivered by January 23, 1944. The over-all volume of Ordnance Group activities generally was, however, shrinking by that time in parallel with the revision downwards of orders for ammunition and other war-like stores. Employment in the Factories exceeded 6,000 in mid-1943 but had fallen to 3,300 two years later, by which time the Group was virtually restricted to the Maribyrnong, Bendigo and Echira Factories.

While the Ball-Bearing Factory was steadily gaining in importance on Australian commercial supplies, the Ordnance Factories at Maribyrnong and Bendigo were providing invaluable service during the 1950's for the Naval shipbuilding programme. Maribyrnong was busy with 4.5" Q.F. guns for the mountings being built at Bendigo, with 21" P.R. Mk. 4 torpedo-tube mountings, with anti-submarine mortars, with the conversion of Bofors mountings for the "Battle" and "Daring" class destroyers and other small ships, and with S.T.A.A.G. mountings - for Bofors guns used as close-range anti-aircraft armament - for the destroyers.

Production of thousands of 20 mm. Hispano and 40 mm. H.E. shell a month, and of 4.5" H.E. shell maintained reasonable work-loads in the Shell and Projectile section of the Factory. Assistance was given to the Marine Engine Works by production of components for Doxford engines up to 4,400 h.p. for cargo freighters and bulk ore carriers, and substantial orders for tractor parts added an element of commercial work to the Factory programme.

At Bendigo, in addition to the major task with the 4.5" Twin R.T. 41 mountings for the Navy's destroyers, the order book included also torpedo tube mountings for Daring class destroyers, conversion of General Grant tanks, production of high-precision main propulsion gearing for turbines of destroyers and frigates, mass-production of .303" chargers and links for 20 mm. Hispano cartridges, "Vivian" diesel engines and a supplementary commercial programme of tractor parts to those being made at Maribyrnong.

Further commercial orders flowing to the Bendigo Factory involved production of hundreds of thousands of insulator pins for the Victorian State Electricity Commission and, at the other end of the size scale, huge valves and other control units for the Snowy Mountains Hydro-Electric Authority, cylinders for carpet-making, and hundreds-of-feet-long kilns for cement works.

was an important factor in enabling the work to be undertaken efficiently. At the same time, the commercial work helped in keeping in service costly plant needed for Defence projects and also in maintaining the skills of the tradesmen using the machinery.

MARINE ENGINE WORKS.

The Commonwealth Government Marine Engine Works had been established at Port Melbourne in the early stages of the 1939-45 War at a cost of approximately £250,000, supplementing a similar Works at Brisbane, conducted by Evans Deakin & Company. They were required to build "the steam main propulsion machinery" for some of the larger merchant ships ordered by the Australian Shipbuilding Board, with existing engine works in New South Wales providing for ships built in that State.

War-time production at the Port Melbourne Works included :-

- .. two triple-expansion engines of the River Class Ships (9,000 tons), each of 4,100 shaft horsepower and including a Bauer-Wach exhaust turbine
- .. four similar engines of 2,750 shaft horse power for "B" Class steamships (6,000-tons)
- .. three double-compound "LENZ" type engines of 1850 shaft horse-power for "D" Class ships (2,500-tons).

Shortly after the War ended, the decision was reached by the Government to dispose of the Engine Works at Brisbane but to retain that at Port Melbourne as a Government Factory to continue to provide engines for Australian-made ships. It was decided also to change from the production of steam engines to marine diesels.

To this end, a licence was arranged with William Doxford & Sons (Engineers) of Sunderland (England) authorising Australian production of the Doxford design of opposed-piston marine diesel engines and providing for all technical and other assistance needed in establishing production and maintaining the engines in service.

Plant installed at the Marine Engine Works has been maintained at modern standards, single units ranging in size from the large planer - with a stroke of 31-ft., accommodating work pieces up to 14 ft. between the columns -- to a very small highly-precise automatic machine for drilling holes of .025"-diameter in

bays with the central section high enough to house Doxford engines up to 33 ft. high. There was also a test annexe to permit full-load testing of the engines. Plant installed included heat exchangers, evaporative coolers, starting air-compressor and receiver, oil and water pumps and a hydraulic dynamometer capable of absorbing up to 6000 brake horse-power.

Engines were thoroughly tested before being delivered - each engine was backed by a guarantee of satisfactory performance and effective continuing after-sales service. Supply of spare parts for Doxford engines in ships visiting Australian ports was also assured.

Although specialised items of equipment for the engines were usually imported, there was approximately 80 per cent. Australian content in the engines as delivered to the shipyards. Most of the forgings and the major fabrications - bed-plate, columns, etc. -- were supplied by Ordnance Factory, Maribyrnong and that Factory and Ordnance Factory, Bendigo assisted also with machining of components.

When the Engine Works replaced production of the Doxford engines by the more modern Swiss-designed "Sulzer" engines, the same close collaboration with the other Factories in the Ordnance Group was maintained.