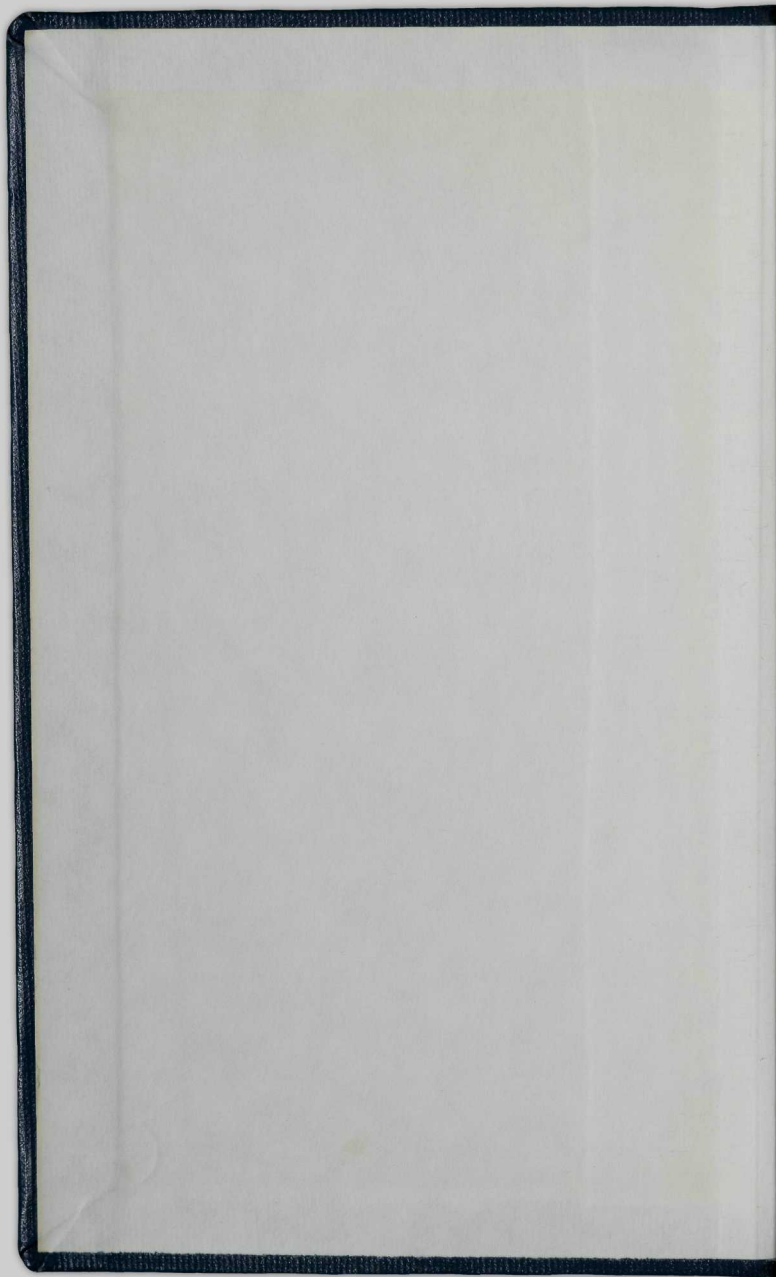


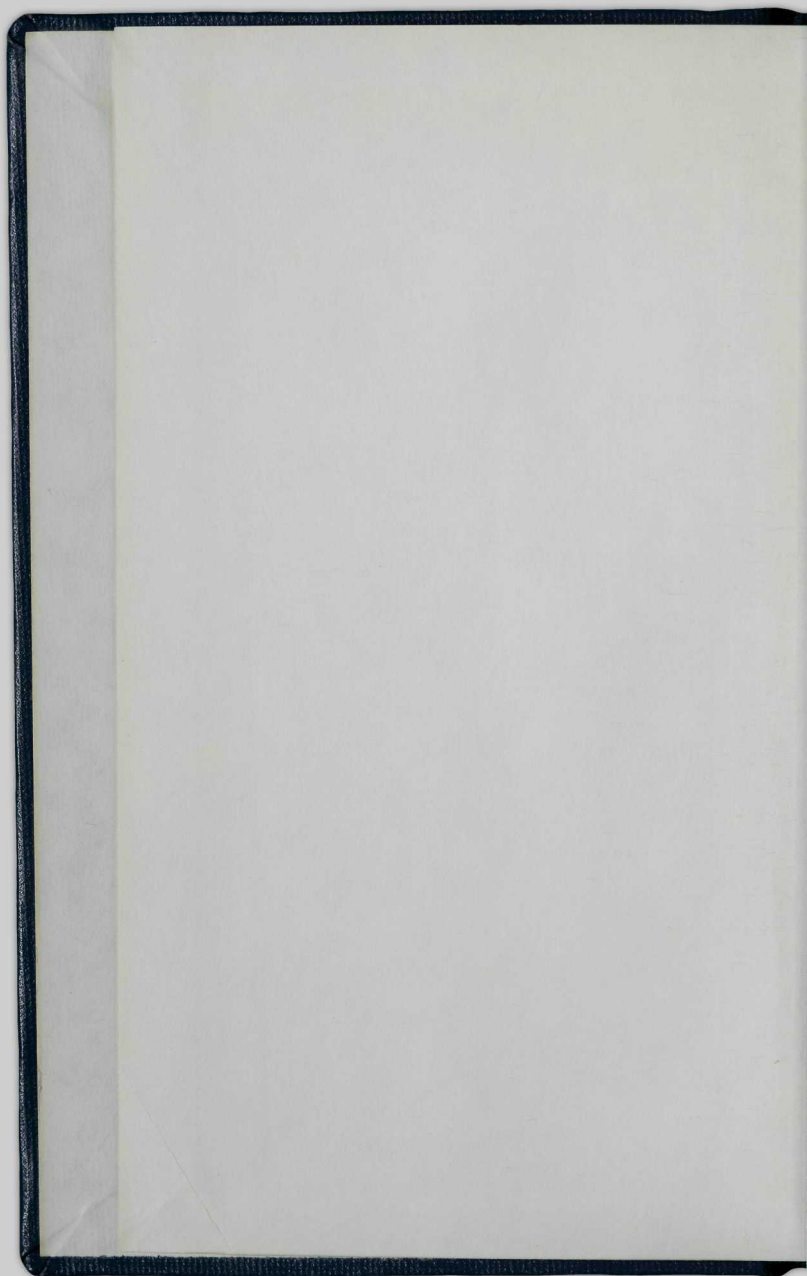
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THE HISTORY OF MUNITIONS
SUPPLY IN CANADA, 1914—1918

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FIELD-MARSHAL H.R.H. THE DUKE OF CONNAUGHT, K.G., GOVERNOR-GENERAL
OF CANADA, 1911-1916

[From photograph by W. & D. Downey]

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H.R.H. The Duke of Connaught

FIELD-MARSHAL H.R.H. THE DUKE OF CONNAUGHT, K.G., GOVERNOR-GENERAL
OF CANADA, 1911-1916

[From photograph by W. & D. Downey]

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FOREWORD

By the Rt. Hon. D. LLOYD GEORGE, O.M., M.P.,

First Minister of Munitions, England, and subsequently Prime
Minister during and after the War.

To most of us it is an effort to recall with any clearness the events of 1914-18. To some it is difficult by reason of the deadening after-effects of the strain of that prolonged nightmare of strife. To others it is painful, owing to the smart of the wounds inflicted on our souls, of which the scars have not yet healed. Nevertheless, amongst the recollections, sad, bitter or proud, of our efforts to carry on during that period there are memories of incidents, activities, and developments so great in conception, so appealing in sentiment, so fruitful in result, that they stand out against the sombre but glorious background of that time of trial. And of these possibly the greatest from a national point of view was the immediate confirmation by act and deed of the solidarity of the Empire brought about by the threat to its existence.

In 1914, when the storm broke, our thoughts at first turned, naturally, in the direction of the provision of fighting forces—man-power, always the obvious corollary of warfare. The surge of patriotic enthusiasm showed itself in the streams of men who pressed forward in formed bodies, or as individuals, from every portion of the Globe over which flew the Union Jack, and from many lands where our flag flew only in their hearts, to offer their services, and if necessary their lives, for King and Country.

The spirit was there. The clans gathered. And

very soon we could say truly that we heard 'the tramp of thousands.' But war, especially modern war, demands more than the right spirit and the big battalions; and we could not for a long time add—'and of armed men the hum,' for there were not the arms for the assembled hosts. And in the word 'arms' is included everything material calculated to assist the man to fight most effectively with least risk. That the Great War was unexpected by us is true in a greater degree of its nature and magnitude than of its actual occurrence. Amongst other facts to which our eyes were at first shut was the vital importance of war material and the difficulty of improvising its production. The realisation of what the enemy had done in this direction during years of stealthy preparation for the 'day' came as a shock perhaps even greater than that caused by the discovery of his numerical strength, and was followed by the painful awakening as to what we had to undertake in order to catch up.

What the nation as a whole was capable of in this direction when aroused and organised, and what it did achieve was a revelation.

What one section of it, small in numbers, but rich in patriotism, energy, and resource, could contribute was a further revelation of which the full tale is only now told.

I do not propose to enter into what is so well and clearly set forth in the following pages. The history of Canada's munition effort is the history of two great voluntary organisations—the Shell Committee, and its successor the Imperial Munitions Board—both of which were improvised under the stress of war. In the case of the first the problem was even more difficult than it was in this country, since the existing sources of output capable of expansion were negligible. The war had not lasted for three weeks when the great demand for artillery ammunition and dire need for the expansion of the sources of supply caused the War Office to appeal for help to the Canadian Government. Though the material required could not then be produced in Canada, for, it must be remembered, no private manufacturer had ever made a

shell in that country and the output of the only arsenal need not be considered, the Canadian manufacturers, under the initiative and leadership of the Minister of Militia—the late General Sir Sam Hughes—turned their attention to the subject, with the result that before the war was two months old they undertook to produce a limited number of shell, which they were asked by the War Office to do. This led to the birth in September, 1914, of the Shell Committee, composed of representatives of the Government and the manufacturers, which functioned by entering into contracts with the Minister of Militia as agent for the British Government. This body performed invaluable work which rapidly increased in scope, not the least useful side of its activity being its educative effect, for it was in fact a pioneer in showing what could be done in an entirely new direction by determination and organised good will.

It was when I became Minister of Munitions in 1915 that I first had any direct connection with what was going on in Canada; and the development and increase of the production of munitions in the Dominion was one of the first subjects to claim my attention. It was found, as happened in the case of many other bodies hastily improvised under the stress of war, in spite of all that had been done by the Committee, evolution and reorganisation was necessary to enable the growing demands to be coped with. This led to its metamorphosis in the end of November, 1915, into the Imperial Munitions Board, which, under the chairmanship of Sir Joseph Flavelle, one of the best known business men of Canada, continued until the Armistice on a wider scale the work which had been carried on by its predecessor for fourteen months. A remarkable and somewhat peculiar fact about the constitution of this Board was that it was not under the Canadian Government, but was directly under the British Government, being responsible to the Ministry of Munitions.

If the results speak well for the energies of those who so patriotically gave their time and services to its work,

the fact that they were achieved under the somewhat unusual conditions is proof, if proof were needed, of the goodwill and whole-hearted co-operation of the Dominion Government and departments and all concerned. By the end of the war its activities had expanded vastly and covered many things, some of which cannot be included literally in the term munitions.

The statistical side of the development of munition production in Canada is amply dealt with by Colonel Carnegie in this book. But I cannot refrain from giving one or two figures illustrative of what the expansion actually was. For instance, the shipments of shell to Europe rose from 3000 shells in 1914 to nearly 24,000,000 in 1917, and was over 16,000,000 for 1918, when demands were reduced, up to the Armistice. In regard to finance, during 1917 the Board's expenditure reached the approximate total of fifty million dollars per month, and at one time its rate of expenditure per annum was three times that of the total disbursements of the Canadian Government for the year 1914.

This book furnishes food for thought. A record of solid achievement and fact, it has its romantic side, apart from the patriotic sentiment which was the underlying motive of what is described. Who, for instance, before the war, when speculating on the relation of cause and effect in human affairs, would in his wildest dreams have predicted that the tearing up of a scrap of paper in Europe would start a train of events which in less than four years led to the building of wooden ships on the Pacific coast of Canada, and set the lumber men of British Columbia prospecting the forests for special timber for the construction of aeroplanes?

As time passes each one of us, though possibly forgetting his own share, is being given the chance of learning something more of what others did in the Great War. This process of enlightenment is perforce slow, owing to the colossal range of the subject; but every fresh record given to us reveals something new of the sacrifices, the struggle, the failures, and the successes in many

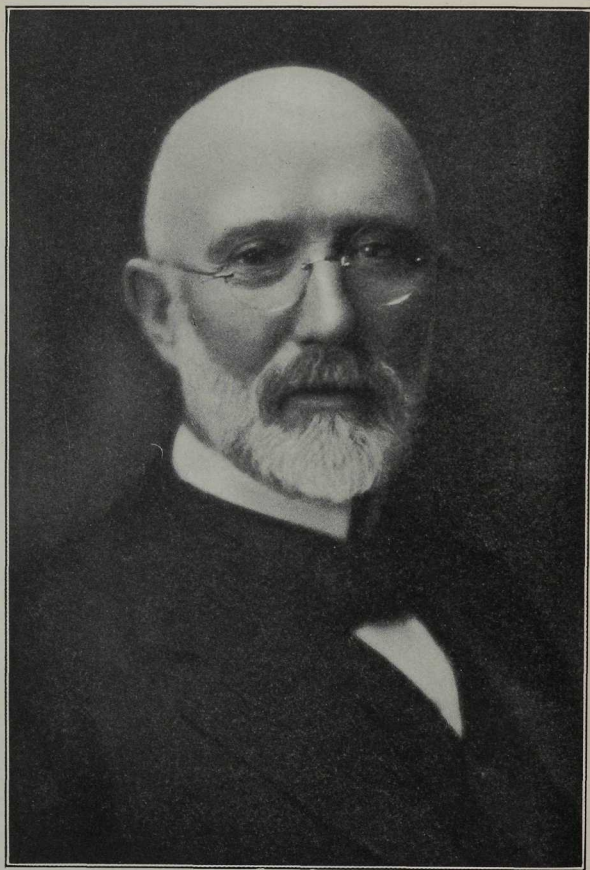
FOREWORD

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unknown directions, some obscure, others almost fantastic. It is good that such records should be compiled before memories grow dim and interest fades. It is good that they should be published, so that 'he who runs may read' and learn something not only of the far-reaching ramifications of a world struggle, the like of which we hope never again to see, but also of the colossal effort actually made by the Empire, and of its potentialities when its energies and resources are applied to one end.

Canada did well in giving her sons to fight in the common cause for the freedom of the world. As Colonel Carnegie here shows us, she played no less splendid a part in helping the fighting men of the Allies to meet the foe with every possible advantage on their side.

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SIR JOSEPH W. FLAVELLE, BART.

INTRODUCTORY NOTE

By Sir JOSEPH W. FLAVELLE, Bart.,
Chairman Imperial Munitions Board

COLONEL CARNEGIE, who in the following pages tells of the production of munitions of war in Canada from 1914 to 1918, had personal association with the work during the entire period of operation. As Ordnance Adviser to both the Shell Committee and the Imperial Munitions Board, he gave service of great value. He brought to his duties technical knowledge as engineer and metallurgist, and through his Woolwich training in ordnance, supplied experience which Canada did not possess. He was throughout devoted to his duty and unselfishly loyal to his associates.

The operation of the British Ministry of Munitions in Canada through the Imperial Munitions Board furnishes another illustration of flexibility in working relations between the nations of the British Empire. The Board was responsible only to the British Government through the Ministry of Munitions, yet was almost wholly officered by Canadians, who were given singular freedom in administration. . . . The chief office was in Ottawa, the capital city of the Dominion, and the seat of the Federal Government. To no inconsiderable extent, the Board's financial obligations were met through advances made by the Canadian Treasury to the Imperial Treasury, yet patronage associated with Government enterprises was inoperative, though over one thousand millions of dollars were expended in contracts carried out in all the Provinces of the Dominion. . . . The

Board's bankers asked—what is the legal status of the Imperial Munitions Board in Canada? Inquiry established that it was of an exceedingly doubtful character. Notwithstanding, the great business was carried through without challenge and without dispute requiring appeal to the Courts or to arbitration. . . . When through the shortage of tonnage for ocean transportation of men and supplies, it was proposed that the Royal Air Force should establish in Canada a school for training officers for the Air Service, British officers who had had experience in the Overseas Dominions advised against it, as they feared the exercise of military authority and discipline by an Imperial force in Canada would result in friction and consequent misunderstanding. The Prime Minister of Canada, however, supported the proposal, and it was made effective. There followed, without friction, the successful training of large numbers of Canadian officers who subsequently served with distinction in the Royal Air Force at the Front. The civilian officers (Canadian) of the Board, responsible to the Commanding Officer of the Royal Air Force for the physical equipment of the camps and the mechanical equipment and general supplies for the training schools, had throughout cordial relations with the military officers of the Royal Air Force.

There were doubtless many reasons why the work thus undertaken in Canada by the British Ministry carried the support of all concerned. There was common interest in a great cause; there were mutual advantages to the British and the Canadian people in the successful production of munitions of war in Canada; but is it too much to say that good will, deep underlying good will, was the determining factor? . . . Through it, the Imperial Ministry and Treasury extended complete confidence and measurable autonomy to their working association in Canada, while the Government of Canada not only ignored natural causes for misunderstanding, but gave generous counsel and support during the entire period of the operation of the Ministry.

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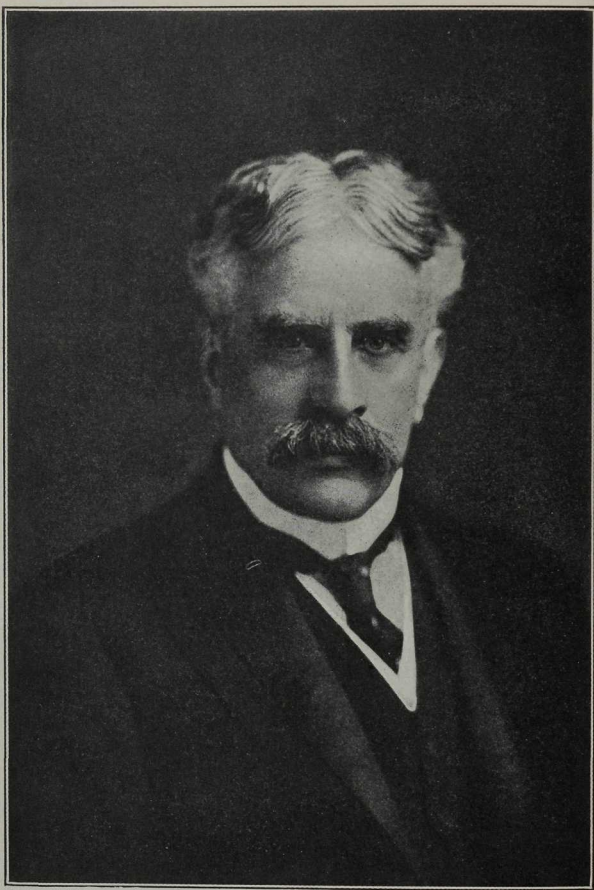


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THE RT. HON. SIR ROBERT BORDEN, G.C.M.G.

INTRODUCTION

THE story of Canadian Munitions Supply during the Great War is full of incident and accomplishment. Canada's life for four, perhaps, of her saddest years is reflected in this narrative. Over her vast territory, thirty-one times greater than the United Kingdom, the weapons of destruction were produced with feverish haste. From St. John's, Newfoundland, to Victoria, British Columbia, 675 factories in 150 different towns were engaged in this deadly business. It was a time of crisis, but Canada was ready. What manufacturing skill and scientific genius she possessed were sorely tested, but she stood the test with great credit. The vastness and quality of her products were the wonder of the Mother Country. For a nation of agriculturists to become expert in the manufacture of implements of war requiring very considerable metallurgical, chemical and engineering skill was an accomplishment of no mean order. The standard of skill, so rapidly acquired, came in no magical manner, but by persistent indomitable efforts inspired by a rare spirit of comradeship, made alive by a renewed sense of right. Canada, in this great trial, was as one man, and she devoted her whole soul to the persistent pursuit and inspiring confidence of victory.

Date and Influence.—The events recorded date from August 24, 1914. They are woven into the historic fabric of the nation's life. Their influence upon the general prosperity of the Dominion cannot be over-estimated. Every industry was directly or indirectly improved. Statistics show that, in 1915, there were 21,306 manufacturing establishments which yielded

products to the gross value of \$1,407,137,140, whereas, in 1919, the number of establishments had increased to 38,344 and produced a gross value of \$3,520,731,589.¹ Even when the difference in the prices of products during 1915 and 1919 is allowed the progress is unmistakable. Perhaps an even better index of this industrial stimulus is found in the comparison of the numbers of wage earners of 1915 and 1919. They were respectively 462,200 and 594,118.² This increase is all the more remarkable when it is remembered that 418,000 officers and men went overseas in the Canadian Expeditionary Force.³

Object.—The object of this story is to record and preserve accurate and interesting facts of a remarkable achievement by Canadians upon which the statistician may rely and of which the Empire may be justly proud.

First Shell Inquiry.—The Great War had only run twenty days when a cable from London reached the Minister of Militia, Ottawa. 'Can you provide or obtain from America shell empty shrapnel?' We are left to imagine what the big-hearted, courageous general, Sir Sam Hughes, said when he read that cable. I have no doubt that the word 'America' led him to exclaim in his unique way: 'Why not Canada?' Why not? But later, when the inquiry became definite and 200,000 shells were asked for, the problem stood out thus: '200,000 shells! Ah! Over eleven years' work at the Dominion Arsenal, Quebec! No! That's no good! Our manufacturers can do them, and they will.' So they did, not only 200,000, but ultimately 75,000,000. At one period Canada was actually producing per week over 400,000 18-pdr. shrapnel shells, not empty, as called for in the first order, but filled, fused and ready for the guns. In addition to this remarkable output, shells ranging in size up to 9.2 in. were being produced at the weekly rate of over 300,000.

Early Struggles.—The record tells how the machinery

¹ *Canada Year Book*, 1921, p. 363.

² *Canada Year Book*, 1921, p. 640.

³ *Canada Year Book*, 1921, p. 796.

set up by General Sir Sam Hughes for this project came into operation, and of the outstanding men who did the spade work on the Shell Committee, such as its Chairman, Sir Alex. Bertram, the late Colonel Lafferty, and Colonel Cantley. Mr. D. A. Thomas (the late Lord Rhondda) did not exaggerate in any degree when he said of General Bertram that 'he worked like a Trojan night and day.'

Throughout the story I have sought to gather the workers round the work they did. For instance, the names of Colonel Greville Harston, Colonel Ogilvie, and afterwards the late General Edwards and Captain Durley, are inseparably linked with the exacting work of inspection.

It is inspiring to trace the distinctive qualities exhibited in the patient training of the raw human material in the art of using gauges and in examining products. They were qualities which discarded the miraculous element in honest work and applied common sense and dogged perseverance to a task almost unsurpassed in difficulty.

Toluol and Zinc.—The struggle to obtain plant and skill to manufacture high explosives rapidly is full of fascination. The work of Mr. Plummer, President of the Dominion Iron and Steel Co., in this connection will not be forgotten, for through his efforts the first toluol in Canada was produced from the waste gases of coke-ovens. Ultimately an output of over 60,000,000 lb. of trinitrotoluol (T.N.T.) was reached.

How the first zinc was refined in Canada, when there was likely to be a shortage of this material, is another record with which the name of Mr. James J. Warren, President of the Consolidated Mining and Melting Co., will ever be associated.

Other remarkable undertakings by manufacturers in the production of steel, cartridge cases, copper bands, and other component parts of munitions are recorded.

Shell Committee Criticised.—Not the least interesting is the story of the Shell Committee, which, when the pioneer work was over, was seen to be organised on too small a

scale to develop to the full the great potentialities of Canada for the supply of munitions.

Missions of reorganisation came from England to Canada. One of these was headed by Mr. D. A. Thomas (the late Lord Rhondda); another by Mr. W. L. Hitchens and Mr. R. H. Brand; ultimately the reconstruction of the Shell Committee was accomplished.

On November 30, 1915, the last meeting of the Shell Committee was held. It was a memorable meeting at which the records of work done from September 1, 1914, were recounted, showing that the total disbursements of the Committee exceeded 72 million dollars.

The Imperial Munitions Board.—The Imperial Munitions Board, a body entirely responsible to the British Government, took over the work of the Shell Committee immediately. The task before the Chairman, Mr. J. W. Flavelle, now Sir Joseph Flavelle, Bart., was by no means easy. Having full administrative powers, he availed himself of whatever he thought would be of service in the old Committee's work, and gradually built up an organisation which achieved colossal results. I have attempted to tell of his gifts, abounding from an intellect of unusual power, courage, and imposing charm. I have also tried to tell how the Chairman gathered around him men of marked ability from the great industrial and professional spheres of activity, to render unstinted and unselfish service.

Rapid Growth.—The history of how this great business grew and was carried on is full of absorbing interest. The demands from the Ministry of Munitions kept increasing. A member of the Board, the Hon. R. H. Brand, who knew the capacity of Canada for work, did invaluable service in London at the Ministry of Munitions. It was a service without which it would have been almost impossible to accomplish the work undertaken by the Board. Hardly anything that Canada could supply passed to the U.S.A. for manufacture after Mr. Brand went there. Manufacturers from almost every town and industry in Canada flocked to Ottawa to offer their ser-

vices. How to obtain a supply of raw and partly finished materials became a serious problem. The United States had been the chief source of supply, but with the appearance of a long war and the uncertainty of America's attitude to the Allies the problem of supply became full of difficulty. Fortunately the United States continued to help, and with an accelerated output from Canadian manufacturers, a satisfactory distribution of materials was made possible. When it is remembered that in steel alone over 80,000 tons had to be distributed monthly to places many thousands of miles apart, some idea of the magnitude of the work is obtained. The work of purchasing and distribution was carried to success by the remarkably able administrative gifts of Mr. Edward Fitzgerald, C.B.E., who was Assistant to the Chairman in the general direction of the work of the Board.

National Factories.—There came a period in the growth of munitions manufacture when it was necessary for manufacturers to make very great extensions to their factories to meet the increased demands. Large numbers did extend their factories, and some built entirely new ones.

Looking always to the interests of the Crown, the Chairman conceived the idea of establishing National Factories, each financed by, and responsible to, the Imperial Munitions Board, and at the same time controlled and run on commercial lines by a board of directors who gave their services without reward.

Fuses.—The first National Factory was established in Montreal to produce time fuses. The time fuse was a most intricate piece of mechanism. At this time the air was full of stories of corruption over the letting of contracts to the United States instead of to Canadian manufacturers, and as a result an investigation was set up by the Canadian Government.

Sir Charles Gordon, G.B.E., with great ability and courage, backed by the chairman, took the direction of the National Fuse Factory in hand and made a success of a difficult task. It proved beyond doubt that the

Canadian workers could rapidly acquire the art of skilful machining and assembling of fuses although made to the most exacting limits of precision.

Explosives.—Not less interesting than the production of toluol from the coke-oven gases is the story of explosives production at the National Factories directed by Mr. Howard Murray, Mr. Noble Pirrie, and Mr. Wardleworth. The discoveries made in the manufacture of acetone, first by Mr. Matheson from acetic acid, and subsequently by Dr. Weisman at Toronto from cereals, are of absorbing interest.

Electric Steel.—Another achievement is recorded in the establishment of the British Forgings Ltd. at Toronto. Great accumulations of scrap steel turnings from shells became a drug on the Canadian market and were being shipped to other countries at a trifling sum per ton, while large quantities of shell steel were imported from the U.S.A. Steel manufacturers of Canada could, at that time, utilise only a very small amount of scrap steel turnings which were being produced. A National Factory at Toronto was started on January 26, 1917, and by June 16 the first of ten electric steel furnaces produced shell steel ingots from scrap steel. The plant was the largest electric steel equipment in the world. By August 18, 1917, it was in full operation.

To look back upon the efforts of Mr. E. Cousins of the Toronto Harbour Commission and the late Mr. Fred. Miller during the construction of the factory, and of Mr. James Wood in the organisation of its staff and in the output of the works, gives one a sense of wonder and admiration.

Aviation and Aeroplanes.—Perhaps the fascinating subject of aviation and aeroplane manufacture will be most engaging to the general reader. Both subjects include a record of accomplishments of rare skill and courage. Mr. George Morrow's name will be associated always with the striking story of how training camps, for the first Flying Corps in Canada, were quickly built and efficiently maintained.

Sir Frank Baillie, who, we regret, has with several other faithful colleagues crossed the great Divide, undertook what appeared to most men an impossible task. He had shown great ability with cartridge case manufacture, work of a nature always regarded by British manufacturers as perplexing and most difficult; but aeroplanes, an entirely new manufacture and with little past experience to guide one, looked altogether insuperably difficult.

To have established an organisation, put up extensive buildings, installed special plant and trained an army of several thousand male and female workers, and produced aeroplanes at the rate of five per day within a year is almost incredible. This quiet, yet indomitable, character faced the situation with a determination to succeed, and nothing could stand long in his way. It seems like a fairy-tale, but he produced the aeroplanes.

Lumber.—The demand for aeroplanes severely taxed the spruce and other forests of Canada. Not only had the National Factory in Toronto to be supplied, but also British factories. It became a business far exceeding ordinary lumbering. The rate of demand, the quality of the timber felled, and the exacting nature of the inspection made the problem of production difficult of solution. Mr. Taylor of Montreal did good service in the organisation and management of this work, with great credit to himself and to the Board. The statistics alone of wood supplied, under the most trying circumstances, will astonish the reader.

Other Activities.—To refer at any length, in this introduction, to the various activities of the Imperial Munitions Board would make it unduly lengthy. I can only ask readers to turn to the various chapters dealing with matters already mentioned, and with others, such as the construction of ships, the scientific achievements in the production of explosives, the work done by Mr. Mark Irish in the Labour and Welfare Department of the Board's work, the mineral industries stimulated and inaugurated for the first time in Canada, and to many other topics of absorbing interest.

References to the scope of this work would be incomplete without mention of its finances. The story tells that at one time the Board's expenditure reached the enormous sum of fifty million dollars per month, over three times the entire monthly expenditure of the Canadian Government during the year 1914. The story of the Board's finances and accounting is told by Mr. George Edwards, C.B.E., whose work as Auditor as well as Accountant was highly commended by the British Auditor-General.

Appendices.—Through the courtesy of the Chairman, Sir Joseph W. Flavelle, Bart., Appendix I is given. It is an excellent summary of the Board's activities in the form of a report by the Chairman to the Minister of Munitions, dated August 17, 1921.

Appendix II is a statement by the Hon. R. H. Brand, C.M.G., which he wrote as an introduction to the history of the Imperial Munitions Board. It has not hitherto been published. It gives a full view of the magnitude of the Board's work in London carried on at the Ministry of Munitions by Mr. Brand.

Appendix III is a most interesting and valuable statement of munitions and materials exported from Canada during the years 1914 to 1918 inclusive.

An Appreciation.—'You have carried through a work,' said Mr. Winston Churchill, in his cable to the Chairman, on November 25, 1918, 'of the greatest magnitude with uniform success and efficiency, and I wish to pay my personal tribute to the great ability and organising power you, as Chairman, have shown.'

Mr. Churchill will never know, nor any other individual, what this 'work of greatest magnitude' cost Sir Joseph Flavelle. Those who were close to him during those years of struggle wondered and still wonder where he received his gifts of physical and mental endurance. It was indeed a giant's work, not passed on to others, but accomplished by himself with a devotion to service inspired and carried to success with the noblest impulses.

In this volume I have attempted to set forth facts to

INTRODUCTION

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ow what the men and women of Canada did in supplying munitions during the Greatest Crisis in her history. During her magnificent output, which was praised by the British Cabinet in its report of 1917, she established new industries and new standards of skill, the results of which will add permanent value to her national assets.

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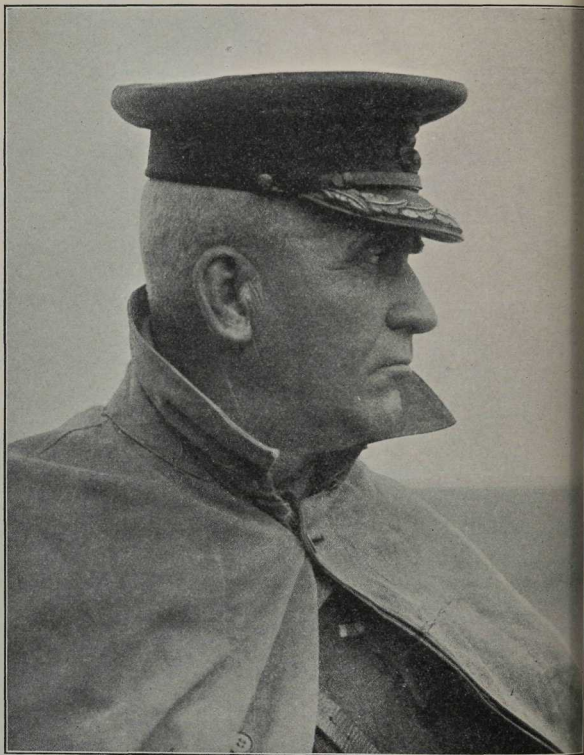


Photo : J. A. Millar]

GEN. SIR SAM HUGHES, K.C.B.

THE HISTORY OF MUNITIONS SUPPLY IN CANADA, 1914-1918

CHAPTER I

THE ORIGIN OF MUNITIONS SUPPLY

To trace the origin of the demand in 1914 for munitions from Canada it is necessary to review the situation at that time.

Conditions in Europe, 1914.—For nearly 100 years the modern civilised world had been comparatively free from warfare. Many concluded that wars were ended for all time.

It was common to frown on influences that seemed only to perpetuate militarism. Some people actually believed that the long-looked-for Millennium was at hand. In spite of this popular trend there were thoughtful men in Europe and America who realised that the dream of universal peace was, at the time, impracticable. In their efforts to show the fallacy of failing to relate such a dream to facts, men like Field-Marshal Lord Roberts met with nothing but derision and not a little insult.

Britain Reduced her Standing Army and Navy.—In 1911 Britain actually commenced to reduce her Army and Navy. Territorial forces, a mere skeleton of Militia, were to take the place of the standing Army of the past.

Military affairs, in the British Empire, were not taken seriously. Men were sneered at, as alarmists and friends of armament manufacturers, who gave warnings of the

danger in Europe. This attitude of mind weakened the sense of duty and responsibility to the Empire and strengthened the love of ease and contempt for the past and indifference to the future.

Archduke of Austria.—Until the death of the Archduke of Austria no one, outside those believed to be in the plot, had any idea of the coming catastrophe. Events followed rapidly the death of the Archduke. His death seemed to be the signal for concerted action by the Central Powers. Austria struck Serbia ; next it was Russia ; then suddenly Germany struck France, through Luxembourg and Belgium, and England was in it.

Action of Britain.—As soon as conflict was inevitable the British Government acted with wisdom and speed. The Canadian Government followed with an enthusiastic participation, as far as Canada was capable of giving aid.

England herself, outside her Navy, was entirely unprepared. The Entente Allies were unprepared. The Central Powers knew this glaring fact. It is now known that, in the early days of the War, the British recruits were drilled with wooden guns. These facts reveal the state of unpreparedness for a conflict which threatened daily to destroy, even in a few months, the best of our civilisation.

Kitchener's Cable to Minister of Militia.—It was in this grave condition of affairs that Lord Kitchener, on August 24, 1914, cabled to the Minister of Militia, Ottawa :

Can you provide or obtain from American trade empty shrapnel, Q.F. Guns, 18-pdr., without cases or fuses ? if so, what rate delivery could you obtain ?

The Minister replied that he could get large quantities from his neighbours and a speedy delivery. He asked for further advice. On August 28 the British Government asked for a quotation on 100,000 shrapnel shells for quick-firing 18-pdr. guns, and indicated requirements for 100,000 15-pdr. shrapnel shells.

While the Minister of Militia was assured of help

THE ORIGIN OF MUNITIONS SUPPLY 3

from the U.S.A. he was actively engaged in ascertaining possibilities of manufacture in Canada.

Meeting with U.S.A. Manufacturers.—American steel men and others were approached, and a meeting was held, late in August, between the Minister and the principals of the Bethlehem Steel Company. At that meeting the question of procuring shrapnel shells in Canada was discussed. It is reported that the U.S.A. men said : ' It is absolutely impossible to carry out such an idea. You have neither the steel nor other facilities.' Bringing his fist down on the table, the Minister, in his characteristic way, said ' I will show you they can be made in Canada.' He was as good as his word.

Meeting with Canadian Manufacturers.—The Minister called to Ottawa a few leading manufacturers to put the situation before them.

They met on September 2, in the Office of the Militia Department. There were present the following : Colonel Alex. Bertram, John Bertram and Sons Co., Dundas, Ont. ; Mr. Winslow, Canadian Ingersoll Rand Co., Sherbrooke, Que. ; Mr. Alex Goldie, Goldie and McCullough Co., Galt, Ont. ; Mr. George W. Watts, General Electric Co., Toronto ; Mr. E. Carnegie, Electric Steel and Metals Co., Welland, Ont. ; Lieut.-Colonel J. W. Harksome, Small Arms Committee, Huntingdon, Que.

In addition to the foregoing, Col. T. Benson, Master General of the Ordnance, Ottawa ; Lieut.-Colonel Lafferty, Superintendent, Dominion Arsenal, Que. ; and Lieut.-Colonel Greville Harston, Chief Inspector of Arms and Ammunition, Que., attended the meeting.

Minutes of First Meeting.—The following is an extract from the minutes of this meeting :

Colonel Hughes explained to those present that the British Government had asked for information regarding the position of Canadian manufacturers in regard to supplying them with 18-pdr. shrapnel shells.

Colonel Lafferty, with the help of sample shells and

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drawings, explained to those present the nature of the work involved. Colonel Greville Harston indicated the nature of the inspection required.

The minutes record that :

The Delegates adjourned for consultation, and afterwards decided that the shells could be manufactured in Canada.

It was an important decision, far greater than any one of them had any conception of.

Colonel Bertram as Chairman.—The manufacturers present proposed that Colonel Bertram should organise the work, and resolved :

that Colonel Bertram act as Chairman, with full power to act between the manufacturers and the Minister of Militia through Colonel Benson, with the idea of working out and formulating some plan of organisation for carrying on the work.

No better choice could have been made, for in Colonel Bertram the manufacturers knew not only a man of business ability but an engineer with courage, integrity, and tact.

Colonel Bertram formulated a plan of action immediately. The next day he sent the following letter to the Minister of Militia :

Hon. Colonel Sam Hughes,
Minister of Militia,
Ottawa, Ont.

Dear Sir,

I beg leave to report that the manufacturers who were present at the meeting yesterday have appointed me Chairman of the Committee. They thought it would facilitate matters a great deal if some person would act for them in conjunction with the Militia Department, and therefore be able to carry on this work in a satisfactory manner.

A number of questions came up, such as

Ordering material,
Where it could be secured,
Shortest date of delivery,
Cost to the Government.

THE ORIGIN OF MUNITIONS SUPPLY 5

They are going to look to me for this information. I have volunteered to devote my whole time to this work ; keep in touch with the heads of your Department and report to you through Colonel Benson on the progress of the work.

I am, therefore, to-day ordering material as suggested by yourself, so as to enable them to proceed with the various operations.

Trusting this will meet with your approval,

I remain, etc.

Instructions to Proceed.—Up to this time no order had been received ; nevertheless General Hughes, confident of success, gave instructions to order materials and proceed. He cabled on September 2 to the War Office :

Am arranging Canadian manufacturers turning hydraulic presses to work on shells. Had meeting with number. Arranging for many more. Already can contract for four thousand shrapnel weekly delivery to begin in about four weeks' time. This could be increased to more than double that quantity. Believe could produce seventy-five thousand before November first. Do you want shell Q.F. empty shrapnel without fuses, as per Vocabulary Stores 1912, part 2, page 480. Have all details, plans and specifications for 18 Pr. but have none for 15 Pr. Please send latter immediately. Price not determined yet. Please advise.

It will be seen from this cable that calculations had been made by the manufacturers who were in consultation and had agreed to undertake the work.

Colonel Lafferty.—Colonel Lafferty, at this stage, was of much service. Although his factory at the Dominion Arsenal was small, it became the training centre for the first munition manufacturers. He devoted himself with untiring energy to this work.

The manufacturers at their first meeting calculated that the capacity they could command for shell production was equal to 4000 per week. Considering the output of 340 per week of the Dominion Arsenal, it was a good estimate. When, however, it is remembered that in 1917 a capacity of 800,000 shells per week, not merely 18-pdr. calibre but including different sizes up to 9.2 in.,

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was reached, some idea of the great development is obtained.

On September 5 General Hughes telegraphed Colonel Bertram :

Kindly meet me with your Committee in Quebec, at Dominion Arsenal, Tuesday afternoon next. Wire me Valcartier Camp to remind me.

Strictly speaking, no committee had been formed at this time.

This wire reminds one that while the Minister of Militia was busy forming what was to become a huge industrial munitions organisation, he was also preparing the first contingent of 33,000 officers and men for the Overseas Canadian Expeditionary Force.

The meeting on September 6, 1914, was held at Valcartier, where General Hughes appointed a Committee.

The following is a copy of the minutes of the proceedings :

* Pursuant to the orders of Colonel the Honourable Sam Hughes, Col. A. Bertram, Montreal, Thomas Cantley, New Glasgow, N.S., George W. Watts, Toronto, met the Minister, who stated that the Secretary of State for War advised the Canadian Government that the War Office were desirous of having shrapnel shells made in Canada, that the Government had decided to intrust this matter to a Committee of Manufacturers and had so advised the War Office and had submitted the names of the gentlemen named above, which suggestion and the personnel of the Committee had been approved by the War Office : That the Committee be enlarged by the addition of three military officers.

Shell Committee.—The following memo. to Colonel Bertram in the handwriting of General Hughes confirmed officially the Shell Committee. It is a historic document. His characteristic 'For action, S.H.' carried with it all the authority of any Government seal.

THE ORIGIN OF MUNITIONS SUPPLY 7



MINISTERS OFFICE

OTTAWA

Valcartier
Camp.

7/9/1914

{ Col. Bertram (Alex.)
Thomas Cantley - } Committee
Geo. Watts - } on
Lt.-Col. Lafferty - } Shells.

Sam Hughes.

For Action
S.H.

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FIRST MEMBERS OF SHELL COMMITTEE

Valcartier Camp,
7/9/1914.

Col. Bertram (Alex.)
Thomas Cantley
Geo. Watts
Lt.-Col. Lafferty } Committee
on
Shells.

For Action
S.H.

SAM HUGHES

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Enlargement of Shell Committee.—On September 7, 1914, the Minister wired to Colonel Bertram : ‘ Kindly add the name of E. Carnegie to your Committee, that will make five of you.—SAM HUGHES.’

On the following day, September 8, the names of the three officers of the Militia Department who were to act in an advisory capacity were added to the membership of the Committee. They were Colonel Benson, Master General of Ordnance ; Lieut.-Colonel Greville



ORIGINAL SHELL COMMITTEE

Left to right: Col. T. Cantley, Lt.-Col. G. Watts, Gen. Sir Alex. Bertram, Col. E. Carnegie, Lt.-Col. F. L. Lafferty.

Harston, Chief Inspector of Arms and Ammunition ; and Lieut.-Colonel F. L. Lafferty, Superintendent of the Dominion Arsenal.

At a meeting held at the Dominion Arsenal, Quebec, attended by the eight members of the Committee and presided over by the Minister of Militia, Colonel Bertram was officially appointed Chairman of the Committee.

The foregoing briefly outlines the origin of the munitions business and the steps taken to provide the machinery for its organisation in Canada.

CHAPTER II

THE SHELL COMMITTEE

THE task committed to the Shell Committee was to obtain shells as fast as possible. How to obtain them was left entirely to the judgment and initiative of that body. Neither the individual members nor the Committee as a whole undertook any financial responsibility for losses which might be incurred ; and they accepted no profits.

Composition of Committee.—The original composition of the Shell Committee combined commercial and manufacturing ability with the technical and military knowledge required in the initial stages of munitions supply. When the first British Shell Contracts Committee was reconstructed in December, 1914, it was formed on the lines of the Canadian Shell Committee. The new Committee, known as the Armaments Committee, consisted of manufacturers and War Office officials.

Relation of Shell Committee to Government.—The relation of the Shell Committee to the Canadian and British Governments was never clearly defined. The members of the Committee who were manufacturers regarded themselves as contractors, but the Committee as a whole was neither the agent nor the contractor to the British Government. The four manufacturing members entered into contractual relations with the Minister of Militia, who acted for the British Government. They signed contracts for all orders received. The Minister of Militia was virtually the agent, although he assumed no responsibility of agency. This indefinite relationship

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led to much questioning as to the status of the Committee and was the cause of considerable misunderstanding by the public and press. These questions became insistent as soon as the Committee became a financial power in the Dominion.

Committee Determined its Own Policy.—The Committee was left a free hand to work out its own plans for the production and supply of munitions. It formulated rules of procedure. The original rules were :

- (1) That as far as possible all materials required for munitions would be made in Canada.
- (2) That the plant and equipment of all manufacturers offering to take contracts for shell parts would be examined before contracts were placed.
- (3) That instead of placing an order for complete shells with any one manufacturer, as was the usual practice in Britain, orders would be placed for the component parts of shells with manufacturers whose equipment was found most suitable, and that the component parts would be sent to other manufacturers for their assembling into shells.
[This decision of the Shell Committee lifted a considerable responsibility from Canadian manufacturers who, in 1914, were not in a financial position to undertake such burdens. But it did more. The specialisation by manufacturers on one or two component parts increased their rate of production, reduced costs, and improved the quality of the product.]
- (4) That all component parts of shells would be examined and accepted or rejected at the works of the makers by duly authorised inspectors before being shipped to the assembly plants.
- (5) That the same price would be paid to all manufacturers for the same article.

[It was considered that the benefits from this rule would eliminate competition, which would reduce the risk of faulty workmanship and materials with their attendant dangers to men and guns, such dangers arising in spite of careful inspection because of the urgency of the demands and the inexperience of the workers.]

THE SHELL COMMITTEE

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- (6) That the Committee would take the responsibility for the inspection of all component parts of shells before their delivery to assembly plants.

[By this decision manufacturers were relieved of a great responsibility. They had not the experience or the skilled men or equipment to carry out the inspection at that time. On the other hand, the Committee would have the assurance that under one authorised Inspection Department all component parts would be correct before the finished shells were submitted for examination to the Government Inspectors.]

- (7) Other rules were made regarding Insurance, Shipping, Transportation, Financing, etc.

First Movements Towards Production.—Before the foregoing policy of the Committee had been fully formulated plans were made to secure material for making the shells. At a meeting of the unofficially formed Committee, held at the Hôtel Château Frontenac, Quebec, on September 7, Colonel Lafferty received instructions, which had the approval of the Minister, to make from the steel he had in stock 2000 shell forgings for delivery to manufacturers. At the same informal meeting the question of steel supply was considered, and it was 'resolved that a supply of steel of the kind and quality now in the Arsenal be kept in stock sufficient for one month's supply (or, say, one hundred tons).'

This minute is most interesting when it is remembered that about 80,000 tons of steel per month were afterwards required for shell production in Canada.

But another equally important matter was decided at this meeting. It is covered by the minute which reads :

Whereas a vital point in the manufacture of shells is thorough inspection, therefore we strongly recommend that the whole matter of inspection be under the direct supervision of Major G. Ogilvie, R.A., a War Office appointee, and that he report direct to Colonel Benson, M.G.O., Ottawa, on all matters relating to the Inspection of Ammunition.

It was fortunate that Colonel Greville Harston had


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Major Ogilvie assisting him at the time, for he proved to be of great value in the inspection of munitions.

First Prices for Shells.—Although the Committee decided to pay all manufacturers the same price for the same article, the Chairman had not received any official notification until September 18, 1914, that the prices the Committee had submitted were approved by the War Office.

The photograph of the telegram approving the prices

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This is an unrepeatable message, and is delivered by request of the sender under these conditions.

H. P. DWIGHT,
President.

HEAD OFFICE, TORONTO.

GEO. D. FERRY
General Manager

RECEIVED BY	DATE	SENT BY	RECEIVED BY	TIME	PRICE	
						<p style="font-size: x-small; margin: 0;">From: <i>Walcarter Camp Ont</i></p> <p style="font-size: x-small; margin: 0;">To: <i>Colonel Lepp Beltram</i></p> <p style="font-size: x-small; margin: 0;"><i>price re fifteen and eighteen</i></p> <p style="font-size: x-small; margin: 0;"><i>pounder shells all right</i></p> <p style="font-size: x-small; margin: 0;"><i>go ahead</i></p> <p style="font-size: x-small; margin: 0;"><i>Sam Hughes</i></p>

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of the 15- and 18-pdr. shell is reproduced. It was the Committee's authority to act.

Administration Costs of Shell Committee.—Up to September 17, 1914, no definite arrangement had been made about meeting the expenses of administration. At a Committee meeting held on that date at Montreal it was decided that the cost of administration should come out of the prices received from the British Government for munitions. Thus the price paid to the Committee for the first 18-pdr. shrapnel shells was \$8.55 each, but the total prices paid to manufacturers by the Committee amounted to \$8.44. From the surplus the cost of

administration was drawn. By care the Chairman, after paying all administration costs, was able to accumulate a big surplus from the difference between the amount paid to manufacturers and that received from the British Government.

Appointment of Ordnance Adviser.—The appointment of the Ordnance Adviser of the Shell Committee came about in this way. He returned to Canada from England on September 19, 1914, about a fortnight after the Committee was formed. The Steel Company in Canada which he had helped to form, during previous visits, was now ready for operation. As Consulting Engineer he planned to be at the starting up of the works and to return to England three weeks later. Sir Charles Ross, a Co-Director, strongly urged him to offer his services to the Minister of Militia. It seemed unmistakably his duty to assist in the munitions work, and he saw him. Later he met General Bertram and Colonel Cantley at the Drummond Building, Montreal. Both persuaded him to remain three months and assist the Committee as Ordnance Adviser. They saw the Minister of Militia, who confirmed their decision. On September 23, 1914, three days after his arrival, he began a service at Drummond Building which terminated with the close of the war. He very soon discovered that he could not serve the Shell Committee and the Steel Company of which he was a director, and, therefore, he resigned from the Company.

The Chairman in Charge.—The members of the Committee, who met almost daily, for consultation, during the first fortnight after its formation, now left to the Chairman the direction of the work. The Ordnance Adviser shared in some measure the responsibility the Chairman undertook.

Problems of Starting Manufacture.—Had a few manufacturers undertaken to make the entire shell the work would have been easier, but, with many manufacturers each doing a part, all had to be supplied with drawings, specifications, and gauges. All these had to be prepared. The organisation for the production had to be planned.

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Everything had to be done in haste. Factories had to be inspected and the capacity of each to produce shells had to be ascertained. Labour and machinery had to be found, so that the situation was one which required calm judgment and quick decision.

Appendix I to this Chapter, which is a copy of the Chairman's report to the Shell Committee on October 31, 1914, gives some idea of these difficulties.

Gauges Designed and Made.—Eighty different gauges had to be designed and made for each manufacturer assembling shells. No makers of gauges were to be found at that time in Canada. No shells could be finished without gauges. Messrs. Pratt and Whitney, Ltd., of the U.S.A., supplied the first sets of gauges to designs hurriedly prepared at the Office of Colonel Greville Harston, Chief Inspector of Arms and Ammunitions, Quebec. Some manufacturers of component parts used improvised gauges made by themselves.

The Canadian Inspections and Testing Laboratories, Ltd.—To carry out the Committee's decision to inspect all materials at the works of the makers of components of shells, before shipping them to the machining and assembling factories, an Inspection Company was appointed for this work. The Canadian Inspection and Testing Laboratories, Ltd., of Montreal, was entrusted with it, and performed it well.

The company not only examined the finished materials at each factory, but, with a standard set of gauges, periodically checked the sets of gauges used by the manufacturers.

Distribution of Components.—At first the decision of the Committee to distribute shell components to factories where they were assembled into shells did not involve much labour, but as the numbers of component parts increased their regulation and supply to different contractors scattered over the Dominion was of an exacting nature.

Gun Proof of Shells.—It was the business of the Shell Committee to arrange for shells to be proved in the gun.

From 1 to 2 per cent. of the shells made had to be fired. Only one gun existed at first for this purpose, but very soon others were mounted and the difficulty was overcome.

General Business of the Committee.—The general work of the Committee, therefore, consisted in controlling and directing, with a small executive staff, the products of a gradually increasing number of munitions factories. The work involved the selection of suitable factories, placing contracts, instructing manufacturers, inspecting, testing, and gun-proving the products, transporting the semi and finished products, insurance, auditing of accounts, etc.

Payment of Contractors.—On the receipt of a certificate from the inspectors that the components or finished shells had been accepted and were ready for shipment, payment was made to the manufacturers. A chartered accountant checked the accounts of the Committee every month. The accounts were subsequently checked by Mr. J. W. Borden, Chief Accountant for the Militia Department, who was also a member of the Committee.

This briefly outlines the functions of the Shell Committee, but fuller details of its work are given in the subsequent chapters.

APPENDIX I

The Chairman's Report to the Shell Committee on Oct. 31, 1914.

TO THE MEMBERS OF THE SHELL COMMITTEE.

Gentlemen,—This being our first monthly meeting since the organisation of your Committee on the manufacture of shrapnel shells, I have thought it well to report on the proceedings of your Committee from the 2nd of September last, giving the proceedings from that date until the 31st of this month. The Secretary will read to you a statement of receipts and expenditures from that date. I have also to report a credit of £100,000 from the War Office, sufficient to carry on the work to the 15th December, when further credits will be advanced. It will be necessary for you to move resolutions authorising the Chairman to sign all cheques and pay all bills and accounts. This resolution should be placed

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in the hands of the Bank of Montreal. I have also to report on the names of manufacturers who are machining and assembling and those who are manufacturing the component parts. On the component parts I have to report from samples furnished that we need have no fear of the result of their work. I have to congratulate this Committee on having secured the services of Mr. David Carnegie, Ordnance Adviser, who has been of invaluable service to this Committee, having visited all of the various factories and taken up all points necessary to facilitate the work.

It has been unfortunate that we were unable to receive the drawings and gauges when agreed upon, *i.e.*, the 15th of September. You are aware that we were called upon to furnish an agreement guaranteeing certain quantities, commencing on the 31st of October. I have been compelled to write the War Office qualifying this and delaying the first shipments, but I am now pleased to report that gauges are now in our hands and work will proceed on Monday. Mr. Carnegie's report will take care of the factory and manufacturing end. We have been compelled to keep the number of manufacturers on machining shells down to 10, owing to the fact that only 10 sets of gauges and 10 inspectors were available for this purpose.

APPENDIX II

This Agreement made this 1st day of October, 1914 :

BETWEEN Alexander Bertram, of Dundee, in the Province of Ontario, Thomas Cantley, of New Glasgow, in the Province of Ontario, and E. Carnegie, of Welland, in the Province of Ontario, Manufacturers, of the First Part, and Colonel the Honourable Sam Hughes, His Majesty's Minister of Militia and Defense of Canada, acting for and on behalf of His Majesty's Secretary of State for War, of the Second Part :

WITNESSETH that the parties of the First Part agree to manufacture and deliver to the party of the Second Part one hundred thousand Shrapnel 18-Pounder Mark III Shells (empty) and one hundred thousand 15-Pounder Mark VII Shells (empty), subject to the following terms and conditions, at the following rates :

(1) The said shells shall be made of such materials and components and in accordance with the drawings and specifications hereto annexed, and signed by the parties hereto.

THE SHELL COMMITTEE

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(2) The parties of the First Part agree to deliver the said shells as follows, viz. :

18-Pounder Mark III Shells

20,000 by 31st October, 1914
 15,000 „ 30th November, 1914
 15,000 „ 31st December, 1914
 15,000 „ 31st January, 1915
 15,000 „ 28th February, 1915
 15,000 „ 31st March, 1915
 5,000 „ 30th April, 1915

15-Pounder Mark VII Shells

15,000 by 30th November, 1914
 15,000 „ 31st December, 1914
 15,000 „ 31st January, 1915
 15,000 „ 28th February, 1915
 15,000 „ 31st March, 1915
 15,000 „ 30th April, 1915
 10,000 „ 31st May, 1915

Delivery to be made to the party of the Second Part or to his authorised officers, f.o.b. Montreal, to the order of the party of the Second Part.

(3) The shells shall be subject to inspection and such tests as may be required by the party of the Second Part during the process of manufacture, and shall moreover be subject at the factory by the party of the Second Part ; the approval and acceptance of any one lot of shells shall not be evidence of approval or acceptance of any other lot.

(4) The prices to be paid for the said shells shall be :

For 18-Pounder Shells \$8.55 per shell

„ 15 „ „ \$8.30 „ „

to be paid within ten days after the date of delivery, subject to certification of the invoices by the authorised officers appointed by the party of the Second Part.

IN WITNESS WHEREOF the parties hereto have hereunto set their hands the day and year first therein written.

Witness : D. CARNEGIE.

ALEX. BERTRAM, Col.

THOS. CANTLEY.

GEO. W. WATTS.

E. CARNEGIE.

CHAPTER III

THE STEEL PROBLEM

ONE of the first problems which faced the Shell Committee was the supply of steel for shell manufacture.

When the Minister of Militia was informed that the 18-pdr. shrapnel shells had to be made from 'acid' steel and that no acid open-hearth steel was made in Canada, he asked Colonel Cantley, one of the members of the Committee, to investigate the matter and report to him.

Colonel Cantley¹ made inquiries immediately at the Dominion Arsenal, Quebec, and 'learned that the British War Office specifications called for acid open-hearth steel of a somewhat exacting analysis and physical tests, and was then informed that basic steel would not be accepted or even considered by the army authorities.' It was on this information that he immediately took action.

British Specifications.—It was well known in England and at the Dominion Arsenal, Quebec, that the British authorities did not accept basic steel for shrapnel shells. The history of basic steel had prejudiced its use in Britain for purposes such as shells, guns, and even steam boilers, but the British specification for 18-pdr. Q.F. forged steel shrapnel shells, in 1914, did not actually specify that basic steel could not be used. It called for 'forged steel of the best quality for the purpose.' The 'purpose,' however, was very carefully safeguarded by definite

¹ Colonel Cantley has very kindly supplied the writer with facts relating to the experiments he made, for which he is indebted to him.

physical and firing tests, upon the results of which shells were accepted or rejected. Colonel Cantley was rightly informed at the Dominion Arsenal, as the material actually used by them for shrapnel shell manufacture was purchased from the United States of America as acid steel.

High Explosive Shell Steel.—British specifications, however, for all high explosive shells called for 'acid' steel. There were therefore two stages in the solution of the problem, the first in overcoming the difficulty in the use of basic steel for shrapnel, and the second and greater difficulty, in proving the suitability of basic steel for high explosive shells.

Basic and Acid Steel.—The label 'basic' as distinguished from 'acid' indicated respectively a poverty and wealth of silica in the iron ores from which the steels were made. Britain had been favoured, for many years, with more of the siliceous ores than America, or the Continental countries of Europe. The latter countries had developed basic steels more than acid, while the reverse was the case in Great Britain.

Both processes of steel-making had been pioneered by Great Britain and were old, although acid was the older. Other countries had derived more benefit from the basic process than Great Britain, because her ores were less suitable than theirs. Germany, France, Belgium, the U.S.A., Canada, and other nations had built up great industries as the result of Britain's discovery—how to use basic ores.

Britain's Cause for Fear.—It was not because she did not know the quality of basic steel that Britain restricted its use for shells, but rather that acid steel, which had for many years given proof of more reliability for munitions purposes, was obtainable in sufficient quantity to meet all her requirements. Undoubtedly, experience in the use of basic steel for some commercial purposes had disturbed the confidence of British users in its reliability. In 1914 Britain's experience with basic steel had covered nearly forty years. Other industrial countries had equal experience, although for fewer years. When war broke

out, basic steel compared favourably with acid steel for many commercial uses. Britain's anxiety, however, for the safety of her men and guns was to be commended until she had proof that basic steel could be used with equal reliability as acid steel.

That was the position of affairs on the evening of September 7, 1914, when General Hughes asked Colonel Cantley to investigate the steel question.

Colonel Cantley Convinced of Success.—Colonel Cantley did not take long to sum up the situation. After a careful examination of the U.S.A. steel at the Dominion Arsenal, and of the British specifications, he was convinced that the Scotia Steel Plant could produce a basic open-hearth steel from their Wabana red hematite ores which could meet the requirements of the specifications, and he advised the newly-formed Shell Committee and the Minister of his opinion.

First Experiments.—Satisfied that he could produce the steel required, he telegraphed to his superintendent at New Glasgow to put in hand at once a heat of steel of definite analysis. He also wired instructions regarding the preparation of tests. Two days later, on his return to New Glasgow, he examined the steel which had been made and saw it tested. He then believed that he had produced a steel which would prove to be equal in all respects but in name to the War Office requirements.

Back at Dominion Arsenal.—From the same 'heat' (of about 50 tons) ingots were rolled down into $3\frac{1}{4}$ in. 'billets' and 'rounds,' and cut to 18-pdr. shrapnel block lengths and forwarded to the Dominion Arsenal, Quebec. The following evening Colonel Cantley was back in Quebec, having taken a number of steel shell blocks with him. Some of the blocks were forged into shells, others were analysed and cut for physical tests. From the shells which were forged test-pieces were cut and machined. The tests from the shell blocks and the shell forgings proved entirely satisfactory. Repeated experiments at New Glasgow and the Dominion Arsenal established beyond doubt that the quality of the product was

equal to the U.S.A. acid steel used at the Dominion Arsenal.

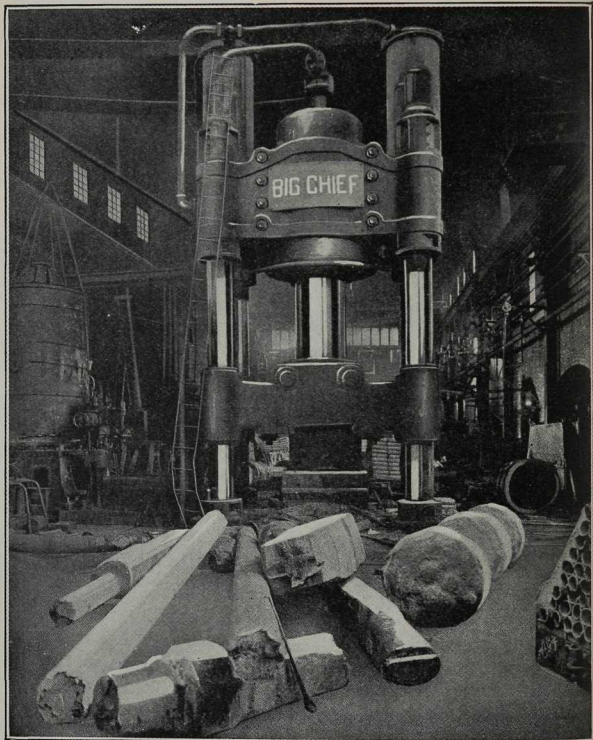
War Office Approval.—The Minister of Militia and the Shell Committee hardly expected such immediate success, but convinced of the results produced they informed the War Office, and subsequently received instructions to accept basic open-hearth steel for shrapnel shells.

Shell Forgings.—While the experiments were being carried out to prove the steel, another department at the works at New Glasgow was preparing punches and dies for forging shells. The first 18-pdr. shrapnel shell forgings made in Canada were forged on a 4000 ton hydraulic press (nearly forty times larger than necessary) which was installed two years earlier. This press was built for the Company at Kalk, Germany. A press suitable for forging ship's frames and heavy masses of steel converted to the punching and drawing of a few pounds of steel. The press was subsequently altered to forge four shells at one time by an ingenious arrangement which led to much economy. On September 21, 1914, the Nova Scotia Steel Co. were advised to proceed with the forging of 200,000 shells, and the large press referred to was used until smaller presses were installed.

Record Delivery of Presses.—It is worthy of record that soon after the Nova Scotia Steel and Coal Co. received the order to forge shells, Colonel Cantley, with Mr. H. H. Vaughan, Superintendent of the Canadian Pacific Railway Angus Shops, Montreal, designed a forging press for 18-pdr. shells. Mr. Vaughan undertook, on behalf of the Angus Shops, to make and deliver four of the presses in four weeks. 'As a matter of fact,' says Colonel Cantley, 'the first press was delivered in twenty days, expressed through to New Glasgow, and was actually working in twenty-three days from the date when designed. The remaining three presses were delivered and working a few days later.' This was a great record, but an index only of the fine spirit which inspired Canada all through the period of the war.

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Basic Steel for Explosive Shells.—Having proved that the steel made by the Nova Scotia Steel and Coal Co.

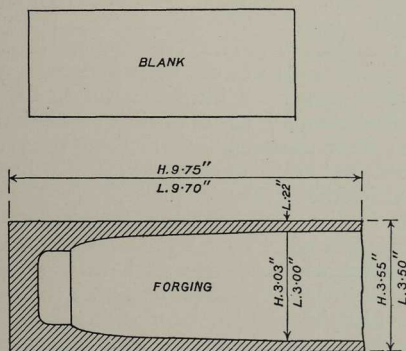


NOVA SCOTIA STEEL & COAL CO., LTD., NEW GLASGOW, NOVA SCOTIA
4000-ton Hydraulic Press converted to forge 18-pdr. Shrapnel Shells. Sept. 1914

could meet the requirements of the British specifications for shrapnel shells, it opened the way to discuss the uses of basic steel for high explosive shells. By the

end of November, 1914, Canadian manufacturers were becoming expert in the heat treatment and finishing of shrapnel shells.

At the suggestion of the Chairman of the Shell Committee, and with the approval of the Minister of Militia, the Ordnance Adviser left for England in December, 1914, with records of the Nova Scotia steel and two sample shells. One of the latter he presented to General Sir Stanley Von Donop, K.C.B., K.C.M.G., Master General



18-PDR. SHRAPNEL SHELL FORGING; ALSO SOLID BLANK OF ROUND STEEL FROM WHICH IT IS FORGED

of the Ordnance, at the British War Office. He and his staff were pleased with the results of the steel tests, and gave a favourable hearing in regard to the use of basic steel for high explosive shells.

Chief Inspector, Woolwich.—It was with the Chief Inspector, Woolwich, and the Ordnance Committee that the decision rested as to the use of basic steel for high explosive shells. From records of hundreds of tests made at New Glasgow, at the Dominion Arsenal, and by the Shell Committee's Inspectors, the Canadian Inspection and Testing Laboratories Ltd., Montreal, the Shell Committee's Ordnance Adviser was able to prove to the

Chief Inspector, Woolwich, and the Ordnance Committee the quality of steel which could be produced, and to persuade them to accept basic steel for high explosive shells. This they agreed to do by modifying the analyses of the steel slightly without altering the physical requirements. It was a great concession. Shells were now more urgently required. The fact that the hydraulic press equipment of Canada was capable of forging much larger shells than 18-pdr. helped the Chief Inspector to reach a decision. Britain, at that time, could not manufacture all the large shells required.

Many Difficulties.—The manufacture of steel for high explosive shells was not quite such an easy matter as that of shrapnel. Adjustments had to be made in the chemical composition to obtain the physical results required; heat treatment had to be devised to break down stubborn 'heats' of steel, and, ultimately, specially controlled methods for air cooling the shells, when forged, had to be applied to some 'heats' of steel. The Nova Scotia Steel Co. having led the way, all the Canadian manufacturers who had any steel melting equipment were called to help in the supply of steel. No steel maker desirous of helping was refused the fullest information as to the methods adopted by the Nova Scotia Steel Co.

The Value of the Result.—It is well to consider what would have happened if basic steel had not proved equal to acid steel for shrapnel and high explosive shells. Canada would have been dependent on the United States for its supply of munitions steel. But more, she would have had to pay accordingly. Colonel Cantley, referring to the question of prices in September, 1914, says: 'This was abundantly evident two days later when the Quebec Arsenal, being desirous of buying one hundred tons of acid shell steel, found that the American steel manufacturers had advanced their prices from 3.75 cents to $7\frac{1}{2}$ cents per lb., although eventually they agreed to accept 4.65 cents.' The Shell Committee was able to obtain the same quality of steel from the Nova Scotia Steel Co. for 3.37 cents per lb.

Shell Contracts Commission.—The members of the Royal Commission on Shell Contracts, the Hon. Sir William Meredith, Chief Justice of the Supreme Court of Ontario, and the Rt. Hon. Lyman Duff, Justice of the Supreme Court, stated in their report to the Governor-General, His Royal Highness the Duke of Connaught, in 1916 :

It may be mentioned here that but for the efforts of Colonel Cantley personally, of the Nova Scotia Steel Company, it would have been impracticable to have obtained orders for the fabrication of shells in Canada. The War Office had been of the opinion that acid steel, which is not made in Canada, was the only suitable material for the manufacture of shells, shrapnel, and high explosive shells. Basic steel is the only kind of steel made in Canada, and this the War Office would not accept. After elaborate and costly experiments under the direction of Colonel Cantley, the Nova Scotia Steel and Coal Company succeeded in producing a quality of basic steel which the War Office was persuaded to accept, and the placing of shell orders in Canada was assumed.

Steel Works in Canada.—As a result of the experiments referred to, all the steel works and foundries in Canada were eventually employed in producing steel in one form or another for munitions purposes until the Armistice. These experiments were but the beginning of many subsequent experiments and improvements which changed the steel-producing capacity of Canada from 800,000 tons in 1914 to 2,500,000 in 1918. They did more ; they prevented a large part of the 800,000 tons capacity of 1914 from lying idle during the war. The manufacturers of munitions steel brought to Canada a fuller metallurgical knowledge of steel, the scientific value of which will be of wide application in commercial pursuits. The appended list of makers of steel witnesses to these results, which should be an inspiration to all students of metallurgy, and a permanent reminder of a great accomplishment.

APPENDIX

Steel Manufacturers in Canada, in 1918, Producing Steel for the Imperial Munitions Board

Company.	Address.	Capacity of Ingot Production per month. tons
Algoma Steel Corporation .	Sault Ste Marie, Ont.	50,000
Armstrong, Whitworth & Co., of Canada	Montreal, Que. .	1,500
British Forgings Ltd. (Na- tional)	Toronto, Ont. .	6,000
Canada Cement Co. . .	Montreal, Que. .	1,500
Canadian Steel Foundries .	Montreal, Que. .	15,000
Thos. Davidson Manufactur- ing Co.	Montreal, Que. .	2,500
Dominion Steel Corporation Ltd.	Sydney, Nova Scotia	33,000
General Car & Machinery Co. Ltd.	Montmagny, Que. .	3,000
Wm. Kennedy & Sons Ltd. .	Own Sound, Ont. .	3,000
Nova Scotia Steel & Coal Co. Ltd.	New Glasgow, N.S.	11,000
Steel Company of Canada Ltd.	Hamilton, Ont. .	30,000
Three Rivers Steel Co. . .	Three Rivers, Que.	1,000
Dominion Steel Foundry Co. .	Hamilton . .	13,000
Electric Steel & Metals Co. .	Welland, Ont. .	1,200

In addition to the foregoing Steel Companies, there were others in Canada making steel castings by the electric furnace and Bessemer Converter processes.

CHAPTER IV

PROBLEMS IN MACHINING SHELLS

WHILE investigations were being made concerning the suitability of basic steel for shells, the Shell Committee had to find manufacturers who would undertake to produce the various components of the shells, and also manufacturers who would assemble the components and finish the shells completely.

Components of 18-Pdr. and 15-Pdr. Shrapnel Shells.—

The manufacture of the 18-pdr. and 15-pdr. shrapnel shells called for the assistance of many industries. The component parts of these shells included the steel body, which had to be forged from a short block of steel cut from a round or square bar ; a steel disc, stamped from a piece cut from a rolled flat bar ; a tin cup for powder stamped and built into shape to fit the chamber in the bottom of the shell ; a brass solid-drawn tube accurately machined to screw into the steel disc and fit also a brass socket which had to be stamped, machined and screwed into the mouth of the shell, the tube thus connecting the socket and the powder cup through the steel disc ; metal balls made from a composition of lead and antimony, the weight, size, and number of which had to be carefully adjusted ; resin, which when melted filled the spaces between the lead balls which occupied the body of the shell between the disc and the socket ; a metal plug which screwed into the socket to keep the inside of the shell clean and dry until fitted with the fuse, which was not supplied with the first shells made in Canada ; a grub screw for fixing fuse in position when screwed into

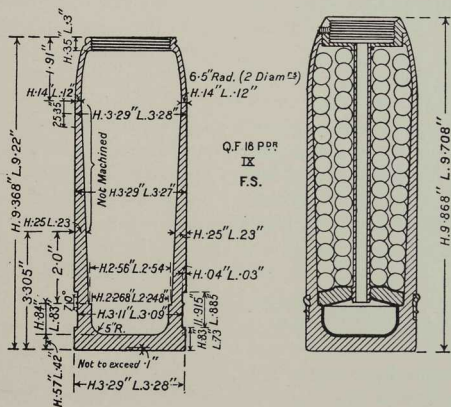
socket; a copper band for groove in outside of shell body; and a wooden box for the shipment of the shells overseas.

How Component Parts were Supplied.—The various components, after inspection, were supplied to the manufacturers who assembled the shells:—the un-machined body of the shell forging; the steel discs completely forged and screwed; the brass tubes completely machined; the brass sockets almost entirely machined except on the outside at the top; the completely finished tin cup for powder; the lead balls finished; the resin ready for melting; the unfinished copper band ready for pressing into the groove of shell; the machined metal plugs and grub screws ready for fitting into the shells; and the wooden boxes for packing the shells when the latter were passed by the government inspectors.

Two Classes of Manufacturers.—From the foregoing it will be seen that the policy adopted by the Shell Committee to divide the work of shell manufacture into different parts led to two main classes of manufacturers being commissioned to do the work—one, who supplied components; the other, who built the components into the shells, and took the responsibility for the finished shell being accepted by the government inspector.

Makers of Component Parts.—As to the first class of manufacturers there were more in Canada than of the second class. Neither the one nor the other could have done the work successfully alone at the time. The supply of steel bars, for instance, from which the material for the shell bodies and the discs were made, presented no difficulty whatever to the steel makers of Canada when once the composition and quality required were determined. The plant equipment for rolling steel into different sections had been in operation in several steel works for years, so that no fresh equipment for this operation was required. Forging the steel body, however, from the steel block was an entirely new class of work. To the steel maker it was new, although the plant and furnace equipment of a steel works produced the natural

sphere in which this work could be done successfully. The steel discs likewise were articles similar in many respects to other commercial products made by companies in Canada who supplied various kinds of steel stampings. Thus, in these two components, manufacturing skill existed or could be readily trained to make them. The same observations could be made with reference to the other components—such as the tin cups for



SECTION OF MACHINED EMPTY
18-PDR. SHRAPNEL SHELL.

SECTION OF 18-PDR. SHRAPNEL
SHELL WITHOUT FUSE

powder, brass tubes, sockets and plugs, steel grub screws, lead balls, and wood boxes for the shipment of shells. With reference, however, to the copper bands it was quite different; these had to be obtained from the United States. There was no equipment in Canada for their manufacture, and at the time all copper required for making them had to be obtained also from the U.S.A.

Shell Machining and Assembling Makers.—With reference to the second class of manufacturers, the machinery equipment and skill required for this work resembled that of the general equipment and skill of a machine

maker or engine builder. The skill of the trained machinist and tool maker was such as could be trained quickly to the various operations required, but there were comparatively few establishments in Canada in 1914 with many such skilled workmen. Then again, ordinary machine shop plant was not the most suitable for shell finishing, either in point of speed, economy, or quality. Special machining for turning, boring, facing, cutting, grooving and finishing the shell body had to be obtained. Special furnaces and presses had to be installed for heating and closing to form the head. Furnaces for heating and tanks for cooling the shell body had to be provided. A special press for squeezing the copper band into the groove in the shell had to be procured; means for filling the shells accurately with lead balls and resin had to be devised, and lathes for finishing the assembled shell had to be provided. Facilities for painting the shells after inspection had also to be introduced. These were roughly the conditions and requirements of skill and equipment in Canada when the 15- and 18-pdr. shells were offered to manufacturers in 1914.

Conditions of Contract.—No contract for a component part or for machining and assembling a shell was placed before the Committee was satisfied that the contractor was able to do the work. The Committee was fortunate in having as its Chairman one who knew nearly all the manufacturers in Canada. Where there was any doubt as to the machinery equipment of a contractor, or of the possibilities of securing suitable equipment in time to complete the contract in accordance with the terms of the contract, a competent inspector was sent to report on the state of the factory, and make the fullest inquiries as to equipment. If new factories were proposed, the plans and equipment were usually submitted for approval.

When satisfied that the work could be carried out, an order was issued stating the number of articles required, along with the specifications and drawings governing the quality, dimensions, and nature of the inspection of the product. The terms of contract always included a clause

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making it subject to cancellation if the work were not delivered in accordance with the promise given.

Particulars Supplied to Manufacturers.—In addition to the foregoing, it was found necessary to issue in the form of a letter definite instructions on various points relating to the manufacture of the shells and their parts. This was done in the form of an open letter, as follows :

OFFICE OF THE SHELL COMMITTEE,
722 DRUMMOND BUILDING,
MONTREAL, Sept. 24, 1914.

TO MAKERS OF SHELLS,—The Shell Committee beg leave to advise for your information that both 18-pr. and 15-pr. shrapnel shells are being manufactured.

The attention of contractors is directed to the following rulings drafted by the Shell Committee governing the manufacture of shells to prevent confusion and possible delays and loss.

1st. The contract calls for 100,000 shrapnel shells of each size, and it is the intention to employ certain factories on each size so as to make prompt deliveries. The factories which have commenced operations on the 18-pr. shells will continue as instructed.

2nd. All small component parts will be purchased by the Shell Committee and will be supplied to the different factories, as required by them, at a uniform fixed price.

3rd. Shell forgings, or rough steel forging blocks and steel discs, will be purchased by the Shell Committee from steel and forge companies, and delivered to the factories as required, and at a uniform price.

4th. All component parts must be inspected by authorised inspectors before they are shipped to the different factories who are assembling the shells.

5th. Companies machining and assembling shells must communicate direct with the Shell Committee, No. 722 Drummond Building, Montreal, when they require any component parts, or information regarding them.

6th. Companies manufacturing component parts must not ship any material unless instructed in writing by the Shell Committee.

7th. Companies making their own component parts must notify Shell Committee what parts and materials they are supplying.

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8th. Deliveries promised by companies machining shells or supplying component parts must be rigidly adhered to, otherwise there will be confusion and delay in delivering completed shells.

9th. Authorised inspectors will be employed by the Shell Committee to inspect the forgings, and all component parts and shells in the process of completion.

10th. All component parts, steel, shell blanks, and discs entering into the manufacture or assembling of the shell must be obtained from the Shell Committee or manufacturers, approved by the Shell Committee, and passed by the official inspector.

11th. All manufacturers are recommended to make a few samples of the parts and work allotted to them, and submit these samples for inspection before completing the parts in large quantities. This will eliminate the risk of loss by having large quantities rejected later.

12th. It is thought desirable that manufacturers assembling shells should submit for firing proof, say, five of the first shells completed by them, so as to insure certainty that all is right before proceeding with the assembling of large quantities. Proof shells, not exceeding five, so supplied, will be paid for by Shell Committee.

13th. List of component parts which can be supplied by the Shell Committee, and prices of same, will be mailed to the manufacturer on application.

14th. One complete set of Master Gauges will be supplied by the Shell Committee free of charge to the manufacturers who have been instructed to finish the shell bodies and assemble the parts complete.

15th. Master Gauges must be kept for reference only, and manufacturing or working gauges must be supplied by the various companies for the use of their employees.

16th. Manufacturers of component parts of shells will be supplied with Master Gauges only for the parts they are ordered to supply.

17th. All Master Gauges must be returned to the Shell Committee immediately after the orders are completed.

Yours very truly,

(Signed) A. BERTRAM.

What Contracts Involved.—As the whole shell business was new to the Committee and manufacturers alike, it was in the interests of rapid production that the

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Committee should provide every means of help possible to the manufacturers.

This was done by arranging for manufacturers to visit the Dominion Arsenal, Quebec, and witness the methods employed there in making 18-pdr. shrapnel shells. They also arranged for the Ordnance Adviser to visit the factories of manufacturers and help them to solve their problems.

Some Difficulties Experienced.—The chief difficulty manufacturers experienced was in rapidly adjusting what machinery they possessed, and in securing the right kind of new machinery to machine the products and give satisfactory results. The shell products were so different from those usually required for commercial purposes, and the quality and dimensions so much more exacting, that at first there was considerable fear lest the inspection and proof called for by the specifications could not be secured.

Added to these difficulties most of the manufacturers had to work for some time without proper gauges and plant equipment. New machinery was most difficult to obtain, but gauges could not be obtained in Canada at any price. No facilities existed in Canada for their manufacture, and only two manufacturing companies in the U.S.A. could give the Shell Committee any assistance. Some weeks actually elapsed before machining and assembling manufacturers could be supplied with the set of gauges promised by the Committee in its letter to them of September 24, 1914.

As soon as one set of gauges was obtained the Committee arranged for its inspectors to go round to manufacturers with the gauges, and help them to check the improvised gauges they had made for preliminary shell operations.

The First Munitions Manufacturers.—In spite of these obstacles, and the fact that trade in Canada had suffered reverses and few were able to make ventures which involved financial outlay, it is worthy of record that so many manufacturers undertook contracts.

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From a minute of a meeting held on September 7, 1914, at Valcartier Camp, Quebec, the names of the first manufacturers were given. They were :

John Bertram & Sons Co. Ltd. .	Dundas
Goldie & McCulloch Co. .	Galt
Canada Foundry Co. .	Toronto
Canadian Rand Drill Co. .	Sherbrooke.

At that meeting it was decided to ship 500 18-pdr. shrapnel shell forgings to each of these companies from the Dominion Arsenal, Quebec. At the same time, the Electric Steel and Metals Co., Welland, undertook a contract for 15-pdr. shrapnel shells.

By September 11 Colonel Bertram informed the Minister of Militia that the following manufacturers had promised to assist him :

John Bertram & Sons Co. .	Dundas, Ont.
Goldie & McCulloch . .	Galt., Ont.
Canadian Machinery Corporation	Galt., Ont.
Canada Forge Co. . . .	Welland, Ont.
Canadian General Electric Co. .	Toronto, Ont.
Canadian Steel Foundries. .	Hamilton, Ont.
John Inglis Co. . . .	Toronto, Ont.
Jas. Morrison Brass Mfg. Co. .	Toronto, Ont.
Galt Brass Co. . . .	Toronto, Ont.
Kemp Mfg. Co. . . .	Toronto, Ont.
Sam. Benjamin Co. . . .	Toronto, Ont.
Thomas Davidson Mfg. Co. .	Montreal, Que.
Crucible Steel Co. of America .	Montreal, Que.
Canadian Rand Drill Co. .	Sherbrook, Que.
Nova Scotia Steel Co. . .	New Glasgow, N.S.
Canadian Locomotive . .	Kingston, Ont.
Electric Steel & Metals Co. .	Welland, Ont.
Steel Company of Canada .	Montreal, Que.
Canada Foundry Co. . .	Toronto, Ont.
McClary Mfg. Co. . . .	London, Ont.
American Can Co. . . .	Montreal, Que.
Northern Electric Mfg. Co. .	Montreal, Que.

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Gas. Robertson Mfg. Co. . .	Montreal, Que.
Billings & Spencer . . .	Welland, Ont.
Dominion Stamping Co. . .	Walkerville, Ont.
Galt Machine Screw Co. . .	Galt, Ont.
Chadwick Bros.	Hamilton, Ont.
National Acme Co.	Montreal, Que.
Tallman Bros. & Co. . . .	Hamilton, Ont.

These manufacturers belonged to the two classes referred to in this chapter, and it may be said that they were the pioneers of the munitions business in Canada.

Rapid Development.—So rapid was the development of shell manufacture in Canada that by the end of October, 1914, thirty-four manufacturers were engaged in making 15- and 18-pdr. shrapnel shells and eighteen more were ready to equip. Fifteen of the manufacturers were machining and assembling, while the remainder were making components. From a report made by the Ordnance Adviser to the Chairman of the Shell Committee, dated November 5, 1914, some idea is obtained of the progress made and the capacity for shell production in Canada at that time. The report was written after visiting the factories. It states :

I estimate that the works now equipped for forging and finishing 18- and 15-pdr. shells could produce 80,000 shells per month by working two or three shifts per day (24 hours) and using their plants to full capacity. In addition to this output I estimate that 20,000 more shells per month could be produced by the contractors who have signified their desire to undertake the manufacture of shells, but for whom no orders are available.

As to capacity the report states :

The plants already engaged in forging shells could undertake the manufacture of all natures of projectiles up to 6 in., and at the Nova Scotia Steel and Coal Co. there is a forging press that could be adapted to forge up to 15-in. armour piercing shells, now being made at the Woolwich Arsenal. From my estimation of the machinery equipment of contractors now engaged on 15- and 18-pdr. shells, I have no hesitation in stating that in many of the works the machinery could be easily converted to produce

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shrapnel and lyddite forged steel shells up to 6 in. The larger works could be equipped under skilful direction for the manufacture of armour piercing projectiles.

War Office Informed and Orders Received.—The British War Office was informed of Canada's capacity, and orders for 400,000 18-pdr. empty shrapnel and for 200,000 18-pdr. shrapnel fixed ammunition complete except fuses were placed on December 4, 1914, and for an additional 900,000 fixed rounds same as the 200,000 on December 26. The Ordnance Adviser left for England early in December, 1914, to inform the War Office of Canada's capacity, and to discuss other matters with the officials there. The progress made by Canada in the manufacture of shells in such a very short period was a revelation to the British officials.

CHAPTER V

SHELL COMMITTEE AND GOVERNMENT INSPECTION

THE inspection of component parts of shells, initiated by the Shell Committee, was a necessary adjunct to the subdivision of the work of making shells. Reference has been made already in Chapter II to the appointment of the Canadian Inspection and Testing Laboratories Ltd., of Montreal, to inspect, on behalf of the Shell Committee, materials and components before their shipment to the machining and assembling shell manufacturers.

No provision was made nor even contemplated by the War Office for such a division of work in making the shells when the specifications were prepared. The course usually adopted in Great Britain was to place a contract for the whole shell, and hold the manufacturer entirely responsible for its supply.

The decision of the Shell Committee to depart from British practice entailed the preparation of supplementary specifications to govern the manufacture and inspection of the component parts. Such inspection did not form part of the general inspection of materials and the final examination and firing proof of the shell which came under the direction of the government inspector.

Extent of Shell Committee's Inspection.—The Shell Committee and the Chief Inspector of Munitions together planned the extent of the subsidiary inspection necessary. For instance, whatever inspection the Shell Committee set up could be regarded only as supplementary to the inspection called for in the War Office specification.

The extent of the inspection instituted was in many respects similar to that which a manufacturer in England, undertaking to make the whole shell, would impose upon a sub-contractor who supplied parts of the shell. As, however, the subdivision of the work by the Shell Committee far exceeded that usually made by munitions manufacturers in England, the extent of the inspection was obviously greater.

Duties of the Shell Committee's Inspectors.—The Inspection Company appointed by the Committee received a copy of the official orders and specifications setting forth exactly the inspection requirements. The Inspection Company also received instructions regarding limits of discretion which they could use where it was found necessary.

The work was new to inspectors and manufacturers alike, so that the inspectors went into the works, not so much as policemen or detectives, but as workers together with the manufacturers in getting products which would pass the final government inspection.

Mr. Griffeth, the President of the Inspection Company, planned in a very creditable manner the distribution of men throughout the factories whom he and his office staff had previously drilled into the methods of inspection.

As inspectors had to be obtained quickly, some of them at first were timid and worked too rigidly to the letter of the specification and the limits set upon the drawings and gauges. This was but natural, and the irritations and delays sometimes occasioned before they gathered experience were gradually broken down by visits to the factories of Mr. Griffeth and others of his staff, who straightened out irregularities. Upon the certificate of the inspector, that the materials and components were supplied in accordance with the specification, payment was made to the component manufacturers. The Shell Committee therefore, and not the manufacturer who assembled the shells, paid for the components and accepted the responsibility for their correctness.

Nature of Inspection.—One or two examples may show exactly the kind of work undertaken by the Inspection Company under the direction of the Shell Committee. For instance, rolled bars made at one works and shipped to another, to be cut and forged into shells, were examined superficially to see that they were free from seams and other defects. Chemical analyses were made also, and physical tests taken from batches of steel known as 'heats' for proof of quality. The steel manufacturers were not entirely relieved from responsibility when bars of steel left their works. When shells were forged, if flaws developed which were obviously due to defects in the steel and which an inspector could not discover by ordinary examination, such material had to be replaced at the manufacturer's cost. Fortunately very few replacements of this kind were necessary. A certain amount of material was left to be machined from the body of the shell forging, which permitted of the removal of surface defects. Forgings had to be inspected and gauged before shipment to the machining and assembling factories. The inspector had to stamp each forging with his own mark and the number of the 'heat,' so that it could be identified throughout each process, and the number appear on the finished shell. Then again, with tin powder cups it was the practice to examine the tinned sheets for thickness, weight, and surface quality before they were stamped and built up into cups. The finished cups had to be inspected again for measurements and superficial condition before they were passed as correct. But all other components were treated likewise according to the nature of inspection required. Enough detail has been given to show that this inspection, self-imposed by the Shell Committee, was vital to the success of rapid production, and was a relief to manufacturers, who thereby knew the extent of their liabilities.

Gauges for Components.—Reference has been made to the difficulty experienced in obtaining gauges for the inspection of materials. Until these were obtained components had to be measured with ordinary tool shop

micrometers and improvised gauges made by manufacturers, but in spite of these handicaps comparatively few rejections resulted. The fact that manufacturers and workers alike knew the urgency and importance of output and quality created a desire to produce their best workmanship.

Government Inspection.—The sudden call for munitions from Canada made demands upon the small staff of the Chief Inspector of Arms and Ammunitions which found him helpless to meet them. But the work of inspection had to be organised. The Shell Committee and government inspectors had one object only, and planned together for its attainment. In the preparation of specifications for and drawings of the first gauges used for the intermediate and final inspection of shells the Shell Committee and the Chief Inspector shared the responsibility. For some weeks the Dominion Arsenal, Quebec, was a veritable hive of industry, night and day. After the first orders for 18-pdr. and 15-pdr. shrapnel shells were placed, every available draughtsman at the Dominion Arsenal and in the district was requisitioned for the design and preparation of drawings of gauges. These gauges exceeded eighty in number for the 18-pdr. shrapnel and the same number for 15-pdr. shells. The greatest care at this stage was necessary to insure accuracy in every detail. Any slight error in the drawings of gauges would have caused great loss and delay. But even with all the energy bestowed in the preparation of the drawings and the unremitting services of the well-known American tool and machinery makers, Messrs. Pratt & Whitney, the gauges were not delivered until October 31, 1914. During this period of about five weeks the manufacturers were getting factories and equipment in order, and were making experiments in many directions to deal with the output.

The time, therefore, was not lost, but on receipt of the first lot of gauges, five sets were distributed among the machining and assembling manufacturers who were furthest forward with their plant and equipment. The

other five sets were retained by the Chief Government Inspector.

Organisation of Government Inspection.—The organisation of the government inspection was planned by Colonel Greville Harston and Major Ogilvie. They had quite as much difficulty in finding and training men as the Shell Committee's Inspection Company. A few men were sent from England, who were made responsible for the oversight of the examiners in the factories in each district.

The first machining and assembling factories were in the provinces of Ontario and Quebec, separated by several hundred miles. It was important to have Chief Examiners in each works who would be responsible for the conduct of all the operations of inspection carried out in the factory.

The principal items of inspections in the machining and assembling factories were :

1. After the shell body was heat treated, test-pieces were cut from one out of a batch not exceeding 120.
2. The machined groove in body of the shell for copper band was examined.
3. The final examination of the entire shell. This included a careful inspection of the copper band to insure that the material was in contact with the bottom of the groove ; the selection of one shell out of a batch and taking it to pieces to examine all components ; the cutting out of copper band to examine in it the impression of the shell ribs.

Firing Proofs.—In addition to the foregoing tests and examination, shells were fired for proof in gun and recovery from every lot examined. If it were found that the shock of discharge had distorted the disc supporting the bullets, or caused such alteration to the internal parts as would interfere with the correct action of the shell, the 'lots' represented by the 'proof shells' would be rejected. They could, however, be resubmitted for further proof. There were other conditions called for which had to be fulfilled, but these were the principal stages in the

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examination of the shells. It was very necessary at the beginning of such work to insist upon it being done correctly.

During the early part of November several 18-pdr. shrapnel shells were completely finished and passed the firing proof. By December, 1914, shells were being produced much faster than the Inspection Department could prove them. At first only one gun was available for proving shells, but other guns were ultimately secured and the proof butts extended.

The work of inspection in these early days was full of difficulties, and great patience was exhibited both by inspectors and manufacturers.

CHAPTER VI

CARTRIDGE CASE MANUFACTURE

BEFORE any 18-pdr. shrapnel shells were completed the Shell Committee received an order, on October 19, 1914, for 100,000 18-pdr. cartridge cases.

Cartridge cases are now known to most people. Since the Armistice many old ones have been converted to carry lights and other domestic ornamentation into the homes of the people. To thousands during the war they were nothing but death containers. Cartridge cases are usually made of brass, and vary in sizes from a few tenths of an inch for small arms to 6 in. for guns. The sizes made in Canada during the war, apart from small arms cartridges, made at the Government Ross Rifle Factories, were principally 18-pdr. and 4.5 in., although 2-pdr., 13-pdr., and 75 millimetre cases were also made in quantities, and some 4.7 in. were made experimentally.

Cartridge cases contain the shell-propelling charge. For the smaller sizes of guns the shell is fixed into the cartridge case. When the shell is fused and the filled case is fitted with a primer, all ready for the gun, the whole is called a complete round or fixed ammunition. The primer, which contains sufficient powder to fire the propellant, is fitted into the bottom of the cartridge case. The detonating cap in the primer receives the blow from the striker on firing the shell, and the empty cartridge case is subsequently ejected from the gun and rectified for use again.

The cartridge case looks a simple thing to make, but,

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long, 4 in. in diameter at the base, and a little over $3\frac{1}{4}$ in. at the end which received the shell. It was first punched into a cup and then drawn in successive stages into a thin tube, and finally 'headed' to form the base. Although brass is soft compared with steel, yet when punched and drawn while cold it becomes very hard and brittle. To remove the brittleness, the material had to be annealed between each forging operation. There were at least thirty operations in making an 18-pdr. cartridge case, including punching, drawing, annealing, basing, machining, tapering, trimming, etc. A mere statement of these facts can give little idea of the initial difficulties experienced in making these cases. There were so many exacting restrictions in the specifications as to the composition of the metal, the manner of their manufacture, the precise form of their outline, the limits of their dimensions and firing tests, that the risks undertaken by Canadian manufacturers were very great. 'But,' said they, 'British manufacturers had overcome the difficulties, why cannot we?'

The Chadwick Brass Co. Ltd.—The first order for 18-pdr. cartridge cases was placed with the Chadwick Brass Co., of Hamilton, Ontario. The company had no previous experience with this type of work, but had to secure complete equipment for its manufacture. Here, again, much help was rendered by Colonel Lafferty, Superintendent of the Dominion Arsenal, Quebec, who gave to the company full facilities to study the operations and methods adopted at the arsenal for making the cases. Before the new plant was delivered another order for 200,000 18-pdr. fixed rounds was received by the Shell Committee on December 4, 1914, the cartridge cases for which were placed with the Canadian Cartridge Co. of Hamilton. This company was formed by the principals of the Chadwick Brass Co. Ltd. While these companies were securing presses and other special equipment for making the cases, another urgent order came from the War Office, on December 26, for 900,000 complete fixed rounds, except fuses. The

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Canadian Pacific Co. was asked if it could help in their manufacture, and the company immediately undertook to convert its existing machinery equipment, and carried out a series of experiments which proved very successful.

Experiments at the Angus Shops.—To Mr. Harry Vaughan, the Chief Mechanical Engineer of the Canadian Pacific Railway, is due the credit of having produced the first 18-pdr. cartridge cases in Canada from ordinary forging machines known as bull-dozer.

Lord Shaughnessy, enthusiastic over the possibilities of using the Angus shops for munitions production, placed at the disposal of the Shell Committee, in November, 1914, the use of the Angus shops, Montreal, and the services of Mr. Vaughan. Mr. Vaughan obtained from the Dominion Arsenal, Quebec, the loan of dies and punches used there for the manufacture of 18-pdr. cases. He fitted them to a bull-dozer in the Angus shops. After repeated failures he succeeded in making a cartridge case to the specifications. In less than ten days from the commencement of experiments he handed to General Bertram, at the Office of the Shell Committee, an entirely satisfactory cartridge case. It was a fine piece of work and a great accomplishment. Its result did much to encourage timid manufacturers who had been struggling towards success. It was the beginning of a new industry to Canada. Metallurgical and mechanical difficulties of no mean order had been overcome. Manufacturers agreed that if with a common bull-dozer cartridge cases could be produced, with proper machinery and annealing equipment they need fear nothing. But further, these experiments at the Angus shops opened the way for Canada to undertake large orders for complete rounds of ammunition. The British Government had placed large orders for 18-pdr. complete rounds in the U.S.A. because it did not consider Canada had the facilities to manufacture complete rounds. The Shell Committee now being assured of cartridge case production informed the British War Office accordingly.

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Cartridge Case Manufacturers.—No sooner was it demonstrated that cartridge cases could be made than several manufacturers offered to take contracts. New companies were formed also. In addition to the Canadian Pacific Railway Co., the General Electric Co. of Toronto, the Canadian Car and Foundry Co. of Montreal, the Montreal Locomotive Co. of Montreal equipped their works for large outputs.

The new companies formed in addition to the Canadian Cartridge Co. were the Montreal Ammunition Co., Montreal, and the Drawing Co., St. Catherine.

Before some of these manufacturers could overcome the initial difficulties, and give the deliveries required, the Shell Committee had to obtain the assistance of the Crosby Co. of Buffalo, which did excellent work and helped the Committee greatly at this period.

Principal Difficulties.—The chief difficulties in manufacture arose when the design of the 18-pdr. cartridge case was changed. Some of the companies almost despaired of ever making them satisfactorily. The correct internal finish and form of the cases were very hard to obtain. At firing proof many thousands failed. Some manufacturers who had been successful in making cases to the Mark I design failed miserably when their cases made to the altered design were submitted to firing proof. One firm lost at proof nearly 30,000 cases during these experimental stages, while others had losses almost as great.

Added to these losses were troubles with the presses used in forming the bases of the cartridge cases. To form the base it required about 900 tons pressure. This pressure applied many thousand times per day on presses not suitably designed for such rapid action caused several breakages and consequent delays.

These were some of the problems the solution of which by patience and exhaustive experiments brought very remarkable results. During the Shell Committee regime no manufacturer received any financial assistance from

the Committee, but each was paid a fixed price for the cartridge cases, from which figure was deducted the price of the brass disc supplied to the manufacturers by the Shell Committee. Some companies spent between two and three hundred thousand dollars in plant equipment and experiments before receiving any return.

First Deliveries of Cases.—These difficulties of manufacture were not without a very marked effect upon the first deliveries. The Shell Committee's promise to the War Office when it undertook the first order of 100,000 18-pdr. cases was to deliver at the rate of 2500 per week after ten weeks following the receipt of specifications, drawings, master manufacturing and inspection gauges, and also one set of gauges for punches and dies, such as used at Woolwich Arsenal.

This promise was given in a cable sent to the War Office on October 6, 1914, in reply to the first inquiry for cartridge cases. It indicates that the Shell Committee were conscious of the difficulties with which the manufacturer was beset. Instructions to proceed were received by cable on October 19, but before any deliveries were made the change in design of case referred to above had taken place, which threw the manufacturers back. The Ordnance Adviser, while in England during the latter part of December, 1914, and January, 1915, was able to obtain from Woolwich Arsenal the fullest information as to the latest improvements in making cases, and his report was circulated among the manufacturers on his return to Canada. By March, 1915, the first deliveries of cartridge cases were made.

From that date rapid progress followed. By June, 1915, an output of nearly 80,000 18-pdr. cases per month was reached, and by September of the same year the monthly rate was approximately 500,000.

Deliveries not Equal to Demands.—In spite of the increased rates of deliveries they were not equal to meet the demands of manufacturers who had undertaken to load and fix the cases to the shells required as complete rounds. From a minute of the Shell Committee's

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meeting of July 3, 1915, the situation at the time gave cause for anxiety. It states that the Ordnance Adviser 'reported at length on the cartridge case situation, stating that deliveries were slow, and after consideration of his report, it was decided that it was necessary to secure further sources of supply.' By the end of 1915 Canada's capacity to produce was about 900,000 cases per month, but only about 700,000 18-pdr. cases had been delivered.

Other Sizes of Cartridge Cases.—In addition to the 18-pdr. cases, to which chief reference has been made, orders were placed for large numbers of 4.5-in. cartridge cases. On February 13, 1915, an order for 600,000 reached the Shell Committee and another order for 1,666,666 on April 23, 1915, and others followed, so that while the manufacture of 18-pdr. cartridge cases was proceeding the 4.5-in. case was also undertaken. At the same time other sizes, before referred to, were being made. It was remarkable that once the spade work was done improvements in methods of production followed. These were witnessed in almost every establishment, the workers, managers, and principals alike striving to devise means for better and quicker production.

Growth and Magnitude of Work.—When the Imperial Munitions Board undertook the work of munitions production very large orders for cartridge cases were being executed. Orders had been placed for over 13 million 18-pdr. and 4¼ million 4.5-in. cartridge cases. Out of these approximately 100,000 4.5-in. and 700,000 18-pdr. had been delivered. The maximum output from all manufacturers of 18-pdr. cases was reached during the month of June, 1917, totalling 1,893,000; and during the month of December, 1916, the maximum output of 4.5-in. cases was 824,000. Both cases were made in the same plants, and the maximum combined output during the month of December, 1916, was 2,560,000.

The Canadian Cartridge Co., Hamilton, produced 1,000,000 during the month of October, 1917, the largest output from any single company. The Montreal

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Ammunition Co., Montreal, came second, with an output of 797,000 cases in the month of November, 1917.

The total number of cases produced during the period of the war was: 18-pdr., 34,715,208, and 4.5-in., 11,980,641, or a total of 46,695,849. In addition to these cases odd lots of cases were manufactured, making the total over 48½ million.

The cartridge case business in Canada required over 400,000 tons of brass, which cost approximately one hundred million dollars.

Sir Frank Baillie.—The story of cartridge case manufacture in Canada would be incomplete without reference to the munificent act of the President of the Canadian Cartridge Co. Ltd., Hamilton.

While Mr. D. A. Thomas (Lord Rhondda) was in Canada he arranged with the President of the Company, then Mr. Frank Baillie, to supply 1,000,000 18-pdr. cartridge cases on certain conditions. These are set out in a letter sent to Mr. D. A. Thomas by Mr. Baillie on August 25, 1915.

Letter to Mr. D. A. Thomas.—The letter reads as follows :

Following our conversation of this morning, we hereby confirm our offer to manufacture 1,000,000 additional 18-pdr. British cartridge cases (following delivery of these now under contract), at cost, from metal to be furnished us ; cost to include full operating and maintenance charges, salaries to employees, but no compensation to the proprietors.

With increased production from both plants and greater experience with the article being manufactured, we believe the manufacturing cost (exclusive of metal) of less than 50 cents per case will be realised.

Inasmuch as we are loath to force our ideas upon the other Canadian manufacturers, we hope you will treat the offer in a confidential manner.

The order was placed and completed, with the following result, given in the letter which Mr. Baillie addressed to the Chairman of the Imperial Munitions Board on July 12, 1916 :

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J. W. Flavell, Esq.,
Chairman, Imperial Munitions Board,
Ottawa, Ontario.

MY DEAR SIR,

Re Order No. 3605.—1,000,000 18-Pdr. Cases, placed
through Mr. D. A. Thomas.

You will no doubt remember this order was placed with us in August last at \$1.75 per case, based on the prices of 22 C. per pound for the brass discs, it being agreed that we should return cheque covering any difference between this price and cost of manufacture; the latter to include full operating and maintenance charges, salaries to employees, but no compensation to the proprietors. We also enclose copy of letter written to Mr. Thomas, dated 25th August 1915, containing the offer. As this was a voluntary act on our part undertaken from a purely patriotic standpoint, we have been most anxious to carry out the obligations assumed.

In addition to anticipating promised deliveries, we think the cases supplied were equal in quality to any manufactured by us. In order to avoid any possible doubt as to whether we have also fully carried out the financial side of the question, we have decided to place our charge for cost of manufacture and maintenance of plant at the relative small sum of \$200,000.

We now have pleasure in enclosing cheque for \$758,248.03, the amount being arrived at as follows:

1,000,000 cases at \$1.75	\$1,750,000.00
Actual weight of 1,000,000 Brass Discs used:	
3,604,426 lb. at 22 C. lb.	\$792,973.72
Our charge	\$200,000.00
	<hr/>
	992,973.72
	<hr/>
	\$ 757,026.28
Interest 2 % allowed by Bank of Nova Scotia on special account opened in connection with this order	\$ 1,221.75
	<hr/>
	\$ 758,248.03
	<hr/>

In a letter acknowledging this remarkable saving on

V.C. LIBRARIES

a contract for 1,000,000 cases, the Chairman of the Board said, among other things :

I observe with great satisfaction that your anticipated cost of less than 50 Cents has been realised, and that you have found, in accordance with the conditions of your communications to Mr. Thomas, the net cost was 20 Cents per case, and that the refund, under the conditions agreed upon, amounts to the great sum of \$758,248.

I desire to express, on behalf of the Board, appreciation of the generous manner in which you have interpreted the obligations of your Company in determining the cost of manufacture, and I wish to record that you have discharged in liberal measure the undertaking given to Mr. Thomas.

I will have satisfaction in conveying to the Minister of Munitions the particulars of the transaction and the manner in which you have carried it out. I will also take pleasure in advising Lord Rhondda of Llanwern the result of the arrangement which he made with you, and the splendid assistance which has been given to the Imperial Treasury through the patriotic offer made by you on behalf of your Company.

For his distinguished services Mr. Baillie was honoured by the King with a knighthood of the Order of the British Empire.

CHAPTER VII

THE FIXED ROUND OF AMMUNITION

By December 4, 1914, the Shell Committee was courageous enough to accept an order for 200,000 fixed rounds of 18-pdr. shrapnel shells without the fuse, and, twenty-two days later, an order for 900,000. Orders came in for shrapnel and high explosive fixed rounds.

The first order for fixed rounds included not only the empty shrapnel shell and cartridge case already described, but also a primer, a brass clip for the base of the cartridge, and the charges of the black powder and of cordite. The primer weighed only $2\frac{1}{2}$ oz. It consisted of six carefully machined and stamped parts. When assembled and fixed in the cartridge case it contained the detonator and powder lighting or priming and propelling charge.

The brass clip weighed the same as the primer and presented little difficulty in manufacture. The charge of cordite was 1 lb. 8 oz., and the black powder for the tin cup of shell weighed 12 oz.

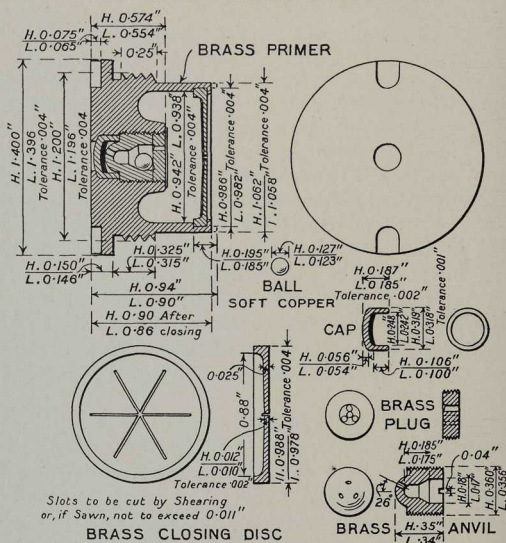
Assembling Fixed Rounds.—The Canadian Explosives Co. was the first to assemble the complete rounds of ammunition in Canada. It had made cordite for the Canadian Government, and undertook to supply the cordite and black powder charges for the shrapnel rounds required by the Shell Committee. The subject of the manufacture of cordite and the other propellant, nitrocellulose, is dealt with in another chapter. All the component parts, except the powder and detonators, were supplied to the Canadian Explosives Company by the Shell Committee.

U.S. LIBRARIES

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Primer Filling and Testing.—The component parts of the primers were shipped from the works of various manufacturers, after inspection, in cases containing complete lots of 500 primers. They consisted of the body, anvil, plug, pea ball and disc, all made of brass. The work of assembling and filling the primers called for

BRITISH CARTRIDGE CASE PRIMER.



the greatest care. The detonation caps containing the detonating mixture had to be carefully gauged by the government inspectors for height and also for the depth of the composition in the cap. The anvils were examined to see that the holes through them were clear. When the detonator was placed in the body of primer the anvil was screwed home on top of detonator cap. Before the pea ball and plug were inserted the bodies were examined by the government inspector to see that the

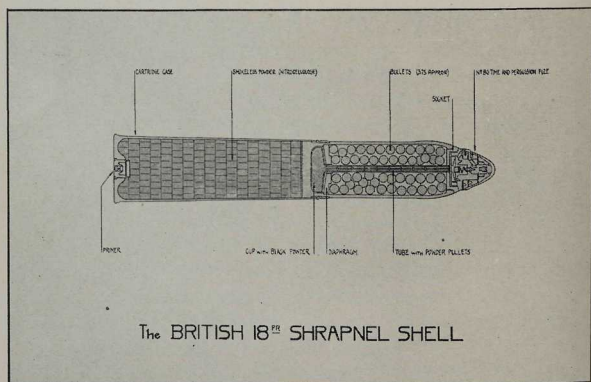
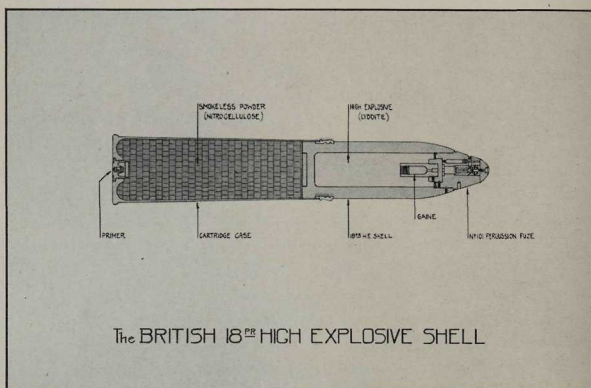
caps gauged properly and were well bedded in the body. After the plug was screwed home it was fixed by a special press and tool, which corrected the interior size of the primer whilst fastening firmly in position the plug. A paper disc was then stuck on the plug to cover the holes through it. The powder was then filled into cavity known as the magazine, after which the disc which had been previously covered with paper was fixed in position by an automatic machine. These are the operations in detail which were usually performed by girls. It is not intended here to describe the manufacture of the component parts of the primers, which were done almost entirely on automatic machinery. It is, however, important to mention that in making the metal parts of the primers the accuracy required in machining them demanded a skill not less important than any other part of the complete round.

Shell Filling.—The empty shells, as finally passed by the inspectors, were filled originally by hand, by pouring the black powder from a container holding the exact quantity of powder, down a funnel into the tin cup in the shell. The shell was then shaken and jolted by hand to ensure that the powder filled the tin cup. The depth of the powder was ascertained by a stick. When filled, a shalloon disc was fixed to the bottom of the shell socket covering the open end of the tube, and then the brass plug was screwed into the socket. Later, when shells were filled at the rate of many thousands per day, the shells were placed upon jolting machines and filled from an overhead hopper having an exact measure of the powder required for each shell. The powder fell from the hopper through a copper funnel into the shell. When the charge was filled a strong proof slide enclosed the shell before the machine started jolting, which was continued for about half a minute. When the shell was removed the gauging of the powder depth and fixing of shalloon disc was done as described above.

Fixing Cartridges.—The charge of cordite was made up in a separate department from that in which the shells

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were fixed to the cases. The charges were cut to length, bundled and weighed and properly examined, then trans-



ferred in properly sealed boxes to the fixing room, and each charge was placed in the cartridge case. When nitrocellulose was afterwards used as well as cordite, the charge

was weighed in a department removed some distance from the fixing room, and conveyed to it in a metal case. A dummy primer was fixed in the cartridge case before the charge of nitro-cellulose powder was filled into the case through a copper funnel. The case was then placed on the loading and fixing machine, and the shell, which had been previously painted with Petman's cement around the base, was placed and squeezed into position.

In the same machine the crimping of the cartridge case into the recess in the copper band of the shell was done by means of small rollers. The fixed shell was then removed from the machine, placed on a rubber band conveyor, and carried to the examining room adjoining. It was inspected by using a chamber gauge corresponding to the chamber of the gun. If correct, the dummy primer was removed and the real primer fixed in its place. The stencilling was then done, and the base clip fixed on the cartridge to protect the detonator cap. The complete round was then conveyed to the boxing department, where four rounds were placed in one box. The boxes were then weighed, stencilled, and passed on for examination by the inspector before the covers were finally screwed down.

Few Loading and Assembling Manufacturers.—It is remarkable that the work of loading and assembling was carried out by so few manufacturers and without any serious accident. The Canadian Explosives Co. at Vaudreuil, Quebec, and subsequently at Nobel, Ontario, produced literally millions of complete rounds. Two other companies only were added to these. One was the Energite Explosives Co., owned by O'Brien's Munitions Ltd., at Renfrew, Ontario, where nitro-cellulose powder was manufactured. This company was afterwards taken over by the Imperial Munitions Board as a National Factory, and its name was changed to the British Explosives Ltd. The other company, known as the Canada Nitro-Products Ltd., of Toronto, owned and directed by Mr. D. J. Johnston of Toronto, was one of the most up-to-date works of its kind. There was hardly any handling

operation either of shells, cartridge cases, or powder, etc.; the work was done automatically. To look at the buildings from the outside, there was nothing to suggest an almost perfect organisation within; but it was so. In this factory alone 35,000 to 40,000 complete rounds were produced daily with the minimum number of employees. It is right to say that it was due to the energy and skill of Mr. Johnston that the price of loading and fixing shells was reduced very considerably.

The Growth of the Work.—It was early in 1915 that the Canadian Explosives Co. erected its first loading and shell fixing plant at Vaudreuil, with a capacity of 22,000 rounds per day of ten hours. A similar plant of about the same capacity was erected at Nobel by the same company, and commenced operations in October, 1915. About October, 1915, the O'Brien's Munitions Co. built works at Renfrew, Ontario, for a capacity of 30,000 rounds daily, and later, in 1916, the Canada Nitro-Products Ltd. was established at Toronto, with a daily capacity of from 35,000 to 40,000 rounds. The combined companies produced 400,000 complete rounds weekly when working at the maximum output in 1917.

The first fixed rounds were completed by the Canadian Explosives Co. in May, 1915, when 35,794 were shipped. The amount shipped during the month of June was 63,793 and 105,984 during July. By the end of November, 1915, the monthly rate had reached 400,000 rounds.

The 18-pdr. shrapnel and high explosive shells were the only fixed ammunition produced in Canada.

Total Production.—Although the Shell Committee placed orders for 2,900,000 fixed rounds of 18-pdr. shrapnel and high explosive shells without fuses and 5,733,333 complete rounds of 18-pdr. with fuses, only about one million complete rounds without fuses were shipped when it handed over its work to the Imperial Munitions Board. During the whole period of the war 41,730,605 fixed rounds were produced, for which over 30 million fuses were manufactured in Canada.

CHAPTER VIII

RAW AND MANUFACTURED MATERIAL FOR MUNITIONS

THE Shell Committee made itself responsible for obtaining for manufacturers the principal raw materials required in making the complete round of ammunition.

Steel, for instance, could be obtained from Canada in sufficient quantity to deal with the earlier orders. The same applied to lead and antimony for shrapnel balls. Tin plates were easily obtained. Resin and timber were plentiful, but there was a shortage of zinc and copper. All the copper and zinc from which the brass parts of the complete round were made came from the U.S.A. Copper for shell bands also came from the U.S.A.

Zinc Shortage.—The great shortage of zinc at that time was serious. Before the war, the U.S.A., Germany, and Belgium produced about 80 per cent. of the world's supply. The Allies during the war were very largely dependent upon the U.S.A. for the zinc required by them. By the end of 1914 a long war seemed to be inevitable. The world's markets were searched for munitions materials by the belligerent nations. The U.S.A. held about 30 per cent. of the world's zinc. Canada had produced for some years the concentrates of zinc and copper matte, but had no facilities to refine them, and sent them to the U.S.A. for that purpose.

German Control.—The Germans controlled the zinc and copper markets of the U.S.A. It was known that some American zinc smelters refused to supply zinc to Britain. The U.S.A. were Canada's only source of supply. Britain could not help her. She had to

import these metals for her own requirements. The Shell Committee's requirements for these metals at the beginning of 1915 were approximately 10,200 tons of zinc and 27,400 tons of copper. The large increase in the demand for cartridge case material made it imperative that the source of supply should be assured. The Shell Committee entertained fears that public opinion and German interests in the U.S.A. might force the Government to place an embargo on these metals.

High Prices of Zinc and Copper.—The scarcity of zinc caused the prices to rise with the demand. During the first four months of 1915 the price of zinc increased from 5 cents to 27 cents per lb. Later the price rose to 40 cents per lb. Copper, although much more plentiful, rose in price from 12 cents to 21 cents per lb. Germans and others with large stocks of these metals made fortunes, and no more fears of German opposition were entertained.

Shell Committee's Decision.—Knowing that Canada had plenty of zinc and copper ores, the Shell Committee approached the Minister of Militia regarding an investigation. He, with the approval of Sir Robert Borden, the Prime Minister, appointed a Commission of investigation to inquire as to the possibility of refining copper and producing metallic zinc in Canada. The Ordnance Adviser was asked to undertake the investigation. He suggested Dr. A. W. G. Wilson, Chief of the Metals Division, Mines Branch, Ottawa, and Dr. Alfred Stansfield, Professor of Metallurgy, McGill University, Montreal, to act with him as Commissioners. Dr. Wilson was specially fitted to deal with the copper, and Dr. Stansfield with the zinc problem, and together they left in April, 1915, for British Columbia.

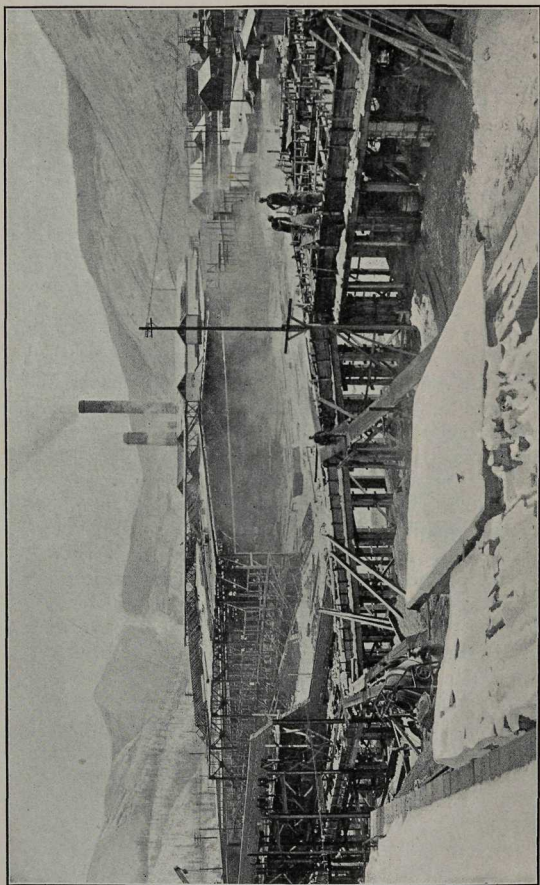
Object of the Investigation.—The object of the investigation was to secure metals as a military and immediate necessity. It was necessary to ascertain: (1) whether the ore deposits would warrant the establishment and maintenance of refining plants; (2) the best location for ores, labour, power, fuel, transportation, and markets; (3) the possibilities of kindred industries being benefited and

new ones established ; (4) the best form of assistance which might be given to mining companies that would undertake such a project; and (5) how Americans would view the proposals and what action they would be likely to take if plants were established in Canada. Questions embodying these subjects and other relevant considerations were submitted to different mining companies, engineers, mine managers, experts, boards of trade, and to members of the British Columbia Government.

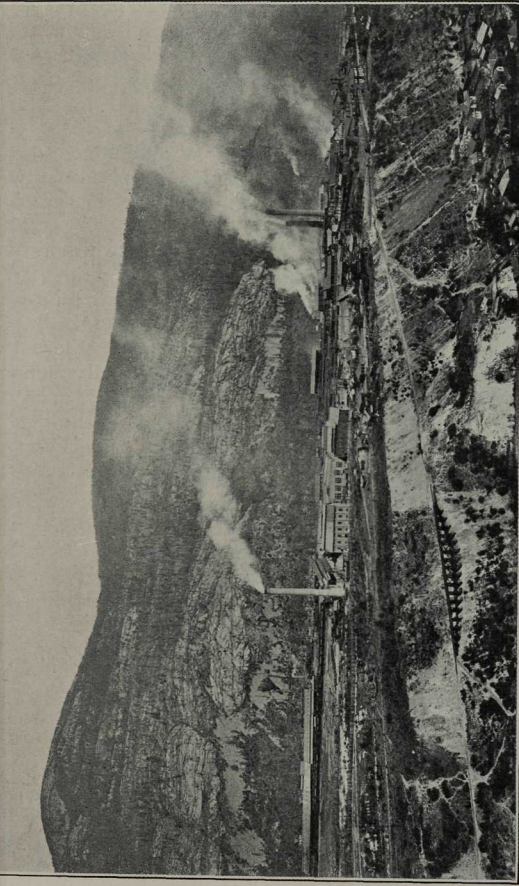
Result of Investigation.—A report on the subject of these metals, full of valuable details, gleaned from reliable sources and covering about 300 pages, was published. The results of this investigation were quickly translated into action, and metallic zinc and refined copper were produced for the first time in Canada.

Experimental Work at Trail, B.C.—Space forbids a record of the work done at the works of the Consolidated Mining and Smelting Co. Ltd. The Commissioners, however, concluded that the company had not only available ores, but had a capable organisation to refine metals. Its resources of lead-zinc-silver ores in the Sullivan and in the Sloan District Mines had been subjected experimentally to different treatments for at least five years. In 1912 experiments with the Ashcroft electrolytic process encouraged the company to pursue its experiments.

Electrolytic Process.—In 1915 the company had reached a stage where there appeared little doubt of the success of the electrolytic process for the treatment of high and low grade ores commercially, if a suitable plant were erected. This opinion was not only shared by the Commissioners, but by many experts who were consulted, and who verified the results obtained. Much doubt had been expressed throughout the metallurgical world as to the commercial value of the electrolytical process for the recovery of metallurgical zinc. No plant of any commercial size had been in successful operation up to this date. Canada's cheap electric power favoured this process. But Norway and other countries had also cheap



THE CONSOLIDATED MINING AND SMELTING CO. LTD., TRAIL, B.C.
Electrolytic Zinc Works in Course of Erection



THE CONSOLIDATED MINING AND SMELTING CO. LTD., TRAIL, B.C.
Electrolytic Zinc Works completed

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electrical power. Something more was required, and Canada possessed it. The staff of this company mastered, with signal success, metallurgical problems which had almost baffled the world. Ultimately a plant was installed and operated at the Trail Smelter to refine 50 tons of zinc daily.

Action of the Canadian Government.—The report of the Commissioners was submitted to a Committee of the Cabinet, and the Canadian Government promised to assist the development of metallic zinc production as follows :

After the expiration of the war, a bounty would be granted on a sliding scale not to exceed 2 cents per lb., when the price of commercial zinc in London fell below £33 per ton of 2000 lb. (approximately 8 cents per lb.) ; the bounty provision to expire two years from the date of contract with the Shell Committee, the total amount of bounty to be paid not to exceed \$40,000 ; the bounty to be payable only on zinc contracted for by the Shell Committee at prices below 8 cents per lb. This was a generous decision and acceptable to the manufacturers, but the duration of the war made the bounty needless.

Order for 8000 Tons.—Mr. James J. Warren, the Managing Director of the Consolidated Mining Co., agreed to undertake a contract to supply 8000 tons of zinc of the required quality at 15 cents per lb. Another company in Quebec, the Weldon Mining Co., offered its entire facilities for two years to the Shell Committee, and quoted a price of 2 cents per lb. above the daily current New York market prices. As the prices at the time ranged round 40 cents per lb., the Shell Committee decided to recommend to the British Government the generous offer of the Consolidated Mining Co., which was accepted.

Erection and Operation of Plant.—The first plant was completed in six months after the receipt of order. It was only then that the real difficulties were discovered. One problem after another appeared, but they were tackled and solved. Many parts of the process had to be

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changed entirely before the standard product was made. Mr. Warren, Mr. R. H. Stewart, the General Manager, Mr. K. Turnbull, and their assistants, together with the loyal and diligent efforts of the plant operators, were rewarded with success. The electrolytic process, perfected at the Trail, B.C., will doubtless, for many years to come, surpass in value the older retort process, particularly where cheap electric power is available. When the Armistice was signed the plant was capable of refining 75 tons of zinc concentrates daily, or 50 tons of crude ore in the same period.

Although the amount of zinc and copper produced in Canada alone proved to be but a small proportion of the total amount used, yet the value of having a domestic source of supply was of greatest importance.

Other Materials.—In addition to the foregoing raw and semi-manufactured materials, many others were required for the manufacture of munitions or for warlike purposes. Apart from materials for the manufacture of explosives and propellants—such as toluol, benzol, acetone, ether alcohol, butyl alcohol, methyl ether ketone, nitrates, sulphur, oleum, cotton, etc.—used in Canada, other materials were ordered by the British Government for shipment direct to England. Most of these were ordered through the Imperial Munitions Board.

Metals.—The following metals were supplied to British and other Allied nations : molybdenite concentrates, as a sulphide of molybdenum ; high grade and prime western qualities of zinc ; antimony ore 50 per cent. ; metallic arsenic not exceeding 5 per cent. impurities ; tungsten concentrates 65 per cent. ; ferro-molybdenum ; calcium carbide of different percentage from 70 per cent. to 15 per cent. ; steel billets and bars ; nickel ; time fuse material ; rods, billets, etc. ; ferro-silicon 80 per cent. to 95 per cent. and 50 per cent. Very large tonnages of these materials were made in Canada and shipped to Britain.

Chemicals and Explosives.—Among the principal chemicals and explosives made in Canada and shipped to

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Britain were benzol, sabulite, T.N.T., cordite, acetone, nitro-cellulose powder, ammonium nitrate, glacial acetic acid.

Miscellaneous Materials and Machinery.—Miscellaneous materials included various kinds of logs and timber suitable for aeroplanes, etc.; asbestos; bending pulp board; wood-cutting tools; chests of screw-cutting tools; logging plant outfit; locomotives and spare parts; railway waggons and waggon wheels and spares; tractors and spare parts; dump waggons; flax-pulling machines; complete cartridge case plant equipment. In fact, there seemed to be nothing that any of the departments of the British Government or the Allied Governments thought Canada could supply but was asked for through the Imperial Munitions Board. These materials were usually ordered direct by cable, but sometimes by asking the Chairman to guide and finance the purchases of materials required through a special envoy sent to Canada. This was the case in procuring asbestos, and it illustrates the miscellaneous nature of the work of the Imperial Munitions Board.

Asbestos.—In the year 1917, owing to a variety of reasons, raw asbestos supplies were becoming more and more difficult to obtain. Stocks in England were low, and an increasing amount of asbestos manufactured goods was being called for. It was decided that some measure of control was imperative, and Captain Turner was asked by the British Government to go to Canada and obtain, through the organisation of the Imperial Munitions Board, regular deliveries of raw asbestos at fair prices. When Captain Turner reached Ottawa, conferences were held at the Offices of the Imperial Munitions Board between Canadian asbestos manufacturers and Sir Joseph Flavelle, Captain Turner, and others. Prices and deliveries were then fixed by Captain Turner with mines able to produce the grades of asbestos required. In fact, Captain Turner made himself responsible for the quality and rates of deliveries of the asbestos.

Two resident inspectors were maintained at Thetford,

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P.Q., whose duty it was to inspect all deliveries, when loading into cars, and to furnish details of tests, and at once communicate any case of difficulty. All invoices were passed by Captain Turner and payments made by the Imperial Munitions Board, Ottawa. Twenty-one kinds of asbestos were shipped to England amounting to 14,487.5 tons. In addition to this amount a considerable tonnage was shipped to France and Italy.

Where Materials were Obtained.—To tell of the arrangements made in securing all the different materials would fill many large volumes. Yet a mere recital of dry statistics of masses of different materials gathered from different parts of Canada and shipped to Europe can convey little idea of the labour, skill, and genius displayed in their production and transportation.

Those who knew the industrial conditions of Canada on August 14, 1914, will understand that its commerce required an abnormal stimulus to rouse it to activity. Every source of trade appeared to be tapped dry. The exchange in real estate had almost paralysed industry, particularly throughout the Western and British Columbia Provinces. Canada was suffering from a financial chill. When the demand for munitions material was made every part of the country was aroused. Those who had dormant mines or saleable products placed them at the disposal of the Shell Committee and Imperial Munitions Board. From north, south, east, and west they flocked to Montreal and Ottawa. This personal necessity, stimulated by patriotic emotion, released human energies which had been suppressed by the stagnant conditions of trade. Steel, toluol, and lumber poured in from the maritime provinces; zinc, copper, molybdenum, and lumber from British Columbia; ferro-silicon, nickel, and steel from Ontario; aluminium, calcium-carbide, magnesium and T.N.T. from Quebec, and so on, until many provinces discovered uses for materials which up till then had no markets.

But Canada could not supply all the materials required.

Nitrates had to be imported from Chili ; sulphur from Louisiana ; cotton from the Southern States ; alcohol from the Corn belt ; and oleum (fuming sulphuric) from New Jersey. In addition, metals, fuels, and machinery had to be imported from the U.S.A. to supplement supplies raised in Canada for its own requirements and for overseas shipments.

How Materials were Produced.—Several chapters relate how many of the materials directly and indirectly used for munitions were manufactured ; here it is necessary only to speak in a general way of the latent energy called into being in transforming raw materials into munitions of war. By the introduction of metallurgical processes and the skilful operation of the electric furnace, rock, carbon and steel turnings were transformed to ferro-silicon ; coke, coal and steel turnings to pig-iron ; carbon and lime to calcium carbide ; coke, steel turnings and manganese ore to ferro-manganese ; and in like manner molybdenum, aluminium and other metals were produced.

But these were by no means all the developments of an agricultural country. The electro-chemical processes yielded as many surprises. The work in changing muddy-looking water to pure zinc by electrolytic attraction nearly broke the hearts of the experimenters before they could obtain a pure zinc deposit. The electro-chemical method of reducing magnesium from the ore, perfected at Shawinigan, produced a much purer metal than any imported by Germany or any other country before the war.

These and like processes taxed heavily the physical and mental resources of Canada's chemists and metallurgists during the war. One who did a great deal during the war in perfecting metallurgical processes said : 'As I observed operations from day to day I experienced the whole gamut of emotions. Some days, when things were going well, I was inwardly carried away with visions of what might be accomplished, another day I was more chastened in spirit.' This quotation very

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aptly expresses the feelings of hundreds of chemists and metallurgists in Canada during the war.

Then again, the mechanical skill which shaped the raw materials into different forms had a great development. There was hardly a workshop throughout the Dominion in which some form of inventive genius was not displayed. It could be seen in the adaption of old machines; in the construction of cutting tools, gauges, and jigs; in the design of furnaces; in the handling of materials, and in many different ways where creative ability was allowed freedom to improve existing means of production.

But perhaps in the realm of explosives the transformations were greatest. The element of danger and the risks taken by experimentalists all added to the value of their achievements. Not only were coal and cotton converted respectively to trinitrotoluol and cordite, but the acids and solvents used in the processes were made in Canada. The recital of the processes and the difficulties overcome in bringing them to success would be to some readers a wearisome statement of cold facts, but to others memories of sleepless nights, furrowed brows, and bewildering anxieties.

When it is remembered that all materials had to be supplied not by rule of thumb, but to exacting specifications, it is marvellous that Canada produced munitions with such a small percentage of rejections.

The Mines Branch.—This chapter would be incomplete without reference to the Mines Branch of the Canadian Government. Dr. Haanel, its director, and his staff, and particularly Mr. Geo. Mackenzie, rendered great service to the Shell Committee and afterwards to the Imperial Munitions Board. It mattered not whether it involved research at Ottawa or investigation in any part of the Dominion, all was undertaken with a generous and energetic response which allowed no difficulty to stand in the way.

Without the help of the Mines Branch the task of obtaining materials for munitions production would have been very much more difficult.

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CHAPTER IX

PRODUCTION OF TOLUOL AND T.N.T.

REFERENCE was made in the last chapter to trinitrotoluol as one of the materials supplied for munitions. Toluol, from which T.N.T. was made, was, like many of the other materials of war, unknown to Canada before the war. Common blasting explosives of different grades served the manufacturing purposes of the country.

T.N.T. became a very important explosive during the war, and was made in such quantities that the history of its origin deserves record.

British War Office Demands.—During the visit of the Ordnance Adviser to the War Office, London, in December, 1914, the Director of Contracts informed him that if Canada intended to make high explosive shells the explosives for them should also be made in Canada and filled into the shells there. The Shell Committee was quite prepared to undertake the manufacture of the shells, but it was considered a little doubtful whether facilities existed in Canada for the production of T.N.T. On December 15, 1914, the Shell Committee was cabled as follows: 'Ask Canadian Explosives Company if they can produce picric or trinitrotoluol and how much per month, large quantities required.' General Bertram replied that no picric could be supplied, but was investigating matter of trinitrotoluol. The Chairman of the Explosives Committee, Lord Moulton, strongly advised the manufacture of T.N.T. in Canada from the waste gases of coke-ovens. He did not take the view of the Director of Contracts

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that it was necessary to fill high explosive shells in Canada. He favoured the manufacture of T.N.T. quite independently of shell-making, and his advice was followed. Lord Moulton was of great help to the Shell Committee at the initiation of this work.

By-Product Coke-Ovens in Canada.—In January, 1915, there were two companies in Canada with by-product coke-ovens, from the waste gases of which, it was ascertained later, about one-quarter of a gallon of toluol could be obtained from each ton of coal converted into coke. The Dominion Steel Corporation Ltd., Sydney, Nova Scotia, had ovens with a coking capacity of about 2500 tons of coal daily, and the Algoma Steel Corporation, at Sault Ste Marie, Ontario, had a capacity of 1500 tons daily. Neither company had any plant for the recovery of toluol. The waste gases were utilised for other purposes.

Investigation by Dominion Steel Corporation Ltd.—Mr. J. H. Plummer, President of the Dominion Steel Corporation Ltd., took a personal interest in the investigation of toluol supply.

From a thorough examination of the coke-oven gases at the works of the Dominion Steel Corporation it was found that the Cape Breton coals yielded specially rich hydrocarbons. From three-eighths to four-tenths of a gallon of toluol was recovered from 1 ton of coal instead of one-quarter of a gallon as was anticipated. This fact gave an impetus to the investigations. Although the capacity of the coking ovens was 2500 tons daily, the company was only handling 1500 tons daily at that time. This amount allowed for a recovery of nearly 600 imperial gallons of toluol daily. The Corporation would not undertake a contract for the supply of toluol until assured that a recovery plant could be obtained.

How to obtain the recovery plant to produce the toluol was the problem. After making exhaustive inquiries as to the design of the best-known benzol recovery plants, absorption towers, exhausters, condensing

plant, etc., and as to the possibilities of their delivery and erection, it was found that it would take at least five months to instal the plant.

Unwilling to present a proposition to the Shell Committee which involved such delay, Mr. Plummer sought the advice and assistance of Mr. Edison of electrical fame. Ultimately an agreement was reached with Mr. Edison that, assuming the plant was proceeded with, they would purchase only those parts of the plant which could be delivered quickly, manufacture the other parts at Sydney to plans supplied by Mr. Edison, and erect a plant similar to that which he was then installing at Johnstown, Pennsylvania. From further investigations, in the Canadian and American equipment markets, it appeared that with Mr. Edison's help in manufacturing important parts of the equipment, and by offering substantial bonuses for quick deliveries of other apparatus, the erection of the plant could be completed in sixty days. This service by one of America's distinguished scientists, long before the United States joined hands with the Allies, was very greatly appreciated by the Shell Committee.

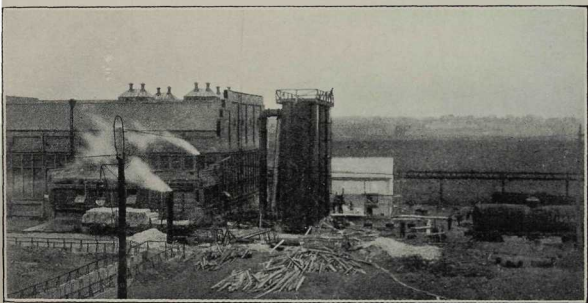
First Contract for Toluol and T.N.T.—The Dominion Steel Corporation Ltd. undertook on February 11, 1915, to deliver toluol to standard requirements in eighty days, and the complete explosive trinitrotoluol to British specification by July 25, 1915. This offer was cabled to and accepted by the British Government. On February 19 the company was informed of the decision. The day after, preliminary plans were forwarded to Sydney, and erection began immediately.

Mr. Edison devoted much of his own time to the preparation of the plans. The keenest interest was taken in the parts of the plant manufactured in the United States, which were closely checked by him. To avoid transportation delays, the various cars of materials were accompanied by a man instructed to bring them to Sydney with minimum delay.

Erection of Plant.—The construction programme

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was carefully scheduled, and although the work was conducted with great difficulty, owing to the severity of the winter, the plant was completed and operated on April 12, when the coke-oven gases were, for the first time, passed through the absorption towers. The remarkable speed with which the work was done and the excellence of the results surpassed all expectations. It was indeed a great achievement undertaken in a patriotic spirit and accomplished with marked skill. Samples of the first toluol produced in Canada—a clear white liquid



DOMINION IRON AND STEEL CO., SYDNEY, NOVA SCOTIA

First Toluol Plant in Canada

—are kept to this day as souvenirs of a fine piece of work.

First Car of Toluol.—On May 15, 1915, the first car of toluol was shipped to Beloeil, Quebec, the works of the Canadian Explosives Co. Ltd., with which company the Dominion Steel Corporation had arranged for its nitration into trinitrotoluol. The first shipment went forward eighty-five days after the acceptance by the War Office of the company's offer.

The original plant was extended and improved, as operating conditions permitted, and it continued the production of toluol until the signing of the Armistice

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in November, 1918, by which time its output was 708,743 imperial gallons.

Sault Ste Marie.—Having met with success at Sydney, Mr. Plummer turned his attention to the by-product coke-ovens at the works of Algoma Steel Corporation. A similar plant to that at Sydney was installed, and began to operate in June, 1915. At first from 200 to 250 gallons of toluol were produced daily, but this amount was increased later to 400 gallons. The coals coked at Algoma were in part low volatile coals from Virginia, and their yield in hydrocarbons was therefore much less than that obtained from the Cape Breton coals.

Trinitrotoluol.—Toluol had to be nitrated three times to become the high explosive required. A nitrating plant had to be provided. There was none in the country. The plant required was quite different from any used in Canada. The safeguards necessary in the manufacture of such an explosive led the Dominion Steel Corporation to entrust the nitration of the toluol with the Canadian Explosives Co., an organisation already familiar with the manufacture of ordinary explosives.

Nitrating Plant.—At the Beloeil Works of the company a two-unit plant, with a capacity of 450,000 lb. per month, was installed and completed by May 15.

Large quantities of machinery and material had to be purchased and delivered, extensive additions had to be made to the acid plant, and thirty additional buildings had to be erected to house the apparatus, all of which were completed in six weeks. Although the agreement called for the delivery of T.N.T. by July, 1915, production was actually commenced several weeks earlier. It is noteworthy that this success was achieved in spite of having to train men who had no previous knowledge of the manufacture of this explosive.

The value of this performance by the company was recognised by the Minister of Militia and his staff, as well as by the Chairman of the Shell Committee and

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others, who visited the company's works at Beloeil on June 3, 1915, and witnessed the manufacture of the first T.N.T. made in Canada.

This plant, with slight modifications, afterwards produced about $1\frac{1}{3}$ million lb. of T.N.T. per month. Every man on the plant was encouraged to make suggestions, every suggestion received consideration, with the result that the output always exceeded the calculated amount. The spirit manifested by the employers was reflected in the staff and in the workers. Both toluol and T.N.T. plants were carried to success with remarkable speed, and were comparatively free from defects and discouragements which are common to the initial operations of new plants.

This was the beginning of the production of trinitrotoluol, which during the war amounted to 41,754,950 lb.

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CHAPTER X

FUSE MANUFACTURE

THE fuse was the only part of the complete round of 18-pdr. fixed ammunition that Canada had not made by the spring of 1915. The Shell Committee was anxious to undertake fuse manufacture, and the Ordnance Adviser, when in England in December, 1914, asked the War Office for an experimental order. An experimental order was suggested, as it was well known that fuse manufacture, and particularly their loading, presented most uncommon difficulties. The officials at the War Office agreed to the placing of an order for 20,000 fuses. They also gave the Ordnance Adviser facilities to study the manufacture of fuses at Woolwich Arsenal, on which he made an extensive report.

On his return to Canada the experimental order for 20,000 fuses was offered to the General Electric Co., Toronto. The President and officials of the company considered the offer carefully, and at the same time examined the Ordnance Adviser's report, and a complete fuse from Woolwich showing what was required.

Although this company had an official who had some knowledge of the manufacture of the mechanical parts of the fuse, the President, Colonel Nichols, wrote on February 15, 1915, declining the offer. Colonel Nichols was influenced in his decision by two or three considerations: (1) risks in manufacture; (2) uncertainty as to the conditions of inspection; (3) the size of the experimental order, which he considered too small to warrant an outlay for plant equipment with any hope of

paying it off without some assurance of larger orders. The Shell Committee appreciated the difficulties presented, and as far as the General Electric Co. was concerned the question was dropped.

Meanwhile the knowledge that fuses were required spread, and offers of supply came from American sources and, later, from Canadian manufacturers, which were considered.

First Order for Complete Rounds with Fuses.—On April 23, 1915, the Shell Committee received orders from the British War Office for 1,666,666 complete rounds of 18-pdr. shrapnel and for the same number of 18-pdr. high explosive shells. These were the first orders for complete rounds. The same number of fuses were ordered for 4.5-in. shells, making a total of 5,000,000 altogether.

Orders for complete rounds of ammunition had been placed before this date with manufacturers in the United States instead of in Canada, because the British Government did not think that fuses could be made in Canada.

The Shell Committee, rather than lose the orders for complete rounds, were prepared to buy fuses from the United States, if it were found impossible to make them in Canada. It was with this object that the Committee pressed the War Office for complete rounds.

Shell Committee Purchased Fuses in U.S.A.—As the Canadian General Electric Co. had considered the experimental order for fuse manufacture, and very clearly pointed out, in addition to the question of covering cost of plant, the delays which would be occasioned before they could consider the manufacture of fuses, the Shell Committee thought that it was extremely doubtful whether any company in Canada at the time could undertake a contract for fuse manufacture with any hope of supplying the fuses in time for delivery of the complete shells.

The Committee was therefore relieved to find that fuses could be obtained in the U.S.A.

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Contracts for Fuses.—After considerable investigation and negotiations with U.S.A. groups, contracts were drawn up and placed with two companies in the U.S.A. for 5,000,000 fuses. The International Arms and Fuse Co. of New York undertook a contract to manufacture 2,500,000 No. 80 time and percussion fuses.

An order also was placed with the American Ammunition Co. of New York for 1,666,666 No. 100 graze fuses as shown on p. 79. This company also undertook a contract to deliver 833,334 No. 80 time and percussion fuses.

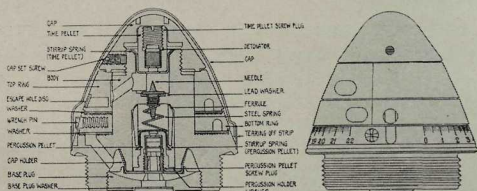
Although the orders for the complete rounds were received on April 23, it was June 19 before the contracts were legally concluded between the companies and the Shell Committee.

Description of Time Fuse.—The time Fuse No. 80 was ordered from the American companies. It has two actions: one which allows it to be set to explode the shell to the tenth part of a second up to twenty-two seconds after leaving the gun; the other, a percussion element, which acts when the shell strikes an object before the timing element functions. The time pellet containing the time detonator gains sufficient energy on shock of discharge to collapse the stirrup spring which holds it in position. This release of the detonator causes it to fall on the firing needle, resulting in the ignition of the powder train of the top ring. This in turn ignites the train of the bottom ring, and from there the flash is carried to the shell, and explosion results. The time of burning is regulated by setting the moveable bottom ring according to the time graduations on the fuse.

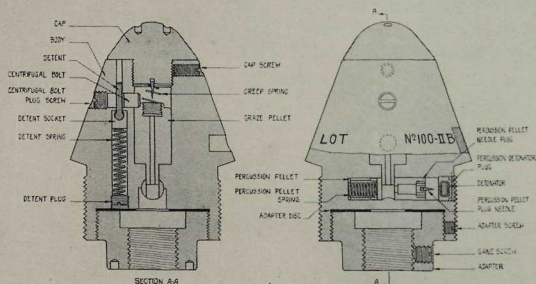
This fuse is much more complicated than the No. 100 fuse. It contains fifty-two separate parts.

Description of the Graze Fuse.—The No. 100 graze fuse has one action only—it operates by percussion. On shock of discharge from the gun the detent spring is compressed, drawing with it the detent, and allowing the centrifugal bolt to move towards the plug screw,

leaving the graze pellet free to move towards the needle against the creep spring immediately the fuse strikes an



The BRITISH TIME AND PERCUSSION FUZE
N°80



The BRITISH GRAZE FUZE
N°100

object. The graze pellet's forward movement liberates the percussion pellet, the needle of which strikes the

detonator, and the flash passes through the channels in the needle plug, and through the body of the fuse to a gane which explodes the shell.

Initial Difficulties.—The International Arms and Fuse Co. built machining and loading factories on the most approved lines at Bloomfield, New Jersey. There was nothing left to chance; all the ripest experience the United States possessed was acquired for this organisation. In addition, technical men were sent to Woolwich Arsenal to study British methods. The factory was ready to produce the fuses by November, 1915, the time promised for the first deliveries. Owing, however, to serious and prolonged strikes in the factories where the gauges were being produced, the International Arms and Fuse Co. could not get the gauges until two months after they were promised. Sample fuses had been made and proved successfully, but the bulk was delayed. Major W. J. Hawkins, formerly of the Frankford Arsenal, U.S.A., who was an expert in fuses, was General Manager of the company, and Colonel Birnie, an Ordnance Officer of the United States, was Ordnance Adviser to the company. But, even with this expert management and skill, much difficulty was experienced in making the fuses. This company used about 275 different gauges in making the time fuses. The delays occasioned in their receipt, and in training of nearly 3000 operators in their use, interfered seriously with deliveries.

Some Mechanical Difficulties.—All the parts of the fuse had to be machined with mathematical exactness. The limits of precision were so fine that some parts had to be machined within one ten-thousandth part of an inch. At the time in question the International Arms and Fuse Co. had very great difficulty in getting any skilled operators, so that the work of training was very slow and troublesome. The task was not less difficult by having to employ girls to do many of the operations.

Loading the Fuses.—The mechanical difficulties, though great, were not equal to those of loading the

fuses. The actual filling of the rings with powder presented perplexing problems. The grade, quality, and condition of the powder had to be maintained to a great exactness. In addition, the humidity, barometric pressure, and temperature of the air at which the powder was pressed into the carefully machined grooves, under a load of 68,000 lb. per square inch, had to be kept constant, otherwise no dependence could be placed upon the fuse.

Inspection of Fuses by the Company.—The officers of the International Arms and Fuse Co., conscious of all the difficulties connected with the production of fuses, set up an important works inspection department. Every part of the fuse had to satisfy their own inspectors before being submitted to the government inspectors. This called for a very heavy percentage of inspectors engaged by the company in addition to those employed by the Government. An elaborate manual for the use of inspectors was compiled by Major Hawkins and published by the company, giving photographs of the fuse and its parts, and the fullest particulars of the inspection and working gauges and of their use. This thoroughness was reflected in everything the company undertook.

Delivery of Fuses.—In spite of the very serious delays experienced by the company by the non-delivery of gauges until two months after they were promised, the International Arms and Fuse Co. delivered 1,900,000 by the end of April, 1916. While this was the date for the completion of the order, the 2,500,000 were completed within two months later.

American Ammunition Co.—The American Ammunition Co., having two different designs of fuses to make, had many more set-backs than the International Arms and Fuse Co. The gauge troubles were increased because so many more were required for the two types of fuses. Then again, the company was dependent upon associated companies for the supply of component parts. It was so much behind in its deliveries that by April 1, 1916, thirty days before the date of the

completion of the contract, only 650,000 No. 100 graze fuses and 2000 No. 80 MK V time fuses were delivered, leaving 1,016,666 No. 100 fuses and 831,334 No. 80 fuses to be completed.

There were many extenuating circumstances, and rather than exercise the right of cancellation which the contract provided, a new agreement was made between the Imperial Munitions Board, which by this time had taken over the work of the Shell Committee, and the American Ammunition Co. In fact, two agreements were made: one placing a new order for 600,000 No. 80 MK VII time fuses, and the other adjusting the terms of delivery of the 2,500,000 under the contract of June 19, 1915. The price of the No. 100 fuse was also reduced.

First Fuses Manufactured in Canada.—At the time the contracts for fuses were placed with the American companies, the Russell Motor Car Co. of Toronto went into the question of manufacture in Canada. Disappointment was felt by the company that they did not receive part of the original order, but about one month later, on July 19, 1915, an order for 500,000 No. 100 graze fuses was placed with the Russell Motor Car Co.

These were for loaded fuses as on p. 79. The company undertook, according to the legal contract signed on August 17, 1915, to install plant to produce by March 1, 1916, 2000 fuses per day, and complete the 500,000 by May 31, 1916. The company actually produced some fuses in February, although many difficulties prevented the completion of the 500,000 fuses by May 31. The production during April exceeded the rate of 100,000 promised for the month by 10,000.

The contract for the 500,000 was completed later, and was the first of a large number amounting to many millions made by this company. The Russell Motor Car Co. also manufactured the No. 80 time fuse, but orders for these were placed after the Imperial Munitions Board was established. To give some idea of the relative difficulty in making the No. 80 and No. 100 fuses from

the experience of the Russell Motor Car Co., it may be mentioned that for every 100 operatives engaged in producing the No. 100 fuse it was found that twenty-eight company inspectors and five government inspectors were required, whereas the No. 80 fuse required fifty company inspectors and ten government inspectors—in other words, every two workers required an inspector employed by the company.

Fuse Investigation.—The work of the Shell Committee on fuses would be incomplete without reference to the investigation set up by the Government of Canada regarding shell contracts, and particularly the contracts for fuses placed in the U.S.A. It was an important inquiry which occupied about six weeks during the spring of 1916, after the Shell Committee had ceased to exist.

It was instigated at the suggestion of Members of Parliament and the Press, who considered that the work should have been placed in Canada. In the report of the Commissioners regarding the manufacture of fuses in Canada, at the time in question, they state (p. 19) :

We are not, we think, called upon to express an opinion as to whether the view that was taken by Colonel Carnegie and the Shell Committee was a sound view ; but the decision of the Committee is not fairly open to adverse criticism, and there can be no doubt that it was honestly arrived at ; and it is equally clear, when all the circumstances are considered, that it cannot be said to have been unreasonable. In our own judgment, the members of the Shell Committee would have assumed a grave responsibility and would have exposed themselves to severe criticism, if the opinion of their expert adviser had been disregarded and the contracts had been given to Canadian manufacturers, and their efforts to produce the fuses had resulted in failure.

It would have been mere folly for the Shell Committee, organised as it was, to have attempted in May, 1915, the establishing of an assembling and loading plant of its own. It had not been authorised by the War Office to provide one, and if it had been, the whole weight would have fallen upon Colonel Carnegie—and he was clearly overburdened with the details of transactions, the burden of which ought not to have been cast upon the shoulders of the Committee's Ordnance Adviser. It is quite

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evident that, at the time, the work of the Committee had increased enormously, and that the Committee's organisation was not adequate to deal with it; and the attempt to do, with the organisation it had, what the Imperial Munitions Board has been able to accomplish in the establishment of its assembling and loading plant, would probably have ended in failure.

In Chapter XVII the work of fuse manufacture in National Factories is described.

CHAPTER XI

GROWTH OF SHELL COMMITTEE'S WORK

In a report sent by the Chairman of the Committee to the Prime Minister of Canada outlining the position of the munitions business in Canada up to March 31, 1915, nearly seven months after the formation of the Committee, it was stated that 155 factories were then engaged in the production of munitions, and approximately 25,000 employees. The report also stated that 163 examiners and inspectors were employed by the Shell Committee, and from 150 to 200 by the Chief Inspector of Arms and Ammunition.

The contracts placed by the War Office amounted to 4,100,000 shells of 15-pdr., 18-pdr., and 4.5-in., requiring 85,051 tons of metal, and 2550 tons of cordite. In addition, 3,000,000 lb. of T.N.T. had been ordered, which valued in all approximately sixty million dollars. This rapid growth in a few months had introduced five new industries to Canada, and quickened the metal mining and refining of steel, brass, copper, zinc, lead, and antimony. It had also revived the engineering, steel forging, rolling-mills, and foundries, timber trades, and explosives industries.

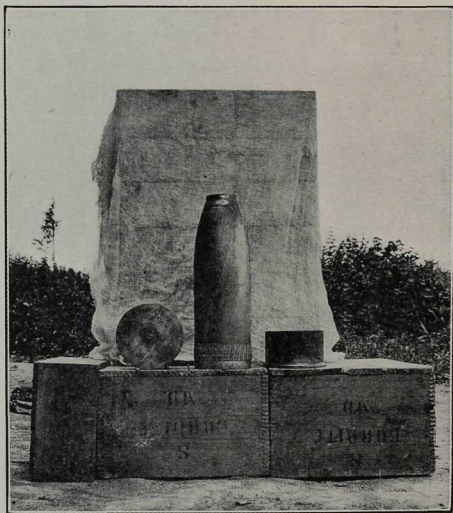
Canada's Manufacturing Capacity.—Although the shipment of shells from Canada at March 31, 1915, did not exceed 193,040, the numbers of shells actually made and in different stages of manufacture exceeded that number many times. Although deliveries were slow, orders continued to come from the War Office. Orders for over 2 $\frac{1}{4}$ million 4.5-in., and 300,000 60-pdr. high

1915. 12. 1915.

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explosive shells were placed by June 30, 1915. For the manufacture of these shells new equipment was required. The total number of shells ordered by the War Office by June 30 exceeded ten millions.

Shell Committee's Headquarters.—The Headquarters of the Shell Committee were at the Drummond Building,



FIRST 4.5 SHELL FIRED IN CANADA

Montreal, until May 20, 1915, when the staff of about forty was transferred to the Stephen Building, Ottawa, which for some months became the new headquarters of the Committee.

The chief work of the Committee at that period was the development of shell manufacturing capacity throughout Canada, and the regulation and distribution of components of shells.

Increase of Factories.—The visit of the Ordnance

Adviser to the Prairie Provinces and British Columbia during April, 1915, opened up new manufacturing capacity, which was used principally for 18-pdr. high explosive shells. There were severe handicaps in connection with the western capacity. The steel from which the shells were machined had to be shipped, in some cases, 4000 miles. Nevertheless, these handicaps did not prevent a service being rendered which contributed to the general output which afterwards exceeded all expectations.

In addition to the establishment of munitions factories in the Western Provinces, new factories and extensions were built and equipped in the Maritime Provinces, Ontario, and Quebec. By the end of June 250 factories were operating, and about as many more were preparing for operation.

Delays in Deliveries.—Although many factories were producing shells and component parts, yet towards the end of June several were much behind deliveries.

Nearly one million empty shells were completed and in stores in Toronto and Montreal waiting for the delivery of cartridge cases. Unprecedented difficulties prevented manufacturers delivering cartridge cases at the rate required to allow of the shells being fixed and shipped to England at the rate promised. There was neither expense nor labour spared by manufacturers in trying to overcome the difficulties. Some manufacturers were two to three months behind in the first deliveries. The same difficulties which Canada experienced during these months of 1915 were common to British manufacturers, with the result that a serious situation was arising at the Front.

The Ministry of Munitions, London.—Long will be remembered the rousing appeal for munitions, made by Mr. D. Lloyd George throughout Britain in the spring of 1915, which resulted in the formation of the Ministry of Munitions. That appeal spread throughout the Dominions. Press and public alike took a deeper interest than before in the supply of munitions. All

sorts of people from almost every part of Canada made offers of assistance to the Shell Committee. All who could do anything were encouraged to undertake contracts.

Mr. D. A. Thomas (Lord Rhondda).—It was about this period of the Shell Committee operations that Mr. D. A. Thomas (afterwards Lord Rhondda), now deceased, visited Canada on behalf of the Ministry of Munitions. He and Major-General Mahon, C.B., and Mr. R. H. Carr spent several weeks from July 27, 1915, going thoroughly into Canada's capacity to produce munitions. The following is an extract from a report made by the Chairman of the Shell Committee on the visit of Mr. D. A. Thomas :

Mr. Thomas and his party were graciously received, and given full opportunities to look into the mode and system of conducting the work here in Canada. Mr. Thomas and his party were given a free hand to inspect our books and accounts, and they were very complimentary with regard to the work which we were doing. On completing their inspection they undertook to visit the factories, commencing at Montreal. They visited the Dominion Bridge and all its plants. They spent two days at this Company's Works, and were very much surprised to find that they had never seen workmen working as hard as our mechanics were, and expressed very favourable opinions of conditions found there. They then proceeded to Quebec, and inspected plants there, and the next day went on to New Glasgow, for the purpose of looking into the shell industry in that portion of the country for the manufacture of large-sized shells—for instance, the 6-in., 8-in., and 12-in. shells ; also the possibility of manufacturing steel guns and other heavy materials. They were very much impressed with what they saw at New Glasgow. General Mahon expressed the opinion that we were turning out four shells to their one in England. After completing their inspection of these plants, they went on to Sydney, and were taken through the Dominion Steel plant by Mr. J. H. Plummer. They at once saw the possibility of manufacturing larger material ; and it was by doing this that they came to the conclusion that a meeting should be held in Ottawa, for the purpose of taking on this larger work. Mr. Thomas then went to Toronto, and inspected the



MEMBERS OF SHELL COMMITTEE AT DOMINION ARSENAL, QUEBEC, WITH MEMBERS OF THE BRITISH MISSION
JULY 31, 1915

Left to right: Col. David Carnegie, Col. Greville Harston, Lt.-Col. George Watts, Gen. Mahon, C.B., Gen. Sir Alex. Bertram, Lord Rhondda, Gen. Benson, Lt.-Col. Ogilvie, Mr. R. H. Carr, Lt.-Col. Lafferty, Col. T. Cantley

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factories there ; also at Hamilton, where he was very much impressed with the steel plants (The Steel Company of Canada and Dominion Steel Foundries) in that city.

The Chairman and Ordnance Adviser accompanied the party during these visits, which gave much hope to Canadian manufacturers that extensive orders would be placed for large shells, and perhaps guns.

Mr. Thomas and Shell Committee's Policy.—No orders were received by the Shell Committee from June 21, 1915, until September 2, 1915. During that period many manufacturers were in a position to undertake contracts, and were surprised at the delays in placing them, seeing that the need for munitions was so great according to Mr. Lloyd George's appeal. The Press took up the matter and became active in condemning the Shell Committee. Meanwhile, it was found that Mr. Thomas did not agree with the policy adopted by the Shell Committee in letting contracts, and was waiting for the return of Sir Robert Borden from England to discuss the matter with him before asking the Ministry of Munitions to place contracts with the Shell Committee. It was a most awkward time for the Committee, as the 'purchaser' under the British Government had changed from the War Office to the Ministry of Munitions. No contracts had been placed with the Shell Committee by the Ministry of Munitions up to this time.

Movement towards Reconstruction.—Perhaps the first movement towards the reconstruction of the Shell Committee came when Mr. D. A. Thomas questioned its authority. From a minute of a meeting held by the Committee on June 19, 1915, the subject of its reconstruction was under consideration. A proposed draft of an Order in Council on the constitution was submitted to the members, which they did not accept, but prepared an amended draft for submission to the Canadian Government.

This minute shows that prior to Lord Rhondda's visit the matter of the Committee's status was under consideration by the Government of Canada.

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Conversations passed between Lord Rhondda and the Prime Minister, Sir Robert Borden, and the executive members of the Shell Committee. Sir Robert Borden thought that the reconstructed Committee should be under the direct authority of the Ministry of Munitions. Nothing, however, at that time was decided.

Great Gun Scheme and Proposed Reconstruction.—

While these discussions were proceeding an inquiry came from the British Government for gun equipment for 12-in. howitzers to 18-pdr. field guns. General Mahon formulated a plan for handling the proposals, which he submitted to the Shell Committee. It was in effect to form out of the Shell Committee an Ordnance Board, consisting of three Sub-Committees, one to deal with ammunition, another with guns, and another with carriages. The Ordnance Board was to be a Department of the Militia Department, with a Deputy Minister of Munitions, or Director-General of Munitions, immediately responsible to the Minister of Militia, and in direct charge of munition supply. There were to be four independent controls under the Director-General : (1) a Committee of Engineers with General Bertram as President ; (2) an Assistant Director in England as Ordnance Adviser ; (3) a Financial Committee ; and (4) an Inspection Department. *

The Minister of Militia favoured a reconstruction of the Committee on the lines suggested by General Mahon, provided that such a scheme would enable Canada to produce guns and carriages in addition to shells. Before giving his approval, however, he decided to call a meeting of leading manufacturers and financial men in Canada, and lay the proposals before them.

Lord Rhondda was also in agreement with the proposed reconstruction.

Meeting of Manufacturers and Bankers.—On September 13, 1915, a meeting was held in the Militia Department, Ottawa, when seventy-five to one hundred manufacturers, bankers, officers, and others discussed

the proposals General Mahon had drawn up for the manufacture of guns and carriages. Sir Sam Hughes presided, and Sir Robert Borden and others took part in the proceedings. The scheme met with hearty approval. A committee was formed to go into the matter, with Sir John Gibson as Chairman and the Ordnance Adviser as Secretary. The decisions were communicated to the Ministry of Munitions, and Sir Frederick Donaldson was sent out to Canada to investigate the subject. He arrived about the middle of October, and confirmed General Mahon's proposals; but, meanwhile, other events happened which interfered with the plans outlined by General Mahon.

Canadian Manufacturers Disappointed.—It was now the beginning of October, 1915. The wonderful stimulus which the meeting of September 13 had given to manufacturers over the prospect of large orders for guns and shells had dissipated. Shell and gun contracts were being placed by the British Government in the U.S.A., and Canadian manufacturers could not understand why they were being overlooked.

From many conversations that the executive of the Shell Committee had with Lord Rhondda, it seemed increasingly clear to them that the cause lay in fundamental differences of opinion between him and the Committee as to the policy involved in the allocation of contracts. Lord Rhondda wished to adopt the competitive tender system, but the Committee, while recognising its value for ordinary commercial transactions, did not consider that Canadian manufacturers had sufficient knowledge of munitions manufacture and inspection to quote for shells. Manufacturers also preferred that the Committee, who had expert knowledge of shell prices, should fix them.

Independence of Shell Committee.—Then again, the Committee held the opinion, rightly or wrongly, that, so long as they supplied the completed ammunition passed by the proper authority at the price accepted by the War Office, no one had any right to criticise either the prices

paid for the component parts or the methods adopted by the Committee in placing the work.

In so far as this attitude to their duties was concerned, the members of the Shell Committee regarded themselves more as contractors selling to the British Government than as government agents.

The situation was most difficult. Lord Rhondda was aware of the semi-agency and semi-contractual relationship which had existed, and it was really impossible to compel members of the Committee to accept his policy under their constitution. They were not willing to accept his proposals, and a deadlock arose. Meanwhile, Mr. Hichens arrived from England, and Lord Rhondda handed over to him the task of reconstruction.

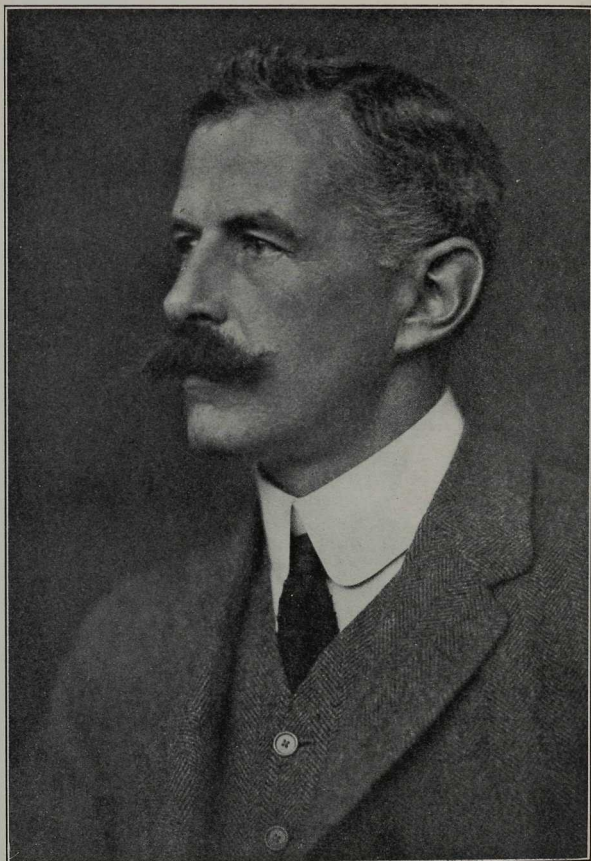


Photo : G. C. Beresford

W. L. HICHENS, ESQ.

CHAPTER XII

RECONSTRUCTION OF SHELL COMMITTEE

It was at the request of Mr. Lloyd George that Mr. W. L. Hichens went to Canada to undertake the work of reconstructing the Shell Committee.

At the instance of Mr. Hichens, and with the consent of the Minister of Munitions, the Hon. R. H. Brand accompanied him to Canada. They left England in October, 1915, and in about six weeks they accomplished a most difficult task.

Mr. Hichens as Administrator.—It was on the afternoon of October 26, 1915, that the Minister of Militia informed the Shell Committee that Mr. Hichens had arrived in Ottawa. All munitions manufacturers were alive with expectation. Those who looked for the fulfilment of Lord Rhondda's plans had been disappointed. The question asked was—Would his successor do better?

General Sir Sam Hughes not Opposed to Reconstruction.—The Minister was not opposed to the reconstruction of the Shell Committee. He welcomed any suggestions which would strengthen the organisation he had called into being. He was conscious of its imperfections, and troubled that in the early months of 1915, when the Committee undertook a great manufacturing programme, delays in deliveries arose in consequence of the enormous expansion of shell manufacture throughout the Dominion. The Press had made much capital out of this fact, and blamed the Shell Committee for the delays. General Hughes would not allow any suggestion that reconstruction was necessary because the Committee was unable to

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do its work. It was because Mr. Hichens knew the characteristics of the Minister of Militia that he proceeded on lines of reconstruction different from those of Lord Rhondda.

Since the days when Mr. Hichens campaigned with Colonel Hughes in South Africa, he had become a man of outstanding ability and capacity for organisation. It is said that Sir Sam discovered his ability during the Boer War. It was through the influence of Lord Milner that Mr. Hichens was appointed Treasurer to the Transvaal Government. Some years later, when the Cammell-Laird Co., one of the largest shipbuilding and steel manufacturing concerns in Britain, found itself in difficulties with the British Government, the man who was asked to restore the fortunes of the company was Mr. Hichens. By his able and just administration the company was restored, and won again a leading place among the British manufacturers. When the Ministry of Munitions was formed, Mr. Hichens was called to the Councils of the Ministry as a leading authority on industrial and munitions matters. This was the man in whom Sir Sam placed absolute confidence.

The Hon. R. H. Brand.—His companion and friend Mr. Brand had won his spurs also in South Africa. The draft Constitution of the Union of South Africa was built up largely by him. This grandson of Lord Hampden, a former Speaker of the House of Commons, had proved his capacity as a skilful negotiator. His financial knowledge was of much value in the reconstruction which Mr. Hichens had undertaken. The two men, each with a scholarly background, formed an excellent team.

Mr. Hichens at Work.—Messrs. Hichens and Brand arrived in Ottawa about one week before Lord Rhondda left. Ten days earlier Sir Frederick Donaldson, K.C.B., Chief Superintendent of Ordnance Factories and Technical Adviser to the Ministry of Munitions, arrived from England. Sir Frederick Donaldson came principally to look into the possibilities of gun manufacture in Canada, but he, and subsequently Mr. Hichens, were drawn into

the question of prices for the 9·2-in., 8-in. and 6-in. shells, and for the time being reconstruction became a secondary one.

The delays in placing contracts for the larger shells, which by this time had run into months, created uneasiness amongst manufacturers who congregated at Ottawa from different parts of the Dominion. The delays had also interfered with the progress of the Shell Committee.

Conference on Shell Prices.—On October 27 and the following days of the week, Lord Rhondda, Mr. Carr, Mr. Hichens, Mr. Brand, General Bertram, and the Ordnance Adviser were chiefly concerned with the placing of contracts for large shells. On October 30 Lord Rhondda handed the matter over to Mr. Hichens, and left Ottawa on the following day. His advisers, Sir Frederick Donaldson and General Mahon, left a day later.

In about a week all the contracts were placed and manufacturers were satisfied.

Pursuit of Investigation.—Whilst the work of settling contracts delayed the progress of reconstruction, it was not without its value. Day after day both Commissioners saw for themselves the nature of the work of the Executive Officers of the Committee, and were able to judge from close observation its extent and importance. There was no detail of the Committee's organisation overlooked. Everything was fully investigated. General Bertram gave them the story of its formation and what had been accomplished. Materials were collected and studied. The members of the Committee were consulted and their opinions considered.

The highest authorities, including the Governor-General, the Prime Minister and his colleagues, as well as the leading manufacturers and all who could give any helpful assistance, were consulted. Messrs. Hichens and Brand visited important works in Montreal and Toronto, and saw for themselves actual manufacturing conditions.

Conclusions of Commissioners.—After a close examination of all the facts, Messrs. Hichens and Brand came to the conclusion to submit two alternatives to the Canadian Government, with the request that they should say which they preferred. They were :

(1) That the Canadian Government should undertake direct responsibility for munitions supply, and should constitute a Ministry of Munitions in the same way as had been done in Great Britain ; and (2) that the British Ministry of Munitions should itself establish an organisation in Canada which would be directly responsible to it, and be in name, as well as in effect, its agent.

The latter proposal was chosen by the Canadian Government, and was accepted by the Minister of Munitions.

Nature of Proposed Organisation.—They had now to decide what constitution the new organisation should have in order to function properly as an agent of the British Government in Canada. They recognised that, although the new body would have to act as the representative and agent of a British Government Department, it would have no governmental powers or standing in Canada. Further, its functions would be more of a commercial than of an administrative nature. The Commissioners therefore considered it advisable to recommend that a Board should be constituted under a Chairman, on the lines of a Company Board, the Chairman having full executive powers, and that this Board should act as the representative of the Ministry of Munitions in Canada. The recommendation was accepted, and the new Board was formed.

Resignation of the Shell Committee.—The last meeting of the Shell Committee is described in the chapter which follows (Chapter XIII), as it is an event deserving of fuller notice than a mere passing reference.

For Mr. Hichens, however, to be placed in the position of having to ask for the resignation of the members of the Committee was perhaps to him the most painful part of his duties.

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As a manufacturer of munitions himself, he knew what those Committee men had done for Canada, and he was deeply conscious of how they had been misrepresented by Press and public through ignorance of their great work.

It was necessary, however, that the Committee should tender their resignations and be relieved of all liabilities attaching to the work of the Committee, so that the scheme which had been agreed to by the Canadian Government and approved by the Minister of Munitions might become an established fact. Suffice it to say here that the members resigned.

Mr. Hichens's Report to the Ministry.—In Mr. Hichens's report to the Ministry of Munitions, under date of November 24, 1915, he stated that the Committee was reorganised with the full approval of the Governor-General, H.R.H. the Duke of Connaught, and the Canadian Government.

The members of the Shell Committee, who had been thoroughly consulted in the matter, were to resign, and were to be replaced by a Board which was to consist of a Chairman, who was to have full administrative authority, a Deputy Chairman, and three or more leading members, who were to be chosen from the leading ranks of Canadian financial and commercial life. In choosing these men, Mr. Hichens was very careful to consult His Royal Highness and members of the Government, and other representatives in different walks of Canadian life.

The matter ended in the choice of four or five men. The difficulty was to find one who would fill all the requirements for the Chairmanship of the Board. Finally, with the authority and full approval of the Governor-General and the Canadian Government, this position was offered to Mr. J. W. Flavelle, afterwards Sir Joseph Flavelle, Bart., of Toronto, 'a man,' says the report, 'of highest standing and proved capacity.'

It was a generous and fine-spirited act of General Bertram to consent to accept the Deputy Chairmanship

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of the new organisation. This fact was only one of the happy reflections of the cordial relations which existed between Mr. Hichens and the Shell Committee.

In Mr. Hichens's report, which he has allowed to be reproduced, it will be observed that he made suggestions regarding a subdivision of the work and of the personnel. It was, however, clearly understood and wisely arranged that the Chairman should have full administrative authority. Sir Joseph Flavelle has permitted the following letter to be published, in which authority is given :

Mr. Hichens's Report to the Minister of Munitions.—

November 24, 1915.

GOVERNOR-GENERAL OF CANADA TO SECRETARY
OF STATE FOR THE COLONIES.

Following from Hichens for Ministry of Munitions :

No. 22. Re-organisation scheme now settled with full approval of H.R.H. the Governor-General and Canadian Government. Main points are as follows :

Existing Shell Committee will resign and be replaced by new Board to be styled Imperial Munitions Board, appointed by and under direct authority of Ministry of Munitions. Board will consist of Chairman with full executive and administrative authority, Deputy Chairman, and three or more members who will be leading representatives of Canadian financial and commercial life. Under authority given, and with full approval of the Governor-General and Canadian Government, position of Chairman has been offered to Mr. J. W. Flavelle, who has accepted it. He is well known as a leading man of business in Toronto of highest standing and proven capacity. He is President of William Davies Company, Director Canadian Bank of Commerce, President National Trust Company.—General Bertram has agreed to remain Deputy Chairman, where his experience will be of greatest value. Other members of Board not finally settled yet.

Under Board there will be five departments :

First : Contracts and Purchasing Department under experienced buyer. I hope to obtain Fitzgerald of Canadian Pacific Railway for this post.

RECONSTRUCTION OF COMMITTEE 101

Second: Technical Department under Colonel Carnegie, who will be member of new Board.

Third: Inspection Department, which will now come directly under new Board, under Major Ogilvie.

Fourth: General Secretarial Department, which will be specially concerned to maintain proper touch with Ministry of Munitions.

Fifth: Financial and Accounting Department.

It is in my opinion of the greatest importance that support and encouragement of Canadian Government shown in past should be extended in future to new Board, and that there should be some visible sign of continuity between present and past. Existence of shell industry in Canada largely due to enthusiasm and energy of General Hughes, and I have therefore asked him whether he would accept position of Honorary President of new Board. He has agreed. I believe organisation as now arranged will be very efficient. I am anxious to carry through scheme with greatest rapidity, but at present it must be kept quite confidential, and no public notification will be made until present Committee have resigned and new Board and organisation completed. This may take a few days. I intend then to make public statement notifying and explaining changes in such a way as to do justice to present Committee, which I consider absolutely necessary. I shall be glad to hear that you approve of scheme. I should like finally to express the debt I owe to H.R.H. the Governor-General, through whose influence Mr. Flavelle's acceptance was secured.

Letter of Appointment of Chairman.—

OTTAWA, December 1, 1915.

SIR,—I have the honour to inform you that I am authorised by the Minister of Munitions to notify you that you have been appointed Chairman of the Imperial Munitions Board, which has been constituted by him to deal with such purchases of munitions supplies as may from time to time be entrusted to it in succession to the Shell Committee. All the rights and powers heretofore vested in the Shell Committee, together with all moneys at the Committee's credit, have been transferred to and vested in the Imperial Munitions Board, and the Shell Committee has been relieved from all liability.

I am directed further by the Minister of Munitions to express to you his warm appreciation of the value to the British

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Government of your public-spirited acceptance of his offer of the position of Chairman.

I have the honour to be, Sir,

Your obedient servant,

(Signed) W. L. HICHENS.

Mr. J. W. Flavelle,
Chairman, Imperial Munitions Board,
Ottawa.

The Result—Success.—Unqualified success followed the labours of Mr. Hichens and Mr. Brand. The confidence they inspired, the criticism their candour disarmed, and the prejudice their singleness of purpose dissolved, cleared the atmosphere which they found on coming to Ottawa. This made possible the free use of their constructive gifts, which resulted in the formation of the Imperial Munitions Board.

CHAPTER XIII

THE LAST MEETING OF THE SHELL COMMITTEE

THE last meeting of the Shell Committee was held in the offices of the Committee, Union Bank Buildings, Ottawa, on November 29, 1915. It was a day full of shattered hopes to Committee men. It was a 'down tools' day, not because they wished to strike, but because they were asked to resign.

It is difficult to gauge the feelings of the members. Some of them had crowded into the fifteen months' service about as many years' normal activity. Little did they anticipate when they gave themselves so heartily to the work in the Drummond Building in September, 1914, that its termination would come in that way. It seemed to them as if they were faced with the ordeal of accepting the inevitable because of a set of circumstances over which they had no control.

They were asked to convince themselves that the vast dimensions to which their energies had brought the munitions business required a different kind of energy for its continuance. Mr. Hichens had certainly won their confidence by his straight dealing, but he had not convinced them that the manufacturing skill and administrative capacity which had enabled them to pioneer to success a big business could not control its expansion.

The Winding Up.—It was on the morning of the 29th that General Bertram presented a statement showing the affairs of the Committee. All the members were present, excepting General Benson (whose place was

filled by Colonel Elliot), Colonel Greville Harston, and Mr. J. W. Borden.

The Committee's Record.—The Chairman recounted with justifiable pride what the Committee had been able to do. In the Appendix to this Chapter are given some interesting details of the contracts made by the Shell Committee, which show, in addition to other items, the amounts of materials required for, and labour employed on, the shell contracts they placed.

In another statement presented to the Committee by the Chairman he showed that there had been a financial loss on certain individual contracts amounting to \$778,210·86, but on the contracts as a whole there had been a profit of \$16,047,829·07. Now that the Chairman was to hand over the keys of office to others he gave a full account of his stewardship. He showed that the total value of all contracts let by the Shell Committee to manufacturers amounted to \$142,435,681·73, whereas the price paid to the Shell Committee by the War Office for the same amounted to \$158,876,766, the difference being \$17,219,295·13. Deducting the above deficit of \$778,210·86, the sum of \$16,441,084·27 is left. The cost of boxes for the shipment of shells and powder amounted to \$393,255·20, which sum deducted from \$16,441,084·27 left the above profit of \$16,047,829·07.

General Bertram's Balance.—This balance gave General Bertram real pleasure. It was a sign that he had carefully administered the funds placed in his hands, and he was proud to be able to hand back to the War Office this substantial amount.

The Last Hour.—It was at 2.30 in the afternoon when the Committee reassembled. General Hughes and Mr. Hichens were present. The Chairman, General Bertram, called upon General Hughes to make a statement.

Sir Sam's Wrath.—Sir Sam, with all the eloquence he could command, outlined the events which had led to the proposal made by Mr. Hichens. One felt that it

was with some reluctance he accepted the proposal of Mr. Hichens. The chief argument he advanced for reconstruction was that the functions of the Committee had gradually become more administrative and less technical ; hence the necessity for munitions manufacturers to be members of the Committee was not so essential as when the Committee was formed. This was as far as he could proceed with his analysis of the situation. The pressure of his contempt of those who had disturbed the harmonious working of the Committee kept rising as he struggled through a formula his intellect accepted but his heart rejected. Ultimately, without a comma or a full stop, he slipped into one of his tempestuous condemnations of the Press for the abuse hurled at the Committee.

Unqualified Praise of His Committee.—When the Minister had emptied his phials of wrath upon those who had ruthlessly attacked his friends and impeded the service they sought to render to the Empire, he turned to General Bertram and spoke of the unselfish and unwearying service he had rendered to King and Country during the fifteen months he had been building up a gigantic business. He spoke with affection that few could understand, and which only those who knew him best believed to be full of disinterested comradeship in a great conflict. He felt more indignant at the slight of his friends than over the bitterest attacks upon himself.

To each of the members who were being asked to retire he addressed a few words of praise. Colonel Cantley in particular he thanked most heartily for having saved Canada from being driven to the United States to buy steel for shells.

Mineral Resources Commission.—In conclusion, the Minister announced that with the approval of the Prime Minister, Sir Robert Borden, a commission for the investigation of the mineral resources of Canada would be appointed, the members of which would include the retiring members of the Shell Committee,

and that Colonel Cantley would be asked to accept the Chairmanship. This, concluded the Minister, would show to Press and public that the members were not being discharged and disgraced, but were being honoured for the excellent and unselfish service they had rendered.

Mr. Hichens's Statement.—Mr. Hichens stated that with the concurrence of the Canadian and British Governments it was decided to form a new organisation which would represent the Ministry of Munitions in London. He dwelt upon the growth of the Committee's work, the fine service General Bertram in particular had rendered, and the excellence of the Committee's work as a whole.

He spoke of his part in the proposed reconstruction as the most difficult work he had ever undertaken. He believed the proposal he had made was right. He had tried to be fair ; he had gone behind no one's back ; he had gone straight to each one from whom he desired information and asked exactly what he wanted to know. He thanked the Minister of Militia for the assistance he had rendered him.

Resolution Dissolving Shell Committee.—The following resolution is copied from the minutes of the last meeting :

Resolved that in view of the desire of the British Government to reorganise the purchasing agency for British munitions of war in Canada, and to place it under the administrative control of the British Minister of Munitions, the members of the Shell Committee hereby place their resignations in the hands of the Minister of Militia and Defence.

Resolved further that all the rights and powers now vested in the Committee, together with all the moneys at the credit of the Committee, be transferred to and vested in the British Government or any body appointed by that Government, provided that the Committee is at the same time relieved from all further liability and the British Government undertakes to carry out all the Committee's obligations.

The resolutions were moved and seconded by members of the Committee and carried unanimously.

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Letters of Thanks.—

Addressed to each Member of the Shell Committee.

CHÂTEAU LAURIER,

OTTAWA, December 1, 1915.

SIR,—I have been asked by the Minister of Munitions to convey to you his sincere appreciation and warm recognition of the valuable services rendered by you as a member of the Shell Committee.

He recognises that the results achieved by the Committee are due to much strenuous work, which the members have carried out with great public spirit and a loyal regard to the needs of the Empire in this great crisis.

I am, Sir,

Your obedient servant,

W. L. HICHENS.

Conclusion.—Thus ended a work having the character of the foundations of a new building. Two of the men, General Sir Alex. Bertram and the Ordnance Adviser, who had helped to lay the foundations, were invited to join the band of men who built the superstructure, a fine edifice surely. While the Shell Committee's work was underground, as the foundations of all great buildings are, yet without it Canada to-day might not have been so prosperous.

APPENDIX

Details of Shell Committee's Contracts

1. *Total Number of Shells placed.*

Including 15- and 18-pdr. shrapnel, 18-pdr. high explosive, 4·5-in. high explosive, 60-pdr. high explosive, 6-in., 8-in., and 9·2-in. high explosive. Approximately . . . 22,000,000

2. *Materials and Quantities used in above Contracts.*

Steel	lb.	800,000,000
Brass (including copper and zinc)	„	44,865,617
Copper	„	21,595,832
Lead	„	101,758,327
Tin	„	1,447,708
Resin	„	10,037,506

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Powder	lb.	4,094,531
Cordite	"	9,649,990
Nitro-cellulose powder	"	3,750,000
Trinitrotoluene	"	10,690,000
3. <i>Shells shipped or waiting Shipment.</i>		
Approximately (empty and complete)		3,000,000
T.N.T.	lb.	1,200,000
4. <i>Present Rate of Monthly Output.</i>		
Empty shells		700,000
Complete rounds		400,000
T.N.T.	lb.	400,000
5. <i>Labour employed.</i>		
Approximately (including skilled and other labour)		80,000 to 90,000 men
6. <i>Inspectors.</i>		
Approximately		1,500
7. <i>Number of Factories engaged</i>		
		329
8. <i>New Industries.</i>		
Zinc refining, copper refining, trinitrotoluene, nitro-cellulose.		

CHAPTER XIV

GENERAL SIR ALEXANDER BERTRAM

'He is an unimpressionable, calculating practical mechanic, calm business man, able captain of industry and military officer of distinction, for that is the way General Bertram can be correctly described.' This was the description given by one of the Ottawa daily papers, on June 11, 1915, of the Shell Committee's Chairman. If the word 'unimpressionable' refers only to his attitude to all influences which would cause him to deviate one particle from the line of duty, I agree that the description is a fair assessment of one of his characteristics. The same journal went on to advise its readers. It said: 'We ask the readers of the *Free Press* to read the cold, unvarnished tale told by General Bertram yesterday, and when they have done that we believe they will, like us, take off their hats to General Hughes and General Bertram.'

Daily Press Criticism.—This hearty praise, as a result of a plain statement, given by General Bertram, of the work of the Shell Committee, came too late. The destructive criticism of the Press had impaired the general's health. Perhaps the policy of the Shell Committee was in some measure responsible for the attitude of the Press to its work. The Press was not kept sufficiently informed, nor had the public any clear knowledge of the Committee's relation to the Government of Canada. The Committee may have failed in not keeping public opinion informed of its operations through the agency of the Press. There was no studied purpose in keeping

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information from the Press. The Committee simply had no publicity department, and was too busy getting



Photo : Notman, Montreal.

GENERAL SIR ALEXANDER BERTRAM

things done to trouble about what politicians and Press thought of its policy. It pursued its course, determined not to be influenced by Press or public.

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As Chairman of the Committee, General Bertram suffered most from the attacks made upon the Committee. He was far from being an 'unimpressible man.' He was sensitive to every reflection upon his course of duty, but he was also courageous and fearless. A few days after the Shell Committee was formed, certain manufacturers approached the Minister of Militia personally about shell contracts. General Bertram heard of it, and promptly wrote to the Minister on September 15, 1914, asking him to direct all inquiries to his office, through which all orders would be issued.

General Bertram, August 4, 1914.—It was while passing through Winnipeg on August 4, 1914, that he heard war was declared by Great Britain against Germany, and wired immediately to the Minister of Militia volunteering his services for the front, and also the services of his company for the manufacture of war munitions.

General Bertram was reared in the school of reverent devotion to God, Country, and Duty. He had passed the sixtieth milestone when war broke out, and was at the time President of the old-established engineering firm of John Bertram and Sons, founded by his father, who had settled in Dundas, Ontario, with a heritage of Scottish character of which his sons were not unnaturally proud.

General Bertram's proposal to go overseas was no empty offer. Although he was trained in the works of his father as a mechanical engineer, and had become one of Canada's industrial leaders, he was also a soldier of no mean order. From bugler in the 13th Regiment, Hamilton, he rose to the command of the 77th Wentworth Regiment, and subsequently to the command of the 3rd Infantry Brigade, West Ontario. In 1909 he commanded the Bisley team with great distinction, and received the Colonial Auxiliary Forces Officer's decoration. Of his attainments he was the last one to speak, but where he could be of service he would not cease to censure himself if he allowed an opportunity to pass without embracing it.

The Chairman's Task.—The Chairman of the Shell Committee undertook his task with a sense of duty and constancy which was reflected in personal and unaffected courage. His early training in thrift had its advantages and drawbacks in handling big business. Had he been less mindful of profits for the British Government, and more concerned about his own health, he would have spent more money on the foundations of the great work he laid so well. During the formative period of the Committee's work he laboured night and day with an extremely limited though very able staff, using his own office in Montreal. But he was extremely careful about the use of other people's money, and wanted to hand back to the British Government every cent he could save in the administration of the work. No one admired these traits of character more and supported him in his worthy aims than the Committee's Ordnance Adviser.

General Bertram had obvious reasons at that time for keeping expenses down. At the beginning of the munitions business in Canada reports were current that the war would be over in a few months. Kitchener had not yet given his prophecy of three years' duration. To have set up an expensive organisation at that time would have been a risk of which prudent finance would have disapproved. But whatever may be said as to the limitations of accommodation and staff at Drummond Building, Montreal, it was there in the offices of the President of John Bertram & Sons that the policy of the Shell Committee was formulated and established.

The Chairman with Contractors and Politicians.—The Chairman's knowledge of manufacturing conditions in Canada was a most valuable asset to him. There was little possibility of contractors or politicians obtaining contracts, unless he was entirely satisfied that they could perform what they were ready to undertake. A few answers to one or two questions as to their equipment and capacity gave him a measure of the situation, and with frankness and courtesy he informed them of his decision. When demands for munitions increased from

the Mother Country, the Stephen Building, Ottawa, to which the Committee's headquarters were removed, soon became too small. Influential contractors, politicians, and other distinguished visitors often complained of insufficient accommodation. It was not uncommon to find the waiting-rooms overcrowded, and the overflow perched on shell boxes in the corridors. But the general saw everybody if they waited long enough. From early morning until midnight the offices were open.

Politicians came from every province to urge the claims of their manufacturers. One day Sir Wilfrid Laurier, the stately ex-Prime Minister, came to the Stephen Building. The Committee was in session. What was the object of his visit? Simply to do a good turn to a small manufacturer who considered he had facilities to manufacture wooden ammunition boxes.

From the highest to the lowest members of the community, the Chairman gave to all a patient and sympathetic hearing. He welcomed any who could contribute to the speedy supply of munitions. He spread broadcast throughout the Dominions contracts for the supply of shells, but efficiency, quality, and rate of output were the determining factors in the selection of manufacturers.

Growth of the Work.—Under his wise Chairmanship the work grew rapidly. He threw himself into all the problems which confronted the Committee, and fathered with energy and skill their solution. Whether the problems related to basic steel, inspection, raw materials, shortage, explosives, cartridge cases, copper bands, or fuses, all were the same to him; they had to be solved. He won the affection of his colleagues and staff, whose energies were devoted to the work which he directed so thoroughly.

General Sir Sam Hughes said of the work :

The result has been nearly 400 million dollars worth of business for Canada; one hundred thousand Canadian workmen trained to be skilled; millions of shells to the front; the furnishing an example and model for all lands; prosperity to Canada; and not one lawsuit.

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Mr. D. A. Thomas (the late Lord Rhondda), during his mission to Canada, said :

The Shell Committee was doing an enormous business, the size of which was hardly recognised by the public. It was probably the biggest business in the Empire to-day. It had grown enormously, almost out of recognition, indeed, since its inception twelve months ago, and when the small orders first entrusted to it were given out. He considered the Committee had done excellent work under most difficult and trying circumstances, and that they had placed the country under a heavy debt of obligation. General Bertram had worked like a trojan, night and day, and had given his services freely to the State without fee or reward.

Mr. W. L. Hichens, who succeeded Mr. D. A. Thomas, said in his report to Sir Robert Borden on November 29, 1915 :

These far-reaching and important results have not been achieved without the most exacting and strenuous labour, which has fallen more particularly upon General Bertram and Colonel Carnegie, and which a single united enthusiasm for the cause has enabled them to sustain.

Reconstruction of Committee Recommended.—General Bertram recognised the necessity for the reconstruction of the Committee, and advised Sir Robert Borden on the lines of the constitution it should have. The Committee's rapid growth, involving a great financial outlay, demanded a well-defined relation between its members and the British Government. The members of the Committee supported the Chairman in the changes which he recommended. His proposals were not followed. He took this to heart very much. His indifferent health, owing to the strain of the work and the worry caused by unwarrantable criticisms of the daily Press, gave his friends much anxiety. He was hurt because he did not feel at liberty to reply to the criticisms made by Mr. D. A. Thomas and others who came to examine the affairs of the Shell Committee. Although it was a great relief to relinquish the task of Chairman of the Shell

Committee, because of the physical and mental fatigue, it was like separating a mother from her child.

In handing over the responsibility to the Imperial Munitions Board of the Committee's work, he also handed over a substantial sum of money which he had saved in its administration.

Honoured by the King.—General Bertram was knighted by the King for the services which he rendered, and was appointed Deputy Chairman of the Imperial Munitions Board, which position he held until it was dissolved.

Lady Bertram.—General Bertram would be the first to recognise how much he owed to the constant and wise counsel of Lady Bertram. She sacrificed much of her husband's company during the strenuous days of the Committee's work, but did it with an unselfish and abounding enthusiasm for the cause to which her devoted husband gave himself to the service of his King and Country.

CHAPTER XV

THE IMPERIAL MUNITIONS BOARD

To describe adequately the organisation known as the Imperial Munitions Board necessitates the marshalling of cold facts relating to constitution, functions, officers, and departments. It is more interesting to tell of its wonderful output than describe the machine which did the work. As, however, this is part of a story more or less a human document, it is necessary to give the names of the men who operated the machine, and what part they played in keeping it going efficiently.

Date of Organisation.—The resignation of the Shell Committee and the announcement of the constitution of the Imperial Munitions Board took place on November 29, 1915.

Constitution of Imperial Munitions Board.—The new Board consisted of General Sir Sam Hughes, Honorary President ; Mr. J. W. Flavelle (now Sir Joseph Flavelle, Bart.), Chairman ; General Alex. Bertram (now General Sir Alex. Bertram), Deputy Chairman ; Colonel David Carnegie, Ordnance Adviser ; Mr. G. H. Dawson, former Surveyor-General of Victoria, B.C. ; Mr. C. B. Gordon (now Sir Charles Gordon, G.B.E.), Vice-President of the Bank of Montreal ; Mr. F. Perry, Financial Member ; Mr. J. A. Vaillancourt, President of the Bank of Hochelaga, Montreal ; and Mr. E. R. Wood, Toronto. The Hon. R. H. Brand, C.M.G., Representative of the Imperial Munitions Board at the Ministry of Munitions, London, and Brigadier-General W. E. Edwards, Director of Inspection, were later appointed to the Board as additional members.

Minister of Militia and Defence, Hon. President.—

Referring to the new Board in a letter written to the Prime Minister of Canada at the time, Mr. W. L. Hichens said of the Minister of Militia :

The Minister of Militia will in any case, I know, use all his influence to support the development of munitions supplies in Canada. But it is very valuable that there should be a recognised continuity in the work, and that it should be clearly seen that the new Board will receive from him the same encouragement and support that has contributed so materially to the success of the Shell Committee. At the request, therefore, of the Minister of Munitions, General the Honourable Sir Sam Hughes, K.C.B., Minister of Militia and Defence, has accepted the position of Honorary President of the Imperial Munitions Board.

The Minister, however, did not attend more than the preliminary meetings of the Imperial Munitions Board. The Chairman, having full administrative authority, carried the responsibility. He had the unqualified backing of the members of the Board.

The Board's Personnel.—In announcing the personnel of the new Board, Mr. Hichens said of the Chairman : ' Mr. J. W. Flavelle has with great public spirit undertaken to make the work of the Board his primary consideration, and he has made the necessary arrangements to this end.'

General Sir Alex. Bertram.—It will always remain to the credit of General Bertram that he was a big enough man to take a second place. He was too much broken in health at the time of the Board's formation to undertake a whole-time service. His medical advisers had warned him against such a course, but after some weeks of rest he returned refreshed, and gave advice freely. He did much to remove the discontent which the change in control created among manufacturers and others. In this and in many ways he made harmony where discord would have interfered with progress. 'General Bertram,' said Mr. Hichens, 'was among the first to call our attention to the fact, and to suggest that the new problems of administration on a greatly increased

scale required for their proper direction an expanded organisation.'

Sir Charles Gordon, G.B.E.—With reference to Mr. C. B. Gordon, afterwards Sir Charles Gordon, Mr. Hichens said: 'He has kindly promised to devote a great part of his time to the work, and I am confident that his wide business experience and reputation will contribute largely to the success of the undertaking.' Mr. Hichens made no mistake in his choice.

Mr. Gordon's successes in commercial undertakings, and the financial standing he had made for himself through sheer hard work and straightforward dealing, placed him in the forefront of industrial men in Montreal.

It was not long before the Chairman of the Board proposed that Mr. Gordon should undertake the duties of Deputy Chairman. Sir Charles gave his whole time to the work of the Board, until he resigned on his appointment as Representative of the Ministry of Munitions, London, at Washington, in the early months of 1917, after the U.S.A. entered the war. Elsewhere are recorded some of the able services he rendered to the Board.

Mr. F. Perry.—Mr. F. Perry, who was in England at the time of his appointment, brought to the Board an extensive knowledge of imperial finance. As financial member of the Board he carried responsibilities which, shared with the Chairman, were indeed heavy. His co-operative service to the Board with that of the Hon. R. H. Brand made their combined help of great value. Mr. Perry not only knew Canada and its financial resources, but had a wide experience of different parts of the Empire, all of which made the part he played of great value.

Mr. G. Herbert Dawson.—In the choice of Mr. Dawson as a member, the Board had one whose wide knowledge of the engineering and commercial possibilities of Canada counted for much. His knowledge was of special value in the selection of suitable suppliers of munitions on the west coast of Canada.

His knowledge was not limited to British Columbia,

although he was at one time the Surveyor-General of the Province. His services to the Canadian Pacific Railway in the early days of his engineering career made him conversant with the broad engineering interests of the Dominion.

Mr. Dawson was of considerable help to the Board during the period of shipbuilding and also when the timber for aeroplanes was urgently required, and when British Columbia lumber saved the situation.

Mr. J. A. Vaillancourt.—Mr. Hichens made a fine selection when he chose Mr. T. A. Vaillancourt as a representative of the French Canadian interests of the Dominion for the Imperial Munitions Board. Mr. Vaillancourt rarely missed a Board meeting. His quiet strength impressed his colleagues. His connection with the Board promoted a wholesome interest among many French Canadian firms who supplied munitions. His experience and good judgment, gained from a successful business and banking career, added weight to the important matters with which the Board had to deal.

Mr. E. R. Wood.—Mr. E. R. Wood could not give his whole time to the service of the Board. His business and financial responsibilities with the largest corporations in Canada and the U.S.A., without the robust health for the energetic mind he carried, prevented him from a full time service to the Board. He commenced his business career as a telegraph operator with the Central Canada Loan and Savings Co., in 1884, and became President of the company in 1914. Mr. Wood, like his friend, the Chairman of the Board, was a man who had proved the value of money in the hard school of experience. He had prospered in the wise administration of large financial and commercial businesses. Mr. Wood was able, though in indifferent health, to render to the Board wise counsel, and to the Chairman he was of particular assistance.

The Hon. R. H. Brand.—Mr. Brand, who with Mr. Hichens was instrumental in forming the Imperial Munitions Board, agreed to become a member of the

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Board at the request of the Chairman. He gave his full unstinted service to the work of the Board in London.

At first it was thought that the work he undertook at

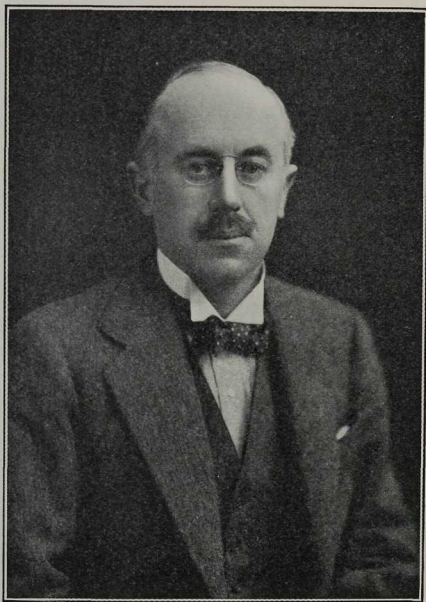


Photo : Speaight, Ltd.

HON. R. H. BRAND, C.M.G.

the Ministry of Munitions, London, as Representative of the Board, would not be of a whole time nature. It was found, however, that it not only demanded the whole of Mr. Brand's time, but, in addition, that of a capable staff under him. (See Appendix II.)

Brigadier-General Edwards.—Brig.-General Edwards, as Director of Inspection, was later appointed a member

of the Board. The very able work carried on by him under difficult conditions is recorded in Chapter XXV. It is sad to think that the life of such a brilliant young officer should have been cut off so soon after the war was over.

The Functions of the Board.—In the same letter to the Prime Minister from which I have before quoted, Mr. Hichens gave, in a general way, the functions of the Board:

The Imperial Munitions Board has been constituted by the British Minister of Munitions as from November 30, 1915, to deal with such purchases of munitions supplies as may from time to time be entrusted to it by the said Minister. All the rights and powers heretofore vested in the Shell Committee, together with all the moneys at the Committee's credit, have been transferred to and vested in the Imperial Munitions Board, and the Shell Committee has been relieved from all liabilities, which will be assumed by the new Board acting on behalf of the Minister of Munitions.

The Offices of the Board.—The headquarters of the Shell Committee in Union Bank Building, Ottawa, were for some months the offices of the new Board. It was not until the end of July, 1916, that the Transportation Building became the hub of the munitions business in Canada, but long before that time the organisation had expanded much beyond the walls of the Union Bank Building.

Board Meetings.—General Board Meetings were held every fortnight—the first on December 10, 1915, and the last in March 1919. It is of interest to record that at the first meeting the following were present:

General Sir Sam Hughes, Honorary Chairman.
Mr. J. W. Flavelle, Chairman.
General Bertram, Vice-Chairman.
Colonel Carnegie.
Mr. Dawson.
Mr. Vaillancourt.
Mr. Gordon.

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At the last meeting, held in March 1919, there were present :

Sir Joseph Flavelle, Bt.
General Bertram.
Colonel Carnegie.
Mr. F. Perry.
Mr. Vaillancourt.
Brigadier-General Edwards.

Executive.—The Chairman, Mr. Gordon, and Mr. Perry gave their whole time, and, together with the Ordnance Adviser, acted as an informal Committee of the Board, in constant session, for consultative purposes. Each undertook the supervision of certain departments, and the Chairman exercised a general control over the whole.

General Officers of the Board.—In addition to the members of the Board the principal officers were : Mr. Edward Fitzgerald, whose outstanding value, not only as Director of Purchases, but as Assistant to the Chairman, was recognised by all ; Mr. George Edwards, Auditor, whose fine work is recorded in Chapter XXVII ; Mr. N. W. Pirrie, Director of Explosives, who afterwards, with Mr. Howard Murray and Mr. Wardleworth, rendered much service in the supply of explosives ; and Mr. Mark H. Irish, Director of Labour, the work of whose department is recorded in Chapter XXVI.

These men were the leading general officers.

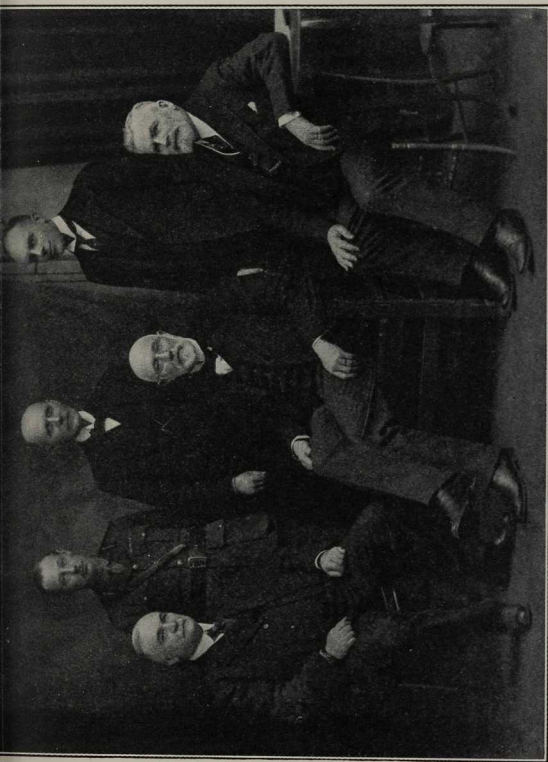
Advisory Committees.—As the work of the Board grew, it was deemed advisable to have consultative committees for each large department. The following committees were therefore appointed :

(1) *Committee on Production of Gun Ammunition.*

Mr. C. B. Gordon, Chairman.
Colonel W. G. Edwards.
Mr. A. G. McAvity.
Mr. W. A. Petersen.

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Mr. Allan McAvity was Director of Factory Organisation and Equipment, and did a fine and painstaking



LAST MEETING OF IMPERIAL MUNITIONS BOARD, MARCH 1919

Left to right: Gen. Sir Alex. Bertram, Brig.-Gen. Edwards, C.M.G., Col. David Carnegie, Sir Joseph Flavelle, Bart., Mr. F. Perry, Mr. Vaillancourt

work. Mr. Petersen inspected factories, and determined what capacity each manufacturer had for the production of munitions. He was of much value in this particular service.

(2) *Committee on Changes in Munitions Design.*

Colonel David Carnegie, Chairman.

Colonel E. W. Edwards.

Colonel Ogilvie.

Captain Durley.

Mr. McAvity.

It became increasingly important that all changes in designs in the munitions being manufactured should be made with the quickest despatch. The changes called for were not merely changes in drawings, but in specifications. Materials were being ordered daily; contracts for shells and explosives were being placed with many hundreds of companies. It was essential that no drawings or specifications should be issued without the scrutiny of the Committee.

Captain Durley was the Director of the Gauge Department, a most important section of the Board's activities. The far-reaching work which he did is recorded in Chapter XXV.

Committee for the Examination of Inventions.—The war stimulated the inventive faculty to a very great degree. Proposals and inventions relating to war work were offered by persons from different parts of the Dominion of Canada and the U.S.A. to the Government Departments at Ottawa. The Patents Office branch of the Government could not deal with them, and other governmental departments frequently passed on what they received to the Chairman of the Imperial Munitions Board for his consideration. Although this subject was a very small part of the Board's activities, it was decided in 1917 to form an Inventions Committee similar to the Inventions Board in London. The object was to examine any proposals which might be forwarded. It was decided to make use of any ideas considered by the Committee to be of service. Such were forwarded to the Inventions Board, London.

The Committee appointed consisted of representatives of the Militia, Naval, and Patent Examination

Departments of the Canadian Government, in addition to officers of the Imperial Munitions Board. The members were :

Colonel David Carnegie, Chairman.

Brigadier-General Elliot, Master General of Ordnance, Militia Department.

Colonel Helmer, Director-General of Musketry, Militia Department.

Engineer-Captain A. C. Darly, R.N., Consulting Naval Engineer, Naval Service.

Captain Durley, Imperial Munitions Board.

Mr. F. C. Ericson, Chief Engineer, Canadian Aeroplanes Ltd.

Professor J. C. McLennan, F.R.S., Toronto University.

Other Committees.—Other committees were formed for the consideration of questions arising on aircraft, explosives, fuses, and raw materials, and met as required. When national factories were organised to manufacture aeroplanes, explosives, and fuses, the committees on these subjects were merged into the factory organisations.

Departments and Officers.—The names of departments and of officers who controlled them are given in Appendix IV.

The departments grew in size as the work of the Board increased. It was necessary to make many departmental subdivisions. In addition to the offices in Ottawa, there were offices in Montreal, Toronto, Moncton, Winnipeg, and Vancouver for the direction of the local business of the Board. For the vast ramifications of the Board's work readers are referred to the chapters which follow.

CHAPTER XVI

SHELL PRODUCTION

THE problem of shell production was one of the first which the Imperial Munitions Board had to solve. Shells which ought to have been delivered were still unfinished. Large orders for heavy shells had been placed by the Shell Committee before its dissolution. The question was how production could be increased.

It was not the time for fault finding, but to inspire those whose difficulties had been great to take courage.

By the end of November, 1915, most of the early difficulties in shell and cartridge case manufacture had been mastered, but at the expense of overdue deliveries.

Shell Shipments.—The first shell shipments made in December, 1914, amounted to 3294. This number was greatly increased in January, 1915, by a shipment of 32,961 and in February of 48,261 shells. During 1915 the rate of production increased, but not in accordance with the promises made by the manufacturers. Many additional manufacturers had undertaken shell contracts and encountered experimental difficulties in training workers, and also with the inspection and gun proof of shells.

It was inevitable that some shells presented for inspection and proof had to be returned for adjustments and rectification. Firing proofs were selected from lots of 100 and upwards. It would have been almost miraculous if during the early stages of manufacture all shells had passed the exacting inspection to which they were subjected. If, however, deliveries were delayed

during the first year, they rapidly increased when the manufacturers got into their stride. In 1915 actually 5,377,000 shells were shipped; in 1916, 19,942,000; and the figure reached 23,782,000 in 1917. In 1918 the production in England had reached such proportions that the requirements from Canada were reduced. The number actually shipped up to November 11 for the year 1918 amounted to 16,325,000.

Numbers no Adequate Measure.—These numbers give no real measure of the value of the shells or the labour and material employed in their manufacture. For instance, to produce 1000 18-pdr. shrapnel shell forgings only about $6\frac{1}{4}$ tons of steel were required, while 1000 9·2-in. high explosive required 174 tons; 80,000 tons of steel were used per month in the manufacture of the different sizes of shells at the busiest period of the Board's operations.

All the early shipments were of small unloaded shells, whereas from 1916 onwards the shipments included larger shells, such as 60-pdr., 6-in., 8-in., and 9-in. In 1916 1,584,000 shells of larger calibre were included in the shipments; 421,000 in 1917; and 7,148,000 in the 1918 shipments.

Loaded Shell Components.—In addition to the above shipments, shell components were manufactured on a large scale—for example, cartridge cases, fuses, primers, etc.—and also explosives and propellants. In the case of high explosive shells, although the components were made in Canada, they were shipped separately to Europe to be assembled there, to avoid any danger in transportation. In the case of shrapnel shell, however, the rounds were assembled in Canada, and were shipped complete and ready for firing to Great Britain, or direct to France.

Complete Shipments.—The following table gives the total shipments from Canada of finished shells and components:

18-pdr. shrapnel shell alone	9,559,652
18-pdr. shrapnel complete rounds except fuses	8,423,152
18-pdr. shrapnel complete rounds	16,522,646

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18-pdr. high explosive shells	1,515,434
18-pdr. high explosive shells complete rounds unfilled	4,177,716
15-pdr. shrapnel	302,208
13-pdr. shrapnel	79,557
4.5 howitzer shell high explosive	12,607,091
60-pdr. high explosive shell	1,104,312
6-in. high explosive shell	11,078,534
8-in. high explosive shell	753,713
9.2-in. high explosive shell	783,538
13-pdr. cartridge cases	1,004,011
8-pdr. cartridge cases	34,742,180
75-mm. cartridge cases	801,024
4.5-in. cartridge cases	11,995,215
Fuses—time	19,816,193
Fuses—graze	9,831,193
Primers	35,698,176
T.N.T. lb.	41,754,950
Cordite „	35,833,657
Nitro-cellulose powder „	24,802,915
Cordite and nitro-cellulose powder loaded in fixed ammunition and complete rounds not included in above „	43,685,271

There were shipped approximately :

25,176,950 shells.
 41,730,605 shells, fixed and complete rounds.
 48,542,430 cartridge cases.
 148,000,000 lb. of high explosives and propellants.

How was this Accomplished ?—It was not a question of simply growing, like 'Topsy' in Kentucky. There was a definite mind at work. That mind was the corporate mind of the people of Canada. While it is true that the directing mind centred first in the Shell Committee, and then in the Imperial Munitions Board, it would have failed utterly in the task undertaken had not employers and employed and all sections of the industries engaged in the work given their loyal and mutual aid.

The decision of the Shell Committee to divide up the work and get assistance from as many manufacturers as

possible made production easier, but it cast a very great responsibility on the Shell Committee and Imperial Munitions Board, for the accurate supply, inspection, and distribution of components.

Purchase and Distribution of Materials.—The purchase and distribution of components was in itself a task of great magnitude. During the Shell Committee's operations, the buying and distribution of materials was under the direction of Mr. Harry Bertram, who for some time single-handed assisted the Executive Officers of the Shell Committee. He and his assistant, Mr. Gordon Woodhouse, laid the foundation of the purchasing and distributing departments which afterwards expanded to such dimensions. It may be better understood what work was involved when it is remembered that for the 15-pdr. shrapnel shell alone twenty-eight different manufacturers in Canada, and three in the U.S.A., were supplying component parts. These had to be delivered in regular lots to the five manufacturers who assembled and machined the complete shells. Even with this comparatively small beginning there was anxiety lest any hitch in the regular distribution and supply of the components should interfere with deliveries of shells. It is difficult to compare the early struggles of the Shell Committee in purchasing for and distributing to manufacturers materials necessary for the production of a few thousand small shells per week, with that of nearly 800,000 shells per week of different sizes ranging from 3-in. to 9·2-in. in diameter.

Mr. Edward Fitzgerald.—The Board's production and distributing machinery of organisation brought into being by the Chairman, and operated by Mr. Edward Fitzgerald, worked with amazing smoothness.

Mr. Fitzgerald brought to the work of the Board his important experience as purchasing agent to the Canadian Pacific Railway, and it proved to be of the utmost value. As the number of manufacturers increased each was supplied with the materials required, no matter whether they had to be transported 1 mile or 4000 miles from the source of supply.

If one source of supply failed another was found. All needs were automatically registered when a contract for shells was placed, and supplies were arranged to meet the requirements of the manufacturers. During a period of the war, when materials were in greatest demand by the Board, the Allied Countries were tapping the same sources of supply as the Board. This fact gave great anxiety to the Purchasing Department.

In view of possible shortage it was necessary to keep on hand huge quantities of every kind of material required. Without this provision, it would have been impossible to maintain the shell-producing capacity of the factories throughout the far-spread Dominion. In spite of these difficulties no serious delay in the supply or distribution of materials arose. This was due to the fact that Mr. Fitzgerald and his loyal and able staff left nothing to chance. The Transportation Building was a veritable clearing-house through which all the requirements of several hundred manufacturers passed and were satisfied without bustle or unnecessary excitement. Mr. Fitzgerald's genial personality won for him not only affection and esteem, but their confidence.

When he was appointed Assistant to the Chairman, everyone recognised the valuable asset he was to the whole work of the Imperial Munitions Board.

In addition to the supply of materials it was necessary for the Board to supervise their making up; to arrange their transfer and transport from one factory to another; to advise on and facilitate the purchase of machinery; to decide upon the suitability or otherwise of the equipment of contractors eager to obtain orders. The Purchasing Department of the Board was responsible both for the purchase of all raw materials and for the making of all contracts with manufacturers.

Mr. Allan McAvity.—Among the first of loyal men that the Chairman gathered round him was Mr. Allan McAvity, who was of great help to manufacturers, particularly those commencing to undertake the manufacture of larger shells. He worked assiduously, directing the

production specially in the machining and assembling factories. He suggested a more complete analysis of the manufacturing capacity of the Canadian industries. The work, therefore, of examining all industrial plants before placing contracts, which was initiated by the Shell Committee, was greatly extended.

Mr. Petersen.—The Canadian Pacific Railway, always ready to be of service, lent to the Board Mr. Petersen, a master mechanic who had been in charge of shell production at the Canadian Pacific Railway Angus shops since the beginning of the war. He undertook the responsibility of examining all factories, and of reporting on the efficiency of their equipment and their probable capacity. His service to manufacturers in advising them on the best machinery to install, and in the use of cutting tools to obtain the greatest output, was much appreciated. Mr. Petersen showed good judgment, which he applied earnestly and effectively in the performance of his duties.

Division of Duties.—It became apparent to the Chairman that the magnitude of the work, growing with leaps and bounds, called for sectional commands. The value of the weekly deliveries of the 18-pdr. shrapnel shell only soon reached a million dollars, and had every appearance of reaching several millions.

Committees of the Board's officers were formed, and directors of production appointed. Leading business men were approached by the Chairman and invited to concentrate on the direction and supply of one or more types of shells. Mr. James Wood, from Toronto, undertook the direction of the 18-pdr. shrapnel and high explosive shells; Mr. Fred N. Southam, from Montreal, the 4·5-in. and 60-pdr.

They made themselves responsible for supervising and assisting manufacturers in the actual work of production; for helping them to obtain machinery; and for advising the Distribution Department as to their requirements. They gave their services without remuneration—services which money could not repay.

Pressure from British Authorities for Delivery.—As the

war proceeded the demands for shells increased. New factories were called into activity. The steel supplies from Canada were inadequate. Steel and shell forgings had to be obtained from the U.S.A. The latter did well, but the delays in transportation, because of gluts on the railroads, threw many factories behind, waiting for supplies. Mr. Larmont undertook the responsibility for steel supplies, and Mr. Miller for tracking the shell forgings and helping forging manufacturers to overcome difficulties in manufacture. The greatest difficulty came towards the end of 1916, when 18-pdr. shrapnel were in urgent demand. The completed shell was wanted at the front.

Mr. James Wood.—The perplexity in attempting to increase deliveries intensified when the U.S.A. entered the war.

Demands were made for 350,000 to 400,000 complete rounds of 18-pdr. shrapnel shells per week. Many attempts had been made to co-ordinate supply to demand of component parts by machining and assembling plants. Over 300 factories in Canada were making components for the 18-pdr. shrapnel, and 20 factories in the U.S.A. In 1917 this number had increased to 381 in Canada and 24 in the U.S.A. These had to supply 61 machining and assembling factories.

Mr. James Wood, with a staff of one or two, and working in conjunction with the Order and Distributing Departments of the Board, revolutionised the production of 18-pdr. shrapnel shells. When he undertook the work towards the middle of 1916, little over 100,000 shells were being shipped per week. In less than one year the output gradually increased to 400,000 per week. There was no bustle. Mr. Wood never seemed to be anxious or excited. He commanded an unusual power of regulating supplies, a good judgment about future probabilities, and he laid his plans accordingly. Think! —400,000 18-pdr. shrapnel complete rounds per week, representing a money value of over \$5,000,000 and a weight of approximately 5000 tons.

Transportation Department.—The enormous volume of traffic in components to assembling factories, and in delivering the completed shells, cartridge cases, primers, fuses, etc., to loading factories, involved, during 1917 alone, the transportation of 1,600,000 tons to and from machining plants, in addition to the handling of 785,000 tons which were shipped overseas. These totals include all sizes of shells and not only the 18-pdr. shrapnel.

All shipments and car movements were carefully followed by the Transportation Department of the Board, so ably superintended by Mr. L. C. Thomson. A complete recording and tracing system was in operation, so that consignments of material of every character used in the Board's operations were continuously under supervision from their originating point to their destination. The Board was thus able to stop, divert or transfer shipments at shortest notice, when the necessity arose. Some idea of the importance of this department may be found in the fact that during its existence the Board spent over 20 million dollars in transportation alone. The last building in which the Imperial Board was housed in Ottawa was appropriately named the Transportation Building.

Orders for Shells from Great Britain to U.S.A. Reduced.—For a considerable period Canada produced between a quarter and a third of the whole supply of the artillery munition used by the British armies. In the course of 1917 the amount was reduced on account of the growth of production in Great Britain itself, and the necessity for economising in shipping space ; but, up to the conclusion of hostilities, it remained a substantial proportion of the whole British supply.

Moreover, on the entry of the U.S.A. into the war, the American Ordnance Department turned to Canada for help in the production of munitions. American orders were placed in Canada. The speed and efficiency with which these were executed was due to the organisation already created for the supply of munitions to the British Government.

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British War Cabinet Appreciation.—In the report issued by the British War Cabinet for the year 1917, and presented to the Imperial Parliament, the following appears :

The manufacturing resources of Canada have been mobilised for war production almost as completely as those of the British Isles.

This is a great tribute when it is remembered that Canadian manufacturers knew nothing about war production in August, 1914.

The report goes on to say :

Canada's contribution during the last year has been striking. Fifteen per cent. of total expenditure of the Ministry of Munitions in the last six months of the year was incurred in that country. She has manufactured nearly every type of shell from 18-pdr. to 9.2-in. In the case of the 18-pdr. no less than 55 per cent. of the output of shrapnel shells in the last six months came from Canada, and most of these were complete rounds of ammunition which went direct to France. Canada also contributed 42 per cent. of the total 4.5-in. shells, 27 per cent. of the 6-in. shells, 20 per cent. of the 8-in., and 16 per cent. of the 9.2-in. In addition, Canada has supplied shell forgings, ammunition components, propellants, acetone, T.N.T., aluminium, nickel, nickel matte, aeroplane parts, agricultural machinery, and timber, besides quantities of railway materials, including no less than 450 miles of rail torn up from Canadian railways, which were shipped direct to France.

Material Used.—The principal materials entering into the manufacture of these shells were steel, copper, lead, and zinc, of which the following amounts were used :

Steel	.	.	.	2,058,000 gross tons
Copper	.	.	.	47,000 net "
Lead	.	.	.	139,000 " "
Zinc	.	.	.	25,000 " "

Of these amounts approximately 1,720,500 tons of steel, 7000 tons of copper, 70,000 tons of lead, and 22,000 tons of zinc were produced in Canada.

Prior to the war the steel capacity of Canada was approximately 1,000,000 tons of ingots annually. By the enlargement of existing plants and creation of new ones this capacity was increased, until at the time that the Armistice was signed the production was equivalent to 2,250,000 tons of ingots per annum.

From December, 1914, to November 11, 1918, 66,430,686 shells were delivered.

It is difficult to convey any adequate idea what this number of shells represented. Perhaps to express the number in miles covered would help to visualise them.

If the 12-pdr. shells had been placed together in one line, each touching the other while standing on their bases, they would have stretched from Canada to Britain, a distance of over 2400 miles.

If all the shells made were so placed together, a length of over 4700 miles would be reached.

RATES OF SHELL PRODUCTION

Without making invidious comparison of the rates of shell production by different manufacturers, it may be of interest to give a few facts as to maximum production by makers of the different sizes of shells. The sizes of shells made in Canada ranged from 13-pdr. to 9.2-in. The 13-pdr. shrapnel empty shell was an odd lot of 79,550 ordered in 1916 and shipped in December of that year. Cartridge cases of the same size amounting to 1,004,011 were manufactured and shipped. A cartridge case known as the 2-pdr. was also manufactured and shipped in a lot of 234,520; 801,024 75-mm. cartridge cases were also supplied. Apart from these lots, the principal shells were undertaken and produced as follows:

15-Pdr. Shrapnel Shells.—The total number of manufacturers employed in making 15-pdr. shrapnel shells was comparatively few. After the first order for 100,000 the demands were chiefly for the 18-pdr. shrapnel; only 302,208 15-pdr. were shipped to England. Five machining and assembling makers and 28 makers of

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components dealt with the entire output. The largest number of any one component made by any one company was 300,000 shell forgings. These were made by the Nova Scotia Steel Co., of New Glasgow. The largest number of shells made by any of the five machining and assembling companies was 180,000 by the Electric Steel Metals Co., of Welland.

18-Pdr. Shrapnel Shells.—With regard to the 18-pdr. shrapnel the number of manufacturers who machined and assembled shells grew from 10 to 61, and to a total of 381 makers of components in Canada and 24 in the United States of America, making in all 466 manufacturers engaged in making this nature of shell.

Of the many Canadian manufacturers who distinguished themselves in the excellent production they made, the one which had the largest *daily* production was the Canadian Fairbanks Morse Co., of Toronto, amounting to 8231.

The Rome Manufacturing Co., of Rome, U.S.A., produced as many as 40,000 copper bands per day, and the Canadian Cartridge Co., of Hamilton, Ontario, reached the enormous daily output of 40,000 18-pdr. cartridge cases, and made a total of 14,510,600. The Montreal Ammunition Co. followed closely upon this daily output.

18-Pdr. High Explosive Shells.—The number of manufacturers employed in machining and assembling the 18-pdr. high explosive shell exceeded the number who supplied components. The shells were machined from round bars, not from forgings, making the work of the machiner and assembler greater than of the component manufacturer.

There were 66 manufacturers who assembled and machined and 20 who made components.

The Transcona Shell Co., afterwards called the Universal Tool Co., of Toronto, had the largest daily output, amounting to 3672, and also made the largest number—476,506 shells. The manufacture of this shell was not commenced until February, 1915, and the first deliveries were made in June of the same year.

4.5-In. High Explosive Shells.—There were 359 manufacturers employed in the manufacture of this shell, 105 machining and assembling, and 254 making component parts. Thirteen U.S.A. manufacturers supplied components. The Dominion Copper Products Co. machined and assembled the largest daily output of 2098, and made 783,272, the largest number made by any one company.

The same company also made the largest number of cartridge cases of this size, namely, 8,246,000.

Manufacture of shells commenced in February, 1915, and the total number made was 12,607,091. There were also 11,995,215 cartridge cases made and shipped.

60-Pdr. High Explosive Shells.—It was not until May, 1915, that the manufacture of 60-pdr. shells was commenced. There were 26 manufacturers machining and assembling, 49 making components in Canada, and 5 in the U.S.A. The Cluff Ammunition Co., of Toronto, made the largest daily output of forgings, namely, 3000. The E. Long Manufacturing Co. machined and assembled 665 daily, which exceeded all other outputs. The company made also the largest total output. The total weight of materials used per shell was 56.34 lb., and 1,104,312 were delivered.

6-In. High Explosive Shells.—Considerable delay arose over the placing of contracts for 6-in. shells. It was November, 1915, before the manufacture of the 6-in. shells was commenced, and the first delivery of them took place in March, 1916. Numerous difficulties and delays took place in the first deliveries, owing to changes in the design of the shells after the orders were placed. There were 53 companies machining and assembling, and 172 making components in Canada, and 16 in the U.S.A. Large supplies of forgings were received from the U.S.A. The weight of steel required to fill the contracts exceeded what could be supplied by Canadian manufacturers.

The largest daily output of finished shells was made by the Montreal Locomotive Co., Montreal—between four and five thousand. This company made also the

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largest number of this shell. The Dominion Copper Co., of Montreal, supplied the largest daily output of any components, namely, 20,000 copper bands. This company was the pioneer company in Canada for the manufacture of copper bands, and was very successful.

The total weight of metals used in this shell was 87.68 lb., and 11,078,534 were delivered.



MONTREAL LOCOMOTIVE WORKS LTD., MONTREAL
Main Machine Shop

8-In. *High Explosive Shells*.—The manufacture of 8-in. high explosive shells was commenced in November, 1915. Twelve companies undertook machining and assembling, and 31 made components in Canada, and 16 in the U.S.A.

The Canadian Fairbanks Morse Co., of Toronto, made the largest daily output of these. It employed a very large number of women. Their factory was a model of engineering skill and organisation; 1458 of these shells, each weighing over 200 lb., were produced daily.

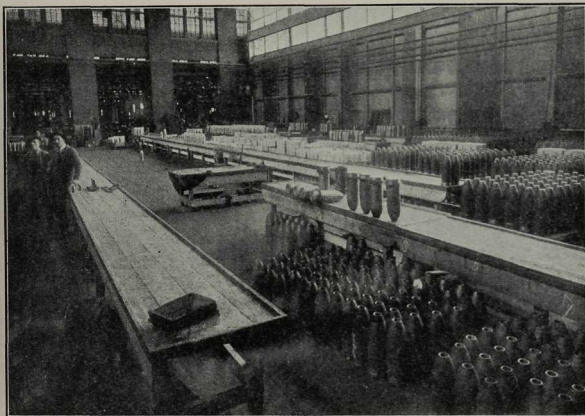
The Canadian Ingersoll Rand Co. produced the

SHELL PRODUCTION

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largest output, namely, 187,451. The Rochester Stamping Co. (U.S.A.) made the largest daily output of any component, namely, 2000 copper bands, and supplied the largest total number, 324,000. By February, 1918, 753,831 shells were completed.

9.2-In. High Explosive Shells.—This was the largest shell made in Canada. There were 11 companies



MONTREAL LOCOMOTIVE WORKS LTD., MONTREAL

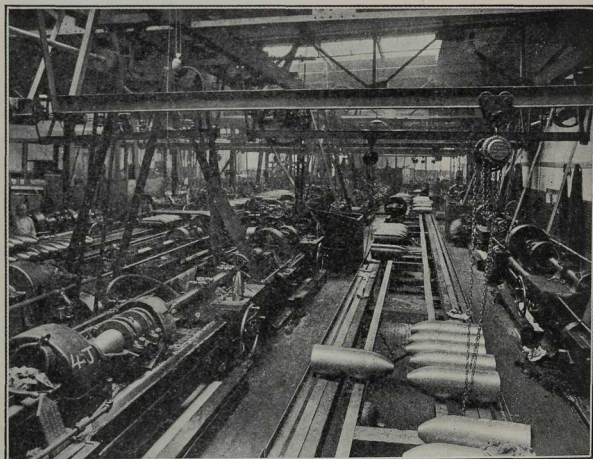
Shell Shop : Inspection Department

machining and assembling, 28 making components in Canada, and 22 in the U.S.A. The Canada Cement Co. produced the largest daily output, 1333, and also the largest total number of any company, namely, 248,998. The factory was specially equipped for this purpose, and mostly women were engaged. The largest daily output of components was made by the Pressed Steel Car Co. (U.S.A.). It produced 1800 shell forgings. The largest number of any component was made by the Steel Co. of Canada, Hamilton; 289,000 shell bases were produced. Manufacture of

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the 9·2-in. shell was commenced in November, 1915, and first deliveries were made in May, 1916. The total weight of the metals per shell was 299·67 lb.

Banquet given by Chairman of Board.—At a banquet given by Sir Joseph Flavelle, Bart., Chairman of the Imperial Munitions Board, on November 25, 1918, to the members and staff of the Board, at the Château



LEASIDE MUNITIONS CO., TORONTO
Turning and Boring 9·2-In. Shells

Laurier, Ottawa, he said, in speaking of the work accomplished by the munitions manufacturers of Canada :

I have been unable to understand why there has been so much feeling, so widely expressed and apparently so commonly held, against the manufacturers of Canada in relation to the manufacture of munitions. They accepted contracts to produce materials greatly needed for the war at prices fixed by the Board and under contract conditions of an exacting character. They have brought honour and great wealth to Canada, and we owe

them much. I feel it is time that in the Houses of Parliament, in the newspapers of the country, and among the rank and file of our people, there should be a recognition that the body of men who have produced this large quantity of munitions, have performed a fine service, and have been a real factor in winning the war.

The above tribute to the manufacturers was given out of a ripe experience of a service well rendered by them. Those who depreciated the manufacturers knew little of the perplexing difficulties, the financial risks, and the magnitude of the service they rendered. Without doubt Canadian manufacturers were done an injustice, through lack of knowledge. We have only to remember the conditions upon which manufacturers undertook contracts to be convinced that they were wrongly judged, and to be assured of the genuine motives which prompted a service which earned for them not only the tribute of the Chairman, but the gratitude of the British and American Governments.

CHAPTER XVII

NATIONAL FACTORIES—FUSES

THE establishment of national factories in Canada for munitions manufacture was an adventure made by the Chairman of the Imperial Munitions Board wholly in the interests of the British Government, and with its approval.

No Reflection on Private Enterprise.—The movement cast no reflection on private enterprise, which was fully employed manufacturing munitions. In fact, at the time in question the factory capacity of the Dominion was overtaxed. Very many manufacturers had extended, and others were making great extensions to their establishments.

The first national factory came into being to produce something hitherto unproduced in Canada. It was not, therefore, competition with private enterprise which inspired the idea, but a determination to keep within Canada an industry which it was believed skill could be found to maintain.

First National Factory.—It was early in 1916 that it was decided to load time fuses in a factory which should be owned and controlled by the Imperial Munitions Board. No time fuses had been made in Canada up to that period. Many fuses were urgently required. It was acknowledged that the No. 80 Mark VII Time Fuse was an intricate piece of mechanism to manufacture. During the Shell Committee's regime the facilities in Canada were not considered sufficient to warrant making them there. One leading manufacturer, after examining the fuse, declined to undertake its manufacture. The decision, therefore, of the Board to

proceed with this particular warlike store was of the first importance.

Basis of National Factory Organisation.—The National Fuse Factory and all the national factories which followed had a commercial form of organisation. They were established as Joint-Stock Limited Companies, with the power to conduct their operations exactly as though they were private corporations. In each case the legal formalities of the formation of companies with letters patent were carried out. The capital of each company was entirely subscribed and held by the Board, which also financed the companies by loans. The Board, as sole shareholder, nominated the directorate of the companies and, through it, the management. Each company kept its own accounts, and was run independently on commercial lines.

Cost of Products.—The output of the company was taken over by the Board at a contract price, which was fixed in no case higher, and in some cases considerably lower, than the price at which outside contracts could have been let at the time the factory was erected. Any economy in the price paid by the Board, and the operating costs of the company was devoted to amortisation. On this method factories which were earliest to be established had, by the Armistice, accumulated a surplus more than sufficient completely to amortise their capital cost. The more recent ones, which had not been operating so long, had naturally made less progress in this direction, and in one or two cases hardly anything had been earned.

Profits from National Factories.—Taking all the companies together, their collective surplus, plus the amount realised from disposal of the properties, was sufficient to amortise the total capital cost, and leave a balance of approximately one million dollars for return to the Treasury.

The Nature of Work Undertaken.—It is not intended to give an extensive description of the work produced at the various national factories, but as each of the

factories was established to undertake work which could not be undertaken readily by private enterprise, each is deserving of special mention.

Number of National Factories.—The first national factory was established at Montreal for the loading of No. 80 Mark VII time fuses. This factory, known as British Munitions Ltd., was a great success. The other national factories were :

The British Chemical Co. Ltd., for the production of acids, gun-cotton, T.N.T., and nitro-cellulose powder.

The British Cordite Co. Ltd., for the production of cordite.

The British Explosives Ltd., for the manufacture of nitro-cellulose.

British Acetones, Toronto, Ltd., for the manufacture of acetone and butyl alcohol.

Canadian Aeroplanes Ltd., for the manufacture of aeroplanes.

British Forgings Ltd., for the manufacture of electric steel from scrap, and the production of shell forgings.

British Munitions Ltd.—To Sir Charles Gordon belongs the honour for the accomplishments of this national factory. The other directors were Mr. E. T. Sise and Mr. J. D. Hathaway, both of the Northern Electric Co., Montreal. Mr. Hathaway, who worked with untiring efforts, undertook the responsibility of managing the factory. He was signally successful in the solution of problems full of great difficulty.

New Factory Built.—The company secured a site at Verdun, Montreal, and in February, 1916, commenced to build. The factory was completed by July, 1916. It was virtually a receiving, assembling, loading and forwarding establishment for 25,000 fuses daily. The metal parts of the fuses were supplied by three Canadian firms, each of which had received an order for the complete metal parts of the No. 80 Mark VII Fuse. The companies were the Russell Motor Car Co. Ltd., Toronto ; the Northern Electric Co., Montreal ; and the Williams Co. Ltd., Toronto.

Operation of Loading Plant.—Although the factory was not finished before July, some fuses were loaded successfully in June, 1916. The Russell Motor Car Co. and the Northern Electric Co. did not commence deliveries of the complete sets of parts until early in the



Photo: Dupras & Colas.

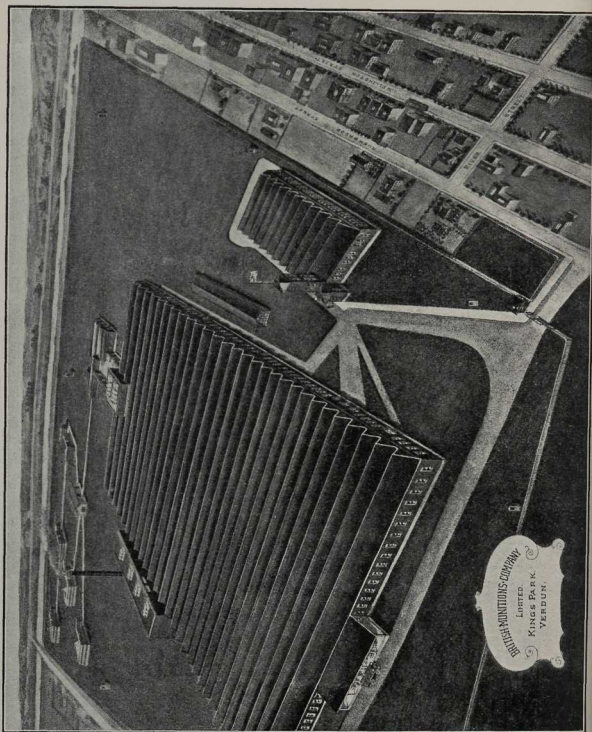
SIR CHARLES BLAIR GORDON, G.B.E.

fall of 1916, and loading operations were commenced at the loading plant immediately thereafter.

Increased Demands.—When Sir Joseph Flavelle was in England, during October, 1916, he promised to supply complete rounds of 18-pdr. shrapnel at the rate of 60,000 per day. At that time the rate of fuse production was

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equal to 25,000. Sir Charles Gordon, with the approval of the Chairman, took immediate steps to increase manufacturing facilities. He asked Mr. Tom Russell,



Vice-President and General Manager of the Russell Motor Car Co. Ltd., to organise manufacturing facilities in Canada for the enlarged programme. With great ability Mr. Russell arranged for the manufacture of

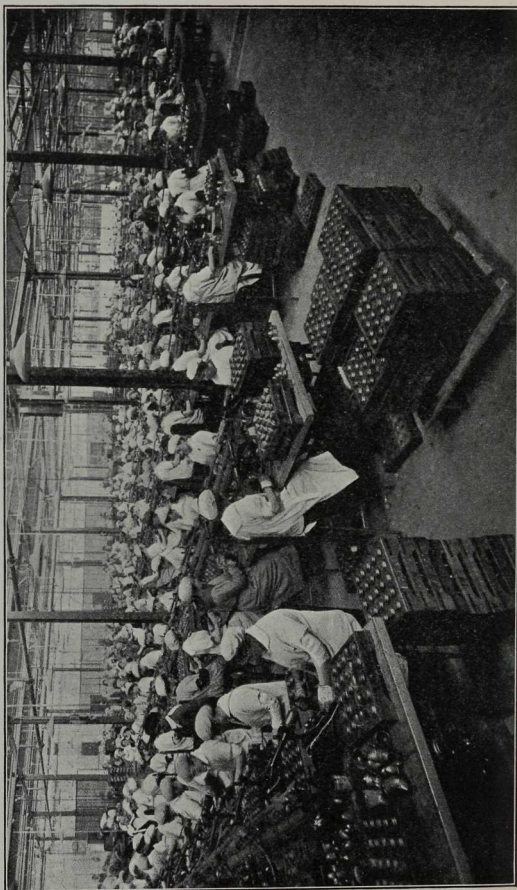
component parts in different factories, and for their inspection at each factory before being shipped to the loading plant. By this arrangement, instead of the three companies each making the total number of parts in a fuse, forty contractors were engaged, some making one part only, others more. By the early spring of 1917 the fuse parts were supplied in well-balanced numbers to meet the increased demands.

Loading Plant Enlarged.—The National Loading Factory was enlarged to produce between 30,000 and 40,000 fuses per day. In addition to this capacity the International Arms and Fuse Co., of Bloomfield, U.S.A., one of the American companies which did admirable service for the Shell Committee and the Imperial Munitions Board, erected a loading plant in Montreal to produce from 25,000 to 30,000 loaded fuses daily. By June, 1917, Canada's time fuse production had been built up to a total of 60,000 to 65,000 fuses per day. This remarkable production is all the more noteworthy, when it is remembered that during the same period a daily output of 40,000 graze fuses had been reached by private enterprise.

Total Output of British Munitions Ltd.—By June, 1917, fuses were being loaded at Verdun at the rate of 30,000 per day, and by June, 1918, a total of 8,167,183 fuses had been made. After that date the plant was turned over to machine 18-pdr. shrapnel shells. The change was made when word came from England that the large production of fuses was no longer required.

HOW IT WAS DONE

The Mechanical Precision.—Adequately to appreciate what the foregoing involved it must be remembered with what mathematical exactness all parts of the fuse had to be machined. The limits of precision were so fine that some parts had to be machined to within one ten-thousandth part of an inch. Engineers and machinists know that such refinement demands the highest quality



SOLDERING FUSE COVERS

of skill. Canada was almost drained of its man-power, and most of the fuse work was done by women who had to be trained for each task. This fact only gives a faint idea of this achievement. For the factory superintendents, whose painstaking instruction led to such scientific accuracy, much praise is due.

Loading Accuracy.—But even these difficulties were small compared with the great care required in loading the fuses. It was the responsibility of this task which the Chairman of the Board removed from the shoulders of the private manufacturer. It was an unknown venture to Canada, but one that Sir Charles Gordon and Mr. Hathaway made possible of success in the hands of women. The plant equipment was perfected so as to have an almost clock-work precision. The discipline of the workers to each task was possible only by painstaking skill. These endeavours gradually broke down one difficulty after another, until the large output was obtained without any serious accidents or delays.

Accuracy of Explosion.—Both the top and bottom rings were accurately grooved to contain the exact amount and quality of powder which would burn invariably to the time fixed by the graduations of the fuse. It requires little imagination to see the importance of accuracy in this work, for on the fuse depends the explosion of the shell at the right moment and place. This action depends upon the relative accuracy of the trains of powder burning to the fraction of a second between the instant of detonation and the flash from the bottom ring to the shell.

A Noteworthy Achievement.—In looking back on what was accomplished by all concerned in this venture, one is surprised at the skill and ingenuity developed, the scientific accuracy secured, and the dogged determination maintained which defied defeat in work not only intricate but dangerous. It was, indeed, a triumph over problems which perpetually challenged human wisdom and endurance.

CHAPTER XVIII

NATIONAL FACTORIES—EXPLOSIVES

THE Imperial Munitions Board had four national factories making explosives. Each factory was controlled by a separate company responsible to the Board. Mr. Howard Murray, Chairman of the Board's Committee on Explosives, did able and difficult work in connection with the national factories for explosives. He was supported by Mr. N. W. Pirrie, Director of Explosives, and Mr. Wardleworth. Mr. Murray was virtually responsible for the Explosives Department of the Board, and for the output of the explosives.

The Explosives Department.—Before national factories were contemplated, the Explosives Department had been engaged dealing with contracts made by the Board with independent companies manufacturing cordite, smokeless powder, and T.N.T.

It was not until the Minister of Munitions called for very much larger supplies than hitherto from Canada of explosives and propellants that national factories for explosives were considered.

The problem was how to obtain the necessary technical help for such factories. All technical knowledge of the kind required was already absorbed by private enterprises.

The Chairman's Judgment.—It was just at such times that the Chairman was found at his best. His invariable method was to decide upon the type of man he wanted and then find him.

How he was able to induce the best man in the line of

NATIONAL FACTORIES—EXPLOSIVES 151

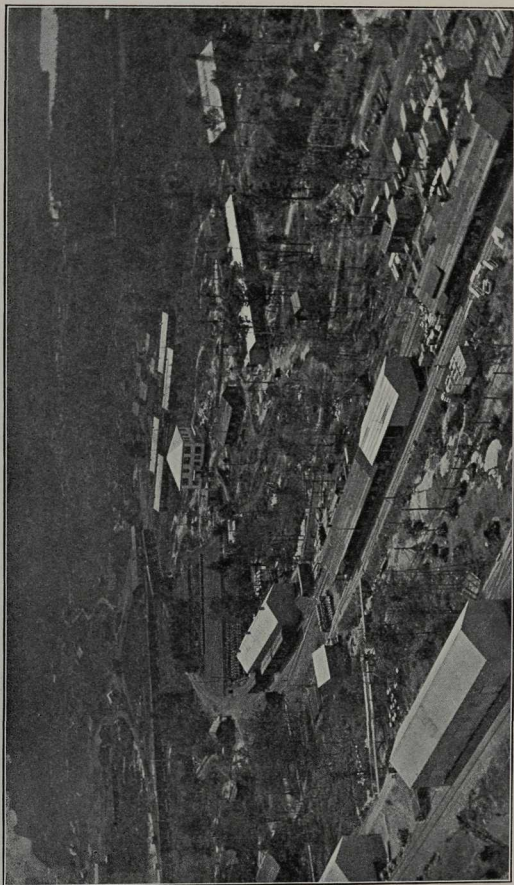
service he wanted to throw in his lot with the Board has always been a mystery, but he did it. It was so when he secured Mr. Howard Murray, the Vice-President of the Shawinigan Water and Power Co., to become Chairman of the Explosives Committee without remuneration.

Private Explosives Enterprises.—To give some measure of the demand for explosives, and the reason for building national factories, one must look at the position of private explosive enterprises at the time, and also at the requirements of the British Army. Before the war the production of military explosives in Canada was limited to about 3000 lb. of rifle cordite per month. This amount was produced by the Canadian Explosives Co. for use at the Quebec Arsenal. A much larger quantity of commercial explosives, approximately twenty-five million pounds per year, had been made.

Before November, 1915, the Beloeil plant of the Canadian Explosives Ltd. had been enlarged and was producing about 350,000 lb. of cordite per month—over a hundred times more than the pre-war output. The same company had also installed plant at Beloeil for the production of 450,000 lb. of T.N.T. per month, and had also installed a similar plant at Shand, James Island, B.C. By February, 1918, the Beloeil plant was extended to have a capacity of 1,400,000 lb. of T.N.T. per month. A third plant was built at Nobel, Ontario, for a production of 1,500,000 lb. of cordite per month. This was started in February, 1918, during a severe winter, and was finished on August 24, 1918.

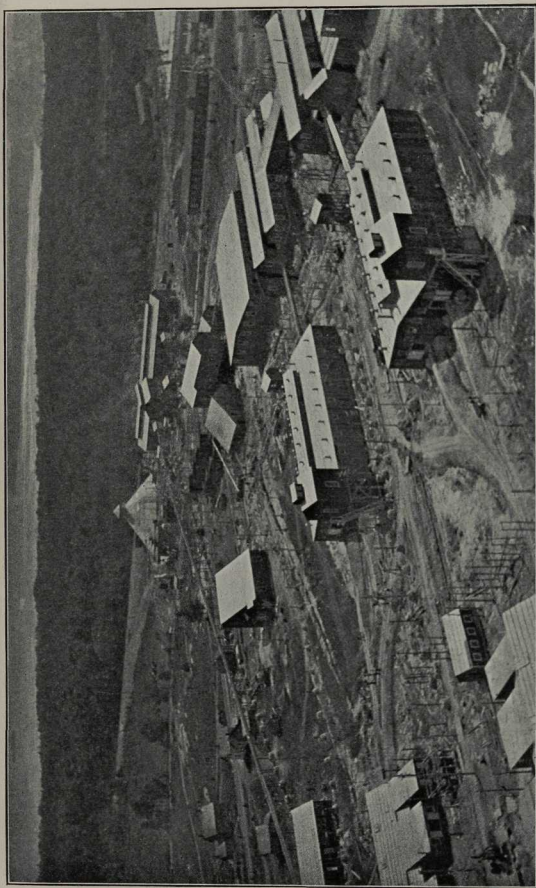
Two enterprising private companies, the Aetna Chemical Co., Drummondville, and the O'Brien's Munitions Ltd., Renfrew, undertook for the first time in Canada the manufacture of nitro-cellulose powder, the propellant chiefly used in the U.S.A. These companies developed a capacity of about 1,800,000 lb. per month, and were the first in the British Empire to produce, on a large scale, this propellant.

Enormous Growth of Privately Owned Companies.—As an instance of the enormous growth of privately owned



BRITISH CORDITE LTD., NOBEL, ONTARIO
Raw Material Stores and Office

342 122222



BRITISH CORDITE LTD., NOBEL, ONTARIO
Gun-cotton Area in foreground. Nitric Acid Plant beyond

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explosives companies in the short space of two years, it is notable that the Canadian Explosives Co., which received in February, 1915, an order for 300,000 lb. of cordite—the largest order ever placed in the country—received in November, 1916, alone, requisitions for ten million pounds of cordite and five million pounds of T.N.T. It was because of this abnormal demand, which grew out of all proportion to the producing capacity of private enterprise, that the Imperial Munitions Board established national factories for explosives.

British Acetones Toronto, Ltd.—The British Acetones Toronto, Ltd. was formed to manufacture acetone. Through the kindness of Colonel Gooderham and Messrs. Gooderham and Worts, of Toronto, a large distillery was made available to the Imperial Munitions Board for the manufacture of acetone. This distillery became the second national plant owned by the Board and operated by the British Acetones Toronto, Ltd.

What Led to its Foundation.—Acetone, a colourless liquid, is one of the best solvents for gun-cotton used in making cordite. It was commonly made from the distillation of hard wood during its carbonisation.

The supply by this process became utterly inadequate. To meet the increasing demands in the manufacture of cordite and nitro-cellulose propellants, something more had to be done.

A Great Discovery—Acetone from Acetylene.—Mr. Howard Murray set on foot experiments to discover some other means for the supply of acetone. To the credit of Mr. H. W. Matheson, formerly with the Research Department of the Dupont Co., U.S.A., experiments conducted at Shawinigan, towards the end of 1915, resulted in the production of acetone from acetic acid, which was synthetically produced from acetylene.

As a result, the Canadian Electro Products Ltd. was formed, early in 1916, to produce acetone commercially.

The Imperial Munitions Board at the same time concluded a contract with the company for its entire output of 300 gross tons per month. A factory was established

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costing \$2,000,000, and by December, 1916, the first acetone was produced. This company continued the supply of acetone until the beginning of 1918, when the demands for aeroplane dope, made from acetic acid, became insistent, and the whole capacity of the plant, amounting to 700 to 800 tons per month, was turned to the production of acetic acid.

Another Great Discovery—Acetone from Cereals.—

While Mr. Matheson was working at his process for producing acetone from acetylene, Dr. Weisman, an able chemist of the British War Office, made the discovery that acetone and butyl alcohol could be produced from cereals. It was by reason of this discovery that the British Acetones Toronto, Ltd. was formed and ultimately became the principal, if not the entire, source of acetone supply within the British Empire. In developing the process the splendid work of Messrs. Speakman and Legg deserves honourable mention. The plant equipment cost about one million dollars, and commenced the production of acetone from grain (maize starch) in the autumn of 1916.

The directors of the above company, Mr. Howard Murray, Mr. Noble Pirrie, and Mr. Wardleworth, with the assistance of others, established the fact that butyl alcohol converted to methyl ethyl ketone could be used as a solvent for gun-cotton. A process for this conversion was developed, and the result was far-reaching.

Thus, by the inventive ability of Dr. Weisman, the Board's chemists, and the capable staff at the distillery in Toronto, the way opened to liberate entirely the Canadian Electric Products Ltd. for the supply of acetic acid. The British Acetones Toronto, Ltd. produced 5,600,000 lb. of acetone and 11,000,000 lb. of butyl alcohol during the period of its operations. The factory actually developed a capacity of 15,000,000 lb. per year of the combined products.

The British Chemical Co., Trenton, Ontario.—The largest national plant for explosives owned by the Imperial Munitions Board was established at Trenton,

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Ontario, and was operated under the name of the British Chemical Co. It was an undertaking involving a cost of \$5,000,000. There were 204 buildings covering 250 acres. The equipment included 7 miles of rails, 33,300 feet of water lines, 20,000 feet of steam lines, 16,000 feet of acid lines, 10,000 feet of compressed air lines, and 70,000 feet of electric wiring. There were employed 2500 men and women in three eight-hour shifts. The boiler installation, used entirely for process purposes, was nearly 5000 horse-power, and, in addition, 6000 horse-power, for power purposes, was obtained from the Hydro-Electric Co., Toronto. The output per month from this great plant was as follows :

8,000,000 lb. of (66° Be)	sulphuric acid.
5,000,000 " " "	nitric acid.
2,200,000 " " "	pyro-cotton.
1,500,000 " " "	nitro-cellulose powder.
1,200,000 " " "	T.N.T.

The value of the monthly output was about \$2,000,000.

Problems Involved.—Even the recital of the foregoing facts, great as they are, convey little idea of the problems involved in bringing the plant to a successful issue.

The Site and Layout.—The site chosen for the plant was fronted by the River Trent and flanked by railway lines, upon each side of which rose fairly high hills, the whole covering approximately 255 acres. In the valley between, facing the river, two gun-cotton lines were located, consisting of a double line of large buildings, each ten in number. To the north, reaching to the rise of one hill, two large chamber acid and nitric plants were placed. Immediately adjacent, and further to the north, was the concentrating plant, with the necessary tankage for mixing. To the south, and reaching behind the second hill, the T.N.T. plant was placed, the idea being that this hill would serve as a buffer in the event of an explosion, and would afford considerable protection to other parts of the development. Away off to the north-east, the powder plant, consisting of forty buildings, was located.

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On the river bank there were situated the buildings and equipment providing the services of water, steam, compressed air, and electric current.

All trenching for pipes for these various services, spread over a large area, was done in rock, and was not by any means a small item of expense.

When Undertaken and Accomplished.—It was in November, 1916, that orders were given for the erection of the plant. The winter was one of the most severe that Canada had experienced. Transportation was in knots. Workmen suffered much with frozen feet and hands. Satisfactory housing and feeding accommodation could not be made for the workmen until the following spring. Only the exigencies of the war would have made this proposal anything but a foolish and expensive adventure. But, withal, they carried the project through to success with much patience and endurance. About the middle of 1917 explosives were produced.

Operation of Plant.—In all the operations extreme care was essential. There was hardly an operation which was not attended by distinct hazards; mistakes might only be made once in most of them. Even an acid spill is a thing men do not care to repeat.

To the scientist a full description of the processes would be full of interest, but no more than the barest details can be given. Suffice it, that all the raw materials, Chilian nitrates, sulphur, cotton, alcohol, oleum, and toluol, had to be imported. These in turn had to be converted into nitric acid, sulphuric acid, pyro-cotton, ether solvent, and T.N.T. The labour in handling the materials was reduced to a minimum. Every modern device to eliminate risk of danger was applied, and the latest processes for the production of T.N.T. and nitro-cellulose powder were used.

Extreme Loyalty.—One of the noticeable features in connection with the operations at Trenton was the extreme loyalty on the part of the men, who set aside, as a secondary consideration, their own protection and safety. In fact, many occasions arose where men committed

acts of bravery which, if done at the Front, under the notice of officers, would have called for the highest commendations in despatches.

Those who knew Mr. Barclay, the manager of the factory, would expect nothing else from his men.

In October, 1918, when an explosion occurred in the T.N.T. plant, causing the destruction of that plant and two gun-cotton lines, Mr. Barclay's heroic action in saving the lives of many of the workers will be long remembered. His courage and self-sacrifice were an outstanding example to his work-people.

The British Cordite Ltd.—The British Cordite Plant at Nobel, Ontario, was built for the production of cordite only. Its organisation and personnel were on the lines of the other national explosives plant.

The plant cost \$3,000,000 and covered 366 acres, with 155 buildings. The plant consisted of :

(1) Acid recoveries	covering	31 acres
(2) Gun-cotton	„	54 „
(3) Nitro-glycerine	„	25 „
(4) Cordite and solvent	„	236 „
(5) Power and safety	„	20 „

There were 6 miles of tramways. The output of the plant reached to 1,767,000 lb. per month, which was valued at \$1,060,000.

Date of Production.—The erection of the Nobel Cordite Factory was commenced about the end of 1916, and cordite was produced about the middle of 1917. The Explosives Department of the Board made itself responsible for the construction of the plant and its operation. Many of the difficulties encountered in building the Trenton explosives plant were repeated at Nobel. The work just had to be done, and no difficulties were allowed to stand in the way of progress.

Operation — Cordite Manufacture.—At Nobel one product only was made. Cordite was by no means a new explosive, but with the demand for skill and trained chemists, the problems were of no mean dimensions.

It is doubtful if even the average chemist appreciates the complexity of an explosive plant producing a single product like cordite. Cordite consists of a colloidal mixture of gun-cotton, nitro-glycerine, and vaseline. The raw products are: cotton, glycerine and vaseline solvents, sodium nitrate and sulphuric acid. The cordite plant is really composed of six main plants, an acid line, a nitro-glycerine line, a gun-cotton line, cordite line, solvent recoveries, ether stills, and a powder plant. Any one of these lines is a large chemical manufacturing plant in itself.

The Nobel plant differed from the Trenton plant in not making its own acids, but it had its acid recovery system, where the waste acid was treated and recovered and concentrated. The gun-cotton line had its own raw materials: cotton, sulphuric and nitric acids. The gun-cotton was nitrated and then purified and delivered to the cordite line containing 30 to 35 per cent. of water. The purification was a long and thorough process, taking about fifty hours of boiling, heating, and washing. The nitro-glycerine plant used as raw products glycerine, nitric and sulphuric acids, and, as in the case of the gun-cotton line, it was a process of nitrogenation and purification requiring great care and close control.

At the cordite lines the constituents, vaseline, nitro-glycerine, and gun-cotton, were brought together with the necessary solvents, mixed, pressed, stored, blended and packed. The solvent stills had alcohol and acetone as 'raw products,' and separated the mixtures of acetone and alcohol as they were returned from the process. Then there was the power plant.

This is a bird's-eye view of the British Cordite Co. Ltd.'s Factory, and of the product it made. The factory cost \$3,500,000, and by November 30, 1918, it produced 21,450,000 lb. of cordite—a very creditable performance.

British Explosives Ltd.—The national company known as British Explosives Ltd. was formed to operate the O'Brien's Munitions Ltd., of Renfrew, a privately

owned explosives company which started munitions manufacture at Renfrew towards the end of 1915. It was one of the two companies referred to which commenced the manufacture of nitro-cellulose powder in Canada for the first time.

Nitro-cellulose powder was not regarded with favour by the British authorities. Prior to the war it was not considered sufficiently stable when kept in store for some time. The fact that an explosion took place in the magazine of one of the ships of the U.S.A. Navy was long remembered against nitro-cellulose powder, even after the stabiliser known as diphenylamine, and used in its manufacture, was proved to be effective in 1908.

During the war prejudices had to be sunk. Nitro-cellulose powder as a corresponding propellant to cordite was of the greatest value. Germany had used it for twenty-two years. Italy, Spain, France, Sweden, Russia, and the U.S.A. had also adopted it. Its supporters could produce evidence to show that it could be kept from twenty to twenty-five years without fear of spontaneous combustion.

The Origin of the Company.—In October, 1915, the organisation responsible for building and operating the Union Powder Corporation's plant at Parlin, N.J., U.S.A., was transferred to Renfrew, Ontario, and built a plant in four months to give a daily capacity of 35,000 lb. of nitro-cellulose powder, which subsequently reached a capacity of 46,000 lb. per day. The work was carried out by Mr. W. C. Cram, jun., an experienced expert in the construction and operation of explosives plants.

When the plant was built, Mr. Cram undertook its general management. About 1 mile from the nitro-cellulose plant there was a loading and assembling factory owned by the same company, and known as the Energite Works, and managed by Captain Eaton, an officer formerly in the Ordnance Department at the Frankford Arsenal, U.S.A.

Gun-Cotton Supply.—Before the beginning of 1917, when the O'Brien's Munitions Ltd. was leased by the

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Imperial Munitions Board and became the national plant known as British Explosives Ltd., the gun-cotton it used was supplied from the Nixon Nitration Works, N.J., U.S.A., in boxes, each containing about 100 lb. When the British Chemical Co. at Trenton commenced to operate, it supplied the gun-cotton, making sufficient for its own use and the British Explosives Co.'s requirements. During the period that this factory was in operation as one of the national factories it produced 16,000,000 lb. of nitro-cellulose powder.

Total Explosives Produced.—Up to the end of 1916, before the national factories were established, the total explosives produced were: acetone, 98,340 lb.; cordite, 6,616,657 lb.; sabulite, 346,826 lb.; T.N.T., 20,099,900 lb.

On December 31, 1918, the totals were as follows:

Acetone . . .	8,544,820 lb.
Acetate of lime . . .	2,270,257 „
Cordite . . .	28,542,157 „
Formaldehyde . . .	95,200 „
Glacial acetic acid . . .	10,844,100 „
Methyl ethyl ketone . . .	40,800 „
Methyl alcohol . . .	321,145 gallons
Nitro-cellulose . . .	19,535,621 lb.
Sabulite . . .	346,826 „
T.N.T. . . .	41,754,950 „

The story of sacrifice and courage these figures represent will never be written. Suffice it, that those who lost their lives while making these great masses of deadly explosives did so as willingly as the bravest soldiers who died for King and Country at the Front.

The Work of Inspection.—This chapter would be incomplete without some reference to the perilous and exacting work of the inspection of explosives carried on so patiently by the officers of the Inspection Department. Nothing approaching the term 'good enough' was tolerated for a moment. The quality and efficiency of the product had to conform to most rigid tests. There

were two distinct tests for propellants—the one ballistic, and the other chemical.

Ballistics.—The ballistic test demanded that the propellant, when used, should fire the shell accurately and uniformly, which meant that a charge picked at random from a lot of 40,000 to 100,000 lb. should give exactly similar results to those produced from any other similar charge picked at random. Such results were obtained by carefully blending and producing a material which had a uniform velocity of burning. To prove these characteristics several shots were fired from samples of the powder, and the results compared by firing the same number of shots under the same conditions, but with a standard propellant. The firing tests were carried out at the Proof Butts at Quebec and Petawawa.

Excellence of Canadian Explosives.—The excellence of propellants made in Canada was repeatedly proved by sending samples of the same lot to both proof branches, where it was found that the velocities registered agreed to within two or three feet per second on a velocity of 1660 feet per second. The results also compared most favourably with the check results obtained at Woolwich Arsenal.

Chemical Tests.—The value of the work of the Inspection Department, with its chemical laboratories and staff of chemists, and inspection at the various plants was very great. Raw products, such as cotton, were visually and chemically inspected. Stability tests were taken on the gun-cotton and pyro-cotton. In the case of nitro-cellulose powder plants an 'Abel' heat test was made on every batch of pyro-cotton. Occasionally tests were run on solvents and other materials, and a general eye was kept on the processes. Scrupulous cleanliness was observed. When any foreign matter appeared in the finished material it was, whenever possible, traced back to its origin. The finished lots were subjected to analyses and stability tests. The physical measurements of the finished sticks and grains were also taken.

T.N.T. Inspection.—The inspection of T.N.T. was

largely confined to an inspection of the finished product. The settling points of the lots were checked, and acidity and alkalinity tests were carried out, and also special tests for organic impurities which were liable to render the material unstable. No ballistic proof was carried out. The material is, of course, of definite chemical compound.

All Contributed.—Thus was produced a fine record of scientific and commercial attainment, by the faithful efforts of the directors, superintendents, managers, inspectors, and, not least of all, the men and women.

To the men and women workers who cheerfully assembled products which held the fatal energy of nature, the Empire owes a special debt of gratitude. Their tasks, though dangerous and monotonous, were done with courage, inspired with the knowledge that they were working to triumph over the enemy against whom their own relatives were fighting.

CHAPTER XIX

NATIONAL FACTORIES—STEEL AND SHELL FORGINGS

THE National Steel Factory built by the Imperial Munitions Board at Ashbridges Bay, Toronto, was the largest electric furnace installation in the world. It came into existence out of sheer necessity.

Canada's Steel Position in 1916.—Towards the end of 1916 the rate of ingot steel output in Canada reached the magnificent figure of 1,500,000 tons per year. This amount was about double the output of 1914. Steel manufacturers showed much ability and enthusiasm for war work. They had made great extensions to their works, but not sufficient to keep pace with the demands for steel by the British Government. As a result, large supplies had to be obtained from the United States of America.

That, however, was not the serious problem which confronted the Imperial Munitions Board when it decided to build a national factory for steel production.

Steel Turnings a Drug on Market.—About 45 per cent. of the steel used in shells was removed from the shell forgings during machining operations in the form of light turnings. These could not be remelted in the ordinary steel furnaces in Canada. As approximately 80,000 tons of shell steel were being used per month, every week thousands of tons of valuable steel scrap kept rising in piles outside machine shops throughout the Dominion. During one year the Scrap Bureau organised by the Board collected over 350,000 tons of steel turnings.

These turnings became a serious drug on the market.

They were deteriorating quickly by exposure to the weather. They appeared to be of little value to anyone, as the prices offered for them were extremely low.

Attempts Made to Use Them.—The irony of the whole situation was that while there was an abundance of light turnings there was a great scarcity of heavy scrap steel. The result was that high prices were charged for heavy scrap. This raised the cost of steel. As the shell turnings belonged to the Imperial Munitions Board, it was the duty of the Board to find the most economical method of their disposal.

Canadian manufacturers were urged to utilise them as much as possible. Experiments were made which resulted in from 10 to 20 per cent. of shell turnings being used in place of heavy scrap in every charge of steel made, but that did not relieve the glut to any appreciable extent. Shell turnings were being disposed of to the U.S.A. at little more than the cost of handling the scrap.

British Forgings Ltd.—The foregoing was the position of affairs at the end of 1916, when the Chairman of the Board considered plans for converting shell turnings into steel ingots for shells. Experiments had been made by a few enterprising firms, who installed electric steel furnaces, and had proved that large charges of light scrap steel could be profitably melted in them. Confident of success, the Chairman approached Mr. James Wood, who had brought the factory production of 18-pdr. shrapnel shells from 100,000 to nearly 400,000 per week at a time when the situation was most perplexing, and asked him if he would become chairman of a company to erect and operate a national factory for steel manufacture.

He could not have found a better man to become chairman of such an enterprise. The other directors were Mr. Fred Miller, Vice-Chairman ; and Colonel Eben. Carnegie, President of the Electric Steel and Engineering Co., Welland, Ontario.

† Mr. Wood managed the company from Ottawa,

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making periodic visits to Toronto, and Mr. Fred Miller was Managing Director, giving his whole time without remuneration. Colonel Eben. Carnegie helped during the construction and operation of the plant, but did not give his whole time to the work.

A Double Task.—When the national factory was contemplated for melting scrap steel, it was decided to include in the plans a shell-forging plant. The total



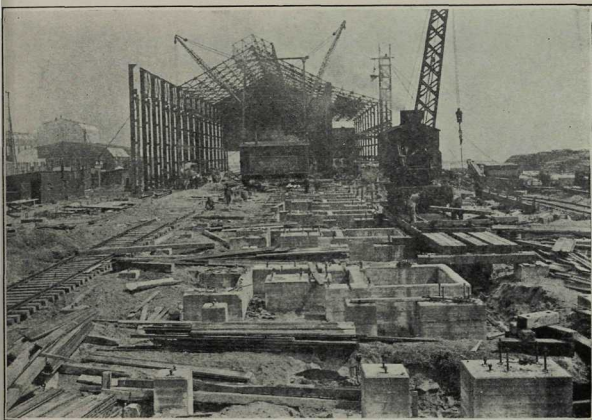
BRITISH FORGINGS LTD., TORONTO
January 31, 1917. Breaking Ground for First Pier

capacity of forging plants in Canada was not equal to the requirements of the Imperial Munitions Board. Plans were, therefore, prepared for the dual purpose of establishing a steel-making and shell-forging plant. It was decided to install, in addition to ten 6-ton electric furnaces, all the necessary steel plant equipment for casting steel ingots and forging them into 6-in. and 9·2-in. high explosive shells. A daily maximum output of 300 tons of steel was planned. It was intended to operate eight furnaces continuously, while two would be

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under repair. As a matter of fact, that output was greatly exceeded, reaching to 400 tons.

There was some opposition by steel makers to the erection of a national factory in Canada. Steel manufacturers considered that they could take care of the requirements. Nevertheless, proposals were not submitted by them to the Board to solve the steel turnings problem. Other manufacturers feared a shortage of



BRITISH FORGINGS LTD., TORONTO
April 20, 1917. Furnace Foundations

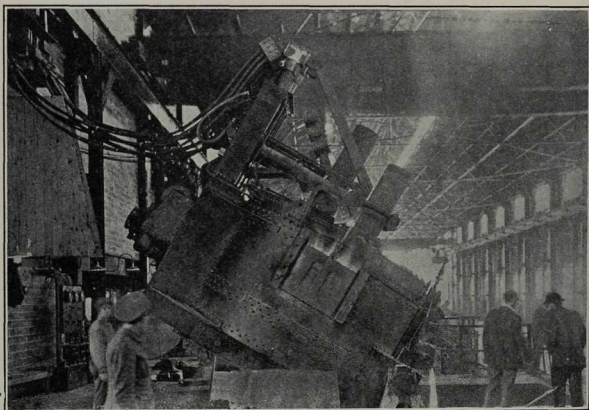
electric power in Ontario, and an enterprising firm suggested the erection of a national steel plant at Shawinigan or Montreal.

Electric Power Supply.—Sir Adam Beck, Chairman of the Hydro-Electric Commission, Toronto, satisfied the Board that electric power could be supplied at a cheaper rate than from Quebec. The actual price of electric power contracted for by manufacturers in Ontario in 1917 with the Hydro-Electric Commission was \$17.50 per horse-power year.

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To encourage the installation of the plant in Toronto, Sir Adam allowed a rebate of \$4 per horse-power year, so that the price fixed for electric power at the National Steel Factory at Ashbridges Bay was \$13.50.

The power was supplied at 13,000 volts, 3 phase, 25 cycles, and was reduced to 100 volts by transformers at the steel works. The Hydro-Electric Commission undertook the electric installation of the plant equip-



BRITISH FORGINGS LTD., TORONTO
June 18, 1917. Tipping the First Heat

ment at Ashbridges Bay, and carried it out well. Both Sir Adam Beck and Mr. Gaby, the Chief Engineer to the Commission, did everything in their power to make a success of the national plant.

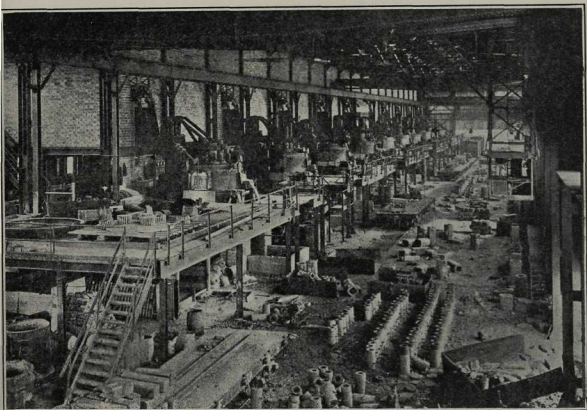
Site of Plant.—Early in January, 1917, the site, covering an area of 127 acres, was obtained from the Toronto Harbour Commissioners. It was on the side of the Lake Ontario, where harbours and a pier wall, nearly 1 mile long, had been already constructed.

The site itself was reclaimed ground built up of sand

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from the bed of the lake. The foundations had, therefore, to be piled very heavily to carry the furnaces, buildings, and other equipment.

Messrs. Perrin & Marshall.—Under the direction of the Ordnance Adviser, plans and work for the plant were commenced by Messrs. Perrin & Marshall, Consulting Engineers, New York. They undertook not only the task of designing buildings and equipment, but also



BRITISH FORGINGS LTD., TORONTO

October 21, 1917. Ten Furnaces in Place—View from East End

of obtaining, through various engineering establishments in Canada and the United States of America, all the parts of the furnaces in record time. It is indeed remarkable that the entire equipment was supplied in a few months at a period of war when every available supply of mechanical and electrical equipment was taxed to its utmost limit. Dr. Lindsay, one of the staff of the Imperial Munitions Board, rendered much assistance at the initial stages, in securing electrical apparatus for the furnaces. Mr. Humbach, the Resident Engineer of

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Messrs. Perrin & Marshall, did good service during the construction of the plant.

Construction.—The surveys, railway tracks, and melting house foundations were carried out by the Toronto Harbour Commissioners under the capable direction of Mr. E. J. Cousins, their Chief Engineer. Mr. Cousins devoted himself to this work with great earnestness.

He co-operated with Mr. Fred. Miller, who on behalf of his firm, Messrs. Roger Miller & Sons Ltd., of Toronto, undertook and carried to success the construction of the plant.

On January 31, 1917, the first ground was broken for foundations while the snow was on the ground, and on June 18, 1917, the first charge of steel was poured. Four and a half months! The melting house was 608 ft. long by 80 ft. wide, with additional bays; 50,000 lineal feet of sturdy wood piles were driven in making the foundations; 1400 tons of steel were used in the building and steel furnaces.

Electrical equipment had to be installed, and power carried to the site.

The Operation of the Plant.—To Mr. Fred. Miller, who, with several of the staff of the Imperial Munitions Board, has joined the great majority, belongs the credit for the successful operation of the plant. He made it a great success in establishing records of output and economy. He was never happier than when breaking records. In his sport, as in all work he undertook, he showed the same intensity. He made the undertaking a financial success.

Mr. Miller's Enthusiasm.—Here is a copy of a wire which shows with what enthusiasm he did his work.

A 543 N Y 107-4 EX.

TORONTO, ONT., N.F. 28,
June 28, 1918.

Col. Carnegie or Mr. Jas. Wood,
Biltmore Hotel, New York, N.Y.

June twenty fifth Ten furnaces in operation. (Stop.) Three hundred seventy one point six nine tons poured. (Stop.) Number

of Six inch ingots Three thousand three hundred and forty five and three point seven four tons of steel castings poured. (Stop.) Forty seven heats. (Stop.) June twenty six Ten furnaces. (Stop.) Three hundred sixty four point nine six tons poured. (Stop.) Three thousand three hundred and one six inch ingots cast and one point eight five tons of steel castings made. (Stop.) Forty six heats. (Stop.) We are now out after four hundred tons. (Stop.) Best wishes for a pleasant and safe journey.

FRED. R. MILLER.

6.35 P.M.

Mr. Miller had not made an ounce of steel before. He was a building contractor. He gathered an organisation together with the assistance of the other directors, and in less than sixteen months' operation paid off nearly the entire capital of \$2,500,000 expended on the plant. He will be remembered as one of the Canadian manufacturers who did great things. His was a short life, but one like many of the fine race of Canadians whose spirit during the war forbids one to think that, in any great crisis in which the mother country may be involved, her sons across the sea would fail her in her hour of need.

What Were the Results?—The plant was erected to produce 300 tons of steel per day, and its output was a maximum of 400 tons, utilising about 9000 tons of shell turnings monthly.

It was not uncommon to produce 371 tons in twenty-four hours, as given in Mr. Miller's wire. This amount produced 3345 6-in. shell ingots and a few tons of miscellaneous castings. Neglecting the latter, the rate of ingots produced throughout the twenty-four hours was 2.3 every minute. The casting rate included the preparation of moulds; their filling with steel; stripping ingots when cast; their removal, and the re-assembly of moulds. It is difficult to find anything in the steel-casting business to equal it in speed.

Both 6-in. and 9.2-in. shell ingots were cast, and shells were forged from them in the adjoining buildings. Over 3,000,000 were forged up to the date of the Armistice in a little over sixteen months.

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How Were the Results Obtained?—The construction of the steel-melting and other departments of the work was modelled on the most modern lines.

Parallel with and adjoining the melting bay was the steel scrap bay. In it were heaped thousands of tons of steel turnings, which were lifted by electric magnets and deposited in light railway trucks, which were pushed alongside the furnace after passing over a weighing-machine.

Ninety-eight per cent. of the furnace charge was steel turnings; the rest was made of suitable additions, to obtain the analyses required. Tests were taken from every charge. It was not simply a melting proposition, but the product was reduced to the refined state by exact methods which eliminated loss of time in melting.

Heats of Steel per Furnace.—As a rule, to obtain four heats of steel in twenty-four hours from an electric furnace is considered good practice; the average at British Forgings Ltd. was from five to six. Here is a copy of a production sheet for June 4, 1918:

DAILY PRODUCTION—STEEL PLANT.

June 4, 1918.

Furnace.	Heat Nos.	No. of Heats.	Production.
A	842-847 inclusive	6	411 6-in. shells
C	867-872 „	5	338 6-in. „
D	869-874 „	6	403 6-in. „
E	637-641 „	5	331 6-in. „
K	676-680 „	5	352 6-in. „
L	600-604 „	5	335 6-in. „
M	468-472 „	5	333 6-in. „
N	482-486 „	5	326 6-in. „
O	152-156 „	5	347 6-in. „
		<hr/>	<hr/>
		Total 47	3176 6-in. shells

It shows that out of ten furnaces nine were in commission. Two of them yielded six heats each, and the remaining seven gave five heats each—in all 349 tons of steel and 3176 6-in. shell ingots.

Shell Forging Department.—When the ingots were cast they were conveyed to the cutting off and breaking department, after each was marked with an identification number, which was carried through on the finished shell. After inspection they were conveyed to the heating furnaces, then to the forging presses, and subsequently to the heat treatment department. The conveying devices employed were almost human in their movement. Nothing was left for the worker to do which mechanical skill could eliminate.

In addition to the employment of first-class equipment and handling appliances, provision was made for the welfare of the workers. There were dining-rooms, a hospital, and every facility for the general comfort of the employee. All these services were fully appreciated by the workers, who reciprocated by showing a devotion to work which was not surpassed in Canada.

Atlantic Avenue.—Prior to the establishment of the national plant at Ashbridges Bay, a small shell forging works was established by the Board at Atlantic Avenue, Toronto, under the direction of Mr. Fred. Miller. This plant, though much smaller than the one at Ashbridges Bay, was maintained until the Armistice as part of the British Forgings Ltd.

Principal Officers.—In addition to the directors, the principal officers were : Mr. R. S. Smith, Secretary-Treasurer; Mr. Frederick Nelson, Assistant to the Vice-President; Mr. J. A. Durfee, General Superintendent, Ashbridges Bay Plant; and Mr. A. E. Gibson, General Superintendent, Atlantic Avenue Plant. To these and the other superintendents and managers, together with all who contributed to make the British Forgings Ltd. a success, there must be the satisfaction that they took part in a great work.

Total Output.—48,000 tons of steel were made at Ashbridges Bay, and over 3,000,000 6-in. and 9·2-in. shell forgings, and the greater part of the capital expended on the enterprise had been paid from the profits earned.

CHAPTER XX

THE STORY OF CANADIAN AVIATION

THE story of Canadian aviation has its origin in efforts made about April, 1916, to induce the British Government to develop the manufacture of aeroplanes, and establish a Flying School in Canada.

These efforts were fruitless until toward the end of 1916, when the Chairman of the Imperial Munitions Board was in London and discussed matters with the Minister of Air. These discussions led to the training in Canada of aviators to recruit the Flying Squadrons at the Front by the establishment of the Canadian Wing of the Royal Flying Corps.

Official Decisions.—At a meeting held at the headquarters of the Air Board in London, on December 17, 1916, decisions were reached, when it was confidently hoped that Canada would form an efficient training ground for aviation. These hopes were more than realised.

The proposals agreed upon were :

- (1) The establishment of an Air Force in Canada.
- (2) Canada to undertake the supply of complete equipment for the use of the Air Force.

With the promise of cordial co-operation by Sir Robert Borden, the Canadian Prime Minister, the Royal Flying Corps of Canada was formed.

It was determined that the general and personal equipment necessary for training recruits would be sent from England, but that the task of producing and furnishing the physical equipment, including flying machines, would be undertaken by the Imperial Munitions Board.

The Work Undertaken.—This work, with its fascinating and popular appeal, involved vaster issues than at first appeared.

The recital of bare facts, such as the erection of buildings, preparation of aerodromes, purchase of supplies, the manufacture of aeroplanes, and the spending of \$23,000,000 in their accomplishment, seems very commonplace. To grip the situation, however, one must remember the colossal tasks already undertaken by the Board—how it tapped almost every source of skill for the execution of its existing commitments, and that the new demands found the country comparatively barren of knowledge of how to satisfy their requirements. The science of aeronautics, still in its infancy, with its alluring prospects and enchanting romance, created an appetite in Canadians for research, and produced results which became a wonder to themselves and others.

Two Organisations.—To carry out effectively this business the Chairman of the Imperial Munitions Board brought into being two organisations, each distinct in its service and yet closely co-related. The one was called the Aviation Department of the Imperial Munitions Board, the other the Canadian Aeroplanes Ltd. Both these departments of the Imperial Munitions Board have a story full of interest. The whole history of Canadian flying is bound up in the story. The novelty of flying and the equipment necessary for success created a zest, an inquisitiveness and accomplishment which older arts and manufactures would have failed to inspire. This enthusiasm, with the abounding interest which filled all the workers on any of the Board's projects, undoubtedly contributed to the phenomenal success which followed both enterprises.

Lieutenant Allan Sullivan.—It is not my object to go over the ground so ably covered by Lieutenant Allan Sullivan in his volume entitled 'Aviation in Canada, 1917-1918,' but I propose telling briefly the story of the work done by the Imperial Munitions Board through both departments which it directed. I am, however,

indebted to Lieutenant Sullivan for some of the facts I give in this chapter.

Mr. E. R. Wood, Member, Imperial Munitions Board.—Sir Joseph Flavelle, ever on the look out to seize upon the best ability for any task he had in view, persuaded Mr. E. R. Wood to undertake the responsibility of 'Director of Aeroplane Service.' Mr. Wood's administrative, financial and personal qualities were well known in Canada. It was a great acquisition to the Board to find him willing to undertake the duties involved in spite of very indifferent health. Unfortunately, he was physically unequal to the strain, and in a few weeks he was forced very reluctantly to give up the charge he had undertaken. This decision was announced to the members of the Board at a meeting on January 25, 1917.

Mr. F. W. Baillie and Mr. G. A. Morrow.—At the same meeting the Chairman announced that Mr. F. W. Baillie had consented to assume the duties of Director, and would have associated with him Mr. G. A. Morrow, of Toronto, both gentlemen having volunteered their services, and would serve without remuneration.

The nature of the work soon lent itself to a clear division of duties in direction, although both services were complimentary to each other. Mr. Frank, afterwards Sir Frank, Baillie became President of Canadian Aeroplanes Ltd., and Mr. Morrow, Director of Aviation.

AVIATION DEPARTMENT, IMPERIAL MUNITIONS BOARD

The problem confronting Mr. Morrow was full of intricacies requiring a disciplined imagination as well as administrative skill.

With confidence the work was tackled. It was completed in the same spirit with every mark of calculated plans, which were successful.

The First Problem.—With the arrival from England of the first members of the Royal Flying Corps on January 23 came the problem of provision for an Imperial Unit of the Air Force.

The question of location and suitable housing was settled with a despatch characteristic of the best flying. The Camp at Borden, 70 miles north of Toronto, used for the Canadian Expeditionary Forces, was secured on January 27. Here the first Canadian aerodrome was constructed. This aerodrome consisted of fifteen flight sheds, with additional buildings and equipment necessary. At the same time the Department of Militia and Defence provided at Long Branch, 9 miles west of Toronto, land on which the first Flying Unit was formed in Canada. Within a few days additional sites were secured for groups of squadrons, one at Leaside, 3 miles, and another at Armour Heights, 7 miles, north of Toronto, and, in addition, at Rathbun and Mohawk, 130 miles east of Toronto. Thus, by the end of January, and in a few days from the arrival of the English contingent, the foundations of this work of aviation were securely laid.

The Second Problem.—The second problem was one of organisation. Loose directing ends in such a business would have been fatal to progress. To classify the skill required for the various services was one thing ; to find the right skill was quite another.

Materials had to be purchased and distributed in a manner and to an amount which called for the best commercial brains.

Materials had to be fabricated into buildings and into equipment which only the skill of the experienced engineer could accomplish.

Special skill of a new order in the science of aeronautics had to be secured, and last but not least the directing mind over the finances and accounts was required.

The Personnel.—Mr. Morrow, keen and calculating, discovered the skill and formed the organisation. The responsible heads were :

Chief Engineer, Mr. J. B. Carswell.

Assistant Chief Engineer, Mr. J. R. Hagelin.

Purchasing Agent, Mr. A. H. Mulcahey.

Assistant Purchasing Agent, Mr. A. S. McNick.

Superintendent Aeronautic Supplies, Mr. W. B. Clelland.

Secretary, Mr. George E. Wishart.

These men, under the direction of Mr. Morrow, distinguished themselves by a great devotion to duty. A very brief reference to the work of each department will perhaps give the best view of the work done.

Engineering Accomplishments.—In considering the work done by the Engineering Section of the Aviation Department, it must be remembered that some of the training grounds were separated by 200 miles, and that each had to be planned with the best town-planning skill. Buildings, streets, sanitation, and all kinds of modern equipment were involved. In less than two years barren and rough ground was transformed into scientifically planned camps. Four hundred buildings were constructed; $22\frac{1}{2}$ miles of roadways; 18 miles of water mains; and 10 miles of sewers. There were 300 miles of telephone and power lines; $6\frac{1}{3}$ miles of railways; 27 miles of aerodrome drainage and steam-heating plants, numbering twenty-six, for individual installations, and 6 for central heating. The chief engineer devoted most of his energies directing the executive work, while his assistant supervised the construction. During the first nine months of these operations the erection of buildings was placed in the hands of various contractors, but after that period their employment ceased, and the entire work of construction was placed under the control of the chief engineer.

The contractors spared neither time nor energy in the fulfilment of their tasks. They had undoubtedly the rough and pioneering work to do, and they did it well.

To engineers who have knowledge of the innumerable difficulties to be overcome in such work, particularly in a country like Canada, where the extremity of winter weather often frustrates progress, the achievement of this department is outstanding. The value of the work is

enhanced because it was accomplished in so short a time. Those directing the design and lay-outs, the lighting, heating, plumbing, road-making, transport, and purchasing did fine work.

When Armistice day arrived, there were in this department alone 2200 men engaged, all of whom did their bit in this great engineering accomplishment.

Commercial Ability.—Under the direction of Mr. Mulcahey expert buyers in different branches supplied the entire requirements of the Flying Corps, except rations, pay, and medical service. The variety and amount of the demands and the uncertainty of their delivery involved the storages of some 20 to 30,000 different articles and appliances, from pins and needles to the complete aeroplane itself. The Purchasing Section issued orders during the period of the war approaching 16,000, and handled considerably over double that number of invoices.

All was arranged with a clockwork precision which produced harmony and satisfaction. Some items purchased, such as coal and gasoline, were very large. For 1918 alone, nearly 30,000 tons of coal for fuel were required, and about 16,000 gallons per month for gasoline. Yet it is on record that, with all the anxiety which prevailed about fuel supplies during a period of great congestion on the railroad, and with difficulties of storage at the different training grounds, not any interruption to flying was experienced.

Traffic Branch.—The success of the Purchasing Department was in no small measure due to the men who traced all materials and directed their course until delivered as required. Their duties included the checking of all freights and express bills, and comparing them with the corresponding invoices and orders.

When the U.S.A. entered the war and the Royal Flying Corps of Canada assisted it in Texas, the Traffic Branch distinguished itself by the speed with which materials, machines, and other supplies were sent to Texas.

Lieutenant Sullivan says :¹ 'The Texas movement involved 375 cars and 5000 men. This was an admirably managed undertaking, so successful that within five days from the date of leaving Canada our machines were climbing into the air above Texas aerodromes.'

Undoubtedly it was a great performance, but without that unfailing co-operation which characterised the actions of contractors and railway companies this feat could not have been accomplished.

Aeronautical Department.—It was fortunate that due importance was given to the link between the actual maintenance of a Flying Corps and the factories and stores for the supply of technical equipment. Mr. W. B. Cleland made an able liaison between these sections.

There were so many details of a technical nature calling for the services of specialists that it was eminently essential that the purchase and supply equipment, such as wireless instruments, machine-guns, all kinds of engine spare parts, cameras, etc., should be in the hands of the experts. The excellent and harmonious results proved the wisdom of such a decision.

The Secretariat.—In all such big organisations the healthy pulse beats from a sound and healthy secretariat. Money is the first and the last essential in our modern systems—the 'silver bullet'!

The Royal Flying Corps, Canada, was paid for by the British Government, and the first credit of four millions sterling was placed with the Imperial Munitions Board for financing the project. It was the duty of Mr. George E. Wishart, as Secretary of the Aviation Department, to watch closely the expenditure, and to render a detailed account weekly of all financial transactions to the Auditor of the Imperial Munitions Board. In this Mr. Wishart excelled, for he kept in constant and close touch with the chief source of financing and accounting at Ottawa.

All payments were made by the Finance Department of the Imperial Munitions Board on the receipt of certified accounts, all of which came under the immediate

¹ P. 39, *Aviation in Canada, 1917-1918.*

survey and control of the Secretary. This work included all financial transactions in connection with the Royal Flying Corps in Canada and in Texas, U.S.A.

The Assistants and Workers.—While it is impossible to name all those who took important and less important shares in the work done in the Aviation Department, it is well to remember that without them, and that spirit of whole-hearted co-operation and energetic effort which they exhibited, Mr. Morrow's work and that of his immediate associates would have been without success.

CHAPTER XXI

THE STORY OF CANADIAN AEROPLANE MANUFACTURE

THE fascinating story of aeroplane manufacture is inseparably linked with the energy and enthusiasm of the late Sir Frank Baillie. His skill and courage as a successful organiser had been proved before the war, chiefly along the lines of banking, financing, and company promoting.

During the war he entered the front line of manufacture.

The story of cartridge case manufacture will ever surround his memory with patriotic service.

It was, however, in aeroplane production that he outdistanced all other achievements.

Small Factory in Toronto.—When Sir Frank Baillie put his hand to the work of manufacturing aeroplanes, there existed in Toronto a small enterprising company which had been making experimental aeroplanes for a private flying school located about 9 miles from Toronto.

This plant was acquired by the Imperial Munitions Board, and formed the starting place of manufacture under the Canadian Aeroplanes Ltd., which was one of the national companies formed by the Imperial Munitions Board.

Rapid Building Construction.—It was indeed a work of the first rank to design, build, and equip in ten weeks a great factory, consisting of several large buildings, which covered about 6 acres. This fine piece of work was carried out during wintry weather. In fact, the snow lay on the ground when, on February 1, 1917, the first hole for foundations was dug.

As a piece of architectural and engineering skill there are few works, if any, to compare with it in rapidity and quality of performance. Engineers and laymen alike will be able to judge from the actual photographs of the buildings in course of erection, shown in illustrations, of this great accomplishment.

In fifteen days substantial walls of brick and steel for the metal and fuselage buildings were well under way. By March 1 (twenty-nine days) the metal, fuselage, and wing buildings were nearly completed. By March 20 a large office building, also wood mill and power buildings, were under construction. By April 1 lumber, stores, garage, experimental, wing, fuselage, metal, power, and office buildings were nearly ready. It seems incredible!

Machinery and Plant Equipment.—While the architect, Mr. J. M. Lyall, and the building superintendent, Mr. Carswell, were making a record in building construction, both Canada and the U.S.A. were being searched for machinery and plant equipment. Hundreds of machines were required for metal work. Wood-working machinery had also to be installed. Special machines for propellers were required, and other wood-working machines for shaping the various parts of the aeroplane. Special stamping and pressing machines, furnaces, ovens, power plant, dust extracting plant, tanks, benches, tools, gauges, and a host of other stores and office equipment had to be obtained. It was fortunate that Sir Frank Baillie had secured the services of Mr. F. G. Ericson, whose previous experience in the manufacture of aeroplanes was of much value in the selection of suitable plant.

In addition to equipment for manufacture, special machinery had to be installed for the examination and testing of metals, woods, and fabrics. There was also the Experimental and Research Department which had to be equipped.

All buildings and equipment were carried forward with equal urgency. Nothing was overlooked. Every-

thing seemed to be timed with the correctness of a book of rules.

Output of Aeroplanes.—Sir Frank Baillie kept in view one object : AEROPLANE OUTPUT.

When the Canadian J.N.4 aeroplane design was approved by the Royal Flying Corps, J.N.4s were Baillie's meat and drink. He lived during these months with one impulse—the music of the completed aeroplane. All the feats of raising buildings in a night, and equipping them, as by magic, with the tools of production, counted nothing more to him than expenditures, unless by their means his programme of aeroplane output could be fulfilled.

Every plan was made to this end. The first building to be completed was designed for the purpose of experiments and tests to set factory production on right lines. A wrong step at the beginning might be fatal to progress.

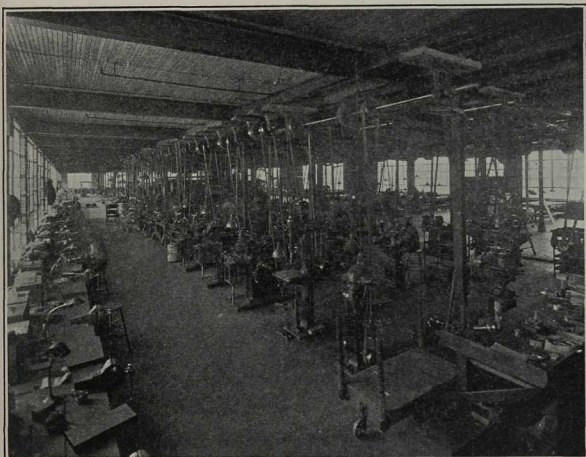
Manufacture Commenced before Buildings Completed.—Before the hammering of the builders ceased the hum of the machines for the manufacture of aeroplanes could be heard. It is remarkable that actually nine J.N.4s were completed during April, and, in addition, the equivalent of two more in spare parts.

The numbers grew from month to month. Counting with the completed machines the equivalent in spares made monthly, the numbers were as follows: 42 in May, 66 in June, 73 in July, 113 in August, 160 in September, 194 in October, 218 in November, and so on until 2900 were completed in twenty-one months. Those who have had the pleasure of visiting the Detroit Works of the Ford Motors Co. can visualise, in some measure, the scene at the works of the Canadian Aeroplanes Ltd. The orderly methods and processes of manufacture of the aeroplanes from the raw material to the finished plane, at the rate of four to five per day, had the features of organisation and progression on the lines of the great motor car organisation.

The Company's Organisation.—2900 aeroplanes of the J.N.4 type with modifications, together with thirty flying

boats for the U.S.A., were not completed in twenty-one months without a well-established and directed organisation.

Canadian Aeroplanes Ltd. consisted of three directors, who formed the Board—Sir Frank Baillie as President, Mr. Frank P. Wood as Vice-President, and Mr. W. Parkyn Murray as Director. These men formed the



CANADIAN AEROPLANES LTD., TORONTO

Tool Room

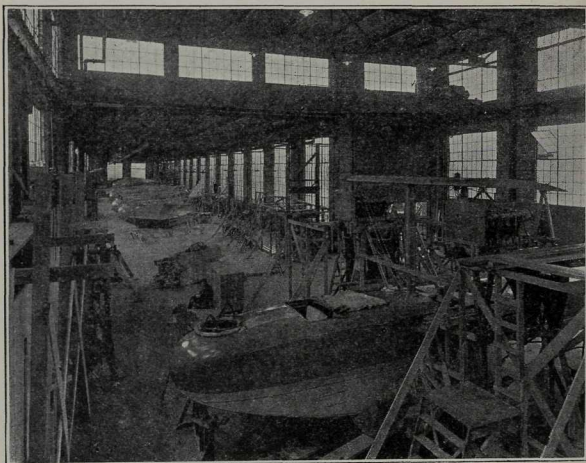
personnel of the Limited Company, financed entirely by the Imperial Munitions Board.

Sir Frank Baillie was virtually Managing Director. He secured the services of Mr. E. T. Musson as Manager of the whole factories ; Mr. F. G. Ericson as Chief Engineer ; Mr. P. H. Brooks as Secretary. Each of these men controlled a staff which grew in importance as the work proceeded.

Under the manager were superintendents of each

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important department of production, such as the metal, wood, employment, assembling, and despatching departments. The chief engineer was responsible for drawings, shop inspection, testing and research, experimental work, and the power services of the factories. The secretary was responsible for finances and accounting. Most of the officials and executive staff remained with



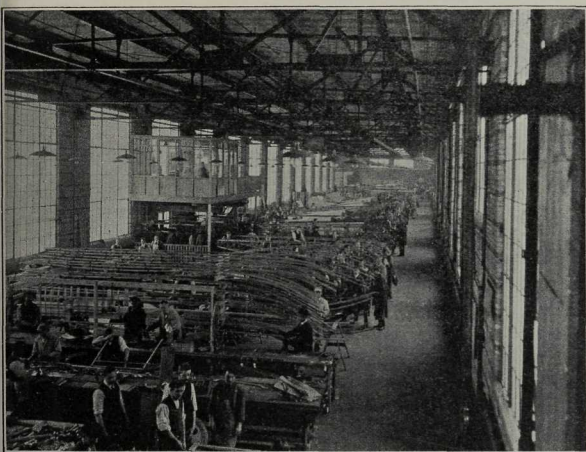
CANADIAN AEROPLANES LTD., TORONTO

Shipping Room : Fuselage Building

the company throughout the war. All contributed to the remarkable production accomplished.

Nature of Materials Employed.—The J.N.4 design was mainly constructed of wood, spruce and ash forming the bulk of the timber. The specifications called for a quality and length of spruce for wing beams, and of ash for the longerons, which appeared only possible to obtain by careful selection involving the rejection of a large bulk of the timber examined. It was impossible at first to

find a suitable source of supply. Almost in desperation it was determined to explore the forests on the western coast of Canada. A department for this purpose was organised by the Imperial Munitions Board at Vancouver. It was found possible under difficult conditions to obtain supplies not only for Canadian Aeroplanes Ltd., but



CANADIAN AEROPLANES LTD., TORONTO

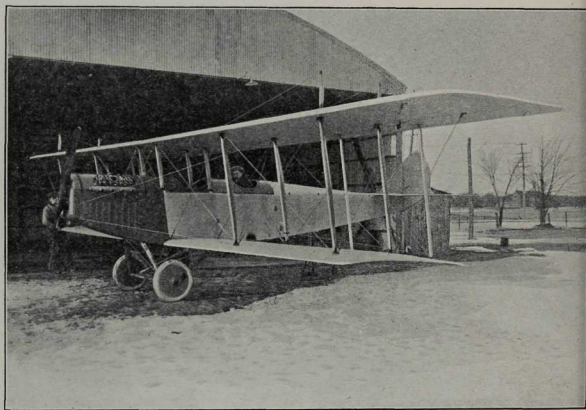
Fuselage Building : Final Assembly

for Great Britain also. The story of how this was accomplished is told in Chapter XXII.

Canadian Aeroplanes Ltd. passed through a very anxious waiting period until supplies were obtained from the Pacific Coast. The first lots of timber were actually expressed by rail in car loads instead of by the usual freight traffic. The materials had to be found, at whatever cost. All the timber was inspected before being shipped from British Columbia. Huge amounts reaching $4\frac{1}{2}$ million feet were inspected monthly.

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How the Timber was Used.—All possible precautions were taken to prevent the use of wood not properly seasoned. Drying by artificial and natural means was employed. One of the difficulties experienced in building the aeroplanes was in finding lumber of sufficient length and free from defects to make certain beams in one length. This was overcome by joining two pieces together by splicing. The kind of splice devised by the



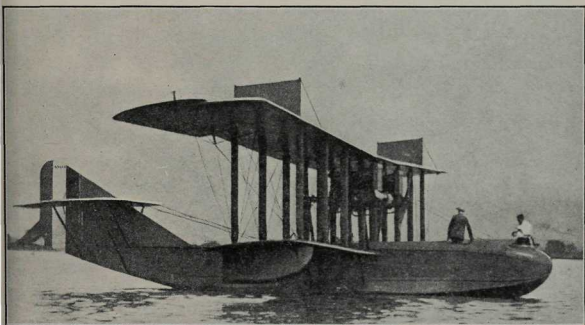
FIRST CANADIAN J.N.4 MACHINE
Front Side View

Canadian Aeroplanes Ltd. was approved and finally adopted by Great Britain and the United States as a standard splice. From tests carried out it was found that spliced members were stronger than members of the same length made from one piece of timber only.

Wing Design.—Those familiar with the design of the wings of the J.N.4 machines, which were built up of a series of panelled girders, will appreciate the care and skill with which the parts had to be shaped and assembled. Each girder panel had to be constructed to give the

maximum strength for the minimum weight. The work was so ably planned that hand labour was reduced to a minimum. Every part was made to standard dimensions and built together with a commendable accuracy.

Propellers.—The most accurately balanced part of the woodwork of the machine was the 9-foot propeller which had to run at 1500 revolutions per minute. Balance and precision were of absolute importance for smooth running. To build a propeller from a solid



CANADIAN AEROPLANES LTD., TORONTO

Flying Boat in Water

piece of wood which would maintain its form was out of the question. Five white oak boards, glued and compressed together, were used. The mass was then shaped into form, first in a lathe with a copy which controlled the tool, and afterwards in a special machine which operated on four propellers at once, the tools of which were all controlled. In this way the hand work on the propellers was practically eliminated, except for the surface finishing and balancing of the blades.

Linen and Dope.—The material used in the first machines for covering the wings and fuselage, etc., was linen. It was imported from Ireland. Cotton, however,

made in Quebec, in the Wabasso Cotton Co.'s Mills at Three Rivers, was found to give entire satisfaction. There was no sentiment exhibited in passing materials; if they did not stand the rigid tests imposed they were rejected. This cheap cotton, thoroughly 'doped,' proved under exhaustive tests to be equal to the best Irish linens. This was a great discovery, in view of the submarine warfare, and the demands from Britain for Irish linen. Chiefly women were employed in the Covering Department. Men did the 'doping.'

Metals.—Various metals were used for the joints, stays, and connections. Sheets, tubes, and rods used in construction were all of steel. The steel was called upon to resist deformity under tensile, bending, crushing, and other tests. These materials were submitted to careful examination and testing before being passed to the factory for manufacture. Sheets had to be cut, stamped, and shaped into different brackets and bracings. Turn buckles of different sizes had to be made with adjustable nuts, and cables of wire were cut and spliced. In the manufacture of the metal parts machinery was employed wherever possible to eliminate hand labour.

Employees.—With the increase of output the number of employees grew until the figure passed 2400 in March of 1918. The class of workmanship and the speed with which products were made were deserving of great praise. Not only were the materials tested with the most minute inspection by the officers and staff of the Inspection Department, but the quality of the work was strictly examined. All component parts were examined and approved before being sent to the Assembling Department. Many thousands of metal parts had to pass inspection daily. When assembled, the aeroplanes were examined before being passed finally for service.

No machine was accepted by the Aircraft Equipment Branch of the Royal Flying Corps unless the Inspection Certificate was signed by the inspector. The manufacture and inspection of aeroplanes were carried out so thoroughly that not one of the 2900 aeroplanes made

met with an accident from faulty design or workmanship. These remarkable results were in no small measure due to the valuable assistance, in maintaining a high standard of workmanship, rendered by Mr. F. J. Toulmin, who was in charge of the inspection of aeronautical supplies. The spirit of comradeship in the staff was carried throughout the factory, and it resulted in a record of output not surpassed in the annals of Canadian industry.

Flying Boats for the U.S.A.—The news of Canadian aeroplane manufacture impressed the United States Government. They wanted to know the man whose organising ability had produced such results. The Chairman of the Imperial Munitions Board was approached with a view to assisting the U.S.A. Navy Department. In April, 1918, Canadian Aeroplanes Ltd. were asked to undertake the manufacture of thirty F.5 Flying Boats, the largest made in America. The company submitted a tender for them in the usual way and obtained the contract. Sir Frank Baillie undertook the work. The F.5 Boat design so differed from the J.N.4s that the J.N.4 seemed a toy compared with this monster.

Particulars of the F.5 Flying Boat.—The particulars of this boat are worthy of record—the manufacture of which an organisation of only one year's standing had the daring to undertake.

The wing span was 102 ft. 2 in. ; length of boat over all, 49 ft. 3 in. ; height over all, 20 ft. 6 in. Total weight, flying load, 12,900 lb. Armament, four guns. Bombs, 1000 lb. ; speed, 85 miles per hour. Crew, six men. Power plant, two Liberty 12-cylinder engines, 800 horse power.

Completed before Promised Delivery.—The Canadian Aeroplanes Ltd. commenced the manufacture of the F.5 Flying Boat on April 22, 1918, and completed the first boat by July 15, 1918, and the thirty, three weeks before the promised date of delivery. In spite of the fact that the construction was entirely different from the machines they had made, and that difficulties arose in securing

material and labour, the work was not only done quickly but exceedingly well.

United States Praise of Workmanship.—The American Admiral, under whose charge the fleet of flying boats was placed, wrote a letter in which he spoke most highly of the 'excellent workmanship of Canadian aeroplanes shown in the construction of Navy flying boats.'

Position at Armistice.—When the Armistice was signed the Canadian Aeroplanes Ltd. had produced, in addition to the U.S.A. flying boats, 2921 aeroplanes. The later type of plane manufactured differed in design from the J.N.4, it being equipped with engines of a larger power, namely, 130 horse-power, but all proved of the greatest service to the Royal Flying Corps. The total cost amounted to \$13,400,000. The buildings and equipment cost one million dollars. The cost of production compared most favourably with that of machines by other makers. Three thousand pilots were trained and sent overseas, and many others were ready to go when peace was declared. Sir Frank Baillie lived to see not only the fulfilment of his task, but the day of victory.

He has gone, and Canada has lost one of her great workers, but his magnificent work for the Empire will long be remembered.

CHAPTER XXII

THE STORY OF TREE FELLING IN CANADA

MANY will doubtless wonder what the peaceful though hazardous pursuit of tree felling has to do with the weapons of death. No one contemplated in 1914 that a forest romance so entrancing would form part of the 'History of Munitions Supply from Canada.' As a matter of fact, it was not the business of the Munitions Ministry at all. Soon after the Imperial Munitions Board became established, the news of its success in handling munitions passed from one Ministry to another in London until the Board became the general purchasing agent in Canada for anything that the British Government wanted with despatch. It was so with ships through the Shipping Ministry, aeroplanes through the Air Ministry, locos and rails through the Ministry of Transport, etc.

Unlimited Demands for Spruce.—When, towards the fall of 1917, the cry was heard from the Air Ministry for spruce for aeroplane construction in unlimited quantities, the Chairman was equal to the occasion.

A Lumber Department of the Board at Ottawa had been operating for some time prior to October, 1917. Eighty per cent. of the timber used for the wooden ships in process of being built—a matter of 70 million feet—had been secured from British Columbia by the Board without creating any definite market disturbance. The business of lumber supply was therefore not entirely new to the Board. Securing timber for ships, however, was quite a different matter from obtaining supplies of spruce for aeroplanes to exacting specifications.

Sitka Spruce.—The Air Ministry knew the value of British Columbia spruce, especially the great Sitka spruce trees of that province. It was the only place within the Empire to find spruce of such fine quality. These mighty sitkas were found towering majestically on the lower slopes of the shores of channels and fjords of the Pacific and Queen Charlotte Islands.

Appointment of Major Taylor.—About the beginning of October, 1917, it seemed to the Chairman desirable to open an office at Vancouver, and appoint someone who would organise means for the supply of the spruce required by the Air Ministry. He secured the services of Major Austin Taylor. On November 15, 1917, at a meeting of the Board he explained what he had done, and a resolution was passed 'that a Department of the Board be established with headquarters in Vancouver, B.C., to be known as the Imperial Munitions Board (Department of Aeronautical Supplies).'

The resolution confirmed the appointment by the Chairman of Major Austin C. Taylor as Director of Aeronautical Supplies, and gave him instructions to secure all the aeroplane spruce possible.

Characteristics of Value.—This was the starting place of an adventure and romance. His instructions to obtain a limitless supply carried the weight of responsibility which acted as a balance to an enthusiasm which was constant in Major Taylor.

He had gathered much profitable business for the Montreal Locomotive Co., with whom he had acted as commercial manager for some years. To the Shell Committee he was well known. His keen bargaining for, and sure fulfilment of, contracts undertaken were outstanding characteristics of the man. When the Imperial Munitions Board was formed the record of the Montreal Locomotive Co. for quality of product and rapid delivery was largely due to Major Taylor. It was because of the Chairman's confidence in him that he committed to Major Taylor untrammelled administrative direction of the Vancouver office of the Board.



THIRD OPERATION, TOPPING TREES, B.C.

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Some Immediate Difficulties.—When Major Taylor reached Vancouver the problems which faced him were : (1) where to find suitable areas of spruce and fir ; and (2) how to organise operations for felling, logging, and water transportation of lumber.

These problems arose out of the great demand for immediate supplies. The winter was fast approaching, and something had to be done at once. When the object of Major Taylor's quest became known in the province he was literally besieged with offers and suggestions from holders of forest land who were prepared not only to sell their forest holdings, but to undertake logging contracts.

Most of the lumber areas were some hundreds of miles from Vancouver, and it was impossible for Major Taylor to examine each area. He had to decide, and that quickly, upon a course of action. What could be done for the quickest, greatest, and best supply of spruce ? That was the question !

Assistance from Provincial Government.—In determining his plan of action Major Taylor received very great help from the British Columbia Government. He decided to place logging contracts for the felling and logging of spruce in approved areas. The Government issued cutting rights on desirable stands of timber to be paid for on a fair basis. The Dominion authorities would not authorise the clearance of lumber from the province, except through the Imperial Munitions Board. The Board had, therefore, the whole supply at its disposal for the use of the British Government.

Transportation Department.—To meet the second difficulty a Transportation Department of the Board was organised immediately. The great distances from the different centres of operation made such a department an urgent necessity. It must be remembered that most of the forest land with suitable timber was virgin country scattered over the rugged Pacific Coast between Vancouver and Alaska and on different parts of Queen Charlotte Islands. All equipment and supplies for each contractor and his men had to be transported to the forest

areas some 400 to 600 miles by water, and then 1 or 2 miles up from the shores, before operations could be begun. This was done by the Transportation Department. From Vancouver to Massett Inlet, in the heart of Graham Island, transportation by water alone was 574 miles.

Operating Establishments.—Establishments were built on the islands and mainland. On Queen Charlotte Islands there were five great logging, milling, and rafting centres. These were :

Masset Inlet .	574 miles from Vancouver
Skidegate Inlet .	457 " " "
Gumshewa Inlet .	444 " " "
Thurston Harbour .	414 " " "
Sedgwick .	369 " " "

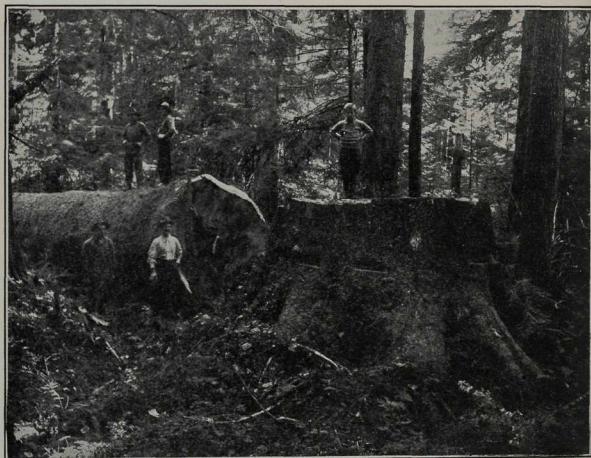
At Thurston Harbour were erected a wireless station, a hospital, a machine shop, and a headquarters' office of the Board. Thurston Harbour became the centre of information, on the island, of the Vancouver office. On the mainland, there were mills at Prince Rupert, Georgetown, Skeena City, Swanson Bay, Ocean Falls, Vancouver, and New Westminster, and holding ground for rafts at Captain Cove. On the Island of Vancouver there were mills at Quatsino Sound and Victoria ; logging contracts at Brooks Bay and Nitinat Lake ; and coaling stations at Union Bay and Nanimo. Those who know the B.C. Coast and the distances of each of the above locations from Vancouver can form some idea of the relative centres of operation. They, however, convey no idea of the difficulties encountered and sacrifices made by that great body of 24,000 men who were engaged in this undertaking.

The Superintendents.—The contractors consisted chiefly of experienced loggers and mill men who possessed established camps for the commercial production of fir, cedar, hemlock, larch, etc., in the southern parts of British Columbia. Many of these contractors, at Major Taylor's request, moved their entire equipment and

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complement of labour to Queen Charlotte Islands, to log spruce for the Imperial Munitions Board. The superintendents, therefore, of the work were experienced men who accompanied and supervised the transfer of camp and equipment.

The Workers.—The large number and complex character of the men required the greatest tact in their management. The physical difficulties in camp life,



LOGGING AEROPLANE SPRUCE, QUEEN CHARLOTTE ISLANDS, B.C.

and the mixture of races, often led to troubles which required strict discipline. Some of the men were of alien races and tried to spread insidious propaganda, but, on the whole, a finer piece of work was not performed anywhere than by those who worked incessantly and did nobly in the production of lumber.

Number of Contracts Placed.—In all, there were 293 individual contracts placed for the purchase of logs. There were fourteen mills cutting spruce exclusively, and ninety-three mills cutting fir, but not exclusively.

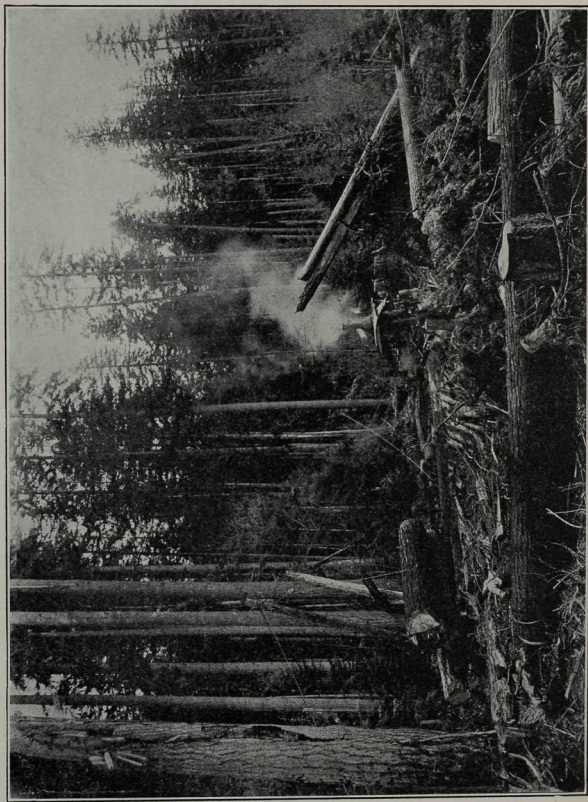
What the Contracts Involved.—The scientific cutting of enormous trees, ranging from 14 feet in diameter and some 300 feet high, demanded a skill of peculiar quality. The mere trimming and felling of those towering monsters so that the trunk would fall uninjured in a predestined spot was an art incomprehensible to the uninitiated. But this was not all. Consider the movement of these monster trees through primeval forest. Trees weighing hundreds of tons were dragged slowly by many oxen, horses, 'donkey' engines, or 'logging engine cable' on skidways over rough improvised ground or logging railway for 2 miles. It is difficult to convey to the imagination even from the photographs the almost insurmountable difficulties encountered in the transportation of these huge masses of timber.

Difficulties in Water Transportation.—The task of transportation was by no means over when the huge lumber monsters had been pulled to the coast. The towage of rafted logs amounted to a haul of 574 miles from the farthest felling ground to Vancouver, and the average haul was 110 miles. Some of the difficulties were increased at certain places, for instance, in the long north and south reef in Hecate Straits. The shallow water there occasionally caused rafts and tugs to touch the bottom. When slight Pacific winds arose towing became most difficult. In very stormy weather towing was actually suspended. These passages accounted for some of the navigation difficulties between Queen Charlotte Islands and the mainland.

Shortage of Tugs.—The problem of transportation became more perplexing when it was found that sufficient tugs could not be obtained. Two new tugs were built by the Board. The Department of Public Works of the Dominion Government lent two, but they had to be lengthened to suit the navigation conditions in the Hecate Straits. Altogether the Transportation Department operated almost continuously eighteen large tugs, twenty-two scows, five barges, two coal hulks, and seven gasoline launches.

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The Work of Selection.—The quality of the trees to be felled was most important. It seemed to those most



FOURTH METHOD OF LOGGING : WITH DONKEY ENGINE AND RAILROAD, QUEEN CHARLOTTE ISLANDS, B.C.

used to felling and logging that any attempt at choosing trees to be felled by a process of selection would be useless and impossible. The idea was foreign to the ordinary

felling contractors. Major Taylor was determined to apply a selective system, by carefully choosing trees which, after examination, conformed to definite requirements. The adoption of this policy was due to scarcity of labour and machinery, together with the necessity of rapidly securing aeroplane timber. As a result 30 per cent. of the spruce logs delivered to the saw mills passed the rigid requirements of aeroplane material inspection. This was an accomplishment which brought great gain, for prior to the selection only $1\frac{1}{2}$ per cent. of 14 million feet of logs felled was acceptable for aeroplane timber. The logs in question were of the standard British Columbia grade usually put on the market. These selection tests were applied afterwards to all spruce obtained for aeroplane manufacture.

Rejection of Fir.—The Air Ministry authorised the use of a certain proportion of fir as a substitute for spruce. To show, however, the exacting requirements in the quality of fir for aeroplane purposes, only $9\frac{1}{4}$ million feet of Douglas fir were obtained of sufficient quality to meet the requirement from 500 million feet produced at private saw mills. No fir of a grade suitable for aeroplane construction was produced in British Columbia prior to the war.

Inspection of Spruce and Fir.—To Mr. R. Craig, of the Inspection Department of the Imperial Munitions Board, fell the task of passing the timber. Mr. Craig was formerly of the Conservation Department of the Dominion Government, and rendered good service to the Board. All the stock of aeroplane lumber exported was inspected. The work of inspection was made lighter at the mills when the process of selection brought a very high grade of spruce to the mills. These logs when delivered were sawn under careful instructions given by the Imperial Munitions Board staff, and to its specifications.

Rigid Inspection Relaxed.—With the development of aircraft manufacture it was found that some of the inspection tests imposed in the examination of the first lots of spruce could be relaxed. By this relaxation aeroplane

spruce which had been previously rejected was passed. The science of aeronautics was in its infancy and growing rapidly. The very rapid extensive war experience in the uses of machines brought a knowledge of the requirements of materials in aircraft construction which admitted of alterations to specification for spruce. This decision was welcomed by producers and the Board alike.

What was Accomplished in about One Year.—One can hardly believe that it was possible to organise a far spread army of 24,000 men, twice the number of the total inhabitants of a city like Welland, Ontario, in 1918 ; scattered on sea and land, operating under conditions demanding great sacrifice, courage, and endurance. This big army, in the course of a year, brought from the thickets of the islands and mainland 35,348,000 feet of aeroplane spruce and fir at an approximate cost of \$8,200,000.

The number of feet indicated is but a small percentage of the total feet of logs it was necessary to cut to obtain lumber of the selected quality required for aeroplane construction. In addition to the production of spruce lumber, the Lumber Department of the Board at Ottawa purchased and supervised the supply of 129,417,361 feet of lumber of all grades.

Pre-war Output.—Prior to the war the quantity of Sitka spruce cut annually did not exceed 3,000,000 feet, of which not more than approximately 150,000 feet would be suitable for aeroplane construction.

Certificate of Praise.—It is pleasing to record that the Air Ministry of London recognised the splendid work performed by the Board in the supply of timber. Here is an extract from a letter dated October 8, 1918, from the Air Ministry, London :

Canada is supplying 40 per cent. of the aeroplane timber used in the construction of aeroplanes in Great Britain. Director-General of Aircraft Production telegraphed last Saturday as follows :

I wish to congratulate you on the remarkable results in spruce and fir produced as shown by the August and September 'output figures.'

TREE FELLING IN CANADA 203

The Controller of Timber telegraphed in reference to the particulars furnished of shipments in September :

It is a notable performance. To have increased production to this extent is a great achievement. This increase should enable us to look forward with some confidence to being able to meet the requirements of the Aircraft Production Department during the year.

We know now that in little more than a month after that date the Armistice was signed, and no more timber was required, but the work done will ever be regarded as a great accomplishment.

CHAPTER XXIII

SHIPBUILDING

FOR some months before the British Ministry of Shipping was formed, the Hon. R. H. Brand, the Representative of the Imperial Munitions Board at the Ministry of Munitions, urged unsuccessfully on the Board of Trade that Canada could build ships to assist in meeting the submarine crisis. Mr. Brand says:¹ 'Even in December, 1916, the Board of Trade informed me that they did not require any ships.' When the Ministry of Shipping was formed the Imperial Munitions Board was authorised to begin a shipbuilding programme in Canada. By this time, the loss of British shipping was so serious that cargo ships became one of the most vital requirements of the war.

Early in 1917 the Ministry of Shipping sent shipbuilding experts to Australia, Canada, and India to investigate what help these countries could give. Mr. (now Sir James) Esplen visited Canada in March, 1917, and made a thorough tour of inspection. Satisfied that assistance could be obtained, he reported favourably to the Chairman of the Imperial Munitions Board, who took immediate steps to negotiate contracts for cargo vessels in Canada, up to the capacity of existing shipbuilding yards.

Mr. Esplen arranged for one of his assistants, Mr. R. R. Gray Chisholm, a representative of the Ministry of Shipping, to remain in Canada and act as technical adviser. Later, Mr. F. T. Green undertook this work, and relieved Mr. Chisholm for other services. All plans

¹ See Appendix II.

of construction were first passed by these gentlemen, and then approved by Mr. James French, the Chief Surveyor of Lloyd's, at New York, before they were issued to builders.

Shipbuilding Department—Colonel Gear.—It was quite evident to the Chairman that the work which the Board was asked to undertake demanded an organisation with technical and administrative skill of no mean order. He approached Colonel William Gear, who consented to undertake the task of Director of Steel Shipbuilding. Colonel Gear set aside his private interests and threw himself whole-heartedly into the work. He was at the time Vice-President of the Robert Redford Co., of Montreal, one of the oldest transcontinental shipping firms of the Dominion.

On May 7, 1917, he proceeded to Ottawa and quickly gathered round him an able and experienced staff. With their valuable assistance he accomplished a work the quality of which received the commendation of British experts.

Mr. Walter Lambert, M.I.N.A., an experienced naval architect, and Mr. Robert McNab, M.I.N.A., a marine engineer, were his technical assistants. It was not long before the office accommodation in the Transportation Building was too limited for the work undertaken, and larger offices had to be secured in the Freeman Building, Ottawa.

At first the intention was to build steel ships only, but the demands for shipping capacity became so great that a building programme for wooden ships was prepared.

Colonel Gear took charge of all steel shipbuilding, and also of the construction of wooden vessels on the St. Lawrence and in the maritime provinces.

Wooden Ships—Mr. R. P. Butchart.—A separate branch of the Shipbuilding Department was formed in British Columbia under the direction of Mr. R. P. Butchart, of Victoria, B.C. It was on the recommendation of Mr. Dawson, the British Columbia member of

the Board, that the Chairman wired to Mr. Butchart asking if he would accept the task of Director of Wooden Shipbuilding. Mr. Butchart consented, and carried out the duties with much success. He gave his services without remuneration. Through the kind permission of Lord Shaughnessy, who was unfailing in his help to the Board, Captain J. W. Troop was liberated from his duties on the Canadian Pacific Railway to act as technical assistant to Mr. Butchart. Both these gentlemen left Vancouver on April 23 for Ottawa, and discussed plans for building in British Columbia.

The work, therefore, of the Shipping Department was in two sections, one under the direction of Colonel Gear, and the other under Mr. R. P. Butchart.

Magnitude of the Work.—At first it was determined to have steel vessels to one standard design, but existing shipyards could not be adapted quickly enough to meet the requirements. It was therefore decided to build to designs for which the shipyards were best fitted. The wisdom of this decision will be recognised when it is remembered what the condition of Canadian shipbuilding was at the time in question. There were about six shipyards which were dragging out a meagre existence by building service vessels for the customs, public works, railways and canals, and for the Marine Department of the Canadian Government. In addition to these were built lake vessels, for carrying ore, grain, and other materials, that could not be built to advantage elsewhere.

Conditions were different nearly 100 years ago, for in 1825 Canada built wooden ships in Quebec up to 24,000 tons. Canada also has the honour of having constructed and equipped with engines the *Royal William*, the first steamer to cross the Atlantic under her own steam. This ship was built at Quebec in the yard of Messrs. Campbell & Black, in 1831, the designer being James Gondie, a native of that city.¹ The background, therefore, of Canada's shipbuilding craft was important, and its shipbuilders were able to approach the

¹ *Imperial Year Book for Canada*, 1917-18, p. 323.

problems of supply of cargo boats with more confidence than manufacturers who undertook munitions supply in September, 1914.

Steel Ships.—Contracts were placed for forty-one steel ships ranging from 1800 to 8800 tons dead-weight, and one car ferry, making in all forty-two vessels. Except in one or two shipyards, all builders had to make additions and improvements to carry out their contracts. New yards were established by the Canadian General Electric Co., of Toronto, at Bridgeburg; the British-American Shipbuilding Co. Ltd., at Welland, Ontario; and the Midland Shipbuilding Co. Ltd., at Midland.

These plants extended from Nova Scotia in the east to British Columbia in the west, involving an organisation for the inspection of the work, including inspectors and surveyors in each yard and a travelling inspector going from yard to yard.

A system of weekly progress reports from inspectors showed the progress of each vessel. The supervision was so carefully carried out that builders were complimented on the excellence of the work. It was stated to be equal to the work done on vessels of similar size made in Britain.

Difficulties Encountered and Overcome.—During the severe winter of 1917–1918 transportation of materials from the U.S.A. to Canada was for some time almost impossible. Practically all the steel required for ships had to be supplied from the U.S.A. The great movement of munitions, food supplies, machinery and other traffic of urgent importance was held up by snow blockades, and complete demoralisation of railway traffic followed. The American Government was forced to control the situation so far as the railroads of the U.S.A. were concerned. The dependence of the importation of anchors, chains, and nautical instruments from England gave considerable anxiety because of ocean transportation.

The severity of the elements also stopped almost entirely, for some time, most of the work at the yards. The Canadian Vickers Ltd., Montreal, was the only

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company which had covered slipways. The others were all in the open, and production suffered accordingly.

Materials Commandeered by the U.S.A.—Another serious difficulty arose in 1917 when the U.S.A. entered the war. The Government of the U.S.A. launched a great building scheme and commandeered all the lumber and steel, as well as machinery equipment, they could find. By this action it was almost impossible for Canadian shipbuilders to obtain supplies of materials. These conditions, added to the disorganisation of transportation, upset deliveries greatly. Further, when materials were received it was often found that the materials which were required last were delivered first and vice versa. The situation was full of perplexity and anxiety, but wise and patient administration brought order out of considerable chaos. Representatives were placed in New York, Pittsburg, and Washington to follow up the various steel and other ship requirements. Men were also placed at divisional railway points to see that lumber and steel, boilers, engines, and the complete ship's requirement were forwarded promptly by the railways.

Difficulties in Obtaining Timber.—Great difficulty was experienced in obtaining timber for the wooden vessels. Nearly 70,000,000 feet, board measure, had to be secured without delay and without exciting unduly the markets. Those in touch with lumber conditions can realise what this meant at the time. About half that amount was used on the Pacific coast and the other half in the Eastern Province. Some of the logs were as large as 36 in. square, the handling of which required the installation of wood-working machinery, with which some of the builders had no previous experience.

Labour Difficulties.—In addition to transportation difficulties, labour shortage and unrest were encountered. Strikes were continually being adjusted on the Pacific coast and in the East, while shortage of labour, and competition between shipbuilders to secure the labour which was available, interfered with production. An attempt was made to restrict the transfer of men from

CHAPTER XXIV.

HOW THE U.S.A. AND CANADA HELPED EACH OTHER

It is impossible to measure by commercial transactions, or by the number of manufacturers in the U.S.A. who made munition materials, the great service that country rendered to Canada and through it to the British Empire and the Allies in the Great War. To say that ninety manufacturers, from fourteen different states covering thousands of miles, supplied so many million dollars' worth of material is to reduce the value of the service to a purely commercial basis. Critics there were who scathingly condemned the Americans for their 'cupboard love.' They scouted the idea that they helped Canada. It was self-help, said they, from first to last; but those who had actually to deal with the Americans know the fine type of men who stepped in at great risk and supplied machinery, tools, gauges, as well as materials, in 1914, which made it possible for Canada to render help to the mother country.

German Element.—It must not be forgotten that there was a very active German element in the U.S.A. Had it prevailed and prevented the spontaneous action of British born citizens and their descendants in the U.S.A. from giving their products to the British Empire, it would have gone badly with the Allies. The critics who condemned the U.S.A. manufacturers and others could never have gauged the pulse of masses who thronged the hotels of New York, Pennsylvania, and even Chicago, where the German fires burned fiercely during the early months of the war.

How did the U.S.A. Help?—The manufacturers in the U.S.A. came to the help of Canadian manufacturers in September, 1914, by supplying machinery equipment. Canada had not the equipment and had not the facilities for its supply. Everything was urgently required to put the wheels of production in motion. The energy and care which they expended were their best. One felt as if they were working to prevent the wreckage of civilisation. They did not hesitate to show by their actions what their feelings were, although they had no official support from their Government in what they did. The above-named help was given direct to Canadian manufacturers and not through the agency of the Shell Committee. Nevertheless, machinery equipment was expressed by rail into Canada with a commendable speed. When the question of gauges gave great anxiety to the Shell Committee, the U.S.A. manufacturers worked day and night to produce them.

Copper Bands and Fuses.—When no possible means of copper supply for shell bands was visible, several manufacturers in the United States undertook to install equipment and make copper bands for the Shell Committee. One manufacturer alone supplied over 30,000,000 copper bands to Canada during the war. When Canada was asked to undertake the supply of complete ammunition and had no facilities for making fuses, two U.S.A. manufacturers laid down expensive equipment and established a large organisation which produced millions of fuses—a really great achievement. And it was the same with steel supply, cartridge cases, and other materials, without which Canada would have failed. Of course, they were paid for what they did, but it was in no mean money-grabbing spirit that the magnificent service was performed, but in a spirit of loyalty to the cause which the U.S.A. Government did not officially assist until 1917.

The States which Contributed.—As a historical record of what the U.S.A. did in connection with the supply of munitions to Canada, apart altogether from what they did for Great Britain and the other Allies, it is better to

give here, at least, the number of States which rendered assistance and the number of manufacturers in each State. There were 42 manufacturers in New York State ; 8 in Ohio ; 7 in Pennsylvania ; 6 in each of the following : Michigan, Illinois, and Connecticut ; 5 in New Jersey ; 2 in Indiana and in Massachusetts ; and 1 in each of the States of Washington, Georgia, Delaware, Maryland, and Wisconsin.

HOW CANADA RECIPROCATED

In the autumn of 1917, after the Government of the United States entered the war, negotiations were opened between the officials of the United States Ordnance Department and the Imperial Munitions Board, with a view to placing at the disposal of the United States the surplus forgings and machining capacity which had developed in Canada.

At the time in question Canada had a shell-forging and machining capacity for 18-pdr. shells of 400,000 per week, and had actually shipped overseas 32,000,000 of these shells. This remarkable development had taken three years' hard work and organisation, but now was not fully required by the British Government, who had increased her manufacturing capacity in Great Britain. The actual requirements of the British Government from Canada amounted to 150,000 to 200,000 per week, leaving an unused capacity of 200,000 to 250,000. It was this latter capacity the Imperial Munitions Board on behalf of the manufacturers of Canada, and in the interest of the Allies, placed at the disposal of the United States Government. The proposal was opportune, as, at the time, the U.S.A. were making desperate efforts to organise for the production of the 75-mm. high explosive shells. This shell was about the same size as the British 18-pdr. shells. It was, therefore, with the object of assisting the United States Ordnance Department in carrying out its munitions programme that negotiations were begun.

Negotiations with the U.S.A. Ordnance Department.—

At the request of the Chairman, and on behalf of the Imperial Munitions Board, Mr. James Wood and the Ordnance Adviser went to Washington in October, 1917, to place before the officers of the U.S.A. Ordnance Department the use of the available manufacturing capacity of Canada. With the assistance of Sir Charles B. Gordon, of the British War Mission, and the Hon. R. H. Brand, a member of the Imperial Munitions Board, conversations were carried on with General Crozier, Colonel Hoffer, Major Cook, Colonel Dunn, Colonel O'Hern, and Major Gillis, regarding the advisability of certain American orders being placed in Canada.

The Position in the U.S.A.—The position in the U.S.A. after the Government declared war with the Central Powers was much the same as in Great Britain in August, 1914. Although many American manufacturers had shell manufacturing capacity, it was fully occupied in fulfilling contracts for the different Allies. It would have defeated the general aim to have compelled manufacturers to cancel their contracts with the Allies and turn over their activity to the Ordnance Department of the U.S.A. The programme that the U.S.A. had planned for the equipment of its armies was vaster than could be carried out in the time required, even if all its munitions manufacturers had given their productive capacity for that purpose. The problems therefore of production before the Ordnance Department were full of perplexity. To organise throughout the States new munitions factories, with all that was involved in the supply of machinery equipment, technical skill, and the training of labour from already depleted industries, presented fears of long delays and unfulfilment which put the whole project in jeopardy.

Keen, however, to keep every dollar's worth of work in the U.S.A., the officers of the Ordnance Department, many of whom had come from civil life to render assistance to the Government, were careful not to hand over to Canadian manufacturers what they calculated could be done in their own country.

The U.S.A. Ordnance Department Welcomed Sugges-

tions.—Suggestions were welcomed for the improvement of the designs of shells they intended to use which would make production easier, cheaper, and quicker. Many questions of a technical nature were discussed with members of the Ordnance Department. There were matters, for instance, relating to the quality of the steel, its carbon contents, the nature of the finish of the shell, inspection tolerances, hydraulic testing, and other like technical questions which required to be specified before contracts could be concluded. On all such matters the Ordnance Department was assured that it could rely upon the Canadian manufacturers to fulfil any contracts undertaken. Questions arose as to how contracts should be placed, whether with the Imperial Munitions Board, the manufacturers direct, or with the Canadian manufacturers through the agency of the Board.

Proposals Made by the Ordnance Department, U.S.A.—

The first proposals made by the Ordnance Department were for the supply of 8,000,000 to 12,000,000 75-mm. high explosive shells. These were transmitted to the Chairman, Sir Joseph Flavelle, who had been kept in touch with the negotiations throughout, and had directed their course from Ottawa. The Chairman had several conferences with the Canadian manufacturers, whom he felt warranted in recommending as being able to carry out the contracts. Detailed drawings and specifications were placed before them. The Chairman suggested that the manufacturers should select from their number a representative body to visit Washington for the purpose of obtaining first-hand information as to the requirements of the U.S.A. Ordnance Department. This proposal was carried out, and the Canadian manufacturers were able to inform the officers at Washington of Canadian conditions and methods of manufacture.

Nature of Proposed Contracts.—While the Ordnance Department was willing to place contracts with Canadian manufacturers who had been recommended as suitable by the Imperial Munitions Board, it was anxious that the Board should exercise the function of agent in a limited sense for the U.S.A. Government. It knew that any

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change of shell programme made by Great Britain might call for the Canadian shell-making capacity which had been handed over to the Ordnance Department. It, therefore, wanted the assurance of the Imperial Munitions Board that any capacity contracted for would not later be commandeered by the British Government. It wanted also a reasonable assurance from the Board that what the manufacturers said they could undertake would be fulfilled by the dates furnished. These and other questions formed part of the preliminary discussions and were the subject of correspondence.

Definite Proposal Made by the Imperial Munitions Board.—The Chairman, who by this time had visited Washington and was conducting the negotiations along with Mr. James Wood and the Ordnance Adviser, made a definite proposal on behalf of the manufacturers of Canada. He was able, on October 29, to give in writing the names of eleven Canadian manufacturers, as a first instalment, who would undertake to forge and machine the 75-mm. high explosive shells, at a fixed price subject to adjustment, according to certain requirements of inspection and tests. All materials for the shells were to be supplied direct to the works of the Canadian contractors by the U.S.A., excepting vaseline and varnish.

A schedule of delivery, both final and monthly, was given for the manufacture of 7,500,000 shells.

Reply from Ordnance Department.—While the proposal made by the Chairman on behalf of the manufacturers was accepted in a general way, Colonel Hoffer on behalf of the Chief of Ordnance, General Crozier, made it quite clear that, while the Ordnance Department proposed to enter into direct contracts with the Canadian manufacturers who had been selected to do this work, a form of agency should be established between the U.S.A. and the Imperial Munitions Board. Following this idea Colonel Hoffer wrote, on November 1, to the Chairman of the Imperial Munitions Board that 'it is desired that the Imperial Munitions Board attend to all details of allotment and apportionment of materials furnished by the United States and follow the operation of the

plants with a view to expediting production and in general act as the agent of this Government¹ and the contractors from the time the contract is executed until the time shells are delivered to and accepted by the United States shall be through and by the Imperial Munitions Board, except that officers of the United States Army will inspect all shells prior to delivery and acceptance thereof.' Colonel Hoffer stated in the same letter that the United States would reimburse the Imperial Munitions Board for expenses incurred, and claimed the right to audit such accounts.

Legal Examinations of Proposals.—Negotiations had proceeded sufficiently far to call for legal examination of the terms of agency proposed with a view to accelerating matters. Sir Joseph Flavelle arranged for Mr. Anglin, of the law firm Blake, Lash, Anglin & Cassels, of Toronto, to go to Washington and examine the terms of contract. He, with Major Grand, an able U.S.A. lawyer, framed terms which ultimately became the subject of official letters between the Chief of Ordnance and the Chairman of the Imperial Munitions Board.

Seven Per Cent. Differentiation.—During the final discussions on the subject of price to be paid to manufacturers in Canada, it was contended by the Ordnance Department that it was necessary to differentiate between the price paid to American and Canadian manufacturers to the extent of 7 per cent. less to the Canadian manufacturers. It was submitted that the ground for this differentiation was due to the extra freight charges for material sent to Canada and lower prices paid for labour in Canada, also the loss to the United States Government of war taxes by reason of the work going out of the country. This was a fly in the ointment which the Canadian negotiators much regretted, for there appeared to them insufficient ground for any differentiation. Labour was not cheaper in Canada. Anyhow it became part of the terms of the

¹ This extract should be read in conjunction with letter on p. 227. It would read more clearly if after the word "Government" and before the words "and the contractors" were inserted the words "in all matters to the end that the intercourse between this Government."

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contract, and the manufacturers of Canada did not allow this reduction to influence their quality or delivery of shells.

Letters of Contract.—The letters forming the contract between the Imperial Munitions Board and the Ordnance Department, U.S.A. Government, are :

- (1) From Major-General Crozier, Chief of Ordnance, dated November 6, 1917.
- (2) From Sir Joseph Flavelle, Chairman, Imperial Munitions Board, dated November 12, 1917.
- (3) 'Amended Agreement'—Colonel Hoffer's Letter of December 20 to the Chairman, Imperial Munitions Board.

All form part of the Appendix to this Chapter.

Major Cook.—Before passing from the subject of negotiations to an account of the work actually done, it is a pleasure to record the admiration of all the Canadian negotiators for the exceptional ability and untiring energy of Major Cook, who died soon after the Armistice, having worn himself out. It is pleasing to know that a medal 'for exceptionally meritorious and distinguished service' was awarded to him after his death, and given to his relatives in memory of his splendid service to his country.

American Department of Imperial Munitions Board.—Immediately negotiations were concluded, and before contracts were arranged between Canadian manufacturers and the U.S.A. Ordnance Department, a department of the Imperial Munitions Board was formed, known as the American Department, for the purpose of negotiating, placing, handling, and supervising United States contracts in Canada which were placed by the United States Ordnance Department through the agency of the Board.

Mr. Holt Gurney.—This department was under the direction of Mr. E. Holt Gurney, of Toronto, assisted by Mr. W. C. Noxon, now Agent-General for Ontario in London, who kept themselves in touch with the

Ordnance Department at Washington by personal visits, and through the special representatives of the Board, Mr. Lloyd Harris and Mr. Frank A. Rolph, at Washington. Mr. Gurney was Managing Director of the Gurney Foundry Co., of Toronto, one of the oldest and most up-to-date foundries in Canada. He brought to the direction of this work an experience of munitions manufacture, gained during the war, which was mature and well balanced.

Co-operation of all Departments.—Mr. Gurney at once sought and obtained the fullest co-operation of all the departments of the Board. For instance, the Board's purchasing agent notified manufacturers of orders which were to be issued to them, and authorised their taking the necessary steps to furnish equipment, pending the actual issue by the United States Ordnance Department of procurement orders and contracts. By this means manufacturers were able to start production, and in some cases made deliveries of shells, before they received the actual contracts from the United States Ordnance Department.

Then again, when orders for larger shells were placed, Mr. Gurney arranged with the various directors of production handling the work of the Board to supervise the production in Canada of shells of similar sizes for the U.S.A. By this means duplication of departments, running on parallel services, was avoided. Not only was the staff of the different departments at Ottawa used, but also the travelling inspectors, engineers, and other officials in connection with the district offices of the Board at Montreal, Moncton, Toronto, and Winnipeg.

Steel for American Contracts.—Most of the steel from which forgings were made for American contracts was supplied from the U.S.A. The Steel Department of the Imperial Munitions Board advised the United States Ordnance as to the amount required by, and order of shipments of steel to, the forging plants in Canada. This department also undertook the responsibility for the distribution of forgings to the machining contractors as required.

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The tonnage of steel actually shipped into Canada for American contracts handled by the Steel Department of the Imperial Munitions Board was :

111,082	tons for	75-mm. forgings.
4,518	„ „	3-in. anti-aircraft.
50,959	„ „	155-mm. forgings.
45,650	„ „	9·2 in. forgings.

In addition to the above, 42,161 tons of 9·2-in. shell blanks were supplied by Canadian manufacturers, making a total of 254,370 tons.

Forgings made in Canada for U.S.A.—The total number of forgings made from the above steel and distributed by the Steel Department numbered approximately 11,017,860. It is truly amazing that, in the short period of one year from the time negotiations were begun, so many shells differing in size from the British designs, and requiring new plant equipment and tools for dealing with them, could have been produced. There were actually seven different natures of shells—75-mm., 3-in. anti-aircraft, 4·7-in., 5-in., 155-mm., 9·2-in., and 240-mm. Credit is due to Mr. Larmon, of the Steel Department of the Board, who had much difficulty to contend with over the irregular supply of steel, which often delayed forging plants and the regular supply of steel forgings to machining plants. On the whole, the work of the department was carried out with great patience and success.

Distribution of Components.—Components received from the U.S.A. for use in finishing the shells were copper bands, lead discs, base covers, and caulking wires. Lots for each size had to be distributed in regular quantities, involving additions to the ordinary staff of the Board. Just as in the case of steel and shell forgings, so in the matter of these components, great care had to be exercised to avoid surplus stocks at some works, while others were held up because of a shortage of components.

Mr. Petersen, Director of Machinery.—In connection with the plant equipment, Mr. Petersen, the Board's

Director of Machinery, visited Washington and conferred with the Engineering Division of the Ordnance Department. When contracts were given out involving the purchase by the United States of additional machinery under the terms of 'increased facilities,' Mr. Petersen accepted the responsibility of controlling the purchase by the contractors of such additional equipment, and of issuing the certificates upon which the Ordnance Department authorised the allowance for 'increased facilities.'

Claims and Adjustments Department.—The Claims and Adjustments Department of the Board, through its able director, Mr. John Craig, did valuable work for the American Department. After consultation with the officials at Washington, he and Colonel Albee, an officer of the U.S.A. Ordnance Department, had authority to make allowance to contractors for the labour spent upon materials, supplied by the U.S.A., which proved defective after being machined. These adjustments were made as occasion arose, instead of leaving their consideration until the completion of the contract, when evidence would have disappeared, and decision as to cost would have become largely a matter of estimate.

Termination of Contracts.—On November 23, 1918, twelve days after the Armistice, notice was sent by order of the Chief of Ordnance to the Imperial Munitions Board requesting that all contracts placed with Canadian contractors should be terminated, and that from each contractor a sworn statement of his claim, if any, against the United States under his contract should be obtained.

Settlement of Claims.—One month later, on December 23, 1918, a letter was addressed to the Chairman of the Board from General Williams, Chief of Ordnance, covering the agreement for the settlement of claims. This letter is given as an Appendix to this Chapter. It shows clearly the confidence which the United States Government reposed in the Chairman of the Board. In the exacting and complex work of settlement the machinery set up for investigating claims included District

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Claims Boards, the members consisting of representative officers of the United States Ordnance Department and officials of the Imperial Munitions Board. Authority was vested in the Chairman of the Board or the Auditor of the Board, Mr. George Edwards, or the Comptroller of the Board, Mr. J. C. Jeffrey, to sign all awards made by the Board in settlement of all claims of Canadian contractors against the Ordnance Department arising out of the termination of their contracts.

Work Done by Canadian Manufacturers.—Approximately 280 contracts were placed by the United States Ordnance Department with Canadian manufacturers; 246 of these were placed through the Imperial Munitions Board.

The value of the 246 contracts amounted to	\$222,392,984.99
In addition to which payments for 'increased facilities' amounted to	9,775,321.53
Total	<u>\$232,168,306.52</u>

The munitions accepted by the United States Ordnance Department in respect of the 246 contracts on vouchers of production	\$ 45,234,181.18
Payments for increased facilities, etc.	5,621,394.79
Total	<u>\$ 50,855,575.97</u>

In addition to the above a gross amount of \$28,837,671.06 (exclusive of \$1 awards) was awarded in claims settlements.

Conclusion.—By the happy ending of the war the work of production was cut off at once; but it can only be regarded as a magnificent performance by the manufacturers of Canada, who, in turn, were served ably by the American Department of the Board in helping the U.S.A. in its munitions programme.

APPENDIX

- (1) *Letter from Major-General Crozier, Chief of Ordnance,
dated November 6, 1917.*

War Department,
Purchase Section,
Gun Division.

OFFICE OF THE CHIEF OF ORDNANCE,
1330 F STREET, WASHINGTON.

November 6, 1917.

GPWO-209-504G.
G826-458A.
GP471.12/965.

IMPERIAL MUNITIONS BOARD,
OTTAWA, CANADA.

Subject : 75-mm. High Explosive Shells.

SIRS,—1. I have to acknowledge receipt of your letter dated Washington, D.C., October 29, 1917 (GP471.12/841), relative to the proposed contracts between the United States Government and Canadian manufacturers for a supply of 75-mm. high explosive shells.

2. It is proposed that the Ordnance Department, United States Army, with the approval and consent in each case of the Imperial Munitions Board, and not otherwise, enter into contracts with Canadian manufacturers who are selected by the Board to do this work. It is understood—

(a) That each such contract shall provide that the Imperial Munitions Board shall be under no liability, express or implied, to Canadian manufacturers under such contracts for anything done or omitted thereunder ;

(b) that, if any such contract provides that this Department may extend or enlarge or renew the same, for any further quantity of shells beyond the number originally firmly contracted for, no such provision shall be acted upon by the Ordnance Department without the consent or approval of the Imperial Munitions Board ;

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(c) that the Imperial Munitions Board, unless otherwise specially directed, shall not execute any contract on behalf of the Ordnance Department ;

(d) that the Imperial Munitions Board may, in connection with this arrangement, employ the ordinary or any additional or special advisors, employees, agents, or assistants ; and

(e) that the Imperial Munitions Board shall not assume or be under any duty or obligation to the United States in connection with this arrangement or anything to be done or omitted under it, except that of acting in good faith.

3. It is desired that the Imperial Munitions Board, acting as the agent of the Ordnance Department, negotiate and arrange the details incident to the placing of contracts, adjust all disputes and claims arising thereunder, attend to all details of allotment and apportionment of the materials furnished by the United States, follow the operation of the plants with a view to expediting production, and in general act as the agent of this Department in all matters to the end that the intercourse between this Department and the contractors from the time the contracts are executed until the time the shells are delivered to and accepted by the United States shall be through and by the Imperial Munitions Board, except that officers of the United States Army or other persons designated by the Chief of Ordnance will inspect all shells prior to delivery and acceptance thereof. It is expected that the Board and the contractors will accord to the United States Army officers, and to other persons designated by the Chief of Ordnance, the same treatment and consideration and assistance in the performance of their duties as they receive at the plants of the American manufacturers.

4. It is estimated that the cost of the service to be rendered by the Board will not exceed one (1) per cent. of the business handled by it ; to this extent, and not beyond unless specific authorisation therefor is given, the United States will reimburse the Imperial Munitions Board for all disbursements on account of the services rendered. Such payments will include a *pro rata* share of the general and overhead expense of the Board and of any other expenses partly attributable to the services rendered. It is understood that this Government will be given the right to audit such accounts to the extent required by the Finance Division of this Department.

5. Reference is made to a letter from this Department of even date addressed to the Imperial Munitions Board containing more definite advices as to the requirements and wishes of this Department in the premises. From time to time similar letters will be issued for the guidance of the Board.

Respectfully,
(Signed) WILLIAM CROZIER,
Major-General, Chief of Ordnance.

The terms and conditions of the foregoing are accepted and agreed to, November 7, 1917.

IMPERIAL MUNITIONS BOARD,
By J. W. FLAVELLE,
Chairman.

NOTE.—Duplicate copy of this letter, signed by the Chairman, sent to General Crozier, 12.11.17.

(2) *Letter from Sir Joseph Flavelle, Chairman, Imperial Munitions Board, dated November 12, 1917.*

November 12, 1917.

MY DEAR GENERAL CROZIER,—I cannot allow the formal letter herewith enclosed to go forward without again expressing appreciation that the relationship between this Board, which has been officially acting for the Imperial authorities, and your Ordnance Department is such that the transaction now consummated carries the hearty goodwill of all concerned. In particular, I appreciate the sustained courtesy by all the officers of your Department to Colonel Carnegie and Mr. Wood during the period of these negotiations.

Faithfully yours,
J. W. FLAVELLE,
Chairman.

Major-General William Crozier,
Chief of Ordnance,
Washington, D.C.

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(3) '*Amended Agreement.*' Colonel Hoffer's Letter of December 20, 1917, to the Chairman, Imperial Munitions Board.

War Department,
Purchase Section,
Gun Division.

December 20, 1917.

In replying refer to
No. GPWP-209-504G.
G826-458A.
GPL.

IMPERIAL MUNITIONS BOARD,
OTTAWA, CANADA.

AMENDED AGREEMENT.

Subject: Orders for Ordnance placed and to be placed in Canada.

GENTLEMEN,—1. Referring to the Department's letter under date of November 6, 1917 (GP471.12/965), and in accordance with the direction of the Secretary of War, I am directed by the Chief of Ordnance to modify the agreement as expressed in the above-mentioned letter to cover and include the procurement of Ordnance material of all classes; as amended the agreement will be as follows:

1. It is proposed that the Imperial Munitions Board will, upon the application of the Ordnance Department, United States Army, select and recommend manufacturers in Canada equipped to produce Ordnance material of various classes, and will extend to this Department the use of its facilities for placing contracts and expediting production in accordance with the following understanding:

It is understood—

(a) That each such contract shall provide that the Imperial Munitions Board shall be under no liability, express or implied, to Canadian manufacturers under such contracts, for anything done or omitted thereunder;

(b) that if any such contract provides that this Department may expand or enlarge or renew the same, for any further quantity of shells beyond the number originally firmly contracted for, no such provision shall be acted upon by the Ordnance Department without the consent or approval of the Canadian Munitions Board;

(c) that the Imperial Munitions Board, unless otherwise specially directed, shall not execute any contract on behalf of the Ordnance Department ;

(d) that the Imperial Munitions Board may, in connection with this arrangement, employ the ordinary or any additional or special advisors, employees, agents, or assistants ; and

(e) that the Imperial Munitions Board shall not assume or be under any duty or obligation to the United States in connection with this arrangement for anything to be done or omitted under it, except that of acting in good faith.

2. It is desired that the Imperial Munitions Board, acting as the agent of the Ordnance Department, and upon a specific request so to do, will negotiate and arrange the details incident to the placing of contracts, adjust all disputes and claims arising thereunder, attend to all details of allotment and apportionment of the materials furnished by the United States, follow the operation of the plants with a view to expediting production, and in general act as the agent of this Department to the end that the intercourse between this Department and the contractors from the time the contracts are executed until the time the shells are delivered to and accepted by the United States shall be through and by the Imperial Munitions Board, except that officers of the United States Army or other persons designated by the Chief of Ordnance will inspect all materials prior to delivery and acceptance thereof. It is expected that the Board and the contractors will accord to the United States Army officers the same treatment and consideration and assistance in the performance of their duties as they receive at the plants of American manufacturers.

3. It is estimated that the cost of the service to be rendered by the Board will not exceed one (1) per cent. of the business handled by it ; to this extent and not beyond unless specific authorisation therefor is given, the United States will reimburse the Imperial Munitions Board for all disbursements on account of the services rendered. Such payments will include a *pro rata* share of the general and overhead expense of the Board and of any other expenses partly attributable to the services rendered. It is understood that this Government will be given the right to audit such accounts to the extent required by the Finance Division of this Department.

4. Reference is made to a letter from this Department, to the Imperial Munitions Board, dated November 8, 1917

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(GP471.12/966), outlining the characteristic features of contracts which will be executed covering orders placed through you in Canada for this supply, and also to telegrams dated November 13, 1917 (GP471.12/1059), and November 15, 1917 (GP741.12/1083). Reference is also made to a letter from this Department to the Imperial Munitions Board, dated November 6, 1917 (GP471.12/964), containing definite advices as to the requirements and wishes of this Department regarding the placing of contracts for 75-mm. shells. From time to time similar letters will be issued for the guidance of the Board.

Respectfully,

JAY E. HOFFER,

Colonel, Ordnance Dept., U.S.A.

- (4) *Letter from General Williams, Chief of Ordnance, dated December 23, 1918.*

December 23, 1918.

THE CHAIRMAN OF THE IMPERIAL MUNITIONS
BOARD, OTTAWA, CANADA.

SIR,—Following upon General Crozier's letter of November 6, 1917, the terms of which are understood to be still in force, except as modified by this letter or other correspondence between us, the under-mentioned proposals for dealing with claims against the Ordnance Department in Canada have been approved by this Department.

Having been settled in consultation with representatives of your Board, I presume that they will be acceptable to you, and shall be glad to receive your confirmation of this.

1. The Imperial Munitions Board, being duly authorised by the British Ministry of Munitions, will undertake to act as the agent of the Ordnance Department for the settlement of all claims of Canadian contractors against the Ordnance Department, arising out of the termination of their contracts, or otherwise, subject to the provisions of Clause 4.

2. The Ordnance Department will appoint two American assessors to assist the Imperial Munitions Board to effect the above settlements. All settlements shall be subject to the concurrency of the assessors, and the agreement or contract recording the terms of such settlements shall be signed on behalf of the Ordnance Department by one of these assessors as Contracting Officer.

3. The Imperial Munitions Board, in consultation with the assessors, will determine the procedure to be adopted in investigating and considering the claims and in negotiating the terms of settlement.

4. The amount payable to contractors in respect to the settlement of their claims shall in no case exceed the full amount which would have been payable if the contract had been carried out to completion. The Board and the assessors, in making agreements of settlement, shall be governed by the terms of the contract or order in each case, with the proviso that such discretionary powers as the contract may vest in the Chief of Ordnance, or Contracting Officer, shall be held to vest in the Board and the assessors.

5. The Ordnance Department will provide funds to meet the amounts required to be paid out from time to time in pursuance of the settlements, and will instruct their disbursing officers to pay out such funds on the approval of the Contracting Officer above mentioned.

6. It shall be open to the Board, with the concurrence of the assessors, in special cases, to agree to make payment to contractors on account, pending the conclusion of a final agreement or contract of settlement: Provided that in each case the contractor shall enter into an agreement to accept such payment on account as part of whatever sum may finally be awarded him by the Board and the assessors, and not to dispute or appeal from such award. Provided also that in no case shall such payment exceed 75 per cent. of the minimum total amount which the Board and the assessor consider likely to be due to the contractor.

7. Subject to the provisions of Clause 4 the awards of the Board and the assessors will be accepted by the Ordnance Department as final and will not be re-opened without the written agreement of the Board.

8. All contracts or orders placed by the Ordnance Department in Canada, which were negotiated through the agency of the Board, shall be held to come under the scope of this agreement. All contracts or orders placed by the Ordnance Department in Canada, which were not negotiated through the Board, shall also be held to come under the scope of this agreement, with the exception of such contracts or orders as are specified in schedule hereto attached.

9. If, in any special case, the Board and the assessors, after examination, come to the conclusion that it might be to the interest of the Ordnance Department for a contract to be concluded, with or without modification, they may lay the case before the

Ordnance Department, in lieu of entering into a settlement contract, and may take the directions of the Ordnance Department thereon. They shall not, however, enter into any agreement or contract, other than for settlement of claims, without express directions from the Ordnance Department.

10. It is understood that the Board and the assessors, in negotiating the terms of settlement, will follow, as far as practicable, and on general lines, the procedure and principles followed by the Claims Board of the Ordnance Department, as notified to them from time to time. But the Board shall not be bound to follow this procedure in all details, or in all matters.

11. The Ordnance Department may at any time request the Board to cease to act under this agreement, and the Board shall thereupon cease to act. Provided, however, that all agreements of settlement duly made by the Board under this agreement, up to the date of their ceasing to act, shall be recognised and given effect to by the Ordnance Department. Similarly, if the Board should at any time desire to cease to act under this agreement, it may give reasonable notice to the Ordnance Department of its intention to do so, and the Ordnance Department will thereupon make arrangements to take over the work, but agreements of settlement duly come to, up to the time of the Board ceasing to act, shall be recognised and carried out.

C. C. WILLIAMS,

Maj.-Gen., Chief of Ordnance, U.S.A.

CHAPTER XXV

THE INSPECTION OF MUNITIONS

REFERENCE was made in Chapter V to the inspection of shells instituted by the Shell Committee, and to the final inspection and firing proof of shells by the government inspectors of the Dominion of Canada.

The work of inspection increased during the Shell Committee's regime just as shell production increased, but the responsibility for inspection continued in the dual form originated by the Shell Committee.

When the Imperial Munitions Board was formed it was decided that all inspection should come directly under the Board, and that its management should be directed by Major G. Ogilvie, R.A. Major Ogilvie, afterwards Lieut.-Colonel Ogilvie, was attached to the Department of Militia and Defence, but the Canadian Government lent him to the Imperial Munitions Board.

Lieut.-Colonel Ogilvie was left a free hand to carry out the work of inspection as required by the British Government.

Division of Inspection Duties.—Lieut.-Colonel Ogilvie planned for the division of inspection duties by increasing the units of inspection in the different districts where offices had already been established. The District Inspector, according to the size of his district, had assistants who were responsible for the direction and supervision of the examiners in the different factories. The inspection of steel demanded all the attention of a chief inspector with assistants. He assisted Lt.-Col. Ogilvie at headquarters, and his assistants had offices in the

different centres where steel was produced. Captain Swaby did good work as a chief inspector of steel. The duties were by no means easy, and the problems of inspection and manufacture of steel were so intimately connected that judgment as well as forbearance was required.

Inspection of explosives was also of a delicate and important nature. Fortunately the factories manufacturing explosives were limited in number to a few, which permitted of the concentration of inspection duties.

The duties of these and other branches of inspection increased greatly the responsibilities of Lt.-Col. Ogilvie. The rapid development in shell manufacture and the growing industry of fuse manufacture with its attendant exacting inspection, together with the necessity for a greatly augmented stock of gauges, tried the resources of the department very much. It was impossible to obtain the necessary assistance from England, and all men had to be trained in Canada to do inspection and examination of munitions.

Inspection of Gauges.—The question of gauge purchase and inspection became increasingly important. Lt.-Col. Ogilvie had delegated to each of the district inspectors the duty of purchasing and inspecting the gauges required for his district. This did not give entire satisfaction, and it was ultimately arranged that all gauges would be purchased through one department, which would also be responsible for the inspection of gauges.

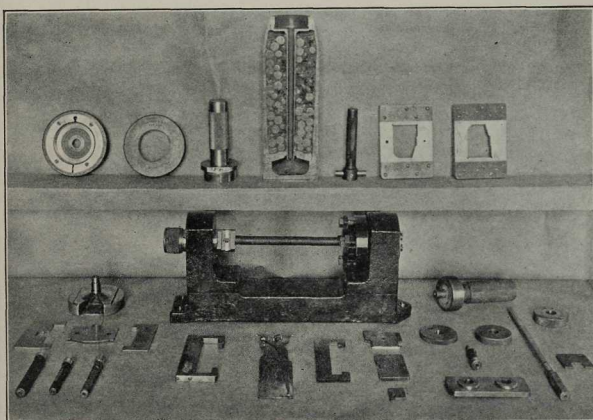
Captain R. J. Durley, formerly a professor of mechanical engineering at the McGill University, Montreal, was appointed in charge of this department, and rendered valuable service. About the work of this department more is said later.

Visit of Colonel Edwards.—Numerous questions having arisen in regard to the inspection of shells, which were causing uneasiness among manufacturers and concern to the Board, the Chairman suggested to the

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Ministry of Munitions, in the autumn of 1916, that he would welcome a visit from a representative of the Inspection Department, London, who would be able to review and report on the situation.

The Ministry complied with this request, and sent, in October, Colonel W. E. Edwards, R.A., Assistant Deputy Director-General of Inspection in the Ministry of Munitions.



SET OF INSPECTION GAUGES FOR 18-PDR. SHRAPNEL SHELL COMPONENTS

Colonel Edwards's Report.—Colonel (afterwards Brigadier-General) Edwards reported on the excellent work which Lt.-Col. Ogilvie had done, but that he was overworked. His efforts to keep the rate and quality of inspection equal to the rate of production had been handicapped by the difficulties in obtaining gauges, and in securing and training examiners. As to the standard of inspection, nothing could induce Lt.-Col. Ogilvie to reduce it. Pressure from manufacturers or from the Board had no effect upon him whatever. It is not, therefore, surprising that General Edwards in his report stated that the

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shells made in Ontario were, in general, up to the home standards.

Director of Inspection.—The enormous growth of production and the necessity for a greater subdivision of the duties of inspection led to the reorganisation of the Inspection Department. General Edwards suggested that the department should come under the Ministry of Munitions in England, and this was approved. He was asked to stay and organise the department. He became the Director of Inspection and a member of the Imperial Munitions Board. Lt.-Col. Ogilvie became Deputy Director of Inspection.

General Edwards immediately secured additional help from England, and at the same time arranged for some of the inspectors in Canada to go to England for instruction. He also established in Canada schools for training examiners.

The Inspection Department over which General Edwards took control had its roots in all the manufacturing parts of Canada. Great work had been done before his arrival. It was its co-ordination and expansion to which he directed his principal attention.

Details of Inspection.—From a staff of three or four men, in 1914, inspecting a few dollars' worth of material, the department grew until, in 1918, the inspection staff consisted of 8000 men and women, and the value of the material inspected was about \$50,000,000 monthly.

The materials inspected ranged from aeroplanes to ferro-silicons, and explosives to steel.

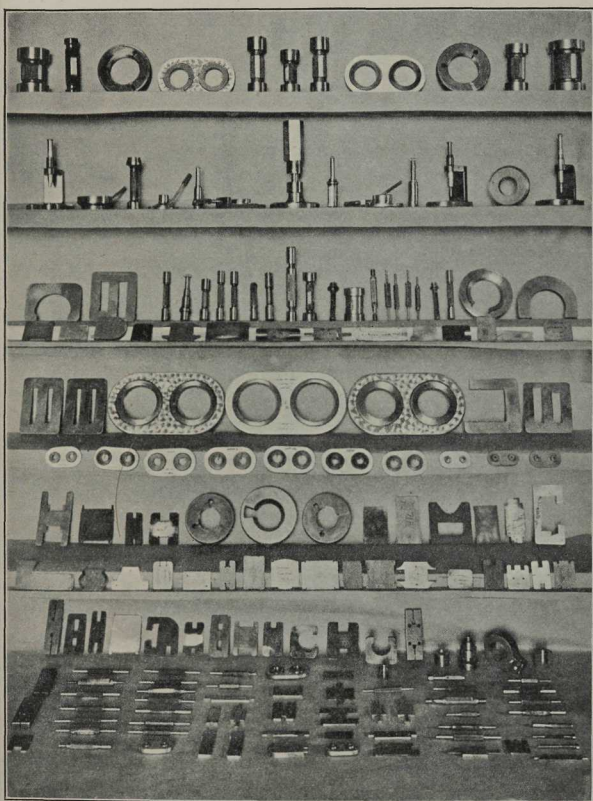
There was nothing demanded by the Ministry of Munitions or the Air Ministry but came within the scope of General Edwards's organisation.

Each department had its own specially trained experts, who in some cases possessed considerable scientific knowledge of the materials they were called upon to inspect.

Nature of Inspection.—In all cases the specification governing the contract determined the nature of inspection. As a rule, three things were required: (1) Analyses

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of materials; (2) physical tests of materials; and (3) superficial examination and measurement of materials. In



SET OF INSPECTION GAUGES FOR NO. 80 MARK VII T. AND P. FUSE

all three things discretionary limits were given to the inspectors beyond which they could not go without

reference to higher authority. Often interpretations of specifications led to serious questions and delay.

Analyses of Materials.—One can hardly imagine what the analyses of materials involved. First, by reason of the number of different materials used in munitions manufacture, very few metals used for munitions escaped without analyses, and second, because of the number of samples for analyses from the same materials. The Inspection Department was greatly assisted in its work by manufacturers themselves, who, as a rule, had their chemical laboratories. This was particularly the case with steel manufacturers. Nearly all the works in Canada had efficient laboratories. Inspectors were allowed to check the analyses taken from different samples at the works with samples selected by themselves for analyses by independent chemists employed by the Inspection Department. In this connection the names of Messrs. J. T. Donald & Co., Montreal, Messrs. Milton Hersey & Co., Montreal, and also the Canadian Inspection and Testing Laboratories Ltd., deserve special reference.

One great difficulty which was a source of trouble and dispute between steel manufacturers and inspectors throughout the course of production was the relation between the analyses and the physical properties of steel.

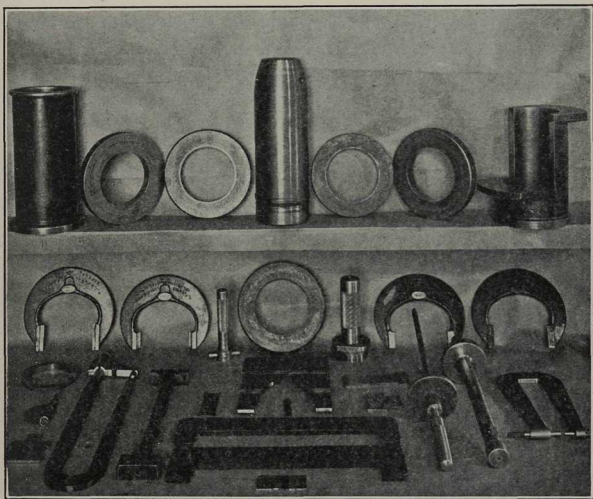
The fact that the specifications were prepared in England, where the general character of the steel used and known as 'acid' differed from the 'basic' steel of Canada, made it necessary to obtain permission to regulate the percentage amounts of the chemical elements in basic steel to produce the physical requirements specified. In Chapter III reference was made to the work of Colonel Cantley in this direction, but, unfortunately, his work was only the beginning of a running conquest over constant difficulties.

Perhaps it was in the realm of steel more than that of any other materials where analyses and physical tests came into greatest conflict. It was in this work where

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General Edwards was very much assisted by Mr. O. F. A. Sandberg, O.B.E., M.Inst.C.E.

Physical Tests.—When it is remembered that about 80,000 tons of steel were required monthly at the busiest period of the Board's activities, some idea of the physical tests can be estimated. From each heat of steel, more often consisting of a few tons than of large tonnages of



COMPLETE SET OF INSPECTION GAUGES

100, several samples were cut from bars rolled from ingots, and from shells forged from them, to obtain information as to the physical properties of the steel.

The bars of steel very often gave satisfactory results within the limits of strength specified, but when they were forged into shells one or other of the physical properties called forth would either exceed the maximum or be less than the minimum limits specified. Sometimes large numbers of shells would be rejected because they did not

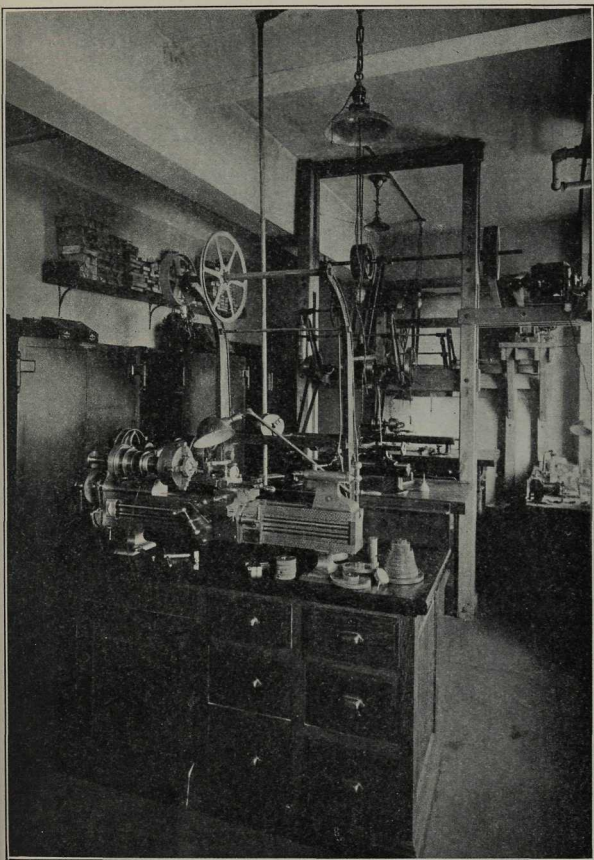
comply in these respects with the specification. The intermediate stage of forging often produced differences in the strength of the material according to the temperature of forging and the rate of cooling the steel after forging.

The story of the heat treatment of shells to recover their physical properties and to allow of their being accepted by the inspectors is too long and complicated to be related here, but it must be mentioned that Mr. Sandberg assisted different manufacturers in Canada to recover many thousands of shells by a method of air-cooling. The process introduced by Mr. Sandberg was based upon scientific principles, and proved to be of great value.

The Ordnance Board, Woolwich.—With reference to questions of inspection, interpretation of specifications, adjustment of analyses, and in many perplexing details relating to the manufacture of shells in Canada, the Ordnance Board, Woolwich, was of great assistance. Every suggestion made by the officers of the Imperial Munitions Board likely to make the work of production and inspection easier and more rapid was not only considered by the Ordnance Board, but was encouraged. The valuable Proceedings of the Ordnance Board were sent regularly to the Imperial Munitions Board, and all suggestions from them which would help manufacturers were immediately conveyed to them.

Superficial Examination and Measurement.—In this section of the inspection duties by far the largest number of examiners were required. Each manufacturer had his own inspectors, who examined the shells and other munitions before they were passed to the government inspectors.

The quality of finish, the form of the outside and inside of shells, the condition of parts fixed to the shells, such as copper bands, bushes, base plates ; the quality and colour of varnish used, and the way it was applied, as well as the exacting mechanical operations of weighing, also of measuring every part of the shell with high and low gauges, required a very large number of men with trained



ONE RIVET PRECISION LATHE AND OTHER GRINDING AND MEASURING
INSTRUMENTS

judgments to handle the work. Much trouble was often occasioned to manufacturers, and delay in production, through inexperienced men not daring to go beyond the letter of the specification as interpreted by them. An organised staff of travelling inspectors did a great deal to minimise the difficulties and delays which arose at first through the fears and limitations of the raw human means which the Inspection Department was forced to use because none else was available. The most unlikely men and women, who at first were awkward and out of place in learning how to examine, became quite expert examiners and inspectors.

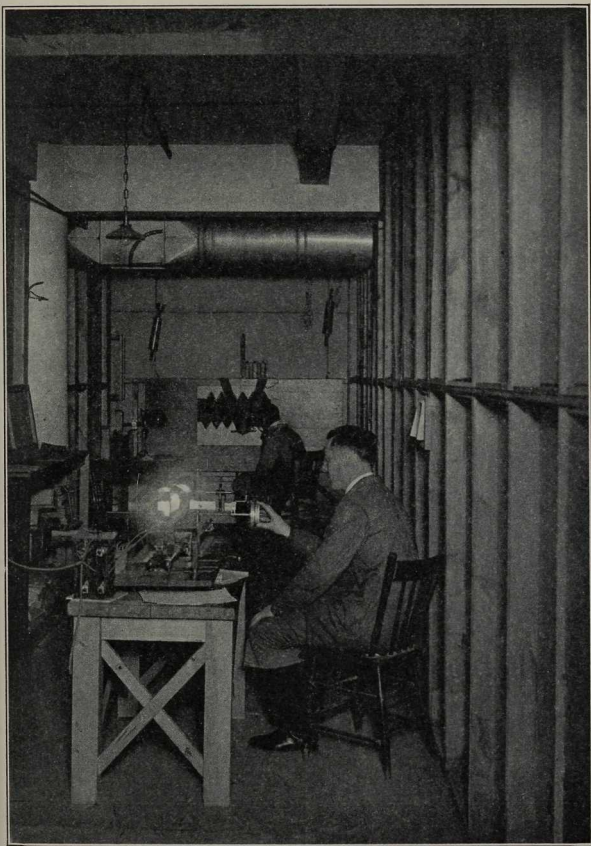
In the inspection of all component parts of shells, such as cartridge cases, fuses, primers, and all the semi-manufactured materials entering into their manufacture, as well as into the shells, preliminary difficulties were found until both manufacturers and inspectors alike gained experience.

Inspection of Explosives.—Each of the large explosive plants formed a district in which a chemist or chemical engineer was placed and was given the complete charge of the inspection of explosives produced in his district. A fully equipped laboratory was erected, and all the chemical tests necessary were carried out in this laboratory. The ballistic tests had to be carried out at the proof butts, one at Quebec and one at Petawawa.

In 1918 inspection districts were organised at Nobel, Trenton, Montreal, Toronto, Ottawa, and Trail, B.C.

Some of the details regarding the nature of the inspection of explosives are given in Chapter XVIII, which deals with their manufacture.

Inspection of Chemicals and Metals.—The majority of chemicals inspected were inflammable, and special precautions, for example against leaky drums, had to be taken. Some of the chemicals were extremely sensitive to contamination from outside sources, acetone, as used as a solvent for cordite, being of this nature. Other chemicals, such as calcium carbide and silicon metal, had to be packed in packages which were water-tight, and in



MEASURING ANGLES ON MALE AND FEMALE THREAD GAUGES

such a way that they were safe for ocean transport. The specifications for these materials called for chemical analyses requiring great accuracy. As in the case of explosives inspection, so in that of chemicals and metals, the great difficulty was because of the largeness of the quantities to be dealt with, and the rate at which they had to be handled owing to urgency of demand.

The output of zinc at Trail, B.C., was inspected and passed by a chemist stationed at the works there. The other metals, such as magnesium, were handled by district inspectors.

Owing to the explosive nature of silicon metal and ferro-silicon they were classed as chemicals. Each sample of ferro-silicon necessitated ten chemical determinations. Those familiar with the analyses of ferro-silicon will realise the work entailed by these tests.

Aeroplanes and Timber.—The intricate and exacting work of the inspection of aeroplanes and of the timber used in their manufacture has been referred to in Chapters XXI and XXII. Here again specialists did the work. The order of inspection was of a very marked character.

Gauge Department.—In looking back on the early efforts of inspection one wonders how the work of inspection, yea, the work of manufacture, was carried out so long and so successfully without a gauge department.

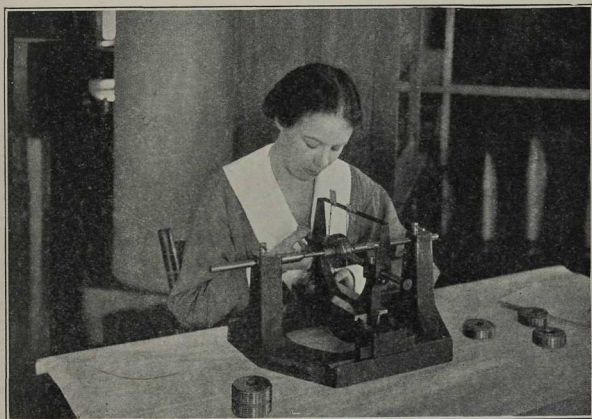
Gauges were constantly wearing out in use. Standard check gauges were kept in the first place by which the working gauges could be compared, but they were inadequate when it came to fine measurements.

Captain R. J. Durley, M.B.E., M.Inst.C.E., established a department which ultimately became a duplicate of the Teddington National Physical Laboratories, London. Every kind of measuring machine which could eliminate error and promote accuracy in checking and supervising the use of gauges was obtained.

The fact that a check was kept of the history of every gauge, and its examination made periodically, gave confidence alike to the manufacturers and shop inspectors.

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Order of Procedure.—Immediately a contract for munitions was placed with manufacturers the Inspection Department was informed. The Gauge Department estimated the number of gauges required for the inspection of the materials ordered, and orders for gauges were placed. When the gauges were received they were examined carefully, and, if correct, they were registered and numbered and entered into stock, to be ready for



MEASURING EFFECTIVE DIAMETER ON THREAD GAUGES

issue as required by the district inspectors, and hence to the shop inspectors.

Captain Durley very soon found that in order to cope with an efficient gauge supply it was necessary to establish a workshop for the repair of gauges.

During the progress of a contract the gauges were checked at regular periods. Gauges would be returned for repair and re-issue without any serious loss of time. To detect defects in thread gauges a special photographic apparatus for projecting on a screen the enlarged thread proved to be of very great service. This apparatus was

but one of numerous means which Captain Durley secured to perfect the work of inspecting and measuring gauges. This wonderful refinement had its effect upon the whole munitions industry throughout Canada.

Men and women in the works who handled the gauges saw limits of precision never before realised in mechanical engineering, and a care was inspired which led to good workmanship.

Growth of Gauge Department.—In about three years the Gauge Department handled over 250,000 gauges. In addition to this number the Gauge Department undertook the responsibility for the supply and care of the necessary inspection of gauges required for the completion of contracts placed by the United States Government in Canada.

When the Shell Committee commenced operations all gauges had to be purchased from the United States. By 1917, about a year after the Imperial Munitions Board Gauge Department was in operation, over twenty different companies in Canada were making gauges at the rate of about 10,000 per month.

Some of these gauges had to be made within a few ten-thousandths of an inch, truly an evidence of a great development in mechanical skill. This skill was not confined to men, but in some measure was shared by women workers.

General Edwards.—It is difficult in a brief chapter to do more than give a summary of the work which General Edwards did so admirably as Director of Inspection. It was a task of no mean order to organise and direct the many-sided inspection operations which his duties involved. Although he was not robust in health, he never failed to inspire the best service from his entire staff because of his own devotion to duty. It is with regret that this very able officer's career was cut short at such an early age. On his return to England after the war he was in indifferent health, but really did not know how ill he was. He kept on duty to within a fortnight of his death.

His work remains, and Canada is better to-day because of the fine service he rendered to industry and to his country.

CHAPTER XXVI

MUNITIONS WORKERS IN CANADA

Looking back into the earnest and determined faces of the men and women who toiled for the Empire in the widespread factories of the Dominion, and thinking of what they accomplished during the four years' struggle, one is impressed with the latent possibilities of the masses which require only noble impulses and opportunities to give them expression.

The motive of self-interest or self-preservation was not the mainspring of their conduct during those dark years. There was behind these very human interests a something which few could clothe in language or analyse, but which found expression in the common word patriotism.

Canada an Agricultural Country.—Before the war the workers of Canada were generally regarded by the rest of the world as agriculturists. Unquestionably this great granary of the world had absorbed a big percentage of its man power, and had taught it in terms of the soil. Agricultural skill was unacquainted with factory life and its demands. It is a mistake, however, to believe that Canada had not a comparatively large industrial skill.

Industrial Canada.—While in 1881 ¹ 48·1 per cent. of the workers in all 'gainful' occupations were employed in agriculture and only 11·7 per cent. in manufacture, in 1911 a marked change had taken place by steady increments during the intervening years which altered the percentages to 34·3 for agriculture and 18 per cent. for

¹ *Canada Year Book*, 1921, p. 600.

250 MUNITIONS SUPPLY IN CANADA

manufacture. The growth of manufacturing production in Canada may be expressed more forcibly in terms of exports of manufactured products, which increased from less than \$3,000,000¹ worth per annum on the average during the years of 1871-1875 to \$435,000,000 in the fiscal year ended March 31, 1920. Taking the figures² of employees, according to the quinquennial census, it is found that in 1870 there were 187,942 compared with 497,170 in 1915. Most of these were in Ontario, Quebec, and the Maritime Provinces. Therefore, although the munitions industry was entirely new to Canada, there was the nucleus of skill from which were drawn the craftsmen who, in 1914, showed to their fellow workers what could be accomplished in finishing products to standards of precision far exceeding their former knowledge.

The Task before Manufacturers.—When the first contracts for munitions were undertaken in 1914 by manufacturers, large drafts of skilled workers from the manufacturing centres had joined up and were in training to go overseas with the first contingent of 330,000. Those who were left had to be trained in the new industries. From the raw inexperienced men who were trained many discoveries of real ability were made. The losses incurred in training were very considerable. One manufacturer said that it cost him approximately \$300 to train each munition worker. His figure was based upon the average losses due to bad workmanship, breakages of machines and tools, during what might be termed the apprenticeship period. This figure was also confirmed by another large employer in another manufacturing district. It was, therefore, sheer hard work and patience on the part of foremen and superintendents which raised the standard of workmanship. There came a time during the war when it seemed impossible to obtain any kind of labour, and the problem was full of perplexity.

During June, July, and August, 1916, the shortage of male labour became so acute that practically all munitions

¹ *Canada Year Book*, 1921, p. 356.

² *Canada Year Book*, 1921, p. 362.

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manufacturers were failing to keep their promises of deliveries. It became evident that the Board would fail in the discharge of its obligations to the British Government unless something was done. The Chairman of the Board resolved to tackle the problem and see how manufacturers could be assisted in securing labour.

Labour Department, Imperial Munitions Board.—The Chairman decided to form a department to deal with labour matters. He approached Mr. Mark Irish, M.P.P., and asked if he would study the problem and see how it could be solved. Mr. Irish's legal and political training, together with his public and political service, fitted him in a peculiar way for investigating the problem. He undertook the direction of the Labour Department of the Imperial Munitions Board, and applied his energies to the tasks immediately. A head office of the department was established at Toronto, it being considered best to commence operations there.

What was Needed.—Mr. Irish concluded that if labour were to be found the people of the country should first be aroused to the vital necessity of producing munitions; and second, conditions of labour should be made attractive; and third, women should be induced to produce munitions. With this programme he gathered together an organisation and worked along these lines, which proved to give excellent results.

How Work-people were Informed.—A publicity campaign in England, through advertising, lectures, and other means met with great success. Mr. H. E. Morgan (now Sir Henry Morgan, K.B.E.) was sent out to Canada from the Ministry of Munitions to confer with the Board on methods of propaganda. He advised an advertising campaign in the daily press which circulated in the districts most acutely affected. With the aid of Mr. T. T. Gibbons, Advertising Expert of Toronto, a programme was mapped out. About this time the Dominion Government established a National Service Board, under the direction of Mr. R. B. Bennett, K.C., M.P., who co-operated with the Imperial Munitions Board, and carried

to completion the advertising campaign under its auspices. The results were most gratifying in providing sufficient unskilled labour.

Shifting of Labour.—As might be expected, the shortage of labour, coupled with the pressing demand for deliveries of munitions, was responsible for a very undesirable and irritating practice which grew up between manufacturers. It amounted to the purchase of labour at the highest prices. For instance, manufacturer A would induce workers to leave manufacturer B for higher wages. This old practice in milder form was common to all industries, but it was greatly aggravated at the time in question because, during 1916, many additional munitions factories were raised, and skilled men had to be found somewhere. The only field was in the existing munitions factories. In the large manufacturing centres the Department of Labour was unable to control this movement of labour, but in the smaller centres, where not more than ten manufacturers operated, the movement was arrested by a common-sense plan of mutual agreement between the manufacturers to pay the same wages for the same labour.

Wages of the Workers.—The wages question, in regard to munitions workers, was not free from embarrassing problems. During the development of the munitions industry two predominating classes of labour held the field. The one class, the tool-maker and millwright, such as the trained mechanic; the other class, the common unskilled worker, taken from any pursuit, who could be trained to tend a machine.

Tool-maker Class.—The wages of the tool-maker rose rapidly because of the great demand for his services. From 35 cents per hour to 65 cents and a maximum of 1 dollar per hour, with time and a half for Sunday labour, was the scale of pay secured by him. The Department of Labour of the Imperial Munitions Board had no authority to set limits or to control the wages paid so long as the manufacturer fulfilled the terms of his contract. The Imperial Munitions Board had no

domestic authority, nor could the Canadian Government interfere.

Tool-makers become Operators.—The workers comprising the great unskilled body of labour which became so skilled in operating machines and in doing other repetition classes of work became known as operators. In nearly all cases operators were paid on a piece-work scale. Often for want of knowledge and experience manufacturers would fix prices, which remained unaltered during the contract, on work which the operators, becoming skilled, could produce at a much greater speed than calculated, with the result that in many cases the wages earned by them far exceeded the wages earned by the skilled tool-makers, tool-setters, and millwrights. When the skilled mechanic saw the unskilled worker reaping such a harvest under the piece-work system, he forsook his trade and joined the ranks of common labour. This, however, reduced further the already depleted ranks of tool-makers. The situation was in some measure relieved by crowding the ranks of the operators with more workers, and enabling the manufacturers to avoid employing a skilled mechanic as an operator, thereby forcing the skilled mechanic back to the tool room.

Importation of Labour from U.S.A.—The Department of Labour established an employment bureau to receive and to allocate to plants, according to their needs, the skilled tool-maker, tool-setter, and millwright. It was necessary for several months to import these tradesmen from the U.S.A. The Immigration Department of the Dominion Government helped the Imperial Munitions Board by allowing men to be brought over, on certificate from the Board's Department of Labour, although they had not the sum of money necessary to comply with the Immigration Act. The Bureau allotted them to factories as required.

After the entry of the U.S.A. into the war, not only was importation stopped, but many of those who had been imported had to return to be drafted into the American Army, or to munitions factories in their own country.

For the last year of the war the number of skilled tradesmen was much below that required for full efficiency.

Assistance of Ontario Government.—The withdrawal of skilled men from Canada by the U.S.A. Government made it imperative to establish offices in different large manufacturing centres for the registration and supply of labour. The Ontario Government very generously placed at the disposal of the Board the head of its Trades and Labour Department. The Government also defrayed all expenses necessary to carry out the plan of opening offices in various towns where munitions contractors could apply for labour without fee. The plan was devised by the Labour Department of the Imperial Munitions Board, and proved to be of much service. Offices were opened in Toronto, Ottawa, and Hamilton. There were numerous offices opened in smaller centres and towns for varying periods according to the requirements of the situation. The Imperial Munitions Board greatly appreciated the help of the Ontario Government.

Women Workers.—35,000 women, it is estimated, helped to produce munitions in Canada during the war. Women from all classes of society contributed to this great service. They worked nobly and inspired success. Prior to October, 1916, no woman had been employed in a metal factory in Canada. The Department of Labour had to meet objections from employers and employees alike when it suggested the use of women workers.

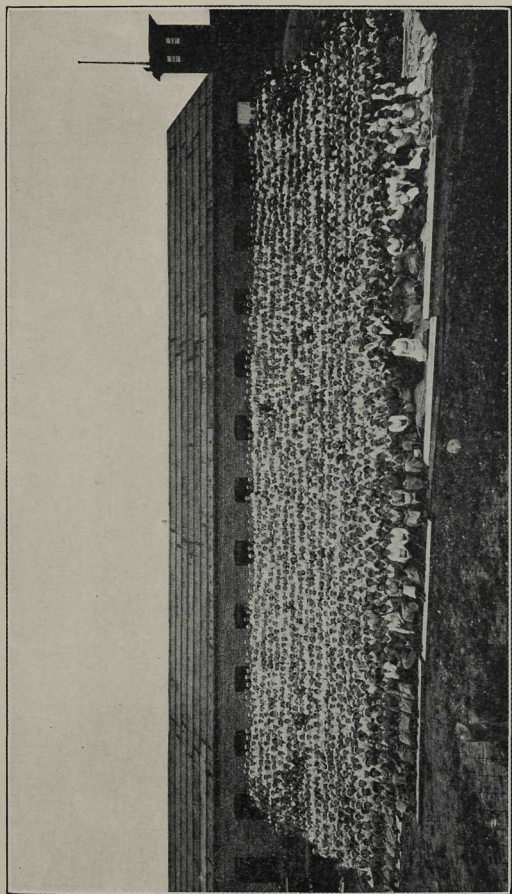
Objections to Women Workers.—Employers doubted the efficiency of women on such work, and feared that expenses would be great in breakages due to accidents.

The employees feared that the innovation might permanently oust the man from his employment.

The women themselves doubted whether they could stand the noise of the factory and its dirt and grime.

All thought that if women did work in the factories they could machine only light parts of munitions.

The Work Women Undertook—Contrary to expectation, all the imaginary objections were removed. Not only were women able to machine light components of



1800 OUT OF 2400 FEMALE EMPLOYEES AT THE NATIONAL FUSE FACTORY, VERDUN, MONTREAL

fuses and similar warlike stores, but, with the assistance of mechanical devices, machined the largest shells made in Canada. The 9·2-in. shells made by the Canada Cement Co., under the able direction of Mr. F. P. Jones, were fabricated entirely by women from the forging to the shipping stage. In less than five weeks from the day Mr. Jones started manufacturing 9·2-in. shells 400 women were successfully employed on this work.

Film Showing Women at Work.—Encouraged in the belief that the labour shortage could be made up by the efforts of women, plans were devised by the Board's Labour Department to distribute literature amongst manufacturers, churches, and all organisations likely to reach the female market. A film also was manufactured and exhibited in every city and town in Canada showing the work women could do in munitions factories. This piece of unremunerated service was done well by Mr. Robert Kidney, who was in charge of this section of the Board's work.

Welfare Work.—The Department of Labour having secured for employers the help of women, it was able to induce them to provide healthy and comfortable conditions for the workers. Various systems were introduced by manufacturers for the employment of women ; some worked a six-hours' shift, others, eight hours. It was also agreed that women would be paid the same rates as men for the same work. In addition to these conditions most employers provided rest rooms for the workers, with a matron in charge. Canteens were also established and run by the Y.W.C.A. In fact, every care was taken for the comfort and welfare of the women workers. Mrs. Fenton, Supervisor of Women Labour in the Department of Labour, did much service to women workers by her influence and care for them.

Conclusion.—Mr. Irish and his band of helpers did a great work. They entered the field at a time when a wave of enthusiasm was required to stir the qualities of heart and mind of the workers to a great service, and they

were successful. Not only were new processes mastered by the workers of Canada, but there was developed a moral sense without which the memory of the struggle would be sordid. Here is one of many incidents during the war which illustrates the kind of character possessed by many of the workers. A woman, while machining 18-pdr. shells, heard the news that her boy had been killed at the Front. For an instant she was stunned. Her comrades advised her to go home, but she would not listen to them. She set her face like a flint and worked harder than before.

To say that the workers were angels and gave no trouble would be untrue. Disputes arose from time to time. They were not always settled without much anxiety and difficulty. By the harmonious efforts, however, of the Imperial Munitions Board, the employers and the workers, a service was rendered by the men and women of Canada which will be the marvel of future generations.

CHAPTER XXVII

FINANCE AND ACCOUNTS

It was of the greatest importance to Canada, during the war, that the Chairman of the Imperial Munitions Board was not only a wise administrator but an able financier.

As President of the National Trust of Toronto and Director of the Bank of Commerce, he touched the sinews and knew the pulse of Canadian finance.

When he took over the work of the Shell Committee upon which 74 million dollars had been expended, and an additional 200 millions were involved in contracts in process of completion, he saw possibilities of great expansion and much greater demands for money.

To secure the necessary money was certainly a problem ; but adequately to safeguard and account for its expenditure was another.

Mr. F. A. Riddell.—The thorough work done by Mr. F. A. Riddell, Financial Adviser to the Shell Committee, and his staff under the direction of Mr. Boyer deserves much praise.

Mr. George Edwards.—Soon after the Imperial Munitions Board was formed, Sir Joseph Flavelle asked Mr. George Edwards if he would examine the methods of accounting employed, and make any suggestions he thought advisable for their improvement.

It was not in the mind of Sir Joseph that Mr. Edwards, the head of a large and important firm of accountants in Toronto, could spare the time to the personal supervision of the accounts, but after Mr. Edwards had gone into the whole matter he volunteered to give his whole time and undivided service to organise and control the accounts of the Board.

It was an important and far-reaching decision—resulting in a distinguished record.

Quiet, unassuming, and retiring might describe superficially this man of figures. His love of truth produced an accuracy and skill which eliminated error. He was scrupulously careful of the smallest details in the great volume of vouchers and other documents which grew to such large dimensions in connection with the work of the Board.

British Authorities' Appreciation.—The imperial authorities spoke in unqualified praise of the character of Mr. Edwards's work, and asked him to supervise, for the Ministry, the opening of the accounts in New York in the same manner as the set of accounts which he developed in Ottawa.

The British Auditor-General, who sent his officials to Ottawa to make an audit annually, spoke in commendation of Mr. Edwards's work.

Mr. Edwards, Auditor as well as Accountant.—In addition to Mr. Edwards being the only officer of the Board in charge of its accounts, he was also Auditor for the Ministry of Munitions, a curious but very interesting anomaly. This fact, however, shows what confidence the British Treasury placed in him.

Liquidators.—But further, when following the Armistice the period of liquidation set in, Mr. Edwards was appointed by the British Ministries concerned, together with the Chairman of the Board, as liquidators of all assets in hand.

Sections I and II by Mr. Edwards.—Mr. Edwards sets forth clearly the following facts in the two sections which follow, regarding the financing and accounting of the Shell Committee and of the Imperial Munitions Board :

SECTION I.—FINANCE

Every story, whether of romance or achievement, has its matter-of-fact side. No great enterprise is now undertaken which does not have to be financed in some way.

These are not the days when temples and pyramids can be reared into space by the devotion of masses of people fired with religious enthusiasm, or the labour of conquered nations held in bondage. Modern enthusiasm stops short of any form of sustained effort for which there are no visible compensations. It was inevitable, therefore, that money—that modern standard by which the value of labour and material is measured under our economic system—would be the key factor in the success of the work undertaken by the Shell Committee and its successor, the Imperial Munitions Board. And where there is money, there must be accounts. While, therefore, a chapter on finance and accounting will lack to a large degree the element of human interest which attaches to other parts of the story, it may help to convey some impressions to the reader who thinks of things accomplished in terms of money and business organisation.

Financing Generally.—Financing the production in Canada of munitions of war and ships, and the training of recruits for the Aeronautical Service, involved a money supply between August, 1914, and November, 1918, of nearly twelve hundred millions of dollars. The necessary business and clerical organisation to safeguard the expenditure of so much money numbered at its highest point about twelve hundred people. This figure, it is to be understood, does not include upwards of three thousand persons whose duties were of a technical nature, chiefly inspection, or any person, however occupied, on the pay rolls of contractors or others with whom the Board transacted its business. In a sense, therefore, each member of the organisation may be said to have spent, or at any rate have represented the expenditure of, approximately a million dollars. If the recognition by all of the common purpose in view, individual devotion to the duty of accomplishing it, and the record which that accomplishment furnished of co-ordinated effort, counts for anything, it is not giving too much credit to say that each one of the twelve hundred took care that his million dollars was spent to good advantage.

How the Shell Committee was Financed.—At the outset of munitions production in Canada the money supplies were furnished by the Imperial Treasury by way of New York through the Minister of Finance for Canada. The funds thus provided down to the date of the disbandment of the Shell Committee amounted to seventy-four million dollars. In the latter part of 1915, however, it became expedient to provide funds for the Board's operations in some other manner, and informal negotiations were set on foot by the British Treasury with the Canadian Government, and also with the Canadian banks, to provide dollars in Canada by way of loan to the British Government for the period of the war, for the purpose of partly meeting British expenditure in Canada on munitions and other purchases, and thus relieving to some extent the drain on the Treasury funds which were available, or could be expected to be available, in New York.

Sir Thomas White Raises Canadian Loan.—About this time, the Canadian Minister of Finance, Sir Thomas White, decided upon an effort to raise money to provide for Canadian war expenditure by means of a domestic loan, a method of financing not previously attempted in Canada. Fifty million dollars were asked for, and somewhat to the surprise of qualified financial experts, something over double that amount was subscribed. With the consent of the subscribers and the approval of the Government, a further fifty million dollars was accepted and specially allocated to assist in financing the production by Canadian industry of the war material required by Great Britain. Consideration of the possibilities of further financing as the result of the abundant circulation of money in aid of Canadian munitions production led to an important understanding between the two governments and the Canadian chartered banks substantially as follows :

Understanding between the British and Canadian Governments and Banks.—(a) The Canadian banks in combination agreed to advance through the Canadian Government to the Imperial Munitions Board a sum of

seventy-six million dollars in the course of 1916, to help to meet the expenditure on munitions in Canada. This amount was afterwards increased in July, 1916, to one hundred million dollars. The advance was secured by the deposit of sterling Treasury bills in London. (b) The Canadian Ministry of Finance undertook, in addition, to advance to the British Government through the Imperial Munitions Board a monthly sum of twenty-five million dollars through the second half of 1916 to assist in financing its expenditure.

The balance of the expenditure of the Board was met as before by remittances from the British Treasury, made out of the Treasury dollar funds in New York.

It should be noted that, in addition to the above, both the Canadian banks and the Canadian Ministry of Finance were also called upon from time to time to make additional advances to the British Government, to assist in financing the purchase of wheat and other foodstuffs in Canada.

Other Sources of Money Supply.—No additional general loans to meet the Board's operations were arranged with the Canadian banks after the first one hundred million dollars referred to above, but the Board at various times obtained additional assistance from one or two of the larger banks, and in one case from the Canadian Pacific Railway Co., in the shape of temporary loans for a fixed period. Generally speaking, however, the burden of making further advances required from time to time was assumed by the Canadian Ministry of Finance, which advanced to the Board in all the amount of ninety-five million dollars during 1916 and of one hundred and thirty million dollars in the first six months of 1917. In the same period the direct remittances of the British Government to the Board on Treasury funds in New York amounted to ninety million dollars and seventy-one million dollars respectively.

New York Money Markets Closed.—Shortly after the United States entered the war the New York market was closed to further loans by the British Government,

whether against collateral or otherwise, as the United States Government took upon itself the duty of providing funds for British war expenditure in the United States. The United States Government, however, insisted that the funds which it provided were to be used for purchases in the United States alone and not for purchases in Canada. Certain exceptions were made to this rule. For instance, it was arranged that the United States credits given to Great Britain could be used, up to a certain amount, for the purchase of wheat in Canada. It was also agreed that a certain monthly sum, calculated to be the equivalent to the amount expended in the purchase of raw material, etc., in the United States for the purpose of munitions manufacture in Canada, should be allowed to be used from the United States credits given to the British Government for disbursements in Canada.

Advances by the Canadian Government.—In spite of the allowances, however, it was necessary for the Canadian credits to the Imperial Munitions Board to be substantially increased, in order to allow the work of the Board to continue on the scale which it had assumed. As a result of the negotiations on this subject between the Canadian Ministry of Finance, the British Treasury, and the Imperial Munitions Board acting for the Ministry of Munitions, the advances of the Canadian Ministry of Finance to the Board were fixed at twenty-five million dollars monthly from the first of July, 1916, and remained at that figure until the conclusion of the Armistice.

In addition to this a special advance of twenty million dollars was made by the Canadian Ministry of Finance to the Board for the purpose of enabling it to undertake wooden shipbuilding in Canada.

The balance of the monies required for the Board's expenditure was provided by the British Government remittances made from New York out of the limited United States credit allowed for this purpose under the arrangements indicated above.

Total Sum Advanced by Canadian Government.—The total sum advanced to the Board by the Canadian

Ministry of Finance, by way of loan to the British Government, was seven hundred and fifty-five million dollars. The Board had also received a loan of one hundred million dollars from the Canadian banks, as stated above, and a sum of three hundred and ninety-five million dollars in direct remittances from the British Government, making a total expenditure of twelve hundred and fifty million dollars.

The advances of the Canadian Government were partly offset by advances made by the British Government in England and France, for the expenditure on the upkeep of the Canadian Expeditionary Force.

How the Money was Expended.—The internal arrangements between the Board, the Ministry of Munitions, and the British Treasury, with regard to its expenditure, were as follows : The Ministry from time to time, after obtaining the Treasury sanction, authorised the Board to proceed with a certain programme of munitions production. After the period at which the estimates of the Board became fixed, *i.e.* after the early part of 1917, it was necessary for the Board to satisfy the Ministry and the Treasury that the proposed programme of production fell within the limits of the funds which would be available, either from the credits promised by the Canadian Ministry of Finance, or from the fixed sum allocated to the Board out of British credits in the United States. The Ministry also authorised a certain cost for each item of the programme, *i.e.* so much per shell or component, etc. The Board was responsible for keeping within the cost, but subject to that had a free hand in letting contracts and making purchases for the execution of the programme. The total actual cost of the munitions production of the Board and the Shell Committee taken together was nine hundred and ninety-five million dollars as compared with an authorised cost of ten hundred and fourteen million dollars ; that is to say, in actual production a saving had been made of over nineteen million dollars as compared with the authorised cost of each item taken separately. The loss sustained in realising upon

the stocks of raw material, components in course of manufacture, and completed munitions awaiting shipment to Europe at the cessation of operations is included in the total cost above mentioned.

Administrative Expenses.—In the matter of administrative expenses the Board was also given a free hand, by special arrangement with the British Treasury. It was agreed that a sum equivalent to three-quarters of 1 per cent. on the amount of its expenditure should be allowed to the Board for administrative and overhead cost. Subject to keeping within this limit, and to referring for sanction by the Ministry and the Treasury a few salaries above a certain figure, the Board was allowed a free hand in its administrative expenditure. The actual administrative expenditure of the Board amounted to six million four hundred and thirty thousand dollars, or about 0·63 per cent. on the amount of its total expenditure.

Inspection Expenses.—A similar arrangement was made with regard to inspection costs. The Board was responsible for the financial though not for the administrative and technical control of the Inspection Department. The Treasury sanctioned an allowance of 2 per cent. to $2\frac{1}{2}$ per cent. on the total expenditure (taken for convenience at $2\frac{1}{4}$ per cent.) for meeting the costs of the Inspection Department, and the Board was responsible for keeping the amount within this figure. The actual amount expended on inspection was twenty-one million dollars, or about 2·11 per cent. on the total expenditure.

National Factories Expenses.—In dealing with the side of finance, a word may be given to the method adopted in regard to the National Factories established by the Board for the production of fuses, aeroplanes, propellants and explosives, shell forgings, etc. Instead of running these as establishments directly owned by the British Government, as was done by the Ministry of Munitions in Great Britain, it was judged more convenient and advisable to adopt a commercial form of organisation. In each case, therefore, a limited liability company was formed under Canadian law, with a capital stock of

\$50,000, the whole of which was subscribed and owned by the Board as Trustee for the British Government. The companies so formed, erected, owned and operated the national plants, the directors and management in each company being nominated by the Board.

Products Fixed at Same Prices as Paid to Contractors.—The product of the plants was charged out to the Board at a fixed price, which in no case was fixed higher, and in some cases considerably lower, than the price at which a contract for the same product could have been let to private contractors at the time the factory was erected. All profits were devoted, first, to amortisation of the capital cost of the plants. Any surplus after this, as well as the ownership of the amortised plants, reverted to the British Government through its ownership of the stock in the companies. The total capital expenditure on seven national factories was seventeen million dollars. Up to the cessation of operations, the accounts of all the companies taken together showed an operating profit of sixteen million dollars, *i.e.* this was the difference between the value of the product at the fixed price and the total cost of production. This sum, together with the sums later realised from the sale of plants, enabled the Board to return to the British Government their original investment, and approximately a million dollars in addition.

Flying Squadron Expenses.—An incidental activity of the Board, not in the strictest sense munitions production, had to do with the training in Canada of aviators to recruit the flying squadrons at the Front. Some discussions had taken place in London in 1916, in which the Chairman of the Board and the Minister of Air participated, regarding the advantages of training such recruits in Canada, but it was considered unwise to set up the necessary imperial military establishment on Canadian territory. Subsequently, the emergencies of the British food transport, combined with the obvious advantages of the plan itself and the promise of cordial co-operation by the Canadian Prime Minister, led to its adoption, and the task of producing and furnishing the physical equipment, including

flying machines, was undertaken by the Board. The outlays for this purpose amounted to over \$23,000,000. It has already been stated that the total value of munitions exported at agreed prices left a margin of profit to the Board of nineteen million dollars. The further sums paid during the course of liquidation by way of compensation to contractors for the cancellation of contracts ultimately reduced this surplus to approximately five million dollars.

No Litigation or Arbitration Necessary.—It is worthy of particular mention that the liquidation and final winding up of this great enterprise involving, in the course of its business operations, a rate of expenditure exceeding that of the Canadian Government itself was accomplished without recourse being had to litigation or arbitration in any single case, notwithstanding the position taken by the liquidator, Sir Joseph Flavelle, that contractors deeming themselves to be unfairly dealt with in the matter of a final settlement should have the same remedies at law as though they were dealing with private parties and not with the Crown. The settlements effected, while in every way conserving imperial interest, were such as to strengthen, in a very definite way, imperial sentiment in Canada.

Net Results.—The precise outcome, therefore, of the Board's operations in Canada on behalf of the British Government is that all costs, including experimental and preliminary expenditure, actual costs of production, administration and inspection, the shrinkage due to the realisation upon surplus material, and the compensation allowed to manufacturers by reason of cancellation or discontinuance of their operations, had been provided for out of the price which the Ministry of Munitions agreed to allow for the munitions actually exported, and in addition there has been returned to the Treasury a net surplus of five million dollars or thereabouts, which is equivalent to one-half of 1 per cent. of the agreed prices.

SECTION II.—ACCOUNTING

The Accounting Department of the Shell Committee had been organised under the direction of well-known chartered accountants, and was admirable in every way.

Some seventy-five millions of dollars had already been expended, and the orders in hand when the Board came into being called for further expenditures of two hundred millions. The existing organisation was enlarged and the system amplified to cope with the enormous prospective business, regard being had rather to the requirements of a commercial undertaking than those of an imperial government department.

Policy of Board.—An accounting department does not lend itself to description, but from the nature of the problems with which the Board had to deal, an adequate system of accounting and finance was bound to include many unusual features. It was the policy of the Board to go to original sources of supply in order to meet its requirements, not alone for the purpose of saving the middleman's profits, but also for the purpose of enabling a greater number of contractors to undertake the Board's work without an undue employment of capital. The material thus purchased was passed on from one contractor to another, each contractor being paid a contract rate for the labour expended upon it. This material took varied and new forms as it passed through the hands of the various contractors and entered into new combinations, all necessary to the production of the finished article. It frequently happened that material purchased in its crude form by the Board passed through the hands of seven or eight contractors before emerging in its finished form, and it was vitally necessary that all these multifarious movements of materials should be under control and properly recorded. The underlying theory of these operations was that of the personal responsibility of the contractor for the material in his hands—each contractor in turn relieving himself from responsibility as to the definite quantities by shipping the same to other

contractors. The Board was without any central storage or merchandising facilities. Its vast stocks of material, amounting at one time to \$100,000,000, were in the hands of the contractors, who were personally accountable to the Board for the quantities acknowledged to have been received by them, and thus one contractor's responsibility only ended when another contractor assumed it. When the time eventually arrived that the manufacture of all this material for munitions was to be discontinued, each contractor who had Board material in his hand either produced the quantities of materials with which his account stood charged on the books of the Board, or, failing that, paid to the Board the cost of what he could not produce. In the final accounting, therefore, the item 'missing stores or materials' as a debit to the Profit and Loss Account was conspicuous by its absence.

Accounting System.—The accounting system consisted substantially of a set of controlling accounts which, in their assembled form, constituted a general ledger. Each of these accounts controlled subsidiary systems which recorded the various phases of the Board's operations. The chief subsidiary groups were those which related to finance, materials and stores in process, personal accounts with contractors, and production and export. By reason of the enormous amount of detail involved in recording these many operations, a daily system of audit was followed. The business of the day commenced at noon and ended at noon of the following day. During each afternoon the transactions of the previous day were recorded; between sunset and sunrise these transactions were audited, and from sunrise to noon the corrections, arising out of the audit, were made and balances struck at midday. This system gave finality to each day's work, and enabled each succeeding day's operations to be recorded without the hampering conditions arising from arrears of any sort, either in accounting or auditing.

The Staff.—The financial, accounting, and auditing staff of the Board at the point of its highest production included something over five hundred persons, or nearly one-half of the total administrative staff.

CHAPTER XXVIII

SIR JOSEPH FLAVELLE, BART., CHAIRMAN OF THE
IMPERIAL MUNITIONS BOARD

It is no exaggeration to say that the work accomplished by the Imperial Munitions Board was the work of a great mind. Judged from any point of view the control and gradual development of this organisation bears the mark of one and the same mind. There were departments, committees, directors, and numerous active officials that multiplied as the work grew ; all performed distinct functions marked with individuality ; and yet all resembled that of a finely geared machine noiselessly running and under the control of an experienced operator.

Full Administrative Authority.—The Chairman of the Board accepted full administrative authority. To some it appeared inadvisable to place in the hands of one man such power. In some hands such authority would have wrecked instead of built up a great organisation. Sir Joseph Flavelle in the exercise of his duties never gave the impression that he alone carried absolute executive authority, but rather made each officer feel that he was master of his own work. While he regarded the machinery of organisation as a necessity, he always considered it secondary to the influence of the individual. In his choice of men he showed great judgment. When he was satisfied that a man was big enough for the task, he left him to it. He made all feel that they were working together as friends for a great cause, and he won their confidence and loyalty.

The Hand on the Wheel.—All the work of the Board was gathered up in complete and concise records for

presentation to the Board meetings fortnightly. The machinery of accounting and finance worked like clock-work. It was ceaseless. Balances were made each twenty-four hours, ending at noon daily. As a result the value of all orders received weekly and the total value to date, along with weekly and total disbursements, were presented to the Board. In addition, the total value of all munitions shipped and the weekly value for the preceding month were given. This involved the insurance and checking of millions of components constantly passing from factory to factory, the insurance for which at one period amounted to 32 million dollars, carried by the contractors. Adjustments also had to be made constantly, due to spoiled and defective components. Everything was ordered with precision and without bustle, but it was regulated by the hand at the wheel.

The Chairman's Room.—The Chairman's room was not only the clearing house for the settlement of all departmental matters and manufacturers' troubles, but it was the audience chamber for envoys from Allied countries. Hardly a day passed without visits from distinguished government officials, either directly or indirectly concerned with some phase of the work. All were received with the same courtesy. In addition to those from afar, Ministers of the Dominion and provincial governments came and consulted him. Each province, except Prince Edward Island, felt the throb of the munitions business. It touched the life of the people. Constantly problems arose which could be settled only by an interview at Ottawa. The room of the Chairman became, in addition to a clearing house and audience chamber, an arbitration court. It was not uncommon for several deputations to wait upon the Chairman during the same day.

Some Characteristics.—The Chairman loved work. Usually from early morning until midnight he was at the Transportation Building. His endurance astonished everybody. One marked characteristic was the ease with which he detached himself from one subject and concentrated with equal grasp on another. No matter how

intricate the problem under discussion he would sum up the facts in a way which usually carried the judgment of all. This characteristic was most apparent in replying to deputations. Men sore and often angry about conditions would pour out their troubles round the conference table. After they had exhausted themselves, the Chairman would analyse one statement after another and finally show the fairness of his decision. Manufacturers and others did not always get what they expected, but, as a rule, they left satisfied that they had a square deal. He seemed to refer everything under consideration back to one standard—his interpretation of trusteeship for the imperial authorities. He allowed neither friend nor foe to deprive him of his high sense of duty to the Crown. In speaking of the work of the Board he said: 'In awarding contracts they (the Imperial Munitions Board) adopted the simple principle of placing them with firms or corporations qualified to do the work. They refused to permit the pressure of personal or party interests to influence their decision.' This 'simple principle' was applied to all his manifold duties.

Risks Taken.—Having full administrative authority he took risks and made decisions which often involved heavy expenditure of money before confirmation of his action could be obtained from the Ministry. One day the representative of the British Auditor-General, who was in Canada inspecting the accounts of the Board, directed attention to certain transactions which were irregular in that they were without authorisation. The Chairman replied they were irregular, there was insufficient authorisation, but good sense directed that they should be undertaken, which brought the rejoinder from the perplexed official 'I must say they seem to have worked out exceedingly well.'

While he took risks he always made sure of his ground. Once he went to Sir Thomas White, the Finance Minister of the Federal Government, and asked for the loan of one million dollars to put up the National Aeroplane Factory in Toronto. He promised at the same

time repayment from the profits made on aeroplanes. Sir Thomas seemed very incredulous about profits. The money, however, was loaned, and the Minister was greatly surprised when, in less than two years, the Chairman handed him a cheque for the million dollars.

Unpleasant Duties.—In considering the work accomplished it must not be forgotten that tasks of extreme difficulty were undertaken. One of the first was the reduction of shell prices. Some of the older contracts for shells were still unfilled, while other contracts for the same sizes of shells were being placed at lower prices. It was the policy of the Shell Committee to review and reduce the price of shells when contracts were renewed, but they did not reduce the price of shells during the term of the contracts. The Chairman of the Board reviewed all contracts where contractors were behind in deliveries, and where the contract prices were higher than were paid for the same work issued at a later date, the undelivered portion was either cancelled or the price reduced unless sufficient reason was given why this course should not be taken.

Manufacturers not unnaturally resented the reduction and cancellation, but had to admit the Chairman was justified in his action, as the high prices had been established through urgent need for early and stated deliveries, and they had failed to make the deliveries. The work of cutting down was done with impartiality, and resulted in a saving of about 4,000,000 dollars.

His Policy.—The policy of employing every factory in Canada which could be adapted for the production of munitions was pursued with great energy. The aim throughout was to purchase from, and manufacture in, Canada everything possible. The Chairman encouraged the small and large manufacturer to equip, extend, and build new factories. Technical and financial help was given when required. By so doing, in little over a year the rate of production increased from 180,000 to 800,000 per week. When it was found that the national factories would serve the interest of the Crown they were

established. He adopted a liberal policy. He met every situation as it arose with the same outlook. When towards the end of 1917 the demands for British shells decreased, he turned to the U.S.A. Government and offered Canada's idle capacity to them, which up to the Armistice was kept busy supplying munitions to the U.S.A.

He Continued to the End.—When the Armistice was signed, work to the value of millions of dollars was suddenly suspended throughout Canada. All materials in different stages of manufacture had to be valued. The intricate and exacting task of assembling and checking records of work done and valuing materials used on each contract for its complete liquidation was much simplified by the Board's excellent system of auditing and accounting.

The Chairman might have chosen to leave the work of liquidation to others and have taken the well-deserved rest he had won, but he did not. With the same deliberate care and justice he presided over this delicate task, and had the satisfaction of seeing it completed without one case of litigation.

His Qualifications.—It may be asked how a man who knew nothing about munitions could in the course of three years build up and maintain such a great business. His career was not uncommon to many Canadians who had by hard work, indomitable perseverance, and integrity carved their way from the lowest position in the office or factory to that of president of a great industrial concern. Here, however, was one who had attained to many such positions of leading influence. Moreover, his public services on commissions for social and other reforms, and his great work for the Hospital and University of Toronto—all expressions of untiring and unselfish effort—told of an uncommon capacity and humanity. It was with this public name for character and ability and achievement that Sir Joseph Flavelle excelled all his past records in administration. His frank, far-seeing way of stating and doing things established the faith of all his

staff in him; and the privilege of his counsel and friendship meant much to each of them personally. It was his great gift of making friends instead of servants which inspired a loyalty unsurpassed in any administration.

Address from Members of Board and Staff.—At a banquet at the Château Laurier on the evening of Monday, November 25, 1918, at which Sir Joseph Flavelle presided and was supported by the Rt. Hon. Sir Thomas White, Acting Prime Minister, and the Hon. N. W. Rowell, President of the Council, and other distinguished guests representative of Allied services, tributes were made to the great work accomplished by the Chairman, and the following address was presented to him:

TO SIR JOSEPH FLAVELLE, BARONET:

His friends, whose names are undersigned, who have been associated with him in the service of the Imperial Munitions Board, wish to offer a most hearty and sincere assurance of their affection, their admiration for his great work, and their respect for his public and private character.

Honoured by the King.—His great services were recognised by His Majesty the King, who conferred upon him the honour of a Baronetcy in 1917.

Cable from Mr. Lloyd George.—Mr. Lloyd George, Prime Minister of the British Government, sent the following cable to Sir Joseph Flavelle after the Armistice:

Now that hostilities have ceased, I am anxious to send you, on behalf of myself and my colleagues in the War Cabinet, our congratulations on the great work of the Imperial Munitions Board for three years, which has been of such signal assistance to the British Empire and to the Allied cause.

It is a great and varied achievement for your Board, not only to have produced so great an output of munitions, representing no small proportion of the shells used by the British armies, but also to have built over 350,000 tons of shipping for the Ministry of Shipping, to have assisted to so great a degree the Royal Air Force in Canada, to have developed the great output of aeroplane timber which has been essential to our Air Service.

As the Board was appointed by me when I was Minister of Munitions, it is particularly pleasurable to me to recognise the success, efficiency, and value of its work, and to thank you, and your staff who have so splendidly assisted you, for the great service so rendered.

Cable from Mr. Winston Churchill.—The following quotation from the cable of the Minister of Munitions sent to Sir Joseph Flavelle, on the conclusion of peace, expresses what all felt about him :

You have carried through a work of the greatest magnitude with uniform success and efficiency, and I wish to pay my personal tribute to the great ability, energy, and organising power you, as Chairman, have shown.

Sir Joseph Flavelle, however, never took the credit to himself. He always sought to share it with his great band of workers, who looked upon him more as the head of a family than of a vast munitions organisation.

CHAPTER XXIX

THE VALUE OF THE MUNITIONS BUSINESS TO CANADIAN INDUSTRY

DURING the war period of munitions manufacture in Canada it became increasingly evident that a new opportunity had arisen for the development of Canadian industry after the war. Many minds were directed to the problems involved, and much valuable work was done towards their solution.

Reconstruction Period.—It was feared that immediately war ceased there would be a period in Canada, as in other industrial countries engaged in munitions manufacture, when the position of trade and of the workers would give rise to some anxiety. It was not the business of the Imperial Munitions Board to prepare for such a period. The Canadian Government, through its Reconstruction and Development Committee and its Labour Committees, had originated investigations for the solution of the after-war industrial problems. The Government of Canada had also created the Honorary Advisory Council for Scientific and Industrial Research with a view to utilising to the best advantage the resources of the country and the skill and energy of the people during and after the war. Boards of trade and different scientific societies in Canada had also been active in promoting plans for the re-establishment of industry on economic and scientific lines.

The subject, therefore, was not overlooked, but many considered that the progress made towards fulfilment was inadequate to cope with the problems.

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Reconstruction and the Imperial Munitions Board.—Towards the end of the war the Chairman of the Imperial Munitions Board instituted certain inquiries from manufacturers with a view to helping the Canadian Government in the work of reconstruction which it had undertaken.

The following letter addressed to manufacturers of munitions, together with the questionnaire, shows what action was taken :

IMPERIAL MUNITIONS BOARD

OTTAWA, October 24, 1918.

DEAR SIR,—With a view to determining what classes of work could be carried on most advantageously by manufacturers at present producing munitions, we desire to compile certain data which may be of use to the organisation which may be set up by the Government of Canada for dealing with the problems incident to the close of hostilities, whether this event be in the near or distant future.

We would be grateful to receive from you answers to the attached questionnaire, with such added information as you may consider may be of service. We appreciate that in some cases these answers must of necessity be approximations.

If the manufacturers having contract relations with the Board to whom this communication is addressed extend to us their confidence in supplying the information desired, care will be taken to treat the information as confidential.

Upon receipt of the replies we will tabulate the particulars without names and will hand them over to the Government authorities here. Later, if the Board is asked for details in particular, we will communicate with the manufacturers before supplying them.

Yours faithfully,
(Signed) J. FLAVELLE,
Chairman.

1. How many men have you now employed on purely munitions work? and how many women?
2. What percentage of your present complete turnover does your munitions business represent?
3. What percentage of your complete personnel do those employed on munitions represent?

4. What are the staple lines which previous to the war represented the larger part of your Company's turnover ?

5. Have you previously done export business to any appreciable percentage of your turnover ? If so, what percentage ?

6. With what countries did you do this export business ?

7. If you have not actually exported goods, have you at any time investigated into the possibilities of exporting articles such as you manufactured prior to the war ? If so, what were the results of such investigations ? What action do you consider it would be desirable to take to secure such export business ?

8. Have you formulated any plan for the use of your munitions equipment, or for otherwise adding to your lines at the conclusion of the war ? If you are warranted in doing so, we will appreciate being advised what such plans contemplate.

Commercial Use of National Factories.—In addition to making the foregoing inquiry the Chairman planned to bring trade to Canada by seeking to dispose of the National Steel Factory at Toronto, when war ceased, for commercial purposes.

While the Ordnance Adviser was in England in August, 1918, the Chairman cabled to him pointing out what steel would be in stock in different stages of manufacture should war cease at any time. He instructed him to make full investigations of the commercial uses to which the National Steel Factory in Toronto could be employed, and to learn if any steel company in England would consider its purchase with a view to the development of new lines of steel manufacture in Canada. Eventually, the factory was purchased by an English corporation. These facts show what was done to re-establish commercial pursuits after the war.

November 11, 1918.—The expected day did come. During the war there were times of gloom and doubt, but never a time when courage failed. The following extract from a letter, written on November 11, 1918, by the Chairman of the Board to the Ordnance Adviser, conveys what the news meant to Canada :

Everything sinks into insignificance in the presence of the cable received in Ottawa early this morning that the Armistice

had been signed and that hostilities had ceased. Since three o'clock this morning the city had given itself over to an exuberant outburst of feeling, in which everything that can make a noise is being used. It does not seem a very fitting way to express our gratitude, but I presume this expression is a somewhat natural reaction from the long strain, and one should not be too critical as to the form it takes. In some of the churches there is to be a service at midday, where a deeper voice of thanksgiving will be heard.

Liquidation and Settlements.—Demobilisation of munitions labour and the cessation of munitions work followed the Armistice, but, in addition, the various settlements of uncompleted contracts and the liquidation of all property belonging to the Ministry had to be undertaken.

The Chairman of the Board was advised by the Ministry that when property, stores, materials, or supplies belonging to the Crown were offered for sale, the Treasury was the department of the Government who assumed control ; on account of this it was necessary for the Ministry to secure the Treasury's ruling as to the method of disposing of the property and assets held in Canada by the Board for the Imperial Government.

The Treasury ruled that the stores, materials, supplies, etc. should be disposed of by the Ministry of Munitions, with a Treasury official associated with the Minister for concurrence in the character of the liquidation.

In accordance with this authority the Ministry appointed the Chairman of the Imperial Munitions Board as Liquidator of the Ministry's properties in Canada, and the Treasury selected the Auditor for the Ministry, Mr. George Edwards, as the representative of the Treasury to be associated with the Chairman. The same procedure was authorised by the Air Ministry for the disposal of property, etc., held by the Board. It is very remarkable that all British contracts were satisfactorily liquidated without a single instance of litigation. The facts concerning this work are given in Chapter XXVII on the finances of the Board.

Some Assets to Canadian Industry.—It is difficult to assess the true value of the munitions business to Canada during the war. The appalling upheaval of ordinary domestic pursuits for the munitions business, and the consequent need of readjustment after the war, made the situation in respect to industrial development one of much concern.

There were, however, certain outstanding assets resulting from the munitions work which made industrial development certain if these assets were used wisely. They were :

- (1) An increased development of natural resources.
- (2) The standardisation of products.
- (3) The standardisation of skill.

There is no doubt that all manufacturers who made war products were conscious of these good things, and were anxious to employ them in domestic pursuits after the war. Here one can only indicate in a very general way what these assets were, and measure the result of their application by the conditions of trade as it exists to-day, nearly six years after victory.

I. DEVELOPMENT OF NATURAL RESOURCES

If we consider the effect that the munitions business had in developing the natural resources of Canada, we are met by some arresting facts.

The development of mineral and metal resources during the war can be measured without doubt. If, for instance, we take steel which requires the iron ore, pig-iron, ferro-silicon, ferro-manganese, and other metal products for its manufacture, we see a development which exceeds in percentage rate that of any other producing nation. It is estimated that the annual total of the world's capacity for steel production before the war was 80 million tons, and immediately after, 100 million tons.

The U.S.A. had increased her annual tonnage from 32 to 45 million tons ; Britain from $7\frac{1}{2}$ to 12 million

tons ; while Canada had increased from 1 to $2\frac{1}{4}$ million tons.

Canada's steel-producing capacity had, therefore, increased from about $1\frac{1}{4}$ per cent. to $2\frac{1}{4}$ per cent. of the total producing capacity of the world—a greater increased percentage than that of any other steel-producing country in the world. It is, however, necessary to point out that Canada had not increased to any great extent her capacity to produce iron ore, pig-iron, or her steel-finishing capacity for domestic purposes.

Undoubtedly her capacity to produce steel was not only demonstrated, but the quality of the product made was greatly improved as the result of scientific knowledge acquired of the processes involved in manufacture.

The freedom of the steel manufacturer to develop his works to full capacity without financial anxiety and doubt about securing contracts liberated talent for metallurgical and chemical investigations.

Steel Position in Canada.—The actual results in steel production during the past three years (1921-23) may appear disappointing, but they show a recovery which is full of hope.

In the year 1921 the total production of steel ingots and castings in Canada was 667,000 tons ; in 1922, 486,000 tons ; and in 1923, 884,000 tons, 82 per cent. more than the output for 1922 and 33 per cent. more than the output of 1921. The state of trade throughout the world is still far from normal. These figures alone are not a true measure of the potentialities of Canada to produce steel. Before the war Canada imported from the U.S.A. and Great Britain a very large and miscellaneous class of steel products, many of which can be produced in Canada to-day. The increasing demand for higher quality steels, such as can be produced by the electric furnaces, gives Canada an excellent opportunity of supplying itself and others with steels used for motor cars, tractors, all kinds of engines and high-class machinery, where excessive wear and corrosion call for more enduring steels and for different kinds of tool steels.

The abundance of cheap electric power, making the cost of carbon electrodes, ferro-silicon, and other special ferro metals used in steel manufacture less than in Great Britain, gives Canada an advantage which should be embraced. One of the largest steel manufacturers in England, who has six electric furnaces for steel manufacture in addition to other types of furnaces, stated that the cost of making electric steel at his works during the war was about twice the cost of steel produced at the Electric Steel Factory of British Forgings Ltd., Toronto.

Hydro-Power Development.—The value of hydro-electric power during the war is shown by the demand made by munitions manufacturers for its use. At the time sources of supply were so severely taxed, particularly in Ontario, that a shortage existed. It was necessary for the Imperial Munitions Board to obtain some means of equalising the available supply.

Sir Henry Drayton was appointed Power Controller, with full authority over all private sources of energy, and to allot blocks of power according to the urgency of the products required. About 131,000 horse-power was absorbed by the munitions manufacturers in Ontario alone, of which 73,000 came from the Hydro-Electric Power Commission.

The impetus given to the use of hydro-electric power by munitions manufactures is reflected in the development since the war finished. According to a review of the Dominion Water Board Branch Department of the Interior, the total water power installation in the Dominion during 1923 amounts to 3,228,000 horse-power. This is an increase of 255,000 horse-power as compared with the total installation at the end of 1922.

Canadian Trade.—The activities resulting from munitions production and high costs of materials during the war influenced the money value of the total trade of the Dominions. In 1901, twenty-two years ago, the total trade of Canada was \$355,362,395. In 1911, ten years later, it had doubled itself, being \$727,041,156. In 1918, the heaviest exporting year of the war, it was

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\$2,593,569,366 (not strictly comparable with pre-war values), and while the value of trade dropped during the years 1919 and 1920, it almost reached the same figure in 1921, namely, \$2,429,322,583. In the year 1922 every industrial country felt the rebound of the war, and Canada was not excluded. The total trade amounted to \$1,646,771,892; but the recovery made in 1923 is very reassuring. In that year the volume of trade amounted to \$1,918,264,789, or an increase of 16·5 per cent. over the preceding twelve months. More important still is the fact that there was a favourable trade balance of \$111,203,759, this amount being the difference between the value of exports and imports.

Canada's total trade per head of population amounted, in 1923, to \$218. Export trade accounted for \$115 per head and import trade for \$103. These figures compare favourably with those of the greatest trading nations in the world. In that year (1923) Canada lost a man who probably did more than any other to build up Canada's trade. For forty-one years Lord Shaughnessy directed the fortunes of the Canadian Pacific Railway, and by it made Canada prosperous. His sudden death on December 19, 1923, came when the rising tide of trade gave encouragement to all. His work for Canada during the war, through the Shell Committee and Imperial Munitions Board, was unselfish and devoted to the Empire.

II. THE STANDARDISATION OF PRODUCTS

One of the greatest assets produced by the munitions business was the standardisation of products. Every part of a shell or any other munition had to be supplied to drawings and specifications, with rigid examination, analyses, and tests before acceptance. Nothing was accepted on the easy principle of 'good enough'; if the products did not reach the standard called for by the specifications they were rejected. This meant a process of refinement for every industry in Canada

which handled munitions. The iron and steel industries ; the metal and metal products ; refractory materials and fuels ; lumber and timber ; leather ; textiles ; paper ; chemicals, and other minor industries, called into being processes and plant which could be adapted for munitions, and also added new processes, new equipment, and new skill where these were required.

In addition to the employment and adaption of existing industries for munitions manufacture entirely new industries were brought into activity. The munitions industries undoubtedly gave an impetus to the mining and subsequent operations in the production of coal, iron, copper, nickel, zinc, molybdenum, antimony, aluminium, and other metals.

The chemicals industries were accelerated by utilising the waste products of coke-ovens for the manufacture of high explosives, products which by skill and ingenuity can be turned to valuable domestic uses.

The electro-chemical industries, such as the refining of copper, zinc, and lead, which were developed during the war, will remain a commercial asset. The electro-thermic processes for the production of ferro alloys, such as ferro-silicon, ferro-manganese, ferro-molybdenum, aluminium, magnesium, and other metals, have produced standardised products.

The training was sometimes difficult and delicate, but it was done ungrudgingly and with patience. As a result, every industry in Canada is on a higher plane of efficiency than before the war.

III. THE STANDARDISATION OF SKILL

The widespread knowledge of new processes, involving the scientific study of metals, the flow of materials, and their physical, chemical and metallurgical values, could not have been supplied by the universities and technical colleges of Canada in many years. The capacity of the colleges would have been unequal to the training of hundreds of thousands who were trained

in the workshops. Every machine shop was a school of training for the skilful handling of gauges and precision instruments. There was hardly a town of any importance in the Dominion in which the workers did not receive some experience in the use of these measuring instruments. Every steel works had its means of registering temperatures, and of studying scientifically the treatment of materials.

The value of such skill was not confined to male workers ; 35,000 women workers also enjoyed these privileges. Never before had there been such an incentive to acquire skill for a purpose of which our civilisation may well be ashamed, but which is nevertheless an asset that cannot fail to continue to be of great value in the peaceful commercial industries for the expansion of Canada.

Moral Assets.—Unquestionably the war developed Canada's material resources and increased the standards of her products and skill—but it did more. It tore from her homes more than one 'idol,' never to be set up again. It sent the mothers and sisters of the boys at the Front into the factories to share the struggles of the toilers. Sacrifice and suffering during those years produced assets far beyond the measures of commerce and science. A moral sense, always virile, independent and resourceful, grew to regard the material gains arising from the war as utterly inadequate compensation for the sacrifices made.

To have only said to those who spent their lives in the munitions factories under so great strain that—

For brass I will bring gold, and for iron I will bring silver, and for wood brass, and for stones iron :—

would have been to mock them and to destroy the vision of a future which was to end war. Material values were secondary. The very qualities of sacrifice, courage, endurance, enterprise, and genius which the war developed could only provoke another war were the people of the Dominions to regard the material assets as a reward for their sacrifices.

The lessons learned placed these assets in their true proportion to the vital issues for the maintenance of peace. History had shown that the material resources of a country had often produced a commercial rivalry between nations. Such rivalry had destroyed the peaceful relationships and often the means of adjusting economic disputes; thus, too, arose political differences which led to the menace of war. Material assets alone, therefore, could give no sense of national security or any assurance of world peace.

Such security and assurance could be found only in maintaining at all costs the exaltation of righteousness, with its commonwealth of interests, above self-interest.

Whatever may prove to be the ultimate value and issue of the munitions business in Canada during 1914-1918, there can be no doubt that the patriotism and devotion to the Mother Country of the munitions workers revealed a love, courage, and sacrifice which won for them the admiration of the Empire.

W. C. LEBARNEZ

APPENDICES

APPENDIX I

REPORT OF CHAIRMAN OF IMPERIAL MUNITIONS BOARD TO THE MINISTER OF MUNITIONS

TORONTO, *August 17, 1921.*

TO THE MINISTER OF MUNITIONS.

MY LORD,—1. The affairs of the Imperial Munitions Board are now wound up. The liquidation of its assets and liabilities commenced within a week of the Armistice, and was for the most part completed before the signature of peace. A few settlements with contractors, however, remained under negotiation, and certain assets were left still to be realised. Moreover, the Board had undertaken, at the request of the United States Ordnance Department, to assist that Department in the investigation and settlement of a large number of contractors' claims in Canada, arising out of orders placed by the United States Government, which were cancelled at the Armistice. To carry on this work necessitated the retention of a small portion of the staff, mainly from the Accounts Department. Nine-tenths of the Board's staff had been disbanded, and its main offices given up by March, 1919 ; but it is only recently that the settlement of the last of the outstanding questions has enabled the disbandment to be completed.

2. I have now, therefore, the honour to place in your Lordship's hands my resignation and that of my colleagues. In doing so I would like to be allowed to thank your Lordship and your Lordship's predecessors, and also Sir Graham Greene, and the other officials of the Ministry, for the courtesy and consideration extended to the Board throughout the period of its activity, and for the sincere desire which was shown by the Ministry of Munitions to utilise to the fullest extent the resources of Canada. I recognise, and I believe all Canadians will recognise, that while the efforts of Canada towards the supply of munitions during

the war were of service to the common cause, they carried an incidental but considerable advantage to Canada through the development of her manufacturing capacity. The action of the Imperial Government in determining to develop that capacity in spite of initial difficulties was fully justified by the results which followed in the way of supply. But it was also an evidence of the feeling of solidarity and common interest which prevails and, it is to be hoped, always will prevail between Great Britain and the Dominions.

3. In tendering to your Lordship the resignation of the Board, perhaps I may be allowed to review as briefly as possible the history of its operations and those of its predecessor, the Shell Committee.

4. The Shell Committee was formed towards the end of 1914 by Lieut.-General Sir Sam Hughes, Canadian Minister of Militia. General Hughes, for whose energy and single-mindedness in organising Canadian assistance to the Empire at that critical time no praise can be too high, had formed the conviction that Canada could give substantial help in materials as well as men. Although the manufacture of munitions was at the time an unknown art in this country—except for rifles and rifle ammunition, which were made here on a small scale—he believed that the skill of Canadian manufacturers and workmen was equal, or could soon be made equal, to the production of shells, and that, granting this premise, an important source of munitions supply might be built up here, in view of the fact that Canada was already a large producer of steel. Accordingly he asked for and obtained from Lord Kitchener an order to make 18-pdr. shells. The quantity ordered, although it may appear trifling by the side of what has been produced since, was large, judged by pre-war standards. For the purpose of carrying out this order, General Hughes constituted the Shell Committee, to which he named as members Colonel (afterwards General) Alexander Bertram, Messrs. G. W. Watts, T. Cantley, and E. Carnegie, together with Colonel Harston, Lieut.-Colonel Lafferty, and General Benson. The four first-named members of the Committee were manufacturers, Messrs. Cantley and Carnegie being at the head of steel-making establishments, and Colonel Bertram and Mr. Watts being connected with businesses which turned out machinery and machine tools. The three last-named members of the Committee were military officers employed by the Canadian Government, General Benson being Master-General of Ordnance, Colonel Harston, Inspector-General of Arms and Ammunition,

and Lieut.-Colonel Lafferty, Superintendent of the Arsenal at Quebec. Colonel Bertram was appointed Chairman of the Committee, and Colonel David Carnegie, brother of Mr. E. Carnegie and a well-known steel expert with extensive experience gained in British armament works, was appointed to act as technical adviser to the Committee.

5. The Shell Committee carried on work from September, 1914, till November, 1915. In form they acted as contractors to the British War Office, making themselves responsible for the execution of the orders which were placed with them. Actually they took the position of agents, working without remuneration, and arranging for and supervising the letting and the carrying-out of the contracts in such factories as they thought best suited to undertake the work. Their activities soon justified their selection and the confidence which General Hughes had felt in the capacity of his country. Shell production began in December, 1914, and in January, 1915, over 30,000 shells were shipped. The total shipments in the course of 1915 amounted to over five and a quarter million shells. This included 15-pdr. shrapnel, 18-pdr. shrapnel, 18-pdr. high explosive, and 4.5-in. howitzer shells.

6. As no armament works whatever existed in Canada, the Committee from the commencement had to undertake much more extensive functions than those of a mere purchasing body. It formed the opinion early that the best results would be obtained by subdividing the work to be done, purchasing the raw materials itself, and allotting them out among various manufacturers who undertook different parts of the work. In some cases the same manufacturer would undertake several or most of the processes, from the production of the steel to the turning out of the finished shell, but in the majority of cases the steel was produced at one plant, the forging done at another, the machining at a third, while other components were produced separately, and the assembling was a final process. The Committee also undertook to assist the manufacturers with technical instruction and advice, as well as to arrange for inspection. This system, which was afterwards continued and developed by the Imperial Munitions Board, was undoubtedly best suited to Canadian conditions, and led to a far greater production than would have been possible if contracts had been confined to those plants which were capable of carrying out an order in its entirety. In adopting it the Shell Committee showed foresight and a just appreciation of local conditions.

7. In the summer of 1915 the Ministry of Munitions was constituted in Great Britain under Mr. Lloyd George. It was realised by this time that the war was likely to be a long one, and that its conversion into a war of trenches meant a long series of siege operations, which would call for the supply of guns and ammunition on a scale hitherto undreamed of. The work of the Shell Committee had already shown that Canadian production was capable of being developed into an important factor in the supply. Mr. D. A. Thomas, afterwards Lord Rhondda, who had been commissioned by Mr. Lloyd George to proceed to the United States in connection with munition orders there, was requested by the Minister to extend his journey to Canada in order to concert with the Dominion Government measures for the increase of Canadian munitions production. As Mr. Thomas was unable to remain at Ottawa more than a short time, Mr. W. I. Hichens, Chairman of Cammell Laird & Co., and the Hon. R. H. Brand, were commissioned by the Minister to complete the negotiations which he had commenced.

8. The work which had already been done in Canada, and a series of consultations with the Shell Committee, with General Hughes and with the leading Canadian manufacturers, convinced the Commissioners that production on a much larger scale might be attempted. In view of this a different form of organisation seemed to be required. The Shell Committee, while it had done excellent work during the year of its operations, was in an anomalous position, being technically a contractor with, but practically an agent for, the British Government. With the exception of General Bertram and Colonel Carnegie, its members were not able to give their whole time to the work. It was considered that if operations were to assume a larger scale, a permanent organisation, with a more clearly defined position, should be created to supervise them. Two alternatives appeared to be indicated. The first, that the Canadian Government should undertake direct responsibility for the work and should constitute a Ministry of Munitions in the same way as had been done in Great Britain; the second, that the British Ministry of Munitions should itself establish an organisation in Canada which would be directly responsible to it, and be in name, as well as in effect, its agent. The Commissioners laid their views before the Canadian Government, and asked which plan they preferred. They elected for the latter, which was accordingly recommended by the Commissioners to the Minister.

ment. Special mention should be given to the work of Colonel Carnegie in this direction on the engineering side, and to that of Mr. Howard Irish in matters connected with labour. A particularly valuable service rendered by Mr. Irish was that of organising and developing the use of women workers in the munitions plants, at a time when the scarcity of male labour threatened to diminish their efficiency.

16. At an early stage of the Board's existence, it became evident that a great number of questions of principle and detail were constantly arising, the settlement of which by cable or by letter gave rise to delay and misunderstanding, and that some special machinery of liaison was needed between the Board and the Ministry. It was accordingly proposed by the Board and agreed to by the Minister, that the Hon. R. H. Brand, who had been one of the 1915 Commissioners, and whose work during his mission had brought him into close touch with the conditions in Canada, should be appointed as additional member of the Board, resident in London, for the purpose of acting as liaison. Mr. Brand was given an office in the Ministry, and thereafter acted as representative of the Board at Ministry Headquarters, and as the channel of communication between the Board and the Ministry. His acquaintance with the conditions and the personnel on both sides, and his first-hand knowledge of matters which it was impossible to explain adequately by correspondence, proved invaluable in getting quick and right decisions, and his work was one of the most important factors in aiding the Board to carry out the Ministry's requirements. In June, 1917, Mr. Brand was detached by the Ministry to assist Sir Charles Gordon in the establishment of a direct representation of the Ministry of Munitions in the United States, and was absent on this work in Washington until June, 1918. During this period his work in London was taken over by Mr. F. Perry, another member of the Board. The Chairman, Sir Charles Gordon, and Mr. Perry also undertook visits in London on various occasions in 1916 and 1917, to deal with special questions which arose. The interchange of views between the Board and the heads of various departments at the Ministry which took place during these visits was consolidated by the constant presence in the Ministry of a representative of the Board closely in touch with all their problems, and this arrangement resulted in a degree of successful co-operation which could otherwise hardly have been attained.

17. As the output of munitions from Canada increased, and as the munitions came to be shipped in a more complete state, the

question of inspection assumed great importance. An inspection branch had been formed in the time of the Shell Committee under Lieut.-Colonel Ogilvie, R.A., a most hard-working and conscientious officer, and had performed its difficult duties satisfactorily in the initial stages. But the number of competent technical assistants on whom Colonel Ogilvie could rely was very small, and in the summer of 1916 it became apparent that the Inspection Branch must be strengthened to deal with the changed conditions. After consultation with the Ministry, Colonel (afterwards Brigadier-General) Edwards, R.A., C.M.G., one of the principal officers in the Ministry's Inspection Department, was sent out to Canada, with several assistants, for the purpose of reorganising the Canadian inspection, and bringing it on to the same lines as those then prevailing in Great Britain.

Eventually General Edwards remained to supervise the new organisation as Director-General of Inspection, Lieut.-Colonel Ogilvie becoming his Second-in-Command. The Inspection Department grew with the output, and came to employ a staff of between four and five thousand persons, mainly as inspectors in the factories. The progressive efficiency of the inspection was such that the practice of re-inspecting Canadian munitions on arrival in Great Britain was gradually abandoned. General Edwards, who was also appointed an additional member of the Board, carried out a thankless task with ability, and a tribute must be paid both to his efficiency in organising his department, and to the patience which he showed on many occasions in dealing with the troublesome situations which frequently arose out of the conflict between the urgent need for output and the necessity for meticulous attention to quality.

18. At the end of 1916 the Board was called upon to undertake an extension of its original duties. The large number of Canadian officers who had distinguished themselves in aviation drew attention to the possibilities of Canada as a recruiting and training ground for the Royal Flying Corps. General Henderson, at that time in charge of the Royal Flying Corps Headquarters in London, expressed himself in favour of the project, and with this encouragement negotiations were set on foot by the Board with the British and Canadian Treasuries, which resulted in sanction being given for the establishment in Canada of a training school and aeroplane factory, the Canadian Government assisting in the financing. Brigadier-General C. G. Hoare was sent out to take charge of the school, with a number of instructors. Aerodromes and training grounds were constructed at Toronto,

Camp Borden, and Deseronto. The training grounds were equipped for the complete instruction of both pilots and mechanics. All recruiting was done in Canada, and during 1917 and 1918 the school turned out over 3000 pilots and 137 observers, most of whom were drafted to the armies in France. At the signing of the Armistice, over 7000 men had recruited for the mechanical section of the Royal Air Force in Canada. In addition to this, the Canadian training grounds were utilised by the United States Government, when they entered the war, for the instruction of a number of their flying officers. While the personnel of the Canadian Aviation training establishments were controlled entirely by the Royal Flying Force, the construction of the training grounds and the provision of equipment was entrusted to the Imperial Munitions Board. The Board formed a special branch at Toronto to deal with this matter, under the charge of Mr. G. A. Morrow, O.B.E., as Director of Aviation.

19. The purpose of the factory was not to manufacture fighting planes, which was better done in Europe, but to provide machines for training purposes. The Board took over a small branch factory which the Curtiss Aeroplane Co., of Buffalo, had established at Toronto, and which had turned out a few experimental machines. Work was carried on in this plant until a new factory could be erected. The building of this was completed within two and a half months from the time of commencement, and at the time of the Armistice it had turned out 2900 training aeroplanes, mostly for the Canadian Aviation School, the balance for the United States Government. The organisation and management of the factory was undertaken by the late Sir Frank Baillie, K.B.E., who, by his remarkable manufacturing genius, turned it into an establishment which was regarded as a model of its kind on this continent.

20. There was also a further development of the Board's activities in the end of 1916, when it was asked to represent the Ministry of Shipping in Canada, as well as the Ministry of Munitions and the Air Board. The serious situation created by the loss of shipping through submarine attack made the building of cargo ships one of the most vital requirements of the war. Acting for the Shipping Ministry, the Board placed orders for cargo vessels in Canada up to the capacity of existing shipbuilding yards. At the same time it formed a shipping department for the purpose of supervising construction and organising additional yards. This was divided into two sections. The eastern section, which was placed under Colonel W. Gear, a partner in a leading

Montreal shipping firm, took charge of all steel shipbuilding orders and of the construction of wooden vessels on the St. Lawrence and in the Maritime Provinces. A separate branch was formed in British Columbia, under Mr. R. P. Butchart, to organise the building of wooden cargo ships on the Pacific Coast, where there were special facilities for this class of construction. Colonel Gear and Mr. Butchart both gave up their own business to devote their whole time to the work. In the case of wooden vessels, it was necessary to construct the yards before building the ships, as practically no yards existed capable of turning out wooden vessels of the size asked for. In the result the Board supplied the Ministry of Shipping with forty-two steel ships, having a total dead-weight tonnage of approximately 207,663 tons, and forty-six wooden ships, having a total dead-weight tonnage of approximately 141,680 tons. Early in 1918 the Canadian Government decided to undertake the formation of a Merchant Marine and to place shipbuilding orders on its own account. As soon as the decision was come to it was arranged that the Board should leave this field to the Government, and accordingly it ceased to place further contracts, but continued to supervise those which it had already placed on behalf of the British Shipping Ministry.

21. The national factories which came to play so large a part in munitions manufacture in Great Britain were only paralleled in Canada to a limited extent. On financial, as well as on other grounds, it seemed preferable to work through existing manufacturing organisations, wherever this was possible. The method of national factories was, however, adopted in some cases—generally because the manufacture was a special one which private enterprise was not ready to undertake. In addition to the fuse factory, and the aeroplane factory mentioned above, the Board constructed and operated factories at Trenton and Renfrew for the manufacture of explosives and propellants, the establishment at Trenton being one of the largest of its kind in existence. It also constructed and operated a large electric steel plant at Toronto, for the special purpose of utilising scrap steel. In all cases a commercial form of organisation was adopted, a joint-stock limited company being formed, the capital of which was entirely subscribed and held by the Board, which also financed the companies by means of loans. The Board, as sole shareholder, nominated the directorate of the companies, and through it the management. Each company kept its own accounts and was run as a separate entity on commercial lines. The product of the company was taken over by the Board at a contract price, which was

fixed in no case higher, and in some cases considerably lower, than the price at which outside contracts could have been let at the time the factory was erected. Any difference between the price paid by the Board and the operating costs of the company was devoted to amortisation. On this method the companies which were earliest to be established had, by the time of the Armistice, accumulated a surplus more than sufficient completely to amortise their capital cost. The more recent ones, which had not been operating so long, had naturally made less progress in this direction, and in one or two cases hardly anything had been earned. Taking all the companies together, however, their collective surplus, plus the amount realised from disposal of the properties, was sufficient to amortise the total capital cost, and leave a balance of approximately one million dollars for return to the Treasury.

22. There was one other development of direct operation by the Board in the last year of the war. A shortage had arisen in the provision of spruce for the manufacture of aeroplanes in Great Britain. The wood required was of a special quality. Large quantities of suitable spruce timber existed in British Columbia, but it was much scattered, and only little of it could be obtained in the course of ordinary lumber operations. It was, therefore, necessary to make special arrangements for getting it out. For the purpose, the Board formed an aeroplane spruce production department under Major Austin Taylor. Major Taylor established his headquarters at Vancouver, and organised his measures with so much success that the shipments of aeroplane spruce and fir had risen from 200,000 feet in June to nearly 5 million feet in September, and at the time of the Armistice over 120 million feet of logs were in sight, suitable for conversion into aeroplane material. The cost of this production was very substantially less per thousand feet than that which was incurred by similar operations in the United States.

23. In addition to its main task of supplying munitions, and to the activities in connection with shipbuilding and aviation mentioned above, the Board was also called upon from time to time to act as intermediary for the purchase of supplies on behalf of some other departments of the Imperial Government, *e.g.* the Admiralty and the Timber Controller. It also executed several orders for the supply of munitions to Allied governments. These were mainly for the Russian Government, whose purchases included not only munitions, but a large amount of railroad equipment. Late in 1916, as it appeared likely that Canada might be called upon to supply a substantial part of the Russian demands

for heavy shell, Mr. F. Perry, a member of the Board, was commissioned by the Board, with the approval of the Ministry, to visit Russia in order to ascertain requirements, and to arrange if possible for the establishment of a Russian Commission in Ottawa to co-operate with the Board. The Board is much indebted to the British Embassy at Petrograd, and to General Sir J. Hanbury Williams, British Military Representative in Russia, for their assistance in those negotiations, which resulted in a Russian Purchasing Commission being sent to Ottawa early in 1917. Unfortunately the Russian Revolution, and the subsequent withdrawal of Russia from the war, led to the stoppage of Russian supplies before the operations of the Commission had assumed any importance.

24. But the most important development of supply to a foreign government took place when the United States entered the war. In order to assist in the provision of munitions for the great expeditionary force which it was preparing, the American Government desired to utilise the capacity which had been built up in Canada. Circumstances were favourable to this, since, by the middle of 1917, the increased output of munitions plants in Great Britain and the shortage of shipping available for munitions transport, had caused the Ministry to cut down its Canadian orders. Thus there was spare capacity available. The United States Ordnance Department naturally sought the advice and assistance of the Imperial Munitions Board, and, with the consent of the Ministry, the Board undertook to act as agents of the Ordnance Department for the purpose of placing munitions orders in Canada, and supervising their execution. A separate department of the Board was created to deal with American orders, and was energetically managed by Mr. Holt Gurney, one of the many Canadian business men who placed their services at the disposal of the Board. Mr. Lloyd Harris, another leading business man, undertook to act as the Board's representative at Washington, a task which he performed with the greatest tact and ability. Later on he was appointed Chairman of the Canadian War Commission at Washington, but was allowed by the Canadian Government to continue in charge of the relations between the Board and the Ordnance Department. The orders placed by the American Government in Canada were of great magnitude, and were executed with marked success. The utilisation of the organisation and experience already existing enabled the first Canadian contracts to be carried out with considerably more despatch than similar contracts placed at the same time in the

United States. Deliveries from Canada to the Ordnance Department commenced early in 1918, and by November, 1918, had reached a total of seven million shells, besides two million forgings and other material. Much larger orders had been placed, and preparations were well under way to execute them, when the Armistice intervened. The total of the Canadian munitions contracts with the American Government amounted to \$178,430,839.99. Of this \$145,645,033.13 were cancelled in consequence of the Armistice, the value of the actual deliveries thus being \$32,785,806.86.¹ The relations of the Board with the United States Ordnance Department were of a most satisfactory nature throughout. In this connection I desire to mention the name of the late Colonel Albee, Chief Representative of the Department in Canada, a man of unflinching courtesy and patience. I would also like to acknowledge the services rendered on several occasions by General Headlam of the British Military Mission at Washington, who lent his tact and experience to the Board in the solution of more than one difficult question.

25. Questions of finance had an important place in the Board's preoccupations. The Shell Committee had depended on remittances from the British Treasury, but as the operations assumed greater magnitude, and as the Treasury, in view of the enormous sums which it was called upon to find in the United States for the purchase of materials and supplies on behalf of Great Britain and her Allies, was obliged more and more to husband its resources, the Board, in conjunction with the Ministry, was, almost from the commencement, obliged to consider not only how munitions orders could be executed in Canada, but also how they could be financed. Fortunately the development of the internal resources of Canada enabled the situation to be met. The commissioners sent out in 1915 had approached the Canadian Minister of Finance with a suggestion that the supply of munitions from Canada might be partly financed by the Canadian Government. This suggestion was favourably received, the Canadian Treasury agreeing to advance certain credits for the purpose of partly meeting the Board's expenditure. A loan of \$100,000,000, to be repaid after the end of the war, was also arranged, with the assistance of the Canadian Government, from a combination of the Canadian banks, this money being used during 1916. In subsequent years smaller temporary loans were obtained by the Board from time to time from one or two of the larger banks, and in one case from the Canadian Pacific Railway Co., which, in this

¹ Paid in respect of 208 contracts.—D. C.

matter as in others, showed an unfailing patriotism. Apart from this temporary accommodation, the Board's expenditure was met either by advances from the Canadian Finance Minister or by remittances from the British Treasury through New York. The provision of the amounts required was from time to time the subject of informal negotiations between the two Treasuries, in which the Board generally took part as intermediary. The Minister of Finance (the Right Hon. Sir T. White, who was in office through the whole period of the war) was disposed to use every effort to assist the supply of munitions from Canada, and was liberal in his undertakings and still more liberal in their fulfilment. Out of the total expenditure of the Board, amounting to approximately twelve hundred and fifty million dollars, seven hundred and fifty-five million dollars was advanced by the Canadian Treasury by way of loan to the British Government, and three hundred and ninety-five million dollars was provided by British Treasury remittances, the balance of one hundred million dollars being accounted for by the loan from Canadian banks mentioned above. The advances made by the Canadian Government were partly offset by advances made by the British Government for the upkeep of the Canadian Expeditionary Forces in England and France.

26. In authorising the Board to place munitions orders in Canada, the Ministry continued the practice, which had been started between the War Office and the Shell Committee, of naming a fixed price for the munitions. This price was fixed in consultation with the Board, according to their estimate of the probable actual cost. The price so fixed during the period of the Board's operations was in almost every case lower than the price paid by the Ministry on similar contracts in the United States. The Board was responsible for keeping within the fixed price, but subject to that had a free hand in letting contracts, making purchases of material, etc. Taking munitions contracts alone, placed by the Board (*i.e.* not including shipbuilding, aviation, etc.), the total authorised cost at the fixed prices was \$1,014,000,000 (including contracts made by the Shell Committee). The total actual cost to the Ministry, after taking the loss incurred in disposing of raw materials on hand at the time of the Armistice and in scrapping shells, etc., not actually shipped, amounted to \$995,000,000. That is to say, there was a saving upon the fixed cost of \$19,000,000, after taking the losses caused by the cessation of manufacture. Against this saving of \$19,000,000 was charged the sum of approximately \$12,000,000, paid out to contractors and manufacturers after the Armistice in settlement of the

compensation to which they were entitled under their contracts for sudden cancellation. The net result, therefore, is that the amount payable by the Ministry for Canadian munitions at the fixed prices, which on the whole were appreciably lower than the prices paid for similar supplies ordered in the United States, sufficed to pay all actual costs of production, to meet losses incurred through the disposal of raw material and stocks on hand at the time of the Armistice, to provide all compensation payable to manufacturers on cancellation, and to leave a surplus of \$5,000,000 for return to the Treasury.

27. With regard to the costs of administration and inspection, a special arrangement was made, with the approval of the British Treasury, whereby the Board was allowed three-quarters of 1 per cent. on the amount of the contracts, for the purpose of meeting its administrative charges, and $2\frac{1}{2}$ per cent. for the purpose of meeting the costs of the Inspection Department. Subject to its keeping within these amounts, the Board controlled its own expenditure on administration and also the costs of the Inspection Department. The actual expenditure on the Inspection Department was \$21,000,000, or about 2·1 per cent. of the expenditure on the contracts inspected by the department. The actual administrative expenditure of the Board was \$6,430,000, or approximately one-half of 1 per cent. on its total expenditure. In this connection, however, it must be remembered that not only the members of the Board (except Colonel Carnegie and General Edwards, who were professional members), but also a considerable number of the heads of departments, served without remuneration.

28. The Board throughout received the fullest assistance and co-operation from the Canadian Ministers and their departments. As pointed out above, although acting for a British Government department, it had no governmental powers or status in Canada. In its relations with manufacturers or contractors or employees, its position was merely that of a private corporation. It could make no laws and impose no regulations otherwise than by embodying them in its contracts. If in the course of its operations governmental regulation of any kind seemed necessary or desirable, it could only be obtained by going to the Canadian Government and convincing them that it was in the public interest that they, as a Government, should take action. It might have been supposed that such a position would give rise to difficulty and friction. Such, however, was not the case. The Canadian Government in all its departments showed itself constantly

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anxious to assist the work of the Board by every means in its power. While in practice it was rarely, if ever, necessary for the Board to ask for direct government action to be taken, the knowledge that such action would be taken if the Board requested it and could make out a case for it, was undoubtedly of great help.

29. Indeed the spirit of co-operation prevailed through the whole Canadian community. In its dealing with manufacturers, the Board found that the ordinary and legitimate desire to do profitable business, while of course it still existed, was largely overridden by a wish to render public service. Time and again pains were taken and risks incurred by individuals and corporations which could not have been induced by ordinary commercial considerations. The same desire to help was shown in the general willingness on the part of men of business to put their own affairs on one side for the purpose of giving direct service to the Board whenever it was asked. Not only the gentlemen mentioned in this despatch, but many others, to whose work I have called attention in previous communications to your Lordship and your Lordship's predecessors, rendered devoted and gratuitous service over a prolonged period, and often at much personal sacrifice. Nor was the spirit any different in other classes. Skilled and unskilled labour, foremen and managers, professional and technical men in numerous branches, all contributed their best efforts, and worked in the cause of munitions production with a zeal and industry heightened far above the ordinary standard.

I have the honour to be,

My Lord,

Your Lordship's most obedient servant,

J. W. FLAVELLE,
Chairman.

APPENDIX II

INTRODUCTION TO THE 'HISTORY OF IMPERIAL MUNITIONS BOARD'

THE following statement was written by the Hon. R. H. Brand, C.M.G., for the official record of munitions supply prepared by the Ministry of Munitions, London.

It gives an account of the many-sided duties of Mr. Brand at the Ministry in London, in connection with the Board's work.

It is published with the permission of Mr. Brand, to whom I am very grateful for the particulars supplied.

I have been asked by those responsible for the compilation of the 'History of the Imperial Munitions Board' to write a short introduction to it. I shall not go into details, as the story is fully given in the following chapters, but it may be worth while to make a few general remarks, as I look back now, nearly three years after the Armistice, on the work done by the Board. My personal connection with the Board actually commenced, if I may say so, before it was formed and lasted until it was finally dissolved.

It was in August, 1914, that the War Office first appealed to Canada for assistance in providing munitions, and it was due to the energy of Sir Sam Hughes that Canada, although entirely without experience in munitions making, immediately responded. The Shell Committee was formed in the manner explained in the following chapters, and in the course of a year developed rapidly the production of munitions in Canada. By January, 1915, however, Mr. Lloyd George, who was then Minister of Munitions, came to the conclusion that it was desirable to ascertain more closely what the Shell Committee were doing, since contractors were very far behindhand, and Mr. D. A. Thomas, afterwards Lord Rhondda, was sent over by him for this purpose. Mr. Thomas came to the conclusion that the Shell Committee was not adequately organised for the great task that it had undertaken. Nevertheless, after spending some months in Canada, he was not

able to reach an agreement with Sir Sam Hughes and the Canadian Government as to the character and personnel of any body which should take its place. Since, moreover, he wished to return to England, Mr. Lloyd George requested Mr. W. L. Hitchens, Chairman of Cammell Laird & Co., to replace him. Mr. Hitchens accepted and asked Mr. Lloyd George whether he might associate me in the work with him. Mr. Lloyd George agreeing, Mr. Hitchens and I left in October, and after spending six weeks in Ottawa, succeeded in securing the resignation of the Shell Committee and replacing it by the Imperial Munitions Board. We had the great advantage of a previous personal acquaintance with Sir Sam Hughes, who assisted us in the task of re-organisation.

The manufacture of munitions in Canada had enormously developed in the course of 1915, and although the members of the Shell Committee had done most excellent work during their period of office, its organisation was quite inadequate for the task it had undertaken. We were exceptionally fortunate in securing for the work of the new Imperial Munitions Board the services of Mr. Flavelle, later on Sir Joseph Flavelle, Bart., as Chairman, of Mr. C. B. Gordon, afterwards Sir Charles Gordon, C.B.E., as Deputy Chairman, of Mr. Edward Fitzgerald, C.B.E., who was then in the service of the Canadian Pacific Railway, of Mr. F. Perry, and of Mr. Edwards, as Chief Accountant. These gentlemen all remained with the Imperial Munitions Board during the whole of its tenure of office, and it was to their energy and ability in the main that the great success of the Board was due. Immediately after the formation of the Board Mr. Hitchens and I left Canada, in order to give the Board at once an entirely free field.

On my return to London I was requested by Sir Joseph Flavelle to look after the interests of the Board in London with the Ministry of Munitions. It was considered that this work would not be of a whole time character, and I accepted the post. I found shortly, however, that the work, if properly performed, was certain to be very heavy, that the Board's representative must necessarily have his own office and staff in the Ministry of Munitions, and these arrangements were accordingly made. From that date, about March, 1916, I looked after the work of the Board in London until the end of the war, with the exception of nine months, during which I was in Washington.

The work was of a peculiar character, and somewhat like that of an Agent-General or High Commissioner. During the course of its existence the Imperial Munitions Board spent over £200,000,000 of the British taxpayers' money. It provided

between a quarter and a third of all the shells used by the British army. It built ships for the Ministry of Shipping, besides providing a great many other materials, which are specified in the following chapters. Its annual expenditure considerably exceeded that of the Canadian Government itself. Besides employing hundreds of contractors throughout Canada, it conducted huge factories of its own.

It was my business to see that no friction or misunderstanding arose between the Ministry of Munitions, the Ministry of Shipping, and the Treasury in England on the one hand, and this great organisation 3000 miles away, carrying on this huge work and spending many millions every month, on the other. Those who have been responsible for conducting a business at a great distance will not need to be told that many opportunities of friction arise. In the course of three years my office sent and received 10,000 cables. It was necessary not only to keep the Board in Canada fully informed, but, a more difficult task, it was necessary to see that Canada got proper treatment from all the different departments of the Ministry, that orders were not placed in the United States which might equally well have been placed in Canada, that when the Ministry's programme was made up for a period many months ahead, as was always necessary, the task that Canada was to perform was fully considered and determined upon, and, lastly, that proper financial arrangements were made to provide the Board with the necessary funds. In the first year or so of the war the possibilities of munitions making in Canada were not by any means fully recognised in England, and very large orders were placed in the United States which it would have been to everyone's interest to place in Canada. When once a huge programme had been started in the United States it was a matter of some difficulty and many months to get it transferred to Canada. Other British departments similarly ignored the great assistance that Canada could be to them. For a good many months I urged unsuccessfully on the Board of Trade that Canada could build ships to assist in meeting the submarine crisis, and on the War Office and the Admiralty that Canada could provide, not only aeroplanes, but an air force. Even in December, 1916, the Board of Trade informed me that they did not require any ships, and it was only after the Ministry of Shipping was formed that the Board was authorised to begin a building programme in Canada. Similarly it was only when the Air Board, the forerunner of the Air Ministry, was formed that serious attention was given to the possibilities of Canada in this direction. I was so convinced of the importance

of this matter that I appeared before the Air Board to urge it at its first meeting. Shortly afterwards a programme was agreed upon: the Board was instructed to begin building aerodromes and aeroplanes, and the Air Ministry took steps to start in conjunction with the Canadian Government the Canadian Air Force, which later supplied so many pilots.

One of the most interesting and difficult aspects of the Board's work was its financial problem. From the very first there was, as may be imagined, no little difficulty in providing the sums necessary to meet the Board's great expenditure, and as the war went on, the problem of providing American dollars to meet American expenditure, and Canadian dollars to meet Canadian, became one of the most pressing of the problems of the British Government—a problem, indeed, which, had it not been for the entry of the United States into the war, might have had a deciding influence on the whole course of the struggle. When in Ottawa, Mr. Hitchens and I formed the opinion that the Canadian Government should itself finance, on behalf of the British Government at any rate, a very large proportion of the Board's expenditure. Canada had hitherto always been a borrowing country. She had borrowed before the war some £40,000,000 a year from England, and it required a great effort of imagination on the part of Canadians to assume not only that they were to cease borrowing from England, but that they were actually rich enough to lend her large sums of money. Such a development had, in fact, never crossed their minds. While in Canada I urged publicly in speeches before the Canadian clubs at Montreal and Ottawa that it was the duty of the Canadian Government and people to lend money generously to the British Government in order to finance the munitions programme, and while we were still in Ottawa the Canadian Government announced that they had decided to lend \$50,000,000 to the British Government for this purpose. A little later, as is fully explained in one of the following chapters, the Canadian banks came forward with another large credit, and in later months the Canadian Government and banks continued to supply large sums of money.

Nevertheless, the financial position of the Board was always difficult, and constant and often acute negotiations with the British Treasury at home and the Minister of Finance in Canada were necessary. It was natural that the Canadian Minister of Finance should disclaim responsibility for the Board's expenditure. The scale of that expenditure had been determined entirely by the British Government; the Board was entirely responsible to that

Government, and it was therefore the duty of the British Government to provide that its expenditure should be duly met. On the other hand, the exigencies of war forced the British Government into incurring, both in the United States and in Canada, obligations far greater than they could meet by their own unaided resources. In America the British Government, indeed, gambled on being able somehow or other to raise money required from the American financial community; a gamble which would certainly have failed had not the United States come into the war. In Canada, perhaps naturally, the British Government assumed that the Canadian Government would strain every nerve that the munitions programme, which the Ministry of Munitions thought necessary for the safety not only of the British but also of the Canadian Army, should not fail for want of funds. The Canadian Government and banks responded nobly to the task, but the former were naturally concerned to make it clear that the aid they gave was of a voluntary character, and that they could not be committed to finance-obligations, the extent of which they had no means of controlling. In the end, by the joint efforts of both Governments, through the assistance also of the Canadian banks, and owing to the fortunate entry of the United States into the war, the task was accomplished, and all the commitments of the Board were punctually fulfilled, though it was found necessary towards the end to curtail the Board's programme.

In the first half of 1917 the Ministry of Munitions decided, as did all the other Allied Governments, that, owing to the entry of the United States into the war, it was necessary for them to have a representative of their own at Washington, in order to deal with the United States Government direct, and to control the activities of all the Ministry's departments there. I suggested to the Minister that Sir Charles Gordon, who was then in England, should be appointed as representative at Washington. Dr. Addison agreed to this proposition, and Sir Charles Gordon requested that I should accompany him for two months to Washington in order to assist him. As the financial situation of the Board was then very critical, I took the opportunity to go to Canada first to consult personally with Sir Joseph Flavelle. When, however, I arrived at Washington I found the work there so heavy and urgent that I was unable to leave, and owing also to Sir Charles Gordon's absence for some months in England, I was compelled to stay in Washington till April, 1918. In August, 1917, therefore, Mr. Perry came to London to take my place as the Board's representative, returning to Canada when I returned to England. During

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the remaining months, from April to October, 1918, the financial situation of the Board was easier, as their programme had been reduced, and as the United States Government was by that time providing the British Government with large dollar credits in New York.

The Imperial Munitions Board was a notable experiment in imperial co-operation. It was not, however, so much an example of co-operation between two Governments, *i.e.* the British and Canadian Governments, as between the British Government and a great Canadian organisation directly responsible to that Government. The experiment was indeed rendered the easier by the fact that the Canadian Board was not a political body responsible to the Canadian electorate, but a purely executive body responsible to and financed by the British Government. It could therefore afford to, and thanks to the determination of its chief officers in Canada it did, entirely ignore all politics and regard every problem before it from the single standpoint of efficiency and good service.

The status of the original Shell Committee was somewhat obscure. It seemed to regard itself as holding the position of a contractor *vis-à-vis* to the British Government, and yet responsible to the Canadian Government in the form of Sir Sam Hughes. Its status, being obscure and never clearly defined, was unsatisfactory, and it was at Sir Robert Borden's express wish that we advised Mr. Lloyd George that the Imperial Munitions Board should be made directly responsible through the Ministry of Munitions to the British Government.

Nevertheless, as I have already said, the size and importance of the Board's operations in Canada rendered close relations between it and the Canadian Government, particularly on finance, inevitable, and it says much for the tact exercised on both sides that so little cause of friction arose. Sir Joseph Flavelle received on all occasions the all-important aid of Sir Thomas White, the Minister of Finance.

My own experience as the Board's representative in London prompts me to make one observation, which may have some bearing on the problem of future imperial relations. If relations in future are to be close between the different governments of the Empire, and between different departments of those different governments, an effective liaison service will be absolutely necessary. The imagination and foresight of human beings are limited, and of civil servants as much as other classes of the community. If the Imperial Munitions Board had had no representative of its own responsible to it, and there for the one purpose of

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 W. A. PETERSEN, Esq.
 Captain R. J. DURLEY, M.B.E.

Committee on Production of Explosives.

HOWARD MURRAY, Esq., O.B.E., Chairman.
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 THEO H. WARDLEWORTH, Esq.

Committee on Inventions.

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NOBLE W. PIRRIE, Esq.		
Captain ARTHUR C. DARLEY, R.N.		Consulting Naval Engineer, Department of Naval Service, Ottawa.
Colonel R. A. HELMER		Director-General of Mus- ketry, Department of Militia and Defence, Ottawa.
Professor J. C. McLENNAN, Ph.D.,		University of Toronto,
F.R.S.		

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Mr. E. F. BRANDON	}	Joint Committee of Tech- nical Organisations of Ontario, Toronto.
Mr. F. G. ERICSON		
		Chief Engineer, Canadian Aeroplanes Limited, Toronto.
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Major J. E. PEARCE	}	Representing Inspection Department.
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Munitions Board

Private Secretary . . . Miss BENSON.

Assisting Representative of { Mr. D. O. MALCOLM.
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Transportation Building, Ottawa, Ont.

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Finance Department.

Financial Member of Board . Mr. F. Perry.

Auditor Mr. Geo. Edwards, C.B.E.

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W. C. LESTER

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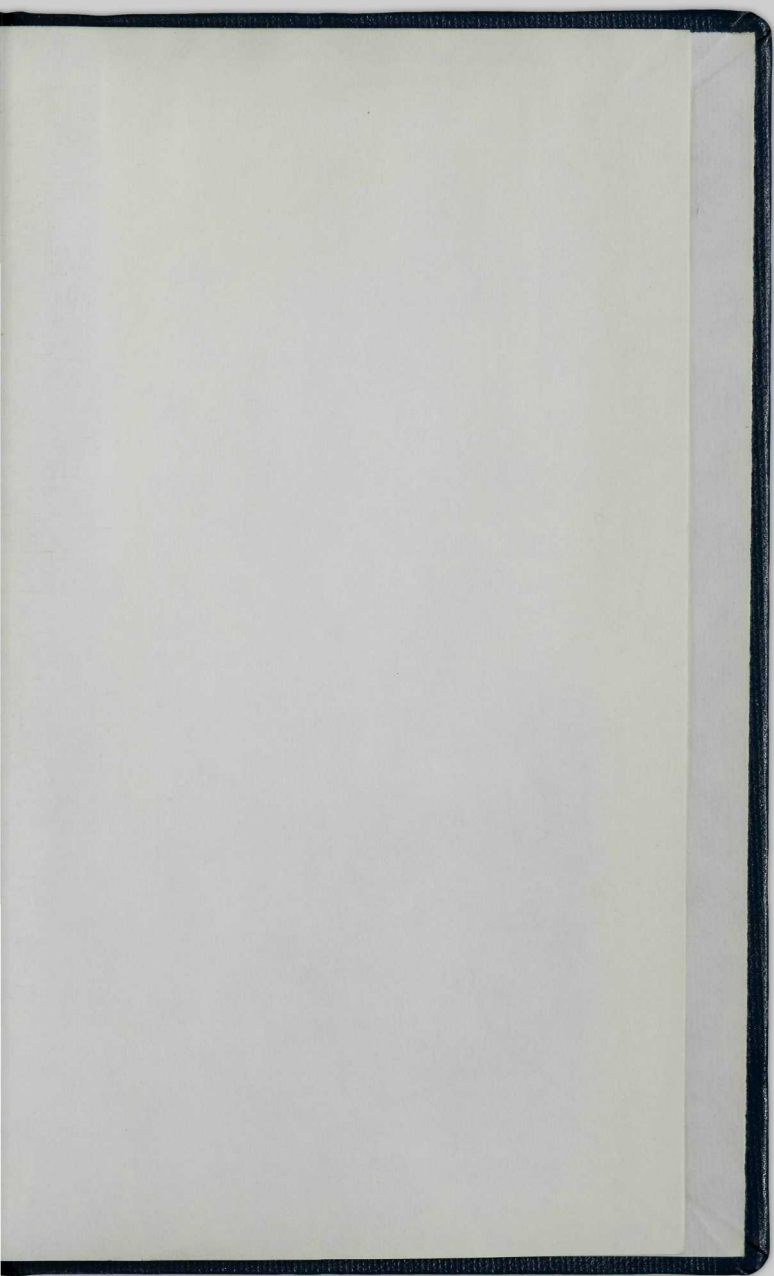
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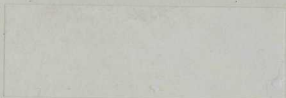


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