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MISS M. CURRIE.

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CANADIAN RUBBER SITUATION

The problem of ensuring adequate supplies of rubber for Canada's war needs has been approached by a program which has centred around the following points:

1. Control and conservation measures regarding existing supplies.
2. Collection of scrap rubber for reclaim purposes.
3. Conservation of rubber by the army--the largest user in wartime.
4. Production of synthetic rubber at the Plymer plant.

The program of scrap utilization, restrictions and controls over existing supplies played an important part in keeping essential needs supplied during the early stages of the war. Successful production of synthetic rubber is now assured, with the Polymer plant turning out a total of 7,000,000 pounds of buna-s and butyl each month, the equivalent of the output from 14,400,000 natural rubber trees covering 120,000 acres in the South Pacific. On the other hand, the demand for natural rubber still exceeds the supply and all available natural rubber is being directed into essential military and civilian uses.

CONTROL AND CONSERVATION OF RUBBER

At the present time this is the rubber control situation in Canada: new, retreaded and used tires, new and used tubes are rationed. They are distributed to essential users by 120 rationing representatives throughout the country. Use of crude rubber is permitted only in the manufacture of essential articles. On the other hand the use of synthetic rubber is being rapidly extended for war and essential civilian purposes.

Fearing the possibility of Japanese intervention in the war, Canada took steps to obtain reserves of rubber early in 1940 .

A government agency, Fairmont Company Limited, established on May 16, 1940, was given the authority to purchase, stockpile and sell crude rubber in accordance with existing and subsequent war needs; later it was given the same authority over synthetic rubber. When rubber was placed under jurisdiction of the Supplies Control on August 26, 1941, the Fairmont reserve amounted to 25,000 tons.

It soon became evident that reduction in civilian consumption of rubber would be necessary in order to maintain an adequate stockpile for war necessities. A program of progressive restriction on use of natural rubber followed in co-operation with manufacturers of tires, footwear, belting and other mechanical rubber items, wire and cable and other articles.

Regulations reducing the quantity of crude rubber which Canadian manufacturers could process were made on a sliding scale as follows: during October, 1941, 90% of the average monthly consumption for civilian purposes during the 12-month period ended May 31, 1941; November, 85% December, 80%; January, 1942, 75%; February, 70%; succeeding months 70% or such amounts as fixed by the controller from time to time.

The Japanese attack on Pearl Harbor changed the situation. Three days after Pearl Harbor, all dealings in new tires and tubes were prohibited except by permit, and the following day all processing of crude rubber for civilian purposes was prohibited until January 2, 1942. These temporary freezing orders were replaced by more permanent regulations which resulted in a reduction of 85% in use of rubber for civilian purposes, the first tire restriction order becoming effective on January 5, 1942.

Jurisdiction over rubber was removed from the Supplies Control and the new Rubber control was established on November 2, 1942.

The following table shows the extent to which use of crude rubber for other than war purposes has been reduced by Rubber Control regulations:

Average pre-war yearly consumption ---------	34,400 long tons.
1942 civilian consumption ------------------	5,031 " "
1943 " " ------------------	4,390 " "

ALLIES STOCKS POOLED

The allies pooled their rubber stocks under the Combined Raw Materials Board, set up on January 26, 1942, which allocated the crude rubber resources of the United Nations equitably to meet demands of war needs for the use of all. Controls in Canada and the United States have been kept more or less parallel and the rubber stockpile has been treated as a U.S.-Canada reserve.

There were 1,029,007 long tons of rubber brought into North America in 1941, compared with 282,653 in the following year and 55,329 in 1943, which shows the reduction in crude rubber imports brought about by Japanese control of Eastern sources of supply.

Reductions in the North American crude rubber stockpile have been as follows during the past three years: stocks on hand January 1, 1942 were 533,344 long tons; on hand January 1, 1943 422,714 long tons, and 139,594 long tons on hand January 1, 1944.

By the end of 1942, reclaim rubber was being substituted wholly or partly in the manufacture of essential articles, including military tires and war supplies. Rubber processors were under tight control and the rubber they used, for war or civilian manufacture, had to be processed according to mandatory specifications. No rubber was released, even for war purposes, except by permit, and no part of the civil allotment could be carried over from one month to the next by a manufacturer.

At the close of 1941 and subsequently applications for civil allotments of natural or synthetic rubber were considered only for the following list of essentials:

1. Medical, surgical and laboratory supplies and druggists' sundries for feeding of infants and care of the sick.
2. Jar rings and sealing compounds for canning of foods (beverages excepted).
3. Protective clothing for certain workers in essential services and industries.
4. Mechanical rubber articles, hard rubber, and compounded latex for industrial equipment and for the repair of industrial plants and mines, for firefighting equipment, for agricultural equipment such as

belting or hose, for fire departments, transportation companies and public services.

5. Component parts, not otherwise specifically mentioned, made wholly or partly of rubber for incorporation in articles of various kinds, if the use of rubber is necessary in their manufacture.
6. Rubber compounds for use in making essential insulated wire and cable.
7. Suction and gasoline hose.
8. Essential plumbers' supplies.
9. Tires and tubes, including bicycle tires, as directed by the controller.
10. Tire and repair materials, other than tire repair kits.
11. Camelback for retreading.
12. Automotive parts, if the controller has first stated in writing that the use of rubber is necessary.
13. Rubber cement for the shoe trade, on a restricted basis, or for such other purpose as may be determined by the controller.
14. Staple black lines of waterproof footwear.

USE AVAILABLE SUPPLIES

The proportionate use of rubber supplies, both natural and synthetic, during 1943, was as follows:

Item	Percentage
Airplane tires	1.0
Bicycle tires	.1
Other tires	81.9
Repair material, including camelback	1.1
Automotive parts	.3
Bogey wheels	4.7
Airplane parts	.5
Belting	.9
Hose	.0
Gas masks	.5
Mechanical goods	1.4
Wire and cable	1.9
Waterproof footwear	3.7
Medical supplies	.4
Protective clothing	.2
Cements	.4
Miscellaneous	.1
	100.00%

The foregoing table covers war and civilian consumption lumped together. With all of Canada on a wartime footing, with virtually all non-essential uses of rubber prohibited, it is not possible to distinguish between military and essential civilian consumption.

SCRAP AND RECLAIM RUBBER.

One of the principal reasons for initiating the scrap rubber campaign was to ensure a continuous supply of reclaimed rubber until adequate supplies of synthetic rubber became available and until its use as a substitute for crude rubber could be developed.

Early in 1940 the government organized an extensive campaign to collect scrap needed for reserves and to feed the two reclaim plants in Canada--one in Montreal and a smaller one in Toronto--and the United States reclaim plants which were then supplying 75% of Canadian requirements.

The campaign was initiated by a separate Scrap Rubber Division of the Department of Munitions and Supply, but this division was merged with the Fairmont Company on July 1, 1942. Assisted in its drive by organized salvage groups in all parts of Canada, Fairmont had received 45,167 tons of scrap rubber by February, 1944, bought at fixed prices, anywhere in Canada.

In 1941 a total of 22,179,755 pounds of reclaim rubber was used in Canada. In the following year this rose to 32,694,000 pounds and to 31,346,000 pounds in 1943.

Canadian scrap rubber was sold to the United States until heavy collections in that country made further shipments no longer necessary. Two yards were opened to store scrap which Canadian reclaimers were unable to accommodate. Arrangements were made with H. Muehlstein and Company Limited to operate the yard in Montreal; and with Federated Rubber Graders Limited to operate the Toronto yard, both on a strictly non-profit basis to the operators.

Measures of control over scrap and reclaim have closely paralleled those over crude rubber. On March 23, 1942, use of reclaim was limited to the same essential articles as those for which natural rubber could be used. In many articles its use was made mandatory and in others manufacturers were compelled to use a specified proportion of reclaim.

When synthetic rubber became available the restrictions on use of reclaim were gradually relaxed and by August, 1944 all "procurement and use" restrictions had been removed.

Fairmont ceased to purchase scrap rubber on February 15, 1944, when increasing amounts of synthetic rubber were being successfully substituted in a wide range of products. In May 1944, Fairmont's sales orders on hand covered 10,500 tons for shipment up to the end of September, approximately 1,000 tons of which had already been delivered. During the period of its dealing in scrap rubber, Fairmont turned about 35,000 tons of scrap over to processers and had only 10,000 tons on hand in May, 1944.

From 650 to 700 tons of scrap rubber are needed to make 500 tons of reclaim rubber. Reclaim rubber, made by grinding scrap, treating the mass to dispose of foreign materials and adding fillers to make the resulting product easily handled, is processed in Canada at the rate of about 7,000 tons a year. A similar amount is imported annually from the United States.

Little reclaim has gone into tires within the last two years, the bulk being directed into production of less essential rubber articles. This rubber is not a 100% substitute for crude rubber, and its pre-war use was largely confined to lower-priced tires and manufactured articles.

New passenger tires were not made in 1942. Beginning in January, 1943, such tires were made from reclaim rubber, but only for essential civilian vehicles under strict rationing restrictions. Altogether, approximately 126,000 of these reclaim tires were manufactured.

As synthetic rubber gradually became available, synthetic passenger tire production got under way on a small scale about the middle of 1943. By the end of August, 1943, the use of reclaim in tire production was discontinued and new passenger tires were made from synthetic. It is thus seen that reclaim rubber served only as a stopgap in a period when the shortage was the most acute.

In short, reclaim rubber played an important part in the solution of problems caused by scarcity of crude rubber in the early stages of the war when the outcome of the synthetic rubber program was indefinite. After the Polymer plant went into successful operation on September 29, 1943, the use of reclaim in the production of rubber articles decreased, in view of progress made in production of synthetic rubber, a highly superior product.

TIRES AND TIRE RATIONING

Three-quarters of Canada's rubber goes into the production of tires and tubes, whether in time of peace or in war.

When Japan entered the war, existing stocks of rubber were frozen and rationed tightly until supplies of synthetic rubber became available for replacement.

One of the first restrictions was a ban on the manufacture of new passenger tires and tubes. Dwindling stocks of used tires and tubes made it necessary to modify the ban after being in effect for a year, if essential cars were to be kept on the road. This was done, but reclaim instead of crude rubber went into the passenger tires made. These tires had to be driven slowly and carefully, but served the purpose of easing the situation brought about by shortage of crude rubber until supplies of synthetic became available for essential civilian tires.

The first tire restriction order, passed on January 5, 1942, replaced the freezing order. It permitted the purchase of new tires and tubes by essential users, upon completion of an essentiality certificate. It soon became apparent that this procedure could be improved and on May 15, 1942 it was replaced by the establishment of tire rationing which has remained in force ever since.

Under the new order a tire rationing representative, whose function was to investigate applications for new and retreaded tires, retreading services and new and used tubes, was appointed for each of the Wartime Prices and Trade Board local and regional offices throughout Canada.

Each such application has to be accompanied by a certificate from an authorized dealer stating that the turned-in tire was so worn that it could not perform its required service. Tire ration permits are issued only to those whose vehicles were included in the list of eligibles.

The following basic points are observed in defining "essential vehicles" for the purpose of determining eligibility under rationing restrictions:

(a) Are the services of the individual essential in time of war?
(b) Is the vehicle really necessary for performance of the services, considering distance, other transportation service available and the time element (particularly for skilled individuals and transportation of strategic materials and supplies)?
(c) Is the vehicle driven 75% or more in annual mileage to perform such duties?

Eligible vehicles were divided into three priority classes:

A. Vehicles for which new, retreaded or used tires, new or used tubes could be bought, including public vehicles, farm tractors and combines, public and other vehicles used for transporting essential commodities and construction materials. In this category are passenger cars used by doctors, visiting nurses, policemen and clergy serving in rural areas.

B. Vehicles for which retreaded tires, retreading services or used tires and tubes could be purchased. This group includes largely the less essential passenger cars, namely, those used by rural mail carriers, certain munitions workers, Red Cross field secretaries, farmers and others. Taxicabs are also in this group. Covering farmers' needs presents the greatest problem as about half the cars in this category appear to be used by farmers.

C. Vehicles eligible for used tires and tubes only. In this class are included vehicles used by such persons as newspaper reporters, rural school teachers, scrap collectors, most of the clergy, some farmers who also own trucks, and others dependent on a car to earn their own living or to perform an essential service.

Modifications, some of greater severity and some of less, have been made in the list of eligible vehicles, but basically it has remained the same as in the original order.

At first used tires could be bought by anyone in the eligible list, merely by filling out a form certifying that the tire was essential in his work. However, used tires soon became scarce, and in July, 1943, dealings in such tires were put on a permit basis.

It has been estimated that about 450,000 out of 1,250,000 passenger cars and approximately 250,000 out of about 300,000 trucks are included in classes A and B. Under the terms of the July, 1943, order, all other passenger cars, whether used for business or for pleasure, were eligible for retreading services, and all trucks, whether or not eligible for new or used tires, also could secure retreading services. The rationing of retreading services came to an end late in 1943 when supplies of buna-s rubber became more plentiful.

No new passenger tires have been made from crude rubber since Pearl Harbor. In 1943, approximately 542,000 passenger tires were released to those qualifying under rationing restrictions. Of these, 314,000 were manufactured during the year, chiefly from reclaim rubber, a few from synthetic. The rest were old pre-war tires.

Tire rationing restrictions will be gradually relaxed starting within a few months of the collapse of Germany, Munitions minister Howe announced on September 29, 1944. 885,000 passenger tires will be released this year, as against 540,000 last year, but the increased number is expected to be insufficient to fill essentialdemands. Ration permit holders may find it difficult to purchase tires as the demand is likely to exceed the supply.

As soon as Germany is defeated the government willtake steps to increase the output of civilian tires. Restrictions on crude rubber, still essential for production of synthetic tires, must be maintained until Far Eastern sources are again in a position to export rubber.

The largest truck tires require a minimum of 30% natural rubber in their construction, to avoid disintregation from overheating. Synthetic tires, not as flexible as natural rubber tires, have a tendency to heat up when driven at high speeds, if over-loaded, under-inflated or under bad driving conditions. Large truck tires, containing 30% to 40% buna-s rubber and built with rayon fabric, were being made from buna-s produced at the Polymer plant in December 1943, soon after the plant went into operation.

At present passenger car and medium-sized truck tires are made from synthetic rubber, and contain only a very small percentage of crude rubber. Synthetic rubber products are subject to rigid tests, to ensure reliability, before being released for civilian or military use.

One of the most important improvements in synthetic tire production for commercial vehicles, manufacture of a new type of synthetic tire was announced on October 22, 1944. Known as the "inlaid carcass", this construction uses from 10% to 30% crude rubber placed directly under the tread where the greatest heat and strain occurrs, synthetic rubber being used in the remainder of the carcass. When rayon cord is used, tests have shown that tires made by this process are as good as the pre-war natural rubber cotton carcass, which was the pre-war standard construction. Added miles of service may be obtained from these tires by recapping, an important factor in maintaining wartime motor transportation.

CONSERVATION OF RUBBER BY THE ARMY

The army has taken steps to eliminate, as far as possible, non-essential use of rubber; and to conserve its available supplies of rubber equipment and tires. Their tire maintenance program has a two-fold purpose:

(a) To prolong life of tires in use by preventive maintenance, thereby easing demands upon the diminishing crude rubber stockpile.

(b) To re-cap and repair worn tires that they may give further service.

Runflat, or combat tires, requiring twice as much rubber as the average standard tire, were extensively used for military purposes at the beginning of the war. When the tire situation became critical in January, 1942, owing to shortage of natural rubber, the Canadian army overseas took conservation measures limiting use of combat tires to essential types of vehicles, namely armored, scout, and reconnaissance cars; and certain ambulances. Up to that time runflat tires were used on training equipment in Canada, but these were gradually replaced by standard commercial-type tires, releasing 40,000 runflat tires for overseas use.

Tires of all army vehicles are inspected monthly by officers in charge of allotted districts, whose recommendations regarding tire maintenance are promptly carried out. Tire inspectors strive to obtain maximum mileage from each tire casing, on the alert for evidences of improper use, such as: "Over and under inflation, external injury, evidence of internal injury distortion, improper mating of duals, misalignment, heel and toe wear, bleeding, missing valve caps, improper fitting of chains, cold patching of tubes, use of tire boots or shoes, and failure to rotate tires at prescribed mileages."

Twenty-eight maintenance shops have been established, with facilities for repair and vulcanization of tubes and tires. These co-operate with all units in various areas regarding tire repair, including road service,

Experimental work on repairing rubber bogie wheels and tank track pads proved successful in Canada, resulting in establishment of a plant in England where rubber track pads are retreaded. At present no rubber tracks, other than retreaded ones, are used in Canada. A number of all-steel tracks are in use, including the Canadian dry pin track, an all-Canadian development.

Curtailment of natural rubber in universal carriers has proved difficult, due to heating and deterioration of synthetic tires when overloaded. Synthetic tires are used whenever possible on idle wheels, where the load carried is light.

Responsibility of the individual driver is stressed in tire conservation, as preservation of tires during period of wear on the original tread is a basic essential. Pamphlets outlining general tire operating conditions within the driver's control were distributed in 1942, to all officers, non-commissioned officers, mechanics and drivers.

Speeding, or negligent operation of military vehicles is severely handled, the driver being subject to reprimand or arrest.

A revised tire inflation table, based on maximum load capacity, and correct pressure for general operations, is posted inside each vehicle. Tire gauges are regularly tested for accuracy.

All tires used by the Canadian Army on vehicles in this country are recapped several times. Plants for this purpose are operated at London, Ontario; Camp Debert, Nova Scotia; and at Vancouver, British Columbia.

DOMESTIC RUBBER PLANTS

Canadian experiments on domestic plants as possible sources of rubber have centred largely on the Russian dandelion and milkweed.

Under a program organized in 1942, the Botany Division of Science Service, Department of Agriculture, was made responsible for a survey of native plants for rubber content, and for the production of rubber-bearing plants. Extraction and testing of the rubber produced was done by the National Research Council.

Approximately 1,500 analyses were made of Canadian plants but remote possibilities of securing large tonnages and the low rubber content in the majority of cases made the results of this survey largely negative.

Species of goldenrod, wild lettuce, and dogbane gave some promise of possible utilization, but much further study is still necessary.

Tests made on milkweed indicated that it had a higher rubber content than that found in other native plants. Analysis of the leaves revealed the presence of considerable amounts of rubber and resinous substances. Further studies made by the National Research Council indicated that milkweed gum might be a useful substance for blending with buna-s synthetic rubber. Extensive experimental work in planting, seed germination, harvesting and handling methods of milkweed is being undertaken. A pilot plant was erected in 1943 to process quantities of milkweed leaves in order to secure sufficient gum for large-scale commercial tests. The future use of milkweed for rubber depends on the results of these tests, being conducted at the present time by the National Research Council.

Seed of the Russian rubber-bearing dandelion, taraxaoum kok-saghyz, was received in Canada in May, 1942. Considerable field and laboratory work has been done by Canadian scientists on this plant, results being that, although kok-saghyz is a source of high quality rubber, numerous agricultural difficulties must be overcome before it can be planted on a large scale. Production of varieties with high rubber content, large roots and completely mechanized processes of planting, cultivating and harvesting would be necessary in order to bring the cost of production to a reasonable level.

Canadian species of the kok-saghyz growing in the Arctic and sub-arctic regions were investigated. None of these proved to be valuable as a source of rubber, but may be useful in the breeding program with kok-saghyz which is now under way.

Experimental work is being conducted on a native British Columbia plant, lactuca diennis, as a possible source of rubber, but its commercial possibilities are yet undetermined.

The plant, known for some time, is reported to have a potential annual yield of 600 pounds an acre, double that of standard rubber plantations. It contains some rubber and yields a quantity of gum, but its practical value as a source of rubber is not yet known.

The possibilities of native rubber production in Canada are being given careful study, although it is unlikely that domestic rubber will play an important part in relieving the present rubber situation.

SYNTHETIC RUBBER

The perfect, all-purpose synthetic rubber has yet to be found, in spite of constant technical research, but the three vulcanizable synthetics most closely resembling crude rubber are: buna-s, butyl and neoprene. With this in mind the North American synthetic rubber program has centred on production of these materials. Production at the Polymer plant, part of this all-over program, is confined to buna-s and butyl.

Demands of mounting war needs found Canada faced with a grave rubber shortage in December, 1941. In co-operation with the United States, a program for the development of synthetic rubber was inaugurated by the Canadian government. A crown company, Polymer Corporation Limited, was set up in March, 1942, to arrange for building and operation of a synthetic rubber plant near Sarnia, Ontario.

Built at a cost of $51,000,000, construction of such a plant in peacetime would have taken three years. Under pressure of war needs it was completed in about half that time. This was accomplished by engineers and key men working seven days a week, and all workmen putting in long hours of overtime.

To transport the vast quantities of materials going into the project required 8,900 freight cars, and to move these materials on the property and to put them into position, approximately 40 tractors, 40 cranes and 120 trucks were in constant use.

BUNA-S

On September 29, 1943, Polymer began commercial production of buna-s rubber, using Canadian-made styrene and butadiene imported from the United States. The styrene unit was rushed to completion, producing commercially on July 14, 1943. The butadiene unit came into operation several months later. In the meantime surplus styrene shipped to the United States in exchange for butadiene enabled Canadian production of buna-s to go forward at a time when rubber was urgently needed. This exchange of basic ingredients was made possible by a policy formulated early in 1942 by the two countries, allowing high priorities on essential materials needed by the two countries.

Buna-s is made up of a combination of butadiene and styrene. These chemicals can be extracted from any hydro-carbon. Canada had the choice of making them from grain alcohol or from petroleum. Both processes were tried during the initial stages of synthetic rubber production, but the present program hinges on the use of petroleum, from which buna-s can be produced under present conditions at less than half the cost of using alcohol.

BUTYL

Another important reason for choosing petroleum as a base for production of butadiene is that butyl rubber is obtained as a by-product of this process. In the manufacture of butadiene the bases are butylenes in the original "cut" from the refinery. There are two types of butylenes, normal butylenes and isobutylenes. Butadiene is made from purified normal butylene after the isobutylene has been extracted. Butyl rubber is made from the isobutylene in a separate unit.

Butyl rubber is used largely in the manufacture of inner tubes of automobiles where it has been found the best substitute for crude rubber. It is also used in gas masks and other essential equipment of that nature.

Extensively used in the manufacture of tire casings, buna-s is a better type of rubber than butyl for this purpose. It possesses superior wearing qualities, stronger resistance to abrasion and blends well with crude rubber, while butyl does not blend. Development of its use in footwear, insulated wire and cables, and tire repairs has reached an advanced stage and substitutions are being made on an increasing scale.

NEOPRENE

Use of neoprene in Canada is largely confined to oil-resistant belting, gaskets and washers, for which its properties make it suitable. Supplies of this synthetic are obtained from the United States, and importations will continue indefinitely, as long as needed. Both neoprene and neoprene latex are used for the making of rubber thread for many articles, such as children's underwear, surgical garments, elastic hose, women's foundation garments and so forth. Neoprene and neoprene latex were released for this purpose in October, 1944.

Before the Polymer plant came into production, buna-s, imported in small quantities from the United States, was used in experimental stages of synthetic rubber production in Canada. It was first used mid-way through 1943, in production of small quantities of synthetic tires for essential civilian vehicles under rationing restrictions. At this time the production of reclaim tires was discontinued.

Production at Polymer in the year ended September 29, 1944, comprised 58,000,000 pounds of buna-s and 2,000,000 pounds of butyl rubber. The original rated capacity was 74,800,000 of buna-s and 8,800,000 pounds of Butyl. The peak annual capacity, reached in May, 1944, was 88,000,000 pounds of buna-s and 5,060,000 pounds of butyl. The present rate of output is 78,000,000 pounds per year of buna-s and 9,000,000 pounds per year of butyl.

Approximately two-thirds of the synthetic rubber produced at the plant during the first year of operations was turned out in the last six months. To meet an urgent need, the output climbed rapidly during the autumn and winter of 1943-44 until it reached a peak annual rate of over 93,000,000 pounds in May, 1944. Thus the plant proved itself capable of producing at a rate 11% greater than its original rated capacity of 83,600,000 pounds.

POLYMER PLANT

Rubber from the Polymer plant has literally kept Canada in the war. It's output, together with production from United States plants, all of which goes into the United Nations' pool, has supplied the armed forces of the allies with the necessary rubber and kept essential civilian needs supplied.

Polymer increased its output of ethyl-benzene beyond requirements needed for production of styrene to meet the demands for anti-knock blending agents in high-octane aviation gasoline. From May to September, 1944, the plant turned out about 1,500,000 pounds per month of surplus ethyl-benzene, a substitute for the cumene now produced at the plant for the same purpose.

When the war against Japan is won, demands for synthetic rubber may decline, but the plant is capable of turning out post-war by-products. It could make styrene, a plastic base, and butadiene, an elastomer base; and with minor alterations it could produce industrial alcohols, acetic and other acids and numerous other products.

The Polymer price for synthetic rubber was set in October, 1943, at 40.515 cents a pound f.o.b. destination in Canada. On June 1, 1944 the price was reduced to 35 cents including freight. This was further reduced on September 30, 1944, to 30 cents a pound, including freight. After the war the sale of other chemicals could have the effect of reducing the pric price still further.

The total consumption of rubber in 1944 is expected to be on the following basis: natural rubber 18%, reclaim 27% and synthetic rubber 55%. The use of synthetic rubber is being extended rapidly and steadily in the manufacture of essential goods for military and civilian use. Restrictions on the use of buna-s, (other than latex) were removed on August 9,1944.

The Sarnia site was chosen for Canada's synthetic rubber plant because of the following points in its favor:

1. Sarnia is the point of intake for the Imperial Oil pipeline which conveys crude oil from the United States midcontinent fields, the safest source of crude oil coming to Canada.
2. Its proximity to the St. Clair river as a source of water made unnecessary the installation of expensive water-cooling apparatus.
3. It is conveniently close to the coke ovens at Sault Ste. Marie and Hamilton.
4. Brine, used in quantities in synthetic rubber production, is easily and cheaply obtained from the Dominion Salt Company, Sarnia.
5. The site is convenient to rail, water and road transport.
6. The plant is not far from Kitchener, Hamilton and Toronto, where many of the principal rubber processing factories are located.
7. The site is level, with a clay soil. No rock had to be blasted, no quagmires filled in and no buildings removed.

The Polymer plant is noted for its complexity, for which it has no equal anywhere in the world. It produces its own end-ingredients for the manufacture of buna-s and butyl; namely, styrene, butadiene and isobutylene, as well as its own steam and electric power. The yearly output of Polymer, about 34,000 long tons of buna-s and 4,000 long tons of butyl, together with small importations of neoprene from the United States, natural rubber from Ceylon, Africa, South and Central America and large amounts of scrap, is sufficient to provide for Canada's wartime requirements.

Really the equivalent of a more or less self-contained village, the plant covers an area of 185 acres, containing 10 factories, each as complex as a good-size munitions plant; its own hospital, fire hall, general store, bowling alley, post office, cafeteria, ball park, dining hall, police department, administration buildings, laboratory, warehouse, machine shop, river dock and railway siding. About 1,600 men and 235 women are employed at the plant.

For its annual output of 38,000 long tons of synthetic rubber, Polymer requires approximately 400,000 tons of coal, over 35,000,000,000 imperial gallons of water, 19,000,000 imperial gallons of light ends petroleum, 2,500,000,000 cubic feet of petroleum gas, 2,250,000 imperial gallons of benzol, and enough brine to contain 18,000,000 pounds of salt, in addition to huge quantities of acids, soaps and other raw materials.

The various units of the Polymer plant are operated on a management-fee basis by the St. Clair Processing Company, Dow Chemical Company of Canada, Limited, and Canadian Synthetic Rubber Limited, under supervision of the Polymer Corporation. The management fee paid by Polymer amounts to about one-half cent per pound of synthetic rubber produced.

The ten "factories" that go to make up the Polymer Plant are:

1. The Supersuspensoid Cracking Coil is a clever adaption of the standard refinery thermal cracking unit, which had been developed by the Imperial Oil Company Limited, and is located in that refinery, not on the Polymer site. In successful operation before rubber production was considered, this development enabled the Polymer management to start operations with a minimum of delay and at considerable savings in production costs.

The Supersuspensoid cracking operation consists of heating naphtha and gas oil to high temperatures and pressures along with a small quantity of catalyst; thus breaking down the molecules into the smaller molecules required. Pipes from the coils convey to Polymer 6,255 barrels of light ends liquid petroleum and 19.4 million cubic feet of petroleum gases per day, which are the crude forms of isobutylene, normal butylenes, ethylene, and propylene, the raw materials used in the Polymer plant.

2. The Light Ends Recovery Unit is a fractional distiller in which the hydrocarbon streams from Imperial Oil are broken up into these components: ethylene, propylene fuel gas and a so-called butane-butylene cut, containing isobutylene, normal butylenes, butane and isobutane. The ethylene is for the production of styrene and the propylene for making cumene.

3. The Isobutylene Extraction Unit separates isobutylene, which later forms the major part of butyl rubber, from the liquified butane-butylene cut by treatment with acid.

4. The Butylene Concentration Unit separates and concentrates the butylene necessary for making butadiene, one of the two chief ingredients of buna-s.

5. Butadiene Unit comprises two sections, one carrying the dehydrogenation (removal of hydrogen from the molecule) and the other the concentration.

The dehydrogenation section is divided into two identical units. The normal butylenes are mixed with high temperature steam and passed over a catalyst, thus removing hydrogen and producing butadiene which is then purified by selective solvent absorption in the extraction section.

6. Styrene Unit and Cumene Section comprises four sections, the Ethyl-benzene, the Cumene, the Styrene Cracking and the Styrene Finishing.

Ethylene from the Light Ends Recovery Unit is piped to the Ethyl-benzene-Cumene building, Benzene (benzol) is brought in by lake tankers during the summer from the coke ovens at Sault Ste. Marie, Ontario, and stored for use in the winter months.

The Ethyl-benzene-Cumene section contains two sub-sections, both originally designed to turn out ethyl-benzene, one now turning out Cumene. One section was able to turn out sufficient ethyl-benzene to make the required styrene for production of buna-s rubber, and the other section produced ethyl-benzene for blending with high octane aviation gasoline. With minor alterations made during the summer of 1944, one of the ethyl-benzene sections was switched over to making Cumene, going into operation September 17, 1944.

In the Ethyl-benzene section the ethylene is reacted with benzene over a catalyst to produce ethyl-benzene.

Styrene Cracking Section dehydrogenates the ethyl-benzene to produce crude styrene, the operation being similar to dehydrogenation in the Butadiene Unit.

Styrene Finishing Section brings the crude styrene up to purity by fractional distillation and the unreacted ethyl-benzene is returned to the Styrene Cracking building for further treating.

Cumene Section is one of the original ethyl-benzene sub-sections converted to making cumene. In producing cumene a propylene "cut" is employed, the propylene being piped from the Light Ends Recovery Unit. It is reacted with benzene to form Cumene. About half the consumption of benzene or approximately 1,125,000 imperial gallons per year, is used in making Cumene, the output of which is about 2,500,000 pounds a month.

The Styrene Unit is operated for Polymer by the Dow Chemical Company of Canada, which employs only 109 persons. The smallness of the staff is made possible by engineers who designed the different sections to run themselves with a minimum of human aid. The Ethyl-benzene and Cumene Sections are jointly operated by two technicians and one helper on each of three eight-hour shifts by the means of a robot control and instrument board. Similar devices are employed at the other buildings.

Styrene is in itself a plastic base which has been in commercial production in the United States for the past seven years. Its uses range from insulation for radio sets used by the army to costume jewellery, combs and lenses. It is impervious to water, is light and resonant.

7. Buna-S Unit comprises two identical parallel units operating independently, which combine butadiene and styrene to produce buna-s rubber. Co-polymerization of these ingredients is accomplished in batch reactors in an aqueous emulsion in the presence of a catalyst and other chemicals. The resulting latex contains some unreacted butadiene and styrene which is later removed. Rubber is coagulated in a two-step operation involving addition of brine and salt, filtered off in rotary filters, dried and baled. The rubber is shipped in 75-pound bales.

8. The Butyl Rubber Unit was built to produce 4,000 long tons of butyl per year. Butyl rubber is made chiefly from isobutylene, built up to complex molecules with a small amount of isoprene, the operation being performed in the presence of a catalyst and inactive solvent at low temperatures. The product is dried in much the same way as is buna-s.

9. Steam and Power Plant in Polymer is the largest of its kind in Canada and one of the largest producers of process steam in the world. It has a rated capacity of 1,375,000 pounds of steam per hour at 450 pounds per square inch pressure, which, if converted into electrical energy, would light 1,200,000 sixty-watt bulbs or one in every household using electricity in Ontario, Alberta and Quebec.

The plant contains five great furnaces, which at their hottest point generate a temperature of 2,500 to 3,000 degrees F., but are so well insulated as to permit a heat loss of only half of one per cent, representing an annual saving of about 8,000 tons of coal.

Air for each furnace is forced in by a 200-horsepower electric fan. Boiler water goes through a treater and a filter before being pumped into the boilers by the means of electric motors and turbines. 400,000 tons of bituminous coal per year are required to feed the five furnaces, or enough to heat every house in Winnepeg and Edmonton. This coal is crushed by means of a pulverizer within the plant which renders it so highly combustible that very little of it goes up in smoke.

10. The Pumping Station has six steam-driven pumping units designed for a flow of 86,800 imperial gallons of water per minute or enough to supply the requirements of a city like Toronto.

St. Clair River water is brought in from a good depth, freed from impurities and pumped under 55 pounds pressure to the various units of the plant. As water required for various processes in a rubber plant must be cool water, the Sarnia site is ideal because the St. Clair River water.is never too hot nor too cold, ranging between 34 degrees F. in winter and 70 degrees in summer.