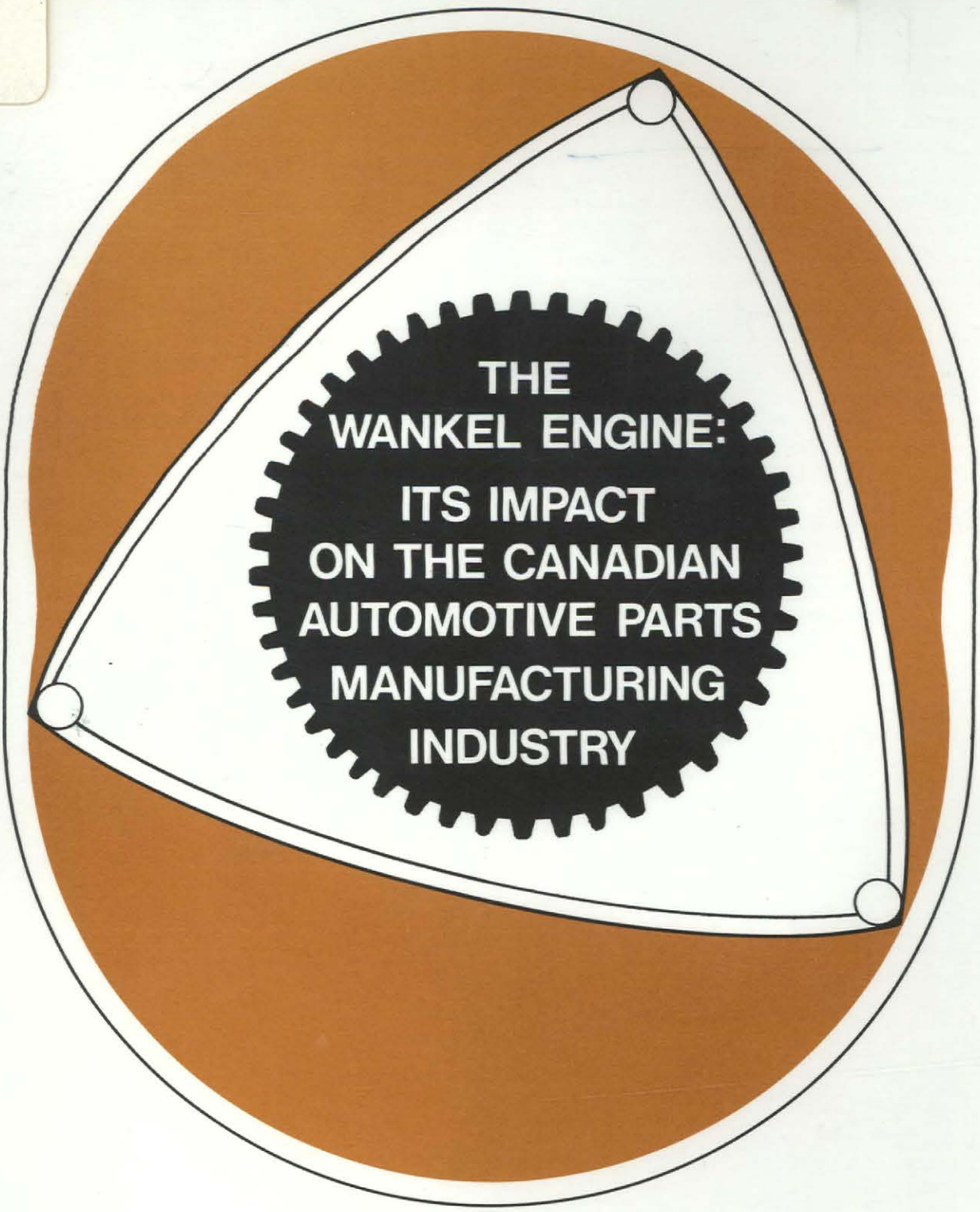

A Report to the Department of Industry, Trade & Commerce

P. S. ROSS & PARTNERS
MANAGEMENT CONSULTANTS

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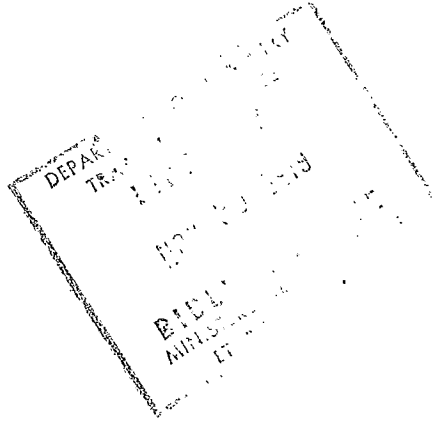

THE WANKEL ENGINE:
ITS IMPACT ON THE
CANADIAN AUTOMOTIVE PARTS
MANUFACTURING INDUSTRY

A Report to the Department of Industry, Trade & Commerce

July, 1973

P. S. ROSS & PARTNERS

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I. EXECUTIVE SUMMARY

Objectives

The study terms of reference required us "to identify the probable effects of the increasing use of the Wankel engine on the activities of Canadian parts suppliers, and recommend action to be taken to ensure that the Canadian parts industry achieves its maximum possible participation as a parts supplier.".

Background

The Wankel rotary engine is not a new development. The principle of the engine was developed about two decades ago by Dr. Felix Wankel, a German inventor, and extensive work on developing the engine for use in automobiles has been going on for years. Its present acceptance can be measured by the fact that over 75 percent of the world's automobile manufacturers have access to manufacturing rights through a variety of licensing and royalty agreements.

The introduction of the rotary combustion engine into the North American automobile industry is likely to have major impact on the products that the automobile industry manufactures. On the other hand, we are ancitipating it will have a much smaller impact on the size of the automobile industry and its economics, the number of people it employs and the number of firms involved.

We have examined the impact of the rotary engine on the original equipment manufacturers and the parts manufacturing industry under four distinct classifications that are categorized by the degree of obsolescence and overall automotive redesign requirements. These are:

1. Obsolete parts - those components which by the very nature of the basic engine design are not required in the rotary engine.

2. Extensive redesign parts - those which require extensive modification to the degree that they bear little resemblance to those in current manufacture.

3. Unique new parts - those new parts unique to the rotary engine.

4. Parts affected by major vehicle redesign - those parts dependent upon the degree to which manufacturers are prepared to redesign the automobile around the basic rotary engine.

In particular, one of the major areas of impact of the move to rotary combustion engines will be the change in material requirements from iron based products to aluminium and powder metal products.

Market and Social Influence

The introduction of the rotary combustion engine in North America comes at a time when there are a variety of other factors impacting on the automobile industry.

* Emerging auto market trends appear to favour the smaller sized car. Eventually, Wankel powered cars will, in general, be smaller in overall exterior dimensions while optimizing interior space to retain or improve useful passenger space equivalent to say a Chevrolet Impala.

* The shortage of fuel and increasing prices which comes as a consequence has added to the trend to the smaller car. The addition of anti-pollution devices does not penalize the rotary to the same extent as the traditional piston which with the addition of more optional equipment is becoming severely penalized in terms of gas mileage potential.

* The Mazda rotary combustion engine was successful in passing the 1975 pollution control standards in the United States. In addition, the rotary engine requires less space and therefore provides more opportunity to install emission control devices.

* General Motors are committed to metric transition and will influence the industry accordingly. The G.M. rotary will be produced in metric measure right from the beginning.

Production Location Considerations

The manufacturing engineering development for the high volume production of the rotary combustion engine has taken place largely in the United States and Japan. In view of the dominant position American firms hold in the Canadian parts manufacturing industry, it is to be anticipated that early introduction of manufacturing capability in North America for the rotary will be in the United States plants most closely adjacent to the source of technology. This has been confirmed by a number of the organizations contacted.

Potential Impact

In general, the automotive parts manufacturing industry has anticipated the development of the rotary engine exceedingly well. Parts manufacturers have established special task forces within their organizations to monitor and study the effects of the rotary engine on their particular business to determine what opportunities exist for them under changing circumstances.

Our main conclusions regarding the impact of the rotary combustion engine on the Canadian automotive parts manufacturing industry are as follows:

* The rotary combustion engine can be expected to achieve a maximum of 30-35 percent original equipment penetration by the year 1980.

* According to our study, approximately 11,000 Canadians are employed in the manufacture of passenger car engines and engine parts at the present time. In our opinion, this exposure does not constitute an immediate threat to employment, primarily because of the time involved in introducing the new engine and its subsequent acceptance. This means that conventional piston engines will continue to dominate production for some time.

* The effect on individual firms will be limited due to their diversification plans and their acknowledged preparedness.

* The main constraint in the conversion to the rotary engine is at the production equipment and transfer equipment level.

* The net effect on the automotive industry in Canada will be to cause a change in product mix and a slight decline in material consumption; however, its effect on the work force will be minimal.

* Apart from the exposure felt by engine assembly plants, the major industrial sector affected would be that composed of the forging companies.

With limited exceptions, industry contact reveals that the characteristic activity of searching for new products to make up for the loss of existing production will be the industry response.

* There appears to be a basic commitment to keep Canadian plants operating and maintain employment which is partly stimulated by labour relations and partly by a commitment to exploit investments currently in place.

Policy Issues and Recommendations

An overview of a number of public policy issues identified two particular areas of immediate concern to the Department of Industry, Trade & Commerce as:

* Industrial Strategy

* Trade Strategy

Within these areas of concern, existing assistance programs were reviewed and a number of recommendations proposed.

Specifically, it is recommended that:

(a) The Department of Industry, Trade & Commerce continue R&D incentive programs presently available as well as an adjustment program similar to AAA to anticipate potential relocation and re-equipment requirements that could develop.

(b) The Department of Industry, Trade & Commerce assist the industry in general by monitoring and disseminating the changing level of technological information.

(c) The Department of Industry, Trade & Commerce reinforce its marketing programs to continue its focus on export potential. The parts industry in Canada exported approximately $85 million to 100 countries other than the U.S. in 1972. The industry is actively promoting, in conjunction with the

Department of Industry, Trade & Commerce, greater export penetration in third world markets. Industry association officials indicate potential third world export sales of $250-$300 million.

In addition to these specific recommendations it should be noted that additional consideration be given to developing possibilities including:

1. Specific incentives directed towards existing and new manufacturers of machine tools and transfer equipment. They could be encouraged to develop and market rotary engine production equipment to meet North American potential demand for this machinery.

2. The active monitoring of increased foreign car penetration into Canada. The potential for bilateral auto-trade agreements with countries other than the United States should be actively pursued as the shift to small car production from outside North America becomes more pronounced.

3. Consideration given to stimulating R&D on rotary engine parts and processes through a research consortia working with Canadian industry in which the Federal Government would accept the greatest financial risk. Licensing and joint venture opportunities could be explored in these areas.

II. INTRODUCTION

A. Background

Early in 1973, the Department of Industry, Trade & Commerce retained P. S. Ross & Partners to conduct an examination of the Canadian automotive parts manufacturing industry, specifically to determine the potential impact on the Canadian automotive parts industry of the development of the rotary combustion engine.

The traditional piston engine has been a basic characteristic of the automobile industry throughout the world. Many firms and indeed, whole industries have grown up over the years on the basis of providing services and products to automobile companies within this context.

B. Market Timing

From time to time innovations appear, such as diesel engines, steam, electric and turbine engines, which threaten a massive restructuring of this otherwise stable industry. The Wankel engine is the latest entrant into this field of innovations. Unlike its predecessors, however, the Wankel is to be introduced as a principal engine by at least one major North American automobile producer following favourable acceptance of a Wankel powered import. The Wankel engine's apparent success leads to the conclusion that perhaps a major restructuring of the auto parts industry might well be imminent with this latest technological development.

C. The Canadian Automotive Parts Industry

It has been noted that Canadian automotive exports are currently worth approximately $4 billion annually. Although there are over 800 producing firms in Canada associated in some way with the industry, less than 10 percent of these firms could be classified as directly affected by the rotary combustion engine in the short term, represented by the balance of the 1970's.

The Canadian automotive industry is a major element in the Canadian economy producing as it does substantial numbers of complete vehicles for domestic and export consumption as well as original equipment and aftermarket parts, tooling services and materials for use in the industry in North America. The parts industry is the second largest in Ontario, and its output is shipped to more than 100 countries.

In 1970* the industry was comprised of 22 motor vehicle manufacturers, 182 motor vehicle parts and accessory manufacturers and 265 truck, body and trailer manufacturers. It employed close to 40,000 people in parts manufacturing alone representing salaries and wages of over $300 million. The parts industry consumed over $700 million worth of material and produced products whose gross selling value is estimated at between $1.5 and $2 billion. In addition to this, the motor vehicle manufacturers occupy a segment as large again producing products valued at close to $2.5 billion and employing over 35 thousand workers with a salary and wage bill of over $350 million.

D. State of the Art

With respect to the specific characteristics of the industry relating to the production of the Wankel engines, the information is more difficult to obtain. The Canadian automotive parts directory of 1972 identified approximately 940 Canadian companies supplying automotive parts, tooling materials and services. These companies employ a vast number of people, however most are involved in manufacturing a wide range of products.

In a later section of the report dealing with the potential exposure of the Canadian automotive industry to the introduction of the rotary engine, we identify approximately 11,000 Canadians and their location, who are employed in the manufacturing of passenger car engines and engine parts at the present time.

In 1970 the value of factory shipments of engine parts manufactured in Canada was in the order of $66 million whereas the total value of all parts shipments was upwards of $1.2 billion.

Engine manufacture itself in Canada is largely a captive enterprise by the motor vehicle manufacturers. The value of factory shipments for gasoline engines have been estimated at approximately $1.4 billion**.

Not only is the auto parts industry and the automobile manufacturing industry important to Canada by virtue of the number of people it employs and the value of its production, it is a significant exporter as well. It is estimated that in 1971 the Canadian automotive industry was responsible for $4.2 billion of exports. During the same period the industry was responsible for a like value of imports so that although it was responsible for a large volume of foreign trade it had a minor net effect on Canada's balance of payments.

** Source: Department of Industry, Trade & Commerce

* Source: Facts and Figures of the Automotive Industry, 1972 Edition, Motor Vehicle Manufacturers' Association

In short, the automotive industry is a major industry in Canada and when technology change of the level of the rotary engine presents itself in such a way as to assume significant proportions relative to the industry, it is vital that its effects be clearly studied and understood.

E. Trade Implications

The introduction of the Wankel engine in North America comes at a time when the Canadian Government is commencing negotiations with the United States Government regarding possible adjustments to the international trade agreement known as the Auto Trade Pact. Both countries are seriously concerned at the present time with matters of employment and the manufacturing industries associated with the automobile represent a major source of employment for both countries. Recent events in the United States have indicated that that country is prepared to deal firmly with matters of international trade and currency. Consequently the Auto Pact negotiations assume vital proportions for both countries.

F. Levels of Impact

There are at least three distinct levels of impact which could be envisioned as a result of major conversion to the rotary engine and each of these involves a wide array of products and services and therefore organizations. These levels are:

i) Primary - Certain parts consumed in substantial quantities in conventional engines could undergo a major change or in some cases, complete obsolescence.

ii) Secondary - Other parts of the vehicle including such support systems as the exhaust system, related anti-pollution devices, structural members and running gear may well be affected materially.

iii) Tertiary - A third level of effect can be envisioned as well. For example, if the rotary engine is capable of performing effectively and efficiently on lower grade fuels such as keorsene or various alcohols, its mass adoption could have an important effect on the petro-chemical field. In addition, key spokesmen for the developing Wankel engine suggest that the engine will basically be a throw away engine, thus having implications for the service repair industry and the rebuild aftermarket.

G. Study Focus

This study will focus on the primary level and comment briefly on the secondary level but it will not go into the tertiary aspects in any detail.

The primary level considers direct effects on labour, material and other investment characteristics associated with engine production. In accordance with our assignment objectives we have assessed the impact of the Wankel engine on the Canadian automotive parts industry. The work program has consisted of secondary source research, consultation with technical authorities, industry interviews, production assessments, policy analysis and the presentation of a special seminar. The Wankel engine has been evaluated in terms of technical, market, social and plant location considerations. This focus has been directed to analyse the potential effect on Canadian automotive parts manufacturers. The report concludes with a discussion of relevant public policy issues.

Although there are a number of so called rotary engines under development such as the Kauertz, Tschudi, Virnel, Mercer, Selwood and Jernaes engines, this report deals specifically with the impact of the Wankel related engine. Any reference to rotary engine, rotary combustion engine or General Motors rotary is intended to mean the Wankel engine for the purpose of this study.

III. ASSIGNMENT OBJECTIVES

The objectives of this study were:

* To identify the probable effects of the increasing use of the rotary combustion engine on the activities of the Canadian parts suppliers; and,

* To recommend the action to be taken by the Department of Industry, Trade & Commerce and the industry to ensure that the Canadian auto parts industry achieves its maximum possible participation as a parts supplier for the rotary combustion engine.

IV. WORK PROGRAM

The work program consisted of five principal elements. The highlights are outlined below.

A. Secondary Sources

A substantial amount of published secondary information associated with the rotary engine was reviewed. Department clipping files were examined as well as a substantial number of books and articles in technical and popular magazines. The amount of published information was found to be substantial because of the general interest in the rotary engine. Appendix A represents a bibliography of the more relevant material.

B. Consultation with Technical Authorities

We have held a number of discussions in depth with prominant individuals associated with the rotary engine and have attended a number of technical seminars particularly those involving Mr. Charley Jones of Curtiss-Wright Corporation in the United States and Dr. David Cole of the University of Michigan, two of the leading North American authorities on the rotary engine.

C. Industry Interviews

We visited personally with senior executives of 23 Canadian firms* directly involved in the manufacture of parts related to the engine. In most cases, several executives were contacted at each firm and frequently, group discussions were held with these men. In addition, we made personal visits to five* large corporations in the U.S. to discuss the rotary engine, their research programs and plans including the relationship with their Canadian based facilities. Again, these interviews usually involved several senior executives from each firm. We augmented these personal visits with additional interviews conducted over the telephone dealing with specific questions and specific executive policies. We contacted three major automobile manufacturing companies and the relevant industry associations as well.

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* Appendix B - Work Program Interview Listing

It should be mentioned that most of the large corporations involved in this industry have established over the past two years internal task forces associated with the development of the Wankel engine. In any case, there is usually one senior executive who has special responsibility for the rotary engine and by concentrating our efforts on these groups and individuals as well as the senior executive spokesmen in the firm we feel that we were able to gather detailed knowledge and current information regarding the state of the companies' involvement in this phenomenon and the industry's posture in general.

In order to gather the information required, we had to assure that we would not identify specific sources or firms with specific statements and information. As can be expected, this industry is guarding information and plans carefully for competitive reasons. Once having provided this assurance of confidentiality, we found that most firms were willing to discuss fairly openly with us some of the principal characteristics of the rotary engine and its development in the industry in which we were interested.

Virtually half of the companies visited were contacted by an industrial engineer from our staff. In addition to gathering significant policy information regarding these firms and their attitudes relative to the rotary engine, we were able, by this method to gain first hand impressions of the degree of commitment of the firms involved to the manufacture of automotive parts. This added a further dimension to our analysis of the likely impact of the rotary engine on the Canadian industry.

The firms interviewed were carefully selected in view of their recognized leadership in the industry as well as the particular nature of the principal engine related parts which they manufacture. For example, we felt it important to examine the situation regarding the following kinds of involvement:

* Firms manufacturing parts which would not be required by the Wankel engine, for example, pistons and connecting rods;

* Firms manufacturing parts which would be substantially unchanged by the rotary engine but would require some minor modification, for example, spark plugs and carburetors;

* Firms supplying specialized material to firms manufacturing parts expected to be obsolete such as firms providing forging steel;

* Firms currently in the industry possessing technology which is likely to be vital to parts development for the rotary engine such as the piston ring companies who are in a position to develop seals;

* The automobile manufacturers themselves in that they have captive engine production.

D. Policy Analysis

We have discussed with various government, industry and associated spokesmen, the policy implications of the rotary engine, and reviewed a number of available reports.

E. Special Seminar

As part of the assignment, a seminar was arranged to discuss the rotary engine and its implications for the Canadian auto industry. The seminar featured Dr. David Cole, from the University of Michigan Ann Arbor, and was attended by senior Department of Industry, Trade & Commerce and P. S. Ross & Partners personnel.

V. THE ROTARY COMBUSTION ENGINE - HISTORY AND TECHNICAL

A. History

The Wankel rotary engine is not a new development. The principle of the engine was developed about two decades ago by Dr. Felix Wankel, a German inventor, and extensive work on developing the engine for use in automobiles has been going on for years. Audi NSU Auto Union AG, and Wankel Inc., two German companies, hold the basic patents. Curtiss-Wright, an American company, acquired the American rights in 1958. Still in the 1960's, the Wankel engine did not seem to be a serious contender for a place in American automobiles. Now, however, its potentials are receiving serious consideration.

Its present status evolved from a combination of improvements in the Wankel and changing needs in the automobile market. Perhaps the significant event which brought the Wankel to North American automobile users' attention, was its actual introduction at the production level by a Japanese firm.

B. Technical Considerations

The Wankel rotary engine operates without the pistons and valves used in standard reciprocating piston engines. The major moving assembly in a Wankel engine is a three sided rotor that draws in and compresses a mixture of air and gas, captures its force, and eliminates the burnt gases. Some engines now in use have two rotors and future engines could have more as Wankel technology improves.

A Wankel engine is smaller, lighter, and has substantially fewer moving parts than a conventional engine. In addition, because of its size and the technology of its operation it is possible, indeed probable that the Wankel engine will be placed transversely in the automobile and eventually manufactured as a unit with the transmission drive train applied to the front wheel of the vehicle. These advantages, plus the implied advantage of lower manufacturing costs, make the Wankel a contender for use in automobiles and in a wide range of non-automotive engine uses. Of particular interest is the acknowledgement by Dr. Cole that the Wankel engine will be essentially a throw away engine. Lower mass production costs will conceivably eliminate a rebuild market when rotor housing repairs are required.

General Motors has compared the rotary engine to some of its present engines; for example, a 200 cubic inch displacement rotary engine is about half the overall size of the 140 cubic inch Vega 4-cylinder engine. The output of the rotary engine is comparable to the company's six cylinder engine and the rotary engine weighs 30 percent less than the six cylinder engine. The rotary engine has about 40 percent fewer parts than a comparable six cylinder engine and it can be balanced more easily than a piston engine.

Another advantage of the rotary combustion engine is the manufacturing flexibility. A variety of rotary engines can be built from common tools. Engine displacement can be varied by changing the width of the rotor chamber or by changing the number of rotors per engine so the rotary engine can simplify the problem of providing different engines for many kinds of cars.

Because it is a relatively new product, the Wankel is not without problems. Dr. David Cole, a recognized U.S. authority, is careful to remind the industry of the length of time that the conventional piston engine required to achieve its present level of technology. The rotary engine is well along; however, it should be anticipated that a continual level of technological improvement and change will be characteristic of the industry for some time to come.

C. Summary of Advantages and Disadvantages

During Dr. Cole's recent seminar in Ottawa, he cited the following advantages and disadvantages in current Wankel technology.

Advantages	Disadvantages
	(Dr. Cole prefers - Question Marks)
- size) vehicle weight reduction	- new product
- weight) equated to potential lower cost of product	- sealing, lubrication and fuel waste
- simplicity	- high exhaust temperatures
- fewer components	- poor fuel economy - 20% penalty
- better breathing	- costs involved
- simple induction system	- cooling
- better speed/HP range	- cold starting
- lower friction	
- reduced quality of fuel lubrication required	
- improved balance characteristics	

Perhaps the most critical technical problem seems to have been with seals, especially those for the tips of the rotors. These apex seals require a considerable amount of new technology in the fields of metallurgy and mechanical engineering. A number of alternative approaches to sealing the engine have been put forward, including special coatings for the inner wall of the housing (epitrochoidal chamber) and combinations of expensive seals with less expensive walls versus less expensive seals with expensive walls have been tried as well. According to Charley Jones, Chief Engineer for the Curtiss-Wright Corporation, and perhaps the most knowledgeable expert in the rotary engine, the technical problems of sealing the engine have been solved. The problem remains of choosing among the options of sealing systems to provide the balance between performance, pollution control, mass production techniques and economy that the industry will require.

D. Industry Concern and Options

The domestic industry's overriding concern, aside from energy conservation, about the Wankel engine is economic. The cost of new facilities and equipment that would be required for an industry that will produce some 12 to 13 million passenger car engines in North America within a decade is formidable. That problem could be reduced to dollars and cents if the industry were to decide that the Wankel is clearly the best power source for automobiles in the future; however, the industry has reason not to move too quickly in committing itself. Obviously manufacturers will not want to commit themselves to one kind of engine if other superior and less expensive alternatives may be available soon after.

The car manufacturers are studying many power options other than the Wankel engine available in the long term. Possibilities include steam engines, turbine engines and batteries all of which have received some publicity in the past. Turbine engines may be adopted for use in trucks in the near future and heavier cars; however, the Wankel seems closest to being used in American passenger cars within the next few years. We should not overlook, however, the possibility of the current piston engine being refined and modified to the point at which it would be a satisfactory power source for years to come. A case in point is Ford motors experimental PROCO (Programmed Combustion Engine). The PROCO is a modified internal combustion engine with stratified charged combustion, direct fuel injection, electronic ignition and elongated spark plugs. Initial results have been promising, but Ford emphasized that the engine is far from ready for large scale commercial production.

Ford Motor Co. has recently signed an agreement with Honda Motor Co. of Japan involving Honda's pre-combustion chamber engine design. Ford will receive access to technical information on the engine and a world-wide non-exclusive licence under the patents to make and sell engines of all sizes for all applications. Ford is optimistic that the design offers the possibility of meeting future emission standards, assuming some relaxation of U.S. standards for nitrogen oxide, without the use of catalysts.

A number of foreign automobile companies have shown interest in the Wankel engine. Mazda, a Japanese company, is producing a rotary engine powered car for public sale, including export to the United States. The initial reception of the car has been good and has offered hope that the rotary engine is both practical as a power plant and acceptable to the consumer.

It should be noted that this Mazda engine has been able to successfully pass the 1975 pollution control standards. These standards were subsequently deferred to 1976 in the face of the fact that conventional engines could not pass it.

Mazda's work with the Wankel was so extensive that Toyo Kogyo ended up filing 400 sub-patents on the improvements to the basic design. Now NSU and many Wankel licensees pay Mazda royalties to use their improvements.

Other Japanese and some German companies have plans for producing cars powered by rotary engines and this specter of impending foreign competition puts some pressure on American companies to keep abreast.

E. North American Patent Status

In the domestic automobile industry the biggest step toward adopting the Wankel so far was the licensing agreement signed by General Motors late in 1970. Under the agreement, General Motors will pay a total of $50 million within five years to the two German companies which hold the basic patent and to Curtiss-Wright. The payment schedule calls for an initial payment of $5 million by the end of 1970, payments for $10 million for each of the next four years and a final payment of $5 million.

Although General Motors has made the initial payment and the first annual payment, the company has the right to terminate the agreement at the end of any year without liability for the remaining payments.

General Motors is currently calling for bids for parts for a rotary engine and it is believed that it will introduce the rotary powered Vega in 1975. It is expected that this Vega will not be specially designed to take maximum advantage of the rotary engine but rather will, as in the case of Mazda, provide a basic automobile in which the rotary can be placed as an extra cost option.

We believe that this is an initial introduction position only and that in a relatively short period of time, small automobiles will appear especially designed to take maximum advantage of the rotary engine. These automobiles cannot be optionally powered by conventional engines because of basic structural changes. Already considerable work is being done on ways of redesigning the automobile to take advantage of the small space requirements and the possibility of linking the engine directly with the transmission thereby avoiding power drain difficulties and the hump inside the car.

In November 1971, Ford-Werke AG, a German subsidiary of Ford Motor Co., also signed an agreement with the two German companies holding the patents. At a cost of $2.3 million, Ford has the right to receive the latest technical information and to manufacture the engine in West Germany. For further payment the agreement could possibly be expanded or a new agreement reached to give Ford more scope, should it decide that its development works justify such a step. In 1971 in its annual report, Ford indicated that the Wankel may have potential for use in vehicles requiring smaller, simpler engines.

Chrysler's position to-date has been one of considerable caution and standoffishness. Although it is watching the rotary engine development carefully, it is considering it to be merely one of a number of engines which are possible. They are sceptical of fuel economy claims in the face of the known fuel disadvantage of the rotary engine at lower speeds. They are maintaining the priority of their engine development on economies of operation and energy conservation. It should be noted that they have recently received additional federal funds for the development of turbine engines. They also site the tight supply situation on grey iron and nodular iron which are required by this engine.

American Motors has joined the "Wankel" club and is expected to purchase its engines from General Motors for the early years of its introduction.

A key firm in the rotary engine industry is of course, Curtiss-Wright. Curtiss-Wright is a non-automotive company, primarily involved in aircraft and other similar technology but it appears to be in a solid position to profit from potential use of the rotary engine in North America and even elsewhere in the world. Anyone wishing to manufacture the engine in North America must come to an agreement with the two German companies and with Curtiss-Wright which would get a major share of the fees or royalties. For example, Curtiss-Wright will receive almost $23 million of the $50 million fee that General Motors may pay during a five-year period for a license to manufacture the Wankel engine in the United States, Canada and Mexico. If other American automobile companies want to manufacture Wankel engines in North America, Curtiss-Wright would presumably collect fees and/or royalties on each engine produced. We believe that Curtiss-Wright would also share in a limited way in licensing the manufacturers who come from outside North America.

F. Manufacturing Factors

Before automotile manufacturers or original equipment suppliers could begin producing Wankel powered automobiles, the tooling must be set up and that would necessitate orders of new machine tools. Since lead times are long, initial orders should be early in the development stage. Indications are that machinery will be highly specialized because the Wankel machinery requirements are complex. Basically, companies with positions as suppliers of grinding machines, transfer lines and certain special cutting equipment would benefit from orders for machine tools.

It is obviously too early to determine the size of the orders, the extent of their potential effect on individual companies or who the supplies may be. For example, an estimated two dozen or so grinder manufacturers are in some stage of developing epitrochoidal grinders. Precision epitrochoidal grinders, a key to efficient production of Wankel engines, are likely to be in demand initially, and that accounts for the abundance of grinder manufacturers who are working in the field both here and overseas.

Ancillary grinding equipment will also be necessary. Assembly equipment may also be needed because the Wankel engine may be suited to automatic assembly. Therefore machine tool manufacturers can be expected to benefit as the projected Wankel production begins to materialize. Among companies that are involved in developing grinding machinery for the Wankel are Gleason Works, Ex-Cell-O, Brown and Sharpe, the Century Division of Babcock and Wilcox, Danly Machine, Triordinate, and Cincinnati Milacron. Cross Company is reportedly working on methods to finish the epitrochoidal chamber and cut side seal grooves in the rotor as a means of automating production.

In short, the introduction of the rotary combustion engine into the North American automobile industry is likely to have major impact on the products that the automobile industry manufactures. On the other hand, we are anticipating it will have a much smaller impact on the size of the automobile industry and its economics, the number of people it employs and the number of firms involved.

The automobile industry is made up of large conglomerate firms mainly based in the United States and the wide range of products manufactured by these organizations render the products associated with the Wankel engine relatively insignificant.

G. Component Parts Implications and Identification

The impact of the rotary engine on the original equipment manufacturers (O.E.M.) and the spare parts manufacturing industry must be examined under four quite distinct classifications. These groups are categorized by the degree of obsolescence and overall automotive redesign requirements.

The first classification are those components which by the very nature of the basic engine design are not required in the rotary engine.

The second classification includes those components which will require extensive modification to the degree that they will bear such a small resemblance to those in current manufacture that they can almost be considered to be new components.

In the third group are the new parts unique to the rotary engine.

The fourth category is made up of items which would require fairly extensive movement in "The state of the art" insofar as North American manufacture is concerned. This category is dependent upon the degree to which manufacturers are prepared to redesign the automobile around the basic rotary engine and apply characteristics such as front wheel drive, which, while not unique, have not been generally applied to units manufactured on this continent. A related consideration is the change in material requirements.

1. Obsolete Parts

In the first category of "parts affected" by the advent of the rotary engine are those which by design characteristics are eliminated as being peculiar to the displaced reciprocating engine. These are:

pistons	connecting rods
piston rings	cylinder sleeves
piston pins	cam shafts and timing gear
push rods	rocker arm assemblies
rocker arm covers	valves
valve springs	valve sleeves
valve lifters (hydraulic)	valve spring retainers
engine heads	engine blocks
timing gear	manifolds, intake and exhaust

2. Extensive Redesign Parts

The components in this category can be considered under two sub-classifications. The first of these includes those components which would in any case have been affected by redesign or substantial modification of the conventional reciprocating engine. These are primarily:

* fuel pumps and carburetors (by adoption of fuel injection);
* distributor and other ignition components (by adoption of solid state transistorized ignition);
* bearings;
* oil pumps;
* oil coolers;
* radiators (water cooling).

The second sub-classification includes those major components which although performing the same basic function with the rotary engine as with the reciprocating engine, will require very extensive modification. These are:

* exhaust system;
* crank shaft;
* exhaust emission control devices.

3. Unique New Parts

The foregoing has identified those components which would be adversely affected to some degree by the introduction of the rotary engine to North American manufacturing. However, there are a number of components peculiar to the Wankel design which provide compensating opportunities to some Canadian manufacturers and new opportunities to others who are not currently engaged in producing components for the automotive industry. The major new parts are:

* the rotor;
* rotor eccentric gears;
* drive gears;
* rotor chamber housing;
* chamber and covers;
* seals, apex, side, etc.
* intake port sleeves.

4. Parts Affected by Major Vehicle Redesign

Full and imaginative use of the rotary engine characteristics provide many opportunities for the basic automobile to be redesigned with beneficial effects on styling, safety, handling characteristics and economy. At this point in time it is impossible to predict the degree to which this opportunity will be accepted, nor the time frame involved because of the economic trade-offs which must be considered in terms of tooling depreciation, new investments in process equipment and transfer devices as well as the yet unmeasured acceptance by the North American car buying public. There is little doubt that the evolution throughout the next ten years will see significant modification to:

* braking systems;
* steering mechanics and geometry;
* suspension;

* power transmission;

* basic body work;

* engine rebuild aftermarket (throw away Wankel).

H. Material Changes

One of the major areas of impact of the move to rotary combustion engines will be the change in material requirements as opposed to labour.

Comparing a small 8 cylinder conventional engine with one of the typical twin rotary engines under development in the United States, the following quantities of material are changed:

* 150 pounds less cast grey iron in the Wankel;

* 10 pounds less cast steel in the Wankel;

* 44 pounds more die-cast aluminium;

* 33 pounds less miscellaneous parts, notably forgings

giving a total for the rotary combustion engine of 336 pounds and the piston engine 463 pounds or a drop in material usage of 126 pounds per engine.

Extending this in terms of a volume of 300,000 engines per year (number of Vega units expected in 1975), the potential change is an increase of 7,100 tons per year of aluminium and a decrease of 20,000 tons per year of iron based products.

In another similar comparison, the current Chevrolet Vega 4 cylinder aluminium block engine weighs 306 pounds and by comparison the Mazda R-100 rotary weighs only 273 pounds.

In discussing the material decline with the steel companies in Canada, it is clear that the automotive industry is a major user of steel; however, the effect of this particular change will be minimal in terms of employment in the primary steel industry. As is the case with the parts manufacturers, this will be reflected merely as a shift in product mix and the capacity made available by a decline in this particular product requirement will be immediately used by increasing the production of other products for which demand is increasing.

Recent comments during the Fourth International Powder Metallurgy Conference in Toronto attended by about 1,500 powder metal technicians from more than 20 countries indicates that the powder metal industry feel a swing to the Wankel engine by U.S. auto makers could benefit the industry. An industry representative noted that a change to the Wankel would involve the automatic transmission which is a major outlet for powder metal products. On the other hand the spokesman felt powder metal was a front runner as the best means of making the rotor which weighs as much as 15 pounds.

VI. THE ROTARY COMBUSTION ENGINE - MARKET AND SOCIAL FACTORS

The introduction of the rotary combustion engine in North America comes at a time when there are a variety of other factors impacting on the automobile industry. Each of these has a significance relative to the automobile industry and is inter-related with each of the other influences. The key influences are as follows:

* shifting auto market patterns;
* the energy crisis;
* pollution control;
* metric transition.

A. Auto Market Patterns

The trend in the automobile industry at the present time appears to be toward the smaller car. Furthermore, the automobile's position in North American society appears to be changing slightly. Most major communities in North America are aggressively seeking ways of reducing the flow of automobile traffic into the downtown areas. Major funds are being committed to research and development with respect to mass transportation systems and apparatus. It is expected that this may have a major effect on the market for cars. Smaller cars could be sufficient for suburban travel and some larger units such as station wagons, campers and highway oriented cars may prove to be the second car in the future.

The average miles per car year are expected to reduce although the patterns of operation by the consumer are sufficiently unpredictable, and it would be dangerous to anticipate aggressively this particular usage reduction. Most of the companies who are working actively in the rotary combustion engine field are expecting to put the early versions in the smaller cars.

The small car is growing in popularity and can be expected to continue to occupy a growing portion of the market. Very large cars are disappearing in popularity and the standard car of today may well be the large car of the future. The rotary engine is more consistently being oriented towards the small car; therefore, the market developments appear to favour the continuing and accelerating introduction of the rotary combustion engine.

B. The Energy Crisis

It is evident that the United States is experiencing an important shortage in petroleum based fuel. A number of oil companies have announced price increases and have indicated that a form of rationing has been instituted such that they are limiting the gallonage to be supplied to their individual stations. Independent gas station operators who rely on purchasing surplus supplies for discounted prices are being squeezed out of business.

The shortage of fuel and increasing price which comes as a consequence has added to the trend to the small car in order to seek higher mileage. The rotary engine is not as efficient an engine as the traditional piston engine for a given output. It operates more efficiently at top speeds and loses fuel economy quickly upon reducing to cruising level speeds. Significant technological advances have been made particularly in the sealing system and Curtiss-Wright claims to have brought the rotary engine to a level of efficiency comparable to the traditional 4 cylinder piston engine common in the smaller cars. The Mazda rotary combustion engine has not yet achieved the same fuel economy as its 4 cylinder counterpart.

On the surface of it, therefore, it would seem that the energy crisis is working against the development of the rotary engine. However, with the addition of more optional equipment such as air conditioning and the continuing development of emission control devices, traditional engines are severly penalized in terms of gas mileage. The rotary engine is not equally penalized; with the emission control devices it achieves a mileage comparable to its 4 cylinder competitor. Therefore, the fuel shortage negative effect on the rotary engine is compensated for by its improved ability to handle anti-pollution devices.

C. Pollution Control

When the rotary engine was originally developed, it was considered a dirty engine. It was unable to meet the most rudamentary pollution control standards; however, efficient work has been done on the engine so that the Mazda rotary combustion engine was successful in passing the 1975 pollution control standards set in the United States. On the surface of it, this should mean a strong impetus for the rotary combustion engine; however, the emission control standards officials in the United States elected instead to defer the 1975 standards for an additional year to allow American manufacturers to develop the necessary emission control devices and engine modifications.

This deferral was largely attributable to the statements by the industry spokesmen with respect to the speed with which the industry could meet control requirements. If one presupposed a general stampede to the rotary engines, it would take approximately 4 to 8 years to completely change-over to rotary engine in compact lines of cars and an additional 2 years to convert intermediates and 2 more to convert standard line cars just from the standpoint of retooling alone. The rate of change over to rotary combustion engine is limited by tooling and in general the maching tool industry. According to a spokesman for the industry, quoted in Metal Working News of March 19, 1973, it would take a minimum of 12.3 years to perform a 100 percent change-over of engines. This is complicated by the fact that normal growth is taking place at the same time and this in turn requires capacity from the machine tool industry; therefore, the change-over affects primarily marginal capacity requirements. It is estimated that under severe pressure only 50 percent of the industry could be converted by 1980.

In short, when the emission control authorities asked the industry what would happen if they required the industry to make conversion to the rotary engine which had passed the 1975 standards, the industry's reply was that it would create a severe engine shortage.

Further, the rotary engine requires less space and therefore provides more opportunity to install emission control devices without overly cramming the engine compartment. Although eventually it is expected that the automobile will be redesigned to take maximum advantage of the transverse mounting of the rotary engine and its small size, with the present technology associated with emission control, this additional space is required for the various devices, heat exchangers, and catalytic converters.

D. Metric Transition

With the announcement in April of this year that General Motors plan to switch to the metric system, it is obvious that this will have powerful influence on U.S. manufacturing to fall in line as soon as possible. General Motors has considerable impact on the machine tool industry in addition to its leading role in the auto industry.

According to General Motors President Edward N. Cole, the Wankel rotary engine being developed by G.M. will be metric right from the beginning.

Although none of the other auto makers have announced formal plans to move to metrification, the growing multinational nature of the industry makes it almost inevitable. Evidently Ford Motor Co. is planning to produce in metric measurements at its new Lima, Ohio engine plant while International Harvester has similar intentions at its Hough plant in Libertyville, Illinois. Chrysler Corporation and American Motors Corporation are still studying the situation. According to Ward's Automotive reports, major suppliers to the automotive industry reveal that they see little or no difficulty in producing inch and metric parts.

Obviously, Canada's commitment to metric conversion will have little effect within the automotive industry until action is taken in the United States.

VII. PRODUCTION LOCATION CONSIDERATIONS

A. Initial Production

In discussing the question of where production will be located for the rotary engine there seems to be general agreement both in the United States and in Canada that initial production will be done in the United States. Once initial production is developed in plants close to the centres where research and development has taken place then production will be shifted throughout the available locations of the firms involved.

B. North American Plant Rationalization

New plants are not likely to be constructed; rather plants that exist at the present time are likely to be renovated to serve as production facilities for rotary engines and components. Most of the firms are involved in the automotive trade pact arrangement between Canada and the United States and have plants available to them on both sides of the border.

The rate at which they move production from one plant to another is considered to be purely a matter of economics once the initial methodology has been established.

It is recognized that Canadian engine plants have been rationalized to take advantage of scale economies. Of the four engine plants in Canada, only five engine models are produced for North American distribution.

C. Research and Development

It should be noted that the original location of rotary engine production is likely to be near the place where the research and development has taken place on the engine. One of the areas in which Canada has not participated is of course in this research and development. That is not to say that some of the divisions involved have not been conducting some specific research on specific components in and near Canada. We did discover that in some cases this research was taking place where the Canadian subsidiary was producing all of a particular component for the North American market. Certain oil pumps and heat exchangers are examples.

Nevertheless, the bulk of the research has taken place in the United States and plants associated with or adjacent to these locations will be prime candidates for initial production of components. So little

is known at this time about the production economics of rotary engine parts and engines that head office organizations will want to maintain a basic hands-on approach during the early production.

D. Implications for Canadian Industry

There may be implied in this a significant opportunity for Canadian industry in the future. If we can encourage greater research and development associated with the rotary engine and other aspects of automotive developments such as anti-pollution gear in Canada centering around our advanced knowledge in metallurgy and perhaps production technology there may be an opportunity to attract initial production of significant manufacturing changes in the future.

Traditionally, when a major new device such as a rotary engine is developed a large number of people begin immediately to focus their technology on improvements and variations. For this reason, it is not anticipated that total international rationalization will occur in the near future. In other words, although it is characteristic in Europe for engine companies to be suppliers to automobile companies, in North America the tradition is that the automobile companies manufacture their own engines in captive plants. The rotary engine is not likely to make a major change in this. The Curtiss-Wright Corporation which controls the licences for manufacturing the rotary engine in North America is not an automotive engine producer and it is unlikely that it will become one in order to provide this international specialization.

E. Automation Factors

Another important consideration on the location of production capability is in the actual engine assembly itself. Although the rotary engine will likely be assembled by the automotive manufacturer in existing engine plant locations, it is anticipated that with the size and technology of this engine it may lend itself to automation in assembly. This may be another significant opportunity for Canadian production know-how, to enhance this automation technology. Specialized production equipment will have to be developed for this purpose and significant opportunities should await such a developer.

F. Preliminary Conclusions

The manufacturing engineering development for high volume production of the rotary combustion engine has taken place largely in the United States. Although other work has been performed elsewhere in the world there has been virtually no major technological development

taking place in Canada. Possible exceptions to this are in the spark plug field and some work with heat exchangers and pumps associated with Canadian subsidiaries of large American organizations. By and large, however, the major technological development has taken place in the United States.

In view of the dominant position American firms hold in the Canadian parts manufacturing industry, then it is to be anticipated that early introduction of manufacturing capability for the rotary combustion engine will be in the United States plants most closely adjacent to the source of technology as discussed earlier. That this will, in fact, take place has been confirmed by a number of the organizations contacted.

VIII. POTENTIAL IMPACT ON CANADIAN AUTOMOTIVE PARTS MANUFACTURERS

Characteristically, the parts manufacturing industry is accustomed to operating under conditions where there are only a small number of suppliers for basic components. This means that they must be prepared for large swings in volume of a particular component which they supply. This in turn has stimulated their diversification into non-automotive fields and to a wider range of parts and components. The industry then has evolved into a series of divisions and subsidiary organizations of large conglomerates such that basic corporate commitment to a single part or component is minimal.

A. Potential Exposure

In examining the exposure of the Canadian Automobile Manufacturing and Parts Manufacturing Industries to the effects of the introduction of the rotary engine, we have attempted to estimate the number of employees currently involved in Canada in producing conventional engines and parts which would not be required in the rotary engine. We regard this as the maximum possible negative effect of the rotary engine and, as indicated earlier, should not be interpreted as the forecast of what we feel would be the likely effect. While it is theoretically possible that all of these jobs could disappear with the rotary engine, such a possibility is predicated on a predicted decision of management to simply close facilities and concentrate rotary engine parts production in the United States.

* Management Attitude

In fact, the attitude of management suggests something quite different from this. The belief is widespread throughout the industry that existing employment characteristics would largely be maintained even in the face of such a development primarily by continued diversification and broadening of product lines both in automotive and non-automotive related fields. In addition, the industry over the past two to three years has achieved a level of international rationalization which spokesmen indicate the companies involved do not wish to undo. Large portions of Canadian parts production and indeed, engine production is destined for export and serves the total North American requirement. Similarly, a considerable portion of the Canadian requirement is served from U.S. sources.

* Engine Production

With respect to engine production, there are approximately 48 engine plants in North America, four of which are in Canada. Canadian engine plants produce only V-8 engines, a large portion of which are exported to the United States. Six cylinder engines are all imported into Canada. A major conversion to rotary engines would have an effect on all engine plants, not just Canadian ones, and a new array of engine manufacturing facilities might well develop. How this array will develop can only be speculated at the present time.

Because of the speculative nature of the future with respect to the rotary engine, it is important to examine the maximum possible negative effect on the Canadian industry. This in turn can best be viewed by examining the present employment committed to engine production and engine part manufacture with particular concern for regional clustering.

* Employee Exposure

According to our study, approximately 11, 000 Canadians are employed in the manufacture of passenger car engines and engine parts at the present time. Approximately 9, 000 of these, or 82 percent, are involved in the assembly of engines. Engine production in turn is concentrated in Windsor and St. Catharines with approximately 78 percent of the engine assembly work taking place in Windsor.

The following table indicates our estimate of the maximum employment exposure:

Town or City	Employees
Windsor	7, 500
St. Catharines/Welland	2, 000
Sarnia	450
Wallaceburg	250
Hamilton	200
St. Thomas	150
Stratford	100
Toronto	100
Kingsville	35
Other	150
TOTAL	10, 935

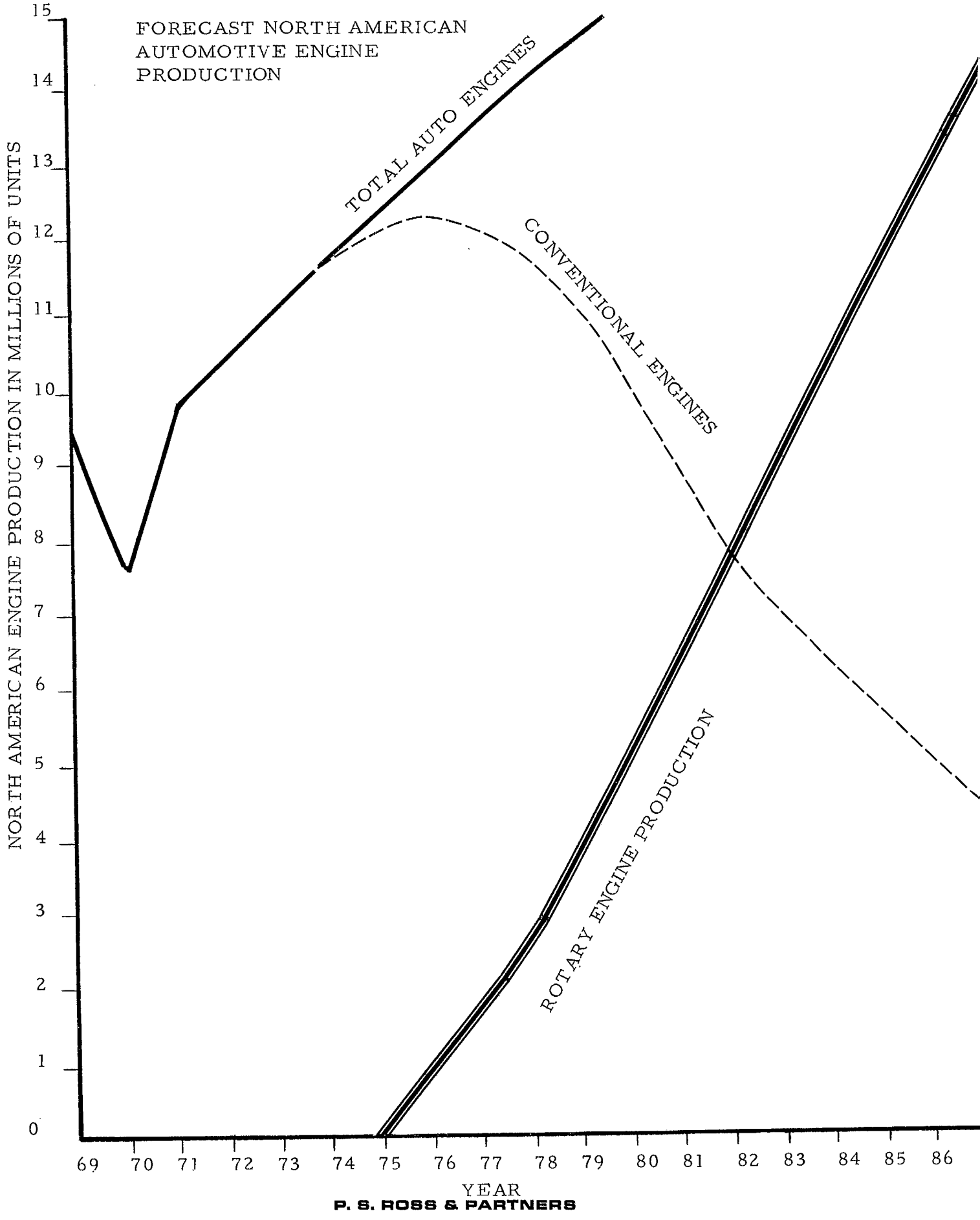
This figure represents approximately 14 percent of the total employees involved in automotive manufacture and parts manufacture (as recorded by Statistics Canada).

It should be stressed once again that this exposure does not constitute an immediate threat to employment in our opinion, primarily because of the time involved in introducing a new engine and its acceptance and capturing of a major share of the market. Our assessment leads us to forecast that although the rotary engine will likely be introduced into a North American car in 1975, even with buoyant acceptance by the North American market it will achieve only approximately 30 to 35 percent penetration by 1980, five years later. This means, of course, that conventional engines will continue to dominate production for some time.

* Engine Forecast

The following graph indicates our forecast of total North American engine production and rotary engine share based on our discussions with industry leaders and our assessment of the industry's capability for change of this type. It assumes effective marketing on the part of North American automobile manufacturers and successful consumer acceptance.

During the Wankel seminar in Ottawa with Dr. David Cole, he highlighted for speculation the potential acceptance of the Wankel. Specifically, he recalled that 75 percent of the world's auto manufacturers are licencees, including General Motors, which has been known to influence consumer acceptance of its products through its domination of the market. In addition he speculated that limited industry talk with respect to specific company intentions and the general no comment attitude is a premonition of feverish behind the scenes activity.


FORECAST NORTH AMERICAN
AUTOMOTIVE ENGINE
PRODUCTION
TOTAL AUTO ENGINES
CONVENTIONAL ENGINES
ROTARY ENGINE PRODUCTION
NORTH AMERICAN ENGINE PRODUCTION IN MILLIONS OF UNITS
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
69
70
71
72
73
74
75
76
77
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79
80
81
82
83
84
85
86
YEAR
P. S. ROSS & PARTNERS

We believe that the Canadian industry will be called on to produce conventional engine components and to continue to assemble conventional engines during the early years of the rotary engine introduction. The effect, therefore, of the estimated exposure of 11,000 jobs would therefore not be felt until possibly 1980 or later.

Because the bulk of this exposure is involved in assembly of conventional engines and therefore involves the motor vehicle manufacturers themselves in four engine plants, management decisions to continue operating or to close these plants could produce a sudden effect. Our discussions with the firms in the industry indicate that while such a move is possible, management is generally committed to maintaining employment in existing facilities and communities. Nevertheless, the exposure should be noted as a possibility. Also to be noted, is the fact that this exposure exists by virtue of the nature of the industry regardless of the introduction of a rotary engine.

* Forging Company Exposure

Apart from the exposure due to engine assembly plants, as indicated earlier, the major industrial sector affected would be that composed of forging companies. We have identified Great Lakes Forgings as significantly exposed and have contacted other forging companies as well. Dominion Forge for example, has indicated that while they are currently involved in producing parts for engines, they have been actively involved as have other parts makers in a program of diversification in order to preclude disasterous effects of a change. In 1969, 70 percent of Dominion Forge production was involved in engine parts, in 1970, 60 percent, while in 1971 the concentration on engine parts dropped to 30 percent where it has remained. This drop was due to the loss of the crank shaft business as casting plants developed technology sufficiently. It should be noted that an industry rumour indicates that the forged crank shafts may return due to field failures of some of the cast items.

In response to this loss of business, Dominion Forge began a search for new forging products and are now producing stabilizer bars, ring gears, steering knuckles, truck brake spiders, and other non-engine related forged parts. These have more than made up for the loss of the crank shaft business and the management of the firm indicates that additional high strength items will be produced as safety standards are more completely enforced.

Sixty percent of Dominion Forge's output is exported to the automobile companies in the United States and they claim to be keeping abreast of the rotary engine developments.

In short, even in the case of a major forging company, the characteristic activity of searching for new products to make up for the loss of existing production appears to be the pattern.

As a further note in the forging field, there has been the suggestion that the captive forge plants of the automobile manufacturing companies in the U.S. will also find their production requirements reduced and will bring in-house business that is currently let out to independent forge shops. Spokesmen for the forging industry indicated that this is not as distinct a possibility as it may seem because of the high level of specialization of the captive forge shops. For example, Chevrolet forge shop in Tonawanda produces over 100,000 connecting rods per day. Similarly, the Ford forge shop in the Detroit area specializes in the same high volume item, connecting rods. They are not geared to produce smaller quantities and continue to buy small fill-in quantities from forge shops such as Canadian forge shops who are better equipped for the short runs.

It should be remembered as well, that the automobile manufacturing companies are not particularly interested in being in the forging business as a diversification move and will move in and out of any of the captive fields quickly in response to the economies of production for high volume specialized items. Therefore, as the connecting rod requirements are reduced with the introduction of the rotary engine, the American

captive forge shops will be under scrutiny by the parent organization until they reach the point where their specialized operations are no longer economical due to shorter runs and they will quickly be phased out and equipment sold to other forging companies.

* Exposure Summary

Naturally, we cannot presume to predict the management decisions which will take place over the next few years in context with the various operating and marketing strategies of the manufacturing companies involved; however, the above is a statement of our belief based on our understanding of the industry's position at the present time and the way in which management decisions of this type tend to be made in this industry.

We should emphasize that the automobile industry in North America is currently experiencing a particularly buoyant time. Attitudes of executives and their staff are optimistic. Undoubtedly these attitudes will have affected their expectations and therefore our findings. For example, for the first six months of 1973, 5,209,599 automobiles have been produced in the U.S. This is an increase of close to 700,000 units from 1972 or approximately $13\frac{1}{2}$ percent. A particularly favourable international business climate has undoubtedly been partially responsible for the success of the American cars during this year but it should be remembered that this industry has traditionally been called on to respond to sudden changes in technology obsolescence of parts and components and continual redesign of specifications. That its spokesmen feel confident that it can continue to respond effectively to major change such as is promised with the introduction of the rotary engine, is in our opinion, based more on a realistic assessment of capability than merely the optimism of the moment.

B. Additional Influential Factors

The potential impact of the rotary engine on the Canadian parts manufacturing industry is difficult to analyse because of a number of factors. From one situation to another these factors may be unrelated, may interact in a counter-balancing mode, or may combine for amplified effect which may be either adverse or beneficial. The major factors include:

* timing of engine change-over;
* component make or buy decisions;
* business and/or government support;
* U.S. trade union reaction;
* production opportunities;
* the Canada - U.S. automotive agreement.

Further elaboration on these factors is detailed in the following analysis.

* Timing

The transition to rotary combustion engines will take place over an extended period of time such that with respect to the original equipment market it is unlikely that conversion will occur at a rate that would exceed 30 percent by the year 1980. The balance of the engines supplied for original equipment during this period would of course be of the conventional type. One should note, however, that the turbine engine and other alternative types of engine are being examined and many have some introduction prior to 1980. At the present time this is considered unlikely. Replacement parts and the after-market for parts associated with the conventional piston engine will of course, continue to be needed for a period up to ten years after the manufacture of the particular engine to which they will be applied.

* Make or Buy

As a change-over is made in American manufacturing capability to accommodate rotary combustion engine parts and manufacture, additional plant capacity will be required to produce conventional engine parts to supply current demand. The firms involved have indicated that

they would turn to their Canadian firms and Canadian plant capacity to provide needed conventional engine components during the change-over period.

After the main facilities in the United States have been converted further international rationalization would again take place and the most efficient plants would be used to produce various components in the most efficient way. In other words, after the initial introduction, production for which should be expected to take place in the United States, there will be a second review of the total rationalization process such that some of the manufacturing capability may then be moved to Canadian plants, and Canadian plants will begin to develop rotary engine manufacturing capability.

* Support

It should be noted as well that the attitude of many of the parts manufacturers in the United States, suggest that the advantage of location in Canada has diminished over the past few years. This is partly due to the wage parity being achieved by the unions and by specific moves in the United States to attract and repatriate manufacturing capability. On the other hand, many of these organizations are accustomed to hedging their manufacturing capability and see the Canadian border as one more opportunity to do so by diversifying the production among several plants.

* Union Reaction

It can be surmised that U.S. unions would be reluctant to export a growth opportunity to Canada if it is going to affect U.S. automotive workers. The success of the Pinto and Maverick production in Canada was due in part to the growing acceptance of the small car in North America. If the Wankel engine is perceived as a strong growth area in the future, union support or opposition to Canadian manufacture will be a critical factor.

* Production Opportunities

The automobile manufacturers traditionally manufacture most of their own engine parts. The parts manufacturing industry on both sides of the international border are primarily occupied in manufacturing non-engine parts and accessories. Independent foundries and forging companies frequently find themselves operating as second source capability for captive facilities by the auto manufacturers. It is anticipated with the development of the rotary engine that the automotive manufacturers will draw engine production even further into their own captive capability and reduce the amount of work jobbed out to independent foundries and forge shops. Again the major impact will be felt in that small number of independent forge shops and foundries with the heavy commitment to the manufacture of one or two parts or components which will disappear in the rotary combustion engine.

* Auto Pact

According to the new Chairman of the Automotive Parts Manufacturers Association (Canada) the auto pact is here to stay. "There has been so much money invested to rationalize the industry on both sides that to abrogate the treaty now will be to tear the whole fabric of the economy and that is not likely to happen." In any event if the Wankel is to be considered as a growth situation, then on an indistry wide basis the central issue is whether Canada will continue to play a role equally as great or greater in the North American automotive market.

C. Economic Impact

As far as the industry is concerned, the most immediate economic considerations always relate to sales volume, profit and employment.

Our findings indicate that there is a clear industry wide commitment to the continuing development of the rotary combustion engine and a basic anticipation that the engine will make significant and increasing impact in replacing the conventional piston engine. In terms of the industry and its response in specific terms the following are key observations:

* The industry in Canada is clearly heavily controlled and in most instances owned by major corporations in the United States. This provides the advantage of diversifications such that very few of the principal companies involved in the manufacture of engine parts for the conventional engine are in a position of relying heavily on that market for their basic firm activity.

* There is a basic commitment to keep Canadian plants operating and maintain employment partly stimulated by labour relations pressure and partly by a commitment to exploit investments made. In other words, as parts are phased out new activities will be found, perhaps not in the automotive parts manufacturing industry to utliize the existing plant and maintain employment.

* The basic industry posture is to regard the move to rotary engines in an individual corporate case as merely a shifting in product mix, such that those products intimately associated with the conventional piston engine are viewed as having a limited future potential thereby freeing up plant capacity for exploitation by new product lines. In some cases these new products will be related to the rotary combustion engine and in other cases they may be associated with other changes in the automobile such as the move to transmission drive chains and the development of new automotive options and anti-pollution gear. As indicated earlier in some cases, new products will be sought outside of automotive application all together.

D. Analysis of Selected Company Situations

As part of the work plan associated with this part of the study, we conducted in-depth interviews with senior officials of a number of parts manufacturing companies. The tabulation in Appendix C lists those companies and indicates the items they currently produce, the share of Canadian manufacturing enjoyed by the company and the direct labour employees affected.

It is apparent that the brunt of the adverse effect of a rapid and significant market penetration by the rotary engine would be felt by a relatively small number of highly specialized companies. Wallace Barnes and Precision Spring would be seriously affected in that between them they share the total Canadian manufacture of valve springs. Eaton Precision Products is the sole manufacturer of hydraulic valve lifters in Canada. The total Canadian production of piston rings is shared by Perfect Circle and Sealed Power Corporation. The total Canadian production of valves is by Thompson Products. Holmes Foundry produces all of the engine blocks for the six cylinder engine requirements of American Motors, and Great Lakes Forgings is entirely committed to the production of connecting rods.

From our selected survey, it would appear that approximately 1,000 could be affected, with 800 of those being in the Sarnia Wallaceburg area and the remainder distributed in four widely separated communities. This is, however, not likely to be the case as the major employer (540 jobs at Holmes Foundry) is a subsidiary of American Motors Corporation, who would, in the opinion of a company official, protect that investment by bringing "in-house" other casting work such as brake drums, now purchased from a variety of small foundries. They would then have some idle capacity in areas such as core and pattern shops but the impact would be far less severe than first impressions would indicate.

The second largest employee group is at Eaton Precision Products in Wallaceburg where 250 persons are employed on hydraulic valve lifters. This company is totally owned by Eaton, Yale & Towne Corporation of the U.S. Together with its parent plant in Saginaw, Michigan, it enjoys a virtual monopoly on the manufacture of hydraulic valve lifters in North America, with the only major competitor appearing to be Johnson Corporation of Chicago. The Senior Executives of the Canadian company are confident that the parent corporation is watching carefully the development of the rotary engine and will develop strategy to protect the investment and hence the Canadian job. One possibility visualized is giving a larger percentage of the declining reciprocating engine market to the Canadian plant while converting the U.S. plant to the manufacture of rotary parts of components or the corporation's other products such as materials handling equipment.

The third largest group is at Great Lakes Forging in Windsor where 135 people are employed in the manufacture of connecting rods. As has been noted, this plant is in effect owned by the Government of Canada, and it is understood that additional capitaliztion has been arranged to make plant modifications which will facilitate compliance with environmental protection regulations as well as improve productivity. With regard to the latter, the officials are confident that they would then be

competitive in other products, such as links for heavy conveyor chain, and that they will be able to phase out of their commitment to the automotive industry without serious difficulty within the time frame that any reasonable projection of rotary engine growth would foresee.

The other three companies in this group do not feel themselves seriously threatened. In the case of Perfect Circle, an executive of the Canadian operation advised that his parent corporation (Hayes, Dana) recently had a corporate seminar related to the potential impact of the Wankel engine and he feels they are well on top of any current Wankel developments. It is his opinion that, assuming forecasts of rotary engine requirements are accurate, the company would commence to manufacture appropriate parts such as the apex seal in its U.S. plant and concentrate reciprocating engine piston ring production in the Canadian operation. Thus any adverse affect on the St. Thomas plant is likely to be limited in scope and a considerable time away.

The other two companies in this group (Wallace Barnes and Precision Spring) are concerned about the possible loss of a significant percentage of their production. They are quick to point out, however, that at one time they were heavily committed to the manufacture of clutch springs and now find themselves producing more automatic transmission springs than they ever had in the former category.

The overall conclusion resulting from this survey of companies is that a dramatic market penetration by the Wankel engine would affect their operations; however, they are almost unanimously confident that although major engineering and production reorientation would be required, the net result would not be of great significance to their shareholders nor to the employment opportunities their plants could provide.

The other items on our list of critical parts are generally speaking concentrated "in-house" by the automobile companies themselves and that part of the industry, although suffering somewhat, could be sustained by the new business opportunities from within the automotive industry or by new products from other markets.

E. Conclusions

The automotive parts manufacturing industry has anticipated the development of the rotary engine exceedingly well. Parts manufacturers have established special task forces within their organizations to monitor and study the effects of the rotary engine on their particular business and determine what opportunities exist for them under changed circumstances. We have discussed the implications with representative firms affected in several ways:

* Firms whose heavy commitment to conventional engine parts leaves them particularly vulnerable due to the complete disappearance of these parts with the rotary engine (for example, the forging companies);

* Firms whose demand for product declines with the rotary engine but whose product remains substantially unaltered (for example, the steel producers);

* Firms whose products must undergo a redesign (for example, the spark plug manufacturer, carburetors, heat exchangers);

* Firms whose technology allows for a move to develop new products peculiar to the rotary combustion engine (for example, the piston ring manufacturers).

The following are our main conclusions regarding the impact of the rotary combustion engine on the Canadian automotive parts manufacturing industry:

* The rotary combustion engine can be expected to achieve a maximum of 30-35 percent original equipment penetration by the year 1980;

* The effect on individual firms will be limited due to diversification and preparedness;

* The main constraint in the conversion of the rotary engine is at the production equipment and transfer equipment level. Considerable technology is being developed with respect to grinding the trochoid housing and choices are being made with respect to different surface coatings and characteristics of the housing surface in contact with the rotor.

* Continuing metallurgical work goes on associated with alternative metals to be used and exotic alloys are being developed for seals;

* The net effect on the automotive industry in Canada will be to cause a change in product mix and a slight decline in material consumption; however, its effect on the work force will be minimal with the exception of the isolated forge shops as indicated earlier in this report.

IX. PUBLIC POLICY CONSIDERATIONS

A. Overview

The future of the rotary combustion engine in the North American automotive market is uncertain. However its potential wide scale introduction has implications in a number of public policy areas. Among them are:

* Balance of Payments
* Employment
* Technology / R&D
* Taxation Revenue
* Foreign Ownership
* Resource Development
* Environmental Issues
* Defence / National Strategy

A commentary on some of the potential issues raised by the Wankel engine are described below. This overview is followed by a more comprehensive review of specific Department of Industry, Trade & Commerce objectives in view of the public policy implications. This focus is intended to highlight areas of greatest concern to the Department. Our analysis concludes with specific recommendations to meet the potential challenge and impact of the rotary engine within the context of national objectives as well as its impact on the Canadian automotive parts manufacturing industry.

* Balance of Payments

Canada is a significant world trader with approximately 20 percent of Gross National Product (G.N.P.) derived from export sales in 1972. By comparison, 4 percent of U.S. G.N.P. is tied to export sales. Total Canada - U.S. trade amounted to $27 billion in 1972. With 70 percent of Canada's exports and 69 percent of imports involving the U.S., Canada is highly dependent on the U.S. economy. To a lesser, but significant, degree the U.S. depends on Canada. In 1972, 25 percent of U.S. exports were delivered to Canada while 27 percent of U.S. imports originated in Canada.

The eight year old Canada - U.S. Auto Trade Agreement has taken Canada from a sizeable deficit position in bilateral auto trade to an essentially break-even position. In 1972, approximately one-half of Canada's total exports to the U.S. were in end products and within that grouping, 68 percent were related to auto pact trade. Notwithstanding the auto trade surplus, Canada is in a growing deficit position in end products with the U.S. which in 1972 amounted to $2.8 billion.

It is obvious that balance of payments consideration is a critical issue in Canada's economic development. The rotary engine could play a significant role in Canada - U.S. trade flows.

* Employment

The Auto Pact has had a favourable effect on the number of factory workers employed in the auto industry in Canada. Average annual automotive employment increased strongly from 1963 to 1966 but now appears to have reached a plateau.* In any event, a mechanism for protecting existing jobs is an obvious consideration in auto pact renegotiations. Of equal or greater importance is the participation in the future growth of the automobile industry. Changes in technology associated with rotary engines will be an important issue.

* Technology / R&D

As a matter of public policy, the Government of Canada has indicated that it wishes to encourage more research and development activities in Canada. At the present time, the amount of technological research being carried out in the Canadian automotive industry is relatively limited. In view of the structure of the industry, the bulk of the research is carried out by parent companies in the U.S. There are some exceptions however. A few companies whose Canadian plants are the prime sources of a particular product also undertake the research and development in connection with that product.

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* The Canada - U.S. Automotive Agreement: An Evaluation, Carl E. Beigie

The Federal Government research incentives have been utilized to some degree by the automotive industry. Under the Industrial Research and Development Incentives Act, 32 grants totalling approximately $520,000 have been approved. Under the program for the Advancement of Industrial Technology, 19 projects have been approved since 1968 for a total research value of $7,600,000.

As well as the research by the auto industry itself, it is reported that research organizations such as the Ontario Research Foundation and private inventors have been active as well. One Canadian inventor has recently filed a U.S. patent covering a rotary combustion engine.

The rationalization of the North American automotive industry has focused attention on production rationalization and productivity. It has been suggested that this has had an unfavourable effect on the number of managerial and professional staff in the Canadian automotive and parts industry. ** To the degree that the management of innovation depends on a complex infrastructure involving marketing, development, engineering, design and production, it is evident that firms must have large scale operations or "critical mass" ** to exploit R&D or in fact even consider it. There are very few independent Canadian firms that have the appropriate infrastructure in place to manage innovation. The firms that do are largely foreign owned with R&D facilities centralized outside of Canada. To develop a uniquely Canadian infrastructure would involve further government involvement in the automotive business. It is questionable whether the needs of foreign subsidiaries and Canadian independents are compatible if an aggressive innovation strategy were to be pursued. Discriminatory legislation would be required. Given the rationalization that has taken place and the benefits in terms of jobs, productivity, and balance of payments, it is doubtful whether an innovation strategy in the Canadian automotive industry is appropriate or even possible. Technological emphasis is probably better suited to other industrial sectors where rationalization terms have not been focused to the extent achieved in the North American auto industry. Areas of emphasis that could offer potential in support of rotary development that we have considered include the production of transfer equipment for rotary production lines plus specialization in safety related equipment that could be incorporated in redesigned rotary powered vehicles.

** The Business Quarterly, Spring 1970, From Auto Pact to Appliance Pact - Steps Toward a Legislated Economy, Harold Crookell.

Technology and R&D is an issue that will require consideration in view of the rotary development as well as an input for future industry sector planning.

* Taxation Revenue

In the context of future developments with respect to the rotary engine, the potential displacement of taxation revenues will depend on production considerations and as such becomes a relevant policy issue.

* Foreign Ownership

Given the rationalization that has taken place in the North American automotive industry and the international characteristics of the industry, it is inappropriate to think in terms of a distinctly Canadian automotive industry. While a Canadian car or industry could be developed insofar as technical aspects are concerned, the lack of an inadequate domestic market and the existence of international competition effectively rule out such an idea. There are a number of Canadian owned auto parts firms and, with encouragement, they should continue to be viable. However, the dominance of the North American industry by U.S. firms will likely require an assumption of continued foreign domination in this industry.

Canada's position in the auto pact is that it operates to enable "the industries of both countries to participate on a fair and equitable basis in the expanding market of the two countries". Providing the definition of fair and equitable can be related to relative equality between automobile production and consumption, the issue of foreign ownership is irrelevant except on emotional grounds. Canada's objective in this regard should be to participate in the growth of the industry in general on a fair and equitable basis and to ensure that foreign ownership will not result in adverse or arbitrary decisions contrary to Canada's national interests.

* Resource Development

It has been noted that the current design of the rotary combustion engine makes greater use of aluminium with a significant drop in cast iron requirements. Depending on final design specifications, the use of aluminium could become a major input to Wankel engine production.

The Canadian Government has expressed a desire to encourage further processing of raw material exports such as aluminium. In this regard, the use of aluminium in the rotary engine and its processing requirements should be noted and further processing in Canada encouraged as demand develops.

* Environmental Issues

The development of the rotary combustion engine relates favourably to the continued pressures directed towards pollution control, increased automotive safety equipment and energy conservation.

Peak combustion temperatures in the rotary are lower than in a piston engine, so the amount of NO formed is lower and it is comparatively easier to reduce levels further with internal exhaust recirculation. Control of CO and HC emissions is facilitated by the ability of the engine to operate on lean mixtures and retarded spark timing. In addition, the engine is readily adaptable to a relatively simple after-burner which responds favourably to the higher exhaust gas temperatures given off by the rotary. In addition, lower noise levels are a characteristic of the engine.

Automotive safety devices can be incorporated more readily into the chassis of a rotary which requires less engine space and facilitates front wheel drive for improved handling characteristics.

Energy conservation is based on a comparative assessment whereby the rotary can operate on leaner mixtures of low octane unleaded fuels. With improvements in sealing and weight reductions due to chassis design, gas mileage is expected to improve significantly whereas conventional piston fuel consumption is deteriorating as pollution controls are added.

Taken in total, the rotary engine offers potentially more agreeable solutions to environmental issues. The ability to control emissions combined with smaller car trends reinforced by a shifting mass transit focus presents opportunities for rotary engine development to meet the wide range of environmental goals.

* Defence / National Strategy

Canada does not have the capability, at present, to assemble a complete car from Canadian produced automotive parts. Rotary engine production could in all likelihood be consolidated outside of Canada and further take away from any Canadian sufficiency ideas. Accordingly, Canada should be concerned by the potential loss of engine production in Canada over the longer term.

In view of the preceding overview of public policy issues, it is possible to identify the areas of greatest concern to the Department of Industry, Trade & Commerce as:

* Industrial Strategy

* Trade Strategy

B. Industrial Strategy

The Government has identified a number of fundamental objectives that relate to industrial planning.

Three of these objectives have been stressed recently by the Minister for the Department.

(a) Canada should have a strong internationally competitive manufacturing sector;

(b) People in all regions of Canada should share in our economic wealth;

(c) Canadians should have greater domestic control over their own economy.

The Minister goes on to suggest that there must be means to realistically evaluate the strengths and weaknesses of individual sectors within the changing international trading environment.

The framework suggested asks the following questions:

- How do we sustain and build on our existing strengths?

- How do we realize our potential strengths?

- How do we assist our weaker industries to adjust to the changing environment and in some cases, shift their resources into more competitive activities?

The automotive sector strategy is to be found in the Canada - U.S. Automotive Agreement which came into effect in 1965. It has been pointed out that Canada has enjoyed a number of benefits since the signing which include increased blue collar employment, improved productivity, and a favourable balance of payments. At the same time it has been suggested that the production rationalization has reduced the number of managerial and professional jobs and thereby served to reduce the necessary innovative infrastructure required to pursue independent innovation for international markets.** There is obviously a trade-off in the auto pact relationship. It would appear that the appropriate emphasis in future auto pact re-negotiations should be directed towards a fair and equitable balance in Canadian automotive production and consumption plus a provision for balanced growth participation. These goals are realistic and reasonable and should continue to meet present and future goals relating to:

- industry employment (blue collar);
- a favourable break-even situation in balance of payments in auto and parts trade (i.e. Canadian production equal to Canadian consumption);
- tax revenue generation.

Consideration must be given to potential displacement in the industry if and when the rotary engine becomes the engine of the future but the terms of reference have to be broad enough to consider growth and fair, equitable participation in general. The Canadian industry, as part of the North American industry, should share in automotive industry growth.

From a strategic point of view, it is important to look beyond individual transport to growing government awareness of mass transit desirability. This shift from individual to mass transit planning could provide a better focus for future government initiatives in Canadian automotive and transportation areas.

C. International Trade Strategy

The Canadian secondary manufacturing sector has traditionally not been a major exporter of end product merchandise. As an importer of capital and exporter of primary goods with domestic manufacturers protected by tariffs, Canada has pursued a trade strategy that has relied on our abundance of natural resources.

** The Business Quarterly, Spring 1970, From Auto Pact to Appliance Pact - Steps Toward a Legislated Economy, Harold Crookell.

Canada's future economic growth cannot proceed under the same emphasis without serious implications for Canada's future viability as a nation. The Economic Council of Canada has outlined major economic and social goals for Canada which have been adopted as desirable objectives to be met in the future. These goals include:

- full employment;
- a high rate of economic growth;
- reasonable price stability;
- a viable balance of payments;
- an equitable distribution of rising incomes.

These are very comprehensive guidelines which by their nature are often in conflict with one another.

Similarily, other nations have equally demanding objectives. The response of nations to the international marketplace is one obvious focus to achieve their goals. The Canada - U.S. Automotive Agreement and the new round of General Agreement on Tariffs and Trade (GATT) negotiations have specific relevance to the Canadian automotive parts manufacturing industry and are typical of the growing awareness of the importance of international economic viability to future growth. Much has been written about Canada's lack of industrial innovation capacity and steps are being taken to respond to this challenge. This emphasis is being approached on an industry by industry basis.

In the automotive industry, the die was cast when the Auto Pact was signed in 1965 to rationalize North American automotive production between Canada and the United States.

In many respects trade strategy closely parallels points made under industrial strategy. In general, there are points of uncertainty with respect to future technological and marketing trends in the transportation field. Shifts in demand towards improved mass transit will be an important planning objective in the future. An obvious trade strategy with broad implications would be to strive towards a stronger position in balance of payments in the total transportation area.

D. Assistance Program Implications

1. Existing Programs

The Department of Industry, Trade & Commerce administers a number of programs providng direct financial incentives to stimulate research, development, innovation and manufacturing by Canadian industry.

The Canadian automotive parts manufacturing industries have made modest use of the available programs. Department information shows the following:

IRDA - Industrial Research and Development Incentives Act;

- 32 grants totalling approximately $520,000.

PAIT - Program for the Advancement of Industrial Technology;

- 19 projects since 1968;
- Total value approved approximately $7,600,000;
- Total value collected to date approximately $3,500,000.

Assuming a budget of $20 million per year for PAIT, the industry has participated in approximately 8 percent of the available funding over the last 5 years.

In addition, the Automotive Adjustment Assistance Program (AAA) made direct loans to manufacturers of original equipment automotive parts, tooling or specified commercial vehicles, and to suppliers of material, who might be affected by the Canadian - U.S. Automotive Agreement. In total approximately 75 loans totalling $80 million, bearing interest over 10 to 20 years, have been made.

The Department of Industry, Trade & Commerce has responded effectively to the automotive industry and the parts manufacturers with assistance and incentive programs. The continuing dialogue between the industry and the Department is obviously in the best interest of both parties. In particular, the export marketing seminars put on and encouraged by the Department of Industry, Trade & Commerce demonstrate the desired export initiative that the Department encourages and the parts industry appears willing to pursue.

2. Program Recommendations

In consideration of the limited effect rotary engine production is perceived to have on the Canadian auto parts manufacturing industry and its expressed willingness to adjust, it is recommended that:

(a) The Department of Industry, Trade & Commerce continue R&D incentive programs presently available as well as an adjustment program similar to AAA to anticipate potential relocation and re-equipment requirements that could develop.

(b) The Department of Industry, Trade & Commerce assist the industry in general by monitoring and disseminating the changing level of technological information.

(c) The Department of Industry, Trade & Commerce reinforce its marketing programs to continue its focus on export potential. The parts industry in Canada exported approximately $85 million to 100 countries other than the U.S. in 1972. The industry is actively promoting, in conjunction with the Department of Industry, Trade & Commerce, greater export penetration in third world markets. Industry association officials indicate potential third world export sales of $250 - $300 million.

In addition to these specific recommendations, it should be noted that additional consideration be given to developing possibilities including:

1. Specific incentives directed towards existing and new manufacturers of machine tools and transfer equipment. They could be encouraged to develop and market rotary engine production equipment to meet North American potential demand for this machinery.

2. The active monitoring of increased foreign car penetration into Canada. The potential for bilateral auto-trade agreements with countries other than the United States should be actively pursued as the shift to small car production from outside North America becomes more pronounced.

3. Consideration given to stimulating R&D on rotary engine parts and processes through a research consortia working with Canadian industry in which the Federal Government would accept the greatest financial risk. Licensing and joint venture opportunities could be explored in those areas.

APPENDIX A

BIBLIOGRAPHY

APPENDIX A

BIBLIOGRAPHY

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APPENDIX B

WORK PROGRAM INTERVIEW LISTING

APPENDIX B

WORK PROGRAM INTERVIEW LISTING

Accurcast Die Casting Ltd., Wallaceburg, Ontario.

Atlas Steels Co., Walland, Ontario

Wallace Barnes Company Ltd., Hamilton, Ontario.

Bundy Canada Ltd. (Sinterings Division), Guelph, Ontario.

Canadian Cold Forging and Coining Co. Ltd., Windsor, Ontario.

Canadian Fram Ltd., Chatham, Ontario.

Canadian SKF Co. Ltd., Scarborough, Ontario.

Carter Carburetors, St. Louis, Missouri.

Champion Spark Plug Co. of Canada Ltd., Windsor, Ontario.

Chrysler Corporation, Detroit, Michigan.

Dana Corp., Perfect Circle Division, Haggerston, Indiana.

Dominion Forge Company Ltd., Windsor, Ontario.

Eaton Precision Products Canada Ltd., Wallaceburg, Ontario.

Gould Manufacturing of Canada Ltd., St. Thomas, Ontario.

Great LakesForgings, Windsor, Ontario.

Hayes-Dana Parts Co., Perfect Circle-Victor Division, St. Thomas, Ontario.

Homes Foundry Ltd., Sarnia, Ontario.

Ingersol Machine and Tool Co. Ltd., Ingersoll, Ontario.

International Harvester Canada Ltd., Chatham, Ontario.

Johnson Matthey and Mallory Ltd., Toronto, Ontario.

Kendan Manufacturing Division, Borg-Warner, Oakville, Ontario.

Long Manufacturing Division, Borg-Warner, Oakville, Ontario.

Morris Chain, Burmingham, Michigan.

National Auto Radiator Mfg. Co. Ltd., Windsor, Ontario.

Precision Spring Ltd.

Stelco, Burlington, Ontario.

Thompson Products, St. Catharines, Ontario.

Zollner Canada Ltd., Leamington, Ontario.

APPENDIX C

SELECTED SURVEY OF

PARTS MANUFACTURERS

APPENDIX C

O - Original Equipment
A - Aftermarket

SELECTED SURVEY OF PARTS MANUFACTURERS

COMPANY	Piston Rings	Connecting Rods	Push Rods	Rocker Arm Covers	Valves	Valve Springs	Valve Sleeves	Valve Lifters	Engine Blocks	Manifolds	Miscellaneous Parts	Employees Affected	%of Canadian Mfg.
Accurcast Die Casting											O	6	20
Wallace Barnes						OA						80	75
Central Stampings				O								8	40
Eaton Precision								O				250	100
Gould Mfg.											O	-	-
Great Lakes Forgings		O										135	40
Ingersoll Machine & Tool											O	-	-
International Harvester											O	-	-
Kendan Mfg.										O		4	25
Perfect Circle	OA											130	55
Precision Spring						OA						35	25
Sinterings (Bundy)											O	-	-
Thompson Products					O							60	100
Zollner											O	-	-